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CHARACTERISTIC OF DAMAGE TO THE STRUCTURAL ELEMENT BY CREATING ITS "DEGRADATION PROFILE"

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Abstract: *This paper presents results of experimental establishment of the extent of damage and changes in strength of a wooden structural element (a rafter base) through the creation of its "degradation profile." The tested part of the structural element was divided into segments by the means of a regular network from which standard test specimens were made with dimensions of 20x20x30 mm on which strength tests under compression along the fibres of wood were carried out. Readings were divided, according to the decrease in the property observed against the values of healthy (undamaged) wood, into 4 quality groups and then transferred back to the network of segments. A graphic model description of the shape and course of degradation of wood caused by wood-destroying fungi was created, marked as the "degradation profile of an element".*

Keywords: ***Wood, Timber, Wood-destroying Fungi, Degradation profile.***

1. Introduction

Durability and reliability of wooden structures and individual wooden structural elements in-built in buildings are considerably affected by the activities of many destructive biological agents. Among the most important biological pests are wood-damaging fungi. There is a considerable amount of information available about their morphology and principles of their destruction effect on wood (Schmidt 2006, Beach-Andersen 1995, Reinprecht 1996). Information on the changes in mechanical properties of wood due to their effects is available mainly based on experiments conducted under laboratory conditions (Singh 1994, Reinprecht 2008). Relatively little attention has been so far paid to the effects of wood-damaging fungi on changes in mechanical properties of wood under real conditions of actual structures.

The performed experiment was aimed at detecting the decrease in mechanical properties - compression strength along the fibres in wood samples prepared from a structural element (the bottom part of a rafter) damaged by the activities of wood-damaging fungi in a roof frame structure of a real building.

What was chosen for the experiment was the bottom part (the base) of a rafter from a roof beam structure of a historic building in the centre of Prague. According to the data collected from the construction documentation, the roof beam structure dates back from 1866 - 1868 when the last known reconstruction of the building was taking place. The roof beam structure of the building's gable roof consisted of 13 trusses. The tested part comes from a rafter on the western side of truss No. 8 (Fig. 1). The rafter base was damaged by wood-damaging fungi (brown rot). The damage took place long time ago. At the time of the survey of the quality condition of wood elements and the realization of repairs, wood-damaging fungi were in a non-active stage. By performing laboratory analysis using the cultivation method, the presence of viable germs of wood-damaging fungi of the *Trametes* and *Gloeophyllum* genera was identified in fragments of wood from the damaged part.

2. Methodology:

Part of the rafter, separated for experimental tests, was 60 cm long with a cross section of 12 x 15 cm (width x height). The damage by wood-damaging fungi observable with the naked eye covered the distance of approx. 40 cm from the end of the element. It was mostly of superficial nature which

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Fig. 1: View of the roof beam structure.

passed from the top surface of the element to the core (central) sections due to the activities of the fungi of the *Gloeophyllum* genus.

With regards to the required size of the test specimens, the dimensions of the tested wooden element and the technological capabilities (handling and woodworking machines), the division of the element "roughly" into a regular network of 12 x 5 x 4 segments of the size of approx. 45 x 25 x 25 mm was selected. More exact test samples of the required size of 20 x 20 x 30 mm were then made from individual segments, where possible. The difference in the sizes of segments and test samples covered losses during the processing (offcut) and allowed to partly offset the natural wood defects (knots, cracks). The division of part of the element by transverse and longitudinal cuts into individual segments and the production of test samples is clear from Fig. 2. Given the extensive damage to some parts and due to the natural defects of the wood, it was not possible, despite this measure, to prepare test samples from some of the segments Fig. 3.

In test samples prepared from individual segments, a test of the limit of compression strength in the direction of fibres was performed. The test was performed using the Testatron load testing apparatus as per the CSN 490110 Czech National Standard. Before the tests, humidity of test samples was adjusted in a climatic chamber to the prescribed 12 %. The testing apparatus and examples from the test of the samples are shown in Fig. 4.

