

When Practice Becomes Form: Carpentry Tools from Japan

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This digital publication is created on the occasion of the exhibition *When Practice Becomes Form: Carpentry Tools from Japan*, March 11–July 11, 2021, organized by Japan Society, New York.

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Note to the reader:

The modified Hepburn Romanization system was employed in transliterating the Japanese language. Macrons are used to indicate long vowels in Japanese names and words, as a guide to pronunciation (e.g. Tōshōdai-ji Temple). Commonly known names and words adopted into English are given without macrons (e.g., Kyoto, Tokyo).

Foreword

Precision is a hallmark of the Japanese experience, from the train arrivals that are timed to the minute to the beautiful presentation and wrapping of gifts. One of the many ways to examine this is through the Japanese concept of *kodawari*—a unique notion that is difficult to translate—referring to the uncompromising, relentless devotion to perfecting one's art, pursuit, profession, or activity.

In a world turned upside down by a pandemic, there has never been a more welcome time to explore this resolute quest for precision and quality in one's work at all levels of *kodawari*— here, in the form of Japanese woodworking. The philosophy that undergirds it is deeply ingrained in Japan Society's own history. As master woodworker George Nakashima wrote in his book, *The Soul of a Tree* (1988), "We can walk in step with a tree to release the joy in her grains, to join with her to realize her potentials, to enhance the environments of man."

Fifty years ago, Junzo Yoshimura, the architect of Japan Society's now-landmarked building, asked that Japanese *hinoki* (Japanese cypress) be used for the coffered ceilings in the Society's lobby, and selected with his own hands stones to be shipped from Japan for the foyer garden. He also specified furniture to be crafted by Nakashima in his New Hope, Pennsylvania workshop— furniture that has stood the test of time and is still in use today.

During the past year, our doors have been closed to the public by the COVID pandemic. This spring, we are delighted to celebrate our reopening with *When Practice Becomes Form: Carpentry Tools from Japan.* This special exhibition explores the extraordinary, centurieslong tradition of Japanese architecture and woodworking artistry, and features a range of hand tools and models that reflect techniques used for hundreds of years to build and restore Japan's wooden architectural masterpieces—temples, shrines, and bridges.

The resilient spirit of Japanese craftsmanship resonates especially as we commemorate the 10th anniversary of the 2011 Great East Japan Earthquake. The presence of tools in our galleries and an exploration of their longstanding heritage for a broad audience highlights the persistent vitality of U.S.-Japan relations and human ingenuity. As a leader, I take inspiration from Nakashima, embracing the strength of the oak tree in the West and flexibility of bamboo in the East to bring out the fortitude, resiliency, and innovation of the U.S.-Japan alliance through my own set of tools.

We are especially grateful for the vision and support of many foundations, corporations, and individuals for this exhibition, which would not have been possible without major support from Takenaka Corporation, one of Japan's five major general contractors, founded in 1909 and still family-led under the management philosophy, "Contribute to society by passing on the best works to future generations." Sincere thanks go to the Takenaka Carpentry Tools Museum in Kobe, Japan, for entrusting us with works from their collection in their New York debut, and for sharing their depth of knowledge about this rich cultural history and heritage. May you discover your own resilience and *kodawari* this year through this special exhibition, in whatever practice becomes your form.

Joshua W. Walker, Ph.D. President & CEO Japan Society

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Introduction: Learning from Tradition

When Practice Becomes Form: Carpentry Tools from Japan explores Japan's rich carpentry tradition in the practice of wooden architecture and craftsmanship.

The abundance of forests in Japan contributed to wood becoming the primary source material for building. The Japanese archipelago nurtures a unique, diverse, and bountiful natural environment with a warm, rainy climate. Owing to this, a distinctive culture around wooden architecture has evolved. The carpenters' role in a major building project begins with selecting trees to be felled. The practice of the master carpenter, *tōryō*, integrates their deep knowledge and refined techniques of construction with local and natural resources.

