Case study no. 6

PRODUCTION BUILDING

1. General information

Fig. 1 The building seen from the north

Date:	Sept.2006 – April 2007
Price:	Approx. 3 Mill. EUR
Investor, design, construction and production:	Palsgaard Træ A/S, Denmark
Location:	Palsgaardvej 5, DK-7362 Hampen
Materials used:	Timber in the main structure
Surrounding:	The building is a new part of an existing production company.

Fig. 2 The building seen from the inside

2. Investment design

The new 5000 m^2 fabrication building is for production of prefabricated trusses. Together with investment in new machinery and flexible production methods it gives a more cost effective production of high quality trusses.

The building design gives small costs for maintenance of the building.

In the production area the staff meets good atmosphere with timber construction, daylight, good noise reduction and the surfaces held in light colours.

3. Bearing system

3.1. General description

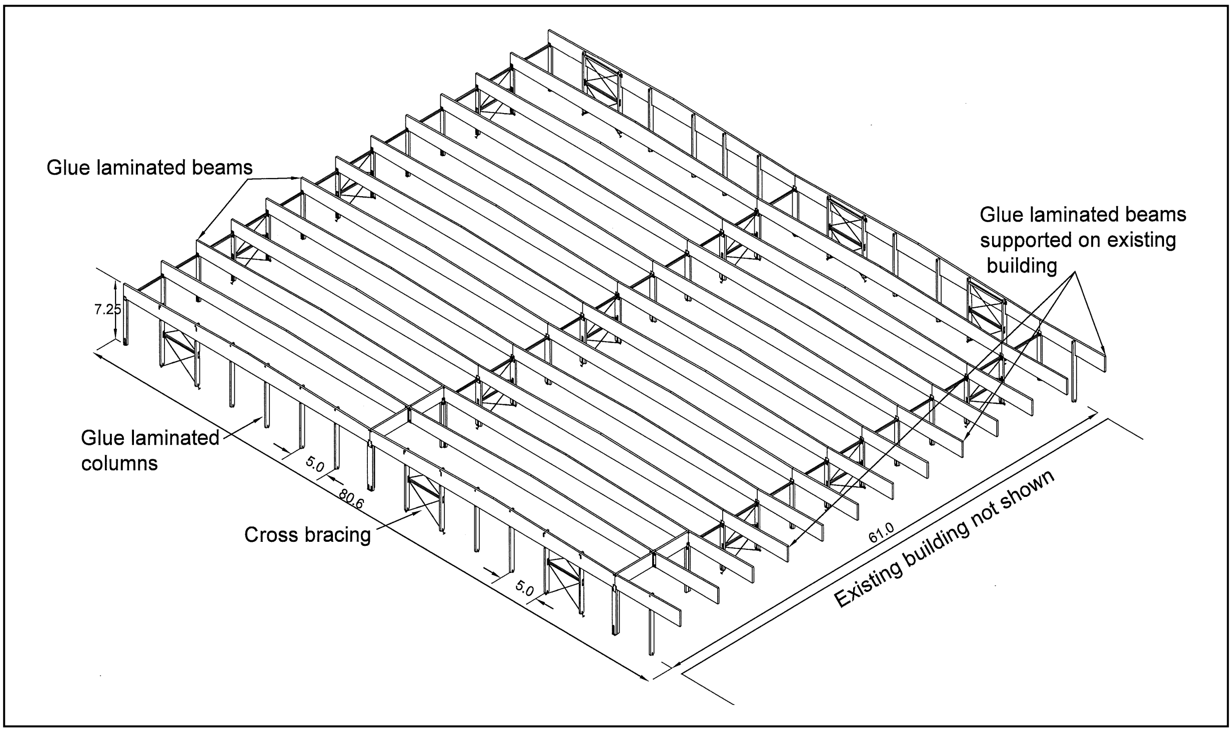


Fig. 3 3D model of the bearing system

The building is in one level with the overall dimensions of 80.6 m x 61 m. The internal height is 7.25 to 7.60 m and the height of the facades is 8.02 m from the floor level.

The main beams are glue-laminated wood with taper. Columns are glue-laminated wood.
The cross bracings are with horizontal members in glue-laminated wood and inclined tension members in steel.

The roof is used as a structural diaphragm. It is made of prefabricated elements with timber beams covered with plywood for horizontal bracing. The connections between the roof elements are with nails.

The facades are with an upper part of prefabricated elements with timber beams and a lower part of prefabricated concrete elements.

