Assessment of glulam structures using shear core samples

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1. INTRODUCTION

1.1. On site evaluation of timber structures

Timber has been a structural material for centuries, and numerous examples throughout the world demonstrate its durability. The advantages of glued laminated timber, including its suitability for long spans, diverse shapes and attractive appearance make it the preferred material in wide span timber structures. But timber is biodegradable, and damage attributed to deterioration decreases the capacity of structural members. At best, replacement of damaged members is an acceptable option; at worst, decommissioning of the complete structure is necessary.

1.2. Shear test of glue-lines

The strength of glue-lines in glued-laminated timber elements can be derived by shear tests on circular core samples according to EN 392 or ASTM D 905-03. Such core samples, although they provide only a local property value, are often used to make inferences on the member strength. Since the quality of the glue-line varies within and between members; multiple samples must be taken to account for irregularities and to obtain reliable global estimates of a member's properties.
For testing, the specimens are placed into the ear test apparatus with the glue-line oriented parallel to the loading direction (Figure 1 right). The maximum shear force value is used to calculate the average shear strength (f_S) of the tested glue-line.

1.3. Objective

Alike other materials, glued laminated timber members need to be regularly inspected to prevent premature degradation and avoid structural failures. However, apart from visual inspection, there is a lack of reliable methods to assess the integrity of members in service and to evaluate the quality of glue-lines. The objective of the presented work is to evaluate the application of shear tests of glue-lines in the assessment of existing timber structures.

2. CASE STUDY

2.1. Decommissioned ice rink

At the beginning of 2006, many timber structures in Central Europe collapsed, mostly due to heavy snow loads. As a consequence, existing timber structures were being monitored more closely. One examined structure was the roof of an ice rink in Switzerland, built in 1982 with seating for 4500 people. The complete assessment demonstrated that the roof structure did no longer fulfill safety requirements and it was decided to decommission it. 3 m long sections of each main beam were transported to the timber & composite lab of the Bern University of Applied Sciences for further tests.

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2.2. Material and methods

A total of 10 beam segments were cut into smaller parts. From each 200 mm wide beam segment, 2 bending test specimen, 16 large scale shear specimen and 60 core samples were cut. From the 150 mm wide beam segments, 2 bending test specimen, 8 shear specimen and 30 core samples were cut. To study the variation of shear strength within one glue-line, eight additional cores were takes from 4 glue-lines each. Therefore a total of 20 bending, 128 large scale shear and 608 core samples were extracted. The bending tests were carried out as three-point tests and the bending strength f_B was computed for each specimen. For the large scale shear tests, the specimens were loaded with three glue-lines being exposed to the shear stress between the support and the loaded steel plate and the shear strengths $f_{S,I}$ were computed for each specimen. The tests on the core samples were performed according to EN 392 and the shear strengths $f_{S,II}$ (for samples without glue-lines) and $f_{S,III}$ (for samples with glue-lines) were computed.

2.3. Results

The correlation between the shear strength of the glue-lines with the other recorded strength values is illustrated in Figure 4.

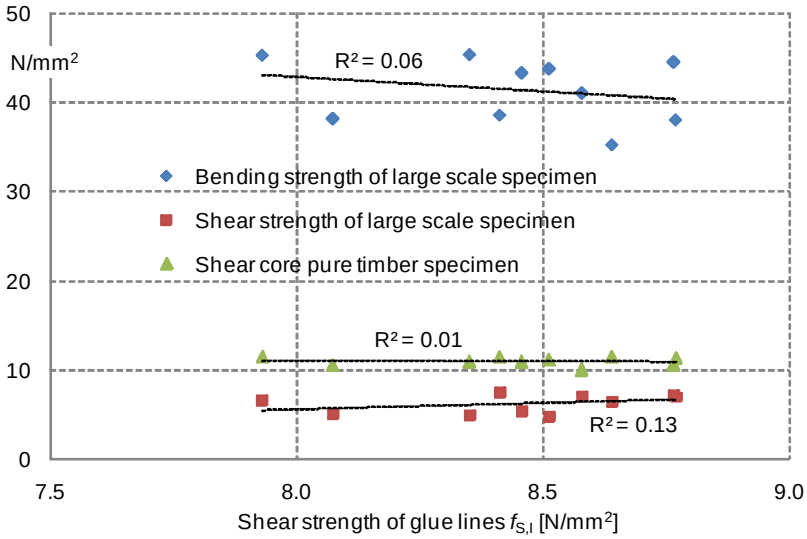

Figure 1 – Correlation between glue-line shear strength and timber strengths

3. CONCLUSIONS

This paper reports on experimental investigations and a subsequent statistical analysis regarding the problematic of making inference on the performance of glued laminated timber beams based on the shear strength of glue-lines. The results can be summarized as follows:

1. Tests on core samples can be used to determine the shear strength of glue-lines; however, as with any technique that utilizes small specimens, the samples give only information about the specific location which they were taken from.
2. No significant correlation between the shear strength of glue-lines and the strength of gluelam beams can be established; this is valid for the bending strength and the shear strength of the beams.
3. The variation in shear strength of samples taken from the same glue-line is significantly smaller than that from samples taken from different glue-lines.
4. Since the results from visual inspections give a clear indication on the state of existing timber structures, the extraction of cores is often unnecessary; if strength estimates are necessary, samples should be taken from the section were either damage is visible or large stresses are expected.
5. As a consequence of the aforementioned, the common practise of deriving the strength of glued laminated timber beams based on the glue-line strength of core samples tested according to EN 392 and evaluated according to EN 396 has to be seriously questioned.