Summary

In the Nordic countries, timber has a long tradition as structural material in building construction. More than 90 % of all single family houses are built with timber. For buildings requiring structures with large spans, such as arenas and public buildings, glulam and LVL are widely used. New performance based fire regulations have also opened for use of timber as the main structural material in multi-storey residential and commercial buildings, although the market share in this segment is still limited. Recent examples illustrating the status of timber construction in the Nordic region are given in the paper.

1. Background

Historically, timber has been the dominating building material in Northern Europe, with its low population density and more or less unlimited access to wood from forested areas. The large supply of raw material has also made the forest industry to one of the most important business sectors in the region. Especially in Sweden and Finland a very significant share of the net export comes from paper, pulp and timber products.

In the Nordic countries today, timber has a relatively strong position in building construction. It is the dominating structural material in single family houses with a market share of about 90 %. These houses are usually produced by system manufacturers, with high degree of factory production. The productivity in the house manufacturing industry has developed well compared to the rest of the construction industry.

For multi-residential houses, however, the market share for timber is significantly lower, with about 7 % in Sweden (mostly two-storey), although it is has been shown that timber construction is a very cost-effective alternative to competing systems based on concrete or steel. The reason for this
is that timber has long been disqualified from multi-storey construction by prescriptive fire regulations requiring non-combustible material for the load bearing structure in larger buildings. As a result, the Swedish government has recently developed a strategy to increase the use of timber in construction for multi-residential and commercial buildings. The Finnish government is now developing a new programme to promote the use of wood in construction following the earlier promotion actions. The political motives are that timber is environmentally friendly, and that the industry should be encouraged to develop more value added products in the nationally important forest sector.

The idea to develop Engineered Wood Products (EWP) for large span construction was explored very early in the Nordic countries. Production of glulam was introduced already in the early twentieth century, when synthetic glues became generally available. Important applications were in railway stations. Many beautiful structures are still preserved in those buildings after some 80 years.

Due to this tradition, the Nordic countries have today successful glulam industries. Their position on the Nordic construction market is significant due to a continued development of products and systems, and a large part of the production is exported (e.g. for Sweden 65% of the total production of 100,000 m³). Another EWP for large span structures, Laminated Veneer Lumber (LVL), is produced since 1980’s by the Finnish company Finnforest, which is the leading manufacturer of LVL in Europe.

In this presentation, we will give some examples from multi-storey building construction as well as large scale timber structures to illustrate the current status and trends in the Nordic region.

2. Multi-storey timber buildings

Large efforts have been made in the Nordic countries since the mid-nineties to develop building concepts and systems to increase the use of timber in construction. A major research program, called Nordic Wood, has been financially supported by Nordic Industrial Fund, national research bodies in Sweden, Finland, Norway, Denmark and Iceland together with a large number of companies from building industry and wood industry. In this R&D programme, the possibilities were explored to develop timber construction into new areas such as multi-storey residential housing, commercial buildings, bridges, parking decks, sound barriers etc. From the market point of view the largest potential is for building applications now dominated by concrete and steel construction, and one the largest projects completed in the Nordic Wood programme was “Multi-storey timber buildings”, between 1995 and 2000. The urbanisation of housing in the Nordic countries enforces multi-storey buildings at the expense of low rise housing. More than 15 housing projects with several hundred flats in 3-5 storeys were associated with the project, involving specialists from many disciplines in collaboration with building professionals working in the housing projects. The development was mainly based on the light-weight timber frame concept, which was adapted for multi-storey construction to meet requirements for fire resistance, sound performance, production methods, robustness and lateral stability, energy conservation, moisture safe design, architectural qualities, durability and service life valid in the Nordic countries and markets. Among other things, it was demonstrated that timber frame systems have a very good potential to be competitive with respect to quality as well as economy. Figure 1 shows one of the buildings constructed during the project.
This project was later followed by another large Nordic Wood project “Solid Wood Construction”, with the goal to develop building systems based on solid wood components. This concept has been tested in both residential and commercial buildings. The advantage with the solid wood concept is that it is more robust and fire resistance and sound performance can be achieved with more simple solutions, although at the expense of a higher consumption of wood in a given building. The latter is of course seen as an advantage by the wood suppliers. In Sweden, an industry consortium has been formed with the purpose to offer system solutions to the market. A promising idea is to combine solid wood type floors with light weight timber frame. This solution was used in the building shown in Figure 2. This makes it easier to meet the high requirements for sound insulation which is expected by the customers in the Nordic countries. In Norway a milestone was recently achieved, namely the decision of Moelven Industrier ASA (owned by Finnforest) and Viken Skog to establish a large scale production plant for solid wood building units.

