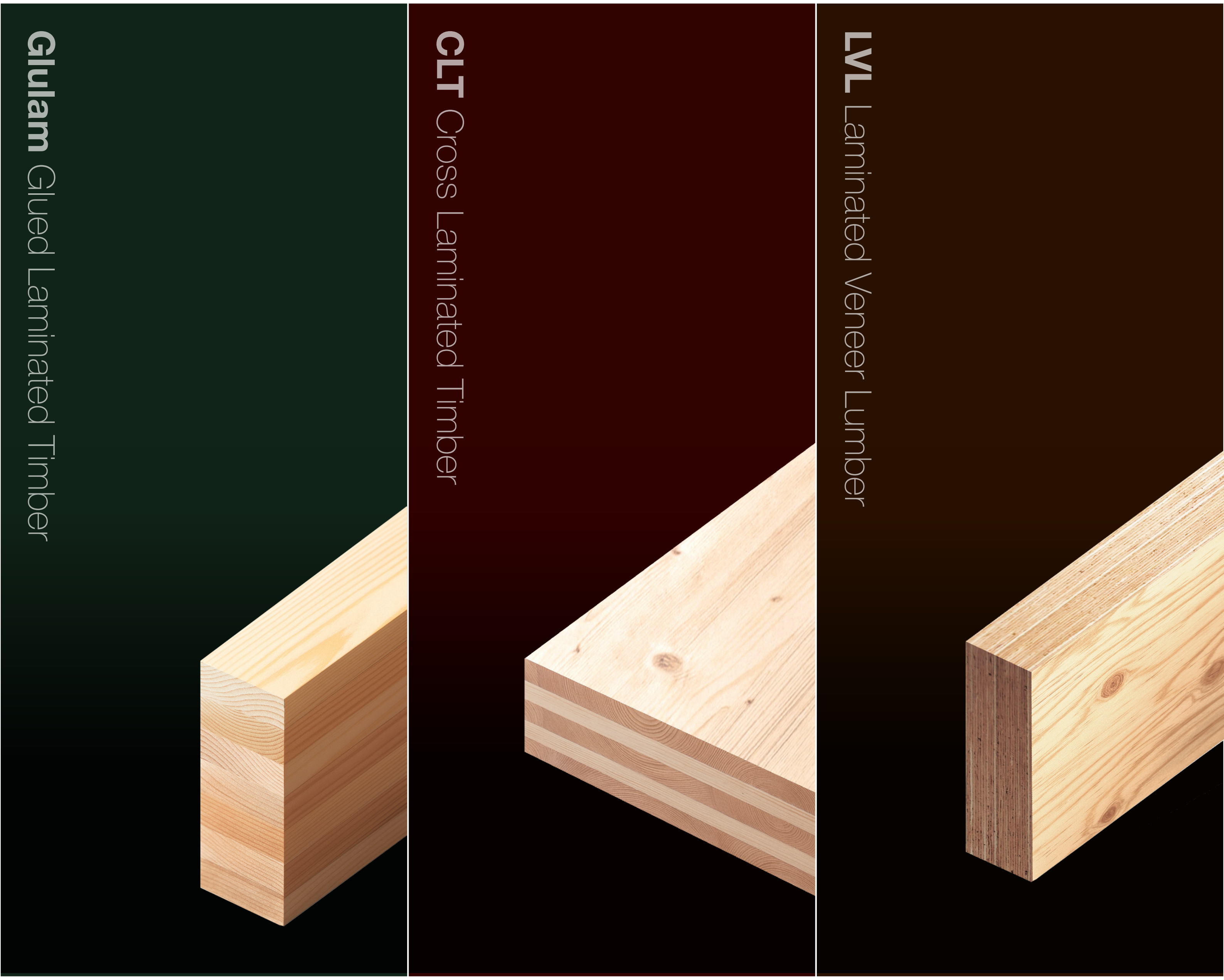
Mass Timber Products
from Japan



Japan Mass Timber Overseas Promotion Council

Preface

Japan has long lived in harmony with wood, nurturing its culture through this natural material.
Building on that heritage, we now share the appeal of Japanese mass timber as a material that contributes to contemporary architecture and urban development.

Sourced from carefully managed forests and manufactured with advanced technology, Japanese mass timber delivers both high quality and high performance. It is sustainable, environmentally friendly, and combines warmth with beauty—bringing new value to cities and projects worldwide.

Through this brochure, we invite you to discover the qualities and potential of Japanese mass timber, and we hope it will inspire and support your future projects.

Japan Mass Timber Overseas Promotion Council

Glulam Glued Laminated Timber

CLT Cross Laminated Timber

LVL Laminated Veneer Lumber

Glulam Glued Laminated Timber

from Japan

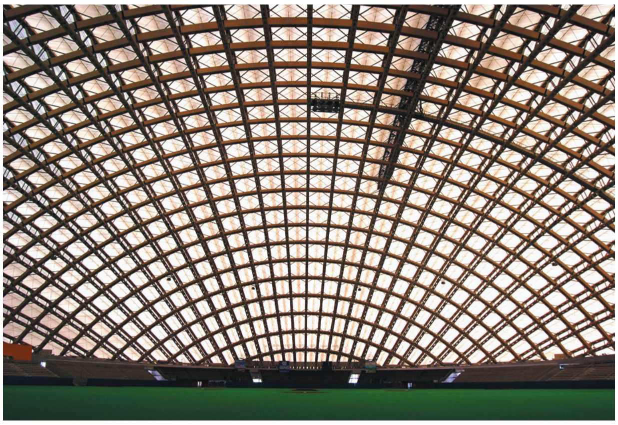


Photo: Courtesy of City of Gojo

Photo: Courtesy of JR-East Design Corporation

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1. Introduction to Glulam

Glulam is manufactured from laminations (lamina) or small sections of timber.
Defects such as large knots or cracks are removed, and the grain direction is aligned nearly parallel.
The laminations are then bonded together in thickness, width, and length to form a strong engineered wood material.

By drying the timber to a moisture content of 15% or less, and by eliminating inherent weaknesses of solid wood, Glulam minimizes deformation, warping, and cracking while ensuring consistent strength and stability.

Unlike synthetic materials, Glulam retains the natural advantages of wood. It can be produced in a wide range of shapes and lengths, making it suitable for diverse applications—from residential houses to large-scale buildings such as Olympic facilities—while maintaining reliable quality.

History of Glulam

In traditional Japanese architecture, such as temples and castles, multiple vertical timbers were bound together with iron bands or planed joints to form single columns or beams. An example can be seen in the Great Buddha Hall of Tōdai-ji (reconstructed in 1709), where wooden columns reaching 49 meters in height employed a similar joining method. Although this does not fall under the modern definition of "Glulam," it demonstrates characteristics comparable to Glulam.

The world's first wooden structure using glued laminated timber is said to be an entertainment facility in Basel, Switzerland, constructed in 1893 with a 40-meter-span, three-hinged arch system for a song festival hall. In June 1901, German engineer Otto Hetzer obtained a patent in Switzerland, leading to the practical use of Glulam. The technology spread to Northern Europe, and by the 1920s it had reached the United States. In 1934, a warehouse at the Forest Products Laboratory in Madison was experimentally built with Glulam. Its excellent performance encouraged the widespread industrialization of Glulam in the U.S.

In Japan, however, little progress was made in the development of glued laminated timber before World War II. The first known use of Glulam in a Japanese building was the Forestry Memorial Hall in Tokyo, completed in 1951. Subsequently, many structures such as school gymnasiums were built with Glulam, but due to stricter building codes and the increasing use of steel structures, Glulam construction declined sharply after reaching a peak around 1961.

© Photo Kishimoto

The Glulam industry in Japan initially developed around decorative laminated products. During the period of rapid economic growth in the 1950s and 1960s, demand for wood increased dramatically, while high-quality timber became difficult to obtain. To address the shortage of fine wood, particularly for traditional Japanese interiors, the industry supplied decorative laminated posts, nageshi (horizontal beams), shikii (thresholds), and kamoi (lintels).

However, the circulation of inferior products also became a problem. To ensure reliable products, industry leaders joined forces in research and development and, in 1963, established the Japan Laminated Wood Products Association. This organization worked on establishing manufacturing standards and introducing the Japan Agricultural Standard (JAS) for laminated wood.

In 1971, the association was reorganized into the Japan Glued Laminated Timber Industry Cooperative Association to strengthen the industry's management base. Efforts were made to improve quality and promote new technologies through structural improvement projects.

By the 1990s, with the increasing Westernization of housing styles and the spread of pre-cut housing components, the industry began supplying non-decorative Glulam posts and beams for residential use. Supported by the enactment of the Housing Quality Assurance Act, Glulam gained high recognition for its consistent quality and proven structural performance. This led to a significant expansion of production, continuing into the present day.

2. Key Features & Outstanding Performance

Features of Glulam

Flexible Shapes and Dimensions

Glulam can be freely bonded and adjusted in width, thickness, and length, making it possible to produce long-span and curved members. Based on design freedom and structural calculations, Glulam can provide members with the required strength for diverse applications.

Design: Yukiharu Takematsu +E.P.A
Photo: Nacasa and Partners

Reduced Deformation, Cracking, and Warping

Since solid wood contains a high level of moisture, insufficient drying often causes deformation, cracking, or warping. Glulam, however, is manufactured from laminations (lamina) that undergo both natural drying and kiln drying. By reducing the moisture content to 15% or less, Glulam minimizes the risk of deformation, cracking, and warping.

Consistent Strength Performance

During production, major defects such as large knots and cracks are removed, while smaller, acceptable imperfections are dispersed within the product. This reduces strength variability and ensures uniform quality. Structural Glulam is manufactured in accordance with the Japan Agricultural Standard (JAS). Laminations are visually and mechanically graded, then combined and bonded to achieve the required strength. As a result, Glulam products, including large cross-sections, offer clearly defined structural performance and dimensional stability.

Beam

Post

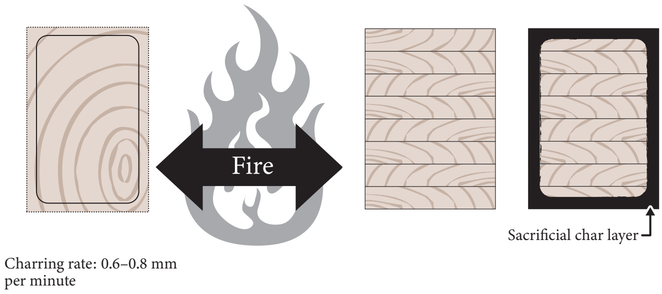
A Natural and Comfortable Material

Among many wood-based materials, Glulam preserves the natural texture of wood. It retains beauty, warmth, and softness, providing a sense of comfort and calm. Since wood has the ability to absorb and release moisture, Glulam also helps regulate indoor humidity and suppress condensation when used as an interior finishing material.

Fire Resistance of Glulam

Fire Performance

When wood ignites, it forms a char layer at a rate of approximately 0.6 to 0.8 mm per minute. This char layer prevents oxygen from reaching the interior and slows heat transfer. As a result, large timber sections require a long time before fire penetrates deeply. While the strength of uncharred portions may decline in areas close to the fire, the reduction is generally not significant, except in zones immediately adjacent to the char layer.



Designing with Char Allowance – Enabling Quasi-Fire-Resistant Structures

Under Japan's Building Standards Act, columns and beams can be used in quasi-fire-resistant structures, even when surface layers are exposed to fire, provided it is confirmed that the remaining cross-section maintains structural integrity. In design, calculations are based on the residual cross-section after deducting the "char allowance." This ensures that even if surface layers are burned in a fire, the building will not collapse. The required thickness of the char allowance depends on the type of wood material and the expected fire duration. Structural Glulam is recognized as being more fire-resistant than solid sawn timber.

Thickness of the Sacrificial Char Layer for Columns and Beams

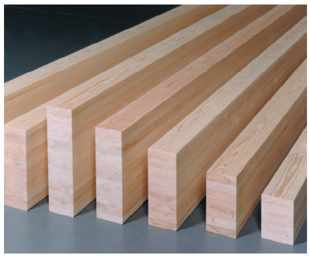
Heating Duration Based on Standard Fire	30 min	45 min	1 hour	75 min
Structural Glued Laminated Timber / Structural Laminated Veneer Lumber	2.5 cm	3.5 cm	4.5 cm	6.5 cm (with phenol-resin adhesives) / 8.5 cm (with non-phenol adhesives)
Structural Solid Timber	3 cm	4.5 cm	6 cm	–

3. Types of Glulam and Applications

Glulam can be broadly classified into structural glulam and non-structural glulam.

Structural Glulam

Structural glulam is manufactured by laminating graded lamina to achieve the required strength. It offers stable structural performance and enables the construction of large-span buildings. Based on size and cross-sectional area, it is classified into large, medium, and small sections. Structural glulam is used for load-bearing members such as columns, beams, girders, and sills.



Medium Cross-Section: Beams, Girders

Examples

- Medium and small section glulam are widely used as columns, beams, girders, and sills in wooden houses.
- Large section glulam is indispensable for large-scale wooden facilities such as gymnasiums, schools, assembly halls, offices, temples, and churches, where high strength, fire resistance, and durability are required.

Small Cross-Section: Columns, Sills

Non-Structural Glulam

This type is produced by laminating lamina in their natural state, highlighting the natural beauty of the wood surface. In some cases, surface treatments such as grooves are applied. These products are mainly used for interior fittings and finishes.

Examples

- Stair components, wall panels, countertops, flooring, and free boards.
- A wide variety of species and finishes are available, accommodating special sizes and shapes.
- Used extensively for housing interiors and furniture applications.



4. Production Process of Glulam

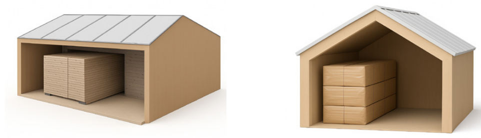
From logs to structural glulam

1. Lumbering

Logs are sawn into lamina boards by sawmills.

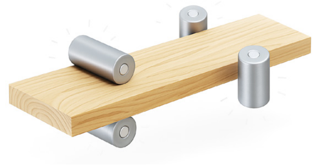
2. Drying

After drying, lamina that pass the moisture content inspection are shipped.
(Imported lamina that have already been dried are also widely used.)



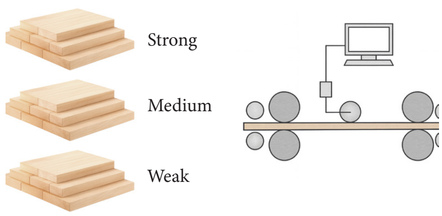
3. Preliminary Cutting

Lamina dimensions are trimmed by a molder.



4. Grading (Mechanical Sorting)

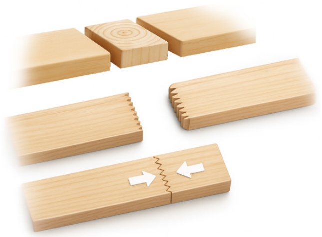
Strength of lamina is determined from the relationship between applied load and deflection.



Lamina are sorted by moisture content, strength test data, and appearance into strength grades

5. Finger Jointing of Lamina

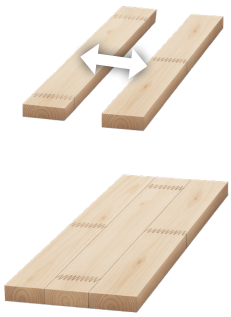
Large knots and defects are removed, and lamina are cut to specified lengths.



Finger jointing:
joining ends of lamina with finger-shaped joints.

6. Edge-Jointing

Lamina are jointed side by side.



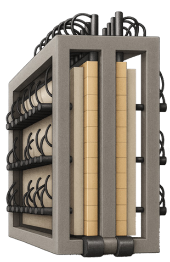
7.Adhesive Application

Adhesive is applied to lamina surfaces.

(Before applying adhesive, lamina surfaces are planed to ensure bonding strength.)

8. Pressing (Compression)

Glulam members are pressed and bonded together using a cold press.



9. Quality Control (Inspection)

Each finished glulam member is visually inspected thoroughly.

10. Packaging

5. Quality Assurance of Glulam

What is JAS?

JAS stands for Japanese Agricultural Standard. While the JAS mark is widely recognized for processed foods, it also applies to wood products such as Glulam, Cross-Laminated Timber (CLT), plywood, and sawn timber. The system certifies that products meet established standards of quality.

JAS and Glulam

Under JAS standards, not only the external quality of Glulam but also less visible properties—such as bonding performance, structural strength, and formaldehyde emission levels—are tested against specified methods and criteria. Glulam that passes these inspections is permitted to carry the JAS mark, guaranteeing product quality to users. (The certification process is referred to as grading.)

Selecting the Right Glulam for Each Application

Glulam with the JAS mark meets the quality standards defined by JAS. Since wood, the raw material of Glulam, is a natural product, variations in quality are inevitable. JAS standards help minimize these variations by setting allowable ranges and standardizing performance. To ensure safe and reliable use, Glulam should be selected according to bonding performance, strength, and other properties suited to the intended application.
It is also important to confirm the manufacturer indicated alongside the JAS mark.

Examples of JAS Marks for Glulam
(Japan Plywood Inspection Association)

Structural Glued Laminated Timber

Decorative Structural Glulam Post

Non-structural Glued Laminated Timber

Decorative Non-structural Glulam Post

At housing construction sites in Japan, many columns and beams bear the blue JAS mark, indicating structural Glulam.

Overview of JAS Standards for Glulam

1. Classification by Cross-Section Size

Glulam is classified into large, medium, and small sections according to cross-sectional size.

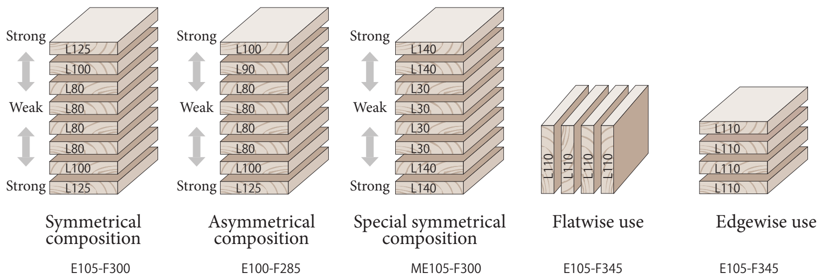
- **Large section:** Short side 15 cm or more, cross-sectional area 300 cm² or more.
- **Medium section:** Short side 7.5 cm or more, long side 15 cm or more.
- **Small section:** Short side less than 7.5 cm or long side less than 15 cm.

2. Classification by Lamina Arrangement

- **Uniform Grade Glulam**: Composed of laminations of the same quality. Uniform grade glulam is generally used for columns, while mixed grade glulam is mainly used for beams.

