PAVEMENT MANAGEMENT GUIDE

2018

HOUSTON AIRPORTS

Submitted to:
Houston Airport System

Submitted by:
Michael Baker International, Inc.

Michael Baker INTERNATIONAL

HOUSTON AIRPORTS

HAS Infrastructure Airfield
Pavement Management Standards

Originated by: HAS Infrastructure FAR 139 Airfield Pavements
Routing Date: 4/26/2019

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HOUSTON AIRPORT SYSTEM

PAVEMENT MANAGEMENT/

MAINTENANCE AND REPAIR PROCEDURE GUIDE

SUBMITTED IN:

SEPTEMBER 2017

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SUBMITTED BY:

MICHAEL BAKER INTERNATIONAL

November 16, 2018

Mr. Dev Raj Pokhrel, P. E.
Houston Airport System
Houston, Texas 77205-0106

Re: HAS Project No. 157838 – HAS Pavement Management Guide

Dear Mr. Pokhrel:

Included in this submission of the Pavement Management Guide, is the combined information from previous Volume I and Volume II Guide. This guide provides guidance on best asset management and proper pavement management procedures for the Houston Airport System. It contains an inventory of existing pavement management and capital improvement plan assets, as well as procedure/workflow. Also included are recommended inspection methods for pavement distresses, and inspection procedure/conduct. The Pavement Management Guide outlines proposed Airfield Repair and Maintenance Procedures. This includes repair procedure, pavement inspection methods, and response. Also included are the evaluation performance measures that outline what is required of each airfield in order to be in compliant with FAA standards. The airports within the scope of this report are: George Bush Intercontinental (IAH), Houston Hobby (HOU), and Ellington Field (EFD).

Michael Baker appreciates the opportunity to be of service to the Houston Airport System on this project. If any questions arise about this submittal, please contact us at your convenience.

Sincerely,

Quintin B. Watkins, P. E.
Project Manager

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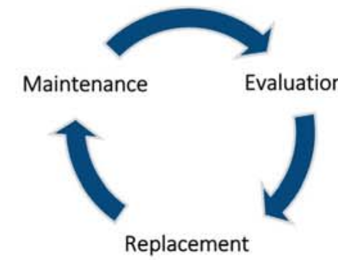
1.0 HOUSTON AIRPORT SYSTEM (HAS)

1.1 PAVEMENT MANAGEMENT WORKFLOW

This Pavement Management Plan is organized to utilize each work group in a way that promotes constant improvement and analysis of airfield pavement conditions. Within the workflow, each group plays a role in the management cycle (Maintenance > Evaluation > Replacement & Repair). At each major transition in focus, some sort of record of accomplished work will be requested in the form of drawings and updates to the GIS/Infor EAM database.

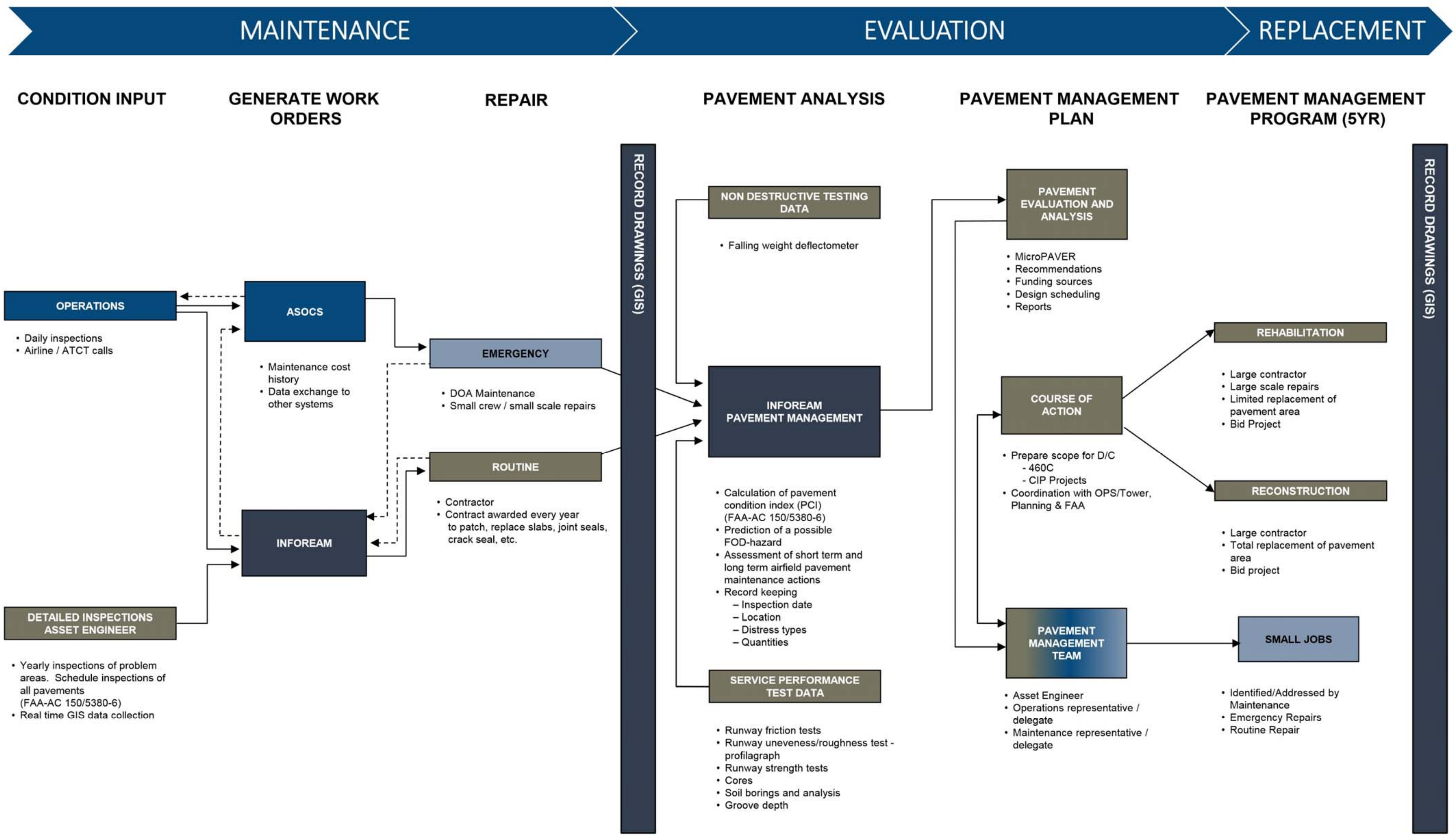
In order for the Pavement Management Workflow system to function adequately, a pavement champion from each of the four groups will be identified to take ownership and represent their group during the communication meeting. Communication meetings are to be held monthly. Weekly and sometimes daily sharing of information is to take place as issues arise. The Pavement Champions will handle problems, especially when safety is involved, until a solution is found. The following workflow chart outlines the various tasks within the Pavement Management Plan and assigns them to a workgroup.

HOUSTON AIRPORT SYSTEM
PAVEMENT MANAGEMENT WORKFLOW



HAS AIRPORTS:
IAH – George Bush International Airport
EFD – Ellington Field
HOU – Houston Hobby Airport

OPERATIONS
MAINTENANCE
GIS
ASSET ENGINEER



1.2 RESPONSIBLE GROUPS

This Pavement Management Guide was written for the Houston Airport System (HAS) to establish a program to manage the airfield pavement at the three airports (IAH, HOU, EFD) that make up HAS. The responsible groups for the airports' pavement assets are the Departments of Operations, the Airfield Maintenance Group, Asset Management and Infrastructure – FAR 139 Pavement. They, like all airports, have a desire to maintain a safe airfield.

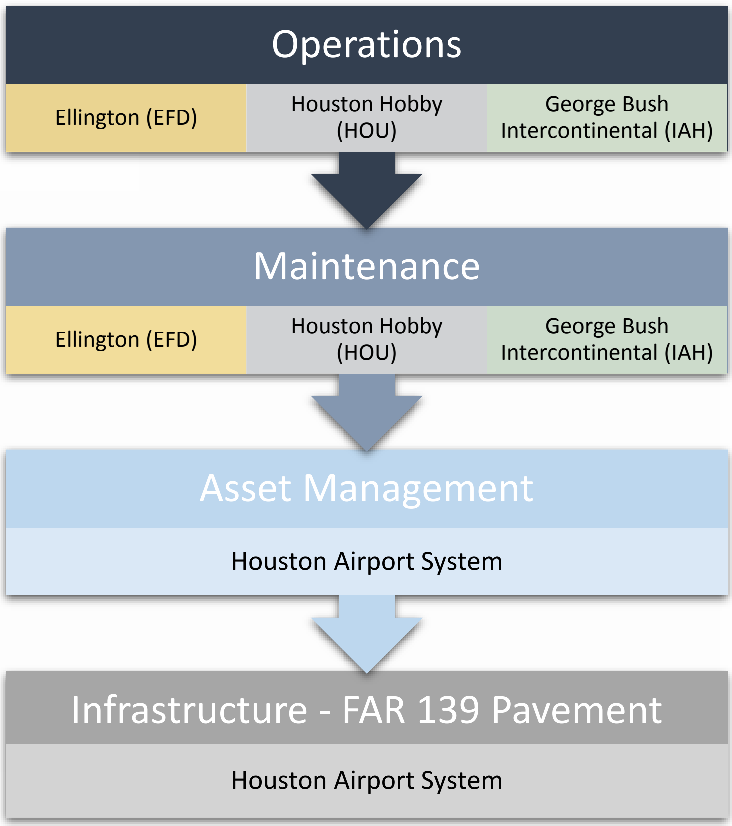


Figure 1.2: Pavement Management Plan Workflow

The Pavement Management Guide requires each group to perform tasks that will feed the other and achieve the goal of a safe and efficient airfield. The guide will describe the steps necessary protocol for distress identification along with maintenance and approved standards for repair of the distress.

1.2.1 OPERATIONS

Operations should undertake a Foreign Object Debris (FOD) Prevention Program, which can be performed through daily inspections of the airfield. FOD Prevention Program includes a clean as you go practice and ensuring the maintenance and proper storage of all equipment. Operations need to identify FOD producing items and the need for immediate attention. If a pavement deficiency is creating the FOD, this could lead to an urgent closure of the site to correct the issue. The repair methods will be discussed in the Pavement Maintenance Guide. Operations are also responsible for biweekly friction testing (see Section 10.0 Pavement Friction Manual).

1.2.2 AIRFIELD MAINTENANCE GROUP

The Airfield Maintenance Group performs repairs that are identified by Operations. They track the repairs and document them, so the information can be passed along to the Asset Management Group.

1.2.3 ASSET MANAGEMENT GROUP (GIS)

The Asset Management Group records and monitors the distresses identified by Operations, Airfield Maintenance and Engineering using GIS and Infor EAM. They provide the data to the Engineering group, who design the repairs and pavement replacements.

1.2.4 INFRASTRUCTURE – FAR 139 PAVEMENT (ASSET ENGINEER)

The Asset Engineer is responsible for performing the Annual Repair inspections and the FAA required Pavement Evaluation, which occur every 3-5 years. They take the data from the Asset Management group and design annual repair contracts and annual pavement replacement projects. FAR 139 Pavement, the Asset Engineer must approve of all repair efforts. All repair efforts must follow this manual.

1.3 SAFETY, SECURITY, AND BADGING

All personal that access and work on the airport are required to pass a background check and been assigned a badge. This process includes but is not limited to a criminal background check and fingerprinting, proof of identification, signed application forms, and educational training courses.

Upon applying for a badge, the employer must indicate the need for AOA driving privileges on the badge application. This will require the applicant to have additional training in SIDA and AOA Non-Movement Driver Training.

The badge is and will remain the property of Houston Airports System. The badge holder is responsible for maintaining the badge and renewing it before its expiration date. If a badge is lost or stolen, it must be reported immediately to the Airport Badging office. The badge will not be replaced until the individual who was issued the badge has completed the Lost/Stolen Badge Report Form. When a badge holder’s work is complete or reassigned at the airport, or upon his or her termination of employment, the employer must immediately notify the badging office of the status change and confiscate the badge. The confiscated badge is to be returned to badging office within 48 hours of confiscation.

For more information about the badging, contact the office listed below or visit the web site https://www.fly2houston.com/biz/resources/badging/

IAH LOCATION AND HOURS
IAH Airport Badging Office
Terminal A, Baggage Claim Level, North Side
2800 North Terminal Road
Houston, TX 77032
Hours of Operation: Monday, Tuesday, Thursday, Friday: 6:30 a.m. - 2:00 p.m. Wednesday: 6:30 a.m. - 12:30 p.m.

Application Processing is by *Appointment Only* using the TimeTrade online scheduling program.
Ask your employer to schedule an appointment using the web-based appointment scheduler. Be sure to arrive at least 10 minutes prior to appointment time.
Lost, stolen or damaged badges are considered emergency processing and will be handled as a walk-in during normal business hours.

HOU LOCATION AND HOURS
HOU Airport Badging Office
William P. Hobby Airport (HOU)
7800 Airport Boulevard
Houston, Texas 77061
Located on the first floor of the terminal, on the east side of the baggage claim area
Hours of Operation: Monday - Friday 8:00 a.m. to 3:00 p.m.

For groups larger than 4, please call the badging office for an appointment

EFD LOCATION AND HOURS
EFD Airport Badging Office
Building 267
11900 Galveston Rd. (Hwy 3)
Houston, TX 77034
Hours of Operation: Monday - Friday, 07:00-11:00

Visitor badges are only valid for 29 days once you obtain the physical badge from JSC or Ellington Field. Allow at least 20 minutes per person at the badge office.

1.4 SAFETY INFORMATION

Construction on Airports often require procedures and conditions associated that affect aircraft operations and can jeopardize operational safety. Safety considerations are paramount and require careful planning, scheduling, and coordination of construction. This is must be done ahead of construction so that the work has a minimal disruption of normal aircraft operations and avoid situations that compromise the airport's operational safety. This planning effort results in a project Construction Safety and Phasing Plan (CSPP). For a general CSPP, refer to Appendix A.

1.5 PERMITTING INFORMATION

The contractor shall be responsible for complying with all federal, state and local laws and will procure all necessary permits and licenses, pay all charges, fees and taxes required for construction and give all notices necessary and incidental to the due and lawful prosecution of the work at no cost to the Houston Airport System. For more information about permitting, contact the office listed below or visit the web site.

BSG Permit Coordinator
HAS Building Standards Group (BSG)
18600 Lee Road
Humble, TX 77338
1-281-233-1051

https://www.fly2houston.com/biz/resources/building-standards-and-permits/

2.0 PAVEMENT CONDITION EVALUATION

Runway, taxiway and apron pavements in the HAS's airports can be categorized as flexible and/or rigid pavement. Flexible pavements are those in which each structural layer is supported by the layer below and ultimately supported by the subgrade. On the other hand, rigid pavements are those in which the principal load resistance is provided by the slab action of the surface concrete layer.

Rigid pavement is usually divided by joints in a series of slabs to minimize warping effects due to variations of moisture content and temperatures that can cause random cracking. Joint spacing is impacted by many factors including: total width and thickness of pavement to be constructed, location and size of in-pavement objects, type of aggregates used in the concrete, range of temperatures that the pavement is exposed to, base restraint as well as warping stresses. Shorter joint spacing generally provides better long-term service performance. The recommended maximum joint spacing is found in table 2.1. Moreover, the required dimension and spacing for steel dowels are listed in table 2.2. Figure 2.0 shows General PCC Joint Detail Sections.

Table 2.1 Recommended Maximum Joint Spacing for Rigid Pavement [1]

a. Without Stabilized Subbase

Slab Thickness	Joint Spacing
6 inches or less (152 mm)	12.5 feet (3.8 m)
6.5-9 inches (165-229 mm)	15 feet (4.6 m)
>9 inches (>229 mm)	20 feet (6.1 m)[2]

b. With Stabilized Subbase

Slab Thickness	Joint Spacing
8–10 inches (203-254 mm)	12.5 feet (3.8 m)
10.5-13 inches (267-330 mm)	15 feet (4.6 m)
13.5-16 inches (343-406 mm)	17.5 feet (5.3 m)
>16 inches (>406 mm)	20 feet (6.1 m)[2]

Notes:
1. Longitudinal Joint Spacing shown in the tables. Transverse spacing should not exceed 1.25 the longitudinal spacing
2. On Group IV Taxiways, 25.5 feet (6.2 m)

Table 2.2 Dimension and Spacing for Steel Dowels

Thickness of Slab	Diameter	Length	Spacing
6-7 in (152-178 mm)	¾ in (20 mm)	18 in (460 mm)	12 in (305 mm)
7.5-12 in (191-305 mm)	1 in (25 mm)	18 in (460 mm)	12 in (305 mm)
12.5-16 in (318-406 mm)	1 ¼ in (30 mm)	20 in (510 mm)	15 in (380 mm)
16.5-20 in (419-508 mm)	1 ½ in (40 mm)	20 in (510 mm)	18 in (460 mm)
20.5-24 in (521-610 mm)	2 in (50 mm)	24 in (610 mm)	18 in (460 mm)

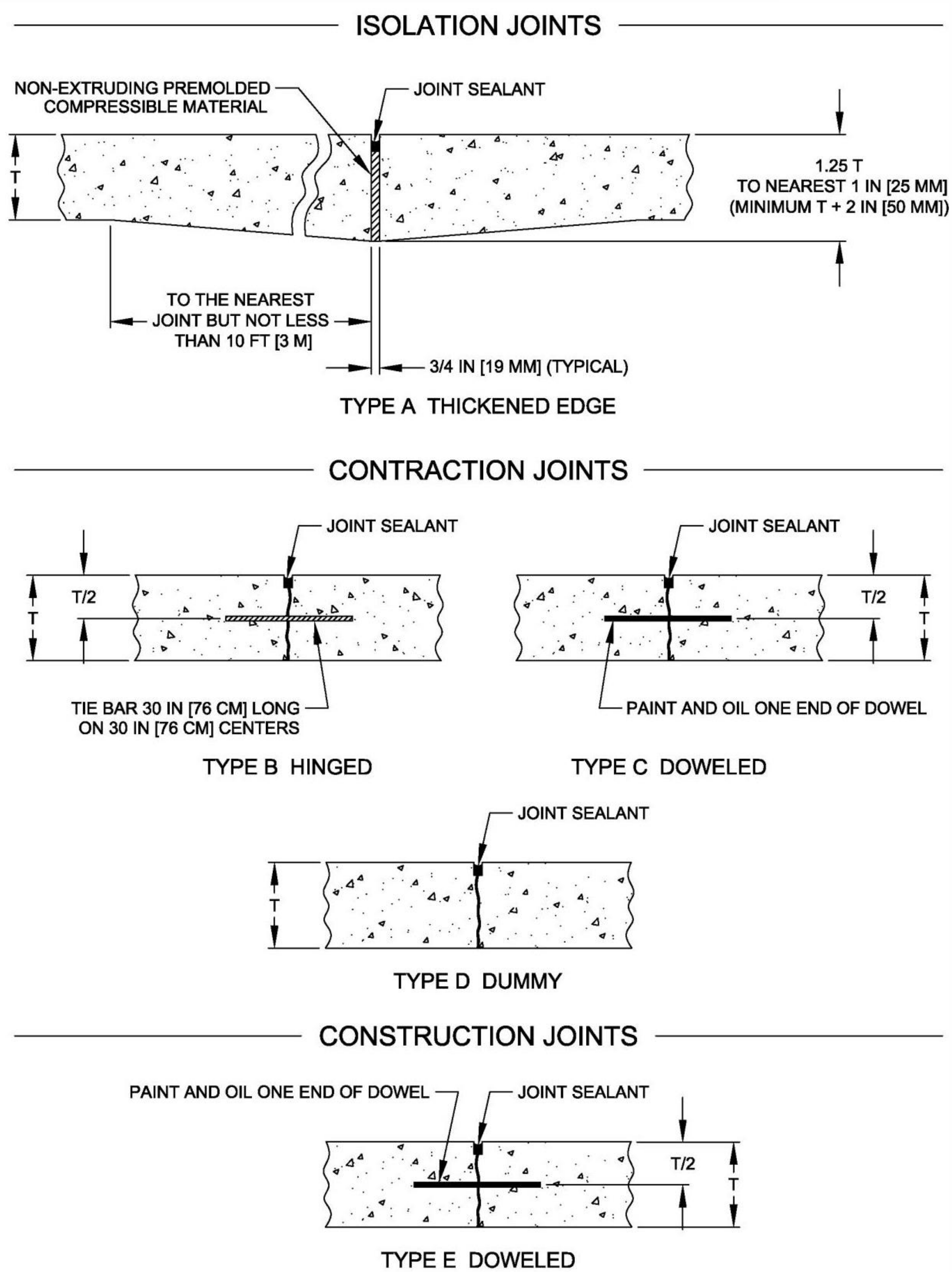


Figure 2.0: General PCC Joint Detail Sections[1]

[1] https://www.faa.gov/airports/engineering/pavement_design/media/pcc-joint-details-sections.pdf

The typical pavement structure consists of surface course, base course, subbase course, and subgrade. The typical section and materials used for both rigid and flexible pavement are illustrated in figure 2.1. Transition between flexible and rigid pavement can also be encountered in different areas along the airports. Figure 2.2 illustrates the typical section of such pavement transitions.

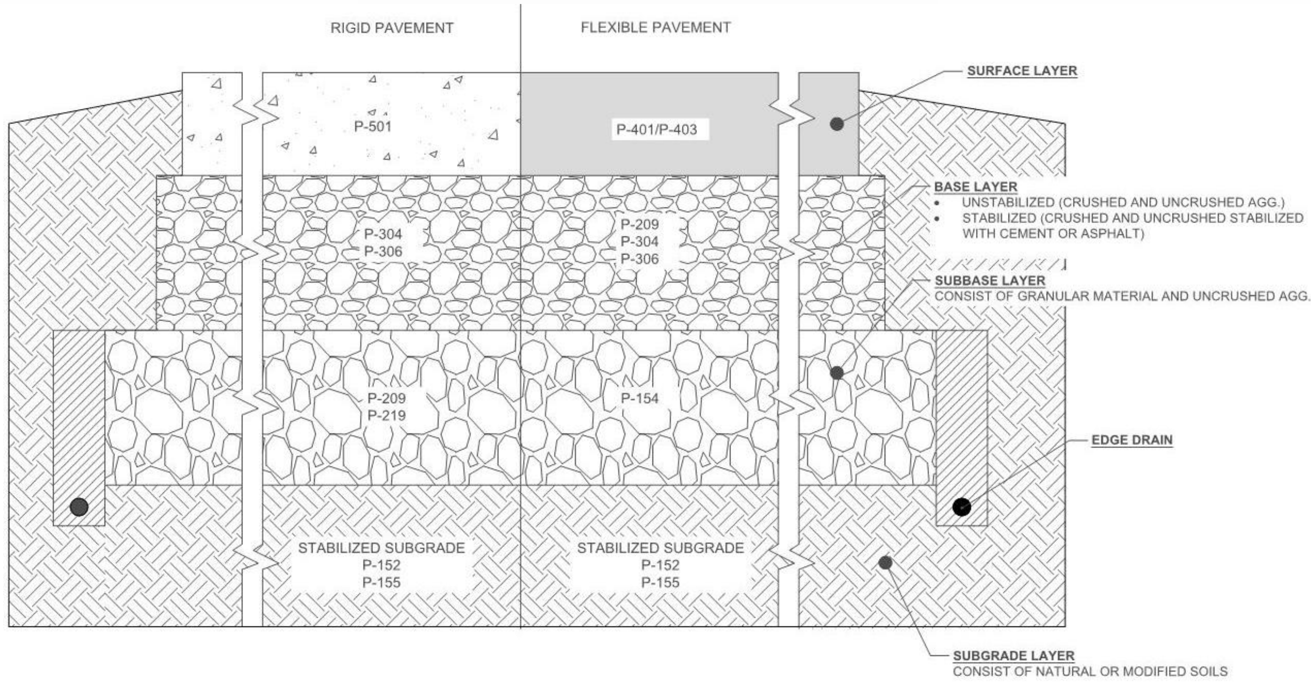


Figure 2.1: Typical pavement structure with reinforcement

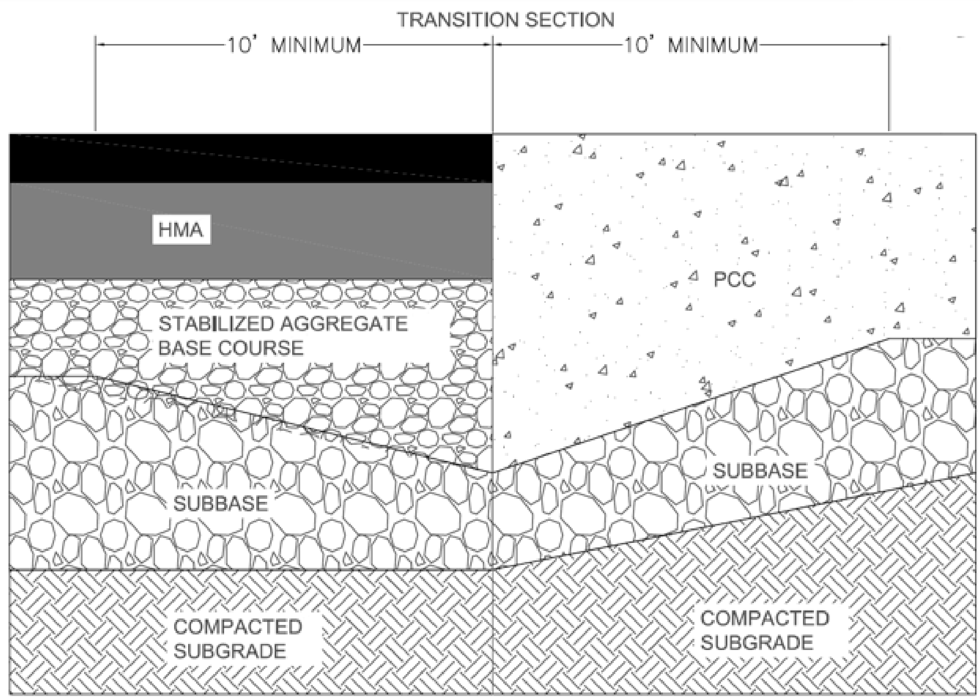


Figure 2.2: Pavement transition details

2.1 PAVEMENT REHABILITATION PLANS

The IAH, HOU, and EFD Airfield Pavement Assessment report (dated June and July 2014, or current) shall be used as the starting point for the annual Airfield Maintenance Plan for pavement replacement. This report lays out the Capital Improvement Plan (CIP) major rehabilitation methods for pavements based on the field inspection data input in PAVER. The report states "although PAVER is a powerful analysis tool the PAVER constrained work plans are not realistic to apply directly to a large airfield". Therefore, further engineering experience is needed when recommending work and that PAVER is primarily to be used to determine general funding costs and repair scenarios.

The Capital Improvement Plan (CIP) Drawings are included here so the areas can be walked and ranked in order of worst condition to lowest priority.

Figure 2.3: George Bush Intercontinental Airport Recommended (IAH) Major M&R CIP Plan
Figure 2.4: Houston Hobby Airport Recommended (HOU) Major M&R CIP Plan
Figure 2.5: Ellington Field (EFD) Major M&R CIP Plan

The Asset Engineer shall meet with Operations and Airfield Maintenance to go over the generated plans to see if there are additional distress areas identified during the daily inspections of the airfield that need to be repaired. The Asset Engineer is to annually walk the pavement areas and rank the condition to determine if some areas are degrading faster than expected based.

The ranking can be based on a single characteristic such as the Pavement Condition Index (PCI) or on a composite indicator that combines PCI with the influence of other factors, including the number of aircraft departures and the functional and operation class of the pavement section. A detailed description of PCI and other factors can be found listed below.

2.2 PAVEMENT CONDITION INDEX (PCI)

Pavement Condition Index (PCI) factor represents pavement characteristics and was assigned the highest weighting in ranking. In general, other pavement characteristics that can be used include a friction index, FOD potential, and maintenance repair frequency.

Minimum PCI service scores are established in order to ensure a standard level of performance and safety from airfield pavement. PCI minimums are broken down by pavement branch. Sections of pavement approaching or below these minimums must be prioritized in upcoming M+R projects.

Table 2.3: Pavement Use PCI Limits

Required Minimum PCI Service Level	
Pavement	**Minimum PCI**
Runway	75
Taxiway	70
Shoulder/Apron	60

A general guideline for Major Rehabilitation by PCI range can be seen in Table 2.4

Table 2.4: Pavement Rehabilitation Policy Based on PCI

Condition Range	PCC Pavements	Asphalt-Surfaced Pavements
PCI > 70		Resurfacing overlay (3 in)
PCI = 50 - 70	Major repairs (slab replacements, patching, and crack sealing)	Resurfacing overlay (4 in)
PCI = 40 - 50		Structural overlay (6 in)
PCI < 40	Reconstruction	Reconstruction

2.3 AIRCRAFT DEPARTURES

The number of annual aircraft departures taking off from the section represents the volume of aircraft movements and can be alternatively represented by the total number of aircraft operations.

2.4 PAVEMENT FUNCTION AND OPERATION

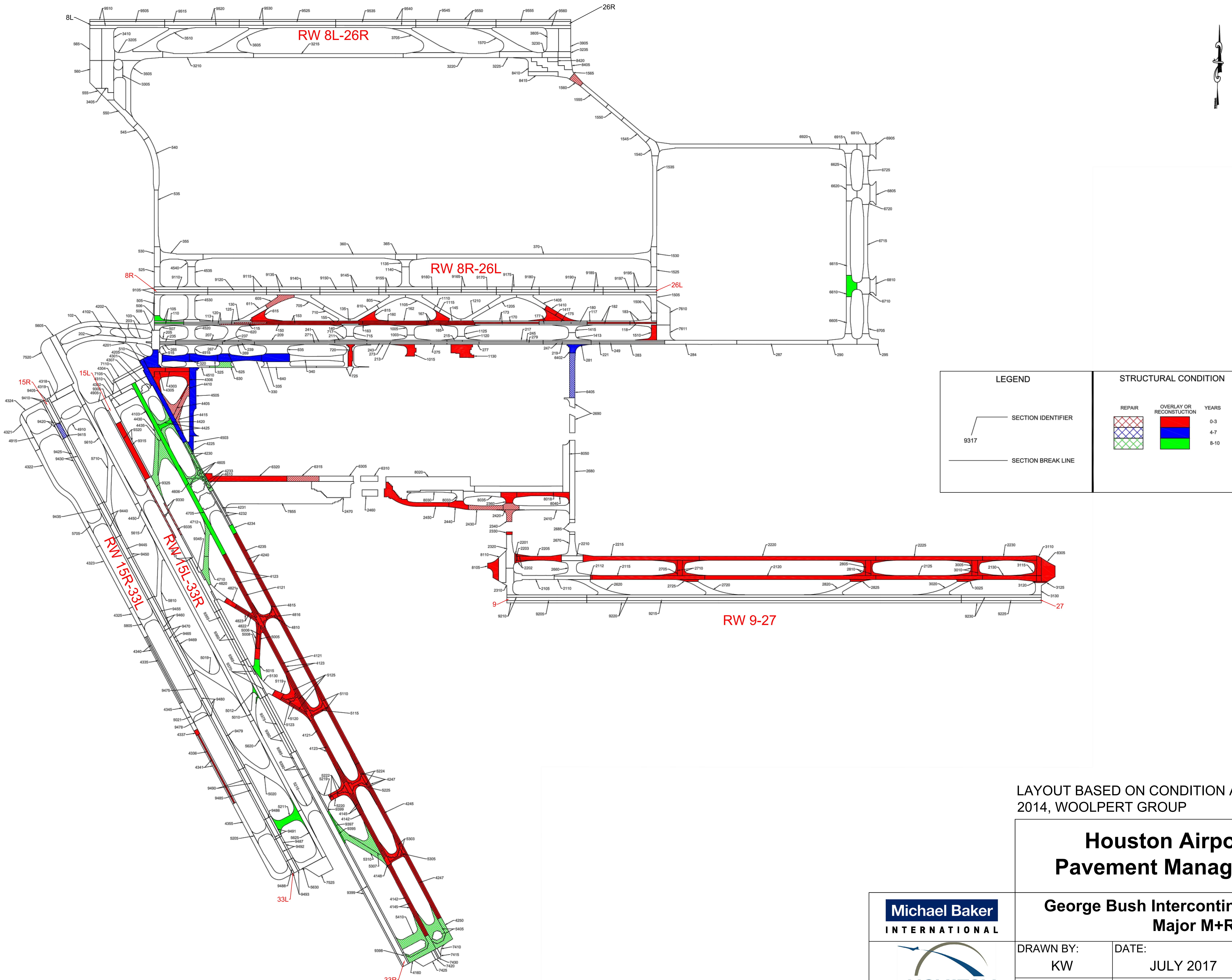
The type of function and operation class of the section to be evaluated (Runway, Taxiway, apron) could factor the project prioritization.

2.5 OTHER FACTORS

Other factors that could factor into project prioritization include:

- Remaining Life of Pavement (Functional)
- Remaining Life of Pavement (Structural)
- Structural Capacity (ACN/PCN)
- Pavement History
- Layered Thickness
- Pavement Modulus
- Potential Replacement ROI

While these factors can all be used when prioritizing future work, they should be considered in tandem with more comprehensive metrics in determining pavement condition. This should be considered on a case by case basis and requires going with engineering judgement. PCI, FOD potential, maintenance repair frequency, aircraft traffic, and functional class of pavement are the most highly recommended methods of prioritizing repair allocations because of their effectiveness in determining pavement repair needs.



LAYOUT BASED ON CONDITION ASSESSMENT REPORT, 2014, WOOLPERT GROUP

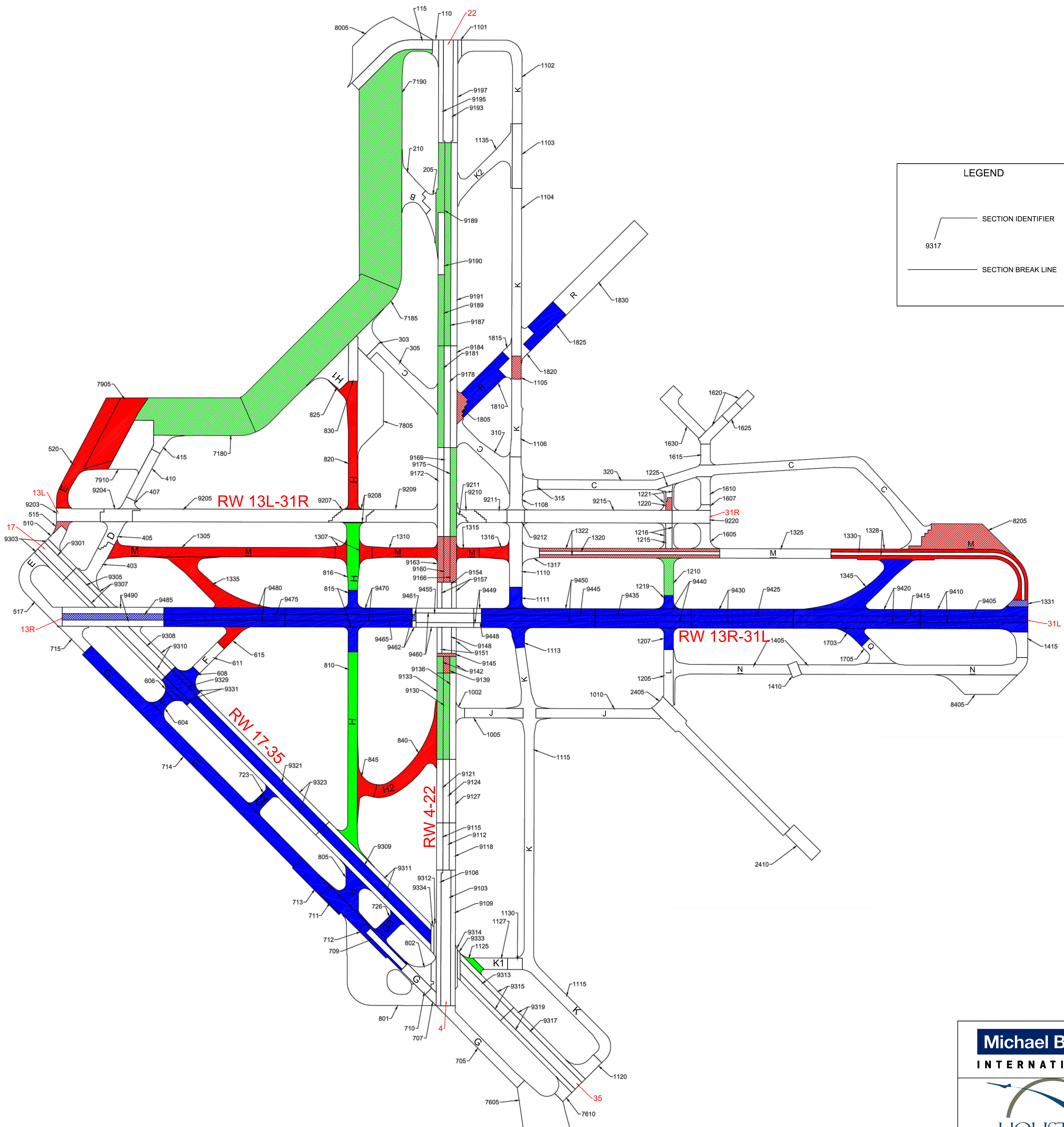
Houston Airport System Pavement Management Guide

Michael Baker INTERNATIONAL

HOUSTON AIRPORTS

George Bush Intercontinental Airport (IAH) Major M+R CIP

DRAWN BY:	DATE:	ISSUED FOR:
KW	JULY 2017	
APPROVED BY:	SCALE:	SHEET NO:
QW		FIGURE 2.3



LEGEND

9317 SECTION IDENTIFIER

SECTION BREAK LINE

STRUCTURAL CONDITION

REPAIR	OVERLAY OR RECONSTRUCTION	YEARS
		0-3
		4-7
		8-10

LAYOUT BASED ON CONDITION ASSESSMENT REPORT, 2014, WOOLPERT GROUP

Houston Airport System Pavement Management Guide

Houston Hobby Airport (HOU) Major M+R CIP

Michael Baker INTERNATIONAL

HOUSTON AIRPORTS

DRAWN BY:	DATE:	ISSUED FOR:
KW	JULY 2017	
APPROVED BY:	SCALE:	SHEET NO:
QW	1":400'	FIGURE 2.4

LAYOUT BASED ON CONDITION ASSESSMENT REPORT, 2014, WOOLPERT GROUP

Houston Airport System
Pavement Management Guide

Michael Baker INTERNATIONAL

HOUSTON AIRPORTS

Ellington Field (EFD)
Major M+R CIP

DRAWN BY:	DATE:	ISSUED FOR:
MR	JULY 2017	
APPROVED BY:	SCALE:	SHEET NO:
QW	1":800'	FIGURE 2.5

3.0 DATA COLLECTION PROCEDURES

Data collection and distribution to the organizations is a major undertaking but is necessary to maintain the system. Short-term and long-term milestones and objectives are outlined in Table 3.1.

Table 3.1: Data Collection and Task Procedures

Task Frequency	Organization	Task Description	Notes
Daily	Operations	Part 139 Inspection - Identify immediate hazards, such as buckled slabs, large potholes, spall producing FOD	Photograph with a GPS phone in order to put in the GIS system and Infor EAM
Weekly	Operations and Maintenance	Meeting to review the list of deficiencies	
		Friction Testing	
Monthly	Operations and INF-FAR 139 Asset Engineer	Inspections -Identify items that need to be tracked such as cracks, spalls not producing FOD	Photograph with a GPS phone in order to put in the GIS System and Infor EAM
Annual	INF-FAR 139 Asset Engineer	Walk pavement to identify distresses for Annual Repair Contract	Photograph, GPS and mark the locations. Create drawings with the locations for the Repair Contract and with a general ranking of the worst pavement areas
		Measure Grooves	
Every 3-5 years (Pavement CIP Recommendations)	INF-FAR 139 Asset Engineer	Hire a firm to perform PCI surveys following ASTM D5340; along with limited Heavy Weight Deflectometer (HWD) testing to create a replacement recommendation plan. An example pavement evaluation scope is in Appendix B.	The plan should include a ranking of the near term, medium, and long-term plan for the worst pavement sections.
			Updates to the PAVER Database to be made.
			Develop/Review CIP plan based on condition assessment report in conjunction with Airport Capital Improvement Plan (ACIP) and Master Plan updates.

3.1 METHODOLOGIES, EQUIPMENT AND PROCEDURES

Operational inspections are the first line of defense in identifying distresses throughout airfield pavement. While they are not the priority of crews on the airfield, it is important that personnel are provided proper instruction in identifying pavement distresses. Correctly identifying distresses reduces the amount of time needed to address them. Periodic major evaluations should be done through pavement walks, where inspectors visually evaluate pavement; as well as, record various pavement distresses – to be recorded and scored in PAVER. More comprehensive pavement evaluations can be performed, such as LIDAR and mechanically assisted inspection, to allow for more autonomous recording of distresses in pavement. These methods are resource intensive and should be seriously considered before they are implemented.

3.2 PAVEMENT DISTRESS OVERVIEW

Pavement distress identification should be made as standard as possible when performing visual inspections of pavement. PAVER™ provides baseline manuals for distress identification. The manuals contain distress definitions, severity levels, and measuring methods for asphalt and concrete surfaced airfields. The information of these manuals can be used to determine the PCI of airfield pavements.

The PAVER™ Distress Identification Manual was developed by the U.S Army Corps of Engineers Research and Development Center – Construction Engineering Research Laboratory (USACE ERDC-CERL). The manuals are available in Appendix C - Concrete Surface Airfields PAVER™ Distress Identification Manual and Appendix D - Asphalt Surface Airfields PAVER™ Distress Identification Manual

4.0 DATA RECORD RETENTION AND UPDATING

The maintenance data should be retained in the GIS system and Infor EAM for each airport. The PCI scores along with the daily and annual repair locations should be updated based on the data collection recommendations. PAVER should only be used to calculate the PCI scores and then transferred to GIS.

The Daily Operation distress data collection should be kept in a separate file. PAVER FieldInspector software is used to document the distress. See Appendix H for PAVER FieldInspector user guide.

The GIS data should be organized by date so that it can be annually revised to remove all the repairs that have been completed.

4.1 DAILY INSPECTIONS

As a part of daily airfield function, Maintenance and Operations crew are to be instructed to observe pavement distresses, as well as FOD. These daily checks do not require closures; however, they are to be performed while other work is being done on the airfield. These inspections inform asset management of any distresses or conflicts on the airfield that occur more spontaneously than normal degradation and possibly addressed in the field. Daily inspections are not inclusive of the entire airfield, which will still require properly scheduled full pavement inspections.

4.2 MAINTENANCE WORK ORDERS

In response to identifying pavement distresses, Airport Operations should communicate with Maintenance and Operations crews about corresponding responses in the form of work orders. As these work orders are issued and addressed, they should be recorded into the airports database (ASOCS and Infor EAM) by airport owners. The database is to be maintained by airport Operations.

5.0 DATA FLOW

5.1 INFOR EAM SOFTWARE

Each airport has its own Operations Department which performs daily inspections of the airfield and inputs the inspection and repair data into Infor EAM. The pavement distresses discovered on the daily inspections are relayed to the Maintenance Department and put on a list of repairs. Currently there is a system that rates the distresses on a level of 1-3 with 1 being an urgent need and 3 just requiring observation. It is recommended that the urgent needs be sent to Maintenance immediately and the level 2 to 3 items be discussed during the weekly meetings. Work orders for field inspections and repair are submitted in ASOCS. The work order information updates simultaneously in Infor EAM. The urgent repairs work orders should be input into ASOCS immediately. At the meetings it can be determined by the group if the other items (ranked 2 and 3) need to be prioritized differently. This will create an environment where everyone will become educated on the distress types and the need for repairs. The repairs can be submitted to Infor EAM after the meeting and therefore progress can be tracked weekly. It is recommended that this meeting be a webinar to expedite decision-making and to reduce team travel requirements.

5.2 PAVER AND FIELDINSPECTOR SOFTWARE

Pavement distress data is recorded with a computer tablet based FieldInspector software. The software, which is a companion of PAVER, allows the user to export collected distress data to PAVER for PCI evaluations. The PAVER software utilizes gathered distress data to grade and rank the PCI of pavement sections. This is a particularly powerful tool in that it maintains a uniformity to pavement analysis that cannot be achieved manually. PAVER provides predictive modeling of pavement conditions, which can then be visualized through GIS as a progressive deterioration map highlighting areas of interest. The software also offers Maintenance and Repair Work Planning as well as Project Scheduling, but team involvement in project planning will determine if these features will be useful.

Pavement records will need to be procured to properly update the databases that PAVER utilizes. This includes work orders, PCI score records, and planned maintenance and repair work. Once this backlog of information is imported into meaningful databases, personnel will need to continually update PAVER as pavement inspections and repair projects are performed. Maintaining accurate historical pavement records is difficult in PAVER.

While PAVER scores can be exported into GIS software, currently there are not any dynamic connections that can be made between the databases, and those connections will also need to be manually updated. Dynamic connections may be available in the near future.

5.3 GIS SOFTWARE

Currently, existing pavement inventories for all three HAS Airports are housed within a GIS database, which can be accessed using ArcGIS or ArcMap. There are also pavement inventories in OASIS. Pavement information and unique attributes (Section ID's, PCI, Age, etc.) will need to be gathered and formatted for the PAVER software. Through ArcMap, PAVER results and analytics can be displayed in layout format and will be the main method of visualizing current pavement system conditions and proposed maintenance and repair work.

Between pavement inspections, GIS data will be what is referred to by Asset Management, rather than data located in PAVER. This ensures that all involved parties are making work decisions based of matching datasets.

5.4 DATA MANAGEMENT WORKFLOW

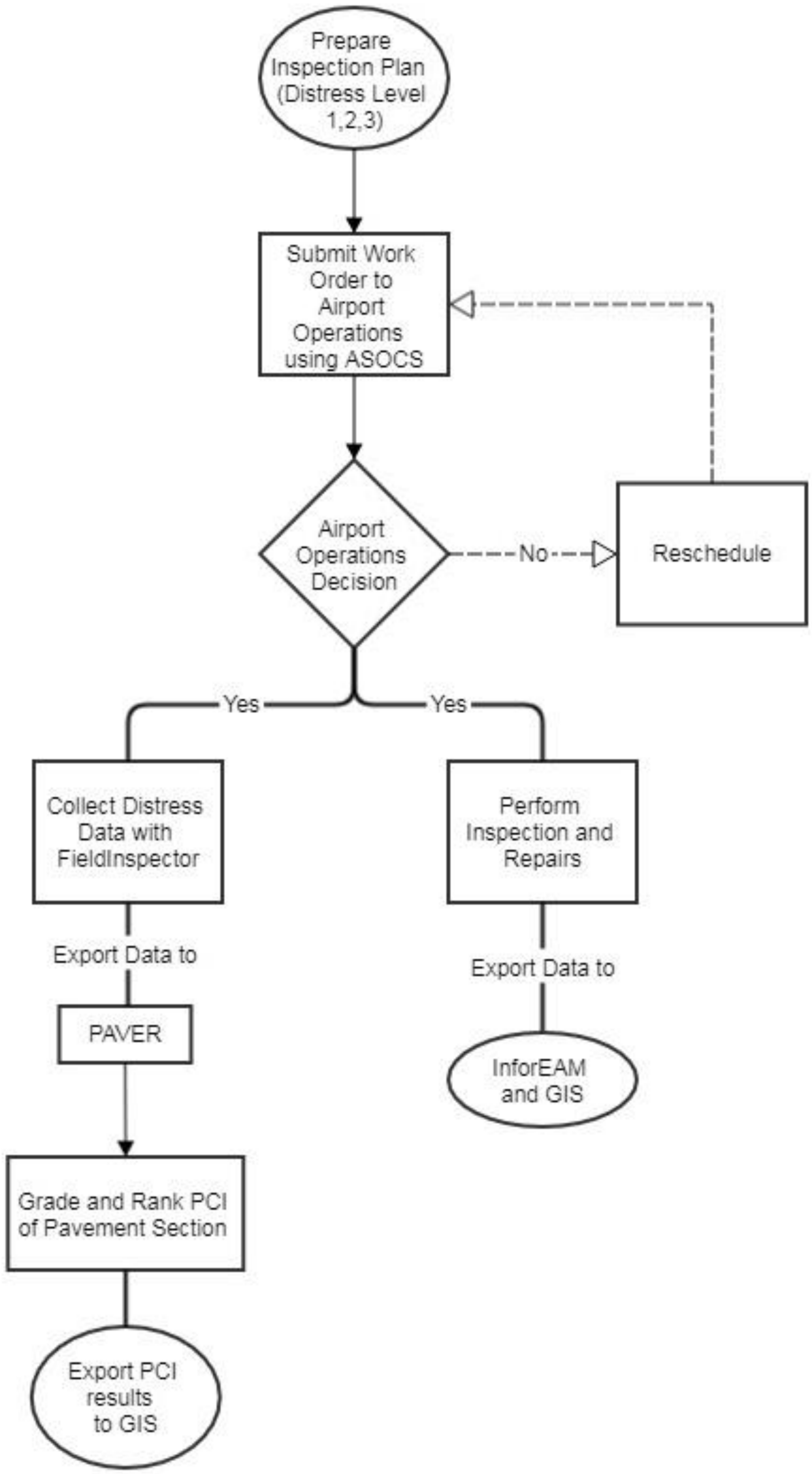


Figure 5.1: Distress Inspection Workflow

6.0 ANNUAL INSPECTIONS AND PCI UPDATES

Annual inspections by a FAR 139 Asset Engineer with Operations is necessary to maintain the pavement and to track the future needs. The inspector should plan to walk each airfield annually. The walks should be completed prior to the award of the annual repair contract at each airport. The annual repair contract will include the repair methods identified in the Pavement Maintenance Guide. The evaluator will walk the pavement during the day based on the traffic operations. A checklist of the inspection protocol is included in Appendix E. During the inspection, the pavement distress will be marked, labeled and captured using GPS. Pavement distress examples, as well as, recommended response actions can be found in *PAVER™ Distress Identification Manual*[2]. The data will be downloaded daily into GIS and then drawings will be created for the Repair Contractor. Just like the replacement strategy a ranking of the distresses needs to occur to use the budget effectively. After airfield pavement repairs have been completed, the PAVER database will be updated, to ensure the most recent PCI information at the section/branch level. Below is a distress prioritization methodology.

6.1 AIRFIELD PAVEMENT REPAIR DISTRESS PRIORITIZATION METHODOLOGY

a) Full Depth

1. All are considered priority

b) Spalls/Potholes

Point (spall) numbers given for the spalls to be included in the current scope only. Spalls without point (spall) numbers are not included in current scope and are future-year spalls

1. Using photos, rank distresses as most severe, severe, moderate, and minor
2. Address all most severe, regardless of location
3. Calculate quantity of all severe inside hold bars
4. Calculate quantity of all moderate on runways (inside edge stripes)

c) Utility Spall

1. All are considered priority and quickly addresses, if possible

d) Crack Seal

1. All runways inside hold bars
2. Any taxiways determined by the team

e) Joint Seal

1. All runways inside hold bars
2. Any taxiways determined by the team

The data collected during these inspections will be saved and exported into an XML file (see Appendix H for a more detailed description of this process). The XML file is then loaded into the AutoCAD file Pavement Walk.dwg, which will be used as the base map for the distresses collected. All distresses with be on there on layer with the date of collection, i.e. Spall distressed collected on January 1st, 2018 will be on the "Spall-01.01.2018" layer. This layer will also include the demo limits, including those not addressed in Airfield Pavement Repair. Demo limits are to be copied for display into the construction documents.

The budget will be determined based on the previous year's pavement distress walk quantities. The quantity will decrease as projects are completed. Additional areas will be identified during the annual and 3-5-year evaluations.

[2] PAVER™ Distress Identification Manual developed by the U.S Army Corps of Engineers Research and Development Center – Construction Engineering Research Laboratory (USACE ERDC-CERL). Manuals available at FAA Airport Websites: http://www.faa.gov/documentLibrary/media/Advisory_Circular/Asphalt-Surfaced-Airfields-Distress-Manual.pdfhttp://www.faa.gov/documentLibrary/media/Advisory_Circular/Concrete-Surfaced-Airfields-Distress-Manual.pdf

7.0 DISTRESS IDENTIFICATION AND EMERGENCY REPAIR

In order for airfields to operate at an efficient and predictable level, the airport must follow best maintenance and rehabilitation practices. This involves incorporating standardized methods of distress identification, response analysis, and repair. In developing methods, rigid pavement (PCC) and flexible pavement (AC), must be seen as separate entities. However, in an emergency situation a temporary repair material solution may be used to open the pavement until the proper repair method can be used. Table 7.1 is a list of available repair materials, along with the time required prior to opening to traffic.

Table 7.1: Observed Repair Material Products w/ Specifications[3]

Product	Type of Material	Usage/Time to Traffic
Delpatch	Polyurethane Polymer Concrete	1 hour
RSP	Polyurethane Polymer Concrete	8-10 minutes
Wabo ElastoPatch	Polyurethane Polymer Concrete	1 hour
FlexPatch (SSI)	Epoxy Polymer Concrete	1-2 hours
FlexKrete	Thermosetting Vinyl Polymer Concrete	45-90 minutes
EucoSpeed MP	Magnesium Polyphosphate	1 hour
MgKrete	Magnesium Polyphosphate	30 minutes
Pavemend 15	Magnesium Polyphosphate	90 minutes
Rapid Set	Hydraulic Cement	1 hour
Sta-Fil	Epoxy Polymer Concrete	1-2 hours
AquaPhalt	Reactive Cold Mix Asphalt	1 hour
Set 45	Magnesium Phosphate Concrete	45 minutes
Kwik-Bond	Polyurethane Polymer Concrete	1 hour

Appendix G for Product Specifications

If time is not a restraint, the recommended materials are P-401 and P-501. In times that a repair is expedited, a reactive cold mix asphalt (Aquaphalt) patch is the recommended material for small repair (less than 1 SF) in AC/PCC and CTS Rapid Set for all repairs in PCC where there is a 3 to 10-hour closure window available. On Apron and Taxilanes only, a temporary steel plate can be placed on top of the repair. This will prevent closures until product has reached optimal cure time, then the steel plate can be removed. The cold mix asphalt patch is temporary as it will rut after less than 10 passes of a wheel load. The patched area will need to be replaced with a more permanent material.

[3] Texas Transportation Institute. (October 2005, Updated May 2006). *Investigation of Spall Repair Materials for Concrete Pavement.* FHWA/TX-06/0-5110-1 (p. 11). (Texas Department of Transportation)

7.1 RIGID PAVEMENT (PCC)

7.1.1 MATERIALS AND METHODS

The replacement of concrete pavement must include using the proper materials. Part of the selection process is finding a material that will have strength within the time available between the pavement repair and the opening to traffic. This is the most critical item with respect to how the pavement performs. Finding materials to use is not the problem but finding one that will not create high maintenance requirements can be a challenge.

Most engineers and contractors select a repair material that achieves very rapid strength gain. The intent in that selection is to achieve a design opening strength in the shortest time. The most common mistake in that process is made determining what design strength is required. It is not necessary to have conventional design strength at all locations where pavement restoration is accomplished. The correct selection is based upon the type of pavement repair being affected, i.e., full depth or partial depth restoration, and where on the pavement, with respect to traffic load, is the repair located.

A full depth pavement repair, within the traffic path of main gear, requires that the design strength of the pavement repair is attained prior to opening to traffic. That strength should be determined based upon the actual aircraft that will be using that pavement. A partial depth pavement repair design strength is not based upon the traditional aircraft mix. A partial depth repair does not require the design flexural strength to support traffic and will only be subject to the compressive load of the tire pressure of the aircraft currently using the pavement.

Refer to Figure 7.1 for a plan view of typical rigid pavement full depth repairs including a corner break; partial slab replacement; and full depth slab replacement.

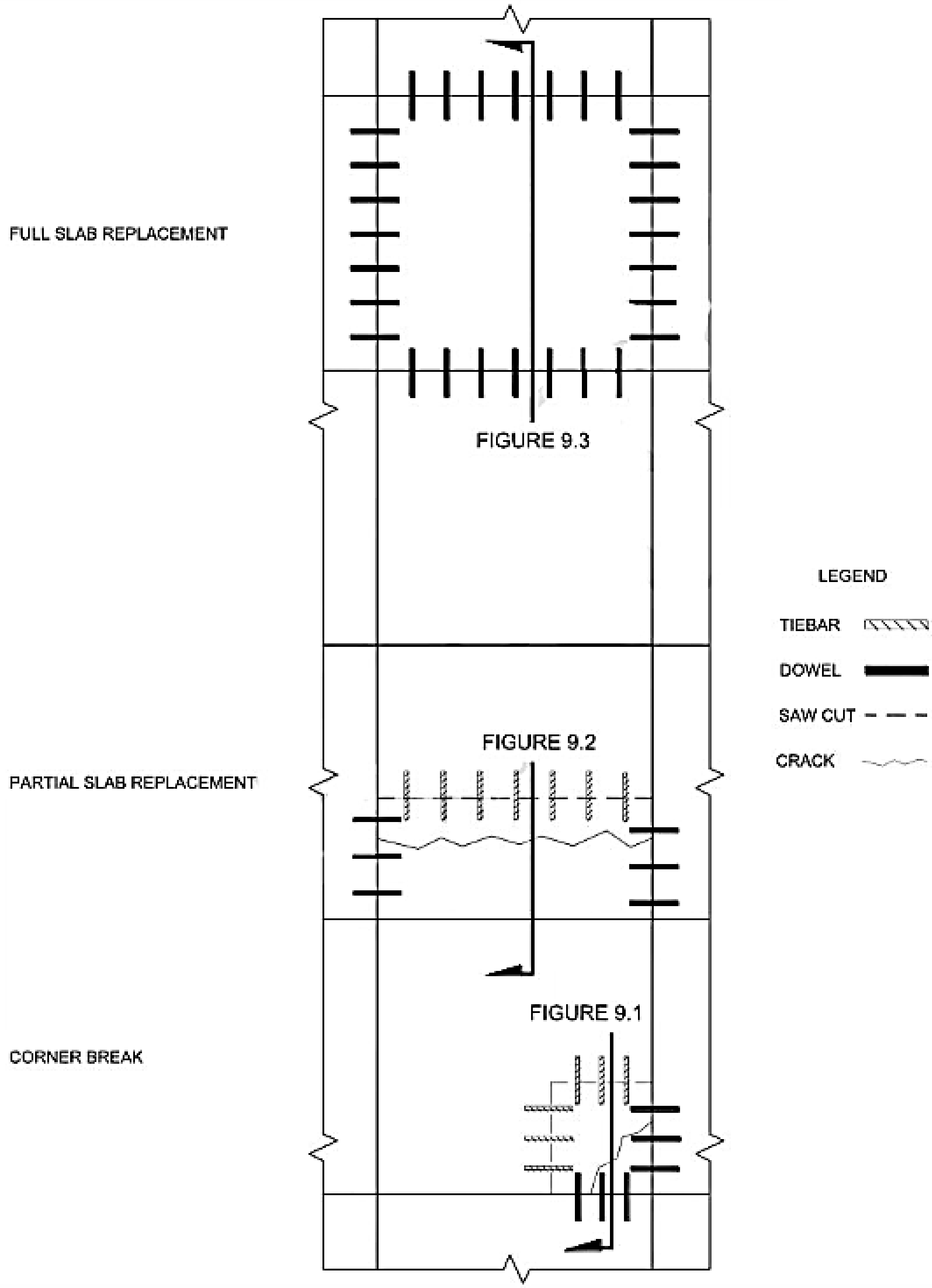


Figure 7.1: Rigid Pavement Repair Plan View[4]

[4] https://www.faa.gov/documentlibrary/media/advisory_circular/draft-150-5380-6c.pdf

The proper repair material used for pavement restoration is Portland cement concrete. The concrete should be locally available and proportioned to minimize shrinkage. The drawback with this material is the lack of rapid strength gain; however, admixtures can be used that will provide the required rapid strength gain. Care must be taken to calculate the required strength to ensure the correct mix is developed.

7.1.2 MONITOR METHODS AND PROCEDURES

All pavement distresses shall be photograph with a GPS phone to put in the GIS system and Infor EAM. Distress that are considered low severity are also be documented. These low distresses are to be part of the communication meetings and daily information shares. All low severity distresses are to be monitored and checked weekly and any changes in severity shall be documented immediately and required repair action taken.

7.1.3 MAINTENANCE & REPAIR (M&R) GUIDELINES

When considering upcoming repairs, certain distresses justify special prioritization. These distresses are listed in Table 7.2. Stopgap maintenance repairs must be addressed by FAR 139 Pavement. Stopgap maintenance distresses require immediate action from airport engineers. The distresses' maintenance actions for Full Depth, Slab Replacement, Grinding require immediate attention which would require closing the section of pavement and repairing. Preventative maintenance is work carried out on pavement in order to avoid its full breakdown or malfunction. It is a regular and routine action taken in order to prevent its breakdown.

Table 7.2. Preventive Maintenance Policy for PCC Pavements

Distress Type	Severity Level	Stopgap Maintenance	Maintenance Action	Repair Procedure*
Blow-Up	Low	Yes	Partial Slab Replacement	Section 9.1.2
	Medium	Yes	Partial Slab Replacement	Section 9.1.2
	High	Yes	Full Slab Replacement	Section 9.1.3
Corner Break	Low	No	Crack Sealing and Epoxy Injection	Section 9.1.5
	Medium	No	Spall Repair	Section 9.1.4
	High	Yes	Corner Full Depth Repair	Section 9.1.1
Longitudinal, Transverse, and Diagonal Cracking	Low	No	Monitor – Epoxy Injection	Section 9.1.5
	Medium	Yes	Crack Sealing	Section 9.1.5
	High	Yes	Partial and Full Slab Replacement	Section 9.1.2, Section 9.1.3
Durability Cracking	Low	No	Monitor	Section 7.1.2
	Medium	Yes	Partial and Full Slab Replacement	Section 9.1.2
	High	Yes	Full Slab Replacement	Section 9.1.3
Joint Seal Damage	Low	No	Monitor	Section 7.1.2
	Medium	No	Joint Seal Replacement	Section 9.1.7
	High	No	Joint Seal Replacement	Section 9.1.7
Lightning Strike	Less than 3”	No	Monitor or Spall Repair	Section 7.1.2 Section 9.1.4
	Greater than 3”	Yes	Seal, Spall Repair or Partial Slab Replacement	Section 9.1.6 Section 9.1.4 Section 9.1.2
Patch (Small)	Low	No	Monitor	Section 7.1.2
	Medium	No	Spall Repair	Section 9.1.4
	High	Yes	Partial Slab Replacement	Section 9.1.2
Patch (Large)	Low	No	Monitor	Section 7.1.2
	Medium	No	Spall Repair	Section 9.1.4
	High	Yes	Partial Slab Replacement	Section 9.1.2
Popouts	N/A	No	Popout Repair	Section 9.1.6
Pumping	N/A	No	Monitor (if prevalent, consider undersealing and/or slab replacement)	Section 7.1.2 Section 9.1.3 Section 9.1.5
Scaling	Low: Runways/Taxiway <1/4”, Aprons 1/8-1/2”	No	Monitor	Section 7.1.2
	Medium: Runways/Taxiways 1/4”-1/2”, Aprons 1/2-1”	No	Partial Depth Repair	Section 9.1.9
	High: Runways/Taxiways > 1/2", Aprons > 1”	Yes	Full Slab Replacement	Section 9.1.3
Settlement	Low	No	Monitor	Section 7.1.2
	Medium	No	Grinding, Slabjacking, or Full Depth Slab Replacement with Base Repair	Section 9.1.3
	High	Yes	Full Depth Slab Replacement with Base Repair	Section 9.1.3
Shattered Slab	Low	No	Crack Sealing	Section 9.1.5
	Medium	No	Slab Replacement	Section 9.1.3
	High	Yes	Slab Replacement	Section 9.1.3
Shrinkage Cracking	N/A	No	Crack Sealing and Epoxy Injection	Section 9.1.5
Spalling (Joint and Corner)	Low	No	Crack Sealing	Section 9.1.5
	Medium	No	Spall Repair	Section 9.1.4
	High	Yes	Spall Repair	Section 9.1.4
Alkali Silica Reaction (ASR)	Low	No	Monitor or Crack Sealing	Section 7.1.2 Section 9.1.5
	Medium	No	Crack Sealing and Partial Depth Repair	Section 9.1.5 Section 9.1.9
	High	Yes	Full Slab Replacement	Section 9.1.3

*See Appendix F and Appendix G and Section 9.1 for Rigid Pavement (PCC), Repair Procedures and Details, and Specification
See Appendix C for Concrete Distress Identification Manual.

7.2 FLEXIBLE PAVEMENT (AC)

7.2.1 MATERIALS AND METHODS

Flexible pavement is otherwise referred to as bituminous asphalt pavement. The pavement failure modes will differ between the two types of pavement, because this type of pavement reacts to and distributes loads differently from PCC pavement.

There are several asphalt pavement repair methods to consider that can be performed using P-401, crack seal or reactive cold mix asphalt patch; however, surface treatment is not recommended if structural distress is present.

Table 7.3 Flexible Pavement Repair Methods

Treatment Type	Repair Method	Section
Crack Treatment	Crack Sealing	Section 9.2.1
	Crack Filling	Section 9.2.2
	Full-Depth Crack Repair	Section 9.2.3
Surface Treatment	Seal Coating	Section 9.2.4
Potholes	Patching	Section 9.2.3

7.2.2 MONITORING METHODS AND PROCEDURES

All pavement distresses shall be photograph with a GPS phone to put in the GIS system and Infor EAM. Distress that are considered low severity are also be documented. These low distresses are to be part of the communication meetings and daily information shares. All low severity distresses are to be monitored and checked weekly and any changes in severity shall be documented immediately and required repair action taken.

7.2.3 MAINTENANCE & REPAIR (M&R) GUIDELINES

Table 7.4 identifies the distress types along with the maintenance action for each severity level. Refer to PAVER™ Distress Identification Manual for distress type images in appendix D. The crack sealing action and patching (small) are maintenance actions that can be corrected in a short closure period (less than 3 hours) using a cold patch asphalt material. When considering upcoming repairs, certain distresses justify special prioritization. These are stopgap maintenance repairs and must be addressed by FAR 139 Pavement. Stopgap maintenance distresses require immediate action from airport engineers. The distresses' maintenance actions in Table 7.4 Full Depth/Partial Depth require closing the section of pavement and use of a P-401 mix.

Table 7.4. Preventive maintenance policy for asphalt-surfaced pavements

Distress Type	Severity Level	Stopgap Maintenance	Maintenance Action	Repair Procedure*
Alligator cracking	Low	No	Monitor	Section 7.2.2
	Medium	Yes	Full Depth Pavement Repair	Section 9.2.3
	High	Yes	Full Depth Pavement Repair	Section 9.2.3
Bleeding and Flushing	N/A	Yes	Scape Off Excess Material	Section 9.2.5
Block Cracking	Low	No	Crack Sealing	Section 9.2.1
	Medium	No	Crack Sealing	Section 9.2.1
	High	Yes	Overlay	Section 9.2.2
Corrugation	Low	No	Monitor	Section 7.2.2
	Medium	No	Full Depth Repair	Section 9.2.3
	High	Yes	Full Depth Repair	Section 9.2.3
Depression	Low	No	Monitor	Section 7.2.2
	Medium	Yes	Partial Full Depth Repair	Section 9.2.3
	High	Yes	Partial Full Depth Repair	Section 9.2.3
Jet Blast	N/A	No	Monitor	Section 7.2.2
Joint Reflection Cracking	Low	No	Crack Sealing	Section 9.2.1
	Medium	No	Overlay	Section 9.2.2
	High	Yes	Full Depth Repair	Section 9.2.3
Longitudinal and Transverse Cracking	Low	No	Crack Sealing	Section 9.2.1
	Medium	No	Overlay	Section 9.2.2
	High	Yes	Full Depth Repair	Section 9.2.3
Oil Spill Damage	N/A	No	Partial Depth Repair	Section 9.2.2
Patching and Utility Cut Patch	Low	No	Partial Depth Repair	Section 9.2.2
	Medium	Yes	Full Depth Repair	Section 9.2.3
	High	Yes	Full Depth Repair	Section 9.2.3
Polished Aggregate	N/A	Yes	Overlay	Section 9.2.2
Raveling	Low	No	Seal Coat or Micro-surfacing*	Section 9.2.4 P-629*
	Medium	No	Seal Coat/Overlay	Section 9.2.4 Section 9.2.2
	High	Yes	Overlay	Section 9.2.2
Rutting	Low	No	Crack Sealing	Section 9.2.1
	Medium	No	Overlay	Section 9.2.2
	High	Yes	Full Depth Repair	Section 9.2.3
Shoving	Low	No	Monitor	Section 7.2.2
	Medium	Yes	Full Depth Repair	Section 9.2.3
	High	Yes	Full Depth Repair	Section 9.2.3
Slippage Cracking	N/A	Yes	Full Depth Repair	Section 9.2.3
Swelling	Low	No	Monitor	Section 7.2.2
	Medium	Yes	Partial Full Depth Repair	Section 9.2.3
	High	Yes	Partial Full Depth Repair	Section 9.2.3
Weathering	Low	No	Monitor	Section 7.2.2
	Medium	No	Seal Coat	Section 9.2.4
	High	Yes	Seal Coat/ Overlay	Section 9.2.4 Section 9.2.2

*Micro-surfacing using P-629 to only be applied on the pavement surfaces of aprons, T hangers, shoulders, and runway overruns.

See Appendix F and Appendix G and Sect. 9.2 for Flexible Pavement (AC), Repair Procedures, Details, and Specifications

See Appendix D for Asphalt Distress Identification Manual.

8.0 PAVEMENT DESIGN

The HAS pavement design will be based on the traffic loading and the subgrade conditions at each airport. The Airfield Pavement Design will follow FAA AC 150/5320-6F - Airport Pavement Design and Evaluation or most up-to-date version, and 150/5370-10G - Standards for Specifying Construction of Airports or most up-to-date version, and COH/HAS Standard Design Manual.

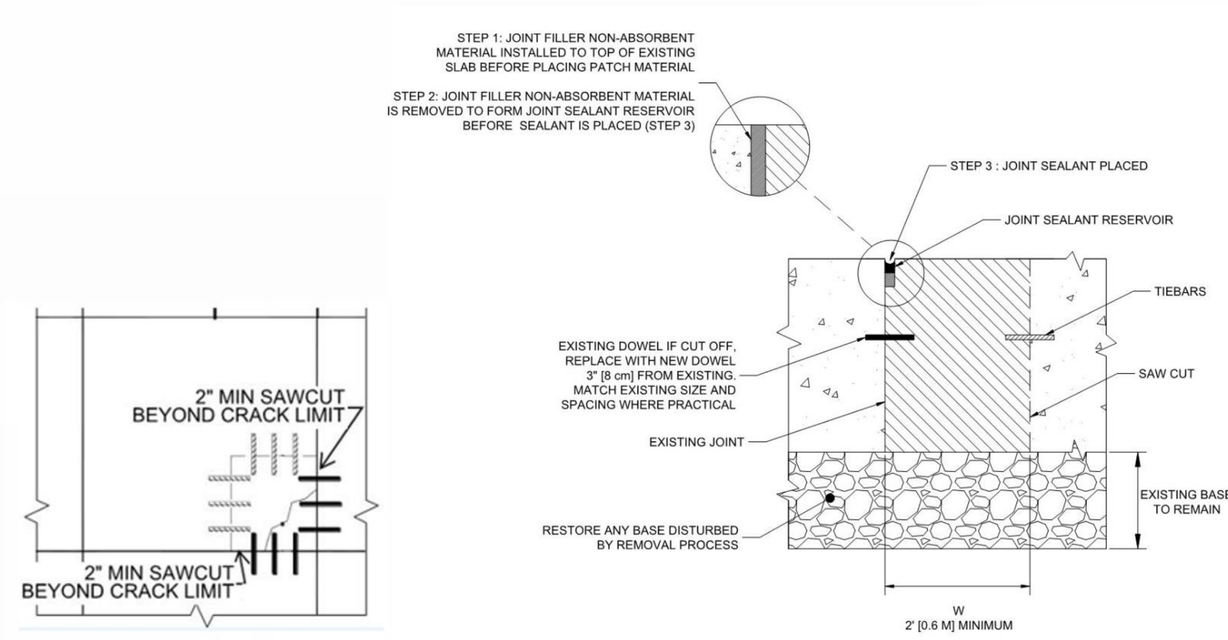
FAA AC 150/5320-6F - Airport Pavement Design and Evaluation
https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5320-6

150/5370-10G - Standards for Specifying Construction of Airports
https://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentnumber/150_5370-10

9.0 REPAIR METHODS AND PROCEDURES

9.1 RIGID PAVEMENT (PCC) REPAIR PROCEDURES

9.1.1 FULL DEPTH REPAIR IN RIGID PAVEMENT – CORNER BREAK[5]



Plan View Profile View

Note: Joint shall be maintained at both directions

Figure 9.1: Full depth repair in rigid pavement – corner break

Materials	Standard Requirement	Recommended Product
Epoxy-Coated Steel Dowels	ASTM A1078	N/A
Deformed and Plain Carbon Steel Bars	ASTM A615	N/A
Liquid Membrane-Forming Compounds for Curing Concrete	ASTM C309	CW-600 Road & Highway Construction / Concrete Chemicals ™ or better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL
Joint and Crack sealants, hot-applied	D6690	PLS Crack/Joint Thermo-Sealant or better
Portland Cement Concrete	P-501	P-501
Portland Cement Concrete*	P-505*	P-505*

* Use only if P-501 is not available. Item P-505 was developed using TxDOT Item 421 requirements

<u>WEATHER AND TEMPERATURE REQUIREMENTS</u>

- Do not begin repairs during inclement weather.
- Do not place concrete unless the ambient temperature is at least 40°F (4°C) and rising and the concrete temperature is greater than or equal to 50°F (10°C).

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[5] Federal Aviation Administration. (October, 2014). Guidelines and Procedures for Maintenance of Airport Pavements. (Advisory Circular 150/5380-6C). 39-40

- Do not place concrete on frozen base, ice, or snow.
- When the ambient temperature exceeds 85°F (29°C), sprinkle the adjacent concrete and base with water immediately before placing concrete.
- Place concrete at the coolest temperature practicable, and never allow the placed concrete temperature to exceed 90°F (32°C).

- **REPAIR PROCEDURE**

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area to be repaired. For corner breaks the repair area should be square.
3. Make a full-depth saw cut along the constructed joints at least 2 feet (0.6 m) beyond the limits of the break and make saw cuts perpendicular to the constructed joints from these points until they intersect.
4. If dowels or tie bars are present along any edges, either of the following options is acceptable:
   - If dowels or tie bars will be exposed and saved, saw edges full depth just beyond the end of the dowels or tie bars. Carefully saw joints on the joint line to within 1 inch (2.5 cm) of the depth of the dowel or tie bar. Use light 30 pound (14 kg) or less jackhammers or other approved equipment to carefully break up and remove the narrow strips of concrete along the doweled edges.
   - If dowel or tie bars are cut and replaced, make a full depth saw cut along the constructed joint cutting the dowels and tie bars.
5. Take care to prevent damage to remaining dowels, tie bars, or concrete.
6. Use light weight equipment, i.e., jackhammers less than 30 pounds (14 kg), hand tools, etc., to remove the remaining damaged PCC pavement. Work from inside the saw cut toward the edge of the slab of the area being removed to prevent damage to the pavement remaining.
7. Remove by hand all loose material and vacuum to minimize any disturbance to the subgrade or base materials.
8. Use P-501 to replace disturbed base or sub-grade material if needed. Use bond breaking between layers as a separator of layer to reduced friction restrain.
9. Install deformed tie-bars in each face of the parent panel by drilling horizontal holes into the face and using an epoxy bonding agent.
10. If existing dowel bars have been cut and removed, install new dowel bars of the type and size of the existing dowel bars in the joint that parallels the direction of traffic. On aprons and areas where traffic may be oblique to joints, install dowels in both joint faces.
11. Install dowels by drilling and epoxying into the PCC pavement at least 3 inches (8 cm) from the location of the existing dowels which were cut off. Space dowel bars at least 3 inches (8 cm) from the edge of the repair area and at least one bar spacing apart at corners of intersecting joints.
12. Oil the exposed ends of dowel bars prior to backfilling the repair area with concrete.
13. Install nonabsorbent board or other approved material within the limits of the joint seal reservoir. The nonabsorbent board will be a standard ½ inch (13 mm) asphalt impregnated fiber-board or other approved material. For joints wider than ½ inch (13 mm), adjust the width of the nonabsorbent board to fit the joint width.
14. Fill the repair area with concrete and consolidate with a vibrator. Concrete should meet the requirements of P-501 or State DOT specifications for pavements.
15. Finish the surface to match existing pavement.
16. Spray with curing compound per ASTM C309.
17. Remove the nonabsorbent board and place joint sealant per ASTM D6690 and manufacturer's requirements.
18. Do not allow traffic until the patch has cured for a minimum of seven (7) days.
19. Completely clean the work area before opening the pavement to aircraft traffic.
20. For required material testing see corresponding material specification in appendix F and/or G.

9.1.2 FULL DEPTH REPAIR IN RIGID PAVEMENT – PARTIAL SLAB REPLACEMENT [5]

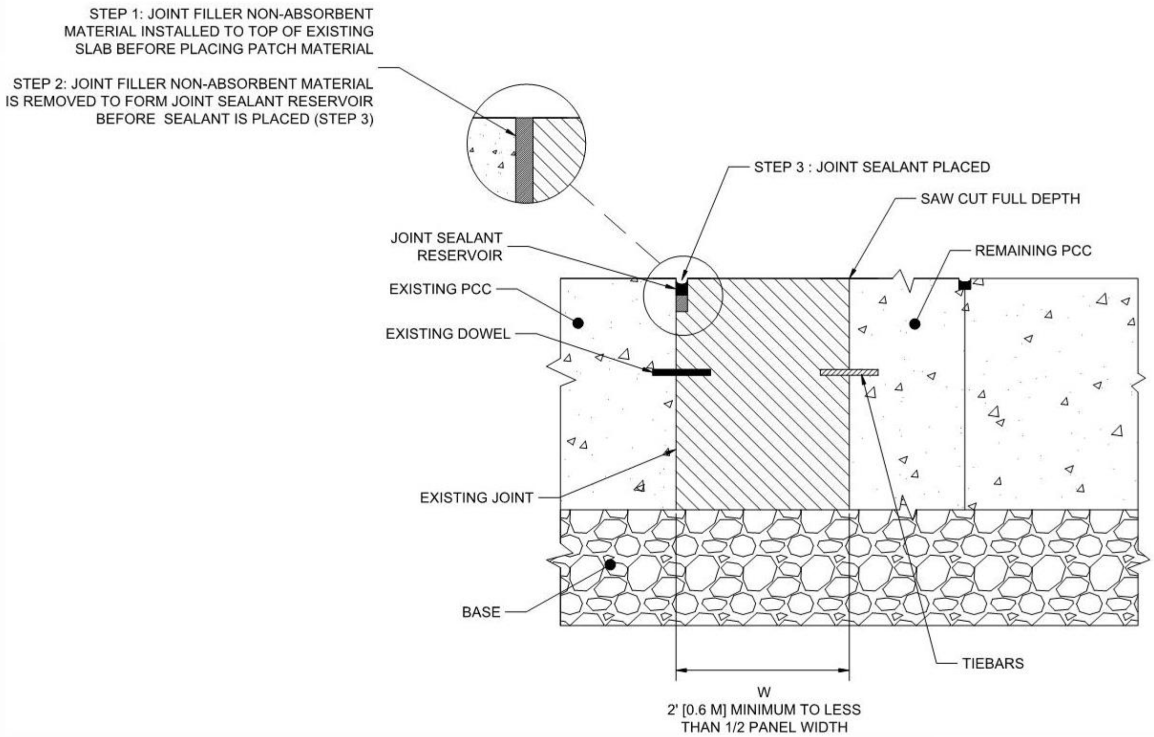


Figure 9.2: Full Depth Repair in Rigid Pavement – Partial Slab Replacement

Materials	Standard Requirement	Recommended Product
Epoxy-Coated Steel Dowels	ASTM A1078	N/A
Deformed and Plain Carbon-Steel Bars	A615	N/A
Liquid Membrane Forming Compounds	C309	CW-600 Road & Highway Construction / Concrete Chemicals ™ or better
Joint and Crack Sealants, hot applied	D6690	PLS Crack/Joint Thermo-Sealant or better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL
Portland Cement Concrete	P-501	P-501
Portland Cement Concrete	P-505	P-501
Portland Cement Concrete*	P-505*	P-505*

*Use only if P-501 is not available. Item P-505 was developed using TxDOT Item 421 requirements

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin repairs during inclement weather.
- Do not place concrete unless the ambient temperature is at least 40°F (4°C) and rising and the concrete temperature is greater than or equal to 50°F (10°C).
- Do not place concrete on frozen base, ice, or snow.
- When the ambient temperature exceeds 85°F (29°C), sprinkle the adjacent concrete and base with water immediately before placing concrete.
- Place concrete at the coolest temperature practicable, and never allow the placed concrete temperature to exceed 90°F (32°C).

[5] Federal Aviation Administration. (October, 2014). Guidelines and Procedures for Maintenance of Airport Pavements. (Advisory Circular 150/5380-6C). 41-42

REPAIR PROCEDURE

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area to be repaired.
3. Make a full-depth saw cut along the constructed joints at least 2 feet (0.6 m) beyond the limits of the damaged pavement and make a saw cut perpendicular to the constructed joints from these points across the width of the pavement panel.
4. If dowels or tie bars are present along any edges, either of the following options is acceptable:
    - If dowels or tie bars will be exposed and saved, saw edges full depth just beyond the end of the dowels or tie bars. Carefully saw joints on the joint line to within 1 inch (2.5 cm) of the depth of the dowel or tie bar. Use light 30 pound (14 kg) or less jackhammers or other approved equipment to carefully break up and remove the narrow strips of concrete along the doweled edges.
    - If dowel or tie bars are cut and replaced, make a full depth saw cut along the constructed joint cutting the dowels and tie bars.
5. Take care to prevent damage to the dowels, tie bars, or to concrete that remains in place.
6. Make additional saw cuts within the limits of the repair area, dividing the repair area into quarters.
7. Use light weight equipment, i.e., jackhammers less than 30 pounds (14 kg), hand tools, etc., to remove the damaged PCC pavement. Work from inside the saw cut toward the interior of the area being removed to prevent damage to the pavement remaining.
8. Remove by hand all loose material and vacuum to minimize any disturbance to the subgrade or base materials.
9. Restore subgrade or base material if required.
10. Install deformed tie-bars in the face of the parent panel by drilling horizontal holes in to the face and using an epoxy bonding agent.
11. If existing dowel bars have been cut and removed, install dowel bars of the type and size of the existing dowel bars in the joints that are parallel to the direction of traffic. On aprons and areas where traffic may be oblique to joints, install dowels in both joint faces.
12. Install dowels by drilling and epoxying into the PCC pavement at least 3 inches (8 cm) from the location of the existing cut dowels. Space dowel bars at least 3 inches (8 cm) from the edge of the repair area and at least one bar spacing apart at corners of intersecting joints.
13. Oil the exposed ends of dowel bars prior to backfilling repair area with concrete.
14. Install nonabsorbent board or other approved material within the limits of the joint seal reservoir. The nonabsorbent board will be a standard ½ inch (13 mm) asphalt impregnated fiber-board. For joints wider than ½ inch (13 mm), adjust the width of the nonabsorbent board to fit the joint width.
15. Fill the repair area with concrete and consolidate with a vibrator. Use concrete meeting the requirements of P-501 or State DOT specifications for pavements.
16. Finish the surface to match the existing surface.
17. Spray with curing compound per ASTM C309.
18. Remove the nonabsorbent board or other approved material and place joint sealant per ASTM D6690.
19. Thoroughly clean the work area before opening the pavement to aircraft traffic.
20. Do not allow traffic until the concrete has cured for a minimum of seven (7) days.
21. For required material testing see corresponding material specification in appendix F and/or G.

9.1.3 FULL DEPTH REPAIR IN RIGID PAVEMENT – FULL SLAB REPLACEMENT[6]

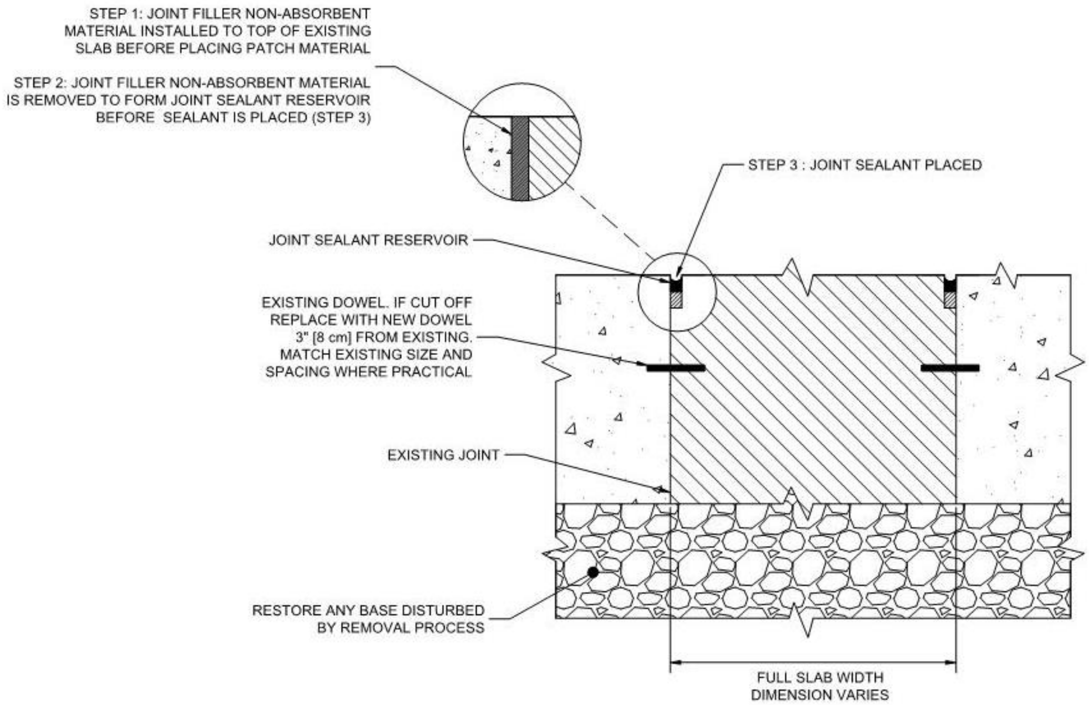


Figure 9.3: Full Depth Repair in Rigid Pavement – Full Slab Replacement

Materials	Standard Requirement	Recommended Product
Epoxy-Coated Steel Dowels	ASTM A1078	N/A
Deformed and Plain Carbon Steel Bars	ASTM A615	N/A
Liquid Membrane forming compound for curing concrete	ASTM C309	CW-600 Road & Highway Construction / Concrete Chemicals ™ or better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL
Joint and Crack Sealants, hot applied	ASTM D6690	PLS Crack/Joint Thermo-Sealant or better
Portland Cement Concrete	P-501	P-501
Portland Cement Concrete*	P-501*	P-501*

*Use only if P-501 is not available. Item P-505 was developed using TxDOT Item 421 requirements

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin repairs during inclement weather.
- Do not place concrete unless the ambient temperature is at least 40°F (4°C) and rising and the concrete temperature is greater than or equal to 50°F (10°C).
- Do not place concrete on frozen base, ice, or snow.
- When the ambient temperature exceeds 85°F (29°C), sprinkle the adjacent concrete and base with water immediately before placing concrete.
- Place concrete at the coolest temperature practicable, and never allow the placed concrete temperature to exceed 90°F (32°C).

[6] Federal Aviation Administration. (October, 2014). Guidelines and Procedures for Maintenance of Airport Pavements. (Advisory Circular 150/5380-6C). 43-44.

REPAIR PROCEDURE

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area to be repaired.
3. Make a full-depth saw cut along the constructed joints at least 2 feet (0.6 m) beyond the limits of the damaged pavement and make a saw cut perpendicular to the constructed joints from these points across the width of the pavement panel.
4. If dowels or tie bars are present along any edges, either of the following options is acceptable:
   - If dowels or tie bars will be exposed and saved, edges will be sawed full depth just beyond the end of the dowels or tie bars. Carefully saw joints on the joint line to within 1 inch (2.5 cm) of the depth of the dowel or tie bar. Carefully break up the narrow strips of concrete along doweled edges using light 30 pound (14 kg) or less jackhammers, or other approved equipment.
   - If dowels or tie bars are to be cut and replaced, make a full depth saw cut along the constructed joint cutting the dowels and tie bars.
5. Take care to prevent damage to the dowels, tie bars, or to concrete that remains in place.
6. Make additional saw cuts within the limits of the repair area dividing the repair area into quarters.
7. Use light weight equipment, i.e., jackhammers less than 30 pounds (14 kg), hand tools, etc., to remove the damaged PCC pavement. Work from inside the saw cut toward the interior of the area being removed to prevent damage to the pavement remaining.
8. Remove by hand all loose material and vacuum to minimize any disturbance to the subgrade or base materials.
9. Restore subgrade or base material if required.
10. If existing dowel bars have been cut and removed, install dowel bars of the type and size of the existing dowel bars in the joints that are parallel to the direction of traffic. On aprons and areas where traffic may be oblique to joints, install dowels in both joint faces.
11. Install dowels by drilling and epoxying into the PCC pavement at least 3 inches (8 cm) from the location of the existing dowels which were cut off. Space dowel bars at least 3 inches (8 cm) from the edge of the repair area and at least one bar spacing apart at corners of intersecting joints.
12. Oil the exposed ends of dowel bars prior to backfilling repair area with concrete.
13. Install nonabsorbent board or other approved material within the limits of the joint seal reservoir. The nonabsorbent board will be a standard ½ inch (13 mm) asphalt impregnated fiber-board. For joints wider than ½ inch (13 mm), adjust the width of the nonabsorbent board to fit the joint width.
14. Fill the repair area with concrete and consolidate with a vibrator. Use concrete meeting the requirements of P-501 or State DOT specifications for pavements.
15. Finish the surface to match the existing surface.
16. Spray with curing compound per ASTM C309.
17. Remove the nonabsorbent board or other approved material and place joint sealant per ASTM D6690.
18. Thoroughly clean the work area before opening the pavement to aircraft traffic.
19. Do not allow traffic until the concrete has cured for a minimum of seven (7)
20. For required material testing see corresponding material specification in appendix F and/or G.

9.1.4 SPALL REPAIR IN RIGID PAVEMENT[7]

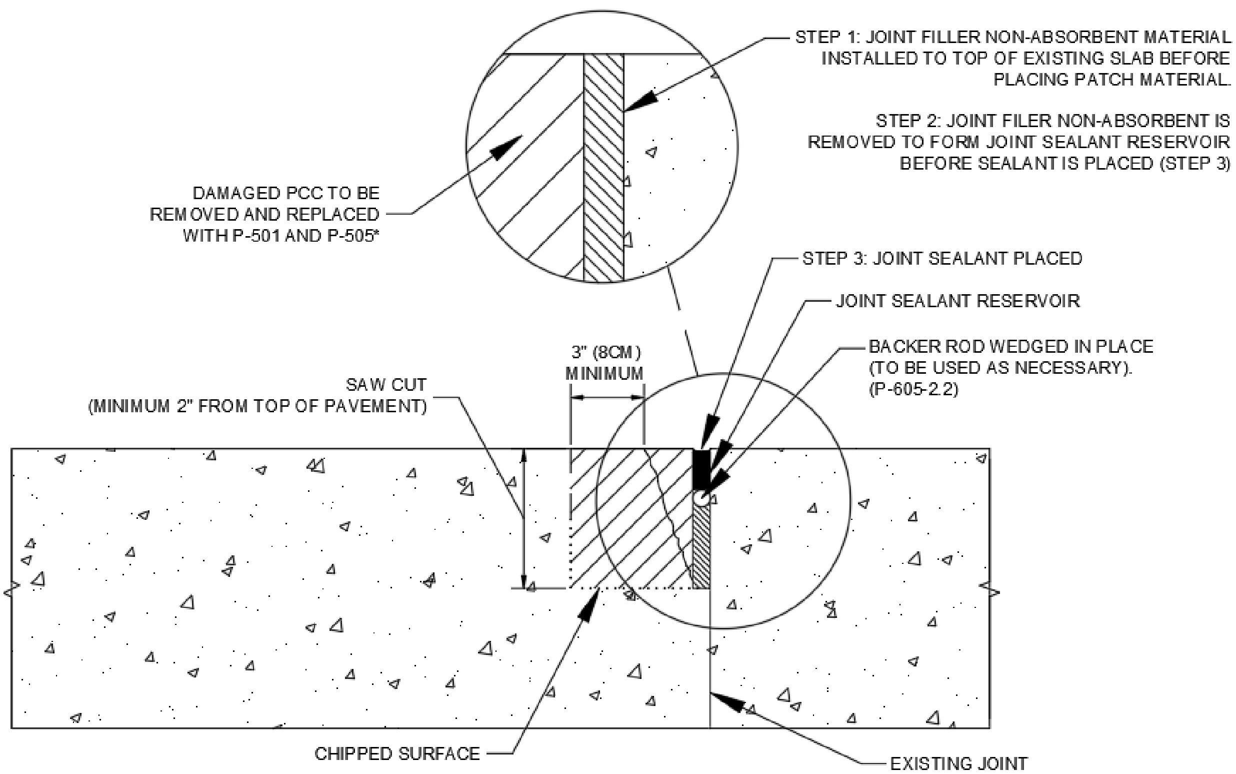


Figure 9.4: Joint Spall Repair in Rigid Pavement

Materials	Standard Requirement	Recommended Product
Liquid Membrane Forming Compounds for Curing Concrete	ASTM C309	Clear Cure VOC J7WB or better
Epoxy Resin Base Bonding System	ASTM C881	EUCO #452 EPOXY SYSTEM or Better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL
Joint and Crack sealants, Hot applied	ASTM D6690	PLS Crack/Joint Thermo-Sealant or better
Portland Cement Concrete	P-501	P-501*

*For Emergency situations use Kwik-Bond material as substitute for EUCO #452

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin repairs during inclement weather.
- Do not place concrete unless the ambient temperature is at least 40°F (4°C) and rising and the concrete temperature is greater than or equal to 50°F (10°C).
- Do not place concrete on frozen base, ice, or snow.
- When the ambient temperature exceeds 85°F (29°C), sprinkle the adjacent concrete and base with water immediately before placing concrete.
- Place concrete at the coolest temperature practicable, and never allow the placed concrete temperature to exceed 90°F (32°C).

[7] Federal Aviation Administration. (October, 2014). Guidelines and Procedures for Maintenance of Airport Pavements. (Advisory Circular 150/5380-6C). 45-46

REPAIR PROCEDURE

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area of spall repair.
3. Make vertical saw cuts a minimum of 2 inches (5 cm) in depth and approximately 3 inches (8 cm) beyond the limit of the spall area. Saw cuts should be straight lines defining the perimeter of the spall repair area. The spall repair area should be a rectangular area.
4. When there are adjacent spall repair areas within a slab, the minimum distance between spall repair areas is 1-1/2 feet (45 cm). When spall repair areas are less than 1-1/2 feet (45 cm) apart, combine the spall repair areas are greater than 1-1/2 feet (45 cm) apart, maintain separate spall repair areas.
5. Chip out and remove all unsound concrete and at least ½ inch (13 mm) of visually sound concrete between the saw cut and the joint, or crack.
6. Use light weight equipment, i.e., jackhammers less than 30 pounds (14 kg), hand tools, etc., to remove the damaged PCC pavement. Work from inside the saw cut toward the joint to prevent damage to the remaining pavement.
7. Remove all loose material by hand and vacuum to minimize any damage to the remaining pavement.
8. Clean the spall repair area with high-pressure water.
9. Place nonabsorbent board or other approved material in the existing joint and form a new joint sealant reservoir adjacent to the repair area. Maintain the joint through the full depth of the spall repair and prevent a bond between the patch and the adjacent slab.
10. Prepare the surface of the joint repair area in accordance with the manufacturer's recommendations for the material used for the repair. This may require treating the surface of the spall repair with a neat cement grout or a liquid bonding agent.
11. Place the patch.
12. Finish the patch to match the texture of the adjacent pavement.
13. Cure the patch in accordance with the material manufacturer's recommendations.
14. Remove the nonabsorbent board or other approved material from the joint and place joint sealant per ASTM D6690.
15. Protect the patch from traffic until the material has set and cure for a minimum seven (7) days or when the flexural strength of the concrete reach a flexural strength of 550 psi.
16. Thoroughly clean the work area before opening the pavement to aircraft traffic.

9.1.5 PROCEDURE FOR CRACK REPAIR OF RIGID PAVEMENT

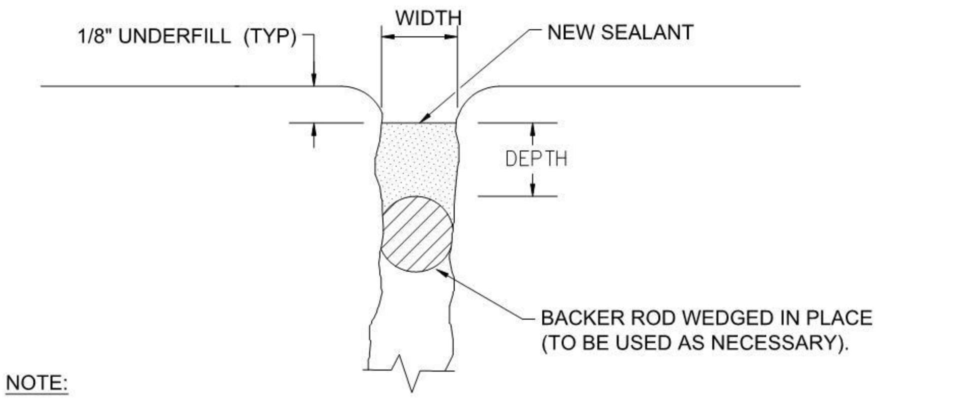


Figure 9.5 Crack repair of rigid pavement

Materials	Standard Requirement	Recommended Product
Cold Applied Single Component, Chemically Curing Silicone Joint sealant	ASTM D5893	Sikasil®-728 SL or better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL
Joint and Crack Sealants, hot applied	ASTM D6690	PLS Crack/Joint Thermo-Sealant or better

<u>WEATHER AND TEMPERATURE REQUIREMENTS</u>

- Do not begin crack repair during inclement weather.
- The pavement temperature should be 50° F (10° C) and rising or meet the manufacturer's recommendations at the time of application of the crack sealing material.
- Do not apply sealant if moisture is observed in the crack.

<u>REPAIR PROCEDURE</u>

<u>Crack Routing and Sealing</u>

- Preparation for concrete pavement crack routing and sealing shall be properly routing the crack to be slightly lower than the existing crack to ensure proper adhesion to the sidewalls. The cracks should be routed out to provide a minimum sealant reservoir 3/8" wide with a minimum depth of 3/8". Thickness and depth below the pavement surface shall be as specified for joint sealant.
- Cracks should be free of dirt, dust, and moisture, and should be frost-free. Wire brushing or compressed air should clean them, and heat lance may be used to dry the surfaces.

<u>Epoxy Injection</u>

- Follow the procedures detailed in ACI 503.7-07 Specification for Crack Repair by Epoxy Injection and ACI RAP-1 Structural Crack Repair by Epoxy Injection (See Section 9.1.8 for Details).

9.1.6 PROCCEDURE FOR POPOUT REPAIR IN RIGID PAVEMENT

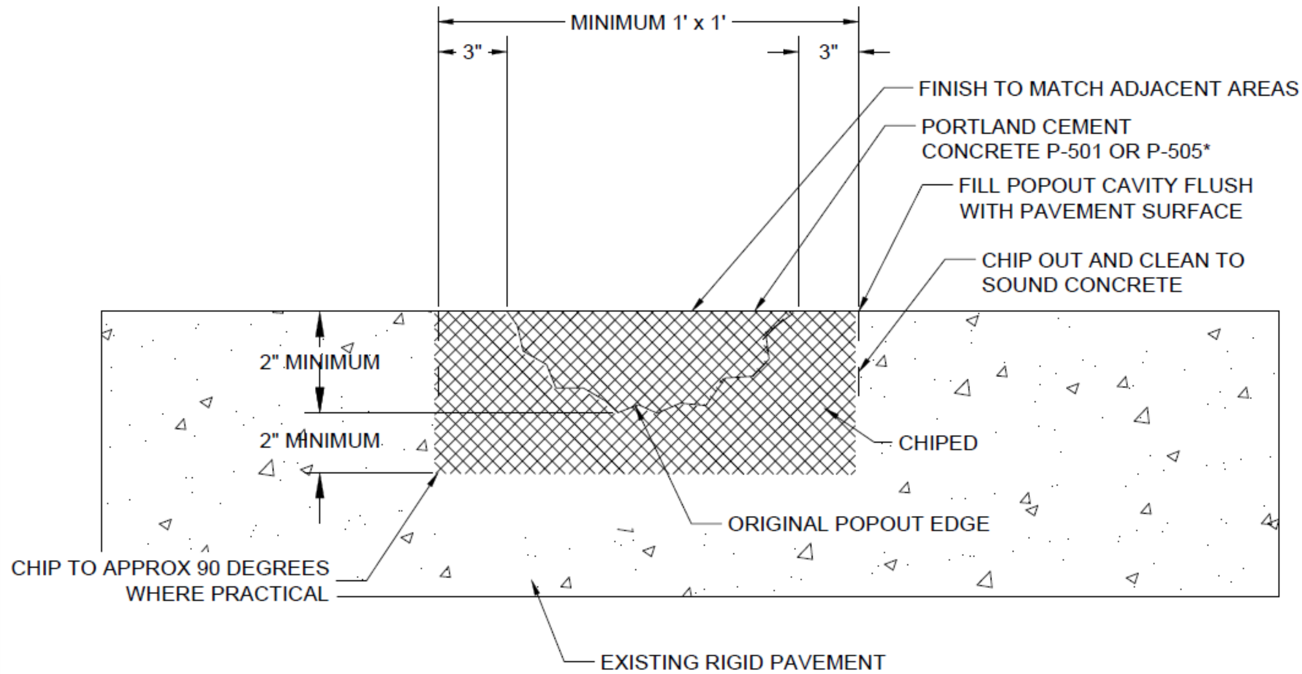


Figure 9.6 Typical Popout Spall Repair Detail

Materials	Standard Requirement	Recommended Product
Portland Cement Concrete	P-501	P-501
Portland Cement Concrete*	P-505*	P-505*

*Use only if P-501 is not available. Item P-505 was developed using TxDOT Item 421 requirements

A popout is defined as a small piece of pavement that breaks loose from the concrete surface. this is caused by freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 to 4 inches in diameter and from 1/2 to 2 inches deep. Per ASTM D5340, to count a slab as having this type of distress, an average greater than three Popouts per square yard is needed.

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin popout repair during inclement weather.
- The pavement temperature should be 50° F (10° C) and rising or meet the P-501-4.7 and/or P-505-5 specifications.
- Do not apply sealant if moisture is observed in the crack.

9.1.7 JOINT SEAL REPLACEMENT

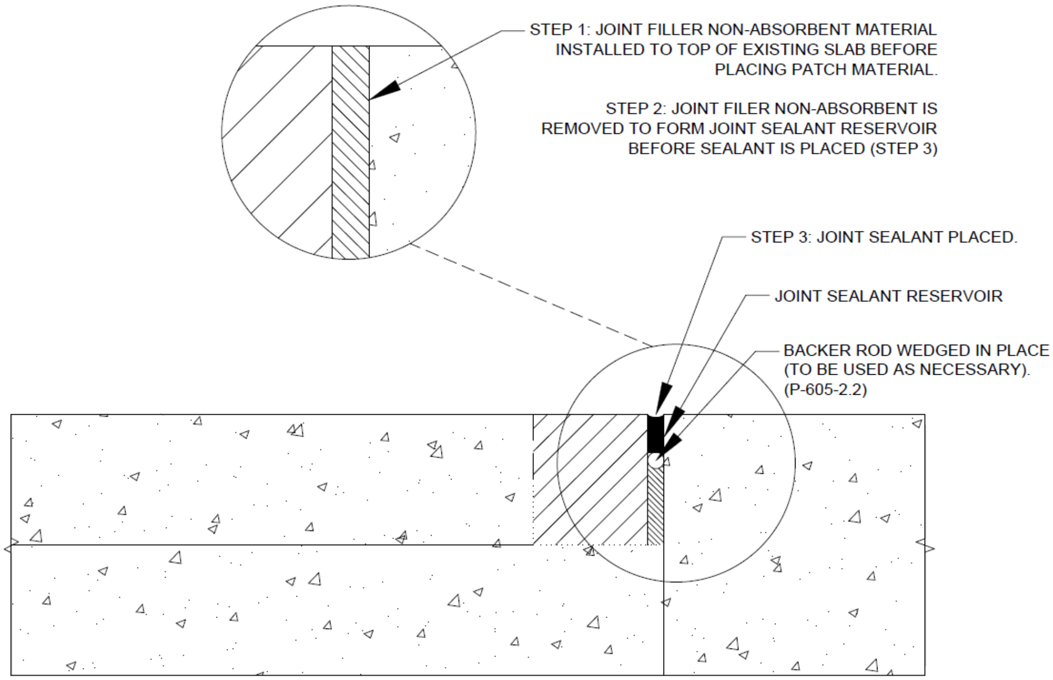


Figure 9.7 Joint Seal Replacement Detail

Materials	Standard Requirement	Recommended Product
Cold Applied Single Component, Chemically Curing Silicone Joint sealant for Portland Cement Pavement	ASTM D5893	Sikasil®-728 SL or better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL

WEATHER AND TEMPERATURE REQUIREMENTS

The pavement temperature shall be 50°F (10°C) and rising at the time of application of the poured joint sealing material. Do not apply sealant if moisture is observed in the joint.

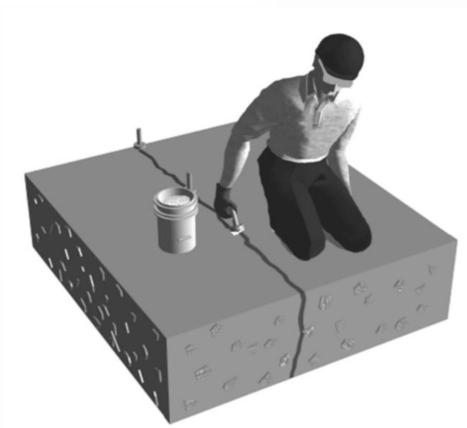
REPAIR PROCEDURE

Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the Engineer before sealing is allowed. Sealants shall be installed in accordance with the following requirements:

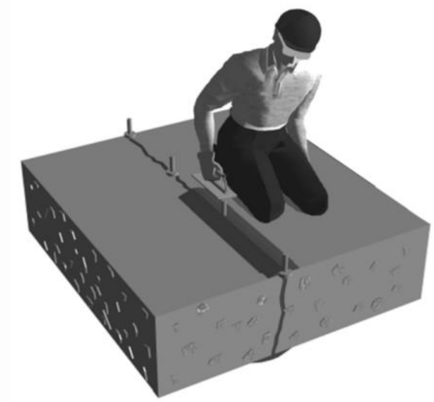
1. Immediately preceding, but not more than 50 feet (15 m) ahead of the joint sealing operations, perform a final cleaning with compressed air.
2. Fill the joints from the bottom below the pavement surface.
3. Remove and discard excess or spilled sealant from the pavement by approved methods.
4. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material.
5. Traffic shall not be permitted over newly sealed pavement until authorized by the Asset Engineer.
6. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.
7. Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

9.1.8 EPOXY INJECTION

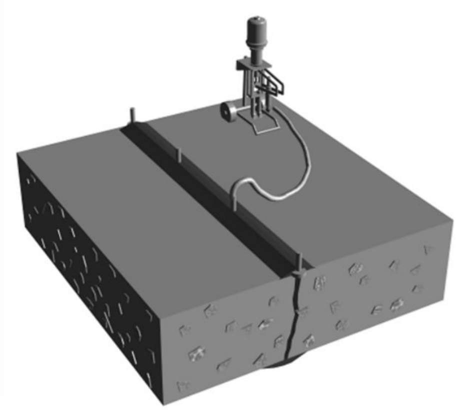
REPAIR PROCEDURES[7]



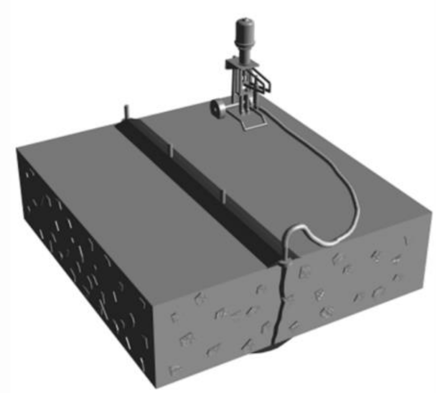
Step 1: Installation of Entry ports



Step 2: Installation of seal cap



Step 3: Start injection at widest segment of the crack



Step 3 cont.: Continue Injection until refusal

Step 4: Remove ports and cap seal

Materials	**Standard Requirement**	**Recommended Product**
Epoxy Resin Base Bonding System	ASTM C881	EUCO #452 EPOXY SYSTEM or Better

[7] America Concrete Institute (ACI), Keane, Brian F. "Structural Crack Repair by Epoxy Injection." *Concrete Repair Bulletin* 17.4 (2004): 21-25.

Step 1. Port Installation

Install the entry ports only after proper surface preparation. Two types of entry ports are available for the injection process:

• Surface-mounted; or

• Socket-mounted.

Entry ports (also called port adapters) can be any tubelike device that provides for the successful transfer of the epoxy resin under pressure into the crack. Proprietary injection guns with special gasketed nozzles are also available for use without port adaptors. Port spacing is typically 8 in. (40 mm) on center, with increased spacing at wider cracks. Port spacing may also be a function of the thickness of the concrete element. Surface-mounted entry ports are normally adequate for most cracks, but socket-mounted ports are used when cracks are blocked, such as when calcified concrete is encountered. Entry ports can also be connected by a manifold system when simultaneous injection of multiple port locations is advantageous.

Step 2. Install the cap seal.

Properly installed, the cap seal contains the epoxy as it is injected under pressure into the crack. When cracks penetrate completely through a section, cap seals perform best when installed on both sides of the cracked element, ensuring containment of the epoxy. Cap seals have been successfully installed using epoxies, polyesters, paraffin wax, and silicone caulk. The selection of the cap seal material should consider the following criteria, subject to the type of crack to be repaired:
• Non-sag consistency (for vertical or overhead);
• Moisture-tolerance;
• Working life; and
• Rigidity (modulus of elasticity)
Concrete temperature changes after installation of the cap seal but prior to injection may cause the cap seal to crack. If this occurs, the cap seal must be repaired prior to resin injection.

Prior to proceeding with installation of the cap seal, mark the location of the widest portion of the crack and pay close attention to the following:
• Use only materials that haven’t exceeded their shelf life;
• Accurate batching of components;
• Small batches to keep material fresh, and dissipate heat;
• Port spacing; and • Consistent application of the material (1 in. wide x 3/16 in. thick [25 x 5 mm]) over the length of the crack.

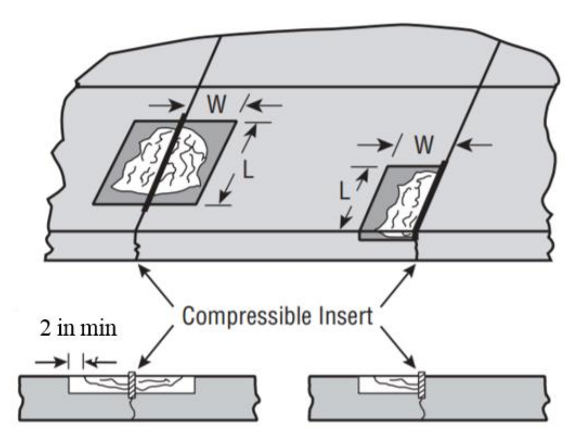
Step 3. Inject the epoxy.

For a successful epoxy injection, start with the proper batching and mixing of the epoxy components in strict accordance with the manufacturer’s requirements. Prior to starting the actual injection, be sure that the cap seal and port adapter adhesive have properly cured so they can sustain the injection pressures. Start the injection at the widest section of a horizontal crack. (Be sure to locate and mark these areas before installing the cap seal.) Vertical cracks are typically injected from the bottom up. Continue the injection until refusal. If an adjacent port starts bleeding, cap the port being injected and continue injection at the furthest bleeding port. Hairline cracks are sometimes not well suited to “pumping to refusal.” In those cases, try injecting the epoxy at increased pressure (approximately 200 psi [1.3 MPa]) for 5 min. Closer port spacing can also be considered. When injection into a port is complete, cap it immediately. Higher pressure can be used for injecting very narrow cracks or increasing the rate of injection. However, the use of higher pressure should be managed with care to prevent a blowout of the cap seal or ports.

Step 4. Remove ports and cap seal

Upon completion of the injection process, remove the ports and cap seal by heat, chipping, or grinding. If the appearance is not objectionable to the client, the cap seal can be left in place. If complete removal is required for a subsequent application of a cosmetic coating, prepare the concrete surface by grinding.

9.1.9 PARTIAL DEPTH REPAIR IN RIGID PAVEMENT [8]



See minimum dimension of repair area for W & L requirements

Figure 9.8 Typical Partial Depth Repair for PCC

Materials	Standard Requirement	Recommended Product
Liquid Membrane Forming Compounds for Curing Concrete	ASTM C309	Clear Cure VOC J7WB or better
Epoxy Resin Base Bonding System	ASTM C881	EUCO #452 EPOXY SYSTEM or Better
Joint Seal (Silicone Joint Sealant)	P-605	Dow Corning 888; DSB 800; DSB 900 SL
Joint and Crack sealants, Hot applied	ASTM D6690	PLS Crack/Joint Thermo-Sealant or better
Portland Cement Concrete (Type III)	P-501	P-501

Minimum dimension of repair area

Location of Distress	Depth (in)	Length (in)	Width (in)
At one Joint	2	10 **or** Length of affected area + 4 **whichever is greater**	4 or width of affected area + 2 **whichever is greater**
At two Joints	2	8 **or** Length of affected area + 2 **whichever is greater**	4 or width of affected area + 2 **whichever is greater**
Away from joints	2	10 **or** length of affected area + 4 **whichever is greater**	5.5 or width of affected area + 4 **whichever is greater**

8

- Concrete Crack and Partial-Depth Spall Repair Manual, JP003P, American Concrete Pavement Association, Skokie, IL, 2003.
- SHRP H 349 Concrete Pavement Repair Manuals of Practice, Materials and Procedures for the Repair of Joint Seals in Concrete Pavements, Materials and Procedures for Rapid Repair of PartialDepth Spalls in Concrete Pavements, Strategic Highway Research Program–National Research Council, Washington, DC, 1993.

Repair Procedure

1. Make a vertical cut with a concrete saw 2 inches in depth and approximately 2 inches outside of the affected area.
2. Remove all unsound concrete until sound, intact material has been reached (into at least 1/2-inch of visually sound concrete).
3. The unsound pavement may be removed by means of milling 2 inches in depth.
4. Remove the unsound concrete material with suitable hand tools such as air hammers, pneumatic drills, electric impact hammers, or grinding equipment and blow out the area with oil-free compressed air.
5. Clean the area to be repaired with high-pressure water.
6. Allow the patch area to dry completely. Treat the surface (all sides and bottom, except any joint face) with tack coat, conforming to FAA specification P-603, to ensure a good bond between the existing PCC pavement and the new repair material. Apply the tack coat before placing the repair material.
7. Finish the patch to match the texture of the adjacent pavement.
8. Cure the patch in accordance with the material manufacturer's recommendations.
9. Remove the nonabsorbent board or other approved material from the joint and place joint sealant per ASTM D6690.
10. Protect the patch from traffic until the material has set and cure for a minimum seven (7) days or when the flexural strength of the concrete reach a flexural strength of 550 psi.
11. Thoroughly clean the work area before opening the pavement to aircraft traffic.

9.2 FLEXIBLE PAVEMENT (AC) REPAIR PROCEDURES

9.2.1 PROCEDURE FOR CRACK REPAIR OF FLEXIBLE PAVEMENT[8]

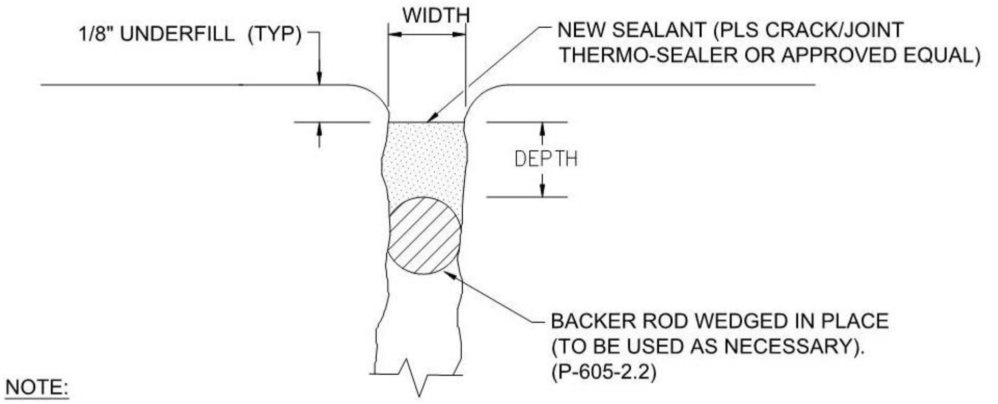


Figure 9.9: Crack Repair of Flexible Pavement

Materials	Standard Requirement	Recommended Product
Backer Material for Use with Cold and Hot Applied Joint sealants	P-605-2.2	N/A
Joint and Crack Sealants, hot applied	P-605	PLS Crack/Joint Thermo-Sealant; DSB 900 SL; equal or better

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin crack repair during inclement weather.
- The pavement temperature should be 50° F (10° C) and rising or meet the manufacturer's recommendations at the time of application of the crack sealing material.
- Do not apply sealant if moisture is observed in the crack.

REPAIR PROCEDURE

Use this procedure to repair cracks less than 1 inch (2.5 cm) in width in flexible pavements.

1. Review the construction safety and phasing plant (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, signs, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area of crack repair.
3. Use and air compressor with an operable oil and water trap to clean all cracks with compressed hot air.
4. If necessary, saw or rout the cracks to the required width and depth. Use the sealant manufacturer's specifications to determine the sealants reservoir dimensions (W x D).
5. Inspect the cracks for proper width, depth, alignment, and preparation. Make sure the crack surface faces are dry.
6. To obtain the width and depth ratio required by the sealant manufacturer's specifications may require installation of backer rod. Make sure the backer rod:
7. Meets the requirements of ASTM D5249
8. Is compatible with the sealant
9. Is 25% larger in diameter than the width of the sealant reservoir
10. Apply the sealant uniformly from the bottom to the top of the crack avoiding voids or entrapping air.
11. Make sure the surface of the sealant remains 1/4 inch to 3/8 inch (6 mm to 9 mm) below the existing pavement surface.
12. Do not allow traffic until the sealants have cured
13. Completely clean the work area before opening to aircraft traffic

[8] Federal Aviation Administration. (October, 2014). Guidelines and Procedures for Maintenance of Airport Pavements. (Advisory Circular 150/5380-6C). 31-32

9.2.2 PARTIAL FULL DEPTH REPAIR/OVERLAY IN FLEXIBLE PAVEMENT[9]

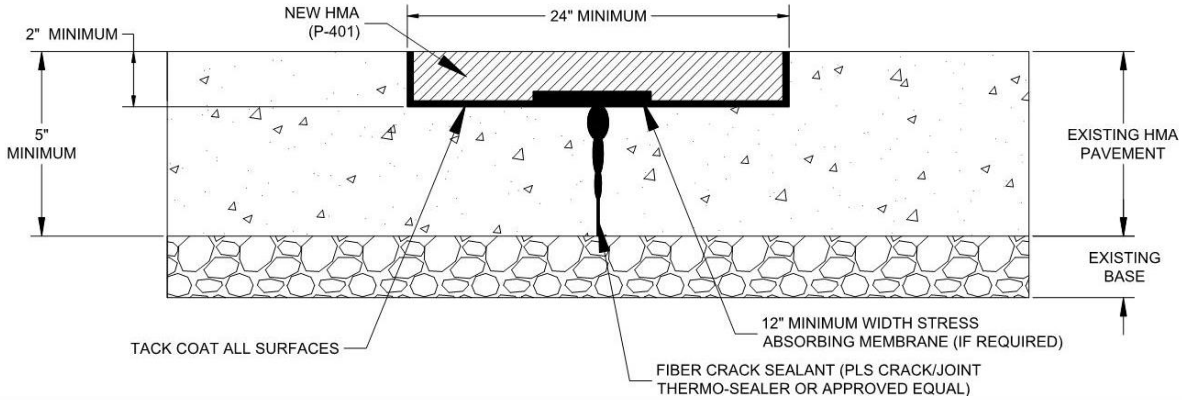


Figure 9.10: Partial Depth Crack Repair in Flexible Pavement

Materials	Standard Requirement	Recommended Product
Selection and Use of Emulsified Asphalt	ASTM D3628	N/A
Joint and Crack Sealants, Hot applied	P-605	PLS Crack/Joint Thermo-Sealant or better
Hot Mix Asphalt (HMA)	P-401	P-401*
Bituminous Tack Coat	P-603	P-603

*For Emergency situations use Aquaphalt as substitution for P-401.

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin crack repair during inclement weather.
- HMA should not be placed upon a wet surface or when the surface temperature of the underlaying course is less than 45°F (7°C)
- The pavement temperature should be 50° F (10° C) and rising or meet the manufacturer's recommendations at the time of application of the crack sealing material.
- Do not apply sealant if moisture is observed in the crack.

REPAIR PROCEDURE

Use this procedure to repair HMA Pavements that are 5 inches (13 cm) or greater in thickness with cracks greater than 1 inch (2.5 cm).

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, signs, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area of crack repair.
3. Saw cut or mill out an area 24 inches (0.6 m) wide by 2 to 3 inches (5 to 8 cm) deep centered on the crack. Extend the saw cut or mill out the area a minimum of 12 inches (30 cm) beyond the limits of the distressed pavement area.
4. Use an air compressor with an operable oil and water trap to clean all cracks with compressed hot air.
5. Fill the crack flush with fiber crack filler per the sealant manufacturer's specifications. Apply the sealant uniformly from the bottom to the top of the crack avoiding voids or entrapping air.
6. Apply a 12-inch (30 cm) repair membrane centered over the crack. (Installation of the membrane is optional.)
7. Apply a tack coat to the bottom and sides of the repair area. Make sure the tack meets the requirements of P-603 and ASTM D3628.
8. Fill the patch area with HMA equivalent or better than the existing pavement. Use P-401 or equivalent State DOT dense mix and compact to the minimum density specified.
9. Use a straight-edge to verify the patch is flush with adjacent pavement.
10. Do not allow traffic until the HMA has cured.
11. Completely clean the work area before opening to aircraft traffic.

[9] Federal Aviation Administration. (October, 2014). Guidelines and Procedures for Maintenance of Airport Pavements. (Advisory Circular 150/5380-6C). 33-34

9.2.3 FULL DEPTH REPAIR IN FLEXIBLE PAVEMENT[10]

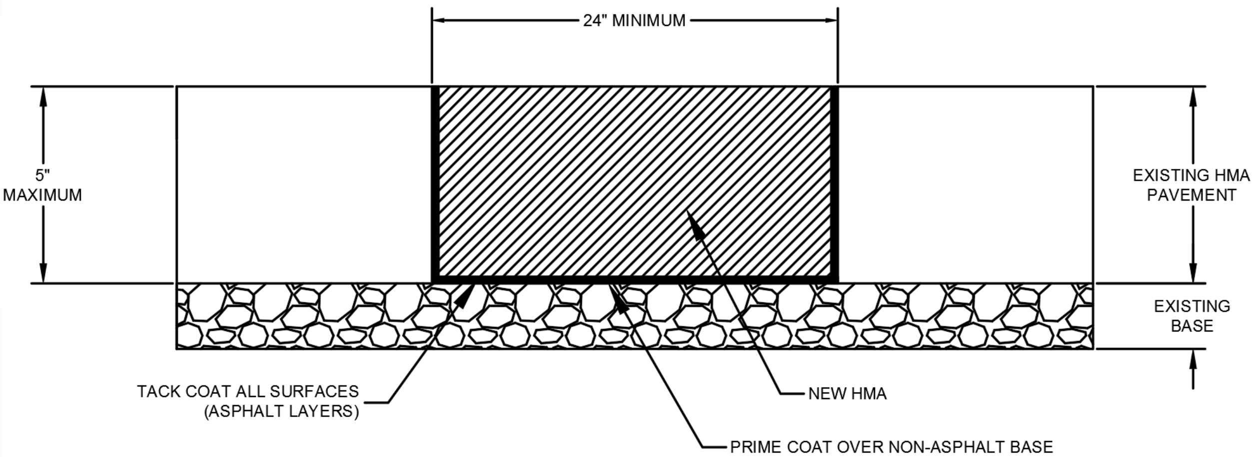


Figure 9.11: Full Depth Crack Repair in Flexible Pavement

Materials	Standard Requirement	Recommended Product
Selection and Use of Emulsified Asphalt	D3628	N/A
Joint and Crack sealant, Hot applied	D6690	PLS Crack/Joint Thermo-Sealant or better
Hot Mix Asphalt (HMA)	P-401	P-401*
Bituminous Tack Coat	P-603	P-603
Bituminous Prime Coat	P-602	P-602

* For Emergency situations use Aquaphalt as substitution for P-401 as a temporary repair material

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin crack repair during inclement weather.
- HMA should not be placed upon a wet surface or when the surface temperature of the underlying course is less than 45°F (7°C).

REPAIR PROCEDURE

Use this procedure to conduct full depth repairs of flexible pavements and to repair cracks greater than 1 inch (2.5 cm) in flexible pavements 5 inches (13 cm) or less in thickness.

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area of crack repair.
3. Saw cut or mill out an area 24 inches (0.6 m) wide to the full depth of the HMA centered on the crack. Extend the saw cut or mill out an area a minimum of 12 inches (30 cm) beyond the limits of the distressed pavement area.
4. Repair and re-compact the base as necessary.
5. Apply a tack coat to the bottom and sides of the repair area. Make sure the tack meets the requirements of P-603 and ASTM D3628. If the patch is being applied directly over a non-asphalt base, apply Prime Coat (P-602) to the bottom and Tack coat to side surfaces.
6. Fill the patch area with HMA equivalent to or better than the existing pavement. Use P-401 or equivalent State DOT dense mix and compact to the minimum density specified.
7. Use a straight-edge to verify that the patch is flush with adjacent pavement.
8. Do not allow traffic until HMA has cured.
9. Completely clean the work area before opening to aircraft traffic

9.2.4 SEAL COATING PROCCEDURES

Figure 9.12: Applications of Seal Coat

Application of seal coat protects existing bituminous pavement surface against air and water intrusion, enriches an existing dry or raveled surface, and slow deterioration of a surface showing sign of distress. Seal Coating should only be used as repair method to non-structural distresses. Application rates would be specified per field conditions and should be recommended by the manufacturer's representative and approved by the engineer from a test are/section evaluation.

