USE OF DOUBLE-THREADED SELF-TAPPING SCREWS FOR IN-SITU REPAIR OF CRACKED TIMBER CONNECTIONS

Stephen Delahunty¹, Ying Hei Chui², Mark McCormick³

ABSTRACT: This paper describes a study to evaluate the effect of longitudinal cracks through a bolted connection containing shear plates on the tensile strength of the connection, and a method to repair these cracks using double-threaded self-tapping screws. A test program was first conducted by testing the tensile strength of connections with varying numbers of screws. The test parameters included number of bolts, number of repair screws, and with and without applied tensile load during insertion of screws. Control groups containing no screws, with and without a crack were also included. Test results showed that the tensile strength of reinforced cracked members was at least equal to that of the ‘un-cracked’ members, indicating that the use of self-tapping screws for repairing cracked bolted connection was effective. This approach was then adopted in repairing cracked connections in-situ in a 25-year old roof truss structure built with solid timber members and the same bolted connections with shear plate.

KEYWORDS: Reinforcement, self-tapping lag screws, shear plates, tensile strength, timber connections

1 INTRODUCTION

Large size timbers are especially prone to cracking in service, especially near connections where the wood is restrained against movement due to moisture fluctuation. Repairing or reinforcing these crack beams and connections in an existing structure is costly, as it generally requires a temporary supporting structure in order for the cracked members to be replaced or repair. The potential use of self-tapping screws to repair cracked timber members in-situ without the need for temporary support is attractive.

There is considerable literature on using self-tapping screws as a method to reinforce timbers perpendicular to grain. Lam et al. [1] studied the contribution of self-tapping screws as perpendicular-to-grain reinforcement for bolted connections with slotted in steel plates. The material used was glulam and the connection type studied was a beam-to-column. Blass and Schmid [2] studied the use of self-tapping screws to avoid splitting of members in connections with dowel-type fasteners. In this case the reinforcement was applied to solid, ‘uncracked’ timber as a means to enhance the capacity of the connection.

The study presented here evaluated the strength of the bolted timber connections containing shear plate in tension. The goal of the study was to provide technical data to support the use of such a method in repairing cracked timber members in the roof structure of a 25-year old building.

2 RESEARCH METHOD

In the roof structure under investigation, the timber members are connected using pairs of gusset plates bolted to the connecting timbers. A pair of shear plates are present at each bolt location. For the experimental program, kiln dried, rough sawn 2x6 SPF No. 2 or better grade lumber was used to simulate the truss members. Since the thickness of the shear plate is over 80% of the thickness of the 2x6 lumber, as opposed to only about 30% to 40% of the timbers, the use of dimension lumber would lead to more conservative results. Pieces containing large knots, wane and slope of grain near the shear plate

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locations were discarded. Artificial longitudinal cracks were created in selected groups using a thin kerf saw blade. The cut was made through the full thickness of the lumber passing through the center of the bolt holes as illustrated in Figure 1. Table 1 gives the test program.

<table>
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<th>No. of bolts/shear plates</th>
<th>Crack present?</th>
<th>No. of screws</th>
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</tr>
<tr>
<td></td>
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Figure 1: Schematic diagram of the test setup

A test fixture was made of 13 mm thick steel side members with 19 mm bolt holes to simulate the gusset plates that connect the timbers. Shear plates, 102 mm in diameter were used in the fabrication of selected test specimens. The shear plates were inserted on one face of the test specimen only. Spacing between shear plates was 127 mm and the shear plate closest to the end had an end distance of 152 mm. The specimens were tested in tension with a loading rate was 40 kN/min.

The double-threaded self-tapping lag screw that was used to repair the crack is illustrated in Figure 2. The screw had a T30 torx head and were manufactured from carbon steel. The thread diameter was 6.5 mm and the overall length was 130 mm.

Following testing, samples were cut near the failure location for measurement of moisture content and specific gravity.

3 RESULTS AND CONCLUSION

Figure 3 summarizes test results, giving the average peak load with standard deviation bars for each test group.

The failure mode was consistent throughout the test program; shear plug failure or longitudinal cracking at shear plate location. As expected, the group with the lowest average peak load was the group containing a crack with no screws for reinforcement. In general, the application of the screws leads to an improvement in the load-carrying capacity when compared to both groups that did not contain any screws (with and without cracks). Therefore inserting the self-tapping screws in the truss members to reinforce cracks was an effective method to improve the load-carrying capacity.

Before extrapolating the test results to be used as a prescription for the repair of the full-scale timber connections, several practical considerations are to be addressed. These include the effectiveness of the screws when: (1) applied to the truss member under in-service load (this would determine if temporary jacking of timbers to a non-loaded position is required), (2) the screws can only be installed between the second and third bolts from the end due to the geometry of the connection and (3) the screws are inserted at an angle to the truss member due to the geometry of the connection. These will be addressed and included in the final paper. Additionally, a design analysis detailing the prescribed repair on the actual truss members will be presented in the full paper.

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REFERENCES