- **Mixed Grade Glulam**: Composed of laminations with stronger lamina placed on the outer layers. This category is further divided into:
  - **Symmetrical Arrangement:** Lamina quality arranged symmetrically around the central axis.
  - **Asymmetrical Arrangement:** Lamina quality strengthened on one side requiring higher strength, not symmetrical about the axis.
  - **Special Symmetrical Arrangement:** A symmetrical composition where lamina are arranged to emphasize superior bending performance.

Examples of Lamina Configurations



L125 indicates that the bending modulus of elasticity (MOE) of the lamina is 12.5 GPa (or 10^3 N/mm²).

3. Strength Grading

Strength classes are indicated by a combination of the bending modulus of elasticity (E) and bending strength (F). The E-F classes vary depending on the wood species and lamina composition, with multiple classifications available.

Wood Species	Symmetrical Mixed Grade Combination	Uniform Grade Combination
Sugi (Japanese Cedar)	E65-F225, E75-F240	E65-F255, E75-F270
Spruce	E95-F270	E85-F300
Hinoki (Japanese Cypress)	E105-F300	E95-F315
European Red Pine	E105-F300	E105-F345
Japanese Larch	E95-F270, E105-F300	E95-F315, E105-F345
Siberian Larch	E120-F330	E120-F375
Douglas Fir	E105-F300, E120-F300	E105-F345, E120-F375

4. Adhesive Performance Classes

Depending on the environmental conditions in which Glulam is used, adhesive performance requirements are classified into three categories: Service Class A, B, and C.

Category	Service Class A	Service Class B	Service Class C
Environmental Conditions	As a structural load-bearing member, where high performance of adhesive in terms of water resistance, weather resistance, or heat resistance is required. 1. Environments where moisture content continuously or intermittently exceeds 19% and is directly exposed to outdoor air (outdoor/indoor use). 2. Environments with prolonged high temperatures due to solar heat, etc. 3. Environments where high adhesive performance is required even under fire conditions.	As a structural load-bearing member, where normal performance of adhesive in terms of water resistance, weather resistance, or heat resistance is required. 1. Environments where moisture content occasionally exceeds 19% (indoor use). 2. Environments that occasionally experience high temperatures due to solar heat, etc. 3. Environments where high adhesive performance is required even under fire conditions.	As a structural load-bearing member, where normal performance of adhesive in terms of water resistance, weather resistance, or heat resistance is required. 1. Environments where moisture content occasionally exceeds 19% (indoor use). 2. Environments that occasionally experience high temperatures due to solar heat, etc.
Main Applications	Large cross-section glulam Medium cross-section glulam Columns and beams of large-scale buildings Primary structural members of quasi-fire-resistant buildings	Medium cross-section glulam Small cross-section glulam Columns and beams of large- and medium-scale buildings Primary structural members of quasi-fire-resistant buildings	Medium cross-section glulam Small cross-section glulam Wooden columns and beams Columns and beams of medium-scale buildings Secondary structural members of large-scale buildings

Curved large-section glulam is also manufactured in accordance with JAS standards.

Glulam and Formaldehyde Emissions

1. JAS Standards for Formaldehyde Emission
According to JAS standards, formaldehyde emissions are classified into four categories. Products are labeled accordingly.

Category	Formaldehyde emission	
	Average Emission (mg/L)	Maximum Emission (mg/L)
F☆☆☆☆	≤0.3	≤0.4
F☆☆☆	≤0.5	≤0.7
F☆☆	≤1.5	≤2.1
F☆S	≤3.0	≤4.2

Labeling is mandatory for non-structural glulam, decorative non-structural glulam, and decorative structural glulam columns, while optional for structural glulam.

2. Relationship between Glulam and Building Standard Law Regulations on Formaldehyde
(Effective July 1, 2003)

Structural members of glulam (such as columns, beams, nageshi [horizontal beams], kamoi [lintels], shikii [thresholds], window frames, stair handrails, posts, and sideboards) are exempt from restrictions. They can be used freely. However, if the exposed surface area exceeds one-tenth of the total installed visible area, restrictions on usage may apply.

For both structural and surface-use members (including flooring, wall panels, countertops, stair treads, and risers), products rated F☆☆☆☆ are exempt from restrictions and may be used freely.

Products rated F☆☆☆ and F☆☆, when used as interior finishing materials, may be subject to limitations on total usage area.

Products rated F☆S cannot be used as interior finishing materials.

Glulam and the Four VOCs

In addition to formaldehyde, four volatile organic compounds (VOCs) are of concern in building materials: toluene, xylene, ethylbenzene, and styrene (hereafter referred to as the “Four VOCs”). Based on the indoor concentration guideline values set by the Ministry of Health, Labour and Welfare of Japan (with the revised value for xylene announced in January 2019).

Reference Values for VOC Emission Rates from Building Materials

Target VOC	VOC emissionstandards	
	Abbreviation	Emission Standard (μg/m2h)
Toluene	T	38
Xylene	X	29
Ethylbenzene	E	550
Styrene	S	32

This standard was established by the Study Group on Voluntary Labeling of VOC Emissions from Building Materials (Secretariat: Japan Building Materials and Housing Equipment Industry Association). The previous emission standard for xylene was 120 μg/m²h.

Based on these guidelines, the building materials industry has established reference emission rate standards and conducts voluntary regulation through a labeling system.

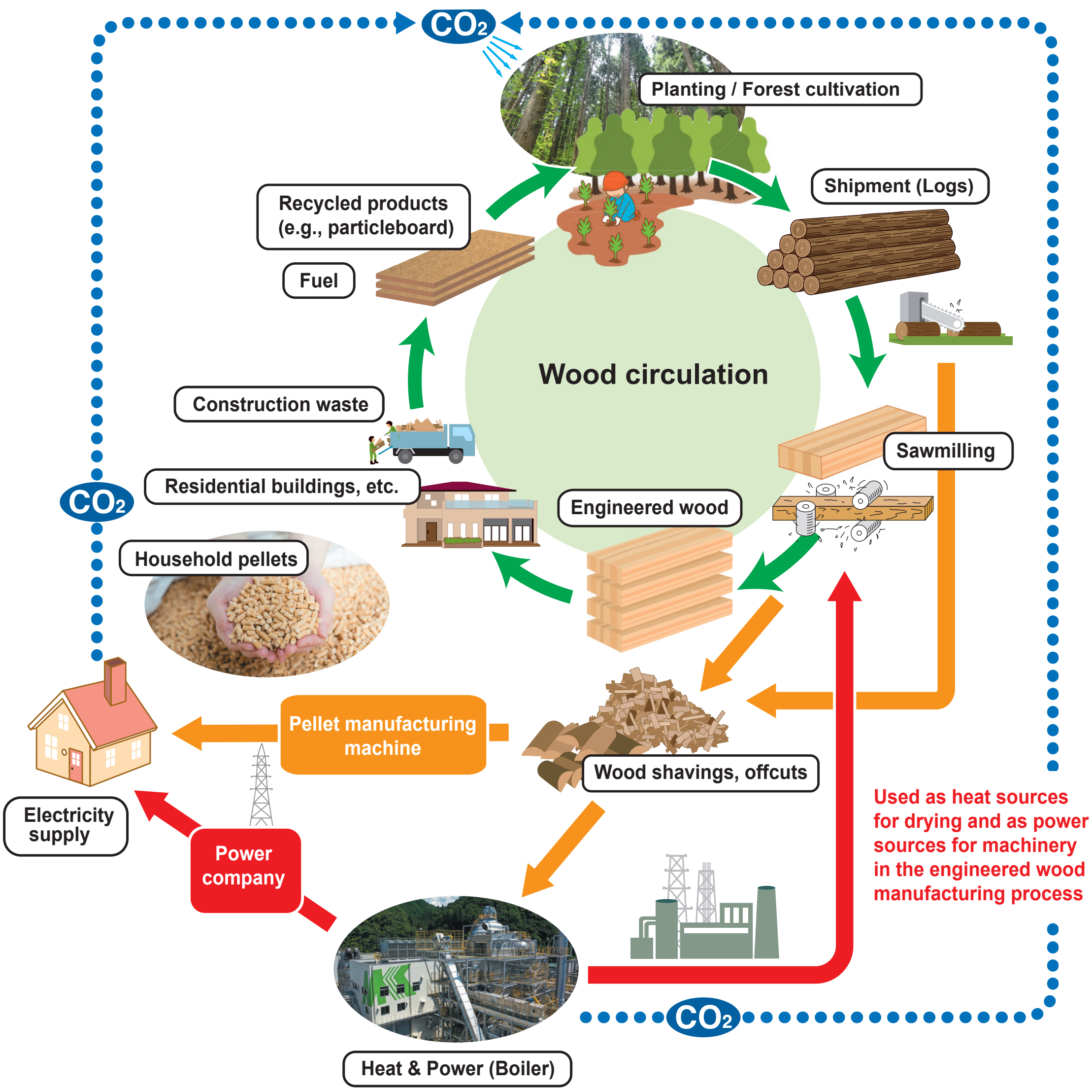
Glulam has also been confirmed to meet the standards, with emission rates of the Four VOCs below the specified limits. Details are shown in the accompanying table. In line with this, the Japan Glued Laminated Timber Industry Cooperative Association also operates a labeling system to ensure compliance.

6. Glulam and the Environment

Wood fixes carbon through photosynthesis, storing it in cellulose and lignin, the main components of trees. Using laminated wood in housing or furniture means fixing the carbon contained in wood for the long term.

In addition, during the process of producing lamina (sawn boards) from logs and manufacturing laminated wood by bonding laminae, wood residues and end cuts are generated. These are burned in boilers, with the heat used for drying the laminae or for generating steam. The generated electricity is used in factory machinery or sold to power companies. Such initiatives reduce dependence on fossil fuels, which is a unique strength of the building materials industry that uses wood as a raw material.

Furthermore, as a measure to address climate change issues, the industry is working on grasping and reducing CO_2 emissions during laminated wood production to contribute to achieving carbon neutrality.



7. Frequently Asked Questions

Q1. Can glulam crack due to drying?

(A) In Japan's high-temperature and humid climate, most houses are equipped with air conditioning. Particularly in traditional homes with exposed beams and columns, the dry air discharged from air conditioners can sometimes make the surface of the wood (laminated wood) drier than its original state, causing surface cracking.
Basically, laminated wood is manufactured with a moisture content of 15% or less, but if dry air from an air conditioner blows directly onto the wood surface, surface cracking may occur.
It is said, however, that these surface cracks have little to no effect on the strength of laminated wood.

Q2. How durable is glulam?

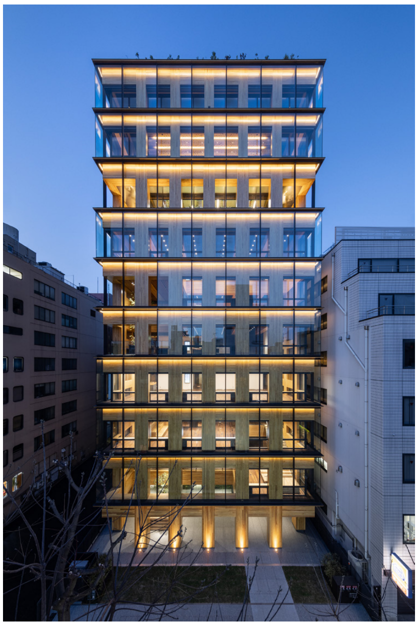
(A) Worldwide, laminated wood has a history of about 100 years. As proof of its durability, the Sanders School Gymnasium in Sweden, built in 1910, and the American Madison Forest Products Laboratory building, built in 1934, are examples that confirm the durability of laminated wood.
In Japan, the full-scale use of laminated wood began in the 1950s. At the time, there were no standards for structural laminated wood, and ungraded materials were used. Today, Japanese Industrial Standards (JAS) are applied, and laminated wood is produced under strict regulations. In fact, in public buildings such as gymnasiums and auditoriums built more than 70 years ago, structures using laminated wood remain in good condition.
While there is no actual proof of durability beyond 100 years, adhesive technology has advanced significantly, and adhesives with semi-permanent durability have been developed. Therefore, when used under conditions free from prolonged exposure to high temperature, humidity, rain, wind, or UV rays, laminated wood can demonstrate durability equal to or greater than solid wood.
That said, in order to prevent rot or insect damage, it is important to apply appropriate protective treatment to the wood itself, as well as to take structural measures.

Q3. How is the quality of glulam managed?

(A) In Japan, laminated wood production is strictly regulated by JAS standards. Inspections and record-keeping are mandatory, ensuring strict quality control. Many of the items are also inspected by accredited certification bodies.

Examples include:
① Moisture content inspection of lamina
② Grading inspection of lamina strength
③ Lamina width inspection
④ Thickness and width inspection by veneer rulers
⑤ Finger joint strength and adhesive strength testing
⑥ Finger joint shape inspection
⑦ Adhesive mixing and curing condition inspection
⑧ Adhesive bond-line inspection
⑨ Moisture content inspection of products
⑩ Product appearance inspection
⑪ Dimensional inspection
⑫ Formaldehyde emission testing
Among structural laminated wood products, items ① , ② , ③ , ④ , ⑤ , ⑧ , ⑨ , ⑩ , and ⑫ are inspected without fail.

CLT CROSS LAMIMNATED TIMBER
from Japan



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1. Introduction to CLT

CLT (Cross Laminated Timber)

CLT stands for Cross Laminated Timber. It is a type of engineered wood material made by stacking boards (lamina) side by side and then laminating them so that the grain direction alternates at right angles. It was developed mainly in Austria around the mid-1990s, and studies and designs began in Japan around 2010. In 2013, CLT was incorporated into the JAS standards, and in 2016, regulations regarding CLT strength and CLT panel construction methods were enacted. This made it possible to design structures with CLT, just as with solid wood, glued laminated timber, and LVL (Laminated Veneer Lumber).

In Japan, CLT made from species such as sugi (Japanese cedar), hinoki (Japanese cypress), and karamatsu (Japanese larch) is manufactured at eight factories (see P14). Depending on regional timber availability and required strength, buildings using CLT of suitable species are being constructed across the country.

3-ply Sugi CLT, 90 mm thick

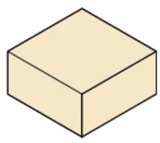
Differences Between Glued Laminated Timber and LVL

Wood materials used in structural frames include not only CLT but also solid wood, glued laminated timber, and LVL. The choice of wood depends on whether it is used as linear material for columns and beams (solid wood, glued laminated timber, LVL), or as surface material for walls, floors, and roofs (CLT, glued laminated timber, LVL). It also depends on the regional timber supply system and whether there are manufacturing facilities for engineered wood products.

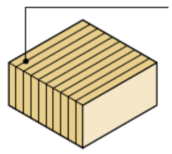
The characteristics of CLT include:

1. Large panels can be manufactured, up to 3 m wide and 12 m long.
2. Because the layers of boards are laminated crosswise, they resist deformation in two directions.
3. The thickness of the panels allows for cut-outs and enables expressive finishes with exposed wood grain and edges.

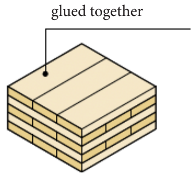
With the advent of CLT, glued laminated timber and LVL, which had traditionally been used mainly as linear elements, can now also be produced as surface materials. Therefore, it is important to understand the properties of each wood material and to design rationally by selecting and applying them appropriately to each structural part.



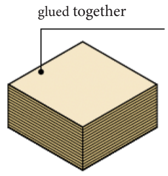
[Solid Wood]



[Glued Laminated Timber]
Japan Laminated Wood Products Industrial Association
http://www.syuseizai.com



[CLT (Cross Laminated Timber)]
Japan CLT Association)
http://clta.jp



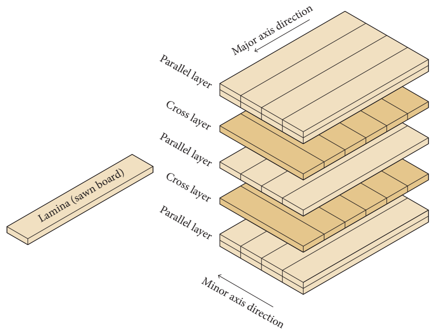
[LVL (Laminated Veneer Lumber)]
Japan LVL Association
http://www.lvl.ne.jp

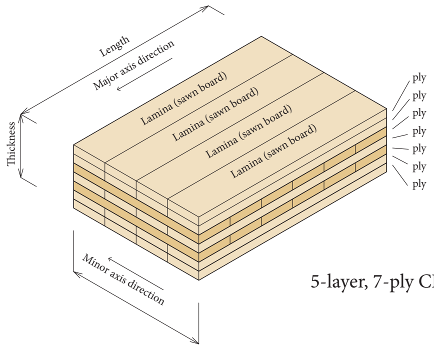
Designing with CLT Manufacturing Methods

The manufacturing of CLT begins with producing large boards, referred to as “motherboards,” which are then cut into the required dimensions. Improving the yield of these motherboards, in other words, reducing waste material, is the first step toward cost control when using CLT.

The dimensions of motherboards vary depending on the factory, generally ranging from 1 m × 4 m to 3 m × 12 m. At the early design stage, it is advisable to confirm both the maximum and minimum dimensions and then plan the module and floor height design with these sizes in mind.

When using CLT in large dimensions, it is also important to consider transportation (panels wider than 2.5 m often require special vehicles) and construction methods (for example, a CLT panel of 3 m × 12 m × 210 mm can weigh more than 3 tons). Coordination with builders and CLT manufacturers during the design phase is therefore recommended.



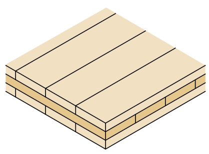


5-layer, 7-ply CLT

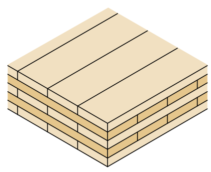
Cantilevering CLT Panels in Two Directions

CLT is a material with both strong and weak axes within the same plane, and its standard strength values are defined for both. As a result, balconies and floors can cantilever in two directions.

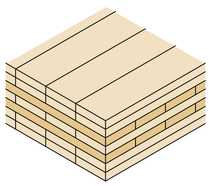
When cantilevering in two directions, sufficient support beyond the span is required. Therefore, it is important to be aware of the motherboard dimensions of the CLT being used. For example, if cantilevering 2 m along the strong axis and 1 m along the weak axis, a minimum panel size of 2 m × 4 m is required.



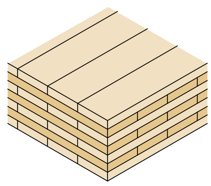
3-layer, 3-ply
(Thickness: 90 mm)



5-layer, 5-ply
(Thickness: 150 mm)



5-layer, 7-ply
(Thickness: 210 mm)



7-layer, 7-ply
(Thickness: 210 mm)

Carving and Exposing the Edge of CLT Panels

Common panel thicknesses are 90 mm (3-ply), 150 mm (5-ply), and 210 mm (5-ply or 7-ply). Taking advantage of this thickness, it is possible to engrave text on the surface of CLT panels or cut circular and square openings into them.