Materials	Standard Requirement	Recommended Product
Seal-Coat	P-608	GSB-88 equal or better

9.2.5 SCRAPE OFF SURFACE MATERIAL

For minor bleeding, a pavement milling or grinding machine may be used to remove the excess asphalt by milling off 1/8 inch to 1/4 inch (3 to 6 mm) of pavement. Prior to milling or grinding, the use of infra-red heaters to soften the HMA pavement surface should be tried. After heating of the pavement surface, scrape the asphalt binder from the surface, apply blotter-sand, roll with a steel-drum roller, then remove any excess blotter-sand from the surface. Repeat the process if bleeding re-occurs through the blotter-sand.

9.3 LIGHT BASE REPAIR AND MAINTENANCE PROCEDURES [11]

9.3.1 FULL DEPTH PAVEMENT REMOVAL FOR LIGHT BASE AND CONDUIT

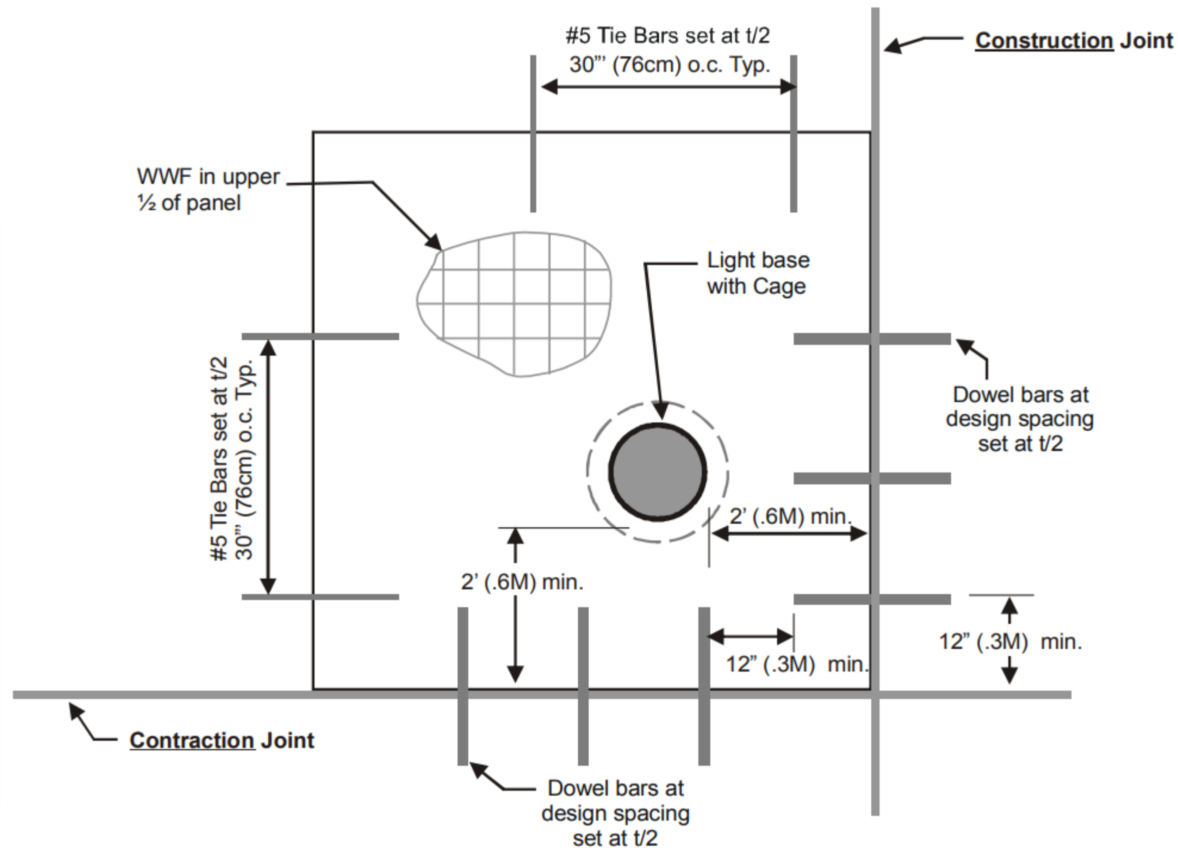


Figure 9.13: Full Depth Partial Slab w/ Light Can Replacement

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin repairs during inclement weather
- Do not place concrete unless the ambient temperature is at least 40° F (4° C) and rising and the concrete temperature is greater than or equal to 50° F (10° C)
- Do not place concrete on frozen base, ice, or snow.
- When the ambient temperature exceeds 85° F (29° C), sprinkle the adjacent concrete and base with water immediately before placing concrete.
- Place concrete at the coolest temperature practicable, and never allow the placed concrete temperature to exceed 90° F (32° C)

[11] Innovative Pavement Research Foundation. (March, 2008) *Constructing In-Pavement Lighting, Portland cement Concrete Pavement*. (IPRF 01-G-002-03-1). 16-43.

REPAIR PROCEDURE

1. Establish light base locations by survey.
2. Saw cut pavement full depth and remove debris.
   - Full Panel PCC Removal. When full panel removal is necessary, refer to '9.1.3 – Full Depth Repair in Rigid Pavement – Full Slab Replacement'.
   - Partial Panel PCC Removal. When partial panel removal is necessary, refer to '9.1.2 – Full Depth Repair in Rigid Pavement – Partial Slab Replacement'.
   - Full Panel AC Removal. When full panel removal is necessary, refer to '9.2.3 Full Depth Crack Repair in Flexible Pavement.
   - Partial Panel AC Removal. When partial panel removal is necessary, refer to '9.2.2 Partial Depth Crack Repair in Flexible Pavement'.
3. Excavate subbase for the light base anchor and connecting conduit.
4. Set light bases on jigs and connect conduit. Verify the location, height, level and azimuth of the light base. Place the concrete anchor.
5. Install load transfer devices, tie bars and, when specified, embedded steel.
   - Dowel bars are smooth steel bars used as load transfer devices. The aircraft gear load must be transferred across joints of concrete pavement. Dowel bars are smooth for the purpose of allowing joint opening and closing during ambient temperature changes.
   - Tie bars are deformed steel bars, usually #5, used to "tie" a partial panel replacement to the original pavement. By tying the repair section to the original panel, the function and load capacity of the original panel, the function and load capacity of the original panel is restored.
   - Dowel bars and tie bars are not interchangeable. Tie bars are not used to tie adjacent panels across planned joints.
   - Embedded steel, usually WWF or small deformed bars at equal spacing to form a mat. Is usually installed in odd shaped full panel replacement. The WWF, or bar mat, is installed in the upper one-third of the pavement leaving a minimum of 2-inches between steel and pavement joints. An odd shaped panel is one where the long side of the panel is more than 1.25 times longer than the short side. A panel that is a shape other than approximately square (e.g., triangle, octagon, parallelogram, etc.) is also odd shaped. Odd shaped slabs will crack. Embedded steel is used for crack control. It does not provide reinforcement for the panel.
   - Full Panel replacement. The full depth saw cut along the joint of an existing panel will cut through dowel bars. Therefore, load transfer must be reestablished along joints where dowel bars were previously used; and, load transfer must be established at a joint that previously functioned as a "contraction joint." Dowel bars should be expected in existing pavement along a construction joint (usually the longitudinal joint for a runway or taxiway). Dowel bars may or may not be present along an existing pavement contraction joint (usually the transverse joint on a runway and taxiway). Holes for new dowel bars are drilled half way between existing dowel bar locations. Dowel bars are not installed closer than 12-inches to planned joint intersections and 12-inches must be maintained between dowel bar ends near joint intersections. The preference for dowel bar spacing is to the construction joint. Embedded steel is used when the panel is odd shaped.
   - Partial Panel replacement. The intent of a partial panel replacement is to restore the functions of the original panel. Load transfer is established at existing planned joints in the same manner as for full panel replacement. The difference is new concrete must be "tied" to the existing panel. Smooth dowel bars, placed using the spacing criterion for full panel replacement, are used for the load transfer at existing planned joints. Deformed steel bars are used to tie the concrete together at the interior joints. Isolation joints are not used. Embedded steel is used when panel is odd shaped.
6. Place the concrete and finish. Finishing at light base locations is accomplished using either the core or "cookie cutter" method

9.3.2 PROCEDURE FOR CORING EXISTING PAVEMENT W/ DIRECTIONAL BORE FOR CONDUIT

(a)

(b)

(c)

(d)

Figure 9.14: In-Field Installation of Pavement Coring with Directional Bore

<u>WEATHER AND TEMPERATURE REQUIREMENTS</u>

Do not begin repairs during inclement weather.

<u>REPAIR PROCEDURE</u>

1. Establish light base locations by survey.
2. Extract, by coring a 36-inch (0.9M) diameter concrete section in the existing pavement. The depth of the core must be sufficient to provide the vertical clearance required to install the light base. The core hole will extend through the concrete and into the subbase.
3. Directional bore. The process requires that the boring begin or end at a light base on an angle and/or large radius. Where a directional bore begins at a light base, a pavement area significantly larger than that required to install the light base must be removed. The area removed is dependent upon the physical characteristics of the machine employed.
4. The light base is positioned with a setting jig. Connect the conduit into the bottom of the light base. Place the anchor and check the height, level and azimuth of the light base.
5. The core or cut in the pavement is restored, and the surface finished using the core or "cookie cutter" method.

9.3.3 PROCEDURE FOR LIGHT CAN BOXOUT INSTALLATION

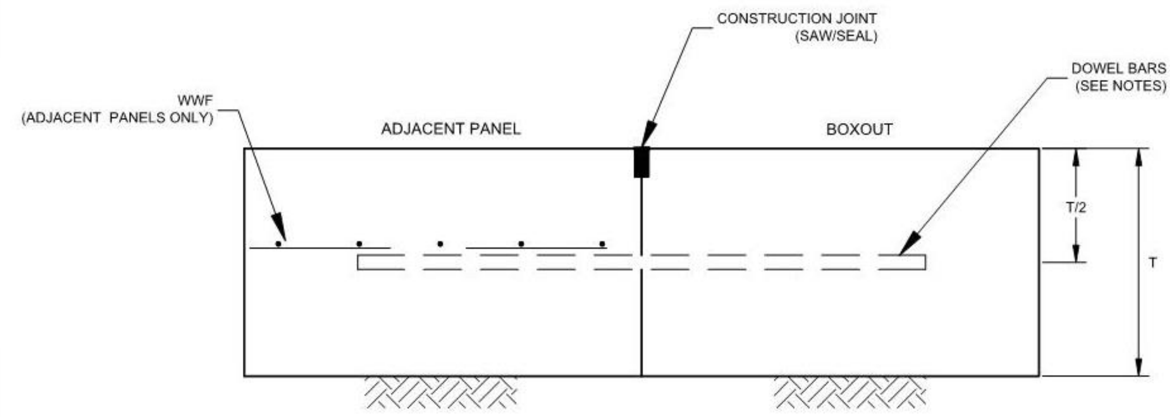


Figure 9.15. Typical Joint Detail at a Single Light Boxout

> **<u>Note</u>** Dowels are only used for the type of boxouts shown in Figure 9-12b on the following page. Dowels are placed parallel to the direction of traffic, but only if there is adequate lateral dimension. Do not install dowels for pavement joints that are oblique to the direction of traffic.

The term “boxout” describes a technique where, during pavement construction, an isolated area is formed that precludes the placing of concrete by mechanical means. After pavement construction, the forms are removed and concrete is placed in the boxout to complete the pavement surface. The boxout is intended to provide continuity at a pavement penetration and a jointed geometry that will minimize the potential for uncontrolled cracking.

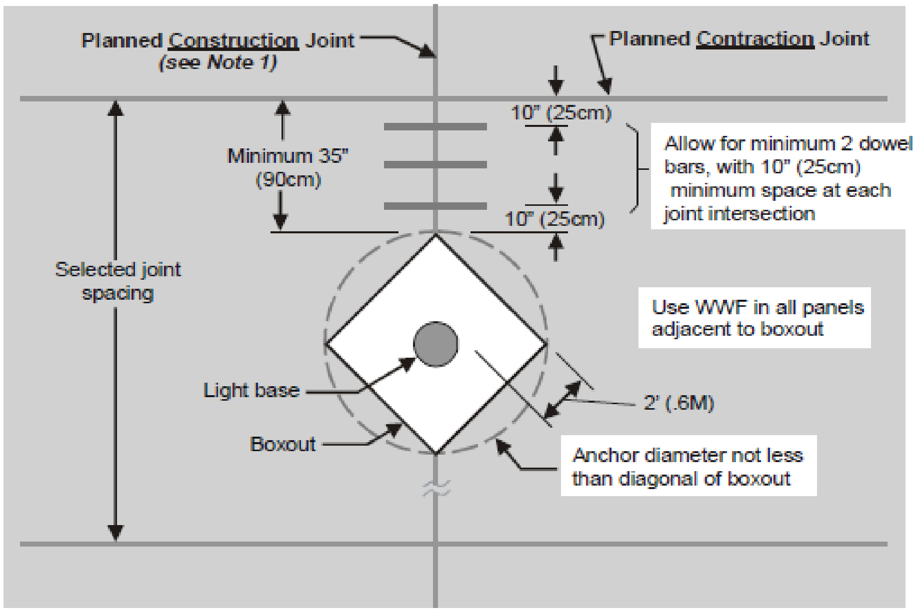
A boxout is not required when an in-pavement light base is installed at or more than two feet from a planned joint. A boxout must be used when a light base must be located closer than two feet to a planned contraction joint. The boxout is an option when locating a light closer than two feet to a construction joint provided that the results of analysis allows for the clearance of construction equipment.

A boxout formed using irregular geometry should not be used. Irregular geometry increases the probability that uncontrolled cracking will occur. Dowels should not be used as a load transfer device between the boxout and the pavement unless considerations for pavement movement are made. Where dowels have been used without consideration of differential movement the result is uncontrolled cracking.

Load transfer at the interface of the pavement and the boxout must be evaluated from the perspective of the actual pavement loading and not what is common practice. For example, the interface between the pavement and boxout is a free edge. The interface should have a thickened edge on both the boxout and the pavement. However, the construction of a boxout with a thickened edge is not practical and usually not warranted.

When dowels are used along the joint of the boxout:

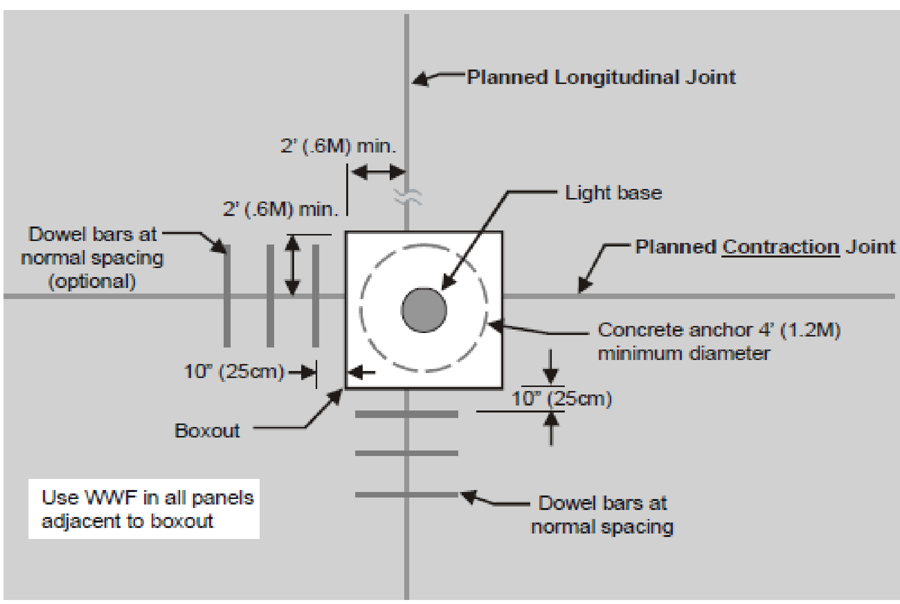
- Align dowel bars with the direction of traffic only
- Do not align dowel bars at oblique angles to the pavement planned joint orientation. Dowel bars are not used with an interior boxout
- Dowel bar spacing along a pavement construction joint has precedence over dowel bar spacing along the boxout joint. A dowel placed along a boxout joint must be located at least 12-inches from the end of a dowel bar placed along the intersecting pavement joint



NOTES:

1. When boxout is used on a planned contraction joint, the joint will be changed to a construction joint.
2. As the location of the light base moves away from the joint, the size of the boxout will increase.

(a) – Interior Boxout at PCC Construction Joint



(b) –Boxout at PCC Joint Intersection.

Figure 9.16: Typical Boxout PCC Joint Intersection

Materials	Standard Requirement	Recommended Product
Epoxy-Coated Steel Dowels	ASTM A1078	N/A
Carbon-Steel Bars	ASTM A615	N/A
Liquid Membrane Forming Compound for curing Concrete	ASTM C309	CW-600 Road & Highway Construction / Concrete Chemicals ™ or better
Joint and Crack Sealants, hot applied	ASTM D6690	PLS Crack/Joint Thermo-Sealant or better
Portland Cement Concrete (PCC)	P-501	P-501*

WEATHER AND TEMPERATURE REQUIREMENTS

- Do not begin repairs during inclement weather.
- Do not place concrete unless the ambient temperature is at least 40° F (4° C) and rising and the concrete temperature is greater than or equal to 50° F (10° C)
- Do not place concrete on frozen base, ice, or snow.
- When the ambient temperature exceeds 85° F (29° C), sprinkle the adjacent concrete and base with water immediately before placing concrete.
- Place concrete at the coolest temperature practicable, and never allow the placed concrete temperature to exceed 90° F (32° C)

REPAIR PROCEDURE

These procedures pertain to establishing boxouts in existing light can joint intersections. 'New' boxouts will have to be established prior to installation of concrete slabs.

1. Review the construction safety and phasing plan (CSPP). Ensure all pavement closures have all required items in place, such as lighted X's, barricades, etc.; and all NOTAMS have been issued for affected areas of the airfield.
2. Mark the limits of the area of the boxout.
3. Depending on the desired shape of the boxout, either a coring method or saw cut method should be employed
   - Coring procedures will refer to '9.3.2 – Procedure for Coring Existing Pavement w/ Directional Bore for Conduit'
   - Saw cut procedures will refer to '9.1.4 – Joint Spall Repair in Rigid Pavement'
4. After concrete removal, remove all loose material by hand and vacuum to minimize any damage to remaining pavement.
5. Clean the newly formed boxout area with high-pressure water.
6. If dowels are deemed necessary for load transfer, they are to be installed according to Figure 9-12
7. Prepare the surface of the boxout area in accordance with the manufacturer's recommendations for the material used for the repair. This may require treating the surface of the spall repair with a neat cement grout or a liquid bonding agent.
8. Install light can within boxout area. Refer to IPRF 01-G-002-03-1 - Constructing In-Pavement Lighting, Portland Cement Concrete Pavement (http://www.iprf.org/products/main.html)
9. for recommended light can placement.
10. Place the patch, as well as install Welded Wife Fabric (WWF) at half of the boxout depth (Figure 9-10)
11. Finish the patch to match the texture of the adjacent pavement.
12. Cure patch in accordance with P-501 for a minimum of seven (7) days or until concrete achieves a flexural strength of 550 psi.
13. Protect the patch from traffic until the material has set.
14. Thoroughly clean the work area before opening the pavement to aircraft traffic.

9.4 BRIDGE DECK REPAIR AND MAINTENANCE PROCEDURES [12]

DESCRIPTION

This section covers bridge deck repairs over relatively small areas. Large-scale deck repair or replacement work should typically include project-specific plans and be in accordance with Item 422, "Concrete Superstructures." The primary use of this section is to address unanticipated localized bridge deck damage that typically must be repaired quickly.

Whenever feasible, full-depth bridge deck repairs should extend such that two sides are bearing on supporting (e.g. girder) elements. Typically, this means extending the repair along the entire width of a bay or bays such that they bear on girders or beams.

The work covered here can be categorized in two ways. First, by depth: (1) partial depth deck repairs, (2) deck repair over precast deck panels (PCP), and (3) full-depth bridge deck repair. Second, by speed: (1) ultra-rapid, (2) rapid, (3) accelerated, and (4) normal.

Anchor: #RCOUVGHR

Defining Bridge Deck Repairs by Depth:

- Partial-depth bridge deck repairs are typically performed on full-depth cast-in-place bridge decks. Damage in the top of the deck only (not progressing full depth) is due to initial slab defects such as improper consolidation or insufficient concrete clear cover over the reinforcing steel; abrasion; wear; or top reinforcing mat steel corrosion.
- Distress can also occur in the cast-in-place sections of deck above precast concrete panels (PCP's). Regardless of the severity, when performing deck repairs in such cases the cast-in-place portion should be removed to expose the top of the PCP, which then becomes the bonding interface for the patch material. When spalling is occurring above a precast panel, the underside of the panel should be checked for distress. If there is substantial staining on the girder side faces indicating roadway drainage passing through the haunch concrete, panels likely should be replaced with a full depth repair.
- When damage extends into the PCP portion of the deck, exhibited by visible cracking on the panel soffit, then it should be treated as a full-depth deck repair.
- Full depth repairs are typically performed when partial depth distress has gone untreated and has progressed to full depth distress as discussed in the commentary of this section and when required to perform expansion joint replacement.

Defining Bridge Deck Repairs by Speed (Required Return to Service):

- Often, the factor that trumps all others in bridge deck repair work is the need to return a structure to service quickly. Bridge deck failures and consequent lane closures can have hugely detrimental impacts on traffic, particularly in urban environments. Over the years, repair material suppliers and contractors have become accustomed to the need for extraordinarily quick turnaround and have catered their services around that need. However, it has been observed that re-repair of previously repaired decks occurs frequently when the rapid strength gaining materials are used. This is further expanded upon in the commentary of this section.

In this section there are four categories of repair material based on the needed return to service time. Ultra-rapid repair material can attain sufficient compressive strength for return to service in 2 to 4 hours. Rapid repair materials can generally be returned to service in 6 to 8 hours. Class K material is batched concrete designed specifically in deck repair applications for accelerated strength gain and return to service, usually in less than 12 hours (not including moist curing time). Class S concrete is the best long-term solution but can take several days to achieve sufficient strength. Follow the plan requirements related to required strength prior to opening to traffic. If no guidance is provided, provide concrete able to obtain a minimum of 3,600 psi compressive strength prior to opening to traffic.

REPAIR MATERIAL

An appropriate repair material can be selected once a project has been categorized based on the needed return to service. All repairs should exceed 3 inches in depth and use material extended with coarse aggregate.

- 3 hours: Use a preapproved Type B Ultra-Rapid Repair Material meeting the requirements of DMS 4655, *Concrete Repair Materials*.

[12] http://onlinemanuals.txdot.gov/txdotmanuals/crm/bridge_deck_spall_repair.htm

- 6 hours: Use a preapproved Type A Rapid Repair Material meeting the requirements of DMS 4655, *Concrete Repair Materials*.
- 24 hours: Use Class K concrete. These are typically specialty mix designs supplied by a Ready-Mix plant. Mix design requires review and approval from the Engineer. Depending on the capabilities of local Ready-Mix plants this option may or may not be available.
- 2 to 4 days: Class S concrete mixes, which are used to cast new bridge decks, offer the best likelihood of long term serviceability. However, it can take several days before the concrete has sufficient strength for return to service. Engineer should review the history of the proposed Class S mix to ensure that relatively fast strength gain (less than 4 days) is likely to occur. Even with rapid strength gain, Class S mixes should be moist cured for 72 hours (absolute minimum 48 hours).

For batched concrete, provide mixes meeting the requirements of P-501 Portland Cement Concrete. If P-501 is not available use P-505 Portland Cement Concrete TxDOT Mix Specification. See Appendix F for material Specification. Note that typical Class HES mixes may not be classified as structural concrete, and should not be used, unless otherwise approved.

REPAIR PROCEDURE

Mixing:

- Except in very small applications (less than 1 cubic yard), use a mortar or volumetric mixer. Ready-Mix suppliers and trucks should typically provide batched concrete (Class K or Class S), though the Engineer may approve volumetric mixers on a case-by-case basis.
- For small applications (less than 1 cubic yard total), mix the components thoroughly until they are well blended (3 minutes minimum) using a low-speed electric drill (400 – 600 rpm) and a clean "Jiffy" type mixing paddle. Do not mix repair material by hand.
- Regardless of the mixer type, carefully proportion the water to ensure water-to-cement ratio falls within manufacturer limits. Do not guess at proper quantities or add water to attain a desired consistency.

NOTE: Contractors often use "5-gallon" buckets to proportion water. The actual volumes of these buckets can vary significantly. The Contractor and Inspector should verify actual volumes rather than assuming the buckets actually hold exactly 5 gallons.

- Do not mix material until surface preparation is complete. Ensure that there are sufficient amounts of material, mixing equipment, and labor to provide a continuous supply of mixed concrete until the placement is complete. Take sufficient steps to prevent cold joints between lifts, keeping in mind that many proprietary materials set up very rapidly (less than 15 minutes) in hot weather.

Removal of Concrete:

- Saw-cut the perimeter of the proposed repair approximately 1/2 to 3/4 inches but do not cut existing reinforcing steel. Adjust depth as necessary to avoid damaging deck steel.
- Use power-driven chipping tools or hydro-demolition equipment to remove concrete. Avoid damage to sound concrete to remain. Contractor may use up to 30-lb. hammers for the bulk of the work. However, 15-lb. hammers or smaller must be used at the base and perimeter of the repair area to avoid damaging the surrounding concrete.
- Remove additional concrete as necessary to keep the repair area to a reasonably uniform depth.
- Partial-Depth Deck Repair
  - Remove damaged concrete to ensure that the remaining deck is sound. Provide a uniformly rough surface with a chipped appearance (1/4-inch minimum surface profile or ICRI Concrete Surface Profile 9).
  - Even if defective material does not extend beyond top layer of reinforcement, remove enough concrete to ensure there is minimum ¾ inch clearance below the top layer of steel in order to provide mechanical bond for new patch material.
- Repairs over PCPs: Completely remove cast-in-place concrete to expose roughened PCP surface. Ensure that demolition operations do not damage the PCPs.
- Full-Depth Deck Repair: Square or slightly undercut the patch perimeter.

- The Engineer or the Inspector may sound the perimeter of the patch area to determine whether demolition operations caused damage beyond the intended perimeter. If that is the case the repair area must be extended to include the unintentionally damaged area.
- For full-depth repairs, remove the concrete and place forms in accordance with Item 422, Concrete Superstructures, or as approved by the Engineer.
- Obtain approval from the Engineer of the completed concrete removal before proceeding with surface preparation.

Reinforcing Steel:

- Remove all rust and other deleterious material from reinforcing steel.
- For non-epoxy coated reinforcing and for epoxy coated steel bars with coating failure, abrasive blast clean steel. Inspect cleaned steel for damage. Replace bars when cross-section is reduced greater than 25 percent.
- Apply an approved epoxy coating to repair minor damage to existing epoxy coated bars.
- When the original epoxy coating on the bars was removed by abrasive blasting, apply an epoxy coat around the entire circumference of the bars extending a minimum of 3 inches from the repair perimeter into the repair area.
- Install reinforcing steel as indicated on the plans or as directed by the Engineer. Place reinforcement parallel to the finished surface. Lap adjacent sheets or bars at least 6 inches and tie them together securely at a spacing of at most 18 inches.
- Pre-bend reinforcing steel fabric to fit around corners and into re-entrant angles before installing it. Place and secure reinforcement to prevent displacement due to repair material application.

Surface Preparation:

- Just prior to patching, thoroughly clean the concrete surfaces (bottom and sides).
- Clean the area to be repaired by high-pressure water blasting, or other approved methods. Remove all loose particles, dirt, deteriorated concrete, or other substances that would impair the bond of the repair material. Follow this with a high-pressure air blast for final cleaning.
- Ensure the surface of the existing concrete is in a saturated surface-dry (SSD) condition but remove all free (ponded) water just before placing repair material. Achieve an SSD condition by high-pressure water blasting 15 to 30 minutes before placing the repair material. An SSD condition is achieved when the surface remains damp after being exposed for 15 minutes.

Placement:

- Place the repair material onto the prepared surfaces. Consolidate using immersion-type vibrators or other methods acceptable to the Engineer.

Curing:

- Moist curing is often neglected in deck repairs due to the need to return the bridge to service quickly. However, lack of adequate curing leads to problems on deck repair materials just as it does on any other cementitious repair. Bridge deck repairs should be moist cured for as long as possible. Although 72 hours of curing time is ideal, that is seldom practical in deck repair applications. Even a few hours of moist curing can be beneficial. Refer to manufactures' guide for optimal curing time. Minimum flexural strength of concrete after cure time should be 550 psi.

COMMENTS

Shallow deck repairs are notorious for exhibiting poor performance. One common cause of early failure is debonding between the patch material and the substrate. Repair material applied over large areas but in thin applications tend to build up very high stresses at the bond line, leading to premature failure. To remedy this the Contractor should excavate below the top layer of steel, which serves two purposes. First, the reinforcing cage provides a mechanical tie for the patch material to the rest of the deck. Second, it helps to prevent overly thin applications that have little chance of performing well.

Another common cause of premature failure is that partial-depth repairs are often implemented when full-depth would have been more appropriate. The deck soffit should be inspected at partial depth repair locations looking for areas of distress that could be weak and fail when the upper surface is being removed. Partial-depth repairs are typically easier to perform because they do not require installation of formwork or road closures under the bridge. Bridge deck distress oftentimes progresses full depth, as evidenced by cracking in the deck soffit. If map pattern cracking is visible, or if there is widespread cracking with efflorescence and rust staining, then full depth repairs should usually be implemented in lieu of partial-depth.

Figure 9.17 Damaged Bridge Deck

Figure 9.18 Bridge Deck Repair Procedure

Intended partial-depth deck repairs can unintentionally become full-depth repairs if the Contractor utilizes equipment too heavy for the application. Contractors should not use equipment larger than necessary to perform the required demolition work and must stay within the applicable limits outlined in the “Surface Preparation” item below, unless specifically allowed otherwise by the Engineer. No additional compensation for full depth repairs caused by contractor’s operations will be made.

While rapid strength gain is beneficial for returning a bridge to service, it typically has detrimental effects for the repair material. Rapid curing of the cementitious material can prevent even distribution of the hydration products. Also, early return of service induces stresses into concrete that can create microcracking and other defects even when the compressive strength is high.

Because deck repairs must usually be performed quickly, Engineers and Contractors often select rapid methods even when they are not necessary. It is imperative that, when feasible, slower-hydrating materials and longer curing cycles be utilized. The faster the return to service, the shorter the anticipated service life of the patch

10.0 PAVEMENT FRICTION MANAGEMENT[13]

10.1 FRICTION ANALYSIS AND CLASSIFICATION

In order for an airfield to maintain a certain standard of safety, pavement friction should be taken into consideration as a high priority performance measure. Current FAA regulations outline how often friction analysis should be performed, based on runway traffic:

Table 10.1: Required Friction Survey Frequency

Number of Daily Minimum Turbojet Aircraft Landings Per Runway End	Minimum Friction Survey Frequency
Less than 15	1 year
15 to 30	6 months
31 to 90	3 months
91 to 150	1 month
151 to 210	2 weeks
Greater than 210	1 week

*Each runway end should be evaluated separately, e.g., Runway 9 and Runway 27

Prior to initial friction evaluation, visual inspections of runways to be observed should be conducted in order to identify any deficiencies in pavement. These deficiencies should be recorded and considered when going through the results of friction evaluation. Proper CFME (Continuous Friction Measurement Equipment) precaution protocol should also be followed prior to any evaluation operations, which includes the following tasks:

- Ensuring operators are fully trained and up-to-date on proper procedures
- Calibration of pavement testing equipment
- Pre-operation vehicle inspections

The airport operator, when conducting friction surveys on runways at 40 mph (65 km/h), should begin recording the data 500 feet (152 m) from the threshold end to allow for adequate distance to safely decelerate the vehicle. When conducting friction surveys at 60 mph (95 km/h), the airport operator should start recording the survey 1,000 feet (305 m) from the threshold end and terminate the survey approximately 1,000 feet from the opposite end of the runway. A complete survey should include tests at both 40 mph and 60 mph. Where travel beyond the end of the runway could result in equipment damage or personal injury, additional runway length should be allowed for stopping. The lateral location on the runway for performing the test is based on the type of aircraft operating on the runway. Unless surface conditions are noticeably different on either side of the runway centerline, a test on one side of the centerline in the same direction the aircraft lands should be sufficient. However, when both runway ends are to be evaluated, vehicle runs can be made to record data on the return trip (both ways).

The lateral location on the runway for performing friction surveys is based on the type and/or mix of aircraft operating on the runway:

a. **Runways Serving only Narrow Body Aircraft**
   Friction surveys should be conducted 10 feet (3 m) to the right of the runway centerline.
b. **Runways Serving Narrow Body and Wide Body Aircraft**
   Friction surveys should be conducted 10 and 20 feet (3 and 6 m) to the right of the runway centerline to determine the worst-case condition. If the worst-case condition is found to be consistently limited to one track, future surveys may be limited to this track. Care should be exercised, however, to account for any future and/or seasonal changes in aircraft mix.

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[13] Federal Aviation Administration. (March, 1997). *Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces*. (Advisory Circular 150/5320-12C). 6-30.

Table 10.2: Friction Level Recommendations for Runway Pavement Surfaces (Various CFME)

	40 mph			60 mph		
	Minimum	Maintenance Planning	New Design/ Construction	Minimum	Maintenance Planning	New Design/ Construction
Mu Meter	0.42	0.52	0.72	0.26	0.38	0.66
Dynatest Consulting, Inc. Runway Friction Teste	0.5	0.6	0.82	0.41	0.54	0.72
Airport Equipment Co. Skiddometer	0.5	0.6	0.82	0.34	0.47	0.74
Airport Surface Friction Tester	0.5	0.6	0.82	0.34	0.47	0.74
Airport Technology USA Safegate Friction Tester	0.5	0.6	0.82	0.34	0.47	0.74
Findlay, Irvine, Ltd. Griptester Friction Meter	0.43	0.53	0.74	0.24	0.36	0.64
Tatra Friction Tester	0.48	0.57	0.76	0.42	0.52	0.67
Norsemeter RUNAR (operated at fixed 16% slip)	0.45	0.52	0.69	0.32	0.42	0.63

The Mu values listed in Table 10.2 provide guidelines on how to classify poor pavement friction. These guidelines take into account that poor friction c for short distances on the runway do not pose a safety problem to aircraft, but long stretches of 'poor friction' pavement are of serious concern and require proper response. Depending on the extent of poor friction along a runway, various actions would need to be taken:

a. 500 ft - Friction Deterioration Below the Maintenance Planning Friction Level

When the average Mu value on the wetted runway is less than the Maintenance Planning Friction Level but above the Minimum Friction Level (Table 10.2) for a distance of 500 ft, and the adjacent 500 ft segments are at or above the Maintenance Planning Friction level, no corrective action is required.

b. 1000 ft - Friction Deterioration Below the Maintenance Planning Friction Level

When the average Mu value on the wetted runway is less than the Maintenance Planning Friction Level (Table 10.2) for a distance of 1000 ft or more, the airport operator should conduct extensive evaluation into the cause(s) and extent of the friction deterioration and take appropriate corrective action.

c. Friction Deterioration Below the Minimum Friction Level

When the averaged Mu value on the wetted runway is below the Minimum Friction Level (Table10.2) for a distance of 500 ft, and the adjacent 500 ft segments are below the Maintenance Planning Friction Level, corrective action should be taken immediately after determining the cause(s) of the friction deterioration. Before undertaking corrective measures, the airport operator should investigate the overall condition of the entire runway pavement surface to determine if any other deficiencies exist.

d. New Design/Construction Friction Level

Newly constructed runway surfaces serving turbojet aircraft operations should have an average Mu on the wetted runway at or above the New Design/Construction Friction Level for each 500 ft segment.

a. Newly Constructed Pavements

The recommended average texture depth for newly constructed concrete and asphalt pavement is 0.045 inch (1.14 mm).

b. Existing Pavements

i. When the average texture depth of a runway zone (touchdown, midpoint, rollout) falls below 0.045 inch (1.14 mm), texture depth measurements should be conducted each time a runway friction survey is conducted.
ii. When the average texture depth of a runway zone falls below 0.030 inch (0.76 mm) but above 0.016 inch (0.40 mm), the airport operator should initiate plans to correct the pavement texture deficiency within a year.
iii. When the average texture depth of a runway zone falls below 0.010 inch (0.25 mm), the airport operator should correct the pavement texture deficiency within 2 months.

c. Retexturing

Average texture depth should be improved by 0.030 inch (0.76 mm) at minimum after retexturing.

10.2 GROOVE DEPTH REQUIREMENTS

When considering pavement macrotexture and pavement grooving, each serve separate roles in skid resistance. Pavement macrotexture provides friction between runway pavement and aircraft tires, enabling aircraft to brake and maneuver. Pavement grooving, while being a feature that provides traction for aircraft tires, does so through drainage and displacement of surface water, allowing tires to make contact with pavement. Hydroplaning and skidding being the main concern for runway pavement surface design, grooving should be prioritized as the necessary feature on runway pavement. Grooving is more effective in reducing hydroplaning due to the forced displacement of water that it provides[14]

Upon conducting runway friction evaluations, if there are deficient or is significantly deteriorating friction levels, the next action should be to conduct texture depth measurements. Runway pavement texture will have different requirements in terms of depth, depending on where the pavement is in its life cycle:

Groove measurement requirements are FAA standard and are defined as being ¼ (±1/16 inch) inch depth by ¼ inch (±1/16 inch) width. Center to center spacing between each grove should be 1 ½ inch. See Figure 10.1 below:

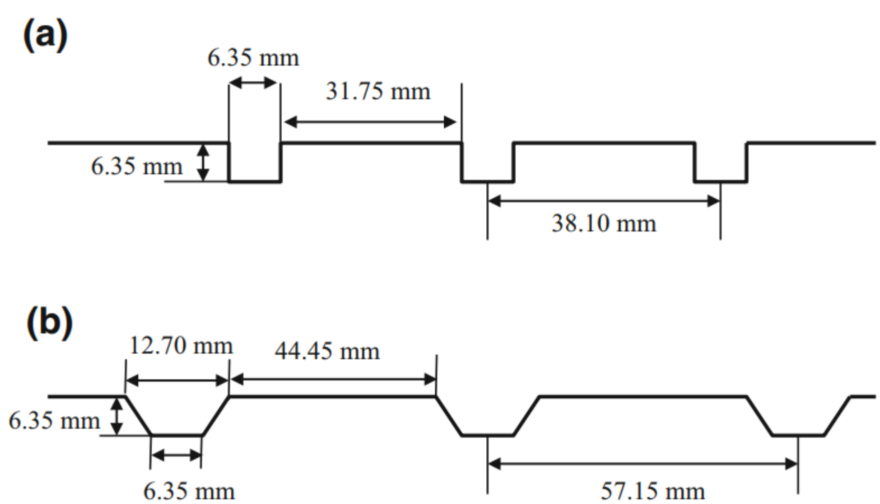


Figure 10.1: (a) FAA Runway Pavement Grooving Measurements vs. (b) Alternative trapezoidal grooving measurements [2]

[14] https://www.icao.int/NACC/Documents/Meetings/2013/ALACPA10/ALACPA10-P23.pdf

In cases where standard square grooving cannot be achieved, a widely accepted alternative is trapezoidal grooving design. This form of grooving provides acceptable operational safety of runway pavement, while keeping maintenance costs reasonable, with improved longevity[15].

Monitoring the groove deterioration of the width and depth is important in maintaining the longevity, performance and functionality of the pavement. Types of groove distress include normal wear, groove closure, rubber deposits, rounding and erosion. Groove collapse commonly occurs in wheel line rutting areas.

The method to measure groove deterioration requires the airport operator to annually measure the depth and width of a runway's grooves to check for wear and damage. When 40 percent of the grooves in the runway are equal to or less than 1/8 inch (3 mm) in depth and/or width for a distance of 1,500 feet (457 m), the grooves' effectiveness for preventing hydroplaning has been considerably reduced. The testing method is described below:

Groove Testing. Grooves will be accepted based on results of zone testing. All acceptance testing necessary to determine conformance with the groove tolerances specified will be performed by the Engineer.

Instruments for measuring groove width and depth must have a range of at least 0.5 inches and a resolution of at least 0.005 inches. Gage blocks or gages machined to standard grooves width, depth, and spacing may be used.

Instruments for measuring center-to-center spacing must have a range of at least 3 inches and a resolution of at least 0.02 inches.

The Engineer will measure grooves in five zones across the pavement width. Measurements will be made at least THREE times every 200 feet. Measurements in all zones will be made. The five zones are as follows:

Table 10.3: Grooves Measurements Zones

Zone 1	Centerline to 5 feet left or right of the centerline.
Zone 2	5 feet to 25 feet left of the centerline.
Zone 3	5 feet 25 feet right of the centerline.
Zone 4	25 feet to edge of grooving left of the centerline.
Zone 5	25 feet to edge of grooving right of the centerline.

At a random location within each zone, five consecutive grooves will be measured for width, depth, and spacing. The five consecutive measurements must be located about the middle of each zone. Measurements will be made along a line perpendicular to the grooves.

- Width or depth measurements less than 0.170 inches shall be considered less than 3/16 inches.
- Width or depth measurements more than 0.330 inches shall be considered more than 5/16 inches.
- Width or depth measurements more than 0.235 inches shall be considered more than 1/4 inches.

The airport operator should take immediate corrective action to reinstate the 1/4 inch (6 mm) groove depth and/or width. The runway friction is improved with runway re-grooving. Re-grooving is an alternative for runways with groove deterioration. This technique consists of re-grooving the existing groove profile in bituminous HMA or concrete runway surface by using existing grooves and alignment. Another method to restore grooves without includes planing the surface and then re-grooving the surface

[15] https://link.springer.com/content/pdf/10.1007%2Fs40890-015-0001-6.pdf

10.3 AIRFIELD PAVEMENT RUBBER TIRE REMOVAL

Another factor of pavement skid resistance and friction is the amount of contaminate build up along runways – aircraft tire rubber in particular. Current FAA Regulations outline how often contaminate buildup should be addressed, based on runway traffic:

Table 10.4: Rubber Deposit Removal Frequency

Number of Daily Minimum Turbojet Aircraft Landings Per Runway End	Minimum Friction Survey Frequency
Less than 15	2 years
15 to 30	1 year
31 to 90	6 months
91 to 150	4 months
151 to 210	3 months
Greater than 210	2 months

(PCC and AC Pavement Surfaces)
*Each runway end should be evaluated separately, e.g., Runway 9 and Runway 27

Currently there are four common methods of treating rubber buildup, each with their own advantages and disadvantages:

High Pressure Water Jetting – A series of high pressure water jets is aimed at the pavement to blast the contaminants from the surface, allowing the water to transport the rubber particles to the edge of the runway. The technique is economical and removes deposits from the pavement surface with minimal downtime to the airport operator. High-pressure water blasting also may be used to improve the surface texture of smooth pavements. Water pressures used vary significantly. **There are so many other parameters that vary from one contractor's equipment to another, however, that the pressure of the water used is not a good indication of the potential for either effectiveness or pavement damage. The airport operator should rely on the contractor's experience, demonstrated expertise, and references.**

Chemical Removal - Chemical solvents have been used successfully for removal of contaminants on both PCC and HMA runways. Any chemicals used on runways must meet federal, state, and local environmental requirements. For removal of rubber deposits on PCC runways, chemicals that have a base of cresylic acid and a blend of benzene are used, with a synthetic detergent for a wetting agent. For removal of rubber deposits on HMA runways, alkaline chemicals are generally used. Because of the volatile and toxic nature of such chemicals, extreme care must be exercised during and after application. If the chemicals remain on the pavement too long, the painted areas on the runway, and possibly the surface itself, could be damaged. It is also very important to dilute the chemical solvent that is washed off the pavement surface so that the effluent will not harm surrounding vegetation or drainage systems, or pollute nearby streams and wildlife habitats. Detergents made of metasilicate and resin soap can be used effectively to remove oil and grease from PCC runway surfaces. For HMA pavements, an absorbent or blotting material such as sawdust or sand combined with a rubber alkaline degreaser may be used. **The airport operator should rely on the contractor's experience since the procedure can cause surface polishing and a reduction in friction due to polishing.**

High Velocity Impact Removal (Shot-Peening) - This method employs the principle of throwing abrasive particles at a very high velocity at the runway pavement surface, thus blasting the contaminants from the surface. Additionally, the machine that performs this operation can be adjusted to produce the desired surface texture, if so required. The abrasive is propelled mechanically from the peripheral tips of radial blades in a high speed, fan like wheel. The entire operation is environmentally clean in that it is self-contained; it collects the abrasive particles, loose contaminants, and dust from the runway surface; it separates and removes the contaminants and dust from the abrasive; and it recycles the abrasive particles for repetitive use. The machine is very mobile and can be removed rapidly from the runway if required by aircraft operations. **The airport operator should rely on the contractor's experience on the velocity of shot-peening since the procedure can cause surface deterioration.**

Mechanical Removal - Mechanical grinding that employs the corrugating technique has been successfully used to remove heavy rubber deposits from both PCC and HMA runways. It has also been used to remove high areas such as bumps on pavement surfaces or at joints where slabs have shifted or faulted. This method greatly improves the pavement surface friction characteristics. Pavement surfaces that are either contaminated (rubber buildup or bleeding) or worn can have their surface friction coefficient greatly increased by a thin milling operation. This technique removes a surface layer between 1/8 and 3/16 inch (3.2 and 4.8 mm) in depth.

Procedures for each of these methods are proprietary to the contractor providing contaminate removal services.

11.0 PAVEMENT SMOOTHNESS MANAGEMENT

11.1 PROFILOGRAPH SMOOTHNESS TEST

After the final asphalt surface rolling, but not later than 24 hours after placement, the surface shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities that exceed the tolerances specified. Equipment and testing methods should produce a surface measurement for each pavement lot. the finished surface course of the pavement shall not vary more than 1/4 inch when evaluated with a 12-foot straightedge.

The results of the average profile index must meet the following requirements: the final average profile index (subsequent to any required corrective action) should not exceed 7 inches per mile. If the final average profile index (subsequent to any required corrective action) exceeds 7 inches per mile, but does not exceed 15 inches per mile, the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index. The adjustment to pay factor can be found in the following table.

Table 11.1. Profilograph Average Profile Index Smoothness Pay Factor

Inches/miles per 1/10 mile	Short Sections	Pay Factor
0.0 - 7	00.0 - 15.0	100%
7.1 - 9	15.1 - 16	98%
9.1 - 11	16.1 - 17	96%
11.1 - 13	17.1 - 18	94%
13.1 - 14	18.1 - 20	92%
14.1 - 15	20.1 - 22	90%
15.1 and up	22.1 and up	Corrective work required*

* The Contractor shall correct pavement areas not meeting these tolerances by removing and replacing the defective work. If the Contractor elects to construct an overlay to correct deficiencies, the minimum thickness of the overlay should be at least three times the maximum aggregate size (approximately four (4) times the nominal maximum aggregate size). The corrective overlay shall not violate grade Criteria and butt joints shall be constructed by sawing and removing the original pavement in compliance with the thickness/ maximum aggregate size ratio. Skin patching shall not be permitted.

11.2 PROFILOGRAPH MEASUREMENT AND TESTING PROCEDURE

When the surface course smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the surface course, full depth removal and replacement of surface course corrections shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified. The Contractor shall apply a surface treatment per Item P-608 to all areas that have been subject to grinding as directed by the Engineer.

(a) Transverse measurements. Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet or more often as determined by the Engineer.

(i) Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. High spots on final surface course > 1/4 inch in transverse direction shall be corrected with diamond grinding or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet or more often if directed by the Engineer. Deviations on final surface course > 1/4 inch in transverse direction shall be corrected with diamond grinding or by removing and replacing full depth of surface course. Each measurement shall be recorded, and a copy of the data shall be furnished to the Engineer at the end of each days testing.

(b) Longitudinal measurements. Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet; and at the third points of paving lanes when widths of paving lanes are 20 ft or greater.

(i) Longitudinal Short Sections. Longitudinal Short Sections are when the longitudinal lot length is less than 200 feet and areas not requiring a profilograph. When approved by the Engineer, the first and last 15 feet of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4 inch when evaluated with a 12-foot straightedge. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) Profilograph Testing. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must grind" bumps and the Profile Index for the pavement using a 0.2 inch blanking band. The bump template must span one inch with an offset of 0.4 inches. The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of one inch equals 25 feet and a vertical scale of one inch equals one inch. A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing.

The pavement must have an average profile index meeting the requirements of Table 11.1. High spots, or "must grind" spots, on final surface course in longitudinal direction shall be corrected with diamond grinding or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15 inches per mile or less. If the initial average profile index was less than 15 inches , only those areas representing greater than 0.4 inch deviation will be re-profiled for correction verification.

(iii) Final profilograph of . Final profilograph shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274.The pavement must have an average profile index meeting the requirements of Table 11.1 The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch blanking band. The bump template must span one inch with an offset of 0.4 inches. The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of one inch equals 25 feet and a vertical scale of one inch equals one inch. A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing. Profilograph of final runway shall be performed one foot right and left of runway centerline and 15 feet right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the Engineer.

Smoothness testing indicated in the above paragraphs except paragraph (iii) shall be performed within 24 hours of placement of material. Smoothness testing indicated in paragraph (iii) shall be performed within 48 hours of paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

11.3 DIAMOND GRINDING

When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch wide and there shall be a minimum of 55 to 60 blades per 12 inches of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the pavement will not be permitted. The depth of grinding shall not exceed 1/2 inch and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. Areas that have been ground will be sealed with a P-608 surface treatment as directed by the Engineer. It may be necessary to seal a larger area to avoid surface treatment creating any conflict with runway or taxiway markings.

12.0 AIRFIELD PAVEMENT MARKINGS

12.1 EVALUATION OF EXISTING MARKINGS

Airfield markings deteriorate over time from traffic wear, ultraviolet light, wind, rain, snowplowing, and sweeping, etc. Certain criteria should be inspected to determine when markings require maintenance because they do not need to be remarked each year. Some of things that should be documents are faded colors or appearance, poor nighttime visibility or retro-reflectivity, existing markings are worn 50 percent, and existing markings are covered with contaminants. Some of the caused for these types of deteriorates can be caused by layers of paint from older markings, rust discoloration, algae growth, and, UV-damage. Observed deterioration should be photographed and documented.

Figure 12.1: Examples of Deteriorated Pavement Markings

12.2 REMOVAL OF EXISTING MARKINGS

Before application of paint, the pavement surface must be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement. The area to be painted shall be cleaned by waterblasting to minimizing damage to the pavement surface. After the cleaning operations, sweeping, blowing, or rinsing with pressurized water shall be performed to ensure the surface is clean and free of grit or other debris left from the cleaning process.

12.3 PAVEMENT MARKING MATERIALS

Pavement Marking Paint shall be waterborne and the non-volatile portion of the vehicle for all paint types shall be composed of a 100% acrylic polymer as determined by infrared spectral analysis.

Additives to pavement markings, such as glass beads, are required/recommended under certain conditions, and are prohibited in others. Table 12.1 outlines when glass beads are to be used.

Table 12.1. Glass Bead Usage by Paint Color
(See Table 12.1 for Application Rates)

Paint Color	Glass Beads, Type I, Gradation A	Glass Beads, Type III	Glass Beads, Type IV
White	See Table 12.2	See Table 12.2	See Table 12.2
Yellow	See Table 12.2	See Table 12.2	See Table 12.2
Red	See Table 12.2	Not used	See Table 12.2
Pink	See Table 12.2	Not used	See Table 12.2
Black	Not used	Not used	Not used
Green	Not used	Not used	Not used

Glass beads shall be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment.

Table 12.2. Application Rates for Paint and Glass Beads

Paint Type	Paint Square feet per gallon, ft^2/gal	Glass Beads, Type I, Gradation A Pounds per gallon of paint-lb/gal	Glass Beads, Type III Pounds per gallon of paint-lb/gal	Glass Beads, Type IV Pounds per gallon of paint-lb/gal
Waterborne Type I or II	115 ft^2/gal max	7 lb/gal min	10 lb/gal min	--
Waterborne Type III	90 ft^2/gal max	--	10 lb/gal min	
Waterborne Type III	55 ft^2/gal max			8 lb/gal min
Solvent Base	115 ft^2/gal max	7 lb/gal min	10 lb/gal min	--
Solvent Base	55 ft^2/gal max	--	--	8 lb/gal min
Epoxy	90 ft^2/gal max	15 lb/gal min	20 lb/gal min (2.4 kg/l)	16 lb/gal min
Methacrylate	45 ft^2/gal max	15 lb/gal min	20 lb/gal min (2.4 kg/l)	16 lb/gal min

Note: The glass bead application rate for Red and Pink paint shall be reduced by 2 lb/gal (0.24 kg/l) for Type I and Type IV beads. Type III beads shall not be applied to Red or Pink paint.

12.4 PAVEMENT MARKING TYPES

Airfield runways and taxiways have marking elements that are specific to each other; outlined are types of markings for each branch type:

Table 12.3: Runway and Taxiway Marking Elements

RUNWAY	TAXIWAY
- Runway Designation Marking - Runway Centerline Markings - Runway Threshold Marking - Runway Aiming Point Marking - Runway Touchdown Zone Marking - Runway Side Strip Marking - Runway Threshold Bar - Demarcation Bar - Arrows/Arrowheads - Chevrons - Blast Pad Markings	- Taxiway Centerline Marking - Taxiway Edge Marking - Holding Position Markings - Runway Intersection Markings - Airfield Navigation Markings *All taxiway markings are painted in yellow

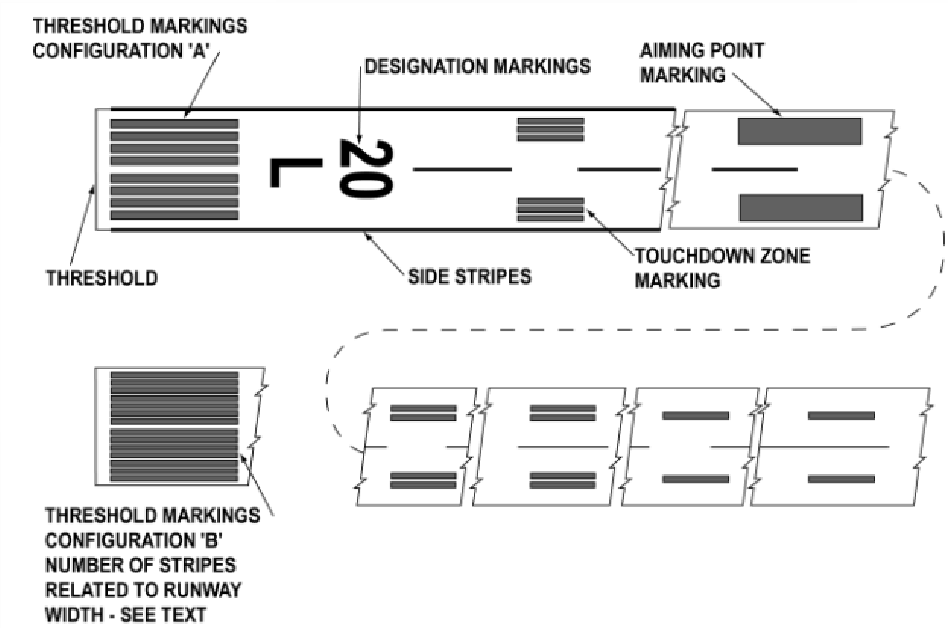
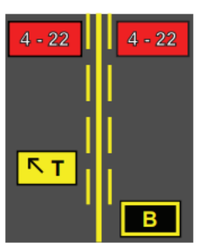


Figure 12.2: Precision Instrument Runway Markings[17]

EXAMPLE	TYPE OF MARKING	PURPOSE	LOCATION/CONVENTION
	Holding Position.	Denotes entrance to runway from a taxiway.	Located across centerline within 10 feet of hold sign on taxiways and on certain runways.
	ILS Critical Area/POFZ Boundary.	Denotes entrance to area to be protected for an ILS signal or approach airspace.	Located on twys where the twys enter the NAVAID critical area or where aircraft on taxiway would violate ILS apch airspace (including POFZ).
	Taxiway/Taxiway Holding Position.	Denotes location on taxiway or apron where aircraft hold short of another taxiway.	Used at ATCT airports where needed to hold traffic at a twy/twy intersection. Installed provides wing clearance.
	Non-Movement Area Boundary.	Delineates movement area under control of ATCT, from non-movement area.	Located on boundary between movement and non-movement area. Located to ensure wing clearance for taxiing aircraft.
	Taxiway Edge.	Defines edge of usable, full strength taxiway.	Located along twy edge where contiguous shoulder or other paved surface NOT intended for use by aircraft.
	Dashed Taxiway Edge.	Defines taxiway edge where adjoining pavement is usable.	Located along twy edge where contiguous paved surface or apron is intended for use by aircraft.
	Surface Painted Holding Position.	Denotes entrance to runway from a taxiway.	Supplements elevated holding position signs. Required where hold line exceeds 200'. Also useful at complex intersections.
	Enhanced Taxiway Centerline.	Provides visual cue to help identify location of hold position.	Taxiway centerlines are enhanced 150' prior to a runway holding position marking.
	Surface Painted Taxiway Direction.	Defines designation/direction of intersecting taxiway(s).	Located L side for turns to left. R side for turns to right. Installed prior to intersection.
	Surface Painted Taxiway Location.	Identifies taxiway on which the aircraft is located.	Located R side. Can be installed on L side if combined with surface painted hold sign.

Ref. AC 150/5340-1J *Standards for Airport Markings*, and AC 150/5340-18D *Standards for Airport Signs Systems*

Figure 12.3: Taxiway Markings

[17] Federal Aviation Administration. (August, 2011). "Airport Marking Aids and Signs". *Aeronautical Information Manual*. Ch. 2 Sec. 3

12.5 PAVEMENT MARKING APPLICATION

Prior to the initial application of markings, the Contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the marking paint and that environmental conditions are appropriate for the material being applied. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. The edges of the markings shall not vary from a straight line more than 1/2 inch in 50 feet , and marking dimensions and spacings shall be within the following tolerances:

Table 12.4: Marking Dimension, Spacing and Tolerance

Dimension and Spacing	Tolerance
36 inch (910 mm) or less	±1/2 inch (12 mm)
greater than 36 inch to 6 feet (910 mm to 1.85 m)	±1 inch (25 mm)
greater than 6 feet to 60 feet (1.85 m to 18.3 m)	±2 inch (50 mm)
greater than 60 feet (18.3 m)	±3 inch (76 mm)

The paint shall be mixed in accordance with the manufacturer’s instructions. The addition of thinner will not be permitted.

After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The Contractor shall remove from the work area all debris, waste, loose or unadhered reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the Engineer. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

13.0 REFERENCES

No.	Source	Title	Date
1	Texas Transportation Institute	**Investigation of Spall Repair Materials for Concrete Pavement, FHWA/TX-06/0-5110-1** https://static.tti.tamu.edu/tti.tamu.edu/documents/0-5110-1.pdf	October, 2005
2	Federal Aviation Administration	**Guidelines and Procedures for Maintenance of Airport Pavements, AC 150/5380-6C** https://www.faa.gov/documentLibrary/media/Advisory_Circular/150-5380-6C.pdf	October, 2014
3	Innovative Pavement Research Foundation	**Constructing In-Pavement Lighting, Portland Cement Concrete Pavement, IPRF 01-G-002-03-1** http://www.iprf.org/products/IPRF%2001-G-002-03-1_FinalReport.pdf	March, 2008
4	Texas Department of Transportation	**Concrete Control Manual** http://onlinemanuals.txdot.gov/txdotmanuals/crm/manual_notice.htm	January, 2017
5	Federal Aviation Administration	**Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces, AC 150/5320-12C** https://www.faa.gov/documentLibrary/media/advisory_circular/150-5320-12C/150_5320_12c.PDF	March, 1997
6	International Civil Aviation Organization	**Runway Grooving and Surface Friction** https://www.icao.int/NACC/Documents/Meetings/2013/ALACPA10/ALACPA10-P23.pdf	October, 2013
7	Transportation in Developing Economies	**Improving Wet- Weather Runway Performance Using trapezoidal Grooving Design** https://link.springer.com/content/pdf/10.1007%2Fs40890-015-0001-6.pdf	October, 2015
8	Federal Aviation Administration	**Preformed Thermoplastic Airport Pavement Markings Memorandum** https://www.faa.gov/airports/engineering/media/Preformed_Thermoplastic_Airport_Pavement_Markings_Memo_20170106.pdf	January, 2017
9	Federal Aviation Administration	**Airport Marking Aids and Signs** http://tfmlearning.fly.faa.gov/publications/atpubs/aim/Chap2/aim0203.html	August, 2011
-	Innovative Pavement Research Foundation	**Airfield Marking Handbook, IPRD 01-G-002-05-1** http://www.iprf.org/products/Final%20Report%2005-1.pdf	September, 2008
-	Transportation Research Board	**Joint Repair Methods for Portland Cement Concrete Pavements, NCHRP Report 281** http://onlinepubs.trb.org/Onlinepubs/nchrp/nchrp_rpt_281.pdf	December, 1995
-	Transportation Research Board	**Common Airport Pavement Maintenance Practices, ACRP Synthesis 22** http://www.dot.ca.gov/hq/planning/aeronaut/documents/acrp/acrp_syn_022.pdf	March, 2011

Appendix A: Construction Safety and Phasing Plan (CSPP)

Appendix A: Construction Safety and Phasing Plan (CSPP)

1. Project Coordination

a. Preconstruction Meeting

A pre-construction meeting will be held for the sharing of information about distresses and all other issues that may arise.

b. Construction Daily Coordination

At all times when construction activities are being performed, the shall meet the requirements of the Pavement Management Plan and Airport Safety Requirements.

c. Post-Construction Meetings

A post-construction meeting will be held to inform other members of the team are aware of the repair.

2. Construction Sequence

a. Overall Scope of Work

The type of work to be done is based on the type of distress and pavement material.

3. Area and Operations Affected by the Construction Activity

Contractor shall not enter any areas outside the designation construction limits. Contractor shall not enter active safety areas for a runway or taxiway without prior coordination with airport operations staff.

4. Navigational Aid (NAVAID) Facilities

Aircraft navigational aids (NAVAIDs) provide visual and electronic information which is used by pilots who operate and land aircraft at the airport. Construction activities can have negative impacts on the functionality and serviceability of NAVAIDs. The Contractor must coordinate their work effort and limit their operations so that NAVAIDs are not impacted beyond what is planned.

Contractor will be required to limit operations so that material, equipment, and personnel do not enter NAVAID critical areas (as shown in the phasing plans) or disturb power to NAVAID facilities without prior coordination with Airport Operations and FAA Tech Ops personnel.

5. Contractor Access

a. Stockpiled Materials

Contractor is limited to placement of stockpiled materials at the locations shown within the phasing plans. Additionally, Contractor may place material stockpiles (topsoil, aggregate, etc.) at any location within the project work limits as delineated by snow fence as shown in the phasing plans.

i. **Height Restrictions**. Stockpiles have height limits of 10 feet due to line of sight constraints

ii. **Wildlife Attractant.** Contractor to manage stockpiles so that they do not attract wildlife

iii. **Foreign Object Debris (FOD).** Contractor to manage stockpiles so that they do not create FOD

iv. **Marking and Lighting of Stockpiles**. Contractor will not be required to mark or light material stockpiles.

b. Vehicle and Personnel Operations

i. **Access to Airport Operations Area (AOA)** The airport operations area is defined by the perimeter fence surrounding the airfield. Access onto the AOA is through any number of gates along the fence or doors through buildings. Contractor access onto the AOA is limited to the gates provided by Airport Operations Personal.

ii. **No person shall enter into the Air Operations Area (AOA**), or any other restricted area except authorized personnel assigned to duty therein. Contractor personnel shall be escorted by authorized personnel on duty.

iii. **Mechanisms to prevent improper movement.** Contractor operations within the AOA are limited to the areas shown on the project layout plan. The layout plan shows locations of work area boundaries. Construction vehicles and personnel must not cross barricades or cones at any time without an escort from Airport Operations personnel.

iv. **Parking areas for personal vehicles and equipment.** Employees may park only in the designated staging area shown in the project layout plan. Contractor vehicles and equipment are allowed inside of the project work area within the AOA. Equipment staging areas are as shown in the project layout plan.

v. **Haul Routes.** The project layout and safety plan depict haul routes for both overall site access from surrounding public roadways and haul routes to the individual phased work areas through the airport perimeter fence. Contractor access and hauling operations are strictly limited to the haul routes shown. Contractor is responsible for any improvements and maintenance to haul routes as needed to efficiently perform construction activities. Following completion of construction. Contractor is required to restore haul route to original condition.

vi. **Airport rules for ground vehicle operations.** The following rules of operation must be followed at all times when driving on the airport. Read each rule carefully and make sure you understand your responsibilities as a driver on the airport.

1) No person shall operate motorized vehicles or equipment of any kind on the airport unless in possession of valid operator's license as required by the State for the type of vehicle being operated.
2) No person shall operate a motor vehicle or other motorized equipment of any kind on the airport in a reckless or negligent manner or without caution or in any manner that endangers or is likely to endanger persons or property, or in excess of the posted speed limit in the following areas:
3) The maximum speed for all vehicles and equipment is 30 miles per hour, with the exception of authorized emergency vehicles during emergency functions operated within the apron areas.
4) Vehicles and equipment operated in all other apron and terminal service areas must not exceed 20 miles per hour with the exception of authorized emergency vehicles during emergency functions.
5) The maximum speed for vehicles operated in the baggage sort areas, around hangars and under the concourse and immediately around the terminal, is 10 miles per hour.
6) The maximum speed for all motor vehicles and ground equipment operated in aircraft safety areas such as runways and taxiways will be determined by the operator in accordance with operational necessity and safe operating practices.
7) No person shall fail to give pedestrians and aircraft the right-of-way over vehicular traffic. All ground vehicles shall pass to the rear of taxiing aircraft.
8) No person operating a motor vehicle on the airport shall fail to give proper signals or fail to observe the directions of posted traffic signs or traffic lanes.
9) No person under the influence of alcohol or drugs shall operate a motor vehicle on the airport.
10) Contractor will not be allowed to operate motor vehicles outside of the designated work areas as identified by barricades or cones. To drive from one work area to another you should, under most circumstances, leave the airfield via an authorized security gate, or then drive the airport service road to the desired work area.
11) Driving privileges to operate in areas controlled by the ATCT (movement areas) are limited to vehicles with an operational necessity and who have been pre- approved by the Aviation Director and have received appropriate Ground Vehicle Movement Area Driver Training. To drive on any part of the airport other than the work areas as defined in the project phasing plans the Contractor must coordinate with and be escorted by Airport Operations personnel, and must obey the following restrictions:
    a) All vehicles operating outside of the project work area must be escorted by an Airport Operations vehicle with a two-way radio in continuous communication with the ATCT. The Contractor provided flagger will communicate with the ATCT at this location to allow construction personnel to cross the movement area.
    b) Vehicles operating in the movement areas must be equipped with a yellow beacon that is turned on and operating and have proper markings.
    c) Vehicle operators are expected to familiarize themselves with airport signs and markings.
12) The Airport Director shall have the authority to tow or otherwise move motor vehicles that are parked by their owners or operators on the airport in violation of the regulations of the airport, at the operator's expense and without liability for damage that may result in the course of or by reason of such moving.

13) Vehicles operating within the Air Operations Areas (AOA) or within the perimeter security fence line shall display a vehicle permit issued by Airport Operations or be escorted by a vehicle with a vehicle permit. This is required for all licensed vehicles operating within the airport security fence on the project, including but not limited to Contractor work truck, haul trucks (aggregate, concrete batch truck, etc.), paint trucks, etc. Machinery and equipment which does not have a license is not required to display a vehicle permit.

14) All Vehicles operating on the airport must have their head / tail lights turned on during darkness and low visibility conditions.

15) Each Contractor licensed vehicle must display a company logo on both sides of sufficient size to be recognizable to airport operations personnel. Signs must be a minimum of 200 square inches and be approved by the Airport. Specialized construction equipment does not require signs.

16) Each Contractor licensed vehicle must have a yellow/amber rotating beacon affixed to the uppermost part of the vehicle. Light must be visible from any direction, day and night, including the air. Specialized construction equipment does not require rotating beacon lights.

c. Radio Communications

i. **Two-way radios**. Contractors may utilize two-way radios on the project provided that they do not interfere with existing Airport and FAA communication equipment and frequencies.

ii. **Air Traffic Control (ATC) radio communication**. Vehicle operations on the movement area (non-radio exempt) require contact with ATC Ground Control. Ground Control directs all aircraft and vehicle movement on the airport movement area. Prior to entering any movement area Ground Control must be contacted via the ground frequency.

1) **Personnel required to communicate with ATC.** All communications with ATC Ground Control will be made by Airport Operations staff, unless directed otherwise by Airport Operations.

2) **Training.** The Contractor provided flaggers must receive Ground Vehicle Movement Area Driver Training. Flaggers without Ground Vehicle Movement Area Driver Training will not be allowed.

3) **Procedure for communicating**

a) **Radio types.** Contractor provided radio capable of monitoring airport ground frequency

b) **Light signals.** Not Applicable.

4) **Frequencies**

a) George Bush Intercontinental 122.95 MHZ

b) William P. Hobby Airport 122.95 MHZ

c) Ellington Airport 122.95 MHZ

d. Airport Security. The International Airport maintains an active security program, and as a commercial service airport security is of primary importance. The project will take place within the Airport's Security Identification Display Area (SIDA), which requires specific security protocol be followed. General project security requirements include the following. General project security requirements include the following.

i. The project plans show the entry point(s), barricades, Contractor's staging area, and work area. The Contractor shall provide security for these areas. The Contractor is to provide to the Airport, for review and approval, all security measures, barricades, and other means to be taken to secure scheduled openings between the secure and non-secure areas, prior to creating the opening. The Airport provides security oversight and patrols of the Airport, but the Contractor should not rely on the patrols to provide full-time security.

ii. No Contractor employee may tamper or interfere with, compromise, modify, attempt to circumvent, or cause a person tamper or interfere with, compromise, modify, or attempt to circumvent any security system, measure, or procedure implemented at the Airport.

iii. Each Contractor employee must immediately notify the Airport when security-related facilities and equipment within the Contractor's area are malfunctioning or are no longer adequate to perform the control function.

iv. No Contractor employee may enter, or be present within, a secured area, AOA, or Sterile Area without complying with the systems, measures, or procedures being applied to control access to, or presence, or movement in, such areas.

e. TSA Requirements. The Transportation Security Administration (TSA) through several Transportation Security Regulations (TSR) has the regulatory power to assess fines for breaches of airport security. The TSA will test the Contractors security means and methods for compliance with applicable security codes and regulations throughout the course of the project. Accordingly, if the Contractor is found culpable for security breaches, fines assessed to the Airport will be collected from the Contractor Security Badging Requirements

f. Security badging requirements. The Contractor will be required to obtain security badging in accordance with the following requirements.

i. Badge Responsibility. The General Contractor is directly responsible to the Airport for authorizing his/her employees and the employees of the sub-contractors access into the AOA. The General Contractor shall also account for photo-ID badges and controlled keys that are issued to his/her employees and the subs' employees. The Contractor shall collect all Airport photo-ID badges from his/her employees at the conclusion of the project and return them to the Airport. The General Contractor shall ensure that all photo-ID badges issued to his sub-contractors are returned to the Airport. If a photo-ID badge is not returned to the Airport within thirty (30) days after the need for such identification badge is no longer required, the deposit on the photo-ID badge will be considered forfeited and shall not be refunded. Airport photo-ID badge deposit for airport identification cards issued with access to areas controlled for security reasons is $100 (per card).

ii. Persons Required to be Badged. All Contractor employees who are working on the site and a daily basis within the airport perimeter fence must be badged. Only those employees making an occasional delivery, a one time visit to the project, or working outside of the perimeter fence (at batch plant site) may be escorted, otherwise all employees must go through the badging process outlined in the following paragraphs.

iii. Obtaining a Badge. No person may be issued any identification media that provides unescorted access to any SIDA unless the person has successfully completed training in accordance with a TSA approved curriculum, completed a criminal history background check, and an assessment from the TSA. This training for all holders of owner issued/approved identification badges is mandatory and will take approximately one hour and a half to complete.

Each Contractor employee designated to receive an Airport Photo-Identification Badge to allow unescorted access must accomplish a criminal history check by submitting to fingerprinting by the Airport Operations Department, accomplish an application form, attend a one hour to one and a half training session, and stand for a photo. The criminal history check determines if the individual has a criminal record. Persons convicted of felonies or other disqualifying crimes are not eligible for a badge. If the person does not have a criminal record, then he/she must submit to fingerprinting. At this time, the identity of the person must be verified by presenting two forms of identification, one of which must be a government form showing the person's photo. Persons must also submit to a Security Threat Assessment.

Persons should report to the Airport Operations Office for fingerprinting at least two weeks before the badge is needed in order to receive the verification in a timely manner. If the person has been denied unescorted access based on the fingerprinted criminal history check, he/she will be notified. If the person has been granted access, he/she will contact the Airport Operations Department for a training session appointment. The training and the badge making equipment are located at the Airport Administration Offices in the terminal building. For additional information or to view forms, please contact the Airport Public Safety Department, or visit this website: https://www.fly2houston.com/biz/resources/badging/

iv. **Limits of Access.** No Contractor employee may use or allow to be used airport-issued access medium or identification medium that authorizes the access, presence, or movement of persons or vehicles in SIDA's, or AOA's in any other manner than that for which it was issued by the authority based in several Transportation Security Regulations (TSR) or the Airport Security Program (ASP).

v. **Badge Type.** The International Airport provides several badge types based on the type and area that may be accessed by each individual person. For this project the Contractor will be issued GOLD airport identification badges with escort privileges.

Contractors may receive “Escort” privileges through prior written request of the Airport. If escorting privileges are given, a superintendent or foreman with a badge may escort a group of employees for the duration of the project within the project work area as defined in the phasing plans. An employee with escort privileges with a badge shall be present at all times during working hours.

vi. **Escorted Access.** Any individual requiring access on an infrequent basis to the project work area must be under the general observation and control of a Contractor employee who has in his possession a valid International Airport photo identification badge with escort privileges. A current badged personnel who does not have their badge at the time of access **CAN NOT** be escorted.

vii. **Badge Display.** Airport-issued identification badges will be displayed on outermost garment above the waist. Persons observed in the SIDA or AOA without proper credentials or without escort will immediately be arrested and charged with criminal trespass as specified under state statute

viii. **Challenge Policy.** Contractor is expected and required to challenge all individuals inside the airport perimeter fence, not displaying airport approved identification or who are acting suspicious. Challenging is a critical step in preventing unauthorized access and all airport personnel are expected to challenge all persons who do not display airport issued identification within the restricted areas of the Airport.

g. Maintenance of Secured Area of the Airport

The Contractor shall provide a guard with an escort badge to control the access into the AOA via the gates identified in the layout plan. Access will not be allowed at any other points beyond those detailed in the project layout plan. Gate guards are required at any time the Contractor is moving materials, equipment, or personnel through the airport perimeter security fence. Gate guards must be outfitted in a readily identifiable uniform and shall have a Contractor-provided cell phone to enable quick communication with the Airport Operations Department.

Guards must be a dedicated security employee who has attended gate guard training from the Airport. Gate guards must be outfitted in a readily identifiable uniform and shall have a Contractor-provided cell phone to enable quick communication with the Airport Operations Department.

If the Contractor fails to provide adequate security or barriers at the breech or other openings between the secure and non-secure areas, the Airport will mandate a guard to be provided with the cost charged against the Contractor or project may be shut down at the discretion of the Airport. The guard will remain until adequate security or barriers are provided or installed. The Contractor is to notify the Owner immediately if a breech in security accidentally occurs.

6. Wildlife Management

i. **Trash** Food scraps must be collected from construction personnel activity.

ii. **Standing Water** Any activity taking place that creates a standing body of water must be remedied immediately.

iii. **Tall Grass and Seeds** A monocultural stand of grass is being specified for all disturbed areas that are being returned to turf throughout the airfield. It will be the responsibility of the Contractor to establish and maintain a schedule that allows a maximum grass height of 10 inches within the construction work area.

iv. **Poorly Maintained Fencing and Gates** Periodic perimeter fence inspections are conducted by Operations Officers to ensure the fence is secured.

v. **Disruption of Existing Wildlife Habitat** Contractor personnel should immediately notify airport operations of a wildlife sighting.

7. Foreign Object Debris (FOD) Management

a. **Description of FOD** Foreign object debris at airports includes any object found in an inappropriate location that can damage aircraft, equipment, or airport personnel. On construction sites FOD typically is comprised of loose gravel, blowing sand, wire bristles from sweeper heads, food wrappers, material packaging. The presence of FOD on an airport’s air operations area (AOA) poses a significant threat to the safety of air travel. FOD has the potential to damage aircraft during critical phases of flight, which can lead to catastrophic loss of life and airframe, and at the very least increased maintenance and operating costs.

b. **Methods of FOD Control**

   i. **Training.** Contractor shall provide training to all employees working within the AOA on effective FOD management. Training shall include description and consequences of FOD, FOD awareness, and housekeeping procedures.

   ii. **Housekeeping.** Preventing FOD from occurring is the most effective form of FOD management. Contractor must monitor construction activities and proactively develop a plan to prevent FOD from occurring. Typical FOD prevention measures include the use of covered trash containers, covered loads, zero tolerance of littering, tying down items which may be easily wind blown, etc.

   iii. **Ground vehicle tire inspections.** Prior to crossing active airfield pavement the Contractor must perform a vehicle tire check for any loose rocks that may be in the tread. Tires covered in mud must be cleaned prior to crossing active pavement in order to prevent tracking of dirt.

   iv. **Pavement sweeps.** Prior to opening sections of pavement within a work area to aircraft traffic, the Contractor will be required to sweep the entire pavement surface (including shoulders). Metal bristled brooms are known to create FOD, and the Contractor will be required to clean all bristles from the pavement. Compressed air and vacuums can be used to clean pavement surfaces as well.

   v. **FOD Inspections.** Refer to Section 10 for FOD inspection requirements.

8. **Hazardous Material Management**

   a. Haz-Mat Procedures to be developed by the Contractor prior to the issuance of the notice-to-proceed including but not limited to:

      i. Fuel Storage Locations

      ii. Spill Procedures

      iii. MSDS

9. **Notification of Construction Activities**

   a. **List of Responsible Representatives.** Persons who have questions concerning policies, procedures, or requirements of the Airport Security Program, should contact Airport Manager. Persons who observe a security violation, suspicious act or any serious act that may endanger persons or property, should immediately contact Airport Manager.

      i. George Bush Intercontinental: Theodore Kitchens -281-230-3100

      ii. William P Hobby Airport: Liliana L. Rambo -713-845-7712

      iii. Ellington Airport: Arturo Machuca -713-847-4200

   b. **NOTAM's** Contractor shall coordinate with Airport Operations personnel for the issuance of all NOTAMs related to the project construction. Airport Operations and FAA shall generate and issue NOTAMs based on Contractor construction schedule and facility impacts.

   c. **Emergency Notification** Procedures In the case of a life-threatening situation, dial 911 and Airport Emergency or Airport Operations immediately thereafter. Airport Operations will coordinate any emergency response.

   d. **Coordination with ARFF** Weekly construction progress meetings will be held throughout the duration of the project and prior to commencement of phasing changes. During this time ARFF will be notified of any rerouting, blocking and restoration of emergency access routes.

   e. **Notification to the FAA** The contractor shall ensure, through the program manager, that all construction equipment is air spaced through the appropriate FAA regional or district office prior to using such equipment on site.

10. **Inspection Requirements**

   a. **FOD Inspection The Contractor shall keep the project site and vehicles clean, employing a "clean as you go" approach throughout the project.**

   b. **Contractor Inspection**

      i. Prior to opening work areas and pavement to aircraft operations the Contractor must coordinate with airport operations for inspection of work area. Pavements must be free of all dirt, sand, gravel, wire bristles or any other objects that could cause damage to aircraft engines. All soil areas must be free of dirt clods, ruts, or surface irregularities that could damage an aircraft should it leave the pavement.

ii. Daily inspections must be completed to assure all traffic control devices are in proper location and working order.

c. **Final Inspection** Coordinate with the FAA Airport Certification Safety Inspector (ACSI) prior to the completion of repair to determine if a final inspection will be necessary

11. Underground Utilities

a. Contractor shall be responsible for the location and identification of all existing utilities and pipelines in the construction area. Any damage to existing utilities or pipelines (on or off airport property) shall be the responsibility of the contractor. The contractor shall repair all utility/pipeline damaged by the contractor at no cost to the owner.

b. FAA cables will be located and marked by FAA prior to construction. Contractor is to notify program manager of required marking to protect cables during construction. Any cables damaged during construction will be replaced by contractor at no cost to the owner.

c. Contractor shall protect existing airport lighting systems and shall repair any damaged systems.

d. Any unplanned, unapproved or accidental shutdown or interruption of service to any lighting circuit or navigational aid requires immediate notification of the program manager by the contractor.

12. Penalties The following penalties will be administered by the Airport, FAA, and TSA as allowed per the requirements of the Construction Safety and Phasing Plan.

a. **Vehicle Operations.** Stiff penalties exist to punish those who violate airport driving regulations. Prosecution can be a fine, imprisonment, lease violation or impoundment of vehicle. Specific penalties include:

b. **Security Violations.** Individuals who violate Airport Security rules may be subject to prosecution. Penalties may be a fine, imprisonment, lease violation or impoundment of vehicle. The TSA can levy fines of up to $11,000 per security incident. In addition to the penalties prescribed in the Municipal Code, the Aviation Director may remove or eject from the airport premises any person who violates any rule or regulation prescribed in Chapter 22 of the Municipal Code, the Airport Board Regulations, or any order or instruction issued by the Aviation Director. Additionally, the Aviation Director may deny the use of the Airport and its facilities to any such person if the Director determines that such denial is necessary for the safety or orderly operation of the airport or for the good of the public.

c. **Authority and Legal Action.**

i. Any person, corporation, or other legal entity who violates or resists the enforcement of Chapter 22 (Vehicle Operations) of the Municipal Code or an Airport Board Regulation shall be guilty of a misdemeanor and shall be punished by a fine not exceeding $100.00, or by imprisonment not exceeding 30 days**.**

ii. In addition to or in the alternative, any person, corporation, or legal entity who violates or resists the enforcement of this chapter shall be guilty of a municipal infraction punishable by a civil penalty of $100.00 for the initial offense and $200.00 for each repeat offense. Each day that a municipal infraction occurs constitutes a separate offense.

iii. Seeking a civil penalty as authorized in this section does not preclude the city from seeking alternative relief, including an order for abatement or injunctive relief, from the court in the same action or as a separate action.

d. **FOD.** The airport has a zero tolerance approach to FOD, and the Contractor may be subject to fines from the Airport, FAA, or other agencies for failure to properly manage FOD during construction activities.

13. Airport Emergencies/Special Conditions Contractor shall monitor any weather conditions, aircraft emergencies, unexpected emergencies and other elements that may cause safety on the project to be jeopardized. Airport staff will immediately clear all construction personnel of all runways and approach areas upon monitoring a distress call. If an aircraft accident occurs, all construction personnel will immediately vacate the AOA until Airport Staff provide permission to resume access to the work area.

14. Visual Aids – Marking, Lighting, Signs, and Visual Aids

a. **General** Airport markings, lighting, signs, and visual NAVAIDs directing aircraft to closed areas of the airport will be covered, removed, or disabled during construction. All airport markings, lighting, signs, and visual NAVAIDs that are in operation must be clear from all obstructions. All temporary markings, signs, lights, or other visual aids must be secured in place to prevent prop wash, jet blast, wing vortices, or other wind currents.

b. Markings Runway closure “X”s will be placed outside of the runway ends along the extended runway centerline during all runway closures.

c. Lights / Signs. Centerline and edge light circuits to be turned off and temporary edge lighting circuit jumpers to be utilized during construction. Runway exit signs for closed taxiways to be covered during the project.

15. Marking and Signs for Access Routes All applicable signs to be installed at the RSA and the TOFA on the service roads.

16. Hazard Marking, Lighting and Signing Low profile barricades with flashing red lights to be used for all pavement closures. Cones shall be utilized to establish limits of construction haul routes and temporary staging of equipment. Barricade spacing may be varied (made smaller) to fit pavement widths but may not exceed 4 feet.

17. Protection of Runway and Taxiway Safety Areas

a. No material stockpile shall occur within an active Runway Object Free Area (ROFA) and Runway Safety Area (RSA).

b. No construction activities or material stockpile shall occur within an active Taxiway Safety Area (TSA).

c. No material stockpile shall occur within an active Taxiway Object Free Area (TOFA).

d. No construction activities or material stockpile shall penetrate the Runway Object Free Zone (ROFZ).

e. No construction activities or material stockpile shall penetrate the Runway approach/departure surface.

f. No open trenches will be permitted within an open RSA or TSA

g. The Contractor shall be aware of location where jet blast may be an issue and make the necessary adjustments.

h. The Contractor is to prepare lockout/tag out plan and communicate the procedures to all staff.

18. Other Limitations on Construction

a. Contractor may not use tall equipment (cranes, concrete pumps, etc.) unless a Form 7460–1, Notice of Proposed Construction or Alteration determination letter is issued for such equipment. This form states that the Contractor agrees to mark and/or light the structure in accordance with established marking & lighting standards as necessary.

b. The use of open flame welding or torches is prohibited unless fire safety precautions are provided and airport operator has approved their use.

c. The use of electrical blasting caps is prohibited on or within 1000 ft. of the airport property.

d. The use of flare pots is prohibited within the AOA.

e. On-Site burning and blasting is prohibited.

Construction Safety Plan (CSP) Checklist

14 CFR Part 139 Certificated Airports

Reference Advisory Circular 150/5370-2, *Operational Safety on Airports during Construction.*

All Applicable Items Must Be Included in Initial CSP Submittal

Project Description **Proposed Start/End Date:**	**Included**	**N/A**
SCOPE OF WORK:		
Clearly identify the scope of work to be performed per phase, including proposed location and duration of work.		
AIRPORT RESCUE AND FIRE FIGHTING (ARFF):		
Clear routes depicted from ARFF stations to active airport operations areas and safety areas, around construction areas.		
Provisions to notify ARFF personnel when working on water lines.		
Emergency access roads affected by construction.		
SECURITY:		
Identification of construction personnel and equipment.		
Security control on temporary gates and relocated fencing.		
GROUND VEHICLES:		
Ground vehicle driver's training program description.		
Contractors with unescorted access trained, or escorted, in accordance with ACM.		
Vehicle marking and color requirements.		
Penalty outlined for anyone involved in a vehicle deviation/runway incursion.		
Employee parking areas identified (off airfield).		
Construction vehicle parking restrictions noted.		
CONSTRUCTION AREAS:		
Clearly depict all haul routes, time frame for use.		
Barricade placement, description included.		
Entry points for vehicles depicted.		
Elevation of equipment operating on haul routes (only if not an existing road).		
Foreign Object Debris (FOD) removal for haul routes that cross movement areas.		
EXCAVATION / TRENCHES:		
Open excavations are identified to include distances from runway centerline, including duration. Will runway/taxiway be open with excavation present?		
Marking and lighting for excavation.		
Identify how the trenches will be covered and duration.		
RUNWAY SAFETY AREAS (RSA):		
Clearly identify RSAs for each proposed and existing runway affected.		
Clearly identify construction located within the RSA, including scope of project and timeframe. If RSA will be reduced for construction, this must be identified.		
RUNWAYS:		
If a threshold is temporarily relocated (partial closure) include:		
New Runway Length that will be available-		
Threshold coordinates of temporary threshold and elevation		
Description of new RSA equal to what existed prior to construction		
Description of Lighting, Marking and Signage that will be available-		
Distance Remaining signs, lighting color scheme		
Proper NOTAMS (partial closure)		
Status of NAVAID during temporary relocated threshold.		

Project Description Proposed Start/End Date:	Included	N/A
If a new permanent threshold is implemented (runway extension or shortening), ensure the following is completed prior to re-opening of the runway.		
Obstruction survey required in scope of project		
Part 139 inspection coordination		
New Marking and Lighting Plan		
New Runway Length, including threshold coordinates and elevations (FAA Form 7480-1)		
Applicable ACM revisions		
Specify if declared distances are implemented (TORA, TODA, ASDA, LDA)		
TAXIWAY SAFETY AREAS (TSA):		
Scope and timeframe for constructions activities affecting TSA.		
Specify the TSA dimensions for each existing and proposed taxiway affected.		
If working within the TSA, description of use and procedures during aircraft operations.		
MARKING AND LIGHTING:		
Lighting will be shielded to not effect the air traffic control tower or flight crews.		
Marking and lighting of construction equipment.		
Marking and lighting of construction areas.		
Marking and lighting of closed airfield pavement areas.		
Type of barricades, height and/or location, and light color.		
Lighted X’s location.		
EQUIPMENT / STOCKPILING:		
Cranes/Equipment, provide for each point:		
Location Coordinates		
Ground Elevation		
Height and Schedule		
Description of the Crane/Equipment		
Fence Line Placement depicts FAA cable and duct banks in the vicinity.		
Batch Plant/Material Sorting/Stockpile Area		
Location Coordinate		
Maximum Structure Height		
Duration (Permanent/Temporary)		
NAVAIDS:		
Location of all existing and proposed NAVAIDS should be depicted.		
Existing and proposed NAVAID critical areas should be depicted		
Shutdown and/or protection of airport electronic/visual aids		
Location of power & control lines for electronic/visual NAVAIDs and infrastructure.		
Provision for temporary utilities and/or immediate repairs.		
Work in NAVAID critical areas:		
Scope of Work		
Duration		

Project Description **Proposed Start/End Date:**	**Included**	**N/A**
WILDLIFE MANAGEMENT:		
Ensure provisions are incorporated into the plan to minimize wildlife attractants during construction.		
Construction plan must be in accordance with airports Wildlife Hazard Management Plan / Provisions (if applicable)		
Ensure procedures, fencing and/or gates are in place to prevent inadvertent entry of wildlife hazards.		
COMMUNICATION/NOTAMs:		
Proper NOTAMs issued describing current airport conditions, including cranes, construction areas, etc…		
Points of Contact identified for relevant Airport/FAA/Consultants personnel on-site during construction duration.		
14 CFR PART 139 COMPLIANCE:		
Provide adequate construction oversight to ensure Part 139 compliance.		
All construction areas must be inspected by airport management in accordance with Part 139 prior to re-opening to air carriers.		
REMARKS/COMMENTS: **ANY SIGN, MARKING, LIGHTING OR CONFIGURATION CHANGE WILL REQUIRE ACM CHANGES. SUBMIT TO ACSI FOR APPROVAL PRIOR TO PROJECT COMPLETION.**		

Appendix B – Example HAS Pavement Evaluation Scope of Work

APPENDIX B: Example HAS Pavement Evaluation Scope of Work

GENERAL SCOPE OF SERVICES FOR PAVEMENT EVALUATION

1. SUMMARY OF SCOPE

1.1. The Houston Airport System Department of Aviation (DOA) is undertaking a project to evaluate existing airfield pavement conditions. A component of the Pavement Management Program (PMP) is the Pavement Management System (PMS) computer program that will assist in evaluating and analyzing test data to make planning recommendations for rehabilitation and reconstruction of airfield pavement. The testing involves conducting on-site pavement condition surveys to determine the structural integrity and surface conditions. This includes collecting nondestructive testing (NDT) data, destructive testing data, and service performance test data.

1.2. The DOA has been maintaining a PMS in accordance with FAA Advisory Circular (AC) 150/5380-7B. The PMS currently consists of PCI evaluations and annual walks documenting distresses for annual repair contracts. It is the intent of the program to inspect all the pavements in a 3-year time frame and to perform testing every 3 to 5 years in order to update the PMS for planning pavement rehabilitation and reconstruction.

2. SCOPE REQUIREMENTS

2.1. Systems Inventory & Review

The Consultant shall perform a system inventory to review the existing pavement structure, age, and physical boundaries of the pavements. Existing records shall include hard copies of historical records, the MicroPAVER database, as-built drawings, and a GIS base map of the existing pavement slab layout and network definition. The Consultant will be expected to establish the naming protocol and GIS slab attributes for new or modified pavements not previously included in the pavement GIS. These slabs shall be incorporated into the GIS base map and the MicroPAVER databases.

2.2. Network Definition

This information is to be gathered during the systems inventory from the existing MicroPAVER database and ArcView GIS base maps. All network definition activities will be conducted in accordance with the procedures outlined in the FAA AC 150/5380-6C and ASTM Standard D5340. These documents describe levels of network definition: facility (branch), feature (section) and sample unit.

2.2.1. Facility (Branch). A facility (branch) is an area of pavement that serves a distinct function. The branches for IAH, HOU and EFD are the following.

Runways	Taxiways	Runway/Taxiway Exits			Ramps/Aprons

2.2.2. Feature (Section). Because of the disparity of characteristics that can occur across an entity as large as a facility, it is further subdivided into units called features (sections). A feature is identified as a portion of the pavement, which has uniform construction history, pavement structure, traffic patterns and condition throughout its entire area.

2.2.3. Sample Unit. Features are further divided into sample units for Pavement Condition Index (PCI) inspection purposes. A sample unit on a concrete pavement is 20 +/- 8 slabs and 5000 SY for asphaltic cement pavement. Each facility and feature will be identified on the GIS drawing by a facility and feature number. The sample units inspected during the PCI survey will be identified on the drawing. Prior to the field work, the sample units identified will be those selected using stratified random selection procedures outlined in ASTM Standard D5340. After the field work is completed, GIS drawings will be updated to show the random and additional sample units that were actually inspected.

2.3. Collection of Pavement Condition Data

The next task involves the evaluation of the surface conditions of the pavements. The PCI procedure is the standard used by the aviation industry to assess pavement condition. The procedure is described in FAA AC 150/5380-6C and ASTM Standard D5340.

The proposed inspection sampling rate for the runways and taxiways will be to sample all the sample units. The sampling rate for the exits, ramps and aprons are shown in the following table.

N	n
1 - 4	All
5 - 9	4
10 - 20	5
21 - 30	6
31 - 50	7
51 - 75	8
>75	10% but <31

Where N=total number of sample units in section
n=number of sample units to inspect

In addition to inspecting the sample units selected using the above table; any unique or isolated pavement situation will be identified as an additional sample unit and inspected, in accordance with FAA AC 150/5380-6C guidelines. Photographs and descriptions will be used to describe the situation in enough detail so that it can be taken into account during the data analysis.

During the field PCI inspections and testing procedures, the survey crew will take digital photos of the pavement conditions of sections at the airport. Digital photos will be integrated into the report.

2.4. Nondestructive and Destructive Testing

2.4.1. Heavy Weight Deflectometer

Limited Heavy Weight Deflectometer (HWD) testing will be performed at three of the four listed locations within each test slab. One location will be in the interior portion of the slab and the second location will be across a transverse joint. The third location will be across a transverse joint at the corner and the fourth location will be across a longitudinal joint. The slab stiffness, deflections and joint efficiencies will be plotted for each test point. The test shall be accomplished once during hot weather (July - August). Approximately 2,000 test points will be recorded over each airfield.

2.4.2. Profiler

Pavement smoothness testing shall be conducted on all runways. Longitudinal profiling will be performed in accordance with FAA AC 150/5380-9.

2.4.3. Coring and Laboratory Testing

Once the nondestructive testing and review of the visual surveys are underway, the Consultant shall meet with the DOA to select typical areas for destructive testing. The testing performed by the DOA testing firm will consist of coring 6-inch diameter cores the DOA testing firm 4-inch diameter cores. All core holes will need to be patched using a fast setting grout after the completion of the borings so that the pavement areas can be opened to traffic during the day. Split tensile testing can be performed on the 6-inch diameter cores in accordance with ASTM Standard C496.

Cores will be polished to evaluate the extent of horizontal cracking and to perform petrographic analysis on the samples to observe the Akali-Silica Reactivity (A5R).

2.4.4. Pavement Skid Resistance Testing

Pavement friction and grooving condition evaluations will be performed in accordance with FAA AC 150/5320-12C.

2.5. Database Update

The MicroPAVER database will be updated containing the survey data.

2.6. Data Analysis

After the database is established, the Consultant will use MicroPAVER and GIS along with Engineering judgement to conduct an analysis of the data. The analysis will include the identification of rehabilitation and reconstruction alternatives, timing and prioritization of these activities and the associated cost. The Consultant will also analyze the historical distress patterns, visual distress data, structural nondestructive and destructive testing data to confirm the rehabilitation and reconstruction.

2.7. Pavement Classification Number

Proponent shall determine and assign allowable gross weight and Pavement Classification Number (PCN) values for all runways and taxiways. FAA AC 150/5335-5C shall be used as guidance in completing this task. Proponent shall use the “Technical” evaluation method in determining the numerical PCN value for each particular pavement.

3. REFERENCES

Work will be performed using the following:

- AC 150-5320-6F, Airport Pavement Design and Evaluation
- AC 150/5370-11B, Use of Nondestructive Testing in the Evaluation of Airport Pavements
- AC 150/5335-5C, Standardized Method of Reporting Airport Pavement Strength -PCN
- AC 150/5380-7B, Airport Pavement Management System
- AC 150/5380-6C, Guidelines and Procedures for Maintenance of Airport Pavements
- AC 150-5380-9, Guidelines and Procedures for Measuring Airfield Pavement Roughness
- AASHTO Standard T294, Standard Method of Test for Resilient of Unbound Granular Base/Subbase Materials and Subgrade Soils
- ASTM Standard C496, Standard Test Method for Splitting Tensile Strength of Cylindrical Concrete Specimens
- ASTM Standard D5340, Standard Test Method for Airport Pavement Condition Index Surveys

Appendix C– Concrete Surfaced Airfields Paver^{TM} Distress Identification Manual

CONCRETE SURFACED AIRFIELDS

PAVER™ DISTRESS IDENTIFICATION MANUAL

DEVELOPED BY:

US ARMY CORPS OF ENGINEERS
ERDC-CERL

SPONSORED BY:

FOREWORD

Funding for this project was provided by the U.S. Air Force Civil Engineering Support Agency (AFCESA/CESC), Tyndall Air Force Base, Florida.

This manual contains definitions and measuring methods for determining the Pavement Condition Index of Concrete Surfaced Airfields. This UFC implements STANAG 7181 ED 1 RD 1, Standard Method For Airfield Pavement Condition Index (PCI) Surveys.

This manual was prepared by Dr. M. Y. Shahin, U. S. Army Engineering Research and Development Center- Construction Engineering Research Laboratory, Champaign, IL.

June 2009

REFERENCES

Kohn S.D. and Shahin, M.Y. (1984). Evaluation of the Pavement Condition Index for Use on Porous Friction Surfaces. Technical Report No. M-351, U.S. Army Construction Engineering Research Laboratory, Champaign, IL.

Shahin, M.Y., Darter, M.I., and Kohn, S.D. (1976-1977) Development of a Pavement Maintenance Management System, Vol. I-V. U.S. Air Force Engineering Services Center (AFESC), Tyndall AFB.

TABLE OF CONTENTS

OBJECTIVE AND SCOPE OF THIS MANUAL

This Manual contains distress definitions and measuring methods for concrete surfaced airfields. This information is used to determine the Pavement Condition Index (PCI).

FREQUENTLY OCCURRING PROBLEMS IN PAVEMENT DISTRESS IDENTIFICATION

Situation	Action	Remarks
1. Low severity scaling (i.e., crazing)	Count only if possible future scaling will occur within 2 to 3 years	
2. Joint seal damage	This is not counted on a slab-by-slab basis	A severity level based on the overall condition of the joint seal in the sample unit is assigned
3. Joint spall small enough to be filled during a joint seal repair	Do not record	
4. Medium or high severity intersecting crack (shattered slab)	No other distress should be counted	
5. Corner or joint spalling caused by "D" cracking	Only "D" cracking should be recorded	If spalls are caused by factors other than "D" cracking, record each factor separately
6. Crack repaired by a narrow patch (e.g. 100 to 250 millimeters wide)	Record only crack and not patch at appropriate severity level	
7. Original distress of patch more severe than patch itself	Original distress type should be recorded	If, for example, patch material present on scaled area of slab, only the scaling is counted
8. Hairline cracks that are only a few feet long and that do not extend across the entire slab	Should be rated as shrinkage cracks	

BLOWUP (61)*

Description

Blowups occur in hot weather, usually at a transverse crack or joint that is not wide enough to permit expansion by the concrete slabs. The insufficient width is usually caused by infiltration of incompressible materials into the joint space. When expansion cannot relieve enough pressure, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups can also occur at utility cuts and drainage inlets. This type of distress is almost always repaired immediately because of severe damage potential to aircraft. Blowups are included for reference when closed sections are being evaluated for reopening.

Severity Levels

L Buckling or shattering has not rendered the pavement inoperative, and only a slight amount of roughness exists.

M Buckling or shattering has not rendered the pavement inoperative, but a significant amount of roughness exists.

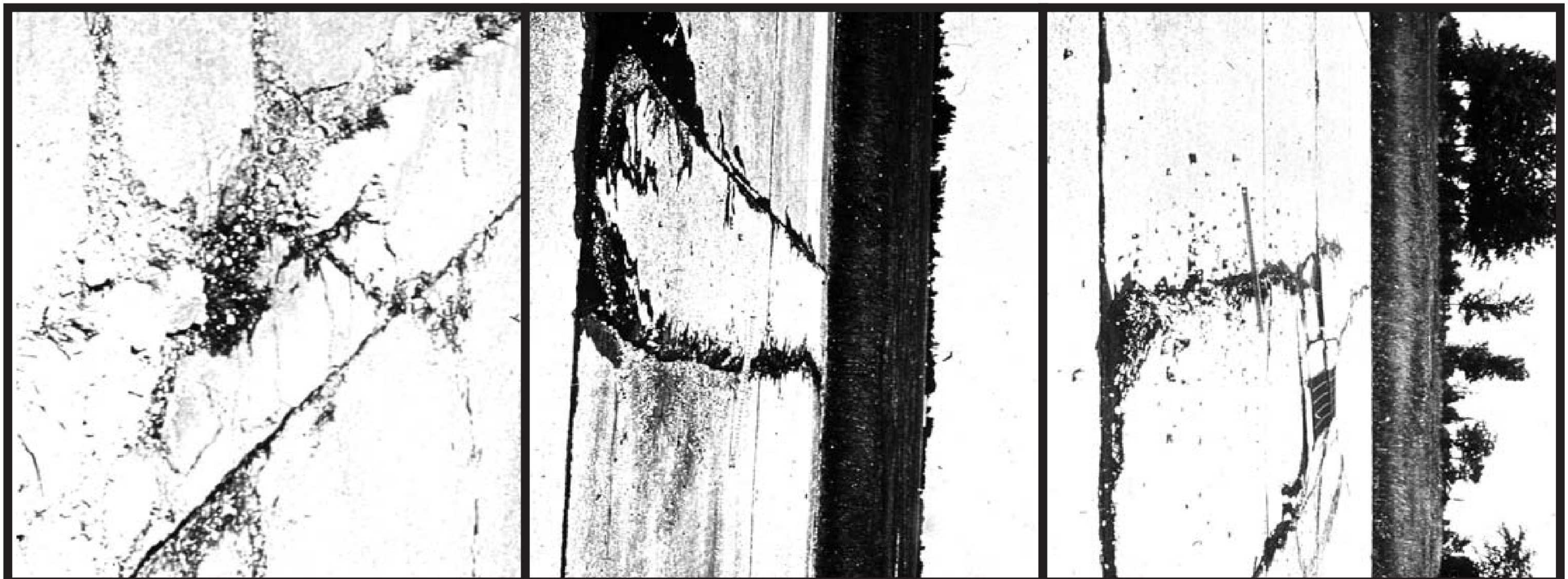
H Buckling or shattering has rendered the pavement inoperative.

(Note: For pavements to be considered operational, all foreign material from blowups must have been removed.)

How To Count

A blowup usually occurs at a transverse crack or joint. At a crack, it is counted as being in one slab, but at a joint, two slabs are affected and the distress should be recorded as occurring in two slabs.

**PAVER™ Distress Code*



HIGH | MEDIUM | LOW

61 BLOWUP

CORNER BREAK (62)

Description

A corner break is a crack that intersects the joints at a distance less than or equal to one-half the slab length on both sides, measured from the corner of the slab. For example, a slab with dimensions of 25 by 25 feet (7 1/2 by 7 1/2 meters) that has a crack intersecting the joint 5 feet (1 1/2 meters) from the corner on one side and 17 feet (5 meters) on the other side is not considered a corner break; it is a diagonal crack. However, a crack that intersects 7 feet (2 meters) on one side and 10 feet (3 meters) on the other is considered a corner break. A corner break differs from a corner spall in that the crack extends vertically through the entire slab thickness, while a corner spall intersects the joint at an angle. Load repetition combined with loss of support and curling stresses cause corner breaks.

Severity Levels

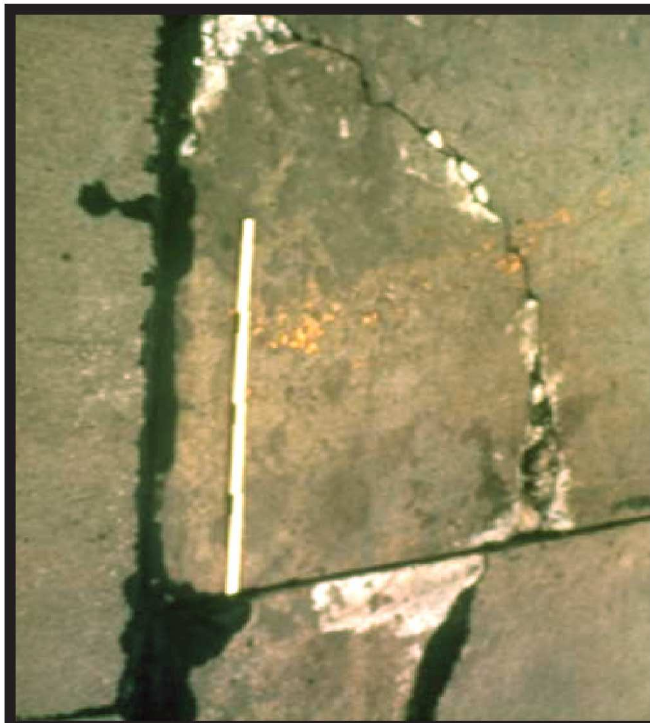
L Crack has either no spalling or minor spalling (no FOD potential). If non-filled, it has a mean width less than approximately 1/8 inch (3 mm); a filled crack can be of any width, but the filler material must be in satisfactory condition. The area between the corner break and the joints is not cracked.

M One of the following conditions exists: (1) filled or non-filled crack is moderately spalled (some FOD potential); (2) a non-filled crack has a mean width between 1/8 inch (3 mm) and 1 inch (25 mm); (3) a filled crack is not spalled or only lightly spalled, but the filler is in unsatisfactory condition; (4) the area between the corner break and the joints is lightly cracked. Lightly cracked means one low severity crack dividing the corner into two pieces.

H One of the following conditions exists: (1) filled or non-filled crack is severely spalled, causing definite FOD potential; (2) a non-filled crack has a mean width greater than approximately 1 inch (25 mm), creating a tire damage potential; or (3) the area between the corner break and the joints is severely cracked.

How To Count

A distressed slab is recorded as one slab if it (1) contains a single corner break, (2) contains more than one break of a particular severity, or (3) contains two or more breaks of different severities. For two or more breaks, the highest level of severity should be recorded. For example, a slab containing both light and medium severity corner breaks should be counted as one slab with a medium severity corner break. Crack widths should be measured between vertical walls, not in spalled areas of the crack. If the corner break is faulted 1/8 inch (3 mm) or more, increase severity to the next higher level. If the corner is faulted more than 1/2 inch (13 mm), rate the corner break at high severity. If faulting in corner is incidental to faulting in the slab, rate faulting separately. The angle of crack into the slab is usually not evident at low severity. Unless the crack angle can be determined, to differentiate between the corner break and corner spall, use the following criteria. If the crack intersects both joints more than 2 feet (600 mm) from the corner, it is a corner break. If it is less than 2 feet, unless you can verify the crack is vertical, call it a spall.



HIGH

MEDIUM

LOW

62 CORNER BREAK

CRACKS (LONGITUDINAL, TRANSVERSE, AND DIAGONAL) (63)

Description

These cracks, which divide the slab into two or three pieces, are usually caused by a combination of load repetition, curling stresses, and shrinkage stresses. (For slabs divided into four or more pieces, see Shattered Slab/ Intersecting Cracks.) Low severity cracks are usually warping or friction related and are not considered major structural distresses. Medium or high severity cracks are usually working cracks and are considered major structural distresses.

Hairline cracks that are only a few feet long and do not extend across the entire slab are rated as shrinkage cracks.

Non-reinforced PCC Severity Levels

L Crack has no spalling or minor spalling (no FOD potential). If non-filled, it is less than 1/8 inch (3 mm) wide. A filled crack can be of any width, but its filler material must be in satisfactory condition; or the slab is divided into three pieces by low severity cracks.

M One of the following conditions exists: (1) a filled or non-filled crack is moderately spalled (some FOD potential); (2) a non-filled crack has a mean width between 1/8 inch (3 mm) and 1 inch (25 mm); (3) a filled crack has no spalling or minor spalling, but the filler is in unsatisfactory condition; or (4) the slab is divided into three pieces by two or more cracks, one of which is at least medium severity.

H One of the following conditions exists: (1) a filled or non-filled crack is severely spalled (definite FOD potential); (2) a non-filled crack has a mean width approximately greater than 1 inch (25 mm), creating tire damage potential, or (3) the slab is divided into three pieces by two or more cracks, one of which is at least high severity.

How To Count

Once the severity has been identified, the distress is recorded as one slab. If a crack is repaired by a narrow patch (e.g., 4 to 10 inches wide (100 to 250 mm)), only the crack and not the patch should be recorded at the appropriate severity level.

Cracks used to define and rate corner breaks, “D” cracks, patches, shrinkage cracks, and spalls are not recorded as L/T/D cracks.



HIGH MEDIUM LOW

63 CRACKS

CRACKS (LONGITUDINAL, TRANSVERSE, AND DIAGONAL) (63) (CONTINUED)

Reinforced Concrete Severity Levels

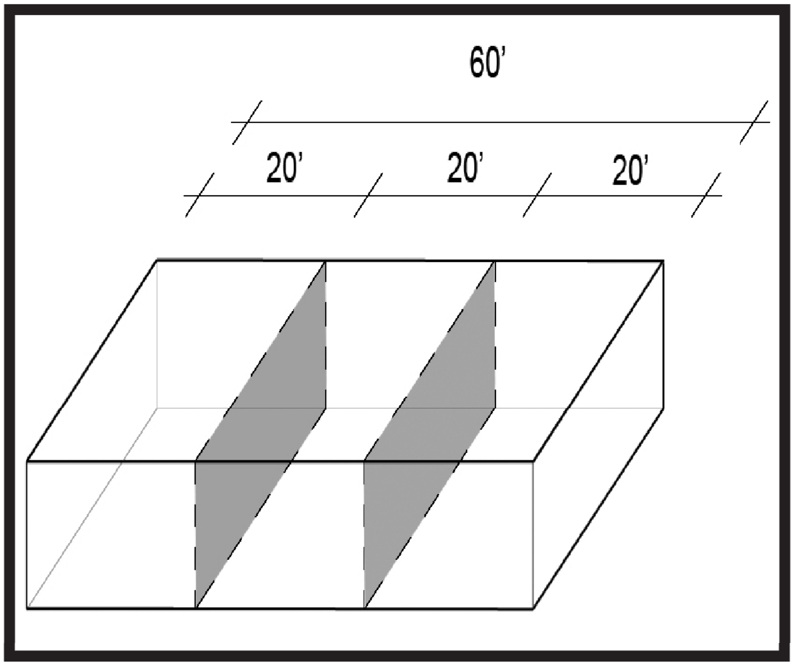
L (1) Non-filled crack, 1/8 inch (3 mm) to 1/2 inch (13 mm) wide, with no faulting or spalling; (2) filled or non-filled cracks of any width < 1/2 inch (13 mm), with low severity spalling; or (3) filled cracks of any width (filler satisfactory), with no faulting or spalling. (Note: Crack less than 1/8 inch (3 mm) wide with no spalling or faulting should be counted as shrinkage cracking.)

M (1) Non-filled cracks, 1/2 inch (13 mm) to 1 inch (25 mm) wide, no faulting or spalling; (2) filled cracks of any width, with faulting < 3/8 inch (10 mm) or medium severity spalling; or (3) non-filled cracks of width < 1 inch (25 mm) with faulting < 3/8 inch (10 mm) or medium severity spalling.

H (1) Non-filled cracks of width > 1 inch (25 mm); (2) non-filled cracks of any width, with faulting > 3/8 inch (10 mm) or medium severity spalling; or (3) filled cracks of any width, with faulting > 3/8 inch (10 mm) or high severity spalling.

How To Count

Once the severity has been identified, the distress is recorded as one slab. If a crack is repaired by a narrow patch (e.g., 4 to 10 inches wide (100 to 250 mm)), only the crack and not the patch should be recorded at the appropriate severity level. Slabs longer than 30 feet (9 meters) are divided into approximately equal length “slabs” having imaginary joints assumed to be in perfect condition.


60'
20'
20'
20'

DURABILITY ("D") CRACKING (64)

Description

Durability cracking is caused by the inability of the concrete to withstand environmental factors such as freeze-thaw cycles. It usually appears as a pattern of cracks running parallel to a joint or linear crack. A dark coloring can usually be seen around the fine durability cracks. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (0.3 to 0.6 meters) of the joint or crack.

Severity Levels

L "D" cracking is defined by hairline cracks occurring in a limited area of the slab, such as one or two corners along one joint. Little or no disintegration has occurred. No FOD potential.

M (1) "D" cracking has developed over a considerable amount of slab area with little or no disintegration or FOD potential; or (2) "D" cracking has occurred in a limited area of the slab, such as in one or two corners or along one joint, but pieces are missing and disintegration has occurred. Some FOD potential.

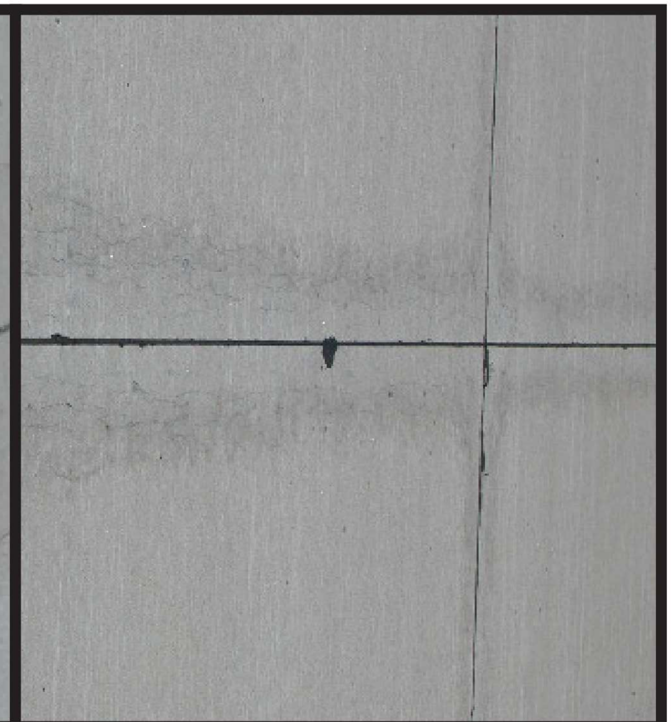
H "D" cracking has developed over a considerable amount of slab area with disintegration or FOD potential.

How To Count

When the distress is located and rated at one severity, it is counted as one slab. If more than one severity level is found, the slab is counted as having the higher severity distress. If "D" cracking is counted, scaling on the same slab should not be recorded.

HIGH

MEDIUM



LOW

64 DURABILITY

JOINT SEAL DAMAGE (65)

Description

Joint seal damage is any condition which enables soil or rocks to accumulate in the joints or allows significant infiltration of water. Accumulation of incompressible materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. A pliable joint filler bonded to the edges of the slabs protects the joints from accumulation of materials and also prevents water from seeping down and softening the foundation supporting the slab. Typical types of joint seal damage are (a) stripping of joint sealant, (b) extrusion of joint sealant, (c) weed growth, (d) hardening of the filler (oxidation), (e) loss of bond to the slab edges, and (f) lack or absence of sealant in the joint.

Severity Levels

L Joint sealer is in generally good condition throughout the sample. Sealant is performing well, with only a minor amount of any of the above types of damage present. Joint seal damage is at low severity if a few of the joints have sealer which has debonded from, but is still in contact with, the joint edge. This condition exists if a knife blade can be inserted between the sealer and joint face without resistance.

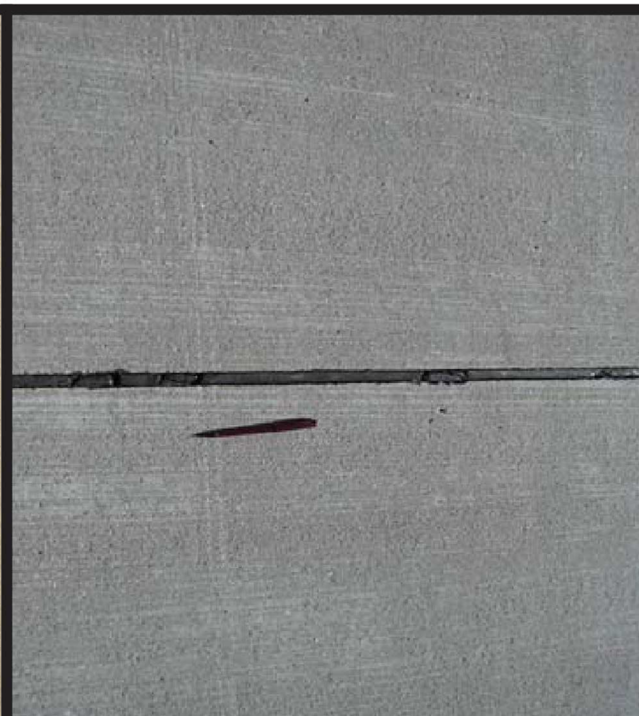
M Joint sealer is in generally fair condition over the entire surveyed section, with one or more of the above types of damage occurring to a moderate degree. Sealant needs replacement within 2 years. Joint seal damage is at medium severity if a few of the joints have any of the following conditions: (1) joint sealer is in place, but water access is possible through visible openings no more than 1/8 inch (3 mm) wide. If a knife blade cannot be inserted easily between sealer and joint face, this condition does not exist; (2) pumping debris are evident at the joint; (3) joint sealer is oxidized and 'lifeless' but pliable (like a rope), and generally fills the joint opening; or (4) vegetation in the joint is obvious, but does not obscure the joint opening.

H Joint sealer is in generally poor condition over the entire surveyed section, with one or more of the above types of damage occurring to a severe degree. Sealant needs immediate replacement. Joint seal damage is at high severity if 10% or more of the joint sealer exceeds limiting criteria listed above, or if 10% or more of sealer is missing.

How To Count

Joint seal damage is not counted on a slab-by-slab basis but is rated based on the overall condition of the sealant in the sample unit. Joint sealer is in satisfactory condition if it prevents entry of water into the joint, it has some elasticity, and if there is no vegetation growing between the sealer and joint face. Premolded sealer is rated using the same criteria as above except as follows: (1) premolded sealer must be elastic and must be firmly pressed against the joint walls; and (2) premolded sealer must be below the joint edge. If it extends above the surface, it can be caught by moving equipment such as snow plows or brooms and be pulled out of the joint. Premolded sealer is recorded at low severity if any part is visible above joint edge. It is at medium severity if 10% or more of the length is above joint edge or if any part is more than 1/2 inch (12 mm) above joint edge. It is at high severity if 20% or more is above joint edge or if any part is more than 1 inch (25 mm) above joint edge, or if 10% or more is missing. Rate joint sealer by joint segment. Sample unit rating is the same as the most severe rating held by at least 20% of segments rated. In rating oxidation, do not rate on appearance. Rate on resilience. Some joint sealer will have a very dull surface, and may even show surface cracks in the oxidized layer. If the sealer is performing satisfactorily and has good characteristics beneath the surface, it is satisfactory.

HIGH



MEDIUM

LOW

65 JOINT SEAL DAMAGE

PATCHING, SMALL (LESS THAN 5.5 FT^2 (0.5 M^2)) (66)

Description

A patch is an area where the original pavement has been removed and replaced by a filler material. For condition evaluation, patching is divided into two types: small (less than 5.5 square feet (0.5 square meters)) and large (over 5.5 square feet (0.5 square meters)). Large patches are described in the next section.

Severity Levels

L Patch is functioning well, with little or no deterioration.

M Patch has deteriorated, and/ or moderate spalling can be seen around the edges. Patch material can be dislodged, with considerable effort (minor FOD potential).

H Patch has deteriorated, either by spalling around the patch or cracking within the patch, to a state which warrants replacement.

How To Measure

If one or more small patches having the same severity level are located in a slab, it is counted as one slab containing that distress. If more than one severity level occurs, it is counted as one slab with the higher severity level being recorded. If a crack is repaired by a narrow patch (e.g., 4 to 10 inches (100 to 250 mm) wide), only the crack and not the patch should be recorded at the appropriate severity level. If the original distress of a patch is more severe than the patch itself, the original distress type should be recorded.

HIGH

MEDIUM

LOW

66 PATCHING, SMALL

PATCHING, LARGE (OVER 5.5 FT^2 (0.5 M^2)) AND UTILITY CUT (67)

Description

Patching is the same as defined in the previous section. A utility cut is a patch that has replaced the original pavement because of placement of underground utilities. The severity levels of a utility cut are the same as those for regular patching.

Severity Levels

L Patch is functioning well with very little or no deterioration.

M Patch has deteriorated and/ or moderate spalling can be seen around the edges. Patch material can be dislodged with considerable effort, causing some FOD potential.

H Patch has deteriorated to a state which causes considerable roughness and/ or high FOD potential. The extent of the deterioration warrants replacement of the patch.

How To Count

The criteria are the same as for small patches.

HIGH

MEDIUM

LOW

67 PATCHING, LARGE

POPOUTS (68)

Description

A popout is a small piece of pavement that breaks loose from the surface due to freeze-thaw action in combination with expansive aggregates. Popouts usually range from approximately 1 inch (25 mm) to 4 inches (100 mm) in diameter and from 1/2 inch (13 mm) to 2 inches (50 mm) deep.

Severity Levels

No degrees of severity are defined for popouts. However, popouts must be extensive before they are counted as a distress; i.e., average popout density must exceed approximately three popouts per square yard (square meter) over the entire slab area.

How To Count

The density of the distress must be measured. If there is any doubt about the average being greater than three popouts per square yard (square meter), at least three, random, 1 square yard (1 square meter) areas should be checked. When the average is greater than this density, the slab is counted.

68 POPOUTS

PUMPING (69)

Description

Pumping is the ejection of material by water through joints or cracks caused by deflection of the slab under passing loads. As the water is ejected, it carries particles of gravel, sand, clay, or silt and results in a progressive loss of pavement support. Surface staining and base or subgrade material on the pavement close to joints or cracks are evidence of pumping. Pumping near joints indicates poor joint sealer and loss of support which will lead to cracking under repeated loads. The joint seal must be identified as defective before pumping can be said to exist. Pumping can occur at cracks as well as joints.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that pumping exists.

How To Count

Slabs are counted as follows: one pumping joint between two slabs is counted as two slabs. However, if the remaining joints around the slab are also pumping, one slab is added per additional pumping joint.

69 PUMPING

SCALING (70)

Description

Surface deterioration caused by construction defects, material defects and environmental factors. Generally scaling is exhibited by delamination or disintegration of the slab surface to the depth of the defect.

Construction defects include: over-finishing, addition of water to the pavement surface during finishing, lack of curing, attempted surface repairs of fresh concrete with mortar. Generally this occurs over a portion of a slab.

Material defects include: inadequate air entrainment for the climate. Generally this occurs over several slabs that were affected by the concrete batches.

Environmental factors: freezing of concrete before adequate strength gained or thermal cycles from certain aircraft. Generally over a large area for freezing, and isolated areas for thermal effects.

Typically, the FOD from scaling is removed by sweeping, but the concrete will continue to scale until the affected depth is removed or expended.

Severity Levels

L Minimal loss of surface paste that poses no FOD hazard. No FOD potential.

M The loss of surface paste that poses some FOD potential including isolated fragments of loose mortar, exposure of the sides of coarse aggregate (less than 1/4 of the width of coarse aggregate), or evidence of coarse aggregate coming loose from the surface.

H The high severity is associated with low durability concrete that will continue to pose a high FOD hazard; normally the layer of surface mortar is observable at the perimeter of the scaled area, and is likely to continue to scale due to environmental or other factors. Indication of high severity FOD is that routine sweeping is not sufficient to avoid FOD issues.

How To Count

If two or more levels of severity exist on a slab, the slab is counted as one slab having the maximum level of severity. If “D” cracking or ASR is counted, scaling is not counted.

HIGH MEDIUM LOW

70 SCALING

SETTLEMENT OR FAULTING (71)

Description

Settlement or faulting is a difference of elevation at a joint or crack caused by upheaval or consolidation.

Severity Levels

Severity levels are defined by the difference in elevation across the fault and the associated decrease in ride quality and safety as severity increases.

Difference In Elevation

Severity	Runways/ Taxiways	Aprons
L	< 1/4 inch (< 6 mm)	1/8 – 1/2 inch (3 – 13 mm)
M	1/4 – 1/2 inch (6 – 13 mm)	1/2 - 1 inch (13 – 25 mm)
H	> 1/2 inch (> 13 mm)	> 1 inch (> 25 mm)

How To Count

In counting settlement, a fault between two slabs is counted as one slab. A straightedge or level should be used to aid in measuring the difference in elevation between the two slabs.

Construction-induced elevation differential is not rated in PCI procedures. Where construction differential exists, it can often be identified by the way the high side of the joint was rolled down by finishers (usually within 6 inches (150 mm) of the joint) to meet the low-slab elevation.

HIGH

MEDIUM

LOW

71 SETTLEMENT

SHATTERED SLAB/ INTERSECTING CRACKS (72)

Description

Intersecting cracks are cracks that break the slab into four or more pieces because of overloading and/ or inadequate support. The high severity level of this distress type, as defined below, is referred to as a shattered slab. If all pieces or cracks are contained within a corner break, the distress is categorized as a severe corner break.

Severity Levels

L Slab is broken into four or five pieces predominantly defined by low severity cracks.

M (1) Slab is broken into four or five pieces with over 15 percent of the cracks of medium severity (no high severity cracks); or (2) slab is broken into six or more pieces with over 85 percent of the cracks of low severity.

