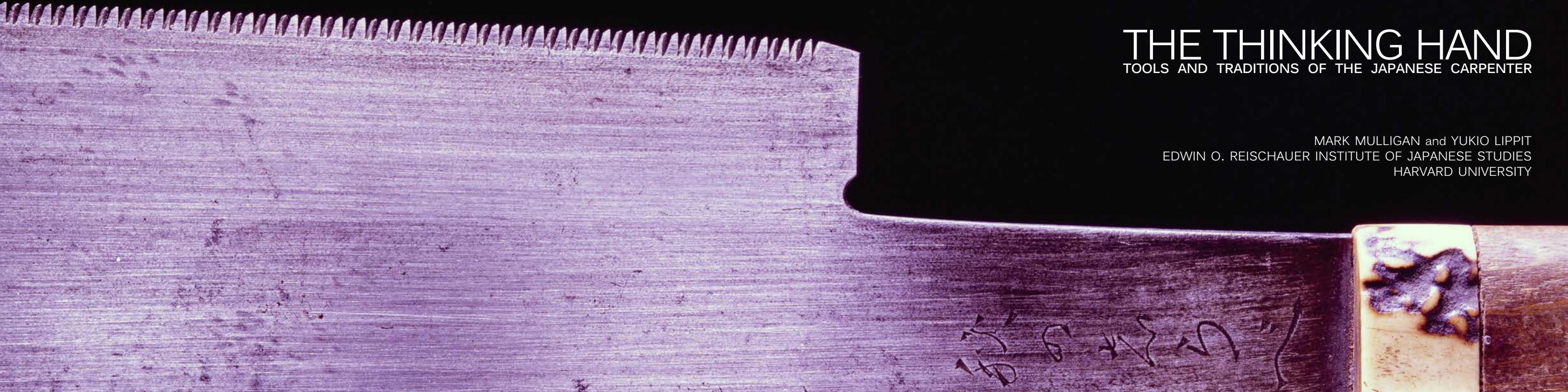




THE THINKING HAND

TOOLS AND TRADITIONS OF THE JAPANESE CARPENTER

MARK MULLIGAN and YUKIO LIPPIT
EDWIN O. REISCHAUER INSTITUTE OF JAPANESE STUDIES
HARVARD UNIVERSITY



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FOREWORD

The Reischauer Institute for Japanese Studies at Harvard University is delighted to celebrate the fortieth anniversary of its founding with this very special exhibition, “The Thinking Hand: Tools and Traditions of the Japanese Carpenter.” This exhibition honors an important gift of traditional woodworking tools of the Japanese *daiku*, or master carpenter, to Harvard’s Graduate School of Design from the Takenaka Carpentry Tools Museum in Kobe, Japan. It marks a unique collaboration among the Graduate School of Design, the Reischauer Institute, and the Takenaka Museum to advance understanding and appreciation in North America of a remarkable, centuries-long tradition of Japanese building and artistry.

Harvard has long been an important center for the study of Japanese architecture, reflected in part by the number of distinguished Japanese architects who have taught at the university; the number of Japan-related exhibitions and design studios held here over the years; and the wide array of curricular offerings and research projects among Harvard faculty and students that address Japanese architecture and urbanism. The Reischauer Institute is pleased to showcase and advance this engagement through an exhibition that explores Japanese architecture, design, and woodworking traditions from the perspective of the tools of the master carpenter, whose craft can be understood as equal parts artisanal and conceptual.

Japanese artisans – whether master carpenters or master chefs – often refer to their skills and their knowledge in bodily terms: *karada de oboeru* (remembering with the body), for example. Speaking of expertise, they may refer to *ude* (the arm) as its locus. This exhibition of carpentry tools and the ways in which these tools can be used to shape wood gives ample evidence that the materiality of tools, the physicality of their use, and the beauty of the results demonstrate *ude no chikara* – the strength of the artisanal arm!

My colleagues at the Reischauer Institute and the Graduate School of Design join me in thanking Chairman Toichi Takenaka, the Takenaka Corporation, the Takenaka Carpentry Tools Museum, and the Rockefeller Fund for East Asian Art for all they have done to make this unique opportunity possible. Particularly crucial to this endeavor were Kenzo Akao, Tadanori Sakamoto, and William Coaldrake, who served as advisors to the exhibition, as well as Joji Kuramado and Daishi Yoshimoto, who initiated our contact with the Museum. Their efforts have yielded not only a special exhibition, but also teaching and research materials through which future generations of Harvard students and faculty will be able to explore the remarkable artistry of the *daiku*.

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Front cover: A pair of *miya-daiku* survey Yakushi-ji’s East Pagoda in preparation for preservation work.

Rear cover: Master carpenter Tsunekazu Nishioka

Front inside cover: © Shigeo Ogawa

Rear inside cover: © Takenaka Carpentry Tools Museum



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THE THINKING HAND

Japanese woodworking tools marry function and beauty. Shaped in a variety of striking forms and prized by carpenters worldwide for their extreme precision, they show how everyday objects can be shaped by culture and practice over many centuries. A closer look at the context of their creation and use reveals intriguing glimpses of the traditional *daiku* (大工), or master carpenter, and his world. More than a mere craftsman, the *daiku* combined the roles of designer and builder of all architecture in Japan until well into modern times. To perform these roles, the *daiku* needed to master a diverse array of specialized tools; with years of practice, these tools became extensions of his hands, providing direct physical feedback about the task at hand.

In January 2014, the Takenaka Carpentry Tools Museum donated a set of sixty-two traditional carpentry tools to the Harvard Graduate School of Design as a resource for architecture students to learn about the rich traditions of Japanese wooden architecture. The tools donated to the GSD represent a base set that would have been employed by a *daiku* working in the Kansai region of Japan in the early 20th-century – a period known among experts as a Golden Age of tool-making, prior to the widespread introduction of power tools and industrial production. Though individual pieces have been drawn from several different sources, all of them bear the imprint of their owner's use: a patina born of interaction between muscle, steel, stone, and wood.

How did the mind of the *daiku* shape these tools? How did these tools shape the mind of the *daiku*? And what kinds of insights do tools offer into Japan's traditional cultures of building? These are questions we explore in "The Thinking Hand."

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FORESTS AND WOODS

Japan's carpentry traditions are rooted in the island country's varied topography, moderate climate, abundant water, and rich biodiversity. Dense forests cover a majority of the land, particularly in mountainous areas unsuitable for agriculture or urbanization. In today's popular imagination, forests constitute a primeval world apart from the urban environments inhabited by humans. But it's worth remembering that forests have long been the primary source of building materials in Japan, and that a sophisticated wooden architectural culture emerged from the intense historical relationship between people and trees. In this sense, we may understand the Japanese respect for nature as something more intimate and intelligent than mere appreciation of scenery: it might also suggest a continuous working relationship.

For much of Japanese history, the *daiku*'s role in a major building project began with selecting trees to be felled; thus his knowledge of a particular piece of wood began long before applying a set of chisels and planes to it. The very best stock – large-diameter, centuries-old Japanese cypress – grew on forested mountainsides (particularly high-altitude and north-facing), where a short summer growing season would increase the density and regularity of wood grain and enhance both strength and workability. Though such trees were abundant during the great era of palace and temple building of the Nara and Heian Periods (7th through 12th centuries), a crisis arose in the 12th century with the near eradication of old-growth cypress on Japan's main islands. The depletion of the country's primary building material was probably the most serious environmental crisis faced by Japan until modern times. It brought the usual way of producing architecture to a halt and challenged Japanese builders to develop new tools (better quality steel for cutting lower-quality woods) and design methods (relying on joinery of smaller pieces rather than on single timbers) and to cultivate a new aesthetic sensibility (appreciating irregularity and patina). It would also lead in later centuries to one of the world's first managed reforestation projects, as entire mountainsides were uniformly replanted with Japanese cypress and cedar.

Four of the most commonly used woods in Japanese structures are Japanese cypress, Japanese cedar, Japanese red pine, and zelkova. Each is recognizable to an experienced *daiku* not only by its color and wood grain but also by its scent when freshly planed.

Preceding pages: Japanese cedar (*sugi*) grows abundantly on the mountains surrounding Kyoto.



Above: Newly harvested cedar logs from the Yoshino district of Nara.



Middle: An enormous Japanese pine log and sawyers in Kiba, Tokyo, 1950s.

Below: Shinto practice holds that trees and other natural features of the landscape may house divine spirits. The *shide* (紙手, folded paper streamers) and *shimenawa* (標縄, enclosing rope) placed around these Japanese cypresses signal to others that they may not be cut down.

Opposite: Straight-growing Yoshino sugi are valued by carpenters for their size and dense grain.



Japanese cypress (*hinoki* 檜 = *Chamaecyparis obtusa*) is the *daiku*'s favored wood - the "gold standard" in traditional Japanese carpentry - thanks to its high strength-to-weight ratio and to the straight, even grain that allows optimal workability. Tight-grained Japanese cypress retains oils longer than other woods, resisting water and insect damage and imbuing it with unparalleled longevity - as attested by the pillars of Hōryū-ji Temple, some of which are over 1,300 years old.

Japanese cedar (*sugi* 杉 = *Cryptomeria japonica*) is a second highly favored structural wood native to Japan, with excellent properties of strength, workability, water-resistance and longevity. A fast-growing softwood that thrives in varied climates and soils, today it is commonly used for most kinds of wood construction.

Japanese red pine (*akamatsu* 赤松 = *Pinus densiflora*) is widely admired for its hardy, rustic qualities. Pine trees may grow in irregular, branching forms, and harvested timbers feature frequent knots and varied grain. It is not uncommon in old houses to find large arching and twisting pine trunks used as primary roof beams, due to their superior strength.

