

Tradition of wooden construction and its recent trends in Japan

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Because of its geography and topography, Japan receives a large amount of rainfall in summer due to the moisture in the wind coming over the Pacific Ocean, while the wind from the Japan Sea brings moisture in the form of snow on the land in winter, nurturing forests in the mountains since ancient times.

During the Edo Period from the 17th century to the 19th century, tree planting became a common practice in many places. In the first half of the 20th century, some of woodlands were cleared and abandoned, but after the Second World War, many areas were reforested with sugi (Japanese Cedar) or hinoki (Japanese Cypress) trees, and those stands are now ready to be cut.



Forests in Japan



Sugi stands in Ryujinmura Village



Horyu-ji Kondo
buddhism architecture around 670 A.D.



Horyu-ji Denpodo
aristocratic residence built in 739

Japan has been blessed with forest resources since ancient times, and wooden construction has always been the main pillar of Japanese architecture. In the sixth century, Japan learned advanced building techniques for temples from China. Those building techniques were reinterpreted and adopted in a Japanese style to construct temples such as Horyu-ji Temple which still stands today. Horyu-ji Kondo or the Golden Hall of Horyu-ji Temple, said to be the oldest wooden architecture in the world, was reportedly built in or around 670 A.D. Legend has it that another building of Horyu-ji, called Dempodo, was the residence of a wife of the emperor at that time.

In those days, buildings were constructed by first erecting columns at a regular spacing and then bridging them with beams. Other types of structures such as log house constructions were often used for warehouses and other buildings which had no windows.



Shosoin: around 756 A.D.

Tamukeyama Hachimangu Shrine: around 8th Century

In Japan, hot and humid in summer, people wanted to have large openings. Rather than having windows as we know them, *Tategu*, or fitting panels were installed between posts.

In the 13th century, the trade with China was revitalized, bringing in new building technologies. The windows of Jisho-ji Temple, better known as Ginkaku-ji Temple, are believed to be built in the Chinese style that came to Japan in the 15th century. Jisho-ji Temple was rare example of a building having windows at that time.

Jisho-ji or Ginkaku-ji Temple:
Katomado or arched windows in 1489Shizutani School Lecture Hall
A building which has typical openings

The Great Buddha Hall of Todai-ji Temple was originally constructed in 758 but was lost to fire. It was rebuilt in 1190, and then destroyed again in 1567. The Great Buddha Hall we see today was completed in 1709. Nevertheless, it is a gigantic structure of wood that is more than 300 years old.



Todai-ji Great Buddha Hall: 1709

Interior of Todai-ji Great Buddha Hall:
Built-up Pillars using timber.

Nandaimon or the Southern Main Gate of *Todaiji*, which stands in front of the Great Buddha Hall, remains intact over 800 years since it was built in 1203. The gate uses a horizontal member called *Nuki*, which goes through columns. The gate that was originally built back in the 8th century fell down due to high wind. Lateral resistance is extremely important in Japan because it is subject to seasonal typhoons and large earthquakes from time to time.



Namdai-mon Gate: 1203



Interior of Namdai-mon:
nukis run through columns.

This approach of constructing a frame with posts and beams was adopted for homes. Braces were not introduced until western architecture came to Japan in the 19th century and later. Up until around 100 years ago, ordinary Japanese houses were built with *nuki* for horizontal resistance. When the post and beam frame is deformed under load, which is different from bracing, the use of *nuki* allows the energy such as seismic energy to be absorbed through the embedment of the *nukis* into the posts.



the traditional residential construction method of today



Post 120 mm x 120 mm
with a *nuki* and a wedge

Nuki is also featured in a style of *torii*, the gate representing the border between the inside and the outside of the sacred premise of a shrine in the Japanese Shinto architecture. In the Myojin Torii style, a *nuki* is used as the connector for the two columns, which is its design feature as well.



Meiji Shrine Omotesando Torii: 2022



Previous Meiji Shrine Omotesando Torii: 1920

The torii of Meiji Shrine was built 100 years ago and replaced in 2022 due to rot and deterioration. The diameter of these columns is 1,067 mm or 3'6". The torii also features *nuki*. The first torii was built using Hinoki or Japanese Cypress back in 1920, but Sugi or Japanese Cedar is used this time. It was simply impossible to acquire Hinoki wood of this size.



Nuki of the Torii



Cross-section of one of the pillars – 1067 mm in diameter



Katsura Imperial Villa-Koshoin and Chushoin: around 1615 to 1662



Katsura Imperial Villa: Interior of Koshoin

Let's turn the clock back by 500 years. In the *Muromachi* Period (1336 to 1573), some of the columns arranged at a regular spacing were removed to allow larger openings, which is called *Shoin-zukuri* style. This practice became more freely applied in the *Edo* Period. Just like any other southern Asian countries, for Japan, with a hot and humid climate, erecting posts to support a roof was the basic approach to construction. For openings, the preferred solution was to place *tategu* or fitting panels between columns, rather than windows. The concept of «windows» was not known to Japan until the end of the 16th century, with a few exceptions.

With the arrival of the Meiji Period came western technologies, bringing major changes to the Japanese wooden architecture. During the Second World War, wood was used to build even an airplane hanger. After the war, large timber structures such as indoor sport facilities were built using glue laminated timber. However, wood construction had to endure a dark period. The Great Kanto Earthquake of 1923 and the aerial bombing during the Second World War caused urban infernos, which raised the concern for the fire risk of wooden buildings greater than necessary. We had to wait till the 1980's to see a re-evaluation of wooden construction. This is a photo of a hotel built in wood, designed by one of my teachers, Masao Hayakawa.