H At this level of severity, the slab is called shattered: (1) slab is broken into four or five pieces with some or all of the cracks of high severity; (2) slab is broken into six or more pieces with over 15 percent of the cracks of medium or high severity.

How To Count

No other distress such as scaling, spalling, or durability cracking should be recorded if the slab is medium or high severity level, since the severity of this distress would affect the slab's rating substantially. Shrinkage cracks should not be counted in determining whether or not the slab is broken into four or more pieces.

HIGH MEDIUM LOW

72 SHATTERED SLAB

SHRINKAGE CRACKS (73)

Description

Shrinkage cracks are hairline cracks that are usually only a few feet long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that shrinkage cracks exist.

How To Count

If one or more shrinkage cracks exist on one particular slab, the slab is counted as one slab with shrinkage cracks.

73 SHRINKAGE

SPALLING (TRANSVERSE AND LONGITUDINAL JOINTS) (74)

Description

Joint spalling is the breakdown of the slab edges within 2 feet (60 mm) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Spalling results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or traffic loads. Weak concrete at the joint (caused by overworking) combined with traffic loads also causes spalling.

Frayed condition as used in this test method indicates material is no longer in place along a joint or crack. Spalling indicates material may or may not be missing along a joint or crack.

Severity Levels

	Spall Length	Description
L	< 2 feet (600 mm)	spall is broken into pieces or fragmented; little FOD or tire damage potential exists.
	> 2 feet (600 mm)	(a) spall is broken into no more than three pieces defined by low or medium severity cracks; little or no FOD potential exists; or (b) joint is lightly frayed; little or no FOD potential exists.
M	< 2 feet (600 mm)	spall is broken into pieces or fragmented, with some of the pieces loose or absent, causing considerable FOD or tire damage potential.
	> 2 feet (600 mm)	(a) spall is broken into more than three pieces defined by light or medium cracks; (b) spall is broken into no more than three pieces with one or more of the cracks being severe with some FOD potential existing; or (c) joint is moderately frayed, with some FOD potential.
H	> 2 feet (600 mm)	(1) spall is broken into more than three pieces defined by one or more high severity cracks with high FOD potential; or (2) joint is severely frayed, with high FOD potential.

How To Count

If the joint spall is located along the edge of one slab, it is counted as one slab with joint spalling. If spalling is located on more than one edge of the same slab, the edge having the highest severity is counted and recorded as one slab. Joint spalling can also occur along the edges of two adjacent slabs. If this is the case, each slab is counted as having joint spalling. If a joint spall is small enough to be filled during a joint seal repair, it should not be recorded.

HIGH

MEDIUM

LOW

74 SPALLING, JOINT

SPALLING (CORNER) (75)

Description

Corner spalling is the raveling or breakdown of the slab within approximately 2 feet (600 mm) of the corner. A corner spall differs from the corner break in that the spall angles downward to intersect the joint, while a break extends vertically through the slab.

Severity Levels

L One of the following conditions exists: (1) spall is broken into one or two pieces defined by low severity cracks (little or no FOD potential), (2) spall is defined by one medium severity crack (little or no FOD potential).

M One of the following conditions exists: (1) spall is broken into two or more pieces defined by medium severity crack(s), and a few small fragments may be absent or loose; (2) spall is defined by one severe, fragmented crack that may be accompanied by a few hairline cracks; or (3) spall has deteriorated to the point where loose material is causing some FOD potential.

H One of the following conditions exists: (1) spall is broken into two or more pieces defined by high severity fragmented crack(s), with loose or absent fragments; (2) pieces of the spall have been displaced to the extent that a tire damage hazard exists; or (3) spall has deteriorated to the point where loose material is causing high FOD potential.

How To Count

If one or more corner spalls having the same severity level are located in a slab, the slab is counted as one slab with corner spalling. If more than one severity level occurs, it is counted as one slab having the higher severity level.

A corner spall smaller than 3 inches (76 mm) wide, measured from the edge of the slab and filled with sealant, is not recorded.

HIGH

MEDIUM

LOW

75 SPALLING, CORNER

ALKALI SILICA REACTION (ASR) (76)

Description

ASR is caused by chemical reaction between alkalis and certain reactive silica minerals which form a gel. The gel absorbs water, causing expansion which may damage the concrete and adjacent structures. Alkalis are most often introduced by the portland cement within the pavement. ASR cracking may be accelerated by chemical pavement deicers.

Visual indicators that ASR may be present include:

1. Cracking of the concrete pavement (often in a map pattern)
2. White, brown, gray or other colored gel or staining may be present at the crack surface
3. Aggregate popouts
4. Increase in concrete volume (expansion) that may result in distortion of adjacent or integral structures or physical elements. Examples of expansion include shoving of asphalt pavements, light can tilting, slab faulting, joint misalignment, and extrusion of joint seals or expansion joint fillers.

Because ASR is material-dependent, ASR is generally present throughout the pavement section. Coring and concrete petrographic analysis is the only definitive method to confirm the presence of ASR. The following should be kept in mind when identifying the presence of ASR through visual inspection:

1. Generally ASR distresses are not observed in the first few years after construction. In contrast, plastic shrinkage cracking can occur the day of construction and is apparent within the first year.
2. ASR is differentiated from D-Cracking by the presence of cracking perpendicular to the joint face. D-Cracking predominantly develops as a series of parallel cracks to joint faces and linear cracking within the slab.
3. ASR is differentiated from Map Cracking/ Scaling by the presence of visual signs of expansion.

Severity Levels

L Minimal to no Foreign Object Damage (FOD) potential from cracks, joints or ASR related popouts; cracks at the surface are tight (predominantly 1 mm or less). Little to no evidence of movement in pavement or surrounding structures or elements.

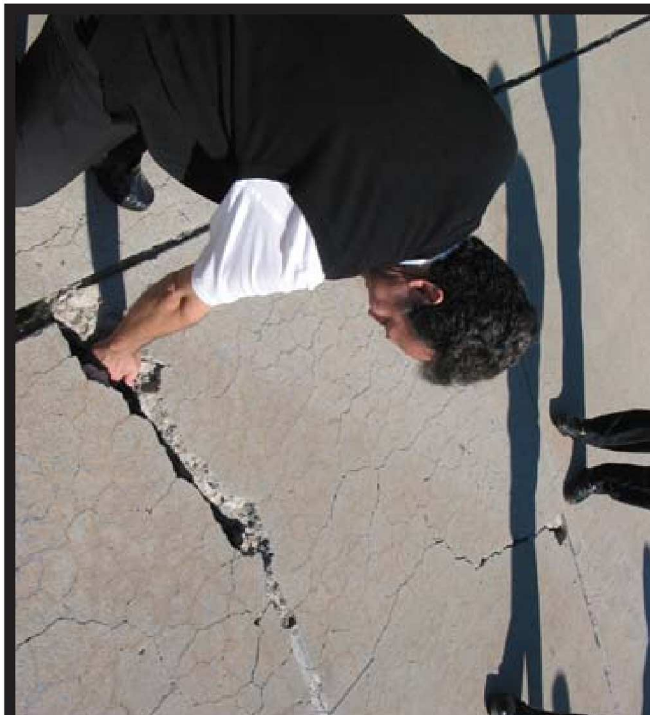
M Some FOD potential; increased sweeping or other FOD removal methods may be required. May be evidence of slab movement and/ or some damage to adjacent structures or elements.

Medium ASR distress is differentiated from low by having one or more of the following: increased FOD potential, increased cracking of the slab, some fragments along cracks or at crack intersections present, surface popouts of concrete may occur, pattern of wider cracks (predominantly 1 mm or wider) that may be subdivided by tighter cracks.

H One or both of the following exist: 1) Loose or missing concrete fragments which pose high FOD potential, 2) Slab surface integrity and function significantly degraded and pavement requires immediate repair; may also require repairs to adjacent structures or elements.

How To Count

No other distresses should be recorded if high severity ASR is recorded.



HIGH

MEDIUM

LOW

76 ASR

Appendix D– Asphalt Surfaced Airfields Paver™ Distress Identification Manual

ASPHALT SURFACED AIRFIELDS

PAVER™ DISTRESS IDENTIFICATION MANUAL

DEVELOPED BY:

US ARMY CORPS OF ENGINEERS
ERDC-CERL

SPONSORED BY:

FOREWORD

Funding for this project was provided by the U.S. Air Force Civil Engineering Support Agency (AFCESA/CESC), Tyndall Air Force Base, Florida.

This manual contains definitions and measuring methods for determining the Pavement Condition Index of Asphalt Surfaced Airfields. This UFC implements STANAG 7181 ED 1 RD 1, Standard Method For Airfield Pavement Condition Index (PCI) Surveys.

This manual was prepared by Dr. M. Y. Shahin, U. S. Army Engineering Research and Development Center - Construction Engineering Research Laboratory, Champaign, IL.

June 2009

REFERENCES

Shahin, M.Y., Darter, M.I., and Kohn, S.D. (1976-1977) Development of a Pavement Maintenance Management System, Vol. I-V. U.S. Air Force Engineering Services Center (AFESC), Tyndall AFB.

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OBJECTIVE AND SCOPE OF THIS MANUAL

This manual contains distress definitions and measurement methods for asphalt surfaced airfields. This information is used to determine the Pavement Condition Index (PCI).

FREQUENTLY OCCURRING PROBLEMS IN ASPHALT PAVEMENT DISTRESS IDENTIFICATION

Situation	Action	Remarks
1. Alligator cracking and rutting in same area	Record each separately at respective severity level	
2. Bleeding counted in area	Polished aggregate is not counted in same area	
3. Polished aggregate in very small amount	Do not count	Polished aggregate is only counted when there is a significant amount
4. Any distress (including cracking) in a patched area	Do not record	Effect of distress is considered in patch severity level
5. Block cracking is recorded	Neither longitudinal nor transverse cracking should be recorded	
6. Asphalt overlay over concrete	Block cracking and joint reflection cracking are recorded separately	AC over PCC could have, for example, 100 percent block cracking and 100 feet of joint reflection cracking

ALLIGATOR OR FATIGUE CRACKING (41)*

Description

Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt surface under repeated traffic loading. The cracking initiates at the bottom of the asphalt surface (or stabilized base) where tensile stress and strain is highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading, the cracks connect and form multi-sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are less than 2 feet (0.6 meters) on the longest side. Alligator cracking occurs only in areas that are subjected to repeated traffic loadings, such as wheel paths. Therefore, it would not occur over an entire area unless the entire area was subjected to traffic loading. (Pattern-type cracking, which occurs over an entire area that is not subject to loading, is rated as block cracking, which is not a load associated distress.) Alligator cracking is considered a major structural distress.

Severity Levels

L Fine, longitudinal hairline cracks running parallel to each other with no or only a few interconnecting cracks. The cracks are not spalled.

M Further development of light alligator cracking into a pattern or network of cracks that may be lightly spalled. Medium severity alligator cracking is defined by a well-defined pattern of interconnecting cracks, where all pieces are securely held in place (good aggregate interlock between pieces).

H Network or pattern cracking progressed so that pieces are well-defined and spalled at the edges; some of the pieces rock under traffic and may cause FOD potential.

How To Measure

Alligator cracking is measured in square feet (square meters) of surface area. The major difficulty in measuring this type of distress is that many times two or three levels of severity exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of severity cannot be easily divided, the entire area should be rated at the highest severity level present. If alligator cracking and rutting occur in the same area, each is recorded separately at its respective severity level.

**PAVER Distress Code*

H I G H | **M E D I U M** | **L O W**

41 ALLIGATOR

BLEEDING (42)

Description

Bleeding is a film of bituminous material on the pavement surface which creates a shiny, glass-like, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphalt cement or tars in the mix and/ or low air-void content. It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the surface of the pavement. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface.

Severity Levels

No degrees of severity are defined. Bleeding should be noted when it is extensive enough to cause a reduction in skid resistance.

How To Measure

Bleeding is measured in square feet (square meters) of surface area. If bleeding is counted, polished aggregate is not counted in the same area.

42 BLEEDING

BLOCK CRACKING (43)

Description

Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 foot to 10 by 10 feet (0.3 by 0.3 meters to 3 by 3 meters). Block cracking is caused mainly by shrinkage of the asphalt concrete (AC) and daily temperature cycling (which results in daily stress/ strain cycling). It is not load associated. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large proportion of pavement area but sometimes will occur in non-traffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, multi-sided pieces with sharp angles. Also, unlike block cracks, alligator cracks are caused by repeated traffic loadings and, therefore, are located only in traffic areas (i.e., wheel paths).

Severity Levels

L Blocks are defined by cracks that are non-spalled (sides of the crack are vertical) or only lightly spalled, causing no FOD potential. Non-filled cracks have 1/4 inch (6 mm) or less mean width, and filled cracks have filler in satisfactory condition.

M Blocks are defined by either: (1) Filled or non-filled cracks that are moderately spalled (some FOD potential); (2) Non-filled cracks that are not spalled or have only minor spalling (some FOD potential), but have a mean width greater than approximately 1/4 inch (6 mm); or (3) Filled cracks that are not spalled or have only minor spalling (some FOD potential), but have filler in unsatisfactory condition.

H Blocks are well-defined by cracks that are severely spalled, causing a definite FOD potential.

How To Measure

Block cracking is measured in square feet (square meters) of surface area. It usually occurs at one severity level in a given pavement section; however, any areas of the pavement section having distinctly different levels of severity should be measured and recorded separately. For asphalt pavements, not including AC over PCC, if block cracking is recorded, no longitudinal and transverse cracking should be recorded in the same area. For asphalt overlay over concrete, block cracking, joint reflection cracking, and longitudinal and transverse cracking reflected from old concrete should all be recorded separately.

HIGH

MEDIUM

LOW

43 BLOCK CRACKING

CORRUGATION (44)

Description

Corrugation is a series of closely spaced ridges and valleys (ripples) occurring at fairly regular intervals, usually less than 5 feet (1 1/2 meters) along the pavement. The ridges are perpendicular to the traffic direction. Traffic action combined with an unstable pavement surface or base usually causes this type of distress.

Severity Levels

L Corrugations are minor and do not significantly affect ride quality (see measurement criteria below).

M Corrugations are noticeable and significantly affect ride quality (see measurement criteria below).

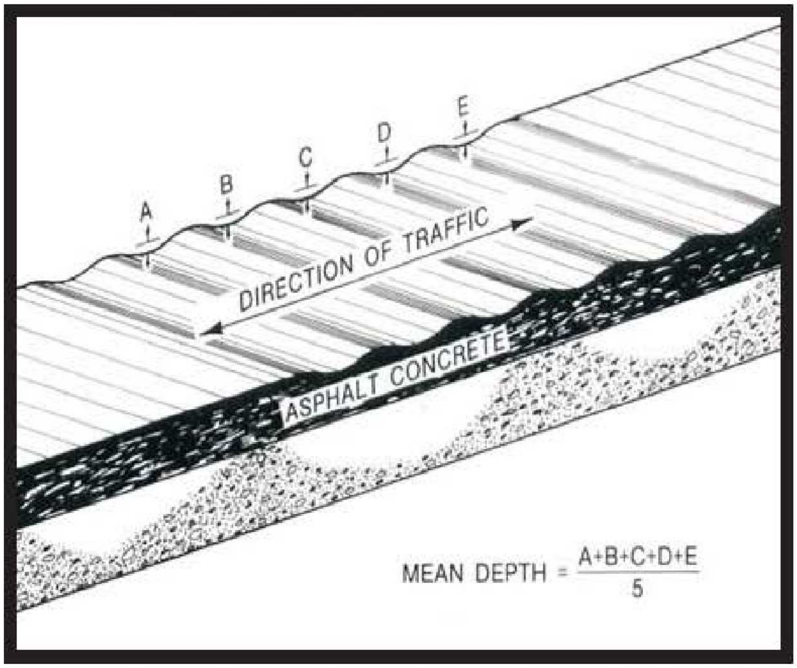
H Corrugations are easily noticed and severely affect ride quality (see measurement criteria below).

How To Measure

Corrugation is measured in square feet (square meters) of surface area. The mean elevation difference between the ridges and valleys of the corrugations indicates the level of severity. To determine the mean elevation difference, a 10 foot (3 meter) straightedge should be placed perpendicular to the corrugations so that the depth of the valleys can be measured in inches (mm). The mean depth is calculated from five such measurements.

Measurement Criteria

Severity	Runways & High-Speed Taxiways	Taxiways & Aprons
L	< 1/4 in. (< 6 mm)	< 1/2 in. (< 13 mm)
M	1/4 to 1/2 in. (6 to 13 mm)	1/2 to 1 in. (13 to 25 mm)
H	> 1/2 in. (> 13 mm)	> 1 in. (> 25 mm)


A
B
C
D
E
DIRECTION OF TRAFFIC
ASPHALT CONCRETE
MEAN DEPTH = $\frac{A+B+C+D+E}{5}$

DEPRESSION (45)

Description

Depressions are localized pavement surface areas having elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when ponding water creates "birdbath" areas; but the depressions can also be located without rain because of stains created by ponding water. Depressions can be caused by settlement of the foundation soil or can be "built up" during construction. Depressions cause roughness and, when filled with water of sufficient depth, can cause hydroplaning of aircraft.

Severity Levels

L Depression can be observed or located by stained areas, only slightly affects pavement riding quality, and may cause hydroplaning potential on runways (see measurement criteria below).

M The depression can be observed, moderately affects pavement riding quality, and causes hydroplaning potential on runways (see measurement criteria below).

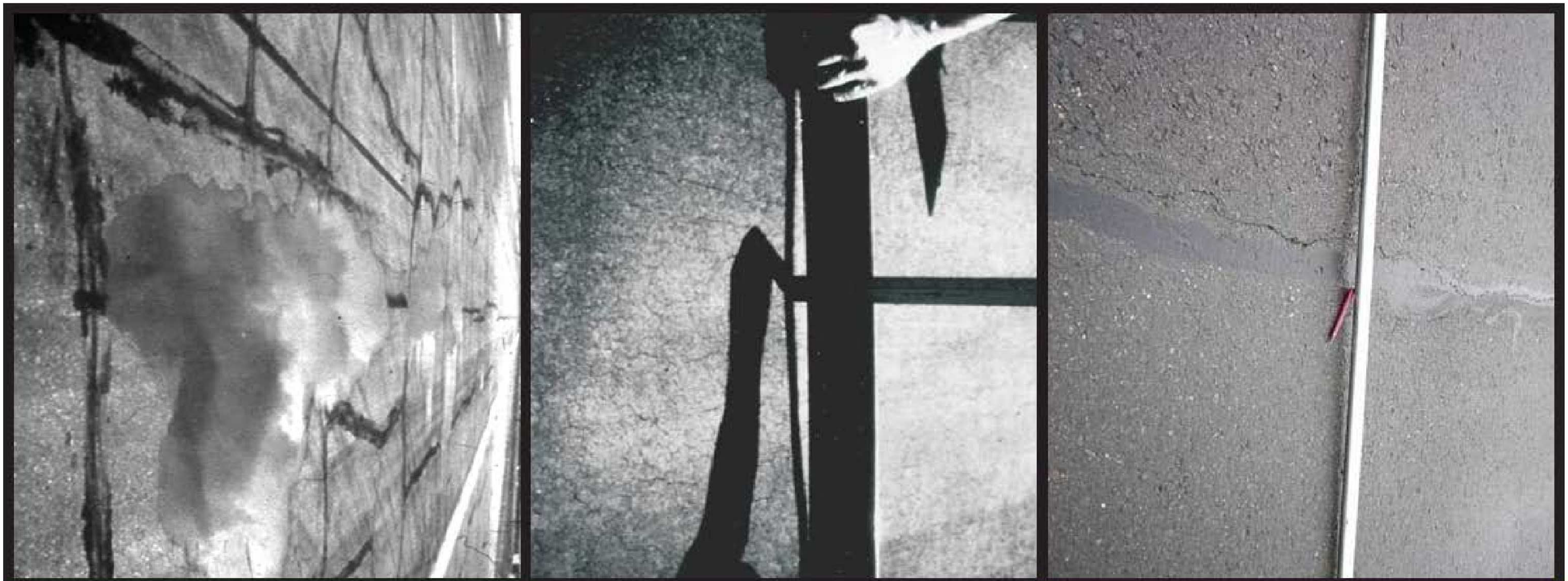
H The depression can be readily observed, severely affects pavement riding quality, and causes definite hydroplaning potential (see measurement criteria below).

How To Measure

Depressions are measured in square feet (square meters) of surface area. The maximum depth of the depression determines the level of severity. This depth can be measured by placing a 10 foot (3 meter) straightedge across the depressed area and measuring the maximum depth in inches (mm). Depressions larger than 10 feet (3 meters) across must be measured by either visual estimation or direct measurement when filled with water.

Maximum Depth of Depression

Severity	Runways & High-Speed Taxiways	Taxiways & Aprons
L	1/8 to 1/2 in. (3 to 13 mm)	1/2 to 1 in. (13 to 25 mm)
M	1/2 to 1 in. (13 to 25 mm)	1 to 2 in. (25 to 51 mm)
H	> 1 in. (> 25 mm)	> 2 in. (> 51 mm)



HIGH MEDIUM LOW

45 DEPRESSION

JET BLAST EROSION (46)

Description

Jet blast erosion causes darkened areas on the pavement surface when bituminous binder has been burned or carbonized; localized burned areas may vary in depth up to approximately 1/2 inch (13 mm).

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that jet blast erosion exists.

How To Measure

Jet blast erosion is measured in square feet (square meters) of surface area.

46 JET BLAST

JOINT REFLECTION CRACKING FROM PCC (47)

Description

This distress occurs only on pavements having an asphalt or tar surface over a PCC slab. This category does not include reflection cracking from any other type of base (i.e., cement stabilized, lime stabilized); such cracks are listed as longitudinal and transverse cracks. Joint reflection cracking is caused mainly by movement of the PCC slab beneath the AC surface because of thermal and moisture changes; it is not load related. However, traffic loading may cause a breakdown of the AC near the crack, resulting in spalling and FOD potential. If the pavement is fragmented along a crack, the crack is said to be spalled. A knowledge of slab dimensions beneath the AC surface will help to identify these cracks.

Severity Levels

L Cracks have only light spalling (little or no FOD potential) or no spalling and can be filled or non-filled. If non-filled, the cracks have a mean width of 1/4 inch (6 mm) or less. Filled cracks are of any width, but their filler material is in satisfactory condition.

M One of the following conditions exists: (1) cracks are moderately spalled (some FOD potential) and can be either filled or non-filled of any width; (2) filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition; (3) non-filled cracks are not spalled or are only lightly spalled, but the mean crack width is greater than 1/4 inch (6 mm); or (4) light random cracking exists near the crack or at the corner of intersecting cracks.

H Cracks are severely spalled (definite FOD potential) and can be either filled or non-filled of any width.

How To Measure

Joint reflection cracking is measured in linear feet (linear meters). The length and severity level of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion should be recorded separately. For example, a crack that is 50 feet (15 meters) long may have 10 feet (3 meters) of high severity, 20 feet (6 meters) of medium severity, and 20 feet (6 meters) of low severity; these would all be recorded separately. If the different levels of severity in a portion of a crack cannot be easily divided, that portion should be rated at the highest severity present.

HIGH

MEDIUM

LOW

47 JOINT REFLECTION

LONGITUDINAL AND TRANSVERSE CRACKING (48) (NON-PCC JOINT REFLECTIVE)

Description

Longitudinal cracks are parallel to the pavement's centerline or laydown direction. They may be caused by (1) a poorly constructed paving lane joint, (2) shrinkage of the AC surface due to low temperatures or hardening of the asphalt, or (3) a reflective crack caused by cracks beneath the surface course, including cracks in PCC slabs (but not at PCC joints). Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. They may be caused by items 2 or 3 above. These types of cracks are not usually load associated. If the pavement is fragmented along a crack, the crack is said to be spalled.

Severity Levels

L Cracks have either minor spalling (little or no FOD potential) or no spalling. The cracks can be filled or non-filled. Non-filled cracks have a mean width of 1/4 inch (6 mm) or less; filled cracks are of any width, but their filler material is in satisfactory condition.

M One of the following conditions exists: (1) Cracks are moderately spalled (some FOD potential) and can be either filled or non-filled of any width; (2) Filled cracks are not spalled or are only lightly spalled, but the filler is in unsatisfactory condition; (3) Non-filled cracks are not spalled or are only lightly spalled, but mean crack width is greater than 1/4 inch (6 mm); or (4) Lightly random cracking exists near the crack or at the corners of intersecting cracks.

H Cracks are severely spalled, causing definite FOD potential. They can be either filled or non-filled of any width.

How To Measure

Longitudinal and transverse cracks are measured in linear feet (linear meters). The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example, see joint reflection cracking. If block cracking is recorded, longitudinal and transverse cracking is not recorded in the same area.


HIGH


MEDIUM


LOW

48 LONG. CRACKING

LONGITUDINAL AND TRANSVERSE CRACKING (48) (NON-PCC JOINT REFLECTIVE) (CONTINUED)

Porous Friction Course Severity Levels

Note: These severity levels are in addition to the existing definitions.

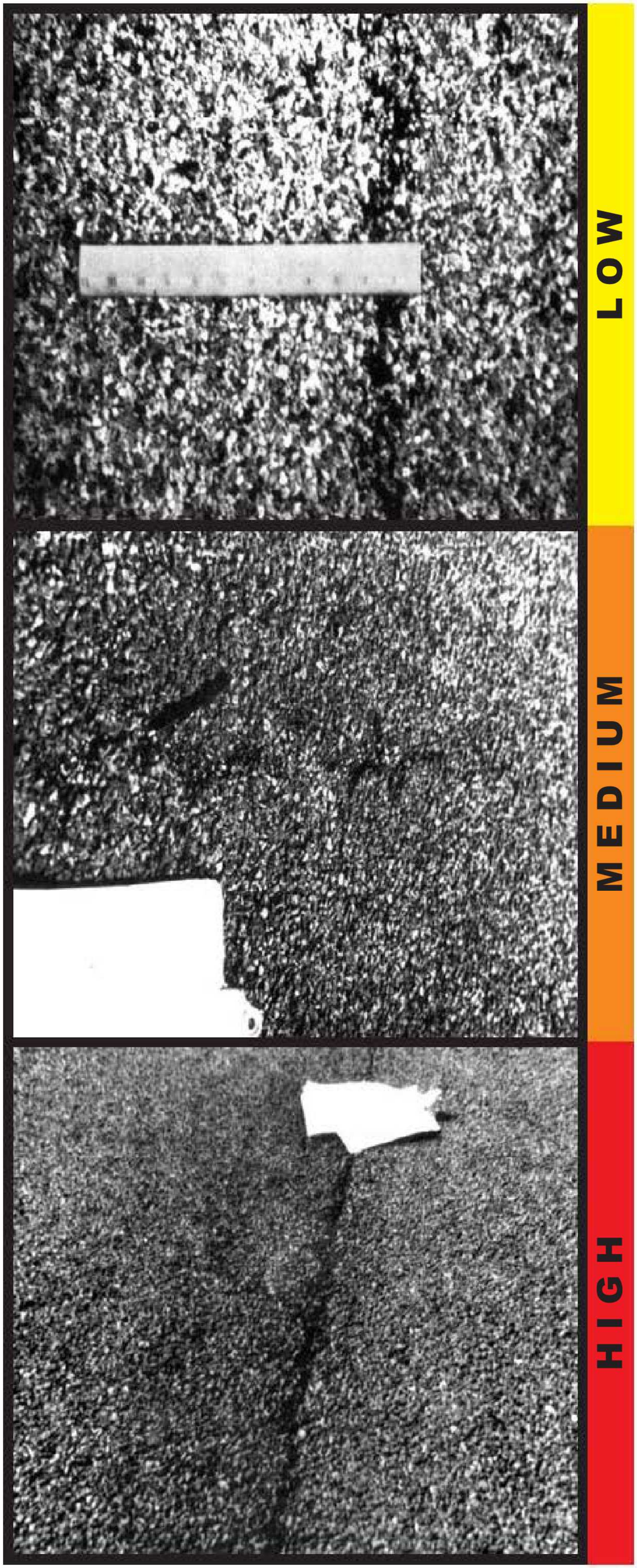
L Average raveled area around the crack is less than 1/4 inch (6 mm) wide.

M Average raveled area around the crack is 1/4 to 1 inch (6 to 25 mm) wide.

H Average raveled area around the crack is greater than 1 inch (25 mm) wide.

How To Measure

Longitudinal and transverse cracks are measured in linear feet (linear meters). The length and severity of each crack should be identified and recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately. For an example, see Joint Reflection Cracking. If Block Cracking is recorded, Longitudinal and Transverse Cracking is not recorded in the same area.


LOW
MEDIUM
HIGH

OIL SPILLAGE (49)

Description

Oil spillage is the deterioration or softening of the pavement surface caused by the spilling of oil, fuel, or other solvents.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that oil spillage exists.

How To Measure

Oil spillage is measured in square feet (square meters) of surface area. A stain is not a distress unless material has been lost or binder has been softened. If hardness is approximately the same as on surrounding pavement, and if no material has been lost, do not record as a distress.

49 OIL SPILLAGE

PATCHING AND UTILITY CUT PATCH (50)

Description

A patch is considered a defect, regardless of how well it is performing.

Severity Levels

L Patch is in good condition and is performing satisfactorily. Little or no FOD potential.

M Patch is somewhat deteriorated and affects riding quality to some extent. Some FOD potential.

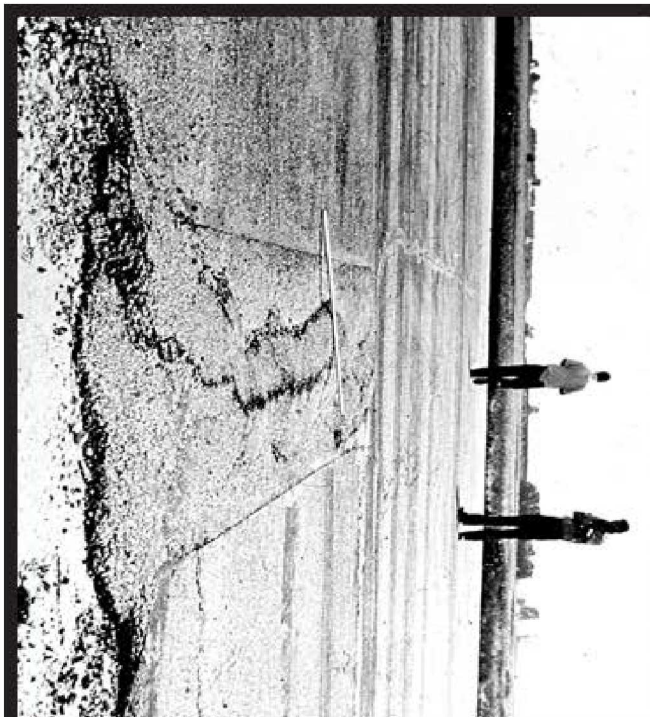
H Patch is badly deteriorated and affects riding quality significantly or has high FOD potential. Patch needs replacement.

The use of dense-graded AC patches in PCC surfaces causes a water damming effect at the patch that contributes to differential skid resistance of the surface. Low severity, dense-graded patches should be rated as medium severity because of the differential friction problem. Medium and high severity patches are rated the same as above.

How To Measure

Patching is measured in square feet (square meters) of surface area. However, if a single patch has areas of differing severity levels, these areas should be measured and recorded separately. For example, a 25 ft^2 (2 1/2 m^2) patch may have 10 ft^2 (1 m^2) medium severity and 15 ft^2 (1 1/2 m^2) of low severity. These areas would be recorded separately. Any distress found in a patched area will not be recorded; however, its effects on the patch will be considered when determining the patch's severity level.

A very large patch (area > 2500 ft^2 (230 m^2)), or feathered-edge pavement, may qualify as an additional sample unit or a separate section.



HIGH MEDIUM LOW

50 PATCHING

POLISHED AGGREGATE (51)

Description

Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when close examination of a pavement reveals that the portion of aggregate extending above the asphalt is either very small or there are no rough or angular aggregate particles to provide good skid resistance. Existence of this type of distress is also indicated when the number on a skid resistance rating test is low or has dropped significantly from previous ratings.

Severity Levels

No degrees of severity are defined. However, the degree of polishing should be significant before it is included in the condition survey and rated as a defect.

How To Measure

Polished aggregate is measured in square feet (square meters) of surface area. If bleeding is counted, polished aggregate is not counted in the same area.

51 POLISHED AGG.

RAVELING (52)

Description

Raveling is the dislodging of coarse aggregate particles from the pavement surface.

Dense Mix Severity Levels

As used herein, coarse aggregate refers to predominant coarse aggregate sizes of the asphalt mix. Aggregate clusters refer to when more than one adjoining coarse aggregate piece is missing. If in doubt about a severity level, three representative areas of 1 square yard (1 square meter) each should be examined and the number of missing coarse aggregate particles counted.

L Low severity occurs if any one of these conditions exist: (1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is between 5 and 20. (2) Missing aggregate clusters is less than 2 percent of the examined square yard (square meter) area. In low severity raveling, there is little or no FOD potential.

M Medium severity occurs if any one of these conditions exist: (1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is between 21 and 40. (2) Missing aggregate clusters is between 2 and 10 percent of the examined square yard (square meter) area. In medium severity raveling, there is some FOD potential.

H High severity occurs if any one of these conditions exist: (1) In a square yard (square meter) representative area, the number of coarse aggregate particles missing is over 40. (2) Missing aggregate clusters is more than 10 percent of the examined square yard (square meter) area. In high severity raveling, there is significant FOD potential.

How To Measure

Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.

HIGH MEDIUM LOW

52 RAVELING

RAVELING (52) (CONTINUED)

Slurry Seal/ Coal Tar Over Dense Mix Severity Levels

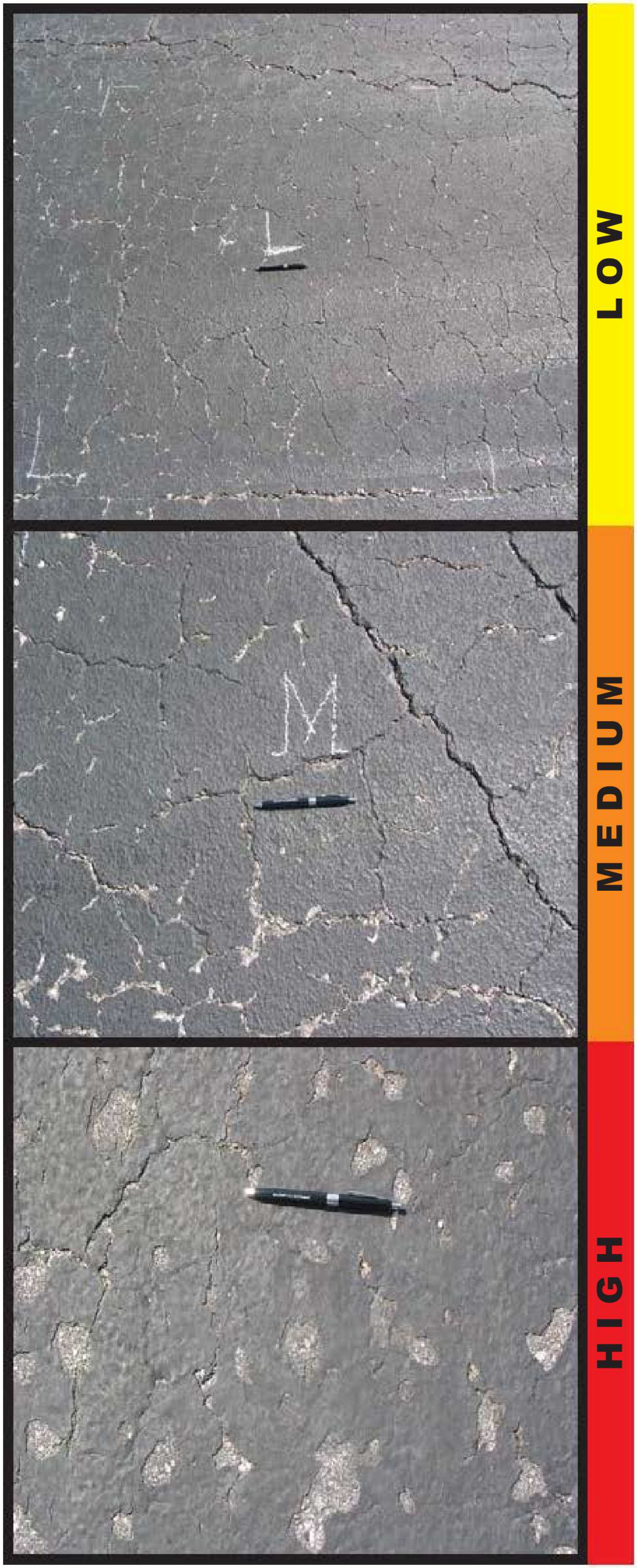
L (1) The scaled area is less than 1 percent. (2) In the case of coal tar where pattern cracking has developed, the surface cracks are less than 1/4 inch (6 mm) wide.

M (1) The scaled area is between 1 and 10 percent. (2) In the case of coal tar where pattern cracking has developed, the cracks are 1/4 inch (6 mm) wide or greater.

H (1) The scaled area is over 10 percent. (2) In the case of coal tar the surface is peeling off.

How To Measure

Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.


LOW
MEDIUM
HIGH

RAVELING (52) (CONTINUED)

Porous Friction Course Severity Levels

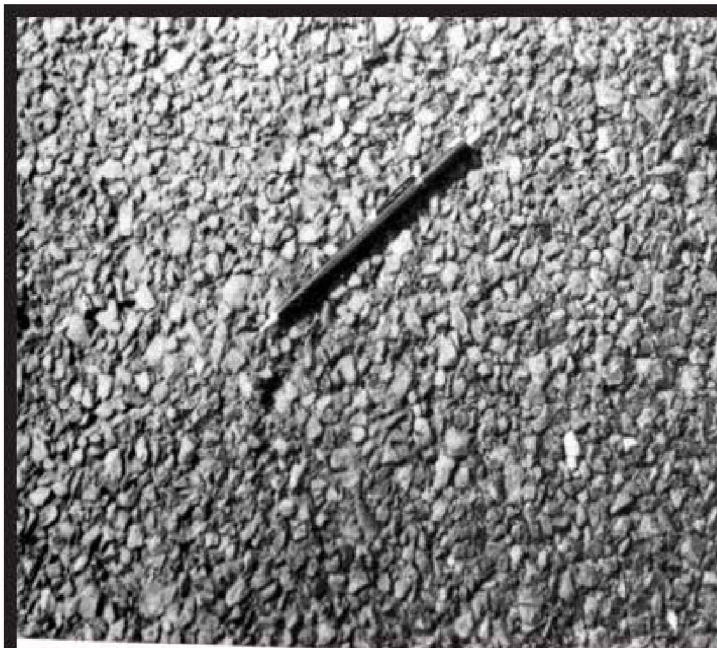
L In a 1 square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is between 5 and 20 and/ or the number of missing aggregate clusters does not exceed 1.

M In a 1 square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is between 21 and 40 and/ or the number of missing aggregate clusters is greater than 1 but does not exceed 25 percent of the area.

H In a 1 square foot (1/10 square meter) representative sample, the number of aggregate pieces missing is over 40 and/ or the number of missing aggregate clusters is greater than 25 percent of the area.

How To Measure

Raveling is measured in square feet (square meters) of surface area. Mechanical damage caused by hook drags, tire rims, or snowplows is counted as areas of high severity raveling.



LOW

MEDIUM

HIGH

RUTTING (53)

Description

A rut is a surface depression in the wheel path. Pavement uplift may occur along the sides of the rut; however, in many instances ruts are noticeable only after a rainfall, when the wheel paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrade. It is usually caused by consolidation or lateral movement of the materials due to traffic loads. Significant rutting can lead to major structural failure of the pavement.

Severity Levels

Mean Rut Depth Criteria

Severity	All Pavement Sections
L	1/4 to 1/2 in. (6 to 13 mm)
M	1/2 to 1 in. (13 to 25 mm)
H	> 1 in. (> 25 mm)

How To Measure

Rutting is measured in square feet (square meters) of surface area, and its severity is determined by the depth of the rut. To determine the rut depth, a straightedge should be laid across the rut and the depth measured. The mean depth in inches (mm) should be computed from measurements taken along the length of the rut. If alligator cracking and rutting occur in the same area, each is recorded at its respective severity level.

HIGH

MEDIUM

LOW

53 RUTTING

SHOVING OF ASPHALT PAVEMENT BY PCC SLABS (54)

Description

PCC pavements occasionally increase in length at ends where they adjoin flexible pavements (commonly referred to as “pavement growth”). This “growth” shoves the asphalt or tar surfaced pavements, causing them to swell and crack. The PCC slab “growth” is caused by a gradual opening of the joints as they are filled with incompressible materials that prevent them from reclosing.

Severity Levels

As a guide, the swell table below may be used to determine the severity levels of shoving. At the present time, no significant research has been conducted to quantify levels of severity of shoving.

Shoving Criteria

Severity	Height Differential
L	< 3/4 in. (< 19 mm)
M	3/4 in. to 1 1/2 in. (19 mm to 38 mm)
H	> 1 1/2 in. (> 38 mm)

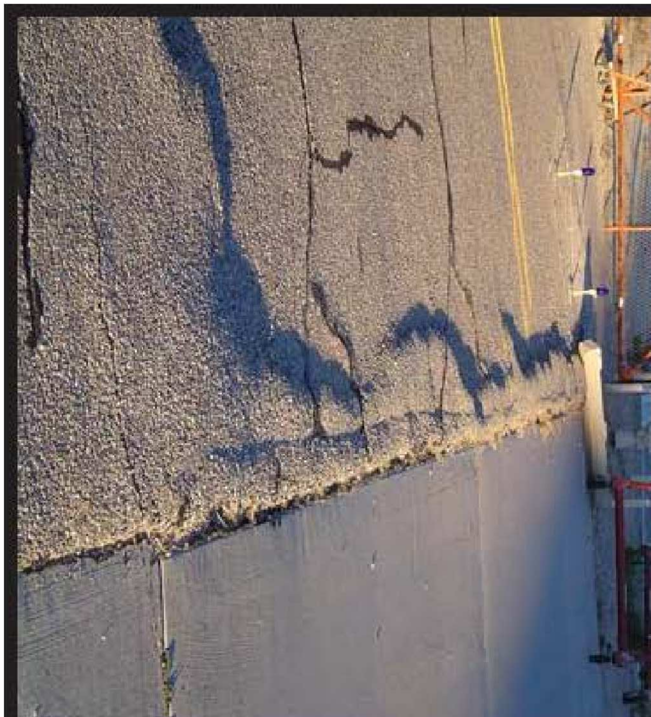
L A slight amount of shoving has occurred, with little effect on ride quality and no breakup of the asphalt pavement.

M A significant amount of shoving has occurred, causing moderate roughness or breakup of the asphalt pavement.

H A large amount of shoving has occurred, causing severe roughness or breakup of the asphalt pavement.

How To Measure

Shoving is measured by determining the area in square feet (square meters) of the swell caused by shoving.


HIGH


MEDIUM


LOW

54 SHOVING

SLIPPAGE CRACKING (55)

Description

Slippage cracks are crescent or half-moon shaped cracks having two ends pointed in the direction of traffic. They are produced when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low strength surface mix or poor bond between the surface and next layer of pavement structure.

Severity Levels

No degrees of severity are defined. It is sufficient to indicate that a slippage crack exists.

How To Measure

Slippage cracking is measured in square feet (square meters) of surface area.

55 SLIPPAGE

SWELL (56)

Description

A swell is characterized by an upward bulge in the pavement's surface. A swell may occur sharply over a small area or as a longer, gradual wave. Either type of swell can be accompanied by surface cracking. A swell is usually caused by frost action in the subgrade or by swelling soil, but a small swell can also occur on the surface of an asphalt overlay (over PCC) as a result of a blowup in the PCC slab.

Severity Levels

L Swell is barely visible and has a minor effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration. (Low severity swells may not always be observable, but their existence can be confirmed by driving a vehicle over the section at the normal aircraft speed. An upward acceleration will occur if the swell is present).

M Swell can be observed without difficulty and has a significant effect on the pavement's ride quality as determined at the normal aircraft speed for the pavement section under consideration.

H Swell can be readily observed and severely affects the pavement's ride quality at the normal aircraft speed for the pavement section under consideration.

How To Measure

The surface area of the swell is measured in square feet (square meters). The severity rating should consider the type of pavement section (i. e., runway, taxiway, or apron). For example, a swell of sufficient magnitude to cause considerable roughness on a runway at high speeds would be rated as more severe than the same swell located on the apron or taxiway where the normal aircraft operating speeds are much lower. The following guidance is provided for runways:

Swell Criteria

Severity	Height Differential
L	< 3/4 in. (< 19 mm)
M	3/4 to 1 1/2 in. (19 to 38 mm)
H	> 1 1/2 in. (> 38 mm)

56 SWELL

WEATHERING (SURFACE WEAR) - DENSE MIX ASPHALT (57)

Description

The wearing away of the asphalt binder and fine aggregate matrix from the pavement surface.

Severity Levels

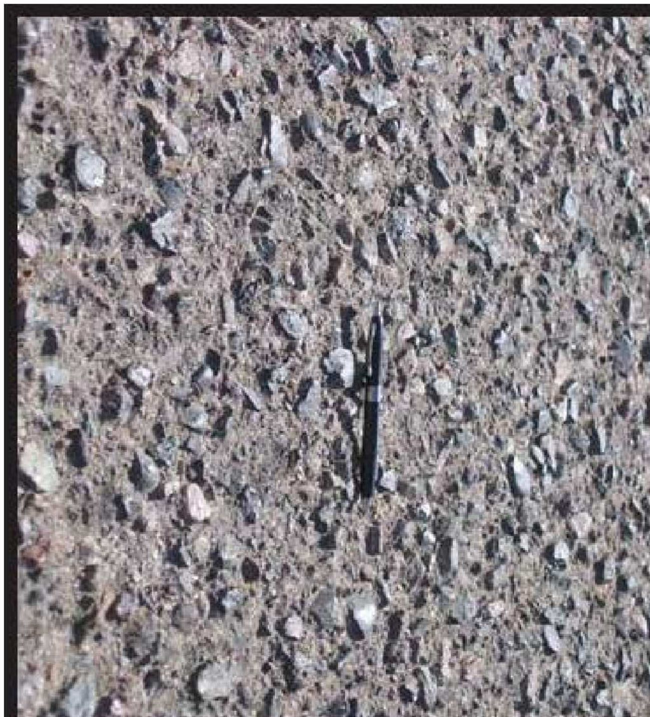
L Asphalt surface beginning to show signs of aging which may be accelerated by climatic conditions. Loss of the fine aggregate matrix is noticeable and may be accompanied by fading of the asphalt color. Edges of the coarse aggregates are beginning to be exposed (less than 0.05 inches or 1 mm). Pavement may be relatively new (as new as 6 months old).

M Loss of fine aggregate matrix is noticeable and edges of coarse aggregate have been exposed up to ¼ width (of the longest side) of the coarse aggregate due to the loss of fine aggregate matrix.

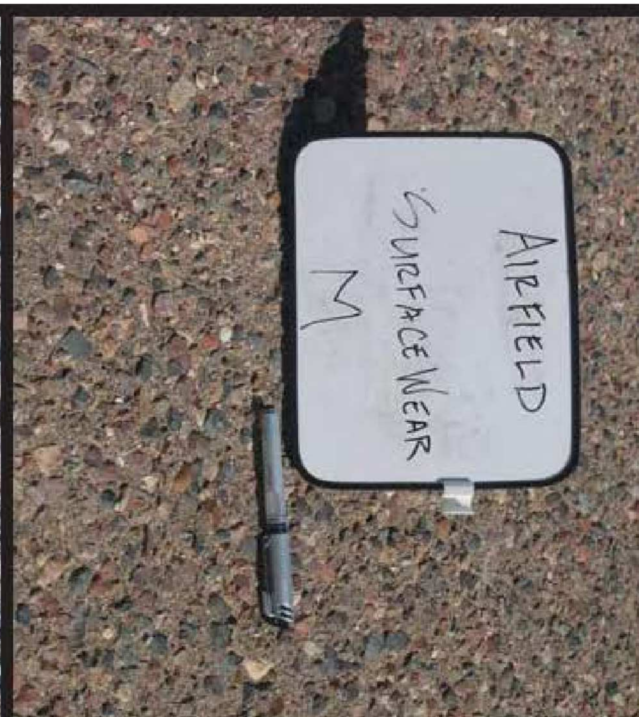
H Edges of coarse aggregate have been exposed greater than ¼ width (of the longest side) of the coarse aggregate. There is considerable loss of fine aggregate matrix leading to potential or some loss of coarse aggregate.

How To Measure

Surface wear is measured in square feet (square meters). Surface wear is not recorded if medium or high severity raveling is recorded.



HIGH



MEDIUM

LOW

57 WEATHERING

Appendix E– Pavement Inspection Checklist

APPENDIX E - Pavement Inspection Protocol Checklist

Day of Closure

	Call Airside Operations to confirm they received closure requests for that day. Request should've been sent the previous day

Required Items

Safety equipment

	Safety Glasses
	Gloves
	Ear Plugs
	Yellow vest

Evaluator 1

	Paint box(es), use two boxes for runways.
	Motorola City radio
	Camera
	City and personal cell phones
	Portable ground radio
	Use vehicle with ground radio
	Ruler with Inches

Evaluator 2

	Dowel Bar
	Paint wand

Evaluator 3

	Receiver
	Bracket
	Trimble Data Collector
	Cell phone
	Rod – In yellow bag
	Handheld ground radio

Arrival at Airport (approximately 2130)

	Check weather
	Check GPS survey equipment.
	Create new job on data collector: Files, New Job, <Type in name>.
	Call Airport Unit on Airside phone number to check in and let them know where working.
	Call Maintenance to check in and let them know working.
	Call Operations on City radio to check-in and advise of arrival time on site.

In Field

	Inspect mainline, then connectors.
	Mark phase boundaries on concrete periodically during inspections to denote areas that have been inspected.

Field Data Collection

On the Trimble Data Collector, use the button corresponding to the distress seen in the field. The data collector creates a text file (.CSV) in N, E, Elevation, Description format. The distress button writes the test in the description field.

Spalls	
	Number spalls on the southwest corner.
	Take photos of all spalls (Take photo from SW corner where possible)
	Survey is taken counterclockwise starting at the SW corner.
	Spall limits are established using dowel bar to sound concrete.
	The spall is evaluated to determine if it is high or medium severity.
	Limits of distress are painted on the pavement.
	One of the collected data point numbers is used as a spall ID.
	Spall ID number is to be painted on the SW corner.
	A photo taken of the spall (include ID number in photo)

Cracks and Joint Seal	
	Identify Crack End Points. (Cracks have just two points unless they take a sharp turn. For cracks that continue across multiple joints, Sidestep a few inches and stagger shots at joints. This allows for easier data reduction and identify the end points of the cracks.)
	Identify Joint Seal End Points. Joint seal has two points, but shoot new a point at joint intersections
	Inspect high speeds along joint lines. Begin on the wide side. Offset two joints lines for each consecutive pass.

Utility Spalls	
	Collect data at the four corners of the distress.
	For utility spalls at lights, and shots around the circumference of the light

Slab Replacements	
	Collect Data at the corners of the slab(s).

Post Inspection (Work to Preformed on the Same Day as Inspection)

	Set up new data folders for inspected areas (photos and distresses).
	Copy photos to proper directory and Clear camera (after ensuring photos are stored on drive).
	Copy .CSV file from data collector to raw data directory and inspection date-specific directory.
	Use notes for “Downloading Survey Data from the Trimble Data Collector”.
	Put away equipment and charge data collector, cell phone battery, and receiver battery
	E-mail Airside Operations to request next day’s areas.
	Update base map with areas inspected (Create new layer for each inspection date)
	Update actuals spreadsheet with areas inspected and time required.
	Forecast time required to complete next areas to be inspected.

Data Reduction

	Sort data by distress type.
	Import data into drawing.
	Connect points.
	Measure quantities.
	Update quantities spreadsheet

Distress Base Drawing

Import Raw Data	
	Raw data is imported from data collector into the distress base drawing.
	Raw linework is cleaned up relative to existing joints. Raw locations are offset 6 inches.
	Photos are used to assist with exact shape.

Clean Up Linework		
	Raw data is cleaned up to create rectangular patches.	
	The raw lines are offset 6 inches and trimmed to not cross adjacent joints unless specifically desired.	
	The cleaned up distresses are placed on separate layers.	
		Spall – High
		Spall - Medium
		Spall – Utility
		Crack
		Joint Seal
		Divot
		Expansion Joint
		Slab Replacement
	In some cases, the field data does not match the joints in the base map. Part of the cleanup process is to address these types of discrepancies	

Distress Drawings

The contractor uses drawings to create individual bar bending diagrams based on the dimensions of repair areas. They also use drawings and CAD files to plan their work.

	Plans showing all distresses are prepared for the contractor and separated into 4 different categories	
		Spalls
		Cracks
		Joint Seal
		Retrofit Conduit Trench Repairs

Distress Quantities Spreadsheet Notes

- Field quantities are developed from the Distress Base drawing. They are entered by facility into the Distress Quantities spreadsheet.
- This data rolls-up to the summary sheet tab. This sheet shows the total amount of each distress type by Runway or Taxiway
- If these values exceed what is assumed, decisions need to be made regarding what can be addressed during a given contract. Typically, the hierarchy to follow is to address anything found on runways, regardless of severity. High severity spalls will be included for taxiways. If funding permits, medium taxiway spalls are addressed.

Appendix F– FAA and TxDOT Design Specifications

Table of Contents

Part 2 – Earthwork

Item P-152 Excavation, Subgrade, and Embankment

DESCRIPTION

152-1.1 This item covers excavation, disposal, placement, and compaction of all materials within the limits of the work required to construct safety areas, runways, taxiways, aprons, and intermediate areas as well as other areas for drainage, building construction, parking, or other purposes in accordance with these specifications and in conformity to the dimensions and typical sections shown on the plans.

152-1.2 Classification. All material excavated shall be classified as defined below:

a. Unclassified excavation. Unclassified excavation shall consist of the excavation and disposal of all material, regardless of its nature which is not otherwise classified and paid for under one of the following items.

~~**152-1.3 Unsuitable excavation.** Any material containing vegetable or organic matter, such as muck, peat, organic silt, or sod shall be considered unsuitable for use in embankment construction. Material, suitable for topsoil may be used on the embankment slope when approved by the Engineer.~~

CONSTRUCTION METHODS

152-2.1 General. ~~Before beginning excavation, grading, and embankment operations in any area, the area shall be completely cleared and grubbed in accordance with Item P-151.~~

~~The suitability of material to be placed in embankments shall be subject to approval by the Engineer. All unsuitable material shall be disposed of in waste areas shown on the plans. All waste areas shall be graded to allow positive drainage of the area and of adjacent areas. The surface elevation of waste areas shall not extend above the surface elevation of adjacent usable areas of the airport, unless specified on the plans or approved by the Engineer.~~

When the Contractor's excavating operations encounter artifacts of historical or archaeological significance, the operations shall be temporarily discontinued and the Engineer notified per subsection 70-20. At the direction of the Engineer, the Contractor shall excavate the site in such a manner as to preserve the artifacts encountered and allow for their removal. Such excavation will be paid for as extra work.

Those areas outside of the limits of the pavement areas where the top layer of soil material has become compacted by hauling or other Contractor activities shall be scarified and disked to a depth of 4 inches (100 mm), to loosen and pulverize the soil.

If it is necessary to interrupt existing surface drainage, sewers or under-drainage, conduits, utilities, or similar underground structures, the Contractor shall be responsible for and shall take all necessary precautions to preserve them or provide temporary services. When such facilities are encountered, the Contractor shall notify the Engineer, who shall arrange for their removal if necessary. The Contractor, at his or her expense, shall satisfactorily repair or pay the cost of all damage to such facilities or structures that may result from any of the Contractor's operations during the period of the contract.

152-2.2 Excavation. No excavation shall be started until the work has been staked out by the Contractor and the Engineer has obtained from the Contractor, the survey notes of the elevations and measurements of the ground surface. ~~All areas to be excavated shall be stripped of vegetation and topsoil. Topsoil shall be stockpiled for future use in areas designated on the plans or by the Engineer. All suitable excavated material shall be used in the formation of embankment, subgrade, or other purposes shown on the plans.~~ All unsuitable material shall be disposed ~~of as shown on the plans.~~ off Site.

When the volume of the excavation exceeds that required to construct the embankments to the grades indicated, the excess shall be used to grade the areas of ultimate development or disposed as directed by the Engineer. When the volume of excavation is not sufficient for constructing the embankments to the grades indicated, the deficiency shall be obtained from borrow areas.

The grade shall be maintained so that the surface is well drained at all times. When necessary, temporary drains and drainage ditches shall be installed to intercept or divert surface water that may affect the work.

a. Selective grading. When selective grading is indicated on the plans, the more suitable material designated by the Engineer shall be used in constructing the embankment or in capping the pavement subgrade. If, at the time of excavation, it is not possible to place this material in its final location, it shall be stockpiled in approved areas so that it can be measured for payment as specified in paragraph 152-3.3.

b. Undercutting. Rock, shale, hardpan, loose rock, boulders, or other material unsatisfactory for safety areas, subgrades, roads, shoulders, or any areas intended for turf shall be excavated to a minimum depth of 12 inches (300 mm) below the subgrade or to the depth specified by the Engineer. Muck, peat, matted roots, or other yielding material, unsatisfactory for subgrade foundation, shall be removed to the depth specified. Unsuitable materials shall be disposed of off the airport. The cost is incidental to this item. ~~This excavated material shall be paid for at the contract unit price per cubic yard for **undercutting**. The excavated area shall be backfilled with suitable material obtained from the grading operations or borrow areas and compacted to specified densities. The necessary backfill will constitute a part of the embankment. Where rock cuts are made, backfill with select material. Any pockets created in the rock surface shall be drained in accordance with the details shown on the plans.~~

c. Overbreak. Overbreak, including slides, is that portion of any material displaced or loosened beyond the finished work as planned or authorized by the Engineer. All overbreak shall be graded or removed by the Contractor and disposed of as directed by the Engineer. The Engineer shall determine if the displacement of such material was unavoidable and his or her decision shall be final. Payment will not be made for the removal and disposal of overbreak that the Engineer determines as avoidable. Unavoidable overbreak will be classified as "Unclassified Excavation."

d. Removal of utilities. The removal of existing structures and utilities required to permit the orderly progress of work will be accomplished by someone other than the Contractor; for example, the utility unless otherwise shown on the plans. All existing foundations shall be excavated at least 2 feet (60 cm) below the top of subgrade or as indicated on the plans, and the material disposed of as directed by the Engineer. All foundations thus excavated shall be backfilled with suitable material and compacted as specified.

e. Compaction requirements. Compact the subgrade with roller until there is no evidence of further consolidation. Maintain a level layer to ensure uniform compaction. Recompact and refinish the subgrade at no additional expense if the required stability or finish is lost for any reason. Density requirements are waived for these repair locations.

~~**f. Proof rolling.** After compaction is completed, the subgrade area shall be proof rolled with a heavy pneumatic-tired roller having four or more tires abreast, each tire loaded to a minimum of 30,000 pounds and inflated to a minimum of 125 psi in the presence of the Engineer. Apply a minimum of **4** coverage, or as specified by the Engineer, to all paved areas. A coverage is defined as the application of one tire print over the designated area. Soft areas of subgrade that deflect more than 1 inch (25 mm) or show permanent~~

~~deformation greater than 1 inch (25 mm) shall be removed and replaced with suitable material or reworked to conform to the moisture content and compaction requirements in accordance with these specifications.~~

152-2.7 Finishing and protection of subgrade. After the subgrade is substantially complete, the Contractor shall remove any soft or other unstable material over the full width of the subgrade that will not compact properly. All low areas, holes or depressions in the subgrade shall be brought to grade with suitable select material. Scarifying, blading, rolling and other methods shall be performed to provide a thoroughly compacted subgrade shaped to the lines and grades shown on the plans.No subbase, base, or surface course shall be placed on the subgrade until the subgrade has been approved by the Engineer.

152-2.8 Haul. All hauling will be considered a necessary and incidental part of the work. The Contractor shall include the cost in the contract unit price for the pay of items of work involved. No payment will be made separately or directly for hauling on any part of the work.

METHOD OF MEASUREMENT

152-3.1 The quantity of excavation to be paid for shall be measured as a lump sum item. Measurement shall not include the quantity of materials excavated without authorization beyond normal slope lines, or the quantity of material used for purposes other than those directed.

~~**152-3.2** Borrow material shall be paid for on the basis of the number of cubic yards (cubic meters) measured in its original position at the borrow pit.~~

~~**152-3.3** Stockpiled material shall be paid for on the basis of the number of cubic yards (cubic meters) measured in the stockpiled position.~~

~~**152-3.4** For payment specified by the cubic yard, measurement for all excavation shall be computed by the average end area method. The end area is that bound by the original ground line established by field cross-sections and the final theoretical pay line established by excavation cross-sections shown on the plans, subject to verification by the Engineer. After completion of all excavation operations and prior to the placing of base or subbase material, the final excavation shall be verified by the Engineer by means of field cross-sections taken randomly at intervals not exceeding 500 linear feet (150 m).~~

~~**152-3.6** There shall be no separate measurement or payment for dewatering. All costs related to dewatering shall be considered incidental and shall be included in the contract unit price for other payment items.~~

~~**152-3.7** There shall be no separate measurement or payment for proof rolling. All costs related to proof rolling shall be considered incidental and shall be included in the contract unit price for other payment items.~~

BASIS OF PAYMENT

152-4.1 “Unclassified excavation” payment shall be made at the contract unit price per cubic yard (cubic meter). This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

152-4.2 “Undercutting” payment shall be made at the contract unit price per lump sum. This price shall be full compensation for furnishing all materials, labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-152.1	Unclassified Excavation - per lump sum
Item P-152.2	Undercutting - per cubic yard

TESTING REQUIREMENTS

ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2700 kN-m/m^3))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D6938	Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

END OF ITEM P-152

Item P-154 Subbase Course

DESCRIPTION

154-1.1 This item shall consist of a subbase course composed of granular materials constructed on a prepared subgrade or underlying course in accordance with these specifications, and in conformity with the dimensions and typical cross-section shown on the plans.

MATERIALS

154-2.1 Materials. The subbase material shall consist of hard durable particles or fragments of granular aggregates. This material will be mixed or blended with fine sand, clay, stone dust, or other similar binding or filler materials produced from approved sources. This mixture must be uniform and shall comply with the requirements of these specifications as to gradation, soil constants, and shall be capable of being compacted into a dense and stable subbase. The material shall be free from vegetative matter, lumps or excessive amounts of clay, and other objectionable or foreign substances. Pit-run material may be used, provided the material meets the gradation requirements specified.

Gradation Requirements

Sieve designation (square openings) as per ASTM C136 and ASTM D422	Percentage by weight passing sieves
3 inch (75 mm)	100
No. 10 (2.0 mm)	20-100
No. 40 (0.450 mm)	5-60
No. 200 (0.075 mm)	0-8

The portion of the material passing the No. 40 (0.450 mm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than six (6) when tested in accordance with ASTM D4318.

The material finer than 0.02 mm shall be limited to a maximum of 3% and the maximum allowable material passing the No. 200 sieve shall be reduced from 0-8% to 0-5%. Testing per ASTM D422 will be required for the percentage passing the 0.02 mm particle size once per lot.

154-2.2 Sampling and testing. Material used on the project shall be sampled per ASTM D75 and tested per ASTM C136 and ASTM C117. Results shall be furnished to the Engineer by the Contractor prior to the start of construction and once per day during construction.

CONSTRUCTION METHODS

154-3.1 General. The subbase course shall be placed where designated on the plans or as directed by the Engineer. The material shall be shaped and thoroughly compacted within the tolerances specified.

Granular subbases which, due to grain sizes or shapes, are not sufficiently stable to support the construction equipment without movement, shall be mechanically stabilized to the depth necessary to provide stability as directed by the Engineer. The mechanical stabilization shall include the addition of a fine-grained medium to bind the particles of the subbase material sufficiently to furnish a bearing strength, so the course will not deform under construction equipment traffic. The addition of the binding medium to the subbase material shall not increase the soil constants of that material above the specified limits.

154-3.2 Operation in pits. The subbase material shall be obtained from pits or sources that have been approved by the Engineer. The material in the pits shall be excavated and handled to produce a uniform and satisfactory product. All work involved in clearing and stripping pits and handling unsuitable material encountered shall be performed by the Contractor. The cost of this work is incidental to this item.

154-3.3 Preparing underlying course. Prior to constructing the subbase course, clean the underlying course or subgrade of all foreign substances. The surface of the underlying course or subgrade shall meet specified compaction and surface tolerances. Correct ruts, or soft yielding spots, in the underlying courses and subgrade areas having inadequate compaction and deviations of the surface from the specified requirements by loosening and removing soft or unsatisfactory material and by adding approved material, reshaping to line and grade, and recompacting to specified density requirements. For cohesionless underlying courses or subgrades containing sands or gravels, as defined in ASTM D2487, the surface shall be stabilized prior to placement of the overlying course. Accomplish stabilization by mixing the overlying course material into the underlying course, and compacting by approved methods. The stabilized material shall be considered as part of the underlying course and shall meet all requirements for the underlying course. The finished underlying course shall not be disturbed by traffic or other operations and shall be maintained in a satisfactory condition until the overlying course is placed. The course shall be checked and accepted by the Engineer before placing and spreading operations are started.

To protect the subgrade and to ensure proper drainage, the spreading of the subbase shall begin along the centerline of the pavement on a crowned section or on the high side of pavements with a one-way slope.

154-3.4 Materials acceptance in existing condition. When the entire subbase material is in a uniform and satisfactory condition at approximately the required moisture content, the approved material may be moved directly to the spreading equipment for placing. The material may be obtained from gravel pits, stockpiles, or may be produced from a crushing and screening plant with proper blending. The materials from these sources shall meet the requirements for gradation, quality, and consistency. The intent of the specifications is to secure materials that will not require further mixing. The moisture content of the material shall be approximately that required to obtain maximum density. Any minor deficiency or excess in moisture content may be corrected by surface sprinkling or by aeration. Some mixing or aeration may be required prior to rolling to obtain the required moisture content. Blading or dragging, if necessary, shall be performed to obtain a smooth uniform surface true to line and grade.

~~**154-3.5 Plant mixing.** When materials from several sources will be blended and mixed, the subbase material shall be processed in a central mixing plant. The subbase material, together with any blended material, shall be thoroughly mixed with the required amount of water. After the mixing is complete, the material shall be transported to and spread on the underlying course without undue loss of moisture content.~~

154-3.5.1 MIXED IN PLACE

When materials from different sources are to be proportioned and mixed or blended in place, the relative The subbase material shall be deposited and spread evenly to a uniform thickness and width. Then the binder, filler or other material shall be deposited and spread evenly over the first layer. There shall be as many layers of materials added as the Engineer may direct to obtain the required subbase mixture.

When the required amount of materials have been placed, they shall be thoroughly mixed and blended by means of graders, discs, harrows, rotary tillers, supplemented by other suitable equipment if necessary. The mixing shall continue until the mixture is uniformly blended. Areas of segregated material shall be corrected by the addition of binder or filler material and by thorough remixing. Water shall be uniformly applied prior to and during the mixing operations, if necessary, to maintain the material at its required moisture content. When the mixing and blending has been completed, the material shall be spread in a uniform layer which, when compacted, will meet the requirements of thickness and typical crosssection. proportions of the components of the mixture shall be as designated by the Engineer.

154-3.6 General methods for placing. The subbase course shall be constructed in layers of not less than inches (75 mm) nor more than 8 inches (200 mm) of compacted thickness. The subbase material shall be deposited and spread evenly to a uniform thickness and width. The material, as spread, shall be of uniform gradation with no pockets of fine or coarse materials. The subbase, unless otherwise permitted by the Engineer, shall not be spread more than 2,000 square yards (1700 sq m) in advance of the rolling. Any necessary sprinkling shall be kept within this limit. No material shall be placed in snow or on a soft, muddy, or frozen course.

When more than one layer is required, the construction procedure described here shall apply similarly to each layer.

During the placing and spreading, sufficient caution shall be exercised to prevent the incorporation of subgrade, shoulder, or foreign material in the subbase course mixture.

154-3.7 Finishing and compacting. After spreading or mixing, the subbase material shall be thoroughly compacted by rolling and sprinkling, when necessary. Sufficient rollers shall be furnished to adequately handle the rate of placing and spreading of the subbase course.

The field density of the compacted material shall be at least 100% of the maximum density of laboratory specimens prepared from samples of the subbase material delivered to the jobsite. The laboratory specimens shall be compacted and tested in accordance with ASTM D1557. The in-place field density shall be determined in accordance with ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. The moisture content of the material at the start of compaction shall be within ±2% of the optimum moisture content. All testing shall be done by the Contractor's laboratory in the presence of the Engineer, and density test results shall be furnished upon completion to the Engineer for acceptance determination.

The course shall not be rolled when the underlying course is soft or yielding or when the rolling causes undulation in the subbase. When the rolling develops irregularities that exceed 3/8 inch (9 mm) when tested with a 12 feet (3.7 m) straightedge, the irregular surface shall be loosened and then refilled with the same kind of material as that used in constructing the course and again rolled as required above.

Along places inaccessible to rollers, the subbase material shall be tamped thoroughly with mechanical or hand tampers.

Sprinkling during rolling, if necessary, shall be by equipment approved by the Engineer. Water shall not be added in manner or quantity that allows free water to reach the underlying layer and cause it to become soft.

154-3.8 Surface tolerance. The surface of the top layer shall show no deviations in excess of 3/8 inch (9 mm) when tested with a 12-foot (3.7-m) straightedge. Take measurements in successive positions parallel to the centerline of the area to be paved. Measurements shall also be taken perpendicular to the centerline at 50 foot intervals. Correct deviations exceeding this amount by removing material and replacing with new material, or by reworking existing material and compacting it to meet these specifications.

154-3.9 Thickness control. The completed thickness of the course(s) shall be in accordance with the thickness and grade indicated on the drawings. The completed course shall not be more than 1/2 inch (12 mm) deficient in thickness nor more than 1/2 inch (12 mm) above or below the established grade. Where any of these tolerances are exceeded, correct such areas by scarifying, adding new material of proper gradation or removing material, and compacting, as directed. Where the measured thickness is 1/2 inch (12 mm) or more thicker than shown, the course will be considered as conforming with the specified thickness requirements plus 1/2 inch (12 mm). The average job thickness shall be the average of the job measurements as specified above but within 1/4 inch (6 mm) of the thickness shown. The thickness of the completed subbase course shall be determined by the survey.

154-3.10 Protection. Work on subbase course shall not be conducted during freezing temperatures nor when the subgrade is wet. When the subbase material contains frozen material or when the underlying course is frozen, the construction shall be stopped. The Contractor shall protect and maintain the subgrade from yielding until the subbase is accepted.

154-3.11 Maintenance. The Contractor shall maintain the completed course in a satisfactory condition until accepted by the Engineer.

METHOD OF MEASUREMENT

154-4.1 Subbase course shall be measured by the number of square yards of subbase course material placed, compacted, and accepted in the completed course. The quantity of subbase course material shall be as measured in its final position.

BASIS OF PAYMENT

154-5.1 Payment shall be made at the contract unit price per square yard for subbase course. This price shall be full compensation for furnishing all materials; for all preparation, hauling, and placing of these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

TESTING REQUIREMENTS

ASTM C117	Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2,700 kN-m/m^3))
ASTM D2487	Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
ASTM D4253	Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4718	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

END OF ITEM P-154

Item P-155 Lime-Treated Subgrade

DESCRIPTION

155-1.1 This item shall be used for soil modification to achieve specific needs that require strength gain to a specific level. This item shall consist of constructing one or more courses of a mixture of soil, lime, and water in accordance with this specification, and in conformity with the lines, grades, thicknesses, and typical cross-sections shown on the plans.

MATERIALS

155-2.1 Lime. Quicklime and hydrated lime, either high-calcium dolomitic, or magnesium lime, as defined by ASTM C51, shall conform to the requirements of ASTM C977. Lime not produced from calcining limestone shall not be permitted.

155-2.2 Commercial lime slurry. Commercial lime slurry shall be a pumpable suspension of solids in water. The water or liquid portion of the slurry shall not contain dissolved material in sufficient quantity naturally injurious or objectionable for the purpose intended. The solids portion of the mixture, when considered on the basis of "solids content," shall consist principally of hydrated lime of a quality and fineness sufficient to meet the following requirements as to chemical composition and residue.

a. Chemical composition. The "solids content" of the lime slurry shall consist of a minimum of 70%, by weight, of calcium and magnesium oxides.

b. Residue. The percent by weight of residue retained in the "solids content" of lime slurry shall conform to the following requirements:

Residue retained on a No. 6 (3360 micron) sieve = maximum 0.0%

Residue retained on a No. 10 (2000 micron) sieve = maximum 1.0%

Residue retained on a No. 30 (590 micron) sieve = maximum 2.5%

c. Grade. Commercial lime slurry shall conform to one of the following two grades:

Grade 1. The "dry solids content" shall be at least 31% by weight, of the slurry.

Grade 2. The "dry solids content" shall be at least 35%, by weight, of the slurry.

155-2.3 Water. Water used for mixing or curing shall be potable, reasonably clean and free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product.

155-2.4 Soil. The soil for this work shall consist of inorganic natural materials on the site or selected materials from other sources; uniform in quality and gradation; and shall be approved by the Engineer. The soil shall be free of roots, sod, weeds, and stones larger than 2-1/2 inches (60 mm).

COMPOSITION

155-3.1 Soil-lime mixture. Ten days prior to the commencement of the work, the Contractor shall submit a soil-lime mixture, developed by the Contractor's laboratory, showing the amount of lime and water required per cubic yard (per cubic meter), and procedures for blending the lime/subgrade mixture for each type of existing soil. The soil-lime mixture shall include process type and number of: lime applications, stages of mixing, slurry injection depths, mixing depths, and depths of compaction lifts. Also, the Contractor shall submit a list of equipment to be used and their relation to method of mix proportioning, spreading, pulverizing and compacting subgrade, slurry injection, jet slurry mixing, and other related work. The soil-lime mixture shall also contain amount of lime, either in sacks or pounds per cubic yard (kg per cubic meter) and the amount of water to be used, if slurry method is used. Use the ASTM D3551 laboratory test method when applicable.

155-3.2 Tolerances. At final compaction, the lime and water content for each course of subgrade treatment shall conform to the following tolerances:

Material	**Tolerance**
Lime	+ 0.5%
Water	+ 2%, -0%

WEATHER LIMITATIONS

155-4.1 Weather limitation. Do not construct subgrade when weather conditions detrimentally affect the quality of the materials. Do not apply lime unless the air temperature is at least 40°F (4°C) and rising. Do not apply lime to soils that are frozen or contain frost. If the air temperature falls below 35°F (2°C), protect completed lime-treated areas by approved methods against the detrimental effects of freezing. Remove and replace any damaged portion of the completed soil-lime treated area with new soil-lime material in accordance with this specification.

EQUIPMENT

155-5.1 Equipment. The equipment required shall include all equipment necessary to complete this item such as: grading and scarifying equipment, a spreader for the lime or lime slurry, mixing or pulverizing equipment, sheepsfoot and pneumatic or vibrating rollers, sprinkling equipment, and trucks.

CONSTRUCTION METHODS

155-6.1 General. This specification is to construct a subgrade consisting of a uniform lime mixture which shall be free from loose or segregated areas. The subgrade shall be of uniform density and moisture content, well mixed for its full depth, and have a smooth surface suitable for placing subsequent courses. The Contractor shall be responsible to meet the above requirements.

Before beginning lime treatment, the subgrade shall be constructed as specified in Item P-152, Excavation, Subgrade and Embankment, and shaped to conform to the typical sections, lines, and grades as shown on the plans. If the Contractor elects to use a cutting and pulverizing machine that will remove the subgrade material accurately to the secondary grade and pulverize the material at the same time, he will not be required to expose the secondary grade nor windrow the material. The machine must give visible indication at all times that it is cutting the material uniformly to the proper depth over the entire width of the cut.

If a cutting and pulverizing machine is not used, the material to be treated shall be excavated to the secondary grade (proposed bottom of lime treatment) and removed or windrowed to expose the secondary grade. The excavated material shall then be spread to the desired cross-section and uniformly mixed and compacted.

155-6.2 Application. Lime shall be spread only over an area where the initial mixing operations can be completed during the same work day. The application and mixing of lime with the soil shall be accomplished by the methods described as “Dry Placing” or “Slurry Placing.” The Contractor may use either method when hydrated lime is specified.

a. Dry placing. The lime shall be spread uniformly over the subgrade by an approved screw-type spreader box or other approved spreading equipment. The amount of lime spread shall be the amount required for mixing to the specified depth that will result in the amount determined in the soil-lime mixture or as specified on the plans. The material shall be sprinkled until the specified moisture content has been reached.

The lime shall be distributed in a manner that will minimize scattering by wind. Lime shall not be applied when wind conditions, in the opinion of the Engineer, are detrimental to proper application. A motor grader shall not be used to spread the lime.

b. Slurry placing. The lime shall be mixed with water in trucks with approved distributors and applied as a thin water suspension or slurry. Commercial lime slurry shall be applied with a lime percentage not less than that applicable for the grade used. The distribution of lime shall be by successive passes over a measured section of subgrade until the specified amount of lime has been spread. The amount of lime spread shall be the amount required for mixing to the specified depth that will result in the amount determined in the soil-lime mixture or as shown on the plans. The distributor truck shall continually agitate the slurry to keep the mixture uniform.

155-6.3 Mixing. The mixing procedure shall be the same for "Dry Placing" or "Slurry Placing" as described below:

a. Preliminary mixing. The full depth of the treated subgrade shall be mixed with an approved mixing machine. Lime shall not be left exposed for more than six (6) hours. The mixing machine shall make two coverages. Water shall be added to the subgrade during mixing to provide a moisture content approximately 5% above the optimum moisture of the material and to ensure chemical action of the lime and subgrade. After mixing, the subgrade shall be lightly rolled to seal the surface and help prevent evaporation of moisture. The water content of the subgrade mixture shall be maintained at a moisture content above the optimum moisture content for a minimum of 48 hours or until the material becomes friable. During the curing period, the material shall be sprinkled as directed by the Engineer.

b. Final mixing. After the required curing time, the material shall be uniformly mixed by approved methods. If the mixture contains clods, they shall be reduced in size by blading, discing, harrowing, scarifying, or the use of other approved pulverization methods so that the remainder of the clods shall meet the following requirements when tested dry by laboratory sieves. After curing, pulverize lime treated material until soil particles pass a one inch (25 mm) sieve and 60% pass the No. 4 (4.75 mm) sieve. If resultant mixture contains clods, reduce their size by scarifying, remixing, or pulverization to meet specified gradation.

155-6.4 Compaction. Compaction of the mixture shall immediately follow the final mixing operation with no part of the mixture uncompacted more than 30 minutes after final mixing. The material shall be aerated or sprinkled as necessary to provide the optimum moisture content during compaction. The field density of the compacted mixture shall be at least 93% of the maximum density of laboratory specimens prepared from samples taken from the material in place. The specimens shall be compacted and tested in accordance with ASTM D698 to determine maximum density and optimum moisture content. The in-place field density shall be determined in accordance with <u>ASTM D6938, Procedure A, direct transmission method</u>. Testing frequency shall be a minimum of one compaction test per <u>500</u> square yards of stabilized base or as directed by the Engineer.

The material shall be sprinkled and rolled as directed by the Engineer. All irregularities, depressions, or weak spots that develop shall be corrected immediately by scarifying the areas affected, adding or removing material as required, and reshaping and recompacting. The surface of the subgrade shall be maintained in a smooth condition, free from undulations and ruts, until other work is placed on it or the work is accepted by the Engineer.

The full depth of the material shown on the plans shall be compacted to remain firm and stable under construction equipment. All testing shall be done by the Engineer. Perform in-place density test to determine degree of compaction between 24 and 72 hours after final compaction and 24 hour moist cure period. If the material fails to meet the density requirements, it shall be reworked to meet the density requirements. The shape of the course shall be maintained smooth and shall conform to the typical section shown on the plans and the established lines and grades. If the material loses the specified stability, density, and finish before the next course is placed or the work is accepted by the Engineer, the material shall be recompacted and refinished by the Contractor, and the cost shall be incidental to this item.

155-6.5 Finishing and curing. After the final layer or course of lime-treated subgrade has been compacted, it shall be brought to the required lines and grades in accordance with the typical sections. The completed section shall then be finished by rolling, as directed by the Engineer, with a pneumatic or other suitable roller sufficiently light to prevent hairline cracking. The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 12 feet (3.7 m) straightedge applied parallel with and at right angles to the pavement centerline. Any variations in excess of this tolerance shall be corrected by the Contractor in a manner satisfactory to the Engineer, and the cost shall be incidental to this item.

The completed section shall be moist-cured for a minimum of seven (7) days before further courses are added or any traffic is permitted, unless otherwise directed by the Engineer. Subsequent courses shall be applied within 14 days after the lime-treated subgrade is cured.

155-6.6 Thickness control. The thickness of the final lime-treated subgrade shall be not less than the thickness specified. Thickness shall be determined by depth tests or cores taken at intervals so that each test shall represent no more than 300 square yards (250 sq m). When the base deficiency is more than 1/2 inch (12 mm), the Contractor shall correct such areas in a manner satisfactory to the Engineer. The Contractor shall replace the base material where borings are taken for test purposes. This cost shall be incidental to this item.

155-6.7 Maintenance. The Contractor shall protect and maintain the lime-treated subgrade from yielding until the lime-treated subgrade is covered by placement of the next layer. The cost of this maintenance shall be incidental to this item.

155-6.8 Handling and safety. The Contractor shall obtain and enforce the lime supplier’s instructions for proper safety and handling of the lime to prevent physical eye or skin contact with lime during transport or application.

METHOD OF MEASUREMENT

155-7.1 Lime-treated subgrade shall be paid for by the square yard (square meter) in the completed and accepted work.

155-7.2 ~~Lime shall be paid by the number of tons (kg) of Hydrated Lime, or the calculated equivalent, used in the completed and accepted work. “Calculated Equivalent” will be determined by the Engineer as follows:~~

~~**a.** Hydrated lime delivered to the project in dry form will be measured according to the actual tonnage either spread on the subgrade or batched on site into a slurry, whichever is applicable.~~

~~**b.** Lime delivered to the project in slurry form will be paid for on the basis of certified chemical composition tickets and batch weight tickets. The Owner shall reserve the right to have the dry lime content verified by an independent testing laboratory. If the chemical composition is reported on the basis of Pebble Quicklime, the equivalent hydrated lime will be determined in accordance with paragraph c. below.~~

~~**c.** If Pebble Quicklime is delivered to the project in dry form it will be measured for payment on the basis of the following formula:~~

~~(Total Quicklime (CaO)(Tons) × % Purity × 1.32 Factor) + (Total Quicklime (CaO)(Tons) × % Impurities × 1.00 Factor) = Equivalent Hydrated Lime~~ ~~$Ca(OH)_2$(Tons)~~

~~The above will apply whether the quicklime is spread dry (if allowed) or batched into a slurry.~~

BASIS OF PAYMENT

155-8.1 Payment shall be made at the contract unit price per square yard (square meter) for the lime-treated subgrade at the thickness specified. The price shall be full compensation for furnishing all material, including the lime, and for all preparation, delivering, placing and mixing these materials, and all labor, equipment, tools and incidentals necessary to complete this item.

155-8.2 ~~Payment shall be made at the contract unit price per pound (kg) of lime. This price shall be full compensation for furnishing, delivery, and placing this material~~.

Payment will be made under:

Item P-155	Lime-treated subgrade - per square yard

TESTING REQUIREMENTS

ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3) (600 kN-m/m^3)
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

MATERIAL REQUIREMENTS

ASTM C51	Standard Terminology Relating to Lime and Limestone (as used by the Industry)
ASTM C977	Standard Specification for Quicklime and Hydrated Lime for Soil Stabilization
ASTM D3551	Standard Practice for Laboratory Preparation of Soil-Lime Mixtures Using Mechanical Mixer

END OF ITEM P-155

Part 3 – Flexible Base Courses

Item P-209 Crushed Aggregate Base Course

DESCRIPTION

209-1.1 This item consists of a base course composed of crushed aggregate base constructed on a prepared course in accordance with these specifications and in conformity to the dimensions and typical cross-sections shown on the plans.

MATERIALS

209-2.1 Crushed aggregate base. Crushed aggregate shall consist of clean, sound, durable particles of crushed stone, crushed gravel, and shall be free from coatings of clay, silt, organic material, or other objectionable materials. Aggregates shall contain no clay lumps or balls. Fine aggregate passing the No. 4 (4.75 mm) sieve shall consist of fines from the coarse aggregate crushing operation. If necessary, fine aggregate may be added to produce the correct gradation. The fine aggregate shall be produced by crushing stone, gravel, that meet the coarse aggregate requirements for wear and soundness.

The coarse aggregate portion, defined as the material retained on the No. 4 (4.75 mm) sieve, shall not have a loss of greater than 45% when tested per ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after five cycles, when tested in accordance with ASTM C88. The aggregate shall contain no more than 15%, by weight, of flat, elongated, or flat and elongated particles per ASTM D4791. A flat particle is one having a ratio of width to thickness greater than 3; an elongated particle is one having a ratio of length to width greater than three (3). The aggregate shall have at least 90% by weight of particles with at least two fractured faces and 100% with at least one fractured face per ASTM D5821. The area of each face shall be equal to at least 75% of the smallest mid-sectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces.

a. Sampling and testing for initial aggregate base requirements. Samples shall be taken by the Contractor in the presence of the Engineer. Material shall meet the requirements in paragraph 209-2.1 and 209-2.2. This sampling and testing will be the basis for approval of the aggregate base quality requirements.

209-2.2 Gradation requirements. The gradation of the aggregate base material shall meet the requirements of the gradation given in the following table when tested per ASTM C117 and ASTM C136. The gradation shall be well graded from coarse to fine as defined by ASTM D2487 and shall not vary from the lower limit on one sieve to the high limit on an adjacent sieve or vice versa. The fraction of material passing the No. 200 (0.075 mm) sieve shall not exceed one-half the fraction passing the No. 40 (0.45 mm) sieve.

Requirements For Gradation Of Aggregate Base

Sieve Size	Design Range Percentage by Weight	Contractor's Final Gradation	Job Control Grading Band Tolerances for Contractor's Final Gradation Percent
2 inch (50 mm)	100		0
1-1/2 inch (38 mm)	95-100		±5
1 inch (25 mm)	70-95		±8
3/4 inch (19 mm)	55-85		±8

Sieve Size	Design Range Percentage by Weight	Contractor's Final Gradation	Job Control Grading Band Tolerances for Contractor's Final Gradation Percent
No. 4 (4.75 mm)	30-60		±8
No. 40 (0.45 mm)	10-30		±5
No. 200 (0.075 mm)	0-8		±3

The "Job Control Grading Band Tolerances for Contractor's Final Gradation" in the table shall be applied to "Contractor's Final Gradation" to establish a job control grading band. The full tolerance still applies if application of the tolerances results in a job control grading band outside the design range.

a. Sampling and testing for gradation. Gradation tests shall be performed by the Engineer per ASTM C136 and sieve analysis on material passing the No. 200 sieve (75 mm) per ASTM C117. The Engineer shall take at least two aggregate base samples per lot to check the final gradation. Sampling shall be per ASTM D75. The lot will be consistent with the lot size used for density. The samples shall be taken from the in-place, un-compacted material in the presence of the Engineer. Sampling points and intervals will be designated by the Engineer.

CONSTRUCTION METHODS

209-3.1 Preparing underlying subgrade and/or subbase. The underlying subgrade and/or subbase shall be checked and accepted by the Engineer before base course placing and spreading operations begin. Re-proof rolling of the subgrade or proof rolling of the subbase in accordance with P-152, at the Contractor's expense, may be required by the Engineer if the Contractor fails to ensure proper drainage or protect the subgrade and/or subbase. Any ruts or soft, yielding areas due to improper drainage conditions, hauling, or any other cause, shall be corrected before the base course is placed. To ensure proper drainage, the spreading of the base shall begin along the centerline of the pavement on a crowned section or on the high side of the pavement with a one-way slope.

209-3.2 Production. The aggregate shall be uniformly blended and, when at a satisfactory moisture content per paragraph 209-3.4, the approved material may be transported directly to the spreading equipment.

209-3.3 Placing. The aggregate base material shall be placed on the prepared underlying subgrade and/or subbase and compacted in layers to the thickness shown on the plans. Work shall progress without interruption. The material shall be deposited and spread in lanes in a uniform layer without segregation to such loose depth that, when compacted, the layer shall have the specified thickness. The aggregate base course shall be constructed in layers of uniform thickness of not less than 3 inches (75 mm) nor more than 6 inches (150 mm) of compacted thickness. The aggregate as spread shall be of uniform grading with no pockets of fine or coarse materials. The aggregate, unless otherwise permitted by the Engineer, shall not be spread more than 2,000 square yards (1700 sq m) in advance of the rolling. Any necessary sprinkling shall be kept within these limits. Care shall be taken to prevent cutting into the underlying layer during spreading. No material shall be placed in snow or on a soft, muddy, or frozen course. The aggregate base material shall be spread by spreader boxes or other approved devices. This equipment shall have positive thickness controls that spread the aggregate in the required amount to avoid or minimize the need for hand manipulation. Dumping from vehicles that require re-handling shall not be permitted. Hauling over the uncompacted base course shall not be permitted.

When more than one layer is required, the construction procedure described herein shall apply similarly to each layer.

209-3.4 Compaction. Immediately after completion of the spreading operations, compact each layer of the base course, as specified, with approved compaction equipment. The number, type, and weight of rollers shall be sufficient to compact the material to the required density within the same day that the aggregate is placed on the subgrade. The moisture content of the material during placing operations shall be within ±2 percentage points of the optimum moisture content as determined by ASTM D6938 using Procedure A, the direct transmission method and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated per ASTM D6938.

209-3.5 Acceptance sampling and testing for density. Aggregate base course shall be accepted for density on a lot basis. A lot will consist of one day's production if it does not exceed 2,400 square yards (2000 sq m). A lot will consist of one-half day's production if a day's production consists of between 2,400 and 4,800 square yards (2000 and 4000 sq m). The **Engineer shall perform all density tests.**

Each lot shall be divided into two equal sublots. One test shall be made for each sublot and shall consist of the average of two random locations for density determination. Sampling locations will be determined by the Engineer on a random basis per ASTM D3665.

Each lot will be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens. The specimens shall be compacted and tested per ASTM **D1557**. The in-place field density shall be determined per ASTM D6938 using Procedure A, the direct transmission method, and ASTM D6938 shall be used to determine the moisture content of the material. The machine shall be calibrated in accordance with ASTM D6938. If the specified density is not attained, the entire lot shall be reworked and/or recompacted and two additional random tests made at the Contractor's expense. This procedure shall be followed until the specified density is reached.

209-3.6 Surface tolerances. After the course has been compacted, the surface shall be tested for smoothness and accuracy of grade and crown. Any portion lacking the required smoothness or failing in accuracy of grade or crown shall be scarified to a depth of at least 3 inches (75 mm), reshaped and recompacted to grade until the required smoothness and accuracy are obtained and approved by the Engineer. Any deviation in surface tolerances shall be corrected by the Contractor at the Contractor's expense. The smoothness and accuracy requirements specified here apply only to the top layer when base course is constructed in more than one layer.

a. Smoothness. The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with and at right angles to the centerline. The straightedge shall be moved continuously at half the length of the 12-foot (3.7-m) straightedge for the full length of each line on a 50-foot (15-m) grid.

b. Accuracy. The grade and crown shall be measured on a 50-foot (15-m) grid and shall be within +0 and -1/2 inch (12 mm) of the specified grade.

209-3.7 Thickness control. The thickness of the base course shall be within +0 and -1/2 inch (12 mm) of the specified thickness as determined by depth tests taken by the Contractor in the presence of the Engineer. Tests shall be taken at intervals representing no more than 300 square yards (250 sq m) per test. Sampling locations will be determined by the Engineer per ASTM D3665. Where the thickness is deficient by more than 1/2 inch (12 mm), the Contractor shall correct such areas at no additional cost by scarifying to a depth of at least 3 inches (75 mm), adding new material of proper gradation, and the material shall be blended and recompacted to grade. Additional test holes may be required to identify the limits of deficient areas. The Contractor shall replace, at his expense, base material where depth tests have been taken.

209-3.8 Protection. Perform construction when the atmospheric temperature is above 35°F (2°C). When the temperature falls below 35°F (2°C), protect all completed areas by approved methods against detrimental effects of freezing. Correct completed areas damaged by freezing, rainfall, or other weather conditions to meet specified requirements. When the aggregates contain frozen materials or when the underlying course is frozen or wet, the construction shall be stopped. Hauling equipment may be routed over completed portions of the base course, provided no damage results. Equipment shall be routed over the full width of the base course to avoid rutting or uneven compaction. The Engineer will stop all hauling over completed or partially completed base course when, in the Engineer's opinion, such hauling is causing damage. Any damage to the base course shall be repaired by the Contractor at the Contractor's expense.

209-3.9 Maintenance. The Contractor shall maintain the base course in a satisfactory condition until the full pavement section is completed and accepted by the Engineer. The surface shall be kept clean and free from foreign material and properly drained at all times. Maintenance shall include immediate repairs to any defects and shall be repeated as often as necessary to keep the area intact. Any base course that is not paved over prior to the onset of winter shall be retested to verify that it still complies with the requirements of this specification. Any area of base course that is damaged shall be reworked or replaced as necessary to comply with this specification.

Equipment used in the construction of an adjoining section may be routed over completed base course, if no damage results and the equipment is routed over the full width of the base course to avoid rutting or uneven compaction.

The Contractor shall remove all survey and grade hubs from the base courses prior to placing any bituminous surface course.

METHOD OF MEASUREMENT

209-4.1 The quantity of crushed aggregate base course will be determined by measurement of the number of square yards of material actually constructed and accepted by the Engineer as complying with the plans and specifications. Base materials shall not be included in any other excavation quantities.

BASIS OF PAYMENT

209-5.1 Payment shall be made at the contract unit price per square yard for crushed aggregate base course. This price shall be full compensation for furnishing all materials, for preparing and placing these materials, and for all labor, equipment tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-209	Crushed Aggregate Base Course - per square yard

TESTING REQUIREMENTS

ASTM C29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM D75	Standard Practice for Sampling Aggregates

ASTM D422	Standard Test Method for Particle-Size Analysis of Soils
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2700 kN-m/m^3))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D4718	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D5821	Standard Test Method for Determining the Percentage of Fractured Particles in Coarse Aggregate
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

END OF ITEM P-209

Item P-219 Recycled Concrete Aggregate Base Course

DESCRIPTION

219-1.1 This item consists of a base course composed of recycled concrete aggregate, crushed to meet a particular gradation, constructed on a prepared course per these specifications and in conformity to the dimensions and typical cross-sections shown on the plans.

MATERIALS

219-2.1 Aggregate. Recycled concrete aggregate shall consist of portland cement concrete (PCC) or other concrete containing pozzolanic binder material. The recycled concrete material shall be free of reinforcing steel and expansion material. Asphalt concrete overlays shall be removed from the PCC surface prior to pavement removal and crushing. Any full-slab asphalt concrete panels (used as a replacement for a removed PCC slab) shall also be removed. An incidental amount of recycled asphalt concrete pavement and other foreign material may be present in the recycled concrete aggregate.

Concrete that exhibits deterioration from alkali-silica reaction (ASR), in the opinion of the Engineer, shall not be used for recycled concrete aggregate. percentage consisting of incidental asphalt concrete:

Recycled concrete aggregate base course shall consist of at least 90%, by weight, Portland cement concrete, with the remaining ~~10% consisting of the following materials:~~

~~Wood~~	~~0.1% maximum~~
~~Brick, mica, schist, or other friable materials~~	~~4% maximum~~
~~Asphalt concrete~~	~~10% maximum~~

Virgin aggregates may be added to meet the 90% minimum PCC requirement.

The percentage ~~of wood, brick, mica, schist, other friable materials, and~~ asphalt concrete shall be determined by weighing that material retained on the No. 4 sieve, and dividing by the total weight of recycled concrete aggregate material retained on the No. 4 sieve.

The fine aggregate shall be produced by crushing stone, gravel, slag, or recycled concrete that meet the requirements for wear and soundness specified for coarse aggregate. Fine aggregate may be added to produce the correct gradation.

The amount of flat and elongated particles in recycled concrete aggregate shall not exceed 20% for the fraction retained on the 1/2 inch (12 mm) sieve nor 20% for the fraction passing the 1/2 inch (12 mm) sieve when tested per ASTM D4791. A flat particle is one having a f width to thickness ratio greater than 3; an elongated particle is one having a length to width ratio greater than 3.

The percentage of wear shall not be greater than 45% when tested per ASTM C131. The sodium sulfate soundness test (ASTM C88) requirement is waived for recycled concrete aggregate.

The fraction passing the No. 40 (0.42-mm) sieve shall have a liquid limit no greater than 25 and a plasticity index of not more than four (4) when tested per ASTM D4318. The fine aggregate shall have a minimum sand equivalent value of 35 when tested per ASTM D2419.

a. Sampling and testing. Recycled concrete aggregate samples for preliminary testing shall be furnished by the Contractor prior to the start of base construction. All tests for initial aggregate submittals necessary to determine compliance with the specification requirements will be made by the Engineer at no expense to the Contractor.

Samples of recycled concrete aggregate shall be furnished by the Contractor at the start of production and at intervals during production. The sampling points and intervals will be designated by the Engineer. The samples will be the basis of approval of specific lots of recycled concrete aggregate for the quality requirements.

Samples of recycled concrete aggregate to check gradation shall be taken at least once daily. Sampling shall be per ASTM D75, and testing shall be per ASTM C136 and ASTM C117.

b. Gradation requirements. The gradation (job mix) of the final mixture shall fall within the design range indicated in the following table, when tested per ASTM C117 and ASTM C136. The final gradation shall be continuously graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on an adjacent sieve or vice versa.

Requirements for Gradation Of Recycled Concrete Aggregate Base

Sieve Size	Percentage by Weight Passing Sieves	Job Mix Tolerances Percent
2 inch (50 mm)	100	--
1-1/2 inch (38 mm)	95 - 100	±5
1 inch (25 mm)	70 - 95	±8
3/4 inch (19 mm)	55 - 85	±8
No. 4 (4.75 mm)	30 - 60	±8
No. 30 (0.60 mm)	12 - 30	±5
No. 200 (0.075 mm)	0 - 5	±3

The job mix tolerances in the table shall be applied to the job mix gradation to establish a job control gradation band. The full tolerance still will apply if application of the tolerances results in a job control gradation band outside the design range.

EQUIPMENT

219-3.1 General. All equipment necessary to mix, transport, place, compact, and finish the recycled concrete aggregate base course shall be furnished by the Contractor. The Contractor shall provide written certification to the Engineer that all equipment meets the requirements for this section. The equipment shall be inspected by the Engineer at the job site prior to the start of construction operations.

219-3.2 Mixing equipment. Base course shall be thoroughly mixed in a plant suitable for recycled concrete aggregate. The mixer shall be a batch or continuous-flow type equipped with a calibrated metering and feeding device that introduce the aggregate and water into the mixer in specified quantities. If necessary, a screening device shall be installed to remove oversized material greater than 2 inches (50 mm) from the recycled concrete aggregate feed.

The Engineer shall have access to the plant at all times for inspection of the plant’s equipment and operation and for sampling the mixed recycled concrete aggregate materials.

219-3.3 Hauling equipment. The mixed recycled concrete aggregate base course shall be transported from the plant to the job site in hauling equipment having beds that are smooth, clean, and tight. Truck bed covers shall be provided and used to protect the mixed recycled concrete aggregate base course from rain during transport.

219-3.4 Placing equipment. Recycled concrete aggregate shall be placed using a mechanical spreader or machine capable of receiving, spreading, and shaping the material into a uniform layer or lift without segregation. The placing equipment shall be equipped with a strike off plate that can be adjusted to the layer thickness

219-3.5 Compaction equipment. Recycled concrete aggregate base course shall be compacted using one or a combination of the following pieces of equipment: steel-wheeled roller; vibratory roller; pneumatic-tire roller; and/or hand-operated power tampers (for areas inaccessible to rollers).

219-3.6 Finishing equipment. Trimming of the compacted recycled concrete aggregate to meet surface requirements shall be accomplished using a self-propelled grader or trimming machine, with a mold board cutting edge of 12 feet (3.7 m) minimum width automatically controlled by sensors in conjunction with an independent grade control from a taut stringline. Stringline will be required on both sides of the sensor controls for all lanes.

CONSTRUCTION METHODS

219-4.1 Weather limitations. Construction is allowed only when the atmospheric temperature is at or above 35°F (2°C). When the temperature falls below 35°F (2°C), the Contractor shall protect all completed areas against detrimental effects of freezing. The Contractor shall repair any areas damaged by freezing, rainfall, or other weather conditions.

219-4.2 Preparing underlying course. The underlying course shall be checked by the Engineer before placing and spreading operations are started. Any ruts or soft yielding places caused by improper drainage conditions, hauling, or any other cause shall be corrected at the Contractor’s expense before the base course is placed there. Material shall not be placed on frozen material.

To protect the existing layers and to ensure proper drainage, the spreading of the recycled concrete aggregate base course shall begin along the centerline of the pavement on a crowned section or on the greatest contour elevation of a pavement with a variable uniform cross slope.

219-4.3 Grade control. Grade control between the edges of the recycled concrete aggregate base course lanes shall be accomplished by grade stakes, steel pins, or forms placed in lanes parallel to the centerline and at intervals of 50 feet (15 m) or less on the longitudinal grade and 25 feet (7.5 m) or less on the transverse grade.

219-4.4 Mixing. The recycled concrete shall be uniformly blended during crushing operations and mixed with water in a mixing plant suitable for recycled concrete aggregate. The plant shall blend and mix the materials to meet the specifications and to secure the proper moisture content for compaction.

219-4.5 Placing. The recycled concrete aggregate base material shall be placed on the moistened subgrade or base in layers of uniform thickness with an approved mechanical spreader.

The maximum depth of a compacted layer shall be 6 inches (150 mm). If the total depth of the compacted material is more than 6 inches (150 mm), it shall be constructed in two or more layers. In multi-layer construction, the material shall be placed in approximately equal-depth layers.

The previously constructed layer shall be cleaned of loose and foreign material prior to placing the next layer. The surface of the compacted material shall be kept moist until covered with the next layer.

Adjustments in placing procedures or equipment shall be made to obtain grades, to minimize segregation grading, to adjust the water content, and to ensure an acceptable recycled concrete aggregate base course.

219-4.6 Compaction. Immediately after completion of the spreading operations, the recycled concrete aggregate shall be compacted. The number, type, and weight of rollers shall be sufficient to compact the material to the required density.

Each layer of the recycled concrete aggregate base course shall be compacted to the required density using the compaction equipment. The moisture content of the material during placing operations shall be within ±1-1/2 percentage points of the optimum moisture content as determined by ASTM D1557.

The compaction shall continue until each layer has reached compaction that is at least 100% of the laboratory maximum density through the full depth of the layer. The Contractor shall make adjustments in compacting or finishing techniques to obtain true grades, to minimize segregation and degradation, to reduce or increase water content and to ensure a satisfactory base course. Any unsatisfactory materials shall be removed and replaced with satisfactory material or reworked, to meet the requirements of this specification.

219-4.7 Acceptance sampling and testing for density. The Engineer shall perform all density tests. Recycled concrete aggregate shall be accepted for density on a lot basis. A lot will consist of one day's production where it does not exceed 2,400 square yards (2000 sq m) per lift. A lot will consist of one-half day's production, where a day's production is between 2,400 and 4,800 square yards (2000 and 4000 sq m) per lift.

Each lot shall be divided into two equal sublots. One density test shall be made for each sublot and shall consist of the average of two random locations for density determination. Sampling locations will be determined by the Engineer on a random basis per ASTM D3665.

Each lot will be accepted for gradation when it falls within the limits and tolerances shown in the table above when tested per ASTM C117 and ASTM C131. If the proper gradation is not attained the gradation test will be repeated. If the re-test does not indicate gradations within the limits of the table above, the entire lot shall be rejected and replaced by the Contractor at the Contractor's expense.

Each lot will be accepted for density when the field density is at least 100% of the maximum density of laboratory specimens prepared from samples of the base course material. The specimens shall be compacted and tested per ASTM D1557. The in-place field density shall be determined per D6938. The field density shall be determined in accordance with ASTM D6938 using Procedure A, the direct transmission method and the machines shall be calibrated in accordance with per ASTM D6938. When using the nuclear method, ASTM D4643 shall be used to determine the moisture content of the material. If the specified density is not attained, the entire lot shall be reworked and two additional random tests made. This procedure shall be followed until the specified density is reached.

219-4.8 Finishing. The surface of the recycled concrete aggregate base course shall be finished by equipment designed for this purpose.

Adding a thin layer of material to the top of the base course to meet grade shall not be allowed. If the elevation of the layer is 1/2 inch (12 mm) or more below grade, the layer shall be scarified to a depth of at least 3 inches (75 mm), new material added, and the layer shall be recompacted. If the finished surface is above plan grade, it shall be cut back to grade and rerolled. The grade shall be measured on a maximum 25-foot (7.5-m) grid (longitudinal and transverse). Thickness results shall be furnished to the Engineer daily for acceptance determination.

Should the surface become rough, corrugated, uneven in texture, or traffic marked prior to completion, the unsatisfactory portion shall be scarified, and recompacted or replaced at the Contractor's expense.

219-4.9 Surface tolerances. The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with or at right angles to the centerline. The Contractor shall correct any deviation in excess of this amount, at the Contractor's expense.

219-4.10 Thickness control. The completed thickness of the base course shall be within 1/2 inch (12 mm) of the design thickness. Four thickness determinations shall be made for each lot of material placed. Each lot shall be divided into four equal sublots and one test shall be made for each sublot. Sampling locations will be determined per ASTM D3665. Where the thickness is y more than 1/2 inch (12 mm) deficient, the Contractor, at his or her expense, shall correct the areas by excavating to the required depth and replacing with new material. Additional test holes may be required to identify the limits of deficient areas.

219-4.11 Traffic. Equipment used in construction may be routed over completed portions of the base course, provided there is no damage to the base course. The equipment shall be routed evenly over the full width of the base course to avoid rutting or uneven compaction.

219-4.12 Maintenance. The base course shall be maintained until the base course is completed and accepted. Maintenance will include immediate repairs to any defects and shall be repeated as often as necessary to keep the completed work intact. The Contractor, at his or her expense, will rework any area of the recycled concrete aggregate base course that is damaged.

METHOD OF MEASUREMENT

219-5.1 The quantity of recycled concrete aggregate base course shall be measured by the number of square yards (square meters) of material actually constructed and accepted as complying with the plans and specifications.

BASIS OF PAYMENT

219-6.1 Payment shall be made at the contract unit price per square yard (square meter) for each indicated thickness of aggregate base course. This price shall be full compensation for furnishing all materials, for preparing and placing these materials, and for all labor, equipment tools, and incidentals necessary to complete the item.

TESTING REQUIREMENTS

ASTM C29	Standard Test Method for Bulk Density ("Unit Weight") and Voids in Aggregate
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM D75	Standard Practice for Sampling Aggregates
ASTM C117	Standard Test Method for Materials Finer than 75 µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM D698	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft^3 (600 kN-m/m^3))
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method
ASTM D1557	Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft^3 (2700 kN-m/m^3))
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber-Balloon Method
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate

ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4643	Standard Test Method for Determination of Water (Moisture) Content of Soil by Microwave Oven Heating
ASTM D4718	Standard Practice for Correction of Unit Weight and Water Content for Soils Containing Oversize Particles
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

END OF ITEM P-219

Part 4 – Rigid Base Courses

Item P-304 Cement-Treated Base Course

DESCRIPTION

304-1.1 This item shall consist of a cement-treated base (CTB) course composed of mineral aggregate and cement, uniformly blended and mixed with water. The mixed material shall be spread and shaped with a mechanical spreader, and compacted with rollers in accordance with these specifications and in conformance to the lines, grades, dimensions, and cross-sections shown on the plans.

MATERIALS

304-2.1 Aggregate. The aggregate shall be select granular materials, comprised of crushed or uncrushed gravel and/or stone, or recycled crushed and graded portland cement concrete (PCC). The material shall be free of roots, sod, and weeds. The crushed or uncrushed aggregate shall consist of hard, durable particles of accepted quality, free from an excess of soft, flat, elongated, or disintegrated pieces, and objectionable matter. The method used to produce the aggregate shall ensure the finished product is as consistent as practicable. All inferior quality stones and rocks shall be wasted. If recycled PCC is used as the aggregate, it must meet the requirements for virgin aggregate.

The percentage of wear of the crushed aggregate retained on the No. 4 (4.75-mm) sieve shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 10%, or the magnesium sulfate soundness loss shall not exceed 15%, after five cycles, when tested in accordance with ASTM C88.

When tested in accordance with ASTM C136, the aggregate shall conform to the gradation(s) shown in the table below (titled Aggregate Gradation for CTB Material). An aggregate blend that meets the requirements of the table shall be selected by the Contractor and used in the final mix design. The final aggregate blend shall be well graded from coarse to fine within the limits designated in the table and shall not vary from the low limit on one sieve to the high limit on adjacent sieves, or vice versa. The portion of final aggregate blend passing the No. 40 (425 µm) sieve shall have a liquid limit of not more than 25 and a plasticity index of not more than six (6) when tested in accordance with ASTM D4318.

Aggregate Gradation for CTB Material

Sieve Size	Percentage by Weight Passing Sieves	
	Gradation A	Gradation B
2 inch (50 mm)	100 [1]	100 [1]
No. 4 (4.75 mm)	45 - 100	55 - 100
No. 10 (1.80 mm)	37 - 80	45 - 100
No. 40 (450 µm)	15 - 50	25 - 80
No. 80 (210 µm)	0 - 25	10 - 35

[1] Maximum nominal size of aggregate is 1 inch (25 mm).

All aggregate samples required for testing shall be furnished by the Contractor at the expense of the Contractor. Sampling shall be performed by the Contractor in accordance with ASTM D75.

304-2.2 Cement. Cement shall conform to the requirements of ASTM C150, Type II.

304-2.3 Cementitious additives. Pozzolanic and slag cement may be added to the CTB mix. If used, each material must meet the following requirements:

a. Pozzolan. Pozzolanic materials must meet the requirements of ASTM C618, Class F, or N with the exception of loss of ignition, where the maximum shall be less than 6%. **[** The supplementary optional physical requirements of Table 3 contained in ASTM C618 shall apply. **]**

b. Slag Cement. Slag shall conform to ASTM C989, Grade 80, 100, or 120.

304-2.4 Water. Water used in mixing or curing shall be potable, clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product.

304-2.5 Curing materials. For curing CTB placed under PCC pavement, use white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class A or Class B (wax-based).

~~For curing CTB placed under HMA pavement, use emulsified asphalt conforming to **[___]**.~~

~~**304-2.6 Sand blotter**. Sand shall be applied, when required, to prevent tracking of the emulsion curing materials. The sand material shall be clean, dry, and non-plastic. **]**~~

COMPOSITION OF MIXTURE

304-3.1 General. The CTB material shall be composed of a mixture of aggregate, cementitious material, and water. Fly ash or slag cement may be used as a partial replacement for Portland cement.

304-3.2 Mix design. The mix design shall use a cement content that, when tested in the laboratory per ASTM D1633, produces a 7-day compressive strength between 400 pounds per square inch (2758 kPa) minimum and 800 pounds per square inch (5516 kPa) maximum. The 28-day strength shall not exceed 1000 pounds per square inch (6895 kPa).

The mix design shall include a complete list of materials, including type, brand, source, and amount of cement, fine aggregate, coarse aggregate, water, and cementitious additives.

Should a change be made in aggregate sources or type of cement, or if cementitious additives are added or deleted from the mix, production of the CTB mix shall be stopped and a new mix design shall be submitted.

304-3.3 Submittals. At least 30 days prior to the placement of the CTB, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the CTB material. Tests older than six (6) months shall not be used. The certification shall show the ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:

a. Source(s) of materials, including aggregate, cement, cementitious additives, curing, and bond-breaking materials.

b. Physical properties of the aggregates, cement, cementitious additives, curing, and bond-breaking materials.

c. Mix design:

- Mix identification number
- Aggregate gradation
- Cement content
- Water content

- Cementitious materials content

d. Laboratory test results:

- Compaction and strength test procedures
- Laboratory compaction characteristics (maximum dry density and optimum moisture content)
- Compressive strength at seven (7) days
- Wet-dry and/or freeze-thaw weight loss, if applicable

No CTB material shall be placed until the submittal is accepted in writing by the Engineer.

During production, the Contractor shall submit batch tickets for each delivered load.

EQUIPMENT

All equipment necessary to mix, transport, place, compact, and finish the CTB material shall be furnished by the Contractor. The equipment shall be inspected and approved by the Engineer at the job site prior to the start of construction operations.

304-4.1 Mixing. The mixer shall be a batch or continuous-flow type stationary mixer. The mixer shall be equipped with calibrated metering and feeding devices that introduce the aggregate, cement, water, and cementitious additives (if used) into the mixer in the specified quantities. If necessary, a screening device shall be used to remove oversized material greater than 2 inches (50 mm) from the raw aggregate feed prior to mixing.

The Engineer shall have free access to the plant at all times for inspection of the plant's equipment and operation and for sampling the CTB mixture and its components.

304-4.2 Hauling. The mixed CTB material shall be transported from the plant to the job site in trucks or other hauling equipment having beds that are smooth, clean, and tight. Truck bed covers shall be provided and used to protect the CTB from rain. CTB material that becomes wet during transport shall be rejected.

304-4.3 Placing. CTB material shall be placed using a mechanical spreader or a machine capable of receiving, spreading, and shaping the mixture without segregation into a uniform layer or lift. The equipment shall be equipped with a strike-off plate capable of being adjusted to the specified layer thickness. It shall also be equipped with two end gates or cut off plates, so that the CTB may be spread in widths varying up to lane width.

304-4.4 Compaction. Compaction of the CTB layer shall be accomplished using one or a combination of the following pieces of equipment: tamping or grid roller; steel-wheeled roller; vibratory roller; pneumatic-tire roller, and/or vibrating plate compactor (for areas inaccessible to rollers). The number, type, and weight of rollers and/or compactors shall be sufficient to compact the mixture to the required density.

304-4.5 Finishing. Final trimming of the compacted CTB to meet surface requirements shall be accomplished using a self-propelled grader or trimming machine, with a mold board cutting edge, which is at least 12 feet (3.7 m) wide and is automatically controlled by sensors in conjunction with an independent grade control from a taut stringline. Stringline will be required on both sides of the sensor controls for the pilot lane. For all other lanes, a single stringline on the outside and grade matching with previously completed adjacent lanes is permissible.

CONSTRUCTION METHODS

304-5.1 Weather limitations.

304-5.1.1 Cold weather. Do not construct base when weather conditions will detrimentally affect quality of the finished course. Apply cement when the ambient temperature is a minimum of 40°F (4°C) and rising. Do not apply cement to aggregate materials that are frozen or contain frost. If ambient temperature falls below 40°F (4°C), protect completed cement-treated areas against freezing. Reprocess, reshape, and recompact damaged material. The CTB shall not be placed on frozen surfaces. Provide drainage to prevent water from collecting or standing on stabilized areas, and on the pulverized, mixed, or partially mixed materials.

304-5.1.2 Rain. The CTB may not be placed when it is raining. If unexpected rain occurs during placement, the layer should be quickly compacted. CTB material that becomes wet by rain during transport or placement shall be evaluated by the Engineer, and may be rejected.

304-5.2 Preparation of underlying course. The underlying course shall be checked by the Engineer before placing and spreading operations are started, to ensure that it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places shall be corrected before the CTB mixture is placed. The underlying course shall be wetted in advance of placing the CTB layer. The final prepared grade prior to placing the CTB should be in a firm and moist condition free of frost. Use of chemicals to eliminate frost will not be permitted.

To ensure proper drainage, placement of the base shall begin along the centerline of the pavement on a crowned section or on the highest elevation contour of a pavement with variable cross slope.

304-5.3 Grade control. Grade control between the edges of the CTB shall be accomplished at intervals of 50 feet (15 m) or less on the longitudinal grade and at 25 feet (7.5 m) or less on the transverse grade.

304-5.4 Handling, measuring, and batching. The continuous flow central plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Aggregate stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials. Aggregates that are segregated or mixed with earth or foreign material will not be accepted.

Continuous flow plants shall be equipped with feeders to automatically and accurately proportion aggregates and bulk cement, by weight. When bulk cement is used, the Contractor shall use a suitable method of handling the cement such as a chute, boot or other device, to prevent loss of cement between the weigh hopper and mixer. The device shall provide positive assurance that the specified cement content is present in each batch.

304-5.5 Mixing. Aggregate and cement may be proportioned either by weight or volume, and shall be mixed sufficiently to prevent the forming of cement balls when water is added. The mixing time shall be that required to secure a well-blended, uniform mixture of aggregate, cement, water, and pozzolan (if used). The minimum mixing time will be based on the uniformity and consistency of the mixture.

304-5.6 Placing. The CTB mixture shall be deposited on the moistened subgrade or subbase and spread into a uniform layer of specified width and thickness that, when compacted and trimmed, conforms to the required line, grade, and cross-section. The Contractor may install the CTB layer in single or multiple compacted lifts; however, each compacted lift must be no greater than 6 inches (150 mm) thick. In multi-lift construction, the surface of the compacted lift shall be kept moist until covered with the next lift. Successive lifts shall be placed and compacted so that the required total depth of the CTB layer is completed within 12 hours.

A single spreader may be used, provided it is capable of placing a uniform, full-depth layer of material across the full width of the base in one pass. Otherwise, two or more spreaders will be required, and shall be operated so that spreading progresses along the full width of the base in a uniform manner.

304-5.7 Compaction. Immediately upon completion of the spreading operations, the CTB material shall be thoroughly compacted using approved compaction equipment. At the start of compaction, the moisture content shall be within ±2 percentage points of the specified optimum moisture.

304-5.8 Finishing. After completing compaction, the surface of the CTB layer shall be shaped to the specified lines, grades, and cross-section. During the finishing process, the surface shall be kept moist by means of fog-type sprayers. Compaction and finishing shall produce a smooth, dense surface, free of ruts, cracks, ridges, and loose material. All placement, compaction, and finishing operations shall be completed within two (2) hours from the start of mixing. Material not completed within the 2-hour time limit shall be removed and replaced at the Contractor's expense.

CTB layer limits that extend beyond the edges of the new PCC surface course shall be rolled down or shaped to ensure the drainage is away from the new PCC surface course edge.

304-5.9 Construction joints. At the end of each day's construction, a transverse construction joint shall be formed that is a true vertical face (perpendicular to the centerline) and is free of loose material.

Longitudinal construction joints (parallel to the centerline) shall be formed to a consistent, well-defined vertical edge that is free of loose material. The longitudinal joints shall be located so there is a 2-foot (0.6-m) minimum offset from planned joints in any overlying layer.

While forming construction joints, the Contractor shall make sure the material in the joint area is adequately compacted and that the joints are finished level and even with the remainder of the CTB layer.

304-5.10 Curing. The compacted and finished CTB shall be cured with the approved curing agents as soon as possible and in no case later than two (2) hours after completion of the finishing operations. The layer shall be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied.

When a liquid membrane-forming curing compound is used as the curing agent, the surface of the CTB layer shall be uniformly sprayed with the curing compound at the rate of one gallon (3.8 liters) to not more than 200 square feet (18.6 m^2) to obtain a uniform cover over the surface. The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. The curing compound shall be thoroughly and uniformly mixed with the pigment in the storage tank. During application, the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and CTB surfaces exposed by the removal of forms is permitted.

The curing seal shall be maintained and protected until the pavement is placed. If the surface of the finished CTB and/or the curing seal becomes damaged, additional curing material shall be applied at the time it is damaged or when the damage is first observed.

304-5.11 Protection. Completed portions of the cement-stabilized area may be opened to local traffic provided the curing process is not impaired and to other traffic after the curing period has elapsed, provided that the cement-stabilized course has hardened sufficiently to prevent surface marring or distortion by equipment or traffic. Do not permit construction equipment on the area during protection and curing periods. Necessary cement and water may be hauled over the area with pneumatic-tired equipment on approval of the Engineer. Protect finished portions of cement stabilized base from traffic of equipment used in constructing adjoining sections in a manner to prevent marring or damaging completed work. The CTB shall also be protected from freezing at all times.

304-5.12 Bond-breaker. When the CTB is to be placed directly beneath PCC, the entire surface of the CTB shall be coated with a de-bonding compound applied in a quality sufficient to prevent bonding of the PCC pavement to the base course. The bond-breaker shall be a second application of the same compound from P304-2.5 and at the same rate per P304-5.10. If the film becomes damaged from any cause, the damged portions shall be repaired immediately with additional compound or other approved metods. ~~If an impervious membrane or asphalt emulsion is used as a curing material, additional applications of curing materials may be required. The Contractor shall be responsible for selecting the de-bonding compound and determining the necessary application rate. The de-bonding compound shall be approved by the Engineer prior to being incorporated into the work.~~

MATERIAL ACCEPTANCE

304-6.1 Acceptance sampling and testing. All acceptance sampling and testing, with the exception of thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The Contractor shall provide the required CTB samples during construction for acceptance testing purposes. The samples shall be taken by ~~in the presence of~~ the Engineer, or the Egineer's authorized representative.

Testing organizations performing these tests shall meet the requirements of ASTM D3666. All test equipment in Contractor-furnished laboratories shall be calibrated by the testing organization prior to the start of operations.

The CTB layer shall be tested for density, thickness, grade, and surface tolerance on a lot basis, with a lot consisting of either (1) one day's production not to exceed 2,000 square yards (1700 sq m), or (2) a half day's production, where a day's production consists of 2,000 to 4,000 square yards (1675 to 3350 m^2).

Each lot shall be divided into four equal sublots. Within each sublot, one density test, one thickness measurement, and continuous surface straightedge tests (surface tolerance testing) shall be performed, as described below. Sampling locations shall be determined by the Engineer per ASTM D3665.

If only three sublots are produced, the three sublots shall constitute a complete lot. If one or two sublots are produced for the same reason, they shall be incorporated into the next or previous lot, and the total number of sublots shall be used in the acceptance criteria calculation.

End-of-production sublots (that is, sublots associated with the final placement of CTB for the project and are less than a complete lot) shall be handled as (1) three sublots shall constitute a lot, or (2) one or two sublots shall be incorporated into the previous lot.

304-6.1.1 Density testing. CTB samples shall be taken from each sublot and used to create laboratory test specimens representing the various sublots. The specimens shall be compacted and tested for density and moisture content per ASTM D558. The density for each sublot comprising a lot, shall be used to determine an average density for the lot, which will serve as the basis for acceptance of the lot for density.

Within each sublot in the field, one in-place density test shall be performed in accordance with ASTM D6938. The location of the test shall be randomly selected per ASTM D3665. The in-place density for each sublot comprising the lot shall be averaged and compared with the corresponding average lot density. Acceptance criteria for CTB density are provided in paragraph 304-6.2.1. All testing shall be done by the Contractor's laboratory in the presence of the Engineer or the Engineer's authorized representative and density test results shall be furnished upon completion to the Engineer for acceptance determination.

304-6.1.2 Thickness testing. The CTB shall be tested for thickness using the same lot and sublots established for density testing. After three (3) days of curing, one 3-inch (75 mm) diameter core per sublot shall be obtained from a random location, per ASTM D3665. The thickness of each sampled core shall be determined using the caliper measurement procedures provided in ASTM C174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for CTB thickness are provided in paragraph 304-6.2.2. At all locations where cores have been drilled, the resulting core holes shall be filled by the Contractor with CTB or non-shrink grout.

304-6.1.3 Grade testing. The elevations of the finished CTB shall be surveyed every 25 feet (7.5 m) on both sides of the CTB lane as soon as it has hardened sufficiently. Acceptance criteria for CTB grade are provided in paragraph 306-6.2.3.

304-6.1.4 Surface tolerance testing. After the CTB has hardened sufficiently, it shall be tested for surface tolerance with a 12-foot (3.7-m) straightedge or other approved measuring device for tolerances outlined in paragraph 304-6.2.

304-6.2 Acceptance criteria. Acceptance of CTB will be based on density, thickness, grade, and surface tolerance, as described in the paragraphs below.

304-6.2.1 Density requirements. For density, each lot of compacted material will be accepted without adjustment if the average in-place density of the lot is equal to or greater than 98% of the average laboratory density determined for the lot. Each lot of compacted CTB shall be accepted and payment adjusted in accordance with the table below.

Sliding Pay Scale Factors For Density

Average Dry Density (%)	Payment (%)
98.0 and greater	100
97.0 - 97.9	95
96.0 - 96.9	90
95.0 - 95.9	75
Less than 95.0	Reject

If the average density is below 95%, the lot will be rejected and shall be removed and replaced at the Contractor’s expense. In multi-layer construction, density shall be tested for each lift, and all lifts within a rejected lot shall be removed and replaced. No payment shall be made for removed lifts. Replacement lifts shall be paid in accordance with this section.

304-6.2.2 Thickness requirements. The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than one inch (25 mm), it shall be removed and replaced at the Contractor’s expense. When such measurement is deficient by more than 1/2 inch (12 mm) but less than one inch (25 mm) from the plan thickness, one additional core shall be taken at random from each sublot within the lot. The thickness of these additional cores shall be determined as indicated in paragraph 304-6.1.2. A new average lot thickness shall be recomputed based on these additional cores and the original cores taken from each sublot. If the recomputed average lot thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than 1/2 inch (12 mm) from the plan thickness, the entire lot shall be removed and replaced at the Contractor’s expense or shall be permitted to remain in-place at an adjusted payment of 75% of the contract unit price.

When the measured thickness is more than that indicated on the plans, it will be considered as conforming to the requirements, provided the surface of the completed CTB layer is within the established grade and surface tolerance requirements.

304-6.2.3 Grade requirements. When the completed surface is higher than 1/2 inch (12 mm) above the grade shown in the plans, the surface shall be trimmed, at the Contractor’s expense, with an approved grinding machine to an elevation that falls within a tolerance of 1/4 inch (6 mm) or less.

304-6.2.4 Surface tolerance requirements. The finished surface shall not vary more than 3/8 inch (9 mm) when tested with a 12-foot (3.7-m) straightedge applied parallel with, or at right angles to, the centerline of the CTB area. Areas in the CTB showing high spots greater than 3/8 inch (9 mm) over 12 feet (3.7 m) shall be marked and immediately trimmed with an approved grinding machine. Such trimming shall be at the Contractor's expense.

304-6.2.5 Compression Strength. The thickness cores from 304-6.2.2 shall be tested for compressive strength at 3 days. If more than 20% of the individual cores for the Lot, have 3-days strengths greater than 500 pounds per square foot(3,447 kPa), the contractor shall construct transverse joints in the cement treated base layer in accordance with paragraph 304-5.9. The joints shall be made by sawcutting the hardened cement treated base to a depth of at least one-third of the thickness of the cement treated base. Sawcuts due to exceeding the strength limit will,be incidental to the item.

