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

Structural Design of Modular Construction Demystified

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DCI ENGINEERS

Disclaimer: This presentation was developed by a third party and is not funded by WoodWorks or the Softwood Lumber Board.

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

Wood Modular **Guerdon /** Pyatok

Wood Modular **Guerdon /** David Baker

Wood Modular **Champion /** Schematic Workshop

Wood Modular **Guerdon /** Lowney Architecture

Steel Container **CIMC /** HLW International

Wood Modular **ONE Build /** Hamilton Urban

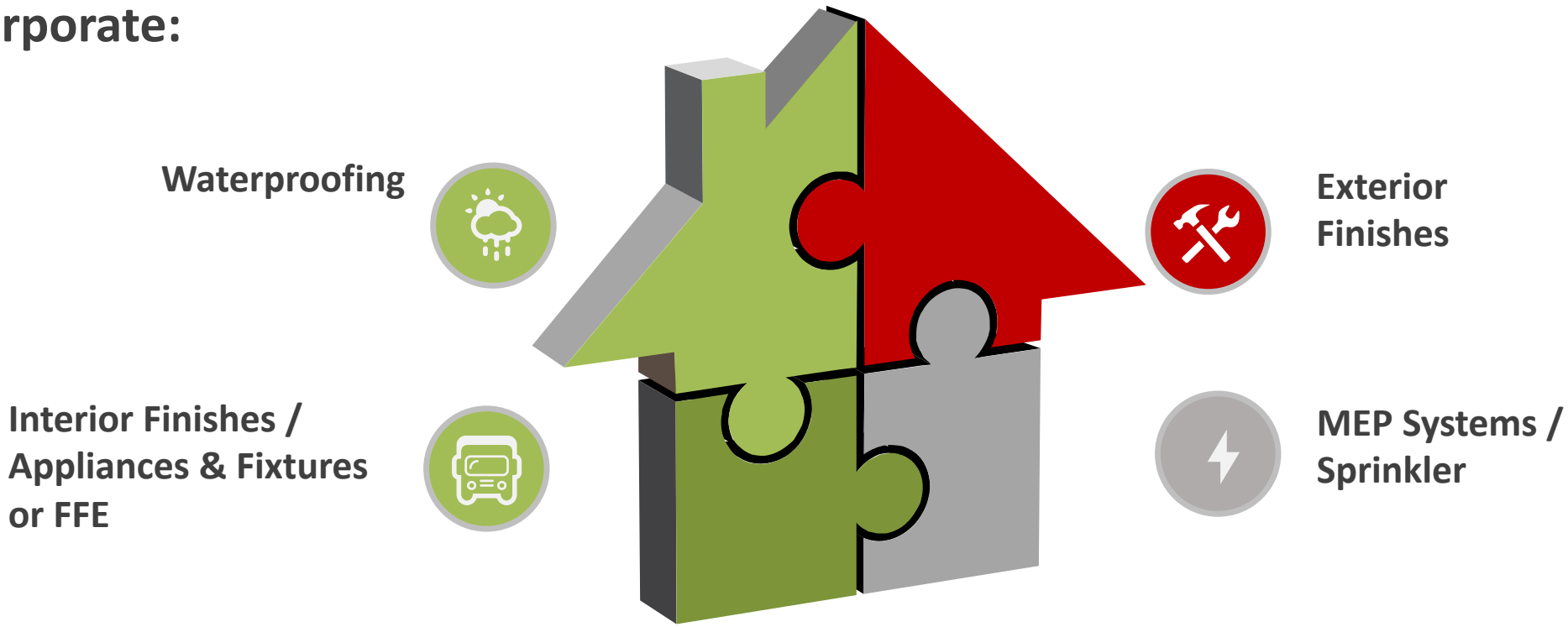
Wood Modular **Transform /** Driscoll Architects

Steel Container **CIMC /** Panoramic Interests

Volumetric Wood Modular

OFF-SITE FACTORY BUILT CONSTRUCTION

- More efficient building delivery & higher quality
- Designed & inspected to meet current IBC codes
- Can incorporate:



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

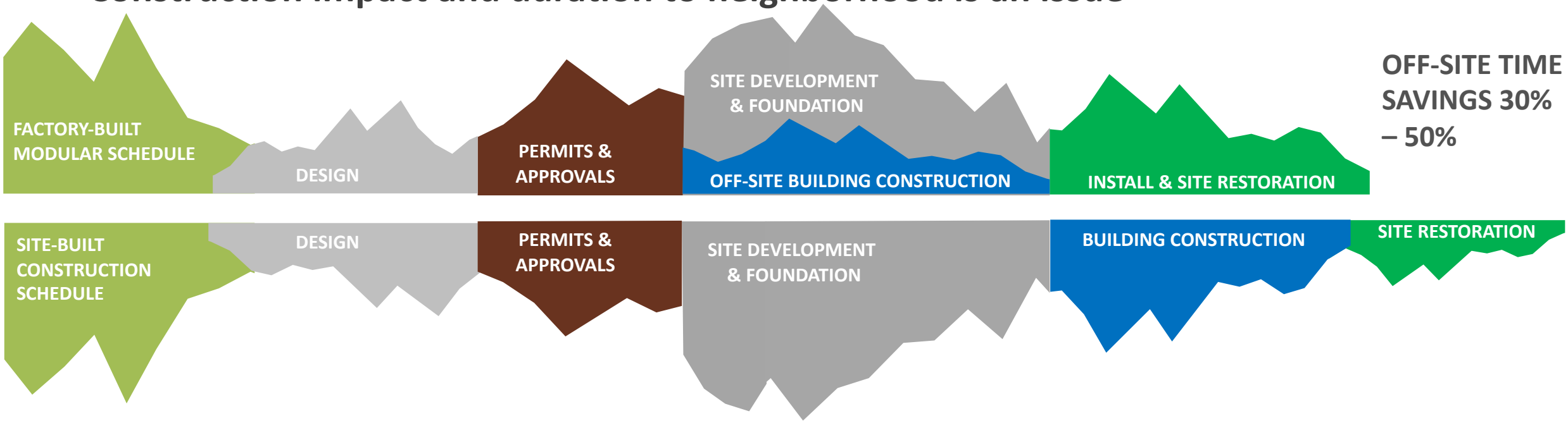
Early collaboration between designers and trades ensures better coordination of final product

