

Round timber in construction: An introduction

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Report prepared for the Forestry Commission 2003 and published with their permission 2004 by TRADA Technology Ltd.

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Historical background

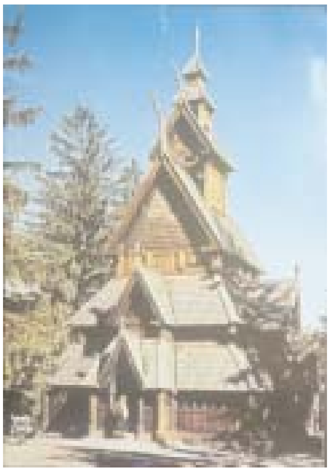


Figure 1 Norwegian Stave church

Wood is man's oldest structural material, and prior to the introduction of tools such as saws it was largely used in its natural round form, often connected together with lashings rather than by mechanical jointing. The earliest simple pole structures were probably nomadic homes such as wigwams and yurts with saplings forming the structure and covered with leaves, skins or felt.

This early form of construction led to the design of all the classical styles of architecture both Western and Oriental which evolved from the use of round wood for supports. Tree trunks were still used as columns long after the classical period and the pole supports of such buildings as the Stave churches (standing poles used as columns) of Norway which still survive since their construction in the 12th and 13th centuries.

In many countries simple round wood structures have been used traditionally for agricultural buildings, but quite major engineering structures such as bridges have also used wood in this form. This includes the early historic bridges of China and Japan through to the large span trestle bridges built for the American railroads in the 19th century.

Pole construction has always been used for marine construction – piers, jetties, docks etc, where it has often survived for many centuries despite being partially submerged and exposed to extreme weather conditions and structural forces.

Figure 2. Round timber piles jetty at Derwent Water, Keswick, Lake District, UK

A favourable context

The use of logs and structural round timbers in building applications benefits from:

- low cost of logs and round timber compared with other (structural) building materials
- low construction costs (for specific open or not fully insulated applications or self built developments)
- strong environmental credentials due to low embodied energy and potential positive environmental and social impact on UK

woodlands many of which have independently certified standard of forest management

- forthcoming European standards framework for testing and strength grading of poles and round timbers
- general acceptance in specific niches of the construction market place such as rural buildings (agricultural and others) and environmentally sensitive buildings.

Log construction (log homes or log cabins)

In those countries where the land was largely covered with coniferous forests it was logical to use this plentiful source of material for building houses in the simplest manner.

By stacking tree trunks one on top of another and overlapping the logs at the corners, the 'log cabin' was born. Interlocking corners were soon developed by notching the logs at the ends, resulting in strong 'box-like' structures which were also easier to make weather-tight by inserting moss or other soft material into the joints. As the original coniferous forest extended over the coldest parts of the world there was a prime need to keep these houses warm, and the insulating properties of the solid wood were a great advantage over a frame construction merely covered with skins, felt, boards or shingles. Over the centuries increasingly complex joints were developed to ensure more weather tight joints between the logs but these profiles were still largely based on the round log.

In the Wood Museum in Trondheim, Norway, fourteen different traditional profiles are shown, but a basic form of log construction was used all over North Europe and Asia. These methods of log building were transferred to North America with the early settlers, where it became a popular form of construction for the pioneers settling in the far north and the more mountainous parts of America and Canada where winter conditions were often extreme.

Log construction was also used for some much larger buildings, and there are examples of buildings up to 4 storeys tall both in Scandinavia and Canada built in the 19th century, probably chosen to evoke either the romantic image of rural life or the early pioneering settlements of North America.

Figure 3. Le Chateau Montebello, Quebec. The largest log hotel in the world, built in 1930. It features a three storey high central atrium

Modern log construction all over Europe and North America is becoming increasingly popular for residential buildings such as summerhouses or cabins and for leisure facilities in outdoor centres. It is also being used for larger buildings such as visitor centres and community buildings, although generally limited to single storey construction.

In the UK many of these log buildings have been imported from Scandinavia, or Canada, as prefabricated 'kits'. However with the increasing availability of home-grown sources of timber such kits could in the future be manufactured in the UK for the domestic market, and possibly even exported to other countries.

The Forestry Commission recently commissoned a new log-cabin type garage, storage and workshop building at Dornoch Forest District. The log cabin was manufactured and erected by a Scottish contractor. 30 cm diameter logs of locally grown 45 year old Sitka spruce were hand crafted to provide the interlocking wall elements. The logs were originally cross-cut into 12 and 6 m lengths. The building itself is 8 m long by 4 m wide.

