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Constructing life while building bridges

The trials and evolution of Craig Finley, Jr. 10

Sneek bridges show potential of timber

Innovative processes used in open truss foot bridges. 15

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Sneek bridges show potential of timber

Innovative processes used in open truss foot bridges.

By Frank Miebach

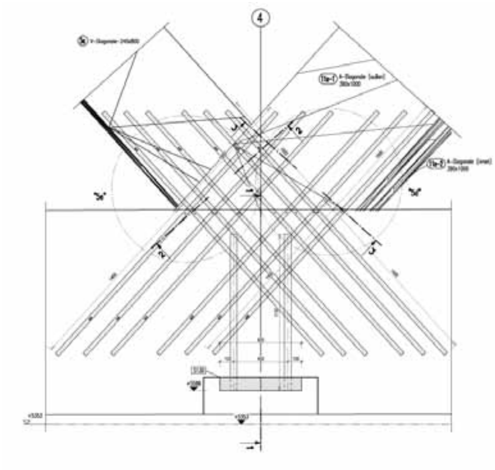
Sneek, the Netherlands, is home to two singular bridge constructions that carry multiple innovations. Connection technique, assembly, and a new modified wood highlight the potential of timber in construction.

The Sneek bridges cross the A7 motorway, connecting two districts. Each of them has a weight of approximately 450 tons, a height of 52 feet, a length of 105 feet, and a width of 39 and 26 feet, respectively. The new eye catchers were manufactured out of a modified wood: 24,367 cubic feet of Accoya wood, made from FSC-certified radiata pine that undergoes a non-toxic modification process called acetylation, making it more dimensionally stable and highly durable. The construction is an open truss bridge with a spatially twisted truss.

The architecture

The architecture firm OAK (Onix Achterbosch Architecture) won a publicized competition for the project with distinctive timber bridge drafts. Sneek, located in the province of

The twisted construction units feature a cutout from a spiral and/or a helix, requiring direct, twisted gluing for which there are few existing examples.



Glued thread rods were used as bending resistant main methods of jointing. The bars have partial lengths more than 6 feet, 7 inches, and are drilled into the cross-grained wood of the diagonals.

Sporting a solid, complex shell construction made from exposed wood beams, a bridge located in the Netherlands was designed to reference the town of Sneek's historical water gate landmark.

Friesland (in the north of the country), has a beautiful historic town center, is well known for water sports and tourism, and has, among other things, a salient historical water gate as a landmark. In the course of a new motorway bypass, which leads circularly around the center, crossing bridges were necessary. In order to give anyone crossing the bridges the feeling of passing a gate with certain reference to the landmark, the planners devised a daring design: A solid, complex shell construction made from exposed wood beams.

Based on the cross-section of roofed bridges, the idea of the framework system was an intentional creative constant. A cross-section, triangular arrangement of the beams made sense for a non-roofed bridge, but the building geometry to free space profile ratio was not particularly favorable. Therefore, a cross-section curved form, which guaranteed an adequate free space without being too large, was created.

The form of a triangular overhead truss appears in the side view. A framework-like filling of this triangle stretches itself with crossing diagonals like a grid network into the shell geometry.

The daring geometry of the structure deemed wood the ideal design solution. The exposed arrangement also set enormous demands on the material and challenged the production process. For both aspects, solutions had to be found.

Material

Apart from the desire for incorporating a natural material, a life span of 80 years was required. Under normal circumstances, this would hardly be achievable for such an exposed, unprotected construction. This could only be realized by constructional wood with high durability and stability.

It was clear that the complex geometry and large size would require glued construction units. However, naturally durable woods such as bongossi (azobe) or oak can only be used unglued in the exterior. Therefore, a technical innovation in the timber construction was required using a sustainably sourced softwood, which is modified in a non-toxic process that results in Class 1 durability. This high-technology wood called Accoya, manufactured by Accsys Technologies, is made from radiata pine sourced from New Zealand.

