Introduction

- The 2015 National Building Code of Canada raised the limit of wood-frame construction to 6 storeys (mid-rise).

- A Mid-rise Wood-Frame Construction Handbook was developed by FPInnovations to provide guidelines for design and construction of mid-rise wood-frame buildings according to 2015 NBCC.

- This paper provides information on some of the topics covered in the Handbook related to the seismic analysis and design of mid-rise wood-frame buildings:
  - Determination of building period
  - Linear dynamic analysis of wood-frame structures
  - Diaphragm classification
  - Capacity-based design for wood-frame structures
  - Design of wood-frame buildings on concrete podiums

Proposed Steps for LDA

- Step one (preliminary analysis): Perform an initial analysis and design to determine the properties of each wall of the LLRS
  - Allows designers to get the information required to determine stiffness and deflection characteristics of the shearwalls

- Step two: Use the preliminary analysis info to generate input data for LDA for a multi-level structure
  - The design base shear must be the larger of:
    - The dynamic design force Vd
    - 100% of static design force V

Properties of Shear Walls for LDA

- Shear walls can be modeled as beam elements in commercial software
- Calculations for equivalent beam element properties (flexural and shear stiffness) are given based on the basic wall parameters

Deflections of Shear Walls

\[
\Delta_i = \Delta_{i,\text{bend}} + \Delta_{i,\text{shear}} + \Delta_{i,\text{plate}} + \Delta_{i,\text{anch}}
\]

Where:
- \(\Delta_{i,\text{bend}}\) is deflection of i-th storey due to bending
- \(\Delta_{i,\text{shear}}\) is deflection of i-th storey due to panel shear
- \(\Delta_{i,\text{plate}}\) is the deflection of i-th storey due to wood plate bearing and anchorage slip
- \(\Delta_{i,\text{anch}}\) is the deflection of i-th storey due to rotation at the bottom of the shear wall

Deflection Components

\[
\Delta_{i,\text{bend}} = \frac{F_i}{E_i I_i} L_i, \quad \Delta_{i,\text{shear}} = \frac{F_i H_i}{C_{i,R_i}}, \quad \Delta_{i,\text{plate}} = \frac{0.0025 H_i f_{w,i}}{C_{i,R_i}}
\]

Where:
- \(M_i\) = overturning moment at level i
- \(H_i\) = height of shear wall at i-th storey
- \(f_{w,i}\) = effective bending stiffness of shear wall at i-th storey
- \(L_i\) = length of shear wall at i-th storey
- \(C_{i,R_i}\) = shear-through-thickness rigidity of wall panels
- \(d_{n,i}\) = nail deformation for shear wall at i-th storey
- \(d_{b,i}\) = sum of vertical deformation at i-th storey due to wood plate bearing and anchorage slip

In-Plane Diaphragm Flexibility

- In-plane diaphragm stiffness affects the overall response of the building subjected to lateral forces
  - Whether a diaphragm is treated as flexible, rigid, or semi-rigid, depends on the in-plane stiffness of the diaphragm relative to the stiffness of the vertical LLRS underneath
  - Suggested to use ASCE 41-13 (Flexible if MDD > 2 ADVE)

Current Code Status and Approaches for Podium Buildings

- Not explicitly included in 2015 NBCC or 2014 CSA O86
- Designers can choose between two methods that implicitly cover podium buildings in NBCC
  - First: Linear Dynamic Analysis (LDA) as default NBC approach
    - Analytical model should include both concrete and wood portions with their own strength and stiffness properties
    - Distribution of linear shear forces along the height is obtained
    - Corresponding R_{R,s} factors for each storey are used to determine the design shear forces

Conclusion

- The Mid-rise Wood-Frame Construction Handbook provides guidelines for early adopters and mainstream practitioners to design and construct mid-rise wood-frame construction in compliance with the 2015 NBCC, Provincial Codes, and 2014 CSA O86
- A total of 42 industry, research, and design experts have been involved in the development of the Handbook
- The information in the Handbook shall be used in addition to the info already available in CWCC’s Wood Design Manual (2010), the APEBC Bulletin for design and construction of 5- and 6-storey wood-frame construction, and the 2013 Quebec guidelines from Mégis du bâtiment du Québec