Industrial hall

From I-beams to profit

▶I An industrial building has to pay its way. Surprisingly, constructing a production hall with an integrated crane runway to Passive House standards turned out to be the most economical solution. Intelligent construction made it possible.

Production below, office space above: two stories adds strength to the hall

When a manufacturer of Passive House windows needs a new production hall, then one thing is clear from the outset: the hall has to meet Passive House requirements. Initially, the construction type was still open to debate. But after it became obvious then that the designs available on the market for steel-constructed halls with sandwich panels of aluminium and a polyurethane core do not provide sufficient heat insulation or an air-tight construction, the developer turned to timber constructions.

At the end of 2010 Günter Pazen, CEO and owner of Pazen Fenster + Technik GmbH, contacted the architect and master carpenter Gerrit Horn, with whom he had worked on Passive House projects for 15 years, to talk him through the options and cost of a timber construction production hall. He had in mind 1100 m² production and warehouse space, an additional 400 m² for office and social rooms plus a crane runway for the manufacture of large-scale façade sections.

Dynamic horizontal stress

PATZEN FENSTER & TECHNIK

The requirements posed a specific question: Could the conventional supports mounted in sleeve foundations required for a crane runway be avoided? Because, to comply with Passive House standards the foundations must be free of thermal bridges. Cladding the steel or reinforced concrete columns in the ground with thermal insulation would mean that the dynamic horizontal loads from using the crane would no longer be compensated correctly, that is, the rigid restraint would not work effectively.

A timber construction is ideal for solving this problem as the dynamic horizontal stresses of the crane runway can be borne and transmitted by the timber planking. The stress is transferred to an 8 m wide two story building shell constructed in parallel along the 50 m long hall. Offices and social rooms are housed in the upper story while the workshops and technical rooms are on the ground floor of 3.6 m height. The crane has a hook clearance of 5 m in a 14.5 m wide hall with 7 m high inner eaves. This ensures easy loading of HGVs at the gable end.

The design allowed for a merged individual footing system on pressure-resistant perimeter insulation. Hard foam polystyrene insulation XPS of 200 mm depth with a thermal conductivity of 0.039 W / (mK) was installed under a 25 cm thick reinforced concrete floor along with edge insulation, making the use of side rails redundant.

The 32 cm deep cellulose insulation is blown into the building from outside

injected

Base planking was assembled from above, avoiding the need to turn the construction elements

The hall width of 14.50 m required 55 cm deep metal beams

After completion of the floor slab, the paving of the external area was started and then completed at the same time as the fence at the beginning of the timber construction. The result was a clean and, more importantly, a safe construction site. That was important, as only then could the unusual method of preparing the timber elements on-site go ahead.

Preparation on-site

The idea of prefabricating the timber elements on-site emerged from consideration of where to store and how to transport the project materials.

Transport could be minimized by having the building materials delivered straight from the dealer to the construction site. All the pre-fabricated elements totalled a volume of 1380 m³, the equivalent of 25 to 30 HGV trips from the woodworking company to the construction site. In addition,

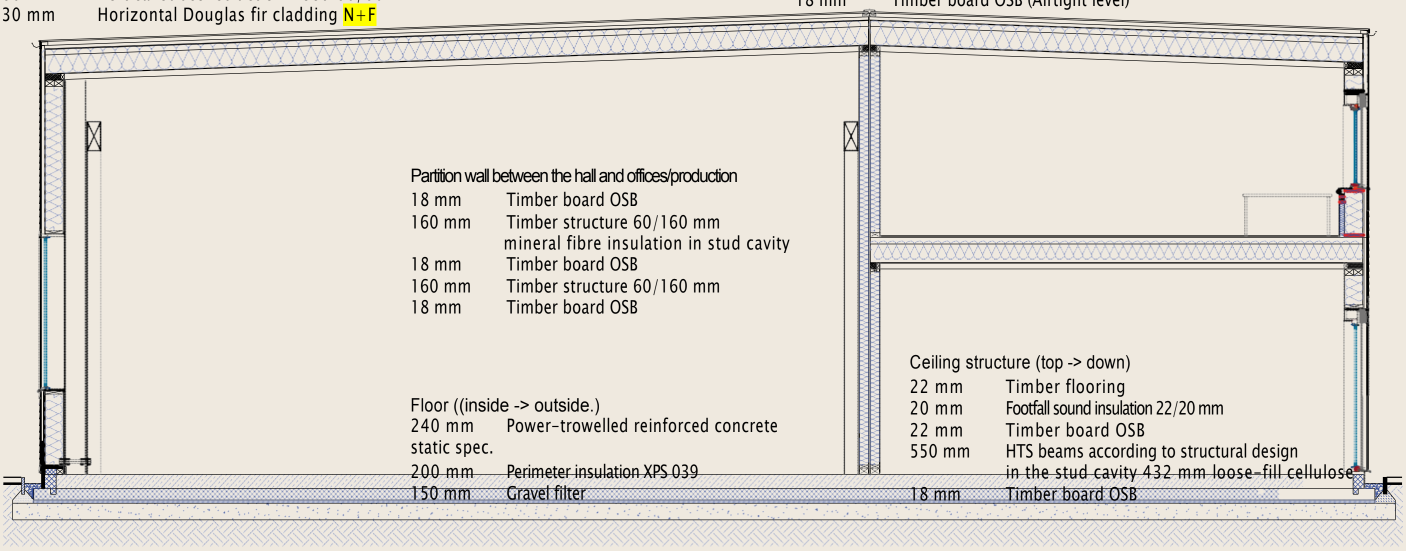
Building section drawing

External wall construction (inside -> outside.)

