6-Story Wood Frame Committee

Interim Report – December 2008

The provincial government is intending to issue a revision to the BCBC to allow 5 and 6 story wood framed residential buildings in early January 2009. A committee of SEABC has been looking at the issues surrounding the increase in allowable building height to 50% more than contemplated by the existing wood code and the proposed CSA O86-09 code. This committee is working toward a guideline to be published jointly with APEGBC to assist engineers designing these buildings but since it has been a volunteer committee it is difficult for us all to find the time to produce this guideline quickly. At the request of the Government, APEGBC submitted a proposal for some funding to produce the guideline but our initial request was turned down. Recently the government has agreed to fund a shortened guideline to approximately 1/4 of the requested level so there will be help for some coming but it will remain mainly a volunteer effort. This Interim report in intended to let designers know what we and others are working on and some things you should consider in your designs prior to the publication of the guide.

The committee has responded to the government code proposals and our response is attached. Please read the government proposal on the web and our comments. http://www.housing.gov.bc.ca/building/wood_frame/6storey_form.html

FPInnovations-Forintek Division has funded Mr. Robert Malczyk to re-do the SECBC 4 story wood frame example developed under Mr. Bill Marsh's coordination, and first published in December of 1997, converting it to a 6 story building. This will be useful as was the original template. Mr. Malczyk has completed his first draft of the work, but still needs to incorporate some revisions that came out of the work of others. Although, the exact publication date of this document is unknown, it is expected that it will be out in early 2009.

Mr. Grant Newfield has completed analysis and design of typical 4 and 6-story wood-frame buildings for Forintek to be used in their research. Forintek is part of a research group that is going to test a 6 story building on a shake table in Japan in the summer of 2009. They are also doing some non-linear time history analysis of 4 and 6-storey wood-frame buildings both at their laboratory at UBC Campus and at Colorado State University.

Our shortened guideline is envisioned to cover the following topics:

- Design, Drawing and Review Practice
- Shear Walls
- Diaphragms
- Shrinkage
- Fire & Elevator Walls
- Hybrid Systems

Design, Drawing and Review Practice

- A good first draft of the practice guidelines is attached.

Shear Walls (the following comments generally apply to high seismic areas)

- No type 4 and 5 Irregularities allowed (perhaps in the top floor, see our comments to the government)
- Design to the draft CSA O86-09 Clause 9.8. ***Special Seismic Design Considerations for Shearwalls and Diaphragms***
- No drywall contributing shear walls in high seismic zones.
- There may be more stringent capacity design requirements for the connection of the wood frame to supporting suspended concrete systems.
- Building lateral drift/stiffness calculations including the incremental effects of shear wall bending, not just the story deformation approach contained in the Wood Handbook will be required. Drift due to anchor slip and shrinkage will also need to be included
- Seismic design forces to BCBC Clause 4.1.8.11 using a rational method (example in guidelines) to calculate building period. This will usually result in a period greater that twice the empirically derived period of Clause 4.1.8.11.3)c) so twice the empirical period may be used for force determination 4.1.8.11.3)d)iii) and the calculated period used to determine forces for drift calculations 4.1.8.11.3)d)iv). This procedure is required since if you just use the straight static you are likely will have trouble with building drifts and holddowns may be HSS sections in lower floors.
- Since the nail slip portion of shear wall deflection is non-linear (load dependent) determination of building deflection and period will be an iterative process. Estimate forces, perform the design, calculate deflections, determine period, calculate forces based on the period, and redesign. Repeat until convergence. After a designer had done this a few times, we imagine he/she will be able to get fairly close the first time.
- Hold-downs need to be shrinkage compensating type.
- Forintek and a Task Group of the Wood Frame Committee are examining the possibility of wood shear walls forming weak/soft stories under seismic loading. This problem was identified for structural steel braced systems in S16-01(S16S1-05) and measures taken to address the problem (see commentary to Clause 27.5.2.1). Preliminary results from dynamic analysis conducted by Forintek and Colorado State University will be available late 2008. Forintek is also developing solutions should the results indicate that the capacity based design procedures proposed in NBCC 2010 and CSA O86 do not fully address this issue.