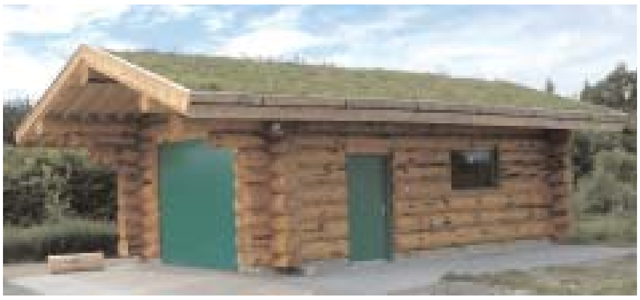


Figure 4. Building works. New Forestry Commission garage, storage and workshop building at Dornoch Forest District, 2003. Contractor: Alan Mackintosh, Log-ical Building. Contractor: Alan Mackintosh

Structural round timber for buildings

An alternative to log construction is to form structures using machine-debarked or machine rounded timbers as conventional structural elements such as columns, beams, rafters etc. Assemblies such as trusses and portal frames are also used.

In construction the terms "round timber" or "pole" commonly denote machine debarked timbers of round cross section which retain the natural taper of the original tree. On the other hand, term "machine rounded timber" denotes mechanically shaped cylindrical round timbers of constant cross-section. The mechanical removal of bark reduces the strength of poles in comparison with manual debarking which limits damage to the natural structural arrangements of the wood fibres, eg swelling around knots. Logically therefore, machine rounding also affects strength, and it increases material wastage. Using machine rounded timbers can however facilitate detailing, jointing and construction and, depending on end use, improve the appearance of the structure. Material specification must also consider drying and durability aspects in relation to the service conditions of structural timber elements. Finally the term "structural round timber" denotes strength graded round timber.

A number of UK grown timber both hardwood and softwood timbers are available that will meet designer's specifications, eg sweet chestnut, European oak, Douglas fir, Sitka spruce, European larch, European whitewood and Scots pine.

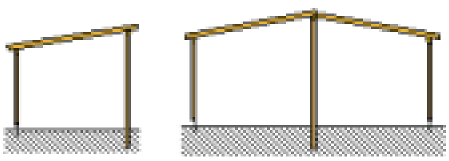
Service conditions affect the structural performance of timbers and durability throughout the service life. The heartwood of some timber species feature good natural durability without preservative treatment (eg oak, sweet chestnut, larch) in external uses isolated from the ground. Sapwood of all timber species, as well as heartwood of less durable timber species, requires preservative treatment when fully or partially (ie covered) exposed to weather.

For building applications, round timber structures may be sorted into two categories. The first, “conventional structures” includes post and beam forms, portal frames, and propped frames mainly for agricultural uses and semi-rural domestic and office uses. The second, “alternative and experimental applications” comprise space frames, specialist roofs as well as towers, domes, timber-fabric structures and prestressed pole structures (light pre-stressed arches and bent poles). Typical structural forms, spans, heights and uses are illustrated below.

Round timber buildings such as pole barns are popular for low-cost self-built developments as well as rural buildings, particularly open or uninsulated buildings.

Typical structural forms

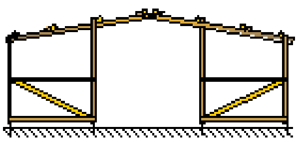
Mono-pitch and duo-pitch post and beam



Span: 6m to 10m; lower eaves height: 3m

End use: Animal accomodation and storage.

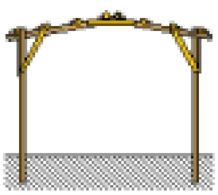
Propped frame



Span: 7.5m; lower eaves height : 2m

End use: Animal accomodation.