The foundation and the floor are in reinforced concrete.

3.2. Vertical loads transferred to the foundation

The vertical loads are from self-weight, imposed load, snow and wind.

The roof element transfers the loads to the glue-laminated beams. From the beams the loads are transferred to the columns and then to the foundation.

The facades are directly supported on the foundation.

3.3. Horizontal loads transferred to the foundation

The most important horizontal loads on this building are the wind loads. Other loads are brake forces from the cranes and forces from stabilization of members in compression.

The facades transfer the most part of the horizontal wind loads to the columns. The pin joint columns transfer the loads to the roof and the foundation. A smaller part of the wind loads on the top of the facades is transferred directly to the roof.

Now the roof acts like a diaphragm. It transfers the loads to the vertical cross bracing. From the cross bracing the loads are transferred to the foundation.

4. Computational models used

Beams, columns, façade elements and roof elements are calculated as simply supported elements with the supplier's computer programs. The global stability analysis of the building is documented by hand calculations.

5. Actions on structures

Actions on the structures are according to the Danish Code DS 410:1998.

The actions from cranes are based upon information from the supplier.

The characteristic maximum velocity pressure q_{max} is 0.80 kN/m^2 with basic wind velocity at v_b = 24 m/s and terrain category II (farmland).

The basic value for the characteristic snow load on the ground is $s_{k,0}$ = 0.90 kN/m^2.

In Denmark the mass loads come from small earth quakes, structures out of plumb, etc.
The calculation for this project shows, that it isn't necessary to use the mass loads, because they are smaller than the wind loads.

5% of the roofs area consists of windows used as fire ventilation. According to the Danish Building Regulation (BR-82) there are no requirements for the fire protection of the main construction in the building.

Collision actions from the internal traffic are taken by a separate construction of steel cantilevered from the foundation.

6. Project documentation, plans, and drawings

The main drawings are the ground floor plan, the foundation plan, the construction plan, facades, cross sections and details.

There is a full documentation with static calculations according to the Danish Building Regulation.

Element drawings, element plans and an isometric model of the main constructions are used for the fabrication and erection of the building.

There are also detailed working descriptions.

7. Erection

Fig. 4 Erection of the building

The erection of the building is done by cranes. The roof elements are delivered with one layer of bitumen felt. It is important with a quick covering with bitumen felt of the joints between the roof elements to protect them against rain.

8. Interesting construction details

8.1. Roof elements

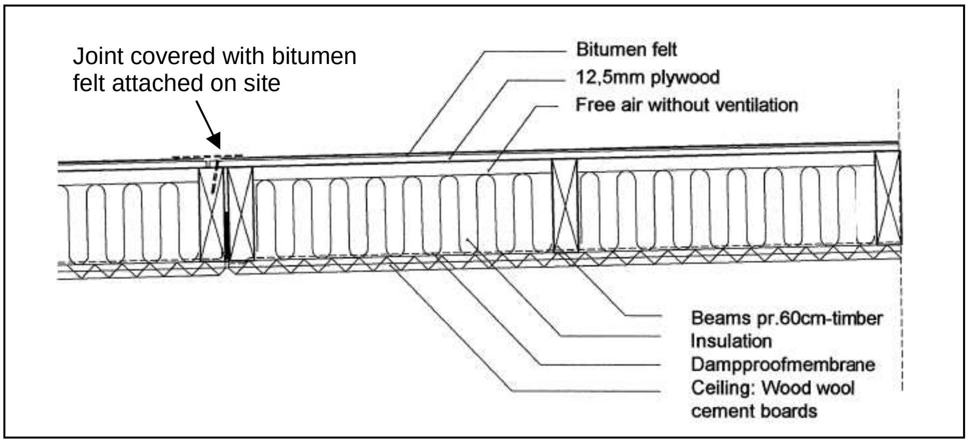


Fig. 5 Cross section in roof elements

The roof elements are PT-elements type 1 from Palsgaard Træ A/S. They are without air ventilation and can bee used for room climate class 1, because the production does not generate much moisture.

The damp proof membrane is made with a special filter. It can drain possible water to the downside of the membrane.

The differences in moisture in the elements give the roof elements vertical deformations from winter to summer. These deformations may be larger than the deformations from snow.