Zelkova (*keyaki* 楸 = *Zelkova serrata*), also known as Chinese elm, is the only hardwood species traditionally used in Japan for structural purposes. Zelkova has irregular, curving grain that makes it more difficult to work than comparable softwoods but also imbues it with decorative appeal.





PRIMARY SHAPING

The transformation of living trees into structural members of precise, stable dimension is fundamental to all wooden architecture. Prior to the development of industrial mills and power tools in the past century, this task of primary shaping was the most physically demanding part of the *daiku*'s work. For relatively minimal transformations such as producing large cylindrical columns from straight logs, a combination of axe, adze, and planing knife would have been sufficient. Producing precisely measured rectangular-section columns, beams, and planks from these same logs, however, required the development of diverse kinds of saws.

Japanese sawing techniques and saw shaping have evolved significantly over the last several centuries – from the medieval gang-saws that harvested beams and planks from enormous old-growth trees to the combination of mechanized and hand-held saws used in modern times. Dramatic improvements in steel-making technology drove this evolution, with sharper, stronger, more efficiently configured teeth allowing saw blades to become lighter and easier to control. Japanese saws differ from Western and Chinese saws in the orientation of teeth, with the sharp side located towards the handle rather than away from it. Cutting while pulling puts the saw blade in tension – a more efficient mechanism than pushing, in that it allows the steel blades to be very thin without deflecting out of plane under stress. Japanese saws are divided into two families: ripsaws (cutting parallel to the grain) and cross-cut saws (cutting across the grain). Both types are combined for convenience in the modern double-edged saw. Finer distinctions in blade shaping and tooth configuration correspond to the type of wood (soft or hard) and degree of finish expected.

Axes and adzes once played an important and versatile role in Japanese carpentry. Before the advent of power tools, the axe was used not only for felling trees but also for hewing them into rough shapes prior to more refined finishing. The adze was once used for hewing rough timbers, but today its use is limited to specialized finish work for aesthetic effect: the mark of its perpendicularly swung blade creates an attractive rustic texture.

The planing knife (*yariganna*, 槍鉋) requires a light, expert touch to smooth the surface of a wood member. Used since ancient times, it has since been replaced in common use by block planes.



Above: A daiku uses his carpenter's square (*sashigane*, 曲尺) and a bamboo pen to mark an axis line.

Below: Sawyers use a 19th century wide-bladed ripsaw to produce dimensional lumber from an enormous cedar log.

Opposite: Rough hewing with an axe.





Left: A saw produces the rough shape of a tenon (male joint).

Right: Sawing a groove at the top of a slender, round column.

Opposite: Chopping with an adze produces a roughly textured surface.





FINE SHAPING AND JOINERY

While axes and saws are responsible for much of the *daiku*'s work, it is undoubtedly his chisels and planes that we most closely associate 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. As the *daiku* moves his plane across the wood surface – or as he chisels with or against its grain – he experiences a degree of resistance given by the wood to his steel blade. This resistance may be greater or lesser than expected based on visual cues, and it may vary across the individual piece. Based on this constant physical feedback, the carpenter's hand instinctively reacts with greater or lesser force, greater or lesser speed, or he may choose another tool to complete the task. The immediacy of this interaction produces an intimate knowledge of the individual building materials and informs his decisions in real time.

Essential to this physical interaction is the tool blade. The extremely sharp and strong blades characteristic of pre-modern Japanese chisels and planes are the result of labor-intensive steel fabrication techniques developed and perfected in the age of the samurai. The production of high-strength steel requires several days of repeated heating, hammering, folding, and cooling in a traditional forge. The continuous refinement of high-carbon steel requires separating out low-carbon steel (the largest portion, used for the stem or core of the blade), then hammering and folding high- and medium-strength steel into alternating, microscopically thin layers to produce strong yet ductile blades. The highest grade of hand-forged steel, known as *tamahagane* (玉鋼), is far superior to today's industrially produced steel.

Even the most expertly crafted tool blade is not considered complete when newly produced, however; its owner must become accustomed to its particular qualities and how those work with his hand's range of motion. An expert *daiku* devotes many hours every week to maintaining (sharpening, adjusting) his blades, and over time those efforts will reshape his tools into a set that is uniquely fitted to his own hand.

A block plane is pulled towards the body rather than pushed away, allowing precise control of the blade.



Right: A *daiku* uses a planing knife (*yarihanna*) to smooth the surface of a round column.

Opposite: In planing a wood member to a smooth finish, a *daiku* produces delicate ribbons of wood – often thinner than a human hair.





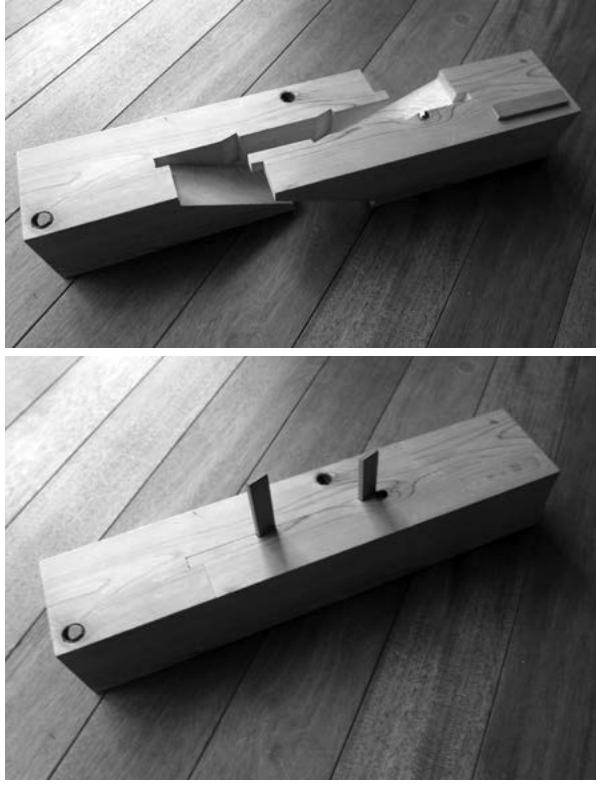
Above: Hammers are used with striking chisels to help them cut against tough grain.



Below: A large-scale paring chisel allows the *daiku* to channel his own weight to the cutting edge.

Opposite: Preparing a wooden member for assembly may require a large number of mortises (female joints), each precisely measured and carved with chisels.





Left: A rabbeted halves scarf joint (*miyajima-tsugi*) uses wedge-shaped pins to lock two beam ends together; seen here in open and locked positions.

Right: The x-shaped ship end joint (*kai-no-kuchi-tsugi*) is used with pins for joining round columns.

Opposite: While assembling a bracket complex, the *daiku* may mark each component where it cannot be seen.



Traditional Japanese architectural joinery is executed largely without the aid of nails. Its complex geometry evolved over the centuries from a basic problem-solving approach (how to resist earthquakes, how to create long-spanning timbers from smaller stock) to a highly aestheticized display of ingenuity and skill. The pleasing geometry of each joint corresponds to structural necessity: a tight fit between properly sized surfaces is essential for resisting shear and bending stresses. Resilient wood-to-wood joints also absorb considerable energy during earthquakes and help prevent timber-frame buildings from collapsing.

