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TIMBER-CONCRETE COMPOSITE BEAMS WITH DUCTILE CONNECTION

KEYWORDS: Timber-concrete composite beam, Composite action, Ductile connection, Incremental method, Elastic-perfectly plastic

OVERVIEW OF PROJECT

In timber-concrete composite beams, timber and concrete are inherently brittle materials that behave linearly elastic in both tension and bending. However, the shear connection between the members can exhibit significant ductility. It is therefore possible to develop timber-concrete composite beams with ductile connection that behave in a ductile fashion. The analysis of the timber-concrete composite beam is laborious when connection ductility has to be accounted for. This study combines the elastic analysis with the theory of plasticity, and illustrates an incremental method to predict the nonlinear load-deflection response of the composite beam with ductile connection. The study further verifies the validity of the analytical method by comparing analytical results to experimental measurements collected by previous researchers.

KEY RESULTS

This study developed a simple and rational model for calculating the internal shear forces and the complete nonlinear load-deflection response of a timber-concrete composite beam in which the two materials are linked by means of discrete shear connectors that exhibit a linear elastic-perfectly plastic load-deformation response (Figure 1).

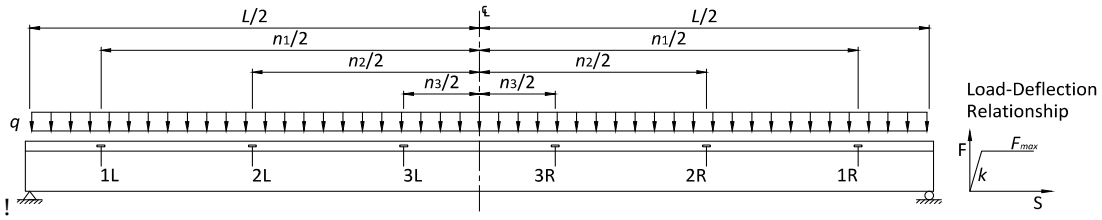

Figure 1: Composite beam, loading, and load-deformation response of a given connector

The model is developed initially for the more simple case of linear-elastic behavior for all shear connectors. Although this is not necessarily desirable from a design perspective, it does simplify the derivation of the formulas that will be required. The force method is used to calculate forces in the member for a given load. The shear forces transferred by the connectors are taken to be the unknown redundant forces. This approach is generally applicable to any composite beam made of two layers that are connected by discrete connectors of linear stiffness properties.

The method then produces a rigorous nonlinear analysis (shown in Figure 2) as a combination of a set of specifically chosen linear calculations, each of which with the

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components (timber, concrete, and shear connectors) behaving linear elastically . A given structure is loaded until the onset of yielding is attained in the first connector. A new structural system is then created in which the yielding connector is removed. An increment of load beyond initial yielding is then applied to the new system until yielding in the second connector is detected. The second connector is then removed, thus producing the third structural system, to which an additional increment of load is applied. Forces in the original system are calculated as the sum of forces in the complete set of systems considered.

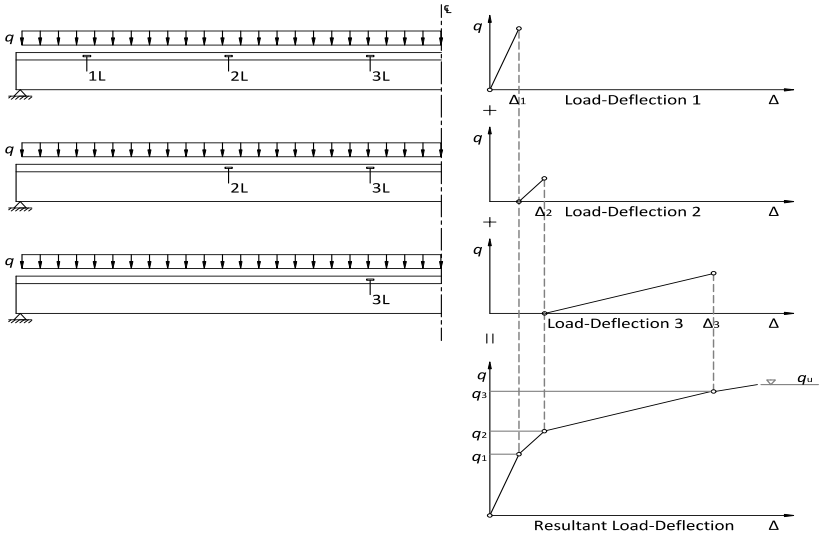

Figure 2: An incremental method for determining non-linear load-deflection response

The proposed analytical method was validated using experimental data recorded by previous researchers. Overall, the agreement between the measured load-deflection response and the response computed using the proposed method was good (Figure 3).

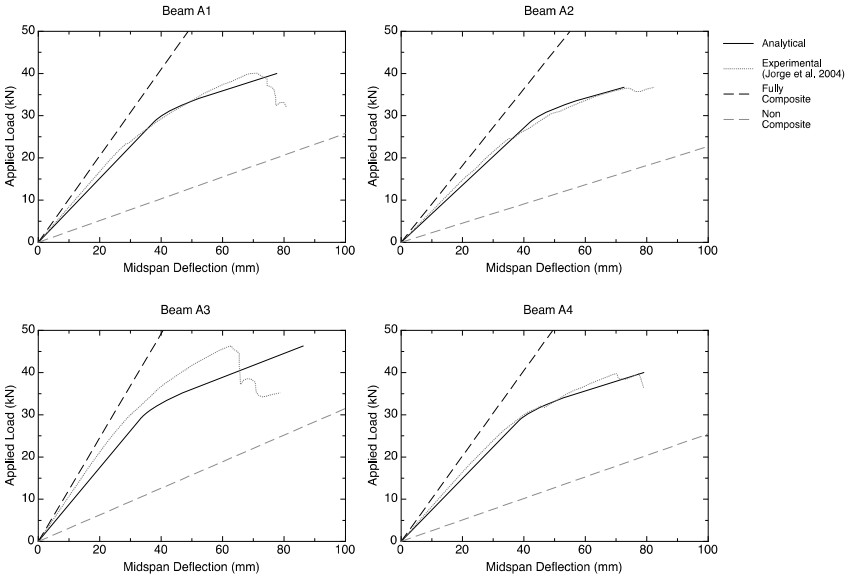

Figure 3: Comparison between experimental and analytical load-deflection responses

THESIS

Zhang, C. 2013. Analysis of the Timber-Concrete Composite Systems with Ductile Connection. Master Thesis, University of Toronto, Toronto, Canada.