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# Mechanism of Pull-out Performance in Lagscrewbolted Timber Joints III.†

## Development of a theory of pull-out properties perpendicular to the grain

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**Abstract:** Lagscrewbolts were developed as simple and economical moment-resisting connectors for glulam constructions. A lagscrewbolt has two threads :a screw type thread on the outside surface at one end and a bolt type thread at the other end of the shank. A lagscrewbolt is embedded into a glulam member by the screw thread and connected to another piece by the bolt thread. The theory on pull-out resistance of an embedded lagscrewbolt parallel to the grain direction was developed in a previous paper. The purpose of this study was the development of a theory on pull-out resistance perpendicular to the grain direction and its verification using experimental results. The theory for perpendicular to the grain was developed on the basis of Volkersen theory, similar to the theory of parallel to the grain. Shear strength perpendicular to the grain direction $fv_{90}$ and shear stiffness $\Gamma_{90}$, both necessary parameters in the theoretical formula, were determined by pull-out tests of thin 15-mm specimens made of glulam. The effective area of glulam ($A_w$) was determined by an energy equivalent concept, the deformation energy by the theory of a beam on an elastic foundation or the bending theory of a short beam as being equal to the deformation energy of work at the effective area of the glulam. A verification experiment was conducted by using three kinds of lagscrewbolts, in which the top threat diameters were 25, 30 and 35mm, and influences of various embedment depths on the pull-out properties were examined. The developed

theory predicted maximum pull-out load and slip modulus well.

***Keywords:*** lagscrewbolt, pull-out, perpendicular to the grain, Volkersen model, effective area ($A_w$)



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