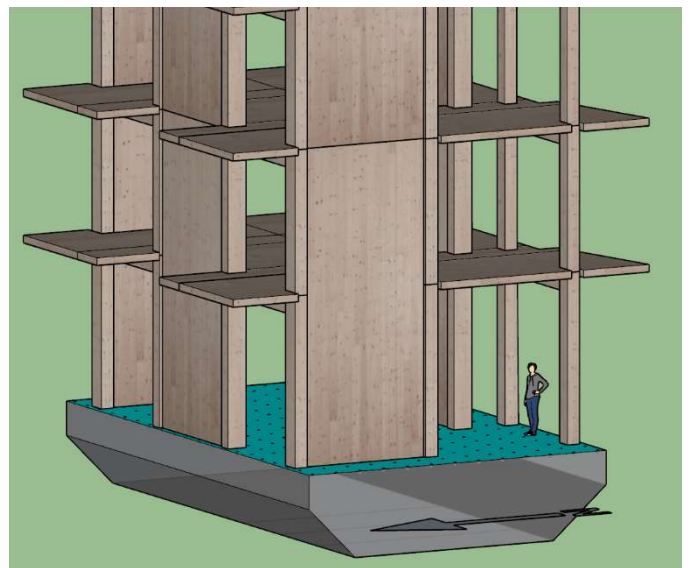
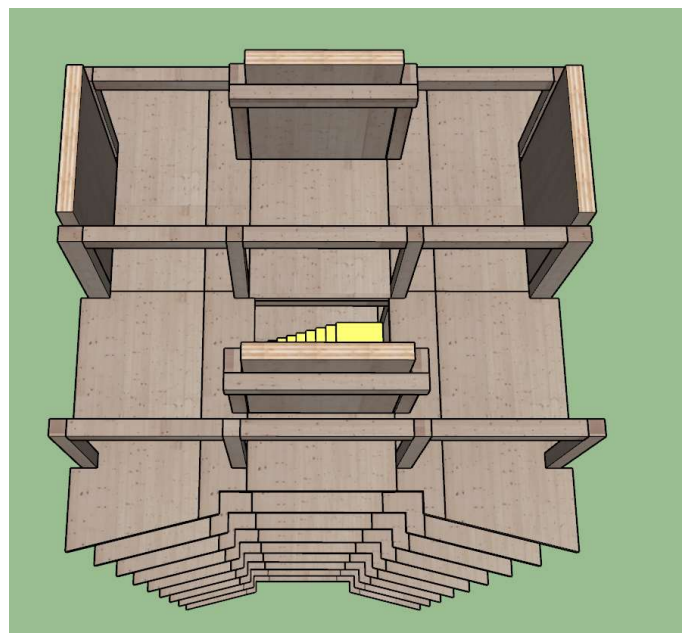
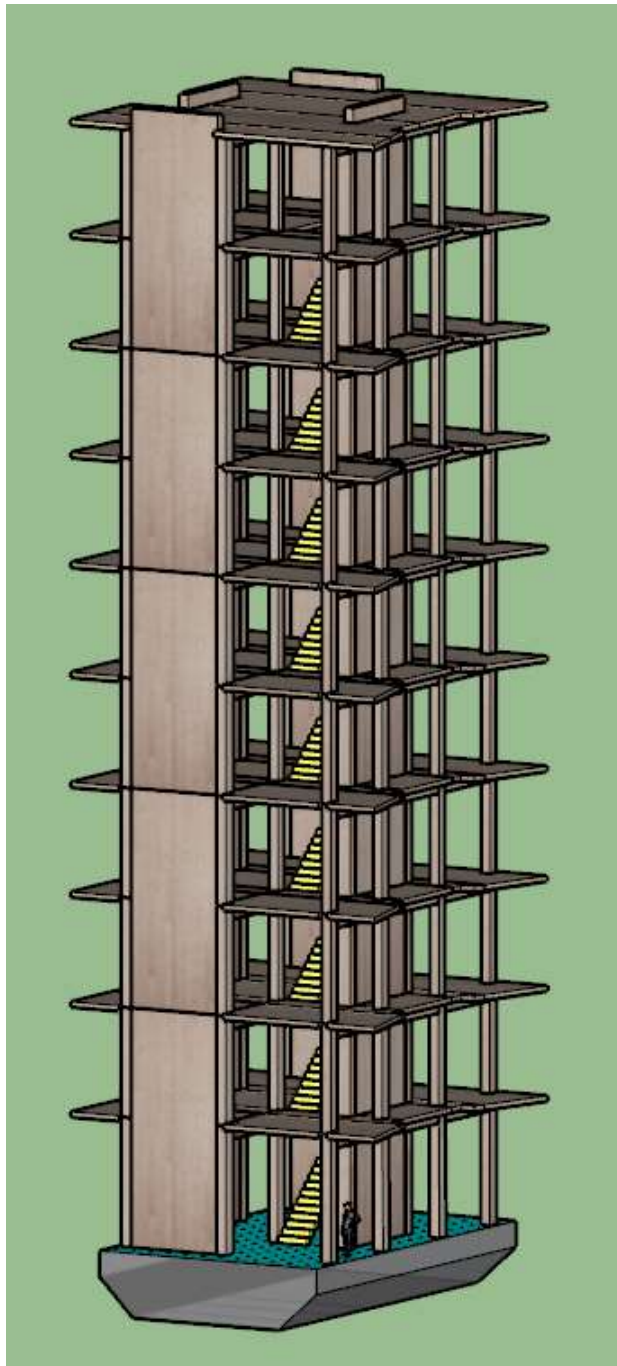


