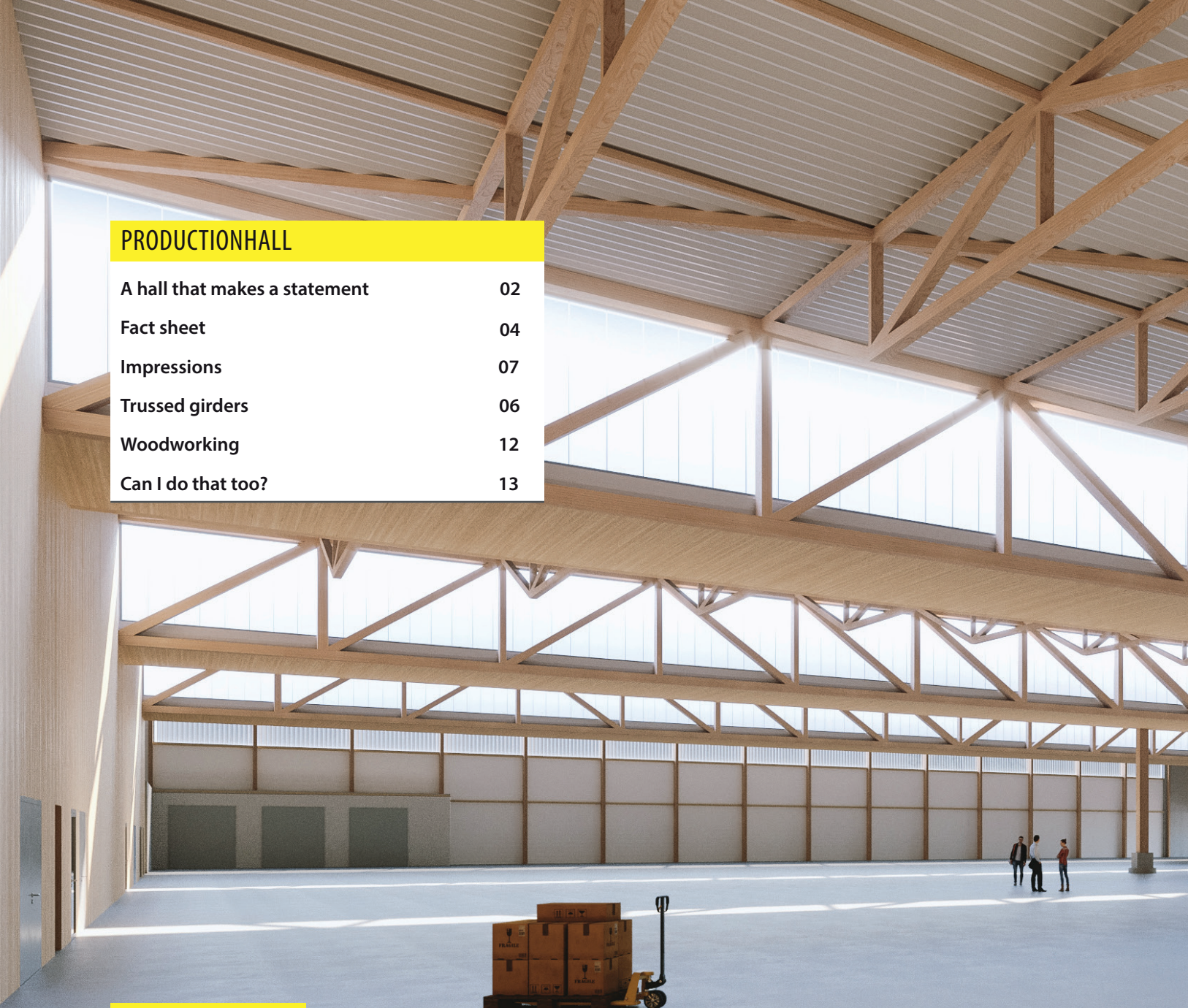
SWG
Schraubenwerk Gaisbach GmbH

ENGINEERING TIMBER CONSTRUCTION

A hall that makes a statement

PRODUCTIONHALL



PRODUCTIONHALL

A hall that makes a statement

The construction of the new SWG production hall in Waldenburg has resulted in a unique building. The BauBuche roof structure bridges enormous spans but nevertheless enables the architectural design of a filigree construction to be realised.

With the new, unique building complex consisting of a production hall, office building and exhibition pavilion, the division Production of SWG Schraubenwerk Gaisbach GmbH has created new capacities at its company headquarters in Waldenburg in the Hohenlohe district. This new building that was decided on years ago will be fully completed in spring 2020.

In many ways, the new building complex marks a very special milestone for the future of the company, as previous history shows: The building inventory includes a hardening shop, administration and production facilities, with further extension planned due to the constant expansion. An additional production facility was required for the production of long screws, and the original plan was to extend the existing buildings by adding a correspondingly large new hall.

Since an extension usually also has consequences for the existing buildings, the architects advised the client to design the new production hall as an independent building in which everything is combined under one roof – just as if you were building a first hall.

This is how the new production hall came into being as a veritable new building and thus also with an independent, new face to allow a new appearance and embodies a new self-image. With its conscious decision to build in wood, the company is also making a statement and pointing out the positive effect of the natural building material for climate protection through CO^2 storage.

Founded in 1967 and also part of the Würth Group, the company is one of the largest screw manufacturers in Europe. With around 230 employees, it produces up to 12 million screws per day – and the trend is rising. The new building now reflects this development.

