Building with wood

Building with wood has a Chinese tradition and is proven over the centuries

Wood construction offers solutions for China, including seismic performance and energy conservation

It is popular for single and multi-family housing

And suitable for commercial and public buildings

It is appropriate for medium-rise buildings which address China’s wider housing needs

It can be used in combination with concrete structures to improve new and existing buildings

Structural glulam, with its strong aesthetic appeal, is ideal for large span construction
Building with wood is proven over the centuries

Using wood in building structures is nothing new - China has been building with wood for thousands of years. It has been used as a building material throughout the ages wherever forests grow. And today, the international timber trade provides countries which do not have extensive forest resources with wood from sustainable and certified forestry to build with.

Experience, research and product development have resulted in a range of effective building codes and standards.

Building with wood is becoming increasingly popular as countries round the world seek more sustainable construction; already 70 per cent of the housing constructed in the developed world use wood frame. Although concrete and steel are more common construction materials in China, the government is looking at different solutions, like wood building, as part of its sustainability strategy. And considerable advances have been made in the development of the codes and standards required to ensure safety, structural integrity, and durability (see Chapter 7 Codes and standards).

“Is it OK to build with wood in China? There are many misunderstandings among consumers, developers, and policy-making authorities. In fact, wood frame construction has a lot of advantages. There is a rationale for most countries of the world to build with wood... It is necessary to analyze opportunities and issues calmly and scientifically, and then move forward to fill this void in Chinese architecture and construction.”

Mr. Zhu Guangian, President, China Timber and Wood Products Distribution Association, 2010

Previous page: Re-roofing of medium-rise apartment building, downtown Beijing
Top left: Traditional Chinese wood houses, Sichuan
Top right: 4-storey wood frame apartment buildings, Canada
Above: Single family villa, wood-frame construction, Europe
Wood has many benefits as a building material. It is naturally beautiful and widely available. Its low thermal resistance and capacity to insulate economically provide excellent energy-efficiency. Strong and light, with exceptional load-bearing capacity, it is easy to handle and transport. It reduces the need for massive foundations. Fast, flexible and simple to renovate, it is easy to work with on-site using simple tools, yet ideally suited to factory pre-fabrication. It is available as solid wood lumber products, graded to meet performance requirements, or can be engineered into panels, columns and beams manufactured to meet precise performance characteristics. Above all, it is a naturally renewable, organic material that makes a significant contribution to the reduction of the earth’s emissions of carbon dioxide.

Wood construction has major advantages in severe seismic zones because of its light weight and natural flexibility (see Chapter 5 Safety and durability). Pre-fabrication makes wood buildings even faster to erect, which is another reason why they are cost-effective. And they are built to the same code requirements and performance levels of fire safety and durability as concrete and steel buildings. Chinese national codes and standards (see Chapter 7 Codes and standards) have been published to ensure appropriate design and detailing to resist potential vulnerability to fire, microbial activity and movement due to changes in moisture.

Wood housing, particularly multiple family units, is consistent with China’s land use and zoning policies. And there are different wood construction systems appropriate for the different needs of urban, suburban and rural districts.

“It is practical to build wood frame housing, despite the high Chinese population density. Wood frame houses are generally low-density, because of current code restrictions on the number of storeys. As a result, some may think it is not suitable to build low-density housing in China, with its large population and limits on land use... Japan is one of the highest population density countries. Its population density is 2.5 times higher than China. Yet, its light wood frame construction and low-density housing are a high proportion of total housing.”

Mr. Zhu Guangian, President, China Timber and Wood Products Distribution Association, 2010
Wood frame construction is already being used for housing in China, from single family dwellings in the suburbs of cities such as Shanghai and Beijing, to low-cost rural developments where land availability is not a problem. They have proved cost-competitive and perform well in comparison with concrete and steel frame housing.

But much more can be done. Wood construction is the solution to other building requirements in China as well. These include medium-density multi-storey apartments, small commercial and office buildings, schools, medical clinics, nursing homes, universities and research centres, sports arenas and other recreational facilities.

Above: Single family wood frame community, Beijing
Right: Semi-detached wood frame house, Sichuan
Wood can make a contribution to solving China’s housing shortages through high density multi-family solutions. While these can take the form of two or three-storey apartment blocks, the future lies in the higher-rise buildings which are well-proven in Europe and North America.

They have gained popularity in these regions because of lower building costs, wood’s suitability for highly efficient industrial building methods, better energy-efficiency, better seismic performance and a growing environmental awareness. And, because of their low weight, multi-storey wood buildings can be constructed without the need for extensive pile foundations. This makes it possible to develop sites which would previously have been impractical.

