Construction

Suitability For Construction

New Zealand pine (Pinus radiata) is a preferred material for construction both as sawn lumber or as engineered products such as glue-laminated timber, plywood and other panel products.

Chief amongst these properties are its medium density and uniform grain which confer good fastening and working properties. New Zealand pine's strength and stiffness, ease of drying, and suitability for treatment with preservatives and fire-retardant chemicals are also advantageous for construction.

It is a relatively stable wood and kiln drying further improves its stability.

In common with other natural forest or plantation-grown softwoods, grading of the sawn lumber is important in order to meet required structural properties. Ring widths can be large in comparison with natural forest lumber without compromising strength. For this reason, ring width is not a good indicator of strength properties compared with other grading criteria.

Wood Frame Construction

New Zealand pine is the preferred species for wood frame construction (the 2x4 system) in New Zealand and Australia. This system uses dimension lumber of 35 mm to 45 mm thickness and widths up to 300 mm. The system is common in North America and is finding increasing acceptance in the United Kingdom, Japan and other significant markets. A particular advantage of the 2x4 system is the extensive load sharing that occurs between the individual framing members. This allows the use of lumber with relatively large defects (knots up to half the cross section) because any weakness in one member will be compensated for by strength in an adjacent member. Another advantage is the lateral restraint provided to the framing members by the exterior claddings, interior linings, flooring and ceilings. This lateral restraint increases the strength of the completed structure.

Claddings of wood-based materials such as wooden weatherboards, wood-fibre cement boards, or architecturally grooved plywood panels are most common but masonry veneers of brick, natural stone, or concrete blocks are also used. Thus, the suitability of New Zealand pine for house frames as well as for finishing and joinery has been well established. New Zealand is subject to high winds and earthquakes. The New Zealand pine wood framing system, backed up by a comprehensive set of building and lumber standards, has been proven to meet these demanding structural requirements well.

Studs

New Zealand pine is excellent for the vertical wall framing members called studs. Usually, a lower grade of lumber is used for the construction of non-load bearing partitions.

Joists

The stiffest grades of New Zealand pine are required for floor joists to minimise flexibility in floors under load. Kiln drying of joists is recommended before installation to minimise distortion allowing accurate floor surfaces to be formed.

Rafters

Lumber of an intermediate grade is appropriate for use as roof framing. It has moderate strength to resist wind uplift if lightweight roofing is used, or to resist high gravity loads imposed by tiled roofs. New Zealand pine's excellent fastening properties are advantageous too, enabling the roof to be constructed of trusses or framed in a more traditional manner.

Flooring

The composite materials of particle board, plywood or medium density fibreboard (MDF) are commonly used with a clear coating or overlay. They have a cost advantage due to the speed of construction and a practical advantage in that there are few joints.

Exterior & interior cladding

Finger-jointed, preservative treated New Zealand pine can be used as exterior weatherboard cladding, provided it has a well maintained protective coating of paint or semi-transparent coating called stains. Plywood panels machined to look like vertical boarding, also make an excellent cladding, with the advantage that it requires less maintenance than weatherboards. Feature interior finishings are also used in New Zealand.

Bracing

The best system of bracing in the 2x4 system is plywood cladding on all walls. Other methods are used, such as diagonal metal strap or angle members. These are nailed to the framing members at each end and wherever they cross a framing member. Interior sheet cladding such as gypsum plasterboard also adds considerable bracing to structures.

Subfloor & foundations

Because New Zealand pine can easily be treated to last permanently in ground contact, it is excellent for foundation piles and poles. Bearers are easily attached to the piles to support floor joists.