METHOD OF MEASUREMENT

304-7.1 Cement-treated base course. The quantity of cement-treated base course will be determined by measurement of the number of square yards (m^2) of CTB actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

304-8.1 Cement-treated base course. Payment shall be made at the contract unit price per square yard (m^2) for cement-treated base course. This price shall be full compensation for furnishing all materials, including cement; for all preparation, manipulation, placing, and curing of these materials; and for all labor, equipment, tools, and incidentals necessary to complete the item.

Each lot of CTB material will be accepted for density at the full contract price adjusted in accordance with paragraph 304-6.2.1.

Item P-304-8.1	Payment will be made for cement-treated base course - per square yard (m^2)

TESTING REQUIREMENTS

ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregate
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D558	Standard Test Methods for Moisture-Density (Unit Weight) Relations of Soil-Cement Mixtures
ASTM D1556	Standard Test Method for Density and Unit Weight of Soil in Place by the Sand-Cone Method
ASTM D1633	Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders
ASTM D2167	Standard Test Method for Density and Unit Weight of Soil in Place by the Rubber Balloon Method

ASTM D6938	Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
AASHTO T135	Standard Method of Test for Wetting-and-Drying Test of Compacted Soil-Cement Mixtures
AASHTO T136	Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures

MATERIAL REQUIREMENTS

ASTM C150	Standard Specification for Portland Cement
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D977	Standard Specification for Emulsified Asphalt
ASTM D2397	Standard Specification for Cationic Emulsified Asphalt

END OF ITEM P-304

Item P-306 Lean Concrete Base Course

DESCRIPTION

306-1.1 This item shall consist of a subbase material, herein termed lean concrete, that is composed of aggregate and cement uniformly blended together and mixed with water. The mixture may also include approved cementitious additives, in the form of fly ash or slag, and chemical admixtures. The mixed material shall be spread, shaped, and consolidated using concrete paving equipment in accordance with these specifications and in conformity to the lines, grades, dimensions, and typical cross-sections shown on the plans.

MATERIALS

306-2.1 Aggregate. The coarse aggregate fraction shall be crushed stone, crushed or uncrushed gravel, crushed and adequately seasoned, air-cooled, iron blast furnace slag, crushed recycled concrete, or a combination thereof. The fine aggregate fraction may be part of the natural aggregate blend as obtained from the borrow source or it may be natural sand that is added at the time of mixing.

The aggregate shall consist of hard, durable particles, free from an excess of flat, elongated, soft, or disintegrated pieces, or objectionable matter such as roots, sod, weeds, organic impurities, etc. A flat particle is one having a ratio of width to thickness greater than five; an elongated particle is one having a ratio of length to width greater than five.

The design aggregate blend shall conform to the gradation(s) shown in the table below, when tested in accordance with ASTM C136. The aggregates shall be within the limits for deleterious material contained in ASTM C33 Table 3 type 4S. Aggregates shall not contain any substance which may be deleteriously reactive with the alkalies in the cement, except as permitted in ASTM C33.

Aggregate Gradation For Lean Concrete

Sieve Size (square openings)	Percentage by Weight Passing Sieves	
	Gradation A	**Gradation B**
2 inch (50 mm)	--	--
1-1/2 inch (38 mm)	100	--
1 inch (25 mm)	70 - 95	100
3/4 inch (19 mm)	55 - 85	70 - 100
No. 4 (4.75 mm)	30 - 60	35 - 65
No. 40 (425 µm)	10 - 30	15 - 30
No. 200 (75 µm)	0 - 15	0 - 15

306-2.2 Cement. Cement shall conform to the requirements of ASTM 150, Type I or II.

306-2.3 Cementitious additives. Pozzolanic and slag cement may be added to the lean concrete mix. If used, each material must meet the following requirements:

a. Pozzolan. Pozzolanic materials must meet the requirements of ASTM C618, Class N, F, or C Fly Ash, except the loss on ignition shall be 6% for Class N and F.

b. Ground granulated blast furnace slag (slag cement). Slag shall conform to ASTM C989, Grade 120.

306-2.4 Chemical admixtures. The Contractor shall submit certificates indicating that the material to be furnished meets all the requirements listed below. In addition, the Engineer may require the Contractor to submit complete test data showing that the material to be furnished meets all the requirements of the cited specification.

a. Air-entraining admixtures. Air-entraining admixtures shall meet the requirements of ASTM C260.

b. Water-reducing admixtures. Water-reducing, set-controlling admixtures shall meet the requirements of ASTM C494, Type A, D, E, F, or G. Water-reducing admixtures shall be added at the mixer separately from air-entraining admixtures in accordance with the manufacturer's printed instructions. The air entrainment agent and the water-reducing admixture shall be compatible.

c. Retarding admixtures. Retarding admixtures shall meet the requirements of ASTM C494, Type B or D.

d. Accelerating admixtures. Accelerating admixtures shall meet the requirements of ASTM C494, Type C.

306-2.5 Water. Water used in mixing or curing shall be potable, clean and free of oil, salt, acid, alkali, sugar, vegetable, or other deleterious substances injurious to the finished product.

306-2.6 Curing materials. For curing lean concrete, use white-pigmented, liquid membrane-forming compound conforming to ASTM C309, Type 2, Class B, or clear or translucent Type 1-D, Class B with white fugitive dye.

COMPOSITION OF MIXTURE

306-3.1 Mix design. The lean concrete mix design shall be based on trial batch results conducted in the laboratory. The lean concrete shall be designed to meet the criteria in this section.

306-3.1.1 Compressive strength. Compressive strength shall not be less than 500 pounds per square inch (3,445 kPa) nor greater than 800 pounds per square inch (5,516 kPa) at seven (7) days. Three-day and seven-day strengths shall be taken as the average of two compressive strength test results. All compressive strength specimens shall be prepared and tested in accordance with ASTM C192 and ASTM C39, respectively.

If the 3-day strength is greater than 500 pounds per square inch (3,447 kPa), the Contractor shall construct transverse joints in the lean concrete layer in accordance with paragraph 306-5.10.2.

If there is a change in aggregate sources, type of cement used, or pozzolanic materials, a new mix design must be submitted.

306-3.1.2 Air content. The percentage of air entrainment shall be 6%, ±1/2%. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

306-3.2 Submittals. At least 30 days prior to the placement of the lean concrete, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction, as well as the mix design information for the lean concrete material. Tests older than six (6) months shall not be used. The certification shall show the appropriate ASTM or AASHTO specifications or tests for the material, the name of the company performing the tests, the date of the tests, the test results, and a statement that the material did or did not comply with the applicable specifications. The submittal package shall include the following:

a. Sources of materials, including aggregate, cement, admixtures, and curing and bond breaking materials.

b. Physical properties of the aggregates, cement, admixtures, curing and bond breaking materials.

c. Mix design:

- Mix identification number
- Weight of saturated surface-dry aggregates (fine and coarse)
- Combined aggregate gradation
- Cement factor
- Water content
- Water-cementitious material ratio (by weight)
- Volume of admixtures and yield for one cubic yard (cubic meter) of lean concrete

d. Laboratory test results:

- Slump
- Air content
- Compressive strength at 3, 7, and 28 days (average values)
- Freeze-thaw weight loss (when applicable)

In addition, where applicable, the Contractor shall submit for approval by the Engineer a jointing plan for transverse joints in the lean concrete layer.

During production, the Contractor shall submit batch tickets for each delivered load.

EQUIPMENT

306-4.1 All equipment necessary to mix, transport, place, compact, and finish the lean concrete material shall be furnished by the Contractor. The equipment shall be subject to inspection and approval by the Engineer.

306-4.2 Mixing. Lean concrete may be mixed in a stationary mixer (central batch plant or at the site), or in a truck mixer. The mixer type and capacity shall be inspected and approved by the Engineer before production begins. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

306-4.2.1 Stationary plant mixer. The batch plant and equipment shall conform to the requirements of ASTM C94. The Engineer shall have unrestricted access to the plant at all times for inspection of the plant's equipment and operation and for sampling the lean concrete mixture and its components.

The mixers shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades.

306-4.2.2 Truck mixers. Truck mixers used for mixing lean concrete shall conform to the requirements of ASTM C94. Lean concrete may be entirely mixed in a truck mixer or partially mixed in a stationary mixer with mixing completed in a truck mixer. Truck mixers shall be equipped with an accurate continuous registering electronically or mechanically activated revolution counter, to verify the number of drum revolutions.

306-4.3 Hauling. Mixed lean concrete shall be hauled from the stationary plant to the job site in a truck agitator, a truck mixer operating at agitating speed, or a non-agitating truck. All equipment shall conform to the requirements of ASTM C94. When truck mixers are used to mix lean concrete, they may be transported to the job site in the same truck operating at agitating speeds, truck agitators, or a non-agitating truck. The bodies of non-agitating trucks shall be smooth, metal containers and shall be capable of discharging the concrete at a controlled rate without segregation.

306-4.4 Placing and finishing.

306-4.4.1 Forms. Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge. Flexible or curved forms of proper radius shall be used for curves of 100 feet (30 m) radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer.

The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when accepted by the Engineer.

306-4.4.2 Fixed form or slip-form pavers. Lean concrete can be placed using fixed form or slip-form pavers. The paver shall be fully energized, self-propelled and capable of spreading, consolidating, and finishing the lean concrete material, true to grade, tolerances, and cross-sections. The paver shall be capable of finishing the surface so that hand finishing is not required. The paver shall be of sufficient weight and power to construct the maximum specified concrete paving lane width, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The slip-form paver shall be equipped with electronic or hydraulic horizontal and vertical control devises using guide wires or stringlines on both sides of the machine. Slope control will not be allowed.

a. Concrete pavers. Concrete pavers are approved as paver-finishing machines for lean concrete, providing they are capable of handling the amount of lean concrete required for the full-lane width specified, and consolidating the lean concrete full depth. A concrete paver is a power-driven machine with augers, strike-off and tamper bars ahead of a pan screed, with at least one trailing oscillating screed or belt finisher.

b. Bridge deck pavers. Bridge deck pavers are approved as paver-finishing machines for lean concrete, providing they are capable of handling the amount of lean concrete required for the full-lane width specified, and consolidating the lean concrete full depth. A bridge deck paver is an automatic truss paving machine, with paving carriage that strikes off, vibrates, paves, and textures the lean concrete with augers, internal vibration, paving rollers, and drag pan.

306-4.5 Consolidation. For side-form construction, vibrators may be either the surface pan type for pavements less than 8 inches (200 mm) thick or the internal type with either immersed tube or multiple spuds for the full width of the slab. They may be attached to the spreader or the finishing machine, or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms.

For slip-form construction, the paver shall vibrate the lean concrete for the full width and depth of the strip of pavement being placed. Vibration shall be accomplished by internal vibrators.

The number, spacing, frequency, and eccentric weights of vibrators shall be provided to achieve acceptable consolidation without segregation and finishing quality. Adequate power to operate all vibrators at the weight and frequency required for a satisfactory finish shall be available on the paver. The internal vibrators may be supplemented by vibrating screeds operating on the surface of the lean concrete. The Contractor shall constantly monitor the frequency of each of the individual vibrators and shall provide constant monitoring of the consolidation process to avoid honeycombing or segregation. Areas that are visually determined to be honeycombed or segregated shall be corrected at the Contractor's expense.

The vibrators and tamping elements shall be automatically controlled so that they stop operation as forward motion ceases. Any override switch shall be of the spring-loaded, momentary-contact type.

Hand held vibrators may be used in irregular areas.

306-4.6 Jointing. The Contractor shall provide sawing equipment adequate in number of units and power to produce contraction or construction joints of the required dimensions as shown on the plans. The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations.

CONSTRUCTION METHODS

306-5.1 Weather limitations.

306-5.1.1 Cold weather. Unless authorized by the Engineer, the temperature of the mixed lean concrete shall not be less than 50°F (10°C) at the time of placement. In addition, the lean concrete shall not be placed when the ambient temperature is below 40°F (4°C) or when conditions indicate that the temperature may fall below 35°F (2°C) within 24 hours. Under no circumstances shall the lean concrete be placed on frozen underlying courses or mixed when the aggregate is frozen.

When mixing and placing is authorized during cold weather, the Engineer may require the water and/or the aggregates to be heated to not less than 70°F (21°C) nor more than 150°F (66°C). The aggregates may be heated by either steam or dry heat prior to being placed in the mixer. The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials. The Contractor shall adhere to the practices recommended in American Concrete Institute (ACI) 306R, Guide to Cold Weather Concreting.

306-5.1.2 Hot weather. To prevent rapid drying of newly constructed lean concrete, the lean concrete temperature from initial mixing through final cure shall not exceed 90°F (32°C). The aggregates and/or mixing water shall be cooled as necessary to maintain the lean concrete temperature at or not more than the specified maximum. Ice or ice water may be substituted for the mixing water for this purpose. The Contractor shall adhere to the practices recommended in ACI 305R.

In addition, during periods of warm weather when the maximum daily air temperature exceeds 85°F (30°C), the forms and/or the underlying material shall be sprinkled with water immediately before placing the lean concrete.

306-5.1.3 Rain. All mixing and batching operations should be halted during rain showers and any plastic lean concrete placed should be covered immediately. The lean concrete shall be kept covered with plastic sheeting or other waterproof material until such time that the rain does not make any surface indentation on the lean concrete layer. Areas damaged by rain shall be refinished or replaced.

306-5.2 Form setting. Forms shall be set sufficiently in advance of the lean concrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the grade shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place with not less than three (3) pins for each 10 feet (3 m) section. A pin shall be placed at each side of every joint.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/4 inch (6 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of lean concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the lean concrete. When any form has been disturbed or any grade has become unstable, the form shall be reset and rechecked.

306-5.3 Preparation of underlying course. The underlying course shall be checked by the Engineer before placing and spreading operations are started, to ensure it is free of any ruts, depressions, or bumps and is finished to the correct grade. Any ruts or soft yielding places in the underlying course shall be corrected at the Contractor’s expense before the lean concrete mixture is placed. The underlying course should be wetted down in advance of placing the lean concrete to ensure a firm, moist condition at the time of lean concrete placement. The underlying course shall be protected from frost. Usage of chemicals to eliminate frost is not permissible.

306-5.4 Grade control. Grade control between the edges of the pavement shall be accomplished at intervals of 50 feet (15 m) or less on the longitudinal grade and at 25 feet (7.5 m) or less on the transverse grade. To protect the underlying course and ensure proper drainage, the lean concrete paving shall begin along the centerline of the pavement on a crowned section or on the greatest contour elevation of a pavement with variable cross slope.

306-5.5 Handling, measuring, and batching material. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in a manner that prevents segregation and intermixing of deleterious materials.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours transit will be accepted as adequate binning if the car bodies permit free drainage.

Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using approved interlocked proportioning devises. When bulk cement is used, the Contractor shall use a suitable method such as a chute, boot or other device approved by the Engineer to handle the cement between the weighing hopper and the transporting container or into the batch itself for transportation to the mixer, to prevent loss of cement. The device shall provide positive assurance that each batch has the specified cement content.

306-5.6 Mixing. All lean concrete shall be mixed and delivered to the site per the requirements of ASTM C94. The mixing time should be adequate to produce lean concrete that is uniform in appearance, with all ingredients evenly distributed. Mixing time shall be measured from the time all materials are emptied into the drum (provided all the water is added before one-fourth the preset mixing time has elapsed) and continues until the time the discharge chute is opened to deliver the lean concrete.

If mixing in a plant, the mixing time shall not be less than 50 or greater than 90 seconds. If mixing in a truck, the mixing time shall not be less than 70 or more than 125 truck-drum revolutions at a mixing speed of not less than six (6) or more than 18 truck-drum revolutions per minute.

Re-tempering lean concrete by adding water or by other means will not be permitted, except when lean concrete is delivered in truck mixers. With truck mixers, additional water may be added to the batch materials and additional mixing performed to allow proper placement of the material, provided (a) the addition of water is performed within 45 minutes after the initial mixing operations and (b) the slump and water/cementitious ratio specified in the mix design is not exceeded.

306-5.7 Hauling. The elapsed time from the addition of cementitious material to the mix until the lean concrete is deposited in place at the work site shall not exceed 45 minutes when the concrete is hauled in nonagitating trucks, or 90 minutes when it is hauled in truck mixers or truck agitators.

306-5.8 Placing, consolidating, and finishing. Prior to placement of the lean concrete layer, the prepared underlying course shall be moistened with water, without saturating, to prevent rapid loss of moisture from the lean concrete. In cold weather, the underlying course shall be protected so that it will be entirely free of frost when lean concrete is placed.

The Contractor has the option of side- form or slip-form paving. Either option shall require the hauled lean concrete material to be discharged onto the prepared underlying course such that segregation of the mix is minimized and minimum handling of the mix is needed. The lean concrete shall be placed continuously at a uniform rate without unscheduled stops except for equipment failure or other emergencies. Avoid contamination of plastic lean concrete with foreign material on construction equipment, workman's footwear, or any other sources. Lean concrete shall not be mixed, placed, or finished when the natural light is insufficient, unless an adequate artificial lighting system is provided.

306-5.8.1 Side-form construction. For side-form placement, the Contractor shall verify the elevations of the fixed forms so the thickness and finished grade of the lean concrete layer will be in accordance with the requirements of the project plans and specifications. The lean concrete shall be spread uniformly between the forms immediately after it is placed using a spreading machine. Necessary hand spreading shall be done with shovels. Rakes shall not be allowed for spreading lean concrete.

The spreading shall be followed immediately by thorough consolidation using vibrating screeds or spud vibrators. Vibrators may be external or internal type, depending on the thickness of the lean concrete layer. The surface vibrators may be attached to the spreader or they may be mounted on a separate carriage. They shall not come in contact with the joint, subgrade, or side forms. When spud vibrators are used, the lean concrete shall be thoroughly consolidated against and along the faces of all forms and previously placed lean concrete. Vibrators shall not be permitted to come in contact with a joint assembly, the grade, or a side form. In no case shall the vibrator be operated longer than 20 seconds in any one location, nor shall the vibrators be used to move the lean concrete.

Hand finishing will not be permitted except in areas where the mechanical finisher cannot operate.

306-5.8.2 Slip-form construction. For slip-form construction, the Contractor shall verify the elevations of the guide wires controlling slip-form pavers such that the thickness and finished grade of the lean concrete will be in accordance with the requirements of the project plans and specifications. The slip-form paver should spread, consolidate, and shape the freshly placed lean concrete in one complete pass of the machine. The machine shall vibrate and finish the lean concrete for the full width and depth of the layer.

306-5.9 Final finishing. Final finishing shall be accomplished while the lean concrete is still in the plastic state. Limited surface refinishing by hand is acceptable to meet the grade and surface tolerance established in paragraphs 306-6.2.3 and 306-6.2.4, after strike off and consolidation.

If the overlying layer is to be PCC pavement, the surface of the lean concrete shall not be textured. If the overlying layer is to be HMA pavement, and if the bond between the HMA layer and the lean concrete is considered important for pavement performance, tining or scarifying the surface to provide a coarse texture may be permitted.

306-5.10 Joints. Joints shall be constructed as shown on the plans.

306-5.10.1 Construction joints. Locate all longitudinal and transverse construction joints as shown on the plans. If longitudinal joints are not shown, locate longitudinal joints within 6 inches (150 mm) from planned joints in the PCC to be placed over the lean concrete.

306-5.10.2 Contraction joints. If required by paragraph 306-3.1.1 or if shown on the plans, transverse contraction joints shall be constructed by sawing the hardened lean concrete to a depth of at least one-third the thickness of the lean concrete base. These joints shall match within 3 inches (75 mm) the planned joints of the overlying concrete surface.

306-5.10.3 Concrete saws. When sawing of joints are specified, the Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions and at the required rate. The Contractor shall provide at least one standby saw in good working order. An ample supply of saw blades shall be maintained at the site of the work at all times during sawing operations. The Contractor shall provide adequate artificial lighting facilities for night sawing. All equipment shall be on the job at all times during lean concrete placement.

306-5.11 Curing. Immediately after the finishing operations are complete and within two (2) hours of placement of the lean concrete, the entire surface and edges of the newly placed lean concrete shall be sprayed uniformly with white pigmented, liquid membrane forming curing compound. The layer should be kept moist using a moisture-retaining cover or a light application of water until the curing material is applied. The curing compound shall not be applied during rainfall.

The curing material shall be applied at a maximum rate of 200 square feet per gallon (5.0 m^2/l) using pressurized mechanical sprayers. The spraying equipment shall be a fully atomizing type equipped with a tank agitator. At the time of use, the curing compound in the tank shall be thoroughly and uniformly mixed with the pigment. During application the curing compound shall be continuously stirred by mechanical means.

Hand spraying of odd widths or shapes and lean concrete surfaces exposed by the removal of forms is permitted.

If the film of curing material becomes damaged from any cause, including sawing operations, within the required 7-day curing period or until the overlying course is constructed, the damaged portions shall be repaired immediately with additional compound or other approved means as quickly as practical.

Edges of the lean concrete layer shall be sprayed with curing compound immediately following placement with slip-form pavers or when side-forms are removed.

306-5.11.1 Curing in cold weather. The lean concrete shall be maintained at a temperature of at least 50°F (10°C) during curing. Cover lean concrete and provide with a source of heat sufficient to maintain 50°F (10°C) minimum while curing. The Contractor shall adhere to the practices recommended in ACI 306R. The Contractor shall be responsible for the quality and strength of the lean concrete placed during cold weather, and any lean concrete injured by frost action shall be removed and replaced at the Contractor’s expense.

306-5.11.2 Curing in hot weather. Lean concrete temperature from initial mixing through final cure shall not exceed 90°F (32°C). Shade the fresh lean concrete and start curing as soon as the surface is sufficiently hard to permit curing without damage. The Contractor shall adhere to the practices recommended in ACI 305R.

306-5.12 Protection. The Contractor shall protect the lean concrete from injurious action by sun, rain, flowing water, frost, or mechanical injury. Protect lean concrete surfaces from foot and vehicular traffic and other sources of abrasion for a minimum of 72 hours. The Engineer shall decide when the pavement shall be opened to traffic. Traffic shall not be allowed on the pavement until test specimens made per ASTM C31 have attained a compressive strength of 350 psi (2,413 kPa) when tested per ASTM C39. The Contractor shall maintain continuity of applied curing method for the entire curing period.

306-5.13 Bond-breaker. When the lean concrete is placed directly beneath PCC pavement, a bond-breaker shall be used. The entire surface of the lean concrete shall be coated with a de-bonding compound applied in a sufficient quantity to prevent bonding between the PCC pavement and the lean concrete. The Contractor shall be responsible for selecting the de-bonding compound and determining the appropriate application rate. This application shall be made at least eight (8) hours and not more than 24 hours before placement of the PCC pavement. If an impervious membrane is used as a bond breaker, a second application of curing materials is required and shall be placed no more than 24 hours prior to placement of the PCC pavement. After application of the bond-breaker coat, traffic will be limited to that required for placement of the PCC pavement.

MATERIAL ACCEPTANCE

306-6.1 Acceptance sampling and testing. All acceptance sampling and testing, with the exception of coring for thickness determination, necessary to determine conformance with the requirements specified in this section will be performed by the Engineer. The Contractor shall provide the required lean concrete samples during construction for acceptance testing purposes. The samples shall be taken in the presence of the Engineer.

The lean concrete layer shall be tested for air content, strength, thickness, grade, and surface tolerance. Sampling and testing for air shall be as specified in paragraph 306-6.1.1. Sampling and testing for strength, thickness, grade, and surface tolerance shall be on a lot basis, with a lot consisting of either: (1) one day's production not to exceed 2,000 square yards (1700 sq m), or (2) a half day's production, where a day's production is expected to consist of between 2,000 and 4,000 square yards (1675 and 3350 m^2).

Each lot will be divided into four equal sublots. In the event that only three sublots are produced, the three sublots shall constitute a complete lot. If only one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation.

End-of-production sublots (sublots associated with the final placement of lean concrete for the project which are less than a complete lot) shall be handled as (1) three sublots shall constitute a lot, or (2) one or sublots shall be incorporated into the previous lot.

306-6.1.1 Air content testing. Air content tests shall be performed on the first three truckloads of lean concrete produced at the start of operations each day and the first three truckloads produced after any scheduled or non-scheduled shutdown. Additional tests shall be performed each time a sample is taken for a strength test and when requested by the Engineer.

Air content tests shall be made in accordance with ASTM C231. Air content test results shall be between 4% and 8%.

If the first test on a truckload of lean concrete is not within the specification limits, a second test on the same truckload shall be made. If the second test is within the specification limits, the lean concrete will be accepted with respect to entrained air content. If the second test is not within the specification limits, the truckload shall be rejected.

306-6.1.2 Compressive strength testing. One sample of freshly delivered lean concrete shall be taken from each sublot for compressive strength testing. The lean concrete shall be sampled in accordance with ASTM C172. Sampling locations shall be determined per ASTM D3665.

At least two test cylinders shall be made from each sample per ASTM C31. The 7-day compressive strength of each cylinder shall be determined per ASTM C39.

The Contractor shall provide adequate facilities for the initial curing of cylinders. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80°F (16 to 27°C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met.

The compressive strength for each sublot shall be computed by averaging the 7-day compressive strengths of the two test cylinders representing that sublot. The compressive strength of the lot shall be the average compressive strength of the individual sublots comprising the lot.

Specimens that are noticeably defective shall not be considered in the determination of the strength. If the test specimens fail to conform to the requirements for strength, the Engineer shall request changes in the lean concrete mixture to increase the strength to meet the requirements.

If the maximum 7-day compressive strength values exceed the maximum strength requirements when evaluated in accordance with paragraph 306-6-2.1, the Contractor shall propose a jointing plan for approval by the Engineer.

306-6.1.3 Thickness testing. After the lean concrete base has cured for three (3) days, one 4-inch (100 mm) diameter core per sublot shall be obtained per ASTM D3665. The thickness of each sampled core shall be determined using the caliper measurement procedures per ASTM C174. The average thickness for the lot shall be determined using the individual sublot core thicknesses. Acceptance criteria for lean concrete thickness are provided in paragraph 306-6.2.2.

When such measurement is deficient more than 1/2 inch (12 mm) and not more than 1 inch (25 mm) from the plan thickness, two additional cores shall be taken at random and used in determining the average thickness for that lot. The thickness of the cores shall be determined by average caliper measurement of cores tested in accordance with ASTM C174.

At all locations where cores have been drilled, the resulting holes shall be filled with lean concrete or non-shrink grout material, as approved by the Engineer.

306-6.1.4 Grade testing. The elevations of the finished lean concrete shall be surveyed on both sides of the lean concrete lane, every 25 feet (7.5 m).

306-6.1.5 Surface tolerance testing. After the lean concrete has hardened sufficiently, it shall be tested for surface tolerance with a 12 feet (3.7 m) straightedge provided by the Contractor.

306-6.2 Acceptance criteria. Acceptance of lean concrete will be based on compressive strength, thickness, grade, and surface tolerance, as described in the paragraphs below.

306-6.2.1 Compressive strength requirements. The lean concrete shall meet all of the following compressive strength requirements on a lot basis:

- The compressive strength of the lot, tested at seven (7) days, shall be greater than 500 pounds per square inch (3,445 kPa). When a given lot of lean concrete fails to meet the minimum compressive strength requirements, the entire lot shall be replaced at the Contractor’s expense.
- Not more than 20% of the individual cylinders in a given lot, tested at seven (7) days, shall have a compressive strength greater than 800 pounds per square inch (5,512 kPa). When greater than 20% of the individual cylinders in a given lot have 7-day compressive strengths in excess of 800 pounds per square inch (5,512 kPa), and transverse joints have not been constructed, a bond-breaker shall be used.

306-6.2.2 Thickness requirements. The completed thickness shall be as shown on the plans. When the average lot thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness, full payment shall be made. If the lot average thickness is deficient by more than one inch (25 mm), it shall be removed and replaced at the Contractor’s expense. When such measurement is deficient more than 1/2 inch (12 mm) and not more than one inch (25 mm) from the plan thickness, one additional core shall be taken at random from each sublot within the lot. The thickness of these additional cores shall be determined as indicated in paragraph 304-6.1.2. A new lot average thickness shall be recomputed based on these additional cores and the original cores taken from each sublot. When the recomputed average lot thickness is not deficient by more than 1/2 inch (12 mm) from the plan thickness, full payment shall be made. If the average lot thickness is deficient by more than 1/2 inch (12 mm) from the plan thickness, the entire lot shall be removed and replaced at the Contractor’s expense or shall be permitted to remain in place at an adjusted payment of 75% of the contract unit price.

When the measured thickness is more than that indicated on the plans, it will be considered as conforming to the requirements, provided the surface of the completed lean concrete layer is within the established grade and surface tolerance requirements.

306-6.2.3 Grade requirements. When the completed surface is more than 1/2 inch (12 mm) above the grade shown in the plans, the surface shall be trimmed at the Contractor's expense using an approved grinding machine to an elevation that falls within a tolerance of 1/4 inch (6 mm).

306-6.2.4 Surface tolerance requirements. Surface deviations shall not exceed 3/8 inch (9 mm) from a 12-foot (3.7-m) straightedge laid in any location parallel with or at right angles to the longitudinal axis of the centerline (includes along all edges of the paving lane). Any high spots of more than 3/8 inch (9 mm) in 12-foot (3.7-m) shall be marked and immediately trimmed with an approved grinding machine. If the overlying layer is PCC pavement, the ground surface shall be sprayed with a double application of the curing compound at the specified rate prior to paving.

METHOD OF MEASUREMENT

306-7.1 The quantity of lean concrete will be determined by the number of square yard (m^2) of lean concrete actually constructed and accepted by the Engineer as complying with the plans and specifications.

BASIS OF PAYMENT

306-8.1 The accepted quantities of lean concrete will be paid for at the contract unit price per square yard (m^2) for lean concrete base. The price and payment shall be full compensation for furnishing and placing all materials, provided; however, for any pavement found deficient in thickness as specified in paragraph 306-6.2.2, the reduced unit price shall be paid.

Item P-306-8.1	Payment will be made for lean concrete base course - per square yard (m^2).

TESTING REQUIREMENTS

ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C192	Standard Practice for Making and Curing Concrete Test Specimens in the Laboratory
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregates (Accelerated Mortar-Bar Method)
AASHTO T136	Standard Method of Test for Freezing-and-Thawing Tests of Compacted Soil-Cement Mixtures
ASTM D3665	Standard Practice for Random Sampling of Construction Materials

MATERIAL REQUIREMENTS

ACI 305R	Guide to Hot Weather Concreting
ACI 306R	Guide to Cold Weather Concreting
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C150	Standard Specification for Portland Cement
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Specification for Coal Fly Ash and Raw and Calcined Natural Pozzolans for Use in Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars

END OF ITEM P-306

Part 5 – Flexible Surface Courses

Item P-401 Hot Mix Asphalt (HMA) Pavements

DESCRIPTION

401-1.1 This item shall consist of pavement courses composed of mineral aggregate and asphalt cement binder (asphalt binder) mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross-sections shown on the plans. Each course shall be constructed to the depth, typical section, and elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

MATERIALS

401-2.1 Aggregate. Aggregates shall consist of crushed stone, crushed gravel, crushed slag, screenings, natural sand and mineral filler, as required. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause "rust" staining that can bleed through pavement markings. The portion retained on the No. 4 (4.75 mm) sieve is coarse aggregate. The portion passing the No. 4 (4.75 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler.

a. Coarse aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from films of matter that would prevent thorough coating and bonding with the bituminous material and free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 40% when tested in accordance with ASTM C131. The sodium sulfate soundness loss shall not exceed 12%, or the magnesium sulfate soundness loss shall not exceed 18%, after five cycles, when tested in accordance with ASTM C88. Clay lumps and friable particles shall not exceed 1.0% when tested in accordance with ASTM C142.

Aggregate shall contain at least 75 percent by weight of individual pieces having two or more fractured faces and 85 percent by weight having at least one fractured face. The area of each face shall be equal to at least 75% of the smallest midsectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be achieved by crushing.

The aggregate shall not contain more than a total of 8%, by weight, of flat particles, elongated particles, and flat and elongated particles, when tested in accordance with ASTM D4791 with a value of 5:1

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C29.

b. Fine aggregate. Fine aggregate shall consist of clean, sound, tough, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter.

The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than six (6) and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

Clay lumps and friable particles shall not exceed 1.0%, by weight, when tested in accordance with ASTM C142.

Natural (non-manufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. The fine aggregate shall not contain more than 15% natural sand by weight of total aggregates. If used, the natural sand shall meet the requirements of ASTM D1073 and shall have a plasticity index of not more than six (6) and a liquid limit of not more than 25 when tested in accordance with ASTM D4318.

The aggregate shall have sand equivalent values of 45 or greater when tested in accordance with ASTM D2419.

c. Sampling. ASTM D75 shall be used in sampling coarse and fine aggregate, and ASTM C183 shall be used in sampling mineral filler.

401-2.2 Mineral filler. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D242.

401-2.3 Asphalt cement binder. Asphalt cement binder shall conform to ASTM D6373 Performance Grade (PG) 76-22. A certificate of compliance from the manufacturer shall be included with the mix design submittal.

The supplier’s certified test report with test data indicating grade certification for the asphalt binder shall be provided to the Engineer for each load at the time of delivery to the mix plant. A certified test report with test data indicating grade certification for the asphalt binder shall also be provided to the Engineer for any modification of the asphalt binder after delivery to the mix plant and before use in the HMA.

401-2.4 Preliminary material acceptance. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse aggregate:

(1) Percent of wear

(2) Soundness

(3) Clay lumps and friable particles

(4) Percent fractured faces

(5) Flat and elongated particles

(6) Unit weight of slag

b. Fine aggregate:

(1) Liquid limit and Plasticity index

(2) Soundness

(3) Clay lumps and friable particles

(4) Percent natural sand

(5) Sand equivalent

c. Mineral filler.

d. Asphalt binder. Test results for asphalt binder shall include temperature/viscosity charts for mixing and compaction temperatures.

The certifications shall show the appropriate ASTM tests for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

401-2.5 Anti-stripping agent. Any anti-stripping agent or additive if required shall be heat stable, shall not change the asphalt cement viscosity beyond specifications, shall contain no harmful ingredients, shall be added in recommended proportion by approved method, and shall be a material approved by the Department of Transportation of the State in which the project is located.

COMPOSITION

401-3.1 Composition of mixture. The HMA mix shall be composed of a mixture of well-graded aggregate, filler and anti-strip agent if required, and asphalt binder. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

401-3.2 Job mix formula (JMF). No hot-mixed asphalt (HMA) for payment shall be produced until a JMF has been approved in writing by the Engineer. The asphalt mix-design and JMF shall be prepared by an accredited laboratory that meets the requirements of paragraph 401-3.4. The HMA shall be designed using procedures contained in Asphalt Institute MS-2 Mix Design Manual, 7th Edition. ASTM D6926 shall be used for preparation of specimens using the manually held and operated hammer for the mix design procedure. ASTM D6927 shall be used for testing for Marshall stability and flow.

If material variability exceeds the standard deviations indicated, the JMF and subsequent production targets shall be based on a stability greater than shown in Table 1 and the flow shall be targeted close to the mid-range of the criteria in order to meet the acceptance requirements.

Tensile strength ratio (TSR) of the composite mixture, as determined by ASTM D4867, shall not be less than 75 when tested at a saturation of 70-80% or an anti-stripping agent shall be added to the HMA, as necessary, to produce a TSR of not less than 75 when tested at a saturation of 70-80%. If an anti-strip agent is required, it shall be provided by the Contractor at no additional cost to the Owner.

The JMF shall be submitted in writing by the Contractor at least 30 days prior to the start of paving operations. The JMF shall be developed within the same construction season using aggregates currently being produced.

The submitted JMF shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

a. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percent by weight of each stockpile used in the job mix formula.

b. Percent of asphalt cement.

c. Asphalt performance grade and type of modifier if used.

d. Number of blows per side of molded specimen**.**

e. Laboratory mixing temperature.

f. Laboratory compaction temperature.

g. Temperature-viscosity relationship of the PG asphalt cement binder showing acceptable range of mixing and compaction temperatures; and for modified binders include supplier recommended mixing and compaction temperatures.

h. Plot of the combined gradation on a 0.45 power gradation curve.

i. Graphical plots of stability, flow, air voids, voids in the mineral aggregate, and unit weight versus asphalt content

j. Specific Gravity and absorption of each aggregate.

k. Percent natural sand.

l. Percent fractured faces.

m. Percent by weight of flat particles**,** elongated particles, and flat and elongated particles (and criteria).

n. Tensile Strength Ratio (TSR).

o. Anti-strip agent (if required).

p. Date the JMF was developed. Mix designs that are not dated or which are from a prior construction season shall not be accepted.

The Contractor shall submit to the Engineer the results of verification testing of three (3) asphalt samples prepared at the optimum asphalt content. The average of the results of this testing shall indicate conformance with the JMF requirements specified in Tables 1 and 3.

When the project requires asphalt mixtures of differing aggregate gradations, a separate JMF and the results of JMF verification testing shall be submitted for each mix.

The JMF for each mixture shall be in effect until a modification is approved in writing by the Engineer. Should a change in sources of materials be made, a new JMF must be submitted within 15 days and approved by the Engineer in writing before the new material is used. After the initial production JMF has been approved by the Engineer and a new or modified JMF is required for whatever reason, the subsequent cost of the Engineer's approval of the new or modified JMF, including a new test strip when required by the engineer, will be borne by the Contractor. There will be no time extension given or considerations for extra costs associated with the stoppage of production paving or restart of production paving due to the time needed for the Engineer to approve the initial, new or modified JMF.

The Marshall Design Criteria applicable to the project shall meet the criteria specified in Table 1**.**

Table 1. Marshall Design Criteria

Test Property	Value
Number of blows	75
Stability, pounds (Newtons) minimum	21502150 (9560)
Flow, 0.01 in. (0.25 mm)	10-16
Air voids (%)	3.5
Percent voids in mineral aggregate, minimum	See Table 2

Table 2. Minimum Percent Voids In Mineral Aggregate (VMA)

Aggregate (See Table 3)	Minimum VMA
Gradation 3	16%
~~Gradation 2~~	~~15%~~
~~Gradation 1~~	~~14%~~

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory sieves, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM C136 and ASTM C117.

The gradations in Table 3 represent the limits that shall determine the suitability of aggregate for use from the sources of supply; be well graded from coarse to fine and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa.

Table 3. Aggregate - HMA Pavements

Sieve Size	Percentage by Weight Passing Sieve
1 inch (25 mm)	100
3/4 inch (19 mm)	76-98
1/2 inch (12 mm)	66-86
3/8 inch (9 mm)	57-77
No. 4 (4.75 mm)	40-60
No. 8 (2.36 mm)	26-46
No. 16 (1.18 mm)	17-37
No. 30 (0.60 mm)	11-27
No. 50 (0.30 mm)	7-19
No. 100 (0.15 mm)	6-16
No. 200 (0.075 mm)	3-6
Asphalt Percent:	
Stone or gravel	5.5-8.0
Slag	7.0-10.5

The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when aggregates of varying specific gravities are used, as indicated in the Asphalt Institute MS-2 Mix Design Manual, 7th Edition.

401-3.3 Reclaimed asphalt pavement (RAP).

RAP shall not be used.

401-3.4 Job mix formula (JMF) laboratory. The Contractor's laboratory used to develop the JMF shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the JMF must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

401-3.5 Test section.

A test section is not required.

CONSTRUCTION METHODS

401-4.1 Weather limitations. The HMA shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

Table 4. Surface Temperature Limitations of Underlying Course

Mat Thickness	Base Temperature (Minimum)	
	°F	°C
3 inches (7.5 cm) or greater	40	4
Greater than 2 inches (50 mm) but less than 3 inches (7.5 cm)	45	7

401-4.2 HMA plant. Plants used for the preparation of HMA shall conform to the requirements of American Association of State Highway and Transportation Officials (AASHTO) M156 with the following changes:

Requirements for all plants include:

a. Truck scales. The HMA shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, subsection 90-01.

In lieu of scales, and as approved by the Engineer, HMA weight may be determined by the use of an electronic weighing system equipped with an automatic printer that weighs the total HMA production and as often thereafter as requested by the Engineer.

b. Testing facilities. The Contractor shall ensure laboratory facilities are provided at the plant for the use of the Engineer. The lab shall have sufficient space and equipment so that both testing representatives (Engineer's and Contractor's) can operate efficiently. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, calibrations, current reference standards to comply with the specifications and a masonry saw with diamond blade for trimming pavement cores and samples.

The plant testing laboratory shall have a floor space area of not less than 200 square feet (18.5 sq m), with a ceiling height of not less than 7-1/2 feet (2 m). The laboratory shall be weather tight, sufficiently heated in cold weather, air-conditioned in hot weather to maintain temperatures for testing purposes of 70°F ±5°F (21°C ±2.3°C). The plant testing laboratory shall be located on the plant site to provide an unobstructed view, from one of its windows, of the trucks being loaded with the plant mix materials. In addition, the facility shall include the minimum:

(1) Adequate artificial lighting.

(2) Electrical outlets sufficient in number and capacity for operating the required testing equipment and drying samples.

(3) A minimum of two (2) Underwriter's Laboratories approved fire extinguishers of the appropriate types and class.

(4) Work benches for testing.

(5) Desk with chairs and file cabinet.

(6) Sanitary facilities convenient to testing laboratory.

(7) Exhaust fan to outside air.

(8) Sink with running water.

Failure to provide the specified facilities shall be sufficient cause for disapproving HMA plant operations.

Laboratory facilities shall be kept clean, and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting the test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

c. Inspection of plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant: verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

d. Storage bins and surge bins. The HMA stored in storage and surge bins shall meet the same requirements as HMA loaded directly into trucks and may be permitted under the following conditions:

(1) Stored in non-insulated bins for a period of time not to exceed three (3) hours.

(2) Stored in insulated bins for a period of time not to exceed eight (8) hours.

If the Engineer determines that there is an excessive amount of heat loss, segregation, or oxidation of the HMA due to temporary storage, no temporary storage will be allowed.

401-4.3 Hauling equipment. Trucks used for hauling HMA shall have tight, clean, and smooth metal beds. To prevent the HMA from sticking to the truck beds, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other material approved by the Engineer. Petroleum products shall not be used for coating truck beds. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

401-4.3.1 Material transfer vehicle (MTV). Material transfer vehicles are not required.

401-4.4 HMA pavers. HMA pavers shall be self-propelled with an activated heated screed, capable of spreading and finishing courses of HMA that will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the HMA uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

If, during construction, it is found that the spreading and finishing equipment in use leaves tracks or indented areas, or produces other blemishes in the pavement that are not satisfactorily corrected by the scheduled operations, the use of such equipment shall be discontinued and satisfactory equipment shall be provided by the Contractor.

401-4.4.1 Automatic grade controls. The HMA paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices that will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within ±0.1%.

The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet (9 m) in length.

b. Taut string-line (wire) set to grade.

c. Short ski or shoe.

d. Laser control.

401-4.5 Rollers. Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the HMA. The number, type, and weight of rollers shall be sufficient to compact the HMA to the required density while it is still in a workable condition.

All rollers shall be specifically designed and suitable for compacting HMA concrete and shall be properly used. Rollers that impair the stability of any layer of a pavement structure or underlying soils shall not be used. Depressions in pavement surfaces caused by rollers shall be repaired by the Contractor at their own expense.

The use of equipment that causes crushing of the aggregate will not be permitted.

401-4.6. Density device. The Contractor shall have on site a density gauge during all paving operations in order to assist in the determination of the optimum rolling pattern, type of roller and frequencies, as well as to monitor the effect of the rolling operations during production paving. The Contractor shall also supply a qualified technician during all paving operations to calibrate the gauge and obtain accurate density readings for all new HMA. These densities shall be supplied to the Engineer upon request at any time during construction. No separate payment will be made for supplying the density gauge and technician.

401-4.7 Preparation of asphalt binder. The asphalt binder shall be heated in a manner that will avoid local overheating and provide a continuous supply of the asphalt binder to the mixer at a uniform temperature. The temperature of unmodified asphalt binder delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325°F (160°C) when added to the aggregate. The temperature of modified asphalt binder shall be no more than 350°F (175°C) when added to the aggregate.

401-4.8 Preparation of mineral aggregate. The aggregate for the HMA shall be heated and dried. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350°F (175°C) when the asphalt binder is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

401-4.9 Preparation of HMA. The aggregates and the asphalt binder shall be weighed or metered and introduced into the mixer in the amount specified by the JMF. The combined materials shall be mixed until the aggregate obtains a uniform coating of asphalt binder and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM

D2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95% of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all HMA upon discharge shall not exceed 0.5%.

401-4.10 Preparation of the underlying surface. Immediately before placing the HMA, the underlying course shall be cleaned of all dust and debris. A prime coat **or** tack coat shall be applied in accordance with Item P-602 **or** P-603 , if shown on the plans.

401-4.11 Laydown plan, transporting, placing, and finishing. Prior to the placement of the HMA, the Contractor shall prepare a laydown plan for approval by the Engineer. This is to minimize the number of cold joints in the pavement. The laydown plan shall include the sequence of paving laydown by stations, width of lanes, temporary ramp locations, and laydown temperature. The laydown plan shall also include estimated time of completion for each portion of the work (that is, milling, paving, rolling, cooling, etc.). Modifications to the laydown plan shall be approved by the Engineer.

The HMA shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 401-4.3. Deliveries shall be scheduled so that placing and compacting of HMA is uniform with minimum stopping and starting of the paver. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose for the first lift of all runway and taxiway pavements. Successive lifts of HMA surface course may be placed using a ski, or laser control per paragraph 401-4.4.1, provided grades of the first lift of HMA surface course meet the tolerances of paragraphs 401-5.2b(6) as verified by a survey. Contractor shall survey each lift of HMA surface course and certify to Engineer that every lot of each lift meets the grade tolerances of paragraph 401-5.2b(6) before the next lift can be placed.

The initial placement and compaction of the HMA shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250°F (121°C).

Edges of existing HMA pavement abutting the new work shall be saw cut and carefully removed as shown on the drawings and coated with asphalt tack coat before new material is placed against it.

Upon arrival, the HMA shall be placed to the full width by a HMA paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the HMA mat. Unless otherwise permitted, placement of the HMA shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. ~~The HMA shall be placed in consecutive adjacent strips having a minimum width of **[ ]** feet (m) except where edge lanes require less width to complete the area.~~ Additional screed sections shall not be attached to widen paver to meet the minimum lane width requirements specified above unless additional auger sections are added to match. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1 foot (30 cm); however, the joint in the surface top course shall be at the centerline of crowned pavements. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

~~Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).~~

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the HMA may be spread and luted by hand tools.

Areas of segregation in the surface course, as determined by the Engineer, shall be removed and replaced at the Contractor’s expense. The area shall be removed by saw cutting and milling a minimum of 2 inches

(50 mm) deep. The area to be removed and replaced shall be a minimum width of the paver and a minimum of 10 feet (3 m) long.

401-4.12 Compaction of HMA. After placing, the HMA shall be thoroughly and uniformly compacted by power rollers. The surface shall be compacted as soon as possible when the HMA has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor. The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross-section, and the required field density is obtained. To prevent adhesion of the HMA to the roller, the wheels shall be equipped with a scraper and kept properly moistened but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with approved power driven tampers. Tampers shall weigh not less than 275 pounds (125 kg), have a tamping plate width not less than 15 inches (38 cm), be rated at not less than 4,200 vibrations per minute, and be suitably equipped with a standard tamping plate wetting device.

Any HMA that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor’s expense. Skin patching shall not be allowed.

401-4.13 Joints. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid HMA except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be coated with an asphalt tack coat before placing any fresh HMA against the joint.

Longitudinal joints which have been left exposed for more than four (4) hours; the surface temperature has cooled to less than 175°F (80°C); or are irregular, damaged, uncompacted or otherwise defective shall be cut back 3 inches (75 mm) to 6 inches (150 mm) to expose a clean, sound, uniform vertical surface for the full depth of the course. All cutback material shall be removed from the project. Asphalt tack coat or other product approved by the Engineer shall be applied to the clean, dry joint, prior to placing any additional fresh HMA against the joint. Any laitance produced from cutting joints shall be removed by vacuuming and washing. The cost of this work shall be considered incidental to the cost of the HMA.

401-4.14 Saw-cut grooving. If ~~shown on the plans, saw cut grooves shall be provided as specified in Item P-621.~~

401-4.15 Diamond grinding. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the pavement will not be permitted. The depth of grinding shall not exceed 1/2 inch (13mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. Areas that have been ground will be sealed with a P-608 surface treatment as directed by the Engineer. It may be necessary to seal a larger area to avoid surface treatment creating any conflict with runway or taxiway markings.

401-4.16 Nighttime paving requirements. Paving during nighttime construction shall require the following:

a. All paving machines, rollers, distribution trucks and other vehicles required by the Contractor for his operations shall be equipped with artificial illumination sufficient to safely complete the work.

b. Minimum illumination level shall be twenty (20) horizontal foot-candles and maintained in the following areas:

(1) An area of 30 feet (9 m) wide by 30 feet (9 m) long immediately behind the paving machines during the operations of the machines.

(2) An area 15 feet (4.5 m) wide by 30 feet (9 m) long immediately in front and back of all rolling equipment, during operation of the equipment.

(3) An area 15 feet (4.5 m) wide by 15 feet (4.5 m) long at any point where an area is being tack coated prior to the placement of pavement.

c. As partial fulfillment of the above requirements, the Contractor shall furnish and use, complete artificial lighting units with a minimum capacity of 3,000 watt electric beam lights, affixed to all equipment in such a way to direct illumination on the area under construction.

d. A lighting plan must be submitted by the Contractor and approved by the Engineer prior to the start of any nighttime work.

MATERIAL ACCEPTANCE

401-5.1 Acceptance sampling and testing. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the Contractor except that coring **[** and profilograph testing **]** as required in this section shall be completed and paid for by the Contractor.

Testing organizations performing these tests **[** except profilograph **]** shall be accredited in accordance with ASTM D3666. The laboratory accreditation must be current and listed on the accrediting authority’s website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory’s current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction. All equipment in Contractor furnished laboratories shall be calibrated by an independent testing organization prior to the start of operations at the Contractor’s expense.

a. Hot mixed asphalt. Plant-produced HMA shall be tested for air voids and stability and flow on a lot basis. Sampling shall be from material deposited into trucks at the plant or from trucks at the job site. Samples shall be taken in accordance with ASTM D979.

A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

Where more than one plant is simultaneously producing HMA for the job, the lot sizes shall apply separately for each plant.

(1) Sampling. Each lot will consist of four equal sublots. Sufficient HMA for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D3665. Samples will be taken in accordance with ASTM D979.

The sample of HMA may be put in a covered metal tin and placed in an oven for not less than 30 minutes nor more than 60 minutes to stabilize to compaction temperature. The compaction temperature of the specimens shall be as specified in the JMF.

(2) Testing. Sample specimens shall be tested for stability and flow in accordance with ASTM D6927. Air voids will be determined by the Engineer in accordance with ASTM D3203. One set of laboratory compacted specimens will be prepared for each sublot in accordance with ASTM D6926 at the number of blows required by paragraph 401-3.2, Table 1. Each set of laboratory compacted specimens will consist of three test specimens prepared from the same sample. The manual hammer in ASTM D6926 shall be used, however mechanical hammers may be used if they are approved by the engineer and calibrated to the same manual hammer density by varying the number of blows and for each specific mix. When calibrating the mechanical hammer, at least 5 samples should be compacted with the manual hammer (50 or 75 blows as specified) to establish an average density. Five samples should also be compacted at various blow counts with the mechanical hammer and plotted to give a curve that shows density vs blows. Where the average density of the manual hammer intersects the curve developed from the mechanical hammer, the number of blows required for the mechanical hammer is identified. The guide to control the vertical axis of the hammer shall not be used during compaction.

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D2726 using the procedure for laboratory-prepared thoroughly dry specimens for use in computing air voids and pavement density.

For air voids determination, the theoretical maximum specific gravity of the mixture shall be measured one time for each sublot in accordance with ASTM D2041. The value used in the air voids computation for each sublot shall be based on theoretical maximum specific gravity measurement for the sublot.

The stability and flow for each sublot shall be computed by averaging the results of all test specimens representing that sublot.

(3) Acceptance. Acceptance of plant produced HMA for stability, flow, and air voids shall be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b.

b. In-place HMA. HMA placed in the field shall be tested for mat and joint density on a lot basis. A standard lot shall be equal to one day’s production or 2000 tons (1814 metric tons) whichever is smaller. If the day’s production is expected to exceed 2000 tons (1814 metric tons), but less than 4000 tons (3628 metric tons), the lot size shall be 1/2 day’s production. If the day’s production exceeds 4000 tons (3628 metric tons), the lot size shall be an equal sized fraction of the day’s production, but shall not exceed 2000 tons (1814 metric tons).

(1) Mat density. The lot size shall be the same as that indicated in paragraph 401-5.1a and shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665. Cores for mat density shall not be taken closer than one foot (30 cm) from a transverse or longitudinal joint.

(2) Joint density. The lot size shall be the total length of longitudinal joints constructed by a lot of HMA as defined in paragraph 401-5.1a. The lot shall be divided into four equal sublots. One core of finished, compacted HMA shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D3665.

All cores for joint density shall be taken centered on the joint. The minimum core diameter for joint density determination shall be 5 inches (125 mm).

(3) Sampling. Samples shall be neatly cut with a diamond core drill bit. Samples will be taken in accordance with ASTM D979. The minimum diameter of the sample shall be 5 inches (125 mm). Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples, cleaning, and filling the cored pavement. Cored pavement shall be cleaned and core holes shall be filled in a manner acceptable to the Engineer and within one day after sampling. Laitance produced by the coring operation shall be removed immediately.

The top most lift of HMA shall be completely bonded to the underlying layer. If any of the cores reveal that the surface is not bonded to the layer immediately below the surface then additional cores shall be taken as directed by the Engineer in accordance with paragraph 401-5.1b to determine the extent of any delamination. All delaminated areas shall be completely removed by milling to the limits and depth and replaced as directed by the Engineer at no additional cost.

(4) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D2726. Samples will be taken in accordance with ASTM D979. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the average bulk specific gravity of all laboratory prepared specimens for the lot, as determined in paragraph 401-5.1a(2). The bulk specific gravity used to determine the joint density at joints formed between different lots shall be the lowest of the bulk specific gravity values from the two different lots.

(5) Acceptance. Acceptance of field placed HMA for mat density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b(1). Acceptance for joint density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b(3).

c. Partial lots. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. In addition, an agreed to minor placement will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, that is, $n = 5$ or $n = 6$, for example. Partial lots at the end of asphalt production on the project shall be included with the previous lot. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, shall less than three (3) cored samples be obtained, that is, $n = 3$.

401-5.2 Acceptance criteria.

a. General. Acceptance will be based on the following characteristics of the HMA and completed pavement as well as the implementation of the Contractor Quality Control Program and test results:

(1) Air voids

(2) Mat density

(3) Joint density

(4) Thickness

(5) Smoothness

(6) Grade

(7) Stability

(8) Flow

Mat density and air voids will be evaluated for acceptance in accordance with paragraph 401-5.2b(1). Stability and flow will be evaluated for acceptance in accordance with paragraph 401-5.2b(2). Joint density will be evaluated for acceptance in accordance with paragraph 401-5.2b(3).

Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 401-5.2b(4). Acceptance for smoothness will be based on the criteria contained in paragraph 401-5.2b(5). Acceptance for grade will be based on the criteria contained in paragraph 401-5.2b(7).

The Engineer may at any time, reject and require the Contractor to dispose of any batch of HMA which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Acceptance criteria.

(1) Mat density and air voids. Acceptance of each lot of plant produced material for mat density and air voids shall be based on the percentage of material within specification limits (PWL). If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment shall be determined in accordance with paragraph 401-8.1.

(2) Stability [and flow]. Acceptance of each lot of plant produced HMA for stability and flow shall be based on the PWL. If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. If the PWL is less than 90%, the Contractor shall determine the reason and take corrective action. If the PWL is below 80%, the Contractor must stop production until the reason for poor stability and/or flow has been determined and adjustments to the HMA are made.

(3) Joint density. Acceptance of each lot of plant produced HMA for joint density shall be based on the PWL. If the PWL of the lot is equal to or exceeds 90%, the lot shall be considered acceptable. If the PWL is less than 90%, the Contractor shall evaluate the reason and act accordingly. If the PWL is less than 80%, the Contractor shall cease operations and until the reason for poor compaction has been determined. If the PWL is less than 71%, the pay factor for the lot used to complete the joint shall be reduced by five (5) percentage points. This lot pay factor reduction shall be incorporated and evaluated in accordance with paragraph 401-8.1.

(4) Thickness. Thickness of each lift of surface course shall be evaluated by the Engineer for compliance to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each sublot for density measurement. The maximum allowable deficiency at any point shall not be more than 1/4 inch (6 mm) less than the thickness indicated for the lift. Average thickness of lift, or combined lifts, shall not be less than the indicated thickness. Where the thickness tolerances are not met, the lot or sublot shall be corrected by the Contractor at his expense by removing the deficient area and replacing with new pavement. The Contractor, at his expense, may take additional cores as approved by the Engineer to circumscribe the deficient area.

(5) Smoothness. The final surface shall be free from roller marks. After the final rolling, but not later than 24 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The Contractor shall furnish paving equipment and employ methods that produce a surface for each pavement lot having an average profile index meeting the requirements of paragraph 401-8.1d when evaluated with a profilograph; and the finished surface course of the pavement shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface course smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the surface course, full depth removal and replacement of surface course corrections shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified. The Contractor shall apply a surface treatment per Item P-608 or P-609 to all areas that have been subject to grinding as directed by the Engineer.

(a) Transverse measurements. Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the Engineer.

(i) Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. High spots on final surface course > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet (15m) or more often if directed by the Engineer. Deviations on final surface course > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

(b) Longitudinal measurements. Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6m); and at the third points of paving lanes when widths of paving lanes are 20 ft (6m) or greater.

(i) Longitudinal Short Sections. Longitudinal Short Sections are when the longitudinal lot length is less than 200 feet (60m) and areas not requiring a profilograph. When approved by the Engineer, the first and last 15 feet (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final surface course > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

~~(ii) Profilograph Testing. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must grind" bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing.~~

~~The pavement must have an average profile index meeting the requirements of paragraph 401-8.1d. High spots, or "must grind" spots, on final surface course in longitudinal direction shall be corrected with diamond grinding per paragraph 401-4.15 or by removing and replacing full depth of surface course. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.~~

~~Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15 inches (38 cm) per mile or less. If the initial average profile index was less than 15 inches (38 cm), only those areas representing greater than 0.4 inch (10 mm) deviation will be re-profiled for correction verification.~~

~~(iii) Final profilograph of [runway]. Final profilograph, full length of runway, shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274.The pavement must have an average profile index meeting the requirements of paragraph 401-8.1d. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate "must grind" bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing. Profilograph of final runway shall be performed one foot right and left of runway centerline and 15 feet (4.5 m) right and left of centerline. Any areas that indicate "must grind" will be corrected as directed by the Engineer.~~

Smoothness testing indicated in the above paragraph~~s except paragraph (iii)~~ shall be performed within 24 hours of placement of material~~. Smoothness testing indicated in paragraph (iii) shall be performed within 48 hours of paving completion.~~ The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor's machines and/or methods are producing significant areas that need corrective actions then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

(6) Grade. Grade shall be evaluated on the first day of placement and then as a minimum, every **2 days or less** to allow adjustments to paving operations if measurements do not meet specification requirements. The Contractor must submit the survey data to the Engineer by the following day after measurements have been taken. The finished surface of the pavement shall not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet (15 m)) to determine the elevation of the completed pavement. The Contractor shall pay the cost of surveying of the level runs that shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer. The lot size shall be **2,000** square yards (m^2). When more than 15% of all the measurements within a lot are outside the specified tolerance, or if any one shot within the lot deviates 3/4 inch (19 mm) or more from planned grade, the Contractor shall remove the deficient area to the depth of the final course plus 1/2 inch (12 mm) of pavement and replace with new material. Skin patching shall not be permitted. Isolated high points may be ground off provided the course thickness complies with the thickness specified on the plans. The surface of the ground pavement shall have a texture consisting of grooves between 0.090 and 0.130 inches (2 and 3.5 mm) wide. The peaks and ridges shall be approximately 1/32 inch (1 mm) higher than the bottom of the grooves. The pavement shall be left in a clean condition. The removal of all of the slurry resulting from the grinding operation shall be continuous The grinding operation should be controlled so the residue from the operation does not flow across other lanes of pavement. High point grinding will be limited to 15 square yards (12.5 m^2). Areas in excess of 15 square yards (12.5 m^2) will require removal and replacement of the pavement in accordance with the limitations noted above. The Contractor shall apply a surface treatment per P-608 to all areas that have been subject to grinding.

c. Percentage of material within specification limits (PWL). The PWL shall be determined in accordance with procedures specified in Section 110 of the General Provisions. The specification tolerance limits (L) for lower and (U) for upper are contained in Table 5.

Table 5. Marshall acceptance limits for stability, flow, air voids, density

TEST PROPERTY		
Number of Blows	75 blows	
	Specification Tolerance Limits	
	L	**U**
Stability, minimum (lbs)	1800	**--**
Flow, 0.01-in	8	18*
Air Voids Total Mix (%)	2	5
Surface Course Mat Density (%)	96.3	**[** 101.3 **]**
Base Course Mat Density (%)	95.5	**[** 101.3 **]**
Joint density (%)	93.3	**--**

d. Outliers. All individual tests for mat density and air voids shall be checked for outliers (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the PWL shall be determined using the remaining test values.The criteria in Table 5 is based on production processes which have a variability with the following standard deviations: Surface Course Mat Density (%), 1.30; Base Course Mat Density (%), 1.55; Joint Density (%), 2.1.

The Contractor should note that (1) 90 PWL is achieved when consistently producing a surface course with an average mat density of at least 98% with 1.30% or less variability, (2) 90 PWL is achieved when consistently producing a base course with an average mat density of at least 97.5% with 1.55% or less variability, and (3) 90 PWL is achieved when consistently producing joints with an average joint density of at least 96% with 2.1% or less variability.

401-5.3 Resampling pavement for mat density.

a. General. Resampling of a lot of pavement will only be allowed for mat density, and then, only if the Contractor requests same, in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 401-5.1b and 401-5.2b(1). Only one resampling per lot will be permitted.

(1) A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for resampled lots. The redefined PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 6.

c. Outliers. Check for outliers in accordance with ASTM E178, at a significance level of 5%.

CONTRACTOR QUALITY CONTROL

401-6.1 General. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including, but not limited to:

a. Mix design

b. Aggregate grading

c. Quality of materials

d. Stockpile management

e. Proportioning

f. Mixing and transportation

g. Placing and finishing

h. Joints

i. Compaction

j. Surface smoothness

k. Personnel

l. Laydown plan

The Contractor shall perform quality control sampling, testing, and inspection during all phases of the work and shall perform them at a rate sufficient to ensure that the work conforms to the contract requirements, and at minimum test frequencies required by paragraph 401-6.3 and Section 100 of the General Provisions. As a part of the process for approving the Contractor's plan, the Engineer may require the Contractor's technician to perform testing of samples to demonstrate an acceptable level of performance.

No partial payment will be made for materials that are subject to specific quality control requirements without an approved plan.

401-6.2 Contractor testing laboratory. The lab shall meet the requirements of ASTM D3666 including all necessary equipment, materials, and current reference standards to comply with the specifications. All costs associated with the testing laboratory shall be included in the unit prices for P-401.

401-6.3 Quality control testing. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the approved Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Asphalt content. A minimum of two asphalt content tests shall be performed per lot in accordance with ASTM D6307 or ASTM D2172 if the correction factor in ASTM D6307 is greater than 1.0. The asphalt content for the lot will be determined by averaging the test results.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with ASTM D5444, ASTM C136, and ASTM C117.

c. Moisture content of aggregate. The moisture content of aggregate used for production shall be determined a minimum of once per lot in accordance with ASTM C566.

d. Moisture content of HMA. The moisture content shall be determined once per lot in accordance with ASTM D1461.

e. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the asphalt binder in the storage tank, the HMA at the plant, and the HMA at the job site.

f. In-place density monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D2950.

g. Additional testing. Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

h. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

401-6.4 Sampling. When directed by the Engineer, the Contractor shall sample and test any material that appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

401-6.5 Control charts. The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for aggregate gradation, asphalt content, and VMA. The VMA for each sublot will be calculated and monitored by the Quality Control laboratory.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual measurements. Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation, asphalt content, and VMA. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

Control Chart Limits For Individual Measurements		
Sieve	**Action Limit**	**Suspension Limit**
3/4 inch (19 mm)	±6%	±9%
1/2 inch (12 mm)	±6%	±9%
3/8 inch (9 mm)	±6%	±9%
No. 4 (4.75 mm)	±6%	±9%
No. 16 (1.18 mm)	±5%	±7.5%
No. 50 (0.30 mm)	±3%	±4.5%
No. 200 (0.075 mm)	±2%	±3%
Asphalt Content	±0.45%	±0.70%
VMA	-1.00%	-1.50%

b. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

Control Chart Limits Based On Range (Based On n = 2)	
Sieve	**Suspension Limit**
1/2 inch (12 mm)	11%
3/8 inch (9 mm)	11%
No. 4 (4.75 mm)	11%
No. 16 (1.18 mm)	9%
No. 50 (0.30 mm)	6%
No. 200 (0.075 mm)	3.5%
Asphalt Content	0.8%

c. Corrective Action. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range; or

(2) Two points in a row fall outside the Action Limit line for individual measurements.

401-6.6 Quality control reports. The Contractor shall maintain records and shall submit reports of quality control activities daily, in accordance with the Contractor Quality Control Program described in General Provisions, Section 100.

METHOD OF MEASUREMENT

401-7.1 Measurement. HMA shall be measured by the number of tons (kg) of HMA used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage.

Bituminous surface course material utilized in emergency repair shall be measured by the number of square yards of material constructed and accepted. This shall include all associated demolition operations.

BASIS OF PAYMENT

401-8.1 Payment. Payment for a lot of HMA meeting all acceptance criteria as specified in paragraph 401-5.2 shall be made based on results of tests for mat density and air voids. Payment for acceptable lots shall be adjusted according to paragraph 401-8.1a for mat density and air voids and 401-8.1c for smoothness, subject to the limitation that:

a. The total project payment for plant mix bituminous concrete pavement shall not exceed **100** percent of the product of the contract unit price and the total number of tons (kg) of HMA used in the accepted work (See Note 1 under Table 6).

b. The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

c. Basis of adjusted payment. The pay factor for each individual lot shall be calculated in accordance with Table 6. A pay factor shall be calculated for both mat density and air voids. The lot pay factor shall be the higher of the two values when calculations for both mat density and air voids are 100% or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either mat density or air voids is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both mat density and air voids are less than 100%. If PWL for joint density is less than 71 percent then the lot pay factor shall be reduced by 5% but be no higher than 95%.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 401-8.1. Payment in excess of 100% for accepted lots of HMA shall be used to offset payment for accepted lots of bituminous concrete pavement that achieve a lot pay factor less than 100%.

Table 6. Price adjustment schedule[1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
93 – 100	103
90 – 93	PWL + 10
70 – 89	0.125 PWL + 88.75
40 – 69	0.75 PWL + 45
Below 40	Reject [2]

[1] Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment above 100% shall be subject to the total project payment limitation specified in paragraph 401-8.1.

[2] The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment shall be reduced by the amount withheld for the rejected lot.

~~**d. Profilograph smoothness.** When the final average profile index (subsequent to any required corrective action) does not exceed 7 inches per mile (18 cm per 1.6 km), payment will be made at the contract unit price for the completed pavement. If the final average profile index (subsequent to any required corrective action) exceeds 7 inches per mile (18 cm per 1.6 km), but does not exceed 15 inches per mile (38 cm per 1.6 m), the Contractor may elect to accept a contract unit price adjustment in lieu of reducing the profile index.~~

~~**e. Basis of adjusted payment for smoothness.** Price adjustment for pavement smoothness will be made in accordance with Table 7. The adjustment will apply to the total tonnage of HMA within a lot of pavement and shall be applied with the following equation:~~

~~(Tons of asphalt concrete in lot) × (lot pay factor) × (unit price per ton) × (smoothness pay factor) = payment for lot~~

~~**Table 7. Profilograph Average Profile Index Smoothness Pay Factor**~~

~~**Inches/miles per 1/10 mile**~~	~~**Short Sections**~~	~~**Pay Factor**~~
~~0.0 - 7~~	~~00.0 - 15.0~~	~~100%~~
~~7.1 - 9~~	~~15.1 - 16~~	~~98%~~
~~9.1 - 11~~	~~16.1 - 17~~	~~96%~~
~~11.1 - 13~~	~~17.1 - 18~~	~~94%~~
~~13.1 - 14~~	~~18.1 - 20~~	~~92%~~
~~14.1 - 15~~	~~20.1 - 22~~	~~90%~~
~~15.1 and up~~	~~22.1 and up~~	~~Corrective work required[1]~~

~~[1] The Contractor shall correct pavement areas not meeting these tolerances by removing and replacing the defective work. If the Contractor elects to construct an overlay to correct deficiencies, the minimum thickness of the overlay should be at least three times the maximum aggregate size (approximately four (4) times the nominal maximum aggregate size). The corrective overlay shall not violate grade Criteria and butt joints shall be constructed by sawing and removing the original pavement in compliance with the thickness/ maximum aggregate size ratio. Skin patching shall not be permitted.~~

~~HMA placed above the specified grade shall not be included in the quantities for payment~~.

Payment for bituminous material placed and utilized for emergency repairs shall be made at the contract unit price per square yard. This payement shall be full compensation for all associated demolition operations, for furnishing all materials, for preparing and placing these materials, and for all labor equipment, tools, and incidentals necessary to complete the item.

401-8.1.1. Payment. Payment will be made under:

Item P-401-8.1.1	Bituminous Surface Course (PG76-22)- per ton (kg)
Item P-401-8.2	Bituminous Base Course (PG 76-22) -- per ton (kg)
Item P-401-8.3	Demo & Bituminous Surface Course (PG 76-22) – Emergency Repair -- per square yard
Item P-401-8.4	Bituminous Surface Course (PG 76-22) - Haul Road Repair -- per ton

TESTING REQUIREMENTS

ASTM C29	Standard Test Method for Bulk Density (“Unit Weight”) and Voids in Aggregate

ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C127	Standard Test Method for Density, Relative Density (Specific Gravity) and Absorption of Coarse Aggregate
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C183	Standard Practice for Sampling and the Amount of Testing of Hydraulic Cement
ASTM C566	Standard Test Method for Total Evaporable Moisture Content of Aggregate by Drying
ASTM D75	Standard Practice for Sampling Aggregates
ASTM D979	Standard Practice for Sampling Bituminous Paving Mixtures
ASTM D1073	Standard Specification for Fine Aggregate for Bituminous Paving Mixtures
ASTM D2172	Standard Test Method for Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D1461	Standard Test Method for Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D2041	Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D2419	Standard Test Method for Sand Equivalent Value of Soils and Fine Aggregate
ASTM D2489	Standard Practice for Estimating Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D2726	Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures
ASTM D2950	Standard Test Method for Density of Bituminous Concrete in Place by Nuclear Methods
ASTM D3203	Standard Test Method for Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D3666	Standard Specification for Minimum Requirements for Agencies Testing and Inspecting Road and Paving Materials
ASTM D4318	Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM D4867	Standard Test Method for Effect of Moisture on Asphalt Concrete Paving Mixtures

ASTM D5444	Standard Test Method for Mechanical Size Analysis of Extracted Aggregate
ASTM D6084	Standard Test Method for Elastic Recovery of Bituminous Materials by Ductilometer
ASTM D6307	Standard Test Method for Asphalt Content of Hot Mix Asphalt by Ignition Method
ASTM D6752	Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures Using Automatic Vacuum Sealing Method
ASTM D6926	Standard Practice for Preparation of Bituminous Specimens Using Marshall Apparatus
ASTM D6927	Standard Test Method for Marshall Stability and Flow of Bituminous mixtures
ASTM E11	Standard Specification for Woven Wire Test Sieve Cloth and Test Sieves
ASTM E178	Standard Practice for Dealing with Outlying Observations
ASTM E1274	Standard Test Method for Measuring Pavement Roughness Using a Profilograph
AASHTO T030	Standard Method of Test for Mechanical Analysis of Extracted Aggregate
AASHTO T110	Standard Method of Test for Moisture or Volatile Distillates in Hot Mix Asphalt (HMA)
AASHTO T275	Standard Method of Test for Bulk Specific Gravity (Gmb) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens
AASHTO M156	Standard Specification for Requirements for Mixing Plants for Hot-Mixed, Hot-Laid Bituminous Paving Mixtures.
AASHTO T329	Standard Method of Test for Moisture Content of Hot Mix Asphalt (HMA) by Oven Method
Asphalt Institute Handbook MS-26,	Asphalt Binder
Asphalt Institute MS-2	Mix Design Manual, 7th Edition

MATERIAL REQUIREMENTS

ASTM D242	Standard Specification for Mineral Filler for Bituminous Paving Mixtures
ASTM D946	Standard Specification for Penetration-Graded Asphalt Cement for Use in Pavement Construction
ASTM D3381	Standard Specification for Viscosity-Graded Asphalt Cement for Use in Pavement Construction
ASTM D4552	Standard Practice for Classifying Hot-Mix Recycling Agents
ASTM D6373	Standard Specification for Performance Graded Asphalt Binder

END OF ITEM P-401

Part 6 – Rigid Pavement

Item P-501 Portland Cement Concrete (PCC) Pavement

DESCRIPTION

501-1.1 This work shall consist of pavement composed of portland cement concrete (PCC), with reinforcement constructed on a prepared underlying surface in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross-sections shown on the plans.

MATERIALS

501-2.1 Aggregates.

a. Reactivity. Fine and Coarse aggregates to be used in all concrete shall be evaluated and tested by the Contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and ASTM C1567. Aggregate and mix proportion reactivity tests shall be performed for each project.

(1) Coarse and fine aggregate shall be tested separately in accordance with ASTM C1260. The aggregate shall be considered innocuous if the expansion of test specimens, tested in accordance with ASTM C1260, does not exceed 0.10% at 28 days (30 days from casting).

(2) Combined coarse and fine aggregate shall be tested in accordance with ASTM C1567, modified for combined aggregates, using the proposed mixture design proportions of aggregates, cementitious materials, and/or specific reactivity reducing chemicals. If lithium nitrate is proposed for use with or without supplementary cementitious materials, the aggregates shall be tested in accordance with Corps of Engineers (COE) Concrete Research Division (CRD) C662. If lithium nitrate admixture is used, it shall be nominal 30% ±0.5% weight lithium nitrate in water.

(3) If the expansion of the proposed combined materials test specimens, tested in accordance with ASTM C1567, modified for combined aggregates, or COE CRD C662, does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion of the proposed combined materials test specimens is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

b. Fine aggregate. Fine aggregate shall conform to the requirements of ASTM C33. Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33 and shall have a fineness modulus of not less than 2.50 nor more than 3.40. The soundness loss shall not exceed 10% when sodium sulfate is used or 15% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

The amount of deleterious material in the fine aggregate shall not exceed the following limits:

Limits for Deleterious Substances in Fine Aggregate for Concrete

Deleterious material	ASTM	Percentage by Mass
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than 0.075mm (No. 200 sieve)	ASTM C117	3.0
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Total of all deleterious Material		3.0

c. Coarse aggregate. Gradation, within the separated size groups, shall meet the coarse aggregate grading requirements of ASTM C33 when tested in accordance with ASTM C136. When the nominal maximum size of the aggregate is greater than one inch (25 mm), the aggregates shall be furnished in two size groups.

Aggregates delivered to the mixer shall consist of crushed stone, crushed or uncrushed gravel, ~~air-cooled iron blast furnace slag,~~ crushed recycled concrete pavement, or a combination. The aggregates should be free of ferrous sulfides, such as pyrite, that would cause “rust” staining that can bleed through pavement markings. Steel blast furnace slag shall not be permitted. The aggregate shall be composed of clean, hard, uncoated particles. Dust and other coating shall be removed from the aggregates by washing.

The percentage of wear shall be no more than **40%** when tested in accordance with ASTM C131.

The quantity of flat, elongated, and flat and elongated particles in any size group coarser than 3/8 sieve (9 mm) shall not exceed 8% by weight when tested in accordance with ASTM D4791. A flat particle is defined as one having a ratio of width to thickness greater than 5. An elongated particle is one having a ratio of length to width greater than 5.

The soundness loss shall not exceed 12% when sodium sulfate is used or 18% when magnesium sulfate is used, after five cycles, when tested per ASTM C88.

The amount of deleterious material in the coarse aggregate shall not exceed the following limits:

Limits for Deleterious Substances in Coarse Aggregate for Concrete

Deleterious material	ASTM	Percentage by Mass
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than No. 200 sieve (0.075mm)	ASTM C117	1.0
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Chert (less than 2.40 Sp Gr.)	ASTM C123 using a medium with a density of Sp. Gr. of 2.40)	1.0
Total of all deleterious Material		3.0

Table 1. Gradation For Coarse Aggregate

(ASTM C33)

Sieve Designations (square openings)		Percentage by Weight Passing Sieves		
		From 1-1/2 inch to No. 4 (38 mm - 4.75 mm)		From 1 inch to No. 4 (25.0 mm-4.75 mm)
		#4 1-1/2 inch - 3/4 inch	#67 3/4 inch - No. 4	#57 1 inch - No. 4
inch	mm			
2-1/2	60	---	---	---
2	50	100	---	---
1-1/2	38	90-100	---	100
1	25	20-55	100	95-100
3/4	19	0-15	90-100	---
1/2	13	---	---	25-60
3/8	9	0-5	20-55	---
No. 4	4.75	---	0-10	0-10
No. 8	2.36	---	0-5	0-5

(1) Aggregate susceptibility to durability (D) cracking. Coarse aggregate may be accepted from sources that have a 20 year service history for the same gradation to be supplied with no durability issues. Aggregates that do not have a record of 20 years of service without major repairs (less than 5% of slabs replaced) in similar conditions without D-cracking shall not be used unless it meets the following:

(a) Material currently being produced shall have a durability factor ≥ 95 using ASTM C666 procedure B. Coarse aggregates that are crushed granite, calcite cemented sandstone, quartzite, basalt, diabase, rhyolite or trap rock are considered to meet the D-cracking test but must meet all other quality tests. Aggregates meeting State Highway Department material specifications may be acceptable.

(b) The Contractor shall submit a current certification that the aggregate does not have a history of D-cracking and that the aggregate meets the state specifications for use in PCC pavement for use on interstate highways. Certifications, tests and any history reports must be for the same gradation as being proposed for use on the project. Certifications which are not dated or which are over one (1) year old or which are for different gradations will not be accepted. Test results will only be accepted when tests were performed by a State Department of Transportation (DOT) materials laboratory or an accredited laboratory.

(2) Combined aggregate gradation. If substituted for the grading requirements specified for coarse aggregate and for fine aggregateand when approved by the Engineer, the combined aggregate grading shall meet the following requirements:

(a) The materials selected and the proportions used shall be such that when the Coarseness Factor (CF) and the Workability Factor (WF) are plotted on a diagram as described in d. below, the point thus determined shall fall within the parallelogram described therein.

(b) The CF shall be determined from the following equation:

CF = (cumulative percent retained on the 3/8 in. sieve)(100) / (cumulative percent retained on the No. 8 sieve)

(c) The Workability Factor WF is defined as the percent passing the No. 8 (2.36 mm) sieve based on the combined gradation. However, WF shall be adjusted, upwards only, by 2.5 percentage points for each 94 pounds (42 kg) of cementitious material per cubic meter yard greater than 564 pounds per cubic yard (335 kg per cubic meter).

(d) A diagram shall be plotted using a rectangular scale with WF on the Y-axis with units from 20 (bottom) to 45 (top), and with CF on the X-axis with units from 80 (left side) to 30 (right side). On this diagram a parallelogram shall be plotted with corners at the following coordinates (CF-75, WF-28), (CF-75, WF-40), (CF-45, WF-32.5), and (CF-45, WF-44.5). If the point determined by the intersection of the computed CF and WF does not fall within the above parallelogram, the grading of each size of aggregate used and the proportions selected shall be changed as necessary.

Reference United States Air Force Engineering Technical Letter (ETL) 97-5:
Proportioning Concrete Mixtures with Graded Aggregates for Rigid Airfield Pavements.
The ETL is available at the following website:
http://www.wbdg.org/ccb/AF/AFETL/etl_97_5.pdf.

501-2.2 Cement. Cement shall conform to the requirements of ASTM C150 Type I/II. Low Alkali cements which contains less than 0.6% equivalent alkalies shall be used.

If aggregates are deemed innocuous when tested in accordance with paragraph 501-2.1.a.1 and accepted in accordance with paragraph 501-2.1.a.2, higher equivalent alkali content in the cement may be allowed if approved by the Engineer and FAA. If cement becomes partially set or contains lumps of caked cement, it shall be rejected. Cement salvaged from discarded or used bags shall not be used.

501-2.3 Cementitious materials.

a. Fly ash. Fly ash Class C shall meet the requirements of ASTM C618, with the exception of loss of ignition, where the maximum shall be less than 6%. Fly ash for use in mitigating alkali-silica reactivity shall have a Calcium Oxide (CaO) content of less than 13% and a total available alkali content less than 3% per ASTM C311. Fly ash produced in furnace operations using liming materials or soda ash (sodium carbonate) as an additive shall not be acceptable. The Contractor shall furnish the previous three most recent, consecutive ASTM C618 reports for each source of fly ash proposed in the mix design, and shall furnish each additional report as they become available during the project. The reports can be used for acceptance or the material may be tested independently by the Engineer.

b. Slag cement (ground granulated blast furnace(GGBF)). Slag cement shall conform to ASTM C989, Grade 100 or Grade 120. Slag cement shall be used only at a rate between 25% and 55% of the total cementitious material by mass.

c. Raw or calcined natural pozzolan. Natural pozzolan shall be raw or calcined and conform to ASTM C618, Class N, including the optional requirements for uniformity and effectiveness in controlling Alkali-Silica reaction and shall have a loss on ignition not exceeding 6%. Class N pozzolan for use in mitigating Alkali-Silica Reactivity shall have a total available alkali content less than 3%.

d. Ultrafine fly ash and ultrafine pozzolan. UltraFine Fly Ash (UFFA) and UltraFine Pozzolan (UFP) shall conform to ASTM C618, Class F or N, and the following additional requirements:

(1) The strength activity index at 28 days of age shall be at least 95% of the control specimens.

(2) The average particle size shall not exceed 6 microns.

501-2.4 Joint seal. The joint seal for the joints in the concrete pavement shall meet the requirements of Item P-604 or Item P-605 and shall be of the type specified in the plans.

501-2.5 Isolation joint filler. Premolded joint filler for isolation joints shall conform to the requirements of ASTM and shall be where shown on the plans. The filler for each joint shall be furnished in a single piece for the full depth and width required for the joint, unless otherwise specified by the Engineer. When the use of more than one piece is required for a joint, the abutting ends shall be fastened securely and held accurately to shape by stapling or other positive fastening means satisfactory to the Engineer.

501-2.6 Steel reinforcement. Reinforcing shall consist of Welded Wire Steel Fabric conforming to the requirements of ASTM A1064. Welded wire fabric shall be furnished in flat sheets only.

501-2.7 Dowel and tie bars. Dowel bars shall be plain steel bars conforming to ASTM A615 and shall be free from burring or other deformation restricting slippage in the concrete. Before delivery to the construction site each dowel bar shall be epoxy coated per ASTM A1078. The dowels shall be coated with a bond-breaker recommended by the manufacturer. Dowel sleeves or inserts are not permitted. Grout retention rings shall be fully circular metal or plastic devices capable of supporting the dowel until the grout hardens.

Tie bars shall be deformed steel bars and conform to the requirements of ASTM A615. Tie bars designated as Grade 60 in ASTM A615 or ASTM A706 shall be used for construction requiring bent bars.

501-2.8 Water. Water used in mixing or curing shall be potable, clean, free of oil, salt, acid, alkali, sugar, vegetable, or other substances injurious to the finished product, except that non-potable water, or water from concrete production operations, may be used if it meets the requirements of ASTM C1602.

501-2.9 Material for curing concrete. Curing materials shall conform to one of the following specifications:

a. Liquid membrane-forming compounds for curing concrete shall conform to the requirements of ASTM C309, Type 2, Class B, or Class A if wax base only.

b. ~~White polyethylene film for curing concrete shall conform to the requirements of ASTM C171.~~

~~**c.** White burlap-polyethylene sheeting for curing concrete shall conform to the requirements of ASTM C171.~~

d. ~~Waterproof paper for curing concrete shall conform to the requirements of ASTM C171.~~

501-2.10 Admixtures. The Contractor shall submit certificates indicating that the material to be furnished meets all of the requirements indicated below. In addition, the Engineer may require the Contractor to submit complete test data from an approved laboratory showing that the material to be furnished meets all of the requirements of the cited specifications. Subsequent tests may be made of samples taken by the

Engineer from the supply of the material being furnished or proposed for use on the work to determine whether the admixture is uniform in quality with that approved.

a. Air-entraining admixtures. Air-entraining admixtures shall meet the requirements of ASTM C260 and shall consistently entrain the air content in the specified ranges under field conditions. The air-entrainment agent and any water reducer admixture shall be compatible.

b. Water-reducing admixtures. Water-reducing admixture shall meet the requirements of ASTM C494, Type A, B, or D. ASTM C494, Type F and G high range water reducing admixtures and ASTM C1017 flowable admixtures shall not be used.

c. Other admixtures. The use of set retarding, and set-accelerating admixtures shall be approved by the Engineer. Retarding shall meet the requirements of ASTM C494, Type A, B, or D and set-accelerating shall meet the requirements of ASTM C494, Type C. Calcium chloride and admixtures containing calcium chloride shall not be used.

d. Lithium Nitrate. The lithium admixture shall be a nominal 30% aqueous solution of Lithium Nitrate, with a density of 10 pounds/gallon (1.2 kg/L), and shall have the approximate chemical form as shown below:

Constituent	Limit (Percent by Mass)
$LiNO_3$ (Lithium Nitrate)	30 ±0.5
SO_4 (Sulfate Ion)	0.1 (max)
Cl (Chloride Ion)	0.2 (max)
Na (Sodium Ion)	0.1 (max)
K (Potassium Ion)	0.1 (max)

Provide a trained manufacturer's representative to supervise the lithium nitrate admixture dispensing and mixing operations.

501-2.11 Epoxy-resin. All epoxy-resin materials shall be two-component materials conforming to the requirements of ASTM C881, Class as appropriate for each application temperature to be encountered, except that in addition, the materials shall meet the following requirements:

a. Material for use for embedding dowels and anchor bolts shall be Type IV, Grade 3.

b. Material for use as patching materials for complete filling of spalls and other voids and for use in preparing epoxy resin mortar shall be Type III, Grade as approved.

c. Material for use for injecting cracks shall be Type IV, Grade 1.

d. Material for bonding freshly mixed Portland cement concrete or mortar or freshly mixed epoxy resin concrete or mortar to hardened concrete shall be Type V, Grade as approved.

501-2.12 Material acceptance. Prior to use of materials, the Contractor shall submit certified test reports to the Engineer for those materials proposed for use during construction. The certification shall show the appropriate ASTM test for each material, the test results, and a statement that the material passed or failed.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

MIX DESIGN

501-3.1. General. No concrete shall be placed until the mix design has been submitted to the Engineer for review and the Engineer has taken appropriate action. The Engineer's review shall not relieve the Contractor of the responsibility to select and proportion the materials to comply with this section.

501-3.2 Proportions. The laboratory preparing the mix design shall be accredited in accordance with ASTM C1077. The mix design for all Portland cement concrete placed under P-501 shall be stamped or sealed by the responsible professional Engineer of the laboratory. Concrete shall be proportioned to achieve a 28-day flexural strength that meets or exceeds the acceptance criteria contained in paragraph 501-5.2 for a flexural strength of **650** psi per ASTM C78. The mix shall be developed using the procedures contained in the Portland Cement Association's (PCA) publication, "Design and Control of Concrete Mixtures".

The minimum cementitious material shall be adequate to ensure a workable, durable mix. The minimum cementitious material (cement plus fly ash, or slag cement) shall be **470** pounds per cubic yard. The ratio of water to cementitious material, including free surface moisture on the aggregates but not including moisture absorbed by the aggregates shall not be more than 0.45 by weight.

Flexural strength test specimens shall be prepared in accordance with ASTM C192 and tested in accordance with ASTM C78. The mix determined shall be workable concrete having a maximum allowable slump between one and two inches (25mm and 50 mm) as determined by ASTM C143. For slip-form concrete, the slump shall be between 1/2 inch (12 mm) and 1-1/2 inch (38 mm). At the start of the project, the Contractor shall determine a maximum allowable slump for slip-form pavement which will produce in-place pavement to control the edge slump. The selected slump shall be applicable to both pilot and fill-in lanes.

Before the start of paving operations and after approval of all material to be used in the concrete, the Contractor shall submit a mix design showing the proportions and flexural strength obtained from the concrete at seven (7) and 28 days. The mix design shall include copies of test reports, including test dates, and a complete list of materials including type, brand, source, and amount of cement, fly ash, ground slag, coarse aggregate, fine aggregate, water, and admixtures. The mix design shall be submitted to the Engineer at least 30 days prior to the start of operations. The submitted mix design shall not be more than 90 days old. Production shall not begin until the mix design is approved in writing by the Engineer.

If a change in sources is made, or admixtures added or deleted from the mix, a new mix design must be submitted to the Engineer for approval. Previously approved mix designs for airfield paving older than 90 days shall not be used without re-submitting and re-approval.

The results of the mix design shall include a statement giving the maximum nominal coarse aggregate size and the weights and volumes of each ingredient proportioned on a one cubic yard (meter) basis. Aggregate quantities shall be based on the mass in a saturated surface dry condition. The recommended mixture proportions shall be accompanied by test results demonstrating that the proportions selected will produce concrete of the qualities indicated. Trial mixtures having proportions, slumps, and air content suitable for the work shall be based on methodology described in PCA's publication, Design and Control of Concrete Mixtures, modified as necessary to accommodate flexural strength.

The submitted mix design shall be stamped or sealed by the responsible professional Engineer of the laboratory and shall include the following items as a minimum:

a. Coarse, fine, and combined aggregate gradations and plots including fineness modulus of the fine aggregate.

b. Reactivity Test Results.

c. Coarse aggregate quality test results, including deleterious materials.

d. Fine aggregate quality test results, including deleterious materials.

e. Mill certificates for cement and supplemental cementitious materials.

f. Certified test results for all admixtures, including Lithium Nitrate if applicable.

g. Specified flexural strength, slump, and air content.

h. Recommended proportions/volumes for proposed mixture and trial water-cementitious materials ratio, including actual slump and air content.

i. Flexural and compressive strength summaries and plots, including all individual beam and cylinder breaks.

j. Correlation ratios for acceptance testing and Contractor Quality Control testing, when applicable.

k. Historical record of test results documenting production standard deviation, when applicable.

501-3.3 Cementitious materials.

a. Fly ash. When fly ash is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If fly ash is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

b. Slag cement (ground granulated blast furnace (GGBF)). Slag cement may be used. The slag cement, or slag cement plus fly ash if both are used, may constitute between 25 to 55% of the total cementitious material by weight. If the concrete is to be used for slipforming operations and the air temperature is expected to be lower than 55°F (13°C) the percent slag cement shall not exceed 30% by weight.

c. Raw or calcined natural pozzolan. Natural pozzolan may be used in the mix design. When pozzolan is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between 20 and 30% by weight of the total cementitious material. If pozzolan is used in conjunction with slag cement the maximum replacement rate shall not exceed 10% by weight of total cementitious material.

d. Ultrafine fly ash (UFFA) and ultrafine pozzolan (UFP). UFFA and UFP may be used in the mix design with the Engineer’s approval. When UFFA and UFP is used as a partial replacement for cement, the replacement rate shall be determined from laboratory trial mixes, and shall be between seven (7) and 16% by weight of the total cementitious material.

501-3.4 Admixtures.

a. Air-entraining admixtures. Air-entraining admixture are to be added in such a manner that will ensure uniform distribution of the agent throughout the batch. The air content of freshly mixed air-entrained concrete shall be based upon trial mixes with the materials to be used in the work adjusted to produce concrete of the required plasticity and workability. The percentage of air in the mix shall be 4%. Air content shall be determined by testing in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag and other highly porous coarse aggregate.

b. Water-reducing admixtures. Water-reducing admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, with the materials to be used in the work, in accordance with ASTM C494.

c. Other admixtures. Set controlling, and other approved admixtures shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements. Tests shall be conducted on trial mixes, with the materials to be used in the work, in accordance with ASTM C 494.

d. Lithium nitrate. Lithium nitrate shall be added to the mix in the manner recommended by the manufacturer and in the amount necessary to comply with the specification requirements in accordance with paragraph 501-2.10d.

501-3.5 Concrete mix design laboratory. The Contractor's laboratory used to develop the concrete mix design shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for developing the concrete mix design must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction

CONSTRUCTION METHODS

501-4.1 Equipment. Equipment necessary for handling materials and performing all parts of the work shall be approved by the Engineer, but does not relieve the Contractor of the responsibility for the proper operation of equipment and maintaining the equipment in good working condition. The equipment shall be at the jobsite sufficiently ahead of the start of paving operations to be examined thoroughly and approved.

a. Batch plant and equipment. The batch plant and equipment shall conform to the requirements of ASTM C94.

b. Mixers and transportation equipment.

(1) General. Concrete may be mixed at a central plant, or wholly or in part in truck mixers. Each mixer shall have attached in a prominent place a manufacturer's nameplate showing the capacity of the drum in terms of volume of mixed concrete and the speed of rotation of the mixing drum or blades.

(2) Central plant mixer. Central plant mixers shall conform to the requirements of ASTM C94. The mixer shall be examined daily for changes in condition due to accumulation of hard concrete or mortar or wear of blades. The pickup and throwover blades shall be replaced when they have worn down 3/4 inch (19 mm) or more. The Contractor shall have a copy of the manufacturer's design on hand showing dimensions and arrangement of blades in reference to original height and depth.

(3) Truck mixers and truck agitators. Truck mixers used for mixing and hauling concrete and truck agitators used for hauling central-mixed concrete shall conform to the requirements of ASTM C94.

(4) Nonagitator trucks. Nonagitating hauling equipment shall conform to the requirements of ASTM C94.

(5) Transfer and spreading equipment. Equipment for transferring concrete from the transporting equipment to the paving lane in front of the paver shall be specially manufactured, self-propelled transfer equipment which will accept the concrete outside the paving lane and will transfer and spread it evenly across the paving lane in front of the paver and strike off the surface evenly to a depth which permits the paver to operate efficiently.

c. Finishing equipment. The standard method of constructing concrete pavements shall be with an approved slip-form paving equipment designed and operated to spread, consolidate, screed, and float-finish the freshly placed concrete in one complete pass of the machine so that the end result is a dense and homogeneous pavement which is achieved with a minimum of hand finishing. The paver-finisher shall be a heavy duty, self-propelled machine designed specifically for paving and finishing high quality concrete pavements. It shall weigh at least 2,200 lbs per foot (3274 kg/m) of paving lane width and powered by an engine having at least 6.0 horsepower per foot of lane width.

On projects requiring less than 500 square yard (418 sq m) of cement concrete pavement or requiring individual placement areas of less than 500 square yard (418 sq m), or irregular areas at locations inaccessible to slip-form paving equipment, concrete pavement may be placed with approved placement and finishing equipment using stationary side forms. Hand screeding and float finishing may only be used on small irregular areas as allowed by the Engineer.

d. Vibrators. Vibrator shall be the internal type. Operating frequency for internal vibrators shall be between 8,000 and 12,000 vibrations per minute. Average amplitude for internal vibrators shall be 0.025-0.05 inch (0.06 - 0.13 cm).

The number, spacing, and frequency shall be as necessary to provide a dense and homogeneous pavement and meet the recommendations of American Concrete Institute (ACI) 309, Guide for Consolidation of Concrete. Adequate power to operate all vibrators shall be available on the paver. The vibrators shall be automatically controlled so that they shall be stopped as forward motion ceases. The Contractor shall provide an electronic or mechanical means to monitor vibrator status. The checks on vibrator status shall occur a minimum of two times per day or when requested by the Engineer.

Hand held vibrators may be used in irregular areas only, but shall meet the recommendations of ACI 309R, Guide for Consolidation of Concrete.

e. Concrete saws. The Contractor shall provide sawing equipment adequate in number of units and power to complete the sawing to the required dimensions. The Contractor shall provide at least one standby saw in good working order and a supply of saw blades at the site of the work at all times during sawing operations. Early-entry saws may be used, subject to demonstration and approval of the Engineer.

f. Side forms. Straight side forms shall be made of steel and shall be furnished in sections not less than 10 feet (3 m) in length. Forms shall have a depth equal to the pavement thickness at the edge, and a base width equal to or greater than the depth. Flexible or curved forms of proper radius shall be used for curves of 100-foot (31 m) radius or less. Forms shall be provided with adequate devices for secure settings so that when in place they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms with battered top surfaces and bent, twisted or broken forms shall not be used. Built-up forms shall not be used, except as approved by the Engineer. The top face of the form shall not vary from a true plane more than 1/8 inch (3 mm) in 10 feet (3 m), and the upstanding leg shall not vary more than 1/4 inch (6 mm). The forms shall contain provisions for locking the ends of abutting sections together tightly for secure setting. Wood forms may be used under special conditions, when approved by the Engineer.

g. Pavers. The paver shall be fully energized, self-propelled, and designed for the specific purpose of placing, consolidating, and finishing the concrete pavement, true to grade, tolerances, and cross-section. It shall be of sufficient weight and power to construct the maximum specified concrete paving lane width as shown in the plans, at adequate forward speed, without transverse, longitudinal or vertical instability or without displacement. The paver shall be equipped with electronic or hydraulic horizontal and vertical control devices.

501-4.2 Form setting. Forms shall be set sufficiently in advance of the concrete placement to ensure continuous paving operation. After the forms have been set to correct grade, the underlying surface shall be thoroughly tamped, either mechanically or by hand, at both the inside and outside edges of the base of the forms. Forms shall be staked into place sufficiently to maintain the form in position for the method of placement.

Form sections shall be tightly locked and shall be free from play or movement in any direction. The forms shall not deviate from true line by more than 1/8 inch (3 mm) at any joint. Forms shall be so set that they will withstand, without visible spring or settlement, the impact and vibration of the consolidating and finishing equipment. Forms shall be cleaned and oiled prior to the placing of concrete.

The alignment and grade elevations of the forms shall be checked and corrections made by the Contractor immediately before placing the concrete.

501-4.3 Conditioning of underlying surface. The compacted underlying surface on which the pavement will be placed shall be widened approximately 3 feet (1 m) to extend beyond the paving machine track to support the paver without any noticeable displacement. After the underlying surface has been placed and compacted to the required density, the areas that will support the paving machine and the area to be paved shall be trimmed or graded to the plan grade elevation and profile by means of a properly designed machine. The grade of the underlying surface shall be controlled by a positive grade control system using lasers, stringlines, or guide wires. If the density of the underlying surface is disturbed by the trimming operations, it shall be corrected by additional compaction and retested at the option of the Engineer before the concrete is placed except when stabilized subbases are being constructed. If damage occurs on a stabilized subbase, it shall be corrected full depth by the Contractor. If traffic is allowed to use the prepared grade, the grade shall be checked and corrected immediately before the placement of concrete. The prepared grade shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from concrete. The underlying surface shall be protected so that it will be entirely free of frost when concrete is placed.

501-4.4 Conditioning of underlying surface, side-form and fill-in lane construction. The prepared underlying surface shall be moistened with water, without saturating, immediately ahead of concrete placement to prevent rapid loss of moisture from the concrete. Damage caused by hauling or usage of other equipment shall be corrected and retested at the option of the Engineers. If damage occurs to a stabilized subbase, it shall be corrected full depth by the Contractor. A template shall be provided and operated on the forms immediately in advance of the placing of all concrete. The template shall be propelled only by hand and not attached to a tractor or other power unit. Templates shall be adjustable so that they may be set and maintained at the correct contour of the underlying surface. The adjustment and operation of the templates shall be such as will provide an accurate retest of the grade before placing the concrete thereon. All excess material shall be removed and wasted. Low areas shall be filled and compacted to a condition similar to that of the surrounding grade. The underlying surface shall be protected so that it will be entirely free from frost when the concrete is placed. The use of chemicals to eliminate frost in the underlying surface shall not be permitted.

The template shall be maintained in accurate adjustment, at all times by the Contractor, and shall be checked daily.

501-4.5 Handling, measuring, and batching material. The batch plant site, layout, equipment, and provisions for transporting material shall assure a continuous supply of material to the work. Stockpiles shall be constructed in such a manner that prevents segregation and intermixing of deleterious materials. Aggregates from different sources shall be stockpiled, weighed and batched separately at the concrete batch plant.

Aggregates that have become segregated or mixed with earth or foreign material shall not be used. All aggregates produced or handled by hydraulic methods, and washed aggregates, shall be stockpiled or binned for draining at least 12 hours before being batched. Rail shipments requiring more than 12 hours will be accepted as adequate binning only if the car bodies permit free drainage.

Batching plants shall be equipped to proportion aggregates and bulk cement, by weight, automatically using interlocked proportioning devices of an approved type. When bulk cement is used, the Contractor shall use a suitable method of handling the cement from weighing hopper to transporting container or into the batch itself for transportation to the mixer, such as a chute, boot, or other approved device, to prevent loss of cement. The device shall be arranged to provide positive assurance that the cement content specified is present in each batch.

501-4.6 Mixing concrete. The concrete may be mixed at the work site, in a central mix plant or in truck mixers. The mixer shall be of an approved type and capacity. Mixing time shall be measured from the time all materials, except water, are emptied into the drum. All concrete shall be mixed and delivered to the site in accordance with the requirements of ASTM C94.

Mixed concrete from the central mixing plant shall be transported in truck mixers, truck agitators, or non-agitating trucks. The elapsed time from the addition of cementitious material to the mix until the concrete is deposited in place at the work site shall not exceed 30 minutes when the concrete is hauled in non-agitating trucks, nor 90 minutes when the concrete is hauled in truck mixers or truck agitators. Retempering concrete by adding water or by other means will not be permitted. With transit mixers additional water may be added to the batch materials and additional mixing performed to increase the slump to meet the specified requirements provided the addition of water is performed within 45 minutes after the initial mixing operations and provided the water/cementitious ratio specified in the approved mix design is not exceeded, and approved by the Engineer.

501-4.7 Limitations on mixing and placing. No concrete shall be mixed, placed, or finished when the natural light is insufficient, unless an adequate and approved artificial lighting system is operated.

a. Cold weather. Unless authorized in writing by the Engineer, mixing and concreting operations shall be discontinued when a descending air temperature in the shade and away from artificial heat reaches 40°F (4°C) and shall not be resumed until an ascending air temperature in the shade and away from artificial heat reaches 35°F (2°C).

The aggregate shall be free of ice, snow, and frozen lumps before entering the mixer. The temperature of the mixed concrete shall not be less than 50°F (10°C) at the time of placement. Concrete shall not be placed on frozen material nor shall frozen aggregates be used in the concrete.

When concreting is authorized during cold weather, water and/or the aggregates may be heated to not more than 150°F (66°C). The apparatus used shall heat the mass uniformly and shall be arranged to preclude the possible occurrence of overheated areas which might be detrimental to the materials.

b. Hot weather. During periods of hot weather when the maximum daily air temperature exceeds 85°F (30°C), the following precautions shall be taken.

The forms and/or the underlying surface shall be sprinkled with water immediately before placing the concrete. The concrete shall be placed at the coolest temperature practicable, and in no case shall the temperature of the concrete when placed exceed 90°F (32°C). The aggregates and/or mixing water shall be cooled as necessary to maintain the concrete temperature at or not more than the specified maximum.

The finished surfaces of the newly laid pavement shall be kept damp by applying a water-fog or mist with approved spraying equipment until the pavement is covered by the curing medium. When necessary, wind screens shall be provided to protect the concrete from an evaporation rate in excess of 0.2 psf (0.98 kg/m^2 per hour) per hour. When conditions are such that problems with plastic cracking can be expected, and particularly if any plastic cracking begins to occur, the Contractor shall immediately take such additional measures as necessary to protect the concrete surface. Such measures shall consist of wind screens, more effective fog sprays, and similar measures commencing immediately behind the paver. If these measures are not effective in preventing plastic cracking, paving operations shall be immediately stopped.

c. Temperature management program. Prior to the start of paving operation for each day of paving, the Contractor shall provide the Engineer with a Temperature Management Program for the concrete to be placed to assure that uncontrolled cracking is avoided. As a minimum the program shall address the following items:

(1) Anticipated tensile strains in the fresh concrete as related to heating and cooling of the concrete material.

(2) Anticipated weather conditions such as ambient temperatures, wind velocity, and relative humidity; and anticipated evaporation rate using Figure 11-8, PCA, Design and Control of Concrete Mixtures.

(3) Anticipated timing of initial sawing of joint.

(4) Anticipated number and type of saws to be used.

501-4.8 Placing concrete. At any point in concrete conveyance, the free vertical drop of the concrete from one point to another or to the underlying surface shall not exceed 3 feet (1 m). The finished concrete product must be dense and homogeneous, without segregation and conforming to the standards in this specification. Backhoes and grading equipment shall not be used to distribute the concrete in front of the paver. Front end loaders will not be used. All concrete shall be consolidated without voids or segregation, including under and around all load-transfer devices, joint assembly units, and other features embedded in the pavement. Hauling equipment or other mechanical equipment can be permitted on adjoining previously constructed pavement when the concrete strength reaches a flexural strength of 550 psi (3792 kPa) , based on the average of four field cured specimens per 2,000 cubic yards (1,530 cubic meters) of concrete placed. Also, subgrade and subbase planers, concrete pavers, and concrete finishing equipment may be permitted to ride upon the edges of previously constructed pavement when the concrete has attained a minimum flexural strength of 400 psi (2757 kPa).

The Contractor shall have available materials for the protection of the concrete during inclement weather. Such protective materials shall consist of rolled polyethylene sheeting at least 4 mils (0.1 mm) thick of sufficient length and width to cover the plastic concrete slab and any edges. The sheeting may be mounted on either the paver or a separate movable bridge from which it can be unrolled without dragging over the plastic concrete surface. When rain appears imminent, all paving operations shall stop and all available personnel shall begin covering the surface of the unhardened concrete with the protective covering.

a. Slip-form construction. The concrete shall be distributed uniformly into final position by a self-propelled slip-form paver without delay. The alignment and elevation of the paver shall be regulated from outside reference lines established for this purpose. The paver shall vibrate the concrete for the full width and depth of the strip of pavement being placed and the vibration shall be adequate to provide a consistency of concrete that will stand normal to the surface with sharp well defined edges. The sliding forms shall be rigidly held together laterally to prevent spreading of the forms. The plastic concrete shall be effectively consolidated by internal vibration with transverse vibrating units for the full width of the pavement and/or a series of equally placed longitudinal vibrating units. The space from the outer edge of the pavement to longitudinal unit shall not exceed 9 inches (23 cm) for slipform and at the end of the dowels for the fill-in lanes The spacing of internal units shall be uniform and shall not exceed 18 inches (0.5 m).

The term internal vibration means vibrating units located within the specified thickness of pavement section.

The rate of vibration of each vibrating unit shall be within 8000 to 12000 cycles per minute and the amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete along the entire length of the vibrating unit and for a distance of at least one foot (30 cm). The frequency of vibration or amplitude shall vary proportionately with the rate of travel to result in a uniform density and air content. The paving machine shall be equipped with a tachometer or other suitable device for measuring and indicating the actual frequency of vibrations.

The concrete shall be held at a uniform consistency. The slip-form paver shall be operated with as nearly a continuous forward movement as possible and all operations of mixing, delivering, and spreading concrete shall be coordinated to provide uniform progress with stopping and starting of the paver held to a minimum. If for any reason, it is necessary to stop the forward movement of the paver, the vibratory and tamping elements shall also be stopped immediately. No tractive force shall be applied to the machine, except that which is controlled from the machine.

When concrete is being placed adjacent to an existing pavement, that part of the equipment which is supported on the existing pavement shall be equipped with protective pads on crawler tracks or rubber-tired wheels on which the bearing surface is offset to run a sufficient distance from the edge of the pavement to avoid breaking the pavement edge.

Not more than 15% of the total free edge of each 500 foot (150 m) segment of pavement, or fraction thereof, shall have an edge slump exceeding 1/4 inch (6 mm), and none of the free edge of the pavement shall have an edge slump exceeding 3/8 inch (9 mm). (The total free edge of 500 feet (150 m) of pavement will be considered the cumulative total linear measurement of pavement edge originally constructed as nonadjacent to any existing pavement; that is, 500 feet (150 m) of paving lane originally constructed as a separate lane will have 1,000 feet (300 m) of free edge, 500 feet (150 m) of fill-in lane will have no free edge, etc.). The area affected by the downward movement of the concrete along the pavement edge shall be limited to not more than 18 inches (0.5 m) from the edge. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor as directed by the Engineer.

b. Side-form construction. Side form sections shall be straight, free from warps, bends, indentations, or other defects. Defective forms shall be removed from the work. Metal side forms shall be used except at end closures and transverse construction joints where straight forms of other suitable material may be used.

Side forms may be built up by rigidly attaching a section to either top or bottom of forms. If such build-up is attached to the top of metal forms, the build-up shall also be metal.

Width of the base of all forms shall be equal to or greater than the specified pavement thickness.

Side forms shall be of sufficient rigidity, both in the form and in the interlocking connection with adjoining forms, that springing will not occur under the weight of subgrading and paving equipment or from the pressure of the concrete. The Contractor shall provide sufficient forms so that there will be no delay in placing concrete due to lack of forms.

Before placing side forms, the underlying material shall be at the proper grade. Side forms shall have full bearing upon the foundation throughout their length and width of base and shall be placed to the required grade and alignment of the finished pavement. They shall be firmly supported during the entire operation of placing, compacting, and finishing the pavement.

Forms shall be drilled in advance of being placed to line and grade to accommodate tie bars where these are specified.

Immediately in advance of placing concrete and after all subbase operations are completed, side forms shall be trued and maintained to the required line and grade for a distance sufficient to prevent delay in placing.

Side forms shall remain in place at least 12 hours after the concrete has been placed, and in all cases until the edge of the pavement no longer requires the protection of the forms. Curing compound shall be applied to the concrete immediately after the forms have been removed.

Side forms shall be thoroughly cleaned and oiled each time they are used and before concrete is placed against them.

Concrete shall be spread, screeded, shaped and consolidated by one or more self-propelled machines. These machines shall uniformly distribute and consolidate concrete without segregation so that the completed pavement will conform to the required cross-section with a minimum of handwork.

The number and capacity of machines furnished shall be adequate to perform the work required at a rate equal to that of concrete delivery.

Concrete for the full paving width shall be effectively consolidated by internal vibrators without causing segregation. Internal type vibrators' rate of vibration shall be not less than 7,000 cycles per minute. Amplitude of vibration shall be sufficient to be perceptible on the surface of the concrete more than one foot (30 cm) from the vibrating element. The Contractor shall furnish a tachometer or other suitable device for measuring and indicating frequency of vibration.

Power to vibrators shall be connected so that vibration ceases when forward or backward motion of the machine is stopped.

The provisions relating to the frequency and amplitude of internal vibration shall be considered the minimum requirements and are intended to ensure adequate density in the hardened concrete.

c. Consolidation. Concrete shall be consolidated with the specified type of lane-spanning, gang-mounted, mechanical, immersion type vibrating equipment mounted in front of the paver, supplemented, in rare instances as specified, by hand-operated vibrators. The vibrators shall be inserted into the concrete to a depth that will provide the best full-depth consolidation but not closer to the underlying material than inches (50 mm). Excessive vibration shall not be permitted. If the vibrators cause visible tracking in the paving lane, the paving operation shall be stopped and equipment and operations modified to prevent it. Concrete in small, odd-shaped slabs or in isolated locations inaccessible to the gang-mounted vibration equipment shall be vibrated with an approved hand-operated immersion vibrator operated from a bridge spanning the area. Vibrators shall not be used to transport or spread the concrete. Hand-operated vibrators shall not be operated in the concrete at one location for more than 20 seconds. Insertion locations for hand-operated vibrators shall be between 6 to 15 inches (150 to 400 mm) on centers. For each paving train, at least one additional vibrator spud, or sufficient parts for rapid replacement and repair of vibrators shall be maintained at the paving site at all times. Any evidence of inadequate consolidation (honeycomb along the edges, large air pockets, or any other evidence) shall require the immediate stopping of the paving operation and adjustment of the equipment or procedures as approved by the Engineer.

If a lack of consolidation of the concrete is suspected by the Engineer, referee testing may be required. Referee testing of hardened concrete will be performed by the Engineer by cutting cores from the finished pavement after a minimum of 24 hours curing. Density determinations will be made by the Engineer based on the water content of the core as taken. ASTM C642 shall be used for the determination of core density in the saturated-surface dry condition. When required, referee cores will be taken at the minimum rate of one for each 500 cubic yards (382 m^2) of pavement, or fraction. The Contractor shall be responsible for all referee testing cost if they fail to meet the required density.

The average density of the cores shall be at least 97% of the original mix design density, with no cores having a density of less than 96% of the original mix design density. Failure to meet the referee tests will be considered evidence that the minimum requirements for vibration are inadequate for the job conditions. Additional vibrating units or other means of increasing the effect of vibration shall be employed so that the density of the hardened concrete conforms to the above requirements.

501-4.9 Strike-off of concrete and placement of reinforcement. Following the placing of the concrete, it shall be struck off to conform to the cross-section shown on the plans and to an elevation that when the concrete is properly consolidated and finished, the surface of the pavement shall be at the elevation shown on the plans. When reinforced concrete pavement is placed in two layers, the bottom layer shall be struck off to such length and depth that the sheet of reinforcing steel fabric or bar mat may be laid full length on the concrete in its final position without further manipulation. The reinforcement shall then be placed directly upon the concrete, after which the top layer of the concrete shall be placed, struck off, and screeded. If any portion of the bottom layer of concrete has been placed more than 30 minutes without being covered with the top layer or if initial set has taken place, it shall be removed and replaced with freshly mixed concrete at the Contractor's expense. When reinforced concrete is placed in one layer, the reinforcement may be positioned in advance of concrete placement or it may be placed in plastic concrete by mechanical or vibratory means after spreading.

Reinforcing steel, at the time concrete is placed, shall be free of mud, oil, or other organic matter that may adversely affect or reduce bond. Reinforcing steel with rust, mill scale or a combination of both will be considered satisfactory, provided the minimum dimensions, weight, and tensile properties of a hand wire-brushed test specimen are not less than the applicable ASTM specification requirements.

501-4.10 Joints. Joints shall be constructed as shown on the plans and in accordance with these requirements. All joints shall be constructed with their faces perpendicular to the surface of the pavement and finished or edged as shown on the plans. Joints shall not vary more than 1/2 inch (12 mm) from their designated position and shall be true to line with not more than 1/4 inch (6 mm) variation in 10 feet (3 m). The surface across the joints shall be tested with a 12 feet (3 m) straightedge as the joints are finished and any irregularities in excess of 1/4 inch (6 mm) shall be corrected before the concrete has hardened. All joints shall be so prepared, finished, or cut to provide a groove of uniform width and depth as shown on the plans.

a. Construction. Longitudinal construction joints shall be slip-formed or formed against side forms as shown in the plans.

Transverse construction joints shall be installed at the end of each day's placing operations and at any other points within a paving lane when concrete placement is interrupted for more than 30 minutes or it appears that the concrete will obtain its initial set before fresh concrete arrives. The installation of the joint shall be located at a planned contraction or expansion joint. If placing of the concrete is stopped, the Contractor shall remove the excess concrete back to the previous planned joint.

b. Contraction. Contraction joints shall be installed at the locations and spacing as shown on the plans. Contraction joints shall be installed to the dimensions required by forming a groove or cleft in the top of the slab while the concrete is still plastic or by sawing a groove into the concrete surface after the concrete has hardened. When the groove is formed in plastic concrete the sides of the grooves shall be finished even and smooth with an edging tool. If an insert material is used, the installation and edge finish shall be according to the manufacturer's instructions. The groove shall be finished or cut clean so that spalling will be avoided at intersections with other joints. Grooving or sawing shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans.

c. Isolation (expansion). Isolation joints shall be installed as shown on the plans. The premolded filler of the thickness as shown on the plans, shall extend for the full depth and width of the slab at the joint, except for space for sealant at the top of the slab. The filler shall be securely staked or fastened into position perpendicular to the proposed finished surface. A cap shall be provided to protect the top edge of the filler and to permit the concrete to be placed and finished. After the concrete has been placed and struck off, the cap shall be carefully withdrawn leaving the space over the premolded filler. The edges of the joint shall be finished and tooled while the concrete is still plastic. Any concrete bridging the joint space shall be removed for the full width and depth of the joint.

d. Tie bars. Tie bars shall consist of deformed bars installed in joints as shown on the plans. Tie bars shall be placed at right angles to the centerline of the concrete slab and shall be spaced at intervals shown on the plans. They shall be held in position parallel to the pavement surface and in the middle of the slab depth. When tie bars extend into an unpaved lane, they may be bent against the form at longitudinal construction joints, unless threaded bolt or other assembled tie bars are specified. Tie bars shall not be painted, greased, or enclosed in sleeves. When slip-form operations call for tie bars, two-piece hook bolts can be installed.

e. Dowel bars. Dowel bars or other load-transfer units of an approved type shall be placed across joints as shown on the plans. They shall be of the dimensions and spacings as shown and held rigidly in the middle of the slab depth in the proper horizontal and vertical alignment by an approved assembly device to be left permanently in place. The dowel or load-transfer and joint devices shall be rigid enough to permit complete assembly as a unit ready to be lifted and placed into position. The dowels shall be coated with a bond-breaker or other lubricant recommended by the manufacturer and approved by the Engineer.

f. Dowels bars at longitudinal construction joints shall be bonded in drilled holes.

g. Placing dowels and tie bars. The method used in installing and holding dowels in position shall ensure that the error in alignment of any dowel from its required horizontal and vertical alignment after the pavement has been completed will not be greater than 1/8 inch per feet (3 mm per 0.3 m). Except as otherwise specified below, horizontal spacing of dowels shall be within a tolerance of ±5/8 inch (16 mm). The vertical location on the face of the slab shall be within a tolerance of ±1/2 inch (12 mm). The vertical alignment of the dowels shall be measured parallel to the designated top surface of the pavement, except for those across the crown or other grade change joints. Dowels across crowns and other joints at grade changes shall be measured to a level surface. Horizontal alignment shall be checked perpendicular to the joint edge. The horizontal alignment shall be checked with a framing square. Dowels and tie bars shall not be placed closer than 0.6 times the dowel bar or tie bar length to the planned joint line. If the last regularly spaced longitudinal dowel or tie bar is closer than that dimension, it shall be moved away from the joint to a location 0.6 times the dowel bar or tie bar length, but not closer than 6 inches (150 mm) to its nearest neighbor. The portion of each dowel intended to move within the concrete or expansion cap shall be wiped clean and coated with a thin, even film of lubricating oil or light grease before the concrete is placed. Dowels shall be installed as specified in the following subparagraphs.

(1) Contraction joints. Dowels and tie bars in longitudinal and transverse contraction joints within the paving lane shall be held securely in place, as indicated, by means of rigid metal frames or basket assemblies of an approved type. The basket assemblies shall be held securely in the proper location by means of suitable pins or anchors. Do not cut or crimp the dowel basket tie wires. At the Contractor's option, in lieu of the above, dowels and tie bars in contraction joints shall be installed near the front of the paver by insertion into the plastic concrete using approved equipment and procedures. Approval will be based on the results of a preconstruction demonstration, showing that the dowels and tie bars are installed within specified tolerances.

(2) Construction joints. Install dowels and tie bars by the cast-in- place or the drill-and-dowel method. Installation by removing and replacing in preformed holes will not be permitted. Dowels and tie bars shall be prepared and placed across joints where indicated, correctly aligned, and securely held in the proper horizontal and vertical position during placing and finishing operations, by means of devices fastened to the forms. The spacing of dowels and tie bars in construction joints shall be as indicated.

(3) Dowels installed in isolation joints and other hardened concrete. Install dowels for isolation joints and in other hardened concrete by bonding the dowels into holes drilled into the hardened concrete. The concrete shall have cured for seven (7) days or reached a minimum flexural strength of 450 psi (3.1 MPa) before drilling commences. Holes 1/8 inch (3 mm) greater in diameter than the dowels shall be drilled into the hardened concrete using rotary-core drills. Rotary-percussion drills may be used, provided that excessive spalling does not occur to the concrete joint face. Modification of the equipment and operation shall be required if, in the Engineer's opinion, the equipment and/or operation is causing excessive damage. Depth of dowel hole shall be within a tolerance of ±1/2 inch (12 mm) of the dimension shown on the drawings. On completion of the drilling operation, the dowel hole shall be blown out with oil-free, compressed air. Dowels shall be bonded in the drilled holes using epoxy resin. Epoxy resin shall be injected at the back of the hole before installing the dowel and extruded to the collar during insertion of the dowel so as to completely fill the void around the dowel. Application by buttering the dowel will not be permitted. The dowels shall be held in alignment at the collar of the hole, after insertion and before the grout hardens, by means of a suitable metal or plastic grout retention ring fitted around the dowel. Dowels required to be installed in any joints between new and existing concrete shall be grouted in holes drilled in the existing concrete, all as specified above.

h. Sawing of joints. Joints shall be cut as shown on the plans. Equipment shall be as described in paragraph 501-4.1. The circular cutter shall be capable of cutting a groove in a straight line and shall produce a slot at least 1/8 inch (3 mm) wide and to the depth shown on the plans. The top of the slot shall be widened by sawing to provide adequate space for joint sealers as shown on the plans. Sawing shall commence, without regard to day or night, as soon as the concrete has hardened sufficiently to permit cutting without chipping, spalling, or tearing and before uncontrolled shrinkage cracking of the pavement occurs and shall continue without interruption until all joints have been sawn. The joints shall be sawn at the required spacing. All slurry and debris produced in the sawing of joints shall be removed by vacuuming and washing. Curing compound or system shall be reapplied in the initial sawcut and maintained for the remaining cure period.

501-4.11 Finishing. Finishing operations shall be a continuing part of placing operations starting immediately behind the strike-off of the paver. Initial finishing shall be provided by the transverse screed or extrusion plate. The sequence of operations shall be transverse finishing, longitudinal machine floating if used, straightedge finishing, texturing, and then edging of joints. Finishing shall be by the machine method. The hand method shall be used only on isolated areas of odd slab widths or shapes and in the event of a breakdown of the mechanical finishing equipment. Supplemental hand finishing for machine finished pavement shall be kept to an absolute minimum. Any machine finishing operation which requires appreciable hand finishing, other than a moderate amount of straightedge finishing, shall be immediately stopped and proper adjustments made or the equipment replaced. Any operations which produce more than 1/8 inch (3 mm) of mortar-rich surface (defined as deficient in plus U.S. No. 4 (4.75 mm) sieve size aggregate) shall be halted immediately and the equipment, mixture, or procedures modified as necessary. Compensation shall be made for surging behind the screeds or extrusion plate and settlement during hardening and care shall be taken to ensure that paving and finishing machines are properly adjusted so that the finished surface of the concrete (not just the cutting edges of the screeds) will be at the required line and grade. Finishing equipment and tools shall be maintained clean and in an approved condition. At no time shall water be added to the surface of the slab with the finishing equipment or tools, or in any other way, except for fog (mist) sprays specified to prevent plastic shrinkage cracking.

a. Machine finishing with slipform pavers. The slipform paver shall be operated so that only a very minimum of additional finishing work is required to produce pavement surfaces and edges meeting the specified tolerances. Any equipment or procedure that fails to meet these specified requirements shall immediately be replaced or modified as necessary. A self-propelled non-rotating pipe float may be used while the concrete is still plastic, to remove minor irregularities and score marks. Only one pass of the pipe float shall be allowed. If there is concrete slurry or fluid paste on the surface that runs over the edge of the pavement, the paving operation shall be immediately stopped and the equipment, mixture, or operation modified to prevent formation of such slurry. Any slurry which does run down the vertical edges shall be immediately removed by hand, using stiff brushes or scrapers. No slurry, concrete or concrete mortar shall be used to build up along the edges of the pavement to compensate for excessive edge slump, either while the concrete is plastic or after it hardens.

b. Machine finishing with fixed forms. The machine shall be designed to straddle the forms and shall be operated to screed and consolidate the concrete. Machines that cause displacement of the forms shall be replaced. The machine shall make only one pass over each area of pavement. If the equipment and procedures do not produce a surface of uniform texture, true to grade, in one pass, the operation shall be immediately stopped and the equipment, mixture, and procedures adjusted as necessary.

c. Other types of finishing equipment. Clary screeds, other rotating tube floats, or bridge deck finishers are not allowed on mainline paving, but may be allowed on irregular or odd-shaped slabs, and near buildings or trench drains, subject to the Engineer’s approval.

Bridge deck finishers shall have a minimum operating weight of 7500 pounds (3400 kg) and shall have a transversely operating carriage containing a knock-down auger and a minimum of two immersion vibrators. Vibrating screeds or pans shall be used only for isolated slabs where hand finishing is permitted as specified, and only where specifically approved.

d. Hand finishing. Hand finishing methods will not be permitted, except under the following conditions: (1) in the event of breakdown of the mechanical equipment, hand methods may be used to finish the concrete already deposited on the grade and (2) in areas of narrow widths or of irregular dimensions where operation of the mechanical equipment is impractical. Use hand finishing operations only as specified below.

(1) Equipment and screed. In addition to approved mechanical internal vibrators for consolidating the concrete, provide a strike-off and tamping screed and a longitudinal float for hand finishing. The screed shall be at least one foot (30 cm) longer than the width of pavement being finished, of an approved design, and sufficiently rigid to retain its shape, and shall be constructed of metal or other suitable material shod with metal. The longitudinal float shall be at least 10 feet (3 m) long, of approved design, and rigid and substantially braced, and shall maintain a plane surface on the bottom. Grate tampers (jitterbugs) shall not be used.