In China, as of 2009, existing fire codes do not allow wood frame apartment blocks of four or more storeys. However, this may be an option for the future, as these codes are often under review and the scientific experience supports more storeys.
Wood frame in China

At present, wood frame is used for single family and multi-family homes of two or three storeys in China. Wood members form a structural framework which is sheathed with structural wood panels. Foundations are generally concrete. The floor above can be either wood or a concrete slab and forms the platform for the next storey. Roof and wall insulation and water-proof membranes provide energy-efficiency and protection from moisture. Interiors are usually dry-lined with fire-resistant gypsum board, and many different materials can be used for external cladding. Because the structure has multiple wood members, panels, fasteners and connectors, loads can be carried through a number of alternative pathways. As a result, wood frame buildings are highly resistant to sudden failure in earthquakes or high winds.

Above: Multiple living-unit wood frame construction, Sichuan
Left: A typical wall assembly for wood frame construction
Facing page: Multiple living-unit wood frame construction, Sichuan
Multi-family units are built using the same techniques and under the same building codes as single family units, and are separated by code-required fire-rated assemblies. The units generally range in size from 100 to 300 square meters.

Multi-storey wood frame buildings are popular in many countries. Where five and six-storey blocks are now being built, apartments are generally on a single storey, separated from each other by fire resistant assemblies. Horizontal stability in these taller buildings is achieved using engineering design which incorporates braced walls and heavy-duty metal connections between assemblies.

Noise is an important consideration, too. Effective solutions are available to limit sound transmission through floors and walls.
Hybrid construction: wood frame storeys on concrete structure

Hybrid construction, where wood construction is combined with concrete and/or steel, is a promising opportunity for the future of China. This includes the construction of buildings which have the lower storey or storeys (or parkade) in concrete, to which a light-weight energy-efficient wood super-structure can be attached.

In Europe and North America, wood frame buildings of up to six or seven storeys are achieved using a concrete lower storey. And in China, buildings of up to three wood frame storeys on top of up to four concrete storeys may soon be accepted.

These hybrids can combine commercial space, such as stores and offices, in the concrete portion of the building, with housing in the wood frame part. In some settings, hybrids may be the most practical, efficient, and cost-effective option.

Left: Light-weight wood frame storeys on multi-storey concrete building, Europe
Above: Multi-family wood frame apartment building on concrete parkade, Canada
Hybrid construction: wood frame walls in concrete structures

Chinese fire safety codes allow the use of infill wood frame exterior walls in concrete structures up to six storeys, soon likely to be extended to seven storeys high for residential, offices, and certain factories and warehouses. These structures have been built cost-competitively at up to twenty storeys in northern Europe for a number of years, where increasingly stringent energy-efficiency requirements are a key driver.

Exterior infill walls are light, as they are designed to take only the load of their weight and the wind and seismic loads that directly affect them. They can be pre-fabricated in a factory or built on-site and have very good insulation characteristics in relation to their thickness, providing substantially better energy performance than traditional concrete, masonry or steel construction.

Where wood frame is used for interior walls in concrete and steel structures as partitions, it provides flexibility of design, including floor layout, fire safety, sound insulation and renovation. Wood infill partitions are non-structural, lightweight, and are suitable for a range of interior finishes. They can also be designed to meet the fire and sound requirements for apartment partition walls. Wood frame partitions are approved up to eighteen stories.

The main benefits of exterior wood infill walls:

• Outstanding thermal properties and energy conservation
• Reduced wall thickness maximizes usable living space by a typical 2 per cent
• Shorter on-site construction time through pre-fabrication
• Reduced foundation load
• Improved seismic performance

Top left: High-rise apartment building using wood frame infill wall panels, Europe
Above: Assembling pre-fabricated wood frame exterior infill wall panels in a multi-storey concrete structure building, Europe
Many of the typically concrete medium-rise residential buildings throughout China have flat roofs that tend to leak and are poorly insulated for energy conservation and thermal comfort. These existing roofs can be covered with a pitched wood frame truss roof. This is a cost-effective way of keeping the rain out, improving the look of the building and, with additional insulation in the roof cavity, reducing energy costs. It is also an effective way of delivering a thermally comfortable attic space for extra accommodation, or of installing mechanical systems for heating, cooling, and ventilation.

This system is as competitive for installing roof systems on new concrete structures as for replacing old concrete roof systems.

Above: Re-roofed apartment buildings with habitable attic, downtown Beijing
Top right: Attic living space, downtown Beijing
Centre right: Installing thermal insulation in wood frame attic living space
Right: Re-roofed apartment buildings, Xu Hui district, Shanghai
Engineered wood construction: solid wood panels

Solid wood panel structures provide a leading-edge alternative for six to ten-storey buildings. Although the technology is relatively new and not yet recognized in Chinese codes, it is widely used across Europe. The tallest built so far is a nine-storey residential building in London, England.

