TALL BUILDING DESIGN PROJECT

Friday, September 20th, 2013
FPInnovations, 2665 East Mall, Vancouver, B.C.

Objectives:

To analyze the structural, fire and building envelope performance of a tall wood building based on tools and technical data arising from the research and outreach programs of NEWBuildS and FPInnovations.

Design Team:

Architecture / Building Envelope Subgroup:

- Robert Drew, *Perkins + Wills*; Dr. Hua Ge, *Concordia;* Dr. Jieying Wang, *FPInnovations*; Caroline Frenette, *Cecobois*; Sabrina D'Ambra, *Concordia;* Dr. Mohamed Nadim Adi, Hadia Awad, *UAlberta;*

Structural Subgroup:

- Eric Karsh, Mahmoud Rezai, *Equilibrium Consulting*; Dr. Frank Lam, *UBC*; Dr. Y. H. Chui, *UNB*; Marjan Popovski, *FPInnovations*; Dr. Minghao Li, *UBC;* Dr. Zhiyong Chen, *UNB;*

Fire Subgroup:

- Andrew Harmsworth, Gary Chen, *GHL Consultants*; Dr. George Hadjisophocleous, *Carleton*; Christian Dagenais, *FPInnovations*; Xiao Li, Alejandro Medina, *Carleton;*

Administration:

- Dr. Y H Chui, *UNB*; Conroy Lum, Kenneth Koo, *FPInnovations*; Helen Griffin, CWC; Lynn Embury-Williams, *NEWBuildS;* Steven Kuan, *BC FII*;

8:30 am	**Welcome and Introduction** **Dr. Y. H. Chui**
8:45 am	Introduction to **FPInnovations Technical Guide Design and Construction of Canadian Tall Wood Buildings** *(90% draft)* **Mr. Conroy Lum,** FPInnovations
9:30 am	**Building concepts, scope and project administration** • Possible building concepts - storeys, lay-out, dimensions, location, occupancy, main structural systems and materials • Levels of design details • Milestones, process and project administration
10:15 am	Break
10:30 am	**Structural Design** • Scope of design – lateral load, gravity load, member and connection design, serviceability considerations • Analysis tools and data required, others • Deliverables, task assignments and time lines
12:00 pm	Lunch
1:00 pm	**Architecture & Building Envelope Design** • Scope of design – Exterior wall details to meet energy and durability requirements, acoustics, openings, exterior cladding, LCA, market requirements, others • Analysis tools and data required • Deliverables, task assignments and time lines
2:30 pm	Break
2:45 pm	**Fire Design** • Scope of design – fire protection design of residential and commercial occupancies, egress, exterior cladding, demonstration of performance-based design approaches, others • Analysis tools and data required • Deliverables, task assignments and time lines
4:15 pm	**Summary of tasks and next meeting**
4:30 pm	Adjournment

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NEWBuildS

NEWBuildS / FPInnovations HQP Tall Wood Building Design Project Team

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Architect / Building Envelope
Structural
Fire

Design Team - Sub Group membership

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Application of analysis tools from NEWBuildS research network in design of a high-rise wood building

NSERC Strategic Network on Innovative Wood Products and Building Systems (NEWBuildS)

Rationale:

The ultimate goal of NEWBuildS is to develop technical information that supports the use of wood-based products in multi-storey and non-residential construction. Its research program consists of 37 projects which are divided into 4 themes. The four themes are: cross laminated timber, hybrid buildings, fire and serviceability of building systems, and sustainability and durability of building systems. NEWBuildS commenced its program in January 2010, and has started to generate results that are ready to be implemented by the end users and code authorities. The success of NEWBuildS research program will be judged by how much impact the developed research information and tools is implemented by wood industry, designers, builders and code authorities to increase the use of wood in non-traditional construction market. This project is intended to expand the scope of NEWBuildS research projects by demonstrating the implementation of the generated results in assisting with the design of a high-rise wood building, thereby contributing to the realization of the goal of constructing the first high-rise wood building in British Columbia and Canada. The project is being jointly funded by NSERC and BC FII.