Post & Beam Construction

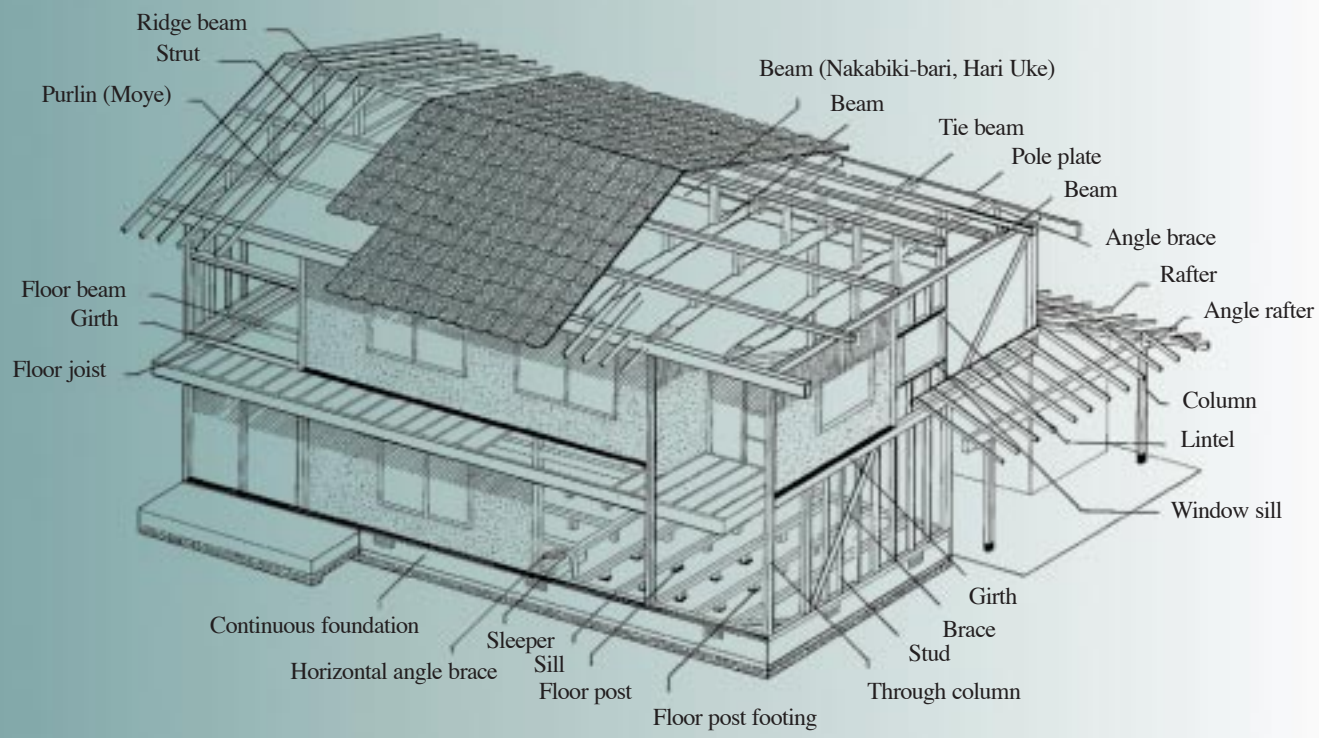
The building system that uses members of 75 mm or more in thickness as the primary framework is found throughout Japan, Europe and parts of Asia. It requires lumber of high strength because each member carries a significant load. The wood must be inherently stable because the system provides little restraint against possible distortion. Where it is exposed to view in the interior of the building it must have high visual appeal. New Zealand pine can fulfill all these requirements particularly if it is glue-laminated.

Excellent gluing characteristics mean that a permanent decorative veneer of another species is easy to apply.

New Zealand pine sawn lumber is a versatile structural building material which is well suited to the 2x4 building system. It is used equally successfully in larger buildings as glue-laminated lumber and for many other structural applications.

Construction

Post & Beam Conventional Construction



Beams

Laminated New Zealand pine makes excellent beams for this system. Such beams may contain many finger-joints in the laminations where defects have been removed to achieve the high strength and good appearance needed. High stiffness will be achieved if the laminations are selected by a grading machine.

Bracing

Diagonal bracing members in the post and beam system usually carry high loads when the building is subjected to earthquake or typhoon conditions. Properly designed metal fastening systems are needed to transmit these loads through the framework. The excellent resistance of New Zealand pine to splitting and shear forces means that such metal fastening systems perform well. A better method for providing bracing in this system is to use plywood nailed to the horizontal and vertical wall framing members.

Sills

Sill members are exposed to decay conditions because they are close to the ground and will become damp unless special moisture barriers are used. New Zealand pine, preservative treated to appropriate levels, will permanently withstand attack from insect and decay and provide the anchorage needed for the framing members attached to them.

Flooring

As for the 2x4 system, the most cost effective type of flooring is particle board or MDF

Roof framing

The roof framing can be a trussed system of dimension lumber. If heavy framing members are used, glue-laminated members are appropriate.