ENVIRONMENT

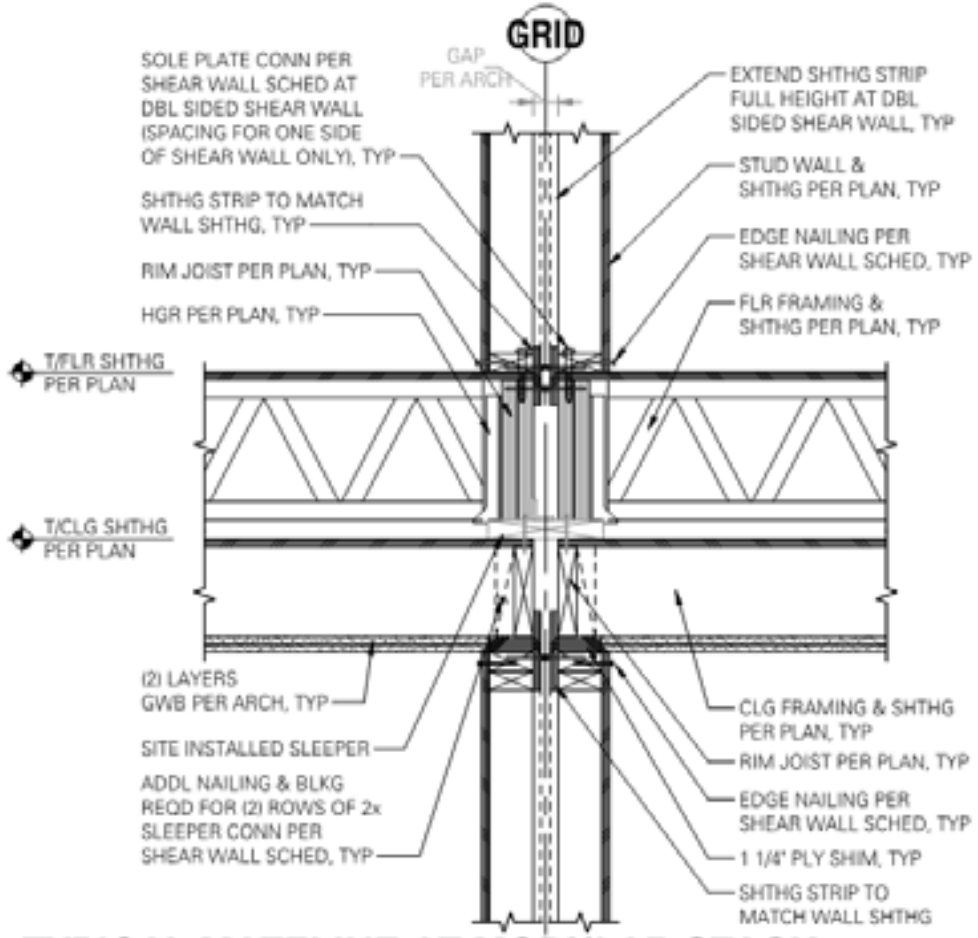
Produces less waste, LEED® credits awarded

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

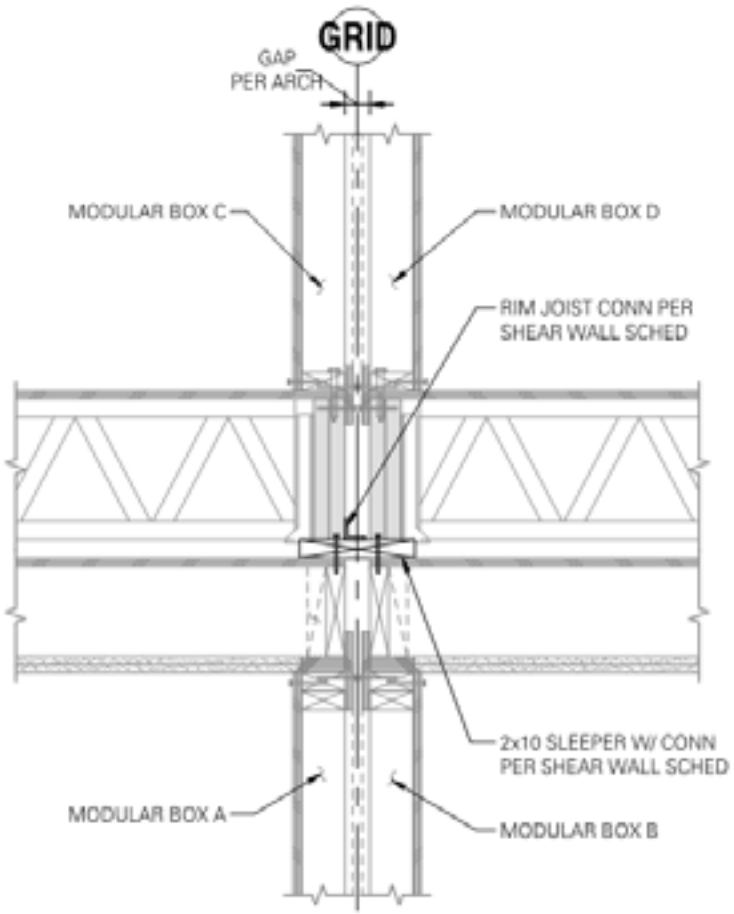


Example Structural Details - Mateline



TYPICAL MATELINE AT MODULAR STACK (FACTORY)