Project Objectives and Outcome:

The three key objectives of the design project are:

1. To demonstrate the use of tools developed and adopted within the NEWBuildS research program in designing a tall wood building, thereby potentially making them available for future use by designers and code authorities for evaluating building designs under the alternative solution path.
2. Through this exercise, to identify potential technical challenges facing designers when they choose the alternative solution path for high-rise wood buildings, and future research needs. A key deliverable of this project will be a technical publication that will contain information on the design building, detailed analysis and design for each of the target building performance issues e.g. fire, structural and building envelope. The findings and recommendations will also be presented in a workshop.
3. To provide a real-world training environment for NEWBuildS graduate students and post-doctoral fellows who will play a key role in filling the human resources needs of the building design profession and the engineered wood industry.

Work plan

The overall objective of this project is to execute the design process of a demonstration high-rise wood building by a team of professional experts and researchers in their respective areas of expertise. The expected impact is to establish a process and procedure on how to expedite the technology transfer from research results to actual building design. This process and procedure is not well practiced in North America and, in a way, acts as a hindrance to wood product innovations and leads to lengthy delay before new wood products and design solutions can be implemented in the market. This demonstration project will be performed by a team, consisting of graduate students and postdoctoral fellows (PDF) from NEWBuildS who will be supervised by three professional consultants. At the outset, the specifications, including geometry, location and occupancy, of a high-rise building, will be developed by the design team. It is entirely possible that an actual planned

building be used in this design project. The demonstration building will likely be a hybrid structure consisting of CLT in combination with other structural materials. It is proposed that the NEWBuildS design team will consist of 6 graduate students / PDF with the following expertise and background: 1. Structural engineering 2. Fire engineering 3. Building envelope, including durability and thermal performance. The mathematical tools (e.g. 3-D structural model, hygrothermal model, fire risk model) and technical data, such as material and connection properties, hygrothermal and environmental data on specific materials that were adopted or developed in relevant NEWBuildS projects will be used in the design project. The supervisory team will consist of 3 consultants: structural engineer, code consultant specializing in fire engineering, and an architect with a specialization in building envelope. It is expected that some of the students' and PDF's academic supervisors, and FPInnovations and NRC scientists will also provide expert input into the design project. In view of the time limit of the students and PDF, the design will focus on key building elements only.

Each practising consultant will supervise 2 NEWBuildS researchers. Together, they form a sub-group that will work on one performance aspect. In total, there will be three sub-groups on structural engineering design, fire engineering design and building envelope design respectively. In the case of structural design it will focus on resisting wind and seismic load only since it is a major design issue for tall buildings. Mathematical models developed in projects of Themes 1 and 2 of NEWBuildS research network will be used by the structural sub-group to analyse the responses of the building to seismic and wind loads. From these structural responses, the sizes of the structural members and connection details will be determined based on the requirements of the appropriate material design standards, such as CSA O86 ‘Engineering design in wood'. These mathematical models will predict the time history response of the demonstration building under a number of previously recorded earthquake ground motions on the west coast of North America. The response of the building to wind load excitation relevant for the west coast of Canada will also be predicted using the mathematical models. These analyses will help demonstrate that demonstration building can resist the seismic and wind actions likely to be encountered in BC.

Using the developed member and connection details, the fire design sub-group will develop fire protection requirements. A key mathematical tool in developing the fire protection requirements will be the fire risk model, CUrisk, first developed at Carleton University, and recently further refined under Theme 3 of NEWBuildS. The fire risk model can predict fire and smoke development in a building based on the building material properties, building dimensions and layout, and presence of any fire suppression facilities. Since the design building dimensions will be outside the allowable limit in the building code for combustible construction, the goal of the fire design is to demonstrate that any fire protection measures implemented will meet the intent and objectives of the BC Building Code with respect to protection of occupants in the event of a fire. Such fire protection measures will likely include the use of gypsum boards, sprinklers and fire escape routes. Because of the height of the building, other technologies such as encapsulation of structural wood members, which is currently being researched at the National Research Council, may also be required for compartmentation purposes i.e. containment of fire to the compartment of origin of fire. The CUrisk program will help demonstrate that the demonstration building with the proposed structural details and fire protection measures meets the fire safety objective of the BC Building Code.