Hakkoda Hotel: 1991 designed by Masao Hayakawa Modernized four-way insert construction (*Kanzashi*)

In or around 1989, the Building Research Institute (BRI), a Japanese national research organization, began to study construction methods for large timber construction in Japan. At that time, the focus was how to construct posts and beams using glulams effectively and efficiently. I was in charge of the project for the connection shown in this picture.



BRI's large wooden building as a pilot

Prototype connection by BRI

So-called rigid frame construction, where columns and beams are rigidly connected, is difficult to create using wood, and the work is on-going even today. There are very recent examples of mid-sized wooden buildings using new connecting details designed with a broader market in mind.



Example of rigid connection: designed by architectural design office *Building Landscape* in 2023

As shown, the post and beam construction is popular in Japan. There are many reasons for this, with the major ones being the freedom of planning and large openings. In addition, it may be that Japanese love the texture and varying appearance of wood.

Of course, platform wood frame construction is used as well. CLT is good for horizontal application, and we see more buildings using CLTs or LVLs.

Now let me show you recent projects of wood construction in Japan. This one is a school in wood, using different types of engineered wood. Wooden walls, needless to say, also work against horizontal forces.



Oguro-no-mori Middle School: designed by Nihon Sekkei in 2022

Interior

A large span open space using wood is also sought after. This Ariake Gymnastic Stadium was designed by Nikken Sekkei and Shimizu Corp. for the 2020 Tokyo Olympic Games.



Gymnasium at Oguro-no-mori Middle School

Ariake Gymnastic Stadium in 2019

We see more office buildings and research institutions being built in wood.



Tsukuba Research Institute, Sumitomo Forestry in 2019

Interior of the Institute

These photos are of the training facility, named Port Plus, of Obayashi Corporation, a construction company. The building demonstrates a characteristic of post & beam structures by exposing wood elements as architectural ones. The building was designed by Obayashi.



Port Plus 2022



interior

We are seeing more of CLT and other materials for shear walls against lateral forces, and a study is on-going for shear walls that can transmit light. This is an example of such technology developed by Masahiro Inayama, specializing in wooden materials. The architect, Masamitsu Nozawa, applied it to an office building. You can see that CLT is also used as V-shaped beams.



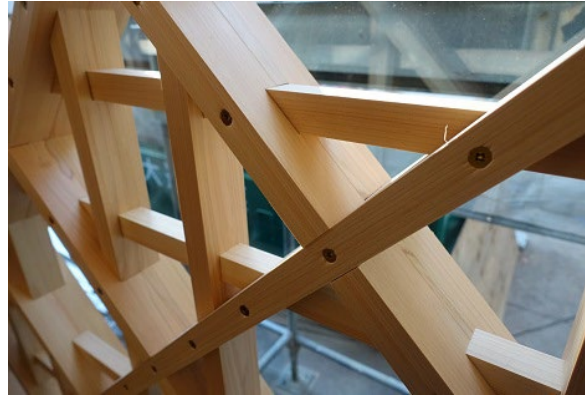
Chamber Commerce of Hanno: 2020



V-shaped beams of CLT



shear walls against lateral forces transmitting light



Kumiko-like bearing walls

Also, I am happy to report that the *nuki* construction is receiving renewed interest. It must be a part of a larger movement to revitalize and utilize traditional techniques in the present. This photo shows a fire department built with gluelams, which succeeded to create large openings to accommodate fire engines by using wood everywhere with *nuki* connection.



Sumita-cho branch fire station



It is recognized that the use of *nukis* would create uniquely Japanese architectural features, and the main venue of Expo 2025 Osaka, Kansai, Japan has a plan for a structure featuring wood in abundance using *nukis* for construction.

The main venue is designed by Sou Fujimoto architects, Tohata Architects & Engineers and Azusa Sekkei

Venue of Expo 2025 Osaka, Kansai, Japan
(courtesy of Obayashi Corporation)under construction Details of the *nuki* connection
(courtesy of Obayashi Corporation)

Please come and visit the Expo 2025 in Osaka!

Osaka is a great starting point for a tour of historical wooden buildings in nearby Kyoto and Nara.

This shows the stage of Kiyomizu-dera Temple in Kyoto, a very famous tourist spot.



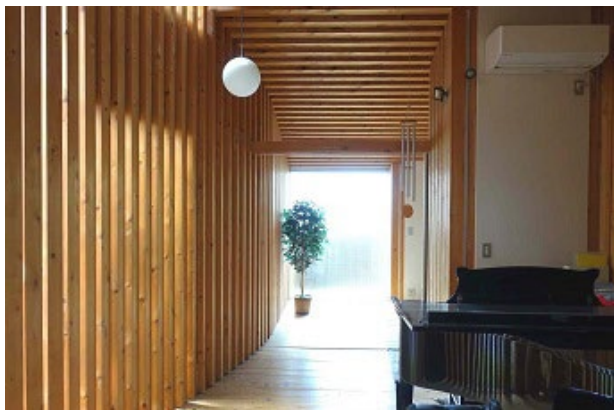
The stage at Kiyomizu Temple: 1633

The stage of Kiyomizu Temple: a shot from the bottom

Before concluding my paper, I will show the extension project of my own residence I did 27 years ago in 1996.

I call this *Shigebashira no Ie* or Residence of Close-set Posts. It is not a large project, but a trailblazer one at that time because of its use of a massive amount of wood.

Post-WWII plantations in Japan started to produce *Sugi and Hinoki* lumber for posts (120 mm x 120 mm), which was available at a very reasonable price, and I made the decision to use it in abundance.



Shigbashira no ie or House of Close-set Posts: located in Suginami, Tokyo, designed by Seiichi Fukao in 1996
It is important to use wood in an efficient manner, but using a lot of it is also meaningful as a form of sequestration of CO₂.