Solid Wood Systems

Traditional solid timber wall type of construction and modern variations of this are popular forms of construction in New Zealand. The best-known system is the Lockwood type which uses laminated machined planks of 63 mm thickness for the external walls, and non-laminated planks of 43 mm thickness for the internal walls. This system has a well proven cyclone and earthquake resistant performance.

PREFABRICATION SYSTEMS

There are many varieties of panelised prefabricated housing systems in production. Kiln dried New Zealand pine is excellent for these systems which use a lumber frame overlaid with sheet materials because it is dimensionally stable, adequately strong and stiff, and has good fastening characteristics.

COMMERCIAL & INDUSTRIAL

Multi-residential condominium developments up to 5 stories have been built in the 2x4 system. Sound insulation in floors is achieved using a lightweight concrete topping over a floor of plywood or particleboard. Fire protection and sound insulation between tenancies is achieved by building walls with staggered studs and multiple layers of gypsum plasterboard.

The success of New Zealand pine in housing is matched by its success in industrial building. Various structural forms using glue-laminated lumber in the form of curved arches, portal frames, or straight beams are used in larger industrial buildings.

New Zealand pine roundwood treated with preservatives also has its place in house construction as foundation piles or pole frames, and in industrial pole buildings. Pole columns supporting glue-laminated beam rafters are a very efficient form of warehouse building. In horticultural and agricultural uses, New Zealand pine poles and sawn lumber play a vital role in crop support structures, stock fencing and yards, and agricultural buildings.

Built-up beams using plywood box construction have been made in spans up to 50 metres. Other composite beams using metal webs and lumber chords are competitive in the long-span purlin market.

Trusses assembled with toothed metal plates have come to dominate the domestic roofing market in many countries using the 2x4 building system, and radiata pine is

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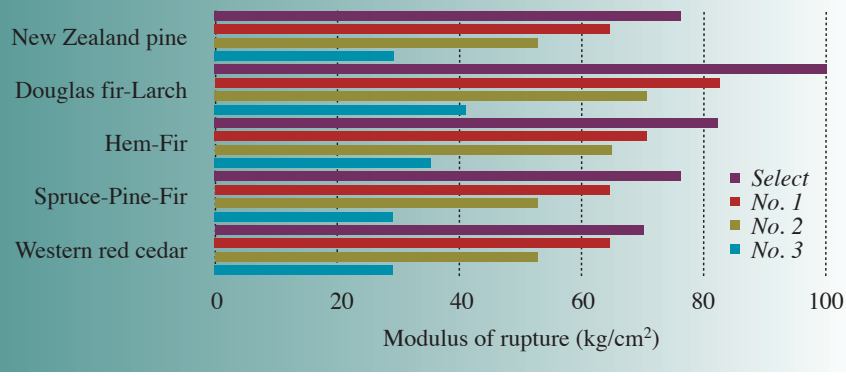
STRENGTH PROPERTIES

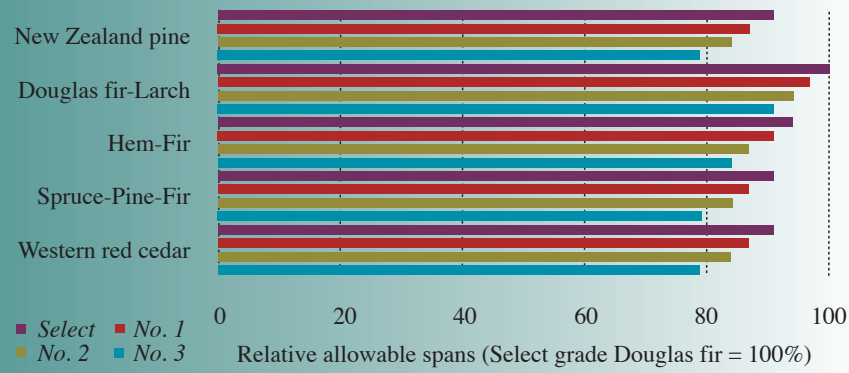
New Zealand pine compares favourably with other species in bending strength, bending stiffness, and fastening (properties which relate well to density). The grade used for most structural framing in the 2x4 system in Japan is the JAS 600 No. 2 and better grade. The same practice is followed in North America. Under JAS 600 New Zealand pine is rated as equivalent to spruce-pine-fir and better than western red cedar.