# Gravity Design of the NHERI TallWood 10-story Test Building



Contact: Shiling Pei ([spei@mines.edu](mailto:spei@mines.edu))

Through project team discussion, the gravity design for the 10-story test has been completed. The design and drafting was primarily performed by CSM team in collaboration with KPFF, Holmes Structures, and LEVER Architecture. This document described the basic design parameters and the floor plan of the test specimen. The complete document for the design also include the Excel spreadsheets on ASD and LRFD calculations following NDS 2015, the AutoCAD floor plans and elevations, and a Sketch-up 3D model. This current design package focused on structural elements, the size of the rocking wall is determined based on preliminary lateral design.

The objective of this design package is to provide a basis for the research team and potential collaborators to quantify and plan materials and components.

In summary, NDS-ASD design format was used considering:

- Dead load of 70 lb/sq.ft. for all floors and roof (Steel plates will be added to the specimen during testing to reach this total dead load level. Thus this is the total seismic mass that should be assigned for any simulation and as-built analysis)
- Live load of 65 lb/sq.ft. for all floors (load will NOT be added during test, only used here for design and sizing of members)
- All columns and beams were designed with sacrificial layers ensuring 2 hour fire rating (@ 3.6 inch/2hr char rate on all exposed surfaces)

For geometry and materials, we made the following assumptions:

- 13' First Floor height (top of floor to top of the next floor, Not clear height)
- 11' All other Floor height
- 24F-1.8E (V4) Stress Class for glulam, Western Species or equivalent
- 5 Ply CLT (6-7/8 inch) SPF-V2 panels for floors
- 9 Ply CLT (Assumed E1M5) (12-3/8 inch) panels for Rocking Walls (Note although rocking walls are not part of the gravity system, this size is close to the final design and can be used for cost estimates on materials and construction)

We also made assumptions on the allowable stress adjustment factors for the beams and columns. The following table shows the different factors we used for each:

Beam Adjustment Factors:

$C_M$	1
$C_D$	0.9
$C_t$	1
$C_v$	Varies**

Column Adjustment Factors:

$C_M$	1
$C_t$	1
$C_D$	0.9
$C_P$	Varies**

\*\* Varies indicates that the values differ from case to case and can be found in the design excel spreadsheet for each case. The design excel sheet can be shared but should not be needed for cost/construction estimation.

A summary of the member sizes selected is listed in the following table.

**Table 1: Column and Beam Sizes Summary**

Member	Size (in)	Control D/C ratio before fire	Control D/C ratio after fire
Columns (Floor 1-2)	12.25 x 15	0.576	1.041
Columns (Floor 3-6)	12.25 x 13.5	0.512	1.031
Columns (Floor 7-10)	12.25 x 12	0.288	0.677
Rocking wall bounding Columns (All Floor)	12.25 x 18	0.480	0.752
Beam (All)	12.25 x 13.5	0.459	0.732

**Table 2: Approximate material quantity**

Member	Size or Thickness (in)	Length (ft) Or Area (ft <sup>2</sup> )	Total Volume (ft <sup>3</sup> )
Columns (Floor 1-2)	12.25 x 15	144 ft	184
Columns (Floor 3-6)	12.25 x 13.5	264 ft	303
Columns (Floor 7-10)	12.25 x 12	264 ft	270
Rocking wall bounding Columns (All Floor)	12.25 x 18	896 ft	1372
Beam (All)	12.25 x 13.5	966 ft	1109
CLT floor panel (5-ply)	~6-7/8	9010 ft <sup>2</sup>	5162
Rocking wall Panel (9-ply)	~12-3/8	4513 ft <sup>2</sup>	4654