The edge of a CLT panel exposes the cross-section of the laminated boards, with different appearances depending on the layer orientation. By intentionally highlighting these edges, designers can create distinctive expressions unique to CLT.

2. Production and Processing of CLT

Manufacturing and Processing Flow - Example of Cypress Sunadaya Co.Ltd

CLT manufacturing begins by sawing logs into boards (lamina), which are then dried until their moisture content is below 15%. After that, the lamina are sorted and processed, and then laminated, glued, and pressed into large panels called “motherboards.” These panels are then cut into the required sizes. Depending on the factory, the maximum motherboard size varies (see P14), and after cutting, openings for joints, metal fittings, and facility piping are machined as needed.

The maximum size of CLT panels that can be transported using standard trucks and trailers is approximately 2.5 m in width × 12 m in length. For larger sizes, special vehicles are required, and restrictions such as road limitations and designated transport time windows may apply, potentially limiting transport feasibility.

By visiting CLT factories and consulting with manufacturers in advance of basic design, it becomes easier to create designs that maximize the potential of large-scale CLT.

CLT production in Japan

9 factories in operation

Annual production capacity: 100,000 m^3

Production volume in 2024: 18,000 m^3

1. Log unloading

2. Temporary storage of logs in yard

3. Log debarking

4. Sawing logs into lamina

5. Stacking lamina

6. Air-drying lamina

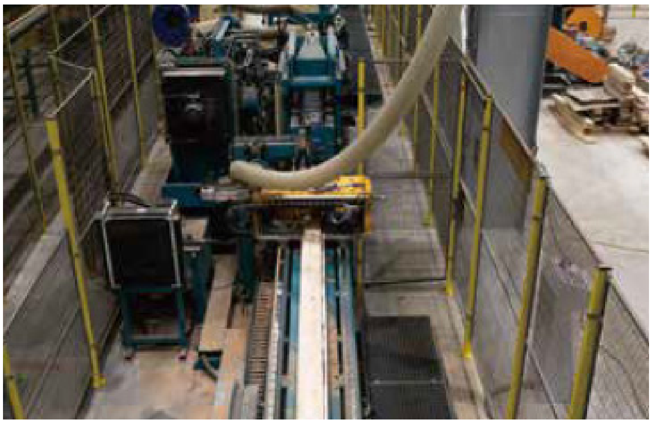
7. Kiln-drying lamina (moisture content ≤ 15%)

8. Moisture content measurement of lamina (all pieces)

9. Young's modulus measurement and sorting of lamina (all pieces)

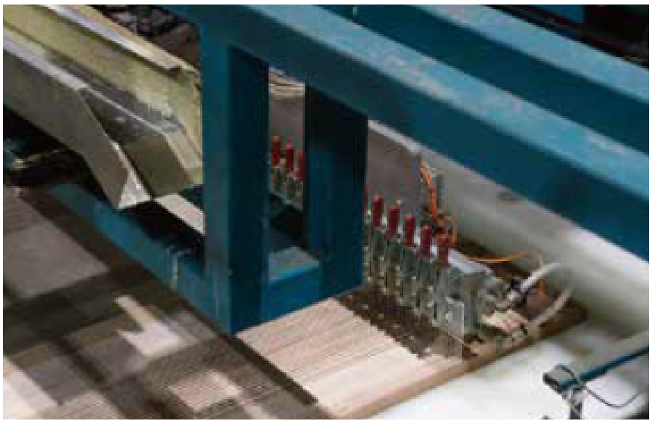
10. Visual grading of lamina [optional process]

11. Finger-joint processing of lamina ends

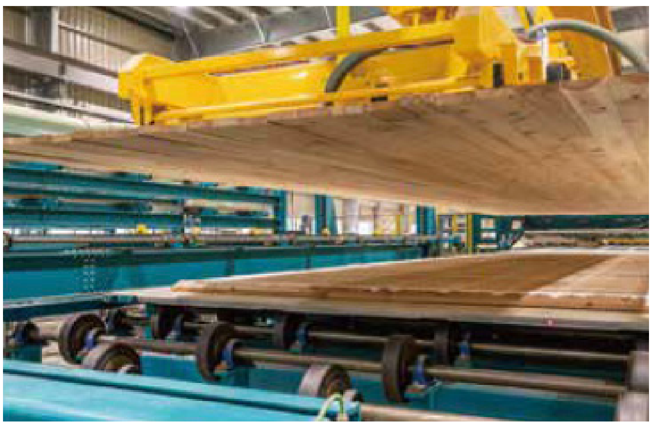


12. Longitudinal joining of lamina (finger joint)

13. Finishing planing of lamina (thickness 30 mm)



14. Application of adhesive to aligned lamina



15. Lamination of lamina (3, 5, 7, or 9 layers) into CLT panels

16. Pressing CLT (adhesive curing)

17. Sugi CLT motherboard (3 m × 12 m)

18. Hinoki CLT motherboard (3 m × 12 m)

19. Sanding finish of CLT surface [optional process]

20. Cutting and machining with dedicated CLT processing equipment

21. Loading CLT panels onto truck by crane

22. Shipment of CLT panels

3. Application of CLT

Structural Performance

CLT is characterized as a thick wood-based panel material and is mainly used for walls and floors in structural components. Thick walls can support not only horizontal forces (earthquakes, wind) but also vertical loads in place of columns. Thick floors can create flat ceilings without the irregularities of beams. Since column placement is less of a concern, detailed design studies make it possible to accommodate various plan configurations, including skip floors.

In 2015, a shaking table experiment was conducted at the National Research Institute for Earth Science and Disaster Resilience (NIED) on the 3D shaking table "E-Defense," using five-story and three-story buildings. Input motions larger than those observed during the Great Hanshin-Awaji Earthquake were applied to examine deformation and damage, confirming that the buildings did not collapse.

Against horizontal forces, wall panels resist loads; structural design requires ensuring strength with solid walls and securing ductility with partition walls, waist-high walls, and joints. Unlike conventional structural plywood or braced panels, CLT has different properties, so detailed study is necessary when used together with other construction methods.

Because CLT walls tend to become key structural elements, spaces may feel enclosed. However, by combining randomly placed openings and column-beam frameworks, open and expansive spaces can also be realized.

Fire Resistance

Thick timber panels such as CLT form a char layer on their surface during fire exposure, which insulates the interior. The charring progresses slowly at a rate of about 1 mm per minute, as confirmed by many fire tests. Utilizing this property, the remaining effective thickness of CLT after a given fire duration can be calculated.

A fire resistance test of CLT exposed walls in quasi-fire-resistant construction was conducted at the fire testing furnace of the Japan Housing and Wood Technology Center. Utilizing the property of wood that chars inward at a slow rate of approximately 1 mm per minute, it was confirmed that a 90 mm thick CLT wall could resist burn-through for more than one hour.

By accounting for the sacrificial char layer in design, buildings can be designed to remain standing for a certain period during a fire, a method known as "charring design."

Building standards specify the required charring allowances for quasi-fire-resistant walls, floors, roofs, columns, and beams. For example, in residential buildings up to three stories, schools, offices, or in two-story or lower commercial facilities and daycare centers, CLT can be used in quasi-fire-resistant construction. With charring design, it is possible to expose CLT surfaces as part of the architectural design.

However, even thick CLT can eventually ignite at the surface, leading to interior finishing restrictions depending on use and building scale. In such cases, additional measures are necessary.

Construction Methods

1) CLT Panel Method

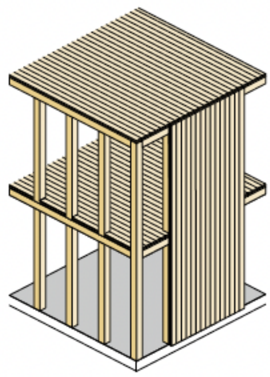
In the CLT panel method, CLT can be used as walls that resist both horizontal and vertical loads. Technical standards for structural design are defined in Ministry Notification No. 611 of 2016, which specifies the CLT panel method. Depending on panel size and joint details, there are two structural types:
- Small-panel frame structures using solid wall panels without openings.
- Large-panel frame structures using panels with openings.
In the latter, the difference lies in whether failure occurs around the openings or whether performance depends on the arrangement of joints.

CLT Panel Method

2) Post-and-Beam Method + CLT Panels

In traditional post-and-beam timber construction, CLT can be used for walls resisting either horizontal loads or vertical loads, as well as for floor slabs. Structural calculations are generally the same as in conventional timber post-and-beam structures.

However, according to Building Standard Law provisions (Notification No. 1898 of 2020), CLT is not listed among the materials permitted for use in axial load-bearing members. Therefore, CLT walls cannot serve simultaneously as column substitutes. CLT can only be applied where wall strength calculations are carried out according to Article 46, Paragraph 4 of the Building Standard Law

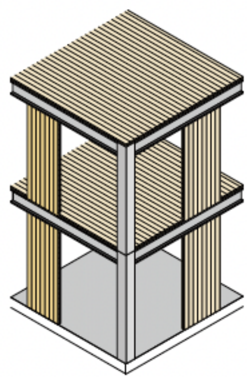


Post-and-Beam Method + CLT Panels

3) Hybrid Construction

In hybrid structures, lower stories may be built with reinforced concrete (RC) or steel, while upper stories can be constructed using CLT. CLT panels can be layered to form multi-story hybrid systems with RC or steel frames.

In vertical hybrid structures, appropriate design standards must be applied separately for each structural type. CLT may also be used for walls and floors in RC or steel structures. However, when combining CLT walls with those systems on the same floor, detailed structural analysis is required.



Steel Frame + CLT Hybrid Construction

How to Utilize the Characteristics of CLT Panels

Panel Method — Creating a Box

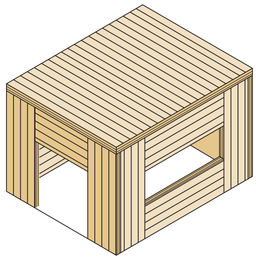
The basic principle of the CLT panel method is to form a "box" by using panels for walls, floors, and roofs.

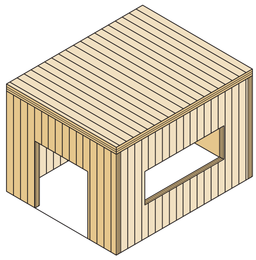
For walls, just as in wall structural calculations, unit-length wall segments are placed. At the four corners of each wall, joints are installed to resist tensile forces during earthquakes, while additional joints are provided to transfer shear forces. Thus, the structure is assembled.

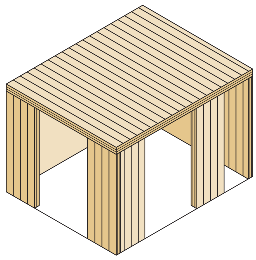
The performance of walls depends on panel size and whether openings are included. The simplest structure is a small-panel solid wall, which ensures strength without openings. However, since CLT is a panel material with relatively high brittleness, ductility must be secured through joints. Although it is not mandatory to install partition walls or waist-high walls, including them can improve shear strength and deformation capacity.

Large-panel structures are designed under the assumption that damage initiates at the top and bottom edges of openings and eventually redistributes loads to smaller solid wall panels. This allows the number of joints around openings to be minimized, improving construction efficiency.

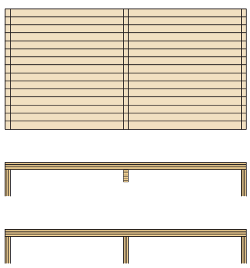
Floors can be constructed using CLT panels as spanning members. However, as spans increase, it may be necessary to introduce secondary beams to subdivide the span. CLT floor panels must be jointed with connectors to ensure performance against horizontal forces.

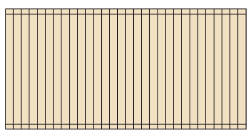

Narrow panel


Large panel


Option to eliminate drop walls and spandrel walls


Bus shelter in front of Maniwa City Hall without drop walls or spandrel walls


Floor with secondary beams


Floor spanning in the short direction

For narrow panels and large panels, the orientation of the surface laminations differs in drop walls and spandrel walls. For floor panels as well, the surface laminations generally run in the short direction enclosed by walls and beams.

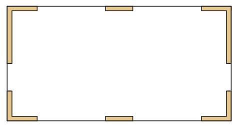
Panel Method — Placing Walls

In the CLT panel method, the structure is essentially box-shaped. Thus, walls serve not only to resist horizontal forces (earthquakes, wind) but also to carry vertical loads in the same way as columns. Careful consideration must therefore be given to the placement of walls, floors, and roofs as vertical load-bearing members.

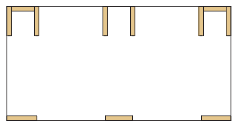
By adopting high-strength CLT panels, the number of walls can be reduced. However, if reduced excessively, additional walls may be required to support the floors, so care is necessary. Vertical load-bearing can also be supplemented with auxiliary columns in addition to walls.

Wall placement requires attention to balance in plan layout, similar to wall structural calculations. In multi-story buildings, placement of walls in upper and lower floors must also be considered. In particular, when beams are not used, transferring compressive or tensile forces between upper and lower walls through floors can be difficult, making coordinated wall placement important.

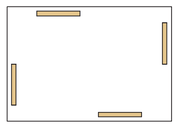
CLT boxes, with their rectilinear geometry, allow for diverse plan arrangements by combining walls of varying lengths and shapes. Structural evaluation is carried out in both horizontal directions, considering angle changes and overall torsional behavior. However, the effective angle range is limited, and attention must be paid to preventing torsional distortion and ensuring overall ductility when subjected to eccentric forces.



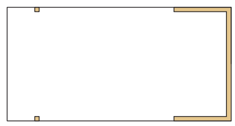
Placing walls along the perimeter



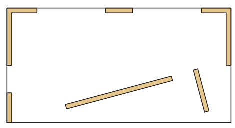
Placing a series of wing walls



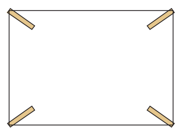
Placing walls away from the corners



Placing walls with allowed eccentricity



Placing walls diagonally



Placing walls considering torsion

As in wall quantity calculations, placing walls at the four corners is the basic approach. However, by carefully considering eccentricity and torsion, the flexibility in wall placement can be increased.

Kochi Forest Association Hall with a series of wing walls

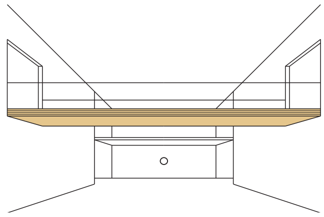
Panel Method — Floors and Roofs

CLT panels are thick enough to function independently as floor slabs. Unlike post-and-beam construction, where floors are supported by linear members such as beams, CLT allows support spans to be set freely, similar to shelves. This enables stepped floors or skip floors that bring variety to spatial layouts.

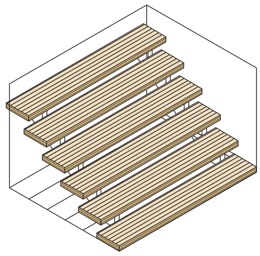
Beamless floor structures such as CLT bridges or cantilevered balconies are also characteristic forms made possible by CLT. Standard CLT floors are supported along two edges in the strong axis direction. However, by utilizing the cross-laminated structure, more complex support forms are possible, such as four-edge support at right angles or two-directional cantilevers at openings, which are generally difficult to achieve with anisotropic wood materials.

That said, the maximum practical span for single-panel CLT floors (e.g., five-ply sugi panels, 210 mm thick) is approximately 4–5 meters. For larger spans, solutions include subdividing the span with secondary beams to reduce effective spans, or supplementing with trusses, lattice beams, or composite beams of wood and other materials.

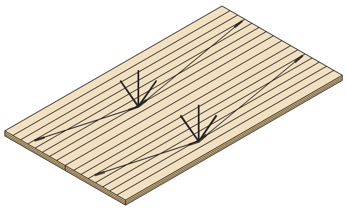
Additionally, by using CLT panels as upper and lower chords in combination with steel tension members below, folded-plate structures or origami-inspired folded systems can be realized. These structural systems take advantage of CLT's panel thickness and material characteristics.



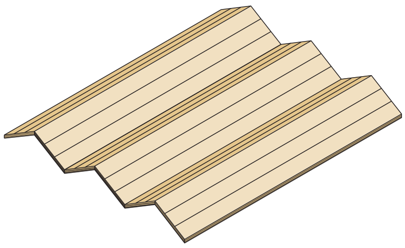
Bridge with two-edge supported slab



Stepped floor



Roof with tension beams



Roof with folded-plate structure

Kochi Prefectural University of Forestry with a roof structure using tension beams

Structural systems that utilize the properties of thick panels can be realized, including one-way slabs, two-way slabs, flat slabs, and folded-plate structures.

Panel Method — Repetition

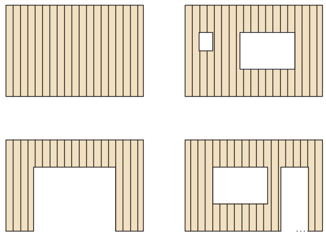
One of the advantages of the CLT panel method is that, as a dry construction system, it shortens the construction period and offers economic efficiency. This is particularly effective for mid- to large-scale buildings such as collective housing, accommodation facilities, service-oriented elderly housing, and other projects requiring spacious interiors.

In designing buildings with CLT panels, however, it is important to plan not only the final architectural appearance but also prefabrication methods, transportation, and construction methods (including lifting plans).

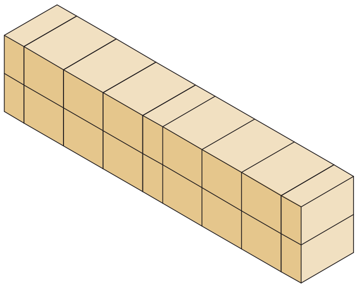
Repeated use of wall panels offers two options: employing small panels to increase the number of units, thereby enhancing flexibility in plan layouts, or using large panels to reduce the number of construction units while expressing openness through larger openings.

Repetition can be considered not only at the level of single wall panels, but also at the scale of boxes composed of walls, floors, and roofs. By arranging panels with slight angular adjustments, or by stacking them with deliberate shifts, buildings with distinctive spatial forms can be created.

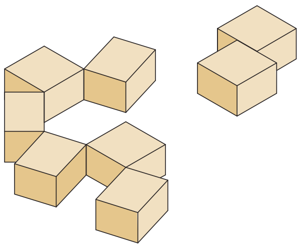
When mechanical joints such as bolt connections are used, the assembly process becomes simple, and disassembly is facilitated. This allows for repeated use of the panels in temporary or relocatable buildings.



