SESSION 1 – THE PAST:
Verifying Computer Analysis Results with Hand Calculations

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SAM RUBENZER, PE, SE

- Founded FORSE Consulting in 2010
- Assists structural engineers on a wide variety of designs with an assortment of structural engineering design software

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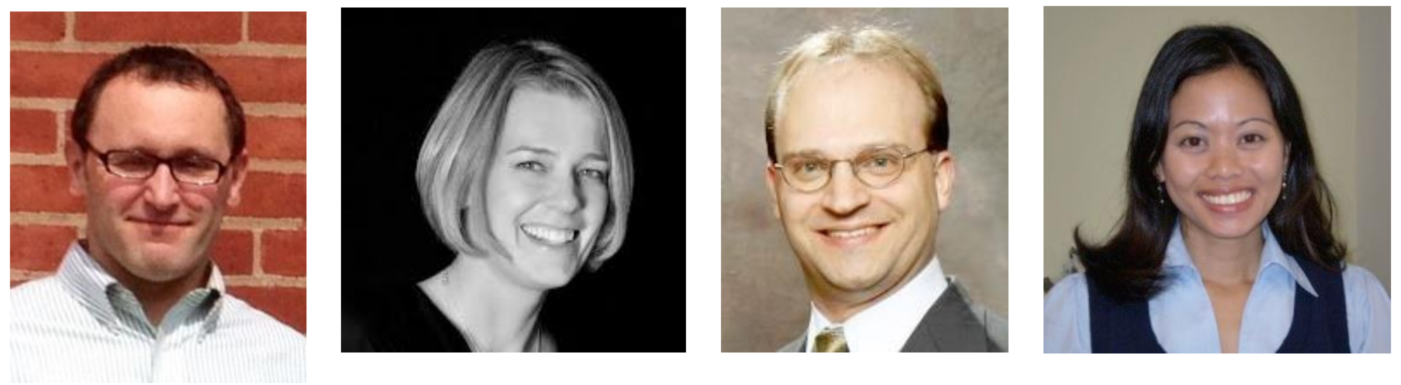
- Many years of experience as licensed engineers
- FORSE has worked hard to learn each of the software programs used by SEs and created many presentations comparing attributes of different software tools
- Worked as consultants with software companies teaching others about SE software



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Abstract

- Structural Engineers are relying more and more on structural engineering software for analysis and design.
- Understanding the different options available for modeling is paramount in ensuring the best model is created to imitate reality and give engineers the best possible design.
- This presentation reviews various hand calculation methods for verifying the loads defined on models, and verifying the analysis results.
- Lastly, we will verify the design checks made for members within the model. It is easy to assume that all structural engineering software solves engineering problems correctly. Unfortunately, there can be errors from programming and user mistakes. Engineers must have a good understanding apart from software to spot these errors.

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A Word About Software

- Structural engineers rely on finite elements models for analysis and design
- Understanding the different options available for modeling is paramount
- Best model is created to imitate reality and give engineers the best possible design

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Is Your Software Model a Good Representation of Reality?

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Structural Engineering Software

- Software is continuously changing our ability to do many things in our lives, personal and professional
- This is no different with structural engineering. Software will make you a better engineer as long as you use the software as a tool, and don't become an "operator"
- Never let the software think for you, only let it think faster
- Never let the software decide for you. Period.