Shear strength is particularly good, a further benefit gained from its uniform texture.

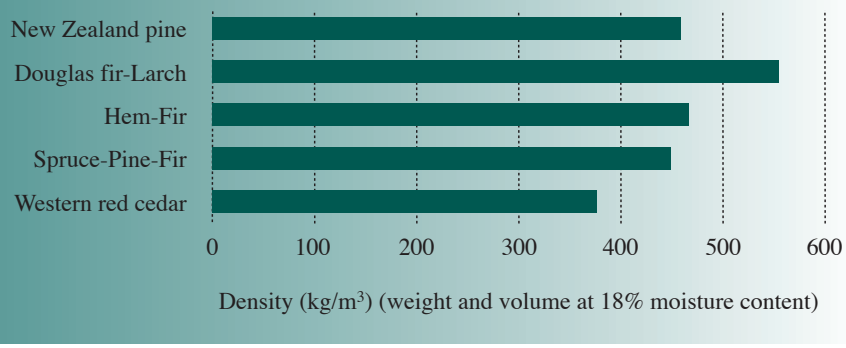
ALLOWABLE BENDING STRESSES FOR FRAMING LUMBER



BENDING STIFFNESS OF FRAMING LUMBER



DENSITY OF FRAMING LUMBER



commonly used in these trusses. In commercial structures, New Zealand pine trusses up to 30 metres span are routine and even larger trusses have been built and used successfully.

CODE ACCEPTANCE

New Zealand pine is fully accepted as a structural lumber in the construction codes of New Zealand, Australia, and the United Kingdom.

In Japan, it is included in the JAS 600 grading rules for structural lumber, in JAS 2054 for glue-laminated lumber and in JAS 1516 for plywood. It is acknowledged as a suitable construction material by the Ministry of Construction.

FASTENING PROPERTIES

Uniform texture gives better fastening properties than coarser-grained woods such as Douglas fir and larch. There is less difference between the density of the spring wood and summer wood bands within each growth ring. Thus, for a given average density, the spring wood bands in New Zealand pine are of a higher density than those in coarser-grained species.

These higher-density spring wood bands give excellent resistance to splitting and so the lumber can be nailed at relatively close centres. This means that New Zealand pine can be nailed green or dry.

Similarly, the lower-density summer wood bands, compared with coarser-grained species, make nailing and drilling easier. The uniform grain structure allows nails to drive true without any tendency to follow the growth rings, as can happen in coarser-grained woods such as Douglas fir.

Other mechanical fasteners such as truss plates, nail plates, and screws also perform well in radiata pine.

Uniform density and low extractives content ensure strong glued joints for both laminated and finger-jointed lumber.

Glued joints may be made with preservative-treated lumber provided it is planed within a few hours of gluing.

Development of the GreenWeld process at the NZFRI allows New Zealand pine to be glued when green to produce structural fingerjoints which are as strong as joints made with dry lumber.

The glue-laminated lumber portal frame made with moment-resisting knee joints has been successful in enabling industrial portal frame buildings in wood to compete with their steel or concrete equivalents. These knee joints have been made with nailed plywood or steel gusset plates and can develop the full strength of the members joined. Close spacing of nails possible with New Zealand pine assists the efficiency of these joints.

Cross-lapped glue-laminated lumber portal frame knee joints in New Zealand pine have been researched by Dr Kohei Komatsu at the NZFRI and a design method has been developed.

The most recent development in jointing has been to fasten threaded steel rods into the timber with epoxy adhesive. An embedment depth of 10 times the bar diameter is sufficient to develop the full strength of the steel. Joints with completely hidden steel bars can be made to give good appearance, good ductility, and good fire resistance.

OTHER STRUCTURAL USES

The versatility of New Zealand pine structural wood products, together with the high durability conferred by modern preservative treatment processes, has enabled the species to be used in a number of applications other than buildings. Examples include marine piles for wharfs and marinas, landscaping lumber for retaining walls, wooden water-reservoirs, cable drums and packaging, and railway sleepers.

In bridge construction, New Zealand pine has been used as glue-laminated lumber both for the main beams and for decking, although nail-laminated sawn lumber is also used for decking.