Mid- and high-rise timber buildings in Japan

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1. Forests and Timber buildings in Japan

Buildings in Japan have been constructed using timber since olden times. At the same time, Japan is a country beset by earthquake and timber buildings were weak against fire. So, from 1950 to 1987 timber buildings over 13m height were prohibited by law. Revision of the Building Standards Law 2000 allowed the construction of timer buildings four-story or taller with fire-resistance performance.
In Japan, as typified by Horyu-ji Temple, timber structures have been built since ancient times. To protect them from wind, rain, and outside enemies, they have been built using natural materials that are readily available. In Japan, where forest resources are abundant, wood was used, stone was used if it was readily available, and adobe bricks were used in arid regions.

In modern times, advances in science and technology have led to the creation of purpose-made industrial products from natural materials. In the architectural world, steel and reinforced concrete are representative of such products, and in the Modernism architecture was born under a rational spirit in combination with glass. In Japan, too, buildings made of steel, concrete, and brick became mainstream after the Meiji era. In particular, damage to timber buildings caused by the war, together with the movement to make cities noncombustible and the depletion of forest resources due to the war, led to the restriction of wood use in the building industry to detached wooden houses.

In the 1980s, trade friction and the development of timber construction technology led to the deregulation of timber construction for large-scale spatial structures and three storied timber buildings, but timber construction remained limited to local use, as symbolized by local production for local consumption.

In 2000, with the introduction of performance standards in the Building Standard Law, as shown in Figure 1, the use of forest resources was aimed at, since the forests planted after World War II had reached the stage of utilization for trees of 50 years old or older, and forests were being revitalized in response to global warming. The main trees planted in Japan at this time were Japanese cedar and cypress, which are the main building materials.

In 2010, the «Law for Promotion of Use of Wood in Public Buildings, etc.» was enacted to promote the use of wood in low-rise public buildings, such as low-rise schools and government buildings, and in 2021, the «Law for Promotion of Use of Wood in Buildings, etc. for Contributing to Realization of a Decarbonized Society» was enacted to promote the use of wood in buildings.

In 2021, the «Law for Promotion of Use of Wood in Buildings, etc. to Contribute to Realization of Decarbonized Society» was revised and renamed, which expanded the use of wood in buildings from public buildings to buildings in general, including private buildings. The goal was to shift from local production for local consumption to promote the use of wood in urban areas, in other words, large-scale, midrise- and high-rise urban timber construction.