Accoya wood's process alters the wood's chemistry through a process called acetylation. Ordinary wood contains molecules called free hydroxyl groups. They easily absorb and give up water, which causes wood to swell and shrink. Acetylated wood has been treated with acetic anhydride, which transforms the free hydroxyl groups into a greater number of naturally occurring acetyl groups that do not bond to water. Shrinking and swelling is decreased by 75 percent. Acetylation keeps water from being in proximity with a food source and thus an environment prone to fungi rot and insect attack.

As with all redwoods, Accoya wood can be glued easily, so it seemed suitable for this application; however, it was being used in this kind of application for the first time. Numerous tests had to prove in advance that acetylating does not impair the glue procedure negatively. The tests showed that Accoya can be glued just as well as conventional glued-laminated timber when using the specific resorcinol resin.

Construction

Translating the architecturally impressive geometry into the language of the technical mechanics was handled by a well-known firm with considerable experience in this exacting area: Emil Lüning, which has experience with complex structures through geodetic timber-domed structures. Emil Lüning tackled the job despite the challenges associated with new methodology.

Sneek bridges characteristics

Length	Approximately 105 feet
Width	Approximately 39 feet and 26 feet
Height	Approximately 52 feet
Material	Open truss Accoya wood bridge with a spatially twisted truss, www.accoya.com
Principal	**Province of Friesland**, Sneek, Netherlands, www.a7sneek.nl
Architecture	**Achterbosch**, Leeuwarden, Netherlands, www.achterboscharchitectuur.nl **Onix**, Groningen, Netherlands, www.onix.nl
Design/ Construction	**Grontmij, De Bilt**, Netherlands — coordination/concrete construction **Oranjewoud**, Heerenven, Netherlands — steel construction **Emil Lüning**, Doetinchem, Netherlands — timber construction
Statistics	**Blaß & Eberhardt**, Karlsruhe, Germany, www.ing-bue.de
Timber Construction Company	**Schaffitzel Holzindustrie GmbH**, Schwäbisch Hall, Germany, www.schaffitzel.de
Project management	**IB Miebach**, Cologne, Germany, www.ib-miebach.de

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It turned out the methods of laminating and jointing are of great importance because the first bridge handles heavy-duty transportion, requiring guaranteed trafficability performance of 60 tons.

Glued thread rods

Thread rods needed to offer high flux with little visibility. Apart from conventional methods, special attention was paid to a new method. Glued thread rods (which are certified in Germany only up to 1.18 inches in diameter) were used with dimensions up to 1.89 inches as bending resistant main methods of jointing. The bars have partial lengths more than 6 feet, 7 inches, and are drilled into the cross-grained wood of the diagonals. Since there is little historical data for these dimensions, numerous experiments were carried out at SHR, the Netherlands timber research institute in Wageningen. An epoxy resin that already delivered an optimal performance for timber reconstruction and is frequently used in that application area was used eventually.

Apart from the space requirement by edge distances, the method of joint connecting causes a high quota of carrier diffusion. This had to be considered statically. The firm Blaß & Eberhardt from Karlsruhe, Germany, was commissioned to do verifiable calculations for the threaded rods for nearly all connections. Some construction units were penetrated extensively and so could be calculated at only 50 percent of the cross section.

Input tension/pre-stressing of the bottom chord

Additionally, the bottom chord had to be coupled with the diagonally upward-running compression arch. This was resolved with a lengthwise chord, which runs within the bottom chord.

The decking is attached on the underside to the wooden bottom chords in both constructions. The first bridge was built in 2008 with an orthotropic steel plate; the second bridge, built in 2010, has a wooden plate with melted asphalt. A prestressed cable in transverse direction also was used here.

An important factor is the possibility of motion between the decking and supporting formwork, which is avoided through suitable connections with elastomer strips and slotted hole restraints.

