Study of the long time behaviour of glulam structures

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EXTENDED ABSTRACT

In this article the design, construction, and behaviour over time of 44,4 m span glulam trusses is discussed. The main design parameters of the trusses are as follows: span 44.4m, height 6.49m (theoretical), length of glulam upper chords 24.0m, spacing of trusses 5.0m, spacing of purlins 1.85m, height of the reinforced concrete columns 8.05m. The truss upper chord consists of two parallel-placed glulam elements with a cross-section of 115×900mm. Glulam elements are connected between with blocks of 130×130mm wood. Struts are designed from glulam with a cross-section of 195×360mm.
Steel tensioned diagonals are made from managanese steel Ø50mm and 2Ø31mm for lower chord cable.

The trusses are used for the supporting structure of the first largest sports hall in Tallinn, Estonia. The hall was erected in 1992/93. During 18 years of maintenance, behavior of the structure was carefully observed, and from time to time deformations measured. In some places cracks in glulam elements were strengthened, and bracing between trusses adjusted.

The glulam grade used was class GL24. Trusses were designed by Soviet codes (SniP). The Characteristic value for snow load was given at 0.7kN/m^2, that makes for truss 3.5kN/m (partial factor for snow load 1.6).

Because the design was unique, experimental investigations were carried out using a model in scale 1:5. Large model testing showed the possibility of reducing theoretically determined cross-sections and bracings.
Before erection, field testing of two braced trusses under the static design load was also carried out. These tests demonstrated a good correspondence between theoretical calculations, and model test results.

After completing of hall the moisture content of wood was decreased from 15% to 8% in very short time. It caused cracks in compressed elements, in the upper chord, near the supports. Additional lag screws were used for strengthening cracked glulam elements.

During the first maintenance period (first year), steel bracing between the trusses also became loose. After the correction of tensioning in bracing and a relatively small strengthening of some damaged glulam elements, the structure then behaved normally.

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This research consisted of observing of development of cracks in glulam, periodical measurement of deflections, determining of stress changes in cables, and cracking of bracings. Changes after different loads from self-weight to snow loads were checked. In spring after withdrawal of the snow load, residual deflections were found. It was caused by the local compression of wood elements perpendicular to the grain and by shift in joints.
Vertical deflections of whole system are in accordance with theoretical values. Cables showed some residual strains, Zn-Al alloy connections of cables acted correctly and without shifts.
Cracks in glulam were caused mainly by rapid change indoor climate of the hall. The most dangerous cracks are those that begun in places of high stress concentration (wood-steel joints). After 7 months the cracking mostly stopped.

CONCLUSIONS

The growth of vertical deflection has almost stopped after ten years, and timber connection deformations, or movement does not influence the girder deformations any more.
In spite of bad storage conditions on the building site before erection, and some small cracks that appeared on glulam elements surface during first years of maintenance, the overall technical state (performance) is good. All the same, it is reasonable to re-adjust steel tie-rod forces.