The role of the carpenter in Japan goes beyond that of craftsman to include the roles of designer as well as builder. The master carpenter orchestrates the whole process of researching, designing, scheduling and managing a variety of craftsmen to execute every aspect of a project.



Temple and shrine carpenter (*miya-daiku*) Tsunekazu Nishioka and his assistant produce a detailed technical drawing elaborating the roof construction of the Three-Storey Pagoda of Hōrin-ji Temple (Mii, Nara Prefecture). The original 7th century structure was destroyed by lightning in 1947 and reconstructed in 1975.

This exhibition unpacks the intangible wisdom of craftsmanship—the consummate experience, wide-ranging knowledge, and honed skills of master carpenters—and charts how this has been transformed into significant forms of architecture, such as temples, shrines, and bridges, which extends to Japan's cultural heritage today. This digital publication explains how a diverse array of tools have played an important role as the extension of carpenters' hands. Their tools have both function and beauty, and traditionally carpenters in Japan have created their tools and customized them to suit their own body.

Integral to the processes of master carpenters is their extensive knowledge of the local environment and of wood as an essential material. Learning from their predecessors' practices, they construct buildings using a refined methodology. Their philosophy of sustainability—to restore or repair buildings as needed—has been handed down over generations.

As another vital participant of the exhibition, contemporary Japanese architect Sou Fujimoto conceived the exhibition design. Exploring the coexistence between nature and man-made design and being inspired by tradition to develop new architectural directions today, his inspiration shines a new light on traditional Japanese craftsmanship and connects architectural creativity past and present. Fujimoto developed the exhibition design in collaboration with Brooklyn-based Popular Architecture as local architect. Even in this challenging period of the pandemic, which does not allow physical travel, another strong cultural tie between the U.S. and Japan has been created.



Installation view at Japan Society, 2021. Exhibition design by Sou Fujimoto in collaboration with Brooklyn-based Popular Architecture.

This year is the 50th anniversary of the landmark building of Japan Society, designed by visionary architect Junzo Yoshimura, who integrated traditional Japanese craftsmanship with Modernist design, allowing Japan Society to become a platform to study tradition and embrace the new in order to greet the present. Also as it is the 10th memorial year since the devastating Great East Japan Earthquake, now more than ever, the resilience and creativity of Japanese carpentry inspires us with a vision of sustainability.

Yukie Kamiya Director, Gallery Japan Society



Tools

Tools

Japanese carpentry tools have both function and beauty. Shaped in a variety of striking and graceful forms with extremely precise functions, these tools have developed over a millennium through a dialogue between carpenters and wood since Buddhism was introduced into Japan in the 6th century. At that time, many cultural transformations were taking place, including writing, governing, and city planning as well as techniques for building that originated in China and Korea.

The uniqueness of Japanese carpentry tools is, first, their variation. Major categories include saws, chisels, hammers, planes, axes, and adzes. Before World War II, the complete set of tools reached around 180 items with diverse sizes of chisels and planes to create varieties of joinery. Even the standard set of tools included over 70 items. However, in the postwar period, with the emergence of power tools and shifts in construction methods, the number of frequently used tools declined.

Also unique to Japanese tools is the manner of how they are used. A number of Japanese carpentry tools are pulled, rather than pushed, in order to cut or shape wood, unlike in woodworking traditions in other locations such as China, Europe, and the United States. The difference is especially notable in the case of saws and planes. Japanese carpentry has evolved to prioritize control over force.

Historically, *daiku* (carpenters) created their tools, customizing them as an extension of their hands and to suit their body. Each tool became the physical embodiment of a specific range of skills and an irreplaceable object for their occupation. It is not customary for one carpenter to use another carpenter's set of tools.

Carpenter's Toolbox (Dogubako)





Rip Saw

Fundamental to wooden architecture is the transformation of live trees into timber to create lumber: cutting down, trimming, shaping, and further refining. Before the advent of power tools, this task was primarily done by a woodcutter with the aid of axes and adzes to achieve rough, cylindrical logs. However, saws were required for producing rectangular planks or sections of wood. The wide-blade rip saw is the typical tool used for lumbering.