Manufacturing

Schaffitzel, located in Schäbisch Hall, Germany, was selected to manufacture the bridge due to its specialization in timber construction. The large body of experience within the company in laminated block beams was very important for the principal. The most important factor was the construction of the two-axled way bent construction units. The first step was to glue the construction units' uniaxial to a block and then to mill out the two-axle bending with CNC machines from the full material. It was necessary to look for alternative solutions in order to find potential savings. The twisted construction units feature a cutout from a spiral and/or a helix, requiring direct, twisted gluing for which there are few existing examples.

The procedure had to be empiric in this case as well, and sample construction units were glued. The most urgent question of the owner was whether the geometry could be maintained with this approach, as a tolerance of only .08 inches was required. It had to be clarified how much a twisted construction unit moved

To prepare for final assembly, workers placed a large tent over the shells and heated it. After this, the bonding of the threaded rods using the prepared holes could take place.

Two self-propelled modular transporters (SPMT) vehicles were used to move the 400-ton bridge 2,624 feet, 8 inches from the assemble area to the final location.

backward when the gluing presses are opened (resetting). A defined measure showed up with the test pieces, so that a sufficient resetting could be considered and the maximum tolerance could be maintained in the manufacturing process.

The drilling of the 8.8-foot-long holes also posed additional challenges. Since the close drilling raster allowed only small deviations, high precision was necessary, but without CNC support. The tilted drillings were completed in the technically most demanding curved units with templates and auxiliary constructions.

As a pre-assembly assistance for the two shells, a curved assembling table was built for each part with the same radius as the final shell. The glued construction units were laid out and tied successively on the table, with individual parts weighing as much as 20 tons. After this pre-assembly, the threaded rods were glued in the middle vertical carrier (king handle). Due to the large size, the remaining construction units could only be glued to the others at the final assembly site.

Assembling

For the final assembly, all prefabricated parts were delivered to an assembling area near the final bridge location. The parts were laid-out on the assembling tables. After all threaded rods were added, the workers placed a large tent over the shells and heated it. After this, the bonding of the threaded rods using the prepared holes could take place.

In the same way, special plans were necessary for the two ridge steel plates of the first bridge — they were 3.94 inches thick, more than 16 feet, 4 inches long, and 5 feet, 3 inches high — and thus could only be inserted onsite. After completion of the two timber shells, the joining of the three large elements took place: The two timber shells were taken up laterally on the decking and attached from the underside.

The final assembly of the bridge took place as a complete unit with nearly 400 tons of weight that had to be moved 2,624 feet, 8 inches from the assembly area to the final location. For that purpose, two self-propelled modular transporter (SPMT) vehicles, each with 10 guidable single axles, were used.

After reaching the final location over the motorway, the construction was pushed up to the final height of approximately 16 feet, 5 inches by presses and brought in accurately.

Conclusion

The impressive impact of the Accoya wood bridge is possible through its solidity and uniqueness of design by using timber. During the production phases, several challenges were encountered, which were close to the limit of what is technically feasible. Thus, such a construction project also must be considered from a critical perspective. The technical achievement of the timber construction company Schaffitzel deserves special mention here — particularly as the proof of high precision without CNC assistance was demonstrated.

The enormous motivation by all parties involved brought the project to perfect completion, and will probably be a historical moment in the building of timber bridges.

Frank Miebach, Dipl. Ing. (FH), is a graduated engineer and co-founder of Schaffitzel + Miebach Faszination Brücken, a firm specializing in the design, planning, and construction of timber bridges. He can be contacted at presseservice@schaffitzel-miebach.com or www.schaffitzel-miebach.com.

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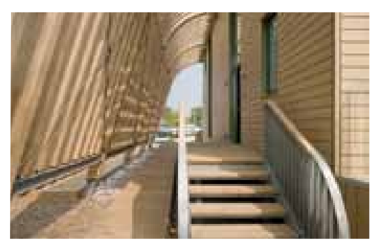

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