(2) Finishing and floating. As soon as placed and vibrated, the concrete shall be struck off and screeded to the crown and cross-section and to such elevation above grade that when consolidated and finished, the surface of the pavement will be at the required elevation. In addition to previously specified complete coverage with handheld immersion vibrators, the entire surface shall be tamped with the strike-off and tamping template, and the tamping operation continued until the required compaction and reduction of internal and surface voids are accomplished. Immediately following the final tamping of the surface, the pavement shall be floated longitudinally from bridges resting on the side forms and spanning but not touching the concrete. If necessary, additional concrete shall be placed, consolidated and screeded, and the float operated until a satisfactory surface has been produced. The floating operation shall be advanced not more than half the length of the float and then continued over the new and previously floated surfaces.

e. Straightedge testing and surface correction. After the pavement has been struck off and while the concrete is still plastic, it shall be tested for trueness with a Contractor furnished 12-foot (3.7-m) straightedge swung from handles 3 feet (1 m) longer than one-half the width of the slab. The straightedge shall be held in contact with the surface in successive positions parallel to the centerline and the whole area gone over from one side of the slab to the other, as necessary. Advancing shall be in successive stages of not more than one-half the length of the straightedge. Any excess water and laitance in excess of 1/8 inch (3 mm) thick shall be removed from the surface of the pavement and wasted. Any depressions shall be immediately filled with freshly mixed concrete, struck off, consolidated, and refinished. High areas shall be cut down and refinished. Special attention shall be given to assure that the surface across joints meets the smoothness requirements of paragraph 501-5.2e(3). Straightedge testing and surface corrections shall continue until the entire surface is found to be free from observable departures from the straightedge and until the slab conforms to the required grade and cross-section. The use of long-handled wood floats shall be confined to a minimum; they may be used only in emergencies and in areas not accessible to finishing equipment. This straight-edging is not a replacement for the straightedge testing of paragraph 501-5.2e(3), Smoothness.

501-4.12 Surface texture. The surface of the pavement shall be finished with either a brush or broom, burlap drag, or artificial turf finish for all newly constructed concrete pavements. It is important that the texturing equipment not tear or unduly roughen the pavement surface during the operation. Any imperfections resulting from the texturing operation shall be corrected to the satisfaction of the Engineer.

a. Burlap drag finish. If a burlap drag is used to texture the pavement surface, it shall be at least 15 ounces per square yard (555 grams per square meter). To obtain a textured surface, the transverse threads of the burlap shall be removed approximately one foot (30 cm) from the trailing edge. A heavy buildup of grout on the burlap threads produces the desired wide sweeping longitudinal striations on the pavement surface. The corrugations shall be uniform in appearance and approximately 1/16 inch (2 mm) in depth.

501-4.13 Curing. Immediately after finishing operations are completed and marring of the concrete will not occur, the entire surface of the newly placed concrete shall be cured for a 7-day cure period in accordance with one of the methods below. Failure to provide sufficient cover material of whatever kind the Contractor may elect to use, or lack of water to adequately take care of both curing and other requirements, shall be cause for immediate suspension of concreting operations. The concrete shall not be left exposed for more than 1/2 hour during the curing period.

When a two-sawcut method is used to construct the contraction joint, the curing compound shall be applied to the sawcut immediately after the initial cut has been made. The sealant reservoir shall not be sawed until after the curing period has been completed. When the one cut method is used to construct the contraction joint, the joint shall be cured with wet rope, wet rags, or wet blankets. The rags, ropes, or blankets shall be kept moist for the duration of the curing period.

a. Impervious membrane method. The entire surface of the pavement shall be sprayed uniformly with white pigmented curing compound immediately after the finishing of the surface and before the set of the concrete has taken place. The curing compound shall not be applied during rainfall. Curing compound shall be applied by mechanical sprayers under pressure at the rate of one gallon (4 liters) to not more than 150 sq ft (14 sq m). The spraying equipment shall be of the fully atomizing type equipped with a tank agitator. At the time of use, the compound shall be in a thoroughly mixed condition with the pigment uniformly dispersed throughout the vehicle. During application the compound shall be stirred continuously by mechanical means. Hand spraying of odd widths or shapes and concrete surfaces exposed by the removal of forms will be permitted. When hand spraying is approved by the Engineer, a double application rate shall be used to ensure coverage. The curing compound shall be of such character that the film will harden within 30 minutes after application. Should the film become damaged from any cause, including sawing operations, within the required curing period, the damaged portions shall be repaired immediately with additional compound or other approved means. Upon removal of side forms, the sides of the exposed slabs shall be protected immediately to provide a curing treatment equal to that provided for the surface. Curing shall be applied immediately after the bleed water is gone from the surface.

b. Concrete protection for cold weather. The concrete shall be maintained at an ambient temperature of at least 50°F (10°C) for a period of 72 hours after placing and at a temperature above freezing for the remainder of the curing time. The Contractor shall be responsible for the quality and strength of the concrete placed during cold weather; and any concrete damaged shall be removed and replaced at the Contractor’s expense.

c. Concrete protection for hot weather. Concrete should be continuous moisture cured for the entire curing period and shall commence as soon as the surfaces are finished and continue for at least 24 hours. However, if moisture curing is not practical beyond 24 hours, the concrete surface shall be protected from drying with application of a liquid membrane-forming curing compound while the surfaces are still damp. Other curing methods may be approved by the Engineer.

501-4.14 Removing forms. Unless otherwise specified, forms shall not be removed from freshly placed concrete until it has hardened sufficiently to permit removal without chipping, spalling, or tearing. After the forms have been removed, the sides of the slab shall be cured as per the methods indicated in paragraph 501-4.13. Major honeycombed areas shall be considered as defective work and shall be removed and replaced in accordance with paragraph 501-5.2(f).

501-4.15 S**aw-cut grooving.** If shown on the plans, grooved surfaces shall be provided in accordance with the requirements of Item P-621.

501-4.16 Sealing joints. The joints in the pavement shall be sealed in accordance with Item P-604 or P-605.

501-4.17 Protection of pavement. The Contractor shall protect the pavement and its appurtenances against both public traffic and traffic caused by the Contractor’s employees and agents until accepted by the Engineer. This shall include watchmen to direct traffic and the erection and maintenance of warning signs, lights, pavement bridges, crossovers, and protection of unsealed joints from intrusion of foreign material, etc. Any damage to the pavement occurring prior to final acceptance shall be repaired or the pavement replaced at the Contractor’s expense.

Aggregates, rubble, or other similar construction materials shall not be placed on airfield pavements. Traffic shall be excluded from the new pavement by erecting and maintaining barricades and signs until the concrete is at least seven (7) days old, or for a longer period if directed by the Engineer.

In paving intermediate lanes between newly paved pilot lanes, operation of the hauling and paving equipment will be permitted on the new pavement after the pavement has been cured for seven (7) days and the joints have been sealed or otherwise protected, and the concrete has attained a minimum field cured flexural strength of 550 psi (37928 kPa) and approved means are furnished to prevent damage to the slab edge.

All new and existing pavement carrying construction traffic or equipment shall be continuously kept completely clean, and spillage of concrete or other materials shall be cleaned up immediately upon occurrence.

Damaged pavements shall be removed and replaced at the Contractor's expense. Slabs shall be removed to the full depth, width, and length of the slab.

501-4.18 Opening to construction traffic. The pavement shall not be opened to traffic until test specimens molded and cured in accordance with ASTM C31 have attained a flexural strength of 550 lb / square inch (3.8 kPa) when tested in accordance with ASTM C78. If such tests are not conducted, the pavement shall not be opened to traffic until 14 days after the concrete was placed. Prior to opening the pavement to construction traffic, all joints shall either be sealed or protected from damage to the joint edge and intrusion of foreign materials into the joint. As a minimum, backer rod or tape may be used to protect the joints from foreign matter intrusion.

501-4.19 Repair, removal, or replacement of slabs.

a. General. New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable shall be removed and replaced or repaired, as directed by the Engineer and as specified hereinafter at no cost to the Owner. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The Engineer will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 4 inch (100 mm) diameter, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with epoxy resin, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Owner. All epoxy resin used in this work shall conform to ASTM C881, Type V. Repair of cracks as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with an absence of coarse aggregate in the upper 1/8 inch (3 mm) of the pavement surface.

b. Shrinkage cracks. Shrinkage cracks, which do not exceed 4 inches (100 mm) in depth, shall be cleaned and then pressure injected with epoxy resin, Type IV, Grade 1, using procedures as approved by the Engineer. Care shall be taken to assure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the Engineer. Shrinkage cracks, which exceed 4 inches (100 mm) in depth, shall be treated as full depth cracks in accordance with paragraphs 4.19b and 4.19c.

c. Slabs with cracks through interior areas. Interior area is defined as that area more than 6 inches (150 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the Owner, when there are any full depth cracks, or cracks greater than 4 inches (100 mm) in depth, that extend into the interior area.

d. Cracks close to and parallel to joints. All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 inches (150 mm) either side of the joint shall be treated as specified here. Any crack extending more than 6 inches (150 mm) from the joint shall be treated as specified above in subparagraph c.

(1) Full depth cracks present, original joint not opened. When the original un-cracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 inches (19 mm), ±1/16 inch (2 mm), and to a width of 5/8 inch (16 mm), ±1/8 inch (3 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remained of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(2) Full depth cracks present, original joint also cracked. At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

e. Removal and replacement of full slabs. Where it is necessary to remove full slabs, unless there are dowels present, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface. If dowels, or tie bars are present along any edges, these edges shall be sawed full depth just beyond the end of the dowels or tie bars. These joints shall then be carefully sawed on the joint line to within one inch (25 mm) of the depth of the dowel or tie bar.

The main slab shall be further divided by sawing full depth, at appropriate locations, and each piece lifted out and removed. Suitable equipment shall be used to provide a truly vertical lift, and approved safe lifting devices used for attachment to the slabs. The narrow strips along doweled edges shall be carefully broken up and removed using light, hand-held jackhammers, 30 lb (14 kg) or less, or other approved similar equipment.

Care shall be taken to prevent damage to the dowels, tie bars, or to concrete to remain in place. The joint face below dowels shall be suitably trimmed so that there is not abrupt offset in any direction greater than 1/2 inch (12 mm) and no gradual offset greater than one inch (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge.

No mechanical impact breakers, other than the above hand-held equipment shall be used for any removal of slabs. If underbreak between 1-1/2 and 4 inches (38 and 100 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If underbreak over 4 inches (100 mm) deep occurs, the entire slab containing the underbreak shall be removed and replaced. Where there are no dowels or tie bars, or where they have been damaged, dowels or tie bars of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four (4) edges of the new slab shall contain dowels or original tie bars.

Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate section of these specifications. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

f. Repairing spalls along joints. Where directed, spalls along joints of new slabs, and along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least one inch (25 mm) outside the spalled area and to a depth of at least 2 inch (50 mm). Saw cuts shall be straight lines forming rectangular areas. The concrete between the saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 inch (12 mm) of visually sound concrete. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of epoxy resin shall be avoided. The cavity shall be filled with low slump Portland cement concrete or mortar or with epoxy resin concrete or mortar. Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. (0.014 m^3) in size, and mortar shall be used for the smaller ones. Any spall less than 0.1 cu. ft. (0.003 m^3) shall be repaired only with epoxy resin mortar or a Grade III epoxy resin. Portland cement concrete and mortar mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the Engineer. The epoxy resin materials shall be placed in the cavity in layers not over 2 inches (50 mm) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140°F (60°C) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints. If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified If any spall would require over 25% of the length of any single joint to be repaired, the entire slab shall be removed and replaced. Repair of spalls as described in this section shall not be allowed if in the opinion of the Engineer the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of spalls shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper one-eight (1/8th) inch of the pavement surface.

g. Diamond grinding of PCC surfaces. Diamond grinding of the hardened concrete with an approved diamond grinding machine should not be performed until the concrete is 14 days or more old and concrete has reached full minimum strength. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide.

Equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The area corrected by diamond grinding the surface of the hardened concrete should not exceed 10% of the total area of any sublot. The depth of diamond grinding shall not exceed 1/2 inch (13 mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, may require removing and replacing in conformance with paragraph 501-4.19.

501-4.20 Existing concrete pavement removal and repair.

All operations shall be carefully controlled to prevent damage to the concrete pavement and to the underlying material to remain in place. All saw cuts shall be made perpendicular to the slab surface.

a. Removal of existing pavement slab.

When it is necessary to remove existing concrete pavement and leave adjacent concrete in place, the joint between the removal area and adjoining pavement to stay in place, including dowels or tie bars, shall first be cut full depth with a standard diamond-type concrete saw. If dowels are present at this joint, the saw cut shall be made full depth just beyond the end of dowels. The edge shall then be carefully sawed on the joint line to within one inch (25 mm) of the top of the dowel. Next, a full depth saw cut shall be made parallel to the joint at least 24 inches (600 mm) from the joint and at least 12 inches (300 mm) from the end of any dowels. All pavement between this last saw cut and the joint line shall be carefully broken up and removed using hand-held jackhammers, 30 lb (14 kg) or less, or the approved light-duty equipment which will not cause stress to propagate across the joint saw cut and cause distress in the pavement which is to remain in place. Where dowels are present, care shall be taken to produce an even, vertical joint face below the dowels. If the Contractor is unable to produce such a joint face, or if underbreak or other distress occurs, the Contractor shall saw the dowels flush with the joint. The Contractor shall then install new dowels, of the size and spacing used for other similar joints, by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph 501-4.10g. All this shall be at no additional cost to the Owner. Dowels of the size and spacing indicated shall be installed as shown on the drawings by epoxy resin bonding them in holes drilled in the joint face as specified in paragraph 501-4.10g. The joint face shall be sawed or otherwise trimmed so that there is no abrupt offset in any direction greater than 1/2 inches (12 mm) and no gradual offset greater than one inch (25 mm) when tested in a horizontal direction with a 12-foot (3.7-m) straightedge. The Contractor shall exercise extreme caution during all panel removal operations. Any damage to adjacent pavements or underlying base courses scheduled to remain in place shall be repaired at no additional cost to the Owner.

b. Edge repair.

The edge of existing concrete pavement against which new pavement abuts shall be protected from damage at all times. Areas that are damaged during construction shall be repaired at no cost to the Owner.

(1) Spall repair. Spalls shall be repaired where indicated and where directed by the Engineer. Repair materials and procedures shall be as previously specified in subparagraph 501-4.19f.

(2) Underbreak repair. All underbreak shall be repaired. First, all delaminated and loose material shall be carefully removed. Next, the underlying material shall be recompacted, without addition of any new material. Finally, the void shall be completely filled with paving concrete, thoroughly consolidated. Care shall be taken to produce an even joint face from top to bottom. Prior to placing concrete, the underlying material shall be thoroughly moistened. After placement, the exposed surface shall be heavily coated with curing compound.

(3) Underlying material. The underlying material adjacent to the edge and under the existing pavement which is to remain in place shall be protected from damage or disturbance during removal operations and until placement of new concrete, and shall be shaped as shown on the drawings or as directed. Sufficient material shall be kept in place outside the joint line to prevent disturbance (or sloughing) of material under the pavement that is to remain in place. Any material under the portion of the concrete pavement to remain in place, which is disturbed or loses its compaction shall be carefully removed and replaced with concrete as specified in paragraph 501-4.20b(2). The underlying material outside the joint line shall be thoroughly compacted and moist when new concrete is placed.

MATERIAL ACCEPTANCE

501-5.1 Acceptance sampling and testing. All acceptance sampling and testing necessary to determine conformance with the requirements specified in this section, with the exception of coring for thickness determination, will be performed by the Engineer at no cost to the Contractor. The Contractor shall bear the cost of providing curing facilities for the strength specimens, per paragraph 501-5.1a(3), and coring and filling operations, per paragraph 501-5.1b(1). Testing organizations performing these tests shall be accredited in accordance with ASTM C1077. The laboratory accreditation must be current and listed on the accrediting authority's website. All test methods required for acceptance sampling and testing must be listed on the lab accreditation. A copy of the laboratory's current accreditation and accredited test methods shall be submitted to the Engineer prior to start of construction.

Concrete shall be accepted for strength and thickness on a lot basis.

A lot shall consist of a day's production not to exceed 2,000 cubic yards (1530 cubic meters).

a. Flexural strength.

(1) Sampling. Each lot shall be divided into four equal sublots. One sample shall be taken for each sublot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. The concrete shall be sampled in accordance with ASTM C172.

(2) Testing. Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C31 and the flexural strength of each specimen shall be determined in accordance with ASTM C78. The flexural strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot.

Immediately prior to testing for flexural strength, the beam shall be weighed and measured for determination of a sample unit weight. Measurements shall be made for each dimension; height, depth, and length, at the mid-point of the specimen and reported to the nearest 1/10 inch (3 mm). The weight of the specimen shall be reported to the nearest 0.1 pound (45 gm). The sample unit weight shall be calculated by dividing the sample weight by the calculated volume of the sample. This information shall be reported as companion information to the measured flexural strength for each specimen.

The samples will be transported while in the molds. The curing, except for the initial cure period, will be accomplished using the immersion in saturated lime water method.

Slump, air content, and temperature tests will also be conducted by the quality assurance laboratory for each set of strength test samples, per ASTM C31.

(3) Curing. The Contractor shall provide adequate facilities for the initial curing of beams. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60° to 80°F (16° to 27°C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather, or in heavyweight closed plastic bags, or using other suitable methods, provided the temperature and moisture loss requirements are met.

(4) Acceptance. Acceptance of pavement for flexural strength will be determined by the Engineer in accordance with paragraph 501-5.2b.

b. Pavement thickness.

(1) Sampling. Each lot shall be divided into four equal sublots and one core shall be taken by the Contractor for each sublot. Sampling locations shall be determined by the Engineer in accordance with random sampling procedures contained in ASTM D3665. Areas, such as thickened edges, with planned variable thickness, shall be excluded from sample locations.

Cores shall be neatly cut with a core drill. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored hole. Core holes shall be filled by the Contractor with a non-shrink grout approved by the Engineer within one day after sampling.

(2) Testing. The thickness of the cores shall be determined by the Engineer by the average caliper measurement in accordance with ASTM C174.

(3) Acceptance. Acceptance of pavement for thickness shall be determined by the Engineer in accordance with paragraph 501-5.2c.

c. Partial lots. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or minor placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

Where three sublots have been produced, they shall constitute a lot. Where one or two sublots have been produced, they shall be incorporated into the next lot or the previous lot and the total number of sublots shall be used in the acceptance criteria calculation, that is, n=5 or n=6.

d. Outliers. All individual flexural strength tests within a lot shall be checked for an outlier (test criterion) in accordance with ASTM E178, at a significance level of 5%. Outliers shall be discarded, and the percentage of material within specification limits (PWL) shall be determined using the remaining test values.

501-5.2 Acceptance criteria.

a. General. Acceptance will be based on the following characteristics of the completed pavement discussed in paragraph 501-5.2e:

(1) Flexural strength

(2) Thickness

(3) Smoothness

(4) Grade

(5) Edge slump

Flexural strength and thickness shall be evaluated for acceptance on a lot basis using the method of estimating PWL. Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L).

Acceptance for flexural strength will be based on the criteria contained in accordance with paragraph 501-5.2e(1). Acceptance for thickness will be based on the criteria contained in paragraph 501-5.2e(2). Acceptance for smoothness will be based on the criteria contained in paragraph 501-5.2e(3). Acceptance for grade will be based on the criteria contained in paragraph 501-5.2e(4).

The Engineer may at any time, notwithstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to contamination, segregation, or improper slump. Such rejection may be based on only visual inspection. In the event of such rejection, the Contractor may take a representative sample of the rejected material in the presence of the Engineer, and if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Flexural strength. Acceptance of each lot of in-place pavement for flexural strength shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

c. Pavement thickness. Acceptance of each lot of in-place pavement shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher.

d. Percentage of material within limits (PWL). The PWL shall be determined in accordance with procedures specified in Section 110 of the General Provisions.

The lower specification tolerance limit (L) for flexural strength and thickness shall be:

Lower Specification Tolerance Limit (L)

Flexural Strength	0.93 × strength specified in paragraph 501-3.1
Thickness	Lot Plan Thickness in inches, - 0.50 in

e. Acceptance criteria.

(1) Flexural Strength. If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.

(2) Thickness. If the PWL of the lot equals or exceeds 90%, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 501-8.1.

(3) Smoothness. As soon as the concrete has hardened sufficiently, but not later than 48 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness to reveal all surface irregularities exceeding the tolerances specified. The Contractor shall furnish paving equipment and employ methods that produce a surface for each section of pavement having an average profile index meeting the requirements of paragraph 501-8.1c when evaluated with a profilograph; and the finished surface of the pavement shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. When the surface smoothness exceeds specification tolerances which cannot be corrected by diamond grinding of the pavement, full depth removal and replacement of pavement shall be to the limit of the longitudinal placement. Corrections involving diamond grinding will be subject to the final pavement thickness tolerances specified.

(a) Transverse measurements. Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15m) or more often as determined by the Engineer.

(i) Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. Smoothness readings will not be made across grade changes or cross slope transitions; at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final pavement > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) The joint between lots shall be tested separately to facilitate smoothness between lots. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface, with half the straightedge on one side of the joint and the other half of the straightedge on the other side of the joint. Measure the maximum gap between the straightedge and the pavement surface in the area between these two high points. One measurement shall be taken at the joint every 50 feet (15m) or more often if directed by the Engineer. Maximum gap on final pavement surface > 1/4 inch (6mm) in transverse direction shall be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of surface. Each measurement shall be recorded and a copy of the data shall be furnished to the Engineer at the end of each days testing.

(b) Longitudinal measurements. Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6m); and at the one third points of paving lanes when widths of paving lanes are 20 ft (6m) or greater.

(i) Longitudinal Short Sections. Longitudinal Short Sections are when the longitudinal lot length is less than 200 feet (60m) and areas not requiring a profilograph. When approved by the Engineer, the first and last 15 feet (4.5m) of the lot can also be considered as short sections for smoothness. The finished surface shall not vary more than 1/4 inch (6mm) when evaluated with a 12-foot (3.7m) straightedge. Smoothness readings will not be made across grade changes or cross slope transitions, at these transition areas, the straightedge position shall be adjusted to measure surface smoothness and not design grade or cross slope transitions. Testing shall be continuous across all joints, starting with one-half the length of the straight edge at the edge of pavement section being tested and then moved ahead one-half the length of the straight edge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. Deviations on final pavement surface > 1/4 inch (6mm) in longitudinal direction will be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of surface. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

(ii) Profilograph Testing. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing.

The pavement must have an average profile index meeting the requirements of paragraph 501-8.1c. Deviations on final surface in longitudinal direction shall be corrected with diamond grinding per paragraph 501-4.19g or by removing and replacing full depth of pavement. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. The area corrected by grinding should not exceed 10% of the total area and these areas shall be retested after grinding.

Where corrections are necessary, second profilograph runs shall be performed to verify that the corrections produced an average profile index of 15 inches (38 cm) per mile or less. If the initial average profile index was less than 15 inches (38 cm), only those areas representing greater than 0.4 inch (10 mm) deviation will be re-profiled for correction verification.

(iii) Final profilograph of [runway]. Final profilograph, full length of runway, shall be performed to facilitate testing of smoothness between lots. Profilograph testing shall be performed by the contractor using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index meeting the requirements of paragraph 501-8.1c. The equipment shall utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms shall be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). A copy of the reduced tapes shall be furnished to the Engineer at the end of each days testing. Profilograph of final runway shall be performed one foot right and left of runway centerline and 15 feet right and left of centerline. Any areas that indicate “must grind” will be corrected as directed by the Engineer.

Smoothness testing indicated in the above paragraphs except paragraph (iii) shall be performed within 48 hours of placement of material. Smoothness texting indicated in paragraph (iii) shall be performed within 48 hours final paving completion. The primary purpose of smoothness testing is to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. If the contractor’s machines and/or methods are producing significant areas that need corrective actions then production should be stopped until corrective measures can be implemented. If corrective measures are not implemented and when directed by the Engineer, production shall be stopped until corrective measures can be implemented.

(4) Grade. An evaluation of the surface grade shall be made by the Engineer for compliance to the tolerances contained below. The finish grade will be determined by running levels at intervals of 50 feet (15 m) or less longitudinally and all breaks in grade transversely (not to exceed 50 feet (15 m)) to determine the elevation of the completed pavement. The Contractor shall pay the costs of surveying the level runs, and this work shall be performed by a licensed surveyor. The documentation, stamped and signed by a licensed surveyor, shall be provided by the Contractor to the Engineer.

(a) Lateral deviation. Lateral deviation from established alignment of the pavement edge shall not exceed ±0.10 feet (30 mm) in any lane.

(b) Vertical deviation. Vertical deviation from established grade shall not exceed ±0.04 feet (12 mm) at any point.

(5) Edge slump. When excessive edge slump cannot be corrected before the concrete has hardened, the area with excessive edge slump shall be removed and replaced at the expense of the Contractor as directed by the Engineer in accordance with paragraph 501-4.8a.

f. Removal and replacement of concrete. Any area or section of concrete that is removed and replaced shall be removed and replaced back to planned joints. The Contractor shall replace damaged dowels and the requirements for doweled longitudinal construction joints in paragraph 501-4.10 shall apply to all contraction joints exposed by concrete removal. Removal and replacement shall be in accordance with paragraph 501-4.20.

CONTRACTOR QUALITY CONTROL

501-6.1 Quality control program. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements that affect the quality of the pavement including but not limited to:

a. Mix Design

b. Aggregate Gradation

c. Quality of Materials

d. Stockpile Management

e. Proportioning

f. Mixing and Transportation

g. Placing and Consolidation

h. Joints

i. Dowel Placement and Alignment

j. Flexural or Compressive Strength

k. Finishing and Curing

l. Surface Smoothness

501-6.2 Quality control testing. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to this specification and as set forth in the Quality Control Program. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content.

A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Fine aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C70 or ASTM C566.

b. Coarse Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566.

c. Slump. Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in paragraph 501-5.1. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

d. Air content. Four air content tests, shall be performed for each lot of material produced in accordance with the lot size defined in paragraph 501-5.1. One test shall be made for each sublot. Air content tests shall be performed in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

e. Four unit weight and yield tests shall be made in accordance with ASTM C138. The samples shall be taken in accordance with ASTM C172 and at the same time as the air content tests.

501-6.3 Control charts. The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, moisture content and air content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and suspension Limits, or Specification limits, applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the Engineer may halt production or acceptance of the material.

a. Fine and coarse aggregate gradation. The Contractor shall record the running average of the last five gradation tests for each control sieve on linear control charts. Specification limits contained in the Lower Specification Tolerance Limit (L) table above and the Control Chart Limits table below shall be superimposed on the Control Chart for job control.

b. Slump and air content. The Contractor shall maintain linear control charts both for individual measurements and range (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

Control Chart Limits

Control Parameter	Individual Measurements		Range Suspension Limit
	Action Limit	Suspension Limit	
Slip Form:			
Slump	+0 to -1 inch (0-25 mm)	+0.5 to -1.5 inch (13-38 mm)	±1.5 inch (38 mm)
Air Content	±1.2%	±1.8%	±2.5%
Side Form:			
Slump	+0.5 to -1 inch (13-25 mm)	+1 to -1.5 inch (25-38 mm)	±1.5 inch (38 mm)
Air Content	±1.2%	±1.8%	±2.5%

The individual measurement control charts shall use the mix design target values as indicators of central tendency.

501-6.4 Corrective action. The Contractor Quality Control Program shall indicate that appropriate action shall be taken when the process is believed to be out of control. The Contractor Quality Control Program shall detail what action will be taken to bring the process into control and shall contain sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

a. Fine and coarse aggregate gradation. When two consecutive averages of five tests are outside of the specification limits in paragraph 501-2.1, immediate steps, including a halt to production, shall be taken to correct the grading.

b. Fine and coarse aggregate moisture content. Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5%, the scale settings for the aggregate batcher and water batcher shall be adjusted.

c. Slump. The Contractor shall halt production and make appropriate adjustments whenever:

(1) one point falls outside the Suspension Limit line for individual measurements or range

OR

(2) two points in a row fall outside the Action Limit line for individual measurements.

d. Air content. The Contractor shall halt production and adjust the amount of air-entraining admixture whenever:

(1) one point falls outside the Suspension Limit line for individual measurements or range

OR

(2) two points in a row fall outside the Action Limit line for individual measurements.

Whenever a point falls outside the Action Limits line, the air-entraining admixture dispenser shall be calibrated to ensure that it is operating correctly and with good reproducibility.

METHOD OF MEASUREMENT

501-7.1 Portland cement concrete pavement shall be measured by the number of square yards of either plain or reinforced pavement as specified in-place, completed and accepted. The Contractor shall exercise extreme caution during all panel removal operations. Any damage to adjacent pavements or underlying base courses scheduled to remain in place shall be repaired at no additional cost to the Owner.

BASIS OF PAYMENT

501-8.1 Payment. Payment for concrete pavement meeting all acceptance criteria as specified in paragraph 501-5.2 Acceptance Criteria shall be based on results of smoothness, strength and thickness tests. Payment for acceptable lots of concrete pavement shall be adjusted in accordance with paragraph 501-8.1a for strength and thickness and 501-8.1c for smoothness, subject to the limitation that:

The total project payment for concrete pavement shall not exceed **100** percent of the product of the contract unit price and the total number of square yards of concrete pavement used in the accepted work (See Note 1 under the Price Adjustment Schedule table below).

Payment shall be full compensation for all labor, materials, tools, equipment, and incidentals required to complete the work as specified herein and on the drawings. The Contractor shall exercise extreme caution during all panel removal operations. Any damage to adjacent pavements or underlying base courses scheduled to remain in place shall be repaired at no additional cost to the Owner.

a. Basis of adjusted payment. The pay factor for each individual lot shall be calculated in accordance with the Price Adjustment Schedule table below. A pay factor shall be calculated for both flexural strength and thickness. The lot pay factor shall be the higher of the two values when calculations for both flexural strength and thickness are 100% or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either flexural strength or thickness is 100% or higher. The lot pay factor shall be the lower of the two values when calculations for both flexural strength and thickness are less than 100%.

Price Adjustment Schedule[1]

Percentage of Materials Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 90	0.5 PWL + 55
55 – 74	1.4 PWL – 12
Below 55	Reject[2]

[1] Although it is theoretically possible to achieve a pay factor of 106% for each lot, actual payment in excess of 100% shall be subject to the total project payment limitation specified in paragraph 501-8.1.

[2] The lot shall be removed and replaced. However, if the Engineer and the FAA have decided to allow the rejected lot to remain in accordance with Section 50-02 after the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50% of the contract unit price and the total project payment limitation shall be reduced by the amount withheld for the rejected lot.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 501-8.1. Payment in excess of 100% for accepted lots of concrete pavement shall be used to offset payment for accepted lots of concrete pavement that achieve a lot pay factor less than 100%.

b. Payment. Payment shall be made under:

Item P-501-8.1 Portland Cement Concrete Pavement per cubic yard

c. Basis of adjusted payment for smoothness. Price adjustment for pavement smoothness will apply to the total area of concrete within a section of pavement and shall be applied in accordance the following equation and schedule:

(Square yard in section) × (original unit price per square yard) × PFm = reduction in payment for area within section

Average Profile Index (Inches Per Mile) Pavement Strength Rating			Contract Unit Price Adjustment (PFm)
Over 30,000 lb	**30,000 lb or Less**	**Short Sections**	
0 - 7	0 - 10	0 - 15	0.00
7.1 - 9	10.1 - 11	15.1 - 16	0.02
9.1 - 11	11.1 - 12	16.1 - 17	0.04
11.1 - 13	12.1 - 13	17.1 - 18	0.06
13.1 - 14	13.1 - 14	18.1 - 20	0.08
14.1 - 15	14.1 - 15	20.1 - 22	0.10
15.1 and up	15.1 and up	22.1 and up	Corrective work required

TESTING REQUIREMENTS

ASTM C31	Standard Practice for Making and Curing Concrete Test Specimens in the Field
ASTM C39	Standard Test Method for Compressive Strength of Cylindrical Concrete Specimens
ASTM C70	Standard Test Method for Surface Moisture in Fine Aggregate
ASTM C78	Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
ASTM C88	Standard Test Method for Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C117	Standard Test Method for Materials Finer Than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C138	Standard Test Method for Density (Unit Weight), Yield, and Air Content (Gravimetric) of Concrete
ASTM C142	Standard Test Method for Clay Lumps and Friable Particles in Aggregates
ASTM C143	Standard Test Method for Slump of Hydraulic-Cement Concrete
ASTM C172	Standard Practice for Sampling Freshly Mixed Concrete
ASTM C173	Standard Test Method for Air Content of Freshly Mixed Concrete by the Volumetric Method
ASTM C174	Standard Test Method for Measuring Thickness of Concrete Elements Using Drilled Concrete Cores
ASTM C227	Standard Test Method for Potential Alkali Reactivity of Cement-Aggregate Combinations (Mortar-Bar Method)
ASTM C231	Standard Test Method for Air Content of Freshly Mixed Concrete by the Pressure Method
ASTM C289	Standard Test Method for Potential Alkali-Silica Reactivity of Aggregates (Chemical Method)
ASTM C295	Standard Guide for Petrographic Examination of Aggregates for Concrete
ASTM C114	Standard Test Methods for Chemical Analysis of Hydraulic Cement
ASTM C311	Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland Cement Concrete
ASTM C566	Standard Test Method for Total Evaporable Moisture Content of Aggregates by Drying
ASTM C642	Standard Test Method for Density, Absorption, and Voids in Hardened Concrete
ASTM C666	Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing

ASTM C1077	Standard Practice for Agencies Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Testing Agency Evaluation
ASTM C1260	Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)
ASTM C1567	Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar-Bar Method)
ASTM C1602	Standard Specification for Mixing Water Used in the Production of Hydraulic Cement Concrete
ASTM D3665	Standard Practice for Random Sampling of Construction Materials
ASTM D4791	Standard Test Method for Flat Particles, Elongated Particles, or Flat and Elongated Particles in Coarse Aggregate
ASTM E178	Standard Practice for Dealing With Outlying Observations
ASTM E1274	Standard Test Method for Measuring Pavement Roughness Using a Profilograph

U.S. Army Corps of Engineers (USACE) Concrete Research Division (CRD) C662
Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials, Lithium Nitrate Admixture and Aggregate (Accelerated Mortar-Bar Method)

MATERIAL REQUIREMENTS

ASTM A184	Standard Specification for Welded Deformed Steel Bar Mats for Concrete Reinforcement
ASTM A615	Standard Specification for Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement
ASTM A704	Standard Specification for Welded Steel Plain Bar or Rod Mats for Concrete Reinforcement
ASTM A706	Standard Specification for Low-Alloy Steel Deformed and Plain Bars for Concrete Reinforcement
ASTM A714	Standard Specification for High-Strength Low-Alloy Welded and Seamless Steel Pipe
ASTM A775	Standard Specification for Epoxy-Coated Steel Reinforcing Bars
ASTM A934	Standard Specification for Epoxy-Coated Prefabricated Steel Reinforcing Bars
ASTM A996	Standard Specification for Rail-Steel and Axle-Steel Deformed Bars for Concrete Reinforcement
ASTM A1064	Standard Specification for Carbon-Steel Wire and Welded Wire Reinforcement, Plain and Deformed, for Concrete
ASTM A1078	Standard Specification for Epoxy-Coated Steel Dowels for Concrete Pavement
ASTM C33	Standard Specification for Concrete Aggregates
ASTM C94	Standard Specification for Ready-Mixed Concrete
ASTM C150	Standard Specification for Portland Cement

ASTM C171	Standard Specification for Sheet Materials for Curing Concrete
ASTM C260	Standard Specification for Air-Entraining Admixtures for Concrete
ASTM C309	Standard Specification for Liquid Membrane-Forming Compounds for Curing Concrete
ASTM C494	Standard Specification for Chemical Admixtures for Concrete
ASTM C595	Standard Specification for Blended Hydraulic Cements
ASTM C618	Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete
ASTM C881	Standard Specification for Epoxy-Resin-Base Bonding Systems for Concrete
ASTM C989	Standard Specification for Slag Cement for Use in Concrete and Mortars
ASTM D1751	Standard Specification for Preformed Expansion Joint Filler for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types)
ASTM D1752	Standard Specification for Preformed Sponge Rubber and Cork and Recycled PVC Expansion Joint Fillers for Concrete Paving And Structural Construction
ACI 211.1	Standard Practice for Selecting Proportions for Normal, Heavyweight, and Mass Concrete
ACI 305R	Guide to Hot Weather Concreting
ACI 306R	Guide to Cold Weather Concreting
ACI 309R	Guide for Consolidation of Concrete
AC 150/5320-6	Airport Pavement Design and Evaluation
PCA	Design and Control of Concrete Mixtures

END ITEM P-501

Item P-505 Portland Cement Concrete (PCC) TxDOT Mix Specification

505-1.1 General. This work shall consist of pavement composed of Portland cement concrete (PCC) constructed on a prepared surface in accordance with these specifications and shall conform to the lines, grades, thickness, and typical cross sections shown on the plans.

Except as modified herein the PCC shall be in accordance with the TxDOT specification sections: Item 421 Hydraulic Cement Concrete.

If there is a conflict between this (the project) specification and the state specification the project specification shall govern.

505-1.2 Definitions: Wherever the words “Secretary”, “State” or “Department” are found, they shall mean the City of Houston, Texas Airport Authority, (the airport owner), or its designated representative.

505-2.1 Aggregates.

a. Reactivity. Fine and Coarse aggregates to be used in PCC on this project shall be tested and evaluated by the Contractor for alkali-aggregate reactivity in accordance with both ASTM C1260 and ASTM C1567. Tests must be representative of aggregate sources which will be providing material for production. ASTM C1260 and ASTM C1567 tests may be run concurrently.

(1) Coarse and fine aggregate shall be tested separately in accordance with ASTM 642 C1260, however, the length of test shall be extended to 28 days (30 days from casting). Tests 643 must be completed within the last 6 months.

(2) Combined coarse and fine aggregate shall be tested in accordance with ASTM C1567, modified for combined aggregates, using the proposed mixture design proportions of aggregates, cementitious materials, and/or specific reactivity reducing chemicals. If the expansion does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

(3) If lithium nitrate is proposed for use with or without supplementary cementitious materials, the aggregates shall be tested in accordance with Corps of Engineers (COE) Concrete Research Division (CRD) C662 in lieu of ASTM C1567. If lithium nitrate admixture is used, it shall be nominal 30% ±0.5% weight lithium nitrate in water. If the expansion does not exceed 0.10% at 28 days, the proposed combined materials will be accepted. If the expansion is greater than 0.10% at 28 days, the aggregates will not be accepted unless adjustments to the combined materials mixture can reduce the expansion to less than 0.10% at 28 days, or new aggregates shall be evaluated and tested.

b. Fine aggregate. Grading of the fine aggregate, as delivered to the mixer, shall conform to the requirements of ASTM C33. Fine aggregate material requirements and deleterious limits are shown in the table below.

Fine Aggregate Material Requirements (Portion Passing the 3/8 inch (9.5 mm) sieve and retained on the No. 200 (75 µm))		
Soundness of Aggregates by Use of Sodium Sulfate **or** Magnesium Sulfate	Loss after 5 cycles: 10% maximum using Sodium sulfate - or - 15% maximum using magnesium sulfate	ASTM C88
Sand Equivalent	45	ASTM D2419
Fineness Modulus (FM)	$2.50 \leq FM \leq 3.40$	ASTM C136
Limits for Deleterious Substances in Fine Aggregate for Concrete		
Clay lumps and friable particles	1.0% maximum	ASTM C142
Coal and lignite	0.5% using a medium with a density of Sp. Gr. of 2.0	ASTM C123
Total Deleterious Material	1.0% maximum	

Coarse aggregate. The maximum size coarse aggregate shall be 1 inch.
Aggregates delivered to the mixer shall be clean, hard, uncoated aggregates consisting of crushed stone, crushed or uncrushed gravel, air-cooled iron blast furnace slag, crushed recycled concrete pavement, or a combination. To the best of the aggregate producer's knowledge, the aggregates shall have no known history of detrimental pavement staining. Steel blast furnace slag shall not be permitted. The aggregate shall be composed of clean, hard, uncoated particles. Coarse aggregate material requirements and deleterious limits are shown in the table below.

Coarse Aggregate Material Requirements (Portion retained on the No. 4 (4.75 mm) sieve)		
Material Test	**Requirement**	**Standard**
Resistance to Degradation	Loss: 40% maximum	ASTM C131
Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate	Loss after 5 cycles: 12% maximum using Sodium sulfate - or - 18% maximum using magnesium sulfate	ASTM C88
Flat, Elongated, or Flat and Elongated Particles	8% maximum, by weight, of flat, elongated, or flat and elongated particles at 5:1 for any size group coarser than 3/8 (9.5 mm) sieve [1]	ASTM D4791
Bulk density of slag[2]	Weigh not less than 70 pounds per cubic foot (1.12 Mg/cubic meter)	ASTM C29
~~[D-cracking (FreezeThaw)[3]]~~	~~Durability factor ≥ 95~~	~~ASTM C666~~

[1] flat particle is one having a ratio of width to thickness greater than five (5); an elongated particle is one having a ratio of length to width greater than five (5).
[2] Only required if slag is specified.

~~[3] Coarse aggregate may only be accepted from sources that have a 20-year service history for the same gradation to be supplied with no history of D-Cracking. Aggregates that do not have a 20 year record of service free from major repairs (less than 5% of slabs replaced) in similar conditions without D-cracking shall not be used unless the material currently being produced has a durability factor greater than or equal to 95 per ASTM C666 procedure B. The Contractor shall submit a current certification and test results to verify the aggregate acceptability. Test results will only be accepted from a State Department of Transportation (DOT) materials laboratory or an accredited laboratory. Certification and test results which are not dated or which are over one (1) year old or which are for different gradations will not be accepted.~~

The amount of deleterious material in the coarse aggregate shall not exceed the following limits:

Limits for Deleterious Substances in Coarse Aggregate for Concrete		
Deleterious material	**ASTM**	**Percentage by Mass**
Clay Lumps and friable particles	ASTM C142	1.0
Material finer than No. 200 sieve (75 µm)	ASTM C117	1.0[1]
Lightweight particles	ASTM C123 using a medium with a density of Sp. Gr. of 2.0	0.5
Chert (less than 2.40 Sp Gr.)	ASTM C123 using a medium with a density of Sp. Gr. of 2.40)	1.0[2]
Total of all deleterious Material		3.0[1]

[1] The limit for material finer than 75-µm is allowed to be increased to 1.5% for crushed aggregates consisting of dust of fracture that is essentially free from clay or shale (material finer than 2 µm). Test results supporting acceptance of increasing limit to 1.5% with statement indicating material is dust of fracture must be submitted with Mix Design. Acceptable techniques to characterizing these fines include methylene blue adsorption, hydrometer analyses, or X-ray diffraction analysis. The total of all deleterious materials increases up to 3.5%.

[2] The limit for chert may be limited to 0.1 percent by mass in areas subject to severe freeze and thaw.

505-3 Mix Design: TxDOT Item 421 Class S Concrete

~~The Contractor shall provide a mix design to the Resident Project Representative (RPR) for approval at least [28] days prior to first placement of PCC.~~ PCC shall be designed to achieve a 28-day compressive strength of 4,500 psi (31 Mpa) or flexural strength of 650 psi (4.5 Mpa).

~~**505-4 Control Section**. The initial 250 feet (76 m) of pavement shall be considered the control section. The Contractor shall demonstrate, in the presence of the RPR, that the materials, equipment, and construction processes meet the requirements of the specification. Upon acceptance of the control section by the RPR, the Contractor shall use the same equipment, materials, and construction methods for the remainder of construction, unless adjustments made by the Contractor are approved in advance by the RPR.~~

505-5 Construction. In addition to construction requirements in state standards specifications include:

a. Temperature Management/Stress Management Program: Prior to the start of paving operations for each day of paving the contractor shall provide the RPR with a Temperature Management / Stress Management Program to assure that uncontrolled cracking is avoided. As a minimum the program should address:

1. Anticipated tensile strains in fresh concrete as related to heating and cooling of the concrete material.
2. Anticipated weather conditions including temperature, wind velocity, and relative humidity.
3. Anticipated timing of initial saw cut.
4. Anticipated number and type of saws to be utilized for saw cutting.
5. Provisions for backup or additional equipment for saw cutting.

505-6 Repair, removal, or replacement of slabs

a. General. New pavement slabs that are broken or contain cracks or are otherwise defective or unacceptable as defined by the acceptance criteria in 505-8 shall be removed and replaced or repaired, as directed by the RPR and as specified hereinafter at no cost to the Owner. Spalls along joints shall be repaired as specified. Removal of partial slabs is not permitted. Removal and replacement shall be full depth, shall be full width of the slab, and the limit of removal shall be normal to the paving lane and to each original transverse joint. The RPR will determine whether cracks extend full depth of the pavement and may require cores to be drilled on the crack to determine depth of cracking. Such cores shall be 2 inches (50 mm) to 4 inches (100 mm) 728 diameter, shall be drilled by the Contractor and shall be filled by the Contractor with a well consolidated concrete mixture bonded to the walls of the hole with a bonding agent, using approved procedures. Drilling of cores and refilling holes shall be at no expense to the Owner. Repair of cracks as described in this section shall not be allowed if in the opinion of the RPR the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of cracks shall be allowed in any panel that demonstrates segregated aggregate with an absence of coarse aggregate in the upper 1/4 inch (6 735 mm) of the pavement surface.

b. Shrinkage cracks. Shrinkage cracks which do not exceed one-third of the pavement depth shall be cleaned and either high molecular weight methacrylate (HMWM) applied; or epoxy resin (Type IV, Grade 1) per ASTM C881, pressure injected using procedures recommended by the manufacturer and approved by the RPR. Sandblasting of the surface may be required following the application of HMWM to restore skid resistance. Care shall be taken to ensure that the crack is not widened during epoxy resin injection. All epoxy resin injection shall take place in the presence of the RPR. Shrinkage cracks which exceed one-third the pavement depth shall be treated as full depth cracks.

c. Slabs with cracks through interior areas. Interior area is defined as that area more than 6 inches (150 mm) from either adjacent original transverse joint. The full slab shall be removed and replaced at no cost to the Owner, when there are any full depth cracks, or cracks greater than one-third the pavement depth, that extend into the interior area.

d. Cracks close to and parallel to joints. All cracks essentially parallel to original joints, extending full depth of the slab, and lying wholly within 6 inches (150 mm) either side of the joint shall be treated as specified here. Any crack extending more than 6 inches (150 mm) from the joint shall be treated as specified above in subparagraph c.

(1) Full depth cracks present, original joint not opened. When the original un-cracked joint has not opened, the crack shall be sawed and sealed, and the original joint filled with epoxy resin as specified below. The crack shall be sawed with equipment specially designed to follow random cracks. The reservoir for joint sealant in the crack shall be formed by sawing to a depth of 3/4 inches (19 mm), ±1/16 inch (2 mm), and to a width of 5/8 inch (16 mm), ±1/8 inch (3 757 mm). Any equipment or procedure which causes raveling or spalling along the crack shall be modified or replaced to prevent such raveling or spalling. The joint sealant shall be a liquid sealant as specified. Installation of joint seal shall be as specified for sealing joints or as directed. If the joint sealant reservoir has been sawed out, the reservoir and as much of the lower saw cut as possible shall be filled with epoxy resin, Type IV, Grade 2, per ASTM C881, thoroughly tooled into the void using approved procedures.

If only the original narrow saw cut has been made, it shall be cleaned and pressure injected with epoxy resin, Type IV, Grade 1, per ASTM C881, using approved procedures. If filler type material has been used to form a weakened plane in the transverse joint, it shall be completely sawed out and the saw cut pressure injected with epoxy resin, Type IV, Grade 1, per ASTM C881, using approved procedures. Where a parallel crack goes part way across paving lane and then intersects and follows the original joint which is cracked only for the remainder of the width, it shall be treated as specified above for a parallel crack, and the cracked original joint shall be prepared and sealed as originally designed.

(2) Full depth cracks present, original joint also cracked. At a joint, if there is any place in the lane width where a parallel crack and a cracked portion of the original joint overlap, the entire slab containing the crack shall be removed and replaced for the full lane width and length.

e. Removal and replacement of full slabs. Where it is necessary to remove full slabs, all edges of the slab shall be cut full depth with a concrete saw. All saw cuts shall be perpendicular to the slab surface

No mechanical impact breakers, prior to full depth saw cut around edges of removal area, shall be used for any removal of slabs. If under break between 1-1/2 and 4 inches (38 and 100 780 mm) deep occurs at any point along any edge, the area shall be repaired as directed before replacing the removed slab. Procedures directed will be similar to those specified for surface spalls, modified as necessary.

If under break over 4 inches (100 mm) deep occurs, the entire slab containing the under break shall be removed and replaced. Dowels or tie bars of the size and spacing as specified for other joints in similar pavement shall be installed by epoxy grouting them into holes drilled into the existing concrete using procedures as specified. Original damaged dowels or tie bars shall be cut off flush with the joint face. Protruding portions of dowels shall be painted and lightly oiled. All four (4) edges of the new slab shall contain dowels or tie bars.

Placement of concrete shall be as specified for original construction. Prior to placement of new concrete, the underlying material (unless it is stabilized) shall be re-compacted and shaped as specified in the appropriate section of these specifications. The surfaces of all four joint faces shall be cleaned of all loose material and contaminants and coated with a double application of membrane forming curing compound as bond breaker. Care shall be taken to prevent any curing compound from contacting dowels or tie bars. The resulting joints around the new slab shall be prepared and sealed as specified for original construction.

f. Repairing spalls along joints. Where directed, spalls along joints of new slabs, and spalls along parallel cracks used as replacement joints, shall be repaired by first making a vertical saw cut at least one inch (25 mm) outside the spalled area and to a depth of at least 2 inch (50 mm). Saw cuts shall be straight lines forming rectangular areas surrounding the spalled area. The concrete between the new saw cut and the joint, or crack, shall be chipped out to remove all unsound concrete and at least 1/2 inch (12 mm) of visually sound concrete, do not remove over ½ of the slab depth or the entire slab must be replaced. The cavity thus formed shall be thoroughly cleaned with high-pressure water jets supplemented with compressed air as needed to remove all loose material. Immediately before filling the cavity, a prime coat of epoxy resin, Type III, Grade I, shall be applied to the dry cleaned surface of all sides and bottom of the cavity, except any joint face. The prime coat shall be applied in a thin coating and scrubbed into the surface with a stiff-bristle brush. Pooling of the prime coat epoxy resin shall be avoided. The cavity shall be filled with low slump Portland cement concrete or mortar or with epoxy resin concrete or mortar. Concrete shall be used for larger spalls, generally those more than 1/2 cu. ft. (0.014 m3) in size, and mortar shall be used for the smaller ones. Any spall less than 0.1 cu. ft. (0.003 m3) shall be repaired only with epoxy resin mortar or a Grade III epoxy resin. Portland cement concrete and mortar mixtures shall be proportioned as directed and shall be mixed, placed, consolidated, and cured as directed. Epoxy resin mortars shall be made with Type III, Grade 1, epoxy resin, using proportions and mixing and placing procedures as recommended by the manufacturer and approved by the RPR. The epoxy resin materials shall be placed in the cavity in layers not over 2 inches (50 mm) thick. The time interval between placement of additional layers shall be such that the temperature of the epoxy resin material does not exceed 140°F (60°C) at any time during hardening. Mechanical vibrators and hand tampers shall be used to consolidate the concrete or mortar. Any repair material on the surrounding surfaces of the existing concrete shall be removed before it hardens. Where the spalled area abuts a joint, an insert or other bond-breaking medium shall be used to prevent bond at the joint face. A reservoir for the joint sealant shall be sawed to the dimensions required for other joints, or as required to be routed for cracks. The reservoir shall be thoroughly cleaned and sealed with the sealer specified for the joints. If any spall penetrates half the depth of the slab or more, the entire slab shall be removed and replaced as previously specified. If any spall would require over 25% of the length of any single joint to be repaired, the entire slab shall be removed and replaced. Repair of spalls as described in this section shall not be allowed if in the opinion of the RPR the overall condition of the pavement indicates that such repair is unlikely to achieve an acceptable and durable finished pavement. No repair of spalls shall be allowed in any panel that demonstrates segregated aggregate with a significant absence of coarse aggregate in the upper one-eight (1/8th) inch of the pavement surface. Any slabs that have spall repairs will have a 5% reduction 832 in payment, and may not receive more than 95% payment for that slab.

g. Diamond grinding of PCC surfaces. Diamond grinding of the hardened concrete with an approved diamond grinding machine should not be performed until the concrete is 14 days or more old and concrete has reached full minimum strength. When required, diamond grinding shall be accomplished by sawing with saw blades impregnated with industrial diamond abrasive. The saw blades shall be assembled in a cutting head mounted on a machine designed specifically for diamond grinding that will produce the required texture and smoothness level without damage to the pavement. The saw blades shall be 1/8-inch (3-mm) wide and there shall be a minimum of 55 to 60 blades per 12 inches (300 mm) of cutting head width; the actual number of blades will be determined by the Contractor and depend on the hardness of the aggregate. Each machine shall be capable of cutting a path at least 3 feet (0.9 m) wide. Equipment that causes ravels, aggregate fractures, spalls or disturbance to the joints will not be permitted. The depth of diamond grinding shall not exceed 1/2 inch (13 mm) and all areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. All grinding shall be at the expense of the Contractor. All pavement areas requiring plan grade or surface smoothness corrections in excess of the limits specified above, may require removing and replacing in conformance with paragraph 505-6. Any sublots that have over 50% of the sublots with diamond grinding may not receive more than 95% payment for that sublot.

505-7 Contractor Quality Control (QC).

505-7.1 Contractor QC testing. The Contractor shall perform all QC tests necessary to control the production and construction processes applicable to this specification. The testing program shall include, but not necessarily be limited to, tests for aggregate gradation, aggregate moisture content, slump, and air content. A QC Testing Plan shall be developed by the contractor and approved by the RPR.

The RPR may at any time, notwithstanding previous plant acceptance, reject and require the contractor to dispose of any batch of concrete mixture which is rendered unfit for use due to 859 contamination, segregation, or improper slump. Such rejection may be based on only visual 860 inspection. In the event of such rejection, the Contractor may take a representative sample of the 861 rejected material in the presence of the RPR, and if it can be demonstrated in the laboratory, in 862 the presence of the RPR, that such material was erroneously rejected, payment will be made for 863 the material at the contract unit price.

a. Fine aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C70 or ASTM C566.

(3) Deleterious substances. Fine aggregate as delivered to the mixer shall be tested for deleterious substances in fine aggregate for concrete as specified in paragraph 505-2.1b prior to production of the control strip, and a minimum of every 30-days during production or more frequently as necessary to control deleterious substances.

b. Coarse Aggregate.

(1) Gradation. A sieve analysis shall be made at least twice daily for each size of aggregate. Tests shall be made in accordance with ASTM C136 from randomly sampled material taken from the discharge gate of storage bins or from the conveyor belt.

(2) Moisture content. If an electric moisture meter is used, at least two direct measurements of moisture content shall be made per week to check the calibration. If direct measurements are made in lieu of using an electric meter, two tests shall be made per day. Tests shall be made in accordance with ASTM C566.

(3) Deleterious substances. Coarse aggregate as delivered to the mixer shall be tested for deleterious substances in coarse aggregate for concrete as specified in paragraph 505-2.1c, prior to production of the control strip, and a minimum of every 30-days during production or more frequently as necessary to control deleterious substances.

c. Slump. Four slump tests shall be performed for each lot of material produced in accordance with the lot size defined in paragraph 505-8.1. One test shall be made for each sublot. Slump tests shall be performed in accordance with ASTM C143 from material randomly sampled from material discharged from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

d. Air content. Four air content tests shall be performed for each lot of material produced in accordance with the lot size defined in paragraph 505-8.1. One test shall be made for each sublot. Air content tests shall be performed in accordance with ASTM C231 for gravel and stone coarse aggregate and ASTM C173 for slag or other porous coarse aggregate, from material randomly sampled from trucks at the paving site. Material samples shall be taken in accordance with ASTM C172.

e. Unit weight and Yield. Four unit weight and yield tests shall be made in accordance with the lot size defined in paragraph 505-5.1. One test shall be made for each sublot. Unit weight and yield tests shall be in accordance with ASTM C138. The samples shall be taken in accordance with ASTM C172 and at the same time as the air content tests.

f. Temperatures. Temperatures shall be checked at least four times per lot at the job site in accordance with ASTM C1064.

g. Smoothness.

The Contractor shall perform daily smoothness testing on each sublot to verify that the construction processes are producing pavement that meets the following guidelines. If the smoothness criteria is not met, appropriate changes and corrections to the construction process shall be made by the contractor before construction continues.

Smoothness shall be tested in both the transverse and longitudinal direction of each lot to identify areas that may be prone to ponding of water which could lead to hydroplaning of aircraft. The final surface shall be free from finishing marks. After the final finishing, but not later than 48 hours after placement, the surface of each lot shall be tested in both longitudinal and transverse directions for smoothness. The contractor has the option of using either a 12-foot (3.7 m) straightedge and/or a rolling inclinometer meeting the requirements of ASTM E2133. Testing shall be continuous across all joints. Straightedge testing shall start with one-half the length of the straightedge at the edge of pavement section being tested and then moved ahead one-half the length of the straightedge for each successive measurement. The amount of surface irregularity shall be determined by placing the freestanding (unleveled) straightedge on the pavement surface and allowing it to rest upon the two highest spots covered by its length, and measuring the maximum gap between the straightedge and the pavement surface in the area between these two high points. The contractor may choose to evaluate daily lot compliance with the 1/4-inch straightedge requirement using a rolling inclinometer. If the rolling inclinometer is used, the acquired data can be read into the FAA profile program, ProFAA, using the straightedge simulation function to assess the compliance with 1/4-inch variance with a 12-foot straightedge. If the contractor opts to use a rolling inclinometer, the device shall be operated in accordance with ASTM E2133.

The final finished surface course of the pavement shall not vary more than 1/4 inch (6 mm) transversely. Smoothness readings will not be made across grade changes or cross slope transitions. Deviations on final surface course in either the transverse or longitudinal that will trap water > 1/4 inch (6 mm) will be corrected with diamond grinding per paragraph 505-6g or by removing and replacing the surface course to full depth. Grinding will be tapered in all directions to provide smooth transitions to areas not requiring grinding. All areas in which diamond grinding has been performed will be subject to the final pavement thickness tolerances specified in paragraph 505-8.4.

(1) Transverse measurements. Transverse measurements will be taken for each lot placed. Transverse measurements will be taken perpendicular to the pavement centerline each 50 feet (15 m) or more often as determined by the RPR. The joint between lots shall be tested separately to facilitate smoothness between lots.

(2) Longitudinal measurements. Longitudinal measurements will be taken for each lot placed. Longitudinal tests will be parallel to the centerline of paving; at the center of paving lanes when widths of paving lanes are less than 20 feet (6 m); and at the third points of paving lanes when widths of paving lanes are 20 ft (6 m) or greater.

If the contractor's machines and/or methods are producing significant areas that need corrective actions then production must be stopped until corrective measures can be implemented.

h. Grade. Grade will be evaluated prior to placement of the PCC surface and then, as a minimum, after placement of the PCC surface. The Contractor must submit the survey data to the RPR by the following day after measurements have been taken with measurements taken at appropriate gradelines (as a minimum at center and edges of paving lane) and longitudinal spacing as shown on cross-sections and plans verifying that the project is in conformance with project plans and cross-sections. The final finished surface of the pavement of the completed project will not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm) vertically. The documentation, stamped and signed by a licensed surveyor, will be provided by the Contractor to the RPR. The contractor will pay the cost of the surveying and level runs. Grinding will be in accordance with paragraph 505-6g.

505-7.2 Control charts. The Contractor shall maintain linear control charts for fine and coarse aggregate gradation, slump, moisture content and air content. Control charts shall be posted in a location satisfactory to the RPR and shall be kept up to date at all times. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and suspension Limits, or Specification limits, applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a potential problem and the Contractor is not taking satisfactory corrective action, the RPR may halt production or acceptance of the material.

a. Fine and coarse aggregate gradation. The Contractor shall record the running average of the last five gradation tests for each control sieve on linear control charts. Superimposed on the control charts shall be the action and suspension limits. Gradation tests shall be performed by the Contractor per ASTMC136. The Contractor shall take at least two samples per lot to check the final gradation. Sampling shall be per ASTM D75 from the flowing aggregate stream or conveyor belt.

b. Slump and air content. The Contractor shall maintain linear control charts both for 981 individual measurements and range (that is, difference between highest and lowest measurements) for slump and air content in accordance with the following Action and Suspension Limits.

505-7.3 Corrective action at Suspension Limit. The quality control plan shall indicate that appropriate action shall be taken when the process is believed to be out of control. The quality control plan shall detail what action will be taken to bring the process into control and shall contain sets of rules to gauge when a process is out of control. As a minimum, a process shall be deemed out of control and corrective action taken if any one of the following conditions exists.

a. Fine and coarse aggregate gradation. When two consecutive averages of five tests are outside of the suspension limits, immediate steps, including a halt to production, shall be taken to correct the grading.

b. Fine and coarse aggregate moisture content. Whenever the moisture content of the fine or coarse aggregate changes by more than 0.5%, the scale settings for the aggregate batcher and water batcher shall be adjusted.

c. Slump. The Contractor shall halt production and make appropriate adjustments whenever:

(1) one point falls outside the Suspension Limit line for individual measurements

Or

(2) two points in a row fall outside the Action Limit line for individual measurements

d. Air content. The Contractor shall halt production and adjust the amount of air-entraining admixture whenever:

(1) one point falls outside the Suspension Limit line for individual measurements

Or

(2) two points in a row fall outside the Action Limit line for individual measurements.

505-8 Quality Assurance (QA) Acceptance

~~**505-8.1. Lot size**. Concrete will be accepted for strength and thickness on a lot basis. A lot will consist of a day's production not to exceed 2,000 cubic yards. Each lot will be divided into approximately equal sublots with individual sublots between 400 to 600 cubic yards. Where three sublots are produced, they will constitute a lot. Where one or two sublots are produced, they will be incorporated into the previous or next lot. Where more than one plant is simultaneously producing concrete for the job, the lot sizes will apply separately for each plant.~~

~~**505-8.2 Partial lots.** When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot or for overages or minor placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.~~

~~Where three sublots have been produced, they will constitute a lot. Where one or two sublots have been produced, they will be incorporated into the next lot or the previous lot and the total number of sublots will be used in the acceptance criteria calculation, that is, n=5 or n=6.~~

505-8.3. Compressive Strength.

(a) Sampling. Each lot shall be divided into equal sublots. One sample shall be taken for each sublot from the plastic concrete delivered to the job site. Sampling locations shall be determined by the RPR in accordance with random sampling procedures contained in ASTM D 3665. The concrete shall be sampled in accordance with ASTM C 172. All cylinders for compressive strength testing shall be 6" x 12". Any pavement that does not meet the minimum strength specified in paragraph 505-3 shall be removed and replaced.

(b) Testing. Two (2) specimens shall be made from each sample. Specimens shall be made in accordance with ASTM C 31 and the compressive strength of each specimen shall be determined in accordance with

ASTM C 39. The compressive strength for each sublot shall be computed by averaging the results of the two test specimens representing that sublot. Cylinders shall be 6” x 12.”

(c) Curing. The Contractor shall provide adequate facilities for the initial curing of cylinders/beams. During the 24 hours after molding, the temperature immediately adjacent to the specimens must be maintained in the range of 60 to 80 degrees F (16 to 27 degrees C), and loss of moisture from the specimens must be prevented. The specimens may be stored in tightly constructed wooden boxes, damp sand pits, temporary buildings at construction sites, under wet burlap in favorable weather or in heavyweight closed plastic bags, or use other suitable methods, provided the temperature and moisture loss requirements are met.

505-8.4. Thickness. The sublot thickness shall not be less than 0.5 inches (12 mm) from plan thickness. One core shall be taken by the contractor for each sublot. Sampling locations shall be determined by the RPR in accordance with random sampling procedures contained in ASTM D 3665. Areas such as thickened edges with planned variable thickness shall be excluded from sample locations.

Cores shall be neatly cut with a core drill. The Contractor shall furnish all tools, labor, and 1054 materials for cutting samples and filling the cored hole. Core holes shall be filled by the Contractor with a non-shrink grout approved by the RPR within one day after sampling.

The thickness of the cores shall be determined by the RPR by the average caliper measurement method in accordance with ASTM C 174.

505-8.5. Grade. Grade will be evaluated prior to the first day of placement and then as a minimum, prior to placement of the surface lift and after the placement of the surface lift to allow adjustments to paving operations if measurements do not meet specification requirements. The Contractor must submit the survey data to the RPR by the following day after measurements have been taken with measurements taken at appropriate gradelines (as a minimum at center and edges of paving lane) and 50 foot longitudinal spacing on cross-sections verifying that project is in conformance with project plans and cross-sections. The final finished surface of the pavement of the completed project will not vary from the gradeline elevations and cross-sections shown on the plans by more than 1/2 inch (12 mm) vertically. The documentation, stamped and signed by a licensed surveyor, will be provided by the Contractor to the RPR. The contractor will pay the cost of the surveying and level runs. Grinding will be in accordance with P-505-6g. High points may be ground off provided the course thickness after grinding is not more than ½ inch (12 mm) less than the thickness specified on the plans.

~~[**505-8.6. Profilograph Smoothness**. The final profilograph will be the full length of the project to facilitate testing of smoothness between lots. Profilograph testing will be performed by the [contractor, in the presence of the RPR] [RPR] using approved equipment and procedures as described as ASTM E1274. The pavement must have an average profile index less than 15 inches per mile per 1/10 mile. The equipment will utilize electronic recording and automatic computerized reduction of data to indicate “must grind” bumps and the Profile Index for the pavement using a 0.2 inch (5 mm) blanking band. The bump template must span one inch (25 1078 mm) with an offset of 0.4 inches (10 mm). The profilograph must be calibrated prior to use and operated by a factory or State DOT approved, trained operator. Profilograms will be recorded on a longitudinal scale of one inch (25 mm) equals 25 feet (7.5 m) and a vertical scale of one inch (25 mm) equals one inch (25 mm). Profilograph will be performed one foot right and left of project centerline and 15 feet (4.5 m) right and left of project centerline. Any areas that indicate “must grind” will be corrected with diamond grinding per paragraph 505-6g or by removing and replacing full depth of surface course. as directed by the RPR. Where corrections are necessary, second profilograph runs will be performed to verify that the corrections produced an average profile index of 15 inches per mile per 1/10 mile or less].~~

~~**[505-8.7. Adjustments for repair**. Panels with spall repairs, partial panel replacement or grinding over 50% of panel will be limited to no more than 95% payment.]~~

505-9 Measurement. Portland cement concrete pavement shall be measured by the number of square yards of pavement as specified in-place, completed and accepted.

505-10 Payment. Payment shall be made under:

Item P-505-10 Portland Cement Concrete Pavement. Per square yard.

END ITEM P-505

Item P-602 Bituminous Prime Coat

DESCRIPTION

602-1.1 This item shall consist of an application of bituminous material on the prepared base course in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

MATERIALS

602-2.1 Bituminous material. The bituminous material shall be an emulsified asphalt indicated in ASTM D3628 as a bituminous application for prime coat appropriate to local conditions or as designated by the Engineer.

CONSTRUCTION METHODS

602-3.1 Weather limitations. The prime coat shall be applied only when the existing surface is dry; the atmospheric temperature is 50°F (10°C) or above, and the temperature has not been below 35°F (2°C) for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Engineer.

602-3.2 Equipment. The equipment shall include a self-powered pressure bituminous material distributor and equipment for heating bituminous material.

Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 65.0 psi (4.5 kg/sq cm) of tire width to prevent rutting, shoving or otherwise damaging the base, surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard (0.23 to 9.05 L/square meter), with a pressure range of 25 to 75 psi (172.4 to 517.1 kPa) and with an allowable variation from the specified rate of not more than ±5%, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. If the distributor is not equipped with an operable quick shutoff valve, the prime operations shall be started and stopped on building paper. The Contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the Owner.

A power broom and power blower suitable for cleaning the surfaces to which the bituminous coat is to be applied shall be provided.

602-3.3 Application of bituminous material. Immediately before applying the prime coat, the full width of the surface to be primed shall be swept with a power broom to remove all loose dirt and other objectionable material.

The bituminous material shall be uniformly applied with a bituminous distributor at the rate of 0.15 to 0.30 gallons per square yard (0.68 to 1.36 liters per square meter) depending on the base course surface texture. The type of bituminous material and application rate shall be approved by the Engineer prior to application.

Following application of the bituminous material and prior to application of the succeeding layer of pavement, allow the bituminous coat to cure and to obtain evaporation of any volatiles or moisture. Maintain the coated surface until the succeeding layer of pavement is placed, by protecting the surface against damage and by repairing and recoating deficient areas. Allow the prime coat to cure without being disturbed for a period of at least 48 hours or longer, as may be necessary to attain penetration into the treated course. Furnish and spread enough sand to effectively blot up and cure excess bituminous material. Keep traffic off surfaces freshly treated with bituminous material. Provide sufficient warning signs and barricades so that traffic will not travel over freshly treated surfaces.

602-3.4 Trial applications. Before providing the complete bituminous coat, the Contractor shall apply three lengths of at least 100 feet (30 m) for the full width of the distributor bar to evaluate the amount of bituminous material that can be satisfactorily applied with the equipment. Apply three different trial application rates of bituminous materials within the application range specified in paragraph 602-3.3. Other trial applications will be made using various amounts of material as deemed necessary by the Engineer.

602-3.5 Bituminous material Contractor's responsibility. The Contractor shall provide a statement of source and character of the proposed bituminous material which must be submitted to and approved by the Engineer before any shipment of bituminous materials to the project. The Contractor shall furnish vendor's certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The test reports shall be provided to and approved by the Engineer before the bituminous material is applied. If the bituminous material does not meet the specifications, it shall be replaced at the Contractor's expense. Furnishing the vendor's certified test report for the bituminous material shall not be interpreted as basis for final acceptance.

602-3.6 Freight and weigh bills. The Contractor shall submit waybills and delivery tickets during the progress of the work. Before the final estimate is allowed, file with the Engineer certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

METHOD OF MEASUREMENT

602-4.1 The bituminous material for prime coat shall be measured by the gallon. Volume shall be corrected to the volume at 60°F (16°C) in accordance with ASTM D1250. The bituminous material paid for will be the measured quantities used in the accepted work, provided that the measured quantities are not 10% over the specified application rate. Any amount of bituminous material more than 10% over the specified application rate for each application will be deducted from the measured quantities, except for irregular areas where hand spraying of the bituminous material is necessary. Water added to emulsified asphalt will not be measured for payment.

BASIS OF PAYMENT

602-5.1 Payment shall be made at the contract unit price per gallon for bituminous prime coat. This price shall be full compensation for furnishing all materials and for all preparation, delivering, and applying the materials, and for all labor, equipment, tools, and incidentals necessary to complete this item.

Payment will be made under:

Item P-602	Bituminous Prime Coat - per gallon

TESTING REQUIREMENTS

ASTM D1250	Standard Guide for Use of the Petroleum Measurement Tables

MATERIAL REQUIREMENTS

ASTM D977	Standard Specification for Emulsified Asphalt
ASTM D2028	Standard Specification for Cutback Asphalt (Rapid-Curing Type)
ASTM D2397	Standard Specification for Cationic Emulsified Asphalt
ASTM D3628	Standard Practice for Selection and Use of Emulsified Asphalts

END OF ITEM P-602

Item P-603 Bituminous Tack Coat

DESCRIPTION

603-1.1 This item shall consist of preparing and treating a bituminous or concrete surface with bituminous material in accordance with these specifications and in reasonably close conformity to the lines shown on the plans.

MATERIALS

603-2.1 Bituminous materials. The bituminous material shall be an emulsified asphalt indicated in ASTM D3628 as a bituminous application for tack coat appropriate to local conditions or as designated by the Engineer.

CONSTRUCTION METHODS

603-3.1 Weather limitations. The tack coat shall be applied only when the existing surface is dry and the atmospheric temperature is 50°F (10°C) or above; the temperature has not been below 35°F (2°C) for the 12 hours prior to application; and when the weather is not foggy or rainy. The temperature requirements may be waived when directed by the Engineer.

603-3.2 Equipment. The Contractor shall provide equipment for heating and applying the bituminous material.

Provide a distributor with pneumatic tires of such size and number that the load produced on the base surface does not exceed 65.0 psi (4.5 kg/sq cm) of tire width to prevent rutting, shoving or otherwise damaging the base, surface or other layers in the pavement structure. Design and equip the distributor to spray the bituminous material in a uniform coverage at the specified temperature, at readily determined and controlled rates from 0.05 to 2.0 gallons per square yard (0.23 to 9.05 L/square meter), with a pressure range of 25 to 75 psi (172.4 to 517.1 kPa) and with an allowable variation from the specified rate of not more than ±5%, and at variable widths. Include with the distributor equipment a separate power unit for the bitumen pump, full-circulation spray bars, tachometer, pressure gauges, volume-measuring devices, adequate heaters for heating of materials to the proper application temperature, a thermometer for reading the temperature of tank contents, and a hand hose attachment suitable for applying bituminous material manually to areas inaccessible to the distributor. Equip the distributor to circulate and agitate the bituminous material during the heating process. If the distributor is not equipped with an operable quick shutoff valve, the tack operations shall be started and stopped on building paper. The Contractor shall remove blotting sand prior to asphalt concrete lay down operations at no additional expense to the Owner.

A power broom and/or power blower suitable for cleaning the surfaces to which the bituminous tack coat is to be applied shall be provided.

603-3.3 Application of bituminous material. Immediately before applying the tack coat, the full width of surface to be treated shall be swept with a power broom and/or power blower to remove all loose dirt and other objectionable material.

Emulsified asphalt shall be diluted by the addition of water when directed by the Engineer and shall be applied a sufficient time in advance of the paver to ensure that all water has evaporated before the overlying mixture is placed on the tacked surface.

The bituminous material including vehicle shall be uniformly applied with a bituminous distributor at the rate of 0.05 to 0.10 gallons per square yard (0.20 to 0.50 liters per square meter) depending on the condition of the existing surface. The type of bituminous material and application rate shall be approved by the Engineer prior to application.

After application of the tack coat, the surface shall be allowed to cure without being disturbed for the period of time necessary to permit drying and setting of the tack coat. This period shall be determined by the Engineer. The Contractor shall protect the tack coat and maintain the surface until the next course has been placed.

603-3.4 Bituminous material Contractor's responsibility. The Contractor shall provide a statement of source and character of the proposed bituminous material which must be submitted and approved by the Engineer before any shipment of bituminous materials to the project.

The Contractor shall furnish the vendor's certified test reports for each carload, or equivalent, of bituminous material shipped to the project. The tests reports shall be provided to and approved by the Engineer before the bituminous material is applied. If the bituminous material does not meet the specifications, it shall be replaced at the Contractor's expense. Furnishing the vendor's certified test report for the bituminous material shall not be interpreted as a basis for final acceptance.

603-3.5 Freight and weigh bills The Contractor shall submit waybills and delivery tickets, during progress of the work. Before the final statement is allowed, file with the Engineer certified waybills and certified delivery tickets for all bituminous materials used in the construction of the pavement covered by the contract. Do not remove bituminous material from storage until the initial outage and temperature measurements have been taken. The delivery or storage units will not be released until the final outage has been taken.

METHOD OF MEASUREMENT

603-4.1 The bituminous material for tack coat shall be measured by the gallon. Volume shall be corrected to the volume at 60°F (16°C) in accordance with ASTM D1250. The bituminous material paid for will be the measured quantities used in the accepted work, provided that the measured quantities are not 10% over the specified application rate. Any amount of bituminous material more than 10% over the specified application rate for each application will be deducted from the measured quantities, except for irregular areas where hand spraying of the bituminous material is necessary. Water added to emulsified asphalt will not be measured for payment.

BASIS OF PAYMENT

603.5-1 Payment shall be made at the contract unit price per gallon of bituminous material. This price shall be full compensation for furnishing all materials, for all preparation, delivery, and application of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-603-5.1	Bituminous Tack Coat - per gallon

MATERIAL REQUIREMENTS

ASTM D633	Standard Volume Correction Table for Road Tar
ASTM D977	Standard Specification for Emulsified Asphalt
ASTM D1250	Standard Guide for Use of the Petroleum Measurement Tables
ASTM D2028	Standard Specification for Cutback Asphalt (Rapid-Curing Type)
ASTM D2397	Standard Specification for Cationic Emulsified Asphalt
ASTM D3628	Standard Practice for Selection and Use of Emulsified Asphalts

END ITEM P-603

Item P-604 Compression Joint Seals for Concrete Pavements

DESCRIPTION

604-1.1 This item shall consist of preformed polychloroprene compression seals used for sealing joints of rigid pavements.

MATERIALS

604-2.1 Compression seals. Compression joint seal materials shall be a vulcanized elastomeric compound using polychloroprene as the only base polymer. The material and the manufactured seal shall conform to ASTM D2628 and Corps of Engineers Concrete Research Division (CRD) C548 where jet fuel and/or heat blast resistance is required **.** The joint seal shall be a labyrinth type seal. The uncompressed depth of the face of the compression seal (that is to be bonded to the joint wall) shall be greater than the uncompressed width of the seal, except that for seals one inch (25 mm) or greater in width, the depth need be only one inch (25 mm) or greater. The actual width of the uncompressed seal for construction and contraction joints shall be 3/16 or one inches and for expansion joints shall be 1.25 inches. The tolerance on the seal shall be plus 1/8 inch or minus 1/16 inch.

604-2.2 Lubricant/adhesive. Lubricant/adhesive used for the compression elastomeric joint seal shall be a one-component compound conforming to ASTM D2835.

604-2.3 Delivery and storage. Materials delivered to the job site shall be inspected for defects, unloaded, and stored with a minimum of handling to avoid damage. Storage facilities shall be provided at the job site to protect materials from weather and maintain materials at temperatures recommended by the manufacturer.

604-2.4 Submittals. Certified copies of test results shall be provided 60 days prior to use of material on the project.

a. Construction equipment list. List of proposed equipment to be used in the performance of construction work, including descriptive data shall be provided to the Engineer 60 days prior to use on the project.

b. Manufacturer’s instructions. Where installation procedures are required in accordance with the manufacturer’s recommendations, printed copies of these recommendations shall be submitted to the Engineer 60 days prior to use on the project. Installation of the material shall not be allowed until the recommendations are received.

c. Test reports. The Contractor shall submit certified copies of the test reports to the Engineer for written approval 60 days prior to use on the project. Printed directions from the manufacturer on recommended installation criteria shall be furnished with the test reports, plus the manufacturer’s certification that the selected seal is recommend for the installation on this project. No material will be used until it has been approved by the Engineer.

604-2.5 Test requirements. Each lot of compression joint seal and lubricant/adhesive shall be sampled, identified, and tested for conformance with the applicable material specification. A lot of preformed seal shall consist of one day’s production or 20,000 linear feet (6000 meters) for each cross-section, whichever is less. A lot of lubricant/adhesive shall consist of one day’s production. No material shall be used at the project prior to receipt of written notice that the materials meet the laboratory requirements.

Testing of the preformed joint and lubricant/adhesive material shall be the responsibility of the Contractor and shall be performed in an approved independent laboratory and certified copies of the test reports shall be submitted for approval 60 days prior to the use of the materials at the job site. Samples of each lot of material shall also be submitted and will be retained by the Engineer for possible future testing should the materials appear defective during or after application. The Contractor shall furnish additional samples of materials, in sufficient quantity to be tested, upon request. Final acceptance will be based on **c**onformance to the specified test requirements and the performance of the in-place materials.

CONSTRUCTION METHODS

604-3.1 Equipment. Machines, tools, and equipment used in the performance of the work required by this section shall be approved by the Engineer before the work starts and shall be maintained by the Contractor in satisfactory condition at all times.

a. Joint cleaning equipment.

(**1) Concrete saw.** A self-propelled power saw with water-cooled diamond saw blades shall be provided for cutting joints to the depths and widths specified and for removing filler, existing old joint seal or other material embedded in the joints or adhered to the joint faces.

(**2) Sandblasting equipment.** Sandblasting equipment shall include an air compressor, hose, and a long-wearing venturi-type nozzle of proper size, shape, and opening. The maximum nozzle opening should not exceed 1/4 inch (6 mm). The air compressor shall be portable and shall be capable of furnishing not less than 150 cubic feet (4200 liters) per minute and maintaining a line pressure of not less than 90 psi (620 kPa) at the nozzle while in use. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint about one inch (25 mm) above the pavement surface and will direct the blast to clean the joint walls. The height, angle of inclination, and the size of the nozzle shall be adjusted as necessary to ensure satisfactory results.

(**3) Waterblasting equipment.** Waterblasting equipment shall include a trailer-mounted water tank, pumps, high-pressure hose, a wand with safety release cutoff controls, nozzle, and auxiliary water resupply equipment. The water tank and auxiliary water resupply equipment shall be of sufficient capacity to permit continuous operations. The pumps, hoses, wand, and nozzle shall be of sufficient capacity to permit the cleaning of both walls of the joint and the pavement surface for a width of at least 1/2 inch (12 mm) on either side of the joint. The pump shall be capable of supplying a pressure of at least 3,000 psi (20.7 MPa). A pressure gauge mounted at the pump shall show at all times the pressure in pounds per square inch (psi) (kPa) at which the equipment is operating.

b. Sealing equipment. Equipment used to install the compression seal shall place the compression seal to the prescribed depths within the specified tolerances without cutting, nicking, twisting, or otherwise damaging the seal. The equipment shall not stretch or compress the seal more than 2.0% longitudinally during installation. The machine shall be an automatic self-propelled joint seal application equipment and shall be engine powered. The machine shall include a reservoir for the lubricant/adhesive, a device for conveying the lubricant/adhesive in the proper quantities to the sides the preformed seal or the sidewalls of the joint, a reel capable of holding one full spool of compression seal, and a power-driven apparatus for feeding the joint seal through a compression device and inserting the seal into the joint. The equipment shall also include a guide to maintain the proper course along the joint being sealed. The machine shall at all times be operated by an experienced operator.

CONSTRUCTION METHODS

604-4.1 Environmental conditions. The ambient temperature and the pavement temperature within the joint wall shall be at least 35°F and rising at the time of installation of the materials. Sealant application will not be permitted if moisture or any foreign material is observed in the joint.

604-4.2 Trial joint seal and lubricant/adhesive installation. Prior to the cleaning and sealing of the joints for the entire project, a test section at least 200 feet (69 meters) long shall be prepared at a location in the project pavement directed by the Engineer using the specified materials and the approved equipment, to demonstrate the proposed joint preparation and sealing of all types of joints in the project. Following the completion of the trial length and before any other joint is sealed, the trial joints will be inspected by the Engineer to determine that the materials and installation meet the requirements specified. If materials or installation do not meet requirements the materials shall be removed, and the joints shall be recleaned and resealed at no cost to the Owner. No other joints shall be sealed until the test installation has been approved by the Engineer. If the trial section is approved, it may be incorporated into the permanent work. All other joints shall be sealed in the manner approved for sealing the trial joints.

604-4.3 Preparation of joints. Immediately before installation of the compression joint seal, the joints shall be thoroughly cleaned to remove all laitance, filler, existing sealer, foreign material and protrusions of hardened concrete from the sides and upper edges of the joint space to be sealed. Cleaning shall be performed using equipment in accordance with paragraph 604-3.1a and shall extend along pavement surfaces at least 1/2 inch (12 mm) on either side of the joint. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water. Demonstrate that the selected cleaning operation meets the cleanliness requirements. Any irregularity in the joint face that would prevent uniform contact between the joint seal and the joint face shall be corrected prior to the installation of the joint seal.

a. Sawing. Joints shall be sawed to clean and to open them to the full specified width and depth. Immediately following the sawing operation, the joint faces and opening shall be thoroughly cleaned using a water jet to remove all saw cuttings or debris remaining on the faces or in the joint opening. Compression seal shall be installed within three (3) calendar days of the time the joint cavity is sawed. Depth of the joint cavity shall be in accordance with manufacturer's instructions. Submit printed copies of manufacturers' instructions 60 days prior to use on the project. The saw cut for the joint seal cavity shall at all locations be centered over the joint line. The nominal width of the sawed joint seal cavity shall be as follows; the actual width shall be within a tolerance of ±1/16 inch (2 mm):

(**1)** If a nominal 13/16 inch wide compression seal is furnished, the nominal width of the saw cut shall be 1/2 inches when the pavement temperature at the time of sawing is between 25 and 80°F. If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1/16 inch (2 mm). If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1/16 inch (2 mm).

(**2)** If a nominal one inch wide compression seal is furnished, the nominal width of the saw cut shall be 9/16 inches when the pavement temperature at the time of sawing is between 25 and 140°F. If the pavement temperature at the time of sawing is above this range, the nominal width of the saw cut shall be decreased 1/16 inch. If the pavement temperature at the time of sawing is below this range, the nominal width of the saw cut shall be increased 1/16 inch.

(3) The pavement temperature shall be measured and recorded in the presence of the Engineer. Measurement shall be made each day before commencing sawing and at any other time during the day when the temperature appears to be moving out of the allowable sawing range.

b. Sandblast cleaning. The concrete joint faces and pavement surfaces extending at least 1/2 inch (12 mm) from the joint edges shall be sandblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water.

c. Waterblast cleaning. The concrete joint faces and pavement surfaces extending at least 1/2 inch (12 mm) from the joint edges shall be waterblasted clean. A multiple pass technique shall be used until the surfaces are free of dust, dirt, curing compound, or any residue that might prevent ready insertion or uniform contact of the seal and bonding of the lubricant/adhesive to the concrete. After final cleaning and immediately prior to sealing, the joints shall be blown out with compressed air and left completely free of debris and water.

d. Rate of progress. Sandblasting or waterblasting of the joint faces and air pressure cleaning of the joints shall be limited to the linear footage of joint that can be sealed during the same workday.

604-4.4 Installation of the compression seal.

a. Time of installation. Joints shall be sealed within three (3) calendar days of sawing the joint seal cavity and immediately following concrete cure and the final cleaning of the joint walls. Open joints ready for sealing that cannot be sealed under the conditions specified shall be provided with an approved temporary seal to prevent infiltration of foreign material. When rain interrupts the sealing operations, the joints shall be washed, air pressure cleaned and allowed to dry prior to installing the lubricant/adhesive and compression seal.

b. Sequence of installation. Longitudinal joints shall be sealed first, followed by transverse joints. Seals in longitudinal joints shall be installed so that all transverse joint seals will be intact from edge to edge of the pavement. Intersections shall be made monolithic by use of joint seal adhesive and care in fitting the intersection parts together. Extender pieces of seal shall not be used at intersections. Any seal falling short of the intersection shall be removed and replaced with new seal at no additional cost to the Owner.

604-4.5 Sealing of joints. The joint seal shall be installed using the equipment specified in paragraph 604-3.1b. The sides of the joint seal or the sides of the joint shall be covered with a coating of lubricant/adhesive and the seal installed as specified. Butt joints and seal intersections shall be coated with liberal applications of lubricant/adhesive. Lubricant/adhesive spilled on the pavement shall be removed immediately to prevent setting on the pavement. An in-place joint seal shall be in an upright position and free from twisting, distortion, and cuts. Adjustments shall be made to the installation equipment and procedure, if the stretch exceeds 1%. Any seal exceeding 2% stretch shall be removed and replaced. The joint seal shall be placed at a uniform depth within the tolerances specified. In-place joint seal that fails to meet the specified requirements shall be removed and replaced with new joint seal in a satisfactory manner at no additional cost to the Owner. The compression joint seal shall be placed to a depth of 3/16 inch (5 mm), ±1/8 inch (3 mm), below the pavement surface or below the depth of the groove unless otherwise directed by the Engineer. No part of the seal shall be allowed to project above the surface of the pavement. The seal shall be installed in the longest practicable lengths in longitudinal joints and shall be cut at the joint intersections so as to provide continuous installation of the seal in the transverse joints. The lubricant/adhesive in the longitudinal shall be allowed to set for one (1) hour prior to cutting at the joint intersections to reduce the possibility of shrinkage. For all transverse joints, the minimum length of the preformed joint seal shall be the pavement width from edge to edge.

604-4.6 Clean-up. Upon completion of the project, all unused materials shall be removed from the site, all lubricant/adhesive on the pavement surface shall be removed, and the pavement shall be left in clean condition.

604-4.7 Quality control provisions.

a. Equipment. The application equipment shall be inspected to assure uniform application of lubricant/adhesive to the sides of the compression joint seal or the walls of the joint. If any equipment causes cutting, twisting, nicking, excessive stretching or compressing of the compression seal, or improper application of the lubricant/adhesive, the operation shall be suspended until causes of the deficiencies are determined and corrected by the Contractor.

b. Procedures.

(1) Quality control provisions shall be provided during the joint cleaning process to prevent or correct improper equipment and cleaning techniques that damage the concrete in any manner. Cleaned joints shall be approved by the Engineer prior to installation of the lubricant/adhesive and compression joint seal.

(**2)** Conformance to stretching and compression limitations shall be determined by the Engineer. Mark the top surface of the compression seal at one foot (30 cm) intervals in a manner clear and durable to enable length determinations of the seal. After installation, the distance between the marks on the seal shall be measured by the Contractor. If the stretching or compression exceeds the specified limit, the seal shall be removed and replaced with new joint seal at no additional cost to the Owner. The seal shall be removed up to the last correct measurement. The seal shall be inspected by the Contractor a minimum of once per 400 feet (120 m) of seal for compliance to the shrinkage or compression requirements. Measurements shall also be made at the same interval to determine conformance with depth and width installation requirements. All compression seal that is not in conformance with specification requirements shall be removed and replaced with new joint seal at no additional cost to the Owner.

c. Inspection. The joint sealing system (compression seal and lubricant/adhesive) shall be inspected by the Engineer for proper rate of cure and bonding to the concrete, cuts, twists, nicks, and other deficiencies. Seals exhibiting any defects, at any time prior to final acceptance of the project, shall be removed from the joint, wasted, and replaced in a satisfactory manner, as determined by the Engineer.

METHOD OF MEASUREMENT

604-5.1 Measurement. The quantity of each sealing item will be determined by actual measurement of the number of linear feet of in-place material that has been approved.

BASIS OF PAYMENT

604-6.1 Payment. Payment will be made at the contract unit bid prices per linear foot (meter) for the sealing items scheduled, including approved trial joint installation. The unit bid prices shall include the cost of all labor, materials, the use of all equipment, and tools required to complete the work.

Item 604-6.1	Compression Joint Seals for Concrete Pavements

TESTING REQUIREMENTS

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in this text by basic designation only.

ASTM D2628	Standard Specification for Preformed Polychloroprene Elastomeric Joint Seals for Concrete Pavements
ASTM D2835	Standard Specification for Lubricant for Installation of Preformed Compression Seals in Concrete Pavements
Corps of Engineers CRD C548	Standard Specification for Jet-Fuel and Heat Resistant Preformed Polychloroprene Elastomeric Joint Seals for Rigid Pavements
UFC 3-250-08FA	Standard Practice for Sealing Joints and Cracks in Rigid and Flexible Pavements

END ITEM P-604

Item P-605 Joint Sealants for Concrete Pavements

DESCRIPTION

605-1.1 This item shall consist of providing and installing a resilient and adhesive joint sealing material capable of effectively sealing joints and cracks in rigid pavements.

MATERIALS

605-2.1 Joint sealants. Joint sealant materials shall meet the requirements of ASTM D5893 Standard Specifications for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.

Each lot or batch of sealant shall be delivered to the jobsite in the manufacturer's original sealed container. Each container shall be marked with the manufacturer's name, batch or lot number, the safe heating temperature, and shall be accompanied by the manufacturer's certification stating that the sealant meets the requirements of this specification.

605-2.2 Backer rod. The material furnished shall be a compressible, non-shrinking, non-staining, non-absorbing material that is non-reactive with the joint sealant. The material shall have a water absorption of not more than 5% when tested in accordance with ASTM C509. The backer-rod material shall be 25% ± 5 % larger in diameter than the nominal width of the crack.

605-2.3 Backup materials. Provide backup material that is a compressible, nonshrinking, nonstaining, nonabsorbing material, nonreactive with the joint sealant. The material shall have a melting point at least 5°F (3°C) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The material shall have a water absorption of not more than 5% of the sample weight when tested in accordance with ASTM C509. The backup material shall be 25 ±5% larger in diameter than the nominal width of the crack.

605-2.4 Bond breaking tapes. Provide a bond breaking tape or separating material that is a flexible, nonshrinkable, nonabsorbing, nonstaining, and nonreacting adhesive-backed tape. The material shall have a melting point at least 5°F (3°C) greater than the pouring temperature of the sealant being used when tested in accordance with ASTM D789. The bond breaker tape shall be approximately 1/8 inch (3 mm) wider than the nominal width of the joint and shall not bond to the joint sealant.

CONSTRUCTION METHODS

605-3.1 Time of application. Joints shall be sealed as soon after completion of the curing period as feasible and before the pavement is opened to traffic, including construction equipment. The pavement temperature shall be 50°F (10°C) and rising at the time of application of the poured joint sealing material. Do not apply sealant if moisture is observed in the joint.

605-3.2 Equipment. Machines, tools, and equipment used in the performance of the work required by this section shall be approved before the work is started and maintained in satisfactory condition at all times. Submit a list of proposed equipment to be used in performance of construction work including descriptive data, **7** days prior to use on the project.

a. Tractor-mounted routing tool. Provide a routing tool, used for removing old sealant from the joints, of such shape and dimensions and so mounted on the tractor that it will not damage the sides of the joints. The tool shall be designed so that it can be adjusted to remove the old material to varying depths as required. The use of V-shaped tools or rotary impact routing devices will not be permitted. Hand-operated spindle routing devices may be used to clean and enlarge random cracks.

b. Concrete saw. Provide a self-propelled power saw, with water-cooled diamond or abrasive saw blades, for cutting joints to the depths and widths specified or for refacing joints or cleaning sawed joints where sandblasting does not provide a clean joint.

c. Sandblasting equipment. Include with the sandblasting equipment an air compressor, hose, and long-wearing venturi-type nozzle of proper size, shape and opening. The maximum nozzle opening should not exceed 1/4 inch (6 mm). The air compressor shall be portable and capable of furnishing not less than 150 cfm (71 L/s) and maintaining a line pressure of not less than 90 psi (621 kPa) at the nozzle while in use. Demonstrate compressor capability, under job conditions, before approval. The compressor shall be equipped with traps that will maintain the compressed air free of oil and water. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately one inch (25 mm) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to secure satisfactory results.

d. Waterblasting equipment. Include with the waterblasting equipment a trailer-mounted water tank, pumps, high-pressure hose, wand with safety release cutoff control, nozzle, and auxiliary water resupply equipment. Provide water tank and auxiliary resupply equipment of sufficient capacity to permit continuous operations. The nozzle shall have an adjustable guide that will hold the nozzle aligned with the joint approximately one inch (25 mm) above the pavement surface. Adjust the height, angle of inclination and the size of the nozzle as necessary to obtain satisfactory results. A pressure gauge mounted at the pump shall show at all times the pressure in psi (kPa) at which the equipment is operating.

e. Hand tools. Hand tools may be used, when approved, for removing defective sealant from a crack and repairing or cleaning the crack faces.

f. Hot-poured sealing equipment. The unit applicators used for heating and installing ASTM D6690 joint sealant materials shall be mobile and shall be equipped with a double-boiler, agitator-type kettle with an oil medium in the outer space for heat transfer; a direct-connected pressure-type extruding device with a nozzle shaped for inserting in the joint to be filled; positive temperature devices for controlling the temperature of the transfer oil and sealant; and a recording type thermometer for indicating the temperature of the sealant. The applicator unit shall be designed so that the sealant will circulate through the delivery hose and return to the inner kettle when not in use.

g. Two-component, cold-applied, machine mix sealing equipment. Provide equipment used for proportioning, mixing, and installing Federal Specification SS-S-200 Type M joint sealants designed to deliver two semifluid components through hoses to a portable mixer at a preset ratio of one (1) to one (1) by volume using pumps with an accuracy of ±5% for the quantity of each component. The reservoir for each component shall be equipped with mechanical agitation devices that will maintain the components in a uniform condition without entrapping air. Incorporate provisions to permit thermostatically controlled indirect heating of the components, when required. However, immediately prior to proportioning and mixing, the temperature of either component shall not exceed 90°F (32°C). Provide screens near the top of each reservoir to remove any foreign particles or partially polymerized material that could clog fluid lines or otherwise cause misproportioning or improper mixing of the two components. Provide equipment capable of thoroughly mixing the two components through a range of application rates of 10 to 60 gallons (37.8 to 189 L) per hour and through a range of application pressures from 50 to 1500 psi (345 kPa to 10.3 MPa) as required by material, climatic, or operating conditions. Design the mixer for the easy removal of the supply lines for cleaning and proportioning of the components. The mixing head shall accommodate nozzles of different types and sizes as may be required by various operations. The dimensions of the nozzle shall be such that the nozzle tip will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval.

h. Two-component, cold-applied, hand-mix sealing equipment. Mixing equipment for Federal Specification SS-S-200 Type H sealants shall consist of a slow-speed electric drill or air-driven mixer with a stirrer in accordance with the manufacturer's recommendations. Submit printed copies of manufacturer's recommendations **7** days prior to use on the project where installation procedures, or any part thereof, are required to be in accordance with those recommendations. Installation of the material will not be allowed until the recommendations are received. Failure to furnish these recommendations can be cause for rejection of the material.

i. Cold-applied, single-component sealing equipment. The equipment for installing ASTM D5893 single component joint sealants shall consist of an extrusion pump, air compressor, following plate, hoses, and nozzle for transferring the sealant from the storage container into the joint opening. The dimension of the nozzle shall be such that the tip of the nozzle will extend into the joint to allow sealing from the bottom of the joint to the top. Maintain the initially approved equipment in good working condition, serviced in accordance with the supplier's instructions, and unaltered in any way without obtaining prior approval. Small hand-held air-powered equipment (i.e., caulking guns) may be used for small applications.

605-3.3 Preparation of joints.

a. Sawing. All joints shall be sawed in accordance with specifications and plan details. Immediately after sawing the joint, the resulting slurry shall be completely removed from joint and adjacent area by flushing with a jet of water, and by use of other tools as necessary.

b. Sealing. Immediately before sealing, the joints shall be thoroughly cleaned of all remaining laitance, curing compound, filler, protrusions of hardened concrete, old sealant and other foreign material from the sides and upper edges of the joint space to be sealed. Cleaning shall be accomplished by sandblasting, concrete saw, and/or waterblaster as specified in paragraph 605-3.2. The newly exposed concrete joint faces and the pavement surface extending a minimum of 1/2 inch (12 mm) from the joint edge shall be sandblasted clean. Sandblasting shall be accomplished in a minimum of two passes. One pass per joint face with the nozzle held at an angle directly toward the joint face and not more than 3 inches (75 mm) from it. After final cleaning and immediately prior to sealing, blow out the joints with compressed air and leave them completely free of debris and water. The joint faces shall be surface dry when the seal is applied.

c. Back-up material. When the joint opening is of a greater depth than indicated for the sealant depth, plug or seal off the lower portion of the joint opening using a back-up material to prevent the entrance of the sealant below the specified depth. Take care to ensure that the backup material is placed at the specified depth and is not stretched or twisted during installation.

d. Bond-breaking tape. Where inserts or filler materials contain bitumen, or the depth of the joint opening does not allow for the use of a backup material, insert a bond-breaker separating tape to prevent incompatibility with the filler materials and three-sided adhesion of the sealant. Securely bond the tape to the bottom of the joint opening so it will not float up into the new sealant.

605-3.4 Installation of sealants. Joints shall be inspected for proper width, depth, alignment, and preparation, and shall be approved by the Engineer before sealing is allowed. Sealants shall be installed in accordance with the following requirements:

Immediately preceding, but not more than 50 feet (15 m) ahead of the joint sealing operations, perform a final cleaning with compressed air. Fill the joints from the bottom up to 1/4 inch ±1/16 inch below the pavement surface. Remove and discard excess or spilled sealant from the pavement by approved methods. Install the sealant in such a manner as to prevent the formation of voids and entrapped air. In no case shall gravity methods or pouring pots be used to install the sealant material. Traffic shall not be permitted over newly sealed pavement until authorized by the Contracting Officer. When a primer is recommended by the manufacturer, apply it evenly to the joint faces in accordance with the manufacturer's instructions. Check the joints frequently to ensure that the newly installed sealant is cured to a tack-free condition within the time specified.

605-3.5 Inspection. The Contractor shall inspect the joint sealant for proper rate of cure and set, bonding to the joint walls, cohesive separation within the sealant, reversion to liquid, entrapped air and voids. Sealants exhibiting any of these deficiencies at any time prior to the final acceptance of the project shall be removed from the joint, wasted, and replaced as specified at no additional cost to the airport.

605-3.6 Clean-up. Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

METHOD OF MEASUREMENT

605-4.1 Joint sealing material shall be measured by the **gallon** of sealant in place, completed, and accepted.

BASIS OF PAYMENT

605-5.1 Payment for joint sealing material shall be made at the contract unit price per **gallon**. The price shall be full compensation for furnishing all materials, for all preparation, delivering, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-605-5.1	Joint Sealing Filler, per gallon (liter)
Item P-605-5.2	Joint Sealing Filler, per pound (kg)
Item P-605-5.3	Joint Sealing Filler, per linear foot (meter)

TESTING REQUIREMENTS

ASTM D412	Standard Test Methods for Vulcanized Rubber and Thermoplastic Elastomers – Tension
ASTM C509	Standard Specification for Elastomeric Cellular Preformed Gasket and Sealing Material
ASTM D1644	Standard Test Methods for Nonvolatile Content of Varnishes

MATERIAL REQUIREMENTS

AC 150/5340-30	Design and Installation Details for Airport Visual Aids
ASTM D789	Standard Test Method for Determination of Relative Viscosity of Polyamide (PA)
ASTM D5893	Standard Specification for Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements
ASTM D6690	Standard Specification for Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements

END ITEM P-605

Item P-608 Emulsified Asphalt Seal Coat

DESCRIPTION [1]

608-1.1 This item shall consist of the application of a emulsified asphalt surface treatment composed of an emulsion of natural and refined asphalt materials, water and, if specified, a polymer additive, for taxiways and runways with the application of a suitable aggregate to maintain adequate surface friction; and airfield secondary and tertiary pavements including low-speed taxiways, shoulders, overruns, roads, parking areas, and other general applications with or without aggregate applied. Emulsified Asphalt Seal Coat products assist in pavement preservation through reducing the rate of pavement oxidation. The emulsified asphalt surface treatment shall be applied in accordance with these specifications, and as shown on the plans or as directed by the Engineer.

[1] The terms seal coat and sealer binder and asphalt material are interchangeable throughout this specification. The term emulsified asphalt means an emulsion of natural and refined asphalt materials.

608-1.2 Quantities of materials per square yard (square meter). The approximate amounts of materials per square yard (square meter) for the asphalt surface treatment shall be as provided in the table for the treatment area(s) at the specified dilution rate(s) as noted on the plans. The actual application rates will vary within the range specified to suit field conditions and will be recommended by the manufacturer's representative and approved by the Engineer from the test area/sections evaluation.

Application Rate

Dilution Rate	Quantity of Emulsion gal/yd^2 (l/m^2)	Quantity of Aggregate lb/yd^2 (kg/m^2)
1:1	0.10-0.15 (0.45-0.68)	0.20-0.50 (0.11-0.27)
2:1	0.08-0.15 (0.36-0.54)	0.20-0.50 (0.11-0.27)

MATERIALS

608-2.1 Aggregate. The aggregate material shall be a dry, clean, dust and dirt free, sound, durable, angular shaped manufactured specialty sand, such as that used as an abrasive, with a Mohs hardness of 6 to 8. The Contractor shall submit manufacturer's technical data and a manufacturer's certification indicating that the specialty sand meets the requirements of the specification to the Engineer prior to start of construction. The sand must be approved for use by the Engineer and shall meet the following gradation limits when tested in accordance with ASTM C136 and ASTM C117:

Aggregate Material Gradation Requirements

Sieve Designation (square openings)	Percentage by Weight Retained Sieves
No. 8 (2.38 mm)	0
No. 16 (1.19 mm)	0-8
No. 20 (0.84 mm)	0-28
No. 30 (0.60 mm)	20-50
No. 40 (0.42 mm)	10-55
No. 50 (0.30 mm)	0-30
No. 70 (0.21 mm)	0-5
No. 100 (0.15 mm)	0-2
No. 200 (0.07 mm)	0-2

The Contractor shall provide a certification showing particle size analysis and properties of the material delivered for use on the project. The Contractor's certification may be subject to verification by testing the material delivered for use on the project.

608-2.2 Asphalt material. The Contractor shall furnish the vendor's certified test reports for the emulsified asphalt, in its concentrated form, to the Engineer, showing that the material meets the following properties:

Concentrated Asphalt Material Properties

Properties	Specification	Limits
Saybolt Furol Viscosity at 77°F (25°C)	ASTM D244	20 – 100 seconds
Residue by Distillation or Evaporation	ASTM D244	57% minimum
Sieve Test	ASTM D244	0.1% maximum
24-hour Stability	ASTM D244	1% maximum
5-day Settlement Test	ASTM D244	5.0% maximum
Particle Charge [1]	ASTM D244	Positive 6.5 maximum pH

[1] pH may be used in lieu of the particle charge test which is sometimes inconclusive in slow setting, asphalt emulsions.

The asphalt material concentrate must be diluted with heated water prior to application. The asphalt material, when diluted in the volumetric proportion of one part concentrated asphalt material to one part hot water shall have the following properties:

One-to-One Dilution Emulsion Properties

Properties	Specification	Limits
In Ready-to-Apply Form, one part concentrate to one part water, by volume		
Saybolt Furol Viscosity at 77°F (25°C)	ASTM D244	10 – 50 seconds
Residue by Distillation or Evaporation	ASTM D244	28.5% minimum
Pumping Stability [1]		Pass

[1] Pumping stability is tested by pumping one pint (475 ml) of seal coat diluted one (1) part concentrate to one (1) part water, at 77°F (25°C), through a 1/4-inch (6 mm) gear pump operating 1750 rpm for 10 minutes with no significant separation or coagulation.

Two-to-One Dilution Emulsion Properties

Properties	Specification	Limits
In Ready-to-Apply Form, two parts concentrate to one part water, byolume		
Saybolt Furol Viscosity at 77°F (25°C)	ASTM D244	10 – 50 seconds
Residue by Distillation or Evaporation	ASTM D244	38% minimum
Pumping Stability [1]		Pass

[1] Pumping stability is tested by pumping one pint (475 ml) of seal coat diluted one (1) part concentrate to one (1) part water, at 77°F (25°C), through a 1/4-inch (6 mm) gear pump operating 1750 rpm for 10 minutes with no significant separation or coagulation.

The asphalt material base residue shall contain not less than 20% gilsonite, or uintaite and shall not contain any tall oil pitch or coal tar material. The material shall be compatible with asphaltic concrete, and have a 5-year minimum proven performance record at airports with similar climatic conditions. Curing time, under recommended application conditions, shall not exceed eight (8) hours.

Emulsion Residue by Distillation or Evaporation Tests

Properties	Specification	Limits
Viscosity at 275°F (135°C)	ASTM D4402	1750 cts maximum
Solubility in 1, 1, 1 trichloroethylene	ASTM D2042	97.5% minimum
Penetration	ASTM D5	50 dmm maximum
Asphaltenes	ASTM D2007	15% minimum
Saturates	ASTM D2007	15% maximum
Polar Compounds	ASTM D2007	25% minimum
Aromatics	ASTM D2007	15% minimum

The Contractor shall furnish vendor's certified test reports showing that the material is the type, grade and quality specified for each load of asphalt material delivered to the project. The certification shall also show the shipment number, refinery, consignee, destination, contract number and date of shipment. The test reports and certification shall be delivered to the Engineer before permission is granted to use the material. The furnishing of the vendor's certified test report for the asphalt material shall not be interpreted as a basis for final acceptance. The manufacturer's material test report certification may be subject to verification by testing the material delivered for use on the project.

The asphalt material storage and handling temperature shall be between 50°F - 160°F (10°C - 70°C) and the material shall be protected from freezing, or whenever outside temperature drops below 40°F (4°C) for prolonged time periods.

608-2.3 Water. Water used in making the emulsion shall be potable, free from harmful soluble salts and chemicals, and at least 100°F (38°C).

~~**608-2.4 Polymer.** The polymer shall be a vinyl acrylic polymer approved for use by the asphalt material manufacturer. The Contractor shall submit manufacturer's technical data, the manufacturer's certification indicating that the polymer meets the requirements of the specification, and the asphalt material manufacturer's approval of its use to the Engineer. The polymer must be approved for use by the Engineer and shall meet the following properties:~~

~~**Polymer Properties**~~

~~**Properties**~~	~~**Limits**~~
~~Solids Content~~	~~54 to 57%,~~ ~~Percent by Weight~~
~~Weight~~	~~8.9 to 9.8 pounds/gallon (1.07 to 1.17 kg/L)~~
~~pH~~	~~4.0 to 6.0~~
~~Particle Charge~~	~~Nonionic/Anionic~~
~~Mechanical Stability~~	~~Excellent~~
~~Film Forming Temperature, °C~~	~~+5°C, minimum~~
~~Tg, °C~~	~~22°C, maximum~~

APPLICATION RATE

608-3.1 Material performance for runway and high-speed taxiway projects. The Contractor shall submit to the Engineer friction tests, from previous airport projects which used the seal coat materials in a similar environment, in accordance with AC 150/5320-12, at 40 or 60 mph (65 or 95 km/h) wet, showing, as a minimum; friction value of pavement surface prior to sealant application; two values, tested between 24 and 96 hours after application, with a minimum of 24 hours between tests; and one value tested at no less than 180 days or greater than 360 days after the application. The results of the two tests between 24 and 96 hours shall indicate friction is increasing at a rate to obtain similar friction value of the pavement surface prior to application, and the long term test shall indicate no apparent adverse effect with time relative to friction values and existing pavement surface. The Contractor shall submit to the Engineer a list of airports which meet the above requirements, as well as technical details on application rates, aggregate rates, and point of contact at these airports to confirm use and success of sealer with aggregate. Friction tests shall be submitted from no less than one of the airports on the list and each set of tests described above, must be from one project.

Seal coat material submittal without required friction performance will not be approved. Friction tests performed on this project cannot be used as a substitute of this requirement.

608-3.2 Test areas and test sections. A qualified manufacturer's representative shall be present in the field to assist the Contractor in applying test areas and/or test sections to determine the appropriate application rate of both emulsion and sand to be approved by the Engineer.

A test area and/or section shall be applied for each differing HMA pavement surface identified in the project. The test area(s) and/or test section(s) shall be used to determine the material application rate(s) of both emulsion and sand prior to full production. The same equipment and method of operation shall be utilized on the test area(s) and/or test section(s) as will be utilized on the remainder of the work.

a. For taxiway, taxilane and apron surfaces. Prior to full application, the Contractor shall place test areas at varying application rates as advised by the manufacturer's representative and acceptable to the Engineer to determine appropriate application rate(s). The test areas will be located on representative section(s) of the pavement to receive the asphalt surface treatment designated by the Engineer.

b. For runway and high speed exit taxiway surfaces. Prior to full application, the Contractor shall place a series of test sections a minimum of 300 feet (90 m) long by 12 feet (3.6 m) wide, or width of anticipated application, whichever is greater, at varying application rates as recommended by the manufacturer's representative and acceptable to the Engineer to determine appropriate application rate(s). The area to be tested will be located on a representative section of the pavement to receive the asphalt surface treatment designated by the Engineer. Before beginning the test section(s), the skid resistance of the existing pavement shall be determined for each test section with a continuous friction measuring equipment (CFME). The skid resistance test after application shall be at approximately the same location as the test done on the existing pavement. The Contractor may begin testing the skid resistance of runway and high speed exit taxiway test sections after application of the asphalt surface treatment has fully cured. Aircraft shall not be permitted on the runway or high speed exit taxiway test sections for a minimum of 24 hours and until such time as the Contractor validates that its surface friction meets AC 150/5320-12. The results of the friction evaluation meet or exceed the Maintenance Planning levels provided in Table 3-2, "Friction Level Classification for Runway Pavement Surfaces," in AC 150/5320-12, Measurement, Construction, and Maintenance of Skid-resistant Airport Pavement Surfaces, when tested at speeds of 40 and 60 mph (65 and 95 km/h) wet with approved CFME.

If the test section should prove to be unsatisfactory, necessary adjustments to the application rate, placement operations, and equipment shall be made. Additional test sections shall be placed and additional skid resistance tests performed and evaluated. Full production shall not begin without the

Engineer's approval of an appropriate application rate(s). Acceptable test sections shall be paid for in accordance with paragraph 608-8.1 (incidental to P-608 Emulsified Asphalt Seal Coat).

CONSTRUCTION METHODS

608-4.1 Worker safety. The seal coat product shall be handled with caution. The Contractor shall obtain a Material Safety Data Sheet (MSDS) for both the asphalt emulsion product and sand and require workmen to follow the manufacturer's recommended safety precautions.

608-4.2 Weather limitations. The asphalt emulsion shall be applied only when the existing pavement surface is dry and when the weather is not foggy, rainy, or when the wind velocity will prevent the uniform application of the material. No material shall be applied when dust or sand is blowing or when rain is anticipated within eight (8) hours of application completion. The atmospheric temperature and the pavement surface temperature shall both be above 60°F (16°C) and rising. During application, account for wind drift. Cover existing buildings, structures, runway edge lights, taxiway edge lights, informational signs, retro-reflective marking and in-pavement duct markers as necessary to protect against overspray before applying the emulsion. Should emulsion get on any light or marker fixture, promptly clean the fixture. If cleaning is not satisfactory to the Engineer, the Contractor shall replace any light, sign or marker with equivalent equipment at no cost to the Owner.

608-4.3 Equipment and tools. The Contractor shall furnish all equipment, tools, and machinery necessary for the performance of the work.

a. Pressure distributor. The emulsion shall be applied with a manufacturer-approved computer rate-controlled asphalt distributor. The equipment shall be in good working order and contain no contaminants or diluents in the tank. Spreader bar tips must be clean, free of burrs, and of a size to maintain an even distribution of the emulsion. Any type of tip or pressure source is suitable that will maintain predetermined flow rates and constant pressure during the application process with application speeds under eight (8) miles per hour (13 km per hour) or seven (700) feet per minute (213 m per minute). Test the equipment under pressure for leaks and to ensure it is in good working order before use.

The distributor truck shall be equipped with a 12-foot (3.7-m), minimum, spreader bar with individual nozzle control. The distributor truck shall be capable of specific application rates in the range of 0.05 to 0.25 gallons per square yard (0.15 to 0.80 liters per square meter). These rates shall be computer-controlled rather than mechanical. The distributor truck shall have an easily accessible thermometer that constantly monitors the temperature of the emulsion, and have an operable mechanical tank gauge that can be used to cross-check the computer accuracy.

A distributor truck shall be provided, if necessary, equipped to effectively heat and mix the material to the required temperature prior to application. Heating and mixing shall be done in accordance with the manufacturer's recommendations. Care shall be taken not to overheat or over mix the material.

The distributor shall be equipped to hand spray the emulsion in areas identified either on the plans or by the Engineer.

b. Aggregate spreader. The asphalt distributor truck will be equipped with an aggregate spreader mounted to the distributer truck that can apply sand to the emulsion in a single pass operation without driving through wet emulsion. The aggregate spreader shall be equipped with a variable control system capable of uniformly distributing the sand at the specified rate at varying application widths and speeds. The sander shall have a minimum hopper capacity of at least 3,000 pounds (1361 kg) of sand. Push-type hand sanders will be allowed for use around lights, signs and other obstructions.

c. Power broom/blower. A power broom and/or blower shall be provided for removing loose material from the surface to be treated.

d. Equipment calibration. The Contractor shall calibrate the equipment using either of the following procedures:

(1) First procedure. The Contractor shall furnish a State Calibration Certification for the emulsified asphalt distributor, from any state providing that service, or other acceptable agency certification approved by the Engineer, and the calibration date shall have been within six (6) months of the contract award, or up to 12 months if supporting documents substantiate continuous work using the same distributor.

(2) Second procedure. The Contractor shall furnish all equipment, materials and labor necessary to calibrate the emulsified asphalt distributor and the aggregate spreader. Perform all calibrations with the approved job materials and prior to applying the specified coatings to the prepared surface. Perform calibration of the emulsified asphalt distributor in accordance with ASTM D2995. Perform work to calibrate the tank and measuring devices of the distributor. Perform inspection and calibration at the beginning of the work and at least once a day during construction.

608-4.4 Preparation of asphalt pavement surfaces. Clean pavement surface immediately prior to placing the seal coat by sweeping, flushing well with water leaving no standing water, or a combination of both, so that it is free of dust, dirt, grease, vegetation, oil or any type of objectionable surface film. Remove oil or grease that has not penetrated the asphalt pavement by scraping or by scrubbing with a detergent, then wash thoroughly with clean water. After cleaning, treat these areas with the oil spot primer. Any additional surface preparation, such as crack repair, shall be in accordance with paragraph 101-3.6.

a. New asphalt pavement surfaces. Allow new asphalt pavement surfaces to cure so that there is no concentration of oils on the surface. A period of at least 30 days at 70°F (21°C) daytime temperatures shall elapse between the placement of a hot mixed asphalt concrete surface course and the application of the surface treatment.

Perform a water-break-free test to confirm that the surface oils have degraded and dissipated. (Cast approximately one gallon (4 liters) of clean water out over the surface. The water should sheet out and wet the surface uniformly without crawling or showing oil rings.) If signs of crawling or oil rings are apparent on the pavement surface, additional time must be allowed for additional curing and retesting of the pavement surface prior to treatment.

608-4.5 Emulsion mixing. The application emulsion shall be obtained by blending asphalt material concentrate, water and polymer, if specified. Always add heated water to the asphalt material concentrate, never add asphalt material concentrate to heated water. Mix one part heated water to one part (Runway and Taxiway Pavements), and two parts (Apron Pavement) asphalt material concentrate, by volume.

If polymer is required, add 1% polymer, by volume, to the emulsion mix. If the polymer is added to the emulsion mix at the plant, submit weigh scale tickets to the Engineer. As an option, the polymer may be added to the emulsion mix at the job site provided the polymer is added slowly while the circulating pump is running. The mix must be agitated for a minimum of 15 minutes or until the polymer is mixed to the satisfaction of the Engineer.

608-4.6 Application of asphalt emulsion. The asphalt emulsion shall be applied using a pressure distributor upon the properly prepared, clean and dry surface at the application rate recommended by the manufacturer's representative and approved by the Engineer from the test area/sections evaluation for each designated treatment area. The asphalt emulsion should be applied at a temperature between 130°F (54°C) and 160°F (70°C) or in accordance with the manufacturer's recommendation.

Pavement surfaces which have excessive runoff of seal coat due to excessive amount of material being applied or excessive surface grade shall be treated in two or more applications to the specified application rate at no additional cost to the Owner. Each additional application shall be performed after the prior application of material has penetrated into the pavement.

If low spots and depressions greater than 1/2 inch (12 mm) in depth in the pavement surface cause ponding or puddling of the applied materials, the pavement surface shall be broomed with a broom drag. Brooming shall continue until the pavement surface is free of any pools of excess material. Ponding and/or puddling shall not cause excessive pavement softening and/or additional distress. The Engineer shall inspect and approve areas after brooming.

During all applications, the surfaces of adjacent structures shall be protected to prevent their being spattered or marred. Asphalt materials shall not be discharged into borrow pits or gutters or on the airport area.

608-4.7 Application of aggregate material. Immediately following the application of the asphalt emulsion or as directed by the Engineer, sand at the rate recommended by the manufacturer's representative and approved by the Engineer from the test area/sections evaluation for each designated application area, shall be spread uniformly over the asphalt emulsion. The aggregate shall be spread to the same width of application as the asphalt material and shall not be applied in such thickness as to cause blanketing.

Sprinkling of additional aggregate material, and spraying additional asphalt material over areas that show up having insufficient cover or bitumen, shall be done by hand whenever necessary. In areas where hand work is necessitated, the sand shall be applied before the sealant begins to break.

Sanding shall be performed to prevent excessive amounts of sand from accumulating on the pavement prior to the emulsion being applied. The Contractor shall clean areas with excess or loose sand and dispose of off airport property.

QUALITY CONTROL

608-5.1 Manufacturer's representation. The manufacturer's representative shall have knowledge of the material, procedures, and equipment described in the specification and shall be responsible for determining the application rates and shall oversee the preparation and application of the seal coat product. Documentation of the manufacturer representative's experience and knowledge for applying the seal coat product shall be furnished to the Engineer a minimum of 10 work days prior to placement of the test sections. The cost of the manufacturer's representative shall be included in the bid price.

608-5.2 Contractor qualifications. The Contractor shall provide the Engineer Contractor qualifications for applicators, personnel and equipment. The Contractor shall also provide documentation that the Contractor is qualified to apply the seal coat and to have made at least three (3) applications similar to this project in the past two (2) years.

MATERIAL ACCEPTANCE

608-6.1 Friction tests. Friction tests in accordance with AC 150/5320-12, Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces, shall be accomplished on all runway and high-speed taxiways that have received a seal coat. The Contractor shall coordinate testing with the Engineer. Each test includes performing friction tests at 40 mph and 60 mph (65 or 95 km/h) both wet, 15 feet (4.5 m) to each side of runway centerline. Friction test shall be run within 30 days prior to application of the seal coat to runway and/or high-speed taxiways and after application of the seal coat. The Engineer shall be present for testing. The Contractor shall provide a written report of friction test results.

METHOD OF MEASUREMENT

608-7.1 Asphalt surface treatment. The quantity of asphalt surface treatment shall be measured by the square yards of material applied in accordance with the plans and specifications and accepted by the Engineer.

The Contractor must furnish the Engineer with the certified weigh bills when materials are received for the asphalt material used under this contract. The Contractor must not remove material from the tank car or storage tank until initial amounts and temperature measurements have been verified.

Friction testing shall be considered incidental to Item P-608 Emulsified Asphalt Seal Coat.

BASIS OF PAYMENT

608-8.1 Payment shall be made at the contract unit price per square yard **[** square meter **]** for the asphalt surface treatment applied and accepted by the Engineer, and the contract unit price per lump sum for runway friction testing. This price shall be full compensation for all surface preparation, furnishing all materials, delivery and application of these materials, for all labor, equipment, tools, and incidentals necessary to complete the item, including the friction testing and all work required to meet AC 150/5320-12, and any costs associated with furnishing a qualified manufacturer's representative to assist with test strips.

Payment will be made under:

Item P-608-8.1	Asphalt Surface Seal Coat – per square yard

MATERIAL REQUIREMENTS

ASTM C117	Standard Test Method for Materials Finer than 75-µm (No. 200) Sieve in Mineral Aggregates by Washing
ASTM C136	Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
ASTM D5	Standard Test Method for Penetration of Bituminous Materials
ASTM D244	Standard Test Methods and Practices for Emulsified Asphalts
ASTM D2007	Standard Test Method for Characteristic Groups in Rubber Extender and Processing Oils and Other Petroleum-Derived Oils by the Clay-Gel Absorption Chromatographic Method
ASTM D2042	Standard Test Method for Solubility of Asphalt Materials in Trichloroethylene
ASTM D2995	Standard Practice for Estimating Application Rate of Bituminous Distributors
ASTM D4402	Standard Test Method for Viscosity Determination of Asphalt at Elevated Temperatures Using a Rotational Viscometer
ASTM D5340	Standard Test Method for Airport Pavement Condition Index Surveys
AC 150/5320-12	Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces
AC 150/5320-17	Airfield Pavement Surface Evaluation and Rating (PASER) Manuals
AC 150/5380-6	Guidelines and Procedures for Maintenance of Airport Pavements

END OF ITEM P-608

Item P-620 Runway and Taxiway Marking

DESCRIPTION

620-1.1 This item shall consist of the preparation and painting of numbers, markings, and stripes on the surface of runways, taxiways, and aprons, in accordance with these specifications and at the locations shown on the plans, or as directed by the Engineer. The terms “paint” and “marking material” as well as “painting” and “application of markings” are interchangeable throughout this specification.

MATERIALS

620-2.1 Materials acceptance. The Contractor shall furnish manufacturer’s certified test reports for materials shipped to the project. The certified test reports shall include a statement that the materials meet the specification requirements. The reports can be used for material acceptance or the Engineer may perform verification testing. The reports shall not be interpreted as a basis for payment. The Contractor shall notify the Engineer upon arrival of a shipment of materials to the site. All material shall arrive in sealed containers 55 gallons or smaller for inspection by the Engineer. Material shall not be loaded into the equipment until inspected by the Engineer.

620-2.2 Marking materials. Paint shall be waterborne, in accordance with the requirements of paragraph 620-2.2. Paint shall be furnished in **White-37925, Yellow- 33538, Black-37038 and Red31136** in accordance with Federal Standard No. 595.

a. Waterborne. Paint shall meet the requirements of Federal Specification TT-P-1952E, Type II. The non-volatile portion of the vehicle for all paint types shall be composed of a 100% acrylic polymer as determined by infrared spectral analysis.

b. Preformed Thermoplastic Airport Pavement Markings. Markings must be composed of ester modified resins in conjunction with aggregates, pigments, and binders that have been factory produced as a finished product. The material must be impervious to degradation by aviation fuels, motor fuels, and lubricants.

(1) The markings must be able to be applied in temperatures as low as 35°F without any special storage, preheating, or treatment of the material before application.

(a) The markings must be supplied with an integral, non-reflectorized black border.

(2) Graded glass beads.

(a) The material must contain a minimum of 30% intermixed graded glass beads by weight. The intermixed beads shall conform to ~~**[** Federal Specification TT-B-1325D, Type I, gradation A **]** **[** Federal Specification TT-B-1325D, Type IV **]**.~~ Federal Specification TT-B-1325D, Type III

(b) The material must have factory applied coated surface beads in addition to the intermixed beads at a rate of one (1) lb (0.45 kg) (±10%) per 10 square feet (1 sq m). These factory applied coated surface beads shall have a minimum of 90% true spheres, minimum refractive index of 1.50, and meet the following gradation.

Size Gradation		Retained, %	Passing, %
U.S. Mesh	µm		
12	1700	0 - 2	98 - 100
14	1400	0 - 3.5	96.5 - 100
16	1180	2 - 25	75 - 98
18	1000	28 - 63	37 - 72
20	850	63 - 72	28 - 37
30	600	67 - 77	23 - 33
50	300	89 - 95	5 - 11
80	200	97 - 100	0 - 3

(3) Heating indicators. The material manufacturer shall provide a method to indicate that the material has achieved satisfactory adhesion and proper bead embedment during application and that the installation procedures have been followed.

(4) Pigments. Percent by weight.

(a) White:

Titanium Dioxide, ASTM D476, type II shall be 10% minimum.

(b) Yellow and Colors:

Titanium Dioxide, ASTM D476, type II shall be 1% minimum.

Organic yellow, other colors, and tinting as required to meet color standard.

(5) Prohibited materials. The manufacturer shall certify that the product does not contain mercury, lead, hexavalent chromium, halogenated solvents, nor any carcinogen as defined in 29 CFR 1910.1200 in amounts exceeding permissible limits as specified in relevant Federal Regulations.

(6) Daylight directional reflectance.

(a) White: The daylight directional reflectance of the white paint shall not be less than 75% (relative to magnesium oxide), when tested in accordance with ASTM E2302.

(b) Yellow: The daylight directional reflectance of the yellow paint shall not be less than 45% (relative to magnesium oxide), when tested in accordance with ASTM E2302. The x and y values shall be consistent with the Federal Hegman yellow color standard chart for traffic yellow standard 33538, or shall be consistent with the tolerance listed below:

x	.462	x	.470	x	.479	x	.501
y	.438	y	.455	y	.428	y	.452

(7) Skid resistance. The surface, with properly applied and embedded surface beads, must provide a minimum resistance value of 45 BPN when tested according to ASTM E303.

(8) Thickness. The material must be supplied at a nominal thickness of 65 mil (1.7 mm).