其二

角木之形同落題

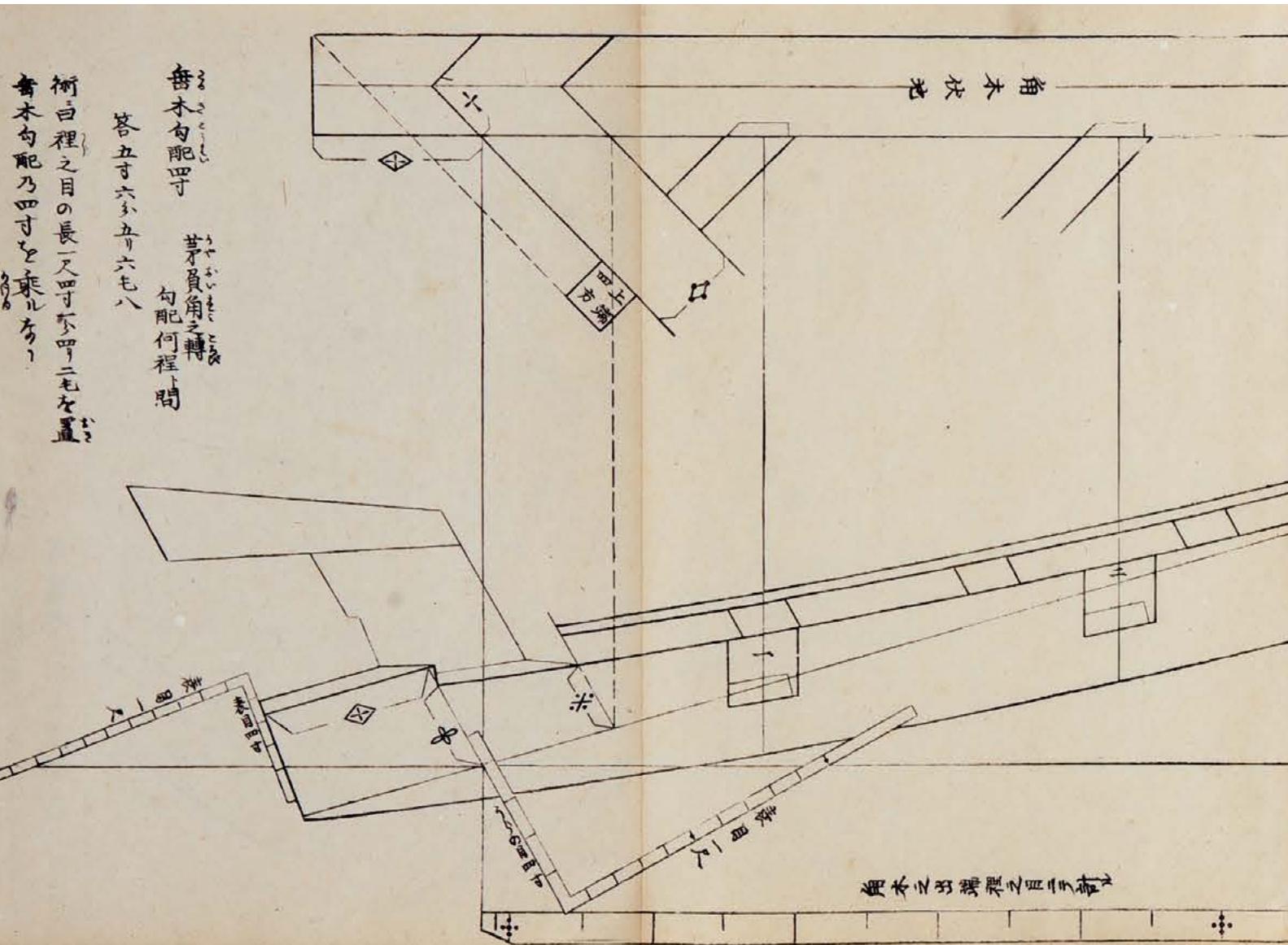
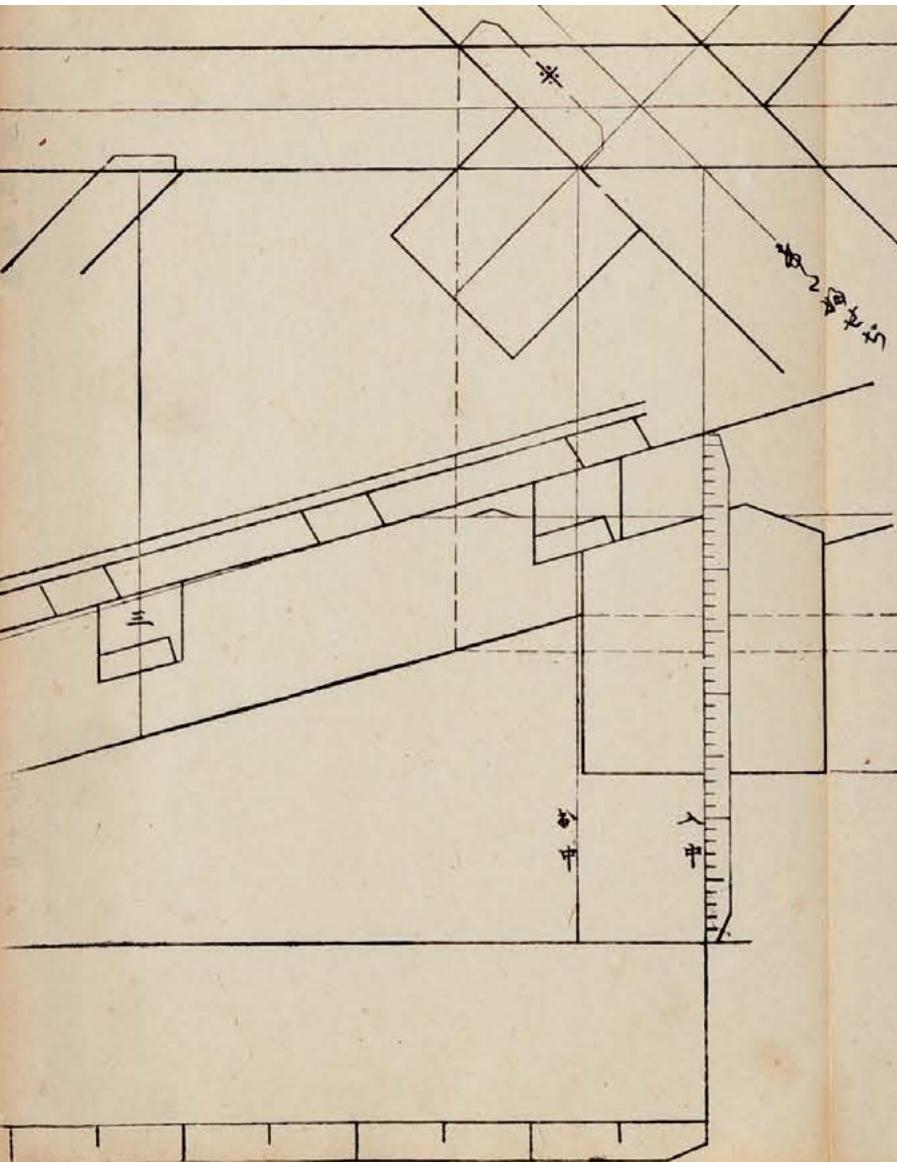
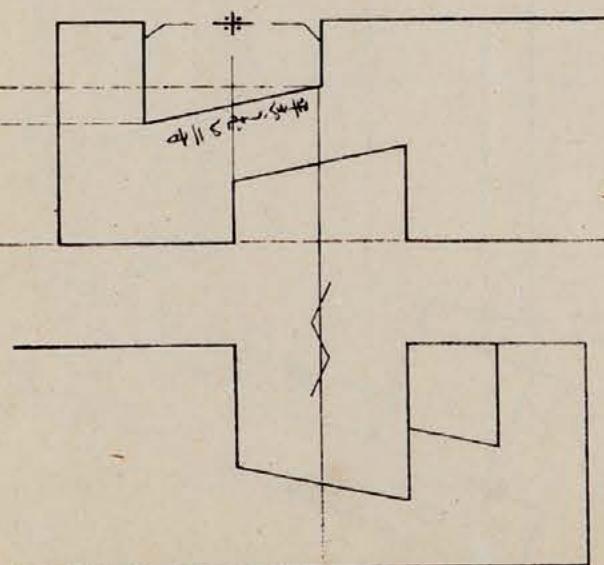
桁

組手
半勾配

茅屋之反
角木摸

中目脛

立水



脚木之形同落題



MEASURE AND ASSEMBLY

Not all Japanese carpentry tools are designed to carve or shape wood directly; the traditional tool set also includes a large number of instruments used for measuring, drawing, and creating design templates. Measuring tools correspond to the *daiku*'s role as designer and leader of all on-site building activity.

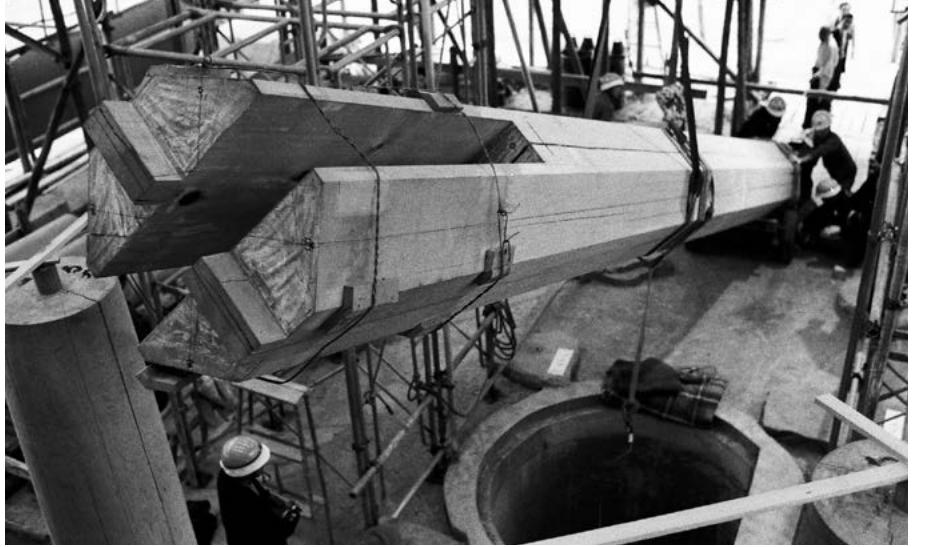
Primary among traditional measuring tools are the inkpot and carpenter's square. The inkpot's retractable thread is drawn across a reservoir of silk wadding soaked in black ink then snapped along the length of a piece of wood, leaving the mark of a straight line to guide subsequent construction. Red inkpots are used for marking geometries on exposed wood finish surfaces, since their lines of water-soluble red ochre (*bengara*) may be washed away later. Unique among all traditional tools, the *daiku*'s inkpot is made from zelkova 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.

The carpenter's square is more than a simple ruler: carefully calibrated measurements incised on its front and back sides allow an experienced user to measure and draw orthogonal, triangular, and complex curvilinear geometries directly on cutting templates. The *daiku* uses his 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. It could be said that the *daiku* masters traditional timber-frame architectural design through his familiarity with the carpenter's square. In contrast to the dictation of measure through modern architectural scaled drawings, the use of the inkpot, carpenter's square, and other measuring tools requires a degree of physical exertion – hence muscle memory – that connects abstract geometric thinking with the actual scale of building elements and the architectural spaces they produce. The well-choreographed measurement of such elements and spaces might be considered a crucial dress rehearsal for assembling the building itself.

The *daiku*'s basic tool set also includes a number of accessory tools that help cutting tools (saws, chisels, planes, etc.) do their work more efficiently. These include gauges, which transform the act of measurement into a repetitive, mechanical activity; hammers used with chisels or nails, or for adjusting tool blades; wooden mallets for fitting structural joints; and sharpening stones for maintaining tool blades in top condition.

Previous pages: Technical drawing from Masatoyo Suzuki's 1847 carpentry manual *Kikushinjutsu nokimawari zukai*, showing how the carpenter's square can be used to measure and mark complex eave geometries.

Opposite: Miya-daiku Tsunekazu Nishioka and his assistant produce a detailed technical drawing elaborating the roof construction of the Three-Story Pagoda of Hōrin-ji Temple (Mii, Nara Prefecture). The original 7th century structure was destroyed by lightning in 1947 and not reconstructed until 1975.