The force at the limit of strength was measured using the load testing apparatus (Fmax). The compression strength was then calculated using formula (1), whereby **σ** is compression strength, $\mathbf{F_{max}}$ is the force at the strength limit and **a**, **b** are dimensions of the loaded surface.

$$\sigma = F_{max} / a * b \tag{1}$$

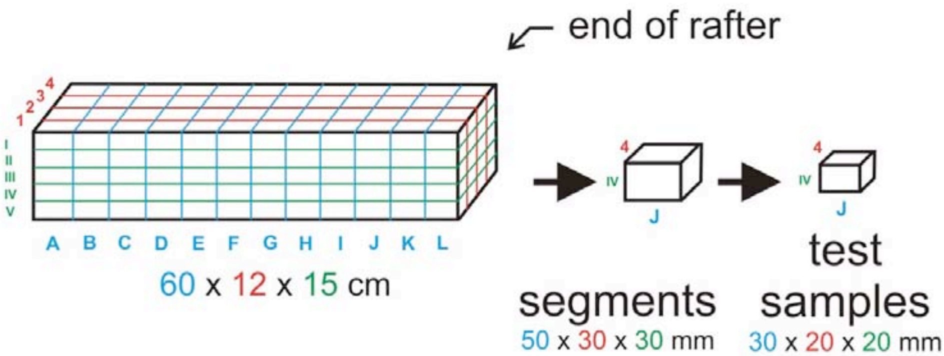

Fig. 2: Division of parts of the rafter into individual segments, their marking and the scheme of the production of test samples.

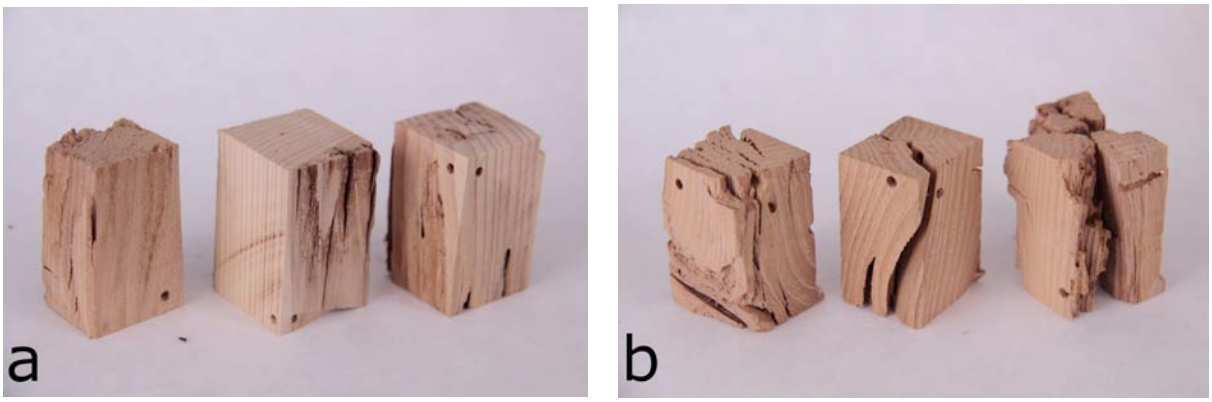

Fig. 3: Examples of segments originated by cutting beams before the production of exact test samples, a) segments with the potential to produce a test sample, b) segments with no opportunity to produce a test sample.

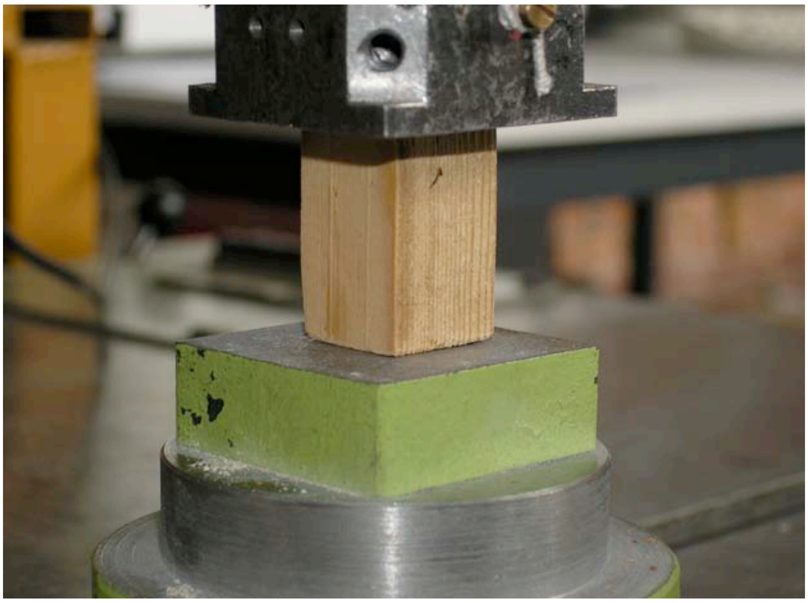

Fig. 4: Tests of mechanical properties of the wood - test of the compression strength in the direction of fibres.

