DESIGN AND CONSTRUCTION OF TALL WOOD BUILDINGS: INPUT DATA, TESTING AND ADVANCED ANALYSIS

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ABSTRACT

In May 2013, the Canadian Wood Council (CWC) has issued a request for an Expression of Interest (EOI) for Canadian developers, institutions, organizations and design teams willing to undertake an innovative approach to designing and building high-rise wood demonstration projects. With funding support from Natural Resources Canada (NRCan), this initiative will link new scientific advances and data with technical expertise to showcase the application, practicality, and environmental benefits of innovative wood based structural building solutions. The intention of the EOI is to identify building projects and systems in the concept, schematic or design development stages, within Canada, which safely and successfully demonstrate the use of wood as a viable structural element/system in buildings of 10-storeys or more. To support the initiative, a Technical Guide for the Design and Construction of Tall Buildings in Canada is currently being developed by FPInnovations. Among others, the Guide will address structural, fire, seismic, vibration and building envelope issues. The Guide is being developed by a team of more than 65 researchers, design engineers, architects and code officials. Information from the Guide will be disseminated to all eligible proponents for the EOI to help them and all designers push the boundaries of wood construction by using innovative solutions that are backed by scientific research and technical expertise.

The Guide is written to be consistent with the underlying code objectives as specified in the 2010 NBCC. Where possible, performance-based philosophy was followed and performance criteria similar to those developed for steel or concrete systems were applied. The Guide follows a generic approach that can be applied to different wood-based or wood-hybrid innovative systems.

This paper will summarize the major items that are discussed in the sections 4.2 and 4.3 of the Guide. Section 4.2 deals with “Design Considerations and Input Parameters for Connections and Assemblies”, while section 4.3 is related to “Advanced Analysis and Testing of Systems for Design”.

In section 4.2 structural and serviceability design considerations and input parameters for connections and assemblies are discussed [1]. Design considerations that are related directly to wood and wood products as structural material such as: compression perpendicular to grain (Figure 1), shrinkage and swelling, duration of load and creep, and punching shear are discussed. Input data for analyzing connections and assemblies such as strength,
stiffness, ductility, and damping are also addressed. In addition, methods for evaluating, testing and detailing of connections and assemblies, as well as deriving design values for connections and assemblies based on test data and requirements for proprietary connections are discussed and suggested.

Figure 1: Post to beam connection detailing to avoid excessive compression perpendicular to grain gravity loads

Section 4.3 of the Guide deals with advanced analysis and testing of systems for design [2]. At the beginning, topics related to the National Building Code of Canada are discussed such as objectives and functional statements, building code compliance, and performance levels. This is followed by discussion on analysis and design of the structural system subjected to gravity loads, which includes: general analysis and design approaches, structural integrity, progressive and partial collapse, blast protection of buildings, the wall or column to foundation interface, compatibility of gravity system for lateral load demand, and testing needed to support gravity load analyses and design.

In the part that deals with analysis and design for earthquake loads items such as seismic force resisting systems and force modification factors are discussed. Main facts on the procedures for determining the R-factors such as FEMA P-695 and P-795 procedures are included, along with suggestions for determining R-factors for dual and hybrid systems. Methods for seismic analysis that can be used for design of tall wood buildings such as equivalent static procedure, linear dynamic analysis, nonlinear static analysis and nonlinear dynamic analysis are described. In addition, some of the input parameters needed for the analyses such as element properties, effective damping, input earthquake motions for analyses, soil properties, and soil structure interaction are included.

In the subsection on methods of seismic design, the main aspects of force-based design, displacement-based design and performance-based design are presented (Figure 2). Also main aspects of capacity-based design procedures for timber structures are discussed, along with the impact of the diaphragm flexibility on the seismic response.

Figure 2: Typical push-over curve of a structural system with the structural performance levels

The subsection on analysis and design for wind loads deals with various aspects related to wind design and performance including static and dynamic analyses, vortex shedding, experimental testing, deflections and wind-induced vibration-controlled design, and testing needed to support wind load analyses and design.

Finally, design methodologies for low seismic damage are discussed including passive and active seismic isolation and vibration control and rocking self-centering post-tensioned systems.

REFERENCES