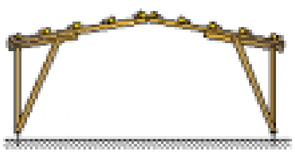
Pole barn



Span: 6m; eaves height: 5m

End use: Storage

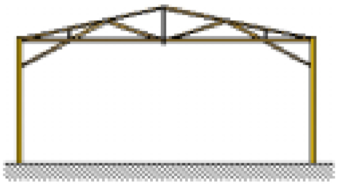
Three hinges portal frame



Span: up to 20m; eaves height 3.85m

End use: Animal accomodation and storage

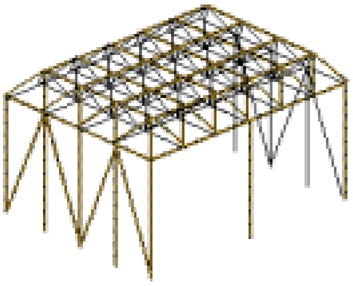
Two hinges portal frame



Span: up to 20m; height under knee brace: 4.65m

End use: Animal accomodation and storage

Space frame



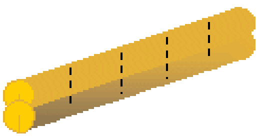
Span:10x16m, 8x18m typical two ways spanning

Typical eaves height 3.85m

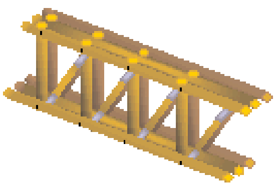
End use: Storage

Assemblies

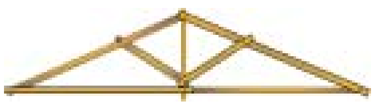
Composite section



Triangulated beam



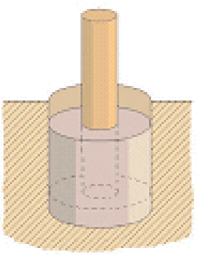
Roof truss



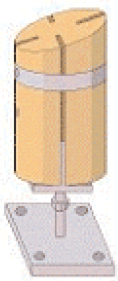
Span 7m typical

Typical details

Embedded column foot in concrete filling

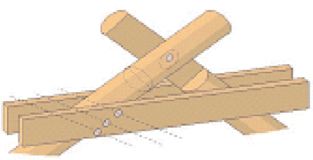


Adjustable steel plate



Knee joint

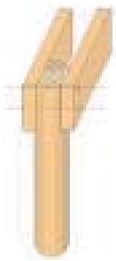
Typical apex



Typical eaves

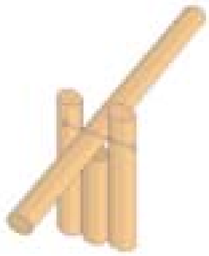
Round column head/round beam connection

Round column head/sawn beams connection

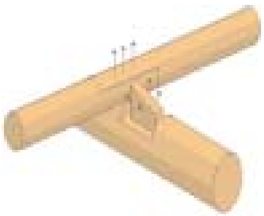


Spreader at round column head and composite beam

Column head/rafter connection



Purlin cleat detail



Very simple structures can be achieved using timber poles. Figures 5 and 6 give good examples of timber pole farm buildings in North Wales. The hay barn shown in Figure 5 utilises Sitka spruce columns, rafters and purlins used in the round while the struts and ties of the trusses are halved. It is worth noticing the half round pressure treated Sitka spruce cladding boards in the lean-to shed.

Figure 5 (left)Hay barn. Sitka spruce timber pole trusses at Tanllyn Farm, North Wales. Designer: Mr Williams Ellis

Figure 6 (right) Pressure treated Sitka spruce timber pole lean-to shed at Glasfryn forest farm, North Wales. Designer: Mr Williams Ellis.

The use of round timber is increasing in semi-rural commercial buildings and visitor centres. Commonly, round elements are used as columns and bracing as well as roof members. Sawn timbers may then be used as principal beams, floor joists and for cladding.

At the Anglo Saxon Village in West Stow, the post and beam structure of the museum and cafeteria building features exposed 200 mm diameter machine rounded British larch columns together with sawn timber beams, floor joists, roof truss elements and cladding boards.

Figure 7. Anglo Saxon Village museum and cafeteria, West Stow, UK. Architectural and structural timber engineering: TRADA Technology,:Timber contractor: Carpenter Oak and Woodland. 1998.

Space frames allow larger spans using short lengths of round timbers and sophisticated nodal connections involving flitch steel plates, dowel type fasteners and even reinforcement systems to enhance connection capacity. A few proprietary systems are available, and one prototype farm building was built in the UK in 1987 using a jointing system developed in the Netherlands by Dr. P. Huybers of the Delft University of Technology. More recently, Feilden Clegg Bradley Architects and Carpenter Oak and Woodlands Timber Framers followed the same principles to build the Solar Canopy of the Earth Centre in Conisborough.