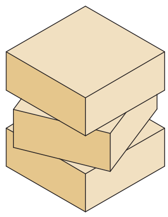
Set basic panels



Arrange boxes of different sizes



Arrange boxes in various orientations



Stack boxes with shifts

Iwaki CLT Reconstruction Public Housing composed of boxes in varying sizes

By repeating boxes made from basic panels sized with consideration of the mother boards (base lumber boards), arranged both in plan and in three dimensions, production and construction efficiency can be enhanced.

Panel Method — Creating Cores

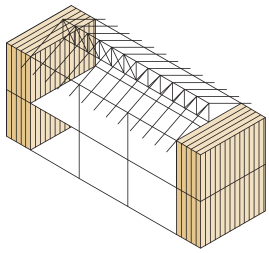
Because the CLT panel method is primarily wall-based, it tends to result in enclosed spaces. However, in large-scale buildings where many people gather, open and expansive spaces are often required.

One way to address this in floor planning is to concentrate enclosed functions such as warehouses, restrooms, and staircases into core zones. By placing these cores together and connecting them, large-span structural spaces can be created around them.

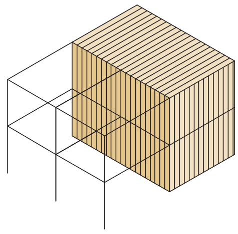
The spanning structures over such spaces need not rely solely on CLT; they can also be realized through established timber construction techniques such as large glued laminated timber or truss and arch systems used in housing prefabrication. Previously, such layouts were typically planned as RC seismic core structures. With the introduction of CLT, however, it has become possible to design timber-based seismic core structures.

These cores serve not only as seismic-resistant elements but also play an effective role in fire safety. In large-scale buildings, fire-resistant core areas can compartmentalize spaces, reducing fire protection requirements for other areas.

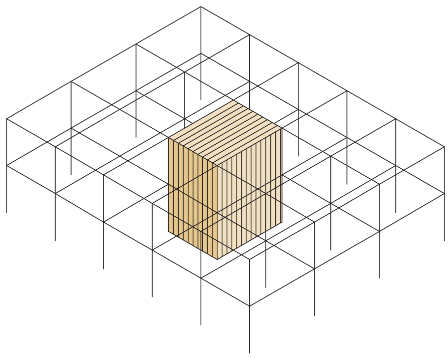
Accordingly, in planning, it is important to consider not only spatial layout but also how structural performance and fire resistance can be integrated. This enables realization of buildings that fully leverage the characteristics of CLT.



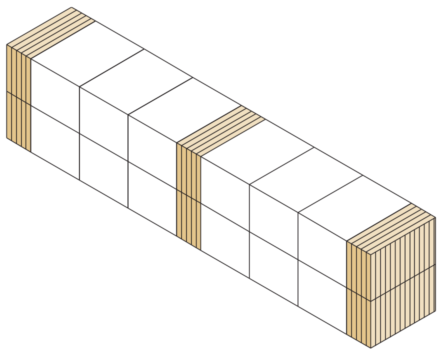
Dual side-core type – low eccentricity



Single side-core type – high eccentricity



Center-core type



Seismic core + fire compartment

By concentrating functions such as stairwells, restrooms, and storage—areas that require relatively few openings—into the core and treating them as seismic elements, the remaining spaces can be designed more openly.

Murotsu Fisheries Cooperative Office designed with a dual side-core layout

Post-and-Beam + CLT — Using CLT in Place of Structural Plywood

CLT walls can be used as shear walls in post-and-beam construction, similar to structural plywood. However, because wall multiplication factors for CLT have not been established, it cannot be directly used in wall multiplier calculations. Instead, design must be based on allowable stress or equivalent methods.

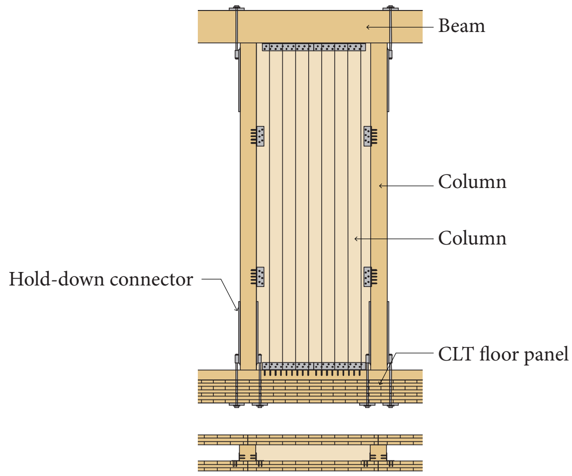
Since CLT can be manufactured in large panels, walls can be designed not only in the conventional 910 mm modules common to timber construction, but also in larger modules such as 1000 mm or 1200 mm.

CLT can be applied both as shear walls and partition walls. For shear walls, its greater thickness compared to plywood means that joints require careful detailing, such as long screws or metal fittings connecting from the back. For partition walls, similar connection details as in the panel method are used, typically with screws or bolts. However, the steepness of screw angles, while convenient for installation, may induce splitting in surrounding members, so careful selection of fasteners, placement, and construction method is required.

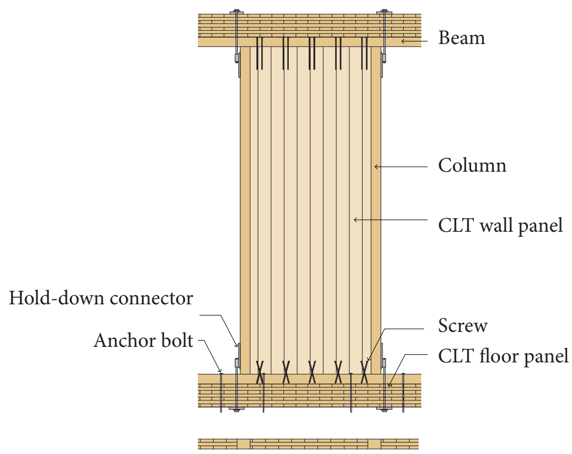
In residential construction using dimension lumber, if high-strength CLT shear walls are introduced, there is an increased risk of damaging surrounding framing. Therefore, CLT shear walls are typically designed to resist short-term shear stresses of about 14 kN/m.

Additionally, thick CLT walls, columns, and beams can be covered with other wood materials, allowing them to be used as sacrificial charring layers in quasi-fire-resistant construction. This improves overall fire performance.

Kochi Prefectural Forest Association Hall using CLT as structural sheathing



In a concealed frame wall, the column and beam framework is hidden, giving the appearance of a standard CLT panel construction. In addition, the columns and beams can be evaluated as providing fire-resistance allowance (sacrificial char layer).



When CLT panels are joined only to the upper and lower beams in an exposed frame wall, the space between the columns and CLT can also be used for electrical wiring or other building services.

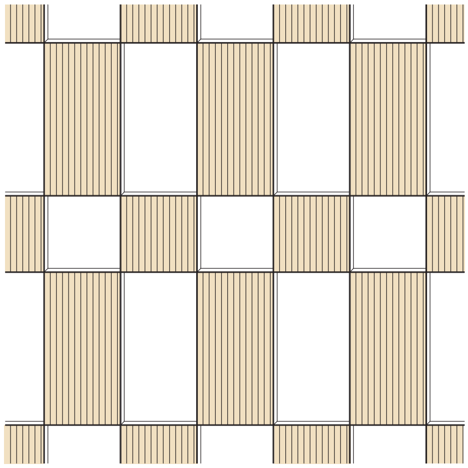
Hybrid Construction — Application in Steel Structures

As in timber post-and-beam systems, CLT can also be used for walls and floors in steel structures. Traditionally, steel construction has employed deck plates with concrete slabs, or ALC panels with horizontal braces for floors, and ALC panels with braces for walls. By replacing these components with CLT panels, both floors and walls can now be constructed with CLT.

When appropriate joint detailing with surrounding steel members is provided, CLT floors can secure in-plane shear strength and eliminate the need for separate horizontal bracing or floor slabs. Similarly, CLT walls can serve not only as finishing material but also as shear walls.

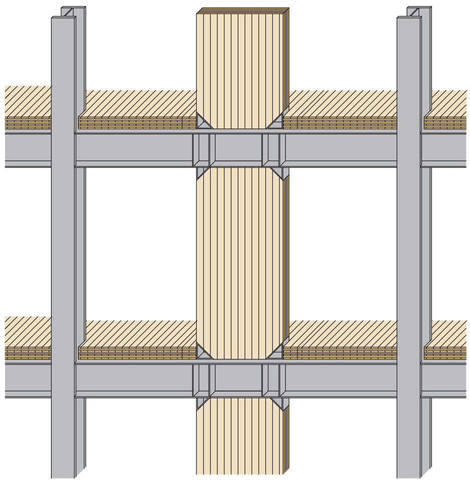
When CLT is used as seismic shear walls, jointing with surrounding steel framing requires special attention. Systems in which CLT absorbs horizontal tensile and compressive forces through connections—such as tension/compression brace panels where CLT panels are fixed to steel frames—can be effective.

When CLT shear walls are used in large post-and-beam structures, however, boundary beams connected to CLT may experience large uplift forces and shear stresses. While this can be addressed with large glued laminated timber or other engineered wood, in some cases, introducing additional steel beams to restrain these forces may provide a more efficient solution.



Steel frame + CLT lattice seismic wall

By inserting CLT panels into steel frames such as flat bars, they can function like compression braces, creating walls that combine seismic resistance with openness.



Steel frame + CLT shear wall and CLT floor

In a steel structural frame, CLT walls and CLT floors serve as seismic elements, primarily resisting shear forces. When used as seismic walls, CLT panels can also be detailed to function as exposed structural walls.

Hyogo Forestry Hall with CLT integrated into a steel structure

Others — Forms and Processing Unique to CLT

In conventional timber construction, post-and-beam connections have been developed as joints between linear members. In contrast, thick panel materials such as CLT introduce joints between planar members, which differ significantly. Panel-to-panel connections may include butt joints with continuous alignment, corner joints utilizing panel edges, or oblique joints where the angle of the connection changes across the panel.

Advanced joinery techniques are possible, such as dovetail joints with three-dimensional angle processing, or interlocking connections produced through computer-controlled machining systems, combined with metal fittings. Such panel-to-panel connections allow for expressive designs that emphasize planar surfaces.

Historically, planar compositions have been central to traditional timber architecture as well, such as vertical firebreak walls, horizontal eaves, and continuous façades of merchant houses in areas like Kurashiki or Gion, which feature strong planar expressions.

Thick CLT panels further enable unique processing and design features. Beyond grooves for pipes or ducts, three-dimensional curved machining can be used to engrave decorative patterns. This allows integration with lighting fixtures, furniture, and other components.

Streetscape of Unomachi Preservation District

Object created with interlocking joints

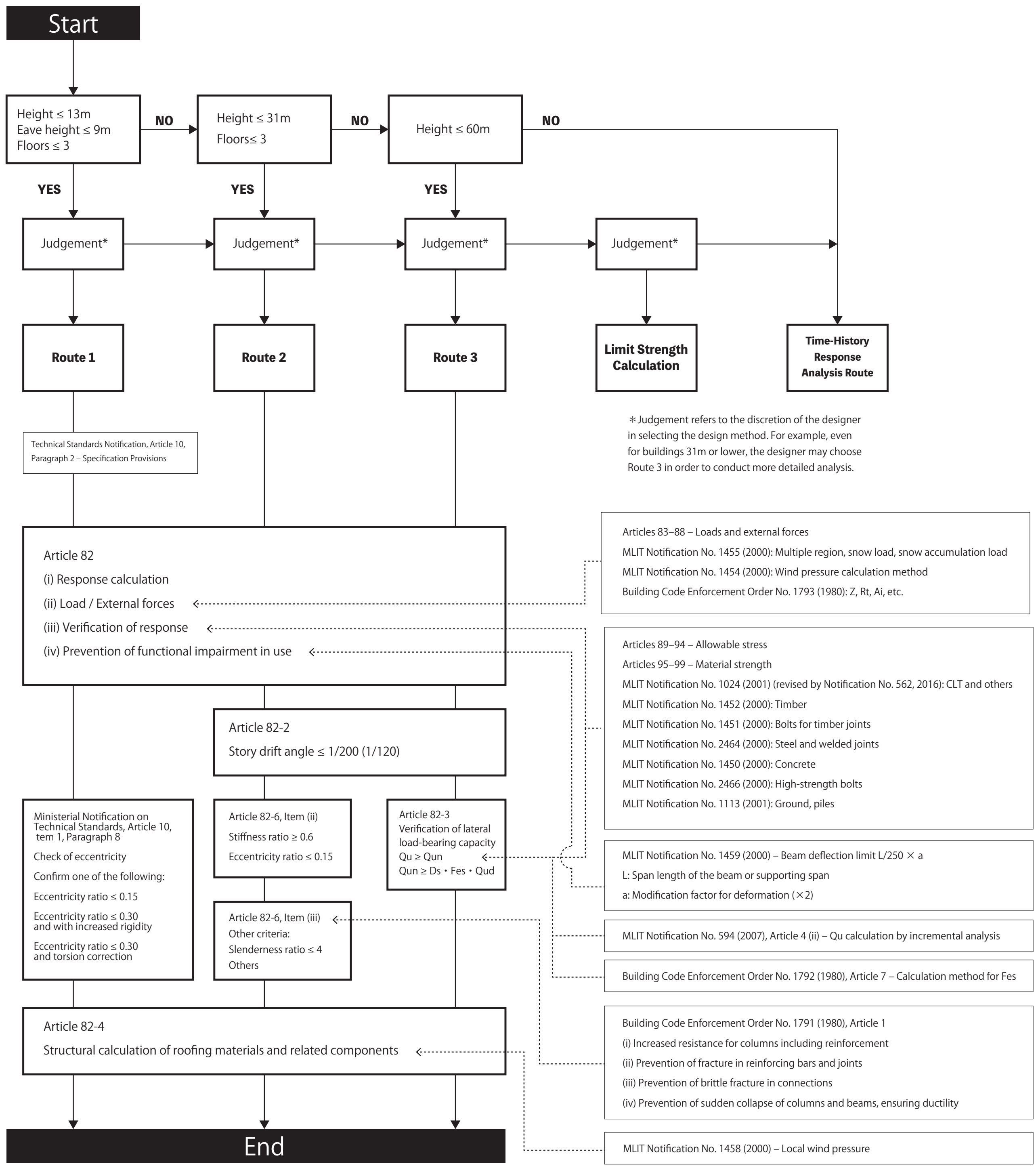
Furniture with folded-plate structure using diagonal processing

Furniture with three-dimensionally curved surfaces

4. Design Using the CLT Panel Method

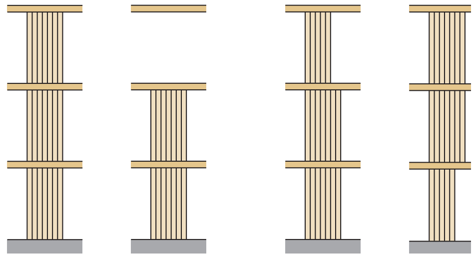
The structural calculation routes for buildings follow the process shown below. In the CLT panel method, where CLT walls bear both vertical and horizontal loads, design can be carried out using Route 1. This route allows for relatively simple calculations, such as manual calculations with a calculator.

Here, the key points for advancing design using the CLT panel method with this simplified calculation approach [Route 1] are summarized.



Applications of the Simplified Design Method [Route 1]

The CLT panel method [Route 1] is a suitable design method for rectangular buildings of up to three stories (with eave heights of 9 m or less and overall heights of 13 m or less). Under current building regulations, the following design restrictions apply. However, if these are addressed from the early design stage, the simplified method can be applied effectively.



Verification of allowable shear wall placement

1. Wall construction must be either a small-panel frame structure or a large-panel frame structure (see right diagram).

2. Directly beneath a shear wall, another shear wall of equal or greater width and thickness must be placed (see right diagram).

3. Both ends of vertical or partition wall panels must connect to shear walls.

4. Shear wall widths must be between 90 cm and 2 m.

5. Openings must be between 90 cm and 4 m wide.

6. Vertical or partition walls must be at least 50 cm high.

7. CLT panels used for walls must meet the following strength grades: S60-3 (3-ply), Mx60-5 (5-ply), or equivalent or higher strength.


Haruna Shrine Offering Tablet Repository
EMERAUDE ARCHITECTURAL LABORATORY CO,LTD.


Santou Industries Shigaraki Main Store
Junichi Kato Architectural Design Office


Okayama City Nishiki Certified Childcare Center
Niwa Architectural Design Office Co., Ltd.


White Lodging Apartment Facility
Suyama Construction Co., First-Class Architect Office

Required Wall Lengths and Span Guidelines in the CLT Panel Method [Route 1]

Based on case studies of offices and multi-family housing designed with the CLT panel method [Route 1], the required wall length per unit floor area on the first floor, as well as the allowable roof and floor spans, have been summarized. In basic design, use the required shear wall lengths defined by building scale, and consider roof and floor spans according to CLT specifications. Note that the values in the span table are reference values; if longer spans are desired, additional design verification will be necessary.

CLT grade S60-3-3 represents strength grade S60 with a 3-ply lamination configuration.

For the creation of the span table, deflection limits were set as follows: roof spans at 1/200 or 2 cm or less, and floor spans at 1/300 or 2 cm or less. The creep amplification factor was considered as 2. The modulus of elasticity of CLT was taken as 0.45E, and the uniformly distributed loads in the table account for CLT self-weight deducted.

The table applies to CLT with the same strength grade S. For strength grade Mx, refer to the Meiken Kogyo Co., Ltd. website (http://www.meikenkogyo.com/product/2018_11_1_15_47_53/html5.html#page=79).

