The Olympic Halls in Lillehammer, Norway.

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(Sponsored by the Timber Development Association)

SUMMARY

The Winter Olympic Games were held in Lillehammer, Norway in February 1994. Three of the main arenas are glulam structures with free spans up to almost 100 m. Glulam trusses were chosen as the principal load–carrying element, two of them are arched trusses.

A great challenge was to develop a jointing system appropriate for these large members and large forces. Steel dowels and slotted–in steel plates were chosen, and the conclusion from different tests and studies was 12 mm dowels in high grade steel combined with 8 mm steel plates. The precision cut slots were sawn by specially developed equipment, based on a computer controlled circular saw blade in a horizontal position.

A basic aim for the organisers was an environmentally friendly Olympics, with buildings that emphasised natural Norwegian wood products. There is no doubt today that this aim was successfully reached.

1. INTRODUCTION

In 1988 the city of Lillehammer in Norway was chosen for the 1994 Winter Olympics, and several large halls had to be built for ice hockey, figure skating and speed skating. An important idea was to arrange an environmentally friendly Olympics, emphasising the use of nature friendly Norwegian products.

The largest Norwegian glulam producer, Moelven Limtre, understood that this was a unique opportunity to further develop and market their laminated timber constructions. They started an intensive development process with the following goals:

- Structures with a clear span up to 120 metres.
- Fire resistance of at least 60 minutes.
- Simple transportation.
- Quick and safe assembly.
- The creation of inspiring architectural and technical designs.
- Cost competitive with steel, concrete and aluminium structures.

The goals have been achieved. The 1994 Lillehammer Olympic Games were a demonstration of glued laminated timber as the basis for large clear spans, good architecture and environmental and resource friendly utilisation of materials.

2. CONSTRUCTION SYSTEM

At an early stage the glulam truss was chosen as the main load–carrying element. Some of the factors that helped to decide this were:

- Effective use of timber.
- Great flexibility in design.
- Can be prefabricated in parts.
- Light weight structures, easier to handle, transport and install.

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3. HAMAR OLYMPIC AMPHITHEATRE

This was the main arena for figure skating and short track speed skating, with a capacity of 6.000 seats. The plan of the building is shown in Fig. 1.

Architect: HRTB A.S., Hovde Arkitekter
Contractor: Martin M. Bakken A.S.

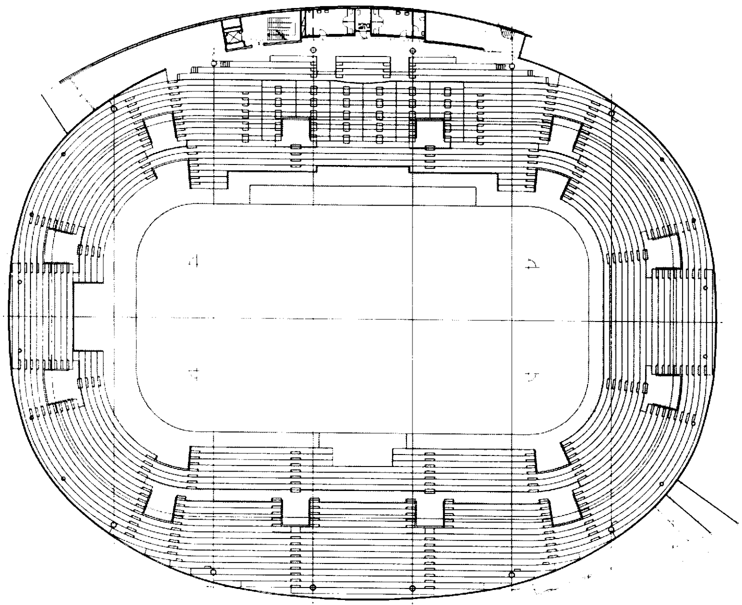

Fig. 1. Plan Hamar Olympic Amphitheatre

The roof is supported by trussed girders with a maximum span of 70,8 m, and a spacing of 13,2 m. The girders are simply supported on concrete columns, as shown in Fig. 2 The straight bottom line places extraordinary tension forces of about 7.500 kN on the splices of the 570x560 mm bottom chord. To transfer this force joints with 11 slotted–in steel plates and 70 dowels were used.

The structures were prefabricated in three sections at the factory and assembled at the building site.

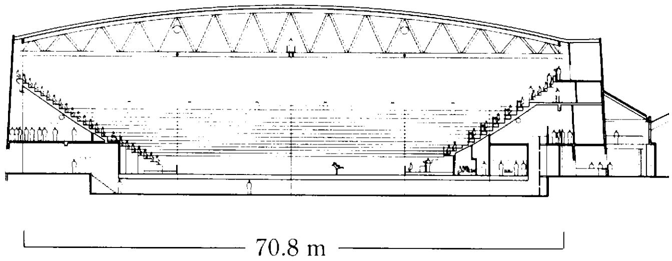

Fig. 2 Cross section Hamar Olympic Amphitheatre

The outer walls of the amphitheatre are constructed of glulam columns and prefabricated wall elements of timber and glass. The internal surface consists of fire–impregnated timber cladding.

A total of 750 cubic metres of glulam were used in the structure.

4. HÅKON'S INDOOR STADIUM

This hall situated in Lillehammer was the main ice hockey arena during the Olympics, with a capacity of 10.000 spectators.

Architect: Ûstgaard Arkitekter A.S
Contractor: A.S. Veidekke

The main structure consists of double arch glulam trusses with a maximum span of 85,8 m, as shown in Fig. 3. The hall has been given an exciting architectural form which blends with the landscape.

