The depth of the beams at mid-span can be minimised, which is good for flood capacity

The concrete deck slab protects the wooden beams

STAYING POWER

A timber and concrete composite bridge which was recently completed in Germany demonstrates an appropriate application for this under-used material, as **Frank Miebach** explains

Though bridges built in wood have a centuries-old tradition, in recent decades they have become considerably less commonly-used. Arguments for not using timber are that it is not durable or that its maintenance costs are too high.

However research carried out by Frühwald and Wegener for the German Institution for Wood Research in Munich not only proved that wooden bridges bind a great deal of CO_2 and therefore are environmentally friendly, but that they also have a significantly longer life expectancy and lower maintenance costs than is commonly assumed. In order to achieve this, the bridge structure must be appropriately configured so that the structural timber is protected.

Advances in connection technologies mean that the two materials can now be combined in a shear resistant way, similar to that of steel-composite construction.

This timber-concrete composite construction is suitable for road bridges of spans ranging between 10m and 30m. Optimal use of the properties of both materials is achieved when the cross-section is designed such that the concrete is in the compression zone and the timber in the tensile zone.

The concrete slab provides the underlying timber with protection against weathering, which can double the life expectancy of such bridges. The costs of maintenance are reduced and compared to concrete bridges, composite bridges are lighter and more efficient in their capacity. Timber meets all the requirements of sustainable construction. One cubic metre of wood stores approximately 1t of CO_2.

To a large extent, timber-concrete composite bridges can be prefabricated, so this type of bridge benefits from a very short site assembly time, sometimes just a few weeks. In general, it is not only the fact that the timber beam is prefabricated in factory conditions, but also that concrete formwork can be assembled ahead of the work on site.

A new timber-concrete composite bridge was recently built over the Agger River in Lohmar near Köln in Germany. The structural system is designed to make the curves of the main beams clearly visible.

The existing bridge which linked these two districts in Lohmar was demolished in 2013 as a result of flood damage. Now a new connection has been built in the form of a timber-concrete composite bridge.

The bridge responds very well using the static properties of the two materials; timber and concrete. In the upper structure, the main load is carried in compression in the concrete deck slab. The timber is used for the main beams in the predominantly tensile parts of the superstructure. As a result, a considerable part of the tensile stress is accommodated by timber, so the concrete can be minimised to a thin slab. To relieve the bending moments in the centre of the span, additionally, the end portions are anchored to the abutment using tension rods. This means that the depth of the timber beams at the mid-span can also be minimised, which is particularly important during flood conditions.

Through the use of natural timber, an ecologically-sustainable structure can be created that blends into the surrounding landscape. The bridge is constructed of approximately 112m^3 of timber, hence about 112t of CO_2 are stored. Combining it with concrete gives the bridge the capacity to resist the high point loads imposed by the heavy traffic. The concrete slab provides the underlying timber with protection, which at least doubles the lifetime.

The structure is designed as a three-span system with the cross-section reducing towards the centre. The curved wooden beams make for an aesthetically-pleasing structure while the design also makes the force behaviour in the structure highly visible. At the intermediate piers the structure experiences high supporting moments.

The timber beams consist of spruce block glulam and durable wood Accoya is used for the exposed handrail. The top of the deck is covered with mastic asphalt, and the footway area is treated with epoxy resin and quartz sand.

The field assembly was carried out using HBV shear connectors supplied by Ticomtec. This is an expanded metal product; the lengths and the heights used depend on the requirements of individual applications. The connector must be embedded perpendicular to the top surface of the wood and its deflection is limited to 10mm. The shear connector and the adhesive provide the composite action between the wood and the concrete.

The wood-concrete composite system with glued-in HBV shear connector was approved at the material testing office of the University of Rhein Main in Wiesbaden, and the structural system was accredited through further tests by the Technical University in Munich. The system showed very rigid load-bearing characteristics from an elasticity perspective and full blown yield characteristics in the failure state.

The structure was designed by Miebach Ingenierbüro for bridge owner Rhein-Sieg-Kreis Planning Office – it has a length of 40m with a main span of 28m and side spans of 5.5m on each end. The width between the parapets is 4.75m and the roadway width is 3.5m. Some 112m^3 of glued laminated timber (spruce GL32c) was used, about 1.8m^3 Accoya and a slab of C35/45 concrete of approximately 66m^3. Construction cost approximately US$730,000 and took nine months; work was carried out by contractor Busmann and specialist Schaffitzel Wood

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