Cross-laminated boards are glued together and used to build walls and joists. Panels are machined in a factory to fine tolerances by computer-controlled equipment. The panels arrive on site with apertures for doors and windows, and wiring and plumbing channels already prepared. The walls can be insulated to provide a high level of energy-efficiency. Superior load-carrying characteristics, including lateral stability against wind and seismic forces, as well as excellent fire safety performance, make cross laminated timbers suitable for medium and even high-rise buildings. And the amount of timber used means buildings made with solid wood panels are highly effective carbon stores.

These environmentally-friendly solid wood buildings offer longer-term opportunities in China, particularly for high density housing requirements.
Engineered wood construction: glued laminated timber (glulam)
In North America and Europe, structural glue laminated timber is widely used in constructions where span width is an issue and/or the unique beauty of the wood is to be exploited architecturally. Glulam beams and columns have a strong aesthetic appeal, as the structure of a building can be expressed in the exposed beauty of the wood.

Glue laminated timber – engineered wood beams and columns - are used in homes, schools, sports halls, railway stations, industrial and commercial buildings, such as shopping centres and expo buildings, and public buildings, such as museums and concert halls. They are also used in landscaping and infrastructure applications such as glulam bridges.

Glulam beams and columns come as standard products, with a variety of cross-sections and lengths. Custom designed beams and columns are pre-fabricated according to customer needs and can include curved shapes and mechanical interfaces to concrete or steel structures etc.

Glulam is a mature technology in Europe, where large span buildings are still in use after almost 100 years. Modern design methods are available and national codes – design, production, fire - supporting glulam construction in China are to be approved in 2010.

Facing page, top: Entertainment park entrance building in curved structural glulam, Chengdu, Sichuan province
Facing page, left: Glulam and wood truss shopping mall, Europe
Facing page, right: Swimming pool with structural glulam roof, Beijing
Top right: Entrance to Swedish pavilion in structural glulam, World Expo 2010, Shanghai
Bottom right: New temple with glulam post and beam structure, Zhejiang
Landscaping

Top: Heavy duty structural glulam road bridge, Europe
Right: Western red cedar landscaping, Canada
Wood products, treated with the latest environmentally-friendly preservatives, or using naturally durable wood such as China fir, Western red cedar, or yellow cedar, are used extensively for landscaping. Whether decking, pathways, fences, retaining walls, or small structures like storage sheds and gazebos, wood products fit naturally into many urban and suburban environments, parks and other recreational projects.

Above: Wood landscaping, Guangzhou
Below left: Wood decking and seating, Pudong, Shanghai
Below right: Glulam structural arch footbridge with wood decking, Shanghai
Wood construction: on-site or prefabrication

The traditional way to construct wood frame buildings in North America is on-site, particularly when there is labour availability. In Europe, wood frame assemblies are typically pre-fabricated. Engineered wood construction, such as glulam, is most commonly erected piece by piece on-site. In China, almost all wood buildings are currently constructed on-site. Building materials and structural components are freighted to the building site and the various assemblies – walls, floors, etc. – are framed on-site. The method requires organization and planning on the building site and measures must be taken to avoid moisture damage to materials. On-site construction relies on a skilled work force and, while much faster than using other materials, is slower than using pre-fabricated elements.

On-site construction does not require the initial capital costs for plant and machinery, nor the need to maintain capacity utilization. It is particularly appropriate where housing volumes are not large, where labour is reasonably priced and plentiful, and where flexibility and low overheads are important.

While more capital-intensive, off-site pre-fabrication has the benefit of controlled factory conditions, less dependence on on-site labour and faster construction times.

In the case of wood frame construction, only a few days on the building site are needed to assemble a water-tight structure, complete with roof. The panels can be pre-fabricated with insulation, windows and doors. Entire units can even be made complete with electricity, water and waste pipes, kitchens and wet rooms, floors and papered walls.

Above: On-site construction of new roof on existing apartment building, Beijing
Facing page, left: Pre-fabrication of wood panels, including installation of services
Facing page, right: Production line for pre-fabrication of wood panels
Pre-fabricated components are relatively light and can be erected at heights of several storeys using simple lifting equipment, such as the cranes on the trucks that deliver components to site. Components may need protection against the elements to prevent dampness.

The extent of pre-fabrication varies widely between countries and companies, depending on economic factors. It does require an up-front investment in plant and equipment which could impose an uncompetitive burden. While this is essentially the case in China at present, over the longer term, pre-fabrication may prove advantageous.