18 mm	Timber board OSB
320 mm	Glulam timber frame 45/320 mm, mineral fibre insulation in stud cavity
16 mm	Engineered wood product DWD
60 mm	Vertical subconstruction wood 60/60 mm
30 mm	Horizontal Douglas fir cladding N+F

Roof construction (top -> down)

	Photovoltaic system
30 mm	Sandwich panel roofing
60 mm	Laths 60/60 mm
60 mm	Counter battens 60/60 mm
16 mm	Roofing deck timber board DWD
550 mm	HTS beams in cavity static spec. 432 mm, loose-fill cellulose WLG 040
18 mm	Timber board OSB (Airtight level)



▲ The timber construction company prefabricated the elements on site in a provisional hall made from two containers and a sheet metal roof

the woodworking unit had to have adequate temporary storage space. The total time spent loading is another cost factor that can be avoided.

To comply with the high quality requirements of the wall, ceiling and roof elements, the woodworking unit constructed a simple temporary assembly hall for on-site prefabrication by placing two 12 m long shipping containers 8 m apart. The working area was kept dry by a cantilevered trapezoidal sheet metal roof.

Mobile assembly tables were constructed from plywood panels, on which the finished elements could be pushed outside ready for the construction crane. One of the containers housed a high-quality compound mitre saw, while the other one provided space for small components and storing tools - as well as a breakroom.

I-beams with steel plate

As there was no turn table for this production method, the planning team came up with an idea for constructing the large-scale roof and ceiling elements that made it possible to complete both sides working from one side only. Timber web t-beams were deployed for the rafters or beams, which the woodwork team then positioned on the assembly wagons using a grid of 83.3 cm. Then they added the bottom OSB panelling as a 80 cm-wide strips between the beams on the lower flange of the support. A rib of glue was applied from an adhesive cartridge to the upper side of the lower flange to ensure air-tight seals. Then the elements of the top panelling and the front ends were completed and the cavity filled with cellulose blow in insulation material.

The planners advocated HTS timber beams with a flange of profiled steel. This meant spans of 14.5 m and 8.5 m could be bridged without intermediate purlins. The dynamic stresses from operating the crane were compensated by the non-rigid connection between the timber flanges and pressed in bar.

A beam height of 55 cm, specified by the structural analysis, meant there was a gap of 43.2 cm for insulation material between the panelling. That is actually a lot, but of course the 0.5 mm thick steel flange reduced the total

▼ The spacious hall has neither supports nor glued high laminated timber or steel beams

▲ The darker band of windows along the 50 m hall is a pleasant and discreet design touch

U value of the construction element from 0.088 W/(m²K) to 0.138 W/(m²K). Even this value easily achieves the Passive House standard.

Other measures included a highly-insulated, tightly-sealed hall door, specially designed for the project, with a U value of less than 0.6 W / (m²K), even better than the Passive House requirements for doors.

And of course, the highly insulated wooden window system "ENERsign" with a U_w value of less than 0.65 W / (m² K) was implemented - as the hall was being built to manufacture these windows.

High energy gains

Thanks to efficient building technology and the highly insulated building envelope, when the building is up and running, it will produce more energy than is consumed during the production process.. The building equipment consists of a ventilation system, a wood chip heating system and a 100-kWp photovoltaic system.

To minimize grey energy, the supporting structure and the surfaces are timber. In addition the insulation material is cellulose.

The wood waste from production generally will be sold as fuel and to a lesser extent used to heat the building itself.

There is a briquette press at the end of the exhaust lines of the woodworking machines. The chip silos customary for woodworking companies are absent, as an exhaust system leading to the outside of the building would have been at odds with the ventilation system.

The total price for the optimized design is entirely competitive in comparison to conventional non-energy-efficient commercial buildings. And as such, the Passive House standard presents a very interesting prospect for this market.

Up until now, the relatively short investment horizons for industrial buildings have meant the Passive House standard stood little chance of success. It is now demonstrably clear that the new approaches to construction can significantly reduce costs.

The positive balance sheet of the building, built with ERDF funding and the support of the Rhineland-Palatinate Timber Buildings Cluster Initiative (Holzbau- Cluster Rheinland-Pfalz) can be designated an energy-producing production hall. It is the first of its kind in Rhineland-Palatinate. And to round things off nicely, the hall will be used to manufacture exclusively energy-efficient products, establishing the building as a model of sustainable economic management.

Gerrit Horn, Kaiserslautern

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Profile

Construction project:
Production hall with offices D-54516 Wittlich Germany

Developer:
Pazen Fenster + Technik GmbH D-54492 Zeltingen-Rachtig Germany www.enersign.com

Structure: Timber frame

Start of planning: January 2011

Construction period:
Pre-production on-site: October 2011 to February 2012

Carcass: March to April 2012

Façade and interior: April to June 2012

Usable area:
1505 m² (including 400 m² office and social space)

Building volume: 9670 m³

Heat requirement:
14 kWh/(m²a)

Construction costs:
1.8 million euro (KG 200 - 500 and 700 incl. photovoltaics)

Architecture and building services:
Architektur- und Ingenieurbüro bau.werk D-67659 Kaiserslautern Germany www.bauwerk-energie.de

Structural engineering:
Dr. Klaus Hemmer D-66851 Queidersbach Germany

Timber construction: Holzbau Horn GmbH D-67686 Mackenbach Germany www.holzbau-horn.de