**Table 3: Rocking Wall Specs**

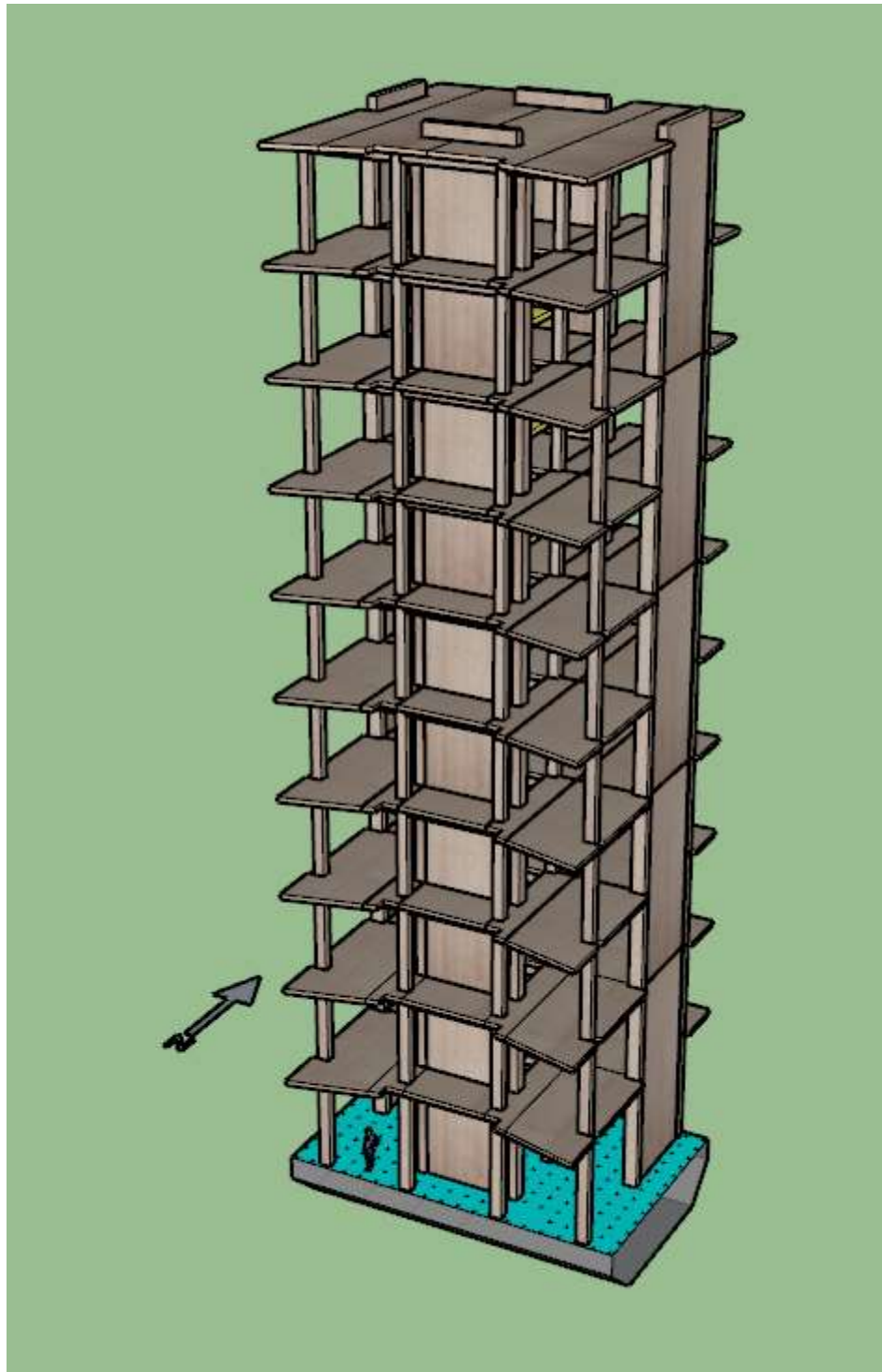
Member	Quantity	Preliminary Size
CLT Rocking Walls	4 total	9-Ply (~12-3/8" thickness)
Post-Tensioning	4 per wall (16 total)	1-3/8" ASTM F1554 Grade 105 Threaded Rods
UFPs	36 per wall (144 total)	½" x 4 ¼" ASTM A572 Grade 42

A few details that may affect construction process/costs:

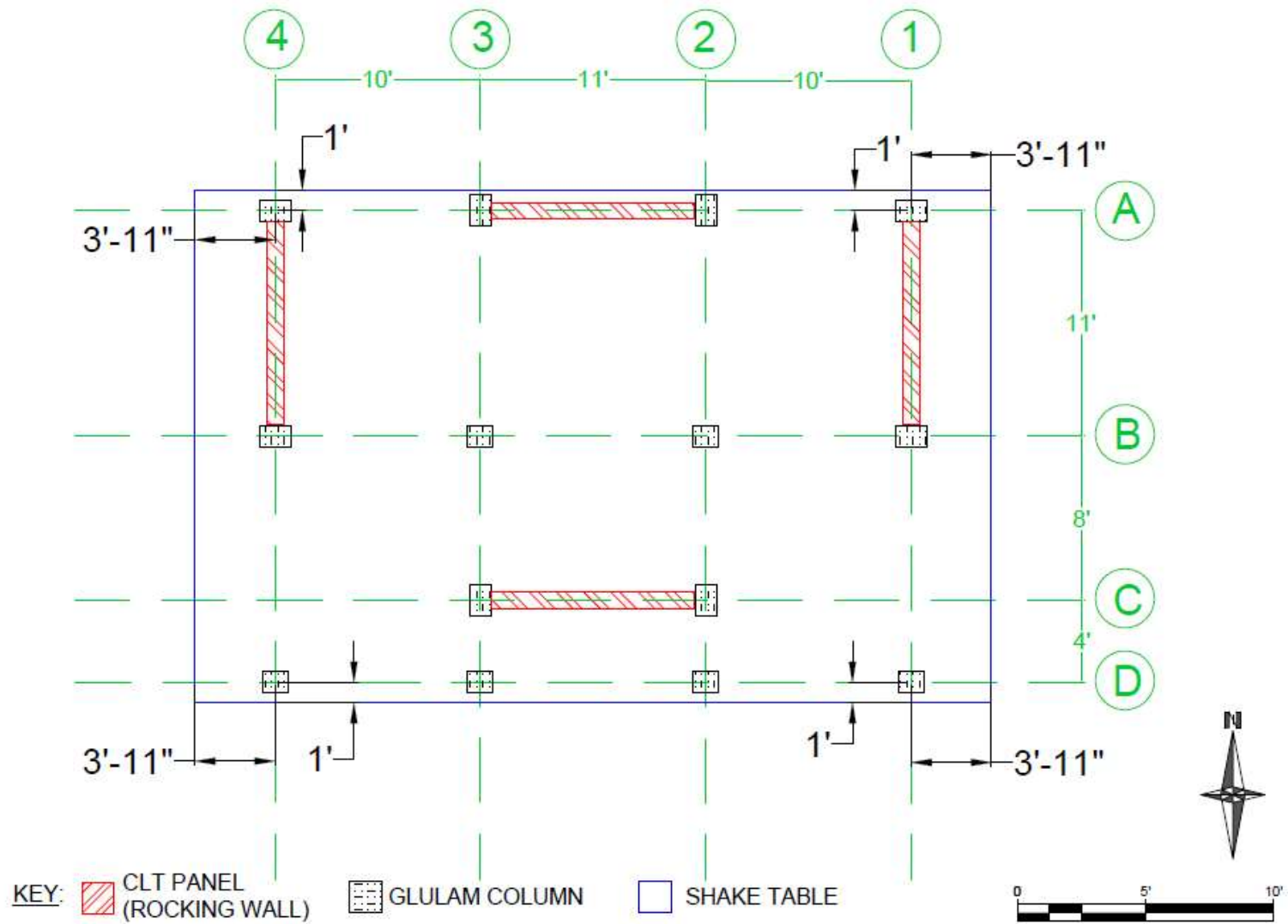
- Supplemental seismic mass for the test will be added to the floor during construction in form of steel trench plates. It is estimated the plates will be 4'x8'x1" each and about 65 of them will be added at each floor. The plates will be stacked in 5-plate piles and secured to the wood floor using 2x4 lumber and screws. The plates are to be rented locally.
- On test site there is a mid-sized crane and forklift for use, but anything higher than 4 stories will need a larger crane rental.
- Safety railing should be included for all floors.
- The estimate should include deconstruction. However, haul-away is likely not needed. The deconstructed wood pieces can be piled on a nearby prep site.