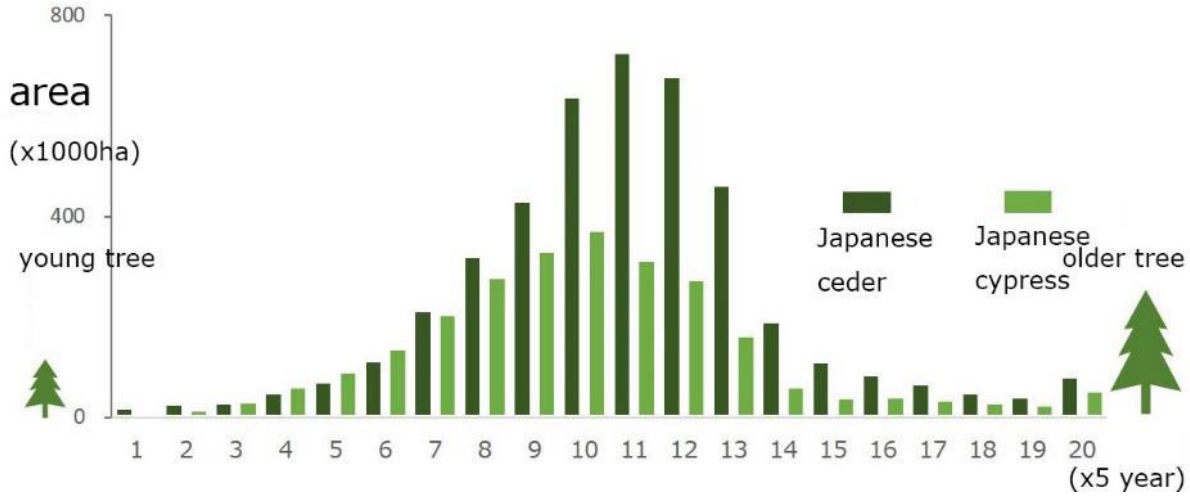


Figure 1: Area of cedar and cypress plantation forests by age grade

2. Timber buildings

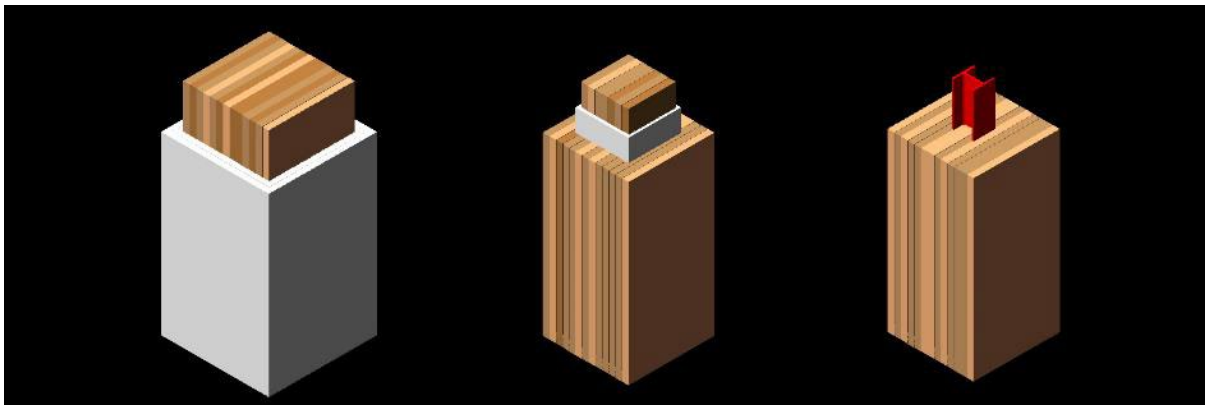
Timber buildings in rural areas aimed at local production for local consumption were originally able to satisfy the limitations on the scale of timber buildings, such as the size of the site, the number of stories of the building, and the area. However, in urban areas, where land prices are high, the scale and use restrictions are so severe that it is impossible to achieve the required architecture, The revision of the Building Standards Law in 2000 made fire-resistant buildings feasible, which greatly expanded the scale (building height, total floor area, etc.) and applications of timber buildings that can be constructed in urban areas. However, large-scale timber buildings in high-density urban areas are an unknown world, having never been experienced in the more than 1,400 years of Japanese wooden building, including Horyu-ji Temple. In terms of traditional wooden building, only the Great Buddha Hall of Todai-ji Temple (floor area of approximately 2,800 m2) is known as a large building in terms of plan, the five-storied pagoda of Toji Temple (height of approximately 55 m) exceeds 50 m in height, and Himeji Castle (six storied) is large in terms of number of floors.

As of November 2023, the tallest skyscraper in Japan is the Azabudai Hills Mori JP Tower in Tokyo, completed in 2023, with 64 floors above ground and 5 floors below with a height of 330 m, surpassing the previous tallest building in Japan, Abeno Harukasu in Osaka.

In the midst of these cities of reinforced concrete and steel-framed high-rise buildings, timber buildings have become legally possible, but this is only the beginning.

3. The birth of urban timber building

The biggest obstacle to wooden construction in urban areas was fire prevention technology. It was necessary to solve the contradiction of using wood, a material that burns, to create fire-resistant buildings. In the «Development of Wood Composite Building Structure Technology» (1999-2003), which started in 1999, three types of wood-based fire-resistant members were developed and maintained. (1) general covering-type members, in which wood is covered with a non-flammable surface material such as gypsum board; (2) «MOEDOMARI», fire stop, members, in which the carbonization time of the wood around the perimeter is used to secure evacuation time, and the fire stop layer and structure are treated with a flame retardant coating; and (3) built-in steel members, in which a large heat capacity steel material is incorporated to reduce the temperature rise of the wood around the perimeter. (Figure 2).



