FINITE ELEMENT MODELS OF EFFECTS OF MOISTURE ON BOLT CONNECTION PROPERTIES OF GLULAM

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ABSTRACT: Connections are critical parts of timber structures, transmitting static and dynamic forces between structural elements. Extensive experiments were conducted and detailed Finite Element (FE) models were developed. The experimental results showed that the stiffness and load-bearing capacity of the joints is reduced by post-fabrication wetting and is increased by post-fabrication drying. It was clear from those test results that changes in mechanical properties were greater than could be explained by effects moisture content changes have on material properties. Three-dimensional (3-D) continuum FE models for connection loaded parallel to grain were successfully developed based on analysis of connections having a single ½ inch (12.7 mm) or ¾ inch (19.1 mm) diameter bolt. The model included the nonlinearity of material and contact analysis between wood and steel and revealed that the connection capacity can be well predicted by using FE techniques.

KEYWORDS: Finite element, moisture content, stress, glulam connections

1 INTRODUCTION

The mechanical performances of timber connections are particularly important for timber engineers involved in the design of the wood structures. In general, joints are often one of the weakest links in timber structures. The mechanism of connection must be well understood in order to design a more safe connection and avoid catastrophic failure. Often connections are made weak fuse elements by deliberate intent to ensure that if structural systems fail it will be by controllable ductile deformation of connections in load paths, instead of brittle timber element failures. This is an important difference compared, for example, to structural steel or reinforced concrete structures where connections are typically designed to be strong elements in load paths. Timber connections are complex to design or model due to the fact that they are affected by several factors such as geometry, type of fasteners, and moisture content of timber elements, loading duration, and density of wood. The effect of the factors above, and others, should all be considered in the design of timber connections. Deformation and movement incompatibilities in timber structures occur when interconnected parts of structural systems distort differently, under influences affecting them in whole or in part.

2 OBJECTIVES

The following are main research objectives of this paper

• To create finite element models capable of predicting deformations in building with glulam heavy-frame structural systems based on scientific understanding of how materials behave under combined influences that occur in ‘real’ buildings.
• Develop finite element model that is able to predict the entire load-displacement curve for dowel-type connections under the different moisture content condition, including temporal variation in moisture content of glulam.
• To facilitate application of advanced understanding in support of using glulam as a mid- and high-rise construction material which can be used in combination with other material to optimize system performance.

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2.1 METHODS USED

The issues of this study are complex and so must be the wide-ranging research method. The following are methods that have been employed to accomplish the objectives,

1) Development of a plan to test bolted glulam connections as a member with metal plate and high yield strength steel bolts that transfer load.

2) Numerical models for one bolt glulam connections were developed. This model includes the prediction of deformation due to short term and medium term loading of glulam connections loaded parallel to grain.

2.2 RESULTS

Uniqueness of what is presented lies in the analysis of the combined influences of moisture content and mechanical loads by both experimental and numerical methods. The primary conclusion of the work reported is that it is highly viable to predict even complex effects that treatments like post-fabrication moisture conditioning have on responses of bolted glulam connections or bolt embedment specimens. This makes such models viable means of supplementing physical test data and analysing of highly complex connection situations.

3 CONCLUSIONS

Post-fabrication moisture content changes strongly influence the mechanical response characteristics of bolted connections wherein a steel plate member is joined to a glulam member by one or more laterally loaded bolts that load the glulam nominally parallel to the grain. The effects of either post-fabrication wetting or drying of the glulam member prior to loading are stronger than can be attributed simply to moisture change induced alteration of mechanical properties of that material. Physical changes like glulam expansion of shrinkage as moisture content changes and development of associated temporally varying moisture stress gradients are important and need to be accounted for to understand and predict how connections in timber structures behave

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