The following figures are only the summary of the design. The detailed 3D Sketch-up model is available for your planning purposes. Please contact Dr. Shiling Pei for design details and discuss potential collaboration.

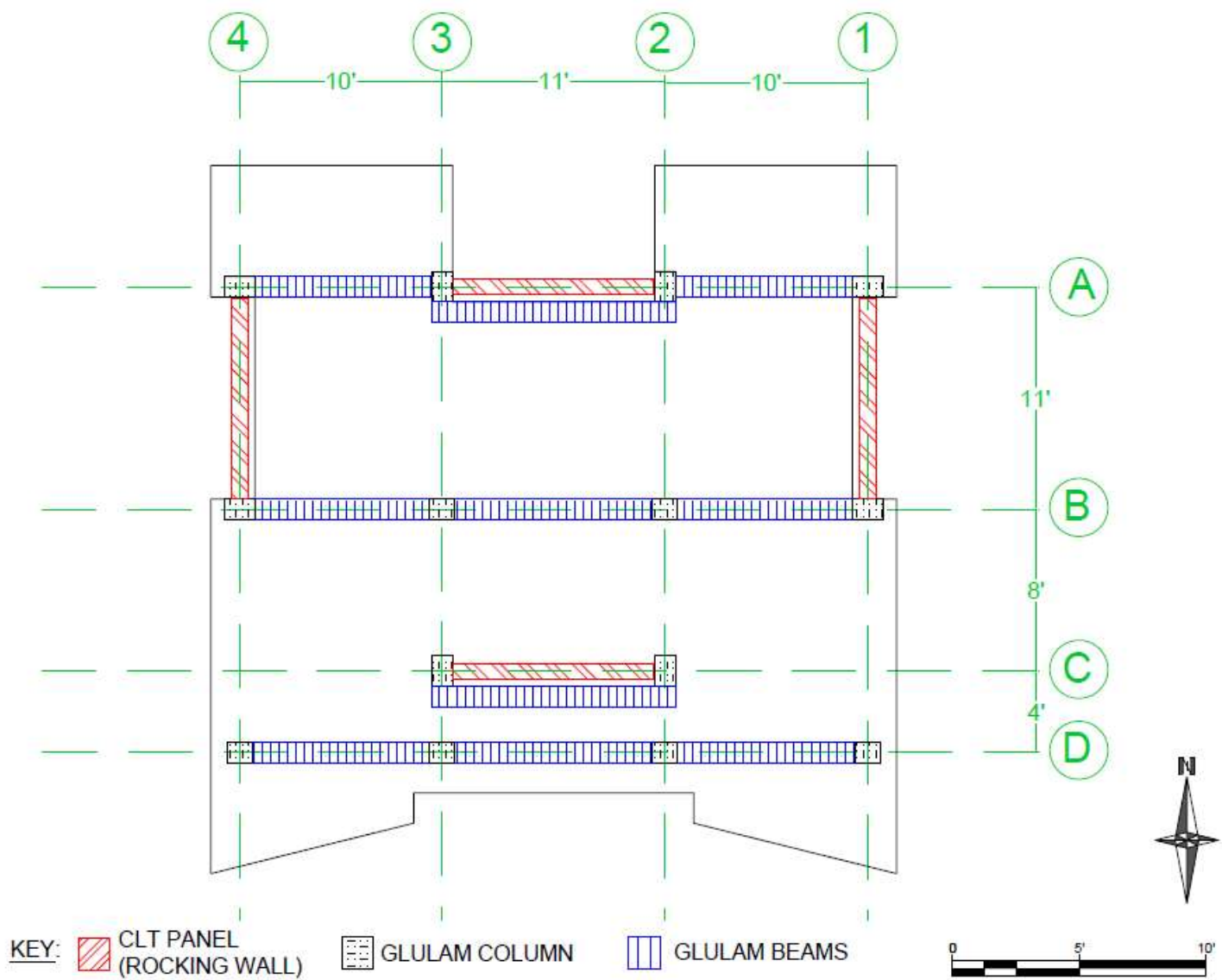
Note that at this stage, only the structural components are shown in the design. But the project team is planning on including envelop and finishing material in the building. If you are interested in non-structural aspects on the test, please use these structural plan information to evaluate the possibility of incorporating your products in the test.