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The roof structure is striking with the projections between the five hall aisles, which visually structure the almost 97 m wide hall to the outside. A bridge links the production hall to the three-storey visitors' pavilion. (Photo credit: HK Architekten)

FACT SHEET

Construction project
Production hall with office and exhibition building in Waldenburg

Construction method
Engineering timber construction

Construction period
October 2018 to May 2020

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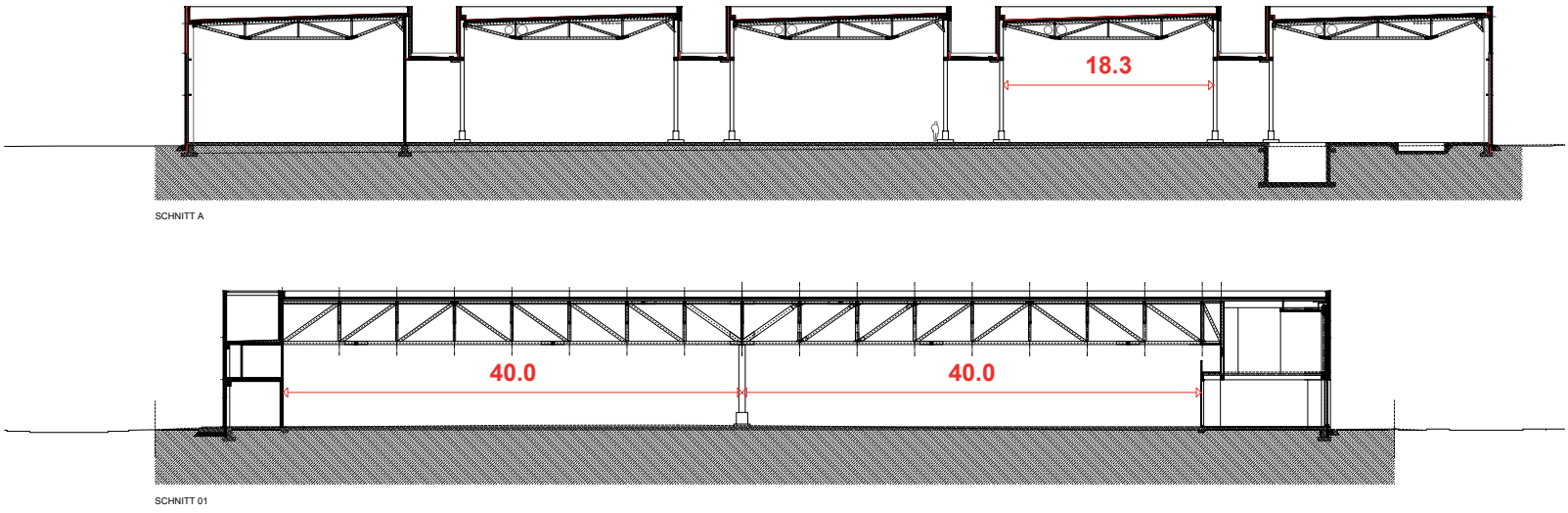
Visualisation of the visitors' pavilion in the entrance and foyer area. (Photo credit: HK Architekten)

Wood architecture creates elegant simplicity



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The cross-section (above) and the longitudinal section (below) show the filigree supporting structure made of different lattice truss types. The main lattice trusses form 40 m and 42 m spans over the hall between the west cross-bar and the east cross-bar (below). The trussed girders (above) are "only" 18.30 m long, but also quite large as secondary girders. (Photo credit: HK Architekten)

Wood architecture creates elegant simplicity

The building complex was designed and planned by the team led by Hermann Kaufmann of Schwarzach (Vorarlberg in Austria) and his new partners Christoph Dünser, Roland Wehinger and Stefan Hiebeler, who have been working together under the name HK Architekten since the beginning of 2018. The choice of wood as the material for the supporting structure and "sheet metal and metal" for the façade are intended to reflect SWG Production's field of activity and the areas of application of the screws for the wood and metalworking sector.

With impressive dimensions of just under 96.50 m in width and 114 m in length, the approximately 12 m high new hall building occupies an area of 12,800 m^2. A manufacturing and logistics area occupy approximately 70%, with another 20% housing an area for tools and toolmaking, along with storage space for raw materials such as wire and similar.

The hall is designed with five aisles and is spanned by a comb-shaped roof. The hall's aisles are each just under 18.50 m wide. Their roofs project down at regular intervals on the longitudinal sides, continuing for a few metres at this height before going back to the original height. On the one hand, these regular projections divide the large hall, while on the other hand they have the same function as shed roofs: They provide plenty of daylight inside the hall – except the other way round, which is why Hermann Kaufmann also calls them shed ditches.

To date, the supporting structure is unique in terms of its size and design. The trussed girders of the roof structure are made of beech laminated veneer lumber (BauBuche) with a high load-bearing capacity. They sometimes bridge enormous spans, such as the 82 m long and 3.80 m high main frameworks in the longitudinal direction of the aisles. Only supported on a BauBuche column, as two-section girders they span a 40 m and a 42 m section.

Thanks to its high strength, BauBuche allowed very slender cross-sections despite these bridging widths. This also impressed Hermann Kaufmann: He commented enthusiastically that "the BauBuche girders were an asset to the design. They have sensationally small dimensions almost slimmer than those of steel girders, and being high up in the roof they appear even more filigree to the observer when installed".

With the hardwood, it was also possible to reduce to a minimum the amount of timber required and so help to conserve resources.

Visualisation of the visitors' pavilion in the entrance and foyer area. (Photo credit: HK Architekten)

Hall with annex for visitors with an interest in wood construction

The hall also got an annex: three-storeys for offices and for conference and exhibition rooms known as the visitors' pavilion. It supplements the new hall and is linked to it via a bridge. The pavilion is where interested parties can learn about products made in-house and how to use them.