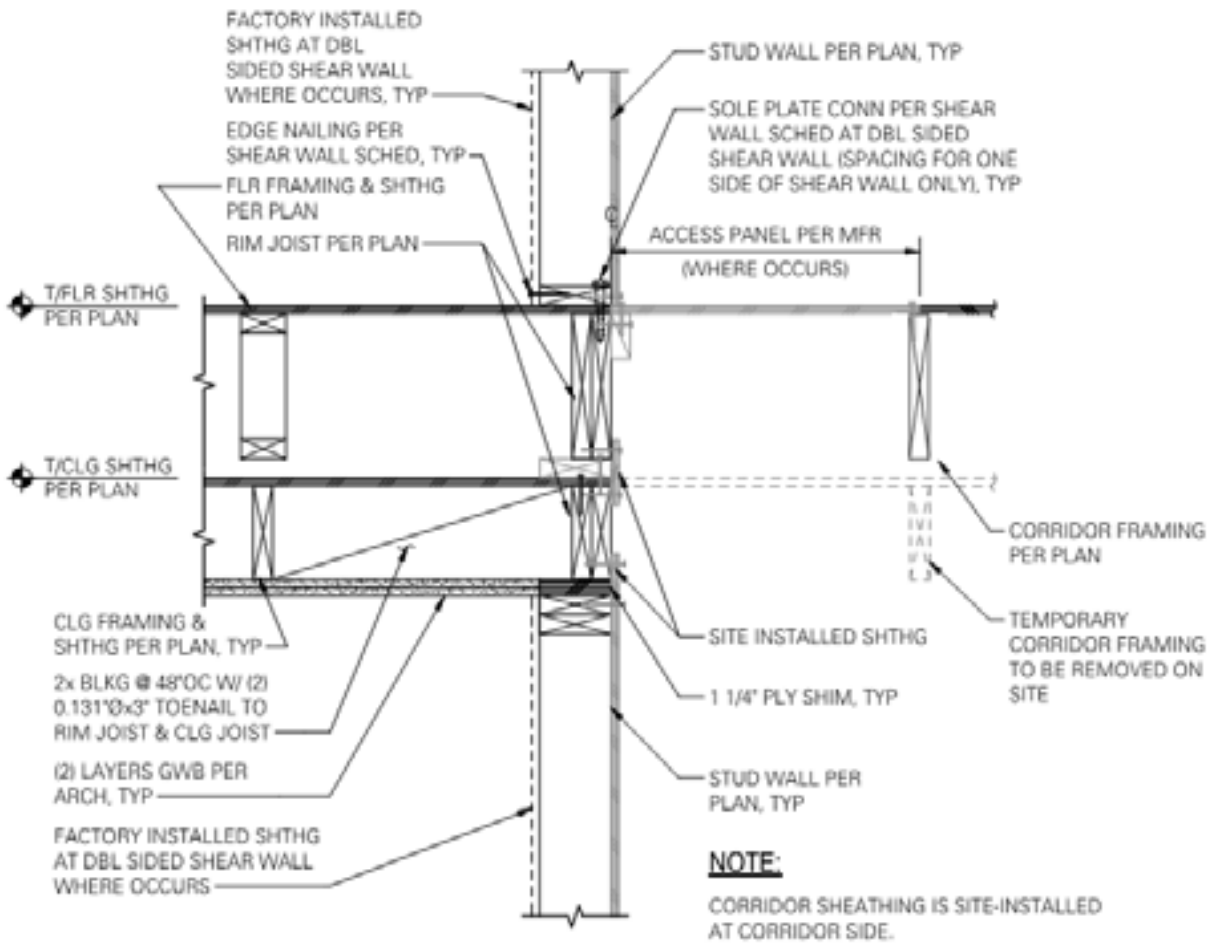
SCALE: 1" = 1'-0"



TYPICAL MATELINE AT MODULAR STACK (SITE-INSTALLED)

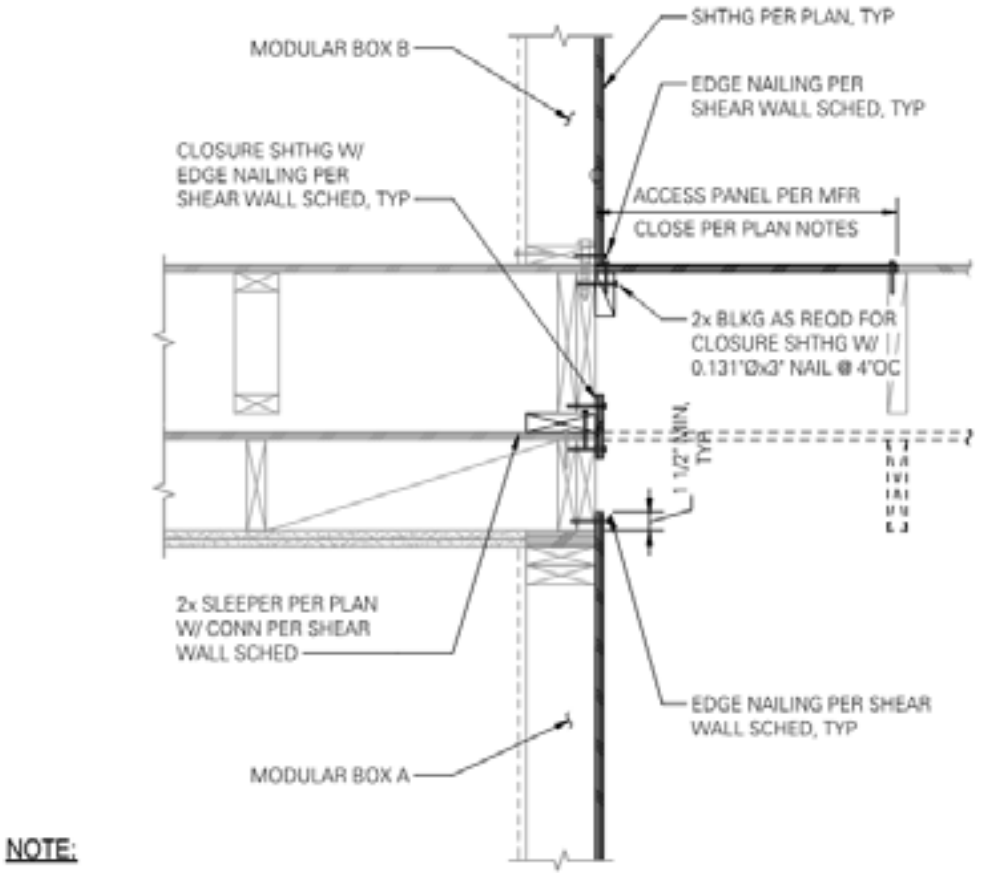
SCALE: 1" = 1'-0"

Example Structural Details - Corridor



TYPICAL CORRIDOR AT MODULAR STACK (FACTORY)

SCALE: 1" = 1'-0"



TYPICAL CORRIDOR AT MODULAR STACK (SITE-INSTALLED)

SCALE: 1" = 1'-0"