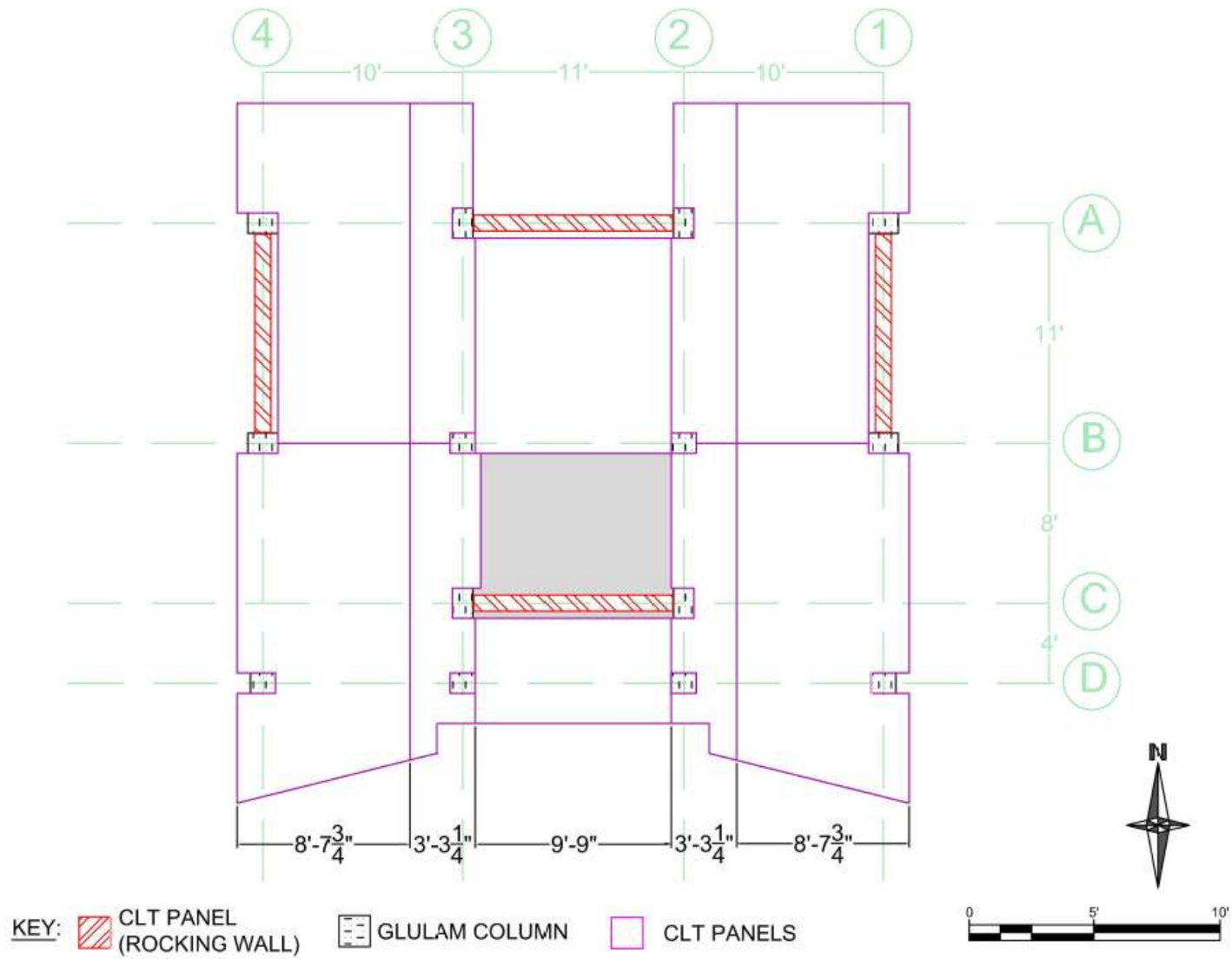
**Fig. 1: 3D model of the Test Building (on the 3D shake table)**



