Inspection of timber bridges with ultrasonic echo technique

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Damages, defects and inhomogenities inside of wooden construction components (e. g. interior rot, knots) or at inaccessible surfaces present an important problem as they can cause sudden failure of the component or structure. Therefore, according to the German standard, regular inspections of (concrete, steel, timber and all other materials) bridges are required every three to six years. In 2008, a 107 m red ironwood bridge was closed immediately, because of vast internal fungal damage of the main supporting structure. It was not visible from the outside during the "normal" structural inspection, but only detected with ultrasonic echo and verified with the drilling resistance technique. Subsequently, according to the Federal Ministry of Transport, Building and Urban Affairs on the 11.12.2008, timber bridges in the field of interstate highways have to be inspected with non- and minor-destructive test methods (in particular with the laminar ultrasonic echo technique) in addition to the usual bridge test according to DIN 1076:1999.

Because of that about 40 pedestrian and bicycle timber bridges were inspected by the authors and their colleagues. All of the bridges were only permitted for pedestrians, bicycles and horses, none of the inspected bridges was for cars or trucks. Most bridges – all smaller ones – were simple beam bridges. Some of the bigger ones are multiple span beam bridges, truss frames, kingpost trusses or arch constructions. Almost all bridges have a simple board decking because of the exclusively pedestrians use. The load-bearing timber structure consists of solid wood, composite or glued cross-sections. Mostly European softwoods (spruce, rarely pine and larch) are used with a low (→ spruce) or medium (→ pine and larch) natural durability. Especially the glued cross-sections are only made from softwoods. Because of the high natural durability, some bridges were made from oak or red ironwood solid timber or composed cross-sections (composed with gate hooks).

For the inspection of timber bridges according to the German standard DIN 1076:1999 a combination of tapping with a hammer and visual inspection is required. Therefore all building components of the bridge have to be accessible by hand, which is not possible at many constructions. Furthermore the visual inspection provides only information about the surface of the building component. Damages in the interior are not visible. Usually tapping with a hammer on the surface is used to detect interior damage, but only damages close to the surfaces can be found.
In suspected areas estimated by visual inspection drilling cores are used to detect damages and their extend in the interior of wooden construction components to calculate the remaining cross-section.

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However, the information from the drilling cores is restricted to the pertaining measurement points. It requires of a lot of experience to conclude on the status of the whole subject. Often numerous measurement points (drilling cores) are necessary, which still may remain insufficient for larger buildings. The destruction from drilling cores (up to 30 mm diameter) must be considered which may be intolerable for statically highly stressed parts (which should all be covered). In heritage-protected buildings, drilling cores are understandably limited.
Only few engineers use the drilling resistance method for the inspection of timber bridges, because a lot of knowledge is required. The ultrasonic echo technique is used just by very few people – here the most knowledge is necessary.
Because the Federal Ministry of Transport, Building and Urban Affairs enacted on the 11.12.2008, that timber bridges in the field of interstate highways have to be inspected with non- and minor-destructive test methods (in particular with ultrasonic echo technique) in addition to the usual bridge test according to DIN 1076:1999, most of the shown timber bridge inspections were made with a combination of visual inspection and ultrasonic echo technique. If there was a clear echo from the back wall it was assumed that the specimen is free of defects. In case of missing back wall echoes, the ultrasonic echo measurements were accompanied by the drilling resistance method.

If the potentials and limitations of the non- or minor destructive testing methods in regard to the evaluation of timber structures are taken into account, the ultrasonic echo technique in combination with the drilling resistance method deliver an accurate view inside the internal structure of the load-bearing timber members of bridges. So the remaining load bearing capacity of the cross sections can be calculated.

The timber bridge inspections showed, that correct and regular maintenance is the main problem at wooden bridges (especially wet dirt and missing or damaged sheetings as constructional wood preservation). Lack of maintenance causes most of the damages. In the paper typical damages of timber bridges (e. g. at the column base, bridge bearing, longitudinal and transverse girders) and the possibilities of their detection by ultrasonic echo technique in combination with drilling resistance are shown in detail.