8.2. Roof element connections

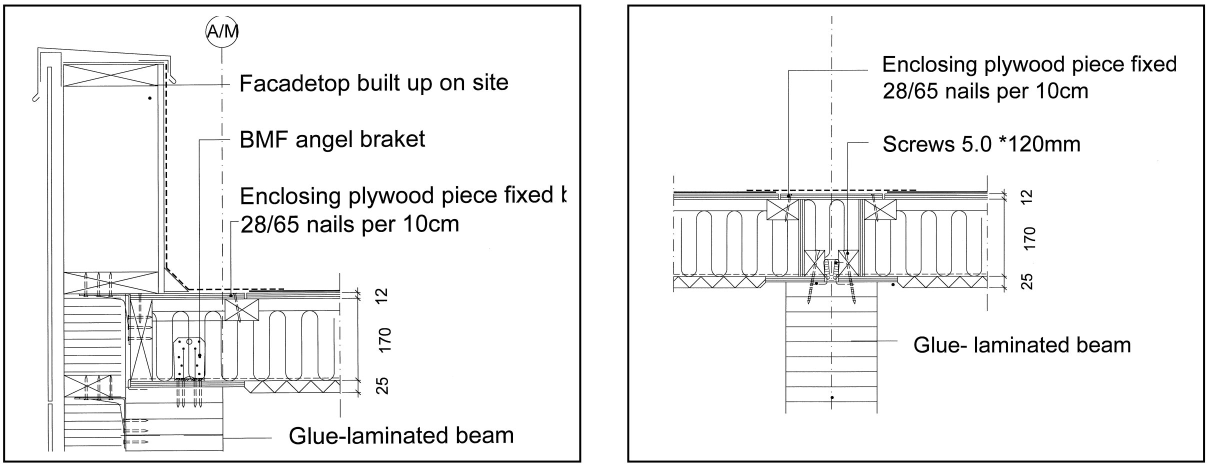
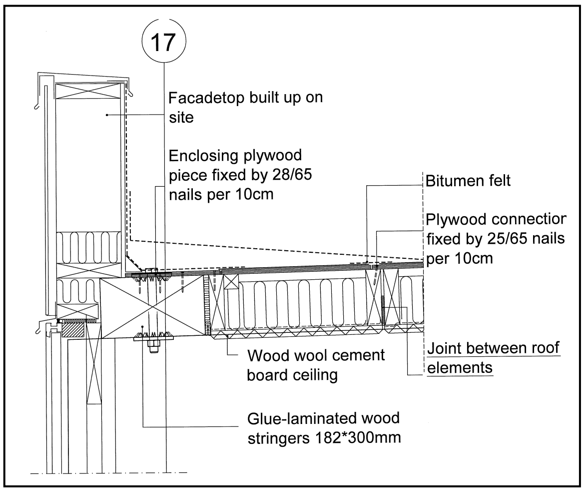


Fig. 6 Roof connections at the laminated beams



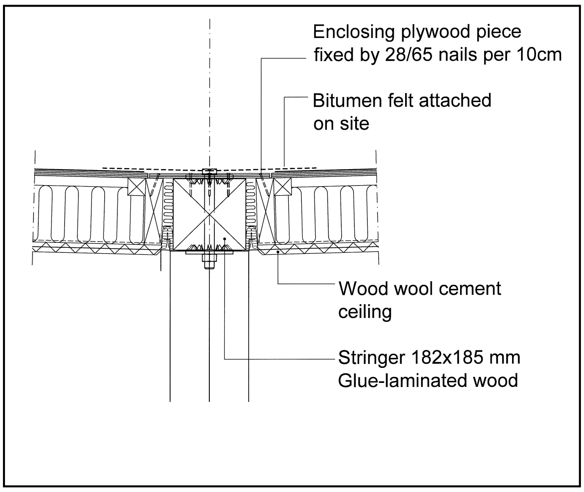


Fig. 7 Roof connections at the stringers

8.3. Facade

Fig. 8 The facade seen from the outside and inside

Fig. 8 shows from inside the upper wall construction covered with wood wool cement boards as a part of the facade elements and the lower wall construction with concrete elements.

