Simulated Response of Degrading Hysteretic Joints With Slack Behavior

By

Christian P. Heine

Committee Chairman: Dr. J.D. Dolan

Wood Science and Forest Products

(Abstract)

A novel, general, numerical model is described that is capable of predicting the load-displacement relationship up to and at failure of multiple-bolt joints in timber of various configurations. The model is not tied to a single input function and bolt holes are permitted to be drilled oversize resulting in a slack system.

The model consists of five parts. A new mathematical hysteresis model describes the stiffness of the individual bolt at each time step increment and accounts for non-linear and slack behavior; a mechanically-based structural stiffness model explains the interaction of one bolt with another bolt within a joint; an analytically-based failure model computes the stresses at each time step and initiates failure if crack length equals fastener spacing; a stochastic routine accounts for material property variation; and a heuristic optimization routine estimates the parameters needed.

The core model is a modified array of differential equations whose solution describes accurate hysteresis shapes for slack systems. Hysteresis parameter identification is carried out by a genetic algorithm routine that searches for the best-fit parameters following evolutionary principles (survival of the fittest). The structural model is a linear spring model. Failure is predicted based on a newly developed 'Displaced-Volume-Method' in conjunction with beam on elastic foundation theory, elastic theory, and a modified Tsai-Wu Failure criterion.

The devised computer model enhances the understanding of the mechanics of multiple-bolt joints in timber, and yields valid predictions of joint response of two-member multiple-bolt joints. This research represents a significant step towards the simulation of structural wood components.