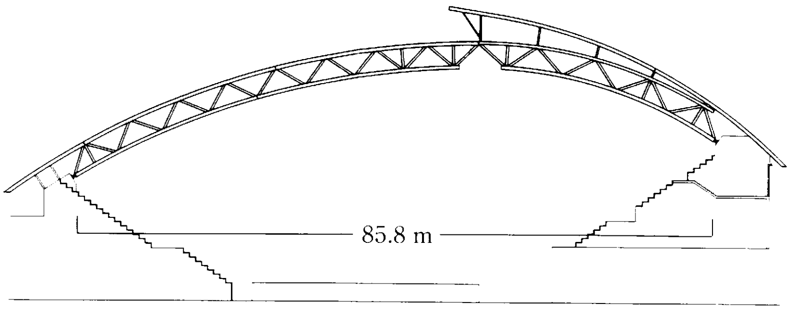

Fig. 3. Cross section Håkon's Indoor Stadium

The stadium has an indoor length of 127 m and is, with its amphitheatre–like grandstands, an intimate arena despite its size. The gable structures are formed by curved beams in glulam, suspended from the main trusses.

1.300 cubic metres of glulam have been used in total.

5. HAMAR OLYMPIC STADIUM – THE VIKING SHIP

This indoor stadium has, with its unusual architectural form of an upturned Viking ship, already become a regional landmark. The Olympic speed skating venue is a multi purpose building and did also house the 1993 world cycling championships. Other options for utilisation include football and concerts, and seating on the floor could raise the capacity from 10.000 to 20.000 seats.

Architect: Biong & Biong/Niels Torp A.S.
Contractor: Ole K. Karlsen A.S.

The main structure consists of arched trusses with spans varying between 30,0 m and 96,4 m, spaced at 12 m centres, see Fig. 4 and Fig. 5.

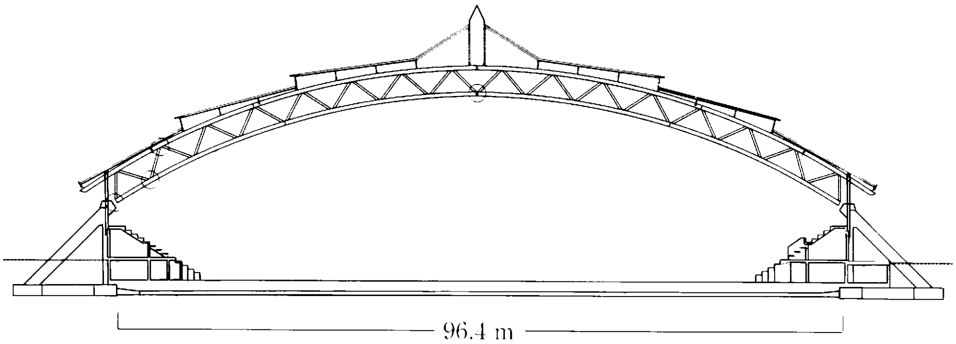

Fig. 4. Cross section Hamar Olympic Stadium

The roof construction consists of corrugated steel sheets with insulation and roofing felt covering, supported by glulam purlins. The stadium has an inside length of 260 m, width of 96 m and a highest point of 35 m. The total glulam consumption was 2.000 cubic metres, and 40.000 dowels were used in the connections.

6. CONCLUSIONS

Moelven Limtre has been responsible for the design, construction, manufacture and erection of all the glulam structures including steel fittings. Accuracy was a password through the whole process, and the experiences with respect to this are very positive.

The choice of dowels and steel plates as connections seems to be a very good one. There were no problems driving the dowels through the holes, not even on the building sites.

As for the future, Moelven's designers see no reason why arched glulam trusses of up to 130 m should not be possible and competitive. This type of timber construction might also be used for other purposes, for example carrying road bridges.

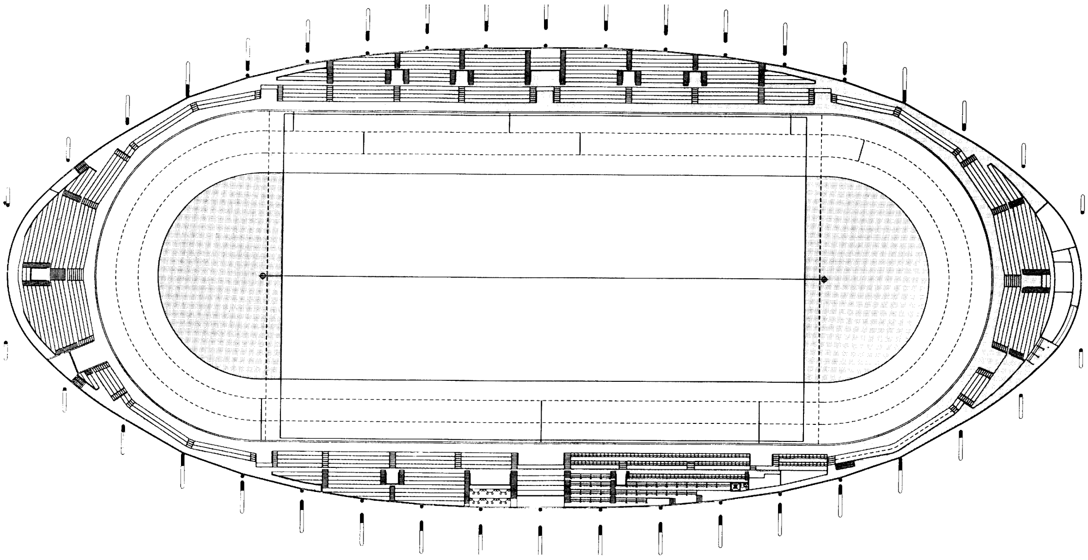

Fig. 5. Plan Hamar Olympic Stadium