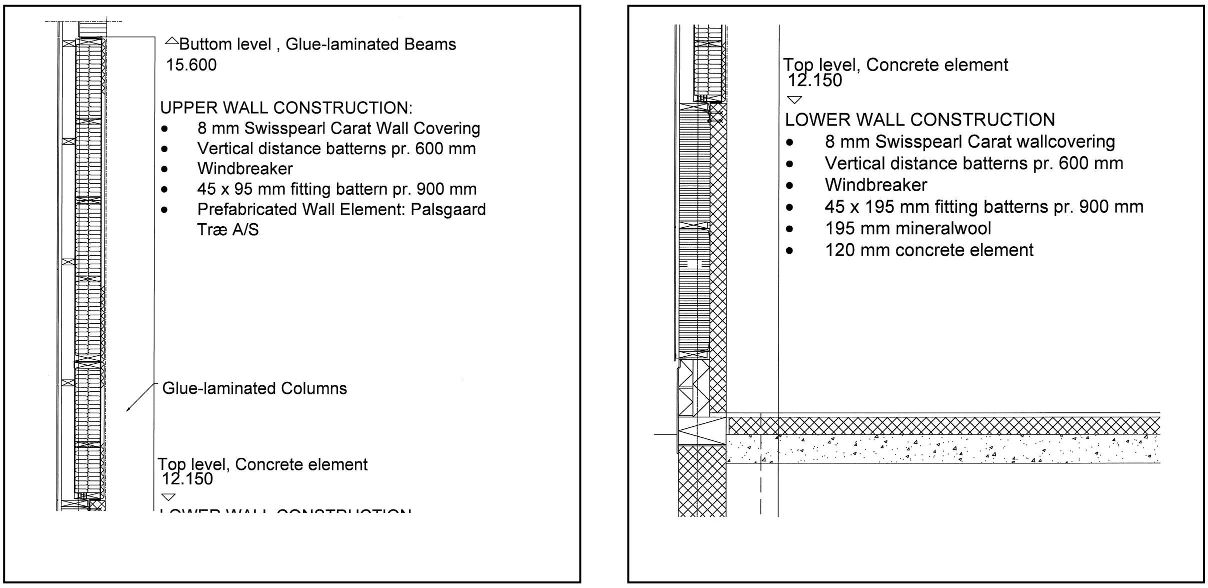


Fig. 9 Cross section in the facade

8.4. Details in the main construction

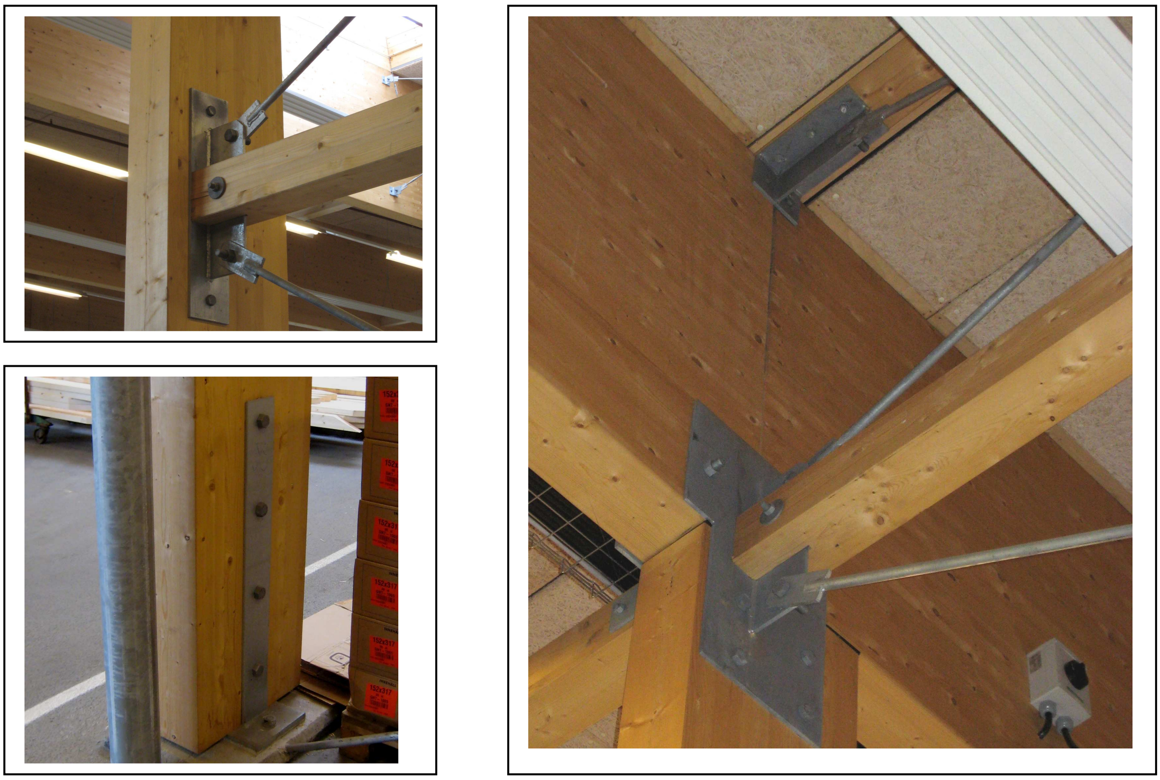


Fig. 10 Details in the wind bracing

8.5. The roof diaphragm

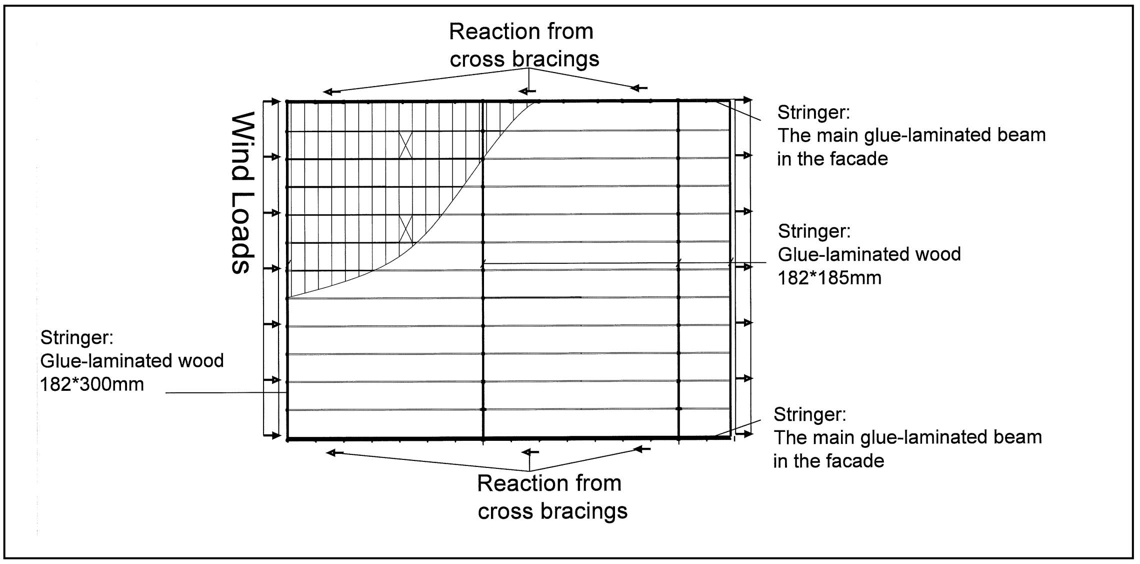


Fig. 11 Plan: Roof diaphragm with wind loads in the longitudinal direction

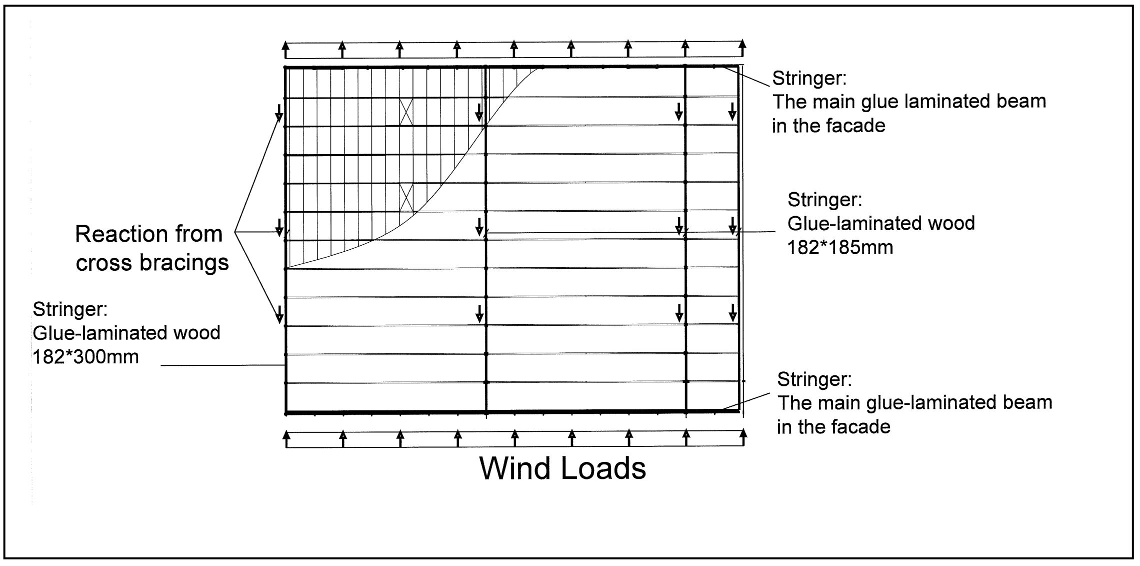


Fig. 12 Plan: Roof diaphragm with wind loads in the transverse direction

The structural system of the roof diaphragm is
1) The plywood boards nailed to the beams in the elements. They take the shear forces in the diaphragm.