CLT panel construction: Reference wall length required per floor area on the first floor under Structural Calculation Route 1

Usage	Office			Apartment			Assumed Loads (unit: N/m²)
Floors	1-story	2-story	3-story	1-story	2-story	3-story	Roof: 1200 (assumed as 900 N/m² plus allowance for eaves, etc.) Walls (per floor area): Office: 1500 Apartment: 1400 (for 2- and 3-story), 900 (for 1-story) Note: For the top floor, loads are assumed as 1/2 of the above values. Floors: Dead load: 1300, Live load: Office 800, Apartment 600
Wall panel thickness (mm)	150	150	150	90	150	150	
Horizontal load (kN/m²)	0.39	1.11	1.83	0.33	0.98	1.7	
Story height (m)	3.6			3.0			
Allowable horizontal resistance (kN/m)	12.5	12.5	8.3	15.0	15.0	10.0	
Required wall quantity (cm²/m)	3.1	8.9	22.0	2.2	6.5	17.0	

Comparison of CLT strength (major axis direction) with standard strengths of structural glulam (mixed grade composition) and structural lumber (unit: N/mm²)

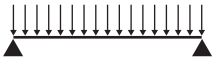
Type	Strength Grade	Compression Fc	Tension Ft	Bending Fb Parallel to lamination	Bending Fb Perpendicular to lamination
CLT	S60-3-3	10.80	8.00	12.68	10.80
	S60-5-5	9.72	7.20	10.42	9.72
	S60-7-7	9.26	6.86	9.36	9.26
	S60-5-7	11.57	8.57	12.16	11.57
	S90-3-3	13.80	10.25	16.20	13.80
	S90-5-5	12.42	9.23	13.32	12.42
	S90-7-7	11.83	8.79	11.96	11.83
	S90-5-7	14.79	10.98	15.54	14.79

Note: CLT lamina specification based on machine grading

Type	Strength Grade	Compression Fc	Tension Ft	Bending Fb Parallel to lamination	Bending Fb Perpendicular to lamination
Structural Glulam	E65-F225	16.7	14.6	22.5	15.0
	E95-F270	21.7	18.9	27.0	20.4
Structural Sawn Timber	F70	23.4	17.4	29.4	
	E90	24.6	18.6	30.6	

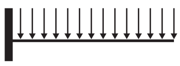
Type	Shear Properties Fs (Unit: N/mm²)		
	CLT	Structural Glulam	Structural Sawn Timber
Sugi (Japanese cedar)	0.9	2.7	1.8
Hinoki (Japanese cypress)	1.2	3.6	2.1

Span table for CLT roofs (simply supported beam)



CLT Specification	Thickness (mm)	Load (N/m²)		Maximum span (m)
		Dead Load	Self-weight of CLT	
S60-3-3	90	500	405	4.0
		1000	405	3.5
S90-3-3		500	405	4.5
		1000	405	4.0
S60-3-4	120	500	540	4.4
		1000	540	3.9
S90-3-4		500	540	4.9
		1000	540	4.4
S60-5-5	150	500	675	5.3
		1000	675	4.8
S90-5-5		500	675	5.9
		1000	675	5.4

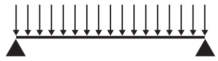
Span table for CLT roofs (cantilever beam)



CLT Specification	Thickness (mm)	Direction	Load (N/m²)		Maximum span (m)
			Dead Load	Self-weight of CLT	
S60-3-3	90	Major Axis	500	405	1.9
			1000	405	1.6
		Minor Axis	500	405	0.65
			1000	405	0.55
S90-3-3	90	Major Axis	500	405	2.2
			1000	405	1.8
		Minor Axis	500	405	0.75
			1000	405	0.65
S60-3-4	120	Major Axis	500	540	2.1
			1000	540	1.8
		Minor Axis	500	540	1.25
			1000	540	1.1
S90-3-4	120	Major Axis	500	540	2.4
			1000	540	2.1
		Minor Axis	500	540	1.4
			1000	540	1.2
S60-5-5	150	Major Axis	500	675	2.7
			1000	675	2.4
		Minor Axis	500	675	1.75
			1000	675	1.55
S90-5-5	150	Major Axis	500	675	3.1
			1000	675	2.7
		Minor Axis	500	675	2.0
			1000	675	1.8

Span table for CLT floors (simply supported beam)

Housing



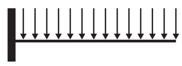
CLT Specification	Thickness (mm)	Load (N/m²)			Maximum span (m)
		Dead Load	Live Load	Self-weight of CLT	
S60-3-3	90	900	1800	405	2.2
S90-3-3					2.6
S60-5-5	150			675	3.5
S90-5-5					4.0
S60-5-7	210			945	5.0
S90-5-7					5.8

Office

CLT Specification	Thickness (mm)	Load (N/m²)			Maximum span (m)
		Dead Load	Live Load	Self-weight of CLT	
S60-3-3	90	900	2900	405	2.0
S90-3-3					2.3
S60-5-5	150			675	3.1
S90-5-5					3.6
S60-5-7	210			945	4.7
S90-5-7					5.3

Span table for CLT floors (cantilever beam)

Housing



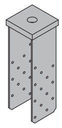
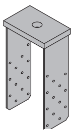
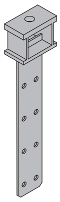
CLT Specification	Thickness (mm)	Load (N/m²)			Maximum span (m)
		Dead Load	Live Load	Self-weight of CLT	
S60-3-3	90	900	1800	405	1.0
S90-3-3					1.2
S60-5-5	150			675	1.5
S90-5-5					1.8
S60-5-7	210			945	2.2
S90-5-7					2.6

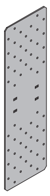
Office

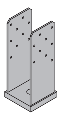
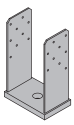
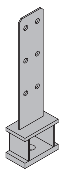
CLT Specification	Thickness (mm)	Load (N/m²)			Maximum span (m)
		Dead Load	Live Load	Self-weight of CLT	
S60-3-3	90	900	2900	405	0.9
S90-3-3					1.0
S60-5-5	150			675	1.4
S90-5-5					1.6
S60-5-7	210			945	2.0
S90-5-7					2.4

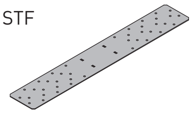
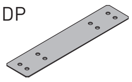
Selection of Connectors

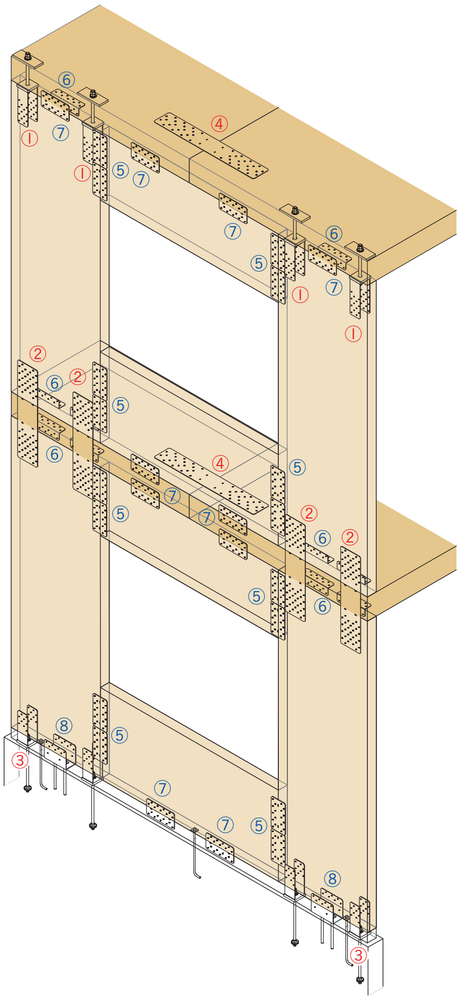
Connectors for CLT panels include those for tension joints and those for shear joints. Here, examples of connectors applicable to structural calculation Route 1 are shown.
For further details, refer to the website of the Japan Housing and Wood Technology Center (https://www.howtec.or.jp/publics/index/134/) (list of connector types marked with an "x" and their corresponding strength performance).

① Wall-to-Floor [Tensile Connectors]
TC-90 
TC-150 
TC-DP 

② Wall-to-Wall [Tensile Connectors]
STW-790 STW-850 

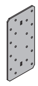
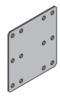
③ Foundation-to-Wall [Tensile Connectors]
TB-90 TB-90P 
TB-150 TB-150P 
TB-DP 

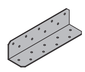
④ Floor-to-Floor [Tensile Connectors]	
STF 	STF-DP 

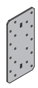


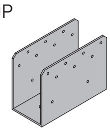
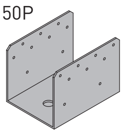
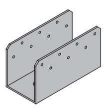
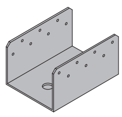
①–④: Tensile connectors
⑤–⑧: Shear connectors

Exterior wall applications

⑤ Wall-to-Wall [Shear Connectors]
SP 
SP-DP  Concealed type

⑥ Wall-to-Floor [Shear Connectors]
LST 

⑦ Wall-to-Floor (Sill) [Shear Connectors]
SP 

⑧ Foundation-to-Wall [Shear Connectors]			
SBM-90 SBM-90P 	SBM-150 SBM-150P 	SB-90  For use without sill plate	SB-150  For use without sill plate

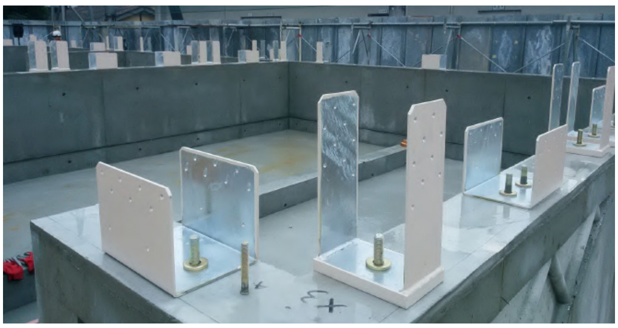
Example of connectors compliant with Structural Calculation Route 1 (as defined under the Japanese Building Standard Law), indicated with an "×" mark.

Strength performance of tensile joints in compliance with Structural Calculation Route 1

Joint Location	Joint Type	Required Performance	Capacity	Connector Example
Wall panel – Foundation	U-shaped steel or equivalent	Connector–CLT ultimate strength Pu ≥ 86 kN Bolt specification M16 (ABR490) Effective length for tensile resistance ≥ 400 mm	≥ 51 kN	TB-90, TB-150 (③)
	Tension bolt	Connector–CLT ultimate strength Pu ≥ 86 kN Bolt specification M16 (ABR490) Effective length for tensile resistance ≥ 400 mm	≥ 51 kN	Angle connector W19
Lower wall panel – Upper wall panel	U-shaped steel or equivalent	Connector–CLT ultimate strength Pu ≥ 135 kN Bolt specification M20 (ABR490) Effective length for tensile resistance ≥ 200 mm	≥ 79.6 kN	TC-90, TC-150 (①)
	Tension bolt	Connector–CLT ultimate strength Pu ≥ 135 kN Bolt specification M20 (ABR490) Effective length for tensile resistance ≥ 200 mm	≥ 79.6 kN	Angle connector W19
	No shape specification	Connector–CLT ultimate strength Pu ≥ 135 kN σu ≥ 20 mm; Elongation ≥ 10% Allowable shear capacity of entire joint Pa ≥ 79.6 kN	≥ 79.6 kN	STW-790, STW-850 (②)
Floor panel to floor panel	No shape specification	Allowable shear capacity of entire joint Pa	≥ 52 kN / joint	STF (④)
Floor panel to beam				-

Strength performance of shear joints in compliance with Structural Calculation Route 1

Joint Location	Joint Type	Required Performance		Connector Example
Wall panel – Drop wall, spandrel wall, wall panel	No shape specification	Allowable shear capacity of the entire joint Pa	≥52 kN / joint	Use 2 × SP connectors (⑤⑦)
Wall panel – Foundation or sill plate	No shape specification	Allowable shear capacity of the entire joint Pa	≥47 kN / joint	SB-90, SB-150, SBM-90, SBM-150 (⑧)
Wall panel – Floor panel, purlin or roof panel	No shape specification	Allowable shear capacity of the entire joint Pa	≥54 kN / joint	Use 2 × LST connectors (⑥)
Floor panel to floor panel, wall panel to wall panel (shear connection)	No shape specification	Allowable shear capacity of the entire joint Pa	≥54 kN / joint	Structural plywood t=27, all-sugi lamina, Type 2, 9-ply



Shear connectors (left) and tensile connectors (center).

Installation of CLT panels. Connectors are left exposed and therefore coated for protection.

LVL Laminated Veneer Lumber

from Japan

Table of Contents

1. Introduction to LVL

What is LVL? LVL is laminated veneer lumber, an engineered wood product made by bonding thin wood veneers together under heat and pressure with strong adhesives. The veneers are usually oriented with the grain running in the same direction, which gives LVL its high strength and stiffness.

Compared to solid timber, LVL offers greater dimensional stability, uniformity, and predictable performance. Because defects such as knots are dispersed across multiple layers, the material shows fewer weaknesses and can carry higher loads over longer spans.

STRUCTURAL LVL

KEYLAM, KEYLAM CROSS

- Structural material

60-min.Quasi-Fireproof Load Bearing Massive Wall

KEYLAM WOOD WALL

- 60-min. quasi-fireproof wall for 3-story or lower non-residential building

All-Wood Fireproof Structural Element of LVL

KEYLAM TAIKA

- Structural element for fireproof construction

I-Joist of Japanese Larch

KEYLAM JOIST

- Beam, joist, rafter, etc. used in the wood frame and post and beam construction methods
- Also used as joist header or end joist in the wood frame construction method

I-Shaped/Girder and Box-Shaped-Girder of LVL

KEYLAM MEGA BEAM

- Floor joist/beam/girder used in the wood frame and post and beam construction methods

LVL for Interior Finishing

KEYLAM Interior

- Interior finishing material
- Quasi non-combustible interior finishing material
- Non-combustible interior finishing material

2. STRUCTURAL LVL

JAS (Japanese Agricultural Standard) certified product | F★★★★ | AQ (Approved Quality) certified product

High-Strength and High-Quality Structural Wood Material.

KEYLAM is a structural LVL which can be manufactured from logs with warps and bends unsuitable for manufacturing lumber.

KEYLAM®

KEYLAM CROSS®

STRUCTURAL LVL

KEYLAM

KEYLAM® is an LVL (Laminated Veneer Lumber) manufactured from rotary-peeled veneers, all of which are glued and pressed together in the grain direction.

Advantages

Excellent Bending Strength

As all of veneers are glued in the grain direction, its property is excellent for using as timber frames such as beams and posts. Especially, when it is used as a beam to support vertical loads, it shows high bending strength.

Optimally Kiln Dried

Because of the fact that kiln drying of the material is done when it is in the form of thin veneer, the moisture content of finished product of LVL is low (about 14 %), hence there is less possibility of causing problems such as deformation, crack, loose joint connection, etc. which can lead to claim after the completion of building.

Suitable for Preservative, Anti-termite Chemical Treatments

By mixing a preservative in the adhesive, preservation can be done easily and thoroughly.

Environmentally Friendly Material

B-grade logs with the defects of warps and bends unsuitable for manufacturing lumber are reborn as structural building materials.

Homogenous Material with Low Dispersion

Since KEYLAM is manufactured by laminating multiple sheets of thin veneer, it has a physical property of lower dispersion in comparison with that of lumber and glulam, even if there are defects in strength such as knots in some parts of some veneers. Because of that, the lower limits of strength are higher in comparison with those of the other materials, and the allowable design stresses are higher.

Possibility to Manufacture Long and Straight Lumber

By scarf jointing veneers, long veneer sheets can be made available for manufacturing long LVL beams and panels. (Max. 12 m)

Application

Structural material

Wood Species

Japanese larch

(For Japanese cedar, red pine, and other wood species, please contact us.)

Specifications

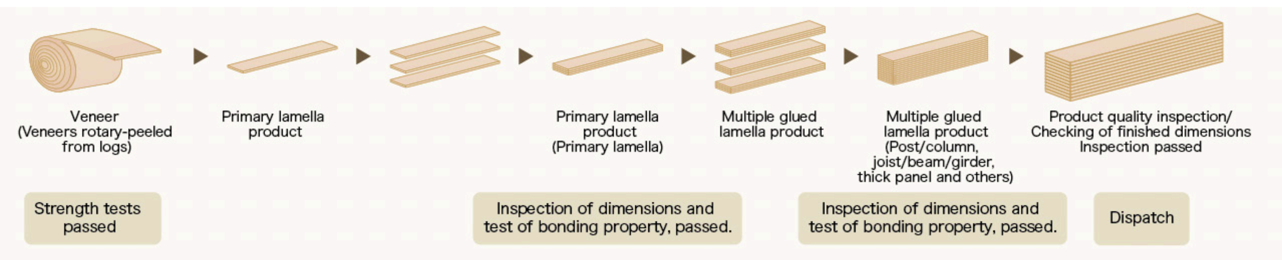
Thickness (mm)	Width (mm)	Length (mm)	Strength
max. 600mm (In case width 600mm)	max.1200	max.12000	As per JAS criteria

If the width of beam is equal to or more than 600 mm, please contact us.

Manufacturing Process

Reliable Integrated System

The structural LVL of KEYLAM® is manufactured by gluing most of dried thin veneers (approx. 3–4 mm thick) in the grain direction, and its excellent properties of strength and dimensional stability have been highly valued.



STRUCTURAL LVL

KEYLAM CROSS

KEYLAM CROSS® is different from KEYLAM®. The difference is that two or more of veneer sheets are glued crosswise. This veneer composition improves the lateral bending strength and stiffness of LVL lamella.
The use of LVL as a structural panel product is made possible.

Advantages

Excellent Dimensional Stability and Good Physical Property for Stronger Joints.

An ideal structural material utilizing characteristics of LVL and offering excellent dimensional stability and good physical property for stronger joints.
KEYLAM CROSS® is the best answer to those who have been involved in construction and remanufacturing businesses and facing the problems inherent in design limitation and dimensional stability of wood.

Application

Structural material

Wood Species

Japanese larch Japanese cedar

Specifications

Japanese larch

Thickness (mm)	Width (mm)	Length (mm)
30	max.1200	max.12000
50	max.1200	max.12000

Please contact us for details.

Japanese cedar

Thickness (mm)	Width (mm)	Length (mm)
25	max.1200	max.12000
30	max.1200	max.12000

Please contact us for details.

Composition

Japanese Larch - Composition of Veneer Sheets

Thickness (mm)	No. of all veneer lamination layers (nos.)	No. of veneer sheets glued in the grain direction (nos.)	No. of veneer sheets glued crosswise (nos.)	Composition of veneer sheets
30	10	8	2	‖—‖‖—‖
50	16	12	4	‖—|||—‖—|||—‖

Japanese Cedar - Composition of Veneer Sheets

Thickness (mm)	No. of all veneer lamination layers (nos.)	No. of veneer sheets glued in the grain direction (nos.)	No. of veneer sheets glued crosswise (nos.)	Composition of veneer sheets
25	9	7	2	‖—|||—‖
30	11	9	2	‖—|||||—‖

AQ Certification: AQ-225-D1-1·2

"KEYLAM® AQ DODAI SEKKON K3" (AQ certified Class K3 Preserved Wood Sill) is certified by Japan Housing and Wood Technology Center as Class 2 (equivalent to Category K3 of JAS) of "Approved Quality (AQ)".
Also, it meets the requirements of Grade 2* or better for the reduction of deterioration factor of the Housing Performance Indication System, hence for housing loan, the basic rate of interest specified by Japan Housing Finance Agency which provides housing loans is applied.