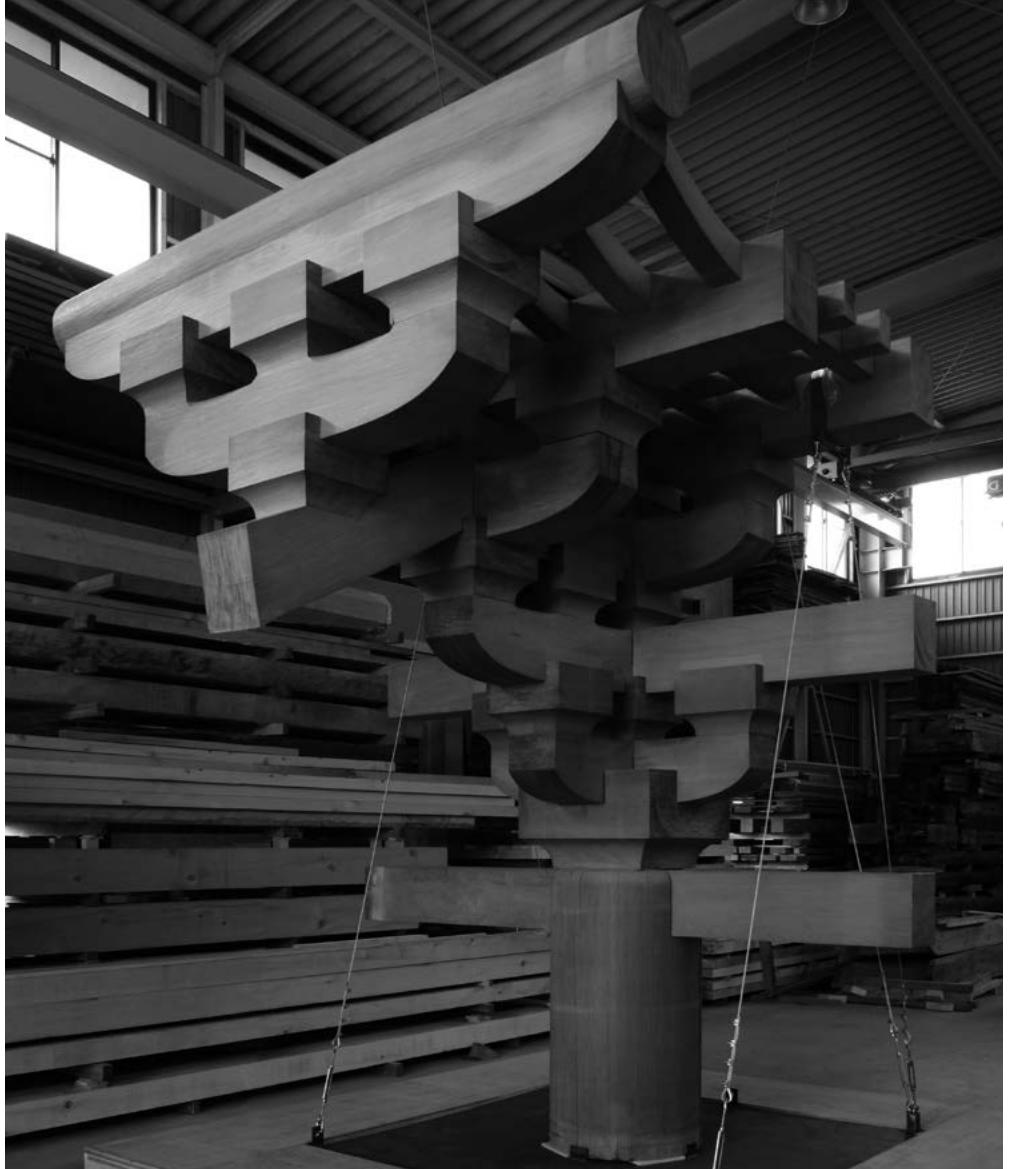
Above: *Daiku* raise the central column of Hōrin-ji's pagoda using ropes and scaffolding.



Below: The structure of a pagoda roof relies on successive layers of stacked beams and hip rafters.

Opposite: *Daiku* use wooden mallets to knock wooden structural members into tight-fitting joints.





Right: Full-scale mock-up of the bracket construction in Tōshōdai-ji's Golden Hall, produced by *daiku* Tsunekazu Nishioka and Ikaruga Kōsha, 1986.

Opposite: A *daiku* maintains his plane blades by sharpening them on a wet stone (left) and gently adjusting its shape with a hammer (right).





ARCHITECTURAL EXAMPLES

The tools and techniques of Japanese carpentry have played a vital role in the development of a variety of architectural genres, each requiring a different set of specialized skills, tools, and materials. The architectural examples seen here represent different paradigms not only of construction but also of aesthetic expression through tectonic detail.

RELIGIOUS ARCHITECTURE

The oldest examples of wooden structures in Japan today are religious buildings – Buddhist temples and Shinto shrines. Some of these temples and shrines are still standing after well over a thousand years, while others have been reconstructed according to historical methods. The Ise Shrines are emblematic of the latter approach; their construction method is refined yet archaic, and their renewal every twenty years keeps ancient architectural meanings and practices alive for new generations. The highly esteemed carpenters known as *miya-daiku* (宮大工) often specialize in both modes of religious architecture. Though dwindling in number, *miya-daiku* are still active today in restoration projects and working on special commissions or occasions such as the renewal of the Ise Shrines.

Buddhist religion spread to Japan from Korea in the 6th century, soon followed by imperial China's sophisticated systems for writing, governing, city planning and building. From the 7th century onward, once Japan's imperial clan began establishing large-scale capitals in the basins at Asuka and Nara, great temple complexes were built on a monumental scale that would have been unimaginable prior to the influx of expert carpenters from the Korean peninsula. Among the particular innovations they brought to Japan were techniques for harvesting centuries-old trees and transforming them into enormous columns and girders; techniques for creating strong, resilient wood joints capable of resisting earthquakes; and bracketing-and-stacking techniques that allowed roof overhangs to achieve cantilevered spans of up to 11.5 meters (37 feet). The ascendancy of Zen Buddhism (another Chinese import) during the 13th century introduced new techniques and expressive possibilities for roof structures. Generally speaking, Buddhist architecture is characterized by symmetrical plan organization in which the weight of a heavy, tiled roof is distributed among an outer perimeter of columns resting on stone bases; bracket sets on top of the pillars facilitate the transfer of roof loads. Spaces between the perimeter columns are filled with non-structural plaster walls and hinged wooden doors. The absence of pillars within the structure allows for a flexible interior space. The large, graciously curving roof, with eaves extending well beyond the wall plane, gives Japanese Buddhist temples their characteristic profile.

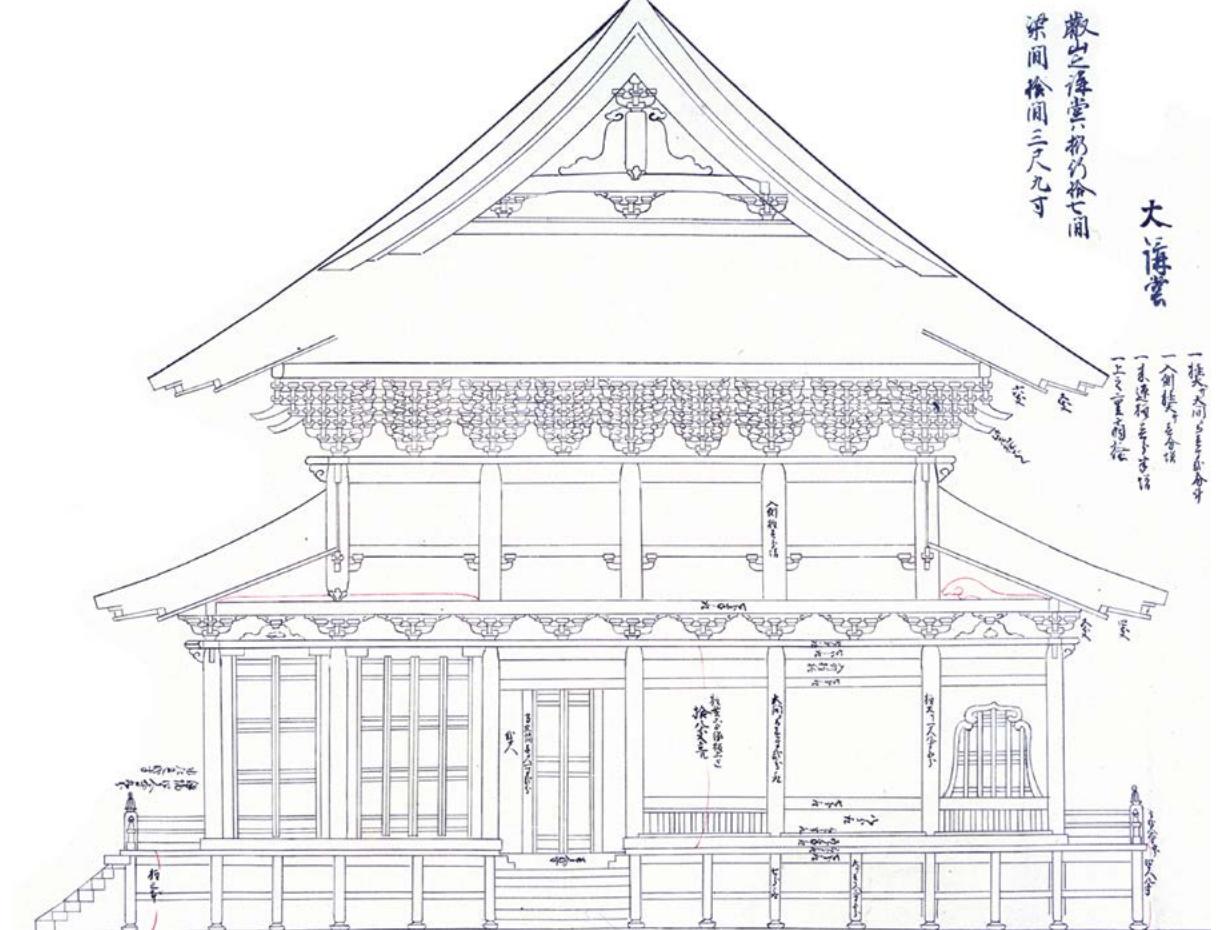
Shinto shrine architecture has generally preserved a pre-continental mode of wooden construction, modeled upon Neolithic rice granaries and featuring unpainted wood structures with raised floors, pillars extending into the ground, and a thatched, gabled roof. The most characteristic roof features – the forked finials (*chigi* 千木) and cylindrical billets that line the ridgepole (*katsuogi* 鯉木) – are stylized remnants of primitive post-and-lintel structures.