Many of the timber housing projects built under this period has been demonstration examples or pilot projects. The next step in the development should be that timber systems shall be seen as an “every day”, natural alternative for medium rise residential and commercial buildings besides the now dominating concrete and steel systems. But that is not yet the case, and there is still a widespread scepticism among many building professionals towards timber. Issues often mentioned are uncertainty about life cycle costs (maintenance and durability), tolerances when it comes to system concepts, sensitivity to moisture etc. The promotion of know-how and support to the customer from the wood sector is still far behind that offered by the suppliers of concrete and steel products.
3. Large scale timber construction

Glued laminated timber (glulam), which became one of the first engineered wood products, is still very competitive in modern construction. By bending the laminations before gluing, it can be produced in curved shapes, and the cross section depth is in principle unlimited. This makes glulam an ideal material to create structures for large spans. An important competitive advantage is also that glulam creates excellent possibilities for good architectural design. The Nordic glulam producers offer a variety of structural systems based on straight and curved glulam members for roofs with spans up to 100 m. Outstanding Norwegian examples are several arenas for the 1994 Olympic Winter games in Lillehammer and the roof for the terminal building in the new airport in Oslo. These achievements have been made possible by development of jointing techniques based on slotted in steel plates with dowels combined with efficient production methods for these types of joints. Other very good examples are the Sibelius Hall in Lahtis, Finland, and Universeum in Gothenburg, Sweden, see Figure 3.

However, a large part of the glulam production is used for more normal building applications. For instance, 50% of the glulam used for construction purposes in Sweden goes into single family housing and rebuilding projects.

Figure 3. Glulam structural system for Universeum, Gothenburg, Sweden

Another emerging application of glulam is bridges, where competitive systems have been developed during the last ten years, partly supported by a large R&D-project in the Nordic Wood programme. The main results of the program are that many new timber bridges have been built, and that there is a considerable increased interest for timber bridges in the Nordic countries. Based on this program and other national and international projects, several hundred timber bridges have been erected. Many of these bridges are pedestrian bridges, but the number of new bridges for heavy traffic is increasing rapidly. In Sweden more than 200 timber bridges have been built, and about half of them are stress laminated decks. One of the more spectacular examples from Sweden is a cable-stayed pedestrian bridge at Vaxholm with a span of 90 m. In Finland the Vihantasalmi Bridge, with a total length of 182 m and glulam king-post trusses in the three middle spans of 42 m, was opened in 1999. The new Flisa Bridge in Norway was opened in 2003, see Figure 4. The deck length is 196 m, and the spans of the glulam trusses are 55+56+70 m. The bridge is replacing an old steel bridge,
and the original supports are re-used. This was possible due to the low total weight of the new timber bridge.

One reason why timber is growing in popularity for bridges is the environmental awareness and the trend towards the use of ecologically sound materials in construction. However, a key factor for timber bridge design is durability. Preservative chemical treatment is not an attractive alternative considering environmental policies of today in the Nordic region. However, by careful design and detailing, the wood material in a timber bridge can be kept more or less constantly dry, so that biological decay is avoided and long service life can be achieved with very limited use of preservative treatment.

Figure 4. Flisa Bridge crossing the Glomma river in Norway.

Laminated veneer lumber (LVL) is another engineered wood product, which are increasingly used in the Nordic countries. A sports hall in Oulu (Oulu-dome) was the first large LVL-building with diameter of 115 m. A recent development is the concept for a canopy structure for sport arenas, one of which will be build in Helsinki Olympic Stadium. The largest timber structure in Finland is a multi-purpose hall in Joensuu being completed this year, see Figure 5. The oval dome has arch trusses built up of glulam and LVL as load bearing structure.
4. Future development of wood construction

The development of wood construction in the Nordic region during the last ten years has shown that there is significant potential for further expansion of wood as a building material, in important segments of the building market. The long tradition of wood construction, good supply of raw material, environmental awareness in society and the industrial structure with strong and efficient manufacturers of high quality wood products are important factors supporting the future development. But suppliers of wood products need to be more customer oriented and more professional in transfer of know-how to the building sector. The great opportunity for the future is to develop industrialised and efficient wood building systems for multi-residential and commercial applications. The interest among current players in the building sector to invest in such a development is however limited at present. An important obstacle is the conservatism and lack of competence about wood construction in large parts of the building sector.

5. Competence in timber construction

Wood design and construction is often quite demanding and mistakes are quite frequent among builders due to limited understanding of timber engineering. Spectacular and catastrophic failures of large scale timber roof structures have recently occurred in Denmark and Finland. In both cases the failure was caused by gross errors in either design (Denmark) or in the production process (Finland). These failures had nothing to do with the quality of the timber products. The events can instead be attributed to the building process as such, with unsatisfactory systems for quality control and management. Nevertheless, events of this type will have a very negative effect on the competitiveness or timber. It is an open question if the probability that gross errors takes place, is higher for timber structures than for other types of structures, due to the fact that the general competence among structural engineers about timber is limited. In a recent study in Finland it was found that nearly all recent structural failures of timber structures are covered by one or more of following reasons:
1. **Loss of stability.** Importance of stability of structural members is not understood by builders on site: compression members are not supported as required or racking resistance of the building is neglected.

2. **Moisture in wood.** Wood is wet for different reasons: leakage, vapour barrier lacking, rain during construction. Various problems result: rot, low compression strength, cracking.

3. **Inexperienced wood designer.** Failure mode of splitting of wood is forgotten. Weakness of wood in perpendicular to grain direction is not obvious to designers having basic education mainly in steel construction. Moisture loads can contribute to this failure mode by shrinkage.

In any case, it is clear that the need to improve education about timber engineering at engineering schools and among building professionals is urgent. Efforts are now being made to improve the position of timber at many engineering and architecture schools in the Nordic countries.