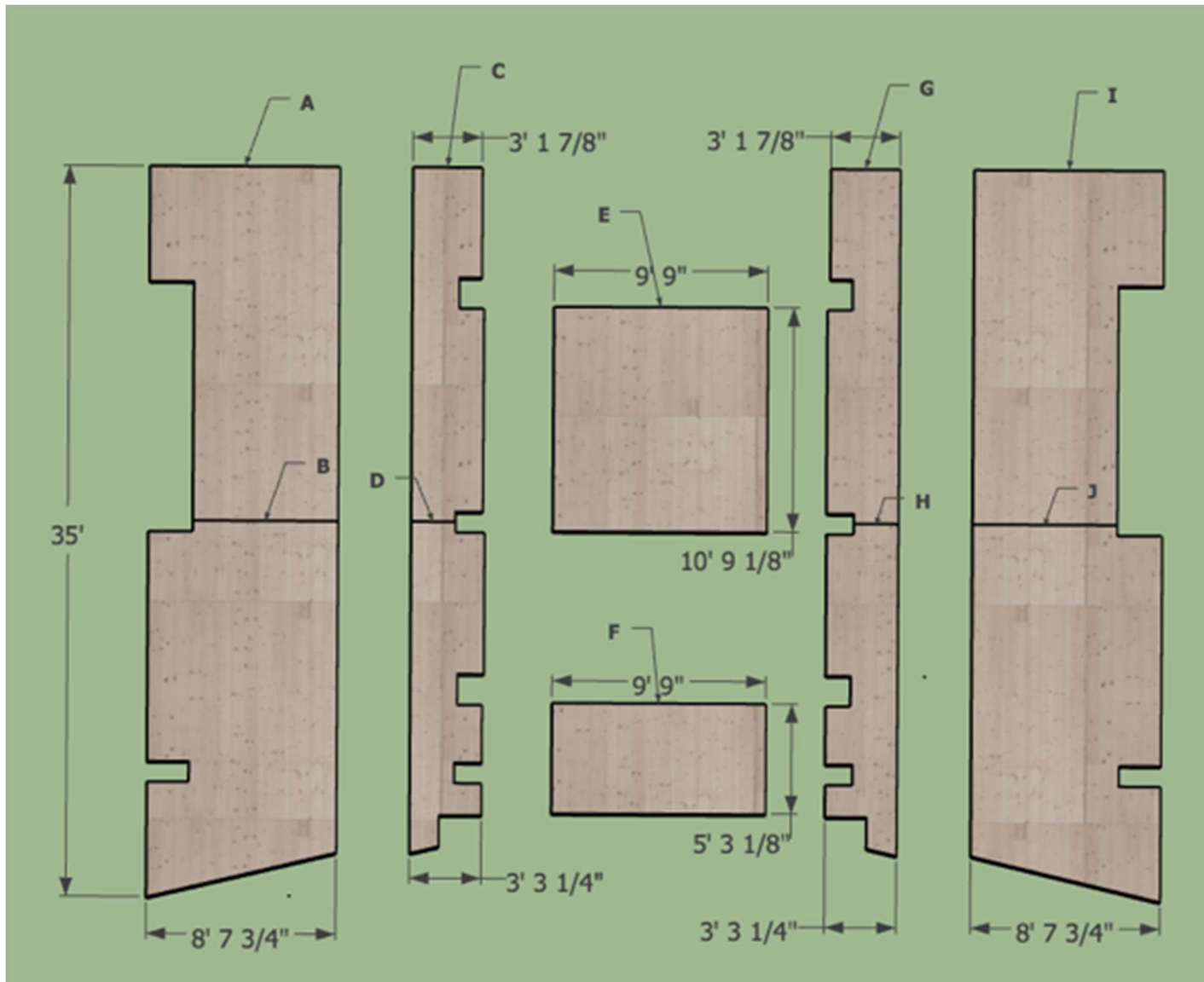
**Fig. 2: Column Placement Relative to Shake Table Surface**



