

Building with wood

Modern Solutions for Wood Construction



Limnologen in Växjö



Cooperhill Mountain Lodge in Åre

A flexible engineering material

Using wood in building structures is nothing new. Throughout the ages, in those places where forests grow, wood has commonly been used as a building material. The international trade with timber also means that countries with limited availability of forest resources can nowadays have access to wood for building purposes, wood that comes from sustainable and certified forestry. Building with wood is energy-efficient, cost-effective and environmentally friendly.

Wood has many benefits as a building material when compared with other ma-

terials. Above all it has a low weight in relation to its strength and load bearing capacity. The material is “flexible” and can be worked and crafted with simple tools. On top of this, it is a renewable, biological material that is part of the natural eco cycle. In this way, the use of wood makes a vital contribution to the reduction of the earth’s emissions of carbon dioxide.

Wood constructions also have significant advantages in severe seismic zones.



Rydebäck in Helsingborg

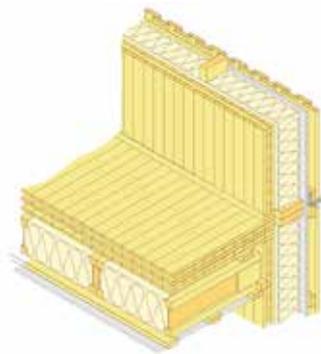
Building techniques

Several common techniques are available for constructing buildings with supporting frameworks made of wood. One way is to use structural wood members to form a frame which is covered by structural wood panels. Foundations are generally concrete. This simple building technology is often used in the construction of single-family houses but also in the construction of multi-storey buildings. Another technique is to use solid timber for the supporting framework. Cross-laminated timber is made of timber which is glued together. It is used to build walls and joists. The walls may need to be insulated to give the building a high level of energy efficiency. The technique is well suited to the construction of multi-storey buildings.

Yet another technique is the system of columns and beams. In this case glue-laminated timber in different forms

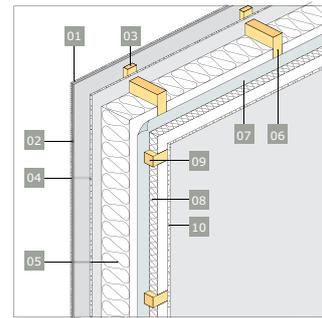
is used to a large extent for the load-bearing construction.

All these framework systems satisfy modern criteria for fire safety, noise pollution and energy efficiency. Special consideration to these functional criteria must be given in the case of multi-storey buildings. Well-tested technical solutions are now widely available.

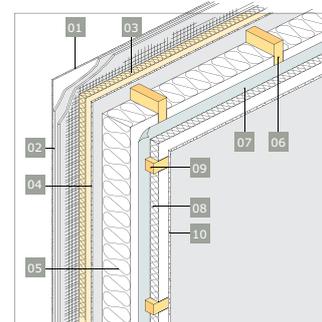


Cross laminated timber.

Examples of outer walls with panel sheeting and timber studs



01. Render 02. Fiber cement board 03. Nailing batten 04. Gypsum wallboard 05. Insulation 06. Vertical stud 07. Plastic foil 08. Insulation 09. Horizontal stud 10. Gypsum wallboard



01. Finishing render 02. Render with reinforcement net 03. Insulation 04. Gypsum wallboard 05. Insulation 06. Vertical stud 07. Plastic foil 08. Insulation 09. Horizontal stud 10. Gypsum wallboard

Building on-site

Building methods vary. The oldest method is to construct the building on site. The building materials are freighted to the building site and the various elements – walls, joists etc. – are put together on site and then erected. The method requires a great deal of organization and planning on the building site. Risks associated with damage to materials and prefabricated structural components, due to moisture must be overcome. Of necessity, on site construction tends to take a long time.

With the on-site building technique, wall components are generally assembled resting on the joists or the ground and then erected manually.



A wood framed construction.

Off-site prefabrication

Far more common today is the prefabrication of various components: off-site building. Wall parts, floor components, roofs, trusses etc. are all built off-site at a factory. Components can be prefabricated, complete with insulation, installations, windows and doors. The trend is towards a higher degree of prefabrication so that the greater part of the building work takes place in an industrial plant in a well-controlled environment with approved quality assurance. The actual assembly of the building, up until the roof is laid, takes one or two days at the building site. At one extreme, entire units are manufactured at the factory, not only with electricity, water and waste pipes installed, but kitchens and wet rooms too; floors are laid and walls papered.

Another advantage of building with prefabricated components in wood is that they are relatively light and can be erected at heights of several stories using simple lifting equipment such as mobile cranes, in some cases with the cranes fitted on the trucks that deliver the components to the site.

