MULTIPLE-BOLT CONNECTIONS FOR LAMINATED VENEER LUMBER

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ABSTRACT: The design of multiple-bolt connections in accordance with the National Design Specification for Wood Construction (NDS) [1] includes provisions for evaluating localized member failure modes of row and group tear-out when the connections are closely spaced. Supported by test results of bolted connections in structural glued laminated timber (glulam) members, the NDS provisions were rationalized by additional data analysis [2] using reduced glulam design shear values. Due to the similarity to glulam in the grain orientation, laminated veneer lumber (LVL) is subject to similar failure modes. As a result, a study was initiated by APA – The Engineered Wood Association and the LVL industry in the U.S., in collaboration with the U.S. Department of Agriculture Forest Products Laboratory (FPL), to determine if reduced LVL design shear values are necessary for the design of multiple-bolt connections in accordance with the NDS provisions. This paper describes the results obtained from the study.

KEYWORDS: Multiple bolted connections; Laminated veneer lumber; Shear strength

1 INTRODUCTION

The design of multiple-bolt connections in accordance with the National Design Specification for Wood Construction (NDS) [1] includes provisions for evaluating localized member failure modes of row and group tear-out when the connections are closely spaced. Supported by test results of bolted connections in structural glued laminated timber (glulam) members, the NDS provisions were rationalized by additional data analysis [2] using reduced glulam design shear values. Due to the similarity to glulam in the grain orientation, laminated veneer lumber (LVL) is subject to similar failure modes. As a result, a study was initiated by APA – The Engineered Wood Association and the LVL industry in the U.S., in collaboration with the U.S. Department of Agriculture Forest Products Laboratory (FPL), to determine if reduced LVL design shear values are necessary for the design of multiple-bolt connections in accordance with the NDS provisions.

2 OBJECTIVES

The main objectives of this study were to evaluate the row and group tear-out failure modes of multiple-bolt connections for LVL when installed with close fastener spacing and to determine if the LVL design shear values are required to be reduced in order to provide an acceptable factor of safety in connection design. The study was initiated by APA – The Engineered wood Association and the LVL industry in the U.S., in collaboration with the FPL, using similar multiple-bolt connection configurations as those used in the previous glulam study.

3 MATERIALS

Forty nominal 1-3/4 in. x 15 in. x 12 ft (44 mm x 381 mm x 3658 mm) commercially available LVL materials were delivered to the FPL in the summer of 2012 for connection testing. Another set of LVL materials that were individually end-matched was delivered to the APA Research Center (APA) in Tacoma, WA at the same time for tension and block shear tests to determine the tensile strength and shear strength of the LVL. The LVL materials at both laboratories were conditioned at 70°F (21°C) and 65% relative humidity (RH) until reaching moisture equilibrium before testing.

Steel side plates of 3/8 in. (9.5 mm) in thickness were fabricated from ASTM A36 steel and used as part of the connections. Bolts were 1 in. (25.4 mm) in diameter, 6 in. (152 mm) in length, and conformed to ASTM 307B.

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3.1 CONNECTION CONFIGURATIONS

Four multiple-bolt connection configurations, as shown in Figure 1, were tested by application of a tensile load from a universal test machine at the FPL. The bolt spacings, end distances, and edge distances are identical to those used in the previous glulam connection tests conducted also at the FPL.

![Figure 1: Connection configurations A through D (top to bottom)](image)

4 TEST METHODS

Figure 2 shows the test setup used to conduct connection tests at the FPL. In order to optimize the testing results, connection configurations were fabricated on each end of the specimen, resulting in 2 connections tested from each specimen. As a result, the ultimate strength of each specimen represented the lower connection strength from both connections of each specimen. The censored data statistics were considered in the data analysis.

![Figure 2: Connection test setup](image)

5 RESULTS

Results of the connection tests obtained from the FPL were compared with the predicted connection strengths using the NDS Appendix E provisions and the tensile and shear strengths of matched LVL tested at APA. The test results demonstrated that the group tear-out failure mode did occur to the LVL, as similar to glulam. However, unlike glulam, the full LVL shear strength can be used without a reduction when designing for multiple-bolt connections in accordance with Appendix E of the NDS.

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REFERENCES