Opposite: The Kondō (金堂, Golden Hall) of Hōryū-ji temple in Nara is among the world's oldest free-standing wooden structures. The 7th century building has been periodically restored, most recently in 1954.

Right: Elevation drawing for a model Daikōdō (大講堂, Large Lecture Hall) in Zen Buddhist style, from a 1689 design manual written and illustrated by Ihei Masahito Kashiwagi, one of the most famous *daiku* of the time.

Opposite, left: The Hattō (法堂, Dharma Hall) of Daitoku-ji, a 14th century Zen monastery in Kyoto (this building dates to the 17th century).

Opposite, right: Detail of wood joinery supporting the roof of Daitoku-ji's Butsuden (仏殿, Buddha Hall). The elegantly curved roofs and dense bracketing of eaves reflect the stylistic influence of Song Dynasty China on Zen Buddhist architecture.



THE ISE GRAND SHRINES

Located in Mie Prefecture, the Ise Grand Shrines are composed of two main shrines and over one hundred smaller, auxiliary shrines. The two main shrines are the Inner Shrine, whose principal deity (*Kami*) is the sun goddess and ancestral spirit of the imperial house, Amaterasu Ōmikami, and the Outer Shrine, whose principal deity is Toyouke no Ōkami, a food goddess serving the sun goddess. The Inner Shrine is situated on the banks of the Isuzu River, while the Outer Shrine is located about two and one-half miles away, in Yamadahara.

According to *Nihon shoki* (a compendium of myth and early Japanese history dated to 720) the legendary Emperor Suinin entrusted the worship of his divine ancestor Amaterasu Ōmikami to a female shaman called Yamato Hime, who received an oracle from the sun goddess: "The province of Ise, of the divine wind, is the land whither repair the waves from the eternal world, the successive waves. It is a secluded and pleasant land. In this land I wish to dwell." This mythical account parallels an imperial decision to move the seat of worship for the divine ancestor of the ruling Yamato clan to a spot directly East of its capital, allowing it to proclaim that it ruled "all under Heaven."

The earliest worship of the Kami took place outdoors, in temporary enclosures where ritualists would invoke the Kami to descend to earth and enter a sacred object, so that offerings and prayers could be presented to them. Only later were permanent structures built as shrines.

The two main sanctuaries face South and are enclosed by multiple nested fences. The complex preserves Japan's earliest architectural forms, modeled on ancient granaries, in a style called *Yuiitsu Shinmei-zukuri*. In each sanctuary, polished metal mirrors represent the Kami. The buildings are raised off the ground by pillars placed directly into the earth. Beneath the center of each sanctuary is a "Heart Pillar," the most sacred element; it protrudes from the ground but is not a structural support. Interpretations of its significance have evolved over the centuries, but it remains the "holy of holies."

In the late seventh century, Emperor Tenmu (reigned 673-686) decreed that the Ise shrines should be rebuilt once in every twenty years, supplanting an earlier practice of rebuilding at indeterminate intervals on adjacent sites of the same size. Why twenty years? Since the pillars are set directly into the earth, they would naturally deteriorate, as would the rush-thatched roofs. Twenty years is roughly

Opposite: The newly reconstructed Main Sanctuary of the Inner Shrine (Kōtai Jingū On-shōden, 皇大神宮御正殿) at Ise.
© Jingū Shichō



a generation, the time required to pass the building techniques from one generation of carpenters to the next.

Each rebuilding displays the sovereign's majesty and power. Beginning in 690 and continuing until 2013, the shrines have been rebuilt sixty-two times, through a remarkable ceremonial sequence called Shikinen Sengū. Construction techniques have been recorded minutely since ancient times, resulting in the transmission of the ancient prototype down to the present. The 62nd Renewal began with preparatory ceremonies in 2005, required the felling of around 13,600 trees, and cost above \$550 million, collected in large part through donations channeled through Shinto shrines nationwide.

Because the rebuilding requires the precise replication of numerous shrine buildings and their treasures, such as swords, sculptures, textiles, altar equipment, vestments, and jeweled ornaments, Shikinen Sengū provides an immense historical repository of Japanese religion, arts, architecture, and culture, preserving precious artistic techniques, and the skills and tools of carpentry.

Helen Hardacre
Reischauer Institute Professor of Japanese Religions and Society
Harvard University

Right: Ornamental tool sets are used in rituals marking important stages of construction, but not for actual construction.

Opposite: Accompanied by priests, the *daiku* uses ceremonial tools in rituals such as the Chōna-hajime-shiki (斬始式), which officially marks the commencement of construction.





RESIDENTIAL ARCHITECTURE

Many of the features that we associate today with the traditional Japanese house – *tatami* floors, sliding paper screens (*shōji*) and paper-sheathed doors (*fusuma*), the earth- or stone-floored entrance vestibule (*genkan*) – were consolidated in the 16th century with the development of an aristocratic style known as *shoin-zukuri* (書院造). The new style reflected both the military elite's need for formal ceremonial spaces and their preference for a less formal living environment. Homes built in this style feature asymmetrical plans based on solar orientation and particular garden views. Flexible, minimally furnished interior spaces may be separated or joined by sliding doors and are typically surrounded by an exterior corridor (*engawa*). Structural elements consist of regularly spaced square columns and rectangular-section beams; joinery is straightforward and unadorned, since the structure itself is not considered as interesting as the interior and garden views that it frames.

Opposite: The New Palace (left) and Middle Shoin (right) of Katsura Imperial Villa, on the outskirts of Kyoto. Completed in 1624, Katsura's main residence epitomizes the refined construction yet informal layout of *shoin-zukuri*.

Above: Interior of the Shōkin-tei (松琴亭) teahouse, Katsura Imperial Villa, Kyoto.



Above: Shisendō (詩仙堂,
Hall of Immortal Poets) in
Kyoto.

Below: Room interior with
painted fusuma, Kōtō-in,
Daitoku-ji temple complex,
Kyoto.

Opposite: The doors of
Katsura's Geppa-rō (月波樓)
pavilion may be completely
removed on sides facing the
garden's large pond, merging
interior and exterior space as a
single composition.

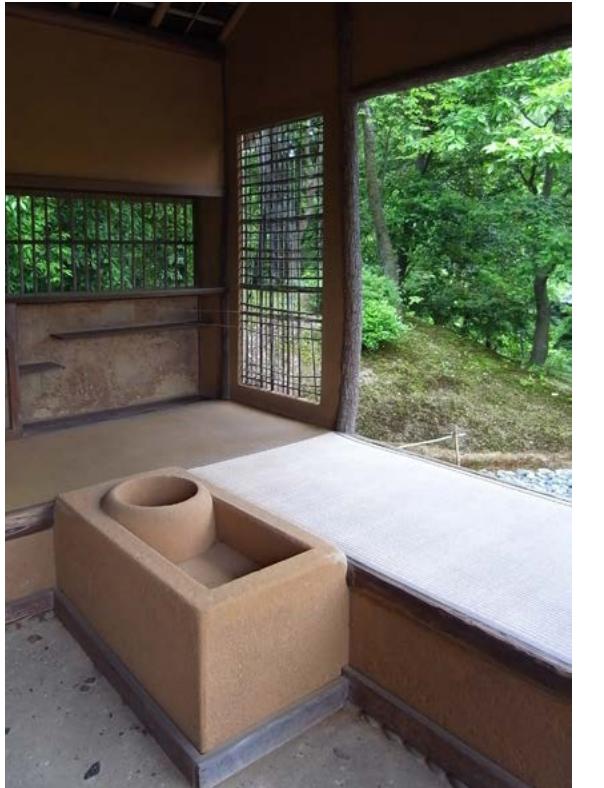




Above: Fold-up paper models became a popular way for *sukiya-daiku* to communicate their designs to patrons, combining writing and drawing; this teahouse model dates from the 19th century.

Below: Surrounded by a grove of cherry trees, the open-air Shōka-tei (賞花亭) teahouse is the most rustic of Katsura's many auxiliary structures.

Opposite: Sukiya architecture favors the use of various round-section members, which recall the natural shape of wood. Tightly fitting round posts and beams together into structural joints, however, requires far greater skill than joining squared-off members.



