SOLID TIMBER BRIDGE CONSTRUCTIONS

Design by material

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Summary
The paper shows inventive design by bloc-glued structures in combination with granite and concrete slabs, and also examples of timber-concrete and timber-granite-composite

Field report with older and new examples from central Europe

Focus: different ways of designing protected bloc-laminated constructions and feedback from clients, case study of timber-concrete composite constructions in combination with bloc laminated beams.

Keywords: timber bridge design; glulam structures; block lamination; timber concrete composite; timber granite composite; natural stone slabs; solid timber structures

1. INTRODUCTION
Glulam is a structural timber product consisting of number of layers glued together to a certain cross section. Further it is possible to block laminate a number of glulam beams together to achieve bigger cross sections. Block lamination generates massive timber cross section to achieve loadbearing structures for large spans with a thin side view.

2. Massive timber structures
2.1 Glulam structures
The development of gluing technology including block lamination is a type of the retarded timber industrialization.

2.2 Block laminated structures
Block lamination generates massive timber cross section to achieve loadbearing structures for large spans with a thin side view. Block lamination comprises three main steps: limitless gluing of lamellas through finger jointing, gluing layers of lamellas to a glulam beam and finally gluing numbers of beams to a massive block.

a) Horizontal block lamination (curvature in side view)
or b) vertical block lamination (curvature in top view).

A part from curved gluing, through block lamination stepped beams are feasible both in cross section and in longitudinal section. There for glulam beams with different height or length are block-laminated to one block beam.

2.3 Timber-concrete-composite bridges
The increasing role of ecology and sustainability of building materials more and more influences construction industry and leads to a rethink on site of the builders. The symbiosis between wood and concrete has the best conditions to meet all resulting claims. Constructions of massive wood beams statically connected to a concrete slab on the upper side ensuring optimum utilization of the material specifications of both materials. In this case the wooden cross-section is considered to take tensile forces and the concrete slab takes the pressure forces. Special connectors ensure the interaction of timber beams and concrete slab to get a more effective loading capacity and serviceability.
2.3.1 HBV-shear connector
The HBV-shear connector by TiComTec (Haibach - GER) is an expanded metal part that is glued perpendicularly into the wooden structure. The dimension and number of connectors is determined to the static needs. The concrete slab usually has a thickness of at least 20 cm and has several functions: road decking, carrier plate for the dispersal of transverse loads and constructional wood protection.

2.3.2 Head bolts
As known from steel-concrete bond structure in this alternative the connecting parts between wood and concrete are steel bars with welded head bolts. The bars fit exactly into milled kerfs and are fixed with screws. To achieve an efficient utilization, the axial distances of the dowel bars correspond to the traffic load and transverse force caused by the traffic load.

Kerfs and Glued in reinforcement bars

3. TIMBER – GRANITE-HYBRIDE
A hybrid structure refers to techniques where the advantages of two technologies or materials are combined optimally together.

So the combination of a carrying timber structure with granite as a bridge flooring material brings interesting prospects:

Two natural materials with different properties: timber has a high tension (and good pressure) capacity, but needs protection against weathering. And granite with its high compression capacity is a waterproof material. So it's attractive to combine both materials for bridges.

Research projects engage in the idea of combining it also statically with shear connectors.

4. INSPECTION AND MONITORING
Bridge structures are part of the traffic infrastructure and therefore part of administrative structures. Owner of the structures are mostly government institutions such as municipalities, counties or the federal government. Regular inspections are standardized in Germany by DIN 1076. Within the planning phase accessibility for inspection as well as possible renovation or replacement of components of a bridge structure need to be considered. Typical damages in timber constructions are caused by a high level of moisture that allows growth of wood-destructing organisms.

4.1 Permanent moisture control
One type of monitoring system is the permanent control of wood moisture. Sensors that measure the level of wood moisture are placed inside a wooden element.

The data is collected in a logbook and can be send online to the client or is read out in a certain period.

4.2 Automatic location of leakage
Another type of monitoring is the permanent control functional test of a sealing. Therefore a fibrous web or membrane is placed between the timber structure and the sealing. The membrane is connected to a minimum electric potential. Once the sealing gets permeable and moisture gets in contact to the membrane an electronic signal is generated. The membrane is connected to a digital system that raises alarm by sending an email to the client, once the electronic signal occurs.

5. CONCLUSIONS
A changed awareness on ecological matters is the proper basis for timber bridges. Timber is the one and only material that saves and stores CO2 permanently. And the technical possibilities are still growing. For example, researches on modern glues and gluing methods show in near future glues will be more efficient (temperature-resistant and the level of bonding pressure during the gluing process will be halved from 0,4 N/mm² to 0,2 N/mm²). Against this background the combination of block lamination and timber-concrete-composite is the beginning of the latest development: The comeback of timber bridges as adequate road bridges.