Nondestructive methods for in-service glulam beam evaluation

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Abstract The stability of existing glulam (Glue Laminated Timber) structures became an important issue after the collapse of early glulam structures. The evaluation of the glulam beams starts with visual investigation. A crack dept determination technique have been developed by using ultrasonic tool. Internal defect localisation is possible by ultra sonic method. Re-evaluation of an existing glulam structure needs strength and stiffness data. Ultrasonic wave velocity determination in fiber direction provides the lamella Modulus Of Elasticity, MOE. and strength class.

Keywords **glulam, crack depth, stiffness, internal decay**

1. INTRODUCTION

Jozsef Bodig Nondestructice Evaluation of Wood Laboratory of the University of West Hungary has developed an in-service glulam evaluation practice. Component of the evaluation are laser line supported visual evaluation, crack depth measurement by ultrasound, and MOE determination of lamellas, provides strength class.

2. NONDESTRUCTIVE METHODES

2.1. Laser supported visual evaluation

Shape change of a glulam beam is indicating possible problems. Minor change in beam shape can be detected by sensitive evaluation. A laser line is applied as reference line and the distance between the beam surface and laser is measured by ruler. In case of curved beam we are using laser distance meter. In case of beam deformation found, the evaluation is focused to that particular beam.

2.2. Crack dept determination

Crack dept detetrmination by acoustics provides more precise data especially when crack path is not straight. The cracks are sound barrier. Placing a sound source (also called start sensor) close to the crack line and a receiver sensor to the opposite side of the crack the transit time between the starter and receiver sensor give us information about the crack depth. The recommended distance between

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sensors is 2-5 cm. We also need to know the transit time in the intact , e.g. no crack case. Using the following term give us the crack depth, L (Divos, 2009).

$$L = 0{,}5\sqrt{V^2(T_c - T_i)^2 + 2V(T_c - T_i)D}$$

where: T_c transit time in case of crack,
T_i transit time in case of intact material,
D Distance between sensors,
V p-wave velocity perpendicular to fibers in intact material.

Ultrasonic tools are applicable for the crack depth determination. Figure 1 shows a crack depth measurement. The ultrasonic sensor has 45 degree wave guide Coupling is made by pressing the sensors to the surface by fingers. A rubber spacer between the sensors is applied to keep the constant distance between sensors. Typically the crack dept measured by acoustic methods provide deeper results in crack depth than feller gauge result. An error source is the velocity data perpendicular to the fibers is not uniform, results around +-/ 5% relative error in crack dept determination.

Figure 1 - Crack depth determination

2.3. Strength prediction of lamellas

Re-evaluation of an existing glulam structure needs strength and stiffness data. In case of old beams often no strength grading was applied. Wave velocity determination in fiber direction provides the lamella Modulus Of Elasticity (MOE). The following term provides the dynamic MOE of the lamella:

$$MOE = \rho V^2$$

where: ρ density
V p-wave velocity in fiber direction

The density in-situ determination is rather difficult. Nominal density value of the given species are used in the practice. Because the velocities neighbouring lamellas are different, the sound path may be affected. Testing a low velocity lamella, sound may arrive earlier to the receiver sensor if travels on a longer path in the neighbouring high-velocity lamella. To eliminate this unwanted case, we limit the distance between sensors: less than 20 times the lamella thickness. Figure 2 shows the lamella p-wave velocity determination using FAKOPP made ultrasonic tool. A low velocity rubber bar connects the sensor, helping to keep the constant sensors distance.

3. CONCLUSION

Based on the visual evaluation and NDT measurements, the condition of the glulam beam can be evaluated. Useful data are provided to structural engineers like:

- Beam shape change.
- The real crack depth measured by ultrasonic technique.
- Modulus of elasticity of individual lamella and strength class of the beam.

The combination of the NDT technique and a theoretical approach of the residual stress determination is our next challenge, requires further development.

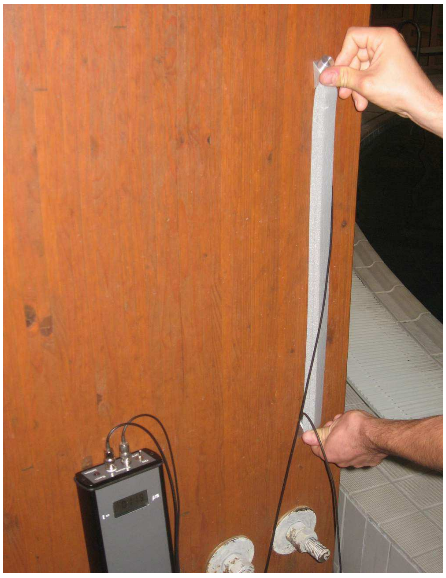

Figure 2 - Velocity determination in a lamella