Mid-Rise Timber over non-combustible Podium Structures

High Performance and Low Cost

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Learning Objectives

At the end of this program, participants will be able to:

1. To examine relevant IBC code provisions applicable to mid-rise podium structures.
2. To discuss the structural design challenges such as lateral load transfer, high vertical loading and effects of shrinkage.
3. To explore the fire and life safety code requirements and the use of fire retardant treated lumber.
4. To identify opportunities for implementation of new products and techniques.
Five story Timber over Podium Structure

Fire and Life Safety

Parking Level
Meets the definition of a basement, does not contribute to area or height limitation.

Ground Floor
Type IA Construction – Occupancy S2, B, E, A2.
- Allowable Height: Unlimited
- Allowable Stories: One Story
- Allowable Area: Unlimited

Podium (2-6)
Type IIIB Construction – Occupancy R2
- Allowable Height: 55’
- Allowable Stories: Four Stories
- Allowable Area: 16,000 sf

Modifications to height

Use automatic sprinkler system to add one story and 20’ to allowable height.

Modified height Allowance (fire and life safety) = 75’

Structural height allowance for plywood shear walls = 65’

Both limitations need to be checked

Extracted from Chapter 11 Balloted Commentary on Definition of Base:

“The validity of having the base above grade is based on the same principles used to justify the two-stage equivalent lateral force procedure for a flexible upper portion of a building with one-tenth the stiffness of the lower portion of the building as permitted in Section 12.2.3.1 of ASCE/SEI 7-10. For a floor level above grade to be considered the base, it should generally not be above grade more than one-half the height of the basement story, as shown in Fig. C11-4. Figure C11-4 illustrates a more massive structure; however, the concept of base level being located at the top of a floor level above grade is also applicable for smaller less massive structures. Typical examples include light-frame floor systems that rest on top of stiff basement walls or stiff crawl space stem walls of concrete or masonry construction.”

Extracted from Chapter 12 Balloted Commentary on the two-stage procedure:

“C12.2.3.2 Two Stage Analysis Procedure. A two stage equivalent lateral force procedure is permitted where the lower portion of the structure has a minimum of 10 times the stiffness of the upper portion of the structure. In addition, the period of the entire structure is not permitted to be greater than 1.1 times the period of the upper portion considered as a separate structure supported at the transition from the upper to the lower portion. An example would be a concrete podium under a wood- or steel-framed upper portion of a structure. The upper portion may be analyzed for seismic forces and drifts using the values of R, \( \phi \), and C\( _d \) for the upper portion as a separate structure. The seismic forces (e.g., shear and overturning) at the base of the upper portion are applied to the top of the lower portion and scaled up by the ratio of \( \frac{R \phi C_d}{R \phi C_d} \) \upper \ to \ \frac{R \phi C_d}{R \phi C_d} \) \lower. The lower portion, which now includes the seismic forces from the upper portion, may then be analyzed using the values of R, \( \phi \), and C\( _d \) for the lower portion of the structure.”

ASCE 7-10 Table 12.2-1:

The table heading now uses the term “structural height” in lieu of building height used previously. The term “structural height” is defined as height from the base. Base is defined as level at which horizontal motions are considered to be imparted to the structure.

The use of the term “structural height” was an intentional change implemented in ASCE 7-10 to address limits on the structure versus other definitions of building height which may be a combination of structure types.
Type IIIIB details

IBC 602.3

“Type III construction is that type of construction in which the exterior walls are of non-combustible materials and the interior building elements are of any material permitted by this code. Fire Retardant Treated Wood framing complying with section 2303.2 shall be permitted within exterior wall assemblies of a 2hr rating or less.”

IBC Tables 601 & 602

- Exterior Bearing Walls – 2hr
- Exterior Non-Bearing Walls – 1hr (0hr if building separation > 30')
- All other walls, floors, and roofs – 0hr

Termination of 2 hour wall at roof

Offset wall / fire rating

No structural composite lumber allowed to be fire treated. This leaves solid sawn lumber for headers, rims, and studs. Beware of shrinkage for large rims and headers!

Congested Exterior Walls = poor building envelope

Consider using corridor walls to resist lateral forces
Consider using 3x or 4x studs at 24”oc at shear walls. Use more shear walls to minimize double sided.

Avoid 4” walls unless absolutely necessary.

Consider 1-1/8” T&G plywood flooring for blocked rigid diaphragm analysis.
Be careful of Cantilevered Wood Balconies!
Place knife plates below deck for maintenance
Brick Veneer supported off Timber
- Already Fire Retardant Treated
- Beware of solid sawn rim board
- Joint often for seismic/wind
- Joint for floor to floor deflection
- 1” gypcrete, eco-roof, and brick veneer creates heavy building (more plywood shear walls)
- Better than 30’ of brick off of podium for shrinkage compatibility

Be prepared for panelization
Prefabrication/Modularization using integrated modeling software
- Can interface directly with computer controlled fabrication
- Direct output of materials/order lists
- High quality and low moisture content
- High speed of construction. Follow on subs will control critical path.

Image from Cost Effective Home Building: A Design and Construction Handbook by the NAHB

Advanced Framing Alignment
Design for deflection!

- Advanced Framing = 33% less shrinkage
- Modified Balloon Framing = no solid sawn rim to shrink
- On the Structural Plans, put a minimum of 3/16” to a ¼” per floor shrinkage notation. Beware of shrinkage calculations that are significantly less that this. MEP needs to account for deflection.
- Be cautious of 30’ brick veneer supported on podium.
- Use shrinkage compensating hold down system
How about CLT?

- Easiest initial commercial market is roofs and floors until AWC incorporates into code (total system is still ok under AM)
- ~3.5” to 6” floor/roof panels will work in most multi-story apartment and affordable housing projects
- Eliminates small headers (two way action)
- Low floor to floor
- High floor performance
- Fast installation

Typical CLT dimensions:

- Length: up to 60’
- Width: up to 15’ 6”
- Thickness: from 2” – 12”
One of the largest timber constructions in the world

- 195,000 sq f CLT (ca. 1 Mio. BF)
- 170,000 BF of glulam and LVL
- 116 to customized steel
- Erection time was two month with eight carpenters

Multi-Story Applications

- 3-storey building
  Judenburg (AUT) | 2002
  CLT by KLH

- 4-storey building
  Judenburg (AUT) | 2002
  CLT by KLH

- 5-storey building
  Berlin (GER) | 2010
  CLT by KLH

Multi-Story Applications

- 5-storey building
  Vienna (AUT) | 2005
  CLT by KLH

- 8-storey building
  London (UK) | 2008
  CLT by KLH

- 8-storey building
  London (UK) | 2010
  CLT by Stora Enso Timber

Schools

- Peggau (AUT) | 2009
  CLT by Mayr-Melnhof Kaufmann

- Innsbruck (AUT) | 2008
  CLT by Binderholz Bausysteme

- Darmstadt (GER) | 2006
  CLT by Finnforest Merk
Cross Laminated Timber Presentation

- CLT Proven History
- Structural Advantages
- Energy Efficiencies
- Design and Manufacturing standards
- Fire Protection
Five stories Timber frame over podium:
• Maximizes density in urban settings
• Functional, durable, economical, and carbon friendly
• Modularization, panelization, CLT and advanced framing, are versatile tools for a sustainable natural resource.