Diaphragms

- Design to CSA O86-09 and NBCC 2010 4.1.8.15
- Consideration of effects of rigid and flexible diaphragm assumptions
- Design and detailing of drag struts and collectors
- Detailing of the transfer of diaphragm forces to shear walls
- Detailed provisions for transferring forces around diaphragm openings

Shrinkage

- A design is required for the shrinkage issues
- Drawing to contain notes detailing the approach to shrinkage and the expected shrinkage on a floor by floor basis as well as the building overall. Notes in a form suitable for architects/mechanical/electrical engineers, window suppliers and others.

- For whatever system chosen all elements within a floor should be the same type, and mixing of sawn and engineered wood products over the same depth is not recommended.
- Flush beams should be the same material as the rest of the floor system
- It is recommended that drop beams be of engineered wood products
- It is recommended that the plates made of kiln-dried material
- Pre-fabricated floor elements should be used whenever possible as they will exhibit relatively less shrinkage
- Details required on drawing for connections to non-shrinking element such as firewalls and elevator shafts reflecting the expected shrinkage deformations.

Fire & Elevator Walls

- We haven't come to grips with this section yet
- Big issues in relative lateral stiffness between wood shear walls and masonry/concrete fire walls
- Elevator shafts same issues plus differential vertical shrinkage between masonry and wood construction
- Proprietary fire wall systems, they are in use in US, more information is required

Hybrid Systems

- Possible 1 concrete + 5 wood or 2 concrete + 4 wood. Height of uppermost floor cannot exceed 18m or the design has to comply with the requirements for high-rise buildings which will not be allowed in this code change.
- Concrete must have $R_dR_o <= R_dR_o$ of wood over
- Mixed concrete and wood systems will have much higher shear forces in the wood section due to the heavy mass of the concrete floors adding to the shears at the wood levels. A full dynamic analysis will be required for these systems for period and force determination. Again it will be iterative due to the non-linear nail slip deflection.
- Possible non-wood lateral force resisting systems, steel, concrete, masonry. Problems with differential shrinkage must be addressed. Steel cross bracing systems have the soft/weak story problem that cannot be solved by the CSA S16 methods so they cannot be used.

WOOD FRAMED STRUCTURAL DESIGN PRACTICE ISSUES

DESIGN DRAWING PRESENTATION

Proposed items to be included in Design Drawing Presentation:

LATERAL DESIGN

- Building Design Parameters - Loadings, site conditions, Rd Ro and Period of the building
- Building Performance Characteristics - Expected lateral deflections, torsional sensitivities and expected shrinkage
- Lateral Resisting System independent of Gravity Design drawings
- Specifications and Standards for sheathing, lumber, treatment, backing material, fasteners, light gauge steel connectors, anchor bolts etc.
- Connection Details – Metal connectors – Force flow – drag details – connector Capacities
- Layout and details of Holddowns (including shrinkage compensators) with dimension of locations.
- Shearwall elevations and shear transfer details including openings
- Diaphragm assumptions – drag members and chord details including openings

GRAVITY DESIGN

- Specifications
- Truss/joist layout with dimensions
- Beam sizes, their connections and supporting conditions
- Sheathing and connection specifications
- Wall components and posts including support details
- Floor to floor connection details
- Architectural elements connection details
- Foundation details

WORKMANSHIP

Contractors should be qualified by their past experiences or be able to demonstrate to the engineer that they have the understanding and competencies in performing the work including proper installation of all details provided by the structural engineer.

The Structural Engineer has the right to disassociate himself for work performed by incompetent contractors or irresponsible developers.

CONSTRUCTION PERFORMANCE AND FIELD REVIEWS

The Structural Engineer can produce a performance guideline of the expected quality of work in accordance to his details and designs from the contractor. Tolerance of construction should be included.
In addition, he can also list the stages of mandatory field reviews, i.e. on a floor to floor stage, in order to satisfy his field review obligations. Field reviews must be able to capture key elements such that they are visible and available at time of inspection.

Initial project startup meeting identify critical elements that need to be seen.

Photo documentation of the field work can be helpful to the process.