Screw connections for wood-concrete composite ceilings developed by SWG Production are to be exhibited there as well as the realisation of classic wood connections, including those with the high-performance construction material BauBuche. The roof structure of the new production hall itself serves as the best illustrative example and can be viewed via the visitor footbridge.

It can be accessed via the bridge in the hall, where the wood construction can be experienced directly. In anticipation of many visitors, the demands placed on the quality of the workmanship, feel and spatial experience were exceptionally high for an industrial building.

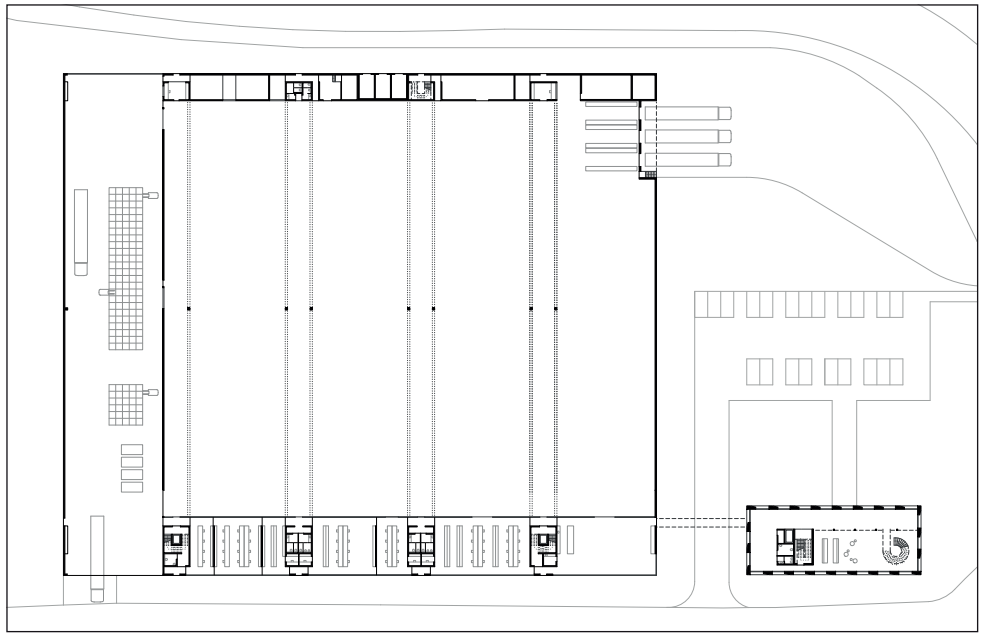
A building complex that makes a public statement

With its new building consisting of the hall and exhibition pavilion, SWG Production is also expecting to make a statement beyond national borders. That's because it shows the general public the dimensions in which modern timber engineering has advanced.

Since SWG Production is expecting a further increase in the demand for screws in timber construction and engineering timber construction over the next few years, the architects have designed the hall so that it can be extended by an additional 11,000 m². But for now, production is commencing in the recently finished hall under the world's largest BauBuche roof supporting structure, a superlative engineering timber construction.

The three-storey side building is planned to have four stories, so an additional storey can be added if necessary. It is flush with the hall's façade and visually extends it. The new hall building increases production capacity, and the three-storey building known as the visitors' pavilion shows interested parties the use of in-house products up close and in so doing gives them an experience of the timber construction. (Photo credit: HK Architekten)

▼ The new SWG Production hall has remarkable dimensions of 114 m wide to almost 97 m deep. The three-storey visitors' pavilion to the right looks small by comparison. (Photo credit: HK Architekten)



IMPRESSIONS

On the building sight

Framework with a Gordian knot

The hall's supporting structure utilises frameworks with sophisticated connection joints, including a highly stressed joint consisting of puzzle-like components to absorb and transmit the enormous forces.

There are many large machines with a lot of technology in the hall, which has determined among other things the building's dimensions and thus also the large spans. Two cross-bars border the hall, one to the east and one to the west. These house service equipment, workshops, the building services and also changing and training rooms. Right on the outside in the hall's last aisle there is a wire warehouse that had to be separated from production by a cross-laminated timber wall to R90 specifications.

The components for the 80 m span of the hall presented a special challenge, although it proved possible to halve this to 40 m with an intermediate support. Reducing the number of supports in the hall to a minimum was a stipulation of the client, who wanted maximum flexibility in production.

The company's own hall developed by the in-house engineering office

The hall's supporting structure was realised by the in-house engineering office SWG Engineering of Rülzheim in the Palatinate region of Germany. That's because besides being a screw manufacturer, SWG Production also plans wooden structures, provides the appropriate statics, programs design software and regards itself as a competent partner in all matters relating to timber construction.

An adequate building material had to be found for both the main and secondary girders. In addition to the "corporate idea" of using wood for the roof structure (which was the client's wish from the outset), the structural engineers also initially examined what it would mean to have a supporting structure of these dimensions and span widths made of steel or prestressed concrete (like in bridge construction). Reinforced concrete was excluded from the beginning due to the span widths.