Structural Design

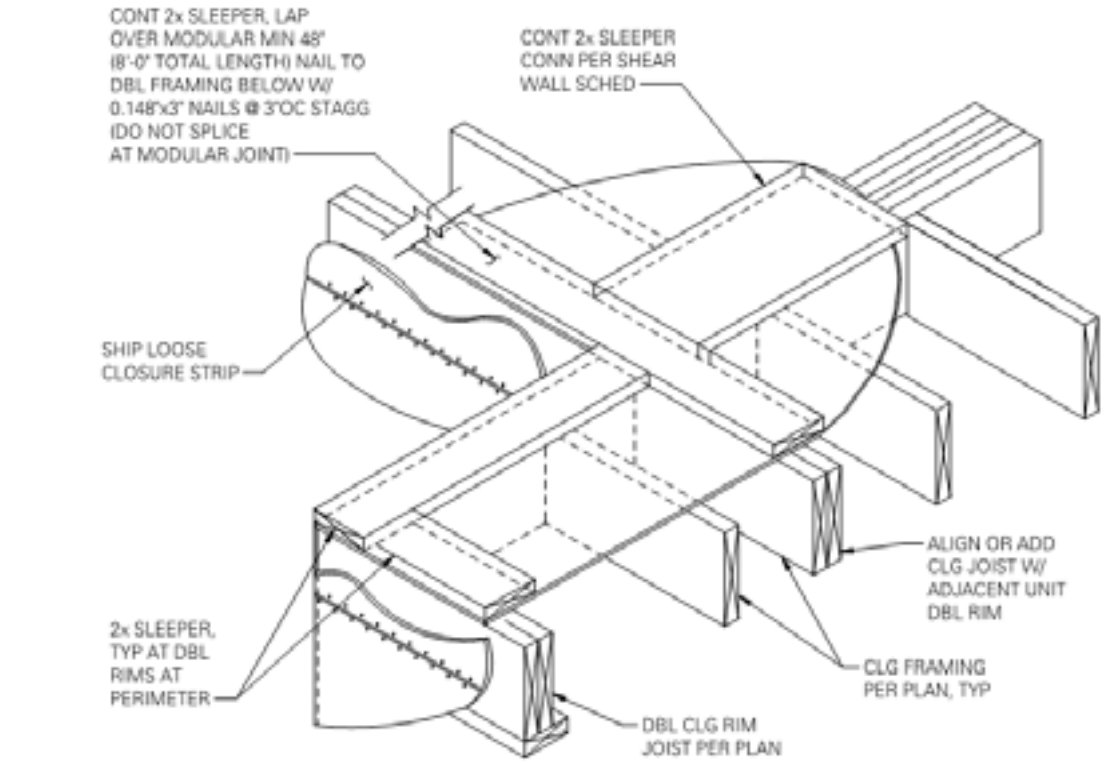
- **Same as site-built stick frame**
  - **Joists, beams, stud walls for gravity**
  - **Wood sheathed diaphragms and shear walls for lateral**
- **The difference is access and timing**
- **Design within building code to avoid alternate means and methods**