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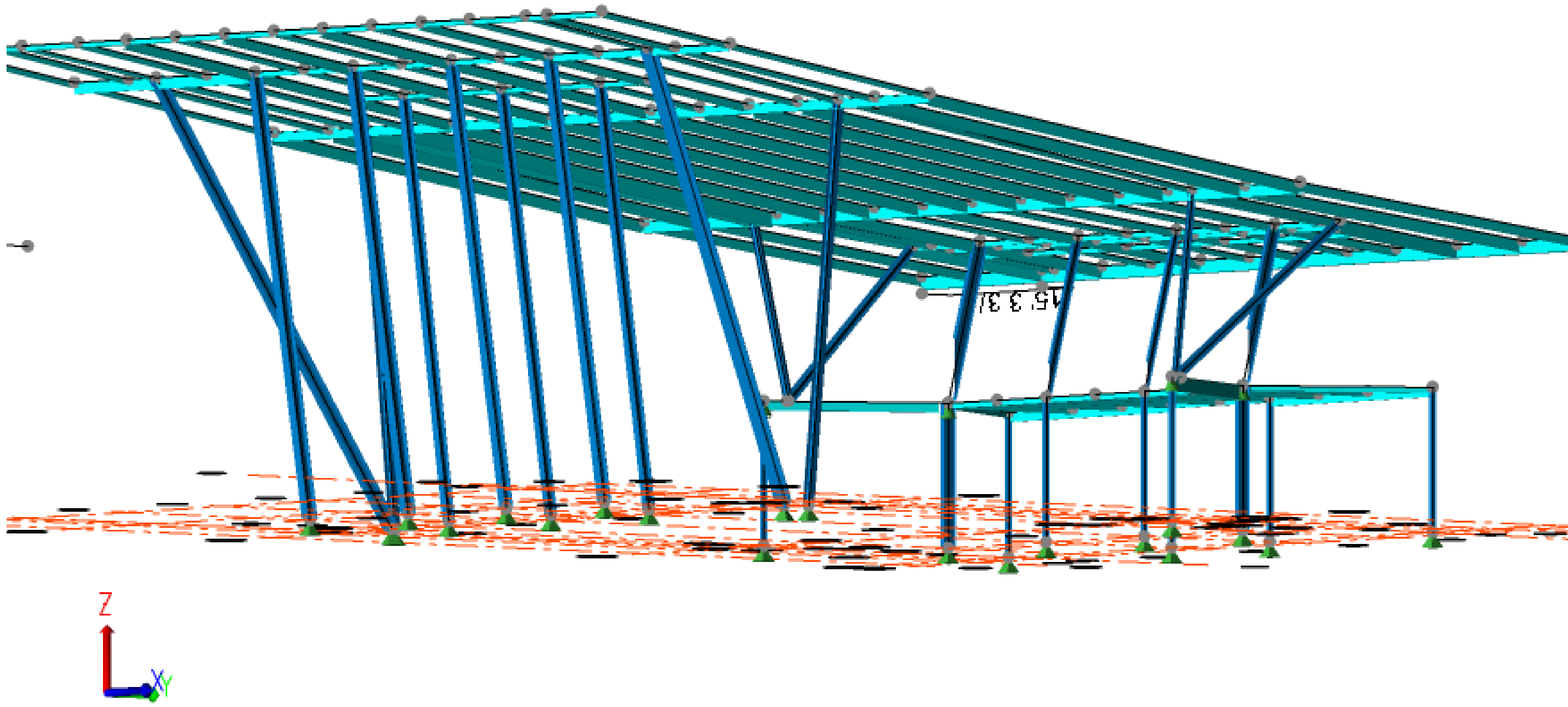
Structural Engineering Software

- Never assume the software is doing anything correctly
- Never assume the software is making the same decisions you would make
- Software programs are tools, you are the engineer, never forget that



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Structural Engineering Software

- **Never assume the software is correct**, or as you would have done it "by hand"
- Examples
  - certain programs will distribute load one-way
    - regardless of the span aspect ratio, even 100:1
  - automatic features are by far the most dangerous
    - settings aren't apparent when using software, in the manual
  - **default settings** are dangerous
    - **create a false sense of a "standard"**

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Structural Engineering Software: “Do You Agree with the Programmer?"

- Structural engineers also rely on:
  - Education, experience, and guidance from the code
  - Your good engineering judgment is still invaluable
- **When programmers develop software for us to use, they are relying on codes and their own judgment**
- You will find that your judgment isn't always in agreement with another structural engineer's
  - Don’t use a feature you don’t agree with
  - Don’t assume other users agree …

    …so it must be OK?

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Need to Know What We Don't Know…

Stated Learning Objectives

- Verify loads applied to models
- Verify analysis results
- Verify design checks

IN ORDER TO VERIFY, YOU NEED TO KNOW WHAT THE PROGRAM IS DOING

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Let’s Start with Philosophy

“Those that wish to succeed must ask the right preliminary questions”

- Aristotle

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Verify Loads Applied to Models

- Manually determine loads on structure
- Approximate distribution
- Know software load generator capabilities
- Review applied loads after load generator application