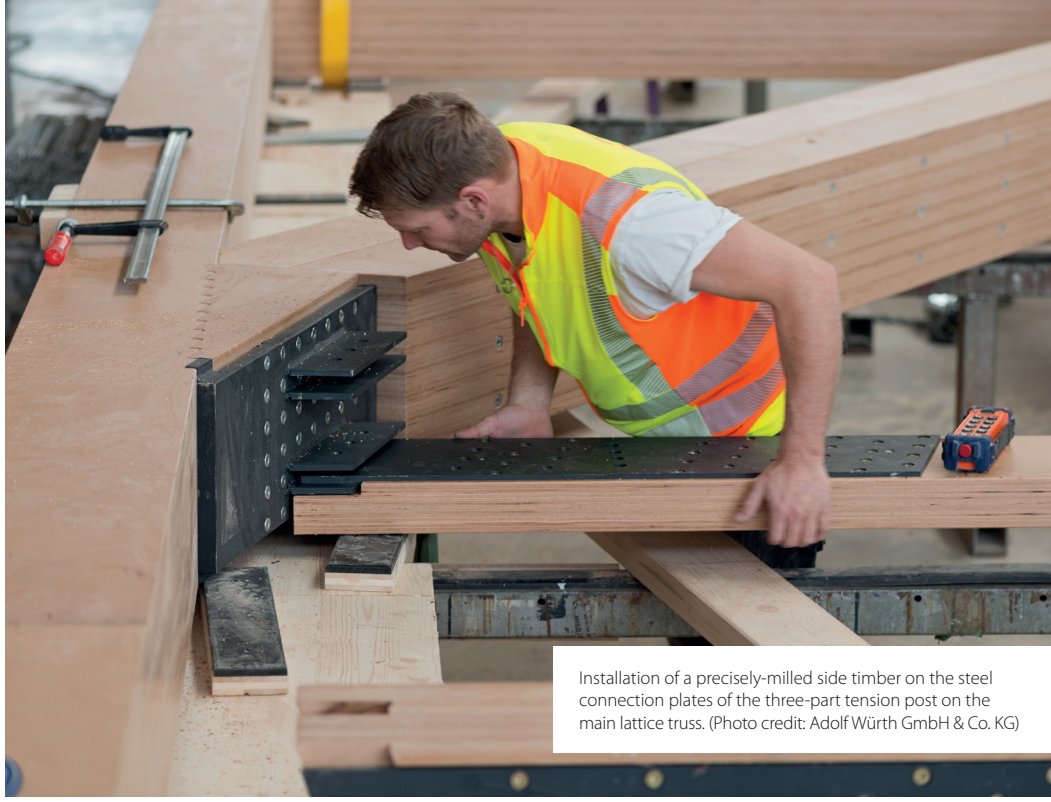
At this stage it became clear that it would not be economically feasible with either of these materials. Besides ruining the architectural vision, components that were much too large, too heavy and in some cases difficult to manufacture would have required enormous foundations and resulted in high costs, given the limited load-bearing capacity of the substrate. Even softwood would have been too bulky and not an alternative. Consequently, only one building material was considered: beech veneer lumber (BauBuche, GL75), which has a high load-bearing capacity and can easily compete with steel in that respect.

Carpentry connections as nodal joints

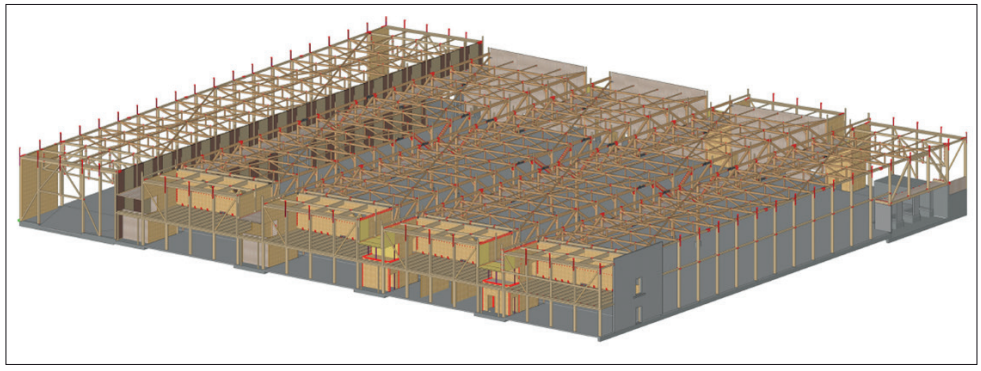
The hall's supporting structure consists of many different framework systems. The roof supporting structure is essentially spanned by the two-part main trussed girders 82 m long and 3.80 m high, and the secondary trussed girders suspended between them that measure 1.50 m high and 18.30 m long. Many of the connections and nodes have been designed by the structural engineers as carpentry joints, but they have been adapted, varied and optimised to suit the material in view of

Two cross-bars, the east cross-bar (in the picture at the front) and the west cross-bar, border the hall. In between the first main frameworks lie packed and ready for installation. (Photo credit: SWG Schraubenwerk Gaisbach GmbH – Production Division)

BauBuche being used.This also arose from the background that the simple geometries of these proven wood joints set well and allow the components to be joined without jamming – while at the same time providing optimum force transmission in the joints. To be as filigree and material-efficient as possible, the engineers made maximum use of the load-bearing capacity of the BauBuche components. In the area of the node of the main lattice truss above the central support, the figure is as high as 99.9%. The particular challenge here was to transfer strong forces over small cross sections. This essentially contradictory requirement was also new territory for the structural engineers. That's because the magnitude of the forces was ten times and in some cases even one hundred times the forces that usually occur in projects.