Over the last several centuries, Japanese sawing techniques have greatly evolved, largely owing to developments in the technology of steel. In contemporary times, we have witnessed the ability to achieve a lighter and stronger tool with more efficiently configured teeth. The two main types of Japanese saws are rip saws (shown in these examples) and cross-cut saws, which are distinguished by the orientation of their saw teeth; while rip saws cut parallel to the grain of wood, cross-cut saws cut across the grain.

Wide-blade Rip Saws (Maebiki-oga)



Axe and Adze

Axes have long been important to the tradition of Japanese carpentry. Prior to the invention of power tools, the axe (together with saws) was used for felling trees, and also for hewing them into rough shapes before being further refined by other tools and woodworking techniques.

The adze was once used for hewing rough timbers, but today its use is limited to specialized finish work for aesthetic effects; the mark of its perpendicularly swung blade creates a decorative, rustic texture.

Felling Axe (Yoki) Broadaxes (Masakari) Adze (Chōna)

Inkpot

Among the primary instruments used for measuring, the inkpot has a retractable silk thread that is pulled through a reservoir of ink. Once placed in the desired location on a piece of rough-hewn lumber, the master carpenter $(t\bar{o}ry\bar{o})$ then pulls the thread taut and snaps a straight line onto the surface. The resulting ink mark indicates an accurate line that guides subsequent construction.

Red inkpots—so called because the ink is made from red iron oxide—are used to mark on finished wood surfaces that are ultimately exposed in their final assembly. This is because red ink is water-soluble and can be washed away. Unique among all traditional tools, the *daiku's* (carpenter's) inkpot is made from wood and frequently features decorative carving; this ornamentation not only establishes the carpenter's individual identity but may also suggest the ceremonial, quasi-religious role that giving measure plays in traditional Japanese carpentry.

Bamboo Inking Pens (Sumisashi) Inkpots (Sumitsubo)





Measuring Tools

Among other measuring tools, including the level and gauge, the carpenter's square (*sashigane*) is more than a simple ruler. It has carefully calibrated measurements incised on both its front and back sides to allow an experienced carpenter to measure and draw orthogonal, triangular, and complex curvilinear geometries directly on cutting templates. The tool was once made of steel or brass, but is now predominantly made of stainless steel, which is less prone to rusting. The master carpenter ($t \bar{t} r y \bar{v}$) uses their square to calculate the complex geometry of joinery on the block of wood itself; these local calculations are intimately tied to the overall modular design of building structures. In contrast to measuring through modern architectural scaled drawings, the use of the inkpot, carpenter's square, and other measuring tools requires a degree of physical exertion that connects abstract geometric thinking with the actual scale of building elements and the architectural spaces they produce.

Small Carpenter's Square (Makigane) Spirit Level (Suiheiki) Line-Marking Gauge (Suji-Kebiki) Reel Tool (Itomaki)

Saw

A saw consists of a bladed steel body and a wooden handle, often made from light woods such as Japanese cedar or paulownia, and its multiple teeth are blades used for cutting. Japanese saws function differently than saws in China, Europe, and the United States: the orientation of their teeth places the sharp side towards the handle, rather than away from it. This configuration results in saws that cut while the carpenter pulls the saw, as opposed to pushing the saw, which is a more efficient action that reduces stress on the steel blades, thereby allowing them to be thinner.

There are a variety of saws, ranging from large saws for rough cuts of logs or beams, to small saws that are used for refinement. Their variety of shapes are suited for different purposes. A keyhole saw (*hikimawashi-noko*), for example, has a narrow blade for cutting round shapes while a double-edged saw (*azebiki-noko*) is used for cutting grooves.

Rounded-Nose Roughing Saw (Anahiki-noko) Standard Crosscut Saw (Hikikiri) Double-edged Saw (Ryōba-noko) Azebiki Double-edged Saw (Azebiki-noko) Keyhole Saw (Hikimawashi-noko)





Chisel

It is undoubtedly chisels and planes that are most closely associated with the idea of Japanese craftsmanship. Together, these tools are used for the precise definition and patient refinement of both simple and complex geometries of individual wood members, preparing them for final assembly into a structure.