2) The stringers are made of glue-laminated wood. They take the moments in the diaphragm by compression and tension. The connections in the stringers shall take compression and tension. The stringers are also used to transfer the forces from the diaphragm to the cross bracing.

8.6. Cranes

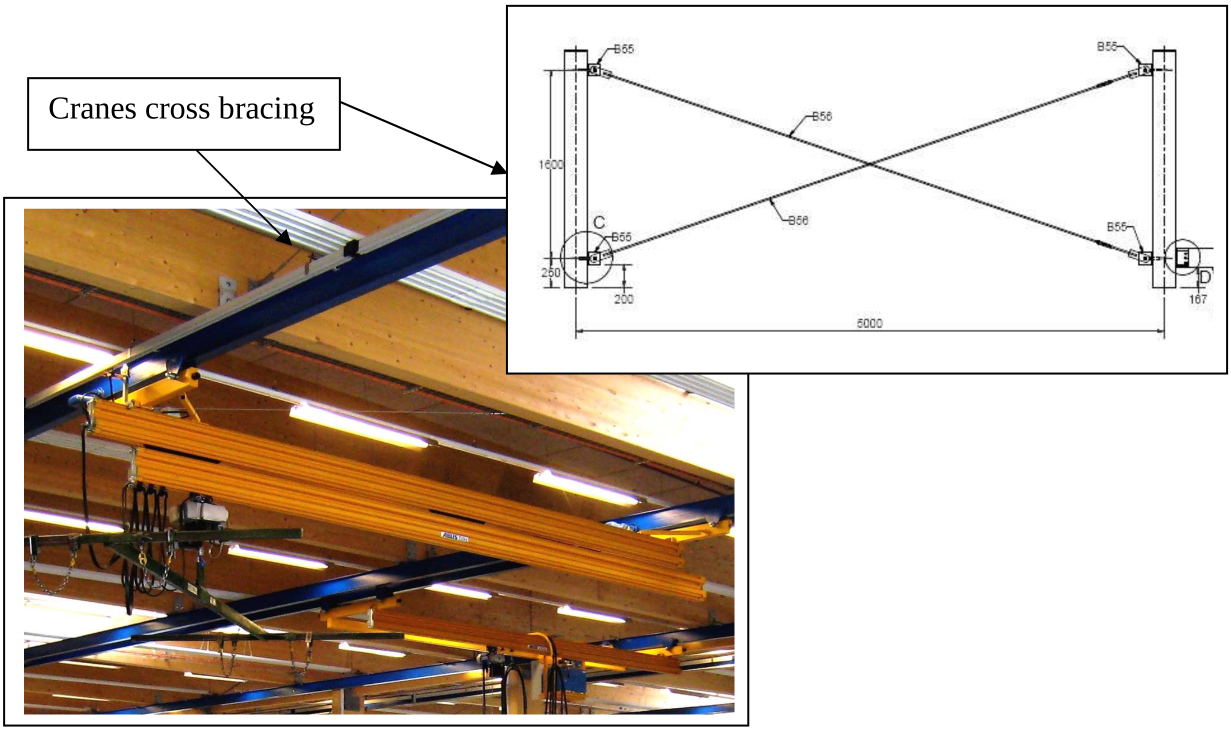


Fig. 13 Cranes and the drawing of the cross bracing to the roof.

The crane system is fixed at the bottom of the main beams. When the cranes stop, horizontal braking forces will develop. To avoid vibration in the construction the support beams of the cranes are braced to the roof.

9. Economical and ecological aspects

According to the investor the building system gives a competitive price, because it consists of standard products on the marked.

The main building material is wood and the roof and facades are well insulated. It is known that wood used in a correct way gives a good ecological profile. In this case, all the wood is unprotected, because it is placed inside the building. The good insulation gives low consumption of energy to heat up the building.

Instructions and case study no 6 are prepared by Senior Lecturer, Civil Engineer MSc, Anders Soevsoe Hansen.

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