SUKIYA ARCHITECTURE

Tea ceremony, or *chanoyu* (茶の湯), developed a devoted following among the elite of 16th century Kyoto and has exerted a powerful aesthetic influence over many forms of artistic production in Japan ever since. The renowned tea master Sen-no-Rikyū preferred to host *chanoyu* in small, rustic teahouses, as these embodied the values of humility and reclusion. The genre of *sukiya* (数寄屋) – an artistically inspired form of faux-rustic construction – soon emerged following his example. In contrast to other traditional genres of wooden architecture, *sukiya* favors slenderness and fragility over robustness. Diverse materials – typically several different kinds of wood, bamboo, reeds, paper, various plasters and mud renders – are minimally treated so that the form, texture, and color of all elements are individually expressed. A *sukiya-daiku* carefully selects all the materials for his work prior to finalizing the design, frequently finding formal inspiration in natural irregularities and imperfections. The structural frame combines both round and square columns, and among the posts and beams may be naturally curved members recalling the live appearance of a tree trunk or branch. Creating precise three-dimensional joints among such diverse structural members requires acute foresight and expertise with specially shaped chisels and planes. The *daiku*'s craftsmanship, together with his eye for aesthetic effect, elevates *sukiya* to a level of artistry quite apart from the rustic construction methods that inspired it.



THINKING HANDS

MARK MULLIGAN

Young people studying to become architects today have some truly remarkable tools at their fingertips: principally the mouse and keyboard that, together with advanced modeling software, allow them to develop geometrically complex objects in a gravity-free computing environment. Armed with these tools and perhaps two years of training, students can produce uncannily photorealistic images of architecture, rich in material textures and lighting effects. The hand-eye coordination skills required to master mouse and keyboard are similar to those required for most other computing tasks and bear no relation to the nature and scale of the design object; they are the same for the design of a piece of hardware and for the design of a city. Schools of architecture are well aware of the abstract, scale-less qualities that digital design tools can produce, and of the growing disparity between what students can imagine and what they know how to construct. Over the past two decades, we have addressed this gap by introducing digital fabrication into our curriculum. Today young design professionals engage the physicality of construction using tools such as laser cutters, 3D printers, CNC routers, and robots to produce scale models and component prototypes – material versions of the virtual objects they've created on the computer. The "hands-on" learning in digital fabrication involves producing a series of fully formed objects in an iterative, automated process; and through repeated failure and redesign, students learn about dimensional constraints inherent in a variety of construction materials and fabrication processes.

Within the context I'm describing of a 21st-century architecture school – particularly one focused on anticipating future design trends – the idea of introducing a set of handcrafted Japanese woodworking tools as a resource for students to learn about construction might strike some as historicist, nostalgic, or backward-looking. And in fairness, the Takenaka Corporation's generous donation of a set of traditional tools to the Harvard Graduate School of Design did require us to think deeply about the use of such tools within our curriculum. The pieces in this set are nearly a century old and, having been used over the lifetime of a particular *daiku*, each has developed a unique shaping and patina that must be preserved as integral to its design. This condition prevents us from allowing architecture students to use the historical tools directly for their own projects in the woodshop (though a dozen modern tools were also donated specifically for this purpose) and relegates them to a role as display items. But are woodworking tools removed from active use fated to be misinterpreted as mere objects of aesthetic appreciation?

Coinciding with the 40th Anniversary celebration of Harvard's Reischauer Institute of Japanese Studies, Yukio Lippit and I organized an exhibition to introduce these tools to the university in a broad cultural context. The exhibition title, "The Thinking Hand," reveals the pedagogical ambition we have for displaying these tools – offering them as physical evidence of a rather specialized mode of cognition that evolved over centuries among Japanese master carpenters. The idea of thinking though one's hands refers to a simultaneous interaction of sensory feedback (through the tool, through the muscles) and abstract

thinking that allows the *daiku* to adjust his image of the thing he wishes to create based on real-time input from the material itself in the process of shaping it. This implies that working with hand-held tools and applying human (rather than mechanized) force to the element being worked will provide a more intimate, physical knowledge of material properties than producing prototypes by machine. The attractiveness of the hand production model rests on its ability to stimulate particular cognitive capabilities that may otherwise lie dormant in humans; this, rather than discussions of production economy or efficiency, is an excellent reason to resist the notion that industrial and digital modes of production have rendered hand tools obsolete.

Is using hand tools in preference to power tools sufficient then to imbue anyone with "thinking hands"? Of course not: our ability to process physical, sensory information simultaneously with purely intellectual projection relies on discipline and repetition. In other words, the more skilled the individual and the more experience he gains in particular tasks, the more his tools will function as extensions of his hand and mind. Rather than basing my argument solely on the *daiku*'s example, let me attempt another explanation for understanding how "thinking hands" develop using an example from a seemingly unrelated field: music.

A professional violinist has typically begun training on her instrument from early childhood, honing her ability to perform intricate musical passages with accurate intonation and control of expression at the same time she is acquiring (non-musical) motor, language, and other basic skills that will serve her in adulthood. Several years into her training, the talented young musician reaches a point where she no longer needs to think consciously about how her right hand holds the bow, or how far apart the fingers of her left hand should be as they press down on the strings. She can rely on muscle memory to carry out the mechanical task of producing the music she hears – or wills into being – in her mind and focus her attention spontaneously on decisions about musical phrasing and expression in real time. But for the violinist I'm describing, "thinking hands" imply more than merely expert muscle memory while performing. She thinks with her hands even when not playing her instrument. For example, while listening to music on the radio, she feels a ghost sensation in her fingers; her left hand is incapable of "hearing" the melodic line without unconsciously signaling to her brain a fingering corresponding to that passage. With no instrument or bow in sight, her right hand instinctively feels the variation of pressure and speed that must be applied to the bow at the top, bottom, and middle of the stroke she imagines without performing it. In these ways, the instrument has become an extension of the musician's body. A way of thinking has been more or less permanently imprinted in her brain based on years of focused training and repetition.

Though much of contemporary music is composed and performed on computers – using sophisticated software whose sound universe far exceeds what was available to Beethoven or Debussy – very few people would deduce from this fact that learning to play traditional instruments (violin, flute, piano, etc.) is a waste of time. Quite the opposite: developmental psychologists promote traditional musical training for children



because it appears to enhance the development of reasoning and cognitive skills in other areas. So why, after the advent of digital fabrication technologies, should the idea of training to become an expert in traditional woodworking seem antiquated today? Could psychologists not construct an argument for cultivating, through the use of hand tools, a proprioceptive mode of thinking and acting uniquely suited to the designer-builder?

Let's consider how one trains to become a *daiku* in Japan. The first task assigned to novices is the seemingly endless sharpening of tool blades for their mentors. Planes and chisels cannot do their job unless their blades are properly sharpened and shaped. For very fine work, a *daiku* might need to sharpen and adjust his plane blade after ten or fewer pulls. Sharpening steel on wetted abrasive stones called *toishi* may seem dull and repetitive, but finding the right pressure to get the desired result requires sensitivity, concentration, and freedom from distraction. For the inexperienced apprentice, learning to judge when the blade has reached the optimal sharpness and shaping is a serious challenge. But the extended assignment of only sharpening blades gives him familiarity with *hagane* steel – before he learns what it can do for a piece of wood – and establishes the craftsman's primary bond to the tools themselves rather than to the work they produce. Two renowned master carpenters of the late 20th century, *miya-daiku* Mitsuo Ogawa and *sukiya-daiku* Mitsugi Sato, have both emphasized in interviews that apprentices advance their skills over time not, as might be assumed, by having techniques patiently explained to them, but by observing their mentors and imitating them. Motivated apprentices will develop their own ability to see where improvement is needed, as they patiently learn techniques of measuring, sawing, planing, chiseling, and so on. Like dancers or athletes in training, as their bodies mature, young carpenters become attuned to the repetitive motions required by each tool's use, finding ways to strengthen muscles, reduce excess motion and strain, and introduce nuance into tool use. Such precise motions will eventually become second-nature to them on and off the job site.

Accumulated familiarity with the diverse tools that, evolving over centuries, have become part of the *daiku*'s standard set connects the young carpenter to the history of those who have come before him; yet it takes years to build his own set by adapting and shaping those he has purchased until they perfectly fit his own body's ergonomic shape and way of working. Over time, the *daiku* comes to think of these tools, which he has customized, as extensions of his hands. Each tool becomes for him the physical embodiment of a specific range of skills. Intimate knowledge of the tool's capabilities, geometry, and weight distribution helps him transfer his sensory focus to the piece of wood he is shaping. As he planes a solid plank of pine and encounters greater or lesser resistance along



the length of its grain – transmitted from blade to hand to arm – he comes to know the plank as a unique element of the structure to be assembled. He sees in it unique possibilities and can adjust his approach to shaping it on the spot. It is particularly useful for carpenters to develop sensitivity to variation, since wood as a construction material retains the irregularities and inconsistencies inherent in the geometry and cellular growth structure of living trees. A *daiku*'s knowledge of wood begins in observing how trees grow in the forest and in learning how to select different kinds of wood stock suitable for specific tasks. By the time his steel blades are applied to this wood, he has had considerable time to consider and prepare his approach.

The physical context of this intensely introverted form of training is also important to consider. The first thing one notices on stepping into a *daiku*'s workplace is its fragrance; the principal structural woods used in Japan, *hinoki* and *sugi*, release wonderful scents into the air as they are sawn, chiseled, and planed. Fresh tatami mats and other natural fiber-based materials add their scents to the rustic mix. Fragrant air gives the Japanese wood construction site a refined and welcoming ambience, completely different from other kinds of construction sites (one needs only to recall the damp, acrid smell of curing concrete and the pungent, burning odor of welded steel to understand why those kinds of modern construction sites are perceived as unpleasant, even dangerous, places). The sounds emanating from the *daiku*'s workplace – the mellow tapping of hammers and smooth gliding of saws and planes across resonant volumes of wood – are similarly soothing. These days in Japan, we may hear the occasional scream of a power saw or a whirring power drill on the job site, but on the whole an atmosphere of quiet reigns as the work steadily progresses. Even banter among the craftsmen is kept to a minimum, as each focuses on his task. We should not discount the possibility that the visual calm we have come to associate with Japanese aesthetics – particularly *sukiya* architecture – derives in part from the *daiku*'s synesthetic response to pleasant sounds and scents of his work environment.