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**

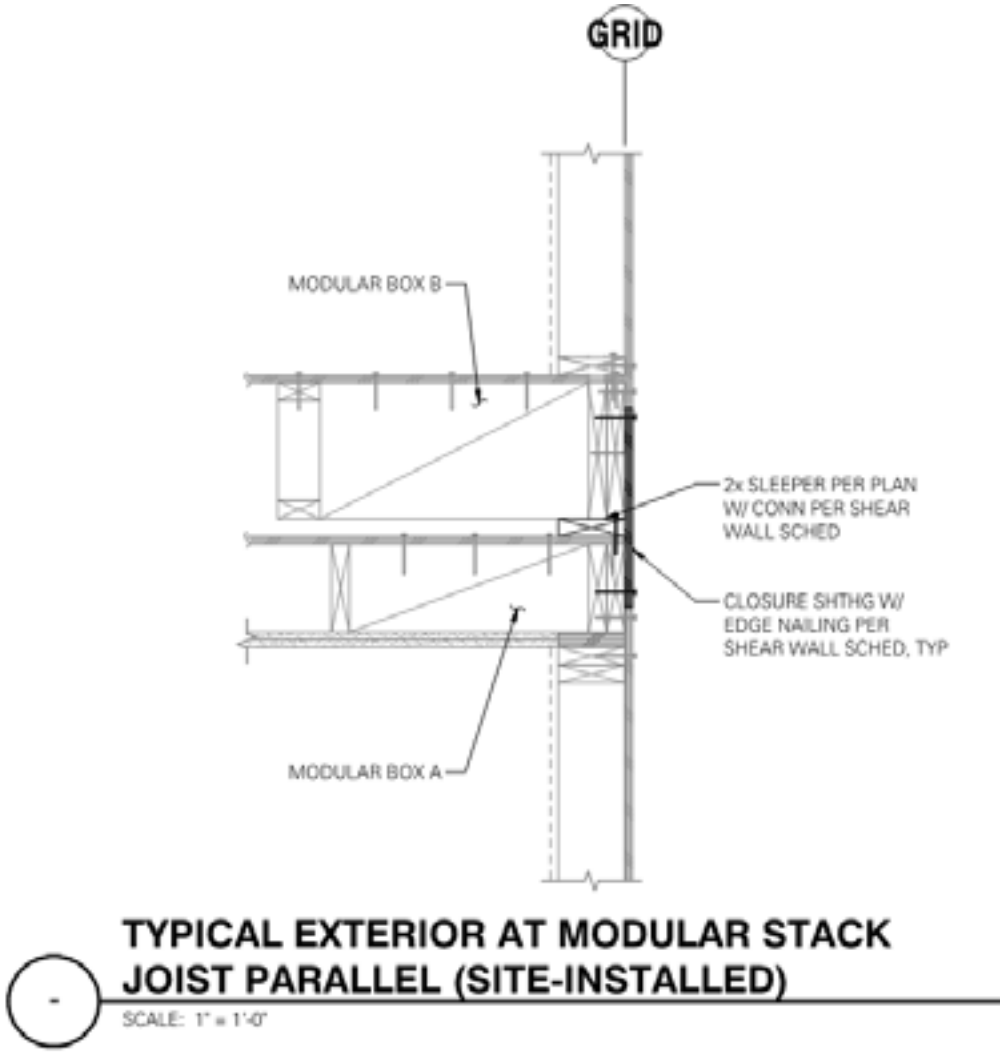
Lateral Design I

- 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

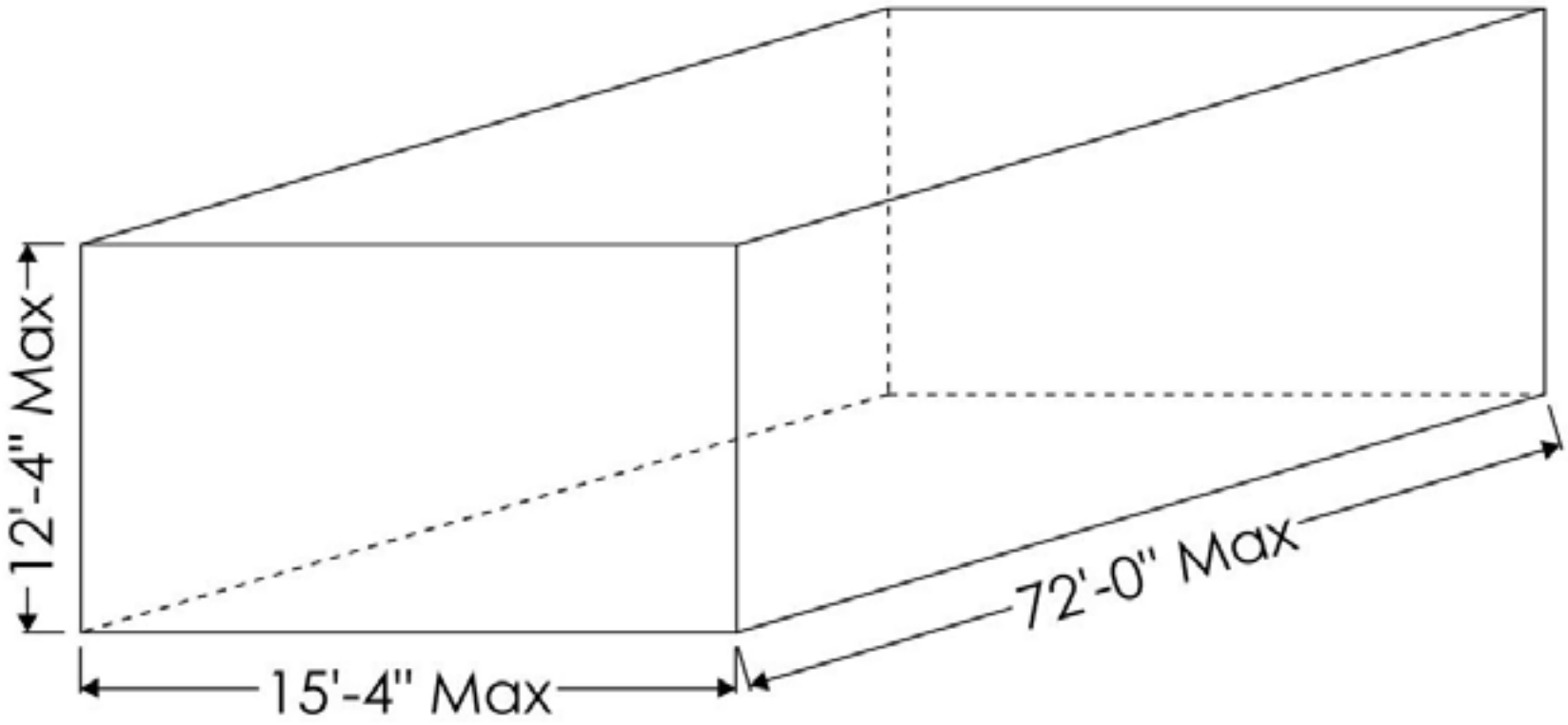
KITCHENS & BATHROOMS

Located adjacent to corridor

SITE CONNECTIONS

Hookups made in corridor

Modular Shipping Parameters

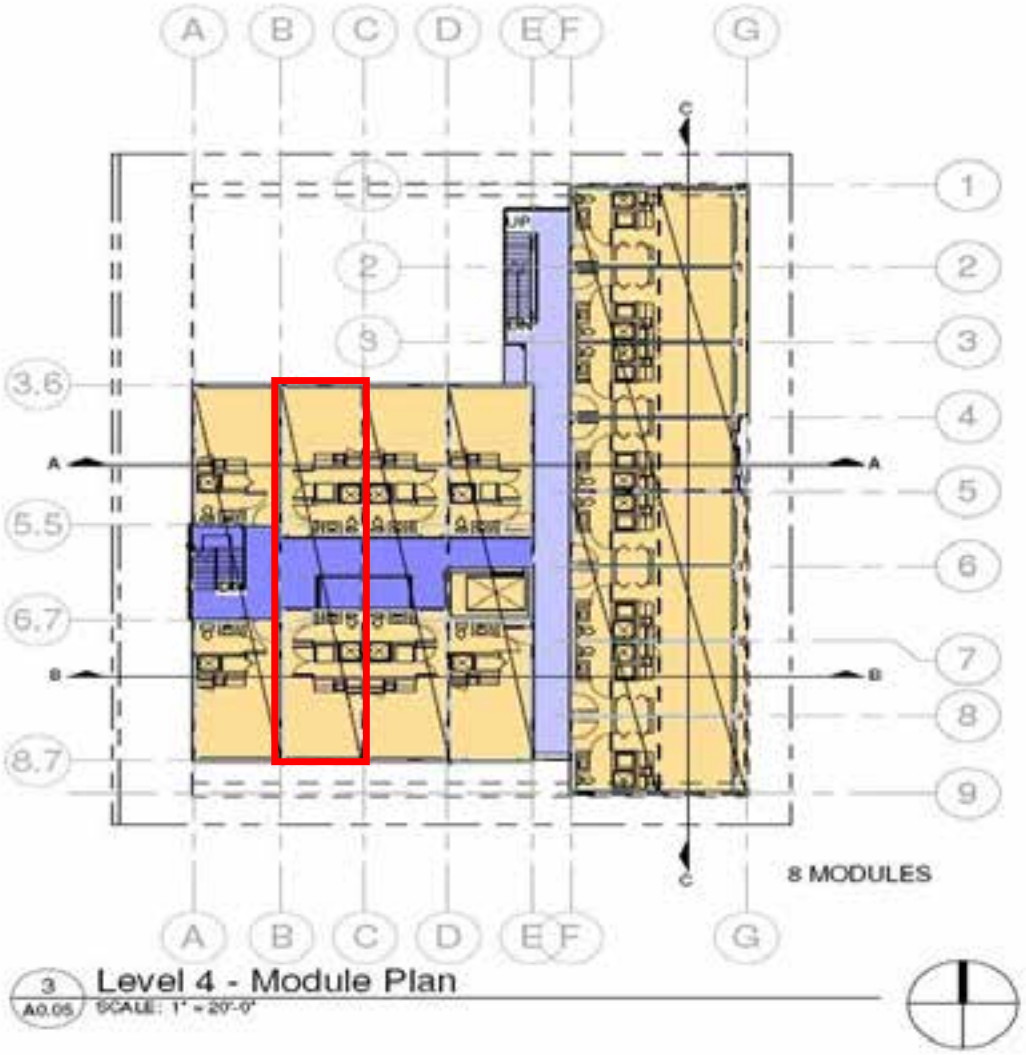


Layout Configuration I

BARBELL CONFIGURATION –

MOST EFFICIENT

- **Units must align across the corridor**
- **Provides workforce access during construction**
- **Openings can be provided between modules (pass throughs)**