It is cost-effective to build off-site using wood-based methods. With prefabricated wood modules, the total cost is up to 20–25% lower compared to building on-site. This is partly due to the fact that the time saving can be up to 80% compared to building on-site.

In Sweden, the market share for multi-storey buildings has increased from 1% 2000 up to 15% today.



A surface unit is delivered to the construction site.



Prefabrication of volumetric units.



Volumetric units are assembled on the construction site.



Single family houses

Wood frame is the most frequently used system for single family houses in Sweden. It is also common for single family houses to be built using prefabricated components.

The construction method allows major variations in the design of the houses,

conforming to national and local building traditions while permitting architectural innovation. To a large extent the design determines the cost of the building, whether it is a luxury home or a cost-effective single family house at a price the average family can afford. The

requirements for fire safety and noise pollution are usually lower for single family houses than for multi-storey buildings. However it is harder to satisfy the demands for low energy consumption in a single family house.



Östra Kvarnslogen in Stockholm.





Räcksta in Stockholm.



Ekorren in Skellefteå.

Multi-storey buildings

In many countries national building regulations have tended to restrict the use of timber frames for the construction of multi-storey buildings. The reason many countries have refrained from using flammable materials is uncertainty about fires in the buildings.

However, extensive research and development has shown that material-neutral building regulations are preferable and for over a decade function-based regulations have been common in many countries. Wood burns, but in a controlled manner. It is possible to estimate how much of the cross section will remain unaffected by the fire after one hour of burning and choose material

dimensions so that the unaffected part of the cross section has the ability to bear the required load. Steel, on the other hand, loses its entire load-bearing capacity at the temperatures that occur during a fully developed fire. Non-flammable surface materials and/or sprinklers can be used to ensure safety during the early stages of a fire.

Modern building regulations have contributed to the increase in construction of multi-storey timber buildings of between three and eight storeys. The dramatic increase can be attributed to several important factors. One factor is the lower cost of building compared



Wood burns in a controlled manner and a cross section can be chosen so that the beam can bear the required load.

Photo by SP Trätekt, Sweden, for the technical guideline Fire safety in timber buildings.

Continued on page 6

with construction using other materials. Timber has shown itself to be the best material for use with industrial building methods, enabling costs to be reduced.

Another factor is growing environmental awareness, where the choice is motivated by the fact that timber is a renewable material and that its use reduces CO₂ emissions, provided that the timber is harvested in forests where sustainable forestry, with replanting and management plans, is practiced.

Another factor is the ability to build on sites where heavier buildings (e.g. those made of concrete) would demand

extensive and expensive pile foundations. Lighter timber constructions, with simpler and inexpensive foundations can make difficult sites feasible.

The design in terms of horizontal stability is especially important because the construction is relatively light. A common practice for buildings with six or seven floors is to build the ground floor in concrete and secure the timber structure to the concrete. Wind loads are transferred via joist elements and shear walls to the ground. Good stability is achieved by utilizing diaphragm action.

An important consideration when designing multi-storey buildings with a load-bearing wood frame is sound transfer. Effective solutions are now available to prevent sound from spreading between the floors and apartments without putting the stability of the building at risk.

Just as with single family houses, multi-storey buildings made of timber can be given an outer architectural design that suits the location where the building is erected.

Seismic performance

Wood constructions have significant advantages in severe seismic zones.

A survey was conducted following the tragic earthquake in China, May 2008. The evidence showed that wood frame buildings had outperformed buildings constructed from other materials. They suffered only minor damage, while many brick infill walls collapsed and concrete buildings suffered severe damage.

This has also been proven by tests; tests show multi-storey hybrid structures can survive the most severe earthquakes¹. A full-scale, seven-storey mixed use condominium tower (six wood frame stories above a one-storey steel structure) was tested in Kobe, Japan.

This was the largest full-scale earthquake test in the world. The building was subjected to a quake that was 180 per cent of the Northridge record at Canoga Park. It suffered no significant damage,

demonstrating that wood buildings can survive even the strongest earthquakes.

There are solutions reducing the impact from earthquakes. Shock absorbing is the latest technology for earthquake protection of bridges and building constructions. The figure shows an example of an anti-vibration device – a panel



Misawa

absorber.

with an anti-vibration unit – developed in Japan, for absorbing seismic energy in wooden constructions. When the force from an earthquake hits the construction, the energy is transformed via the panel to the shock

¹ Lentz, Shelby, *Shaking it up – a test to improve mid-rise, wood framed building design*, 2009. GoStructural.com.