Chisels are widely used for carving, making mortises (female joints), and scraping wood. There are two classifications of chisels: striking chisels (*tataki-nomi*) and paring chisels (*tsu-ki-nomi*). Striking chisels are used with a hammer to carve into a surface, and paring chisels are pushed to scrape away a surface. Chisels have different blade widths, blade lengths, and handle lengths to serve different purposes.

The type of chisel selected reflects the demands and specialization of a carpenter's work. Temple and shrine carpenters deal with large lumber, so they have long, strong striking chisels. Carpenters who make smaller fixtures use a mortise chisel (*mukōmachi-nomi*). Many chisels are used for finishing interior joints and other intricate forms. Therefore, the shapes of special chisels are made to reach these parts. A trowel chisel (*kote-nomi*) is shaped with a bent tip, which is useful to finish the bottom of grooves. A dovetail chisel (*ari-nomi*) has a triangular profile to finish acute-angled corners.

Paring Chisel (Tsuki-nomi) Dovetail Chisel (Ari-nomi) Primary Striking Chisel (Hontataki-nomi) Wide-blade Chisel (Hiro-nomi) Wide-blade Chisel (Hiro-nomi) Gouge (Ura-maru-nomi) Mortise Chisel (Mukōmachi-nomi)

















Hammer and Wooden Mallet

Hammers are used to strike chisels, to nail, to put joints together, or to adjust tool blades. Depending on the materials and shape of the head, they are referred to by different names. Generally, a *gennō* is a hammer used with chisels and a *kanazuchi* is typically used to hit metal nails, but definitions can be ambiguous. A carpenter will select their specific hammer from the shape and weight most comfortable to them. Hammers do not wear out in the way that tools with blades do, and are therefore tools that are readily passed down and used for generations.

Double-faced Hammers (*Ryōguchi-gennō*) Wooden Mallet (*Kizuchi*)

Drill

There are two types of drills in a traditional set of Japanese carpentry tools. Drills that spin in both directions between two hands are called *temomi-kiri*, and drills that spin in one direction are called *handoru-kiri* or *bōruto-kiri*. The most common of Japanese drills was *temomi-kiri* until *handoru-kiri* and *bōruto-kiri* became widespread in the Meiji era (1868–1912). There are many different shapes of drill points for different materials and sizes of holes. The drill points of *handoru-kiri* are interchangeable.

Auger (Bōruto-kiri) Brace (Handoru-kiri) Screw Augers (Bōruto-kiri)











Planes are among the most important tools for the precise refinement of individual members of wood, before they are assembled into their final structure. The variety of types of planes expresses how they are used to shape surfaces of varying kinds—flat, curved, angled, grooved. There are six different types of planes for shaving flat surfaces alone, depending on the level of smoothness desired. In the early Showa period in the 1940s, a carpenter would own approximately 40 planes. Because a plane is required for high-precision work, including surface texture, the quality and sharpness of its blade is critical. Whereas it is common in other countries to finish a wooden surface with paint, Japanese carpentry is always intentionally left unfinished.

Groove Sides Planes (*Wakitori-ganna*) Pointed Side Shaving Planes (*Hibukura-ganna*) Sliding-dovetail Plane (*Ari-jyakuri-ganna*) Machine Plow Plane (*Kikai-jyakuri-ganna*)



Connections

Connections

Japanese carpenters utilize intricate and precise jointing techniques, which allow for a robust extension and assembly of complex forms. This practice, including the skills, ingenuity, and knowledge in jointing wood, is termed *kigumi* in Japanese, and has evolved over centuries, becoming increasingly sophisticated and complex in geometry.

Japanese wood joinery is traditionally created without the use of nails or other fasteners. Instead, the wooden joints are crafted to create a tight wood-to-wood fit that accommodates stresses such as weight or bending; they have been particularly resilient to absorbing the shock of earthquakes. The joint structure is often hidden when fully assembled within the architecture and thus the viewer rarely sees these masterful connections.