Suggestions to improve workmanship include:

- Tolerances
- Compliance with design drawings
    - Enforced through minimum standards of inspection
- Shop drawings or detailed layout provided on structural drawings:
    - Joist layout shop drawings including:
        - Support bearing details and connectors
        - Blocking details at walls, columns, etc.
        - Blocking and bridging
    - Beam layout shop drawings including:
        - Support bearing details and connectors
        - Association of supports to beams and loads onto beams
    - Roof truss layout
        - layout
        - Support bearing details and connectors
    - Diaphragm sheeting layout
        - Sheeting layout
        - Nailing pattern
        - Load transfer to restraint points
    - Seismic elements
        - Position and alignment
        - Drag lines dimensional and layout information
        - Connector specification
        - Capacities of connectors provided
        - Anchorage dimensional layout

ITEMS STILL TO BE REVIEWED/UNDER CONSIDERATION

Contractors should be certified.
Connecting details for wood/concrete/steel
All designs follow the SEAOC seismic design procedure with the following stages:
1) Design the building with flexible diaphragms
2) Obtain deflection, thus stiffness of the building
3) Re-distribute shearwall forces by assuming rigid diaphragms
4) Thus, torsional sensitivity can be included in the calculations.
5) Capture the envelope forces of the shearwalls and redesign the wall.

SEABC Response to Government Mid-Rise Code Change Proposal

Change # 1 – Support with comments

Seismic Clauses may limit building height to 20 m in higher seismic zones. Clarification of "Building Height" in the Seismic Section of the Building Code is required. Definition of "Sloped Roof" is required relative to "Building Height" definition.

Change # 2 – No Comment

Change # 3 – No. Comment

Change # 4 – No. Comment

Change # 5 _ Support with Comments

Proposed to modified as follows:

When a building of any fundamental lateral period, Ta, where Sa(1.0) > 0.25 is constructed of 5 or 6 storeys of continuous combustible construction as permitted by Article 3.2.2.45, walls forming part of the SFRS shall not have irregularities of Type 4 or 5 as described in Table 4.1.8.6. in the combustible levels except for the upper most storey.

Change # 6 - This section should exactly follow the draft diaphragm section of the 2010 NBCC.

Change # 7 - No Comment

Change # 8 – Support with Comments.

The first paragraph may be deleted as the content is confusing.

At the end of the paragraphs, add

"Further wood engineering design guidance may be found in the APEGBC/SEABC Guidelines"

Add to Division C, Part 2, Clause 2.2.4.3 new line "f"

f) Estimated building movements including shrinkage and lateral deformation.

FUTURE CONSIDERATIONS

Independent Third-Party Review of Building Design

With respect to structural engineering, this requirement should be included now. The scope of this review shall follow the APEGBC/SEABC Guidelines.

C. Field Review or Site Inspections

With respect to structural Field Reviews, it is our recommendation that third party field reviews should be carried out by the third party design reviewer and the scope of third party review should follow APEGBC/SEABC Guidelines.

D. Education and Training

There should be mandatory professional education program developed for all structural engineers engaged in the design and field services of Part 3 wood frame structures.

E. Additional Comments

All structural engineers and reviewers engaged in the design of Mid-rise wood structures should be a Designated Structural Engineer (StructEng)

This Code Change Proposals are a major initiative by the BC Government. The review time is relatively short and not all issues may have been considered.

Your Contact Information

SEABC
Mr. David Davey, P.Eng., President
315 Mountain Hwy
North VAncouver, B.C
V7J 2K7
email: djdavey@shaw.ca

Your feedback has been sent directly to:

Building and Safety Policy Branch
Office of Housing and Construction Standards
Ministry of Housing and Social Development

Thank you.

A LOT MORE WORK THEREFORE YOU WILL NEED MORE FEE. REMEMBER APEGBC'S POSITION IS THAT AN INADEQUATE FEE IS NOT AN EXCUSE FOR INADEQUATE WORK

GOOD LUCK TO THOSE WHO ARE PIONEERS IN THESE BUILDINGS, PAY ATTENTION THERE WILL BE MANY MORE PITFALLS THAN WE HAVE IDENTIFIED HERE TO DATE, MORE TO COME

Six story committee

Don Anderson
Dave Davey
Thomas Leung
Bill Marsh
Robert Malczyk
Peter Mitchell
Jim Mutrie
Grant Newfield
Chun Ni
Marjan Popovski
Rob Simpson
Rob Smith