The Duke: Mass Timber & Light Frame Hybrid

Presented by Forrest Bratton, P.E., SECB

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

Owner:
Harris Bay; Granite Bay, CA

Architect:
DesignTrait; Austin, TX

Structural Engineer:
WGI; Austin, TX

MEP Engineer:
AYS; Austin, TX

General Contractor:
Trinity Constructors; Pflugerville, TX

Mass Timber Supplier:
KLH US Holding Corp.; Portland, OR
Design and construct an all-timber 4-story mixed-use building in the heart of the fast-developing East Side of Austin, Texas

Considerations:

• Ground floor retail needs “open” floor plan, minimal walls
• Residential units to have maximal ceiling heights
• Timber structure to be exposed wherever possible
• High local familiarity with light-framed wood construction
• Mass timber desired as proof-of-concept, interest-generation
Building Code:
• 2015 IBC

Building Height:
• 4 stories, 57’-0” tall

Building Area:
• 41,989 SF conditioned
• 1,179 SF patios

Construction Type
• IV at 1st floor, VA above
• (could have been VA throughout)

Occupancy:
• Ground Floor: A-2, B, M (Food service, Business, Mercantile)
• Upper Floors: R-2 (Long-term Residential)
### The Duke: The Concept

**Options considered during concept:**

- Concrete Podium +
  - Heavy timber/Mass timber
  - Light-framed wood (traditional)
  - Light-framed wood + mass timber (hybrid)
- All heavy timber
- Timber “Podium” +
  - Light-framed wood (traditional)
  - Light-framed wood + mass timber (hybrid)
Timber “Podium” + Light-framed wood + mass timber (hybrid)

Challenges

• Unfamiliar construction methods for local contractors
  • Accepted as part of process to develop proof-of-concept → more on this later

• Timber “podium” cannot provide 3-hour fire separation at Level 2
  • 1-hour rating sufficient for separation between occupancies, provided through char per NDS
  • NFPA 13 sprinklers must be provided at all levels

• Deeper structure required for Level 2 than comparable concrete
  • Maximum building height not a controlling criterion for project
  • Lower clear height between (typ. 33”) girders deemed acceptable

• Closer column spacing required than for concrete podium slab
  • Accepted because exposed timber viewed as a feature
The Duke: The Concept

Timber “Podium” + Light-framed wood + mass timber (hybrid)

Advantages

• In keeping with all-timber brief, opportunity for added value
• Lighter than concrete podium options (foundation savings—clay subgrade)
• Faster to erect than cast-in-place concrete
• Optimizes use of wood fiber vs all-mass-timber option
• Flexible layout of residential units
• Walls can incorporate plumbing/electrical as with traditional wood-frame construction
• Fewer separate elements/connectors for lateral structural system
The Duke: Gravity Structure

Upper CLT panels
(160mm floors, 120mm roof)

Light-framed wood walls
(Mix of 2x4 and 2x6)
The Duke: Gravity Structure

Level 2 CLT panels
(280mm “podium” floor)

Glulam Girders & Columns
CLT walls (140mm, 200mm)
The Duke: Lateral Structure

Upper CLT panel diaphragms
(160mm floors, 120mm roof)

Light-framed wood shear walls
(Mix of wood panel and gypsum sheathing)
The Duke: Lateral Structure

Level 2 CLT panels  
(280mm “podium” floor)

CLT walls (140mm, 200mm)
Simple spline joints are used at upper-level panels.

Screws installed from above connect through panels to walls below.
Inclined screws are used for wall connections occurring at panel joints.

Half-lap joints with inclined screws at Level 2 provide better load-sharing and diaphragm stiffness.
Shear wall holdowns use screw plates welded to threaded rod base connectors.

Inclined screws fasten collector straps and attach Level 2 panels to CLT shear walls.
The Duke: Special Considerations

- Fire separation between residential units with exposed CLT/timber
- Waterproofing CLT at exterior balconies
- Performance of CLT as diaphragm/shear wall
- Floor vibrations, especially across units
- Concentrated loads on CLT panels
- Acoustic performance of CLT floor
Mass timber floors need sound attenuation, particularly between residential units.

- Buildup over CLT to achieve minimum STC 55 and IIC 55 ratings with exposed timber panel ceilings.
- Poured underlayment avoided due to weight and potential schedule impact due to cure time.*
- Assembly was value-engineered during bidding, but viable alternative proved difficult to find.

*After start of construction, design team learned that GC would have preferred a poured topping for greater simplicity (but weight is still an issue).
WoodWorks has a resource for acoustically-tested assemblies.
The Duke: Lessons Learned

Poured toppings were too heavy to use for as a late alternative. (12 psf max)

<table>
<thead>
<tr>
<th>CLT Panel</th>
<th>Concrete/Gypsum Topping</th>
<th>Acoustical Mat Product Between CLT and Topping</th>
<th>Finish Floor</th>
<th>STC</th>
<th>IRC</th>
<th>Source</th>
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<tbody>
<tr>
<td>4” concrete</td>
<td>Filtex GericMat** FF16 (FF30 + FF66)</td>
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<td>LVT</td>
<td>56</td>
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</table>

| 2” gypsum     | Keene’s Quiet Quail® G75 |                                              | LVT          | 54  | 50  | 122    |
|               | Keene’s Quiet Quail® ORK |                                              | LVT          | 58  | 50  | 124    |
|               | 1/2” Gypsum Mae Soft Underlayment on Keene’s Quiet Quail® G75 | | LVT          | 58  | 50  | 124    |

| 3” concrete   | Kinetics® RIM 33l 2-24 Systems with 3/4” Plywood | 2 layers of 1/4” USG Fiberock® on Kinetics® Soundmatt | LVT          | 61  | 59  | 114    |
|               | Kinetics® Ultra Quiet 5R with synthetic roofing felt | 2 layers of 1/4” USG Fiberock® on Kinetics® Soundmatt | LVT          | 61  | 58  | 117    |

| 4” concrete   | Kinetics® RIM 33l 2-24 Systems with 3/4” Plywood | None                                          | LVT          | 61  | 52  | 120    |

19 psf

No STC rating

38 psf
Only pre-drill plumbing penetrations where you are 100% sure you have it right.

- If coordinated early, it is easy to pre-core plumbing penetrations, BUT...

- If penetrations are located incorrectly, enlarging holes can be difficult. Cutting/coring also removes more of the structural member, which must be reanalyzed.

- Location/size information is likely communicated to manufacturer via CAD, which is atypical for a formal design deliverable. Scope appropriately, and consider liability implications.

- Contractor may prefer to drill/core all penetrations in field (may need special equipment; EOR must review layout)
Communicate early to verify elevator can be installed as intended.

- Elevator installer may want entire shaft width open at first level for cab installation, BUT...

- If CLT wall is loadbearing - and a shear wall - then what? (door opening comparable to concrete shaft)

- Also consider guide rail bracket attachment – may be nonstandard
This concludes The American Institute of Architects Continuing Education Systems Course

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