Some examples of the assessment of Slovenian historical timber structures

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Abstract In the last 20 years the Section for Timber Structures of Slovenian National Building and Civil Engineering Institute assessed several historic timber structures. The assessment was usually performed as visual inspection, combined with semi-destructive testing. This paper presents typical assessments of timber roof structures, massive and hollow timber floors and timber bridges.

Keywords assessment of timber structures, typical damages, residual load bearing capacity, proposed reinforcement measures

1. INTRODUCTION

1.1. General information

The assessment of deteriorated timber structures should give information whether it is from structural point of view possible to preserve existing structure or it should be decommissioned completely. In the last 20 years Section for Timber Structures of Slovenian National Building and Civil Engineering Institute (ZAG) assessed several (historic) timber structures. Different methods of assessment were used: non-destructive testing – NDT (visual inspection, sound emission, ultrasound), semi-destructive testing – SDT (core drilling) and destructive testing – DT (bending test). The implementation of most commonly used methods is further on introduced on four typical examples of assessment.

2. EXAMPLES OF ASSESMENT

2.1. Roof and floor structure of Minorite monastery in Maribor

Due to the high deterioration level practically all elements of roof structure were at least visually checked (in combination with sound emission and core drilling). The most problematic parts of structure were found on spots where steady wetting was present. In these parts combined attack of fungi and wood insects caused substantial deterioration of roof and floor elements, sometimes even the total loss of strength.

The general assessment conclusion was that due to the high level of deterioration not all timber structures could be preserved. The roof structure and timber floors in the SE part of the building were deteriorated in such extend that their preservation was not reasonable. The roof structures in the other parts of the building could in general be preserved, but all red dot marked elements should be

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replaced. The complete hollow floors and the most damaged elements of massive timber floors should also be replaced.

2.2. Massive timber floor in mansion "Naskov dvorec" in Maribor

When mansion "Naskov dvorec" was renovated, the frescos were discovered under the limed ceiling. Therefore preservation of massive timber floor was essential. Visual overview combined with SDT revealed typical traces of wood fungi and insects attack. Most of the damage on timber elements was caused by the insects, mainly house capricion (Hylotrupes bajulus). The damage caused by fungi was local, mainly on supports and near outside walls.
The assessment proved that the majority of massive timber floor elements could be preserved. The deteriorated parts of massive timber floor elements (or whole elements) should be replaced, all replaced (parts) of elements should be impregnated. The most damaged top layer (2 – 3 cm) of massive timber elements should be manually removed and impregnated with insecticide. Additional separation layer has to be installed to prevent the load transfer to timber beams (additional reinforced self supporting slab will be installed above timber floor).

2.3. Timber floor in Town hall in Kočevje

Subject of assessment were the hollow timber floors in 130 year old masonry building in Kočevje. Since there were no records about the floor structure, the cross sections of floors were evaluated from the opening spots in the 1st and 2nd floor. Both spots (1 x 1.5 m) were located near supports on outer walls. The structure in the first floor was in very good condition. The gravel/sand layer was completely dry. Timber beam members were not deteriorated; only minor side cracks on the beams were identified. Gravel/sand layer on the second floor was also dry, but the consequences of wetting were visible: On the bottom side of top planks fungi were present and the beam elements near support were affected by the brown rot (approximate depth 2 cm).

The ultimate limit state and the serviceably limit state were checked according to EN 1995-1-1:2005 using the EN 1991-1-1:2004. In bending, design action exceeded the design resistance (approximately by 10%). If partition walls were taken into account, the ratio design action/design resistance increased to more than 3.4. Similar conclusions can be made for the serviceability limit state. However, we estimated that all floor structures could be preserved if partition walls were removed and self weight load was decreased – the depth of sand/gravel layer should be reduced or replaced with the new lighter sound isolation material.

2.4. Timber bridges over Krka river

Although the massive most commonly oak timber bridges were quite common in the past, the use of timber for the bridge construction in Slovenia drastically reduced. Two timber bridges that both cross Krka river to island town of Kostanjevica na Krki present the typical examples of traditional timber pile bent bridge construction. Both bridges were subject of systematic periodic inspections which ZAG performed for the Slovenian Roads Agency (DRSC). The periodic inspections were performed as visual, combined with the simple acoustic emission. Besides general information (dates, responsible persons, preformed - or skipped - maintenance work, extraordinary events, etc.) the inspection report includes detailed description of damage (deteriorations, inspection conclusions with general and urgent measures). When assessing the bridge the following components most commonly prove to be problematic: approaches to bridge structure, eroded or overgrown river banks, corrosion of steel connection elements (which sometimes have to be retightened), fungi and insects based deterioration of pillar and beam elements, attachment of upper deck and deteriorated bridge railing. Both bridges were in all periodic inspections assessed as relatively safe with some deficiencies which mainly origin in poor maintenance.

3. CONCLUSIONS

Four typical assessments of timber structures, performed by ZAG, present the application of simple NDT and SDT methods (visual inspection, hammer and chisel, simple acoustic emission, core drilling). Due to the methods used the conservative decisions about the level of deterioration sometimes had to be made. Hopefully we will be able to upgrade presented methods in near future in order to derive more exact picture about the residual performance of structures.