There are two main types of joinery in Japanese kigumi: splicing joints that extend members in the same direction are called *tsugite*, and connecting joints that are made at right angles, or any other specific angles, are called shikuchi. Although shikuchi are essential to wood construction, tsugite are more commonly used in large-scale architecture where a single length of timber proves to be insufficient. Today, metal connections require minimal time and effort. However, the ancient techniques for connecting wood, passed down by generations of carpenters, offer a unique craft for shaping forms.

Most *tsugite* and *shikuchi* joints have technical terms that have been used by carpenters over many years. If examined closely, it becomes evident that their

names are derived by a combination of basic terminology. For example, the *koshikake-aritsugi* (splicing lapped dovetail joint) is formed by joining the *koshikake* (lap joint) with the *aritsugi* (straight dovetail joint). In this way, each joint has a basic form from which several variants have been developed. Some *kigumi* have specific names, such as the *kanawa-tsugi* (mortised rabbeted oblique scarf joint), as they are used often and their constituent names are too long when combined.

In the following pages, *kigumi* are deconstructed diagrammatically. Various wooden joints are photographed in their disassembled states, revealing the beauty and practicality of *kigumi*. The artisan's aesthetics and careful attention that is particular to handcrafted carpentry, and the subtleties distinct to natural wood, are visible through these examples.



Two-stop Tenon (Neji-gumi)

Historically, the most primitive *kigumi* technique was to use rope to tie logs together. Although not having to process the log was a convenience, it was not durable so developments in notching and jointing techniques were pursued. Typically, the abutting surfaces were made flat because gaps lead to a reduction in load resistance. However, during the Edo period (1603–1868), ambitious design aesthetics resulted in the development of fabrication techniques where a curved surface could be retained in a joint, without any resulting gaps. In order to join the logs seamlessly, the log's curved surface must be exactly copied and finely crafted with a *marunomi* gauge. Despite appearing the same from the outside, the techniques and aesthetics driving a *kigumi* joint's fabrication likely vary.



Evolution of the Gooseneck Mortise and Tenon Joint (*Kama-tsugi*)

The *kama-tsugi* is likely the leader of splicing joints from ancient times until today. In ancient times, ease in fabrication was favored, resulting in the limited use of either parallel or perpendicular cuts. This, however, compromised strength; the earlier joint achieved between a third to half the strength of later variations. In the middle ages, the contact surface was increased by slanting the sides, which also resulted in minimizing the cut volume of the mortise side.

The Edo period (1603–1868) emphasized work efficiency, resulting in the return of a parallel neck. When increased strength is required, it was used in conjunction with a *koshi-kake* (lap joint). Marking was easily done with the carpenter's square and most of the cutting could be done with a saw.

During the postwar period, connection methods using metal fittings or hardware began to emerge. These could be fabricated without skilled labor. A more dramatic shift occurred in the 1980s with the emergence of prefabrication technology. Since marking is no longer required and machine tools perform the cutting, it is inexpensive and uniform in quality. Today, prefabricated members are frequently used.

Ancient, Medieval, and Early Modern Gooseneck Joints

Draw Pin (Komisen)

Komisen is a fixing method whereby a pin is driven through the side of a post at the location where the adjoining tie beam's tenon passes through, thus securing the joint through the center of the post and tenon. In this way, a post and tie beam can be secured together; however, it takes time and effort to make the holes accurately. Its use is found in many parts of the world, but it is particularly widespread throughout the Western world where drills were developed and in use.





Ōsaka Castle Front Gate Pillar Joint (Ōsakajyō-Ōtemon-Tsugite)

This joint is an example of *netsugi*, a process whereby new wood is inserted to replace rotten wood in the bottom sections of posts. Its reputation as a "puzzling joint" stems from the seemingly incomprehensible splicing method in which the front and rear faces show an *ari-tsugi* (dovetail joint), whereas the sides show a *sogi-tsugi* (simple scarf joint). An X-ray examination revealed that it was made to be inserted diagonally.