(1) general covering-type members (3) built-in steel members
(2) «MOEDOMARI», fire stop, members

Figure 2: Wood fire-resistant members

First, wood fire-resistant members were certified by the minister as one-hour fire-resistant members, which made it possible to realize fire-resistant timber construction of the upper four floors of a building (or the second to fifth floors in a five-story building). In 2004, a two-by-four building using wood panels for face plate bearing walls was certified as a fire-resistant wood-frame member with general cladding, and a three-story wooden house was constructed. 2005 saw the completion of the Kanazawa M-Building (Ishikawa Prefecture), a five-story building (first floor: RC, second to fifth floors: wood hybrid structure).

In the same general cladding type, the fire resistance performance required for vertical load bearing members (dead weight, loading, snow loads, etc.) and horizontal force resisting elements (earthquakes, wind, etc.) are different. The Shimouma housing complex (Tokyo, 2013) was completed.

In 2006, a fire-resistant material that can be used as a vertical load-bearing member with a fire-retardant structure using exposed wood was approved by the Minister of Land, Infrastructure, Transport, and Tourism, and completed in 2013 at Southwood, a large-scale commercial facility in Kanagawa Prefecture, and Osaka Timber Association Building in Osaka Prefecture.

In 2013, following the development of large-section laminated timber, JAS certification was established for a new wood material, Cross Laminated Timber(CLT). The JAS standard for CLT was established in 2013, and now, laminated laminates 270 mm thick, 3 m wide, and 12 m long can be used for walls and floors.

Kanazawa M-Building

Shimouma housing complex

Osaka Timber Association Building

interior

CLT company dormitory

Kochi Timber Association Building

Figure 3: The birth of urban timber building

4. Development of urban timber building

In the 2010s, the development and improvement of wood fire-resistant members were put into practical use, and further technological development and legal revisions were repeated, aiming for more user-friendly and attractive urban timber building. A five-story timber apartment building in Niigata was completed in 2018, and a seven-story timber office building in Sendai was completed in 2021. In urban areas, even high-rise, large-scale timber buildings are being aimed for, with the completion of the 44.1-meter-high, 11-story PORT PLUS in Yokohama in 2022 as the current achievement of pure-timber construction. It presents a large-section column and beam structure, finishing materials made from a variety of wood materials, and the potential for wood utilization.

Since the late 2010s, economic efficiency and rationality have also been considered for its widespread use. Unfortunately, as a building structural material, the use of wood, a new material, increases construction costs compared to reinforced concrete and steel structures, which have been evolving for nearly 100 years. Even for buildings that are technically feasible with timber construction, the efficient use of wood becomes desirable in terms of cost. First, attention was focused on the use of timber construction in the upper four stories, where fire resistance requirements are slightly lower. Especially in high-rise buildings, the upper floors offer good views and are easy to add value. In Tokyo, as the demand for higher buildings increases from 4- or 5-story timber buildings, they are being realized as mixed-story buildings in the vertical direction.

PORT PLUS (back)

PORT PLUS (interior)

The Royal Park Canvas Sapporo

Kokubunji FlavorLife Office

JUTEC

Figure 4: Development of urban timber building

The Royal Park Canvas Sapporo Odori Koen (Hokkaido), completed in 2021, is an 11-story building with the top three floors (9-11) constructed of wood. The seven-story Kokubunji FlavorLife Office Building has the top four stories constructed of timber.

On the other hand, planar mix structures that actively employ timber construction in areas facing the street are also attractive as urban timber structures that create urban landscapes. The HULIC & New GINZA 8 (2022/TOKYO) and the JUTEC headquarters building (2023/ TOKYO), are designed to create a new landscape facing the street.

As for actual projects currently underway, Mitsui Fudosan and Takenaka Corporation are planning a 17-story, 70-meter-high office building in Nihonbashi to be completed in 2025, and Tokio Marine Holdings, Inc. and Tokio Marine & Nichido Fire Insurance Co. are planning a 20-story, 100-meter-high office building in Marunouchi, 2028.

5. Aiming for a Timber Skyscraper

In 1968, Japan's first skyscraper, the Kasumigaseki Building, was built in Kasumigaseki. It was a steel-framed skyscraper 147 meters high, realized based on the concept of a flexible structure. Fifty years have passed since then. Modern construction technology has made remarkable progress, and after «reinforced concrete» and «steel-frame» construction, «timber» technology is now well established as the structural type that makes skyscraper possible.