Similarly, the building envelope sub-group will develop construction details for wall and roof that meet the thermal performance requirements of the new National Energy Code for Buildings (NECB). This sub-group will also design the exterior cladding for the building envelope. The hygrothermal model adapted in Theme 4 of NEWBuildS, WUFI, along with technical data on material performance and rain loading on multi-storey buildings, will be used to determine if the proposed construction details will lead to moisture-induced durability problems (e.g. condensation and rain penetration) in the envelope of the design building. WUFI is capable of calculating moisture movement and heat transfer through building envelope, thereby confirming if a specific envelope

design meets the durability and energy performance requirements of the building code under the BC climate.

The three sub-groups will initially work independently after the first project meeting, when the specifications of the demonstration building are defined. When preliminary details of the three sub-groups have been developed to satisfy structural, fire and building envelope requirements of the relevant codes and standards, the whole team will meet with FPInnovations and NRC scientists and CWC technical staff to share their findings, and to seek input from a wider audience and ensure that construction details developed by one sub-group will not cause problems in other performance areas. At this stage, advice will also be sought from experts in acoustics and vibration on the developed construction details to ensure that these details will not cause obvious acoustic and vibration problems for the occupants. After this integration exercise and additional consultation, it is likely that changes in construction details and re-analysis using the same mathematical tools will be required to ensure that the building's performance meets the intent of the BC Building Code.

FPInnovations and NRC scientists and other NEWBuildS researchers with the appropriate expertise will be asked to participate in the sub-group design activities. There will be at least three meetings of the whole design team. To minimize travel costs, these meetings will all be held in Vancouver, where all the supervisory consultants and some of the FPInnovations scientists and NEWBuildS researchers who will be involved in this project, are located. The first meeting will be a project initiation meeting. The second meeting will be for discussion of preliminary design and proposed construction details, to ensure compatibility of details and consistency. The last meeting will be devoted to finalizing the design project and its findings before the final report is prepared. In between the project meetings there will be conference calls for the whole group and sub-groups. The graduate students and PDF will work in conjunction with his/her supervisor(s) and sub-group in the design of the building. It is envisaged that the final report will consist of the following chapters: 1. Design of key structural elements and connections to resist wind and seismic load; 2. Prediction of response of the building to earthquake ground motions and vibrational serviceability under wind excitation; 3. Fire protection design of key structural elements and connections; 4. Modeling of fire and smoke development in the building under various fire scenarios; 5. Construction details to meet durability requirements and energy efficiency requirements of the National Energy Code for Buildings. A one-day workshop will be held in conjunction with the NEWBuildS annual meeting to present the results to practitioners, wood industry and government officials. The final report can be considered as supplementary to the FPInnovations technical guide on design of tall wood buildings. Together, they will be valuable reference material for building designers, and will greatly facilitate the design of tall wood buildings in BC, other parts of Canada as well as USA and other markets of BC and Canadian wood products. This project is also expected to identify technical issues that will require further research. Each chapter of the final report will discuss future research topics.

Additional reference documents:

1. **Technical Guide for the Design and Construction of Tall Wood Buildings in Canada** *(90% draft)*
   - FPInnovations
   download from http://www.cwcdemoproject.ca
   (14 M + 397 pages)

2. **THE CASE FOR Tall Wood BUILDINGS**
   - Michael Green:
   download from http://wecbc.smallboxcms.com/database/rte/files/Tall%20Wood.pdf
   (30 M & 240 pages)

3. **SOM Timber Tower Research Project**
   - Skidmore Owings & Merrill LLP (SOM)

   a. Timber Tower Final Report
      https://www.som.com/sites/default/files/20130506_SOM-Timber-Tower-Final-Report_2.pdf
      (1.3 Meg + 72 pages)

   b. Timber Tower Final Sketches
      https://www.som.com/sites/default/files/20130603_SOM-Timber-Tower-Final-Sketches.pdf
      (9.4 Meg + 94 pages)

   c. Timber Tower 3D View
      https://www.som.com/sites/default/files/20130506_SOM-Timber-Tower-3D-PDF.pdf
      (0.4 M + 1 page)