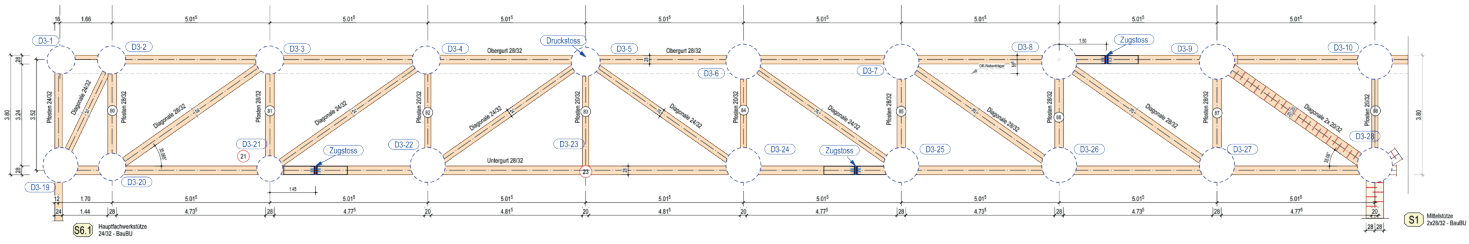


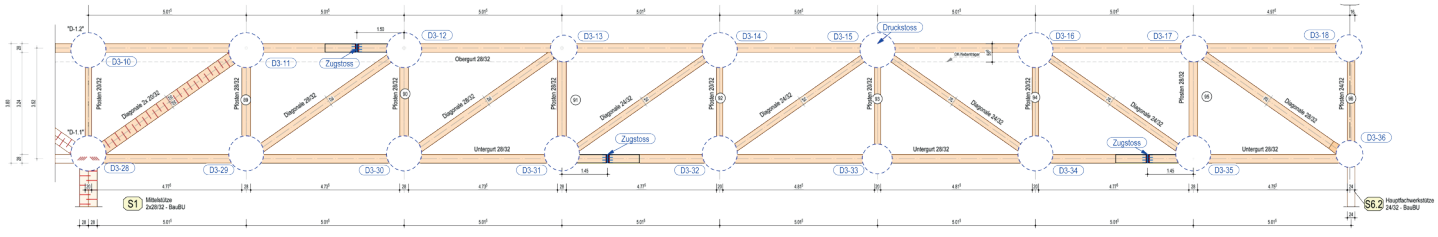
Installation of a precisely-milled side timber on the steel connection plates of the three-part tension post on the main lattice truss. (Photo credit: Adolf Würth GmbH & Co. KG)

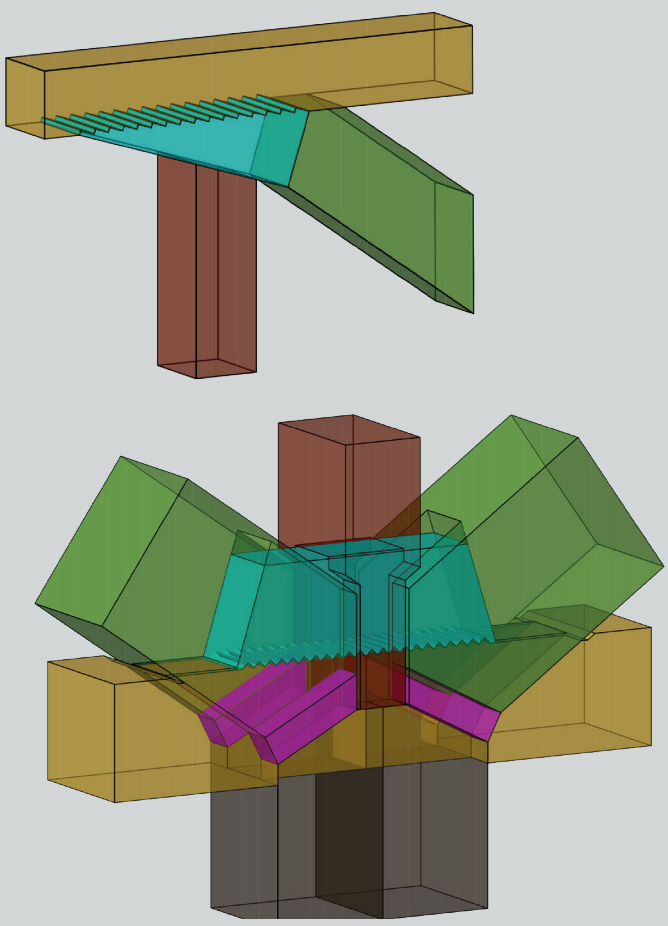


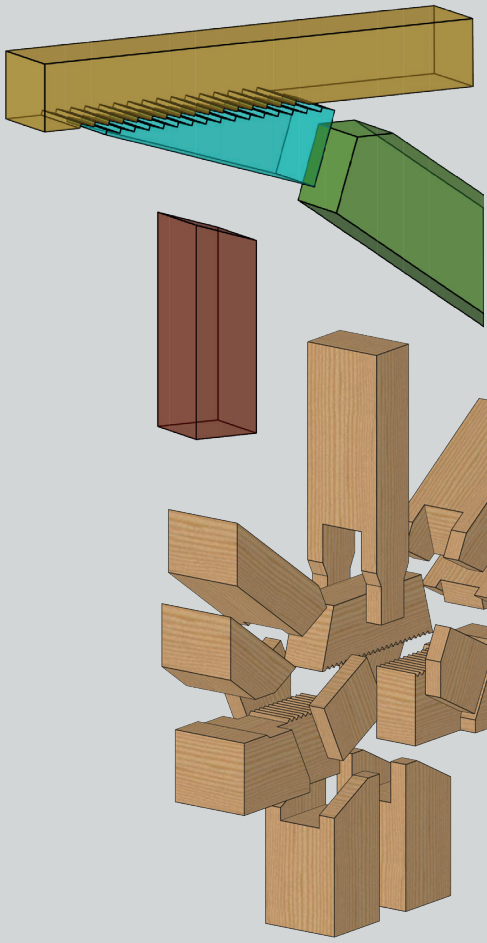
The main lattice trusses consist of two parts: One girder 42 m long (top) and one girder 40 m long (bottom). The central support must absorb enormous forces of 2.8 MN. For this connection, a node had to be developed that brought together the incoming components in such a way that all forces could be transferred and all components could be assembled on site. (Photo credit: SWG Engineering) ▼