Among many experiences I have had witnessing *daiku* at their work, the recent (January 2014) visit of master carpenter Akinori Abo and his assistant Takumi Kato to Harvard University campus stands out for several reasons. The purpose of their visit was to construct as part of our exhibition a replica of a famous 1742 Kyoto teahouse called "Sa-an" built in *sukiya* style. Thanks to Abo-san's extensive preparation of materials in Japan, the small but surprisingly complex teahouse came together quickly over three days as a virtuosic demonstration of what these traditional woodworking tools, in the right hands, could do.

Although it's commonly understood that modular, componentized construction as we know it today originated in Japanese wooden architecture, it's worth noting that *sukiya* architecture illustrates a very different way of thinking – having nothing to do with regularity or repetition, but rather with the expression of individuality and difference among construction elements. Each column and beam in the teahouse had



a different length and cross-section, including round, square, rectangular, and irregular shapes. Several different species of wood – Japanese cypress, two kinds of cedar, red pine – and bamboo were used together, each with different qualities of strength and resilience that would need to be anticipated in the configuration of joints. As more and more tight-fitting joints were locked together from the bottom up, each successive joint was increasingly constrained from being pulled apart to allow mortises and tenons to fit together. Finally, as the *daiku* team attempted to fit the three large roof beams spanning atop the structural posts, a moment of anxious tension arose: so tight were construction tolerances at this point that repeatedly, a minor adjustment to one beam would cause another member to pull out of position. Only with great patience could all three beams be firmly locked into place. Once complete, the structural frame proved not only square and plumb but also remarkably robust – not budging an inch, despite its expressive evocation of fragility and delicacy. Later construction tasks were smaller in scale and diverse – adding a bamboo framed roof overhang, ceilings, *shoji* and sliding doors, *tatami* and wood flooring, and so on. Each new element was freely positioned on the interior in a way that invited the eye to dance from one thoughtful detail to the next.

Witnessing the *daiku* at work on the teahouse was impressive; their discipline, craft, and intelligence were fully on display during those hours. But what fired my own imagination even more – and what may remain with me longer – were those instances where I perceived Abo-san’s “thinking hands” at work while his tools were put away. The first of these occurred shortly after our first meeting, as we embarked on a brief campus tour in January’s late afternoon twilight. The majestic canopy trees of Harvard Yard fascinated Abo-san, even without their foliage. Departing from the paved path to examine a particularly massive trunk with his hands, he identified it (as I could not) as a red oak, at least 150 years old. He inspected

the oak’s sprawling roots and found acorn shell fragments left behind by ravenous squirrels – signs, he said, that the tree was in good health. A few minutes later, Abo-san was again examining New England oak, this time marveling at the robust, exquisitely crafted oak doors, handrails, and interior finishes of Sever Hall. Following his eyes, his hands traveled everywhere within reach, his fingers interpreting clues and reviving in his mind thoughts of 19th century American craftsmen that remain unintelligible to many of us today. What tools had been used for this work? What were the carpenter’s challenges in shaping and assembling oak in this way? Among many other campus buildings we visited, Abo-san held particular regard for Harvard’s oldest existing structure, Massachusetts Hall (1720), whose façade he examined at close range. Its diminutive, weathered bricks recalled for him the delicacy of its near-contemporary in Japan, the 1742 Kyoto teahouse. This perception – so contrary to received ideas about Western masonry architecture as uniformly solid and permanent in contrast to Japan’s fragile wooden architecture – showed that his senses were completely open to his new environment, his impressions unfiltered by preconception.

Becoming a *daiku*, or simply mastering the art of building, requires honing one’s powers of observation, using the senses to experience and collect data about the material world, and then putting this information to creative use – finding potential for new expression in everyday appearances and sensations, surface textures, thickness and apparent weight, material inconsistencies and imperfections. If these broad requirements sound familiar to architecture students in my construction courses, it’s not a coincidence: I regularly cite for them examples of how architecture, traditional and contemporary, derives its greatness from attention to construction and material detail. Hand-crafted or not, such details require both imagination and an intimate knowledge of material properties. I cannot think of many more aesthetically and conceptually liberating experiences for an observant young designer today than a first visit to a *sukiya* teahouse.

A key goal of our exhibition and of the Takenaka Carpentry Tools Museum in Kobe has been to raise awareness of the substantial depth of expertise represented in Japan’s traditional carpentry practices and to promote the *daiku* as a positive model for contemporary designer-builders. If the tools and traditions of Japanese carpentry are not preserved in the coming generations, then the world will have lost a remarkable model for developing holistic design and construction capability within individual minds. Considering today’s technological and economic trends, it would be good to remind those who are currently developing new design tools for the future, digital or otherwise, to consider the capacity of tools to accomplish more than mechanical tasks. As we’ve seen, well designed, responsive tools have a remarkable potential to engage the users’ bodies and minds in ways that establish sensory experience as a dynamic component of design activity. And amid the euphoria of today’s digital revolution, we should remember that the cultivation of the mind and spirit remains mankind’s most important aspiration.

THE CUTTING EDGE: CARPENTRY TOOLS AND JAPANESE ARCHITECTURE

YUKIO LIPPIT

What would a history of Japanese architecture look like if examined through the history of carpentry tools? This is not a trivial question when one considers that traditional Japanese architectural modes are characterized by an overwhelming preponderance of wood as a building material. While other materials certainly play a role in the building culture of Japan, they pale in comparison to wood, a fact that distinguishes it from counterparts in neighboring Korea and China. In Japan wood not only constituted the structure of a building to the near exclusion of other materials, but was also frequently used for the flooring and ceiling, the bark-shingling of roofs, and also an important *dendro-ornamental* role in generating the myriad grain-scapes of *sukiya* architectural interiors.

The selection and carving of the wood was handled by *daiku* or expert carpenters who typically oversaw everything from the rough dressing of timbers to the intricate carving of detailed joinery, to the actual design of complexly engineered timber-frame buildings. The term *daiku* underwent a long evolution throughout its history and early on designated an administrative “master builder” who oversaw the bureaucracy of large-scale architectural projects; only later would it come to refer more generally to a type of carpenter-designer who both fabricated, engineered, and designed his structures. There were many different kinds of *daiku*, but in the modern era this profession has tended to be imagined and even mythified as a singular master craftsman who personifies the wisdom of Japan’s architectural culture.

The historical vagaries of the term *daiku* aside, the architectural carpentry and design specialists it designates dwindled significantly since the Meiji era (1868-1912) and twentieth-century practitioners such as Tsunekazu Nishioka (1908-1995) have come to be celebrated for their efforts in the transmission of centuries-long habits of architectural practice and thinking into the modern era. More recently appreciation has grown for the traditional tools used by the *daiku* – the remarkable array of saws, hammers, planes, chisels, inkpots, and carpenters’ squares that constituted the *daiku*’s established suite of woodworking and design instruments during the premodern era. The systematic study of Japanese carpentry tools began in the postwar period, as the very practices that necessitated their use were falling into steep decline. Thanks to the efforts of pioneering scholars such as Teijiro Muramatsu and Akira Watanabe, the research and programming of the Takenaka Carpentry Tools Museum in Kobe, and William Coaldrake’s *The Way of the Carpenter* – an important English-language introduction to woodworking tools – there is now a much better understanding of the functionality and special nature of the instruments with which *daiku* have plied their craft for centuries.

This commentary has enabled the comparative uniqueness of Japan’s carpentry tools vis-à-vis other woodworking traditions to be grasped in broad contours, and this uniqueness can be described in three primary ways. The first is the sheer number and variation of items in the *daiku*’s toolkit. Although the major

categories of carpentry tools found in Japan – saws, adzes, hammers, chisels, planes, and so forth – do not differ from those found in other woodworking cultures, the number of variations among these categories is significantly greater. According to the comparative research carried out at the Takenaka Carpentry Tools Museum, most tool ensembles around the world, even at their most elaborate, tend to number around sixty items in all, whereas in Japan the full complement of tools reached around 180 items. Many of these tools were varieties of chisels and instruments related to the detailed shaping of timber components, underscoring the correspondence between the number of tools and varieties of joinery found in Japanese architecture. This variety, in turn, can be attributed in part to the fact that because the Japanese archipelago is earthquake prone, the joinery of wood buildings evolved without the use of nails, in order to allow their interlocking parts to absorb the seismic shock emanating from the ground. Indeed, Japan’s traditional timber-frame buildings, even its high-rise pagodas, are celebrated for their ability to withstand the many earthquakes that have visited the islands over the centuries. The rich abundance of joinery types is one reflection of this legacy.

At the same time, however, the intricate woodworking techniques of Japanese architecture cannot be explained solely through natural causes or geographic conditions. The aesthetic demands of elite residential and *sukiya* architecture also drove their evolution. Because the conceit of *sukiya* architecture was that it present itself as rustic and assembled with ordinary, humble materials, the intricate craft that was necessary to accommodate the interface of different material components (bamboo, wood, and stone) was oftentimes hidden from view, necessitating even more variations on standard patterns of joinery. Ultimately, therefore, the historical development of Japanese tool types was overdetermined, and should be understood as engaging in a mutualistic relationship with the evolution of Japanese architecture.

The second aspect of *daiku* tools that differentiates them from the tools of other woodworking traditions is the manner in which they are used. A number of Japanese carpentry tools are uniquely pulled in order to cut or shape wood, as opposed to being pushed. This difference is most notable in the case of saws, whose teeth in certain variations are aligned in such a way as to saw the wood as the blade is pulled towards the body, and the block plane, whose shaving action on a plank of wood is generated similarly by guiding the instrument towards oneself. Woodworking planes everywhere else in the world are pushed away from the body, whether the context is Europe, North America, or even neighboring China and Korea. Because pushing the plane away generates more force, whereas pulling it towards one allows for more control, one might say that the carpentry plane in Japan evolved in such a way as to prioritize control over force. This progression, in turn, was enabled by Japan’s forestry, which is rich in different varieties of softwoods that were privileged for architectural use.