Figure 8. Space frame. Solar Canopy, The Earth Centre, Conisborough. Feilden Clegg Bradley Architects. Timber contractor: Carpenter Oak and Woodlands Timber Framers. Mechanical testing of timbers: TRADA Technology. 1999.

Other applications for structural round timber

Footbridges, retaining structures, marine constructions, playground equipment and innovative timber-fabric structures are other applications for structural round timbers.

An example is shown in Figure 9. The footbridge features two 360mm diameter pressure treated European whitewood poles. The structure of the deck is made of five simply supported panels which are supported via girders made of two mechanically jointed 240mm diameter pressure treated European whitewood round timbers. The deck itself is made of untreated sawn larch timbers.

Figure 9. Cable stayed footbridge in Vallorbe, Switzerland, 1989.

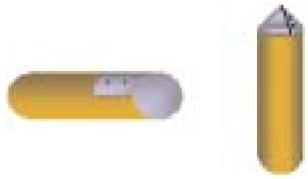
Durability detailing

Design detailing can play a significant role in determining the life of any timber structure. The fundamental principle is to protect the timber from long-term wetting. Some basic guidance is given below:

1- Larger diameter round timbers cannot usually be adequately dried before use, and shrinkage is inevitable. Cracking can be controlled by cutting slots or saw kerfs along the length of the member, and end splitting can be resisted by nailplates driven into the end grain or strapping around the member circumference.

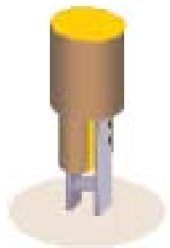
2- As far as possible, structural round timbers should be located such that their ends are not directly exposed to rain, since end grain provides easy access for water. Simple caps or flashings can be used to protect the ends of exposed members, extending their service life.

Examples of cappings at exposed beam end (left) and exposed head of column (right)



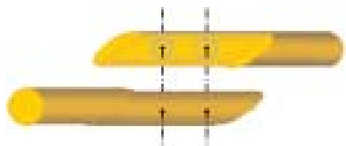
3- To achieve maximum life a round timber structure should be isolated from the ground. This can be achieved by steel shoes, plates, posts or bars, or with concrete base.

Anchorage detail ensuring column's end is isolated from the ground



4- A major cause of decay is the formation of water pockets at joints between structural members or at supports. Shaping, caulking, grooving and drilling can encourage drainage away from joints. Whenever possible and air space should be provided to prevent capillarity action into the end-grain.

Shaping of exposed continuity joint to avoid water traps



5- The design of a structure for agricultural activities -eg animal accommodation - should specifically address robustness aspects - eg risk of animal impact on structural members.

6- Large eaves overhangs can minimize the flow of rainwater over the wall elements, reducing the risk of decay.

7- The choice of the correct timber species is essential to ensure good performance and to minimize maintenance in service. Those which fulfil the basic requirements may need to be treated to improve their natural durability see Structural engineering design with round timber.

8- Preservative treatments are available that enhance timber natural durability. Structural round timbers feature a proportion of sapwood which is not durable. The use of preservative treatments should therefore be examined, see separate sheet 'Round timber in construction: Notes for structural design'.

References

Winter, S. Round wood structures. STEP 2 Lecture E19. Centrum Hout. 1995.

Round small-diameter timber for construction. Final report of project FAIR CT 95-0091. VTT Technical Research Centre of Finland. 1999.

Follett, P. Jayanetti, L. Timber pole construction. TRADA. Second Edition. 2000.

The Roundpole Group. Roundpole in Scotland - A second stage report. Gaia Research. 1999.

Darby, H.J. Building with home grown round timber. Farm Buildings & Engineering (3) 3. 1987.

Natterer, J. Herzog, T. Volz, M. Construire en bois 2. Presses polytechniques et universitaire romandes. 1991.

Log cabins making a comeback. Forestry & British Timber. June 2003.

Huybers, P. Roundwood poles in spatial configurations. Elsevier Science Ltd. 1998.

Paw, C. Rattray, JC. Robertson, AM. Building with roundwood 1. Farm Building Progress. January 1990.

Paw, C. Rattray, JC. Robertson, AM. Building with roundwood 2. Farm Building Progress. July 1990.

Acknowledgements:

The authors thank Mr Bob Selmes (Forestry Commission), Mr Jon Westlake and Mr Angus Mackie (Forest Enterprise), Mr Roger Williams Ellis (Glasfryn Forest Farm) and Mr Peter Caunt (Quercus) for their help.