▲ Trussed girders made of BauBuche span the roof supporting structure: Main trussed girders 82 m long and 3.80 m high in the longitudinal direction with only one intermediate support, and secondary trussed girders 18.30 m long running crossways. The latter are "hanging" between the main trussed girders. (Photo credit: SWG Engineering)









Main lattice truss: Connection of diagonals and posts via a coupling piece with an "extended" stepped offset to the lower boom. (Photo credit: SWG Engineering)

Node as a pure contact connection like a three-dimensional puzzle on the main trussed girder/central support to reduce the lateral pressure in the lower booms and direct load transfer from the diagonals into the support. Right: The built version. (Drawings: SWG Engineering, Photo: SWG Schraubenwerk Gaisbach GmbH – Production Division)

"Puzzle connection" for optimum force transfer to the central support

If, for example, you take the above-mentioned nodal joint above the central support in the main trussed girder (the so-called "puzzle connection") and if you look at the cross-sectional dimensions in relation to the force being absorbed, the "disproportion" becomes clear:

For post dimensions as well as lower boom and top girder dimensions of 28 cm in height and 32 cm in width or diagonals with an h/w of 24 cm x 32 cm, although the strut receives "only" just under 200 kN of normal forces, as much as some 1.2 MN arrive at the lower booms on both sides, but the diagonal forces then reach an enormous magnitude of 2 MN.

The two-part central support must take a corresponding load of 2.8 MN. It is also made of BauBuche and has dimensions of 32 cm wide and 2 x 28 cm deep. So that all of these forces can be absorbed and transmitted in the framework node, the structural engineers at SWG Engineering developed a pure contact connection node that resembles a three-dimensional puzzle. The task to be solved was to reduce the lateral pressure at the node, since BauBuche's lateral pressure resistance in the booms was not sufficient for the load transmission.

The engineers achieved this by, among other things, directly coupling the horizontally-acting load components of the diagonals' compressive forces via an intermediate piece (turquoise block with "extended" stepped offset) and by not directly introducing the support force resulting from the diagonals onto the lower boom but directly into the support. The same applies to the strut's vertical forces.

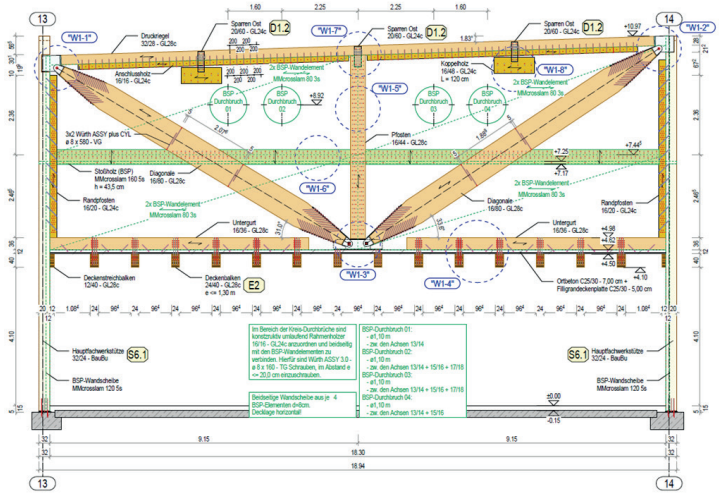
Component dimensioning influenced by available sizes

In order to be able to use the BauBuche as efficiently as possible, the engineers chose cross-sections with upright slats. The advantage lies in the improved shear strength. At the time of planning, however, there was also the fact that the maximum available width of components with horizontal slats was 28 cm. The planners therefore simply tilted the component through 90°, thereby using the 28 cm as the height, which then resulted in the 32 cm for the width – and that was readily available.

Building bracing as a complex interplay of many elements

Due to the architecture with the "shed trenches", each of the five hall aisles had to stand on its own in terms of statics and so had to be separately braced. This gave rise to a complex bracing concept with many

▲ The 12 cm thick CLT panels of the shed trenches are designed as ceiling panels and screwed to the lower booms of the main trussed girders in order to fix them against lateral buckling caused by pressure forces. (Photo credit: SWG Schraubenwerk Gaisbach GmbH – Production Division)



► Static principle of load transfer in the wall-like girders with a cumulative load of around 1.8 MN on the edge support. (Photo credit: SWG Schraubenwerk Gaisbach GmbH – Division Production)

different components interacting. The hall aisles are braced firstly at roof level by means of BauBuche diagonals and bracing beams that stabilize the top girders of the secondary lattice trusses against lateral shift or lateral torsional buckling, and secondly by the CLT panels 12 cm thick that form the low-lying shed roof areas and at the same time brace the lower booms of the main trussed girders and prevent the booms from shifting due to the compressive forces.

In addition, various gluelam timber frameworks have a bracing function, including special bracing frameworks on all five sides of the hall. At 3.80 m, they are as high as the main girders. Their task is to divert the bracing loads into the lower structure. CLT walls that transfer some of the forces into the concrete panels of the wood-concrete composite ceilings in the east cross-bar, along with the CLT outbuilding cores in the east and west cross-bars in the extension of the respective hall aisle are also important bracing elements.