The third characteristic that distinguishes Japanese carpentry tools concerns the manner in which they are constructed. Since the early medieval period, *daiku* tools have been fabricated according to the highest

standards of metallurgy available in Japan in any given era. This meant that the same combination of lightness, flexibility, and sharp cutting edge that famously characterized the smithing of Japanese swords also applied to the various chisels, saws, and planes of the carpenters' toolbox (and transferred as well, it should be noted, to other woodwork-centered crafts, enabling the virtuosity of Buddhist sculpture or the artistry of woodblock print carving).

The metallurgical profile of these tools also points to the dialogic relationship between the history of craft instruments and Japan's environment. The major historical catalyst for the technology transfer from swords to tools was deforestation. Sometime during the early medieval period, perhaps the thirteenth century, quality cypress (*hinoki*), cedar (*sugi*), and other preferred woods for elite architecture became so difficult to procure in the Kinai region that a shift to harder wood types ensued, necessitating a change in the hardness of the tools used to carve them. This shift towards a more diversified range of tree types for architecture not only engendered a change in carpenters' tools, but also subtle shifts in architectural style. In the Japanese context, the harder woods such as zelkova (*keyaki*) tend to yield structural components of shorter length, necessitating new habits of engineering for the timber-frame exoskeletons of large buildings. More importantly, hardwoods tend to have less predictable grain patterns, and in some cases could be characterized by highly marbled and flamboyant grains, which in turn would become highly prized as subtle surface ornamentation in later centuries. Indeed, the culture of prized wood (*meiboku*) and the projective aesthetics of reading "scapes" (*keshiki*) onto them of Edo-period architecture can be understood as partly rooted in the new "granularity" of the Japanese interior engendered by deforestation.



What, then, would a history of Japanese architecture look like if examined through the history of carpentry tools? Situating notable examples of historical architecture within the context of Japanese tool history can be startling. It is estimated that the buildings of the Western Precinct of Hōryū-ji Monastery in Nara, which date to the late seventh century and thus constitute the oldest freestanding timber-frame structures in the world, were constructed by carpenter-builders with approximately ten tool types at their disposal. The bracket sets of the Hōryū-ji pagoda were procured from trees at least one meter in diameter, and the doors of the Hōryū-ji Golden Hall (Kondō), which consist of planks of wood measuring one meter in width and nine centimeters in depth, were procured without the aid of the sophisticated saws that would be employed later on in Japan. Furthermore, because only the handheld spear-plane was available at the time, the surfaces of Hōryū-ji's timber components are far removed from the remarkable glass-like textures that would eventually be achieved with the Japanese block plane.

The context for fabrication at Hōryū-ji can be contrasted with that of the Katsura Villa (c. 1616-63) in Kyoto, an aristocratic residence that was built in several stages over the course of the early to mid seventeenth century. By the time the Katsura Villa was being constructed, the full array of Japanese tool types and variations — approximately 180 tools — was available to its builders, and this wide-ranging toolkit is reflected in its remarkably sophisticated surface textures, showcasing an expansion of *sukiya* aesthetics from the scale of the teahouse to the scale of a sprawling villa. These tools were mobilized to shape and refine at least forty-eight different kinds of wood at Katsura.



Throughout the history of Japanese architecture, there are numerous technical innovations that would not have been possible without advances in tool technology. One striking example is represented by the Great South Gate (Nandaimon) at Tōdai-ji Temple in Nara, which dates to 1199 and is famous for its monumental style of timber-frame engineering that departs in many stylistic and technical aspects from the Japanese modes of wood architecture that came before it. The monk Chōgen (1121-1206) oversaw the reconstruction of Tōdai-ji after most of its buildings were destroyed by fire in 1180, and introduced a continental mode of construction that would later be referred to as “the Great Buddha Style” (Daibutsuyō). Among other features, this approach to wood architecture included the use of penetrating tie-beams that were passed through large apertures in the pillars bearing the massive weight of the roof. Until this period the horizontal beams that tied vertical pillars were non-penetrating and were affixed through joinery. By contrast, the eighteen large columns supporting the Great South Gate, measuring some nineteen meters each, are riddled with openings through which wood beams are inserted all along the upper portion of their shafts. These apertures suggest not only a virtuosity of carpentry technique but also the hardness and sophistication of the instruments that created them.

The dramatic evolution that Japanese carpentry tools underwent throughout the centuries raises interesting questions regarding their impact on architectural practice. The Ise Shrines offer a case in point. Since being formalized as a shrine complex in the late seventh century, the Ise Shrines have been rebuilt every twenty years throughout their history, with only a few exceptions (see Helen Hardacre’s text on pp 42-44). Although the buildings of Ise are understood as having been built in the same appearance according to the same traditional practices, the development of tools during the span of Ise’s sixty-two renewal cycles suggest that at the level of facture, the successive reincarnations of the shrine buildings have differed in terms of surface texture and the integrity of joinery. Indeed, according to these criteria, the current buildings – renewed most recently in the fall of 2013 – are undoubtedly dramatically transformed from the original incarnation of the shrines in the seventh century.

The misalignments between the history of carpentry tools and Japanese architecture are equally revealing. The fact that a temple complex as grand and sophisticated as Hōryū-ji could be constructed with only a small array of tools reinforces the idea that one should not be overly deterministic in linking potentiality in the history of Japanese building to conditions of woodworking and fabrication. Throughout its history, complex modes of architectural timber-frame engineering were transposed to Japan without the conditions of fabrication that characterized their original production contexts in other parts of East Asia. In these instances, communities of builders in Japan resourcefully used and adapted what was available to them at the time, and in the process generated new practices. Japanese cultural history is replete with analogous phenomena. Oil painting was systematically introduced to Japan through Jesuit missionaries in the sixteenth century, when seminarios established in Kyūshū trained Japanese painters to produce Christian icons through habits of European pictorialism and an oil painting palette. Recent conservation

of such works, however, has revealed the degree to which the full array of oil-based binders and pigments were unavailable in the archipelago at the time. Instead of the traditional oil bases of Europe, Japanese painters used substances such as lacquer, whose gooey and unctuous nature must have approximated the affect of oil painting for its initial audiences. Later on during the Edo period (1615-1868), Japanese painters continued to approximate this affect resourcefully by using perilla oil – most commonly used as a cooking oil in East Asia – instead of the more standard oils of Europe extracted from linseed, safflower, walnut, and other substances. Through recourse to these and other local solutions, these artists practiced what might more properly be referred to as “oily painting.”

Ironically, perhaps the mode of Japanese wood building that was most directly enabled by the plenitude and nature of *daiku* instruments is *sukiya* architecture. This is surprising when one considers that *sukiya* buildings aspire to embody in architectural form the ideals of rusticity, simplicity, and lack of ostentation or adornment. Accordingly their complexity of construction is oftentimes understated or simply hidden from view. Accordingly, one might say that while the study of tool history yields numerous insights into the history of architecture, the act of gleaning conditions of fabrication from the buildings themselves remains a complex exercise, one that underscores the complex dialectical relationship that has existed between buildings and their instruments of making throughout Japan’s history.



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CATALOGUE OF TOOLS

adze 鋸



carpenter's hewing axe
大工鉗



standard crosscut saw
挽切



round-nose roughing saw
穴引鋸



coping saw 挽廻鋸



grooving saw 畔挽鋸



back saw 脊付鋸



double-edged saw
両刃鋸



hammer with pointed end
先切金槌



double-faced hammer
両口玄翁

mortise chisel 向う区鑿
mortise chisel 向う区鑿



butt chisel 大入鑿
butt chisel 大入鑿



butt chisel 大入鑿
trowel chisel 鐵鑿



striking chisel 本叩鑿
striking chisel 本叩鑿



wide-striking chisel 広鑿
wide-striking chisel 広鑿



reverse round chisel 裏丸鑿
dovetail pairing chisel 蟻鑿



pairing chisel 突鑿



pairing chisel 突鑿



convex rounding plane
外丸鉋

standing blade plane
台直し鉋

concave rounding plane
内丸鉋

corner-cutting plane
際鉋

roughing plane
平鉋

smoothing plane
平鉋(仕上げ)

standing blade plane
台直し鉋

jack plane
長台鉋

plough plane 底決り鉋
molding plane 面取鉋

side-shaving plane
脇取鉋

fenced plough plane
基市決り鉋



ink pot (墨壺)



bamboo inking pen (墨さし)



red ink pot (朱壺)



red bamboo inking pen (墨さし)



reel (糸巻)



spirit level (水平器)



sickle gauge (鎌野弓)

AFTERWORD

Japan is a country with a long tradition of *monozukuri* - that is, making things by hand. For over a thousand years, Japan's world-famous wooden architecture has been built by the hands of great craftsmen. Supporting this work are the numerous tools of the Japanese carpenter. In the interest of preserving and sharing the cultural heritage embodied within these tools, the Takenaka Carpentry Tools Museum was established in 1984, the same year the Takenaka Corporation celebrated its 85th anniversary as a company. This year the museum celebrates its own 30th anniversary, and to mark this occasion we are delighted to sponsor an exhibition introducing the work of Japanese carpenters to the Cambridge community. Each of the tools exhibited is itself the product of great care by a skilled Japanese craftsman. To those in attendance, it is our sincere hope that we may convey the art and spirit of tradition within Japanese carpentry and that this exhibition may sustain the future of *monozukuri*.

Kenzo Akao
Director, Takenaka Carpentry Tools Museum
January 2014

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40th
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