The full-scale earthquake test. Japan's massive E-Defense Shake Table, the largest shake table in the world

Curtain walls/Infill walls

In many countries infill walls made from timber are becoming an increasingly common solution, together with load-bearing frames made from concrete or steel. External walls of this type are designed only to take the load of the wall component's own weight and the wind loads that directly affect the component. The component has a low weight and can be prefabricated in a factory, which is a great advantage. Infill walls made of timber have very good insulation characteristics. The increasingly stringent requirements for energy efficient buildings in various countries are among the main driving forces behind the use of this wall solution.

The component can be clad with an external layer of plaster, brick, wooden paneling or other sheathing material in order to match the building's design and surrounding buildings.

There are two main ways of fitting timber frame elements into the steel, concrete or masonry structure. Either the panels can be fitted into or partly into the structure or outside the structure.

The primary benefits of the technique are

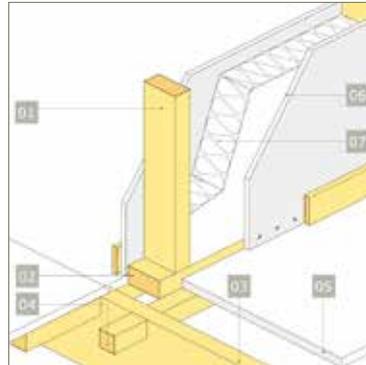
- Excellent thermal insulation properties are easily achievable.
- The usable building area is significantly increased (as compared to a similar insulated building with masonry walls) because of lesser wall thickness.
- Savings in on-site labour and construction time through a systematic off-site manufacturing process.
- From an environmental (LCA) perspective, timber frame structures virtually always perform best.
- The in-fill timber frame wall panel technique allows a wide range of architectural possibilities and cladding materials.



Wood infill walls in a concrete frame.

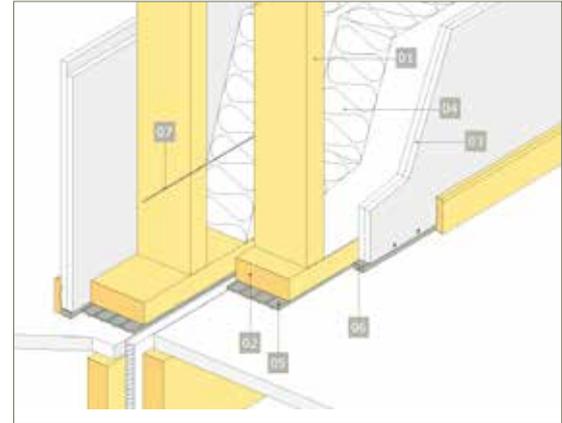
Partition walls/Inner walls

Wood frame in combination with board material is a very common solution when it comes to inner walls which will not bear any loads. These walls are used for dividing up rooms but can also be designed so that they can cope with the fire and sound requirements placed on apartment partition walls.



Inner wall

- 01. Vertical stud
- 02. Sill
- 03. Floorjoist
- 04. Noggin piece
- 05. Chipboard
- 06. Gypsum wall board
- 07. Sound insulation



Partition wall

- 01. Vertical stud
- 02. Sill
- 03. 2 x Gypsum wall board
- 04. Fine insulation
- 05. Rubber gasket
- 06. Sound insulation
- 07. Net to hold fine insulation

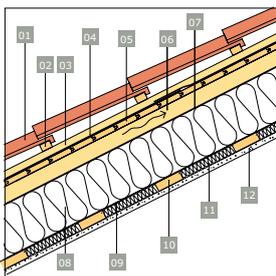
Extensions

Timber offers great potential for changing and modernizing existing, older buildings which are often constructed from concrete, mainly through additional stories or extensions to roofs.

The simplest method is to fit the old building with a new roof designed so that a number of apartments can be built into the attic space. The space can also be used for placing installations for

improving energy efficiency and heat exchangers for ventilation.

As timber structures are light, there are often margins for building additional stories. In such cases, the use of prefabricated components is often suitable. Naturally the design must be verified so that there is a margin for absorbing the additional vertical loads and ensuring horizontal stability.



Roof construction

- 01. Roof tile
- 02. Batten
- 03. Counter batten
- 04. Roofing felt
- 05. Tongued and grooved timber
- 06. Air gap
- 07. Masonite board
- 08. Insulation
- 09. Plastic foil
- 10. Secondary spaced boarding
- 11. Insulation
- 12. Gypsum board



Three additional storeys in wood added to an existing concrete building.

SWEDISH WOOD

part of the Swedish Forest Industries Federation

Swedish Wood spreads knowledge, provides inspiration and encourages development relating to wood, wood products and wood construction. The goal is to increase the use of wood in Sweden and in selected international markets through information and inspiration.

Swedish Wood is a department within the trade and employer organisation the **Swedish Forest Industries Federation**. Swedish Wood is supported by the Swedish sawmill sector.

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