In test samples prepared from individual segments of part of the rafter, the limits of compression strength of the wood in the direction of the fibres were ascertained as ranging from 31.7 to 2.9 MPa. The interval of values of the limit of strength was, for simplification purposes and in order to provide a graphic depiction of the degradation profile of the element, divided into four groups according to the degree of damage or rather the size of the change in the mechanical property under review. The division into groups is clear from Tab. 1.

Based on this division, a degradation profile was prepared, i.e. the graphic depiction of the changes in the wood strength due to degradation by wood-damaging fungi in individual parts of the base part of the rafter. The drawing of the degradation profile in longitudinal sections of rafters (in the pre-selected network of 12 x 5 x 4 segments) is shown in Fig. 5.

3. Conclusions

The experiment presents a considerable impact of destructive wood-damaging fungi on mechanical properties of the attacked wood. From the results of the tests of compression strength of wood and from the processed degradation profile, what is clear is a significant spread of values of strength of wood in individual segments of the element under review. This spread corresponds to the macroscopically observable accompanying phenomena of destruction caused by cellulosevorous

Tab. 1: division of the damage of the elements by wood-damaging fungi into five groups depending on the change (drop) in the monitored mechanical property.

wood	decrease in property (tentative)	limit in compression strength in the direction of fibres
	[%]	[MPa]
sound	0 – 10	31,7 – 28,5
damaged	10 – 40	28,5 – 19,0
strongly damaged	40 – 70	19,0 – 9,5
completly damaged	70 – 100	9,5 – 0

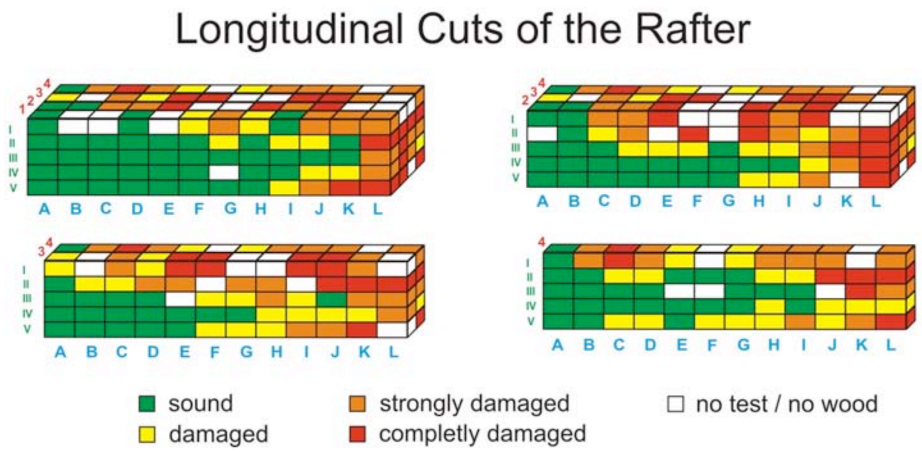

Fig. 5: Examples of segments originated by cutting beams before the production of exact test samples, a) segments with the potential to produce a test sample, b) segments with no opportunity to produce a test sample

wood-damaging fungi (darkening of wood, fissures, disintegration into minuscule particles). The results show that the transition zone between the heavily damaged timber (with a decrease in strength by more than 50%) and healthy wood is relatively narrow and varies in the order of millimetres. The degradation profile of the damaged element reveals changes in shape and considerable reduction of the effective cross section (of sound wood) in the element at the place it was deposited on the top plate.

Spatial descriptions of degradation profiles of elements may serve as a basis for assessing the residual bearing capacity and determining the life of structures in relation to the type of biological damage.

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