Construction

Construction

Traditional Japanese master carpenters $(t\bar{o}ry\bar{o})$ work holistically on executing every aspect of their projects. Their particular knowledge and craft is first expressed onto a two-dimensional plan before it is transformed into three-dimensional architecture, including temples, bridges, and other structures. The dynamic development of these processes, from structural plans to full-scale architectural forms, has been made possible through the experience and wide-ranging knowledge handed down by generations of carpenters. It is the substantial depth of expertise represented in traditional carpentry that informs this progression.

A master carpenter first draws detailed plans considering an actual building to construct, which includes the shapes and dimensions of wooden members, the structure of joints, and its overall design. Full-scale plans are drawn on plywood to confirm the silhouette of a building, especially curved lines such as the roof, eaves, and beams, in order to create pattern templates that are then directly copied onto the lumber. For complex details such as successive layers and stacked backrest and beam, large-scale models are often made to check the design and precision of each member. Full-scale drawings and patterns are created to improve the quality of the final three-dimensional form. However, they are not often made today, owing to the extensive labor and time required.



Elevation and cross section for Höryū-ji Temple Denpödö (Hall of Dharma Transmission)



Elevation plan for Hōrin-ji Temple

Carpentry Patterns

The curved lines of temples and shrines, such as their eaves and engraved members, are essential silhouettes that define their architectural form. The lines are transferred to wood from life-sized wooden patterns, which you can see on the exhibition walls. As paper has limitations in size relative to final architectural forms, a full-scale drawing is produced freehand by a *daiku* onto plywood, followed by a full-scale template. Then, the desired shapes are cut out and later refined using tools such as chisels and planes. This process takes great effort and time, but improves the construction quality.





Hōryū-ji Temple

Hōryū-ji Temple, also known as Ikaruga-ji, named after its location in Nara Prefecture, was founded in the late 7th century by Prince Shōtoku, who played a crucial role in establishing Buddhism in Japan. Its buildings are thought to constitute the oldest freestanding timber-frame structures in the world. The bracket sets of the Hōryū-ji Temple pagoda were procured from trees at least 3.28 feet (1 meter) in diameter, and the doors of the Kondō (Golden Hall), which consist of planks of wood measuring 3.28 feet (1 meter) in width and 3.54 inches (9 centimeters) in depth, were procured without the aid of sophisticated saws. Furthermore, because only the handheld spear-plane was available at the time, the surfaces of the temple's timber components are far removed from the remarkable textures that would eventually be achieved with the Japanese block plane. Hōryū-ji Temple contains over 2,300 important cultural and historical structures and articles, including nearly 190 that have been designated as National Treasures or Important Cultural Properties.

Kondō (Golden Hall)



Daikōdō (Large Lecture Hall) Kyōzō (Sutra Repository)



Kintai-kyō Bridge

Most Japanese wood construction consists of posts and beams. A rare exception is the Kintai-kyō Bridge in Iwakuni, Yamaguchi Prefecture. Here, a wood arch spans an impressive 118 feet (36 meters) without any intermediate supports. A series of five consecutive arches, the bridge was first built in 1673 and has been rebuilt and renovated ever since. The structural arched form of the bridge consists of a *keta* (girder), *kusabi* (wedge), *hari* (cross beam), *ato-dzume* (spreader beam), *fure-dome* (strong back brace), *kuragi* (diagonal brace), and *tasukegi* (arc brace). A levelling packer called *heikin-gi* is installed on top, followed by the *hashi-ita* (bridge plate and tread) and *kōran* (railing). The bridge is constructed from various wood species most appropriate for a particular member's function. For the structural members and members transferring heavy loads, zelkova is used. In other areas, pine is used for its greater resistance to bending. As hinoki cypress is resistant to decay, it is used in areas most exposed to weather, such as the bridge plate and tread, and the railing.





Kintai-kyō Bridge details

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