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3-DIMENSIONAL LATTICE MODEL FOR PREDICTING FAILURE IN STRUCTURAL COMPOSITE LUMBER PRODUCTS

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ABSTRACT

To advance technical information and ensure more efficient design solutions using Structural Composite Lumber (SCL) products, 3-dimensional models were developed to assess and predict mechanical performance of structural components made from SCL. The models are based on regular alignment of meso-scale discrete elements to form a spatially complex, redundant truss structure, recognized as a lattice construct.

The lattice model of the structural composite materials is comprised of 4 distinct linear element types, each representing a principal load-carrying alignment of the material. The planar surface (face) is characterized by element types parallel to the strong axis, perpendicular to the strong axis, and along the line of action for transverse force transmission (shear); the thru-thickness (edge) is represented by a single element type designed to capture the effect of crosswise force transmission perpendicular to strong axis of the material.

Individual elements of the lattice network were assigned strength and stiffness properties through a stochastic simulation procedure. Assigned parameters were a reflection of expected values and variability observed during failures under ‘simple’ stress states of relatively small specimens during subsidiary material property tests. Calibration was established by enforcing congruence between results of material property tests and nominally identical model representations under similar loading scenarios. Model validation was based on experimental data from a 3-point, off-centre notched beam arrangement.

An incremental displacement strategy is applied to the model in an iterative solution process to determine individual element failure. If an element fails in tension or shear, it is removed from the system. If an element exceeds compressive yield strength, strength and stiffness parameters for that element are reassigned to reflect the change in resistance capability. With the elimination of elements and the progressive loss of structural integrity, the structure is re-evaluated and a revised load distribution is determined. The failure pattern then becomes apparent.

Comparison of model and experimental results supports the discrete element representation of SCL as a compelling and useful technique to characterize failure behaviour. Results indicate that this modelling approach provides a reasonable representation of failure behaviour of SCL components. It is able to predict initiation and propagation of fracture planes without prior knowledge of how and where the failure will develop. The power of the model is that it identifies failure location, failure mechanisms and loads in a manner consistent with real behaviour.