► The wall-like girders in the extension of the hall aisles on four of their end faces take high loads, including from the connected ceiling. (Photo credit: SWG Schraubenwerk Gaisbach GmbH – Production Division)

Wall-like girders absorb 10.5 tons per meter

The almost 6 m high, wall-like gluelam girders with diagonal bracings at four ends of the five hall aisles in the east cross-bar also play an important part. They bridge (the aisle width of) 18.30 m. On the underside, not only are the likewise 18.30 m wide ceilings with a 9 m span width to the outer wall plus 2 m cantilever arm towards the hall connected to and suspended on them, but also the main trussed girders on their edge supports.

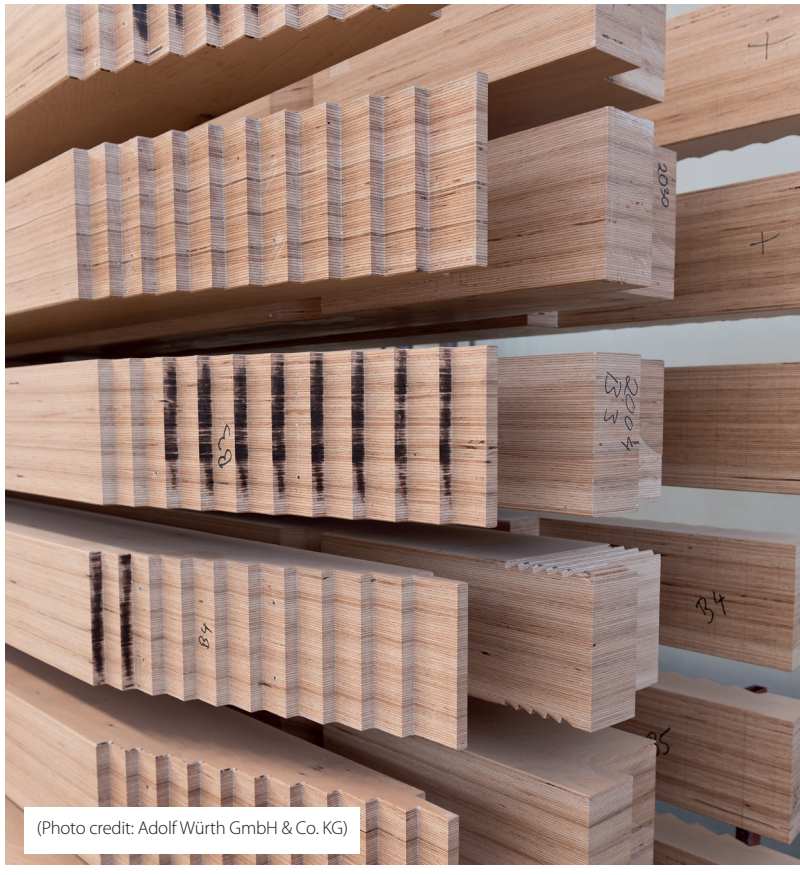
Since the component must bear a ceiling load of 105 kN / m (corresponding to 10.5 tons, pulling downwards each running meter), screw connections are arranged on the lower boom of the wall-like beam at a distance of 1.20 m. The engineers hung the loads from the ceiling and the main trussed girders upwards via the anchors and tie members, and introduced them into the edge supports. The cross-section of the tie members is 16 cm x 60 cm, the cross-section of the struts is comparatively "small" at 28 cm by 32 cm. The total load on the edge supports therefore adds up to about 1.8 MN. In addition there are the bracing forces from the hall roof.

Timber made fire protection particularly cost-effective

Particularly noteworthy is the R90 partition wall, with which the last aisle that houses the wire warehouse had to be separated from the production hall. Since the planners did not want to install a fixed and laboriously manufactured reinforced concrete wall, they developed a special wall that is comprised of CLT elements 18 cm thick, 2.50 m wide and 12 m high. Because it consists of flammable building materials, it has a fire resistance duration of 90 minutes and a fire resistance class of REI 90 B. The fire protection requirement of REI 90 B could also be met relatively cheaply with BauBuche by way of a correspondingly larger component dimensioning (hot dimensioning) and a sophisticated fire protection concept that also included sprinklers. If the plan had been to apply a fire protection coating to a steel supporting structure of this size, the structural fire protection would have been extremely expensive.

Energy concept and recyclability with a view to the future

For all components and structures, great importance was attached to dismantling and separability so that they could be used and recycled beyond the service life of the building. The energy concept is that only the waste heat from the manufacturing process should be used to generate heat for the building. This involves using of state-of-the-art systems with highly efficient heat exchangers. The hall is cooled by means of free cooling at low temperatures (night cooling). The rainwater collected in a cistern is used for the service water (non-drinking water) in the manufacturing process and for flushing toilets. The natural lighting received via the shed trenches, which at the same time prevent heating-up by the sun, reduces power consumption.



(Photo credit: Adolf Würth GmbH & Co. KG)


(Photo credit: HK Architekten)

▲

A partition wall made of CLT panels separates the wire warehouse in the last aisle from the production hall. (Photo credit: HK Architekten)

An elegant building material with a potential for making savings on other materials

Besides allowing the architectural design to be ideally realised, BauBuche also enabled many cost factors to be influenced in a positive way. There was even a cost-saving side benefit like this one:

Thanks to the slim cross-sections of the BauBuche components, the heights of the trussed girders were much lower compared to other materials, resulting in a lower building height and thus less material being used for the building envelope as a whole.

A total of around 1,800 m^3 of timber was used, including around 420 m^3 of the special hardwood, resulting in CO^2 savings of some 3,600 tonnes compared with a conventional construction method (based on a service life of 50 years). In addition, using local timbers had the effect of local added value.

Hardwood know-how

BauBuche trussed girders with large component dimensions are not common. Experienced timber construction specialists are therefore required for works planning, joinery and assembly.