(9) Environmental resistance. The material must be resistant to deterioration due to exposure to sunlight, water, salt, or adverse weather conditions and impervious to aviation fuels, gasoline, and oil.

(10) Retroreflectivity. The material, when applied in accordance with manufacturer’s guidelines, must demonstrate a uniform level of nighttime retroreflection when tested in accordance to ASTM E1710.

(11) Packaging. Packaging shall protect the material from environmental conditions until installation.

(12) Preformed thermoplastic airport pavement marking requirements.

(a) The markings must be a resilient thermoplastic product with uniformly distributed glass beads throughout the entire cross-sectional area. The markings must be resistant to the detrimental effects of aviation fuels, motor fuels and lubricants, hydraulic fluids, deicers, anti-icers, protective coatings, etc. Lines, legends, and symbols must be capable of being affixed to asphalt and/or Portland cement concrete pavements by the use of a large radiant heater. Colors shall be available as required.

(b) The markings must be capable of conforming to pavement contours, breaks, and faults through the action of airport traffic at normal pavement temperatures. The markings must be capable of fully conforming to grooved pavements, including pavement grooving per advisory circular (AC) 150/5320-12, current version. The markings shall have resealing characteristics, such that it is capable of fusing with itself and previously applied thermoplastics when heated with a heat source per manufacturer’s recommendation.

(c) Multicolored markings must consist of interconnected individual pieces of preformed thermoplastic pavement marking material, which through a variety of colors and patterns, make up the desired design. The individual pieces in each large marking segment (typically more than 20 feet (6 m) long) must be factory assembled with a compatible material and interconnected so that in the field it is not necessary to assemble the individual pieces within a marking segment. Obtaining multicolored effect by overlaying materials of different colors is not acceptable due to resulting inconsistent marking thickness and inconsistent application temperature in the marking/substrate interface.

(d) The marking material must set up rapidly, permitting the access route to be re-opened to traffic after application.

(e) The marking material shall have an integral color throughout the thickness of the marking material.

620-2.3 Reflective media. Glass beads shall meet the requirements for **TT-B-1325D, TYPE III**. Glass beads shall be treated with all compatible coupling agents recommended by the manufacturers of the paint and reflective media to ensure adhesion and embedment. At installation, markings shall have minimum retroreflective values of [600] mcd/m2 /lux on white markings and [300] mcd/m2 /lux on yellow markings. The Contractor shall verify minimum retroreflectivity of installed markings. Retroreflectivity shall be measured by a portable retroreflectometer according to ASTM E1710 and the practices in ASTM D7585 shall be followed for taking retroreflectivity readings with a portable retroreflectometer and computing measurement averages. A van-mounted retroreflectometer may also be used.

CONSTRUCTION METHODS

620-3.1 Weather limitations. The painting shall be performed only when the surface is dry and when the surface temperature is at least 45°F (7°C) and rising and the pavement surface temperature is at least 5°F (2.7°C) above the dew point or meets the manufacturer’s recommendations. Painting operations shall be discontinued when the surface temperature exceeds **130**°F. Markings shall not be applied when the pavement temperature is greater than 130°F (55°C). Markings shall not be applied when the wind speed exceeds 10 mph unless windscreens are used to shroud the material guns.

620-3.2 Equipment. Equipment shall include the apparatus necessary to properly clean the existing surface, a mechanical marking machine, a bead dispensing machine, and such auxiliary hand-painting equipment as may be necessary to satisfactorily complete the job.

The mechanical marker shall be an atomizing spray-type or airless-type marking machine suitable for application of traffic paint. It shall produce an even and uniform film thickness at the required coverage and shall apply markings of uniform cross-sections and clear-cut edges without running or spattering and without over spray.

620-3.3 Preparation of surface. Immediately before application of the paint, the surface shall be dry and free from dirt, grease, oil, laitance, or other foreign material that would reduce the bond between the paint and the pavement. The area to be painted shall be cleaned by ~~[waterblasting,] [shotblasting,] [grinding] or [sandblasting] or by other~~ approved methods as required to remove all contaminants minimizing damage to the pavement surface. Use of any chemicals or impact abrasives during surface preparation shall be approved in advance by the Engineer. After the cleaning operations, sweeping, blowing, or rinsing with pressurized water shall be performed to ensure the surface is clean and free of grit or other debris left from the cleaning process.

Paint shall not be applied to Portland cement concrete pavement until the areas to be painted are clean of curing material. Sandblasting or high-pressure water shall be used to remove curing materials.

~~[At least 24 hours prior to remarking existing markings, [loose] existing markings must be removed such that [75%] [90%] [100%] of the [loose] existing markings are removed. After removal, the surface shall be cleaned of all residue or debris either with sweeping or blowing with compressed air or both.]~~

Prior to the application of any markings, the Contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the type of marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufacturer’s surface preparation and application requirements must be submitted and approved by the Engineer prior to the initial application of markings.

620-3.4 Layout of markings. The proposed markings shall be laid out in advance of the paint application. The locations of markings to receive glass beads shall be shown on the plans.

620-3.5 Application. Paint shall be applied at the locations and to the dimensions and spacing shown on the plans. Paint shall not be applied until the layout and condition of the surface has been approved by the Engineer. The edges of the markings shall not vary from a straight line more than 1/2 inch (12 mm) in 50 feet (15 m), and marking dimensions and spacings shall be within the following tolerances:

Dimension and Spacing	Tolerance
36 inch (910 mm) or less	±1/2 inch (12 mm)
greater than 36 inch to 6 feet (910 mm to 1.85 m)	±1 inch (25 mm)
greater than 6 feet to 60 feet (1.85 m to 18.3 m)	±2 inch (50 mm)
greater than 60 feet (18.3 m)	±3 inch (76 mm)

The paint shall be mixed in accordance with the manufacturer’s instructions and applied to the pavement with a marking machine at the rate shown in Table 1. The addition of thinner will not be permitted. A period of 30 shall elapse between placement of a bituminous surface course or seal coat and application of the paint. If the airport operations require pavement marking prior to the waiting period stated above, the paint may be applied in a temporary light coat application of 30% to 50% application rate for temporary markings. TT-P-1952E, Type II or A-A-2886B, Type III may be used for temporary markings when reflectorized temporary markings are required. Glass beads will not adhere well at the low application rates for temporary markings and require immediate sweeping and cleanup before aircraft are allowed to use the pavement. The final full-strength paint application shall occur after the waiting period has passed

Prior to the initial application of markings, the Contractor shall certify in writing that the surface has been prepared in accordance with the paint manufacturer’s requirements, that the application equipment is appropriate for the marking paint and that environmental conditions are appropriate for the material being applied. This certification along with a copy of the paint manufactures application and surface preparation requirements must be submitted to the Engineer prior to the initial application of markings.

620-3.6 Test strip. Prior to the full application of airfield markings, the Contractor shall produce a test strip in the presence of the Engineer. The test strip shall include the application of a minimum of 5 gallons (4 liters) of paint and application of 35 lbs (15.9 kg) of Type I/50 lbs (22.7 kg) of Type III glass beads. The test strip shall be used to establish thickness/darkness standard for all markings. The test strip shall cover no more than the maximum area prescribed in Table 1 (e.g., for 5 gallons (19 liters) of waterborne paint shall cover no more than 575 square feet (53.4 m^2).

Table 1. Application Rates For Paint And Glass Beads
(See Note regarding Red and Pink Paint)

Paint Type	**Paint** **Square feet per gallon, ft^2/gal** **(Sq m per liter, m^2/l)**	**Glass Beads, Type I, Gradation A** **Pounds per gallon of paint-lb/gal** **(Km per liter of paint-kg/l)**	**Glass Beads, Type III** **Pounds per gallon of paint-lb/gal** **(Km per liter of paint-kg/l)**	**Glass Beads, Type IV** **Pounds per gallon of paint-lb/gal** **(Km per liter of paint-kg/l)**
Waterborne Type I or II	115 ft^2/gal max (2.8 m^2/l)	7 lb/gal min (0.85 kg/l)	10 lb/gal min (1.2 kg/l)	--
*	*	*	*	*

Glass beads shall be distributed upon the marked areas at the locations shown on the plans to receive glass beads immediately after application of the paint. A dispenser shall be furnished that is properly designed for attachment to the marking machine and suitable for dispensing glass beadss as the paint is applied. Bead dispensers shall be calibrated in accordance with the manufacturer's recommendations. Glass beads shall be applied at the rate shown in Table 1. Glass beads shall not be applied to black paint or green paint. Glass beads shall adhere to the cured paint or all marking operations shall cease until corrections are made. Different bead types shall not be mixed. Regular monitoring of glass bead embedment should be performed.

All emptied containers shall be returned to the paint storage area for checking by the Engineer. The containers shall not be removed from the airport or destroyed until authorized by the Engineer.

620-3.7 Application--preformed thermoplastic airport pavement markings.

a. Asphalt and Portland cement. To ensure minimum single-pass application time and optimum bond in the marking/substrate interface, the materials must be applied using a variable speed self-propelled mobile heater with an effective heating width of no less than 16 feet (5 m) and a free span between supporting wheels of no less than 18 feet (5.5 m). The heater must emit thermal radiation to the marking material in such a manner that the difference in temperature of 2 inches (50 mm) wide linear segments in the direction of heater travel must be within 5% of the overall average temperature of the heated thermoplastic material as it exits the heater. The material must be able to be applied at ambient and pavement temperatures down to 35°F (2°C) without any preheating of the pavement to a specific temperature. The material must be able to be applied without the use of a thermometer. The pavement shall be clean, dry, and free of debris. A non-volatile organic content (non-VOC) sealer with a maximum applied viscosity of 250 centiPoise must be applied to the pavement shortly before the markings are applied. The supplier must enclose application instructions with each box/package.

620-3.8 Protection and cleanup. After application of the markings, all markings shall be protected from damage until dry. All surfaces shall be protected from excess moisture and/or rain and from disfiguration by spatter, splashes, spillage, or drippings. The Contractor shall remove from the work area all debris, waste, loose or unadhered reflective media, and by-products generated by the surface preparation and application operations to the satisfaction of the Engineer. The Contractor shall dispose of these wastes in strict compliance with all applicable state, local, and Federal environmental statutes and regulations.

METHOD OF MEASUREMENT

620-4.1 The quantity of runway and taxiway markings to be paid for shall be the number of square feet of painting performed in accordance with the specifications and accepted by the engineer.

BASIS OF PAYMENT

620-5.1 Payment shall be made at the respective contract price per square foot for runway and taxiway painting. This price shall be full compensation for furnishing all materials and for all labor, equipment, tools, and incidentals necessary to complete the item.

Payment will be made under:

Item P-620-5.1-1	Runway and Taxiway Marking per square foot.
Item P-620-5.1-2	Reflective Media per pound (km)

TESTING REQUIREMENTS

ASTM C371	Standard Test Method for Wire-Cloth Sieve Analysis of Nonplastic Ceramic Powders
ASTM D92	Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester
ASTM D711	Standard Test Method for No-Pick-Up Time of Traffic Paint
ASTM D968	Standard Test Methods for Abrasion Resistance of Organic Coatings by Falling Abrasive
ASTM D1652	Standard Test Method for Epoxy Content of Epoxy Resins
ASTM D2074	Standard Test Method for Total, Primary, Secondary, and Tertiary Amine Values of Fatty Amines by Alternative Indicator Method
ASTM D2240	Standard Test Method for Rubber Property - Durometer Hardness
ASTM D7585	Standard Practice for Evaluating Retroreflective Pavement Markings Using Portable Hand-Operated Instruments
ASTM E1710	Standard Test Method for Measurement of Retroreflective Pavement Marking Materials with CEN-Prescribed Geometry Using a Portable Retroreflectometer
ASTM E2302	Standard Test Method for Measurement of the Luminance Coefficient Under Diffuse Illumination of Pavement Marking Materials Using a Portable Reflectometer
ASTM G154	Standard Practice for Operating Fluorescent Ultraviolet (UV) Lamp Apparatus for Exposure of Nonmetallic Materials

MATERIAL REQUIREMENTS

ASTM D476	Standard Classification for Dry Pigmentary Titanium Dioxide Products

40 CFR Part 60, Appendix A-7, Method 24
Determination of volatile matter content, water content, density, volume solids, and weight solids of surface coatings

29 CFR Part 1910.1200 Hazard Communication

FED SPEC TT-B-1325D
Beads (Glass Spheres) Retro-Reflective

American Association of State Highway and Transportation Officials (AASHTO) M247
Standard Specification for Glass Beads Used in Pavement Markings

FED SPEC TT-P-1952E
Paint, Traffic and Airfield Marking, Waterborne

Commercial Item Description A-A-2886B
Paint, Traffic, Solvent Based

FED STD 595 Colors used in Government Procurement

AC 150/5340-1 Standards for Airport Markings

END OF ITEM P-620

Item P-629 Thermoplastic Coal Tar Emulsion Surface Treatments

DESCRIPTION

629-1.1. This item shall consist of an application of a thermoplastic resin coal tar emulsion Micro‑Surface applied to an existing, previously prepared asphalt surface, including ~~airport pavements serving small airplanes~~**,** roads, and other general applications. Thermoplastic resin coal tar emulsion products provide a fuel-resistant surface where pavements are subjected to fuel spills. Thermoplastic resin coal tar emulsion products assist in pavement preservation through reducing the rate of pavement oxidation. The application of the surface treatment shall be in accordance with these specifications and shall conform to the dimensions shown on the plans or as directed by the Engineer.

MATERIALS

629-2.1 Thermoplastic coal tar emulsion. The emulsion material shall be a thermoplastic coal tar emulsion made up of plastic resin and emulsified coal tar pitch. The thermoplastic coal tar emulsion shall be manufactured as a complete product and tested at the manufacturing plant for material certification. The water content of the emulsion shall not exceed 48% ±1% when tested in accordance with ASTM D244, paragraph 3.

A dried film shall contain a minimum of 89% of a combination of plastic resin and coal tar with the remaining percentage being inorganic filler. The dried emulsion shall have a softening point greater than 212°F (100°C) when tested in accordance with ASTM D36. A film of the dried emulsion material, 8 mils thick, shall stretch to five (5) times its original length at 70°F (21°C) without breaking, and recover 35% of this length in one minute.

629-2.2 Material certification. The Contractor shall furnish the manufacturer’s certification that each consignment of thermoplastic coal tar emulsion shipped to the project meets the requirements indicated in 629-2.1 and elsewhere in this specification. The Certification shall include actual results of each test and date of when test was performed. The Contractor shall submit a certification that the material proposed has been in field use for a minimum of two (2) years.

629-2.3 Fuel resistance testing. The cured thermoplastic coal tar emulsion sample must pass the fuel-resistance test outlined in Appendix A.

629-2.4 Water. The water used in mixing shall be potable and free from harmful soluble salts. The temperature of the water added during mixing shall be at least 50°F (10°C). The pH of the water added during mixing shall conform to the requirements of the thermoplastic coal tar emulsion manufacturer.

629-2.5 Handling and storage. The mixture shall be continuously agitated from the time it had been mixed until its application on the pavement surface. The distributor or applicator, pumps and all tools shall be maintained in satisfactory working condition. Spray bar nozzles, pumps, or other equipment can be cleaned mechanically or with clean water.

629-2.6 Health, safety, and environment. The Contractor must provide a complete Material Safety Data Sheet (MSDS) in accordance with U.S. Department of Labor, Occupational Safety and Health Administration (OSHA), Regulations (Standards – 29 CFR), 1910.1200 which establishes the requirement and minimum information for the MSDS for hazardous materials. The MSDS, Section II, shall include the Chemical Abstracts Service (CAS) registry numbers for all applicable hazardous ingredients in the coal tar emulsion product. The Contractor must provide the manufacturer’s certification that the product complies with the Code of Federal Regulation (CFR) Title 40 – Protection of Environment. The manufacturer’s certification shall address compliance for Air Programs, Part 59, National Volatile Organic Compound Emission Standards for Consumer and Commercial Products (for the airport location) and Water Programs, Part 116, Designation of Hazardous Substances.

COMPOSITION AND APPLICATION

629–3.0 Thermoplastic coal tar emulsion micro-surface.

629-3.1 Quantities of materials per square yard. Based on the data in this specification, the Contractor shall submit the proportions of water, thermoplastic coal tar emulsion, and aggregate proposed for use to the Engineer for approval prior to the start of operations. A copy of the mix design and test data required by this specification shall be submitted to the Engineer for approval along with the above information. No thermoplastic coal tar emulsion micro-surface shall be produced for payment until a job mix formula has been approved in writing by the Engineer.

The approximate amounts of materials per square yard (square meter) for the micro-surface treatment shall be as provided in the Application Rate table.

Application Rate

Aggregate Type	Composition [i] lbs/gal (kg/l)	Application Rate [ii] lb/yd^2 (kg/m^2)
A	21-23 (2.52-2.75)	8 (4.34)
~~B~~	~~19-21~~ ~~(2.28-2.52)~~	~~6.5~~ ~~(3.53)~~

i. Aggregate (lbs) shall be mixed homogeneously with the thermoplastic coal tar emulsion (gals).

ii. Minimum application rate of uncured thermoplastic coal tar emulsion micro-surface.

629-3.2 Aggregate. The aggregate shall consist of sound, durable crushed igneous type stone (crushed basalt, granite, trap rock, etc.), be free from films of matter that would prevent thorough coating and bonding with the bituminous material and free from coatings of clay, organic matter, and other deleterious materials. The percentage of wear shall not be greater than 35% when tested in accordance with ASTM C131. The aggregate shall meet the gradation in the table below for Type A and for Type B when tested in accordance with ASTM C136.

The Contractor shall provide a certification showing particle size analysis and properties of the material delivered for use on the project.

Aggregate Material Gradation Requirements

Sieve Designation (square openings)	Percentage by Weight Passing Sieves	
	Type A	Type B
No. 4 (4.75mm)	100	100
No. 8 (2.38 mm)	75-95	95-100
No. 16 (1.19 mm)	50-75	75-95
No. 30 (0.60 mm)	30-65	35-65
No. 50 (0.30 mm)	20-50	20-45
No. 100 (0.15 mm)	15-25	10-20

Sieve Designation (square openings)	Percentage by Weight Passing Sieves	
	Type A	Type B
No. 200 (0.07 mm)	5-20	10-20

629-3.3 Application

a. Application of tack coat. After preparation of the pavement and acceptance by the Engineer, the tack coat shall be applied to the pavement surface only where micro-surface will be applied. Apply a tack coat of thermoplastic coal tar emulsion diluted with 50% water at the rate of 0.10 gallons of mix per square yard (0.45 l/m^2).

b. Application of micro-surface. The surface shall be pre-wet by fogging ahead of the spreader box. Water used in pre-wetting the surface shall be applied at such a rate that the entire surface is damp with no apparent flowing water in front of the spreader box. If temperatures are in the colder acceptable range the rate of fogging may be decreased. The mixture shall be of the desired consistency when deposited on the surface, and no additional elements shall be added. A sufficient amount of mixture shall be carried in the spreader box at all times so that even distribution is obtained. No clumped or unmixed aggregate shall be permitted. No segregation of the emulsion and aggregate fines from the coarse aggregate will be permitted.

Upon completion of the work, the thermoplastic coal tar emulsion micro-surface shall have no bare spots or cracks through which liquids or foreign matter could penetrate to the underlying pavement. The finished surface shall present a uniform texture.

In areas where the spreader box cannot be used, the thermoplastic coal tar emulsion micro-surface shall be applied by a means of a hand squeegee.

629-3.4 Friction characteristics. For projects where thermoplastic coal tar emulsion spray seal coat is applied on runway and taxiway surfaces, the Contractor shall submit to the Engineer friction tests, from previous airport projects which used the thermoplastic coal tar emulsion spray seal coat in a similar environment, in accordance with AC 150/5320-12, at 40 or 60 mph (65 or 95 km/h) wet, showing, as a minimum; friction value of pavement surface prior to thermoplastic coal tar emulsion spray seal coat application; two values, tested between 24 and 96 hours after application, with a minimum of 24 hours between tests; and one value tested at no less than 180 days or greater than 360 days after the thermoplastic coal tar emulsion spray seal coat application. The results of the two tests between 24 and 96 hours shall indicate friction is increasing at a rate to obtain similar friction value of the pavement surface prior to application, and the long term test shall indicate no apparent adverse effect with time relative to friction values and existing pavement surface. The Contractor shall submit to the Engineer a list of airports which meet the above requirements, as well as technical details on application rates, aggregate rates, and point of contact at these airports to confirm use and success of thermoplastic coal tar emulsion spray seal coat with aggregate. Friction tests shall be submitted from no less than one of the airports on the list and each set of tests described above, must be from one project.

The thermoplastic coal tar emulsion spray seal coat submittal without the required friction performance will not be approved. Friction tests performed on this project cannot be used as a substitute of this requirement.

CONSTRUCTION METHODS

629-4.1 Worker safety. The thermoplastic coal tar emulsion surface treatment product shall be handled with caution. The Contractor shall obtain a MSDS for both the thermoplastic coal tar emulsion product and sand and require workmen to follow the manufacturer's recommended safety precautions.

629-4.2 Weather limitations. The material shall not be applied when the humidity or impending weather conditions will not allow proper drying or when the atmospheric or pavement temperature is below 50°F (10°C), unless otherwise directed by the Engineer.

During application of thermoplastic coal tar emulsion surface treatment, account for wind drift. Cover existing buildings, structures, runway edge lights, taxiway edge lights, informational signs, retro-reflective marking and in-pavement duct markers as necessary to protect against overspray before applying the emulsion. Should thermoplastic coal tar emulsion surface treatment get on any light or marker fixture, promptly clean the fixture. If cleaning is not satisfactory to the Engineer, the Contractor shall replace any light, sign or marker with equivalent equipment at no cost to the Owner.

629-4.3 Application equipment

a. Mobile mixing machine for micro-surface versions only. The mobile mixing machine shall be a truck-mounted mobile mixing plant with a towed-type spreader box. It shall have a water tank and water pump capable of delivering a constant volume of water.

The mobile mixing machine shall have an agitated storage tank for the thermoplastic coal tar emulsion and a non-shearing peristaltic pump with variable rate of flow for the delivery of this material. The mobile mixing machine shall have a hopper for holding aggregate, supplying this material to the mixing chamber by a conveyor belt. The rate of aggregate delivery shall be volumetrically controlled by an adjustable gate opening. The speed of the conveyor shall be mechanically dependent upon the speed of the peristaltic pump.

The mobile mixing machine shall be a continuous-flow mixing unit capable of delivering predetermined quantities of thermoplastic coal tar emulsion, aggregate, and if necessary water, to the mixing chamber and discharging the thoroughly mixed material on a continuous basis. The mobile mixing machine shall deliver the materials to the mixing chamber in a constant proportion in a manner not dependent on power plant or vehicle speed. The machine shall be equipped with a water spray bar capable of fogging the pavement surface to aid in the application process.

Attached to the mixing machine shall be a mechanical-type squeegee distributor, equipped with flexible material in contact with the surface to prevent loss of material from the distributor. It shall be maintained to prevent loss of micro-surfacing on varying grades and adjusted to assure uniform spread. The spreader box may have an adjustable width.

b. Batch mixing machine. The batch-mixing machine shall be either a truck-mounted 500 to 3,000 gallon (1893 to 11356 liter) tank or a self-propelled batch mixing machine 300 to 1000 gallons (1136 to 3785 liters) containing suitably driven mixing blades to combine predetermined quantities of thermoplastic emulsion, aggregate if specified and if necessary, water into a homogeneous mixture. It shall be equipped with a water tank and diaphragm style pump capable of delivering a constant volume of material to a spray wand or spray bar. The device shall have a bottom ball valve of 3 inches (75 mm) diameter capable of delivering material to a squeegee spreader or a drag box.

c. Auxiliary equipment. Other tools or equipment such as power brooms, power blowers, air compressors, hand brooms, hand squeegees, etc., shall be provided as required.

629-4.4 Test areas and test sections. A qualified manufacturer's representative shall be present in the field to assist the Contractor in applying test areas and/or test sections to determine the optimum application rate. A test area and/or section shall be applied for each differing hot mix asphalt (HMA) pavement surface identified in the project. The test area(s) and/or test section(s) shall be used to determine the material application rate(s) prior to full production. The same equipment and method of operation shall be utilized on the test area(s) and/or test section(s) as will be utilized on the remainder of the work.

a. For Taxiway, taxilane and apron surfaces. Prior to full application, the Contractor shall place test areas at varying application rates as specified by the manufacturer's representative and Engineer to determine application rate(s). The test areas will be located on representative section(s) of the pavement to receive the Thermoplastic coal tar emulsion spray seal coat designated by the Engineer.

b. For spray seal coat on runway and taxiway surfaces. Prior to full application, the Contractor shall place a series of test sections a minimum of 300 feet (90 m) long by 12 feet (3.6 m) wide, or width of anticipated application, whichever is greater, at varying application rates as stipulated by the manufacturer's representative and Engineer to determine application rate(s). The area to be tested will be located on a representative section of the pavement to receive the Thermoplastic coal tar emulsion spray seal coat designated by the Engineer. Before beginning the test section(s), the skid resistance of the existing pavement shall be determined for each test section with a continuous friction measuring equipment (CFME). The skid resistance test after application shall be at approximately the same location as the test done on the existing pavement. The Contractor may begin testing the skid resistance of runway and taxiway test sections after application of the Thermoplastic coal tar emulsion spray seal has fully cured. Aircraft shall not be permitted on the runway or taxiway test sections for a minimum of 24 hours and until such time as the Contractor validates that its surface friction meets AC 150/5320-12. The results of the friction evaluation meet or exceed the Maintenance Planning levels provided in Table 3-2, "Friction Level Classification for Runway Pavement Surfaces," in AC 150/5320-12, Measurement, Construction, and Maintenance of Skid-resistant Airport Pavement Surfaces, when tested at speeds of 40 and 60 mph (65 and 95 km/h) wet with approved CFME.

If the test section should prove to be unsatisfactory, necessary adjustments to the application rate, placement operations, and equipment shall be made. Additional test sections shall be placed and additional skid resistance tests performed and evaluated. Full production shall not begin without the Engineer's approval of an appropriate application rate(s). Acceptable test sections shall be paid for in accordance with paragraph 629-8.1.

629-4.5 Preparation of asphalt pavement surfaces. Clean pavement surface immediately prior to placing the seal coat by sweeping, flushing well with water leaving no standing water, or a combination of both, so that it is free of dust, dirt, grease, vegetation, oil or any type of objectionable surface film. Remove oil or grease that has not penetrated the asphalt pavement by scraping or by scrubbing with a detergent, then wash thoroughly with clean water. After cleaning, treat these areas with the oil spot primer. Any additional surface preparation, such as crack repair, shall be in accordance with paragraph 101-3.6.

629-4.6 Application. Application shall be in accordance with paragraph 629-3.3.

629-4.7 Curing. The mixture shall be permitted to dry for a minimum of 24 hours after the application, before opening to traffic or painting, and shall be sufficiently cured to drive over without damage to the installation. Any damage to the uncured mixture will be the responsibility of the Contractor to repair.

QUALITY CONTROL

629-5.1 Manufacturer's representation. The manufacturer's representative shall have knowledge of the material, procedures, and equipment described in the specification and shall be responsible for determining the application rates and shall oversee the preparation and application of the thermoplastic coal tar emulsion surface treatment. Documentation of the manufacturer representative's experience and knowledge for applying the thermoplastic coal tar emulsion surface treatment shall be furnished to the

Engineer a minimum of 10 work days prior to placement of the test sections. The cost of the manufacturer's representative shall be included in the bid price.

629-5.2 Contractor qualifications. The Contractor shall provide the Engineer contractor qualifications for applicators, personnel and equipment. The Contractor shall also provide, from the thermoplastic coal tar emulsion Manufacturer, documentation that the Contractor is certified to apply the thermoplastic coal tar emulsion surface treatment. Contractor shall provide documentation for at least three (3) applications similar to this project completed in the past two (2) years.

MATERIAL ACCEPTANCE

629-6.1 Friction tests. Friction Test in accordance with AC 150/5320-12, Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces, shall be accomplished on all runway and taxiways that have received a seal coat. The Contractor shall coordinate testing with the Engineer. Each test includes performing friction tests at 40 mph and 60 mph (65 and 95 km/h) both wet, 15 feet (4.5 m) to each side of runway centerline. Friction test shall be run within 30 days prior to application of the seal coat to runway and/or high-speed taxiways and after application of the seal coat. The Engineer shall be present for testing. The Contractor shall provide a written report of friction test results.

METHOD OF MEASUREMENT

629-7.1 Measurement. The Thermoplastic Coal Tar Emulsion Micro-Surface Type A shall be measured by the actual square yardage of the area indicated on the contract drawings or designated by the Engineer.

BASIS OF PAYMENT

629-8.1 Payment. Payment shall be made at the contract unit price per square yard (square meter) for the Thermoplastic Coal Tar Emulsion Micro-Surface Type A. This price shall fully compensate the Contractor for furnishing all materials and for all labor, equipment tools and incidentals necessary to complete the thermoplastic coal tar emulsion product installation, including mix design and data sheets stipulated in these specifications.

Payments will be made under:

Item P-629-8.1 Thermoplastic coal tar emulsion Micro-Surface Type A –per square yard

TESTING REQUIREMENTS

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in this text by basic designation only.

29 CFR Part 1910.1200	Hazard Communication
ASTM C67	Standard Test Method for Sampling and Testing Brick and Structural Clay Tile
ASTM C131	Standard Test Method for Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
ASTM C136	Standard Test Method for Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM D3699	Standard Specification for Kerosene
ASTM D36	Standard Test Method for Softening Point of Bitumen (Ring-and-Ball Apparatus)

ASTM D244	Standard Test Methods and Practices for Emulsified Asphalts
ASTM D5340	Standard Test Method for Airport Pavement Condition Index Surveys
AC 150/5320-12	Measurement, Construction, and Maintenance of Skid-Resistant Airport Pavement Surfaces
AC 150/5320-17	Airfield Pavement Surface Evaluation and Rating (PASER) Manuals

Appendix A

FUEL RESISTANCE TEST
TEST METHODS CRITERION

1. Scope

This method determines the resistance of the thermoplastic coal tar emulsion surface treatment to kerosene.

2. Apparatus

2.1 Two 6″ × 6″ (150 mm × 150 mm) square 16 gauge sheet metal masks with a 4″ × 4″ (100 mm × 100 mm) square center removed.

2.2 6″ × 6″ (150 mm × 150 mm) unglazed white ceramic tile with an absorption rate of 10-18% (determined in accordance with ASTM C67).

2.3 Brass ring, 2″ (50 mm) diameter and 2″ (50 mm) high.

2.4 Kerosene meeting requirements of ASTM D3699.

2.5 Silicone rubber sealant.

3. Procedure

3.1 Immerse the ceramic tile in distilled water for a minimum of ten minutes.

3.2 Remove excess water from the tile to produce a damp surface before applying the thermoplastic coal tar emulsion surface treatment.

3.3 Using the mask described in 2.1 apply thermoplastic coal tar emulsion surface treatment as specified to the tile. Spread even with the top of the mask using a spatula or other straightedge.

3.4 Allow the sample to cure for 96 hours at 77 ±2°F. and 50 ±10% relative humidity.

3.5 After curing, affix the brass ring to the thermoplastic coal tar emulsion surface treatment on the tile with silicone rubber sealant.

3.6 Fill the brass ring with kerosene.

3.7 After 24 hours, remove the kerosene from the brass ring, blot dry and immediately examine the film for softness and loss of adhesion. Immediately after the film is examined, break the tile in half, exposing that part of the tile whose film was subjected to the kerosene.

3.8 Evaluate for penetration of kerosene through the thermoplastic coal tar emulsion surface treatment and loss of adhesion.

4. Report

4.1 Report the results as pass or fail. Visible evidence of leakage or discoloration shall constitute failure of the fuel resistance test.

5. Criterion: A “pass” rating in the fuel resistance test is required prior to full production.

END OF ITEM P-629

Item 300
Asphalts, Oils, and Emulsions

1. DESCRIPTION

Provide asphalt cements, cutback and emulsified asphalts, performance-graded asphalt binders, and other miscellaneous asphalt materials as specified on the plans.

2. MATERIALS

Provide asphalt materials that meet the stated requirements when tested in accordance with the referenced Department, AASHTO, and ASTM test methods. Use asphalt containing recycled materials only if the recycled components meet the requirements of Article 6.9, "Recycled Materials." Provide asphalt materials that have been preapproved for use by the Construction Division in accordance with Tex-545-C.

Acronyms used in this Item are defined in Table 1.

Table 1
Acronyms

Acronym	Definition
Test Procedure Designations	
Tex T or R D	Department AASHTO ASTM
Polymer Modifier Designations	
P SBR or L SBS TR	polymer-modified styrene-butadiene rubber (latex) styrene-butadiene-styrene block co-polymer tire rubber (from ambient temperature grinding of truck and passenger tires)
AC	asphalt cement
AE	asphalt emulsion
AE-P	asphalt emulsion prime
A-R	asphalt-rubber
C	cationic
EAP&T	emulsified asphalt prime and tack
H-suffix	harder residue (lower penetration)
HF	high float
MC	medium-curing
MS	medium-setting
PCE	prime, cure, and erosion control
PG	performance grade
RC	rapid-curing
RS	rapid-setting
S-suffix	stockpile usage
SCM	special cutback material
SS	slow-setting

2.1. **Asphalt Cement.** Provide asphalt cement that is homogeneous, water-free, and nonfoaming when heated to 347°F, and meets the requirements in Table 2.

Table 2
Asphalt Cement

Property	Test Procedure	Viscosity Grade									
		AC-0.6		AC-1.5		AC-3		AC-5		AC-10	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity 140°F, poise 275°F, poise	T 202	 40 0.4	 80 –	 100 0.7	 200 –	 250 1.1	 350 –	 400 1.4	 600 –	 800 1.9	 1,200 –
Penetration, 77°F, 100g, 5 sec.	T 49	350	–	250	–	210	–	135	–	85	–
Flash point, C.O.C., °F	T 48	425	–	425	–	425	–	425	–	450	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.		Neg.	
Tests on residue from Thin-Film Oven Test: Viscosity, 140°F, poise Ductility,[1] 77°F 5 cm/min., cm	T 179 T 202 T 51	 – 100	 180 –	 – 100	 450 –	 – 100	 900 –	 – 100	 1,500 –	 – 100	 3,000 –

1. If AC-0.6 or AC-1.5 ductility at 77°F is less than 100 cm, material is acceptable if ductility at 60°F is more than 100 cm.

2.2. **Polymer-Modified Asphalt Cement**. Provide polymer-modified asphalt cement that is smooth, homogeneous, and meets the requirements of Table 3. Supply samples of the base asphalt cement and polymer additives if requested.

Table 3
Polymer-Modified Asphalt Cement

Property	Test Procedure	Polymer-Modified Viscosity Grade											
		AC-5 w/2% SBR		AC-10 w/2% SBR		AC-15P		AC-20XP		AC-10-2TR		AC-20-5TR	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Polymer		SBR		SBR		SBS		SBS		TR		TR	
Polymer content, % (solids basis)	Tex-533-C	2.0	–	2.0	–	3.0	–	–	–	2.0	–	5.0	–
Dynamic shear, G*/sin δ, 64°C, 10 rad/s, kPa	T 315	–	–	–	–	–	–	1.0	–	–	–	1.0	–
Dynamic shear, G*/sin δ, 58°C, 10 rad/s, kPa	T 315	–	–	–	–	–	–	–	–	1.0	–	–	–
Viscosity 140°F, poise 275°F, poise	 T 202 T 202	 700 –	 – 7.0	 1,300 –	 – 8.0	 1,500 –	 – 8.0	 2,000 –	 – –	 1,000 –	 – 8.0	 2,000 –	 – 10.0
Penetration, 77°F, 100 g, 5 sec.	T 49	120	–	80	–	100	150	75	115	95	130	75	115
Ductility, 5cm/min., 39.2°F, cm	T 51	70	–	60	–	–	–	–	–	–	–	–	–
Elastic recovery, 50°F, %	Tex-539-C	–	–	–	–	55	–	55	–	30	–	55	–
Softening point, °F	T 53	–	–	–	–	–	–	120	–	110	–	120	–
Polymer separation, 48 hr.	Tex-540-C	None		None		None		None		None		None	
Flash point, C.O.C., °F	T 48	425	–	425	–	425	–	425	–	425	–	425	–
Tests on residue from RTFOT aging and pressure aging: Creep stiffness S, -18°C, MPa m-value, -18°C	Tex-541-C and R 28 T 313	 – –	 – –	 – –	 – –	 – 0.300	 300 –	 – 0.300	 300 –	 – 0.300	 300 –	 – 0.300	 300 –

2.3. **Cutback Asphalt**. Provide cutback asphalt that meets the requirements of Tables 4, 5, and 6 for the specified type and grade. Supply samples of the base asphalt cement and polymer additives if requested.

Table 4
Rapid-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade					
		RC-250		RC-800		RC-3000	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	250	400	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	80	–	80	–	80	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		40	75	35	70	20	55
to 500°F		65	90	55	85	45	75
to 600°F		85	–	80	–	70	–
Residue from distillation, volume %		70	–	75	–	82	–
Tests on distillation residue:							
Viscosity, 140°F, poise	T 202	600	2400	600	2400	600	2400
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.	

Table 5
Medium-Curing Cutback Asphalt

Property	Test Procedure	Type–Grade							
		MC-30		MC-250		MC-800		MC-3000	
		Min	Max	Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	30	60	250	500	800	1,600	3,000	6,000
Water, %	D95	–	0.2	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	95	–	122	–	140	–	149	–
Distillation test:	T 78								
Distillate, percentage by volume of total distillate to 680°F									
to 437°F		–	35	–	20	–	–	–	–
to 500°F		30	75	5	55	–	40	–	15
to 600°F		75	95	60	90	45	85	15	75
Residue from distillation, volume %		50	–	67	–	75	–	80	–
Tests on distillation residue:									
Viscosity, 140°F, poise	T 202	300	1200	300	1200	300	1200	300	1200
Ductility, 5 cm/min., 77°F, cm	T 51	100	–	100	–	100	–	100	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–	99.0	–
Spot test	Tex-509-C	Neg.		Neg.		Neg.		Neg.	

Table 6
Special-Use Cutback Asphalt

Property	Test Procedure	Type–Grade					
		MC-2400L		SCM I		SCM II	
		Min	Max	Min	Max	Min	Max
Kinematic viscosity, 140°F, cSt	T 201	2,400	4,800	500	1,000	1,000	2,000
Water, %	D95	–	0.2	–	0.2	–	0.2
Flash point, T.O.C., °F	T 79	150	–	175	–	175	–
Distillation test:	T 78						
Distillate, percentage by volume of total distillate to 680°F							
to 437°F		–	–	–	–	–	–
to 500°F		–	35	–	0.5	–	0.5
to 600°F		35	80	20	60	15	50
Residue from distillation, volume %		78	–	76	–	82	–
Tests on distillation residue:							
Polymer		SBR		–		–	
Polymer content, % (solids basis)	Tex-533-C	2.0	–	–	–	–	–
Penetration, 100 g, 5 sec., 77°F	T 49	150	300	180	–	180	–
Ductility, 5 cm/min., 39.2°F, cm	T 51	50	–	–	–	–	–
Solubility in trichloroethylene, %	T 44	99.0	–	99.0	–	99.0	–

2.4. **Emulsified Asphalt.** Provide emulsified asphalt that is homogeneous, does not separate after thorough mixing, and meets the requirements for the specified type and grade in Tables 7, 8, 9, and 10.

Table 7
Emulsified Asphalt

Property	Test Procedure	Type–Grade									
		Rapid-Setting		Medium-Setting				Slow-Setting			
		HFRS-2		MS-2		AES-300		SS-1		SS-1H	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72										
77°F, sec.		–	–	–	–	75	400	20	100	20	100
122°F, sec.		150	400	100	300	–	–	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility	T 59	–		–		–		Pass		Pass	
Cement mixing, %	T 59	–	–	–	–	–	–	–	2.0	–	2.0
Coating ability and water resistance:	T 59										
Dry aggregate/after spray		–		–		Good/Fair		–		–	
Wet aggregate/after spray		–		–		Fair/Fair		–		–	
Demulsibility, 35 mL of 0.02 N $CaCl_2$, %	T 59	50	–	–	30	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1
Freezing test, 3 cycles[1]	T 59	–		Pass		–		Pass		Pass	
Distillation test:	T 59										
Residue by distillation, % by wt.		65	–	65	–	65	–	60	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	5	–	0.5	–	0.5
Tests on residue from distillation:											
Penetration, 77°F, 100 g, 5 sec.	T 49	100	140	120	160	300	–	120	160	70	100
Solubility in trichloroethylene, %	T 44	97.5	–	97.5		97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	100	–	100		–	–	100	–	80	–
Float test, 140°F, sec.	T 50	1,200	–	–		1,200	–	–	–	–	–

1. Applies only when the Engineer designates material for winter use.

Table 8
Cationic Emulsified Asphalt

Property	Test Procedure	Type–Grade											
		Rapid-Setting				Medium-Setting				Slow-Setting			
		CRS-2		CRS-2H		CMS-2		CMS-2S		CSS-1		CSS-1H	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol													
77°F, sec.	T 72	–	–	–	–	–	–	–	–	20	100	20	100
122°F, sec.		150	400	150	400	100	300	100	300	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Cement mixing, %	T 59	–	–	–	–	–	–	–	–	–	2.0	–	2.0
Coating ability and water resistance:													
Dry aggregate/after spray	T 59	–		–		Good/Fair		Good/Fair		–		–	
Wet aggregate/after spray		–		–		Fair/Fair		Fair/Fair		–		–	
Demulsibility, 35 mL of 0.8% Sodium dioctyl sulfosuccinate, %	T 59	70	–	70	–	–	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1	–	1
Particle charge	T 59	Positive		Positive		Positive		Positive		Positive		Positive	
Distillation test:													
Residue by distillation, % by wt.	T 59	65	–	65	–	65	–	65	–	60	–	60	–
Oil distillate, % by volume of emulsion		–	0.5	–	0.5	–	7	–	5	–	0.5	–	0.5
Tests on residue from distillation:													
Penetration, 77°F, 100 g, 5 sec.	T 49	120	160	70	110	120	200	300	–	120	160	70	110
Solubility in trichloroethylene, %	T 44	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–	97.5	–
Ductility, 77°F, 5 cm/min., cm	T 51	100	–	80	–	100	–	–	–	100	–	80	–

Table 9
Polymer-Modified Emulsified Asphalt

Property	Test Procedure	Type–Grade											
		Rapid-Setting				Medium-Setting				Slow-Setting			
		RS-1P		HFRS-2P		AES-150P		AES-300P		AES-300S		SS-1P	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72												
77°F, sec.		–	–	–	–	75	400	75	400	75	400	30	100
122°F, sec.		50	200	150	400	–	–	–	–	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Miscibility	T 59	–		–		–		–		–		Pass	
Coating ability and water resistance:	T 59												
Dry aggregate/after spray		–		–		Good/Fair		Good/Fair		Good/Fair		–	
Wet aggregate/after spray		–		–		Fair/Fair		Fair/Fair		Fair/Fair		–	
Demulsibility, 35 mL of 0.02 N $CaCl_2$, %	T 59	60	–	50	–	–	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	1	–	1	–	1
Breaking index, g	Tex-542-C	–	80	–	–	–	–	–	–	–	–	–	–
Distillation test:[1]	T 59												
Residue by distillation, % by wt.		65	–	65	–	65	–	65	–	65	–	60	–
Oil distillate, % by volume of emulsion		–	3	–	0.5	–	3	–	5	–	7	–	0.5
Tests on residue from distillation:													
Polymer content, wt. % (solids basis)	Tex-533-C	–	–	3.0	–	–	–	–	–	–	–	3.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	225	300	90	140	150	300	300	–	300	–	100	140
Solubility in trichloroethylene, %	T 44	97.0	–	97.0	–	97.0	–	97.0	–	97.0	–	97.0	–
Viscosity, 140°F, poise	T 202	–	–	1,500	–	–	–	–	–	–	–	1,300	–
Float test, 140°F, sec.	T 50	–	–	1,200	–	1,200	–	1,200	–	1,200	–	–	–
Ductility,[2] 39.2°F, 5 cm/min., cm	T 51	–	–	50	–	–	–	–	–	–	–	50	–
Elastic recovery,[2] 50°F, %	Tex-539-C	55	–	55	–	–	–	–	–	–	–	–	–
Tests on RTFO curing of distillation residue	Tex-541-C												
Elastic recovery, 50°F, %	Tex-539-C	–	–	–	–	50	–	50	–	30	–	–	–

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F ±10°F. Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. HFRS-2P must meet one of either the ductility or elastic recovery requirements.

Table 10
Polymer-Modified Cationic Emulsified Asphalt

Property	Test Procedure	Type-Grade											
		Rapid-Setting						Medium-Setting				Slow-Setting	
		CRS-1P		CRS-2P		CHFRS-2P		CMS-1P[3]		CMS-2P[3]		CSS-1P	
		Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max
Viscosity, Saybolt Furol	T 72												
77°F, sec.		–	–	–	–	–	–	20	100	–	–	20	100
122°F, sec.		50	150	150	400	100	400	–	–	50	400	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1	–	0.1
Demulsibility, 35 mL of 0.8% Sodium dioctyl sulfosuccinate, %	T 59	60	–	70	–	60	–	–	–	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	1	–	–	–	–	–	1
Breaking index, g	Tex-542-C	–	80	–	–	–	–	–	–	–	–	–	–
Particle charge	T 59	Positive		Positive		Positive		Positive		Positive		Positive	
Distillation test:[1]	T 59												
Residue by distillation, % by weight		65	–	65	–	65	–	65	–	65	–	62	–
Oil distillate, % by volume of emulsion		–	3	–	0.5	–	0.5	–	0.5	–	0.5	–	0.5
Tests on residue from distillation:													
Polymer content, wt. % (solids basis)	Tex-533-C	–	–	3.0	–	3.0	–	–	–	–	–	3.0	–
Penetration, 77°F, 100 g, 5 sec.	T 49	225	300	90	150	80	130	40	–	40	–	55	90
Viscosity, 140°F, poise	T 202	–	–	1,300	–	1,300	–	–	5,000	–	5,000	–	–
Solubility in trichloroethylene, %	T 44	97.0	–	97.0	–	95.0	–	–	–	–	–	97.0	–
Softening point, °F	T 53	–	–	–	–	130	–	–	–	–	–	135	–
Ductility, 77°F, 5 cm/min., cm	T 51	–	–	–	–	–	–	–	–	–	–	70	–
Float test, 140°F, sec.	T 50	–	–	–	–	1,800	–	–	–	–	–		
Ductility,[2] 39.2°F, 5 cm/min., cm	T 51	–	–	50	–	–	–	–	–	–	–	–	–
Elastic recovery,[2] 50°F, %	Tex-539-C	45	–	55	–	55	–	45	–	45	–	–	–
Tests on rejuvenating agent:													
Viscosity, 140°F, cSt	T 201	–	–	–	–	–	–	50	175	50	175	–	–
Flash point, C.O.C., °F	T 48	–	–	–	–	–	–	380	–	380	–	–	–
Saturates, % by weight	D2007	–	–	–	–	–	–	–	30	–	30	–	–
Solubility in n-pentane, % by weight	D2007	–	–	–	–	–	–	99	–	99	–	–	–
Tests on rejuvenating agent after TFO or RTFO:	T 240 or T 179												
Weight Change, %		–	–	–	–	–	–	–	6.5	–	6.5	–	–
Viscosity Ratio		–	–	–	–	–	–	–	3.0	–	3.0	–	–
Tests on latex:[4]													
Tensile strength, die C dumbbell, psi	D412[5]	–	–	–	–	–	–	500	–	500	–	–	–
Change in mass after immersion in rejuvenating agent, %	D471	–	–	–	–	–	–	–	40[6]	–	40[6]	–	–

1. Exception to T 59: Bring the temperature on the lower thermometer slowly to 350°F (±0°F). Maintain at this temperature for 20 min. Complete total distillation in 60 min. (±5 min.) from the first application of heat.
2. CRS-2P must meet one of either the ductility or elastic recovery requirements.
3. With all precertification samples of CMS-1P or CMS-2P, submit certified test reports showing that the rejuvenating agent and latex meet the stated requirements. Submit samples of these raw materials if requested by the Engineer.
4. Preparation of latex films: Use any substrate which produces a film of uniform cross-section. Apply latex using a drawdown tool that will deliver enough material to achieve desired residual thickness. Cure films for 14 days at 75°F and 50% relative humidity.
5. Cut samples for tensile strength determination using a crosshead speed of 20 in./min.
6. Specimen must remain intact after exposure and removal of excess rejuvenating agent.

2.5. **Specialty Emulsions.** Provide specialty emulsion that is either asphalt-based or resin-based and meets the requirements of Table 11.

Table 11
Specialty Emulsions

Property	Test Procedure	Type–Grade: Medium-Setting AE–P Min	Medium-Setting AE–P Max	Medium-Setting EAP&T Min	Medium-Setting EAP&T Max	Slow-Setting PCE[1] Min	Slow-Setting PCE[1] Max
Viscosity, Saybolt Furol	T 72						
77°F, sec.		–	–	–	–	10	100
122°F, sec.		15	150	–	–	–	–
Sieve test, %	T 59	–	0.1	–	0.1	–	0.1
Miscibility[2]	T 59	–		Pass		Pass	
Demulsibility, 35 mL of 0.10 N $CaCl_2$, %	T 59	–	70	–	–	–	–
Storage stability, 1 day, %	T 59	–	1	–	1	–	–
Particle size,[5] % by volume < 2.5 µm	Tex-238-F[3]	–	–	90	–	90	–
Asphalt emulsion distillation to 500°F followed by Cutback asphalt distillation of residue to 680°F:	T 59 & T 78						
Residue after both distillations, % by wt.		40	–	–	–	–	–
Total oil distillate from both distillations, % by volume of emulsion		25	40	–	–	–	–
Residue by distillation, % by wt.	T 59	–	–	60	–	–	–
Residue by evaporation,[4] % by wt.	T 59	–	–	–	–	60	–
Tests on residue after all distillation(s):							
Viscosity, 140°F, poise	T 202	–	–	800	–	–	–
Kinematic viscosity,[5] 140°F, cSt	T 201	–	–	–	–	100	350
Flash point C.O.C., °F	T 48	–	–	–	–	400	–
Solubility in trichloroethylene, %	T 44	97.5	–	–	–	–	–
Float test, 122°F, sec.	T 50	50	200	–	–	–	–

Supply with each shipment of PCE:
- a copy of a lab report from an approved analytical lab, signed by a lab official, indicating the PCE formulation does not meet any characteristics of a Resource Conservation Recovery Act (RCRA) hazardous waste;
- a certification from the producer that the formulation supplied does not differ from the one tested and that no listed RCRA hazardous wastes or Polychlorinated Biphenyls (PCBs) have been mixed with the product; and
- a Safety Data Sheet.

Exception to T 59: In dilution, use 350 mL of distilled or deionized water and a 1,000-mL beaker.
Use Tex-238-F, beginning at "Particle Size Analysis by Laser Diffraction," with distilled or deionized water as a medium and no dispersant, or use another approved method.
Exception to T 59: Leave sample in the oven until foaming ceases, then cool and weigh.
PCE must meet either the kinematic viscosity requirement or the particle size requirement.

2.6. **Recycling Agent.** Recycling agent and emulsified recycling agent must meet the requirements in Table 12. Additionally, recycling agent and residue from emulsified recycling agent, when added in the specified proportions to the recycled asphalt, must meet the properties specified on the plans.

Table 12
Recycling Agent and Emulsified Recycling Agent

Property	Test Procedure	Recycling Agent		Emulsified Recycling Agent	
		Min	Max	Min	Max
Viscosity, Saybolt Furol, 77°F, sec.	T 72	–	–	15	100
Sieve test, %	T 59	–	–	–	0.1
Miscibility[1]	T 59	–		No coagulation	
Residue by evaporation,[2] % by wt.	T 59	–	–	60	–
Tests on recycling agent or residue from evaporation:					
Flash point, C.O.C., °F	T 48	400	–	400	–
Kinematic viscosity,	T 201				
140°F, cSt		75	200	75	200
275°F, cSt		–	10.0	–	10.0

1. Exception to T 59: Use 0.02 N CaCl2 solution in place of water.
2. Exception to T 59: Maintain sample at 300°F until foaming ceases, then cool and weigh.

2.7. **Crumb Rubber Modifier**. Crumb rubber modifier (CRM) consists of automobile and truck tires processed by ambient temperature grinding.

CRM must be:

- free from contaminants including fabric, metal, and mineral and other nonrubber substances;
- free-flowing; and
- nonfoaming when added to hot asphalt binder.

Ensure rubber gradation meets the requirements of the grades in Table 13 when tested in accordance with Tex-200-F, Part I, using a 50-g sample.

Table 13
CRM Gradations

Sieve Size (% Passing)	Grade A Min	Grade A Max	Grade B Min	Grade B Max	Grade C Min	Grade C Max	Grade D	Grade E
#8	100	–	–	–	–	–	As shown on the plans	As approved
#10	95	100	100	–	–	–		
#16	–	–	70	100	100	–		
#30	–	–	25	60	90	100		
#40	–	–	–	–	45	100		
#50	0	10	–	–	–	–		
#200	–	–	0	5	–	–		

2.8. **Crack Sealer.** Provide polymer-modified asphalt-emulsion crack sealer meeting the requirements of Table 14. Provide rubber-asphalt crack sealer meeting the requirements of Table 15.

Table 14
Polymer-Modified Asphalt-Emulsion Crack Sealer

Property	Test Procedure	Min	Max
Rotational viscosity, 77°F, cP	D 2196, Method A	10,000	25,000
Sieve test, %	T 59	–	0.1
Storage stability, 1 day, %	T 59	–	1
Evaporation	Tex-543-C		
Residue by evaporation, % by wt.		65	–
Tests on residue from evaporation:			
Penetration, 77°F, 100 g, 5 sec.	T 49	35	75
Softening point, °F	T 53	140	–
Ductility, 39.2°F, 5 cm/min., cm	T 51	100	–

Table 15
Rubber-Asphalt Crack Sealer

Property	Test Procedure	Class A		Class B	
		Min	Max	Min	Max
CRM content, Grade A or B, % by wt.	Tex-544-C	22	26	–	–
CRM content, Grade B, % by wt.	Tex-544-C	–	–	13	17
Virgin rubber content,[1] % by wt.		–	–	2	–
Flash point,[2] C.O.C., °F	T 48	400	–	400	–
Penetration,[3] 77°F, 150 g, 5 sec.	T 49	30	50	30	50
Penetration,[3] 32°F, 200 g, 60 sec.	T 49	12	–	12	–
Softening point, °F	T 53	–	–	170	–
Bond Test, non-immersed, 0.5 in specimen, 50% extension, 20°F[4]	D5329	–		Pass	

1. Provide certification that the Min % virgin rubber was added.
2. Agitate the sealing compound with a 3/8- to 1/2-in. (9.5- to 12.7-mm) wide, square-end metal spatula to bring the material on the bottom of the cup to the surface (i.e., turn the material over) before passing the test flame over the cup. Start at one side of the thermometer, move around to the other, and then return to the starting point using 8 to 10 rapid circular strokes. Accomplish agitation in 3 to 4 sec. Pass the test flame over the cup immediately after stirring is completed.
3. Exception to T 49: Substitute the cone specified in D 217 for the penetration needle.
4. Allow no crack in the crack sealing materials or break in the bond between the sealer and the mortar blocks over 1/4 in. deep for any specimen after completion of the test.

2.9. **Asphalt-Rubber Binders**. Provide asphalt-rubber (A-R) binders that are mixtures of asphalt binder and CRM, which have been reacted at elevated temperatures. Provide A-R binders meeting D6114 and containing a minimum of 15% CRM by weight. Provide Types I or II, containing CRM Grade C, for use in hot-mixed aggregate mixtures. Provide Types II or III, containing CRM Grade B, for use in surface treatment binder. Ensure binder properties meet the requirements of Table 16.

Table 16
A-R Binders

Property	Test Procedure	Binder Type					
		Type I		Type II		Type III	
		Min	Max	Min	Max	Min	Max
Apparent viscosity, 347°F, cP	D2196, Method A	1,500	5,000	1,500	5,000	1,500	5,000
Penetration, 77°F, 100 g, 5 sec.	T 49	25	75	25	75	50	100
Penetration, 39.2°F, 200 g, 60 sec.	T 49	10	–	15	–	25	–
Softening point, °F	T 53	135	–	130	–	125	–
Resilience, 77°F, %	D5329	25	–	20	–	10	–
Flash point, C.O.C., °F	T 48	450	–	450	–	450	–
Tests on residue from Thin-Film Oven Test:	T 179						
Retained penetration ratio, 39.2°F, 200 g, 60 sec., % of original	T 49	75	–	75	–	75	–

2.10. **Performance-Graded Binders**. Provide PG binders that are smooth and homogeneous, show no separation when tested in accordance with Tex-540-C, and meet the requirements of Table 17.

Separation testing is not required if:

- a modifier is introduced separately at the mix plant either by injection in the asphalt line or mixer,
- the binder is blended on site in continuously agitated tanks, or
- binder acceptance is based on field samples taken from an in-line sampling port at the hot-mix plant after the addition of modifiers.

Table 17
Performance-Graded Binders

Property and Test Method	Performance Grade																	
	PG 58			PG 64				PG 70				PG 76				PG 82		
	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28	-34	-16	-22	-28
Average 7-day max pavement design temperature, °C[1]	< 58			< 64				< 70				< 76				< 82		
Min pavement design temperature, °C[1]	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28	>-34	>-16	>-22	>-28
Original Binder																		
Flash point, T 48, Min, °C	230																	
Viscosity, T 316:[2,3] Max, 3.0 Pa·s, test temperature, °C	135																	
Dynamic shear, T 315:[4] G*/sin(δ), Min, 1.00 kPa, Max, 2.00 kPa,[7] Test temperature @ 10 rad/sec., °C	58			64				70				76				82		
Elastic recovery, D 6084, 50°F, % Min	–	–	30	–	–	30	50	–	30	50	60	30	50	60	70	50	60	70
Rolling Thin-Film Oven (Tex-541-C)																		
Mass loss, Tex-541-C, Max, %	1.0																	
Dynamic shear, T 315: G*/sin(δ), Min, 2.20 kPa, Max, 5.00 kPa,[7] Test temperature @ 10 rad/sec., °C	58			64				70				76				82		
Pressure Aging Vessel (PAV) Residue (R 28)																		
PAV aging temperature, °C	100																	
Dynamic shear, T 315: G*sin(δ), Max, 5,000 kPa Test temperature @ 10 rad/sec., °C	25	22	19	28	25	22	19	28	25	22	19	28	25	22	19	28	25	22
Creep stiffness, T 313:[5,6] *S*, max, 300 MPa, *m*-value, Min, 0.300 Test temperature @ 60 sec., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18
Direct tension, T 314:[6] Failure strain, Min, 1.0% Test temperature @ 1.0 mm/min., °C	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18	-24	-6	-12	-18

1. Pavement temperatures are estimated from air temperatures using an algorithm contained in a Department-supplied computer program, may be provided by the Department, or by following the procedures outlined in AASHTO MP 2 and PP 28.
2. This requirement may be waived at the Department's discretion if the supplier warrants that the asphalt binder can be adequately pumped, mixed, and compacted at temperatures that meet all applicable safety, environmental, and constructability requirements. At test temperatures where the binder is a Newtonian fluid, any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
3. Viscosity at 135°C is an indicator of mixing and compaction temperatures that can be expected in the lab and field. High values may indicate high mixing and compaction temperatures. Additionally, significant variation can occur from batch to batch. Contractors should be aware that variation could significantly impact their mixing and compaction operations. Contractors are therefore responsible for addressing any constructability issues that may arise.
4. For quality control of unmodified asphalt binder production, measurement of the viscosity of the original asphalt binder may be substituted for dynamic shear measurements of G*/sin(δ) at test temperatures where the asphalt is a Newtonian fluid. Any suitable standard means of viscosity measurement may be used, including capillary (T 201 or T 202) or rotational viscometry (T 316).
5. Silicone beam molds, as described in AASHTO TP 1-93, are acceptable for use.
6. If creep stiffness is below 300 MPa, direct tension test is not required. If creep stiffness is between 300 and 600 MPa, the direct tension failure strain requirement can be used instead of the creep stiffness requirement. The m-value requirement must be satisfied in both cases.
7. Maximum values for unaged and RTFO aged dynamic shear apply only to materials used as substitute binders, as described in specification Items 340, "Dense-Graded Hot-Mix Asphalt (Small Quantity)," 341, "Dense-Graded Hot-Mix Asphalt," and 344, "Superpave Mixtures."

3. EQUIPMENT

Provide all equipment necessary to transport, store, sample, heat, apply, and incorporate asphalts, oils, and emulsions.

4. CONSTRUCTION

Typical Material Use. Use materials shown in Table 18, unless otherwise determined by the Engineer.

Table 18
Typical Material Use

Material Application	Typically Used Materials
Hot-mixed, hot-laid asphalt mixtures	PG binders, A-R binders Types I and II
Surface treatment	AC-5, AC-10, AC-5 w/2% SBR, AC-10 w/2% SBR, AC-15P, AC-20XP, AC-10-2TR, AC-20-5TR, HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P,CRS-2P, CHFRS-2P, A-R binders Types II and III
Surface treatment (cool weather)	RS-1P, CRS-1P, RC-250, RC-800, RC-3000, MC-250, MC-800, MC-3000, MC-2400L
Precoating	AC-5, AC-10, PG 64-22, SS-1, SS-1H, CSS-1, CSS-1H
Tack coat	PG Binders, SS-1H, CSS-1H, EAP&T
Fog seal	SS-1, SS-1H, CSS-1, CSS-1H
Hot-mixed, cold-laid asphalt mixtures	AC-0.6, AC-1.5, AC-3, AES-300, AES-300P, CMS-2, CMS-2S
Patching mix	MC-800, SCM I, SCM II, AES-300S
Recycling	AC-0.6, AC-1.5, AC-3, AES-150P, AES-300P, recycling agent, emulsified recycling agent
Crack sealing	SS-1P, polymer mod AE crack sealant, rubber asphalt crack sealers (Class A, Class B)
Microsurfacing	CSS-1P
Prime	MC-30, AE-P, EAP&T, PCE
Curing membrane	SS-1, SS-1H, CSS-1, CSS-1H, PCE
Erosion control	SS-1, SS-1H, CSS-1, CSS-1H, PCE

4.1. **Storage and Application Temperatures**. Use storage and application temperatures in accordance with Table 19. Store and apply materials at the lowest temperature yielding satisfactory results. Follow the manufacturer's instructions for any agitation requirements in storage. Manufacturer's instructions regarding recommended application and storage temperatures supersede those of Table 19.

Table 19
Storage and Application Temperatures

Type–Grade	Application		Storage
	Recommended Range (°F)	Maximum Allowable (°F)	Maximum (°F)
AC-0.6, AC-1.5, AC-3	200–300	350	350
AC-5, AC-10	275–350	350	350
AC-5 w/2% SBR, AC-10 w/2% SBR, AC-15P, AC-20-5TR	300–375	375	360
RC-250	125–180	200	200
RC-800	170–230	260	260
RC-3000	215–275	285	285
MC-30, AE-P	70–150	175	175
MC-250	125–210	240	240
MC-800, SCM I, SCM II	175–260	275	275
MC-3000, MC-2400L	225–275	290	290
HFRS-2, MS-2, CRS-2, CRS-2H, HFRS-2P, CRS-2P, CMS-2, CMS-2S, AES-300, AES-300S, AES-150P, AES-300P	120–160	180	180
SS-1, SS-1H, CSS-1, CSS-1H, PCE, EAP&T, SS-1P, RS-1P, CRS-1P, CSS-1P, recycling agent, emulsified recycling agent, polymer mod AE crack sealant	50–130	140	140
PG binders	275–350	350	350
Rubber asphalt crack sealers (Class A, Class B)	350–375	400	–
A-R binders Types I, II, and III	325–425	425	425

5. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but is subsidiary or is included in payment for other pertinent Items.

Item 315
Fog Seal

1. DESCRIPTION

Apply an emulsified asphalt and water mixture as an aggregate loss preventative or surface seal.

2. MATERIALS

Use emulsified asphalt of the type and grade shown on the plans that meet the requirements of Item 300, “Asphalts, Oils, and Emulsions.” Provide water in accordance with Article 204.2., “Materials.”

Use a quantity of emulsified asphalt in the mixture, expressed as a percentage of total volume, which meets the percentage shown on the plans or directed.

3. EQUIPMENT

Provide applicable equipment in accordance with Article 316.3., “Equipment.” Furnish the necessary facilities and equipment for determining the temperature of the mixture, regulating the application rate, and securing uniformity at the junction of 2 distributor loads.

4. CONSTRUCTION

Apply the mixture when the air temperature is at or above 60°F, or above 50°F and rising. Measure the air temperature in the shade away from artificial heat. The Engineer will determine when weather conditions are suitable for application.

The Engineer will select the application temperature within the limits recommended in Item 300, “Asphalts, Oils, and Emulsions.” Apply the material within 15°F of the selected temperature but less than the maximum allowable temperature.

Distribute material at the rate shown on the plans or as directed.

Open the treated surface to traffic when directed. Furnish and uniformly distribute clean, fine sand on the surface to blot the excess when an excessive quantity of asphalt is applied. Maintain ingress and egress as directed by applying sand to freshly sealed areas.

5. MEASUREMENT

This Item will be measured by the gallon of emulsified asphalt used in the emulsified asphalt and water mixture.

6. PAYMENT

The work performed and the materials furnished in accordance with this Item and measured as provided under “Measurement” will be paid for at the unit price bid for “Fog Seal” of the type and grade specified. This price is full compensation for materials, equipment, labor, tools, and incidentals. Blotter sand will not be paid for directly but will be subsidiary to this Item.

Item 421
Hydraulic Cement Concrete

1. DESCRIPTION

Furnish hydraulic cement concrete for concrete pavements, concrete structures, and other concrete construction.

2. MATERIALS

Use materials from prequalified sources listed on the Department website. Provide coarse and fine aggregates from sources listed in the Department's *Concrete Rated Source Quality Catalog* (CRSQC). Use materials from non-listed sources only when tested and approved by the Engineer before use. Allow 30 calendar days for the Engineer to sample, test, and report results for non-listed sources. Do not combine approved material with unapproved material.

2.1. **Cement**. Furnish cement conforming to DMS-4600, "Hydraulic Cement."

2.2. **Supplementary Cementing Materials (SCM)**.

- **Fly Ash**. Furnish fly ash, ultra-fine fly ash (UFFA), and modified Class F fly ash (MFFA) conforming to DMS-4610, "Fly Ash."
- **Slag Cement**. Furnish Slag Cement conforming to DMS-4620, "Slag Cement."
- **Silica Fume**. Furnish silica fume conforming to DMS-4630, "Silica Fume."
- **Metakaolin**. Furnish metakaolin conforming to DMS-4635, "Metakaolin."

2.3. **Cementitious Material**. Cementitious materials are the cement and supplementary cementing materials used in concrete.

2.4. **Chemical Admixtures**. Furnish admixtures conforming to DMS-4640, "Chemical Admixtures for Concrete."

2.5. **Water**. Furnish mixing and curing water that is free from oils, acids, organic matter, or other deleterious substances. Water from municipal supplies approved by the Texas Department of Health will not require testing. Provide test reports showing compliance with Table 1 before use when using water from other sources.

Water that is a blend of concrete wash water and other acceptable water sources, certified by the concrete producer as complying with the requirements of both Table 1 and Table 2, may be used as mix water. Test the blended water weekly for 4 weeks for compliance with Table 1 and Table 2 or provide previous test results. Then test every month for compliance. Provide water test results upon request.

Table 1
Chemical Limits for Mix Water

Contaminant	Test Method	Maximum Concentration (ppm or mg\L)
Chloride (Cl)	ASTM C114	
Prestressed concrete		500
Bridge decks & superstructure		500
All other concrete		1,000
Sulfate (SO4)	ASTM C114	2,000
Alkalies (Na2O + 0.658K2O)	ASTM C114	600
Total solids	ASTM C1603	50,000

Table 2
Acceptance Criteria for Questionable Water Supplies

Property	Test Method	Limits
Compressive strength, min % control at 7 days	ASTM C31, ASTM C39[1,2]	90
Time of set, deviation from control, h:min.	ASTM C403	From 1:00 early to 1:30 later

1. Base comparisons on fixed proportions and the same volume of test water compared to the control mix using 100% potable water or distilled water.
2. Base comparisons on sets consisting of at least 2 standard specimens made from a composite sample.

Do not use mix water that has an adverse effect on the air-entraining agent, on any other chemical admixture, or on strength or time of set of the concrete. Use mixing and curing water free of iron and other impurities that may cause staining or discoloration when using white hydraulic cement.

2.6. **Aggregate**.

2.6.1. **Coarse Aggregate**. Provide coarse aggregate consisting of durable particles of gravel, crushed blast furnace slag, recycled crushed hydraulic cement concrete, crushed stone, or combinations which are free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material, either free or as an adherent coating. Provide coarse aggregate of uniform quality throughout.

Provide coarse aggregate with the requirements listed in Table 3 unless otherwise shown on the plans.

Table 3
Coarse Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.25
Weight of Shale, % Max		1.0
Weight of Laminate and Friable Particle, % Max		5.0
L.A. Abrasion Wear, % Max	Tex-410-A	40
5-Cycle Magnesium Sulfate Soundness,[1,2] non-air-entrained concrete, % Max	Tex-411-A	25
5-Cycle Magnesium Sulfate Soundness,[1,3] air-entrained concrete, % Max		18
Loss by Decantation, % Max	Tex-406-A	1.5

1. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
2. Allowed when air-entrained concrete is used at the Contractor's option.
3. Only when air-entrained concrete is required by the plans.

Increase the loss by decantation limit to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III, in the case of coarse aggregates made primarily from crushing stone unless otherwise shown on the plans. Provide test results upon request.

Provide coarse aggregate or combination of aggregates conforming to the gradation requirements shown in Table 4 when tested in accordance with Tex-401-A unless otherwise specified.

Table 4
Coarse Aggregate Gradation Chart

Aggregate Grade No.[1]	Maximum Nominal Size	Percent Passing on Each Sieve								
		2-1/2"	2"	1-1/2"	1"	3/4"	1/2"	3/8"	#4	#8
1	2"	100	80–100	50–85		20–40			0–10	
2	1-1/2"		100	95–100		35–70		10–30	0–10	
3	1-1/2"		100	95–100		60–90	25–60		0–10	
4 (57)	1"			100	95–100		25–60		0–10	0–5
5 (67)	3/4"				100	90–100		20–55	0–10	0–5
6 (7)	1/2"					100	90–100	40–70	0–15	0–5
7	3/8"						100	70–95	0–25	
8	3/8"						100	95–100	20–65	0–10

1. Corresponding ASTM C33 gradation shown in parentheses.

2.6.2. **Fine Aggregate**. Provide fine aggregate consisting of clean, hard, durable particles of natural, manufactured sand, recycled crushed hydraulic cement concrete, slag, lightweight aggregate, or a combination thereof. Provide fine aggregate free from frozen material and from injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide fine aggregates with the requirements in Table 5 unless otherwise shown on the plans.

Table 5
Fine Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.50
Organic Impurities[1]	Tex-408-A	Color not darker than standard
Sand Equivalent	Tex-203-F	80
Fineness Modulus	Tex-402-A	2.3 to 3.1

1. Only when air-entrained concrete is specified.

Provide fine aggregate or combinations of aggregates conforming to the gradation requirements shown in Table 6 when tested in accordance with Tex-401-A unless otherwise specified.

Table 6
Fine Aggregate Gradation Chart (Grade 1)

Sieve Size	Percent Passing
3/8"	100
#4	95–100
#8	80–100
#16	50–85
#30	25–65
#50	10–35[1]
#100	0–10
#200	0–3[2]

1. 6–35 when sand equivalent value is greater than 85.
2. 0–6 for manufactured sand.

2.6.3. **Intermediate Aggregate**. Provide intermediate aggregate consisting of clean, hard, durable particles of natural, manufactured sand, slag, recycled crushed hydraulic cement concrete, lightweight aggregate, or a combination thereof when optimized aggregate gradation (OAG) concrete is specified or when used at the Contractor's option. Provide intermediate aggregate free from frozen material and injurious amounts of salt, alkali, vegetable matter, or other objectionable material.

Provide intermediate aggregate with the requirements in Table 7.

Table 7
Intermediate Aggregate Requirements

Description	Test Method	Limit
Weight of Clay Lumps, % Max	Tex-413-A	0.50
L.A. Abrasion Wear,[1] % Max	Tex-410-A	40
5-Cycle Magnesium Sulfate Soundness,[1,2,3] non-air-entrained concrete, % Max	Tex-411-A	25
5-Cycle Magnesium Sulfate Soundness,[1,2,4] air-entrained concrete, % Max		18
Organic Impurities[5]	Tex-408-A	Color not darker than standard
Loss by Decantation,[1] % Max	Tex-406-A	1.5

1. Only applies to the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve.
2. Recycled crushed hydraulic cement concrete is not subject to 5-cycle magnesium sulfate soundness requirements.
3. Allowed when air-entrained concrete is used at the Contractor's option.
4. Only when air-entrained concrete is required by the plans.
5. Only applies to the portion passing the 3/8 in. sieve, if more than 30% of the intermediate aggregate is passing the 3/8 in. sieve.

For the portion retained on the No. 4 sieve, if more than 30% of the intermediate aggregate is retained on the No. 4 sieve, and in the case of aggregates made primarily from crushing stone, unless otherwise shown on the plans, the loss by decantation may be increased to 3.0% for all classes of concrete and 5.0% for Class A, B, and P if the material finer than the No. 200 sieve is determined to be at least 85% calcium carbonate in accordance with Tex-406-A, Part III. Provide test results upon request.

2.7. **Mortar and Grout**. Furnish pre-packaged grouts conforming to DMS-4675, "Cementitious Grouts and Mortars for Miscellaneous Applications," when specified for applications other than post-tension grouting.

Section 421.4.2.6., "Mix Design Options," does not apply for mortar and grout.

2.8. **Storage of Materials**.

2.8.1. **Cement and Supplementary Cementing Materials**. Store all cement and supplementary cementing materials in weatherproof enclosures that will protect them from dampness or absorption of moisture.

When permitted, small quantities of packaged cementitious material may be stored in the open, on a raised platform, and under waterproof covering for up to 48 hr.

2.8.2. **Aggregates**. Handle and store concrete aggregates in a manner that prevents contamination with foreign materials. Clear and level the sites for the stockpiles of all vegetation if the aggregates are stored on the ground and do not use the bottom 6-in. layer of aggregate without cleaning the aggregate before use.

Maintain separate stockpiles and prevent intermixing when conditions require the use of 2 or more grades of coarse aggregates. Separate the stockpiles using physical barriers where space is limited. Store aggregates from different sources in different stockpiles unless the Engineer authorizes pre-blending of the aggregates. Minimize segregation in stockpiles. Remix and test stockpiles when segregation is apparent.

Sprinkle stockpiles to control moisture and temperature as necessary. Maintain reasonably uniform moisture content in aggregate stockpiles.

2.8.3. **Chemical Admixtures**. Store admixtures in accordance with manufacturer's recommendations and prevent admixtures from freezing.

3. EQUIPMENT

3.1. **Concrete Plants and Mixing Equipment**. Except for volumetric stationary plant or truck (auger) mixers, each plant and truck mixer must be currently certified by the National Ready Mixed Concrete Association (NRMCA) or have an inspection report signed and sealed by a licensed professional engineer showing concrete measuring, mixing, and delivery equipment meets all requirements of ASTM C94. A new certification or signed and sealed report is required every time a plant is moved. Plants with a licensed professional engineer's inspection require re-inspection every 2 yr. Provide a copy of the certification or the signed and sealed inspection report to the Engineer. Remove equipment or facilities from service until corrected when they fail to meet specification requirements.

When allowed on the plans or by the Engineer, for concrete classes not identified as structural concrete in Table 8 or for Class C concrete not used for bridge-class structures, the Engineer may inspect and approve all plants and trucks instead of the NRMCA or non-Department engineer-sealed certifications. The criteria and frequency of Engineer approval of plants and trucks is the same used for NRMCA certification.

Inspect and furnish inspection reports on the condition of blades and fins and their percent wear from the original manufacturer's design for truck mixers and agitators annually. Repair mixing equipment exhibiting 10% or more wear before use. If an inspection within 12 mo. is not practical, a 2-mo. grace period (for a maximum of 14 mo. between inspections) is permitted.

3.1.1. **Scales**. Check all scales before beginning of operations, after each move, or whenever their accuracy or adequacy is questioned, and at least once every 6 mo. Immediately correct deficiencies, and recalibrate. Provide a record of calibration showing scales in compliance with ASTM C94 requirements. Check batching accuracy of volumetric water batching devices at least every 90 days. Check batching accuracy of chemical admixture dispensing devices at least every 6 mo. Perform daily checks as necessary to ensure measuring accuracy.

3.1.2. **Volumetric Mixers**. Provide volumetric mixers with rating plates defining the capacity and the performance of the mixer in accordance with the Volumetric Mixer Manufacturers Bureau or equivalent. Provide volumetric mixers that comply with ASTM C685. Provide test data showing mixers meet the uniformity test requirements of Tex-472-A.

Unless allowed on the plans or by the Engineer, volumetric truck (auger) mixers may not supply classes of concrete identified as structural concrete in Table 8.

3.1.3. **Agitators and Truck and Stationary Mixers**. Provide stationary and truck mixers capable of combining the ingredients of the concrete into a thoroughly mixed and uniform mass and capable of discharging the concrete so at least 5 of the 6 requirements of Tex-472-A are met.

Perform concrete uniformity tests on mixers or agitators in accordance with Tex-472-A as directed, to resolve issues of mix uniformity and mixer performance.

Perform the mixer or agitator uniformity test at the full rated capacity of the equipment. Remove all equipment that fails the uniformity test from service.

Inspect and maintain mixers and agitators. Keep them free of concrete buildup, and repair or replace worn or damaged blades or fins.

Ensure all mixers have a plate affixed showing manufacturer's recommended operating speed and rated capacity for mixing and agitating.

3.2. **Hauling Equipment**. Provide hauling equipment capable of maintaining the mixed concrete in a thoroughly mixed and uniform mass, and discharging the concrete with a satisfactory degree of uniformity.

Provide equipment with smooth, mortar-tight metal containers equipped with gates that prevent accidental discharge of the concrete when using non-agitating equipment for transporting concrete.

Maintain hauling equipment clean and free of built-up concrete.

3.3. **Testing Equipment**. Furnish and maintain the following in accordance with the pertinent test procedure unless otherwise shown on the plans or specified:

- sieves necessary to perform aggregate gradation analysis when optimized aggregate gradation is specified,
- equipment necessary to perform Tex-415-A and Tex-422-A,
- equipment necessary to perform Tex-409-A or Tex-425-A,
- test molds,
- curing facilities,
- maturity meters if used, and
- wheelbarrow or other container acceptable for the sampling of the concrete.

Provide strength-testing equipment when required in accordance with the Contract-controlling test unless shown otherwise.

4. CONSTRUCTION

4.1. **Classification of Concrete Mix Designs**. Provide classes of concrete meeting the requirements shown in Table 8.

A higher-strength class of concrete with equal or lower water-to-cementitious material (w/cm) ratio may be substituted for the specified class of concrete when approved.

4.2. **Mix Design Proportioning**. Furnish mix designs using ACI 211, Tex-470-A, or other approved procedures for the classes of concrete listed in Table 8 unless a design method is indicated on the plans. Perform mix design proportioning by absolute volume method unless otherwise approved. Perform cement replacement using equivalent weight method unless otherwise approved.

Do not exceed the maximum w/cm ratio listed in Table 8 when designing the mixture.

4.2.1. **Cementitious Materials**. Do not exceed 700 lb. of cementitious material per cubic yard of concrete unless otherwise specified or approved.

- Use cement of the same type and from the same source for monolithic placements.
- Do not use supplementary cementing materials when white hydraulic cement is specified.

Table 8
Concrete Classes

<table>
<tr><th>Class of Concrete</th><th>Design Strength,[1] Min f'_c (psi)</th><th>Max w/cm Ratio</th><th>Coarse Aggregate Grades[2,3,4]</th><th>Cement Types</th><th>Mix Design Options</th><th>Exceptions to Mix Design Options</th><th>General Usage[5]</th></tr>
<tr><td>A</td><td>3,000</td><td>0.60</td><td>1–4, 8</td><td rowspan="2">I, II, I/II, IL, IP, IS, IT, V</td><td rowspan="2">1, 2, 4, & 7</td><td rowspan="2">When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.</td><td>Curb, gutter, curb & gutter, conc. retards, sidewalks, driveways, back-up walls, anchors, non-reinforced drilled shafts</td></tr>
<tr><td>B</td><td>2,000</td><td>0.60</td><td>2–7</td><td>Riprap, traffic signal controller foundations, small roadside signs, and anchors</td></tr>
<tr><td>C[6]</td><td>3,600</td><td>0.45</td><td>1–6</td><td>I, II, I/II, IP, IS, IT,[7] V</td><td>1–8</td><td></td><td>Drilled shafts, bridge substructure, bridge railing, culverts except top slab of direct traffic culverts, headwalls, wing walls, inlets, manholes, concrete traffic barrier (cast-in-place)</td></tr>
<tr><td>E</td><td>3,000</td><td>0.50</td><td>2–5</td><td>I, II, I/II, IL, IP, IS, IT,[7] V</td><td>1–8</td><td>When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.</td><td>Seal concrete</td></tr>
</table>

Table 8 (continued)
Concrete Classes

Class of Concrete	Design Strength,[1] Min f′c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]
F[6]	Note 8	0.45	2–5	I, II, I/II, IP, IS, IT,[7] V			Railroad structures; occasionally for bridge piers, columns, or bents
H[6]	Note 8	0.45	3–6	I, II, I/II, III, IP, IS, IT,[7] V	1–5	Do not use Type III cement in mass placement concrete. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete.	Precast concrete, post-tension members
S[6]	4,000	0.45	2–5	I, II, I/II, IP, IS, IT,[7] V	1–8		Bridge slabs, top slabs of direct traffic culverts, approach slabs
P	See Item 360, "Concrete Pavement."	0.50	2–3	I, II, I/II, IL, IP, IS, IT, V	1–8	When the cementitious material content does not exceed 520 lb./cu. yd., Class C fly ash may be used instead of Class F fly ash.	Concrete pavement
CO[6]	4,600	0.40	6	I, II, I/II, IP, IS, IT,[7] V	1–8		Bridge deck concrete overlay
LMC[6]	4,000	0.40	6–8				Latex-modified concrete overlay
SS[6]	3,600	0.45	4–6			Use a minimum cementitious material content of 658 lb./cu. yd. of concrete.	Slurry displacement shafts, underwater drilled shafts
K[6]	Note 8	0.40	Note 8	I, II, I/II, III IP, IS, IT,[7] V			Note 8
HES	Note 8	0.45	Note 8	I, IL, II, I/II, III		Mix design options do not apply. 700 lb. of cementitious material per cubic yard limit does not apply.	Concrete pavement, concrete pavement repair
"X" (HPC) [6,9,10]	Note 11	0.45	Note 11	I, II, I/II, III IP, IS, IT,[7] V	1–5, & 8	Maximum fly ash replacement for Options 1 and 3 may be increased to 45%. Up to 20% of a blended cement may be replaced with listed SCMs for Option 4. Do not use Option 8 for precast concrete.	
"X" (SRC) [6,9,10]	Note 11	0.45	Note 11	I/II, II, IP, IS, IT,[7] V	1–4 , & 7	Do not use Class C Fly Ash Type III-MS may be used where allowed. Type I and Type III cements may be used with Options 1–3, with a maximum w/cm of 0.40. Up to 20% of blended cement may be replaced with listed SCMs when Option 4 is used for precast concrete. Do not use Option 7 for precast concrete.	

Class of Concrete	Design Strength,[1] Min f′c (psi)	Max w/cm Ratio	Coarse Aggregate Grades[2,3,4]	Cement Types	Mix Design Options	Exceptions to Mix Design Options	General Usage[5]

3. Design strength must be attained within 56 days.
4. Do not use Grade 1 coarse aggregate except in massive foundations with 4 in. minimum clear spacing between reinforcing steel bars, unless otherwise permitted. Do not use Grade 1 aggregate in drilled shafts.
5. Use Grade 8 aggregate in extruded curbs unless otherwise approved.
6. Other grades of coarse aggregate maybe used in non-structural concrete classes when allowed by the Engineer.
7. For information only.
8. Structural concrete classes.
9. Do not use Type IT cements containing > 5% limestone.
10. As shown on the plans or specified.
11. "X" denotes class of concrete shown on the plans or specified.
12. (HPC): High Performance Concrete, (SRC): Sulfate Resistant Concrete.
13. Same as class of concrete shown on the plans.

4.2.2. **Aggregates**. Recycled crushed hydraulic cement concrete may be used as a coarse or fine aggregate in Class A, B, E, and P concrete. Limit recycled crushed concrete fine aggregate to a maximum of 20% of the fine aggregate.

Use light-colored aggregates when white hydraulic cement is specified.

Use fine aggregate with an acid insoluble residue of at least 60% by weight when tested in accordance with Tex-612-J in all concrete subject to direct traffic.

Use the following equation to determine if the aggregate combination meets the acid insoluble residue requirement when blending fine aggregate or using an intermediate aggregate:

$$\frac{(A_1 \times P_1)+(A_2 \times P_2)+(A_{ia} \times P_{ia})}{100} \geq 60\%$$

where:
A_1 = acid insoluble (%) of fine aggregate 1
A_2 = acid insoluble (%) of fine aggregate 2
A_{ia} = acid insoluble (%) of intermediate aggregate passing the 3/8 in. sieve
P_1 = percent by weight of fine aggregate 1 of the fine aggregate blend
P_2 = percent by weight of fine aggregate 2 of the fine aggregate blend
P_{ia} = percent by weight of intermediate aggregate passing the 3/8 in. sieve

Alternatively to the above equation, blend fine aggregate with a micro-deval loss of less than 12%, when tested in accordance with Tex-461-A, with at least 40% of a fine aggregate with an acid insoluble residue of at least 60%.

4.2.3. **Chemical Admixtures**. Do not use Type C, Type E, Type F, or Type G admixtures in Class S bridge deck concrete. Do not use chemical admixtures containing calcium chloride in any concrete.

Use a 30% calcium nitrite solution when a corrosion-inhibiting admixture is required. The corrosion-inhibiting admixture must be set neutral unless otherwise approved. Dose the admixture at the rate of gallons of admixture per cubic yard of concrete shown on the plans.

4.2.4. **Air Entrainment**. Use an approved air-entraining admixture when air-entrained concrete is specified, or when an air-entraining admixture is used at the Contractor's option, and do not exceed the manufacturer's recommended dosage. Ensure the minimum entrained air content is at least 3.0% for all classes of concrete except Class P when air-entrained concrete is specified, during trial batch, or when providing previous field data.

4.2.5. **Slump**. Provide concrete with a slump in accordance with Table 9 unless otherwise specified. When approved, the slump of a given concrete mix may be increased above the values shown in Table 9 using chemical admixtures, provided the admixture-treated concrete has the same or lower water-to-cementitious material ratio and does not exhibit segregation or excessive bleeding. Request approval to exceed the slump limits in Table 9 sufficiently in advance for proper evaluation by the Engineer.

Perform job-control testing of slump in accordance with Section 421.4.8.3.1., "Job-Control Testing."

Table 9
Placement Slump Requirements

General Usage[1]	Placement Slump Range,[2] in.
Walls (over 9 in. thick), caps, columns, piers, approach slabs, concrete overlays	3 to 5
Bridge slabs, top slabs of direct traffic culverts, latex-modified concrete for bridge deck overlays	3 to 5-1/2
Inlets, manholes, walls (less than 9 in. thick), bridge railing, culverts, concrete traffic barrier, concrete pavement (formed), seal concrete	4 to 5-1/2
Precast concrete	4 to 9
Underwater concrete placements	6 to 8-1/2
Drilled shafts, slurry displaced and underwater drilled shafts	See Item 416, "Drilled Shaft Foundations."
Curb, gutter, curb and gutter, concrete retards, sidewalk, driveways, anchors, riprap, small roadside sign foundations, concrete pavement repair, concrete repair	As approved

1. For information only.
2. For fiber reinforced concrete, perform slump before addition of fibers.

4.2.6. **Mix Design Options**.

4.2.6.1. **Option 1**. Replace 20% to 35% of the cement with Class F fly ash.

4.2.6.2. **Option 2**. Replace 35% to 50% of the cement with slag cement or MFFA.

4.2.6.3. **Option 3**. Replace 35% to 50% of the cement with a combination of Class F fly ash, slag cement, MFFA, UFFA, metakaolin, or silica fume; however, no more than 35% may be fly ash, and no more than 10% may be silica fume.

4.2.6.4. **Option 4**. Use Type IP, Type IS, or Type IT cement as allowed in Table 5 for each class of concrete. Up to 10% of a Type IP, Type IS, or Type IT cement may be replaced with Class F fly ash, slag cement, or silica fume. Use no more than 10% silica fume in the final cementitious material mixture if the Type IT cement contains silica fume, and silica fume is used to replace the cement.

4.2.6.5. **Option 5**. Replace 35% to 50% of the cement with a combination of Class C fly ash and at least 6% of silica fume, UFFA, or metakaolin. However, no more than 35% may be Class C fly ash, and no more than 10% may be silica fume.

4.2.6.6. **Option 6**. Use a lithium nitrate admixture at a minimum dosage determined by testing conducted in accordance with Tex-471-A. Before use of the mix, provide an annual certified test report signed and sealed by a licensed professional engineer, from a laboratory on the Department's MPL, certified by the Construction Division as being capable of testing according to Tex-471-A.

4.2.6.7. **Option 7**. Ensure the total alkali contribution from the cement in the concrete does not exceed 3.5 lb. per cubic yard of concrete when using hydraulic cement not containing SCMs calculated as follows:

$$\text{lb. alkali per cu. yd.} = \frac{(\text{lb. cement per cu. yd.}) \times (\%\ \text{Na}_2\text{O equivalent in cement})}{100}$$

In the above calculation, use the maximum cement alkali content reported on the cement mill certificate.

4.2.6.8. **Option 8**. Perform annual testing as required for any deviations from Options 1–5 or use mix design options listed in Table 10. Laboratories performing ASTM C1260, ASTM C1567, and ASTM C1293 testing must be listed on the Department's MPL. Before use of the mix, provide a certified test report signed and sealed by a licensed professional engineer demonstrating the proposed mixture conforms to the requirements of Table 10.

Provide a certified test report signed and sealed by a licensed professional engineer, when HPC is required, and less than 20% of the cement is replaced with SCMs, demonstrating ASTM C1202 test results indicate the permeability of the concrete is less than 1,500 coulombs tested immediately after either of the following curing schedules:

- Moisture cure specimens 56 days at 73°F.
- Moisture cure specimens 7 days at 73°F followed by 21 days at 100°F.

Table 10
Option 8 Testing and Mix Design Requirements

Scenario	ASTM C1260 Result		Testing Requirements for Mix Design Materials or Prescriptive Mix Design Options[1]
	Mix Design Fine Aggregate	Mix Design Coarse Aggregate	
A	> 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of each aggregate[2] to 0.08% when tested individually in accordance with ASTM C1567; or Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%.
B	≤ 0.10%	≤ 0.10%	Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%; or Use any ternary combination which replaces 35% to 50% of cement.
	≤ 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Use a minimum of 20% of any Class C fly ash; or Use any ternary combination which replaces 35% to 50% of cement.
C	≤ 0.10%	> 0.10%	Determine the dosage of SCMs needed to limit the 14-day expansion of coarse and intermediate[2] aggregate to 0.08% when tested individually in accordance with ASTM C1567; or Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%.
D	> 0.10%	≤ 0.10%	Use a minimum of 40% Class C fly ash with a maximum CaO[3] content of 25%; or Use any ternary combination which replaces 35% to 50% of cement.
	> 0.10%	ASTM C1293 1 yr. Expansion ≤ 0.04%	Determine the dosage of SCMs needed to limit the 14-day expansion of fine aggregate to 0.08% when tested in accordance with ASTM C1567.

1. Do not use Class C fly ash if the ASTM C1260 value of the fine, intermediate, or coarse aggregate is 0.30% or greater, unless the fly ash is used as part of a ternary system.
2. Intermediate size aggregates will fall under the requirements of mix design coarse aggregate.
3. Average the CaO content from the previous ten values as listed on the mill certificate.

4.2.7. **Optimized Aggregate Gradation (OAG) Concrete**. The gradation requirements in Table 3 and Table 4 do not apply when OAG concrete is specified or used by the Contractor unless otherwise shown on the plans. Use Tex-470-A to establish the optimized aggregate gradation. Use at least 420 lb. per cubic yard of cementitious material when OAG concrete is used unless otherwise approved. Use a coarse aggregate with a maximum nominal size of 1-1/2 in. for Class P concrete. Use a coarse aggregate for all other classes of concrete with a maximum nominal size not larger than:

- 1/5 the narrowest dimension between sides of forms, or
- 1/3 the depth of slabs, or
- 3/4 the minimum clear spacing between individual reinforcing bars or wires, bundles of bars, individual tendons, bundled tendons, or ducts.

Make necessary adjustments to individual aggregate stockpile proportions during OAG concrete production when the gradation deviates from the optimized gradation requirements.

4.2.8. **Self-Consolidating Concrete (SCC)**. Provide SCC meeting the following requirements shown in Table 11 when approved for use in precast concrete. Use concrete with a slump flow that can be placed without vibration and will not segregate or excessively bleed.

Request approval to exceed the slump flow limits sufficiently in advance for proper evaluation by the Engineer.

Table 11
Mix Design Requirements for SCC

Tests	Test Method	Acceptable Limits
Slump Flow for Precast Concrete	ASTM C1611	22 to 27[1]
T_{50}, sec	ASTM C1611	2 to 7
VSI Rating	ASTM C1611	0 or 1
Passing Ability, in.	ASTM C1621	≤ 2
Segregation Column, %	ASTM C1610	≤ 10
Bleeding, %	ASTM C232	≤ 2.5

1. These slump flow limits are generally acceptable for most applications. However, slump flow limits may be adjusted during mix design approval process and when approved by the Engineer.

4.3. **Concrete Trial Batches**. Perform preliminary and final trial batches when required by the plans, or when previous satisfactory field data is not available. Submit previous satisfactory field data to the Engineer showing the proposed mix design conforms to specification requirements when trial batches are not required and before concrete is placed.

Perform preliminary and final trial batches for all self-consolidating concrete mix designs.

4.3.1. **Preliminary Trial Batches**. Perform all necessary preliminary trial batch testing when required, and provide documentation including mix design, material proportions, and test results substantiating the mix design conforms to specification requirements.

4.3.2. **Final Trial batches**. Make all final trial batches using the proposed ingredients in a mixer that is representative of the mixers to be used on the job when required. Make the batch size at least 50% of the mixer's rated capacity. Perform fresh concrete tests for air content and slump, and make, cure, and test strength specimens for compliance with specification requirements. Test at least one set of design strength specimens, consisting of 2 specimens per set, at 7-day, 28-day, and at least one additional age unless otherwise directed. Before placing, provide the Engineer the option of witnessing final trial batches, including the testing of the concrete. If not provided this option, the Engineer may require additional trial batches, including testing, before the concrete is placed.

Conduct all testing listed in Table 11 when performing trial batches for self-consolidating concrete. Make an additional mixture with 3% more water than the preliminary trial batch. Make necessary adjustments to the mix design if this additional mixture does not meet requirements of Table 11. Cast and evaluate mock-ups for precast concrete that are representative of the actual product as directed. Provide the Engineer the option of witnessing final trial batches, including the testing of the concrete and the casting of the mock-ups before placement. If not provided this option, the Engineer may require additional trial batches, including testing and mock-ups, before the concrete is placed.

Establish 7-day compressive strength target values using the following formula for each Class A, B, and E concrete mix designs to be used:

$$\text{Target value} = \text{Minimum design strength} \times \frac{\text{7-day avg. trial batch strength}}{\text{28-day avg. trial batch strength}}$$

Submit previous satisfactory field data, data from a new trial batch, or other evidence showing the change will not adversely affect the relevant properties of the concrete when changes are made to the type, brand, or source of aggregates, cement, SCM, water, or chemical admixtures. Submit the data for approval before making changes to the mix design. A change in vendor does not necessarily constitute a change in materials or source. The Engineer may waive new trial batches when there is a prior record of satisfactory performance with the ingredients. During concrete production, dosage changes of chemical admixtures used in the trial batches will not require a re-evaluation of the mix design.

The Contractor has the option of performing trial batches in conjunction with concrete placements except for SCC mixtures, when new trial batches are required during the course of the project. If the concrete fails to meet any requirement, the Engineer will determine acceptability and payment adjustments.

Establish the strength–maturity relationship in accordance with Tex-426-A when the maturity method is specified or permitted. When using the maturity method, any changes in any of the ingredients, including changes in proportions, will require the development of a new strength–maturity relationship for the mix.

4.3.3. **Mix Design of Record**. Once a trial batch or previously satisfactory field data substantiates the mix design, the proportions and mixing methods used become the mix design of record. Do not exceed mix design water-to-cementitious material ratio.

4.4. **Production Testing**.

4.4.1. **Aggregate Moisture Testing**. Determine moisture content per Tex-409-A or Tex-425-A for coarse, intermediate, and fine aggregates at least twice a week, when there is an apparent change, or for new shipments of aggregate. When aggregate hoppers or storage bins are equipped with properly maintained electronic moisture probes for continuous moisture determination, moisture tests per Tex-409-A or Tex-425-A are not required. Electronic moisture probes, however, must be verified at least every 90 days against Tex-409-A and be accurate to within 1.0% of the actual moisture content.

When producing SCC, and when aggregate hoppers or storage bins are not equipped with electric moisture probes, determine the moisture content of the aggregates before producing the first concrete batch each day. Thereafter, determine the moisture content every 4 hr. or when there is an apparent change while SCC is being produced.

4.4.2. **Aggregate Gradation Testing**. Perform a sieve analysis in accordance with Tex-401-A on each stockpile used in the blend at least one day before producing OAG concrete when producing optimized aggregate gradation concrete. Perform sieve analysis on each stockpile after every 10,000 cubic yards of OAG concrete produced. Provide sieve analysis data to the Engineer.

4.5. **Measurement of Materials**.

4.5.1. **Non-Volumetric Mixers**. Measure aggregates by weight. Correct batch weight measurements for aggregate moisture content. Measure mixing water, consisting of water added to the batch, ice added to the batch, water occurring as surface moisture on the aggregates, and water introduced in the form of admixtures, by volume or weight. Measure ice by weight. Measure cement and supplementary cementing materials in a hopper and on a separate scale from those used for other materials. Measure the cement first when measuring the cumulative weight. Measure concrete chemical admixtures by weight or volume. Measure batch materials within the tolerances of Table 12.

Table 12
Mix Design Batching Tolerances—Non-Volumetric Mixers

Material	Tolerance (%)
Cement, wt.	-1 to +3
SCM, wt.	-1 to +3
Cement + SCM (cumulative weighing), wt.	-1 to +3
Water, wt. or volume	±3[1]
Fine aggregate, wt.	±2
Coarse aggregate, wt.	±2
Fine + coarse aggregate (cumulative weighing), wt.	±1
Chemical admixtures, wt. or volume	±3

1. Allowable deviation from target weight not including water withheld or moisture in the aggregate. The Engineer will verify the water-to-cementitious material ratio is within specified limits.

Ensure the quantity measured, when measuring cementitious materials at less than 30% of scale capacity, is accurate to not less than the required amount and not more than 4% in excess. Ensure the cumulative quantity, when measuring aggregates in a cumulative weigh batcher at less than 30% of the scale capacity, is measured accurate to ±0.3% of scale capacity or ±3% of the required cumulative weight, whichever is less.

Measure cement in number of bags under special circumstances when approved. Use the weights listed on the packaging. Weighing bags of cement is not required. Ensure fractional bags are not used except for small hand-mixed batches of approximately 5 cu. ft. or less and when an approved method of volumetric or weight measurement is used.

4.5.2. **Volumetric Mixers**. Provide an accurate method of measuring all ingredients by volume, and calibrate equipment to assure correct measurement of materials within the specified tolerances. Base tolerances on volume–weight relationship established by calibration, and measure the various ingredients within the tolerances of Table 13. Correct batch measurements for aggregate moisture content.

Table 13
Mix Design Batching Tolerances—Volumetric Mixers

Material	Tolerance
Cement, wt. %	0 to +4
SCM, wt. %	0 to +4
Fine aggregate, wt. %	±2
Coarse aggregate, wt. %	±2
Admixtures, wt. or volume %	±3
Water, wt. or volume %	±1

4.6. **Mixing and Delivering Concrete**.

4.6.1. **Mixing Concrete**. Operate mixers and agitators within the limits of the rated capacity and speed of rotation for mixing and agitation as designated by the manufacturer of the equipment. Provide concrete in a thoroughly mixed and uniform mass with a satisfactory degree of uniformity when tested in accordance with Tex-472-A.

Do not top-load new concrete onto returned concrete.

Adjust mixing times and batching operations as necessary when the concrete contains silica fume to ensure the material is completely and uniformly dispersed in the mix. The dispersion of the silica fume within the mix will be verified by the Construction Division, Materials and Pavements Section, using cylinders made from trial batches. Make necessary changes to the batching operations, if uniform dispersion is not achieved, until uniform and complete dispersion of the silica fume is achieved.

Mix concrete by hand methods or in a small motor-driven mixer when permitted, for small placements of less than 2 cu. yd. For such placements, proportion the mix by volume or weight.

4.6.2. **Delivering Concrete**. Deliver concrete to the project in a thoroughly mixed and uniform mass, and discharge the concrete with a satisfactory degree of uniformity. Conduct testing in accordance with Tex-472-A when there is a reason to suspect the uniformity of concrete and as directed.

Maintain concrete delivery and placement rates sufficient to prevent cold joints.

Adding chemical admixtures or the portion of water withheld is only permitted at the jobsite, under the supervision of the Engineer, to adjust the slump or slump flow of the concrete. Do not add water or chemical admixtures to the batch after more than an amount needed to conduct slump testing has been discharged. Turn the drum or blades at least 30 additional revolutions at mixing speed to ensure thorough and uniform mixing of the concrete. When this water is added, do not exceed the approved mix design water-to-cementitious material ratio.

Before unloading, furnish the delivery ticket for the batch of concrete containing the information required on Department Form 596, "Concrete Batch Ticket." The Engineer will verify all required information is provided on the delivery tickets. The Engineer may suspend concrete operations until the corrective actions are implemented if delivery tickets do not provide the required information. The Engineer will verify the design water-to-cementitious material ratio is not exceeded.

Begin the discharge of concrete delivered in truck mixers within the times listed in Table 14. Concrete may be discharged after these times provided the concrete temperature and slump meet the requirements listed in this Item and other pertinent Items. Perform these tests with certified testing personnel per Section 421.4.8.1., "Certification of Testing Personnel." Provide the Engineer the option of witnessing testing of the concrete. If not provided this option, the Engineer may require additional testing before the concrete is placed.

Table 14
Concrete Discharge Times

Fresh Concrete Temperature, °F	Max Time After Batching for Concrete Not Containing Type B or D Admixtures, min.	Max Time After Batching for Concrete Containing Type B or D Admixtures,[1] min.
90 and above	45	75
$75 \le T < 90$	60	90
$T < 75$	90	120

1. Concrete must contain at least the minimum manufacturer's recommended dosage of Type B or D admixture.

4.7. **Placing, Finishing, and Curing Concrete**. Place, finish, and cure concrete in accordance with the pertinent Items.

4.8. **Sampling and Testing of Concrete**. Unless otherwise specified, all fresh and hardened concrete is subject to testing as follows:

4.8.1. **Certification of Testing Personnel**. Contractor personnel performing testing must be either ACI-certified or qualified by a Department-recognized equivalent written and performance testing program for the tests being performed. Personnel performing these tests are subject to Department approval. Use of a commercial laboratory is permitted at the Contractor's option. All personnel performing testing using the maturity method must be qualified by a training program recognized by the Department before using this method on the job.

4.8.2. **Fresh Concrete**. Provide safe access and assistance to the Engineer during sampling. Fresh concrete will be sampled for testing at the discharge end if using belt conveyors or pumps. When it is impractical to sample at the discharge end, a sample will be taken at the time of discharge from the delivery equipment and correlation testing will be performed and documented to ensure specification requirements are met at the discharge end.

4.8.3. **Testing of Fresh Concrete**. Test for the fresh properties listed in Table 15.

Table 15
Fresh Concrete Tests

Tests	Test Methods
Slump[1]	Tex-415-A
Temperature[1]	Tex-422-A
Air Content[1,2]	Tex-414-A, Tex-416-A, or ASTM C457

1. Job-control testing performed by the Contractor.
2. Only required when air-entrained concrete is specified on the plans.

Concrete with a slump lower than the minimum placement slump in Table 9 after the addition of all water withheld, or concrete exhibiting segregation and excessive bleeding will be rejected.

4.8.3.1. **Job-Control Testing**. Perform job-control testing as specified in Table 16 unless otherwise specified. Provide the Engineer the opportunity to witness the testing. The Engineer may require a retest if not given the opportunity to witness. Immediately notify the Engineer of any nonconformity issues. Furnish a copy of all test results to the Engineer daily.

Table 16
Job-Control Testing Frequencies

Concrete Placements	Frequency
Bridge Deck Placements	Test the first few loads, then every 60 cu. yd. or fraction thereof.
All Other Structural Class Concrete Placements	One test every 60 cu. yd. or fraction thereof per class per day.
Non-Structural Class Concrete Placements	One test every 180 cu. yd. or fraction thereof.

Immediately resample and retest the concrete slump when the concrete exceeds the slump range at time of placement. If the concrete exceeds the slump range after the retest, and is used at the Contractor's option, the Engineer will make strength specimens as specified in Article 421.5., "Acceptance of Concrete."

4.8.3.2. **Strength Specimen Handling**. Remove specimens from their molds and deliver Department test specimens to curing facilities within 24 to 48 hr. after molding, in accordance with pertinent test procedures unless otherwise shown on the plans or directed. Clean and prepare molds for reuse if necessary.

5. ACCEPTANCE OF CONCRETE

The Engineer will sample and test the fresh and hardened concrete for acceptance. The test results will be reported to the Contractor and the concrete supplier. Investigate the quality of the materials, the concrete production operations, and other possible problem areas to determine the cause for any concrete that fails to meet the required strengths as outlined below. Take necessary actions to correct the problem including redesign of the concrete mix. The Engineer may suspend all concrete operations under the pertinent Items if the Contractor is unable to identify, document, and correct the cause of the low strengths in a timely manner. Resume concrete operations only after obtaining approval for any proposed corrective actions. Concrete failing to meet the required strength as outlined below will be evaluated using the procedures listed in Article 421.6., "Measurement and Payment."

5.1. **Structural Class of Concrete**. For concrete classes identified as structural concrete in Table 8, the Engineer will make and test 7-day and 28-day specimens. Acceptance will be based on attaining the design strength given in Table 8.

5.2. **Class P and Class HES**. The Engineer will base acceptance in accordance with Item 360, "Concrete Pavement," and Item 361, "Repair of Concrete Pavement."

5.3. **All Other Classes of Concrete**. For concrete classes not identified as structural concrete in Table 8, the Engineer will make and test 7-day specimens. The Engineer will base acceptance on the 7-day target value established in accordance with Section 421.4.3., "Concrete Trial Batches."

6. MEASUREMENT AND PAYMENT

The work performed, materials furnished, equipment, labor, tools, and incidentals will not be measured or paid for directly but will be subsidiary to pertinent Items.

The following procedure will be used to evaluate concrete where one or more project acceptance test specimens fail to meet the required design strength specified in this Item or on the plans:

- The concrete for a given placement will be considered structurally adequate and accepted at full price if the average of all test results for specimens made at the time of placement meets the required design strength provided no single test result is less than 85% of the required design strength.
- The Engineer will perform a structural review of the concrete to determine its adequacy to remain in service if the average of all test results for specimens made at the time of placement is less than the required design strength or if any test results are less than 85% of the required design strength. If the in-situ concrete strength is needed for the structural review, take cores at locations designated by the Engineer in accordance with Tex-424-A. The Engineer will test the cores. The coring and testing will be at the Contractor's expense.
- If all of the tested cores meet the required design strength, the concrete will be paid for at full price.
- If any of the tested cores do not meet the required design strength, but the average strength attained is determined to be structurally adequate, the Engineer will determine the limits of the payment adjustment using the following formula:

$$A = B_p \left[-5.37 \left(\frac{S_a}{S_s} \right)^2 + 11.69 \left(\frac{S_a}{S_s} \right) - 5.32 \right]$$

where:
A = Amount to be paid per unit of measure for the entire placement in question
S_a = Actual average strength from cylinders or cores. Use values from cores, if taken.
S_s = Minimum required strength (specified)
B_p = Unit Bid Price

- If the structural review determines the concrete is not adequate to remain in service, the Engineer will determine the limits of the concrete to be removed.
- The decision to reject structurally inadequate concrete or to apply the payment adjustment factor will be made no later than 56 days after placement.

Appendix G – Specialized and Product Specifications

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ITEM G-115

NONWOVEN GEOTEXTILE INTERLAYER

DESCRIPTION

115-1.1 This item shall govern the furnishing of materials and for placement of nonwoven geotextile interlayer as indicated on the Drawings or directed by the Engineer or designated representative. Filter Fabric shall have the capability for allowing the passage of ground water through it without transporting the soil placed around the geotextile.

MATERIALS

115-2.1 Nonwoven Geotextile Interlayer. The following properties shall be met for nonwoven geotextiles used as interlayers in concrete pavement systems.

Property	Requirements[1]	Test Procedure
Geotextile Type	Nonwoven, needle-punched geotextile, no thermal treatment (calendaring or IR)	EN 13249, Annex F (Manufacturer Certification of Production)
Color	Uniform/nominally same color fibers	(Visual Inspection)
Mass per unit area	≥ 450 g/m² (13.3 oz/yd²) ≤ 550 g/m² (16.2 oz/yd²)	ISO 9864 (ASTM D 5261)
Thickness under load (pressure)[2]	[a] At 2 kPa (0.29 psi): ≥ 3.0 mm (0.12 in.) [b] At 20 kPa (2.9 psi): ≥ 2.5 mm (0.10 in.) [c] At 200 kPa (29 psi): ≥ 1.0 mm (0.04 in.)	ISO 9863-1 (ASTM D 5199)
Wide-width tensile strength[3]	≥ 10 kN/m (685 lb/ft)	ISO 10319 (ASTM D 4595)
Wide-width maximum elongation[4]	≤ 130%	ISO 10319 (ASTM D 4595)
Water permeability in normal direction under load (pressure)	At 20 kPa (2.9 psi): ≥ 1×10^{-4} m/s (3.3×10^{-4} ft/s)	DIN 60500-4 (mod. ASTM D 5493 or ASTM D 4491)
In-plane water permeability (transmissivity)[5] under load (pressure)	[a] At 20 kPa (2.9 psi): ≥ 5×10^{-4} m/s (1.6×10^{-3} ft/s) [b] At 200 kPa (29 psi): ≥ 2×10^{-4} m/s (6.6×10^{-4} ft/s)	ISO 12958 (mod. ASTM D 6574 or ASTM D 4716)
Weather resistance	Retained Strength ≥ 60%	EN 12224 (ASTM D 4355 @ 500 hrs. exposure)
Alkali resistance	≥ 96% Polypropylene/Polyethylene	EN 13249, Annex B (Manufacturer Certification of Polymer)

CONSTRUCTION METHODS

115-3.1 The geotextile interlayer shall be installed in accordance with the manufacturer's recommendations, as indicated on the Drawings or as directed by the Engineer or designated representative. When lapping is required, it shall be in accordance with the manufacturer's recommendations. Backfilling around the geotextile interlayer shall be done in such a manner that the geotextile interlayer material will not be damaged during the placement.

115-3.2 Clean-up. Upon completion of the project, remove all unused materials from the site and leave the pavement in a clean condition.

METHOD OF MEASUREMENT

115-4.1 Work and acceptable material for geotextile interlayer will be measured by the square yard, complete in place.

BASIS OF PAYMENT

115-5.1 The work performed and the materials furnished and measured as provided under "Measurement" will be paid at the unit bid price for geotextile interlayer. The unit bid price, when included in the contract as a pay item, shall include full compensation for all materials, excavation and backfilling and all manipulations, labor, tools, equipment and incidentals necessary to complete the work.

Payment will be made under:

Item G-115-5.1 Geotextile Interlayer, per square yard

TESTING REQUIREMENTS

ASTM D5261	Standard Test Method for Measuring Mass per Unit Area of Geotextiles
ASTM D5199	Standard Test Method for Measuring the Nominal Thickness of Geosynthetics
ASTM D4595	Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
ASTM D5493	Standard Test Method for Permittivity of Geotextiles Under Load
ASTM D4491	Standard Test Methods for Water Permeability of Geotextiles by Permittivity
ASTM D6574	Test Method for Determining the (In-Plane) Hydraulic Transmissivity of a Geosynthetic by Radial Flow
ASTM D4716	Test Method for Determining the (In-plane) Flow Rate per Unit Width and Hydraulic Transmissivity of a Geosynthetic Using a Constant Head
ASTM D4355	Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus

END ITEM G-115

REV 11/16

Delpatch™ Elastomeric Concrete
Spall Repair

SECTION I – Description

A. This item shall consist of furnishing and installing suitable material to repair damaged concrete pavement. Spall repair shall consist of sawing concrete behind the spalled area, removing concrete pavement to expose sound pavement throughout the repair area, preparing and installing repair material and completion of the sawn joint.

SECTION II – Identification

A. Before starting spall repair work on the concrete pavement, the contractor and the owner shall inspect the concrete to identify spalls and mark any areas that shall be prepared. Identification of spalls shall be at the sole discretion of the owner.

SECTION III – Materials

A. **Elastomeric Concrete.** The elastomeric concrete shall contain a two-component polyurethane product mix with sand and 1/8" chopped strand fiberglass. The elastomeric concrete shall contain no greater than 21 pounds of sand and fiberglass for every gallon of polymer.

The elastomeric concrete will consist of a fluid base or binder with suitable reinforcing agents to provide a product that mixes in five minutes or less, flows readily, strongly adheres to concrete, requires no external application of heat for curing and cures within a maximum of two hours after mixing. This material shall be Delpatch™ as manufactured by The D.S. Brown Company, 419-257-3561, fax 419-257-2200 or pre-approved equal.

B. **Properties**. The material shall meet the following properties:

Property	Requirements	Test Method
Tensile		
Strength	600 psi	
Elongation	25	
Hardness, Durometer D	50	ASTM D2240
Compressive		
Stress psi 5% Deflection	800min/1400max	ASTM D695
Resilience, % 5% Deflection	95 min	
Impact Ball Drop @ -20°F (No cracking)	>10 ft	
Adhesion to Concrete (psi) Dry Bond	400 min	
Wet Bond	250 min	
Fluid Immersion % Wt, change after 70 hrs in room temp. Jet fuel	8% max	ASTM D471

SECTION IV – Construction Methods

A. **Weather Limitations.** Spall repair shall be performed only when the ambient air temperature is 45°F (7°C) and rising. The temperature of the concrete to be repaired shall be 45°F (7°C) or above.

B. **Preparation and Application of Elastomeric Concrete.**

1. **Area Preparation** - Saw cut area to be repaired to the dimensions indicated in the plans or as directed by the owner. Carefully sandblast all areas, which will be in contact with the elastomeric concrete material. Repair area must be clean and dry before placing elastomeric concrete.

2. **Priming** - Use a pump sprayer or brush to apply the primer. The primer shall be supplied as part of the elastomeric concrete system, product # 105 or pre-approved equal. Apply primer for concrete surfaces to all areas that come in contact with the elastomeric concrete. Allow primer to dry 30 minutes before pouring the spall repair material.
3. **Mixing** - Mix 3,000 ml of Part A and 1,500 ml of Part B for approximately 10 seconds. Add one pre-weighed and portioned bag of sand and fiberglass (provided by the manufacturer) and continue to mix for approximately 1 minute. When properly mixed, the elastomeric concrete is an even gray color.
4. **Pouring** - The elastomeric concrete must be poured into the repair area in a manner that reduces the potential for delaminating. Fill entire area to grade as you go rather than emptying the mix over the entire length of the repair area. Start at the low end of the repair area. The elastomeric concrete is self-leveling. As it cures, use a trowel to achieve a grooved or textured finish. For repairs along existing joints, the joints should be maintained by the use of forming materials or saw cutting method. Masking and forming materials should be removed immediately after troweling. Please review the manufacturer's installation instructions prior to installing the repair material.
5. **Accepting Traffic** - Allow the material to cure two hours before opening to traffic.

SECTION V – Manufacturer's Representative

A. A representative or agent of the manufacturer shall be present during the initial uses of this product to satisfy himself/herself and the owner that it is being properly applied.

300 East Cherry Street • North Baltimore, OH 45872 | Telephone: 419.257.3561 • Fax: 419.257.2200 | www.dsbrown.com

Delpatch™ Elastomeric Concrete

Installation Instructions

Unit Makeup

Each unit consists of twelve (12) bags of sand and fiberglass, two (2) 5-gallon pails of Part A (clear), and one (1) 5-gallon pail of Part B (black). Also included with each unit is 1/6 gallon of primer. Each sand/fiberglass box weighs aproximately 280 lbs. Total unit weight is approximately 425 lbs. Each unit yields approximately 27.7 mixed gallons and fills a void of approximately 3.7 cubic feet. (Part A and Part B materials are also available in drums.)

Miscellaneous

A. Parts A and B may be stored outdoors, but must be protected from freezing weather. The aggregate must be protected from the elements: either store indoors or, if outdoors, off the ground and covered with a waterproof tarp.

Equipment

The D.S. Brown Company recommends the following equipment:

A. Drill mixer, Hobart mixer or pail mixer

B. 5-gallon buckets, mixing bowls/pails (2)

C. Plastic measuring beakers (min. capacity 5000 ml)

D. Notched trowels for finishing, and scrapers (margin or brick trowels) for mixing bowls or pails

E. Personal protective equipment (safety glasses, gloves, safety vests, etc.). See MSDS.

F. Spray bottle for applying primer

G. Funnel for filling spray bottle with primer

The Blockout

A. Repair area must be clean and dry.

B. Minimum application depth is one inch.

C. We recommend that the entire application area be sandblasted, including one inch outside the repair area. Secondary blasting may be needed if contamination, dampness, etc. occurs.

D. Blow area (including a wide portion of roadway surface area) with high pressure air which is free of oil and moisture.

E. It is good practice not to get too far ahead with sandblasting and air blowing or they may need to be repeated.

Priming Concrete

A. Primer is applied with either a hand pump sprayer or a pump-up spray tank.

B. The primer may also be applied by brushing.

C. Use clean brushes at all times.

D. Use smaller “working” can large enough to hold sufficient primer to coat the blockout.

E. Fresh primer must always be used.

F. Avoid making puddles as this increases drying time.

G. It is good practice not to return excess primer to the main one-gallon can.

H. Primer must dry out at least 30 minutes and no longer than 4 hours before placement of Delpatch™.

Mixing

A. There are 12 batches of approximately 2.31 gallons in each unit.

B. Pour 3000 ml Part A and 1500 ml Part B into separate beakers (use level line).

C. Add Part A and Part B to mixing bowl. Start mixer at low speed.

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D. Immediately begin to add sand/fiberglass mixture at a gradual rate (approximately 10 seconds).

E. Increase mixer speed to medium. Mix for 1 minute. An even gray color indicates a consistent mix.

F. Take material to blockout.

Placement & Finishing

A. Delpatch™ is initially self-leveling, but rapidly becomes thicker. Be sure to have an area ready for placement prior to mixing.

B. Delpatch™ must be poured into the blockout in a manner that reduces the potential for delamination. In other words, fill a particular grade on an "as-you-go" basis (including final troweling) rather than emptying the bowl over the entire length of the blockout.

C. Start at the low end of the repair area. Delpatch™ will flow for several minutes; use trowel to push excess "uphill." After Delpatch™ has taken its initial set, use notched trowel to finish to final grade. Avoid "smearing" the excess outside the repair area.

D. Never leave a partially filled blockout at lunch breaks, etc.

E. Total working time with Delpatch™ from adding Parts A and B to initial set is approximately five to ten minutes, depending on temperature.

F. It is good practice to use a notched trowel that is long enough to span the repair area.

G. If edges are masked with duct tape, remove tape immediately after final trowel.

Special Comments

A. On hot, sunny days keep kits under cover or in the shade.

B. Open pails only as needed. To ensure future quality of Delpatch™ parts A and B, tightly close partial containers for reuse.

C. Use empty aggregate boxes under measuring and mixing operations to catch drips and spills.

Accepting Traffic

Delpatch™ Elastomeric Concrete can accept traffic in as little as one hour after the final pour when installed in normal working temperatures.

Cleanup

A. Paddles should be scraped between mixes to reduce buildup.

B. Residue in Part A beaker will set up and can be stripped out.

C. Residue in Part B beakers can be drained into an empty Part B can.

D. Paddles, tools, scrapers, trowels, etc. can be immersed in denatured alcohol or solvent and cleaned later.

Restrictions

A. Delpatch™ must not be installed when air and concrete temperatures are colder than 45°F.

B. Delpatch™ should not be poured in the rain, however slight.

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RSP™ | Technical Data Sheet

CONFIDENTIAL and PROPRIETARY

Description:

RSP is a nominal 65.0 pcf high density rigid polyurethane elastomeric system.

Process Application:

RSP systems are used for repairs to pavement, roads, cement, and for sealing cracks.

Proposed Uses:

- Concrete and Asphalt roadway sections
- Potholes
- Spall
- Cracks in various pavement surfaces

Storage and Shelf life:

Twelve (12) months from date of manufacture, when stored in the original, unopened containers at temperatures between 50°-105°F. While storing, keep containers tightly closed, since this material is moisture sensitive.

Safety:

Safety First! When working with RSP, or any chemicals, eye protection and gloves are recommended. Work in a well-ventilated area. Use respirator if necessary. Refer to MSDS for specific details.

Physical Properties: (Typical Properties when mixed according to instructions.)

Mix Ratio, by Volume	1 Part A, 1 Part B
Demold Time	8-10 Minutes @ 77°F
Density (ASTM D-3574)	65 pcf
Compressive Strength (ASTM D-695)	7,000 psi
Flexural Strength (ASTM D-790)	2,700 psi
Tensile Strength (ASTM D-638)	2,000 psi
Ultimate Elongation (D-638)	5%
Water Absorption (ASTM D2127)	0.00 lb/ft^2

Third Party Testing Available

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BASF
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Wabo®ElastoPatch

Crack and Spall Repair Material

Features	Benefits
• Unique repair solution	Permanent repair to cracks and spalls.
• Rapid installation	Ambient cured material that is mixed in 5 minutes and typically open to traffic in one hour
• Durability	High load bearing and bonding capabilities accommodate heavy and repetitive impact loading

DESCRIPTION:

The Wabo®ElastoPatch is a unique modified elastomeric concrete material for the repair of random cracks and spalls in existing portland cement concrete pavement.

Wabo®ElastoPatch is resistant to wear under repetitive loadings and chemical attack in harsh environments. The superior bonding capabilities to concrete minimizes edge spalling associated with high impact loads. Wabo®ElastoPatch is an ambient cured, flexible material forming a monothilic unit.

RECOMMENDED FOR:

- Airport runways, taxiways, and aprons.
- Airfield pavement lighting
- Sealing of cracks on highways, bridges, and parking decks.
- High impact and repetitive loading spall conditions

PACKAGING/COVERAGE:

- Wabo®ElastoPatch is available in Black only
- Wabo®ElastoPatch
  - PTA – ½ gal container
  - PTB – 1 gal container
  - PTC – 40 lbs aggregate
  - Wabo®Cast Silica Sand – 50 lb Bag
- Wabo®Bonding Agent
  - PTA – 1 qt container
  - PTB – 1 qt container
- Coverage
  - PTA+PTB+PTC = 1 unit
  - One unit = 0.5 cubic feet or 3.75 gal
  - One Bag Wabo®Cast = 10 units

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phone: 716-691-7566
fax: 716-691-9239
wbacorp.com

Watson Bowman Acme

PHYSICAL PROPERTIES:

PHYSICAL PROPERTY	ASTM TEST METHOD	REQUIREMENTS
Binder Only		
Tensile Strength	D 412	1000 psi min.
Elongation at Break	D 412	31% min.
Hardness (Shore D)	D 2240	50
Binder and Aggregate		
Bond Strength	C 190	250 psi min.
Compressive Yield Stress @5% deflection	D 695	1100 psi 500 psi
Impact Resistance 8 ft 10 ft >10ft	See Note[1]	No Cracks No Cracks No Cracks

1 - Specimens are cast discs with a 2.5" diameter and 0.375" thickness. Specimens are conditioned for four hours at test temperatures. A one pound steel ball is dropped onto the center of the specimen through a plastic tube from an initial height of 5 feet. The drop height is increased by intervals up to 7 feet or until the specimen cracks.

Typical Applications

Figure 1:
Crack and Spall

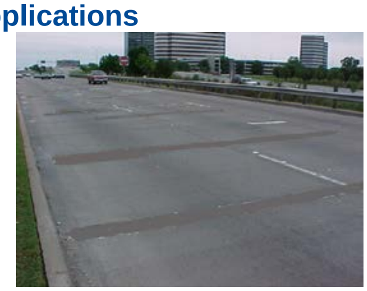
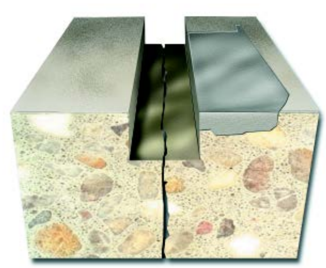


Figure 2:
Renovated Roadway



Pavement Seal Spall Repair

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APPLICATION:

INSTALLATION SUMMARY:

- Saw cut area around spall or crack
- Wabo®Bonding Agent must be used as a primer on the properly prepared concrete before beginning the installation of the Wabo®ElastoPatch
- Brush apply the bonding agent to the concrete surface and immediately begin the installation of the Wabo®ElastoPatch. DO NOT allow the bonding agent to cure.
- Thoroughly stir Wabo®ElastoPatch Part B component separately before pouring entire contents of Part B into a clean 5 gallon container. Add Part A and mix both components with a power mixer equipped with egg beater type paddle for 30 seconds and until well blended.
- Add the aggregate/fiber component to the liquid material and mix until all aggregate is coated (approximately 1 minute)
- After blending, Wabo®ElastoPatch is poured into the spall/crack area to desired thickness and profile.
- Upon completion of pour, broadcast Wabo®Cast Silica Sand on top surface for skid resistance
- Clean all excess material from the edges of the repair area. DO NOT allow the material to cure before removing it.