* For the certification of Grade 2 or better, wood sills need to be treated with a preservative to Category K3 or better.

KEYLAM

Technical Data

Design Strengths

According to the Government of Japan's Ministerial Notification No.1024, Ministry of Land, Infrastructure, Transport and Tourism, dated 2001, the Design Strengths of structural LVL are defined as follows:

A-type Structural LVL

Out of structural LVL, those not having veneer sheets whose grain direction is orthogonal to the main grain direction, or those having veneer sheets whose grain direction is orthogonal to the main grain direction only for the adjacent parts of outermost layer.

Design Strengths of Compression, Tension and Bending

Classification of Young's modulus of bending	Grade	Design Strength (Unit : N/㎟)		
		Compression	Tension	Bending
160E	Grade special	41.4	31.2	51.6
	Grade-1	40.2	27.0	44.4
	Grade-2	37.2	22.2	37.2
140E	Grade special	36.0	27.0	45.0
	Grade-1	34.8	23.4	39.0
	Grade-2	32.4	19.8	32.4
120E	Grade special	31.2	23.4	39.0
	Grade-1	30.0	19.8	33.0
	Grade-2	27.6	16.8	27.6
100E	Grade special	25.8	19.8	32.4
	Grade-1	25.2	16.8	27.6
	Grade-2	23.4	14.4	23.4
90E	Grade special	23.4	17.4	28.8
	Grade-1	22.8	15.0	25.2
	Grade-2	21.0	12.6	21.0
80E	Grade special	21.0	15.6	25.8
	Grade-1	19.8	13.2	22.2
	Grade-2	18.6	11.4	18.6
70E	Grade special	18.0	13.8	22.8
	Grade-1	17.4	12.0	19.8
	Grade-2	16.2	9.6	16.2
60E	Grade special	15.6	12.0	19.8
	Grade-1	15.0	10.2	16.8
	Grade-2	13.8	8.4	13.8
50E	Grade special	12.7	9.5	15.9
	Grade-1	12.3	8.2	13.7
	Grade-2	11.1	6.7	11.1

Design Strengths of Horizontal Shear

Horizontal shear class	Design Strength (Unit : N/㎟)
65V-55H	4.2
60V-51H	3.6
55V-47H	3.6
50V-43H	3.0
45V-38H	3.0
40V-34H	2.4
35V-30H	2.4

Design Strength of Partial Compression

Class of marking of partial compression	Design Strength (Unit : N/㎟)
180B	18.0
160B	16.0
135B	13.5
90B	9.0

※Out of A type structural LVL, only for those LVL marking the partial compression property (in the direction of vertical use).

Design Strengths of Partial Compression (Classification by Wood Species)

Wood Species	Design Strength (Unit : N/㎟)
Red pine Siberian larch Douglas fir	9.0
Japanese cypress Japanese larch	7.8
Radiata pine Japanese cedar	6.0

B-type Structural LVL

Out of structural LVL, those other than A-type structural LVL and conforming to the stipulation as described below.

Item	Criteria
Location of cross grain veneer sheets	1 Cross grain veneer sheets shall be placed in the 3rd layer from the outermost layer. 2 Cross grain veneer sheets shall not be placed continuously.
Consecutive number of layers of parallel veneer sheets	Consecutive number of layers of parallel veneer sheets shall not be less than 2 and not more than 5, and there shall be a part where consecutive number of layers of parallel veneer sheets is not less than 3.
Composition of veneer sheets	Composition of veneer sheets shall be symmetrical to the central axis in the direction of lamination. In addition, the thickness of all composing veneer sheets shall be equal.

Design Strengths of Compression, Tension and Bending

Classification of Young's modulus of bending	Design Strength (Unit : N/mm²)					
	Compression		Tension		Bending	
	Stronger direction	Weaker direction	Stronger direction	Weaker direction	Stronger direction	Weaker direction
140E	21.9	4.3	18.3	2.9	32.2	5.8
120E	18.7	3.7	15.6	2.5	27.5	4.9
110E	17.2	3.4	14.4	2.3	25.3	4.5
100E	15.7	3.1	13.2	2.1	23.2	4.1
90E	14.0	2.8	11.7	1.8	20.6	3.7
80E	12.5	2.5	10.5	1.6	18.4	3.3
70E	10.8	2.1	9.0	1.4	15.9	2.8
60E	9.3	1.8	7.8	1.2	13.7	2.4
50E	7.6	1.5	6.3	1.0	11.1	2.0
40E	6.1	1.2	5.1	0.8	9.0	1.6
30E	4.6	0.9	3.9	0.6	6.8	1.2

There is no category of Grade special, -1 or -2 for B-type Structural LVL.

Design Strengths of Horizontal Shear

Horizontal shear class	Design Strength (Unit : N/mm²)	
	Direction of vertical use	Direction of horizontal use
65V-43H	4.3	2.8
60V-40H	4.0	2.6
55V-36H	3.6	2.4
50V-33H	3.3	2.2
45V-30H	3.0	2.0
40V-26H	2.6	1.7
35V-23H	2.3	1.5
30V-20H	2.0	1.3
25V-16H	1.6	1.0

Preservative and Anti-Termite Treatment

1) The treatment is very simple. As the adhesive is already a chemical mixture of adhesive and preservative/insecticide, the treatment is completed when the LVL is manufactured.
2) The chemical will be uniformly distributed throughout the treated LVL. No need to treat cut and exposed faces with a new preservative/insecticide.
3) Unlike the pressure impregnation method, there is no need for the preservative/insecticide to penetrate the wood; making it possible to manufacture and treat such hardwood LVL as Siberian larch.
4) It is environmentally friendly and much safer than the pressure impregnated type of LVL. In comparison to the pressure impregnated LVL which is treated by impregnating the preservative from the surfaces of product, in this method the ingredients of the preservative in the mixture of adhesive and preservative permeate into the wood from glued faces inside the product and do not come in contact with the surface of LVL product; thus, making it much safer for the end user and environmentally friendly.

3. 60-min.Quasi-Fireproof Load Bearing Massive Wall

KEYLAM WOOD WALL

Highly Strong and Quasi-Fireproof Load Bearing Wall.

“Laminated Wood Wall” is a structural exterior wall system with a thick LVL panel of wood whose natural properties of physical strength and fire prevention/proofing are made use of wisely.

3. 60-min.Quasi-Fireproof Load Bearing Massive Wall

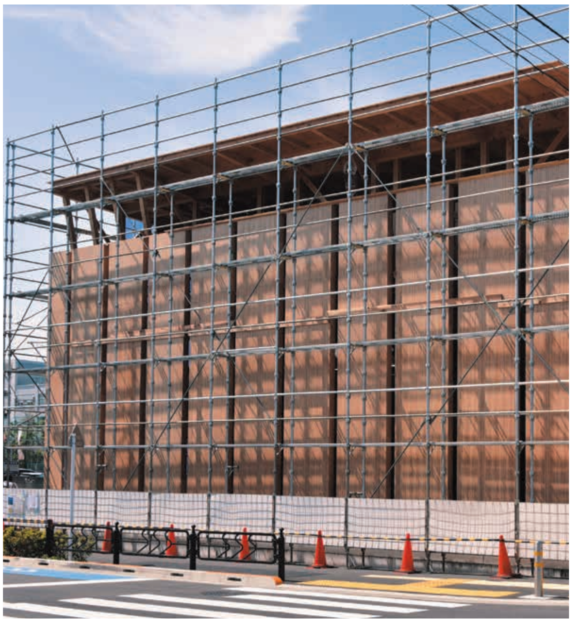


Photo above : Nakoso Certified Kindergarten
Photo lower left : Miyamura Veterinary Clinic Photo lower right : International Center, Kanagawa University

60-min.Quasi-Fireproof Load Bearing Massive Wall

KEYLAM WOOD WALL

Advantages

Excellent Design Possibility & Flexibility

KEYLAM WOOD WALL has two expressions of surfaces with flat grain and laminated glue lines in stripe pattern. The surface with laminated glue lines in stripe pattern, especially, can give architectural space the unique expression which cannot be given by any other wood materials.

Quasi-Fireproof Property

It is known that LVL manufactured by gluing veneers with a fire-resistant adhesive burns slowly, even if it is a wood material. It can be used as a structural wall in quasi-fireproof buildings in accordance with the Ministerial Notification about Fireproof Construction issued in 2015 which stipulated "Fire Resistance Design Method of Solid/Massive wood Construction".

Excellent Structural Performance

In addition to the advantage of higher strengths generally, compared with glulam, it is possible to achieve a short-term allowable shear strength of wall of 40 kN/m or more (equivalent to 20 or more of "the wall magnification factor" for shear strength of wall). It can be used on the condition that structural analysis is done properly for each case.

Applicable to Various Structures

Making good use of its high strength properties, it is possible to reduce the number of shear walls against earthquake, and to have large openings in walls. It can be applicable not only to wood structures but also to steel and RC structures.

Application

Walls and wall columns of wood for wood and other types of buildings

Specifications

Specifications of wood species and strength grades
A-type or B-type (with veneer sheets glued crosswise) structural LVL
120E Grade-1 (Japanese larch A-type)
80E (Japanese larch B-type)
60E Grade-1 (Japanese cedar A-type)
Equivalent to 50E (Japanese cedar B-type)

* Surface with laminated glue lines in stripe pattern is available only in A-type.

Thickness (mm)	Width (mm)	Length (mm)
90	1000	3000
		6000
120		3000
		6000
150		3000
		6000

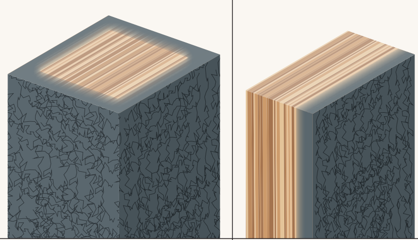
Wood Species

Japanese larch, Japanese cedar

Fire Resistance Design

KEYLAM WOOD WALL can be used as a structural wall in quasi-fireproof buildings in accordance with the Ministerial Notification about Fireproof Construction issued in 2015 which stipulated "Fire Resistance Design Method of Solid/Massive wood Construction".

Fire Protection Cover of Charring Layer of Structural LVL by Required Rate of Fire Resistance

Required rate of fire resistance	Cover of charring layer	
	post / beam	wall / floor / roof
		
30 min. quasi-fireproof	—	25mm
45 min. quasi-fireproof	35mm	35mm
60 min. quasi-fireproof	45mm	45mm

The adhesive must be of phenol or resorcinol resin.
Reference:
Design Manual for Fire Resistive and Fireproofing of Wood Buildings (Published by The Building Center of Japan in March 2017)
For details, please refer to P.108 of the Manual

60-min.Quasi-Fireproof Load Bearing Massive Wall

KEYLAM WOOD WALL

Structural Design

By using connectors embedded in the thick panel of KEYLAM WOOD WALL, it is possible to design a building with strong shear walls against earthquake. The following is an example of design of walls based on the tensile strength per connector.

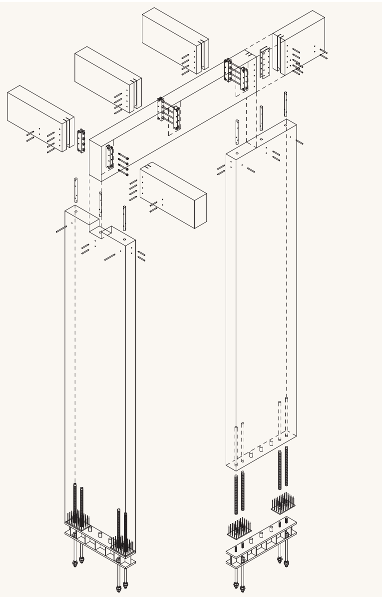
Example of Calculation of Wall Magnification Factor for Shear Strength of Wall

Wood species and Category	Connector (LSB: Lag screw bolt) (GIR: Glued in rod)	2/3Pmax (kN)	Stiffness K (kN/㎜)	Specification of anchor bolt	Yield stress Py (kN)	Wall magnification factor Pa (times)
Japanese cedar A-type	LSB 35㎜ dia. x 445㎜ long - 2 pcs	90.3	281.4	M16 x 400㎜ long - 2 pcs	73.8	12.6
	GIR 24㎜ dia. x 300㎜ long - 4 pcs	153.7	884.3	M22 x 400㎜ long - 2 pcs	142.4	24.2
Japanese cedar B-type	LSB 35㎜ dia. x 445㎜ long - 2 pcs	121.4	220.1	M20 x 400㎜ long - 2 pcs	115.2	19.6
	GIR 24㎜ dia. x 300㎜ long - 4 pcs	173.8	674.9	M24 x 400㎜ long - 2 pcs	165.9	28.2
Japanese larch A-type	LSB 35㎜ dia. x 445㎜ long - 2 pcs	141.8	717.3	M20 x 400㎜ long - 2 pcs	115.2	19.6
	GIR 24㎜ dia. x 300㎜ long - 4 pcs	111.0	579.3	M16 x 490㎜ long - 2 pcs	102.1	17.4
Japanese larch B-type	LSB 35㎜ dia. x 445㎜ long - 2 pcs	256.4	528.8	M24 x 490㎜ long - 2 pcs	229.5	39.0
	GIR 24㎜ dia. x 300㎜ long - 4 pcs	216.5	815.7	M27 x 400㎜ long - 2 pcs	215.7	36.7

2/3 Pmax:2/3 of Pmax (max. stress in connector) K: the average of initial stiffness of connector
Specification of anchor bolt: designed so that the yield stress of anchor bolt is less than 2/3 of Pmax
Py: Yield stress of anchor bolt Pa:Py/(3×1.96) LSB: Manufactured by Stroog Inc. GIR: Home Connector manufactured by SCRIMTEC JAPAN Co., Ltd.
Wall dimensions: thickness 150mm × width 1000mm × length 3000mm
Calculation: Only tensile stresses at wall column bases are checked
Concept: The ductile anchor bolt is made to yield before the connector

For more information such as the tensile strength of each connector, etc., please see "The Manual of Structural Design, 2014 Report of Development of Massive Wall made from LVL of Japanese Cedar" published by National LVL Association and available from HP of the Association at: www.lvl.ne.jp/data/index.html.

Isometric Drawing of the Construction



Ryotaro Sakata Structural Engineers Co., Ltd.
(Metal Connectors (LSB): Manufactured by Stroog Inc.)

Embedding of Lag Screw Bolt LSB

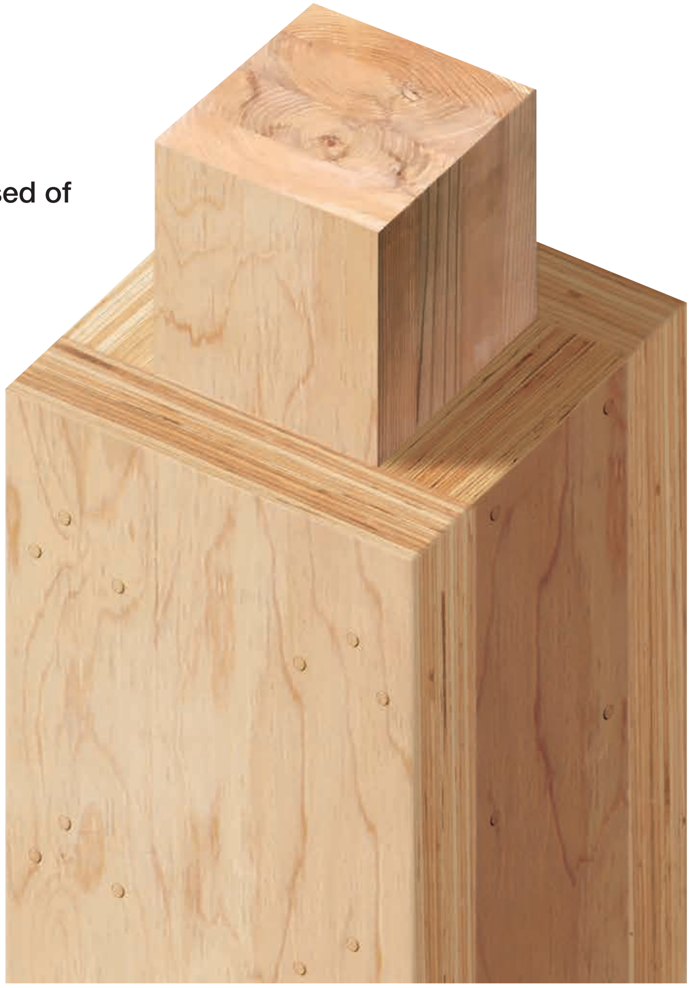
Metal Connectors/Fasteners for Wall Column

4. All-Wood Fireproof Structural Element of LVL

KEYLAM TAIKA

Fireproof Structural Element Composed of Engineered Wood of LVL Only.

By covering the surfaces of wood columns in sizes of 150-600mm with 60mm thick fire-retardant treated LVL panels (rated as "quasi non-combustible"), a 60-min. fireproof structural element is manufactured.

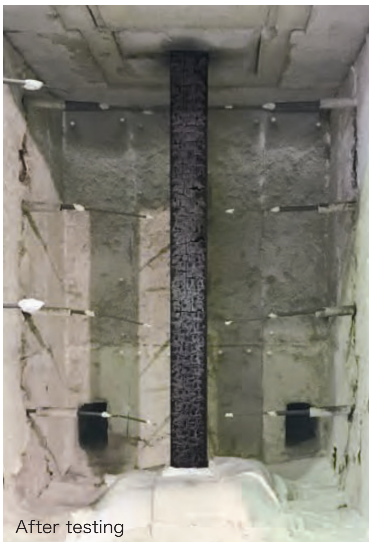


Fire Preventive and Fireproof Performance Test and Evaluation

Test specimens of column were made and fire tested under loading in a laboratory furnace of General Building Research Corporation of Japan to develop 60-min. quasi fireproof columns.
After 60 minutes of incineration, the test specimen was left for 4 hours in the furnace for load testing columns until the temperature went down to near the room temperature. The picture below shows the cut section of the specimen after the test.
No charred parts on the surfaces of the load bearing glulam column of Japanese cedar were seen.

Cut section after testing

Before testing



After testing

Advantages

Possibility of All-Wood Structural Construction

As all-wood structural elements are made available, it is possible to design and construct buildings with these structural and finishing materials even if higher degree of fire-resistivity is required.