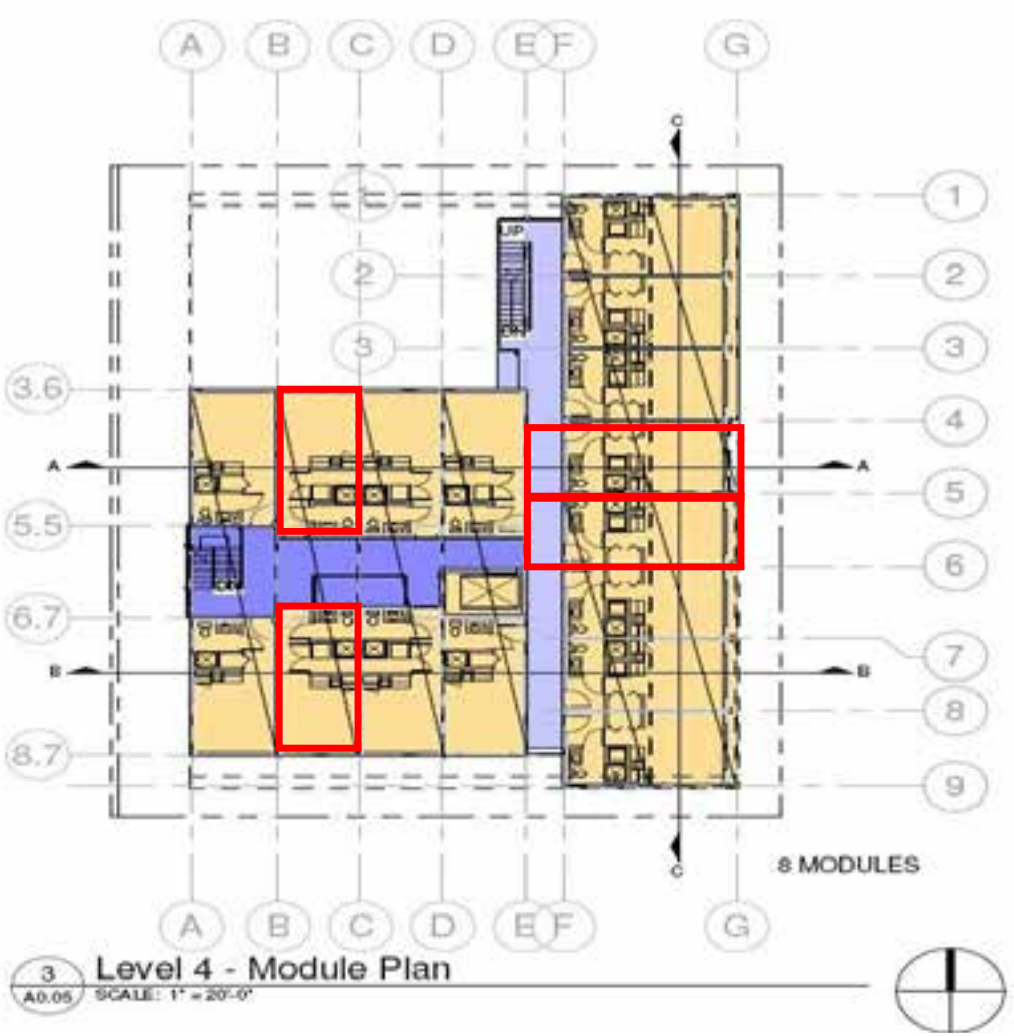


Layout Configuration II

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)**

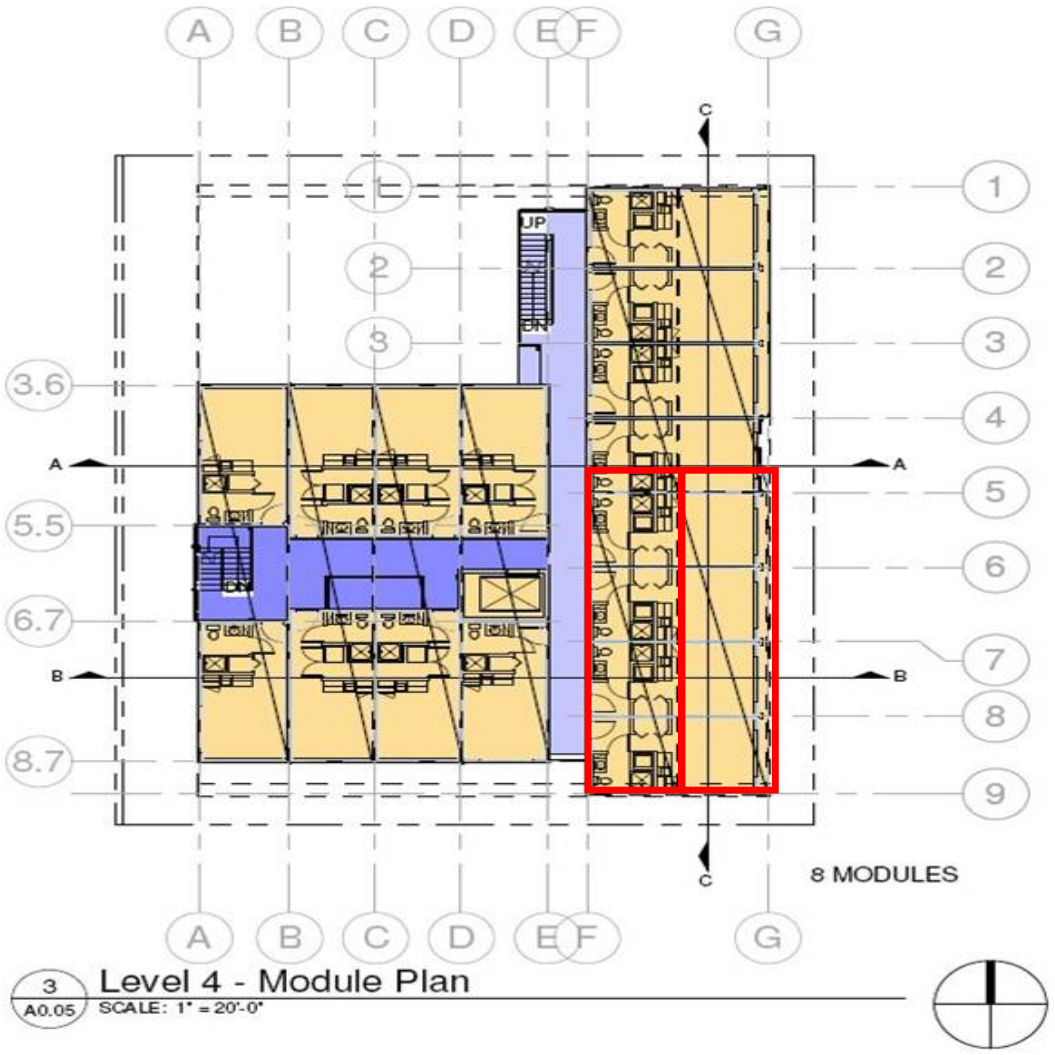


Layout Configuration III

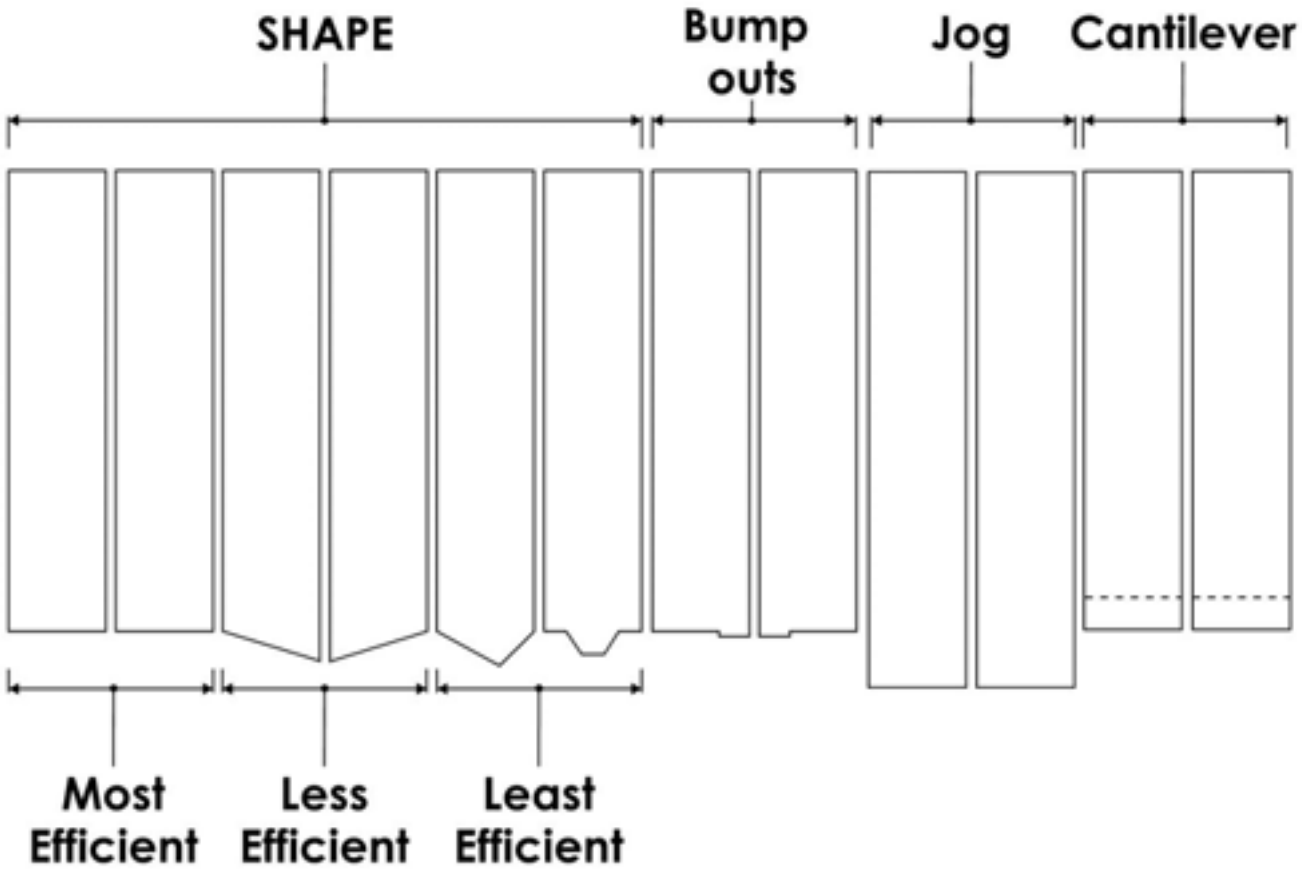