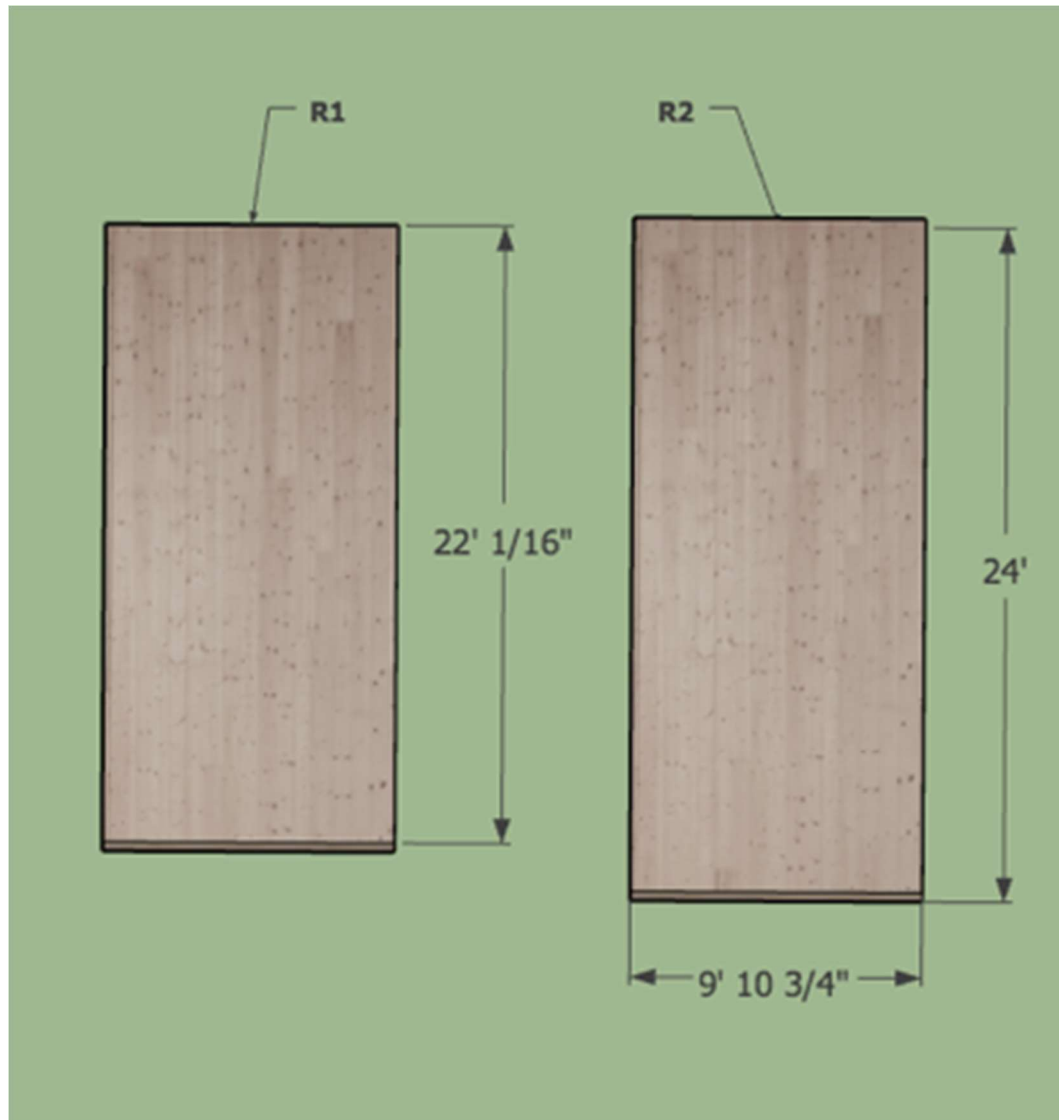
**Fig. 3: Beam and Column Grid of Story 1 (TYP for all, only member sizes different)**