FOR BEST RESULTS:

- Install when concrete substrate is clean, sound, dry, and cured (14 day minimum).
- Do not install if surface temperature is less than 40˚F (4˚C).
- Do not allow any of the components to freeze prior to installation. Store all components out of direct sunlight in a clean, dry location between 50˚F (10˚C) and 90˚F (32˚C).
- Shelf life of chemical components is 1 year.
- Periodically inspect the applied material and repair localized areas as needed. Consult a Watson Bowman Acme representative for additional information.
- Make certain the most current version of the product data sheet is being used. Please consult the website (www.wbacorp.com) or contact a customer service representative.
- Proper application is the responsibility of the user. Field visits by Watson Bowman Acme personnel are for the purpose of making technical recommendations only and not for supervising or providing quality control on the jobsite.

OPTIONS/EQUIPMENT:

- ¾" slow speed, high torque paddle mixer with egg beater (mud beater) style mixing blade.

RELATED DOCUMENTS:

- Material Safety Data Sheets

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SILSPEC® FLEXPATCH

■ DESCRIPTION
SILSPEC® FLEXPATCH is a three-component, 100% solids, multi-purpose, high-strength, non-shrink, waterproof, non-conductive, semi-flexible polymer patching mortar for longer lasting patches with excellent workability. The system combines a high quality polymer resin and curing agent with an engineered blend of graded aggregates.

■ USES
Repair of delaminations and potholes on bridges, roadways, airport runways, parking and garage decks. Conforms to ACPA Bulletin TB003 for use in partial depth pavement repairs.

■ TYPICAL PHYSICAL PROPERTIES
Shelf Life: 2 years in original unopened container.
Storage Conditions: Store at 50° F to 90° F.
Condition material to 65-80°F before mixing.

Compressive Strength	PSI @ 4 hrs. (Method B)	1500 Min	ASTM C 579
	PSI @24 hrs. (Method B)	4500 Min	ASTM C 579
Bond Strength	PSI	2500 Min	ASTM C 882
Linear Shrinkage	Percent	Negligible	ASTM C 531
Abrasion Resistance	Weight Loss H-22 grams	1.0 Max	ASTM C 501
Chloride Ion Permeability	Coulombs	1.0 Max	AASHTO T-277
Thermal Compatibility	Pass	Pass	ASTM C 884

■ PACKAGING & COVERAGE
0.5 cu. ft. Unit (.14 cu. m.)
1.0 cu. ft. Unit (.028 cu. m.)
5.0 cu. ft. Unit (.140 cu. m.)

■ ADVANTAGES
- Specifically engineered to provide a superior patch, while demonstrating physical characteristics similar to the concrete substrate
- Convenient mixing: all components pre-measured
- Rapid curing

■ INSTALLATION PROCEDURES

Surface Preparation
Step 1: Remove all unsound substrate with chipping hammers. Chipping hammer shall not exceed 30 lbs.

Step 2: Thoroughly clean patch area by sandblasting. All exposed reinforcing steel shall be blasted to white metal finish. Blow all dust and loose particles from patch area with oil/moisture free compressed air.

Mixing of Liquid Components
Depending on the batch size required, SILSPEC® FLEXPATCH can be easily mixed using a heavy duty hand drill with a spiral type mixer or a powered paddle type mortar mixer.

Step 1: Pour components A and B into a clean pail and mix thoroughly for 3 minutes with a drill and spiral type mixer on low-speed.

Step 2: For small batches, add the appropriate amount of aggregate to the mixed SILSPEC® FLEXPATCH liquid until thoroughly mixed. For batches mixed in a mortar mixer, add the liquid components first. Then add the aggregate and agitate the mix until the aggregate is totally “wetted-out”.

Patching Concrete
If the depth of the patch is less than 1”, 10% of the aggregate should be withheld. Place SILSPEC® FLEXPATCH into prepared substrate. Screed or float to desired level. Thoroughly compact, and finish with a steel trowel, paying special attention to edges.

Patching Bridge Decks
These instructions are for installation of SILSPEC® FLEXPATCH on a bridge deck using common construction tools and equipment.

Step 1: Use a chain-drag or hammer to determine the outer limits of the unsound deck.

Step 2: Remove all unsound substrate with chipping hammer. Chipping hammer shall not exceed 30 lbs.

Step 3: Use an appropriate size hammer to remove all unsound substrate. The patch should be deep enough to encapsulate the top layer of reinforcing steel.

Step 4: After chipping out the repair area, remove debris and ensure all unsound substrate has been removed.

Step 5: Sandblast patch. Blast all steel to SP-10 (near white). Blow repair area with oil/moisture-free compressed air to remove debris from blasting operation. Be sure sandblasting equipment and blow tubes are equipped with an oil/moisture trap to remove contaminants.

Step 6: Mix SILSPEC® FLEXPATCH per directions and place into prepared substrate.

Step 7: Finish the SILSPEC® FLEXPATCH with a steel trowel and use a screed board to check that it is level with the surrounding driving surface.

Step 8: Allow newly repaired patch to cure before opening to traffic.

Limitations
Minimum substrate temperature is 40°F (5°C).
Minimum age of concrete for bonding should be 28 days unless manufacturer is consulted.

TEMP	WORKING TIME	INITIAL CURE TIME*
50°F	40 min	12 hrs
60°F	30 min	8 hrs
70°F	25 min	4 hrs
80°F	20 min	3 hrs
90°F	15 min	2 hrs
100°F	10 min	1.5 hrs

*Compressive Strength reaches approximately 1000 psi.

■ CAUTION

- Component A: Irritant
- Component B: Corrosive
- Product is a strong sensitizer. Use of safety goggles and chemical resistant gloves is recommended.
- Use of a NIOSH/MSHA organic vapor respirator is recommended if ventilation is inadequate.
- Avoid breathing vapors.
- Avoid skin contact.

■ FIRST AID

EYE CONTACT: Flush immediately with water for at least 15 minutes. Contact physician immediately.

RESPIRATORY CONTACT: Remove person to fresh air.

SKIN CONTACT: Remove any contaminated clothing. Remove polymer immediately with a clean dry towel and wash thoroughly with soap and water. Solvents should not be used as they carry the irritant into the skin. Wash skin thoroughly with soap and water.

CURED POLYMER IS INNOCUOUS.

■ CLEAN UP

EQUIPMENT: Uncured material can be removed with CITRUS CLEANER or other approved solvents. Cured material can only be removed mechanically.

MATERIALS: Collect with absorbent material. Flush area with water. Dispose of in accordance with local, state, and federal disposal regulations.

■ Contact S.S.I. for further information or installation instructions.

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Dallas, TX 75229
972/243-0676

HOUSTON
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Houston, TX 77007
713/862-3900

AUSTIN
4213 Todd Lane
Austin, TX 78744
512/326-1156

SAN ANTONIO
2104 Mannix
San Antonio, TX 78217
210/930-6360

FT. WORTH
2900 Marquita Dr.
Forth Worth, TX 76116
817/731-7890

PRODUCT DATA SHEET   FlexKRETE 102

PRODUCT DESCRIPTION:

FlexKrete 102 is an advanced, thermoset vinyl polymer, formulated for early high strength and quick set times. It can normally be opened to traffic in an hour or less, and with FlexTemp additive, within fifteen minutes. FlexKrete can be used in cold weather and freezer rooms, down to 0°F, and still receive traffic after 1-3 hours. Thick cross sections, as well as thin spall areas, are repaired with FlexKrete, and it's adhesion is greater than the strength of the concrete.

RECOMMENDED USAGE:

- Repair pot holes and broken concrete.
- Repair spalls in concrete.
- Feather edge, or use full depth.
- Rebuild broken curbs and platforms.
- Restore integrity of distressed concrete.
- Bridge deck repairs and slabs.
- Parking lots.
- Parking decks.
- Floors, docks & ramps.
- Non-skid, coating for floors, steps & walk-◘ ways.
- Driveway and sidewalk renovation.
- Rebuild stairways.
- Repair control joints.
- Equipment bases.
- Anchor bolts and posts.
- Level concrete.

CHEMICAL RESISTANCE GUIDE:

EXPOSURE	IMMERSION	SPLASH & SPILL
ACIDS	GOOD	EXCELLENT
ALKALIES	GOOD	EXCELLENT
PETROLEUM	GOOD	GOOD
SALTWATER	EXCELLENT	EXCELLENT
WATER	EXCELLENT	EXCELLENT

NOTE: For specific harsh chemical environments, contact FlexKrete Technologies or your sales rep.

ORDERING INFORMATION:

Shipping Weight:

Wt. Per Gallon, (resin only)   9.2 lbs per gal.

PACKAGING:

Available in 5 gallon pails &

1 gallon kit, consisting of 1 gal. Flexkrete/catalyst, Flex-Prime, aggregate, mixing pails, all shipped in 5 gal. pail.

PHYSICAL DATA:

Solids by wt: approx. (@77º F.)	99%
Solids by vol: approx. (@77º F.)	98%
Specific Gravity @ 77º F.	1.08
Viscosity @ 77º F.	500-600 cps
Flash Point: (ASTM-D-93, Open Cup)	141ºF.
Pot Life with 80% aggregate:	
@77ºF., approx.	20 min.
@100ºF., approx.	12 min.
Pot Life without aggregate:	
@77ºF., approx.	13 min.
@100ºF., approx.	7 min.
Linear Shrinkage (filled)	0%
(unfilled)	1.1%
Tensile Modulus (ASTM D 790)	182,000 psi
Tensile Strength (ASTM D 638)	3,530 lb/in²
Flexural Strength (ASTM D 790)	7,340 lb/in²
Flexural Modulus (ASTM D 790)	390,000 psi
Elongation % (ASTM D 638)	30%
Water Absorption (ASTM D 570)	0.64%
Compressive Strength	>10,000 psi
TXDOT—Tex614-J	350 psi
Hardness-Shore D (ASTM D 2240)	79
VOC:	0
Temperature Limits:	
Continuous:	175º F.
Intermittent:	220° F.
Shelf Life: @77°F, unopened	6 mos.

(For maximum shelf life, store in cool, dry, shaded area in unopened container).

THEORETICAL COVERAGE:

1 Gal. FlexKrete + 4 Gal. #3 Med. Grade Sand =

128 sf @ 1/16" Average Thickness
64 sf @ 1/8" Average Thickness
32 sf @ 1/4" Average Thickness
16 sf @ 1/2" Average Thickness
8 sf @ 1" Average Thickness

One five gallon pail yields approximately 20 gallons of mixed material, or, about 3.3 cu. Ft.

For broadcast repairs, approx. 50-100 sf per gallon, depending on the type and porosity of the substrate. These figures will also vary depending on the type and size of aggregate used.

SURFACE PREPARATION:

For best, long-term results, a clean, rough concrete surface, free of dirt, oils, curing compounds and other debris should be attained. Scarifying, grinding, chipping, sandblasting, shot-blasting, or other cleaning methods may be required. Any unsound concrete areas should be located with chain or hammer and removed, so that a sound, stable concrete base is established.

VEHICULAR TRAFFIC PATCH:

1. Chip or dry saw-cut a ½" deep vertical shoulder around the area to be repaired so that the FlexKrete will be "keyed" into the concrete.
2. Chip out and remove loose and delaminated material and blow or vacuum clean.
3. Determine amount of FlexPrime needed, and combine parts A&B in equal amounts. Hand mix to a smooth, consistent color.
4. Wet out repair areas by brushing or rolling a very thin coat of FlexPrime onto surfaces and down into all cracks and crevices.
5. Pour into measuring bucket, the amount of FlexKrete needed. With catalyst measuring bottle, loosen chamber lid, squeeze bottle for the proper amount of catalyst, and add to the mix. Power mix for approx. 30 seconds.
6. Measure 3-3½ parts blasting sand for 1 part FlexKrete. (Approx., 1 gallon FlexKrete for 50# bag blast sand). Use less sand for a looser, more self-leveling mix, and more sand for a trowelable material.
7. Using a heavy-duty drill motor and a square mud paddle, mix the sand into the liquid for approximately 1 minute, making sure that the aggregate is thoroughly blended with the resin.
8. Fill void. Screed and/or trowel to final grade. Broom or tine, if needed, then broadcast wet surface with aggregate to remove tack and add increase non-skid.

BREAKS AT JOINTS:

1. If joint is unfilled, place a spacer board in it to retain it's function.
2. Prep and repair void exactly the same as above, i.e., clean, chip, blow, prime, fill, and sprinkle sand.
3. Immediately after FlexKrete begins to set, tap the end of the spacer board to release it from joint, then fill, if necessary.
4. (OPTION): Same as above, except, instead of using the spacer board, also, clean and fill the joint with FlexKrete. Wait about an hour for it to cure, then saw-cut the joint back to original, and fill with joint filler.

TRAFFIC IN 15 MINUTES:

When mixing FlexKrete, mix in the standard catalyst as usual, then add the appropriate amount of FlexTemp, (as indicated on the measuring bottle), and mix. DO NOT MIX THE TWO CATALYSTS TOGETHER—as a thermal reaction will occur. MIX THE TWO SEPARATELY. Immediately mix in the aggregate and dump into repair area. Smooth and finish. The set time is dependent upon the ambient, surface, and material temperatures. Varying the amount of FlexTemp can also control how fast it will set, but start with the average amount first.

VERTICAL & OVERHEAD REPAIR:

To repair vertical and overhead areas, clean & prime area as usual; however, FlexPrime needs to tack up so that it is very sticky to the touch. A good test is when a fingerprint can be left from your touch. Otherwise, the patch mix will slip off. It just needs this tackiness to hold on until it cures. To speed this process, and in cold weather, a weed-burner (torch) can be used to warm the concrete just before applying the primer. This can bring about immediate results.

The vertical & overhead mix can vary greatly, depending on what is needed, but a good general mix to start with is: 2 parts fumed silica, 2 parts sand and 1 part FlexKrete. To stiffen the mix and make it lighter, try a 3-1-1 mix. Some contractors prefer to work with a "dough-like consistency in order to "glove" it in place and strike it off with a trowel. A 6" deep section can be applied in one pass with a small amount of experimentation.

OVERLAYS & LARGER REPAIRS:

In a clean mortar mixer, use 3-3½ parts aggregate to 1 part FlexKrete. As normal, add the FlexKrete then the catalyst, and mix for 30 seconds. While the mixer is still turning, add the aggregate and mix for 2 minutes, or until the mixture is totally blended. Dump the mix into a wheelbarrow and transfer to the repair area. If another batch is needed, immediately add <u>uncatalyzed</u> resin to the mixer and allow it to continue turning (no catalyst). This will keep the drum clean until the crew is ready for another batch to be mixed. A screed is used to bring repair to a perfect grade and to produce a smooth, or rough texture, as desired. The wet surface can also be dressed with a broadcast aggregate, but should be done on each pour, before it begins to set. Mixtures can vary, depending on the temperature. Trial batches may be required to determine the proper mix and additives to meet any traffic requirements.

EUCLID CHEMICAL

EUCO-SPEED MP

Magnesium Phosphate Repair Mortar

Description

EUCO-SPEED MP is a rapid-setting, rapid hardening, magnesium phosphate material used to repair concrete and masonry surfaces. EUCO-SPEED MP requires only the addition of water and can be installed with standard equipment and procedures. It bonds tenaciously to properly prepared concrete and provides a durable repair which is resistant to freeze-thaw cycles and deicing salts. For temperatures above 85°F (29°C), EUCO-SPEED MP HOT WEATHER should be used. For large placements use EUCO-SPEED MP HOT WEATHER extended with pea gravel.

Primary Applications

- Bridge decks
- Anchoring
- Parking garages
- Floors
- Hand rail grouting
- Pavements
- Marine structures
- Joint repairs

Features/Benefits

- Rapid-setting for quick turnaround
- Suitable for both interior and exterior applications
- Durable under freeze-thaw cycles and salt exposure
- Versatility in thickness from 1/2" (12 mm) to 8" (20 cm) when extended with aggregate
- May be placed down to 0°F (-17°C)
- Can contribute to LEED points

Technical Information

Typical Engineering Data*

Compressive Strength ASTM C 109, 2" (50 mm) cubes @72°F (22°C)

Age	Strength
2 hours	3,500 psi (24 MPa)
3 hours	5,000 psi (35 MPa)
1 day	6,000 psi (41 MPa)
7 days	7,000 psi (48 MPa)
28 days	7,500 psi (52 MPa)

Flexural Strength ASTM C 78

7 days	400 psi (2.8 MPa)
28 days	500 psi (3.4 MPa)

Freeze/Thaw Resistance ASTM C-666 Procedure A

500 Cycles........... 90% relative dynamic modulus

Bond Strength ASTM C 882 (modified)

3 hours	1,000 psi (7 MPa)
1 day	1,300 psi (9 MPa)
7 days	1,600 psi (11 MPa)
28 days	1,700 psi (12 MPa)

Wheel Traffic .... approx. 2 hours

Setting Time (Gillmore Needles)

Initial Set .... 8 to12 min

Final Set .... 12 to 20 min

* All testing was conducted on neat material under controlled laboratory conditions. Do not expect similar compressive strength results using cylinder type molds. Also, strengths will be affected by the amount and type of aggregate added to extend EUCO-SPEED MP.

Appearance: EUCO-SPEED MP is a free flowing powder as packaged. After mixing and placing, the color may initially appear slightly darker than the surrounding concrete. While this color will lighten up substantially as the concrete cures and dries out, the repair may always appear somewhat darker than the surrounding concrete.

Packaging/yield

EUCO-SPEED MP is available in 50 lb (22.7 kg) bags or pails. **Yield:** Approximately 0.42 ft^3 (0.012 m^3) of mortar when mixed with 0.45 gal (1.7 L) of water. For areas deeper than 1" (25.4 mm), EUCO-SPEED MP must be extended with up to 30 lb (13.6 kg) of 3/8" (9.5 mm) pea gravel*. Yield will increase to approximately 0.57 ft^3 (0.016 m^3) per unit. *** Use only dust free, properly graded hard aggregate. Never extend EUCO-SPEED MP with limestone or aggregate containing limestone.**

Shelf Life

1 year in original, unopened package

19215 Redwood Road • Cleveland, OH 44110
800-321-7628 t • 216-531-9596 f

www.euclidchemical.com

Specifications/compliances

ASTM C 928, Standard Specifications for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repair

Canadian Food Inspection Agency, MTQ, MTO

Coverage

One unit of EUCO-SPEED MP will cover approximately 10 ft^2 (0.93 m^2) when placed at an average depth of 1/2" (13 mm). When one unit of material is extended with 30 lb (13.6 kg) of 3/8" (9.5 mm) pea gravel, the mixed material will cover 13.7 ft^2 (1.3 m^2) when placed at an average depth of 1/2" (13 mm).

Directions for Use

Surface Preparation: Concrete surfaces must be structurally sound, free of loose or deteriorated concrete and free of dust, dirt, paint, efflorescence, oil and all other contaminants. Mechanically abrade the surface to achieve a surface profile equal to CSP 5-7 in accordance with ICRI Guideline 310.2. Properly clean profiled area. **Priming:** Clean and prime exposed steel using a spray or brush coat of DURAPREP A.C.

Bonding: EUCO-SPEED MP requires no bond coat.

Mixing: Single bags may be mixed with a drill and "jiffy" mixer. Use a paddle type mortar mixer for large jobs. Add the appropriate amount of water for the batch size and then add the EUCO-SPEED MP. **The amount of water to be mixed with EUCO-SPEED MP is critical. Add between 0.4 to 0.5 gal (1.5 to 1.9 L) of water per 50 lb (22.7 kg) unit.** Mix material for about 2 minutes as close to the repair site as possible. Quickly place in the repair area and float immediately. For patches greater than 1" (25 mm) in depth, pea gravel must be used. Add the pea gravel (up to 30 lb (13.6 kg)) after the neat material has mixed, then mix for 1 additional minute. In hot weather, greater than 85°F (29°C), the use of EUCO-SPEED MP HOT WEATHER is recommended. For large placements, regardless of the temperature, EUCO-SPEED MP HOT WEATHER is recommended along with the use of cold water to extend setting time.

Placement: EUCO-SPEED MP requires a minimum depth of 1/2" (13 mm). Spread with a trowel, screed, come-a-long or square tipped shovel to a thickness that matches the surrounding concrete. EUCO-SPEED MP sets quickly; the time available for placement and finishing will be very limited.

Finishing: Finish EUCO-SPEED MP to the desired float or broom finish texture. Do not add additional water to the surface during the finishing operation.

Curing and Sealing: EUCO-SPEED MP is self-curing; no curing is needed for this product.

Clean-Up

Clean tools and equipment with water before the material hardens.

Precautions/Limitations

- DUE TO THE CHEMICAL NATURE OF EUCO-SPEED MP, DO NOT LET IT COME IN CONTACT WITH GALVANIZED STEEL.
- Do not overwater.
- As EUCO-SPEED MP cures, a chemical reaction generates excessive heat. Mixed material must be maintained at or below 180°F (82°C) if satisfactory results are to be expected.
- Although EUCO-SPEED MP may be used down to 0°F (-17°C), the material must be stored at a room temperature of 60°-70°F (16°-21°C) for at least 24 hours prior to use.
- Do not add sand or cement.
- Do not place EUCO-SPEED MP over an ice covered substrate.
- When mixing in an enclosed area, provide adequate ventilation.
- Do not featheredge.
- For repairs deeper than 1" (25 mm), pea gravel must be used to extend the product.
- No heavy traffic until the product has reached a minimum of 2,000 psi (13.8 MPa).
- Do not place over carbonated concrete. All carbonation must be removed to assure a good bond.
- In all cases, consult the Safety Data Sheet before use.

Rev. 2.17

The Euclid Chemical Company
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EUCLID CHEMICAL
Guide Specification

EUCO-SPEED MP

Fast Setting Magnesium Phosphate Repair Mortar for turn around in less than one hour. Use for Trowelable Horizontal Repairs ½" to 8" (12mm to 20cm) in Depth

{Note to Specifier: The paragraphs below are meant to be incorporated into Parts 2 and 3 of a ***standard CSI 3 Part Format specification, project's General Structural Notes or directly onto the*** plans. They must be carefully reviewed by a qualified design professional and edited to meet the particular requirements of the project at hand, assure compliance with any governing building codes, and coordinate with other specification sections and drawings.}

PART 2.0: PRODUCT

{PRODUCT}

2.__ CEMENTITIOUS REPAIR MORTAR

A. Trowelable Horizontal Repair Mortar for Application Thicknesses of ½" to 8" (12mm to 20cm) neat: Magnesium phosphate, one-component, fast setting, repair mortar, suitable for interior or exterior use. Material shall have the following properties:
   1. Compressive Strength minimum 3,500 psi at 2 hours, 6,000 psi at 1 day, and 7,000 psi at 28 days per ASTM C 109
   2. Flexural Strength minimum 400 psi at 4 hours and 500 psi at 3 days 28 days per ASTM C 78
   3. Bond Strength minimum 1,000 psi at 3 hours, 1,300 psi 1 day and 1,500 at 28 days per ASTM C 882
   4. Freeze Thaw Resistance of 500 Cycles…93% per ASTM C 666
   5. Product:
      a) Euclid Chemical Company (The); Euco-Speed MP www.euclidchemical.com

B. Manufacturer shall have ISO 9001 Quality Certification. To ensure compatibility all admixtures shall be from the same manufacturer.

C. To ensure compatibility bonding agent and curing compound if used shall be from same manufacturer as repair mortar.

{REPAIR CURING NOTE 1}

2.___ CURING

{Note to Specifier: Euclid Chemical suggests curing this repair mortar with a high solids curing compound. If desired choose a recommended product from the data sheet and insert here. Guide spec language for these products can be found by accessing each product separately through this web site. Be advised that liquid curing compounds are typically not compatible with future penetrating sealer, adhesives or coatings. If such treatments are intended the specifier should insert language for a dissipating resin curing compound such as KUREZ DR VOX, a removable curing compound such as KUREZ RC, or insert language for proper moisture retaining curing methods meeting ACI 308. Duration of such cure should be minimum 3 days.}

PART 3.0: EXECUTION

3.___ SURFACE PREPARATION

{CONCRETE REMOVAL NOTE}

A. Concrete Removal: Remove all loose and unsound concrete per ICRI Guideline 310.1R "Guide for Surface Preparation"
   1. Unsound concrete surface areas shall have perimeter boundaries saw cut to minimum depth of ½" inch or less if such depth will cause saw to come in contact with embedded reinforcing steel. Saw cuts shall be made perpendicular to the concrete surface and all concrete removal boundaries shall be straight and aligned parallel to opposite boundary edges resulting in repair areas that are rectangular in shape.
   2. All concrete shall be removed from within repair boundary to minimum depth of ½" inch. Provide a surface with suitable profile for bond, as defined in repair mortar manufacturer's written recommendations. If delaminations, cracking, or unsound materials exist beyond minimum removal depth, then removal shall continue until all unsound, delaminated, or cracked concrete has been removed from cavity.

{STEEL PREP NOTE 1}

B. Preparing Reinforcing Steel: Clean and prepare any exposed embedded reinforcing steel per ICRI Guideline 310.1R. "Guide for Surface Preparation"
   1. Where ½ or more of diameter of reinforcement steel is exposed either by existing conditions or concrete removal, bond between the concrete and reinforcing steel is broken, or corrosion is present, the concrete shall be removed to provide a minimum ¾" clearance around entire perimeter of steel and along entire exposed length.
   2. Clean all exposed reinforcing steel to bright steel, prior to installation of repair mortar.
      a) Where section loss on a reinforcing bar is more than <insert number>%, or <insert number>% in two or more adjacent bars contact Engineer.

{CONCRETE PREP AND CLEANING NOTE}

C. Concrete Preparation and Cleaning: Areas to receive concrete repair shall be structurally sound and free from deteriorated concrete, dust, dirt, debris, loosened concrete, paint, oil, efflorescence, laitance, and other contaminants, and shall have a minimum Concrete Surface Profile CSP equal to that recommended by the repair mortar manufacturer per ICRI Guideline 310.2.

3.___ REPAIR MORTAR APPLICATION:

{TROWEL APPLIED REPAIR MORTAR APPLICATION}

A. Repair Mortar Trowel Applied: Mix and apply Repair Mortar per manufacturer's recommendations within the open time of the product scrub coat or any bonding agents. Finish to level of surrounding concrete surface utilizing techniques recommended by manufacturer.

3.___ CURING

{REPAIR MORTAR CURING EXECUTION}

{Note to Specifier: Euclid Chemical suggests curing this repair mortar with a high solids curing compound. If desired choose a recommended product from the data sheet and insert here. Guide spec language for these products can be found by accessing each product separately through this web site. Be advised that liquid curing compounds are typically not compatible with future penetrating sealer, adhesives or coatings. If such treatments are intended the specifier should insert language for a dissipating resin curing compound such as KUREZ DR VOX, a removable curing compound such as KUREZ RC, or insert language for proper moisture retaining curing methods meeting ACI 308. Duration of such cure should be minimum 3 days.}

1260
MG-KRETE™
By Imco®

DESCRIPTION
1260 MG-KRETE™ is an inexpensive, two component, high early strength structural repair material that is very easy to use in the field.

BASIC USES
1260 MG-KRETE™ is used for all types of concrete repairs. It is used for patching, from shallow feathering to deep pours. It can be poured into forms, it can be trowelled vertically and overhead, it can fill large cracks or be used as a fast set plug.

MAJOR ADVANTAGES OF 1260 MG-KRETE™
- Cures very rapidly in all weather at all temperatures to form a very hard, tenaciously bonded repair.
- Non-flammable and has high heat resistance.
- Cures very rapidly, most applications can be returned to service in 30 minutes.
- Does not shrink on cure.
- Stronger than concrete within 45 minutes.
- Self-priming and will bond to virtually any construction material.
- Very easy to use, there are no specific slump requirements, no critical mixing ratios, no sophisticated
- and expensive surface preparation.
- Non-toxic, it contains no harmful chemicals, and it cleans-up with water.
- Very cost effective, it has the performance characteristics of the best polymers at a fraction of the cost.
- Totally waterproof, it is resistant to oils, gasoline, salt and UV radiation.
- Approved by Agriculture Canada for incidental food contact.

TECHNICAL AND PRODUCT DATA

• Flash Point:		none
• Compressive Strength:		
	45 minutes	2,610 psi / 18.0 MPa
	24 hours	5,148 psi / 35.5 MPa
	7 days	5,815 psi / 40.1 MPa
	28 days	11,194 psi/ 77.2 MPa
• Set Time:		
	-Initial At 20ºC (68ºF)	15 minutes
• Application temp.:		minimum 0ºF (-10ºC) (with Low Temp. Accelerator) over 70ºF (21ºC) (with High Temp. Retarder)
• Primer:		No primer required
• Clean-up:		Water (before material sets)
• Shelf Life:		1 year, if stored away from direct heat
• No. of Components:		Two (Part A and B)
• Available in fine or regular grade		
• Packaging:		
	Regular grade	22.7 kg (50lb) Part A with 3.78L (1gal) Part B
	Fine grade	20.0 kg (45lb) Part A with 3.78L (1gal) Part B
• Also available in bulk packaging.		
• Yield :	Regular grade:	1 unit = 0.45 cu. ft. of mixed material 78 units = 1 cu. meter
	Fine grade:	1 unit = 0.40 cu. ft. of mixed material

Both grades can be increased by adding clean dry aggregates during mixing.

Do not use limestone with 1260 MG-KRETE™

NOT FOR INDOOR RESIDENTIAL USE

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1260
MG-KRETE™
By Imco®

MIXING
Keep all materials dry, **DO NOT ADD WATER TO THE MIX.** Maintaining the mix ratio as supplied, i.e. one container of liquid activator to one bag of dry component, will give a trowellable consistency suitable for most floor applications, however the slump may be adjusted to the applicator's preference or to suit the specific job conditions by increasing either of the two components. **DO NOT ADJUST THE SLUMP BY THE ADDITION OF WATER.** Mix the two components by mechanical means until all the material is wetted, and place quickly. Dry pea gravel may be added to the mix to increase the yield on deep placements.

APPLICATION INSTRUCTIONS
Surface must be clean, dry and free of loose material. Remove all dirt from area to be covered leaving a rough, clean surface. For applications at ambient temperatures below 50ºF (10ºC) 1261 LOW TEMP ACCELERATOR must be used to ensure a full cure. With temperatures above 70ºF (21ºC) the 1263 HIGH TEMPERATURE RETARDER can be used to extend the working time. Do not pre-wet surface with water. Keep an adequate supply of water on hand to keep equipment clean. Thoroughly dry all equipment before using **1260 MG-KRETE™.**

FINISHING
1260 MG-KRETE™ may be finished with screed, trowel or broom. Do not rework material after it has begun to set.
OVER COATING - Allow **1260 MG-KRETE™** at least 24 hours to cure before over coating. The cured surface must be acid washed, sandblasted or mechanically abraded before coating to ensure sound bonding.

SPECIAL HANDLING
Store materials in a clean dry area away from direct heat. Setting time of the mixed material will be greatly accelerated if the components are stored in a warm or hot environment, conversely, the setting time is extended if the materials are kept cool. Flush all spills with water. Clean all tools with water immediately after each use. Do not attempt to place **1260 MG-KRETE™** in water or where running water will disturb the worksite or rain is imminent.

SAFETY
Please refer to SDS at www.imcotechnologies.com. Use the same precautions as when working with conventional concrete. Although the materials are non-toxic it is good practice to protect exposed skin areas and to wear a face mask to prevent inhalation of the aggregate particles. A small amount of ammonia gas is released during the cure, venting of indoor areas may be required in some applications, although this will present no problems outdoors. Neither of the components nor the mixed product are flammable.

WARRANTY DISCLAIMER
The information herein is to assist customers in determining whether our products are suitable for their application. Our products are intended for sale to industrial and commercial customers. We request that customers inspect and test our products before use and satisfy themselves as to the contents and suitability. We warrant that our products will meet our written specifications. Nothing herein shall constitute a warranty expressed or implied, including any warranty of merchantability or fitness, nor is protection from any loss or patent to be inferred. The exclusive remedy for all proven claims is replacement of our materials and in no event shall we be liable for special, incidental or consequential damages.

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1260
MG-KRETE™
By Imco®

1260 MG-KRETE™, INDEPENDENT LAB
ASTM TEST METHOD RESULTS

The following is a summary of the independent tests that were conducted by accredited laboratories according to the test methods identified. The test results demonstrate the tremendous ability of the 1260 MG-KRETE™ to act and perform as a very efficient fast setting cement repair material in the marketplace.

ASTM C109 Compressive Strength Test

Results:	45 Minutes	2610 psi/18 MPa
	2 Hours	3481 psi/24.8 MPa
	24 Hours	5148 psi/35.50 MPa
	7 Days	5815 psi/40.1 MPa
	28 Days	11194 psi/77 MPa

ASTM C1245 Bond Strength Test

Results :	24 Hours	15.2 MPa
	28 Days	21 MPa

ASTM C293 Flexural Strength Test

Results:	24 Hours	670 psi/4.6 MPa
	7 Days	845 psi/5.8 MPa
	28 Days	1405 psi/9.7 MPa

ASTM D2794 Resistance to Impact

Results:	24 Hours	15.2 ft.-lb
	28 Days	15.2ft.-lb

ASTM C642 Water Absorption Test

Results:	7 Days	2.3% water absorption, 24 hour submersion
	28 Days	3.5% water absorption, 24 hour submersion

ORTECH Two Foot Tunnel

Surface Flame Spread Test

Results: The sample did not ignite and propagate flame beyond the zero point, thereby resulting in an average Flame Spread rating of 0.

ASTM 666-92 Freeze Thaw Test

Results: No Change

ASTM C672-92 Freeze Thaw Test

Results: No Scaling

Conclusion of the Reports:

On the basis of these results, the following conclusions can be made with regard to **MG-KRETE™**

- Fast Setting
- High Early Strength
- Non-Flammable
- Good Impact Resistance

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Pavemend 15.0™

Self Leveling RAPID REPAIR MORTAR

CSI Div. 03
03 31 23 High Performance Structural Concrete

LEED Points
MR Credit 5.1, Regional Materials..........................Up to 2 Points
IEQ Credit 4.2, Low-Emitting Materials Paints and Coatings...1 Point
Using this AQUAFIN product can help contribute to LEED certification of projects in the categories shown above.

General Charateristics:

Pavemend 15.0 is a cementitious, rapid setting, self-leveling structural repair mortar. It is a single component powder that is water activated. Pavemend 15.0 has 7 - 9 minutes of working time and will reach compressive strengths of >2,500 psi within two hours and more than 6,000 psi at 28 days. Designed for horizontal and rapid setting form and pour applications, Pavemend 15.0 can be used in ambient temperature ranges of 30° - 110° F. Rapid strength development and low initial viscosity make Pavemend 15.0 ideal for most pre-cast grouting applications.

Typical Properties:

Pavemend 15.0 is an ideal repair material for roads and bridges, airport runways, warehouse or manufacturing facility floors, post-tension cable repairs and form and pour projects. Can be used as a temporary repair for asphalt pavement.

Site Preparation:

- Substrates must be of load bearing capacity, and free from all potential bond breakers such as dirt, dust, grease, oil, sealers, curing compounds, laitance, loose or deteriorated concrete and any bond-inhibiting foreign substances.
- Mechanically prepare surfaces to achieve a surface profile equal to CSP 5 – 7. Concrete Surface Profile as per ICRI Guideline No. 310.2-1997 (Formerly Guideline No. 03732)
- All surfaces to be repaired should be saturated surface dry (SSD) but have no standing water. Hot surfaces should be cooled and shaded while cold surfaces should be heated and sheltered.Mechanically remove all loose materials by suitable means such as chipping hammer, chisel, sandblast, high pressure water blast (>5000 psi), or similar methods.

Mixing Instructions:

Critical Mix Temperature (CMT): 15.0 undergoes an exothermic chemical reaction during blending Heat, the by-product of the reaction, is the indication that the reaction is complete and that the product is ready to be poured. 15.0 has a CMT of 95˚F/35˚C which MUST BE REACHED before placing to ensure performance. Mixing time to reach the CMT will vary with ambient air and mix water temperatures. Contact Aquafin Technical Department with questions regarding CMT and cold or hot weather placements. The use of an infrared thermometer is required for the mixing process to ensure that the CMT has been achieved.

Physical and Technical Data	
Compressive Strengths, psi (MPa) ASTM C 109	> 2,500 @ 2 hours > 3,500 @ 3 hours > 4,000 @ 24 hours > 5,000 @ 7 days > 6,000 @ 28 days
Flexural Strength, psi (MPa) ASTM C 78	> 600 @ 7 day > 850 @ 28 days
Splitting Tensile Strength, psi (MPa) ASTM C 496	> 200 @ 7 days > 300 @ 28 days
Bond Strength, psi ASTM C 882	> 1,000 @ 24 hours > 1,500 @ 7 days
Scaling Resistance, lbs/ft² ASTM C 672	0 @ 25 cycles
Modulus of Elasticity, msi ASTM C 469	3.3 @ 28 days
Coefficient of Thermal Expansion (millionsth) in/in/°F	2.82 @ 28 days AASHTO TP 60
Length Change, % of total length ASTM C 157	-0.0085/-0.0595 @ 28 days soak/dry
Results provided by licensed engineering test laboratory and represent typical results from production materials. Actual results may vary from third party testing results; however, Pavemend materials meet and/or exceed ASTM C928, and exceed established internal quality control standards, (available upon request). All samples were air cured.	

Additional Physical Properties

Set Times at 72°F/22°C Initial set: 5 - 7 minutes Final set: 7 - 12 minutes		Unit Weight (neat): approximately 115 lb/ft³ (1,842 kg/m³)
Yield per Unit	Neat	Extended 50% with 3/8"or 1/2"fractured aggregate
46 lb. (20.9 kg)	0.42 ft³ (0.012 m³)	0.60 ft³ (0.017 m³)

Standard NEAT Procedures (Bucket Mixing with Drill & Paddle)

- To ensure product performance, do not divide/separate individual units into smaller portions. Mix entire contents at one time.
- Do not hand mix. A drill (6 amp minimum) with a mixer blade turning at least 500 to 800 rpm is required. Drills with speeds greater than 800 rpms may entrain air in the mix.
- Ideal water temperature is between 65°F/18°C and 75°F/24°C. If ambient temperatures are above 85˚F/29˚C, use cold water at approximately 55˚F/13˚C.

1. To begin: Tumble bucket on ground to loosen materials, then dry mix powders in the bucket for approx. 30 seconds with drill and paddle.

2. Pour all required water into bucket, on top of 15.0 powder. It is very important to rapidly incorporate all of the dry 15.0 powders into water to achieve a uniform wet mixture within the first 30 seconds of mixing.:

For Each:	Add:
45 lb (20.4 kg) bucket	1 U.S. gallon (3.8 of water)

3. Mix material until CMT of 95˚F/35˚C is reached. Place material into repair area and spread with a trowel, straight edge or squeegee, filling voids and edges.

For Aggregate Extension: (Bucket Mixing with Drill & Paddle)

- Use only 3/8" (1 cm) or 1/2" (1.3cm) #7 clean washed fracured stone up to 50% maximum by weight.
- Add aggregate to mixed material after mixing for 30 seconds.
- See mixing instruction for NEAT application above.

Application & Finish:

- Minimum NEAT profile thickness is 0.06" (1.5mm). There are no restrictions to the depth of the repair profile.
- For best results, Aquafin recommends monolithic placement of repair materials. Maintain a minimum thickness of 1" if repair material must be layered.
- Upon initial set, a broom finish can be applied. Upon final set, the material can be saw-cut, drilled, sanded and/or polished.
- General loading in 2.0 hours for wheeled traffic and 60 minutes for foot traffic. For applications 0.5" thick and greater, in ambient and/or surface temperatures below 50°F/10°C, extend the loading time by 30 minutes for each 10° below 50°F/10°C. For applications 1.00" thick and greater, in ambient and/or surface temperatures below 40°F/4°C extend the loading time by 30 minutes for each 10° below 40°F/4°C.
- All previously existing joints must be re-established within 1-3 hours of final set.
- Self-curing.
- Clean all tools and equipment with water prior to the material reaching final set.

Limitations:

- Not recommended for surface temperatures above 110˚F/43˚C or below -20°F/10°C. (Contact Aquafin Technical Department for temperatures below 50˚F).
- Will not bond to polymers.
- Cannot be pumped or mixed in grout mixer or rotating drum concrete mixers due to rapid set times.

Packaging & Shelf Life:

- PACKAGING
  45 lb (20.4 kg) 5 gallon (18.9) bucket (GSA P/N: C500)
- SHELF LIFE:
  Buckets - 3 years (when stored in original unopened bucket). Buckets are environmentally sealed and require no special storage requirements.

Note:

Installer is responsible for proper product application. Site visits by Aquafin personnel or representatives are solely for the purpose of making technical recommendations, not for providing supervision or quality control.

Safety:

Refer to Safety Data Sheet (SDS). The use of a dust mask, safety goggles and gloves is recommended. This document does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this document to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use. Dispose of water and materials in accordance with Federal, State and Local regulations. Keep out of the reach of children.

For Professional Use Only.

DOT REPAIR MORTAR

High Performance Concrete Repair Mortar

PRODUCT DATASHEET

DESCRIPTION: Rapid Set® DOT REPAIR MORTAR is a high performance, fast-setting concrete repair material. Durable in wet environments, DOT REPAIR MORTAR is a blend of Rapid Set hydraulic cement, high performance additives and ASTM C33 concrete sand. DOT REPAIR MORTAR is non-metallic and no chlorides are added. Mix DOT REPAIR MORTAR with water to produce a flowable, quality repair material that is ideal where fast strength gain, high durability and low shrinkage are desired. DOT REPAIR MORTAR achieves structural strength in 1 hour.*

USES: Use DOT REPAIR MORTAR where high performance rapid strength gain, early return to service is desired. DOT REPAIR MORTAR is ideal for repairing highways, bridge decks, airport pavement, industrial floors, parking garage decks, and freezer floors. DOT REPAIR MORTAR contains an air-entraining admixture for freeze thaw durability.

ENVIRONMENTAL ADVANTAGES: Use DOT REPAIR MORTAR to reduce your carbon footprint and lower your environmental impact. Production of Rapid Set cement emits far less CO_2 than portland cement. Contact your Rapid Set representative for LEED values and further environmental information.

APPLICATION: Apply DOT REPAIR MORTAR in thicknesses from 1/2" (1.2 cm) to 6" (15.2 cm). For repairs over 3/4" thick, DOT REPAIR MORTAR may be extended up to 50 lbs with coarse aggregate. Use only clean, dry aggregate with a nominal maximum size of 3/8" to 3/4" conforming to ASTM C33.

SURFACE PREPARATION: For repairs, application surface shall be clean, sound and free from any materials that may inhibit bond such as oil, asphalt, curing compound, acid, dirt and loose debris. Mechanically abrade surface and remove all unsound material. Apply DOT REPAIR MORTAR to a thoroughly saturated surface with no standing water.

MIXING: The use of a power driven mechanical mixer, such as a mortar mixer or a drill mounted mixer, is recommended. Organize work so that all personnel and equipment are in place before mixing. Use clean potable water. **DOT REPAIR MORTAR may be mixed using 3.5 to 5.0 quarts (3.3 L to 4.7 L) of water per 70-lb (32-kg) bag. Use up to 5.0 quarts (4.7 L) when extended with dry coarse aggregate. Use less water to achieve higher strengths.** Place the desired quantity of mix water into the mixing container. While the mixer is running, add DOT REPAIR MORTAR. Mix for the minimum amount of time required to achieve a lump-free, uniform consistency (usually 1 to 3 minutes). Do not retemper.

PLACEMENT: DOT REPAIR MORTAR may be placed using traditional construction methods. Organize work so that all personnel and equipment are ready before placement. Place, consolidate and screed quickly to allow for maximum finishing time. Use a method of consolidation that eliminates air voids. On flat work, do not install in layers; install full depth sections and progress horizontally. Do not wait for bleed water. Apply final finish as soon as possible. DOT REPAIR MORTAR may be troweled, floated or broom finished. Do not install on frozen surfaces. The working time for DOT REPAIR MORTAR is 10 to 25 minutes at 70°F (21°C). To extend working time, use Rapid Set® SET Control® retarding admixture from the Rapid Set® Concrete Pharmacy® or use cold mix water. DOT REPAIR MORTAR may be applied in temperatures ranging from 45°F to 90°F (7°C to 32°C).

OVERVIEW

Highlights:

- Fast: Ready for traffic and loading in 1 hour
- Durable: Formulated for long life in critical applications
- Structural: For repair and new construction
- Extendable: Add rock for large placements
- Easy to use: Mix to fluid or stiff consistency
- Multi-purpose: Use for concrete repair, highway repair, construction of pavements, bridges, parking decks, ramps, sidewalks, steps, joint repair, formed work and more

Conforms to:

ASTM C928

MasterFormat® 2016

03 01 30	Maintenance of Cast-in-Place Concrete
03 01 40	Maintenance of Precast Concrete
03 01 50	Maintenance of Cast Decks and Underlayment
03 01 70	Maintenance of Mass Concrete

Manufacturer:

CTS Cement Manufacturing Corp.
11065 Knott Ave., Suite A
Cypress, CA 90630
Tel: 800-929-3030 | Fax: 714-379-8270
Web: www.CTScement.com
E-mail: info@CTScement.com

CURING: Water cure all Rapid Set® DOT REPAIR MORTAR installations by keeping exposed surfaces wet for a minimum of 1 hour. Begin curing as soon as the surface starts to lose its moist sheen. When experiencing extended setting time due to cold temperature or the use of retarder, longer curing times may be required. The objective of water curing shall be to maintain a continuously wet surface until the product has achieved sufficient strength.

COLD WEATHER: Environmental and material temperatures below 70°F (21°C) may delay setting time and reduce the rate of strength gain. Lower temperatures will have a more pronounced effect. Thinner sections will be more significantly affected. To compensate for cold temperatures, keep material warm, use heated mix water, and follow ACI 306 Procedures for Cold Weather Concreting.

WARM WEATHER: Environmental and material temperatures above 70°F (21°C) may shorten setting time and increase the rate of strength gain. Higher temperatures will have a more pronounced effect. To compensate for warm temperatures, keep material cool, use chilled mix water and follow ACI 305 Procedures for Hot Weather Concreting. The use of Rapid Set® SET Control® retarding admixture from the Rapid Set® Concrete Pharmacy® will help offset the effects of high temperatures.

YIELD & PACKAGING: DOT REPAIR MORTAR is available in 70-lb (32-kg) bags. One 70-lb (32-kg) bag will yield approximately 0.7 ft^3 (0.02 m^3). Each bag of DOT Repair Mortar may be extended to yield approximately 0.9 ft^3 (0.02 m^3), using 50 lbs of quality coarse aggregate.

SHELF LIFE: DOT REPAIR MORTAR has a shelf life of 12 months when stored properly in a dry location, protected from moisture, out of direct sunlight, and in an undamaged package.

USER RESPONSIBILITY: Before using CTS products, read current technical data sheets, bulletins, product labels and safety data sheets at www.CTScement.com. It is the user's responsibility to review instructions and warnings for any CTS products prior to use.

WARNING: DO NOT BREATHE DUST. AVOID CONTACT WITH SKIN AND EYES. Use material in well-ventilated areas only. Exposure to cement dust may irritate eyes, nose, throat, and the upper respiratory system/lungs. Silica exposure by inhalation may result in the development of lung injuries and pulmonary diseases, including silicosis and lung cancer. Seek medical treatment if you experience difficulty breathing while using this product. The use of a NIOSH/MSHA-approved respirator (P-, N- or R-95) is recommended to minimize inhalation of cement dust. Eat and drink only in dust-free areas to avoid ingesting cement dust. Skin contact with dry material or wet mixtures may result in bodily injury ranging from moderate irritation and thickening/cracking of skin to severe skin damage from chemical burns. If irritation or burning occurs, seek medical treatment. Protect eyes with goggles or safety glasses with side shields. Cover skin with protective clothing. Use chemical resistant gloves and waterproof boots. In case of skin contact with cement dust, immediately wash off dust with soap and water to avoid skin damage. In case of skin contact with wet concrete, wash exposed skin areas with cold running water as soon as possible. In case of eye contact with cement dust, flush immediately and repeatedly with clean water, and consult a physician. If wet concrete splashes into eyes, rinse eyes with clean water for at least 15 minutes and go to the hospital for further treatment.

PROPOSITION 65 WARNING: This product contains chemicals known to the State of California to cause cancer and birth defects or other reproductive harm.

Please refer to the SDS and www.CTScement.com for additional safety information regarding this material.

LIMITED WARRANTY: CTS CEMENT MANUFACTURING CORP. (CTS) warrants its materials to be of good quality and, at its option, will replace or refund the purchase price of any material proven to be defective within one (1) year from date of purchase. The above remedies shall be the limit of CTS's responsibility. Except for the foregoing, all warranties expressed or implied, including merchantability and fitness for a particular purpose, are excluded. CTS shall not be liable for any consequential, incidental, or special damages arising directly or indirectly from the use of the materials.

TYPICAL PHYSICAL DATA

Set Time, ASTM C266 Mod.	
Initial set	15 minutes
Final set	30 minutes

Compressive Strength, ASTM C109 Mod.	
1 hour*	3500 psi (24.1 MPa)
3 hours	4500 psi (31.0 MPa)
24 hours	6500 psi (44.8 MPa)
7 days	8000 psi (55.2 MPa)
28 days	9000 psi (62.1 MPa)

Flexural Strength, ASTM C78	
4 hours	500 psi (3.45 MPa)
24 hours	650 psi (4.48 MPa)
28 days	1200 psi (8.27 MPa)

Slant Shear Bond, ASTM C882 per C928	
24 hours	2000 psi (13.8 MPa)
28 days	2200 psi (15.2 MPa)

Freeze/Thaw, ASTM C666	
300 cycles	Durability factor >95%

*After final set
Data obtained at flow consistency 100 by ASTM C1437 at 70°F (21°C)

Product Specification for:
Rapid Set® DOT Repair Mortar

SECTION 03 01 30 MAINTENANCE OF CAST-IN-PLACE CONCRETE
SECTION 03 01 40 MAINTENANCE OF PRECAST CONCRETE
SECTION 03 01 50 MAINTENANCE OF CAST DECKS AND UNDERLAYMENT
SECTION 03 01 70 MAINTENANCE OF MASS CONCRETE
(The above were formerly Section 03930)
SECTION 03 62 13 NON-METALLIC NON-SHRINK GROUTING
(The above was formerly Section 03600)
[Note to specifier: Delete unnecessary Sections.]

PART I GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of the contract, including General and Supplementary Conditions, apply to this section.

1.2 SUMMARY

A. This section specifies material for very rapid concrete repairs from 1/2 inch to 24 inches inches thick and material for very rapid non-shrink grouting.

1.3 SUBMITTALS

A. Substitutions:
[Note to specifier: While this does not belong here, it is shown for your review and inclusion in section 01 25 13.] Requests for substitution must be received by Architect at least 14 days prior to bid opening and shall be accepted only from prime bidders. Request shall include: documentation from an approved independent testing laboratory showing compliance with this specification, record of past performance, list of similar installations, detailed comparison of the qualities of the proposed substitute with the specified product, statement of product costs showing all savings passed to owner if approved, and certification by the contractor that the proposed substitute is in every significant way equal to or better than the specified product.

B. Submit 2 copies of product manufacturer’s literature and Material Safety Data Sheets (MSDS). [Note to specifier: Add any other required submissions.]

1.4 QUALITY ASSURANCE

A. References: Comply with the following unless modified by this specification.

1. ASTM C33-03 Standard Specification for Concrete Aggregates
2. ASTM C78-02 Standard Test Method for Flexural Strength of Concrete (Using Simple Beam with Third-Point Loading)
3. ASTM C109/C109M-02 Standard Test Method for Compressive Strength of Hydraulic Cement Mortars (Using 2-in. Cube Specimens)
4. ASTM C191-04 Standard Test Method for Time of Setting of Hydraulic Cement by Vicat Needle
5. ASTM C666/C666M-03 Standard Test Method for Resistance of Concrete to Rapid Freezing and Thawing
6. ASTM C882-99 Standard Test Method for Bond Strength of Epoxy-Resin Systems Used With Concrete By Slant Shear
7. ASTM C928-00 Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs
8. CRD 621-82A Corps of Engineers Non-Shrink Grout

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery: Deliver materials to jobsite in original, unopened, undamaged containers that clearly show the manufacturer’s name, product name, and batch number.

B. Storage: Store material in a dry area off the ground protected from rain, snow, and other sources of moisture. Protect material from temperature extremes. Store bulk sand and coarse aggregate in a well drained area on a clean, solid surface and cover to prevent contamination with foreign matter.

PART 2 PRODUCTS

2.1 REPAIR MATERIAL

A. Shall be manufactured by CTS Cement Manufacturing Corp.,
11065 Knott Avenue, Suite A, Cypress, CA, 90630.
Phone: 800-929-3030 Website: www.ctscement.com

B. Rapid Set® DOT Repair Mortar: Cement based, rapid-setting, low shrinkage, extendable, concrete repair material that can be used from 1/2 inch to 6 inches thick when used neat and from 2 inches to 24 inches thick when extended.

1. Set time per ASTM C191 (Mod.) at 70°F:
   Initial set 17 minutes. Final set 20 minutes.
2. Compressive strength per ASTM C109 (Mod.):
   1 hour* 3140 psi
   3 hour 3725 psi
   4 hour 4650 psi
   8 hour 5500 psi
   * after final set
3. Flexural strength per ASTM C78 (Mod.):
   4 hour 500 psi
   1 day 650 psi
   28 day 1200 psi
4. Bond strength per ASTM C882 (Mod.):
   1 day 2000 psi
   20 day 2200 psi
5. Freeze/thaw per ASTM C666:
   1000 cycles 1.07% loss
   Dynamic modulus 91%
   In 10% sodium-chloride solution
   10 cycles 0.0% loss
   15 cycles 0.0% loss
   25 cycles 0.3% loss
6. Shall meet ASTM C928 for packaged concrete repair materials.
7. Shall meet CRD C621 for non-shrink grouting.
8. Shall be non-metallic with no added chlorides and shall be pre-blended with the sand.

C. Rapid Set® Concrete Pharmacy®: Add these small, pre-measured packets to the repair material per manufacturer's recommendations to change the properties as shown. [Note to specifier: List only the products that you want to be used on your job.]

1. Set Control – slows down the set time
2. Flow Control – increases fluidity and strength
3. Fast – speeds up the set time
4. Bond – increases bond strength
5. Fiber – reduces plastic and crazing cracks
6. Light – lightens the color of the repair material
7. Dark – darkens the color of the repair material

2.2 Course Aggregate: 3/8 to 3/4 inch meeting ASTM C33.

2.3 Water: Potable.

PART 3 EXECUTION

3.1 SURFACE PREPARATION

A. The perimeter of the area to be repaired shall be sawcut slightly undercutting the sound concrete (without cutting reinforcing steel) or chipped perpendicular to the surface to a minimum depth of 2 inches.

B. Mechanically remove unsound, contaminated concrete to a minimum depth of 2 inches.

C. The aggregate fractured surface shall have a minimum profile of 1/8 inch.

D. Concrete must be free of materials such as paint, oil, curing compound, bond breaker, etc. that will inhibit bonding.

E. If placed directly on the subgrade, the subgrade must be well compacted. [Note to specifier: State the compaction you require.]

F. Clean reinforcing steel by sandblasting or other mechanical means to achieve a white metal finish. [Note to specifier: Add special requirements concerning replacement of reinforcing that has lost too much cross-sectional area.]

G. Thoroughly clean extraneous material such as dirt, loose chips, and dust from concrete surface. If compressed air is used, it shall be free of oil.

H. Concrete surface shall be saturated with potable water and standing water shall be removed from surface to achieve a Saturated, Surface Dry (SSD) condition.

I. For grouting applications, build watertight non-absorbant forms leaving sufficient room to pour the grout.

3.2 MIXING

A. Organize personnel and equipment before mixing.

B. Use 5 to 6.5 quarts of water per 70 pound bag of repair material. [Note to specifier: Less water means more strength and more water means a more flowable consistency.]

C. Mixed material should have a temperature of about 70°F. Warmer material will set faster than expected and cooler material will have slower strength gain. Control the mixed temperature by protecting the bags of repair material from temperature extremes and adjust the mixed temperature by using hot or cold water.

D. Place 45 to 50 pounds of coarse aggregate (if the repair material is to be extended) in the mixer. Mix Concrete Pharmacy packets if necessary into the water and add that water to the mixer. Add cement then mix for 2 to 3 minutes to achieve a uniform, lump-free consistency.

E. Do not add any other admixtures. Do not add sand, aggregate, or cement.

F. Do not re-temper.

3.3 PLACEMENT

A. Place repair material onto the Saturated, Surface Dry (SSD) substrate.

B. Place repair material only if surface and ambient temperatures are above 45°F and rising.

C. Protect adjacent surfaces with drop cloths, waterproof paper, or other means to maintain them free of material splashes, water, and debris.

D. Place repair material immediately after mixing.

E. Work repair material firmly into sides and bottom of repair area to achieve good bond.

F. Do not featheredge repair material.

G. For grouting applications, pour the grout from one direction only allowing it to fill the space completely.

H. Do not wait for bleed water, since there will probably be none. Begin final finishing as soon as possible.

3.4 CURING

A. Begin water cure when repair area begins to lose its moist sheen and keep continuously wet until 1 hour after final set.

3.5 CLEAN UP

A. Clean mixer immediately after use or add mix water and begin mixing immediately for the next batch. Do not allow buildup of hardened repair material in the mixer, since this creates inefficient mixing and the heat generated accelerates later batches.

B. Clean all tools immediately after use.

C. Clean excess material from surrounding areas immediately.

END OF SECTION

SAFETY DATA SHEET

SDS #SF01D

1. PRODUCT IDENTIFICATION

Product Name: STA FIL

Product Number: 42500, 42600

Emergency Phone Number: Infotrac: 1-800-535-5053;

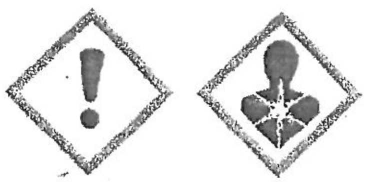
MANUFACTURED FOR:
PIONEER MANUFACTURING CO
4529 INDUSTRIAL PKWY
CLEVELAND, OH 44135
PHONE NUMBER: 800-877-1500

Chemical Family: Asphalt Cold Mix
Effective Date: March 2015
Date Superseded: March 2013

FOR CHEMICAL EMERGENCY
Call INFOTRAC
1-800-535-5053
24 hours per day, 7 days per week

2. HAZARDS IDENTIFICATION

Label Elements:



GHS07 GHS08

Appearance: Black Physical State: Liquid Odor: Coal Tar Odor

Signal Word: Danger
Hazard Statement: Causes skin irritation. May cause cancer. May cause damage to organs through prolonged or repeated exposure.

Potential Health Hazards:
Eyes: Severe irritation including redness, tearing and blurred vision. Wear protective eyewear.
Skin: Irritation. If on skin: Wash with plenty of water for at least 15 minutes. If skin irritation occurs: Get medical advice/attention.
Inhalation: Dizziness, headaches, nausea. May cause respiratory irritation.
Prevention: Do not breathe dust. Wash hands after handling. Wear protective gloves and clothing and eye and face protection. Do not eat, drink or smoke when using this product. Wash or throw away contaminated clothing after use. Get medical attention if you feel unwell. Obtain special instructions before use. Do not handle until all safety precautions have been read and understood.
Response: See **4. FIRST AID MEASURES**
Storage: Store locked up.
Disposal: Dispose of unused product in accordance with all federal, state and local organizations.

3. COMPOSITION AND INFORMATION ON INGREDIENTS

Ingredients	CAS Number	% By Weight
Petroleum Asphalt Base	8052-42-4	2-8
Petroleum Solvent	68476-34-6	1-3
Quartz	14808-60-7	.091-.97

4. FIRST AID MEASURES

Eyes: Rinse immediately with plenty of water. Obtain medical attention if pain, blinking or redness persists.
Skin: Take off contaminated clothing and wash it before reuse. Wash with plenty of soap and water. Launder contaminated items of clothing before wearing. If skin irritation or redness persists or develops after exposure, contact a physician.
Inhalation: Move the individual to fresh air away from the fumes. If he/she is having difficulty breathing or is not fully conscious, administer oxygen or artificial respiration as needed and obtain immediate medical attention.
Swallowing: Rinse mouth. Do NOT induce vomiting. Obtain immediate medical attention.

5. FIRE FIGHTING MEASURES

Flammability: Not available
Extinguishing Method: Foam, dry powder. Carbon dioxide. Water spray. Sand.
Unsuitable Extinguishing Method: Do not use a heavy water stream.
Fire and Explosion Hazards: Never use a welding or cutting torch on or near drums of this material (even empty drums) because material can ignite explosively.
Reactivity: Stable under normal conditions. Sensitivity to mechanical impact: None Sensitivity to static discharge: Not available.
Special Precautions for Fire Fighters and Protective Equipment: A self-contained breathing apparatus with a full-face piece operating in a positive pressure mode may be required. Avoid using a water stream to prevent frothing. Water or foam may cause frothing which can be violent and may present a life-threatening situation. Cool exposed containers to prevent steam pressure buildup and rupture. Use water spray or fog for cooling exposed containers. Exercise caution when fighting any chemical fire. Prevent fire-fighting water from entering environment.

6. ACCIDENTAL SPILL OR LEAK PROCEDURES

Personal Precautions: Ensure adequate ventilation. Avoid contact with skin, eyes and clothing. Deny entry to unprotected personnel.
Methods for Containment and Clean-Up: If applicable, follow applicable emergency response plan for your organization. Ventilate the area. Keep people away. Stop and contain the spill. Minimize skin contact and avoid breathing vapors. Wear respiratory protection, protective clothing, gloves and eye/face protection. Advise authorities if product has entered waterways or sewers. This material can be reused; use old material as a base under fresh product. On land, sweep or shovel into suitable containers. Minimize generation of dust. Store away from other materials.

7. HANDLING AND STORAGE

Precautions for Safe Handling: Wear protective clothing; gloves and OSHA approved eye protection and use good industrial hygiene practices. Avoid breathing vapors or dust. Do not eat drink or smoke when using this product. Wash thoroughly after use and before eating, drinking or smoking and when leaving work.

Storage: Store in a well ventilated area away from heat and flame. Dispose of used containers according to local, state and federal requirements. Securely replace lid on container when not in use. Keep out of reach of children.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

Exposure Guidelines: The following occupational exposure guidelines are for the major ingredients in this material. The permissible Exposure Limit (PEL) and Threshold Limit Value (TLV) are expressed in milligrams per cubic meter (mg/m³) ingredient in the work air.

Ingredient	ACGIH TWA (mg/m³)	PEL	TLV
Petroleum Solvent (68476-34-6)	100 mg/m³	n/a	n/a
Petroleum Asphalt Base (8052-42-4)	n/a	n/a	n/a
Quartz (14808-60-7)	.025 respirable fraction	.1 respirable dust	

Engineering Controls: Provide sufficient ventilation (mechanical ventilation such as a general or local exhaust system) to prevent vapors from accumulating and to maintain exposure levels below TLV(s) and maintain a positive flow of fresh air.
Respiratory Protection: Respiratory protection should not be required when handling these products in the open air. However, if these materials are being handled in a confined area, wear a respirator with a NIOSH-approved organic vapor respiratory cartridge, or NIOSH-approved air supplied breathing equipment to prevent inhaling fumes. A respirator is only required when working with this material in a confined or inadequately ventilated area.
Eye and Skin Protection: Wear a face shield or safety glasses, impervious clothing, gloves and shoes. Have eye baths readily available. Do not wear contact lenses.
Hygiene Practices: Wash thoroughly after working with this material before eating, drinking, smoking or using bathroom facilities. Remove and launder contaminated clothing before wearing.

9. PHYSICAL AND CHEMICAL PROPERTIES

Appearance: Black coated stone.
Color: Black
Odor: Tar, Petroleum
Odor Threshold: Not available.
Physical State: Solid.
PH: Not available.
Melting Point: Not available.
Freezing Point: Not available.
Initial Boiling Point and Boiling Range: Not available.
Flash Point: >200°F Cleveland Tag Open Cup Method.
Evaporation Rate: Slower than ether.
Flammability: Not available
Lower Flammability/Explosive Limit: Not available
Upper Flammability/Explosive Limit: Not available
Vapor Pressure: Not available.
Vapor Density: Not available.
Relative Density/Specific Gravity: Heavier than air.
Solubility: Negligible.
Auto-ignition Temperature: Not available.
Decompostion Temperature: Not available.
Viscosity: Not available.
Percent Volatile, wt. %: Not available.
VOC content, wt. %: Not available.
Explosive Properties: Not available.
Oxidizing Properties: Not available.

Note: These physical data are typical values based on material testing, but may vary from sample to sample. Typical values should not be construed as a guaranteed analysis of any specific lot or as specifications for the product.

10. STABILITY AND REACTIVITY

Hazardous Polymerization: This material will not undergo hazardous polymerization.
Hazardous Decomposition: Carbon monoxide, Carbon dioxide.
Chemical Stability: Stable under normal conditions.
Reactivity: Stable under normal conditions.
Incompatibility: Avoid contact with strong acids and strong bases.
Definition: Hazardous Decomposition: Hazardous decomposition products are formed when a material decomposes (breaks down) because it is unstable, or reacts with common materials such as water or oxygen (in air). This information should be considered when planning storage and handling procedures.

11. TOXICOLOGICAL INFORMATION

Acute toxicity:	Not Classified
Petroleum Solvent (68476-34-6)	
LD50 oral rat	5000 mg/kg
LD50 dermal rabbit	2000 mg/kg
ATE US (oral)	5000.000 mg/kg body weight
ATE US (dermal)	2000.000 mg/kg body weight
ATE US (gases)	4500.000 ppmV/4h
ATE US (vapors)	11.000 mg/l/4h
ATE US (dust, mist)	1.500 mg/l/4h
Petroleum Asphalt Base (8052-42-4)	
LD50 oral rat	>5000 mg/kg
LD50 dermal rabbit	>2000 mg/kg
LC50 inhalation rat (mg/l)	>94.4 ml/m³
Skin corrosion/irritation:	Causes skin irritation
Serious eye damage/irritation:	Not classified
Respiratory/skin sensitization:	Not classified
Germ Cell mutagenicity:	Not classified
Carcinogenicity:	May cause cancer
Petroleum Asphalt Base (8052-42-4)	
IARC group	2A - Probably carcinogenic to humans, 2B - Possibly carcinogenic to humans
Quartz	
IARC group	1 - Carcinogenic to humans
Reproductive toxicity:	Not classified
Specific target organ toxicity (single exposure):	Not classified
Specific target organ toxicity (repeated exposure):	May cause damage to organs through prolonged or repeated exposure.
Aspiration hazard:	Not classified
Potential Adverse human health Effects and symptoms:	Based on available data, the classification criteria are not met.
Symptoms/injuries after Inhalation:	Dizziness, headaches, nausea. May cause respiratory irritation
Symptoms/injuries after Skin contact:	Irritation. Causes skin irritation.
Symptoms/injuries after Eye contact:	Severe irritation including redness, tearing and blurred vision.

12. ECOLOGICAL INFORMATION

Toxicity:	No additional information available
Persistence and degradability:	
Cold Patch	Not established.
Petroleum Solvent (686476-34-6)	May cause long-term adverse effects in the environment
Petroleum Asphalt Base (8052-42-4)	Not established
Quartz (14808-60-7)	Not established

Bioaccumulative potential:	
Cold Patch	Not established
Petroleum Solvent (686476-34-6)	Not established
Petroleum Asphalt Base (8052-42-4)	Not established
Quartz (14808-60-7)	Not established

Although there is no evidence that the components of X-Patch Cold Mix bioaccumulate in food chains, the heavier molecular weight components of asphalt and petroleum solvent may be persistent under some environmental conditions. Release of these products into surface waters should be avoided.

13. DISPOSAL CONSIDERATIONS

This product, when discarded or disposed of, is not specifically listed as a hazardous waste in federal regulations. It could be designated as a hazardous waste according to state regulations. This product could also become a hazardous waste if it is mixed with or comes in contact with a hazardous waste. If such contact occurs, consult 40 CFR, to determine whether it is a hazardous waste.

The transportation, storage, treatment and disposal of this waste must be conducted in accordance with all applicable federal, state and local regulations.

14. TRANSPORTATION INFORMATION

DOT Description:

Proper Shipping Name: Not regulated by DOT as a hazardous substance.
Hazard Class: None
UN Number: None
NA Number: None'
ADR, Transport by Sea, Air Transport: No additional information available.

15. REGULATORY INFORMATION

	TSCA INVENTORY	IARC	NJ Right to Know
Petroleum Solvent (68476-34-6)	Listed	Not Listed	No
Petroleum Asphalt Base (8052-42-4)	Listed	Not Listed	Yes
Quartz, Silica (14808-60-7)	Listed	Listed	Yes

Canadian Regulations - No information available
EU Regulations - No information available

16. OTHER INFORMATION

None

Keep from freezing. Keep out of reach of children. For professional and industrial use only. Always read label plus precautions on back of sales ticket and follow directions carefully. Do not take internally.

The information contained in this SDS is believed to be accurate as of the time that this document was prepared. All chemicals may present unknown health hazards and should be used with caution. Although certain hazards are described herein, we cannot guarantee that these are the only hazards that exist. Final determination of suitability of the chemical(s) is the sole responsibility of the user. Users of any chemical should satisfy themselves that the conditions and methods of use assure that the chemical is used safely.

NO REPRESENTATIONS OR WARRANTIES, EITHER EXPRESSED OR IMPLIED, OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE OR ANY OTHER NATURE ARE MADE HEREUNDER WITH RESPECT TO THE INFORMATION CONTAINED HEREIN OR THE CHEMICAL TO WHICH THE INFORMATION REFERS.

AQUAPHALT™–SUSTAINABLE COLD MIX

TECHNICAL DATA SHEET

Manufactured by: RoadStone Production LLC, 1230 River Road, Charlottesville, VA 22901

Product Description:

Aquaphalt™ is a revolutionary, high performance, flexible, reactive cold mix asphalt repair product for use in repairing asphalt and concrete road surfaces. Aquaphalt™ reacts with plain water to provide a permanent repair solution. All sizes of Aquaphalt™ are free of solvents or volatile organic compounds (VOC's). Aquaphalt™ comes in four (4) sizes (4.0mm, 6.0mm, 9.0mm) for surface, intermediate or base repairs for any type of asphalt or concrete road repair.

Applications: Highways (asphalt or concrete), Runways/Taxiways/Aprons, Bridge Decks, Manhole repairs, Potholes, Utility Cuts, Parking Lots, Driveways, Tennis Courts, Pathways

Performance Features:

Permanent Solution – Aquaphalt™ is stronger than typical hot mix asphalt pavements and unlike other conventional cold patch asphalt products which never deliver a truly permanent repair.

Cost Effective – Aquaphalt™ saves time and money by eliminating costly repeat repairs.

Environmentally Sustainable – Aquaphalt™ contains no toxic solvents of VOC's, making it friendlier to the environment.

Material Specifications:

AGGREGATES: All of the aggregate materials are a crushed granite and are from an approved Virginia DOT source. All of the aggregate materials are from a non-polishing source and have the following properties:
ASTM C-127,128 Specific Gravity 3.0% Max.

Gradation Analysis:

Sieve Sizes	4.0mm % Passing	6.0mm % Passing
1/2" Sieve	100	100
3/8" Sieve	99.89	100
#4 Sieve	95.14	85-100
#8 Sieve	65.40	20-55
#16 Sieve	42.69	12-32
#200 Sieve	7.56	3-6

Gradation Analysis:

Sieve Sizes	9.0mm % Passing
1/2" Sieve	100
3/8" Sieve	85-100
#4 Sieve	35-60
#8 Sieve	15-35
#16 Sieve	14-25
#200 Sieve	3-6

BINDER: **Reactive Binder** is a further development of the "Raps-Asphalt" technology.
"Raps-Asphalt" is a plant based binder with bitumen, a naturally occurring
Organic byproduct of organic materials represents a total weight of approximately 5-8% of the finished product; this binder contains natural rape seed oil which improves stability.
The binder of – Aquaphalt™ is a proprietary liquid that similarly contains renewable natural raw materials.

AQUAPHALT™–SUSTAINABLE COLD MIX

TECHNICAL DATA SHEET

Manufactured by: RoadStone Production LLC, 1230 River Road, Charlottesville, VA 22901

Directions for Use:

Remove all loose material from area to be repaired. Place Aquaphalt ™in the patch and level with a rake or trowel. Allow 0.5”-1.0” additional height for compaction. Saturate with water and compact. If the depth of the pothole is greater than 2-3”, it is advisable to fill the hole in two layers.

Clean Up:

Use Automotive hand cleaners on hands and tools may be cleaned with light oil, mineral spirits or vegetable oil.

Storage and Handling:

Each bucket of Aquaphalt™ contains approximately 55 lbs of material. Store Indoors in cool, dry conditions. Avoid direct sunlight and/or exposure to freezing. Aquaphalt™ can be applied in freezing conditions, but workability is best when it is stored indoors.

General Advice:

Aquaphalt™ hardens quickly for immediate use. After water is applied, Aquaphalt™ will start to cure in 15 minutes and can be opened to traffic immediately. The reactive process happens relatively quickly and Aquaphalt starts to get hard and in most cases will be fully cured in 24 hours.

Since Aquaphalt™ does not release any harmful VOC’s it can be sealed 24 hours after installation.

Guarantee:

RoadStone Production LLC, a Virginia limited liability company (RSP), provides an **unlimited “CURING GUARANTEE”** to the Customer that Aquaphalt™ product[s], produced by RSP LLC, and sold by its authorized Distributors will cure, upon proper installation – as directed in written form by the manufacturer and applicable standards – within a reasonable time frame (24 hours to 120 hours) from the date of installation.

See website for more details. www.aquaphalt.com

BASF
The Chemical Company

Distributed by: BEST MATERIALS LLC
Ph: 800-474-7570, 602-272-8128 Fax: 602-272-8014
www.BestMaterials.com Email: Sales@BestMaterials.com

PRODUCT DATA

3 03 01 00 **Maintenance of Concrete**

SET® 45 AND SET® 45 HW

Chemical-action repair mortar

Description

Set® 45 is a one-component magnesium phosphate-based patching and repair mortar. This concrete repair and anchoring material sets in approximately 15 minutes and takes rubber-tire traffic in 45 minutes. It comes in two formulations: Set® 45 Regular for ambient temperatures below 85° F (29° C) and Set® 45 Hot Weather for ambient temperatures ranging from 85 to 100° F (29 to 38° C).

Yield

A 50 lb (22.7 kg) bag of mixed with the required amount of water produces a volume of approximately 0.39 ft^3 (0.011 m^3); 60% extension using 1/2" (13 mm) rounded, sound aggregate produces approximately 0.58 ft^3 (0.016 m^3).

Packaging

50 lb (22.7 kg) multi-wall bags

Color

Dries to a natural gray color

Shelf Life

1 year when properly stored

Storage

Store in unopened containers in a clean, dry area between 45 and 90° F (7 and 32° C).

Features	Benefits
• Single component	Just add water and mix
• Reaches 2,000 psi compressive strength in 1 hour	Rapidly returns repairs to service
• Wide temperature use range	From below freezing to hot weather exposures
• Superior bonding	Bonds to concrete and masonry without a bonding agent
• Very low drying shrinkage	Improved bond to surrounding concrete
• Resistant to freeze/thaw cycles and deicing chemicals	Usable in most environments
• Only air curing required	Fast, simple curing process
• Thermal expansion and contraction similar to Portland cement concrete	More permanent repairs
• Sulfate resistant	Stable where conventional mortars degrade

Where to Use

APPLICATION

- Heavy industrial repairs
- Dowel bar replacement
- Concrete pavement joint repairs
- Full-depth structural repairs
- Setting of expansion device nosings
- Bridge deck and highway overlays
- Anchoring iron or steel bridge and balcony railings
- Commercial freezer rooms
- Truck docks
- Parking decks and ramps
- Airport runway-light installations

LOCATION

- Horizontal and formed vertical or overhead surfaces
- Indoor and outdoor applications

How to Apply

Surface Preparation

1. A sound substrate is essential for good repairs. Flush the area with clean water to remove all dust.
2. Any surface carbonation in the repair area will inhibit chemical bonding. Apply a pH indicator to the prepared surface to test for carbonation. If carbonation is present, abrade surface to a depth that is not carbonated.
3. Refer to International Concrete Repair Institute publication #s 03730 and 03732 for further surface preparation suggestions.

Protection and Repair

Technical Data

Composition

Set® 45 is a magnesium-phosphate patching and repair mortar.

Test Data

PROPERTY	RESULTS			TEST METHODS
Typical Compressive Strengths*, psi (MPa)				ASTM C 109, modified
	Plain Concrete 72° F (22° C)	**Set® 45 Regular 72° F (22° C)**	**Set® 45 Regular 36° F (2° C)**	**Set® 45 HW 95° F (35° C)**
1 hour	—	2,000 (13.8)	—	—
3 hour	—	5,000 (34.5)	—	3,000 (20.7)
6 hour	—	5,000 (34.5)	1,200 (8.3)	5,000 (34.5)
1 day	500 (3.5)	6,000 (41.4)	5,000 (34.5)	6,000 (41.4)
3 day	1,900 (13.1)	7,000 (48.3)	7,000 (48.3)	7,000 (48.3)
28 day	4,000 (27.6)	8,500 (58.6)	8,500 (58.6)	8,500 (55.2)

NOTE: Only Set® 45 Regular formula, tested at 72° F (22° C), obtains 2,000 psi (13.8 MPa) compressive strength in 1 hour.

PROPERTY	RESULTS		TEST METHODS
Modulus of Elasticity, psi (MPa)			ASTM C 469
	7 days	**28 days**	
Set® 45 Regular	4.18×10^6 (2.88×10^4)	4.55×10^6 (3.14×10^4)	
Set® 45 Hot Weather	4.90×10^6 (3.38×10^4)	5.25×10^6 (3.62×10^4)	
Freeze/thaw durability test, % RDM, 300 cycles, for Set® 45 and Set 45® HW		80	ASTM C 666, Procedure A (modified**)
Scaling resistance to deicing chemicals, Set® 45 and Set 45® HW			ASTM C 672
5 cycles		0	
25 cycles		0	
50 cycles		1.5 (slight scaling)	
Sulfate resistance			ASTM C 1012
Set® 45 length change after 52 weeks, %		0.09	
Type V cement mortar after 52 weeks, %		0.20	
Typical setting times, min, for Set® 45 at 72° F (22° C), and Set® 45 Hot Weather at 95° F (35° C)			Gilmore ASTM C 266, modified
Initial set		9 – 15	
Final set		10 – 20	
Coefficient of thermal expansion,*** both Set® 45 Regular and Set® 45 Hot Weather coefficients		7.15×10^{-6}/° F (12.8×10^{-6}/° C)	CRD-C 39
Flexural Strength, psi (MPa), 3 by 4 by 16" (75 by 100 by 406 mm) prisms, 1 day strength,			ASTM C 78, modified
Set® 45 mortar		550 (3.8)	
Set® 45 mortar with 3/8" (9 mm) pea gravel		600 (4.2)	
Set® 45 mortar with 3/8" (9 mm) crushed angular noncalcareous hard aggregate		650 (4.5)	

* All tests were performed with neat material (no aggregate)

**Method discontinues test when 300 cycles or an RDM of 60% is reached.

***Determined using 1 by 1 by 11" (25 mm by 25 mm by 279 mm) bars. Test was run with neat mixes (no aggregate). Extended mixes (with aggregate) produce lower coefficients of thermal expansion.

Test results are averages obtained under laboratory conditions. Expect reasonable variations.

Mixing

1. Set® 45 must be mixed, placed, and finished within 10 minutes in normal temperatures (72° F [22° C]). Only mix quantities that can be placed in 10 minutes or less.

2. Do not deviate from the following sequence; it is important for reducing mixing time and producing a consistent mix. Use a minimum 1/2" slow-speed drill and mixing paddle or an appropriately sized mortar mixer. Do not mix by hand.

3. Pour clean (potable) water into mixer. Water content is critical. Use a maximum of 4 pts (1.9 L) of water per 50 lb (22.7 kg) bag of Set® 45. Do not deviate from the recommended water content.

4. Add the powder to the water and mix for approximately 1 – 1-1/2 minutes.

5. Use neat material for patches from 1/2 – 2" (6 – 51 mm) in depth or width. For deeper patches, extend a 50 lb (22.7 kg) bag of Set® 45 HW by adding up to 30 lbs (13.6 kg) of properly graded, dust-free, hard, rounded aggregate or noncalcareous crushed angular aggregate, not exceeding 1/2" (13 mm) in accordance with ASTM C 33, #8. If aggregate is damp, reduce water content accordingly. Special procedures must be followed when angular aggregate is used. Contact your local BASF representative for more information. (Do not use calcareous aggregate made from soft limestone. Test aggregate for fizzing with 10% HCL).

Application

1. Immediately place the mixture onto the properly prepared substrate. Work the material firmly into the bottom and sides of the patch to ensure good bond.

2. Level the Set® 45 and screed to the elevation of the existing concrete. Minimal finishing is required. Match the existing concrete texture.

Curing

No curing is required, but protect from rain immediately after placing. Liquid-membrane curing compounds or plastic sheeting may be used to protect the early surface from precipitation, but never wet cure Set® 45.

For Best Performance

- Color variations are not indicators of abnormal product performance.
- Regular Set® 45 will not freeze at temperatures above -20° F (-29° C) when appropriate precautions are taken.
- Do not add sand, fine aggregate, or Portland cement to Set® 45.
- Do not use Set® 45 for patches less than 1/2" (13 mm) deep. For deep patches, use Set® 45 Hot Weather formula extended with aggregate, regardless of the temperature. Consult your BASF representative for further instructions.
- Do not use limestone aggregate.
- Water content is critical. Do not deviate from the recommended water content printed on the bag.
- Precondition these materials to approximately 70° F (21° C) for 24 hours before using.
- Protect repairs from direct sunlight, wind, and other conditions that could cause rapid drying of material.
- When mixing or placing Set® 45 in a closed area, provide adequate ventilation.
- Do not use Set® 45 as a precision machinery grout.
- Never featheredge Set® 45; for best results, always sawcut the edges of a patch.
- Prevent any moisture loss during the first 3 hours after placement. Protect Set® 45 with plastic sheeting or a curing compound in rapid-evaporation conditions.
- Do not wet cure.
- Do not place Set® 45 on a hot (90° F [32° C]), dry substrate.
- When using Set® 45 in contact with galvanized steel or aluminum, consult your local BASF sales representative.
- Make certain the most current versions of product data sheet and MSDS are being used; call Customer Service (1-800-433-9517) to verify the most current versions.
- Proper application is the responsibility of the user. Field visits by BASF personnel are for the purpose of making technical recommendations only and not for supervising or providing quality control on the jobsite.

Health and Safety

SET® 45

WARNING!

Contains silica, crystalline quartz, fly ash, magnesium oxide, phosphoric acid, monoammonium salt, iron oxide, silica, amphorous, aluminum oxide, sulfur trioxide.

Risks

Product is alkaline on contact with water and may cause injury to skin or eyes. Ingestion or inhalation of dust may cause irritation. Contains small amount of free respirable quartz which has been listed as a suspected human carcinogen by NTP and IARC. Repeated or prolonged overexposure to free respirable quartz may cause silicosis or other serious and delayed lung injury.

Precautions

Avoid contact with skin, eyes and clothing. Prevent inhalation of dust. Wash thoroughly after handling. Keep container closed when not in use. DO NOT take internally. Use only with adequate ventilation. Use impervious gloves, eye protection and if the TLV is exceeded or used in a poorly ventilated area, use NIOSH/MSHA approved respiratory protection in accordance with applicable Federal, state and local regulations.

First Aid

In case of eye contact, flush thoroughly with water for at least 15 minutes. In case of skin contact, wash affected areas with soap and water. If irritation persists, SEEK MEDICAL ATTENTION. Remove and wash contaminated clothing. If inhalation causes physical discomfort, remove to fresh air. If discomfort persists or any breathing difficulty occurs or if swallowed, SEEK IMMEDIATE MEDICAL ATTENTION.

Waste Disposal Method

This product when discarded or disposed of is not listed as a hazardous waste in federal regulations. Dispose of in a landfill in accordance with local regulations.

For additional information on personal protective equipment, first aid, and emergency procedures, refer to the product Material Safety Data Sheet (MSDS) on the job site or contact the company at the address or phone numbers given below.

Proposition 65

This product contains material listed by the State of California as known to cause cancer, birth defects or other reproductive harm.

VOC Content

0 g/L or 0 lbs/gal less water and exempt solvents.

For medical emergencies only, call ChemTrec (1-800-424-9300).

BASF Construction Chemicals, LLC – Building Systems

889 Valley Park Drive
Shakopee, MN, 55379

www.BuildingSystems.BASF.com

Customer Service 800-433-9517
Technical Service 800-243-6739

Form No. 1019335 10/11
Printed on recycled paper including 10% post-consumer fiber.

REMR MATERIAL DATA SHEET CM-PC-1.1
CONCRETE PATCHING MATERIAL: SET-45

1. NAME

SET-45

2. MANUFACTURER

Master Builders, Inc.
23700 Chagrin Blvd
Cleveland, OH 44122
Tel 216-831-5500

3. DESCRIPTION

One-component, expansive, fast-setting, magnesium phosphate concrete for concrete repair and for anchoring components to concrete.

4. APPLICABLE SPECIFICATIONS

ASTM C 928-80, "Standard Specification for Packaged, Dry, Rapid-Hardening Cementitious Materials for Concrete Repairs."

5. USES & LIMITATIONS

Uses: Set-45 is designed for: bridge deck and highway overlays; concrete pavement joint repairs; airport runway light installations; full-depth structural repairs; expansion device nosing; anchoring bridge railings; commercial freezer room repairs; truck dock repairs; parking deck and ramp repairs; and heavy industrial repairs.

Limitations: The manufacturer's literature lists the following precautions:

a. Do not add any sand, aggregate fines, or portland cement to Set-45 concrete.

b. Do not use Set-45 for patches less than 1/2 in. deep.

c. Water content is critical. Do not deviate from the recommended water content printed on the product bag.

d. When placing Set-45 in a closed area, provide adequate ventilation.

e. Do not use Set-45 as a precision, nonshrink grout.

f. Do not use Set-45 if it will come into contact with galvanized steel or aluminum.

6. MANUFACTURER'S TECHNICAL DATA

Packaging: 50-lb polyethylene-lined bags

Yield: A 50-lb bag mixed with the required amount of water produces a volume of approximately 0.4 cu ft.

Color: Dries to the color of portland-cement mortar.

Mechanical Data:

Typical Compressive Strengths,* ASTM C 109 (Modified), psi
(Materials and Curing Times at Specified Temperatures)

	Plain Concrete at 72°F (22°C)	Set-45 Regular at 72°F (22°C)	Set-45 Regular at 36°F (22°C)	Set-45 Hot Weather at 95°F (35°C)
1-hour	---	2000	---	---
3-hour	---	5000	---	3000
6-hour	---	5000	1200	5000
1-day	500	6000	5000	6000
3-day	1900	7000	7000	7000
28-day	4000	8500	8500	8000

Typical Flexural Strengths,* ASTM C 78 (Modified), psi

	3-hour	24-hour	7-day
Set-45 Regular at 72°F (22°C)	600	900	1000
Set-45 Hot Weather at 95°F (35°C)	400	900	1000

Modulus of Elasticity, ASTM C 469, psi

	7-day	28-day
Set-45 Regular	4.18×10^6	4.55×10^6
Set-45 Hot Weather	4.90×10^6	5.25×10^6

* Tests were performed with neat material.

Freeze-thaw durability test, ASTM C 666, Procedure A: Both Regular and Hot Weather Set-45 achieved a relative dynamic modulus of 80% after 300 cycles.

Scaling resistance to deicing chemicals, ASTM C 672, Set-45 Regular and Set-45 Hot Weather formulas: After 5 and 25 cycles at a rating of 0, the surface showed no scaling. After 50 cycles at a rating of 1.5, the surface showed slight scaling.

Typical setting times, Gilmore, ASTM C 266: Set-45 Regular at 72°F (22°C) and Set-45 Hot Weather at 95°F (35°C) had the following typical setting times: initial, 10 to 15 min, final, 12 to 20 min.

Coefficient of thermal expansion, CRD-C 39-81: Both Set-45 Regular and Set-45 Hot Weather had coefficients which equaled 7.15×10^{-6}/°F.

7. MANUFACTURER'S GUIDANCE FOR APPLICATION

Surface Preparation: A sound base is essential for good repairs. Remove all oil, grease, dirt, and loose, disintegrated, or unsound concrete from the areas to be patched.

Saw cut 1/2 in. deep or more to form the perimeter of each patch. A bond breaker is required at all joints. Featheredge patching is not recommended.

Where the bond between reinforcing steel and concrete is destroyed, remove the adjacent concrete to a depth that will provide a minimum of 3/4 in. of new concrete over all cleaned concrete surfaces and all exposed reinforcing steel. Remove rust from rebar by wire brushing or sandblasting. Do not use a bonding agent on the steel or on the prepared concrete surface.

Flush the area thoroughly with clean water to remove dust, then air blast to remove all water before placing the Set-45. (Note: Set-45 bonds better to a surface dry interface.)

Equipment: Have the proper measuring containers and tools on the job. Be certain the labor force is adequate to handle the rapid-setting Set-45.

Use a mortar-type mixer as the shearing action of the blades yields optimum blending. For large jobs, the mixer should be capable for mixing up to 500 lb of material. A continuous-type mixer may be used. For smaller quantities, an electric drill with a jiffler-type mixer may also be used.

Addition of Aggregate:

Under 1-in. depth--Use neat material for shallow patches. Set-45 should not be used for patches less than 1/2-in.

Deep patches--A 50-lb bag of Set-45 may be extended by adding up to 30 lb of thoroughly washed, dried, uniform-size, sound 1/4- to 1/2-in. round aggregate. When using angular aggregate, reduce the amount added to obtain proper workability. (Note: Do not add any sand, aggregate fines, or portland cement to Set-45.)

Mixing: Locate the mixer as close as possible to the repair area. Allow no more than 10 min to mix, place, and finish Set-45 in normal temperatures of 72°F (22°C).

NOTE: Water content is critical. Use 1/2 gal of water per 50-lb bag of Set-45. In certain conditions, the water content may vary between 3-1/2 and 4 pints; but, in normal situations, do not deviate from the recommended water content or mixing instructions.

IMPORTANT: Always follow this mixing order:

a. Pour clean water into mixer at the rate of 1/2 gal per 50-lb bag of Set-45.

b. Add aggregate, if necessary, for deep patches. If damp aggregate is used, reduce the water content accordingly.

c. Add Set-45. Mix the Set-45 approximately 1 to 1-1/2 min.

Placing: After mixing, immediately place the Set-45, working from side to side. Do not place Set-45 in lifts. Work the material firmly into the bottom and sides of the patch to ensure a good bond. Do not use a bonding agent.

Level the Set-45 and screed to the elevation of the surrounding concrete. When properly screeded, Set-45 will self-level and yield a skid-resistant finish. Seal the edges and all saw cuts with light hand floating. Minimal finishing is required. Do not retemper Set-45.

Clean tools and mixer frequently with water to prevent build-up.

Special Considerations: The setting speed of Set-45 is dependent upon both the temperature of the mixture and the area to be repaired.

Cold weather, below 50°F (10°C)--Heat the concrete surface until it is warm to the touch. Use warm material and warm the water to 90°F (32°C) to increase the hardening speed. Keep the patch warm by tenting or insulating. This will aid in obtaining a more rapid strength development in cold weather. Do not use anti-freeze or accelerators.

Hot weather, over 85°F (29°C)--Set-45 Hot Weather Formula is recommended. Keep the material cool. The use of ice water for mixing is recommended to extend the working time. (Caution: Placing Set-45 on a hot concrete surface may affect bond. When the sun has heated the surface excessively, delay placement until the slab temperature has been lowered by additional dampening of the area. Be certain to remove all standing water immediately prior to application of Set-45.)

Curing: Set-45 should be allowed to air dry for a proper cure. Do not use a curing compound or wet-curing process. In normal temperatures, Set-45 patches will take traffic approximately 45 min to 1 hr after placing.

8. CORPS OF ENGINEERS' EVALUATION

Mechanical and Physical Data (Set 45 Regular):

Compressive Str, ASTM C 109, psi	1-hr	4410
	2-hr	5970
	3-hr	6350
Compressive Str, ASTM C 39, psi	24-hr	6000
	28-day	9240

Mechanical and Physical Data (Set 45 Regular): (Continued)

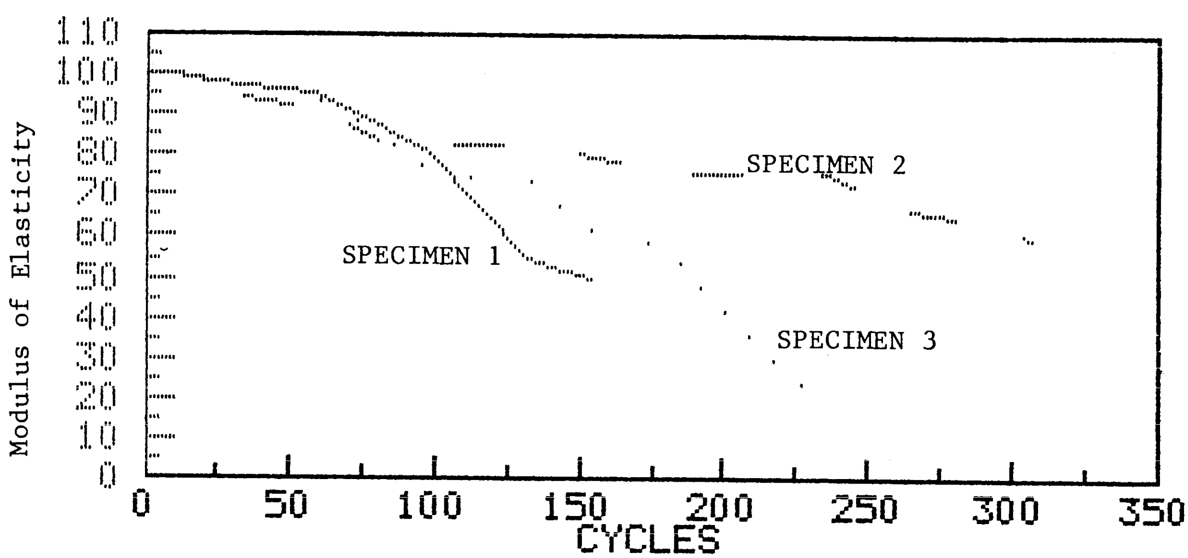
Mod of Elast, ASTM C 469, psi	24-hr	5.16×10^6
	28-day	5.85×10^6
Flexural Str, ASTM C 78, psi	3-hr	560
	24-hr	880
	28-day	1010
Bond to Conc, ASTM C 882, psi	24-hr	1990
	28-day	2250
Shrinkage, percent	GR-83-10*	
(Unconfined condition)[1]		0.137
(Concrete patch)[2]		0.006

* Bureau of Reclamation Technical Report Standard.

1 An exotherm of 60°F was reported on the shrinkage specimen using a mix design of 50 lb of material, 25 lb of aggregate, and 1/2 gal of water.

2 An exotherm of 30°F was reported on the shrinkage specimen using a mix design of 50 lb of material, 25 lb of aggregate, and 1/2 gal of water.

Rapid Freezing and Thawing, ASTM C 666, Relative Dynamic Modulus of Elasticity, %:



Permeability (Hassler Cell)*:

Pressure, psi Source	Pressure, psi Confining	Water Permeability microdarcies
51	101	15.0
92	160	11.0
195	266	1.6

* Specimen length, 5.95 in.; diameter, 3.0 in.

Literature Review Findings:

The material has a good service record when used in steel mill refractory work and generally has performed well as a repair material on bridge deck applications.

Permeability and water absorption of the material have been reported from low to high. The consistency of the material and environment it was exposed to were not identified, making it difficult to establish whether it is a variation on the material performance or application procedures.

Results reported on the long-term durability of the material since 1970 have ranged from excellent to questionable. Similar results have also been reported on laboratory specimens tested in accordance with ASTM C 666.

Results from one study revealed severe strength loss when material was exposed to high heat (100°C) for a long period of time (24 hr). The same study revealed that under autoclave expansion tests, the material disintegrated. This would indicate a potential problem in using the material in a large volume due to the high exotherm with set.

Field Experience:

Set-45 was used to repair concrete walls and floors downstream of a steel liner at Isabella Dam in January 1983. The repair failed.

Set-45 was used to repair honeycombed areas and voids in the concrete along the invert of the conduit at Mulberry Dam in March 1970. Performance has been reported as good.

9. ENVIRONMENTAL CONSIDERATIONS

Reasonable caution should guide the preparation, repair, and cleanup phases of concrete or mortar repair activities involving potentially hazardous and toxic chemical substances. Manufacturer's recommendations to protect occupational health and environmental quality should be carefully followed. Material safety data sheets should be obtained from the manufacturers of such materials. In cases where the effects of a chemical substance on occupational health or environmental quality are unknown, chemical substances should be treated as potentially hazardous toxic materials.

10. AVAILABILITY & COSTS

Availability: This material is available throughout the US through a network of local distributors.

Costs: Varies; approximately 30¢ to 40¢ per pound or $20 per 50-lb bag.

11. TECHNICAL SERVICES

Master Builders maintains a worldwide network of sales and technical assistance offices. Corporate headquarters in Cleveland, Ohio (216-831-5500), can provide information on the nearest office.

KWIK-BOND

Low Temperature Floor Patch

KWIK-BOND is a premixed, 100% solids polyester resin based compound. It provides high early strength with negligible shrinkage. KWIK-BOND cures hard, yet not brittle, and bonds securely to all concrete surfaces. As KWIK-BOND is moisture insensitive, it can be applied to damp surfaces. With its built in flexibility, abrasion, and corrosion resistant properties, KWIK-BOND is an excellent patching and resurfacing compound that can be feather edged. KWIK-BOND is USDA approved for use in federally inspected meat and poultry plants.

KWIK-BOND is designed for concrete repair on frozen surfaces such as freezers, coolers, and holding boxes. KWIK-BOND will set up and cure without the need to raise surface temperatures, use propane torches, or heating lamps to accelerate the cure. KWIK-BOND can be used anywhere a quick set is desired, in any temperature range.

Key Benefits

- Ready for traffic in less than 1 hour
- Repairs holes, cracks, and large spalled areas.
- Requires NO heat lamps, propane torches, or shutdown of freezers and coolers.

Properties

Mixing Ratio:	(parts A & B) 1:1 by volume
Color:	Part A -clear Part B -gray(final cure concrete gray)
Viscosity:	Brookfield RV5/2 @ 75°F
Shelf Life:	12 months
Resistant To:	oil, kerosene, grease, water, gasoline, salts, mild inorganic acids and alkalis
Compressive Strength:	14,000 psi
Tensile Strength:	1750 LBF/IN (12.3N/MM)
Elongation Factor:	1-2×10 LBF/IN (600-12) N/M
Pot Life:	15 minutes @ -20°F to 32°F ; 10 minutes @ 33°F and up

Application

Clean surface of loose aggregate, dirt, grease, and other foreign matter. Empty powdered material, from mixing vessel, on to a clean piece of cardboard. Pour liquid ester resin into mixing vessel. Add powdered material slowly, mixing constantly and trowel on. Repaired area may be open to traffic within one hour. Clean tools with Capital's solvent 302, or high grade lacquer thinner before KWIK-BOND has set.

For more information, call Capital Industries at (631) 298-6300 or email info@kwikbond.com

Caution

Only mix enough material that can be applied within the pot life. USE WITH ADEQUATE VENTILATION. Store in a cool, dark place. Avoid prolonged contact with skin and eyes. After finishing job, wash hands thoroughly with powdered or grit soap.

CW-600™

Water Based, Wax-Based Concrete Curing Compound

Road & Highway Construction / Concrete Chemicals

CW-600™ is a water-based, wax-based, pigmented liquid membrane curing compound that is applied to freshly poured concrete surfaces, preventing rapid water evaporation. When **CW-600™** is applied correctly, the surface concrete forms an impermeable membrane, holding moisture in the concrete, keeping the concrete cool, which prevents crazing and cracking.

USE

CW-600™ is ideal when applying on concrete exterior surfaces such as highways, airports, streets, walkways, concrete slabs & curb paving. May not be suitable for all residential applications.

SPECIFICATIONS

- ASTM C309, Type 2, Class A
- AASHTO M148, Type 2, Class A
- US EPA Architectural Coatings Rule
- SCAQMD 1113
- Ozone Transportation Commission
- FAA P 610 2.11(e)

APPLICATION

Apply **CW-600™** with hand or power spraying mechanism or low pressure sprayer until saturation. Do not thin. Apply at temperatures above 40°F.

COVERAGE

- Approximately 200 ft²/gal (4.91 m²/l).
- Coat uniformly, leave no gaps. For best results use a sprayer at 40 psi with a flow of ½ gallons per minute.

TECHNICAL DATA

Drying Time	Typically 4 to 5 hrs depending on temperature, humidity and application rate. Avoid traffic during this time period.
Flash Point	Greater than 212° F (100°C)
Weight	8.65 ppg
Color	Milky White

PRECAUTIONS

Do not mix or dilute with other compounds that contain solvents such as mineral spirits, or fluids that might contain petroleum distillates. This product is not recommended to be used in areas where other treatments are to be used including hardeners. Restrict foot traffic of a minimum of 4 hours after final application. Follow instruction of MSDS for Health and Safety Instructions.

STORAGE

CW-600™ should be stored in tightly sealed factory containers. We recommend storage in a horizontal position to avoid moister accumulation. Store under roof if possible, especially if temperatures are below 40°F.

PACKAGING

- 5 Gal
- 275 Gal
- 55 Gal
- Bulk

P.O. Box 431, Wharton, Texas 77488 / *phone* (979) 531-1100 / *fax* (979) 531-8030 / www.primeecogroup.com

PRIME ECO GROUP
Ecology Through Technology™

NEYRA® *Professional Grade*

PLS

Crack /Joint Thermo-Sealant

1. PRODUCT NAME
PLS™

2. MANUFACTURER

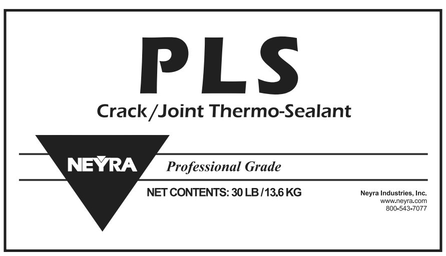
Neyra Industries, Inc.
10700 Evendale Drive
Cincinnati, Ohio 45241

Phone: 513-733-1000
Toll Free: 800-543-7077
Fax: 513-733-3989
Email: info@neyra.com
Website: www.neyra.com

- **Climatically Engineered:** Formulated for a firm set in warmer climates.
- **Tough & Pliable:** A no tracking formula for parking lots.
- **Sets Firm & Fast:** You can seal in 15 minutes or less.
- **No Bleed Through:** Ideal for crackfilling under sealcoating, slurry seals and overlays.
- **Optimum Texture:** Granular rubber improves sealcoat adhesion.
- **Proven Performance:** many ASTM, AASHTO and Federal specs for crack sealants including ASTM D1190 and D6690 Type I.

3. PRODUCT DESCRIPTION

PLS is a highly modified, single component, hot applied, rubber/asphalt joint and crack sealant. Furnished as a solid, it is an elastomeric sealant which is compatible with and bonds aggressively to dry and clean concrete or asphalt pavements.



Packaging:
Available in 30 lb. cardboard boxes. One skid contains 70 boxes.

Color:
PLS is black.

Basic Uses:
PLS is specially formulated for sealing asphalt and portland cement concrete parking lot cracks.

Composition:
As shipped, PLS is composed of asphalt cement, plasticizers, polymers, resins, select oils and recycled rubber.

Limitations:
Do not overheat material. Do not apply to wet or dirty cracks. Not recommended for cracks over 1" wide. Do not store in direct sunlight or where temperature exceeds 120˚F.

4. INSTALLATION

Preparatory Work:
Crack or joint must be properly prepared prior to installation of PLS by means of routing and/or the use of a hot compressed air jet to remove all incompressibles and assure the sidewalls of crack are clean and dry.

Methods:
PLS can only be properly heated in a kettle with both agitation and temperature control. The range of safe heating temperature for the product is between 325-375˚F. Material can be pumped or gravity fed into crack/joint. Care should be taken to minimize the amount of sealant left on the pavement surface.

Mix Design:
Blocks of PLS are formulated as a single component system. Do not add to or mix with any other material.

Application:
Install heated sealant directly into cracks/joints not to exceed a 4 inch wide band. Thickness should be controlled to not more than 1/8 inch above pavement surface. Finished sealed cracks and joints will be uniformly level. Refill to achieve a flush to 1/8 inch concave surface appearance. One pound of PLS will fill the following lineal feet:

Width	*Depth*			
	1/4”	*1/2”*	*3/4”*	*1”*
1/4”	32	16	12	8
1/2”	16	8	5.5	4.5
3/4”	12	5.5	4.5	3
1”	8	4.5	3	2

Precautions:
Extreme care must be taken with hot applied sealants. A long sleeved shirt, long pants, gloves and face protection must be worn. **Severe burn hazard.** Keep out of reach of children. Consult specific Neyra material safety data sheet before use.

5. MAINTENANCE

Remove from equipment and tools with heat. Clean hands with waterless hand cleaner.

6. TECHNICAL DATA

Applicable Standards:
PLS meets the performance standards of AASHTO M173 and D6690 Type I when tested according to ASTM D5329, Standard Test Methods for Hot Applied Sealants.

Environmental Considerations:

PLS is considered non-hazardous when tested according to the EPA's TCLP (Toxicity Characteristic Leaching Procedure).

Performance Requirements:

Refer to chart on back.

7. TECHNICAL SERVICE

Material safety data sheets, product and application recommendations, as well as assistance with special situationsand field service are available upon request.

8. WARRANTY

The above specifications on product usage are believed to be true and accurate. Neyra Industries, Inc. guarantees that all materials manufactured comply with quality standards as described in the product data sheets. Because the application, handling, weather, workmanship and equipment are beyond the control of this manufacturer, only the quality of the products as shipped is guaranteed. In no case will the liability of Neyra Industries, Inc. exceed the purchase price of the shipped materials.

9. ADDITIONAL INFORMATION

Neyra Industries, Inc. manufactures a full line of asphalt pavement maintenance and recreational surface products as well as application equipment sold and distributed nationally at our plants and through distributors and contractors. To find the supplier most convenient to you, please contact us.

NEYRA

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10700 Evendale Drive
Cincinnati, Ohio 45241

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PERFORMANCE REQUIREMENTS

Property	*Results*
Penetration at 77^0 F	55 mm
Penetration at 0^0 F	28 mm
Flow at 140^0 F	0 mm
Resilience	60% min.
Elongation at 77^0 F	600%
Bond Test	Pass 100% extension at 0^0 F
Asphalt Concrete Compatibility	Compatible

DESCRIPTION
Clear Cure VOC J7WB is a VOC compliant, water based clear resin dissipating curing compound. Clear Cure VOC J7WB is a true curing membrane meeting ASTM C309. Clear Cure VOC J7WB provides excellent curing properties for newly placed concrete and is easier to remove than most curing membranes from concrete once curing is completed.

USE
Clear Cure VOC J7WB is designed to be used on freshly finished concrete as a membrane forming curing compound for both horizontal/vertical surfaces as well as interior/exterior applications. Clear Cure VOC J7WB will, when properly applied, maintain moisture required for proper hydration of the cement.

FEATURES
- Meets ASTM C309
- VOC compliant in all areas
- May contribute to LEED credits
- Dissipation normally begins within 7-10 days
- Easier removal than most other membrane forming curing compounds
- Does not interfere with adhesion of subsequent surface treatments once removed
- Tested and Certified by WQA to NSF/ANSI 61

TESTED AND CERTIFIED UNDER INDUSTRY STANDARDS Water Quality

PROPERTIES
Meets: ASTM C-309, AASHTO M148 Type I, Class A & B

Drying time:
Approximately 4 hours at 70°F (21°C), when tested in accordance with ASTM C309.
Dry time may be extended in cool and/or humid conditions.

VOC
Complies with all applicable VOC standards.
VOC < 100 g/L

Estimating Guide
200 ft²/gal. (4.9 M²/L) on exterior broom finished concrete
400 ft²/gal. (9.8 M²/L) on interior concrete or all smooth, tightly finished concrete.

Packaging

PRODUCT CODE	PACKAGE	SIZE	
		Gallons	Liters
143953	Pail	5	18.9
143954	Drum	55	208.2
143955	Tote	275	1041

STORAGE
Store in tightly sealed original factory containers. Prevent water and dirt accumulation from tops of containers. Keep from freezing. Shelf life in unopened containers is 18 months from date of manufacture.

Mixing:
Stir thoroughly prior to use. Do not thin.

Placement:
Apply immediately after all surface (bleed) water has disappeared and the surface cannot be marred. Do not delay in applying the curing compound! Spray application is recommended. Small areas may be roller or brush applied. Clear Cure VOC J7WB must be applied uniformly and at the recommended coverage rates. Spray equipment must be capable of atomizing the product into a fine spray mist. Use a fine spray tip and keep equipment under constant even pressure. Apply uniformly without puddling. For vertical applications, apply two light coats. Apply the second coat while the first coat is still wet. Apply even coats avoiding run-downs or streaks. Properly applied, Clear Cure VOC J7WB will normally begin to dissipate and wear off within 7-10 days after application. At this time product can be removed with water under pressure, using scrubbing equipment or with Dayton Superior Citrus Cleaner J48. The ease of cleaning or the amount of time required for full dissipation is dependent upon application rate, environmental conditions and the amount of sunlight and traffic wear the surface receives. Clear Cure VOC J7WB will dissipate indoors, however dissipation will be slower indoors than outdoors as UV light will accelerate dissipation. Failure to uniformly apply the material in the manner described above may result in longer dissipation times and be harder to remove. Failure to apply uniformly may also result in the concrete having a blotchy appearance due to uneven curing.

Dry time may be extended in cool and/or humid conditions, especially on interior applications. Applying too heavy of an application may result in material remaining tacky for an extended period of time.

APPEARANCE

Creamy Tan colored liquid. Dries from clear to white depending on application rate, timing and ambient conditions. May undergo color changes during dissipation. As dissipation occurs dust may be present on the surface. Concrete will be its natural color upon complete dissipation and removal of the Clear Cure VOC J7WB.

CLEAN UP

For tools and equipment use warm soapy water prior to the material drying. After the product dries, use of a Dayton Superior Citrus Cleaner J48 or organic solvent, such as xylene, may be necessary to remove the product.

LIMITATIONS

This product is certified to NSF/ANSI 61 standard at a maximum surface area to volume ratio not to exceed 7.5 sq. in./L which corresponds to a tank capacity size of 500 gallons. Product may be used on tank sizes greater than or equal to 500 gallons.

FOR PROFESSIONAL USE ONLY

If surface receiving the curing membrane is to receive subsequent surface treatment or flooring, surface should be checked to ensure complete dissipation has occurred. Any residual membrane should be removed. Always consult with manufacturer of subsequent treatment for any additional surface preparation they may require.

Do not apply at temperature below 40°F (4°C). Cool, damp conditions and/or over-application may extend drying and dissipation time. When moisture-sensitive flooring is to be applied to the concrete treated with this product first refer to ACI 302.2R

PRECAUTIONS

READ SDS PRIOR TO USING PRODUCT

- Use with adequate ventilation
- Wear protective clothing, gloves and eye protection (goggles, safety glasses and/or face shield)
- Keep out of the reach of children
- Do not take internally
- In case of ingestion, seek medical help immediately
- May cause skin irritation upon contact, especially prolonged or repeated. If skin contact occurs, wash immediately with soap and water and seek medical help as needed.
- If eye contact occurs, flush immediately with clean water and seek medical help as needed
- Dispose of waste material in accordance with federal, state and local requirements

MANUFACTURER

Dayton Superior Corporation
1125 Byers Road
Miamisburg, OH 45342
Customer Service: 888-977-9600
Technical Services: 877-266-7732
Website: www.daytonsuperior.com

WARRANTY

Dayton Superior Corporation ("Dayton") warrants for 12 months from the date of manufacture or for the duration of the published product shelf life, whichever is less, that at the time of shipment by Dayton, the product is free of manufacturing defects and conforms to Dayton's product properties in force on the date of acceptance by Dayton of the order. Dayton shall only be liable under this warranty if the product has been applied, used, and stored in accordance with Dayton's instructions, especially surface preparation and installation, in force on the date of acceptance by Dayton of the order. The purchaser must examine the product when received and promptly notify Dayton in writing of any non-conformity before the product is used and no later than 30 days after such non-conformity is first discovered. If Dayton, in its sole discretion, determines that the product breached the above warranty, it will, in its sole discretion, replace the non-conforming product, refund the purchase price or issue a credit in the amount of the purchase price. This is the sole and exclusive remedy for breach of this warranty. Only a Dayton officer is authorized to modify this warranty. The information in this data sheet supersedes all other sales information received by the customer during the sales process. THE FOREGOING WARRANTY SHALL BE EXCLUSIVE AND IN LIEU OF ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, INCLUDING WARRANTIES OF MERCHANTABILITY AND FITNESS FOR A PARTICULAR PURPOSE, AND ALL OTHER WARRANTIES OTHERWISE ARISING BY OPERATION OF LAW, COURSE OF DEALING, CUSTOM, TRADE OR OTHERWISE.

TECHNICAL DATA SHEET

Dayton shall not be liable in contract or in tort (including, without limitation, negligence, strict liability or otherwise) for loss of sales, revenues or profits; cost of capital or funds; business interruption or cost of downtime, loss of use, damage to or loss of use of other property (real or personal); failure to realize expected savings; frustration of economic or business expectations; claims by third parties (other than for bodily injury), or economic losses of any kind; or for any special, incidental, indirect, consequential, punitive or exemplary damages arising in any way out of the performance of, or failure to perform, its obligations under any contract for sale of product, even if Dayton could foresee or has been advised of the possibility of such damages. The Parties expressly agree that these limitations on damages are allocations of risk constituting, in part, the consideration for this contract, and also that such limitations shall survive the determination of any court of competent jurisdiction that any remedy provided in these terms or available at law fails of its essential purpose.

EUCO #452 EPOXY SYSTEM

ASTM C 881 Compliant, High Modulus Adhesive

Description

EUCO #452 EPOXY SYSTEM is a 100% reactive, 2 component material designed as a moisture insensitive adhesive and binder for numerous application needs. This high modulus material is available in a low viscosity (LV), medium viscosity (MV) or GEL consistency. EUCO #452 provides normal working times when bonding concrete at temperatures above 40°F (4°C).

Primary Applications

- Bonding concrete, steel, ceramic or wood
- Anchoring bolts, dowels, and pins
- General adhesive needs
- Bonding concrete toppings
- GEL formulations are used for vertical and overhead bonding, anchoring, and repair
- Filling cracks in concrete and masonry

Features/Benefits

- Moisture insensitive for bonding to dry or damp surfaces
- Bonds fresh concrete toppings to hardened concrete slabs
- Forms a tough, wear and chemical resistant coating for industrial floor slabs
- May be extended with sand or aggregate for thick applications and mortar repairs
- Designed for use at temperatures of 40°F (4°C) and above
- Can contribute to LEED points

Technical Information

Property	#452 LV	#452 MV	#452 Gel	#452 Cartridge MV	#452 Cartridge Gel
Gel Time	30 minutes	30 minutes	30 minutes	6 to 8 minutes	30 minutes
Working Time	90 minutes	90 minutes	90 minutes	10 to 20 minutes	90 minutes
Bond Strength	3,200 psi (22 MPa)	2,500 psi (17 MPa)	2,000 psi (14 MPa)	2,200 psi (15 MPa)	2,230 psi (15 MPa)
Water Absorption	0.15%	0.081%	0.4%	0.36%	0.31%
Compressive Modulus	397,600 psi (2,741 MPa)	321,664 psi (2,218 MPa)	265,000 psi (1,827 MPa)	378,000 psi (2,606 MPa)	285,000 psi (1,965 MPa)
Compressive Strength	11,360 psi (78 MPa)	12,890 psi (89 MPa)	10,000 psi (69 MPa)	10,900 psi (75 MPa)	10,200 psi (70 MPa)
Appearance, Mixed	Gray	Gray	Gray	Amber-Clear	Gray

Properties shown were determined at laboratory conditions.

Packaging

EUCO #452 epoxies are two part systems. Bulk packaged material is mixed at a 2 to 1 ratio by volume, Part A to Part B. The units are pre-proportioned and packed in 3 gal (11.4 L) units and 1 gal (3.8 L) units. EUCO #452 MV & GEL is also available in 12/22 fl. oz cartridges (0.7 L) mixed at a 1:1 ratio. Cartridges yield 37 in^3 of epoxy.

Shelf Life

2 years in original, unopened package.

Specifications/Compliances

EUCO #452 LV complies with ASTM C 881 Types I, II, IV, and V, Grade 1, Class B and C.

EUCO #452 MV complies with ASTM C 881 Types I, II, IV, and V, Grade 2, Class B and C.

EUCO #452 GEL complies with ASTM C 881 Types I, II, IV, and V, Grade 3, Class B and C.

EUCO #452 CARTRIDGE MV complies with ASTM C 881 Types I and IV, Grade 1, Class A, B, and C.

EUCO #452 CARTRIDGE GEL complies with ASTM C 881 Types I, II, IV, and V, Grade 3, Class B and C.

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Phone: [216] 531-9222 • Toll-free: [800] 321-7628 • Fax: [216] 531-9596
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Coverage

EUCO #452 LV: 125 ft²/gal (3.1 m²/L) for priming/sealing

25 ft²/gal (0.6 m²/L) for 1/4" (6 mm) mortars

EUCO #452 MV: 100 ft²/gal (2.5 m²/L) for bonding toppings

20 ft²/gal (0.5 m²/L) for 1/4" (6 mm) mortars

EUCO #452 GEL: 60 ft²/gal (1.5 m²/L) for bonding toppings

15 ft²/gal (0.4 m²/L) for 1/4" (6 mm) mortars

Note: Coverage will vary with concrete surface texture, temperature, and the gradation of sand used for mortars. Coverage rates shown are approximate.

Directions for Use

Surface Preparation: New concrete must be a minimum of 28 days old and possess an open, porous and textured surface with all curing compounds and sealers removed. Old concrete must be clean and well textured. All oil, dirt, debris, paint and unsound concrete must be removed. The surface should be prepared mechanically using equipment that will give a surface profile commensurate with the application. The final step in cleaning should be the complete removal of all residue with a vacuum cleaner or pressure washer.

Bulk Mixing: All materials should be in the proper temperature range of 60°F (16°C) to 90°F (32°C). Mix parts A and B (resin & hardener) using a drill and mixing prop. The epoxy must be well mixed to a uniform color with no streaking in order to ensure proper chemical reaction. If aggregate is to be added, the aggregate is added to the epoxy after the part A and part B have been premixed together. Place immediately.

Application: (Priming, Bonding Or Sealing): Use either Low Viscosity or Medium Viscosity formulations in these applications. Apply material by roller, brush, or squeegee in a uniform fashion. Do not allow the material to puddle. Extremely porous surfaces may require a second coat for proper ultimate performance.

Priming & Bonding: If using EUCO #452 as a bonding agent for a cementitious topping, place the topping on the EUCO #452 while the epoxy is still wet. If the epoxy has become "tacky" to the point where it is no longer a sticky liquid, a fresh coat of EUCO #452 must be applied before the topping is placed.

Sealing: If a second coat of EUCO #452 is to be placed on the concrete, the first coat should be slightly tacky (4 to 10 hours old) when the second coat is applied. A slip resistant surface can be created by broadcasting silica sand (20 to 50 mesh) into the coating and then backrolling to embed the sand.

Repair Mortars: Repair mortars can be made with these products by adding aggregate. Size, gradation and the amount of aggregate will be determined by the application. The surface should be primed with EUCO #452 LV prior to application of the repair mortar. Mix the epoxy unit (Part A with Part B) prior to adding the aggregate. Trowel the mortar into place. If the surface is too rough, a topcoat of either EUCO #452 LV or MV can be applied.

Cartridge Epoxy Application Instructions: Remove cap and divider plugs. Attach mixer tip and dispense epoxy with smooth, constant pressure. Discard epoxy until a uniform, streak-free color is achieved. **Anchor installation:** Insert the static mixer tip and fill hole from the bottom, slowly withdrawing the tip as the epoxy is dispensed until the hole is approximately half full. Insert the anchor with a slow, twisting motion to ensure complete epoxy contact with no air voids. Stabilize anchor until epoxy is cured.

Clean-Up

Clean tools and equipment with solvent such as EUCO SOLVENT, xylene, or acetone before the epoxy hardens.

Precautions/Limitations

- This product may vary in color and may yellow and chalk in prolonged exposure to sunlight.
- Bring materials as close to 70°F (21°C) as possible. Store in room temperature environment 24 hours prior to use. Do not heat with open flame.
- Store indoors at 45°F to 110°F (7°C to 43°C).
- Epoxy components may cause skin irritation.
- Do not apply over freestanding water.
- Do not apply over hardened primer or old epoxy without proper surface preparation.
- Not recommended for use as a surface sealer over new concrete less than 30 days old.
- Not recommended for use when base concrete is at a temperature under 40°F (4°C).
- In all cases, consult the Material Safety Data Sheet before use.

Rev. 5.11

Construction

Sikasil®-728 SL

Self-leveling, ultra low-modulus, highway/parking garage, neutral cure silicone sealant

Description

Sikasil-728 SL is a self-leveling, one-component, ultra low modulus, elastomeric, neutral cure silicone sealant. Meets the requirements of ASTM D-5893; ASTM C-920, Type S, Grade P, Class 100/50; Use T, M, G, A, O with an ultra low Shore Hardness; TT-S-00230C, Type I, Class A; TT-S-001543A, Class A.

Where to Use

Construction Application

- Highway joints
- Bridges
- Stadiums
- Parking garages
- Plaza decks
- Driveways
- Decks
- Expansion joints
- Saw cut joints

Substrate

- Concrete, steel, glass, aluminum, tile, ceramic, masonry, asphalt, brick, stone and granite

Advantages

- No tooling, less labor
- Durable
- Ideal for cold climates
- Excellent flexibility for extreme high and low temperature conditions
- Excellent flexibility for dynamic joint movement
- Bonds to most substrates without priming including aged asphalt and concrete
- Ready to use
- All season ease of application
- Good contact/adhesion with hard to reach areas
- Excellent for use on runways and tarmacs
- Jet fuel resistant
- Resistant to road salts

Packaging

4.5 gal (17 L) in a 5 gal pail; 52 gal (197 L) in 55 gal drum; 29 oz. cartridges/12 per case.

Typical Data

RESULTS MAY DIFFER BASED UPON STATISTICAL VARIATIONS DEPENDING UPON MIXING METHODS AND EQUIPMENT, TEMPERATURE, APPLICATION METHODS, TEST METHODS, ACTUAL SITE CONDITIONS AND CURING CONDITIONS.

Shelf Life — 12 months in original unopened container. A product skin may form in pails and drums, remove prior to use.

Storage Conditions — Store in unopened containers at temperatures at or below 90°F (32°C).

Colors — Limestone and Charcoal Gray.

Uncured Properties at 77°F (25°C), 50% R.H.

Cure Time (MNA Method)		1/16" / 24 hours
Skin-over Time (MNA Method)		60 min.
Tack Free Time (ASTM C-679)		115 min.
Extrusion Rate (ASTM C-1183 modified)		900 g/min. 1/8" orifice @ 90 psi
Rheological, Vertical (ASTM C-639)		self-leveling @ 120°F (49°C)
VOC Content		2.27% by wt., 29 g/L, 0.24 lbs/gal
Service Temperature		-80° to 350°F (-62.2° to 176.6°C)

Cured Properties after 7 days at 77°F (25°C), 50% R.H.

Movement Capability (ASTM C-719)		+100%, -50%
Elongation at Break (ASTM D-412)		1100%
Hardness	**Shore OO (ASTM C-661 & ASTM D-2240)**	40
	Shore A (ASTM C-661 & ASTM D-2240)	3-5
Stress at 100% (ASTM D-412)		30 psi (0.21 MPa)
Peel Strength (ASTM C-794)		25 pli
Tensile Strength (ASTM D-412)		100 psi (0.69 MPa)
Bond Durability on glass, (ASTM C-719) aluminum and concrete		+100%, -50%
Weathering Resistance		Excellent

Test results are averages obtained under laboratory conditions. Reasonable variations can be expected.

Sika®

Construction

Coverage

29 oz Cartridge: Yield in Linear feet			
Width \ Depth	1/4"	3/8"	1/2"
1/4"	69.8		
3/8"	46.5	31.0	
1/2"	34.9	23.3	17.4
3/4"	23.3	15.5	11.6
1"			8.7
1.25"			7.0
1.5"			5.8

1 gallon: Yield in Linear feet			
Width \ Depth	1/4"	3/8"	1/2"
1/4"	307.9		
3/8"	205.3	136.8	
1/2"	153.9	102.6	77.0
3/4"	102.6	68.4	51.3
1"			38.5
1.25"			30.8
1.5"			25.7

How to Use

Surface Preparation

Joint Design: The number of joints and the joint width should be designed for a recommended joint movement of +25% and -25% at time of installation. The depth of the sealant should be 1/2 the width of the joint. The maximum depth is 1/2 inch (13 mm) and the minimum is 3/8 inch (10 mm). For joints greater than 1 inch (25.4 mm), do not exceed 1/2 inch (13 mm) in depth.

Joint Backing: To control joint depth, use closed cell polyethylene or non-gassing polyolefin backer rod. If joint depth does not allow for backer rod, use polyethylene bond breaker tape to prevent three-sided adhesion. Closed cell backer rod should be 25% larger than joint width; do not compress more than 40%.

The substrate must be clean, dry, frost free, sound and free of any oils, greases or incompatible sealers, paints or coatings that may interfere with adhesion.

Porous Substrates – clean by mechanical methods to expose a sound surface free of contamination and laitance.

Non-porous substrates – for cleaning non-porous substrates, use two rag wipe method using xylene or an approved commercial solvent. Allow solvent to evaporate prior to sealant application.

Sikasil-728 SL is designed to obtain adhesion without the use of a primer; however, best results are obtained when horizontal joints are primed. Test by applying the sealant and/or primer sealant combination to confirm results and proposed application methods. Refer to Technical Data Sheet for Sikasil Primer and contact Technical Service for additional information.

Application

Ready to use, apply using professional caulking gun or dispensing equipment. Do not open product container until preparation work has been completed. Apply sealant using consistent, positive pressure to force sealant into the joint. Apply the sealant so that it is recessed 1/8 inch (3 mm) below the surface. For parking deck joints, recess 1/4 inch (6 mm). For highway joints, recess 1/2 inch (13 mm). Sikasil-728 SL is self leveling therefore, no tooling is needed. It is typical that 728 SL may retain some residual surface tack in its first 10-14 days of cure. This condition does not affect the time the surface joint can be open to service in a properly recessed sealant joint. Sikasil-728 SL will obtain adhesion to aged, cured asphalt. Never use on newly poured asphalt. Conduct a field test to document and confirm adhesion under actual jobsite conditions.

Removal

Remove excess sealant from substrate while uncured using a commercial solvent, such as xylene. Strictly follow solvent manufacturer's instructions for use and warnings. Cured sealant may be removed by mechanical means. Cured sealant can only be removed by mechanical means.