Application as Interior Finish Material

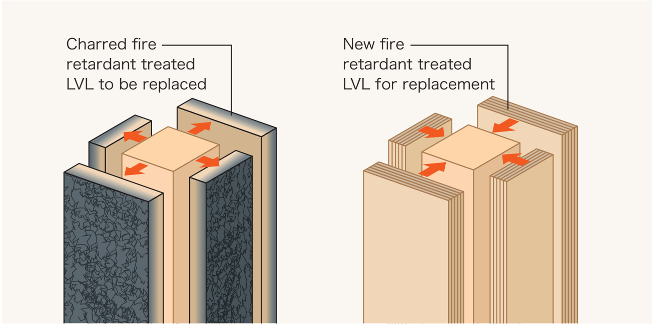
By choosing the beautiful looking LVL panels of LVL as a fireproofing material, they can be used as decorative finish materials at the same time. That means the development of the material functioning both as a fireproofing and decorative finish material has been realized.

Possibility of Site Fabrication/Installation

The fireproofing material is basically fabricated at factory, but fabrication and installation at construction site are also possible.

Replaceable at Site after Fire

If by any chance fire occurs, the damaged fireproofing cover material can be replaced with a new one at site.



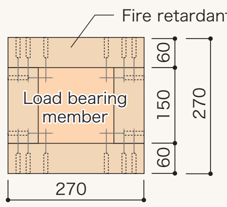
Application

Column for 60-min. fireproof construction

Wood Species

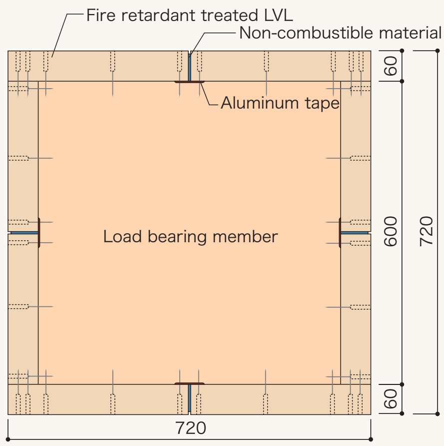
Load bearing member:
Japanese cedar (lumber, glulam and LVL)
Fire-protection covering:
LVL of Japanese cedar

Specifications



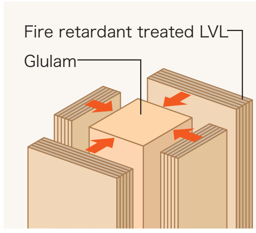
Cross sectional dimensions of load bearing member (mm)
150～600

※ In case of a dimension exceeding 240㎜, there is a vertical joint.



Fire Resistance Design

By covering the surfaces of wood columns in sizes of 150-600mm with 60mm thick fire-retardant treated LVL panels (rated as "quasi non-combustible", a 60-min. fireproof structural element can be manufactured.



Ministerial Certification
(Dimension of load bearing member : 150㎜)

FP060CN-0706: Fire-protection covering of LVL, treated with a phosphorous & nitrogen-based fire retardant, on surfaces of column of Japanese cedar.

General Incorporated Association of "National LVL Association" has received the ministerial certification.

※ For the sizes of over 150 ㎜ ~ 600 ㎜, the certification will be obtained in the near future.

5. I-Joist of Japanese Larch

KEYLAM JOIST

Structural Wood Material Assembled from Flange of LVL and Web of Panel Glued Together.

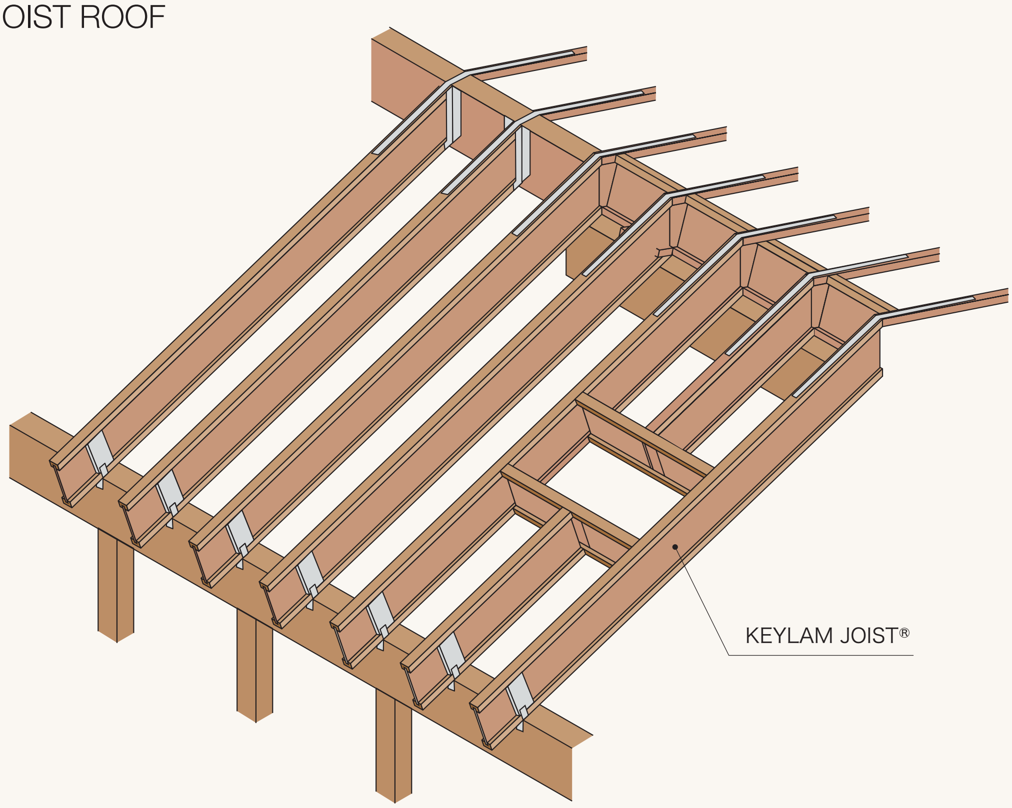
An innovative structural material most suitable for use in floor and roof constructions, reassuring that there is no possibility of leading to a claim against defects such as shrinkage, twist, warp, bow, etc.

5. I-Joist of Japanese Larch

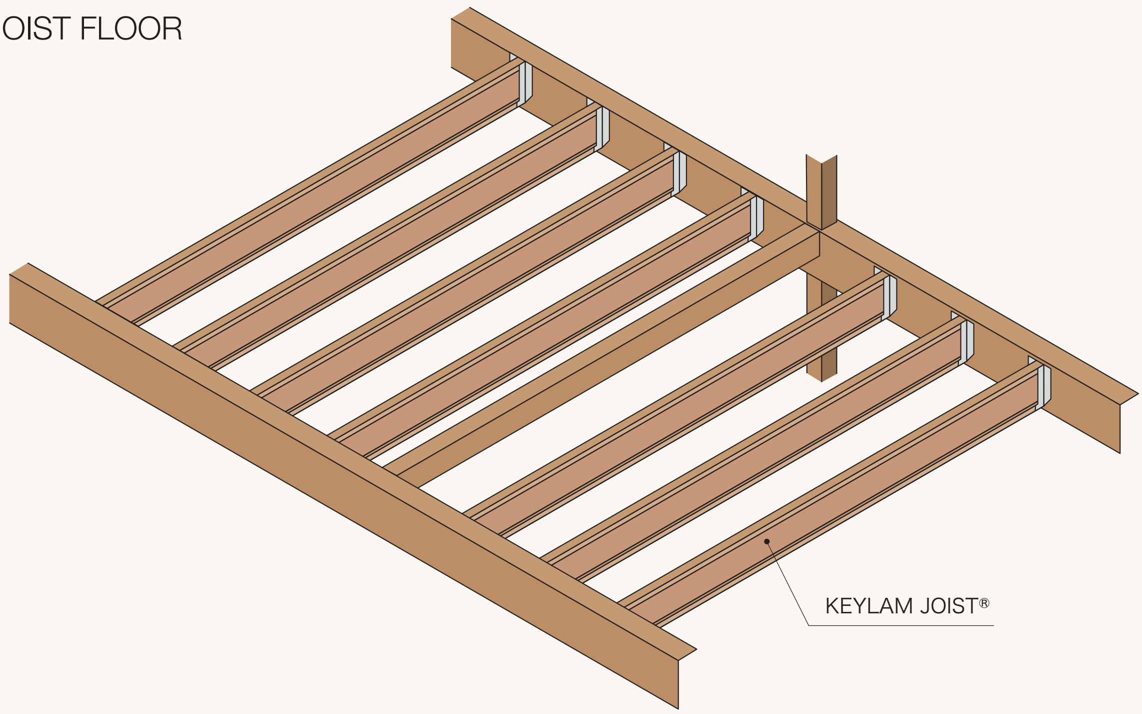
Photo above: Residential house built with the conventional post and beam structural system.
Photos lower left & lower right : Actual application examples of KEYLAM JOIST

I-Joist of Japanese Larch

KEYLAM JOIST ROOF



KEYLAM JOIST FLOOR



I-Joist of Japanese Larch

Advantages

Reliable Quality

This reliable structural product is certified by the Minister of Land, Infrastructure, Transport and Tourism in accordance with the Article 37 of the Building Standard Law of Japan.

Use of Domestic Wood

KEYLAM(LVL)Class 120E) manufactured from domestic wood of Japanese larch is used for the flange of the I-joist.

High Stiffness

The stiffness of floor and wall structures can be improved for less twisting and warping of the structures.

Possibility of Longer Spans

It is possible to use in large-scale buildings having long spans of frame structures to create large architectural space.

Definition of Shear Strength

The shear strength properties of the horizontal plane of structure and of the load bearing metal joint connectors are defined clearly.

Easy Installation

Light and easy to handle so that installation can be completed in shorter time. It is possible to simplify the works of installation onto beams and bearing walls.

Certified 60-min. Fireproof Floor Construction

(with or without Heat Insulating Material)

A 60-min.fireproof floor construction certification has been obtained. Please contact us for details.
[FP060FL-0125] [FP060FL-0131]

Drilling Holes

It is possible to drill holes of up to dia. 220mm in the web for installation of venti-lation ducts in typical residential houses.

Application

Beam, joist, rafter, etc. used in the wood frame and post and beam construction methods
Also used as joist header or end joist in the wood frame construction method

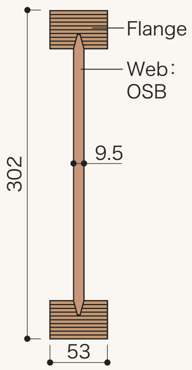
Wood Species

Flanges : Japanese larch

Specifications

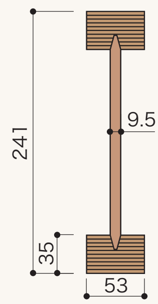
KEYLAM JOIST® 53-302
(Regular)

Height(mm)	Width(mm)	Length(mm)
302	53	3660(12 ft)
		4575(15 ft)
		5490(18 ft)

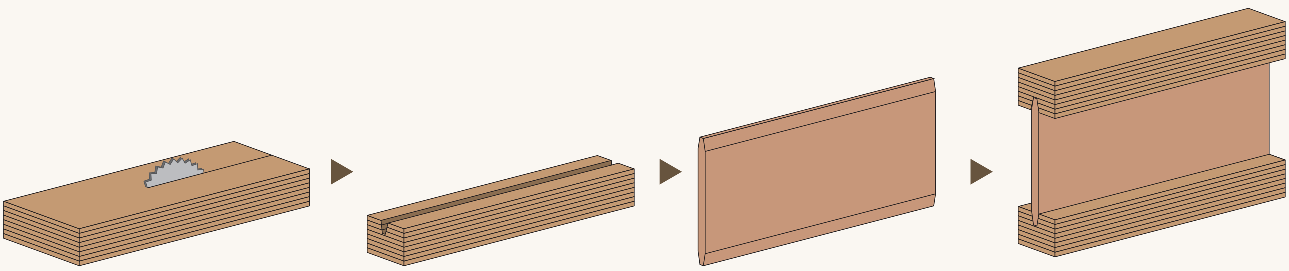


KEYLAM JOIST® 53-241
(Order-made product)

Height(mm)	Width(mm)	Length(mm)
241	53	3660(12 ft)
		4575(15 ft)
		5490(18 ft)
		7320(24 ft)
302	53	7320(24 ft)



Manufacturing Process



Ripping LVL lamella to make a flange

Making a groove in the flange

Bevelling the edges of the web

Assembling the flange with the web by gluing together

I-Joist of Japanese Larch

KEYLAM JOIST

Span Table for Floor Joist

Span Table

Type	Spacing of floor joists (mm)				
	303	333	406	455	500
	Span (m)	Span (m)	Span (m)	Span (m)	Span (m)
53-241	4.78	4.67	4.44	4.31	4.20
53-302	5.30	5.17	4.92	4.78	4.66

The above table is prepared on the following conditions:

- Evenly distributed loading
- Design load for floor W = Dead load WF + Live load P (N/m)
- Dead load WF = Self-weight of floor framework x Spacing of floor joists + Self-weight of floor joists
- Self-weight of floor framework = 600N/m^2
- Live load = 1800N/m^2
- Allowable max. deflection of floor joists is 10mm.

Design Strength

Design Strength

Height h (mm)	Weight (N/m)	Design Strength				Bending stiffness EI (×10^{9}N·mm^2)
		Bending moment M (N·m)	Shear V (N)	Reaction force R (N)		
				45mm (End support)	89mm (Mid-span support)	
241	32.4	11200	15300	10500	23000	570
302	36.3	14000	18000	10500	23000	870

- The reaction forces shown above are based on the condition that the length of support is 45 mm at the ends and 89 mm at the mid-span.
- The formula below is used to estimate the deflection Δ (mm) at the mid-span caused by the evenly distributed loading.
- Deformation enhancement coefficient = 2.0

Estimate of the Deflection Δ (mm) caused by evenly distributed loading

$$\Delta = \frac{5WL^4}{384EI} + \frac{WL^2}{74706h}$$

Δ : Deflection (mm)
W : Design load for floor (N/mm)
EI : Bending stiffness (N/mm^2)
h : Height (mm)
L : Span length (mm)

Notes: 74706=1400N/mm^2×9.5mm×hw/h÷CQ
1400N/mm^2: Shearing modulus of the web
9.5mm: Thickness of the web
CQ: Coefficient according to loading condition
(1/8 in case of evenly distributed loading)
hw/h: Height of the web

Allowable strength shall be as per the following table:

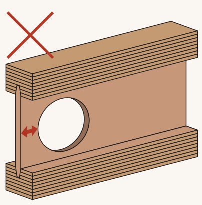
Long term allowable strength			Short term allowable strength		
Bending	Shear	Reaction force	Bending	Shear	Reaction force
1.1M/3	1.1V/3	1.1R/3	2M/3	2V/3	2R/3

M: Design bending strength (N·m)　V: Design shear strength (N)　R: Design reaction force strength (N)

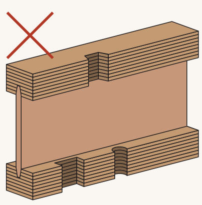
In accordance with "The building Standard Law of Japan, Article 82, Rules No.1~No.3", when checking structural stability under snow loading the allowable strength in relation to long term force shall be the value shown in the above table multiplied by 1.3, and in relation to short term force shall be the value shown in the above table multiplied by 0.8.

Precautions for Use

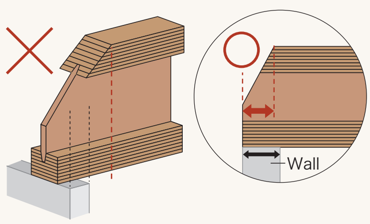
It is prohibited to use the I-joist under the following conditions:



Do not drill a hole too close to the point of support.



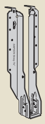
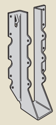
Do not make cuts or notches in the flange.



When cutting the rafter diagonally, the range of cutting must be within the thickness of the supporting wall.

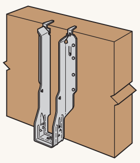
Metal Joint Connectors / Fasteners

Simpson Strong-Tie® Wood Construction Connectors

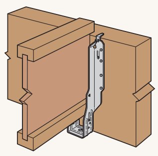
KJI joist height (mm)	Single I-joist — on face mount hanger				Double I-joist — on face mount hanger			
	 Simpson I-Joist Hangers (With the Simpson Strong-Grip® seat which secures I-joists in position without joist nails)				 (Stiffeners are required at ends)			
	Metal Connectors	Allowable strength (N)	Nailing		Metal Connectors	Allowable strength (N)	Nailing	
			Face (to header or beam)	Joist (to lower flange of I-joist)			Face (to header or beam)	Joist (to lower flange of I-joist)
241	IUS2.06/9.5	2990	8-ZN65	—	MIU4.28/9	7580	16-ZN90	2-ZN40、4-ZN65
302	IUS2.06/11.88	3740	10-ZN65	—	MIU4.28/11	7580	20-ZN90	2-ZN40、4-ZN65

Simpson I-Joist Hangers (With the Simpson Strong-Grip® seat which secures I-joists in position without joist nails)

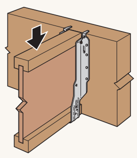
Steps of Installation
(Simpson IUS I-Joist Hanger)



Step 1
Attach the IUS hanger to the header.

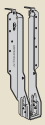
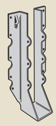


Step 2
Slide the KEYLAM JOIST® downward into the IUS hanger until it rests above the large teardrop.



Step 3
Firmly push or snap KEYLAM JOIST® fully into the seat of the IUS hanger.

Yamabishi Kogyo I-Joist Hangers (With the protrusion on the bottom secures I-joists in position without joist nails)

KJI joist height (mm)	Single I-joist — on face mount hanger				Double I-joist — on face mount hanger			
	 (Without joist nails)				 (Stiffeners are required at ends)			
	Metal Connectors	Allowable strength (N)	Nailing		Metal Connectors	Allowable strength (N)	Nailing	
			Face (to header or beam)	Joist (to lower flange of I-joist)			Face (to header or beam)	Joist (to lower flange of I-joist)
241	I-JOIST55241 CZ	2990	8-ZN65	—	I-JOIST 108241 CZ	7540	14-ZN90	6-ZN65
302	I-JOIST55302 Z	2990	8-ZN65	—	I-JOIST 108302 CZ	7540	14-ZN90	6-ZN65

The allowable strength of the hanger may be more or less than that of the I-joist supported by the hanger; therefore it is recommended to check the strengths of both parts. For further information, please contact us.

Remarks

- Allowable strength of the hanger is only for the loads on floor. For the allowable strength of the hanger in case of snow loading, please contact us.
- Have a clearance of 1-2 mm or more between the faces of supporting header/beam and the end of I-joist.
- Use proper nails to fix the hanger as specified in the table.
- The height of the hanger must be more than 60% of the height of KEYLAM JOIST.
- If the slope of KEYLAM JOIST is over 0.2/10, please use slopeable I-joist hangers.