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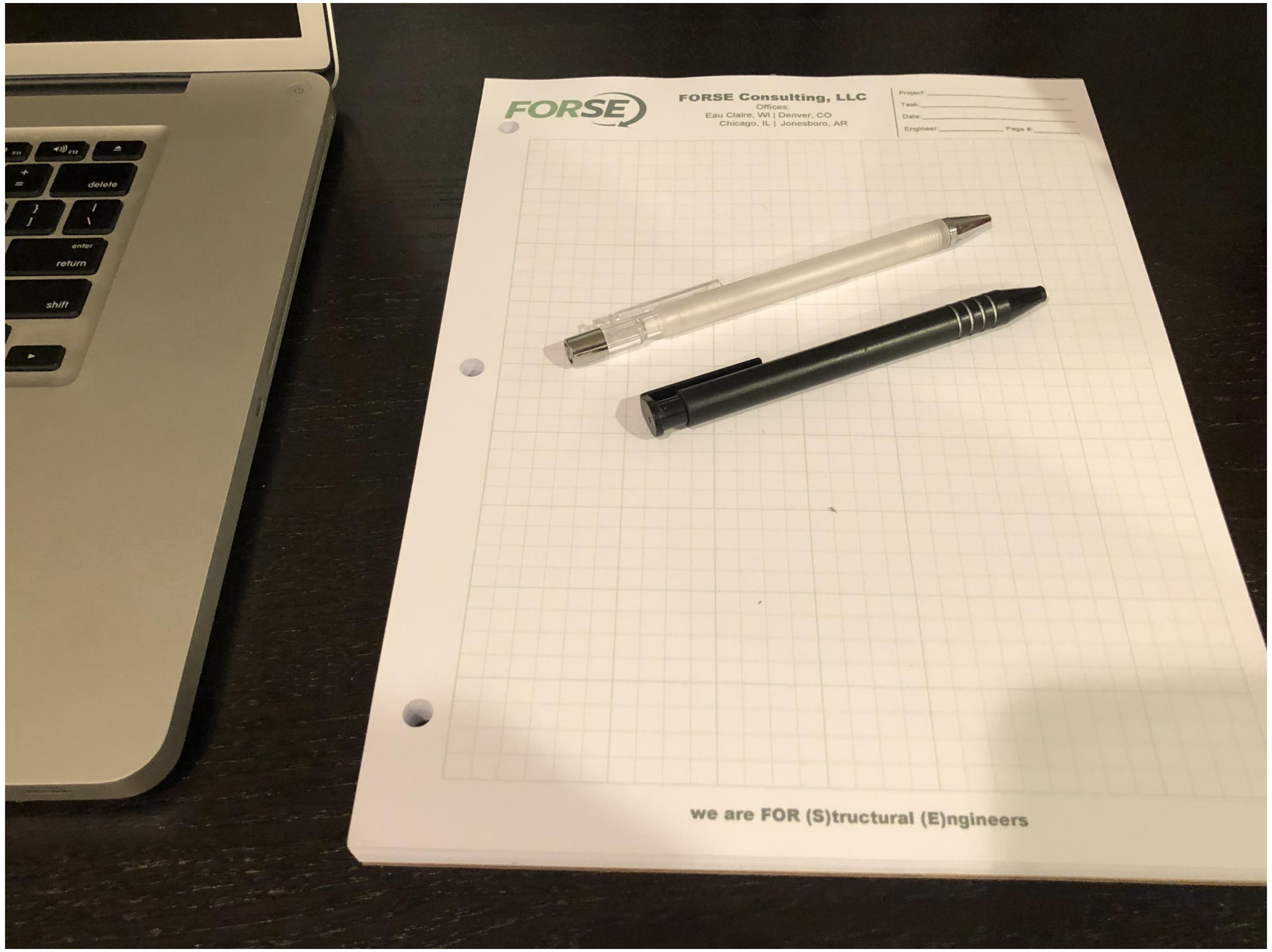
Verify Loads Applied to Models

Verify Loads Applied to Models

- Manually determine loads on structure
- Approximate distribution
- HAND CALCS or SPREADSHEETS

Verify Loads Applied to Models
Approximate Load and Distribution



Verify Loads Applied to Models
Approximate Load and Distribution

Verify Loads - Gravity Load Generators?

- Several programs distribute load without checking span
  - How far can load be distributed?
- Dead
  - Self weight based on members modeled - don’t forget about the elements not modeled, often referred to as super imposed dead load
- Live
  - Live load keyed to ASCE table based on floor usage
  - reducible of not reducible is not the software’s decision to make
- Snow or Roof Live load
  - No automated snow drift generators or ponding load generators on the market

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Verify Loads - General

- when using a structural analysis and design software package, there is a tendency to assume that the program is correctly generating the loads
- software programmers are very good at interpreting and implementing the codes
  - can’t automate every condition that exists in our complex architectural world
- to understand this completely as it pertains to your projects
  - best to know where software programmers get the loads for the load generators.
  - specifically, what sections of the code are used for load generators in common software packages.

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Verify Loads - Questions

- When an engineer chooses to generate wind loads, what sections of the code are considered? For example:
  - How many directions is the load applied?
  - Can enclosed, partially enclosed, and open structures be considered?
- When generating seismic loads what code provisions are considered? For example:
  - Using approximate building period or calculated period?
  - Is accidental torsion checked and provisions applied?