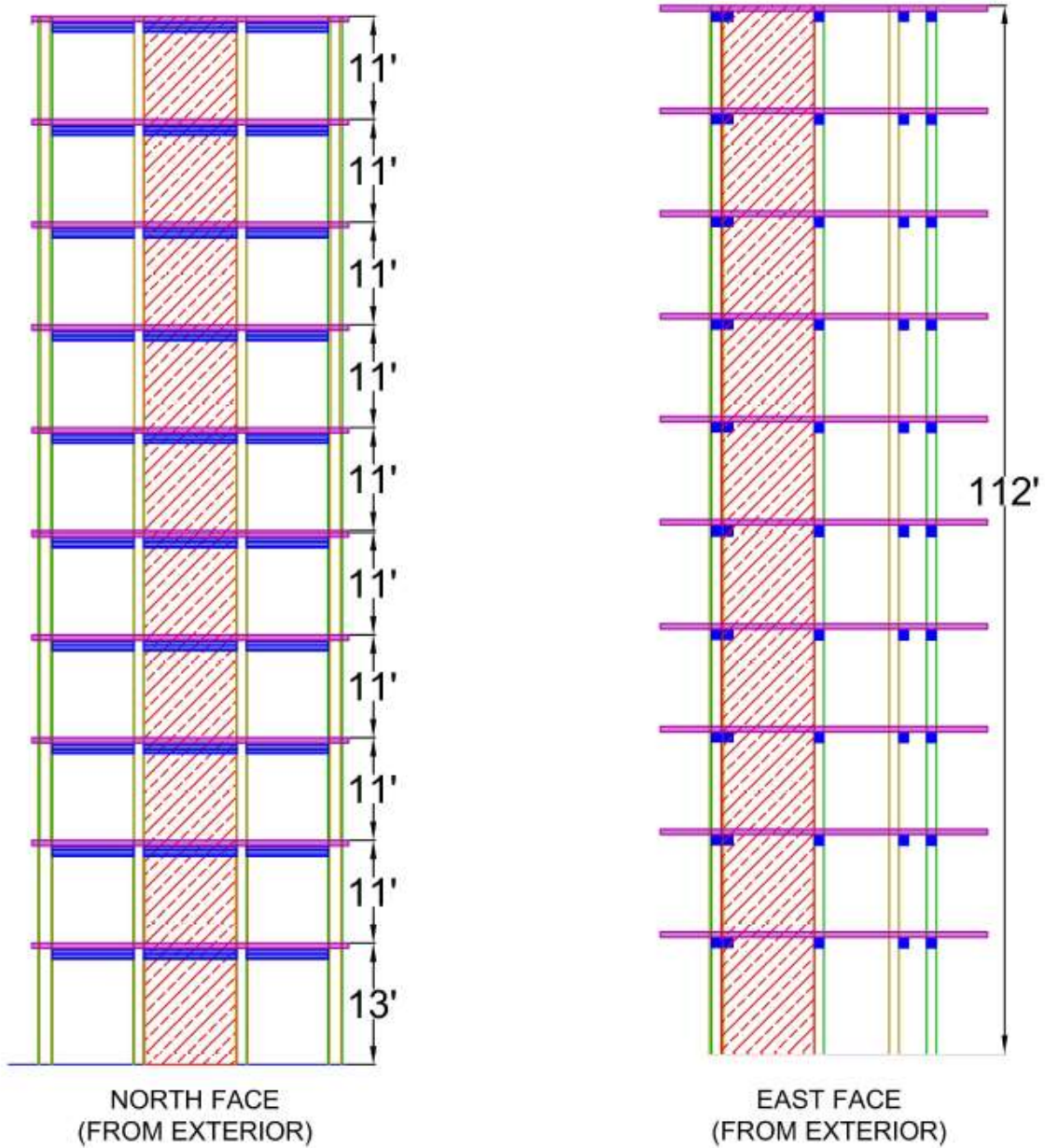




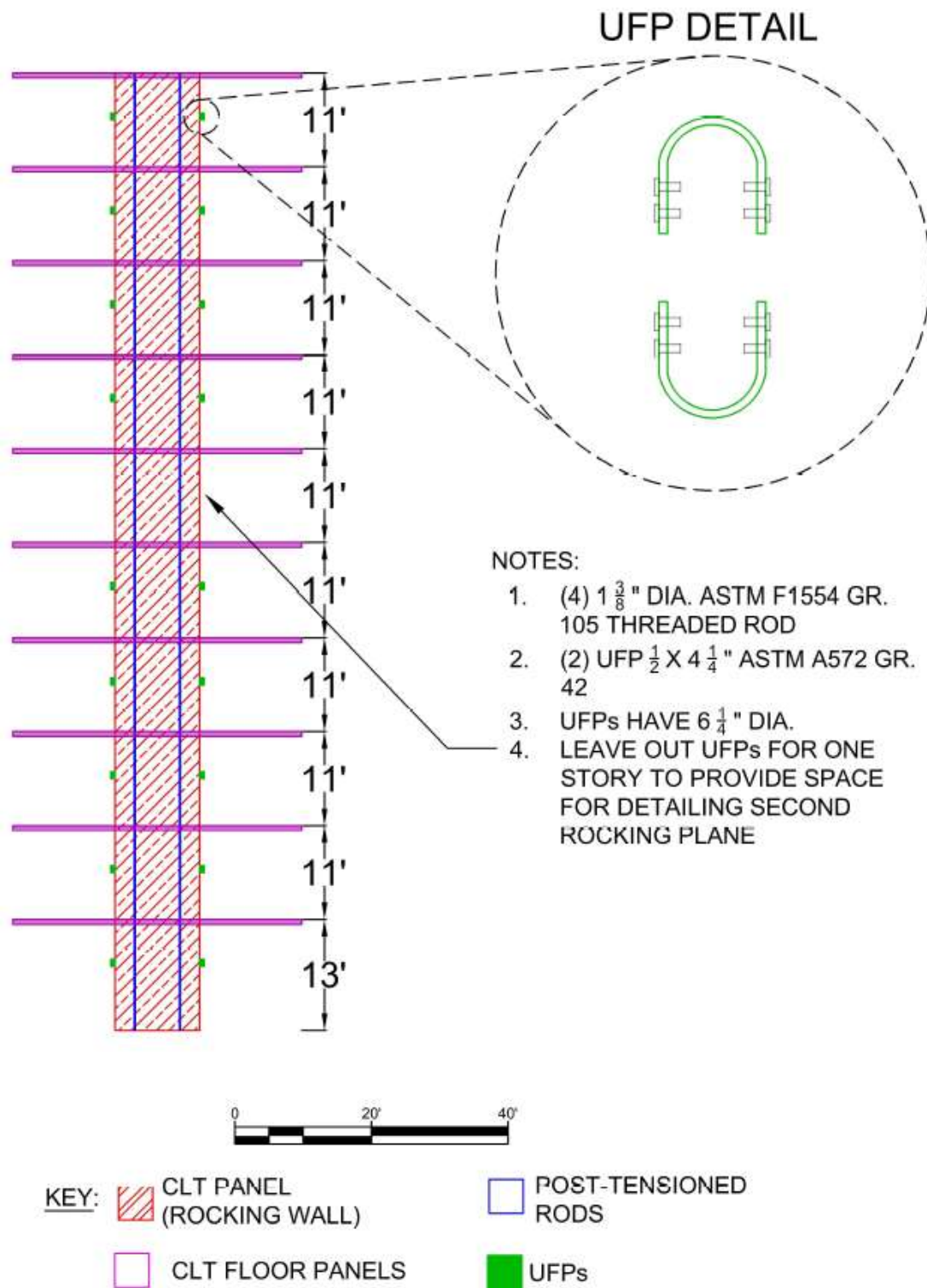
**Fig. 5: Floor Panel Composition (TYP)**



**Fig. 6: Rocking Wall Panel Composition**



**Fig. 7: Elevations of the Test Building**



**Fig. 8: Wall Detail of the Test Building**