Limitations

- Do not allow sealant to come in contact with solvent during cure.
- Do not allow sealant to come in contact with curing polyurethane sealants during cure.
- Not intended for immersion.
- Sealant may be applied below freezing temperatures if substrates are completely dry, frost free and clean. Contact Technical Service for more information.
- Not intended for structural glazing.
- Test recommended for absorptive surfaces such as granite, limestone or marble where staining may occur.
- Do not apply to surfaces that will be painted.
- Do not apply to substrates that bleed oil, plasticizers or solvent.
- Do not apply to damp or wet substrates.
- Lower temperature and humidity will extend tack free and cure rates.
- Allow treated wood to age six months before application.
- Brass and copper may be discolored. Test apply prior to application.
- Test sensitive substrates for compatibility before use.
- Due to the very low tensile strength of asphalt and possibility that asphalt may fail cohesively within itself, Sikasil 728 SL is not recommended for asphalt to asphalt joints.

Visit our website at usa.sika.com **1-800-933-SIKA NATIONWIDE**

Regional Information and Sales Centers. For the location of your nearest Sika sales office, contact your regional center.

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Carretera Libre Celaya Km. 8.5
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Responsible Care
ISO 9001
RC 14001

GSB-88

Product Description:

GSB-88® Emulsified Sealer/Binder is a chemically engineered asphalt preservation product comprised of a cationic emulsion with our Modified Sealer Binder, rejuvenators and specially selected plasticizers. This chemical colloid stabilized emulsion has been specifically formulated for sealing asphalt parking lots, city streets, roads, highways, airport aprons, taxiways, and runways. GSB-88® provides a durable yet flexible seal coat, while special plasticizers and oils penetrate the service binders. The result is an emulsified sealer/binder that restores vital components to asphalt which are lost during the aging and oxidation process, providing a long wearing anti-oxidative seal. GSB-88® also helps to rebind the surface and thereby mitigate raveling issues. It dries to an absolute black color, which beautifies the pavement surface and provides tangible cosmetic benefit. Furthermore, GSB-88® has achieved Green Circle Certification®, which compares the lifespan of a standard asphalt road without GSB-88® treatments and a road with GSB-88® treatments.
(Reference: Environmental Product Declaration)

Specifications:

GSB-88® is available in either a concentrate or ready to use form. The concentrate form allows large shipments via tank truck, ISO container, and flextank or railroad tank car. The concentrate form must be diluted with hot water prior to application.

Specifications for GSB-88® Concentrate are as follows:

Saybolt Viscosity at 77°F (25°C) ASTM D-244	- - - -	20 to 100 seconds
Residue by Distillation, or Evaporation	- - - -	57% min.
Sieve test ASTM D-244 (one tenths of one %)	- - - -	0.1%
5 day Settlement test ASTM D-244	- - - -	5.0% max.
Particle charge (1) ASTM D-244	- - - -	Positive

Specifications for GSB-88® Ready-to-Apply

ONE PART EMULSION TO ONE PART WATER

Saybolt Viscosity at 77°F (25°C) ASTM D-244	- - - -	10 to 50 sec.
Residue by Distillation, or Evaporation	- - - -	28.5 minimum
Pumping Stability test (2)	- - - -	Pass

TWO PARTS EMULSION TO ONE PART WATER

Saybolt Viscosity at 77°F (25°C) ASTM D-244	- - - -	10 to 50 sec.
Residue by Distillation, or Evaporation	- - - -	37.5 minimum
Pumping Stability test (2)	- - - -	Pass

Tests on Residue from Distillation, or Evaporation

Viscosity astm 275°F (135°C) ASTM D-4402	- - - -	1750 cts max.
Solubility in 1,1,1 trichloroethylene ASTM D-2042	- - - -	97.5% min.
Penetration ASTM D-5	- - - -	50 dmm max.
Asphaltenes ASTM D-2007	- - - -	15% min.
Saturates ASTM D-2007	- - - -	15% max.
Polar Compounds ASTM D-2007	- - - -	25% min.
Aromatics ASTM D-2007	- - - -	15% min.
Modified Sealer Binder Content	- - - -	20% min

(1) pH may be used in lieu of the particle charge test which is sometimes inconclusive in slow setting, bituminous emulsions.

(2) Pumping stability is tested by pumping 1 pint, (475 ml) of GSB-88® diluted 1 part concentrate to 1 part water, at 77°F (25°C), through a 1/4inch gear pump operating 1750 rpm for 10 minutes with no significant separation or coagulation.

Storage and Handling Instructions

GSB-88® is to be stored in vertical storage tanks and shall be handled like any standard asphalt emulsion. The storage tank should be equipped with a slow revolution mechanical agitator. Hot water heating coils, electrical coils, or electrical heaters are required in colder climates to prevent the emulsion from freezing. Positive displacement gear pumps should be used to transfer and apply GSB-88® materials. Storage and handling temperature are 50°F (10°C) to 160°F (71oC). GSB-88® should be protected from freezing, or whenever outside temperature drops below 40°F (4°C) for prolonged time periods.

Application Instructions

Equipment: GSB-88® is to be applied with standard bituminous distributors. The equipment must be in good working order, and contain no contaminants or dilutents in the tank. Spreader bar tips must be clean, free of burrs, and adjusted for regulated flow. Any type of tip or pressure source is suitable that will maintain predetermined flow rates and constant pressure during the application process. The equipment should be tested under pressure for leaks and to insure it is in working order before use. No special mixing equipment is necessary since GSB-88® concentrate may be easily diluted with water in the spreader tank.

Dilution: GSB-88® concentrate must be diluted with water. Water for mixing shall be potable, with a maximum hardness of 90ppm calcium and 15ppm magnesium, and deleterious iron, sulfates, and phosphates maximum 7ppm, and less than 1ppm of organic byproducts. Ideally water shall be softened. Water shall be minimum 140F prior to adding to emulsion and shall be within 10F of emulsion temperature. Emulsion shall be 140F to 180F prior to adding water. Always add the water to the concentrate emulsion, never add concentrate emulsion to the water. Two dilution rates are recommended as follows:

• 1 part GSB-88® to 1 part water for most applications is recommended.

• 2 parts GSB-88® to 1 part water for use on hills where run off may be of concern, or on very rough surface texture pavements.

Polymer Addition: The polymer shall be a vinyl acrylic polymer approved for use by Asphalt Systems Inc. Consult Asphalt System's Technical Representative for specific details.

Rate of spread is normally determined by the texture, porosity, and age of the asphalt pavement to be sealed. Application rate can vary from 0.08 to 0.15 gallons per square yard (0.36 to 0.68 Liters to Square Meter). For 2:1 dilution, 0.08 to 0.12 gallons per square yard (0.36 to 0.54 Liters to square meter) is recommended. For 1: 1 dilution, 0.10 to 0.15 gallons per square yard (0.46 to 0.68 Liter to square meter) is recommended. Exceeding recommended application rates is not recommended without consulting Asphalt System's Technical Representative.

Cure Time: Expected cure times with proper applications should generally range from 2-4 hours depending upon local climatic conditions (humidity, surface temperature, daytime/ nighttime application, spread rates and dilution, etc). Sheltered or shady areas may require longer cure times.

Application Precautions

GSB-88® is not to be applied to wet or damp pavement surfaces. Do not apply during rainy or damp weather, or when rain is anticipated within 8 hours after application is completed. Pavement surface temperatures should be 50°F (10°C) and rising before application of GSB-88® is applied. At least three hours of daylight should remain after completion of the application. The Emulsion temperature for application should be 130oF, but not exceed 160oF. GSB-88® should not be applied on extremely windy days.

Caution should be taken when applying GSB-88® over existing coal tar treatments, as curing time and traffic readiness could be compromised, consult with Asphalt System's Technical Representative

Preparation of Pavement Surfaces: Repair and patch all major pavement defects. All cracks, other than hairline cracks, should be filled with suitable bituminous crack filler. Scrape all oil spots to remove excess oil and dirt. Just before applying GSB-88® clean the asphalt surface of all loose dust, dirt, and other debris.

Sanding: If needed, sanding should be done at the same time GSB-88® is applied to maintain adequate surface friction. A hard, highly fractured sand should be used. Because there are regional differences in sand characteristics, a knowledgeable local pavement maintenance engineer should be consulted to insure that the appropriate amount and type of sand is chosen to regain any lost skid resistance. Sanding is best done by mounting a sand slinger on the applicator and applying approximately 0.10 to 0.5 pounds of sand per square yard to achieve needed friction results. Consult Asphalt System's Technical Representative for specific details.

Striping: Striping should be done in two phases, the first phase is to be a 30% stripe after the GSB-88® has had sufficient time to cure. Final Striping should be done 30 days after the final application.

Maintenance: Under normal traffic conditions a single application of GSB-88® when properly applied, should not require reapplication for 3 to 5 years. Thereafter, additional applications of GSB-88® can be reapplied to extend the life of the pavement indefinitely.

Health and Safety: Consult the Safety Data Sheet (SDS) for GSB-88® fire and explosion data, health hazard data, first aid procedures, reactivity data, spill or leak procedures, waste disposal and use of personal protective equipment. Additional copies of the Safety Data Sheet (SDS) can be obtained by calling ASI at 801-972-6433.

D.S. BROWN®
A GIBRALTAR INDUSTRIES COMPANY

www.dsbrown.com

DSB Pourable Pavement Seals

DSB 800™ and DSB 900™ SL Silicone

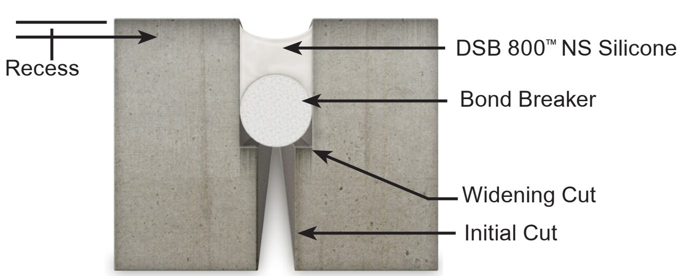
Pavements

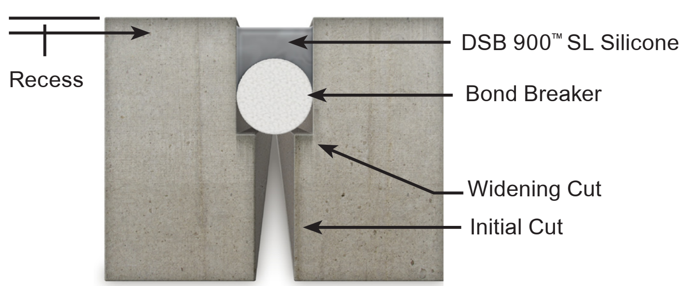
Meeting the Challenge

DSB 800™ and 900™ SL Silicones are formulated for highway, airport and parking structure joints where movement occurs. DSB 800™ and 900™ SL conforms to specifications for low modulus silicone for many highway departments and federal agencies.

Meets ASTM D5893 and FAA P-605

Typical Joint Designs*





*Drawings not to scale.

Bridge the World with Leading Infrastructure Solutions

DSB 800™ and DSB 900™ SL Silicone

DSB 800™ and 900™ SL meet ASTM D5893 and FAA P-605. They are supplied as a ready-to-use, one-component moisture-curing system that provides a lasting and flexible seal. They offer outstanding weathering resistance, remain flexible down to temperatures as low as -50°F (-46°C), are jet-blast resistant and will maintain field serviceability when exposed to intermittent fuel and oil spills. It bonds strongly without the use of a primer. DSB 800™ and 900™ SL are easily applied to joints using bulk dispensing systems.

Packaging

DSB Silicones weigh approximately 11 pounds per gallon. DSB 800™ and 900™ SL are conveniently packaged in three different options:

- 29-ounce tubes
- 5-gallon pails
- 50-gallon drums

DSB 800™ Silicone

DSB 800™ Silicone is a uniquely formulated low modulus non-sag product produced for sealing joints in Portland Cement Concrete pavements in all climates.

DSB 900™ SL Silicone

DSB 900™ SL is a low modulus silicone which offers the performance and durability characteristics of conventional silicone with the ease of installation of self-leveling materials in both concrete and concrete to asphalt joints in all climates.

Properties of DSB 800™ Silicone

ASTM D5893 Physical Requirements	ASTM D5893 NS Requirements	DSB 800™ Requirements
Cure Evaluation	Pass at 21 days	Pass at 14 day max.
Rheological Properties (ASTM D2202)	0.30 in (7.6mm) max. slump	0.30 in (7.6mm) max. slump
Extrusion Rate (ASTM C1183)	Type S, 50 ml/min. minimum	Type S, 50 ml/min. minimum
Tack Free Time (ASTM C679)	5 hr. max.	25-90 minutes
Effects of Heat Aging (ASTM C792)	10% max. loss	10% max. loss
Bond, -29°C (-20°F), 100% extension		
Non-Immersed	Pass 5 Cycles	Pass 5 Cycles
Water Immersed	Pass 5 Cycles	Pass 5 Cycles
Oven-Aged	Pass 5 Cycles	Pass 5 Cycles
Hardness (ASTM C661)		
-29°C (-20°C), Type A2	25 max.	20 max.
23°C (73°F), Type 00	30 min.	30 min.
Flow	No flow	No flow
Rubber Properties in Tension		
Ultimate Elongation	600% min.	800% min.
Stress at 150% Elongation	310 K pa (45 psi) max.	310 K pa (45 psi) max.
Effects of Accelerated Weathering	Pass at 500 hours	Pass at 5000 hours
Resilience	75% min.	75% min.

Properties of DSB 900™ SL Silicone

ASTM D5893 Physical Requirements	ASTM D5893 NS Requirements	DSB 900™ Requirements
Cure Evaluation	Pass at 21 days	Pass at 21 day max.
Rheological Properties (ASTM C63)	Type 1, smooth level surface	Type 1, smooth level surface
Extrusion Rate (ASTM C1183)	Type S, 50 ml/min. minimum	Type S, 200 ml/min. minimum
Tack Free Time (ASTM C679)	5 hr. max.	3 hr. max.
Effects of Heat Aging (ASTM C792)	10% max. loss	10% max. loss
Bond, -29°C (-20°F), 100% extension	Pass 5 Cycles	Pass 5 Cycles
Non-Immersed	Pass 5 Cycles	Pass 5 Cycles
Water Immersed	Pass 5 Cycles	Pass 5 Cycles
Oven-Aged	Pass 5 Cycles	Pass 5 Cycles
Hardness (ASTM C661)		
-29°C (-20°C), Type A2	25 max.	10 max.
23°C (73°F), Type 00	30 min.	40-80 min.
Flow	No flow	No flow
Rubber Properties in Tension		
Ultimate Elongation	600% min.	800% min.
Stress at 150% Elongation	310 K pa (45 psi) max.	207 K pa (30 psi) max.
Effects of Accelerated Weathering	Pass at 500 hours	Pass at 5000 hours
Resilience	75% min.	75% min.

Additional Properties: DSB 800™ Silicone

Specific Gravity (ASTM D792-A)(1)	1.15-1.515
Adhesion to Concrete (MIL 8802)(2)	20 pli (3.5 kg/cm) min.
Bond and Movement Capability +/-50% (ASTM C719)(2)	Pass 10 cycles
Bond to Mortar (AASHTO T132)(2)	50 psi (34.4 N/cm2) min.
Tensile Adhesion, %(ASTM D5329)(3)	400% min.
Flame Resistance (SS-S-200)	Pass

Additional Properties: DSB 900™ SL Silicone

Specific Gravity (ASTM D792-A)(1)	1.10-1.40
Adhesion to Concrete (MIL 8802)(2)	20 pli (3.5 kg/cm) min.
Bond and Movement Capability +/-50% (ASTM C719)(2)	Pass 10 cycles
Bond to Mortar (AASHTO T132)(2)	50 psi (34.4 N/cm2) min.
Tensile Adhesion, %(ASTM D5329)(3)	600% min.
Flame Resistance (SS-S-200)	Pass

800™ and 900™ SL Silicone Notes

1. Specimens shall be obtained from 1/8 inch (3mm) thickness sheets of material which has been cured for 7 days at 77+/- 3°F (25+/- 2°C) and 50 +/- 5% relative humidity.
2. Specimens shall be cured for 28 days at 77 +/- 3°F (25 +/- 2°C) and 50 +/- 5% humidity prior to testing.
3. Specimens shall be 1⁄2" x 1⁄2" x 2" (1.2cm x 1.2cm x 5/0cm), cured 21 days at 77 +/- 3°F (25 +/- 2°C) and 50% +/- 5% relative humidity.

DSB 800™ and 900™ SL Silicone Installation Guide

Application

Product yield will vary depending on thickness of sealant, waste, application techniques, etc. For optimum performance, the width of the sealant bead should be approximately two times the depth. Sealant bead should be a minimum 1/4 inch (.6 cm) thick but no greater than 1/2 inch (1.2 cm) thick. For good adhesion, the joint interface must be sound, clean and dry.

Joint Design & Preparation for Sealing

After appropriate curing of the concrete (a minimum of 7 days is recommended) joint reservoirs for the sealant can be cut into the concrete using appropriate concrete sawing procedures and equipment. In "fast track" or high-early strength concrete mixes, it may be possible to saw and seal the joints sooner than the recommended 7-day minimum for standard concrete mixes. Contact D.S. Brown or your representative for further details.

After sawing, immediately flush the joints with water to remove a majority of the saw slurry. After the joints have dried, just prior to applying sealant, the remaining residue must be removed by sandblasting. Both joint faces must be adequately sandblasted to remove remaining traces of sawing residue. For effective sandblasting, the nozzle should be positioned within 2 inches (5 cm) of the surface being cleaned.

After sandblasting, the joint should be thoroughly cleaned using clean compressed air with a minimum pressure of 90 psi. Moisture and oil traps are required on the compressor unit. The object of the above cleaning operations is to provide vertical, intact and clean bonding surfaces which are free from all contaminants and are dry. Joints should be carefully inspected to assure that an appropriate level of cleanliness has been achieved. This can be accomplished by rubbing your finger along each joint face. If any evidence of dust and contaminants occurs, additional sandblasting should be performed until all dust and contaminants are removed. Alternate cleaning methods that accomplish the same level of cleaning as sandblasting may be considered. Contact D.S. Brown for approval of alternate cleaning methods. Non-water absorptive backer rod of the size specified in Table 1 shall be placed in the joint to the depth listed in Table 1. Do not puncture backer rod during installation because damage can create bubbling in sealant.

Reservoir depths for various joint widths are shown in Table 1. Joint width should be selected to limit movement due to expansion and contraction to no more than 25% of the joint width.

Sealant Application

DSB 900™ SL Silicone sealant is applied to pavement joints using air-powered bulk dispensing systems or standard caulking guns. The applicator unit must be free of all residue left from other brands or types of materials to eliminate contamination and assure proper sealant performance. During application, the sealant is dispensed directly from its container through the applicator hose, wand and nozzle and into the prepared joint. The joint should be filled from the bottom up. DSB 900™ SL Silicones are self-leveling and do not require tooling.

DSB 800™ Silicone NS sealants are not self-leveling, and must be tooled to the proper geometry. Tooling must be accomplished before the sealant forms a surface skin of cured material. (Tool preferably within 5 minutes

Table 1.

*Joint Width	1/4"	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1-1/8"	1-1/4"	1-3/8"	1-1/2"
Minimum Sealant Recess	1/4"	1/4"	5/16"	5/16"	3/8"	3/8"	3/8"	1/2"	1/2"	1/2"	1/2"
Backer Rod Diameter[1]	3/8"	1/2"	5/8"	3/4"	7/8"	1"	1-1/4"	1-1/2"	1-1/2"	1-3/4"	2"
Sealant Bead Thickness[2,3]	1/4"	1/4"	1/4"	5/16"	3/8"	7/16"	1/2"	1/2"	1/2"	1/2"	1/2"
Minimum Joint Saw/Reservoir Depth	1-1/8"	1-1/4"	1-1/2"	1-3/4"	1-7/8"	2"	2-3/8"	2"	2-7/8"	3-1/8"	3-3/8"
Minimum Backer Rod Depth	1/2"	1/2"	5/8"	11/16"	3/4"	13/16"	7/8"	1"	1"	1"	1"
Estimated Usage Non-Sag	245	149	112	70	51	35	26	23	18	16	15
Estimated Usage Self-leveling (ft/gal)	273	172	130	82	58	41	31	27	22	20	19

Notes

1. Backer rod diameter should not be varied from specified dimensions. If larger sizes are used, increased saw depth is needed.
2. Sealant bead thickness can vary ± 25% of design value.
3. Never install DSB Silicone to a depth greater than the joint width (1 to 1).

* Please contact The D.S. Brown Company for additional joint size design recommendations.

after application.) Tooling may be accomplished using a variety of tools including sections of backer rod or other appropriately shaped objects. Tooling should be performed so that the sealant is forced against the joint sidewalls and backer rod and so that the sealant forms a recessed concave surface. Minimum recess depths are listed in Table 1. If insufficient recess is achieved, the sealant surface may be exposed to vehicle tire contact and abrasion that can cause loss of adhesion.

Application Temperatures & Weather Conditions

During application, pavement and ambient temperature should be a minimum of 40°F (4°C) and the joints must be completely clean and dry for adhesion to fully develop. Sealing should not occur at temperatures below the dew point due to an increased chance of having moist or damp joints.

Sealant Curing

After application, DSB Silicone sealant will begin to cure and form a surface skin, generally within 30 minutes. Traffic should be kept off the sealed areas until the sealant is “tack free” as indicated by touching. DSB Silicone will cure approximately 14 days after application to form a strongly bonded, long-lasting seal.

Note: Air voids may develop with self-leveling sealant if the moisture content of the pavement and ambient temperature are high. This phenomenon generally occurs when the sealant has been applied to joints in green concrete during hot and humid conditions. Warm ambient temperatures accelerate pavement hydration and the release of moisture vapors. These moisture vapors will migrate through partially cured sealant creating air pockets. When the sealant has obtained a full cure, no bubbles will develop. A test section should be performed to determine if conditions are adequate so air voids do not develop. Using a non-sag silicone sealant will greatly reduce the risk of air pocket formation. Contact D.S. Brown for further information.

Resealing Joint Design & Preparation for Sealing

Old sealant should be removed by any appropriate method. After removal of old sealant, the joint is to be saw cut to an appropriate width to provide clean vertical bonding surfaces which are free from contamination by old sealant. As a general rule, the joint should be sawed to a width that is between 1/8 inch and 1⁄4 inch (3-6mm) wider than the original joint. The recess, sealant bead thickness, backer rod size and sawed joint depth shall meet requirements shown in Table 1 for the joint width used. The sandblasting, cleaning and sealing operations above shall then be followed.

Cleanup

Uncured sealant can be removed from equipment and tools with solvents such as naphtha or mineral spirits. All hoses and lines in the application equipment should be flushed immediately after use. Extra DSB Silicone in drums should be covered with the plastic liner to prevent exposure to air and the drums should be closed before storing until the next use.

Storage Life

Store DSB Silicone sealant out of direct sunlight, in a cool, dry location. Sealant should not exceed 90°F (32°C), or be exposed to excessive humidity. Storage life is approximately nine months from date of shipment.

Safety Precautions

Prior to use, please read the DSB Silicone Sealant Material Safety Data Sheet for establishing appropriate practices during use and application.

Warranty

The D.S. Brown Company warrants that DSB sealants meet applicable ASTM, AASHTO, federal or state specifications at time of shipment. Techniques used for the preparation of the cracks and joints prior to sealing are beyond our control as are the use and application of the sealants; therefore, The D.S. Brown Company shall not be responsible for improperly applied or misused sealants. Remedies against The D.S. Brown Company, as agreed to by The D.S. Brown Company, are limited to replacing nonconforming product or refund (full or partial) of purchase price from The D.S. Brown Company. All claims for breach of this warranty must be made within three (3) months of the date of use or twelve (12) months from the date of delivery by The D.S. Brown Company, whichever is earlier. There shall be no other warranties expressed or implied. For optimum performance, follow The D.S. Brown Company recommendations for sealant installation.



Silicone Installation, Fort Bliss, Texas

Product Information

Silicone Sealants

DOW CORNING

Dow Corning® 888 Silicone Joint Sealant

Non-sag silicone joint sealant for Portland cement concrete pavement joints.

FEATURES & BENEFITS

- Can be extruded from -20 to 120°F.
- May be used in joints that are not uniform in width.
- Movement capability 100% extension and 50% compression.
- Low modulus.
- Weather and UV resistant.
- Fuel resistant-short term exposure. Refer to Dow Corning form number 62-207 for more information.
- One component, cold applied, ready-to-use as supplied; dispensed directly from the bulk container into the joint by hand or with an air-powered pump.
- Unprimed adhesion – primer is not required for bonding to Portland cement concrete. For optimum adhesion, the surface must be clean, dry and frost-free.
- Cure time – typically, the sealant will have a skin-over time of one hour or less at standard conditions.

COMPOSITION

- One-part, cold applied, non-sag silicone sealant.

APPLICATIONS

- *Dow Corning*® 888 Silicone Joint Sealant can be used for concrete to concrete pavement joints.
- For use in new construction, repair or remedial applications. *Dow Corning* 888 Silicone Joint Sealant may be used to seal joints that are not uniform in width provided the movement capability of the sealant is not exceeded. May also be used in joints with minor spalling.

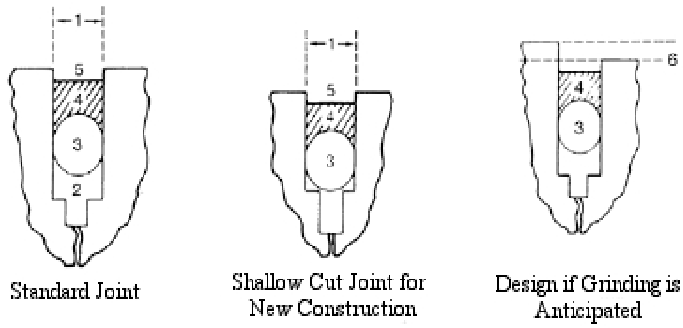
TYPICAL PROPERTIES

Specification Writers: These values are not intended for use in preparing specifications. Please contact your local Dow Corning sales office or your Global Dow Corning Connection before writing specifications on this product.

Test* - Property	Result	D 5893 Requirement
As Supplied		
Color	Gray	
ASTM D 2202, Slump	Pass	<0.30 inches
ASTM C 1183, Extrusion Rate, minimum	72 mL/min	20 mL/min
ASTM C 679, Tack Free Time	Pass	5 hours max
ASTM C 792, Heat Aging	3.05%	10% loss max
ASTM C 661, Durometer Shore A-2	15	25 maximum
ASTM C 792, Specific Gravity	1.48	
Cure Time, ½” x ½”x 2” (73°F, 50% R.H.)	Pass	21 day Cure
As Cured – 21 days at 25°C (77°F) and 50% RH		
Bond, Non-Immersed	Pass	No cracks or separation
Bond, Water Immersed	Pass	No cracks or separation
Bond, Oven Aged	Pass	No cracks or separation
ASTM D 412 (Die C), Ultimate Elongation	≥1000%	600% min
ASTM D 412 (Die C), Tensile Stress @ 150%	28 psi	45 psi max
ASTM C 793, Effects of Accelerate Weathering	Pass	5,000 hours
Resilience	77%	75% min
ASTM C719, Joint Movement Capability, +100/-50 percent, 10 cycles	No failure	

*ASTM: American Society for Testing and Materials.

<u>Figure 1:</u> Good Joint Design



1. Joint width wide enough to accommodate movement. (For additional information on joint width, see papers by Spells and Klosowski, "Silicone Sealants for Use in Concrete Construction," Vol. 1, No. 1, American Concrete Institute, SP-70, 1981; J.B. Cook, "Construction Sealants and Adhesives," Wiley-Interscience, 1970; and J.M. Klosowski, "Sealants in Construction," Marcel Dekker, 1989.).
2. Joint sawed deep enough to allow backer rod/sealant placement and space for pumping of old sealant compounds. NOTE: This applies to standard joints only; void space beneath backer rod in new construction is not needed.
3. Proper backer rod placement to prevent three-sided adhesion.
4. Sealant installed to proper depth and width.
5. Sealant recessed a minimum of 3/8 inch to 1/2 inch (9.53 mm to 12.7 mm) below pavement surface.
6. Depth of lowest slab determines the amount of recess required if grinding is anticipated; once grinding is complete, the sealant will have proper recess below the pavement surface.

DESCRIPTION

Dow Corning 888 Silicone Joint Sealant is a one-part, non-sag silicone material that cures to a low-modulus silicone rubber upon exposure to atmospheric moisture. Can be applied over a wide temperature range.

APPLICABLE STANDARDS

- ASTM D 5893 Type NS
- FAA P-605 for silicone joint sealants
- Meets SS-S-200E (section 4.4.12) Flame Test Requirements
- EN 14187-5 Hydrolysis Test

HOW TO USE

Please refer to the *Dow Corning Silicone Pavement Sealants Installation Guide*, form number 61-507.

HANDLING PRECAUTIONS

PRODUCT SAFETY INFORMATION REQUIRED FOR SAFE USE IS NOT INCLUDED IN THIS DOCUMENT. BEFORE HANDLING, READ PRODUCT AND MATERIAL SAFETY DATA SHEETS AND CONTAINER LABELS FOR SAFE USE, PHYSICAL AND HEALTH HAZARD INFORMATION. THE MATERIAL SAFETY DATA SHEET IS AVAILABLE ON THE DOW CORNING WEBSITE AT DOWCORNING.COM, OR FROM YOUR DOW CORNING SALES APPLICATION ENGINEER, OR DISTRIBUTOR, OR BY CALLING DOW CORNING CUSTOMER SERVICE.

USABLE LIFE AND STORAGE

Keep stored in original, unopened containers at or below 32°C (90°F). Refer to product packaging for "Use By" date. Keep containers tightly closed.

PACKAGING INFORMATION

Dow Corning 888 Silicone Joint Sealant is supplied in 29-fl oz (857-mL) dispos-able plastic cartridges, 4.5-gal (17-L) bulk pails, and 50-gal (189-L) bulk drums.

LIMITATIONS

Dow Corning 888 Silicone Joint Sealant is not recommended for continuous water immersion. It should not be applied in totally confined spaces where the sealant is not exposed to atmospheric moisture.

Not intended for use with asphalt.

The sealant should never be applied to wet or damp asphalt or concrete pavements or installed during inclement weather.

Dow Corning does not promote or warrant the use of *Dow Corning*® brand sealants in applications associated with spill containment areas of any kind.

This product is neither tested nor represented as suitable for medical or pharmaceutical uses.

SHIPPING LIMITATIONS

None.

HEALTH AND ENVIRONMENTAL INFORMATION

To support customers in their product safety needs, Dow Corning has an extensive Product Stewardship organization and a team of Product Safety and Regulatory Compliance (PS&RC) specialists available in each area.

2015, May 13
Form No. 61-408P-01

For further information, please see our website, dowcorning.com or consult your local Dow Corning representative.

LIMITED WARRANTY INFORMATION – PLEASE READ CAREFULLY

The information contained herein is offered in good faith and is believed to be accurate. However, because conditions and methods of use of our products are beyond our control, this information should not be used in substitution for customer's tests to ensure that our products are safe, effective, and fully satisfactory for the intended end use. Suggestions of use shall not be taken as inducements to infringe any patent.

Dow Corning's sole warranty is that our products will meet the sales specifications in effect at the time of shipment.

Your exclusive remedy for breach of such warranty is limited to refund of purchase price or replacement of any product shown to be other than as warranted.

TO THE FULLEST EXTENT PERMITTED BY APPLICABLE LAW, DOW CORNING SPECIFICALLY DISCLAIMS ANY OTHER EXPRESS OR IMPLIED WARRANTY OF FITNESS FOR A PARTICULAR PURPOSE OR MERCHANTABILITY.

DOW CORNING DISCLAIMS LIABILITY FOR ANY INCIDENTAL OR CONSEQUENTIAL DAMAGES.

We help you invent the future.™

dowcorning.com

Table 1: Recommended Backer Rod Installation (Shallow Cut)[1]

Measured in Inches						
Joint Width	1/4	3/8	1/2	3/4	1	>1
Recessed Below Surface	3/8	3/8	3/8 to 1/2	3/8 to 1/2	1/2+	Contact Dow Corning
Sealant Thickness	1/4	1/4	1/4	3/8	1/2	
Backer Rod Diameter	3/8	1/2	5/8	7/8	$1\frac{1}{4}$	
Total Joint Depth	$1\text{–}1\frac{1}{8}$	$1\frac{1}{8}\text{–}1\frac{1}{4}$	$1\frac{1}{4}\text{–}1\frac{3}{8}$	$1\frac{5}{8}\text{–}1\frac{3}{4}$	$2\frac{1}{4}\text{–}2\frac{3}{8}$	
Measured in Millimeters						
Joint Width	6	9	13	19	25	
Recessed Below Surface	9	9	9 to 13	9 to 13	13+	
Sealant Thickness	6	6	6	9	13	
Backer Rod Diameter	9	13	16	22	32	
Total Joint Depth	25–29	29–32	32–35	41–45	57–60	

[1]On road surfaces where grinding is planned at a later date, the sealant and backer rod should be installed so that sealant is approximately 3/8 inch (9.35 mm) below the road surface after grinding is complete. An additional small amount should be added to allow for surface imperfections on the bottom and to provide room for old sealant to pump up from below during rehabilitation work in the summer months.

2015, May 13
Form No. 61-408P-01

Appendix H – PAVERFieldInspector User Manual

User Manual

PAVERFieldInspector™ Version 1.3

January 2015

NEW DIMENSIONS IN PAVEMENT MAINTENANCE MANAGEMENT

US Army Corps of Engineers
Engineer Research and Development Center
Construction Engineering Research Laboratory

PAVERFieldInspector™ Development

Developed By

- U.S. Army Corps of Engineers

  Engineer Research and Development Center (ERDC)/

  Construction Engineering Research Laboratory (CERL), Champaign, Illinois

- Development Team:
  - U.S. Army Corps of Engineers

M. Y. Shahin Ph.D., P.E.	PAVER™ Program Manager
William Welborn P.E.	PAVER™ Principal Investigator
Lindsi Hammond E.I.	Civil Engineer

  - IIT Corp.

Arthur Baskin Ph.D.	System Designer
Ben Hartmann	Program Analyst

  - The PERTAN Group

Ryan Meisel P.E	Civil Engineer

Sponsors

- US Air Force
- US Army
- US Navy

Acknowledgments

Special thanks are due to the following engineers and program analysts for their important contribution to the testing, design input and preparation of the user manual; Mircea Manea (IIT Corp.), Mark Brown (IIT Corp.), Gay Hanson (IIT Corp.), Lindsey Cerda (The PERTAN Group) and Tamara Bushue (Colorado State University).

References

ASTM D5340, Standard Test Method for Airport Pavement Condition Index Surveys. ASTM D6433, Standard Practice for Roads and Parking Lost Pavement Condition Index.

Kohn, S.D. and Shahin, M.Y. (1984). Evaluation of the Pavement Condition Index for Use on Porous Friction Surfaces. Technical Report No. M-351, U.S. Army Construction Engineering Research Laboratory, Champaign, IL.

Shahin, M.Y., Darter, M.I., and Kohn, S.D. (1976-1977). Development of a Pavement Maintenance Management System, Vol. I-V. U.S. Air Force Engineering Service Center (AFESC), Tyndall AFB.

Shahin, M.Y. and Kohn, S.D. (1981). Pavement Maintenance Management For Roads and Parking Lots. Technical Report No. M-294. U.S. Army Construction Engineering Laboratory.

Shahin, M.Y. and Walther, J.A. (1994). Refinements of the PCI Calculation Procedure. U.S. Army Construction Engineering Research Laboratory, Champaign, IL.

Disclaimer

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Table of Contents

Introduction

What is PAVERFieldInspector™

PAVERFieldInspector™ is PAVER™ companion software that takes advantage of GIS/ GPS state of the art technology as well as innovative graphics to facilitate pavement inspection using handheld computer tablets. The program allows the user to identify his location on a pavement network map displayed on his/her tablet computer. As the user clicks on the section to be inspected, the program already knows all the section information and the user is ready for immediate data entry. As the user is entering pavement distress data, the PCI is being calculated and displayed to the inspector in real time and the program has built significant data entry validation tools to identify errors before they are recorded. When inspecting concrete pavement, the program allows the user to generate graphics of the individual concrete panels (slabs) and record identified distresses on each slab. These graphics are stored with the inspection and can be viewed later. When inspection is completed, the program generates an error free XML file for import into PAVER™. The program has wide applications especially for agencies with more than one evaluation team where each team is assigned to inspect different parts of the airfield and the data are later imported into the main copy of PAVER™.

What's new in this version?

Option to view PAVERFieldInspector™ in List or Tablet mode.
In Default Settings under the Preferences menu, the user may select either List or Tablet view. On the Edit Inspector form, List view shows the list of Distresses followed by severity buttons for low, medium, and high for each relevant distress. Tablet view shows the Distresses as large individual buttons with one set of buttons above for low, medium, and high. This view makes it easier to select the correct Distress and Severity in the Field. The Tablet view is not available for PCC distress entry due to the distress unit entry, deletion, and replacement process.

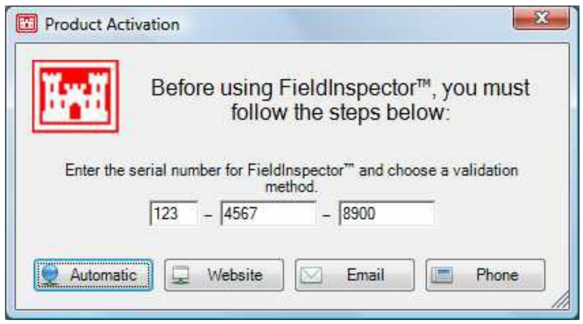
About file and User Manual.
The program now has an About file and a User Manual.

Functionality is unchanged.
The program functions the same way as previously. Only the ability to choose to view the Edit Inspection form in either List or Tablet View has changed.

PAVERFieldInspector™ Licensing

Activation Screen

On the first attempt to open the PAVERFieldInspector™ , hereafter referred to as FieldInspector, a form will appear prompting the user to activate the program. On the Product Activation form, enter the serial number provided by your distributor.



After the serial number entry, choose one of the following four options:

- Automated Web Activation: Select to activate your copy of FieldInspector automatically online.
- Manual Web Activation: Select to activate your copy of FieldInspector via a website.
- Email Activation: Select to activate your copy of FieldInspector via email (an email application such as Outlook must be used with this option).
- Phone Activation: Select to activate your copy of FieldInspector over the phone with the phone number provided in the next screen.

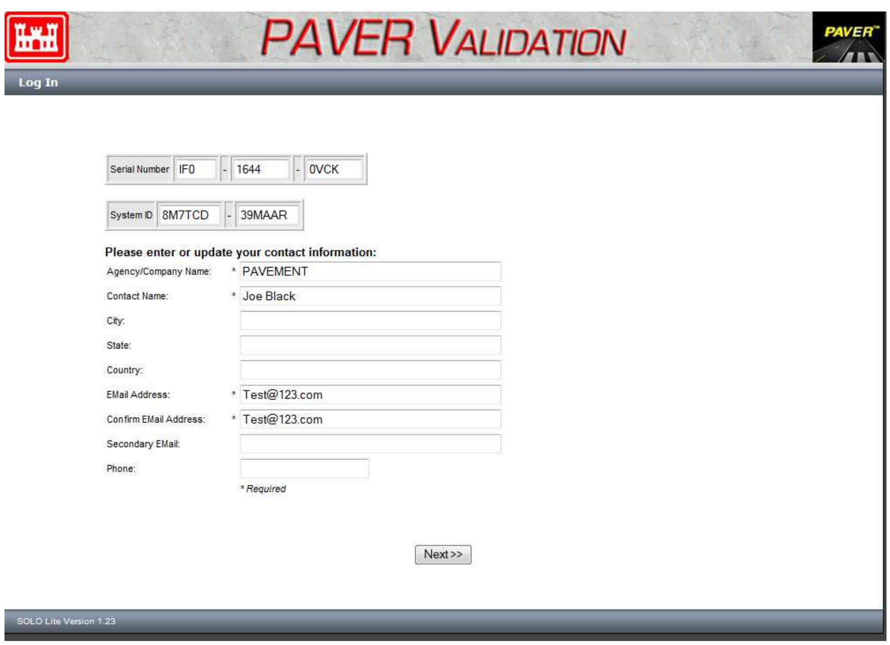
Automatic Web Activation

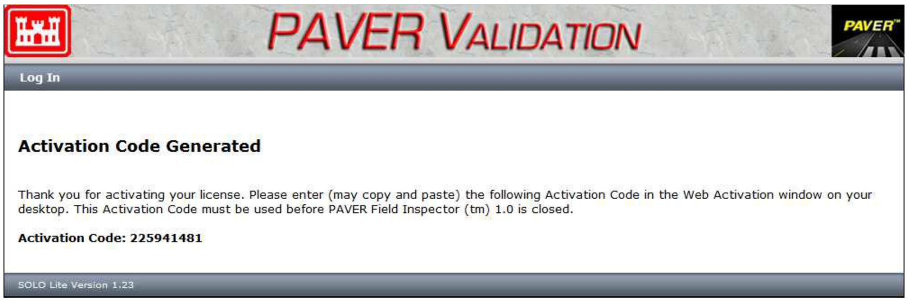
When Automated Web Activation is selected the screen below will be shown.

Fields marked by an asterisk are required, all other fields are optional. Once all required fields are populated, click the “Activate” button to complete the activation process.

Manual Website Activation:

When Manual Web Activation is selected, the following screen will open, along with a webpage where required information needs to be entered. The System ID information will be automatically populated. Do not close the FieldInspector until the activation is completed.

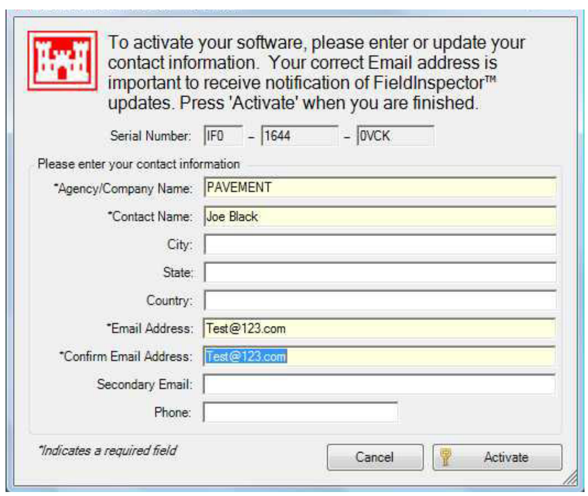




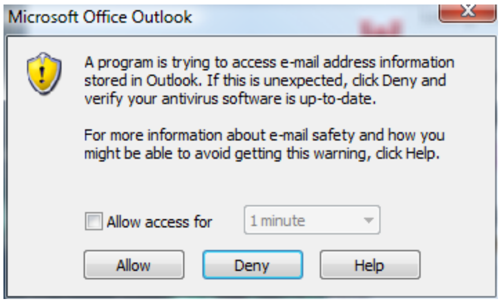
Once required information is entered, the Next button on the bottom of the webpage will be activated. Click on the Next button to receive the activation number. Enter the activation number on the Web Activation form.

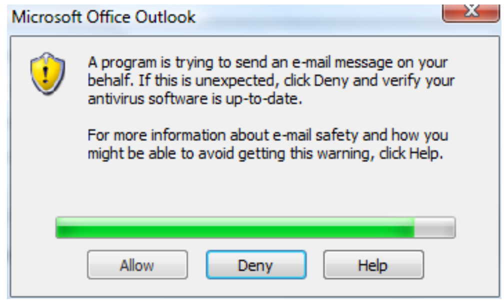
Email Activation:

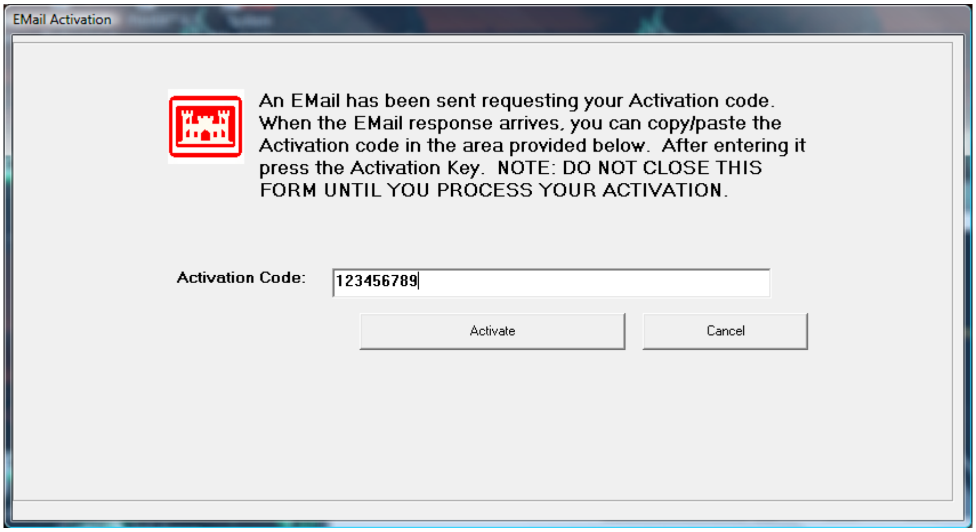
When activating FieldInspector via Email, first enter the required information in the image below.



After clicking “Active” via Email, FieldInspector will automatically use your email application to send an email to the licensing server, which will send an email reply containing the activation code. Enter the activation code from the reply email and click Activate.







Phone Activation:

When activating FieldInspector over the phone:

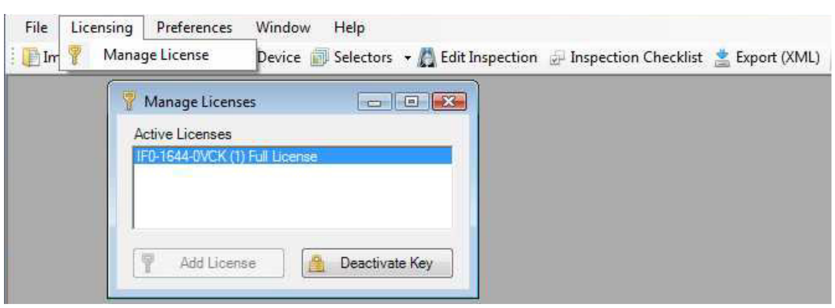
- The serial number will be populated automatically from the first activation screen.
- The system ID will be populated automatically from your computer.
- Call the number shown on the screen and provide the serial number and system ID shown to receive an activation code to enter in the “Activation Key” box.
- Once the activation code has been entered, select “Activate” to activate your copy of FieldInspector.

Activation Complete:

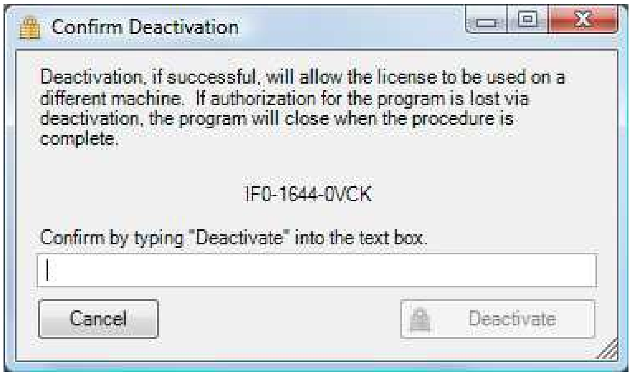
If a valid activation code has been entered the screen below will be shown indicating that FieldInspector has been activated and is now ready for use.

Deactivation:

To deactivate FieldInspector, open the program and select Manage License under the License drop down menu. Select the license you wish to deactivate.



Confirm that you wish to deactivate by typing “Deactivate” into the box. After FieldInspector is deactivated you can install the software on a different computer.

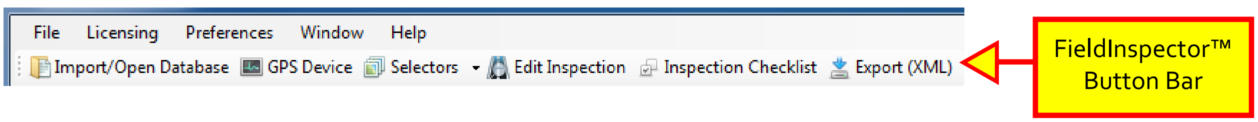


Note: Only one deactivation is allowed per activation.

User Interface

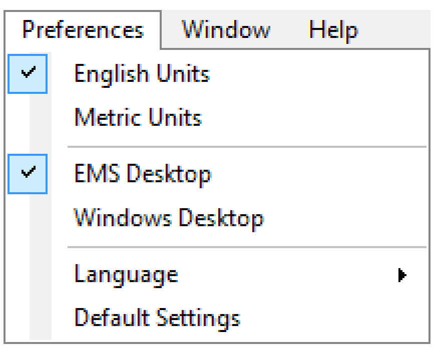
Toolbar:

Like other Windows programs, additional program features are accessed from the drop-down menus located above the FieldInspector Button Bar. The FieldInspector Menu provides standard Windows features such as File (Import/Open Database and Exit), Windows management and Help.



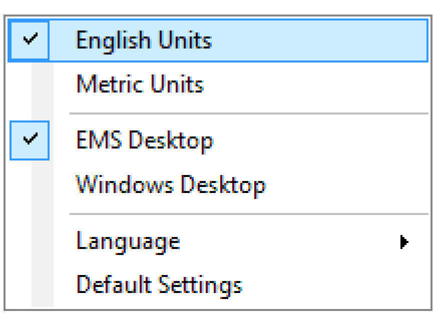
Preferences:

The Preferences Menu provides specialized FieldInspector options for changing the units of measure from English to metric and for changing the Desktop area as well as defining the default selector. Please note: an Inventory must be open before selecting any Preferences.



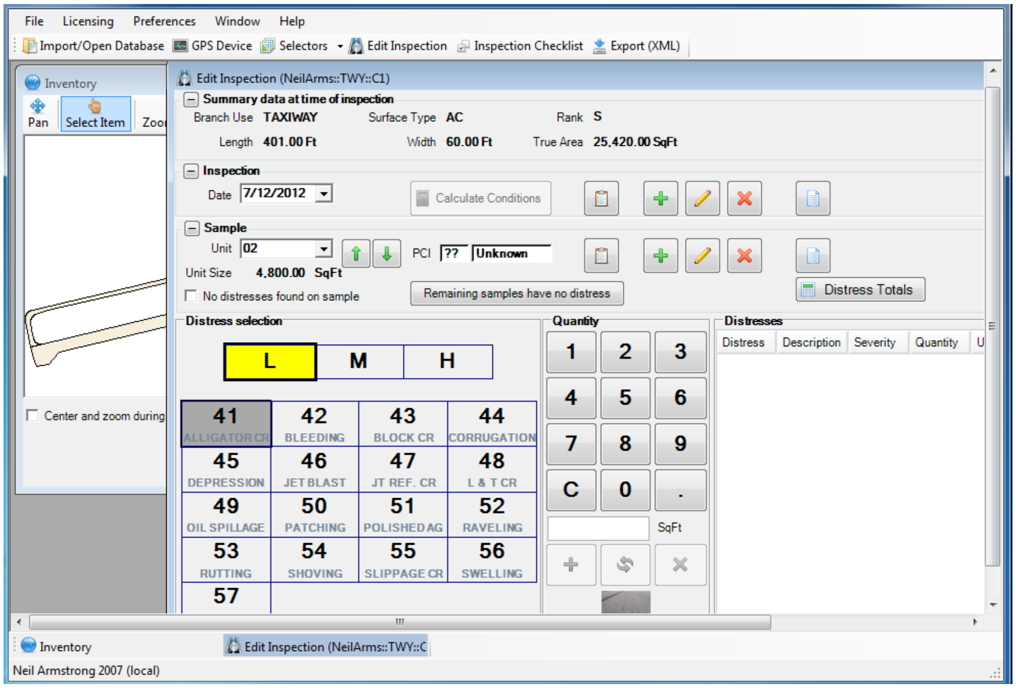
Units:

English is the Default Units.

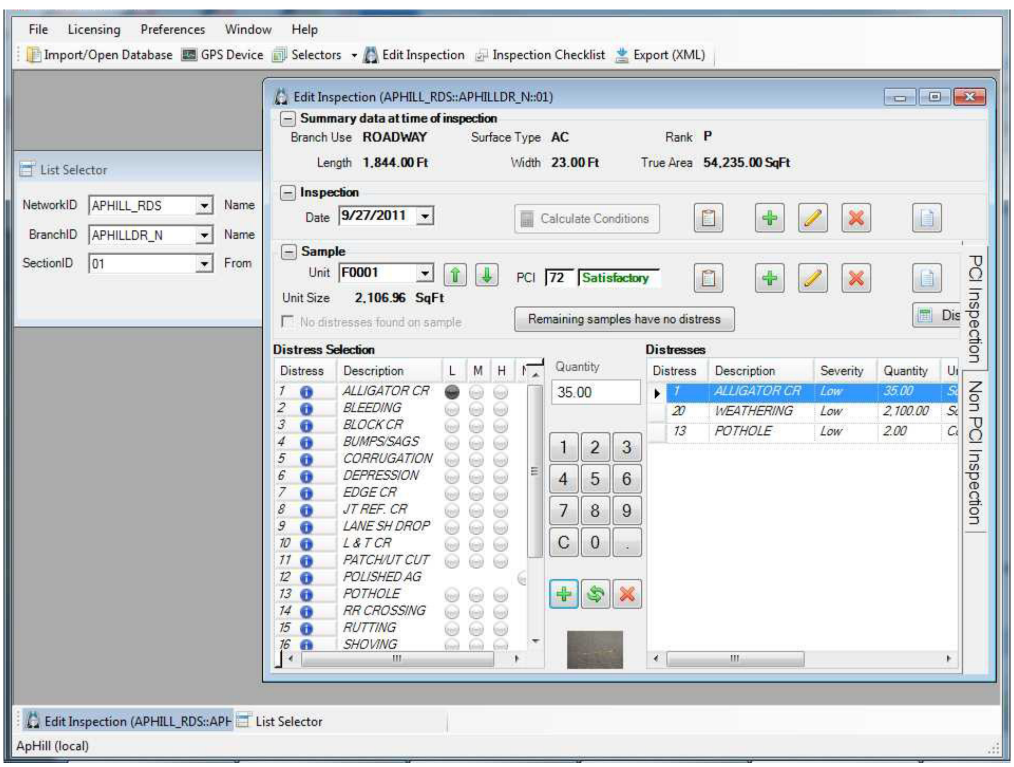


Desktop:

The Default Desk top is EMS Desktop. It displays the screens in the FieldInspector application.

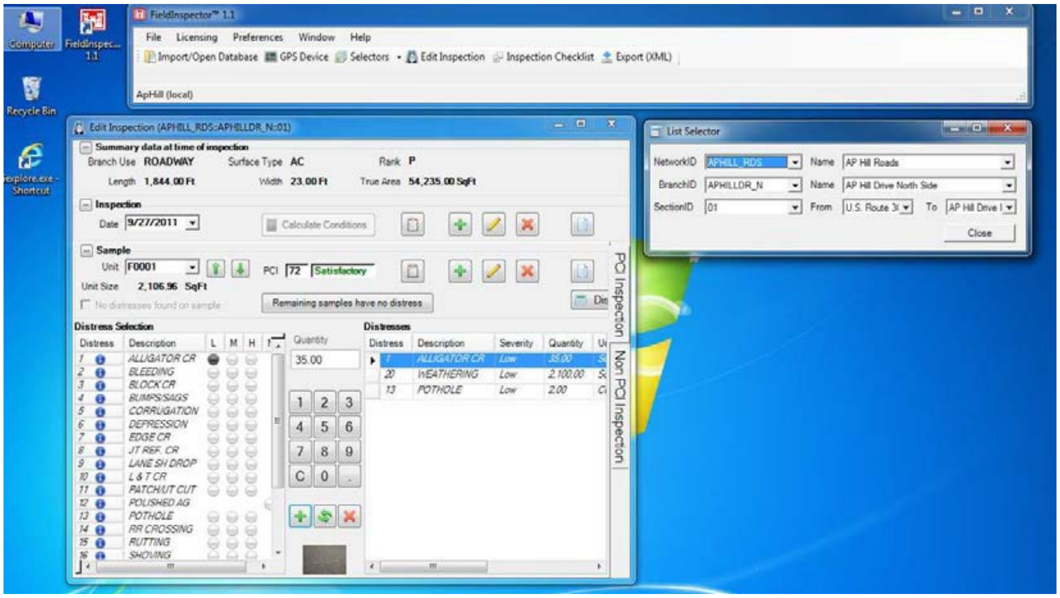


Tablet View with Inventory Map showing.



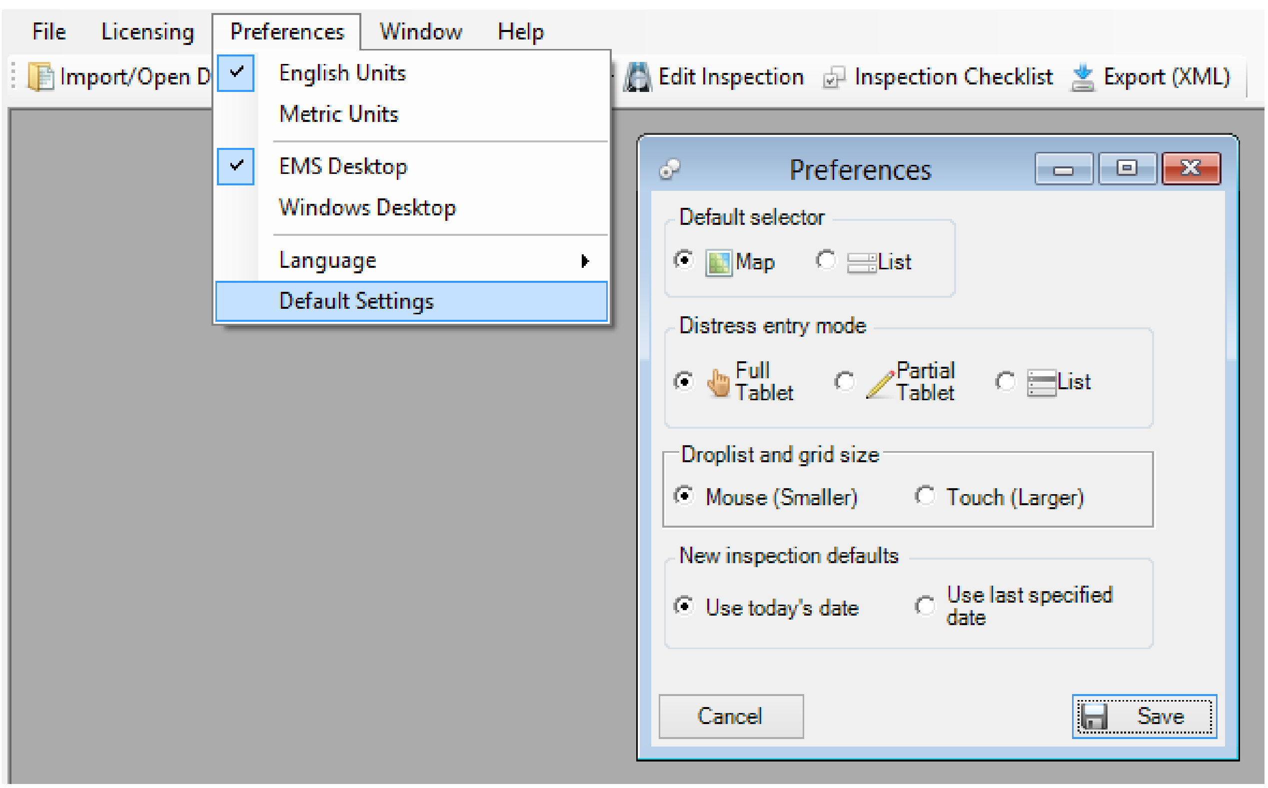
List View with List Selector showing.

The Windows Desktop allows the screens to float on the desktop without being anchored to the FieldInspector.



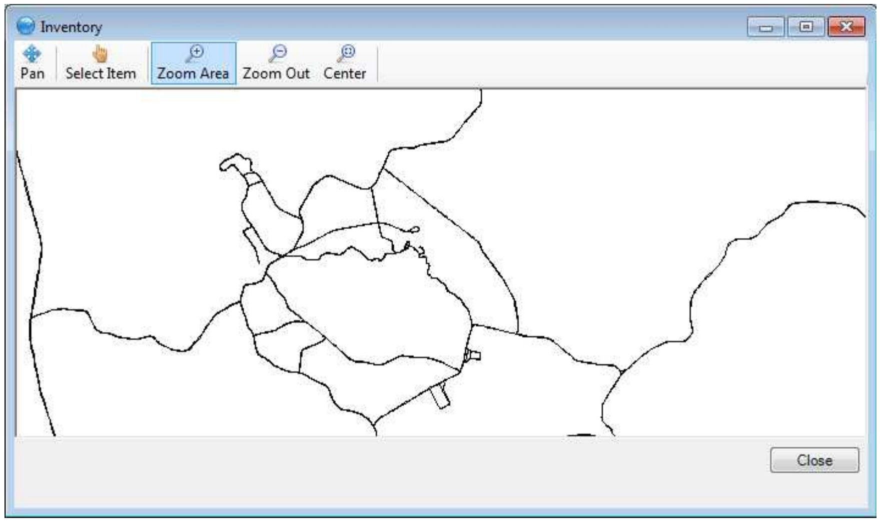
Default Settings:

The options to set defaults are under the Default Settings in the Preferences menu drop down.

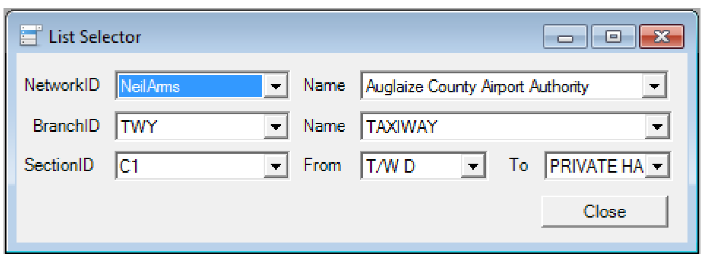


Default Selector:

If your inventory has a linked map, you can click “Map” selector.



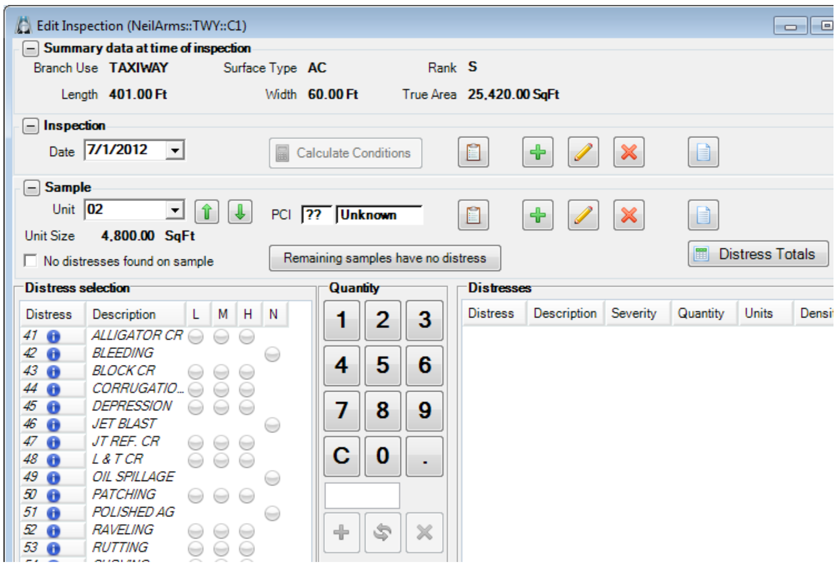
The “List” selector is also available and provides selection based on the Network, Branch, and Section.



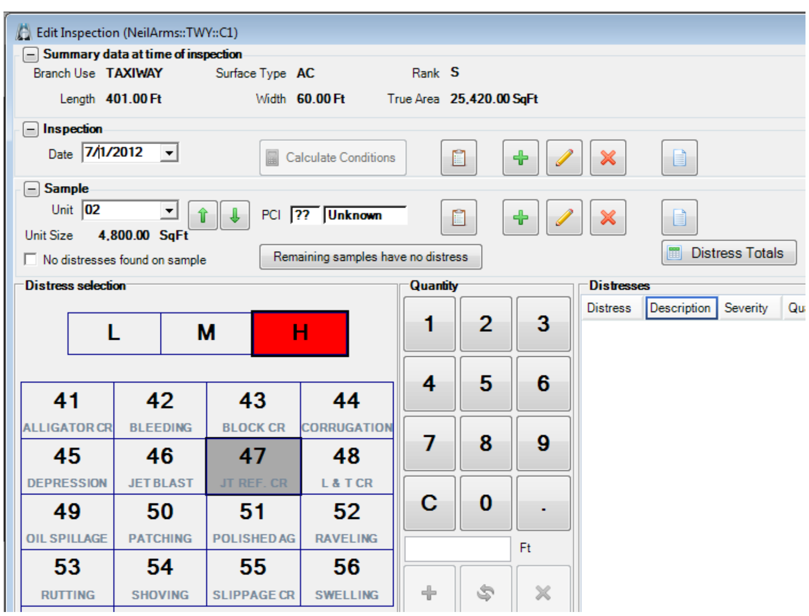
Distress Entry Mode:

The aesthetic of the Edit Inspection screen can be changed. "List" is a more traditional PAVER™ view while "Full Tablet" changes some of the layout and button sizes, making the screen more tablet friendly. "Full Tablet" is recommended for use with tablet computers; however, other options are provided for the user's preference.

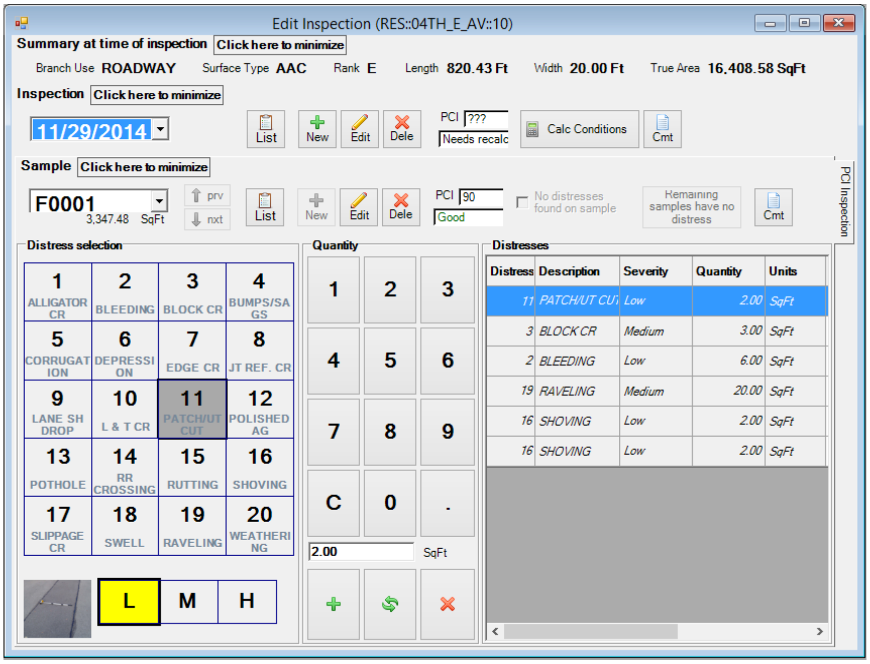
"List" view shows the list of distresses followed by severity buttons for low, medium, and high for each relevant Distress.



"Partial Tablet" view shows the Distresses as large individual buttons with one set of buttons above for low, medium, and high severity. This view makes it easier to select the correct Distress and Severity in the Field. The Partial Tablet view is not available for PCC distress entry due to the distress unit entry, deletion, and replacement process.



In addition to the changes mentioned in "Partial Tablet", “Full Tablet” mode also changes more of the button sizes. The controls will resize themselves to be used in a vertical orientation.



Droplist and Grid Size:

The "Touch" option makes certain controls larger and easier to use with fingers. The "Mouse" option will restore these controls to their normal size.

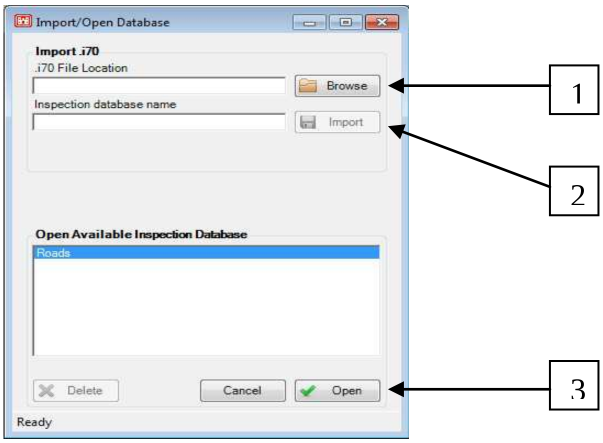
New Inspection Defaults:

The "Use today's date" option makes any newly created inspections select today's date. The "Use last specified date" makes newly created inspections select the most recently entered date. These options speed up entry and only affect the default starting date when creating an inspection.

Import/Open Database:

Use PAVER™ 6.5/7.0 to create an inspection file (.i70). Select "Import/Open Database" in the FieldInspector to use the file.

1. Use the "Browse" button to navigate to your saved i70 file and select it
2. Use the "Import" button to import the selected i70 into the FieldInspector
3. Select an imported database to open.



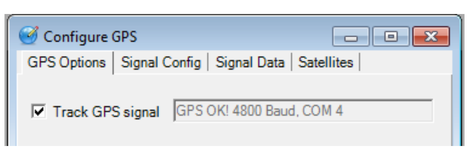
Once you have imported the file it is important to note that the FieldInspector will keep your Inspection Database in the list of available databases so you will not have to import it every time you want to use it.

*Note: Currently, work history and inventory items cannot be edited in FieldInspector.

GPS Device:

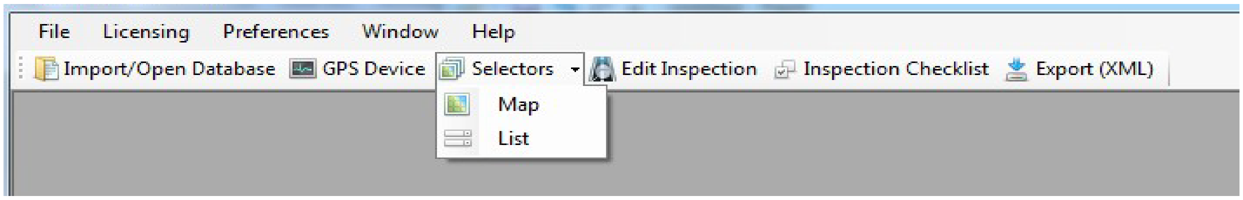
By default, the program will attempt to use location information available from your operating system. These settings are managed by Windows. If you wish to modify them, go to the Control Panel, then "Location Settings." The "Turn on the Windows Location platform" option will allow the program to use location information. If there is not a source of location information, the operating system may ask for a default location. When no active location is available, your GPS position will be set to the default.

If you do not want to use these settings, or you have an older "COM" or USB style device, you will have to manually set it up with the GPS Device form. If "AutoDetect" fails to find your device, you will need to provide the COM port of the GPS device. Once this tool is open, the checkbox next to the Track GPS signal will enable the GPS locator. The other tabs will indicate the strength and details of the acquired GPS signal.



Selectors:

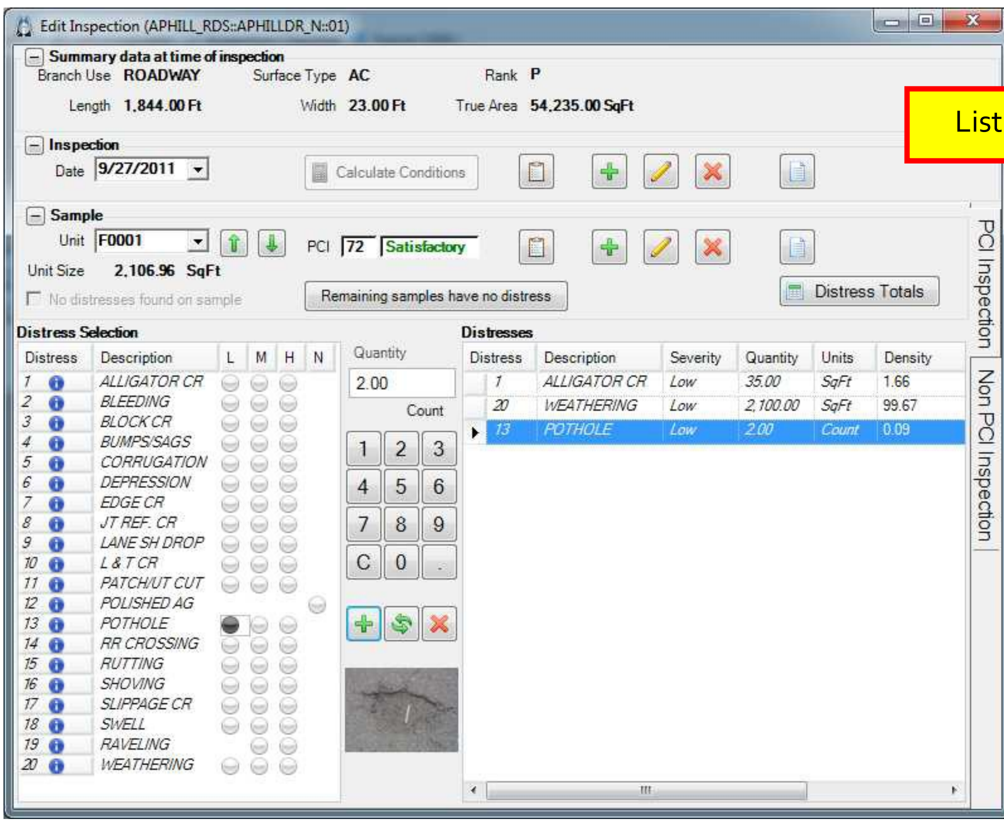
Click on Selectors to bring up the default selector or the arrow to choose which selector to use.



Edit Inspection:

Click "Edit Inspection" to add PCI and non-PCI inspections.

Asphalt Inspections:



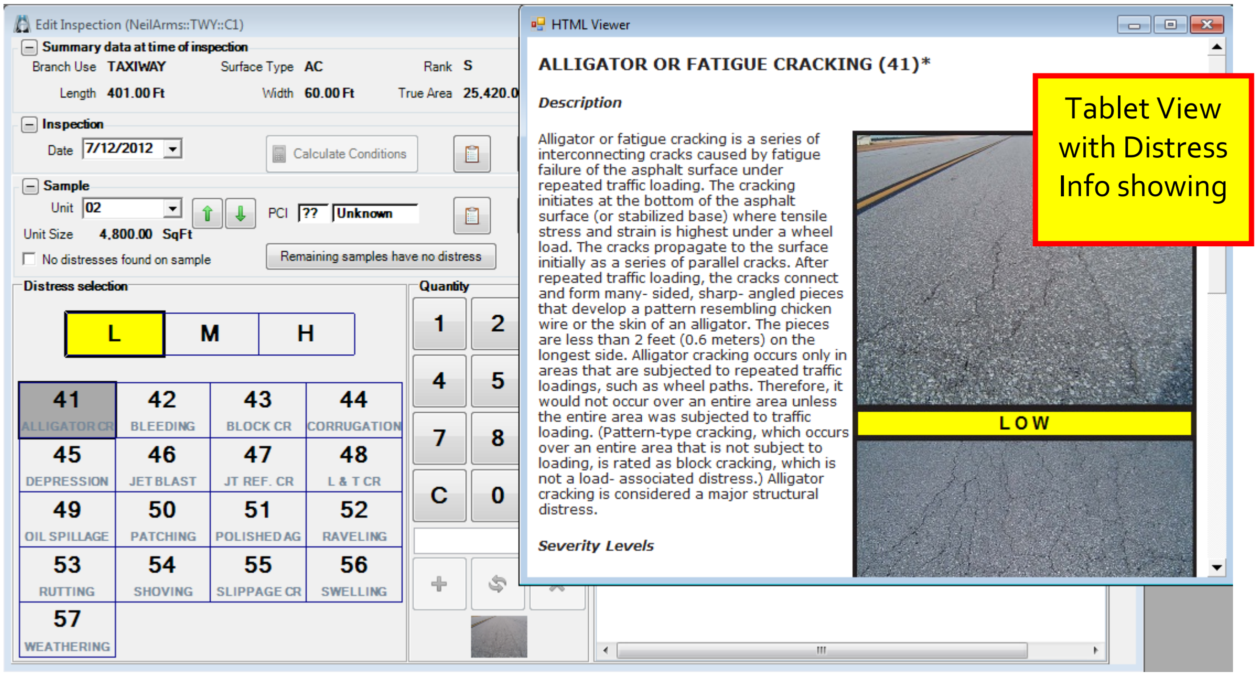
List View

Buttons:

View/Edit Add Edit Delete Comments Replace

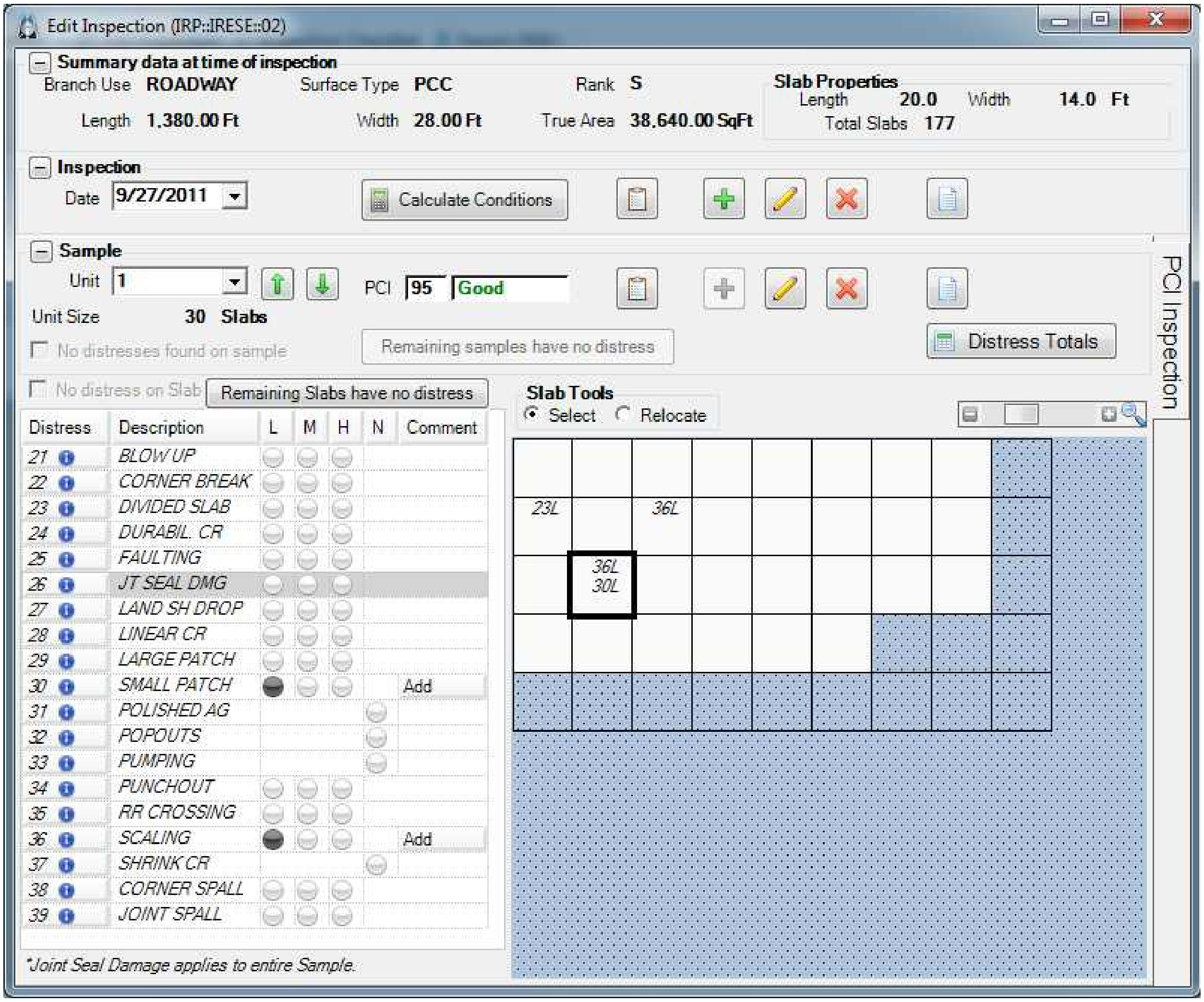
To change or delete a distress, highlight the distress in the distress list and click the delete button or change the quantity and click the replace button.

In List View, click on the info button or the photo icon for more information about the distress.



In Tablet View, right-click on the Distress button or click on the photo icon for more information about the distress.

Concrete Inspections:



When entering distress information by slab, you must first select the slab before the distress entry items will become active. Note that on PCC slab inspections a distress that is selected via the radio button can be un-selected by clicking the same radio button a second time.

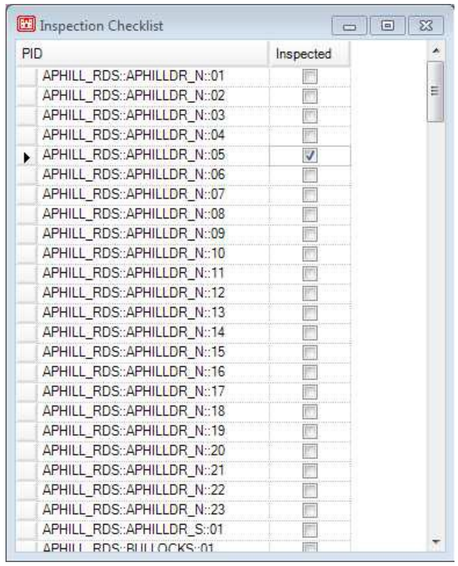
To relocate a slab, click the Relocate radio button under the slab tools. Click on the slab you want to relocate then click on the empty square where you want to place it. Click the Select radio button under the slab tools to continue adding distresses.

Click on the info button for more information about the distress.

Note: The Tablet Selector is not currently available for grid-based Rigid Inspections.

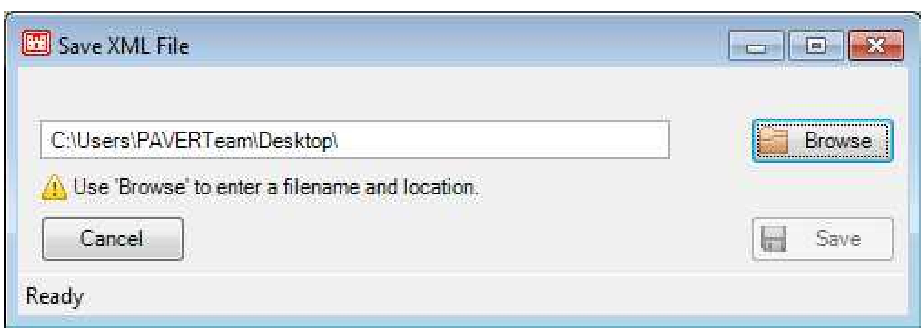
Inspection Checklist:

Allows you to keep track of your completed inspections per section.



Export Inspection:

When finished, click the “Export (XML)” button to create an XML file for import into PAVER™. Once data has been imported into PAVER™ be sure to verify that the data is shown in the “Edit Inventory” form.



Workshops

Workshop 1: Asphalt Inspection

Objectives

Create a new asphalt inspection within a FieldInspector database and understand how to add distresses to the sample units.

Database

Neil Armstrong_2007

Tasks

1. Import the Neil Armstrong_2007 into FieldInspector.
2. Create a new PCI Inspection for a RUNWAY.
3. Create a new sample unit in the inspection.

Survey Information

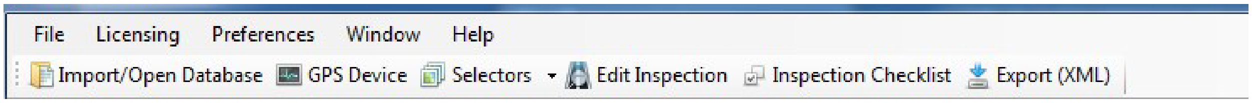
Inspection Date: Today's Date (Screen shots will show 09/27/11)
Branch: 08-26
Section: B
Total Number of Samples in the Section (N) = 20

Sample: 02 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** 57 – Weathering L 1000 sf 57 – Weathering M 600 sf 43 – Block Cracking L 5000 ft	**Sample:** 14 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** No Distresses
Sample: 05 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** 57 – Weathering M 400 sf 43 – Block Cracking L 5000 ft 57 – Weathering L 1000 sf 41 – Alligator Cracking L 100 sf	**Sample:** 16 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** 57 – Weathering L 1000 sf 48 – L&T Cracking L 120 ft
Sample: 08 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** 41 – Alligator Cracking M 1000 sf 41 – Alligator Cracking L 100 sf 48 – L&T Cracking L 180 ft	**Sample:** 18 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** No Distresses
Sample: 12 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** 41 – Alligator Cracking M 1000 sf 57 – Weathering L 1000 sf	**Sample:** 20 **Sample Type:** Random **Sample Size:** 5000 sf **Distress Severity Quantity** 57 – Weathering L 1500 sf

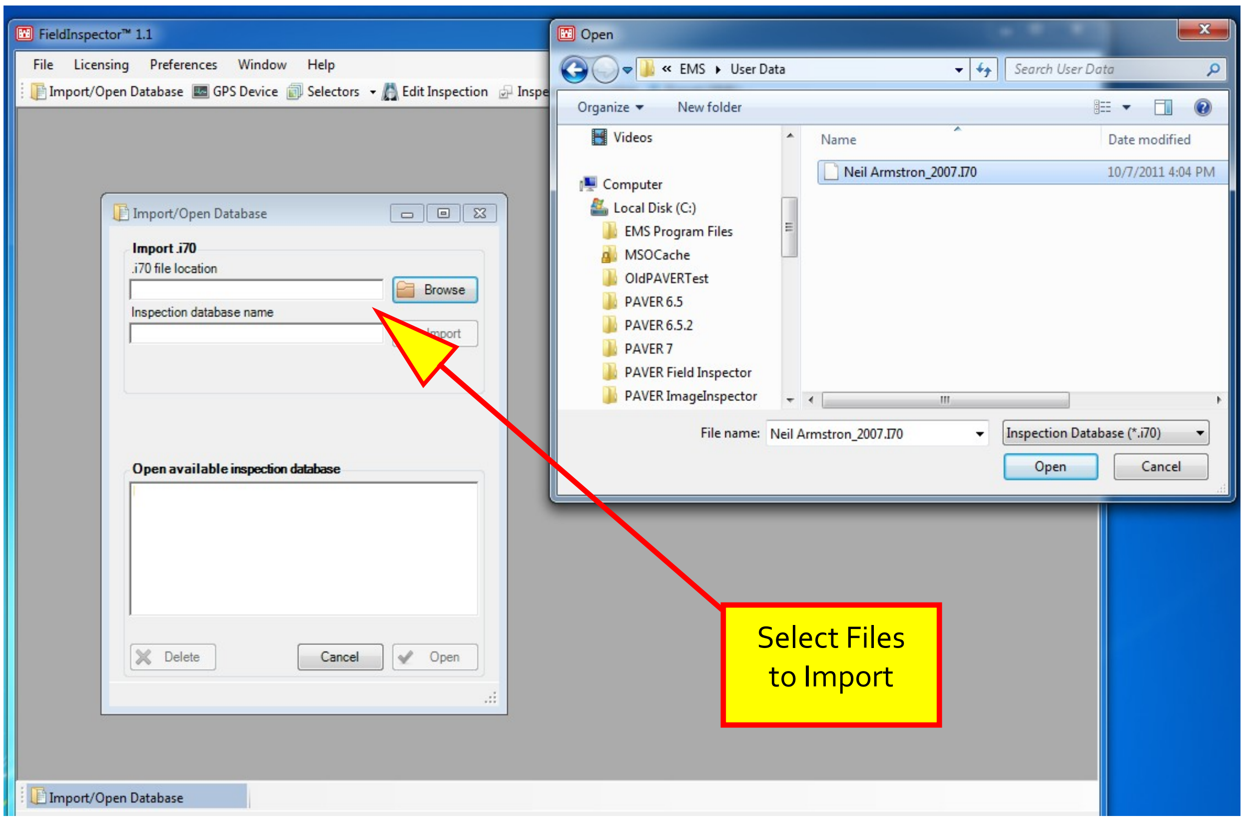
Hints and Solution Guide for Workshop 1

1. Import the Neil Armstrong_2007 into FieldInspector.

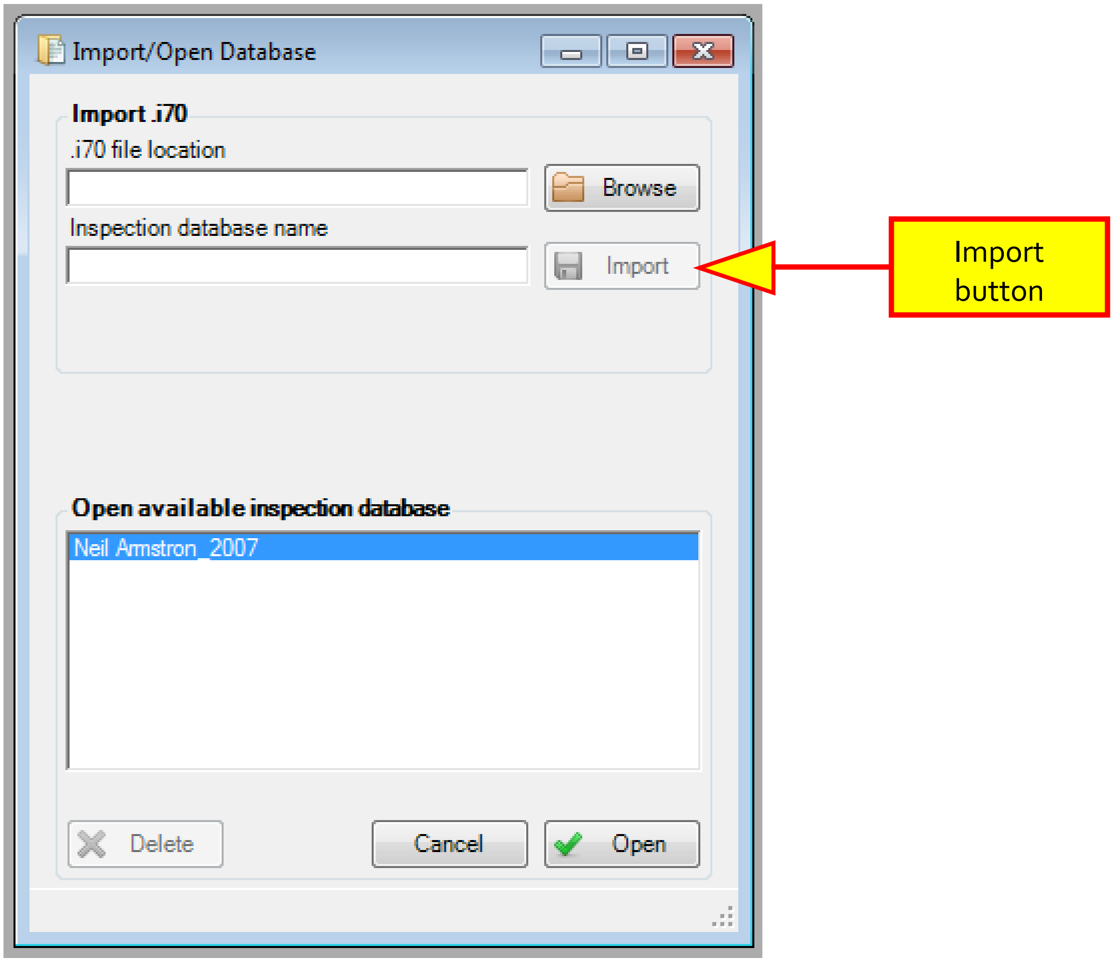
    - Select Import/Open Database from the FieldInspector button bar.



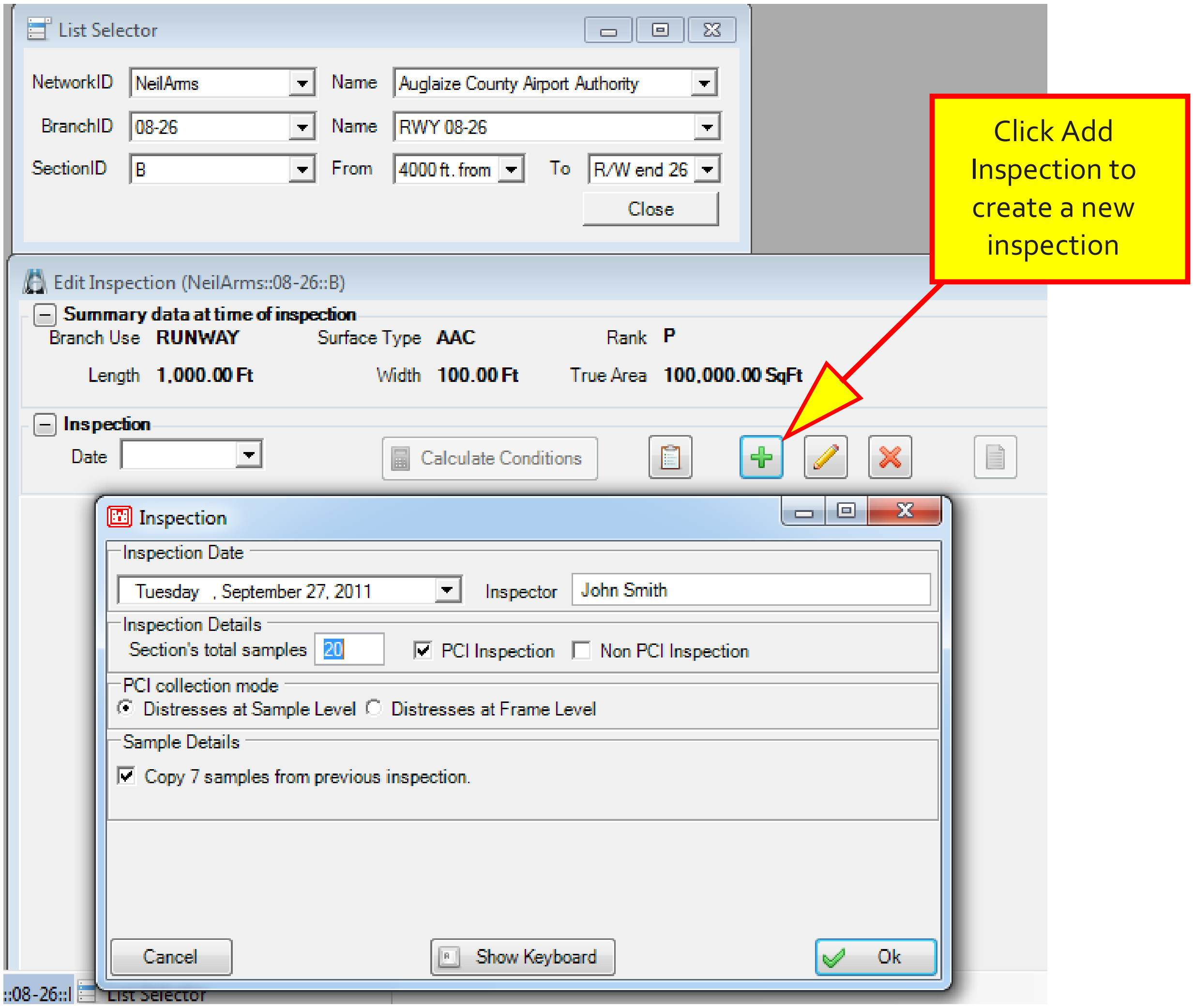
    - To import a database, click Browse next to the .i70 file location Path. For this example use the Neil Armstron_2007.i70 file in the C:\Program Files (x86)\EMS\Field Inspector\User Data\ directory and name it Neil Armstron_2007.



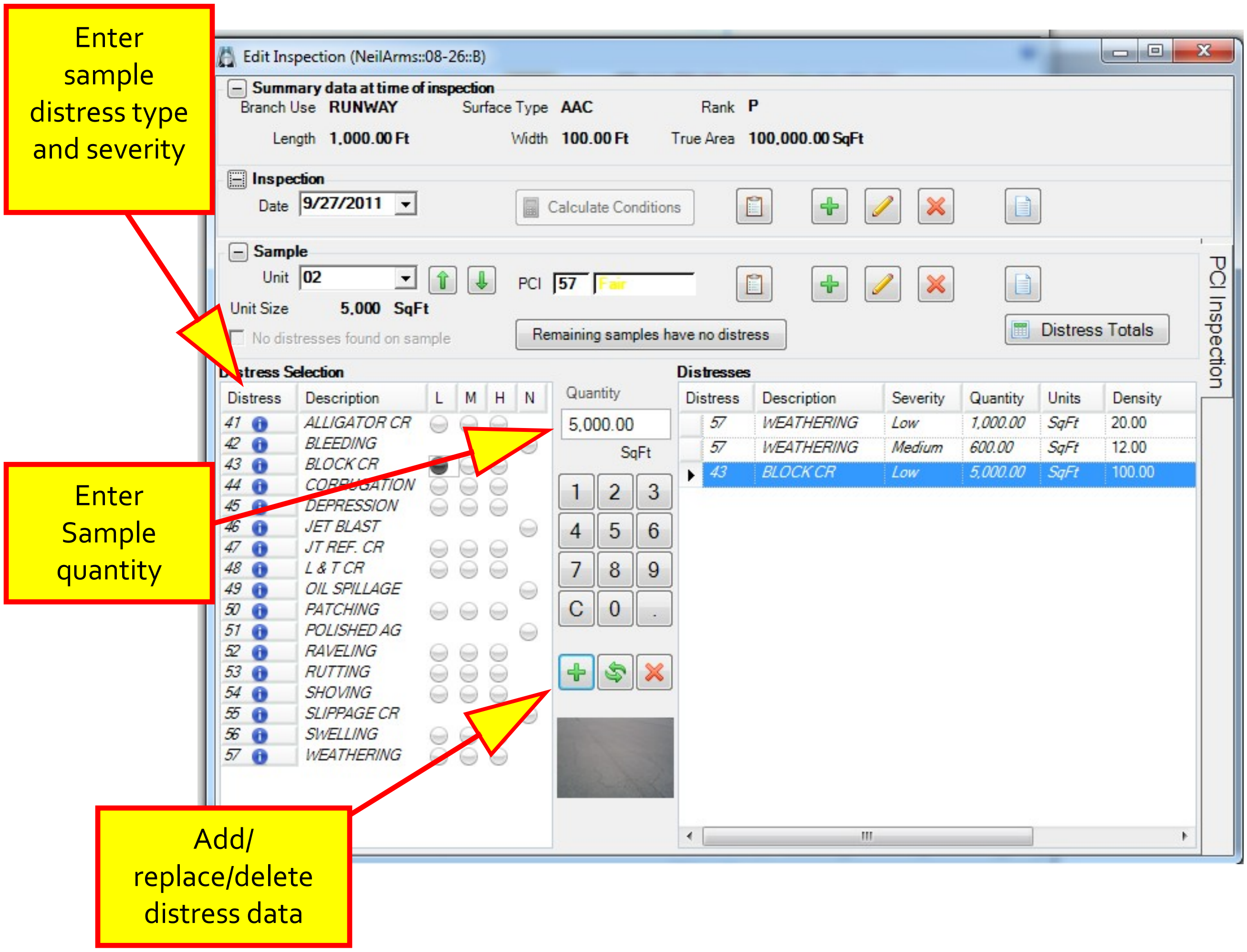
- Click the Import button next to the Inspection database name.
- Highlight the Neil Armstron_2007 database in the available inspection database list and click Open.



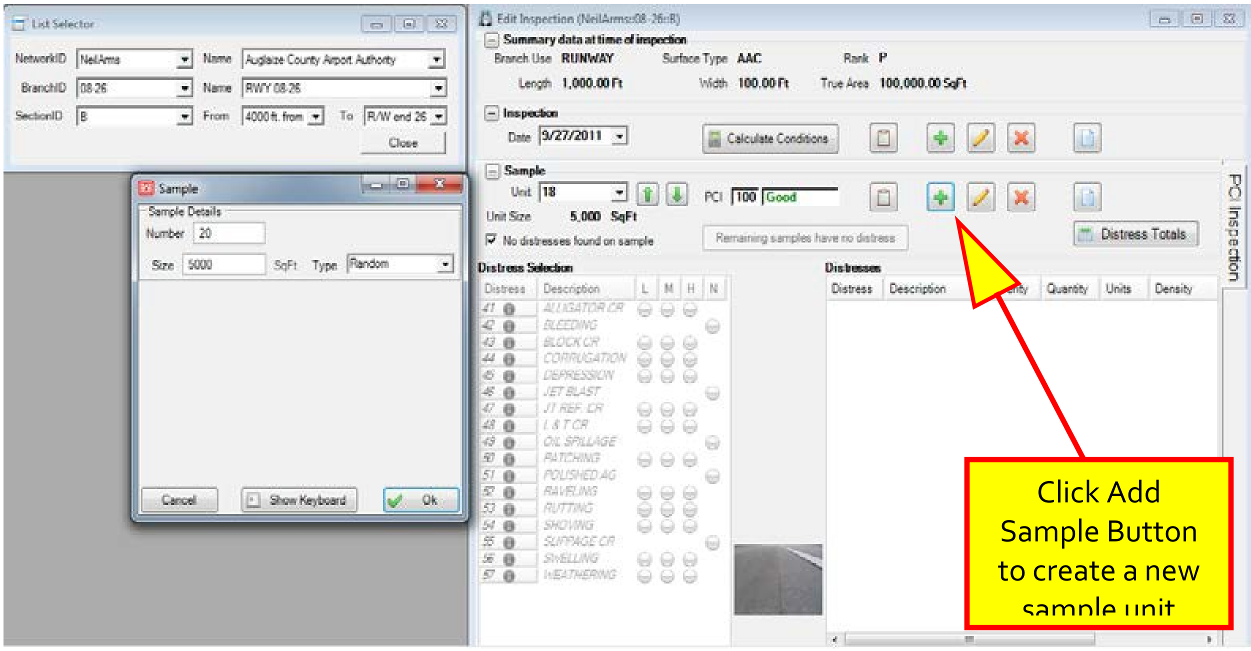
2. Create a new PCI Inspection for Runway 08-26, Section B.
   - Select Edit Inspection from the FieldInspector button bar and using the list selector choose the Network named NeilArms, Branch 08-26, Section B.
   - To add a new inspection within the Edit Inspections window click the Add Inspection Button. Type in the inspection date, enter the total number of sample units possible in the section = 20 (total area 100000 SF >> divided by normal sample size 5000 >> equals 80 sample units possible), not the number you actually inspected, make sure PCI Inspection and copy samples from previous inspection are checked, Distresses at Sample Level is selected, and click OK.



- Enter inspection data for sample unit 02 by clicking on the radio button next to the corresponding distress and under severity level, and then entering in the quantity (per Survey Info at the beginning of this Workshop). When you finish entering the distress information, click  Add Distress and then proceed to enter the remaining distresses in the same fashion. When you are finished with sample unit 02, click on the down arrow and select the next sample unit. Repeat the distress entry for sample units 05, 08, 12, 14, 16 and 18.


Enter sample distress type and severity
Enter Sample quantity
Add/ replace/delete distress data
Edit Inspection (NeilArms::08-26::B)
Summary data at time of inspection
Branch Use RUNWAY
Surface Type AAC
Rank P
Length 1,000.00 Ft
Width 100.00 Ft
True Area 100,000.00 SqFt
Inspection
Date 9/27/2011
Calculate Conditions
Sample
Unit 02
PCI 57
Unit Size 5,000 SqFt
No distresses found on sample
Remaining samples have no distress
Distress Totals
PCI Inspection
Distress Selection
Distress Description L M H N
41 ALLIGATOR CR
42 BLEEDING
43 BLOCK CR
44 CORRUGATION
45 DEPRESSION
46 JET BLAST
47 JT REF. CR
48 L & T CR
49 OIL SPILLAGE
50 PATCHING
51 POLISHED AG
52 RAVELING
53 RUTTING
54 SHOVING
55 SLIPPAGE CR
56 SWELLING
57 WEATHERING
Quantity
5,000.00
SqFt
1 2 3
4 5 6
7 8 9
C 0 .
Distresses
Distress Description Severity Quantity Units Density
57 WEATHERING Low 1,000.00 SqFt 20.00
57 WEATHERING Medium 600.00 SqFt 12.00
43 BLOCK CR Low 5,000.00 SqFt 100.00

3. Create a new sample unit (sample unit #20) in the inspection.
   - To add a new sample unit, within the Edit Inspections window click the Add Sample Button. Change the sample number to 20, enter 5000 for the size, verify the type is Random and click OK.



   - Enter inspection data for sample unit 20 by clicking on the radio button next to the corresponding distress and under severity level, and then entering in the quantity (per Survey Info at the beginning of this Workshop). When you finish entering the distress information, click Add Distress.

Workshop 2: Concrete Inspection

Objectives

Create a new concrete inspection within the FieldInspector. Learn how to concrete grid inspection and relocate slabs to match field sample slabs.

Database

Neil Armstrong_2007

Tasks

1. Create a new PCI Inspection for an APRON.

2. Create a new sample unit in the inspection.

3. Relocate slabs in the sample unit.

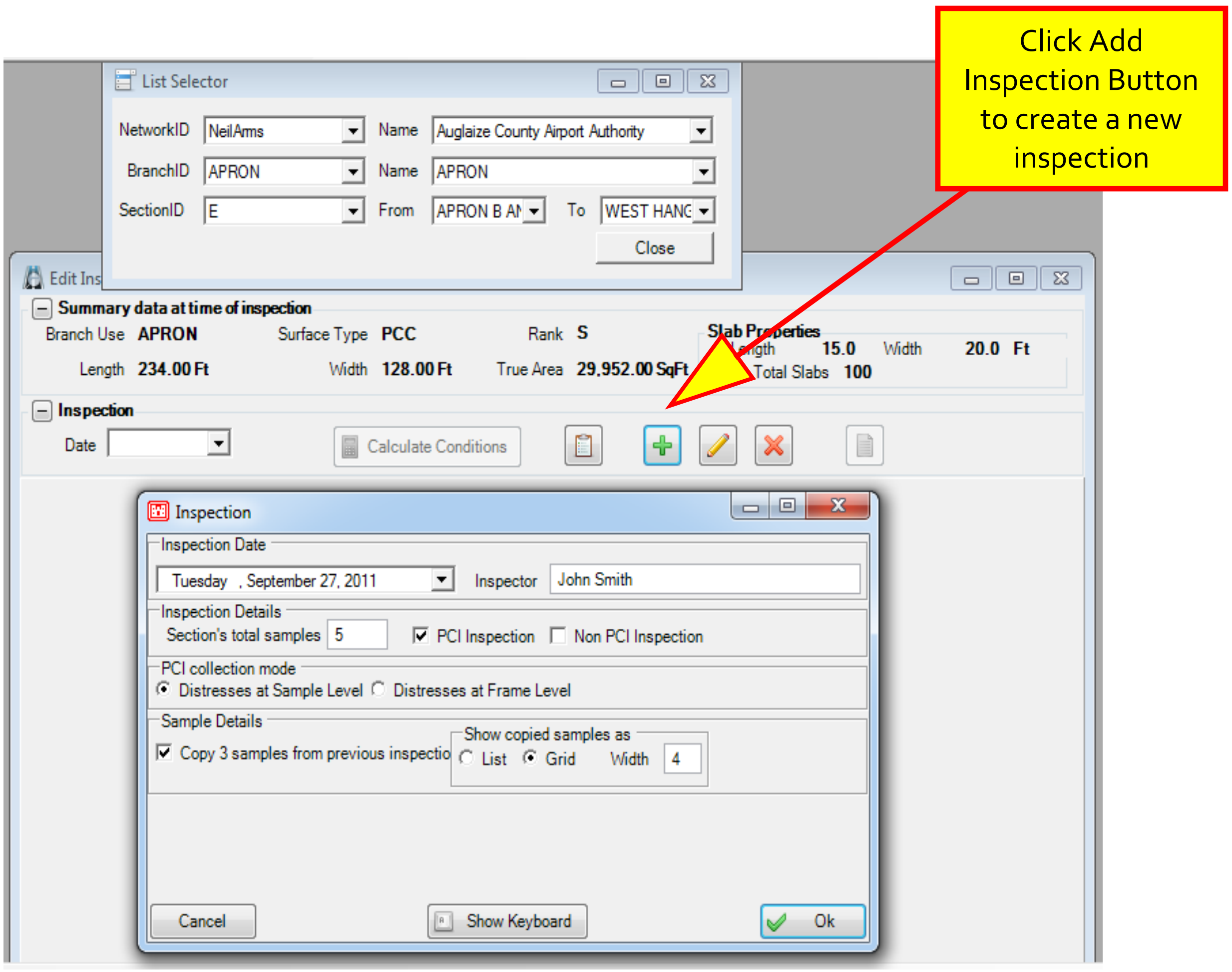
4. Export inspection to an XML.

Survey Information

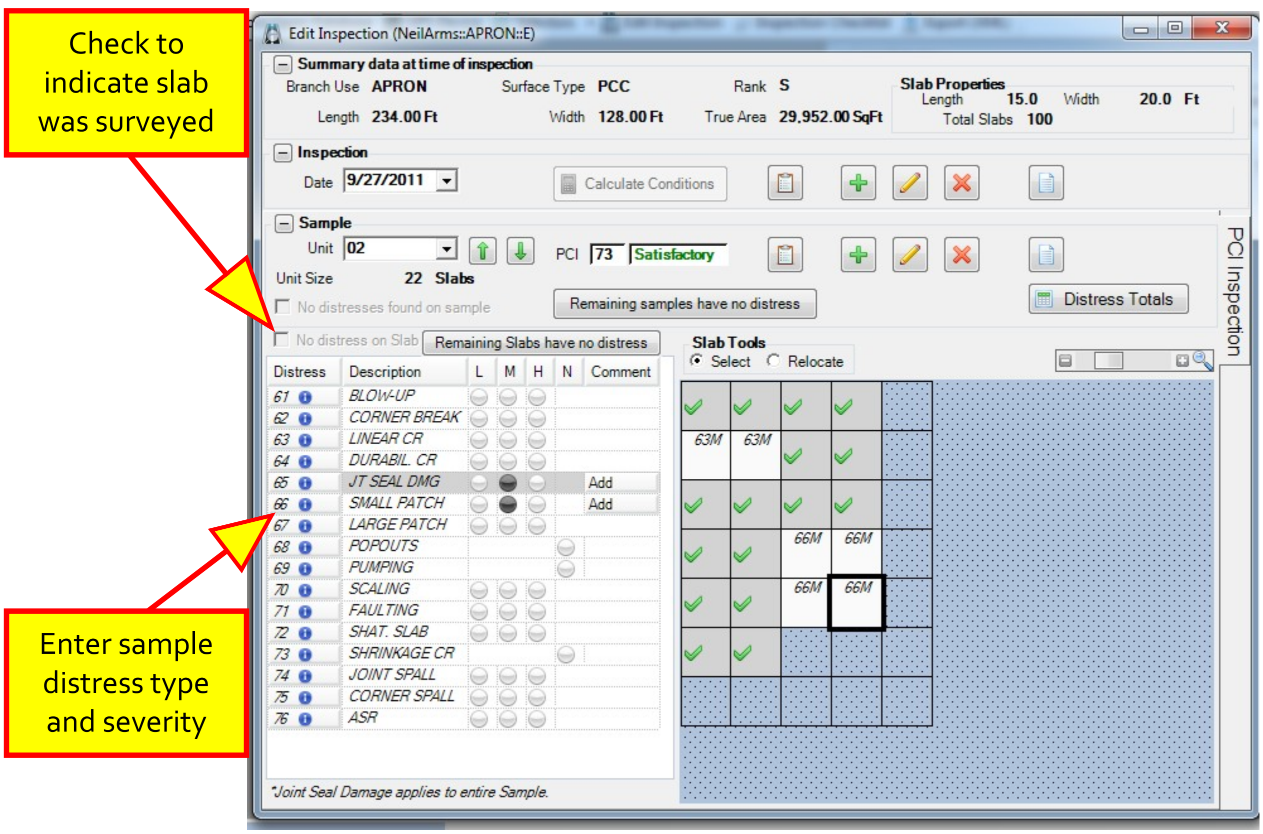
Inspection Date: Today's Date (Screen shots will show 9/27/11) **Branch:** APRON **Section:** A **Total Number of Samples in the Section (N) =** 5	
Sample: 02 **Sample Type:** Random **Sample Size:** 22 slabs **Distress Severity Quantity** 63 – Linear CR M 2 66 – Small Patch M 4 65 – Joint Seal Damage M 22	**Sample:** 05 **Sample Type:** Random **Sample Size:** 22 slabs **Distress Severity Quantity** 28 – Joint Spall L 2 70 – Scaling L 3 65 – Joint Seal Damage M 22
Sample: 03 **Sample Type:** Random **Sample:** 22 slabs **Distress Severity Quantity** 71 – Faulting M 4 70 – Scaling L 5 65 – Joint Seal Damage M 22	**Sample:** 01 **Sample Type:** Random **Sample:** 22 slabs **Distress Severity Quantity** 75 – Corner Spall M 2 65 – Joint Seal Damage M 22

Hints and Solution Guide for Workshop 2

1. Create a new PCI Inspection for Apron A.
   - Select Edit Inspection from the FieldInspector button bar, and using the list selector choose the Network named NeilArms, Branch APRON, Section A.
   - To add a new inspection, within the Edit Inspections window click the  Add Inspection Button. Type in the inspection date, enter the total number of sample units possible in the section (100/20 = 5), not the number you actually inspected, make sure PCI Inspection and copy samples from previous inspection are checked, Distresses at Sample Level is selected, and click OK.

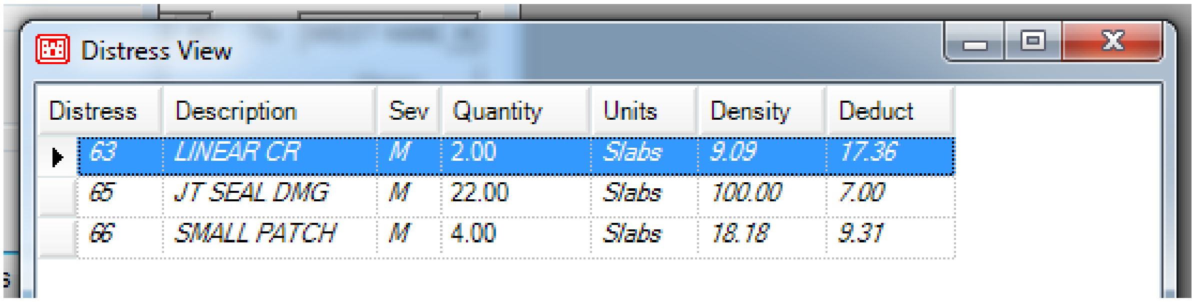


- Enter inspection data for sample unit 02 by clicking on a slab and selecting the radio button next to the corresponding distress and under severity level (per Survey Info at the beginning of this Workshop). The Distress number and severity level will appear in the slab. To remove the distress from the slab, re-click the selected radio button. Proceed to enter the remaining distresses in the same fashion. If there were no distresses found on a slab you can enter a check mark to indicate the slab was surveyed by selecting the slab and checking "No distresses found on Slab".



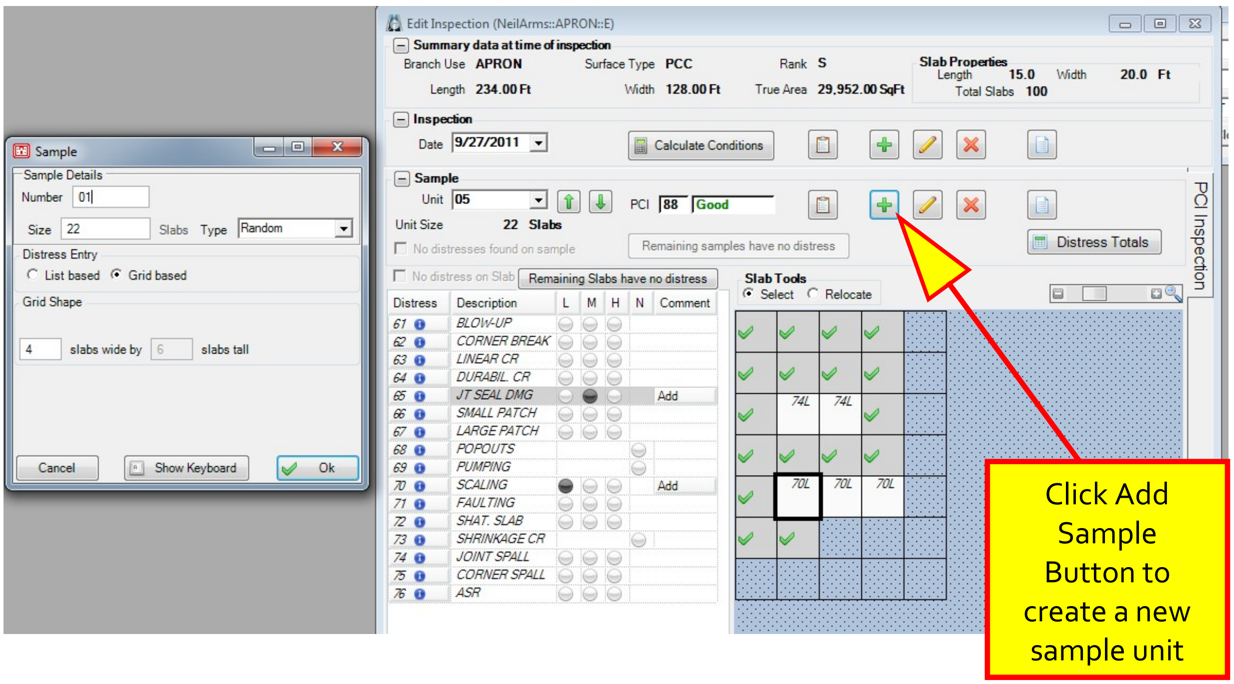
Note: Distress 65 (Joint Seal Damage) is evaluated across the whole sample unit. As a result, the program will automatically enter the distress for every slab in the sample unit.

- When you are finished entering all the distress data for a sample you can verify the totals by selecting the Distress Totals button. This data should match the Survey Info at the beginning of this Workshop.



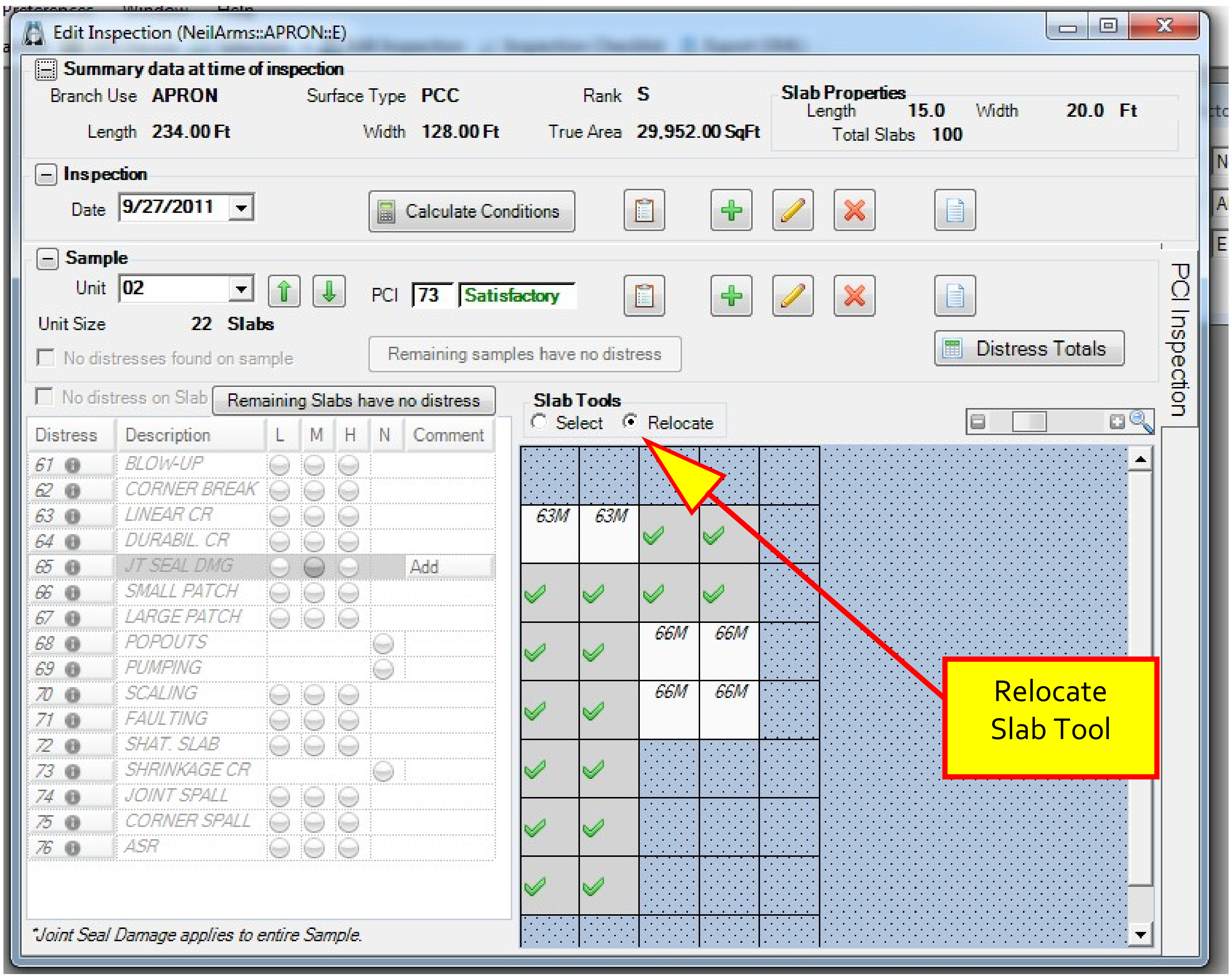
- When you are finished with sample unit 02, click on the down arrow and select the next sample unit. Repeat the distress entry for sample units 03 and 05.

2. Create a new sample unit in the inspection.
    - To add a new sample unit, within the Edit Inspections window click the Add Sample Button. Change the sample number to 01, enter 22 for the size, verify the type is Random, the Distress Entry is Grid based and Grid Shape is 4slabs wide by 6 slabs tall and click OK.

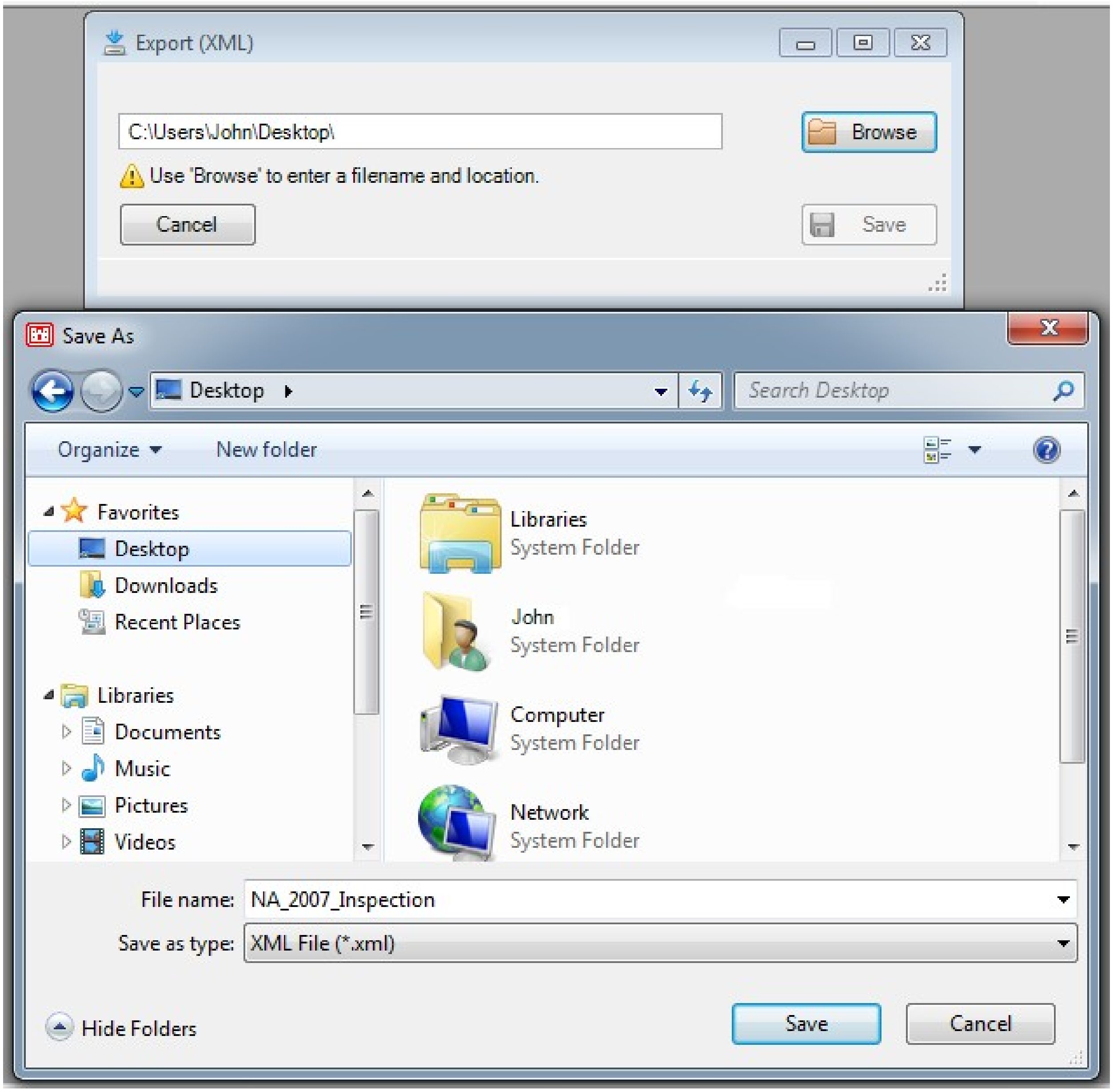


- Enter inspection data for sample unit 01 by clicking on a slab and selecting the radio button next to the corresponding distress and under severity level (per Survey Info at the beginning of this Workshop).

3. Relocate slabs in the sample unit.
   - Using sample unit 02 from above click on the relocate radio button under Slab Tools.
   - Click on a slab you want to relocate then click on the blank space where you want the slab moved.



4. Export inspection to an XML.
   - Select Export (XML) from the FieldInspector button bar.
   - Click Browse next to the Export Path. For this example use the Desktop directory and name it NA_2007_Inspection.



   - Select Save in the Browse window then Save in the Export Window.
   - Go to the Desktop to verify NA_2007_Inspection.xml was created.

PAVERFieldInspector™ Support

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