INVESTIGATION OF LUMBER SHEAR-OUT IN TENSION WEB JOINTS IN METAL-PLATE CONNECTED WOOD TRUSSES

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ABSTRACT: Experimental investigation and comparison to the computational model provided previously [5] using ANSYS non-linear finite element analysis program to model tension web joints in metal-plate-connected wood trusses has been carried out. The theoretical study analysed failure modes of 51x102 mm (2x4-in) Spruce-Pine-Fir web joints and using 3 typical configurations of metal-plate connectors (MPC). The current study tested the same joint configuration over a range of lumber specific gravities that included the specific gravity used in the theoretical study. This study provides results of failure modes for various lumber properties and plate lengths based on the experimental data, including data to support recommendations concerning the limiting tension force per mm (inch) of lumber thickness for a single truss web joint, which will cause joint failure due to wood tension failure, plate withdrawal, plate tension failure or lumber shear-out failure.

KEYWORDS: lumber shear-out, metal-plate connected wood trusses, tension web joints, parallel chord floor truss

1 INTRODUCTION

It has been reported that failure of tension web joints during the testing of truss joints and full-scale parallel chord trusses with metal plate connectors (MPC) has occurred [3]. With metal-plate connectors installed on the narrow face of the lumber, a wood failure sometimes occurs where a block of wood beneath the plate fractures, leaving a significant block of wood embedded in the plate, Figure 1.

There is a concern expressed by some in the industry [3, 4, 6] that the shear-out failure mode can be a controlling failure mode in situations including heavily loaded and short span parallel chord trusses with top chord bearing, with tension webs at very shallow angles, heavily loaded commercial floor trusses, and 102x51 mm (4x2-in) purlin trusses in panelised roof systems.

It is believed that this may be a truss design issue because the plate connector requires some distance to distribute stresses from the tip of the tooth through the thickness of the wood. If significant grain deviations due to knots and/or spiral grain are present near the plate that disrupts the stress flow from the plate to the wood member, then wood tension perpendicular to grain or shear stresses could potentially control the strength of the joint.

2 EXPERIMENTAL INVESTIGATION

In order to provide good comparison, in addition to full-size tension tests, a shear block testing of small clear wood specimens was a necessary task to establish shear strength values and evaluate the shear to tensile strength ratio.

2.1 SHEAR BLOCK TESTS OF SMALL CLEAR WOOD SPECIMENS

In summary, 130 southern yellow pine, hem fir, Douglas fir and northern white pine shear-block specimens were tested according to ASTM D142 [2] to determine their shear strength, Figure 2.
2.2 TENSION TESTS OF METAL-PLATE CONNECTED 51X102 mm (2X4) TRUSS WEB-SPlice TENSION JOINTS

The main objective of this study was to provide experimental comparison to the computational predictions concerning tension splice joint failure modes provided by Vishwanathan [5]. Lumber for this study was selected from the same species as lumber used to fabricate shear block test specimens. 51x102 mm (2x4-in) dimensional lumber of Southern Pine (SP), Douglas Fir (DF), Hem Fir (HF) and White Pine (WP) has been provided from a small commercial lumberyard. The 0.91 mm-thick (20-gage) metal plate connectors were 76x203 mm (3x8-in), 76x254 mm (3x10-in) and 76x356 mm (3x14-in) area with a tooth length of 9.5 mm (3/8-inch) and tooth density of 8 teeth per 6.5 square centimetres (8 teeth per square inch). Test set-up of tension web joint specimens is shown in Figure 3.

3 RESULTS OF JOINT TENSION TESTS

Three types of failures were observed in the tested joints: plate tensile failure, plate withdrawal and lumber shear-out. Plate tensile failures consistently occurred on the net section, across the tooth slots nearest the joint centre. Plate withdrawal is the curling out of the metal plate on one side of the joint. Lumber shear out is a wood failure defined by the separation of a block of wood from one side of the joint.

4 CONCLUSIONS

The current study and the computational study showed agreement on several points. Both studies show that joints with 76x203 mm (3x8-in) plates were most likely to fail by plate withdrawal irrespective of lumber species. Both studies agree that, in general, joints made with 76x254 mm (3x10-in) plates are in a transition zone where the three likely failure modes have similar failure strengths. Joints made with 76x356 mm (3x14-in) plates were predicted by the computational study to primarily fail in plate tension, and this was confirmed by the current study. This study provides data to support recommendations concerning the limiting tension force for a single truss web joint as a function of wood tension failure, plate withdrawal, plate tension failure or lumber shear-out failure.

REFERENCES

[6] Wood Truss Council of America (WTCA) Technical Note, Lumber shear-out at high tension truss plate connections: (TP1-1 Section 8.9 Net Section Lumber Check), Madison, WI, USA, 2006.