Design Conditions

- Classification of the duration of continuous loading is assumed to be the long term (equivalent to 50 years).
- The smaller value of the allowable design strengths of ZN nails and KEYLAM JOIST (on 45mm support at end) is assumed to be the design strength.
- The design strengths of hanger shown in the table are the values based on the condition that the supporting beam or header is of SPF softwood lumber.
- The width of supporting beam or header must be not less than 89mm to fix the hanger.

For further details, please contact the following:
Simpson Strong-Tie Wood Construction Connectors: Tanaka Co., Ltd. (The distributor in Japan)
Yamabishi Kogyo I-Joist Hangers: Yamabishi Kogyo Co., Ltd.

Certification by the Minister of Land, Infrastructure, Transport and Tourism

MWCM-0017

6. I-Shaped Girder and Box-Shaped/Girder of LVL

KEYLAM MEGA BEAM

Highly Stiff I- or Box-Shaped LVL Beam and Girder in whose Web Holes for Pipes and Ducts can be Made.

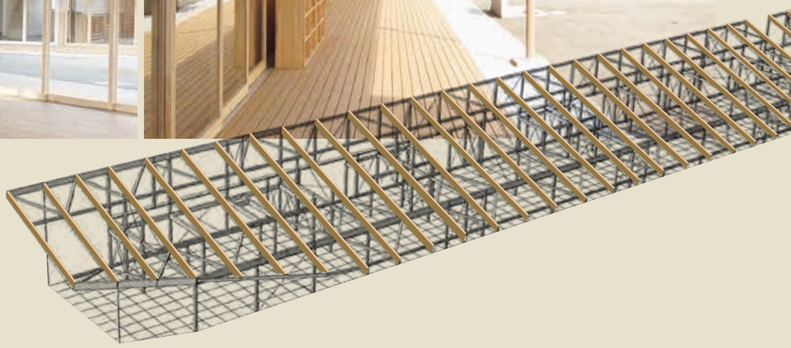
Only the web (LVL) is assumed to take the bending and shear forces alone, while the flange part contributes to increasing the stiffness of floor construction to reduce environmental vibration.

Box-shaped

I-shaped

"Tokyo Yurikago Kindergarten Project" built with KEYLAM MEGA BEAM (T-Shaped Type)® received the Prime Minister's Award of "Kids Design Awards 2016"

The project of "Tokyo Yurikago Kindergarten + Satoyama Educational Initiative" (or initiative for the realization of societies in harmony with nature through conservation and advancement of socio-ecological production landscapes and seascapes) received the Prime Minister's Award which was the highest among the awards of "Kids Design Awards 2016".



A single story wood building with large openings in walls and the characteristic deep pent roof veranda of 100 m long made of KEYLAM MEGA BEAM (I-Shaped Type)®.
The longest beams of KEYLAM MEGA BEAM (I-Shaped Type)® extend from one end of the classroom to the edge of pent roof to create wide open-space for various activities.

Photo above : Tokyo Yurikago Kindergarten - Front view
Photo lower left : Classroom　　Photo lower right : Veranda

I-Shaped Girder and Box-Shaped/Girder of LVL

KEYLAM MEGA BEAM

Advantages

Possibility of Longer Spans

It can be used for composing floor and roof structures having the long spans of 6m~12m in residential houses and medium-high multi-story and large-scale wood buildings.

Light Weight and Low Cost

It is 30% lighter in self-weight compared with a glulam with the equivalent bending property, hence excellent cost performance.

Suitable for Use in Hybrid Construction Systems

It can be used as a floor beam/girder and roof rafter/girder in light-weight structural elements of floor and roof of wood, steel and RC framed buildings.

Design Method

Only the web (LVL) is assumed to take the bending and shear forces alone, while the flange part contributes to increasing the stiffness of floor construction to reduce environmental vibration.

Drilling Holes

It is possible to drill holes of up to dia. 220㎜ in the web for installation of ventilation ducts in typical residential houses.

Certified 60-min. Fireproof Floor Construction (with or without Heat Insulation Material)

A 60-min.fireproof floor construction certification has been obtained. Please contact us for details.
(I-Shaped/Girder only) [FP060FL-0124] [FP060FL-0128]

Application

Floor beam/girder, Roof rafter/girder

Wood Species

Japanese larch

Specifications

I-shaped

Width(㎜)	Height(㎜)	Length(㎜)
114	356	max.12000
	450	
	500	
	550	
	600	

Box-shaped

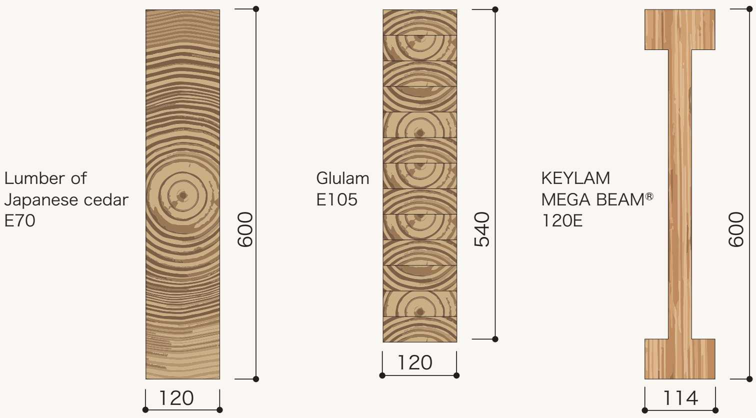
Width(㎜)	Height(㎜)	Length(㎜)
181	750	max.12000
	900	
	1200	

Can be custom-ordered. LVL Class 60E (Japanese cedar), 100E, 120E, 140E(Japanese larch･Siberian larch)

Design of Sectional Dimensions of Structural Members


Bending test

In comparison with glulam, KEYLAM MEGA BEAM® can have the same bending stiffness with a smaller sectional area of the material. Bending property has been verified by conducting bending tests at laboratories.



Span Table

Span Table[Floor]

Product	Spacing (mm)						Live load
	333	455	500	667	910	1000	
KMB - I-shaped 356 120E	8.1	7.1	6.8	—	—	—	Residential house 1800N/m²
KMB - I-shaped 356 120E	7.1	6.1	5.8	—	—	—	Office building 2900N/m²
KMB - Box-shaped 550 120E	—	—	10.6	9.9	9.1	8.9	Office building 2900N/m²

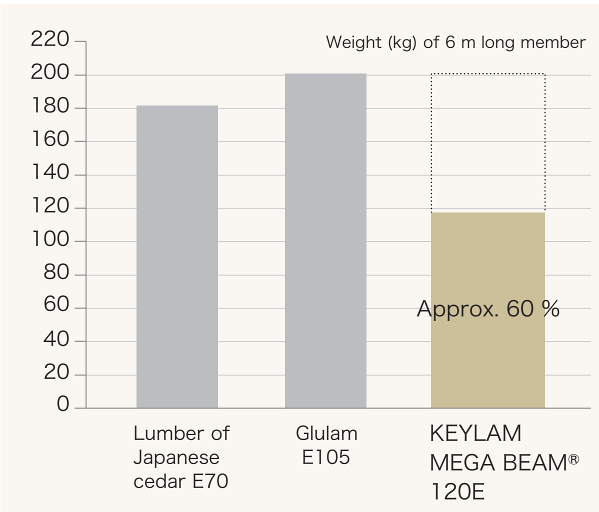
Evenly distributed load, dead load = 1200N/m² (Residential house･Office building)
1.Deflection 15㎜ (Stiffness EI = With full cross sectional area)
2.Span L/ 400 (Stiffness EI = With full cross sectional area)
3.Bending･shear (Checking the long term allowable stresses of the web only)

Span Table[Roof]

Product	Spacing of rafters (mm)	General region				Heavy snowfall region					
		30㎝		50㎝		100㎝		140㎝		200㎝	
		Low-gradient	High-gradient	Low-gradient	High-gradient	Low-gradient	High-gradient	Low-gradient	High-gradient	Low-gradient	High-gradient
KMB - I-shaped 356 120E	455	10.6	10.0	10.1	9.5	7.9	8.2	6.9	7.2	5.9	6.2
KMB - Box-shaped 550 120E	910	12.7	11.9	12.0	11.4	10.1	9.8	9.4	9.1	8.9	8.7

Evenly distributed load, dead load = 530N/m²
1.Deflection 20㎜ (Stiffness EI = With full cross sectional area)
2.Span L/200 (Stiffness EI = With full cross sectional area)
3.Bending･shear (Checking the long term stresses under snow loading of the web only)

Light-Weight Structural Member



The weight of KEYLAM MEGA BEAM is approx. 60% of that of glulam with the same bending property, and because it is light-weight, it is easier to design, transport and install.

Ministerial Certification
KEYLAM MEGA BEAM®
(I-Shaped Type)

60-min. Fireproof Floor Construction
FP060FL-0128
(with heat insulation material)
FP060FL-0124
(without heat insulation material)

7. LVL for Interior Finishing

KEYLAM Interior

Highly Stiff I- or Box-Shaped LVL Beam and Girder in whose Web Holes for Pipes and Ducts can be Made.

Only the web (LVL) is assumed to take the bending and shear forces alone, while the flange part contributes to increasing the stiffness of floor construction to reduce environmental vibration.

7. LVL for Interior Finishing

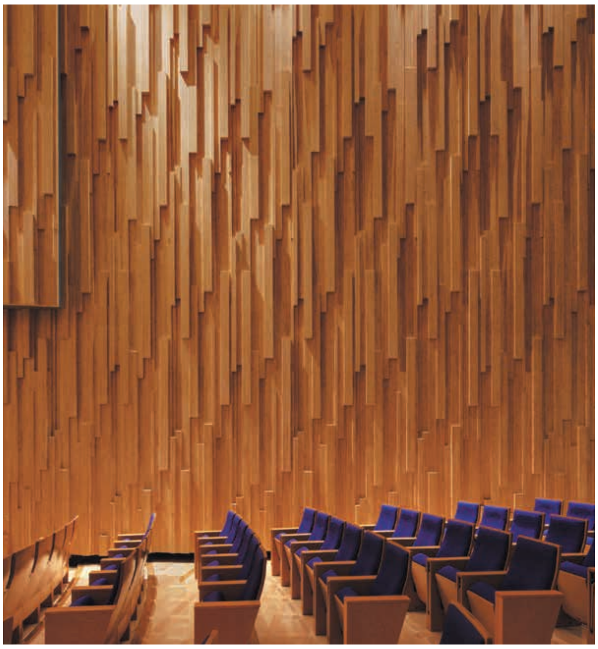


Photo above : Clubhouse of Shimonoseki Golf Club (Photo by : Shimizu Corporation)
Photo lower left : Suzunoki-dai Nursery School   Photo lower right : KEYLAM SS Panel in construction

LVL for Interior Finishing

KEYLAM Interior

Interior finishing wood material with characteristic stripe pattern made possible only with LVL.

KEYLAM Interior Board

Edge glued boards of KEYLAM Interior for interior finishing of a wide range of surfaces.

KEYLAM Interior T&G

Tongued and grooved boards of KEYLAM Interior for easier interior finishing work.

Tongue-and-groove joint specification

KEYLAM Interior FR

By giving KEYLAM Interior a quasi non-combustible property, an interior finish material for versatile interior finishing work with fewer limitations from fire regulations is now available.

Advantages

Unique Stripe Pattern

Face of LVL with unique stripe pattern created from production process of lamination is exposed to view for special architectural effects and interior designs.

Use of Domestic Wood

Domestic or local wood can be used on request.

Application

Interior finish material

Wood Species

Japanese cedar, Japanese larch

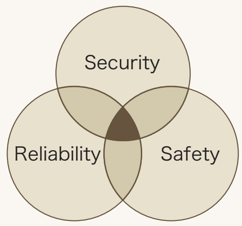
Specifications

Product name		Wood Species	Thickness (mm)	Width (mm)	Length (mm)
KEYLAM Interior®	General specifications	Japanese cedar・Japanese larch	15	150	2000
					4000
			30		2000
					4000
KEYLAM Interior® Board	General specifications	Japanese cedar・Japanese larch	30	600	4000
KEYLAM Interior® T&G	T&G board product Packed in corrugated cardboard (10 pcs/pack)	Japanese cedar・Japanese larch	15	140 ※Effective width	2000
KEYLAM Interior® FR	Quasi non-combustible property	Japanese cedar	15	150	2000
					4000
			30		2000
					4000

※KEYLAM Interior® FR needs to be surface coated.

Quality and Property Control System

Quality is controlled thoroughly and jointly by KEYTEC Co., Ltd. and General Incorporated Association of "National LVL Association". Reliable, secure and safe material is supplied.



Ministerial certification
(KEYLAM Interior® FR)

QM-0821 (3) :
LVL treated with a phosphorous & nitrogen-based fire retardant

(General Incorporated Association of "National LVL Association" has received the ministerial certification.)

Precautions for Use of KEYLAM Interior FR

1. The product is for interior use only, and cannot be used outdoors.

2. The product is pressure impregnated with inorganic fire retardants. If it is exposed to moisture or high humidity in storage or during construction, an efflorescence phenomenon may occur, making the surface covered with whitish crystallized ingredients of the fire retardant which leached out from the inside of pressure impregnated LVL. This phenomenon can spoil the beauty of surface.

3. It is necessary to always surface coat the product in order to prevent an efflorescence phenomenon from occurring. For surface coating, use an acrylic urethane or urethane resin coating material. Some coating materials recommended by us are; "Safety Waltz New Rescue Coat" manufactured by Otani Paint Co., Ltd. and "Pure Flat" by Gen Gen Corporation.
4. The coating material shall be a solvent based coating material. If a water based coating material is used, an efflorescence phenomenon from occurring. can occur and impair the quasi non-combustible property of treated LVL.

5. As the product is dispatched soon after pressure impregnation and drying are completed without further processing for dimensional adjustment, it may be necessary to adjust the dimensions after delivery.

6. When installing the product, joints must be protected with a fire-resistive material in order to prevent fire from burning through the joints. Please be informed that without such joint protection, the product is not qualified as a quasi non-combustible material.

LVL for Interior Finishing

KEYLAM Interior FR Sheet

This is an ultra-thin sheet sliced off with innovative technology from the stripe patterned face of LVL for flexible interior finishing.

Advantages

Unique Stripe Pattern of LVL

A new lineup in the series of KEYTEC's designs of interior finishing products has been added.

Certified Non-Combustible Material

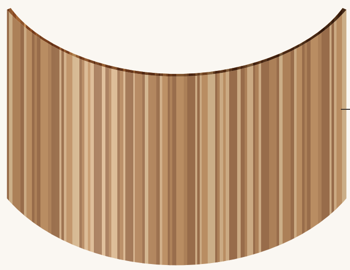
A ministerial certification as a non-combustible material has been obtained. It can be used in places where fire safety restrictions on interior finishing are applied.

Use of Local Wood

Local wood from forests around Japan can be used.

Foldable

The ultra-thinness of the sheet excels in plasticity making it possible to stick it to curved and uneven surfaces.
Around a projected corner part, the sheet can be folded around parallel to the stripe.



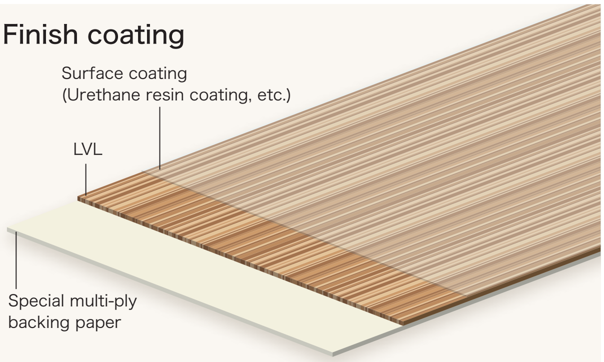
Application

Interior finish material

Wood Species

Japanese cedar

Composition

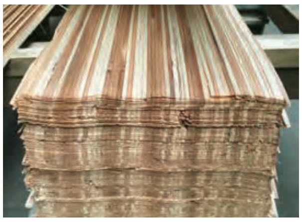


Specifications

Product name	Specifications	Width (mm)	Length (mm)	Thickness (mm)
KEYLAM Interior® FR Sheet	Finish coating	910	2430	approx. 0.28

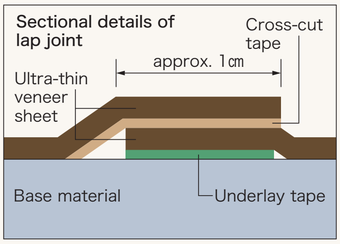
※Order-made product , width 630mm and length 2730mm.

Manufacturing Process

 ▶  ▶  ▶ 

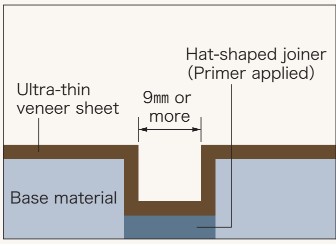
Procedure of Installation

Sticking with lap joint

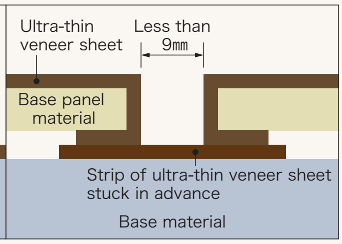


Sticking with lap joint is a method similar to that of sticking vinyl cloth on wall with lap joint.

Sticking with grooved joint (Joint width 9㎜ or more)



Sticking with grooved joint (Joint width less than 9㎜)



Groove width 9㎜ or more	①In case plasterboard is the base Stick widthwise; along the grooved joint, the edge of veneer sheet shall be aligned. The following features are noted: ・The use of hat-shaped joiners eliminates the need for extra layer of plaster-board. ・If the surfaces of the base material cut at construction site need to be covered with the veneer sheets, use always hat-shaped joiners. ・Insert a joint rod along the grooved joint until all installation work is completed. (Recommended width of joint is 9㎜ or more, and that of depth 8㎜ or more.) ②In case calcium silicate board or flexible board is the base Use boards cut with a panel saw to exact dimensions. In case the board is cut at construction site, and for the width and depth of joint, refer to the procedure similar to that of plasterboard.
Groove width less than 9㎜	Stick a strip of ultra-thin veneer sheet on the base material in advance.

Certification by the Minister of Land, Infrastructure, Transport and Tourism

The certification is given on the condition that KEYLAM Interior® FR Sheet is used to surface finish the non-combustible base materials listed in accordance with NM-4383: (Steel & Other Metals), NM-4384: (Aluminium based Materials) and NM-4385: (Inorganic Materials such as Fiber Reinforced Cement Boards, Glasses, Mortar, Stones, Plasterboards of 12mm or thicker).

Manufacturer : BIG Will Co., Ltd.

Japan Mass Timber Overseas Promotion Council

407,2-14-2,Shirakawa,Koto-ku,Tokyo,135-0021,JAPAN

E-mail : team@jtop.link

Produced by MOOPY.Inc

Japan Mass Timber Overseas Promotion Council