Sumitomo Forestry Co., Ltd. has announced the W350 Plan, a research and technology development concept to realize a 350-meter-high timber skyscraper by 2041, the 350th anniversary of its founding.

The NPO team TIMBERIZE has proposed Timberize200, a 200-meter-high timber skyscraper. It is an experimental attempt to see what would happen if the plan and structural span of the «Kasumigaseki Building» were followed and realized using state-of-the-art timber technology. The height of the building was set at 200 m, which is the height at which a timber structure alone can be constructed. By focusing on the elemental technologies required to realize the structure, we attempted to confirm our current state of achievement and to identify the issues that need to be addressed in the next step. The most important feature of Timberize 200 is that it consists of the following three components. The Omo-ya (main frame), the Shitsurai (sub-frame), and the Tategu (screen).

These components are an extension of the techniques developed in traditional wooden architecture. The 2m-square super-large-section axial frame structure that lines up homogeneously in the main building is derived from the Kiwari, wooden module of shrine and temple architecture, while the small-section structures of the room and fittings can be varied according to their functions. The presence or absence and opening/closing of fittings changes the character of the space, and appropriate environmental control is a technique with which we have long been familiar.

The semi-rigid joints of the columns and beams are complemented by the flexible structure of the central core, which has a tenacious seismic damping wall in the form of a lattice. The seismic isolation structure, inspired by the stone-based structure, and modern technology induced by traditional wooden construction, will be applied to wooden architecture once again.

Wooden materials, which gain their flavor with time, will be used in the permanent main building and in the renewal of the room decorations, changing their expressions in accordance with the times, and recycling of resources, such as reuse, will be achieved.

Based on this vision of the future, the realization of a timber skyscraper will not be a dream if each issue is resolved one by one.

Figure 5: Timberize 200

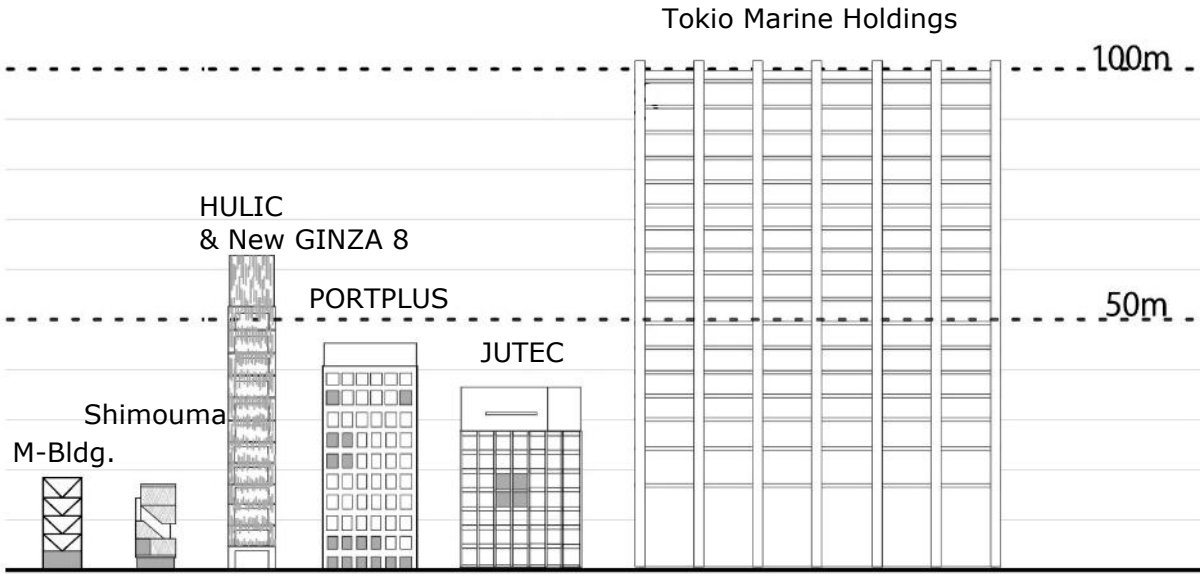


Figure 6: Height of urban wood construction in Japan