Is Wood-Frame Modular the Future of Multi-Family Construction?

Structural Design of Modular Construction Demystified

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Outline

1. Define what is volumetric modular construction
2. Discuss unique structural design considerations
3. Address the interface between site engineer and modular engineer
4. Clarify the delineation between Local and State jurisdictions, code review and inspections
Pre-Fab Options

- Factory Built Wood Modular
- Panelized Walls & Floors
- Cross-Laminated Timber (CLT)
- Composite Floor Systems

- Shipping Container
- Steel Box
- Diversakore
- Sustainable Living Innovations (SLI)
Project Examples
Volumetric Wood Modular

**OFF-SITE FACTORY BUILT CONSTRUCTION**

- More efficient building delivery & higher quality
- Designed & inspected to meet current IBC codes
- Can incorporate:
  - Waterproofing
  - Exterior Finishes
  - Interior Finishes / Appliances & Fixtures or FFE
  - MEP Systems / Sprinkler
Modular Vs Conventional I

TIME
- Reduces on-site construction duration by shifting work to the factory

QUALITY CONTROL
- Factory conditions & repetitive task workers can provide better quality of construction and finishes

COST
- Savings in accelerated construction schedule, site labor reductions & faster speed to market
Modular Vs Conventional II

COMMUNITY
Off-site construction shortens neighborhood impact

TEAM COORDINATION
Early collaboration between designers and trades ensures better coordination of final product

ENVIRONMENT
Produces less waste, LEED® credits awarded
Advantageous When . . .

- Speed of delivery to market is valuable
- Project requires prevailing wages for on-site construction
- Local workforce availability is limited
- Construction impact and duration to neighborhood is an issue
Example Structural Details - Mateline

**Typical Mateline at Modular Stack (Factory)**

- Sole plate conn per shear wall sched at dbl sided shear wall (spacing for one side of shear wall only), typ
- Shthg strip to match wall shthg, typ
- Rim joist per plan, typ
- Hgr per plan, typ

**Typical Mateline at Modular Stack (Site-Installed)**

- Mod box A
- Mod box B
- Mod box C
- Mod box D
- Rim joist conn per shear wall sched
- 2x10 sleeper w/ conn per shear wall sched

Scale: 1” = 1'-0"
Example Structural Details - Corridor
Structural Design

- Same as site-built stick frame
  - Joists, beams, stud walls for gravity
  - Wood sheathed diaphragms and shear walls for lateral
- The difference is access and timing
- Design within building code to avoid alternate means and methods
Gravity Design

- Double assembly
- Design for conservative repetition
- Continuous engineered lumber floor rim joists
  - Act as beams in the final condition
  - Provides stability during transport/install
Lateral Design I

- Similar to site-built stick frame
  - More focus on access
- Continuous diaphragm at ceiling sheathing
- Chords and collectors
  - Factory aligned framing
  - 2x sleepers and metal straps
Lateral Design II

- Corridor left unfinished
- “Belly bands” or “stitch sheathing”
- Hold downs where accessible
- Coordination with crane set sequence
  - Shear Connections
  - Hold downs
Mechanical Electrical Plumbing

FACTORY INSTALLED MEP ROUTES
Corridor left unfinished for access

KITCHENS & BATHROOMS
Located adjacent to corridor

SITE CONNECTIONS
Hookups made in corridor
Modular Shipping Parameters
Layout Configuration I

BARBELL CONFIGURATION – MOST EFFICIENT

• Units must align across the corridor
• Provides workforce access during construction
• Openings can be provided between modules (pass throughs)
SAW BOX CONFIGURATION –
LESS EFFICIENT

• Units do not have to align across corridor
• Still include corridor
• Typically used at building turns
• Solve limited crane maneuverability
• Openings can be provided between modules (pass throughs)
Layout Configuration III

CROSS CUT CONFIGURATION – LEAST EFFICIENT

• Reduce total number of modules
• Most finish work on-site
• Site installed corridors
• No natural vibration breaks
• Requires more extensive MEP coordination
Exterior Articulation Options

SHAPE

Bump outs

Jog

Cantilever

Most Efficient

Less Efficient

Least Efficient

PLAN

SECTION

3'-0" Typ
Supporting Structure

**DIRECT TO FOUNDATION**

- Crawl space on continuous concrete footings
- Concrete mat slab foundation

**PODIUM**

- Concrete podium transfer slab
- Steel podium with concrete over metal deck
- Precast options such as hollow-core plank are feasible but not typical
Site-Built Structure

SITE BUILT FIRST LEVEL

• Conventional wood framed first floor with modular on top
• Steel, wood, or masonry framing to accommodate local transfer areas
Modular Engineer of Record

SITE EOR RESPONSIBILITIES

• Supporting structure
• Simple scope delineation
• Local Permit

MODULAR EOR RESPONSIBILITIES

• Factory-built portion
• Provide building loads to Site EOR
• State Permit
Design for Delivery

TRANSPORTATION
• 72’ Module on 60’ truck bed
• Means and methods

INSTALLATION
• Continuous floor rims
• Irregular shape
• Lift from the bottom
Urban Site Challenges

- Crane access and swing
- Temporary mod storage
- Space for Staging
- Transportation logistics
- Zoning height and site width considerations due to double framing assembly
 Permitting Approach – Dual Jurisdictions

**STATE JURISDICTION**

- Code Review: Modular Portions
  - Built/installed in factory
  - On-site connections (load path)
  - Components connected to the modular structure
- Inspections: Modular Portions
  - Built/Installed in Factory
  - Third party in the factory

**LOCAL JURISDICTION**

- Code Review: Site-Built Portions
  - Fully site-built (e.g. foundations, concrete podium, etc)
- Inspections: Site-Built and Site-installed Modular Portions
  - Modular portions inspected based on State approved drawings
  - Local AHJ or third party
California Specific Permitting

- California State Jurisdiction
  - California Department of Housing and Community Development (HCD)
  - Maintains a handbook to educate local AHJs, builders and general public
    - HCD FBH 314
  - Mandatory pre-app meeting with local jurisdictions required soon (highly recommended)
  - Resume of work (highly recommended)
This concludes The American Institute of Architects Continuing Education Systems Course

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