FRACTURE BEHAVIOUR OF MULTIPLE–BOLT ENGINEERED WOOD PRODUCT CONNECTIONS

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ABSTRACT

Dowel type connections such as bolts are one of the most widely specified mechanical fasteners used in wood frame construction in North America. Current design practice for bolted timber joints is based on the yielding of the bolt or wood rather than the fracture potential of splitting or shear failure in wood. This decision to not formally recognize the influence of fracture within the connection design process could be a critical oversight. Yield-based design of bolted joints can be misleading, especially when multiple bolted connections are considered. This issue becomes even more complex when Engineered Wood Products (EWPs) are introduced as members in the joint systems.

1 INTRODUCTION

According to a survey of current USA and Canadian engineering practices for connections in wood construction administered by University of New Brunswick (UNB) researchers and sponsored by Natural Resources Canada (NRCan); more than 97% of North American design engineers who responded to the survey use one type of dowel connection or another in design of timber structures, with approximately 88% of the respondents specifying bolts for lateral loads (double shear). This testifies to the continued importance of dowel type connections in design with wood construction.

Engineered wood products are manufactured from under-utilized wood species and undersized stems in processes that reduce the raw wood into smaller pieces, then bonds and re-forms them into structural wood products (Green and Hernandez [9]). Presently in North America, mechanical properties of propriety wood composite products are evaluated according to the practices of American Society for Testing and Materials (ASTM) D5456-01 "Standard Specification for Evaluation of Structural Composite Lumber Products" (ASTM [1]). Manufacturers of EWP and connection hardware have responsibility for development of product specific information. As for EWP joints, there is limited information about appropriate test, modelling or design methods. Lack of general design guidance reflects the proprietary nature of the EWP manufacturing processes and wide-range availability of fastener products.

Past work that examined failure behaviour of single dowel connection in engineered wood (Snow et al [16]) indicated that fracture behaviour of different EWPs or solid sawn wood has a profound influence on joint behaviour. Results reinforced the rationale of having fracture theories and models in place to develop generalised predictions of joint capacity. It is essential for continued research on EWP joint systems to consider mechanical properties and failure mechanisms of composite materials as well as behaviour of wood composite joint systems for support and establishment of mechanics-based design methods and methods for obtaining design values.

2 METHOD

This current study examines fracture behaviour for multiple bolt connections of EWP joints under static load conditions and specifically focuses on identification of brittle failure mechanisms in

Laminated Veneer Lumber (LVL), Parallel Strand Lumber (PSL), Laminated Strand Lumber (LSL), and solid sawn wood (used as the control reference). The joint construction examined in this study is a double shear arrangement with 44 mm (1-3/4″) x 89 mm (3-3/4″) EWP or wood used as the main member and 32 mm (1-1/4″) thick GE Lexan® (a high strength transparent polycarbonate) used as side members. Use of the GE Lexan® will facilitate observation and recording of the physical fracture processes. For this study, 19 mm (3/4″) and 10 mm (3/8″) bolt diameters are selected with rigid response of the fasteners ensured in order to capture the brittle fracture modes in wood rather than yielding of bolts.

The concept of constant 'net member area' was used to ensure an unbiased comparison of capacities of different connection arrangements. Net area is the gross cross-sectional area of the member minus the projected area of the bolt-hole(s) within the member at the critical plane. This control will negate the influence of reduction in load carrying capacity of the member due to loss of wood material at the connection and eliminate 'size of cross-section' effects on strength.

The multiple-bolt configuration patterns include two bolts in a single row, two rows of a single bolt, two rows of two bolts, and four bolts with diamond pattern. Loading directions are both parallel and perpendicular to the longitudinal axis of the EWP or wood (central member).

4 RESULTS

Test results include fracture characterizations (crack initiation, crack propagation, and failure mechanism) for bolted group, load-deformation behaviour, and ultimate strength. Comparative analysis of test results with current design parameters is also discussed.

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