EAN 2019
57th conference on experimental stress analysis

Different types of damages of glued laminated timber beams

MELZEROVÁ Lenka[1,a] and ŠMÍDOVÁ Eliška[1,b]

[1]CTU in Prague, Faculty of Civil Engineering; Department of Mechanics; Thákurova 7, 16629, Prague 6, Czech Republic

[a]melzerov@fsv.cvut.cz, [b]eliska.smidova@fsv.cvut.cz

Keywords: Glued Laminated Timber, Two Types of Damages, Four-Point Bending Tests, Finger Joints

Abstract. Twenty-six glued laminated timber beams were tested in four-point bending until failure. Two types of damages have been identified. The first type of failure is a longitudinal crack. This crack usually begins at the point of knot or other wood defects always in the tensile area. The second, more frequent type of failure is the destruction of the finger joint, which is located at the lower edge of the beam in its middle third.

Introduction

Twenty-six glued laminated timber beams were tested in the laboratory of the Faculty of Civil Engineering. Beams have been tested in several series since 2005. Two types of damages have been identified. This work complements research conducted at the other universities with beams of other dimensions. One of the papers on this subject was published by Erik Serrano [1,2]. The investigated beams had cross-sectional dimensions of 0.1x0.32 m and were composed of eight 4 cm lamellas. The beam length was 4.5 m and the support spacing was 4.2 m. The beams were subjected to a destructive four-point bending tests with loads in thirds of the span.

Types of damages

Two detected types of glued laminated timber beams failure are as follows. The first type of failure is a longitudinal crack. This crack usually begins at the point of knot or other wood defects always in the tensile area (Fig. 1). Cracks have always propagated through individual laminations and their transition from one ply to the other was smooth regardless of the horizontal glued surfaces.

Fig. 1: A longitudinal crack

This type of beam failure is exceptional. Large knots are removed during the production of glued laminated timber. The load needed for its creation is extreme. The second, more frequent type of failure is the destruction of the finger joint, which is located at the lower edge of the beam in its middle third (see Fig. 2).

Fig. 2: Destruction of the finger joint

Both types of damages were obtained by the evaluation of the camera recording made during the bending tests for six beams. For the previous twenty beams, a plot of cracks after collapse of the structure is available. In these drawings, cracks are seen through the finger joints. This is the case with thirteen beams. The collapse of these beams occurred at a lower load that corresponds to this failure mechanism [3,4]. The following table (tab. 1) shows the distribution a beam numbers from the presented research program according to their failure, together with the load at the moment of collapse. The load here is the sum of the two loads, in thirds of the span at the four-point bend (see Fig. 3).

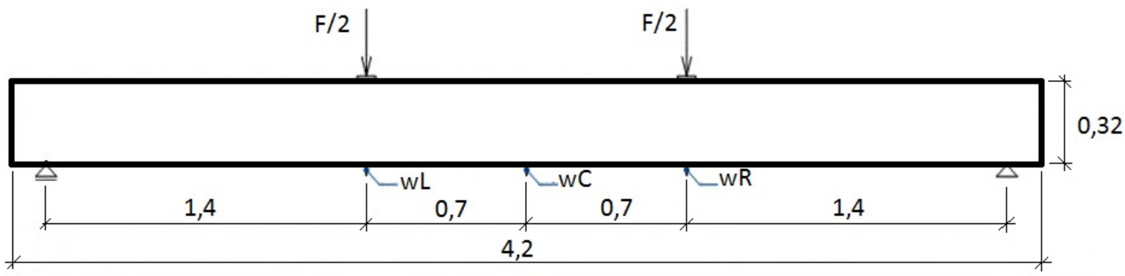

Fig. 3: Example of tested beam

Due to the existence finger joints in the lower lamella, together with a relatively low load level during the collapse of the beam, it is possible to assume damage to the other seven beams through the finger joints.

Table 1: Numbers of beams both damages types

Type of damage	Number of beams	Average loading [kN]
Out of joint	2	138
Through joint	17	72
Unknown	7	85

Further information, which are necessary for the most accurate assessment of beams damage are the results of non-destructive tests. In principle, these tests measure the density of wood. The measured density of wood can also be used to calculate the distribution of modulus of elasticity and wood strength. Non-destructive tests were performed on all 26 beams.

Owing to a considerable heterogeneity of laminated timber structures a large number of local measurements is needed. At present, only one such experimental method, which builds upon driving an indenter with the help of Pilodyn 6J device in into the wood, is available. In particular, a spike 2.5 mm in diameter is shot into the wood with the enforced energy of 6 J. The local elastic modulus in the fiber direction is then evaluated empirically based on the depth of indentation as,

$$E = -564{,}1 \times t_p + 19367, \tag{1}$$

where E is the searched Young's modulus in MPa and t_p is the measured indentation depth in mm.

Research has shown that material with damage, localized at critical finger joints, could be used to model the damage of glued laminated timber beams. The degree of this damage could be determined from the beams presented.

The damage caused by the oblique cracks is always initiated by the knot or other damage to the wood. The knot area ratio (KAR) is significant for this type of damage, which is part of existing research following the well-known Karlsruhe model.

Conclusions

The presented article is the basis for the creation for the detailed models of the failure of glued laminated timber beams. The main goal of the paper is to evaluate the adequacy of available experimentally determined data. It is also necessary to put research into the context of previously published works.

Acknowledgement

The support by the SGS project No. SGS17/168/OHK1/3T/11 is gratefully acknowledged.

References

[1] E. Serrano, Rational Modelling and Design in Timber Engineering Applications Using Fracture Mechanics, in: WCTE 2016 CD-ROM Proceedings, Vienna University of Technology, 2016.

[2] E. Serrano, P.J. Gustafsson, H.J. Larsen: Modeling of Finger-Joint Failure in Glued-Laminated Timber Beams, Journal of Structural Engineering, 127, (2001).

[3] P. Kuklík, L. Melzerová, Kompozitní materiály na bázi dřeva. ČVUT, Praha, 2011.

[4] L. Melzerová, Studie přetváření a porušování nosníků z lepeného lamelového dřeva. ČVUT, Praha, 2018.

[5] L. Melzerová, M. Šejnoha, Results of Penetration Tests Performed on Timber GLT Beams, in: World Conference on Timber Engineering, Proceedings, 49-50, (2014).

[6] L. Melzerová, M. Šejnoha, Influence of Distribution of Finger Joints and Timber Flaws on the Damage Evolution of Laminated Glued Timber Beams during Four Point Bending, in: WCTE 2016 CD-ROM Proceedings, Vienna University of Technology, 2016.