MECHANICAL ANALYSIS OF BEECH I-JOIST WITH PLYWOOD CORRUGATED WEB

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INTRODUCTION

Thanks to continuous climate changes, we can observe major changes in forest species composition in central Europe, specifically in larger representation of European beech (Fagus sylvatica L.). The ideal use of beech wood in timber constructions is in the form of 3D light weight structures such as I-joist with corrugated plywood web. Such a structure has major potential to bear big load with significantly lower predisposition to lateral buckling while loaded in bending.

The aim of experiment was to determine bending stiffness and lateral buckling resistance of I-joist with corrugated plywood web by four-point bending test and evaluate the best corrugation design relating to manufacturing process and mechanical behavior.

MATERIAL AND METHODS

To produce beams with a corrugated web, fingerjoint connected prisms with dimensions (b x h) 100 x 60 mm was used on the flanges. A 10 to 20 mm deep groove was created in these prisms along the axial curve of the corrugated panel using conical CNC milling machines with a minimum thickness equal to the corrugated panel thickness for better guiding of corrugated parts while assembling. Five different heights of I-beams were produced in amount of three for each height. The length of the beams was set according to the ČSN EN 408 standard, where possible or optimized to maximum length of 6500 mm. The corrugated webs were fitted into the flange with a longitudinal butt connection without gluing. Web was glued to the groove in the flange with a waterproof polyurethane-based adhesive and clamped using manual screw clamps.

Fig. 1 Pressing machine

Fig. 2 Pressing process

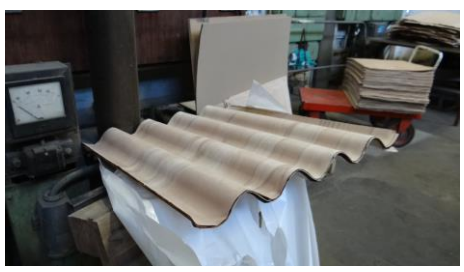

Fig. 3 Corrugated plywood panel

Fig. 4 Record of force measurement

Four-point bending test took place according to ČSN EN 408 which states the distance of the external static supports as 19 times the height of the beam. In case of beams with height of 400 mm and more was impossible to meet standard and the distance of supports was lowered. The loading speed was set so that the max. load is reached in 300 ± 120 seconds.

In real use, the I -joists must also be secured in the transverse direction, otherwise their load-bearing capacity would reach much smaller values. In the case of a corrugated web, where this problem is partially eliminated by the fact that the web is expanded to the sides. The deflection was measured using the optical method (DIC) in combination with side extensometers. Extensometers were placed on both sides of the beam, as it is not possible to predict on which side the beam tilts. The cameras were placed as pointing on the top and bottom of the beam and from the sides of the beam to obtain more accurate data for further numerical model.

RESULTS

When pressing the samples, the corrugated panels tended to tear the surface veneer layers, which would lead to a reduction in the overall strength of corrugated web. The source of this phenomenon is the friction between the top veneers and the mold during press closing. Friction then causes the tension strain which is the highest on the top layers. This tearing was removed operatively during pressing by special 0,2 mm thick silicone paper with weighing of 42 g / m^2. The silicone paper is coated with a silicone layer on one side and waxed layer on the other side. Paper was used in two layers from each side. That significantly lowered friction.

Fig. 5 Silicone and wax paper was inserted in two layers from each side

However, this solution was not 100% functional and sometimes the surface cracks still has occurred. We were able to observe that the cracks appeared in the straight lines and not as fibrous cracks. It was caused by the different quality of left side and right side of the veneer. We have decided to make a pressing test to observe that if we put left side of the veneer i.e. the side in touch with pressure bar while peeling the veneers, we never had the cracks present on the top layers after pressing.

CONCLUSION

During the sample manufacturing, some top layer cracks appeared as expected however we were able to eliminate this phenomenon during pressing by inserting slipping layer and layering top veneers with left side up. Thanks to solving problems with cracking we have made 100% quality corrugated panels which are suitable for further investigation where we can expect higher tilting resistance of the I joist with corrugated plywood web.

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