

Timberize **- Metropolitan Timber Architecture -**

Japanische Entwicklungen im urbanen Holzbau

Les évolutions japonaises en matière de construction
urbaine en bois

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1. Introduction

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 wooden buildings over 13m height were prohibited by law. Revision of the Building Standards Law 2000 allowed the construction of timber buildings four-story or taller with fire-resistance performance. The possibilities of mid-rise and large timber buildings in Japan are extended. 'Kanazawa M-Bldg.', shown in figure 1 is one of the first 5 storied timber building after settlement of Building Standards Law in 1950, Japan.

'Timberize' is our concept for metropolitan timber architecture and new timber building construction. Japan has a long history and many traditional wood building construction, but there was few multi storied timber building. Metropolitan timber architecture should have new building construction different from Japanese traditional wood building.



Figure 1: Street view of Kanazawa M-Bldg.

2. Fire prevention method in Japan

Over three storied building in fire prevention district and quasi-fire-prevention area should be fireproof construction and three storied buildings which an unspecified people visit should be fireproof construction, too. Some special building, a kindergarten and nursery, should be fireproof construction. In Japan upper 4th floor are required 1 hour fireproof construction and upper 5th to 14th floor are required 2 hour fireproof construction.

For timber buildings three type of fireproof members were developed and achieved in Japan shown in figure 2. First type is a membrane member covered with fireproof elements like gypsum boards. This member have been researched and developed by Japan 2x4 home builders association, 'Mokujukyo' which is association for wooden housing industry and some groups. Second type is a built-in steel member for self-extinguish. This member have been researched and developed by Japan Laminated Wood Products Association. 'Kanazawa M-Bldg.' were built using these members and 2 buildings, main office building of MARUMI SANGYO Co.,Ltd and 'Wood square' were built using these member until 2013. Last third type is a burn stop, 'Moedomri', member covered with wood and non-combustible treat wood and have burn stop layer using mortar or wood treated with chemical. In Japan there is a fire proof design method, 'Moeshiro' design method for quasi-fireproof timber construction. 'Moeshiro' means the controlled burnable timber layer. If wood can be assumed to burn 0.7-0.8mm in every minutes, after 1 hour fire timber member lost outer 45-50mm layer but inside area is

escaped from burning and keep their structural performance. Quasi-fire-proof building is designed and keep safety using 'Moeshiro' design method. But in case of fire-proof building, higher safety than quasi-fire-proof building is required. It is required not only the safety after 1 hour fire but also self-extinguishing which we call 'Moedomari'. This is very hard for burnable material, wood. Multi-layered members using wood are researched and developed. Shown in Figure 2(3) first outer layer wood functions as a 'Moeshiro' layer for making fire-prevention time and second layer wood functions as a 'Moedomari' layer for self-extinguish and third layer is non-burnable structural member. With membrane member many large timber building have been built from 2005. Typical building construction system is 2x4 system and post-and-beam system. Kasukabe convention hall and Shimouma apartment are used this fire-prevention system. M-Bldg. and 'Wood square' are used a built-in steel system. 'Osaka Timber Association' building using 'Moedomari' members are completed in 2013.

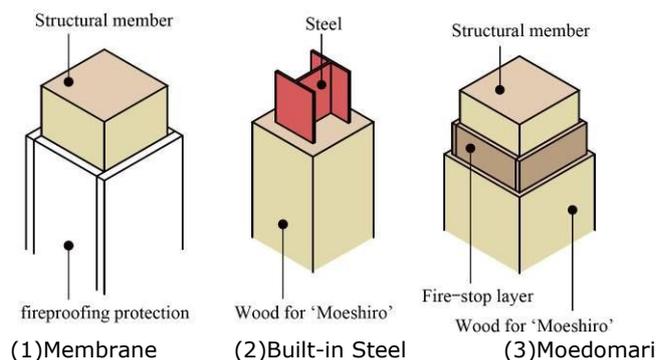


Figure 2: Fire proof member for timber buildings

3. Kasukabe Convention Hall

The Eastern Saitama Regional Development Center "Kasukabe Convention Hall" was constructed in Kasukabe City, Saitama Prefecture in 2011. (Figure 3) This building is six storied mix structure convention hall. From 1st to 4th stories of this building are steel structure and top of 2 stories are timber structure, because there is a large convention hall on the 1-4th floor and meeting room and office, they are small room, are on the 5th -6th floor. Large dimension timber are needed for large span and heavy load.

Structural design of this timber building on 5th-6th floor is very simple. Main structure is post and beam structure like detached wooden houses in Japan, of course the dimensions are larger than that for houses. This main structure support vertical load and should keep that performance after 1 hour fire and self-extinguishing. Membrane fireproof member covered with gypsum boards are used. On the other hand feature of this building is that 2x80mm thick wall is used as shear walls. This wall is made of LVL (Laminated Veneer Lumber). These seismic elements are allowed lower fire resistance than column, beam and floor which support vertical load. So these members can be exposed itself without fireproof coating and can be used as a finishing material and visitors can touch them. This structural and fireproof design become typical plan for fireproof timber building in Japan.

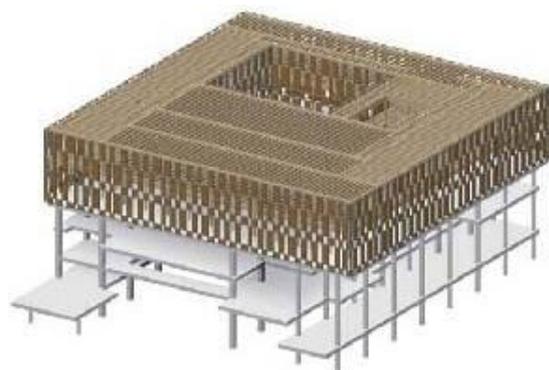


Figure 3: "Kasukabe Convention Hall" Bldg.