CROSS CUT CONFIGURATION –

LEAST EFFICIENT

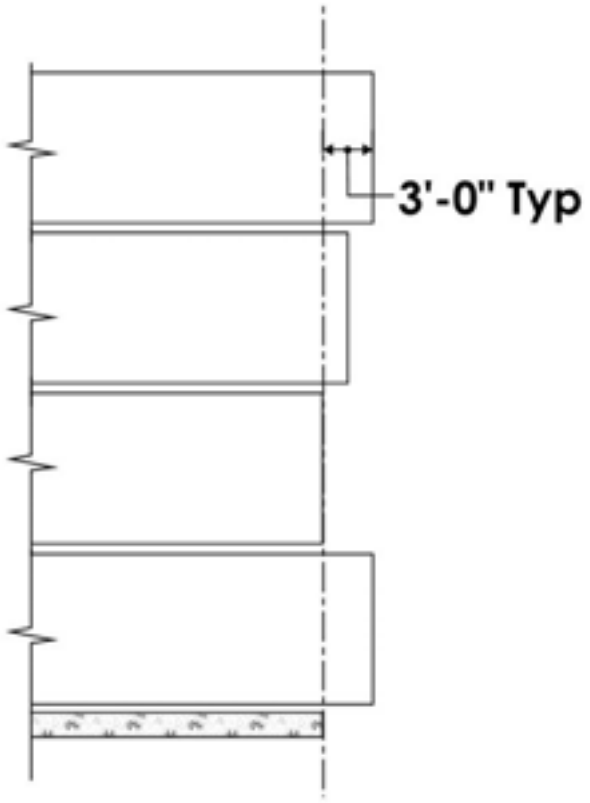
- Reduce total number of modules
- Most finish work on-site
- Site installed corridors
- No natural vibration breaks
- Requires more extensive MEP coordination