SWG Production commissioned Schlosser in Jagstzell (Germany) with the (pre)fabrication, delivery and assembly of the timber construction. That company already had experience in joining and working with BauBuche components. The timber elements were transported from Jagstzell to the industrial park in 44 journeys.

The main trussed girders arrived at the construction site in three parts, wrapped in foil for protection against the weather: Two end sections and one middle section. With the help of scaffolding, they were assembled with CLT panels into three shed trench sections. Mobile cranes first lifted the parts into position on assembly trestles, then finally the still-missing center piece (known as the "T piece") was inserted from above and screwed into place to complete the shed trench.

BauBuche needs BauBuche-compatible screws and tools

Manufacturing BauBuche components requires a certain know-how beyond the usual timber construction methods using softwood. When it came to manufacturing components for the production hall, Schlosser already had the advantage of past experience. Two aspects are particularly important here:

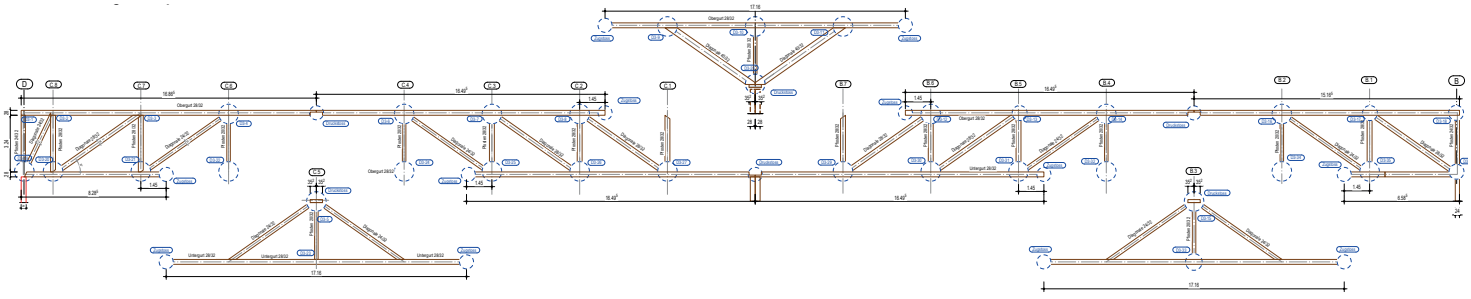
The use of BauBuche requires the use of special screws and steel fasteners approved for BauBuche. Suitable fasteners made by SWG itself were therefore chosen for the frameworks; in particular Würth ASSY® fully-threaded screws – or more precisely the ETA (European Technical Assessment) of BauBuche from Pollmeier (ETA-14/0354) in combination with the ETA of the ASSY® fully-threaded screws from Würth (ETA-11/0190). Because the crucial factor for safe use is the linking of the two ETAs, i.e. the relation that the respective ETA has on the other. By coordinating these two products, the manufacturers give the user and structural engineer the legal certainty of being able to use them together. However, ASSY® fully-threaded screws can also be used for softwood.

The ASSY ® fully-threaded screws are self-tapping screws made of special hardened carbon steel or stainless steel with an anti-friction coating and corrosion protection. The outer thread diameter is between 3 mm and 14 mm, the total length of the screws is between 13 mm and 1.5 m. Because of their great variability in dimensions, this type of screw could be used on all trussed girders, i.e. the main, secondary and bracing trussed girders.

▲ Using BauBuche requires the use of special screws that have been approved for BauBuche. (Photo credit: SWG Schraubenwerk Gaisbach GmbH – Production Division)

Special tool for working with hardwood

Special material-specific tools are also required for working with and assembling hardwood components. For example for predrilling and screwing in the screws. ASSY® are self-tapping screws that do not require pre-drilling. However, due to the high material density pre-drilling is required with BauBuche components. Apart from the fact that this defines the screw positions, which is helpful especially with a large number of screws as with the joints of the production hall, they do not have to be marked out on the construction site.



The assembly concept shows how the individual parts are pre-assembled and subsequently put together in the final assembly to form the 82 m long shed trench. (Photo Credit: SWG Engineering)

This saves time and staff and helps to avoid mistakes. Pre-drilling also enables the screws to be screwed into the components according to plan and accurately, thus ensuring the necessary process safety. Due to the high material density of the BauBuche, it should also be ensured that shorter screws with larger diameters are used rather than long thin ones. And last but not least, you need a screwdriver with high torque to screw in the screws.

Dipl.-Ing. (FH)
Susanne Jacob-Freitag, Karlsruhe

▼ Photo: Raising a shed trench part, which was assembled with the aid of a scaffold on the construction site as a "trench sole" from two trussed girder parts and CLT panels. (Photo: SWG Schraubenwerk Gaisbach GmbH – Production Division)

The 3.80 m high lattice trusses consist of approximately 28 m^3 BauBuche and weigh around 25 tonnes together with the steel fasteners. (Photo credit: SWG Schraubenwerk Gaisbach GmbH – Production Division)

Can I do that too?

Special knowledge and special tools

Building with BauBuche is still a relatively new way of working. Besides special machines, tools and fasteners, some experience is required for assembly, milling and drilling so that this hardwood can be handled and worked with precisely.

These requirements already determine whether you are correctly set up for a job with BauBuche components. Josef Schlosser explained that "we had previously gained experience with smaller BauBuche projects and gradually bought the appropriate tools and invested in our joinery machines for these tasks", adding that: "However, the size of the hall SWG Production was a challenge even for us, and one that we would not have been able to tackle without our previous experience and specialist knowledge."

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