Table 1: Building data

Architect	YAMASHITA SEKKEI INC.
Structural Design	YAMASHITA SEKKEI INC.
Area	10529.08m ² (total floor) / 2848.04m ² (building)
Use	Convention hall
Height	27.086m
number of storeys	6 stories
Structure	Steel structure (1st-4th stories), Timber structure (5th-6th stories)

4. WOOD SQUARE

The 'WOOD SQUARE' bldg. was constructed in Koshigaya City, Saitama Prefecture in 2012 shown as figure 4. This four storied timber building have a timber-based hybrid structure with built-in steel members same as M-bldg. and this is largest building among three buildings using built-in steel members.

This building use the maximum timber-based hybrid beam obtained the approval by the Minister. The beam is 663mm depth and 325mm wide, H-600x200 covered by glulam. M-Bldg. did not need large space and long span for painting school but 'WOOD SQUARE' is large office building and need large entrance hall and meeting space, etc. and need long span and large space. This building used maximum dimension of member but feasible span did not enough for office. Structural design and plan which using continuous beam can achieve 12.8m span. Continuous beams, 4.8m-12.8m-4.8m-9.6m, have advantage to smaller banding moment and smaller deformation. 641 cubic meters of glulam is used in this building.

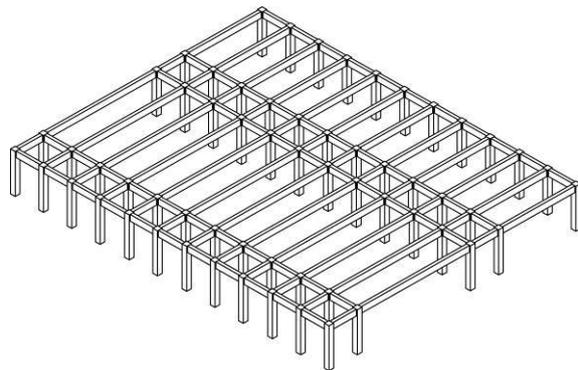


Figure 4: "WOOD SQUARE" Bldg.

Table 2: Building data

Architect	JR EAST DESIGN CORPORATION
Structural Design	JR EAST DESIGN CORPORATION
Area	6592.63m ² (total floor) / 1353.51m ² (building)
Use	Office
Height	21.000m
number of stories	4 stories
Structure	Timber-based hybrid construction

5. Shimouma Apartment

"Shimouma Apartment" is built at Setagaya-ku, Tokyo and complete in 2013 shown in figure 5. This building is five storied timber apartment house.

Structural and fireproof design is almost same as 'Kasukabe Convention Hall'. Main frame support dead-load is post and flat slab. Flat slab construction is rare for timber building but popular for reinforced concrete structure like 'Domino system' proposed by Le Corbusier. Fireproof elements are 7, column, beam, floor, roof, inside wall, outside wall and stair. In the fireproof building all elements should be fireproof element. In 2004, this building were started to design, there is no fireproof element for timber building. Some

element should be developed ourselves and minimum elements, column, floor, roof were chosen. If flat slab construction was chosen, fireproof beam is not need to develop. Because Japan is a country beset by earthquake, not only vertical load element but also seismic element should be placed. In this building many bracings placed on outer wall. For a lattice-shaped member work as a bracing against only horizontal load, earthquake and wind load, bracing can be appear as wood itself and be touched. That means that this timber characteristic appearance is not only finishing member but also a structural member.

Shown in figure 5 all structural elements are timber elements and finally covered with gypsum board for fireproof and only bracing can be seen.

For timber flat-slab construction crossing jointed glue-lam are used. Cross joint are used bolt joint and secondarily used adhesive for stiffness against deformation and vibration. This cross jointed floor can achieve not only one-way construction but also two-way construction and every column place everywhere without grid regulation. All structural elements are modeled and structural performances are calculated using FEM, finite element method.



Figure 5: Shimouma Apartment (Photo by S.Asakawa)

Table 3: Building data

Architect	KUS
Structural Design	M.Koshihara, T.Sato, Y.Kirino
Area	122.89m ² (total floor) / 92.83m ² (building)
Use	Apartment
Height	16.200m
Number of stories	5 stories
Structure	RC structure(1st story) Timber structure(2-4 story)



Figure 6: Interior of Shimouma apartment (4th floor)

6. 'Osaka Timber Association' building

'Osaka Timber Association' building is in Osaka-city, Osaka prefecture. This building are first building using 'Moedomari' member in 2013 shown in figure 7. This building use fire-resistant laminated lumber, 'Moen-Wood' column and beam. By embedding the connection hardware inside the burn stop layers, which are the mortar parts of the column and beam, Takenaka has succeeded in ensuring the structural performance and fire-resistant performance of the connection so that heat is not transmitted by the hardware. Applying same element 4 srotied Japan's first large fire-resistant wooden commercial facility, "Southwood" was built in Yokohama City, Kanagawa prefecture, 2013.



Figure 7: Osaka Timber Association building

Table 4: Building data

Architect	Takenaka Corporation
Structural Design	Takenaka Corporation
Area	1,093m ² (total floor) / 457m ² (building)
Use	Office
Height	
Number of stories	3 stories
Structure	RC structure, timber structure

7. Conclusion

Many type of timber buildings for metropolitan area are completion. These buildings are pioneer and a technology of middle-rise timber building about seismic performance and fire-resistance performance is developing. New technology will create new timber architecture. Attractive timber building in the city should be built continuously.



Figure 8: Timberize City