Exterior Articulation Options



PLAN



SECTION

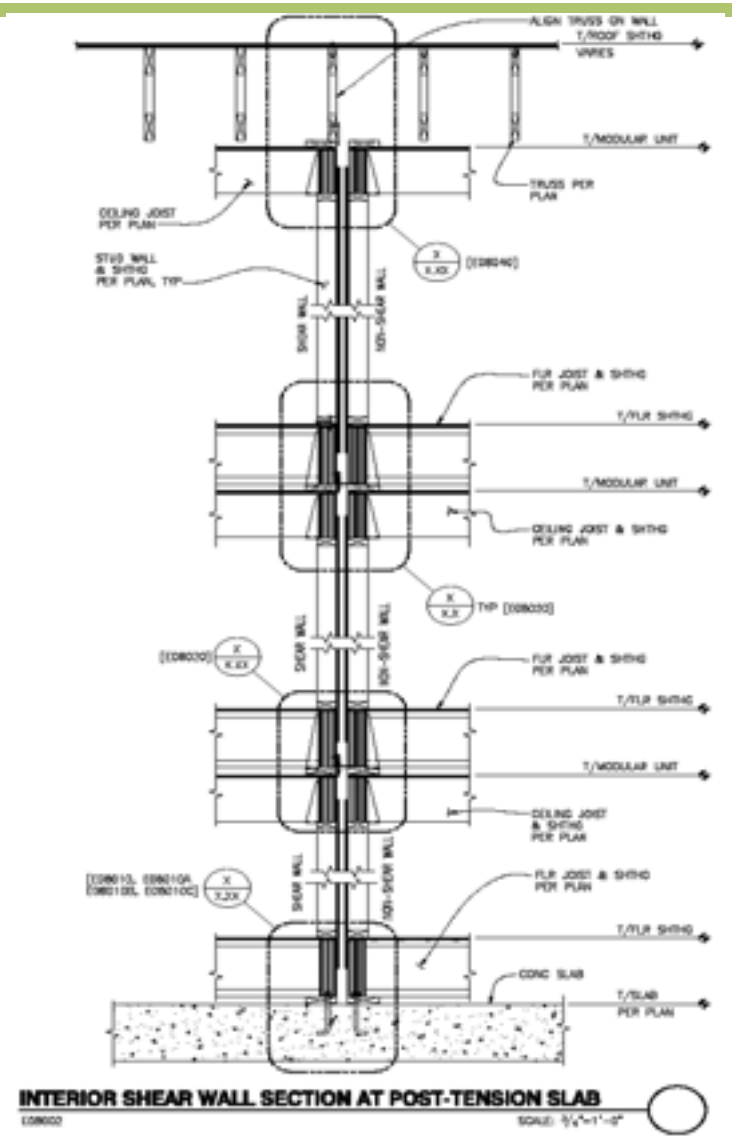
Supporting Structure

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**

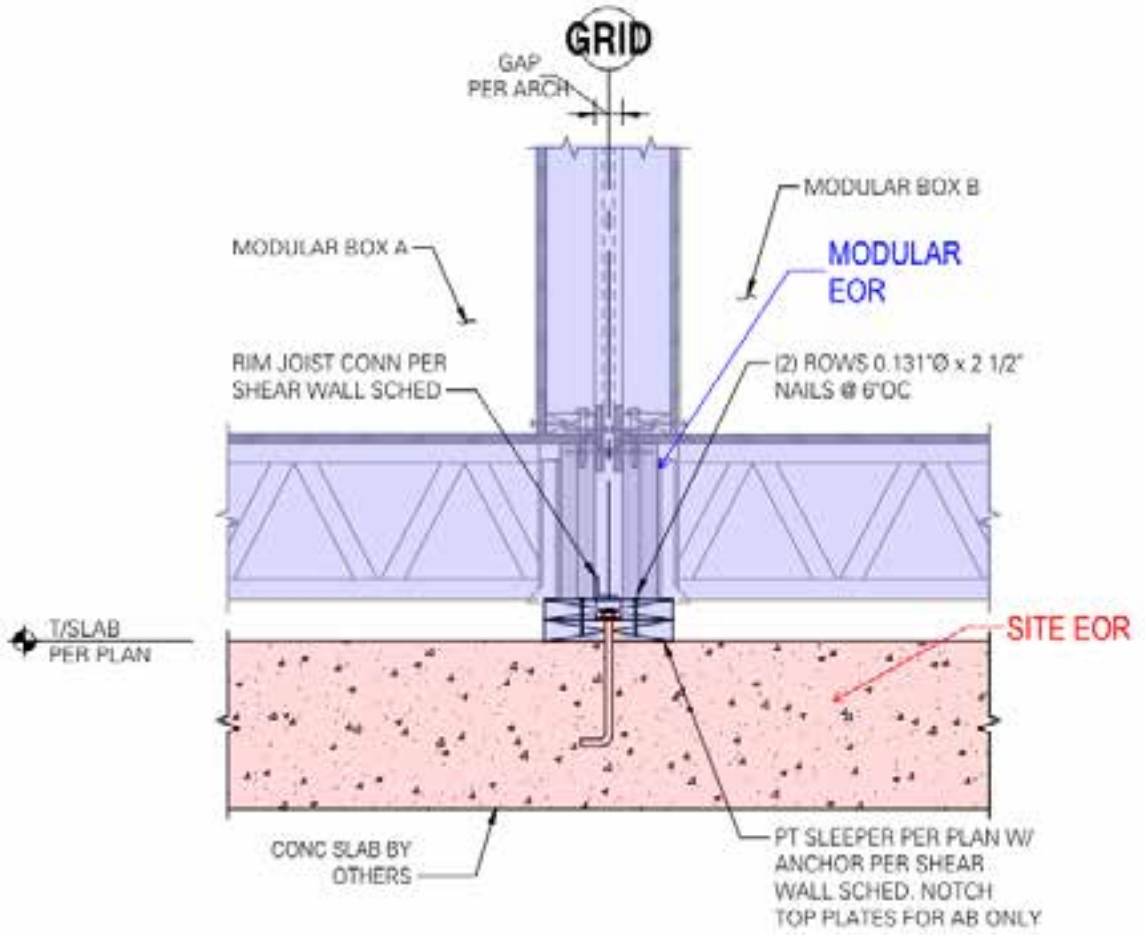
Modular Engineer of Record

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)**

***HCD = California Department of Housing and Community Development
***LAHJ = Local Authority Having Jurisdiction
***FD = Fire Department

Discipline/Description	Plan Review			Inspections			Comments
	HCD	LAHJ	FD	HCD	LAHJ	FD	
Structural							
Podium Slab		X			X		Including embedded elements that modular units will attach to (embeds, anchors, etc)
All construciton below poduim slab		X			X		
Factory-Built (FB) Portions (Modules)	X			X			
Interconnections between modules	X				X		Including hold downs and their connections to the embedded podium elements
Site-built elements in the FB Portion	x				x		e.g. partial corridor framing, parapets and parapet braces, misc framing where indicated
Site-installed wood shear wall components	x				x		e.g. corridor sheathing, ATS rods and hardware, where indicated

QUESTIONS?

This concludes The American Institute of Architects Continuing Education Systems Course

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