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Wind Based on ASCE 7

- ENVELOPE PROCEDURE
- DIRECTIONAL PROCEDURE
  - portions of this procedure are generally used by software to generate wind loads
- WIND TUNNEL PROCEDURE
- Versions
  - 7-02
  - 7-05
  - 7-10 (major change)
  - 7-16

Verify Loads - Quick Facts

- ASCE 7-10
  - pages dedicated to Wind
    - 130
  - pages used for most wind load generators
    - Estimate 10-20, varies depending on software
- so when a software indicates ASCE 7-10 is implemented, be sure you know what that means, what's included, and perhaps more importantly, what's excluded!

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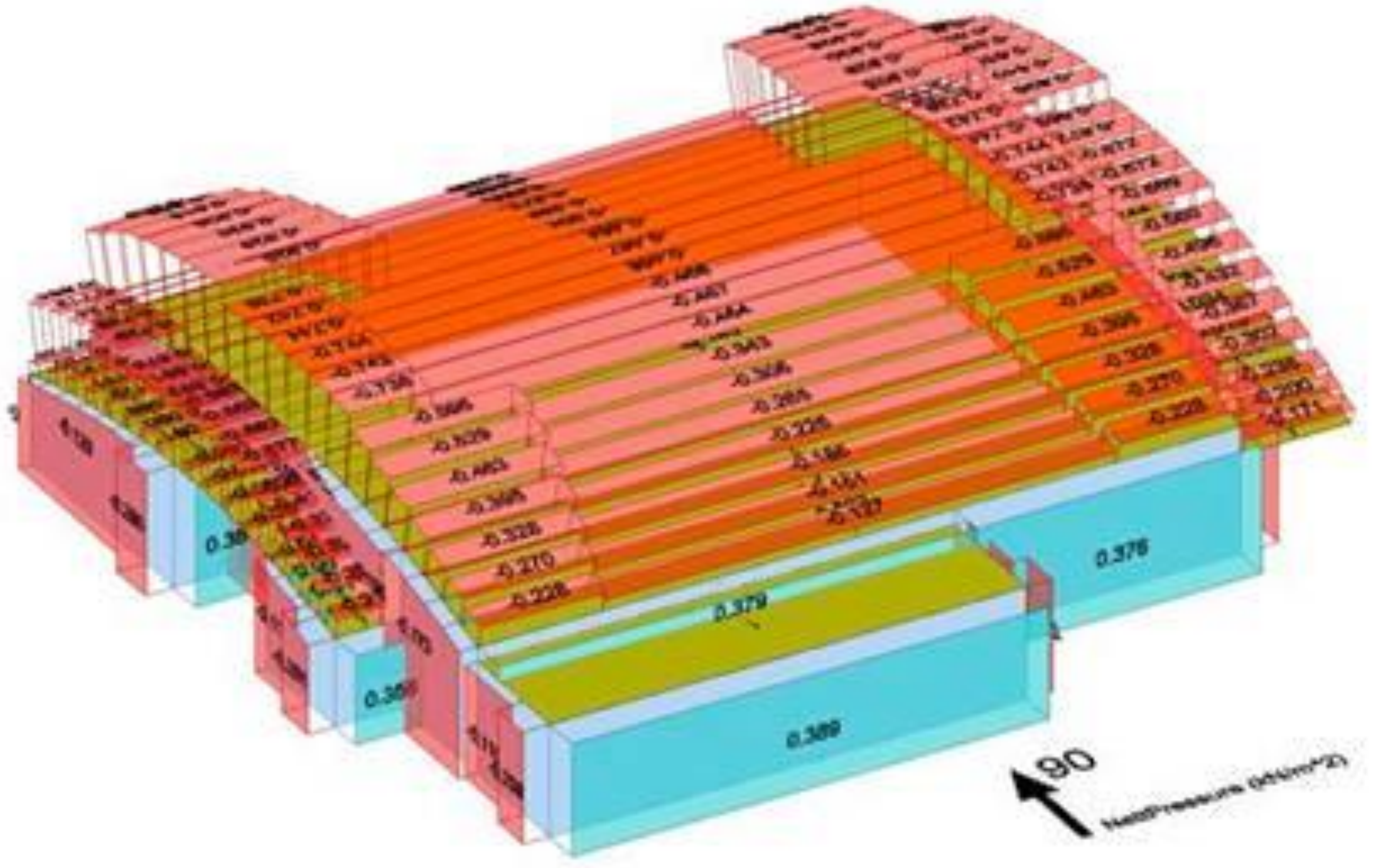
Software Options and Examples

Software Options and Examples

- Auto exposure edges?
  - Determined from defined deck/slab edges
  - Allow Modifications?
- User defined exposure areas?
  - Can user manually define wind exposure areas and distribution?
- Combine with user defined loads?
- Parapets?



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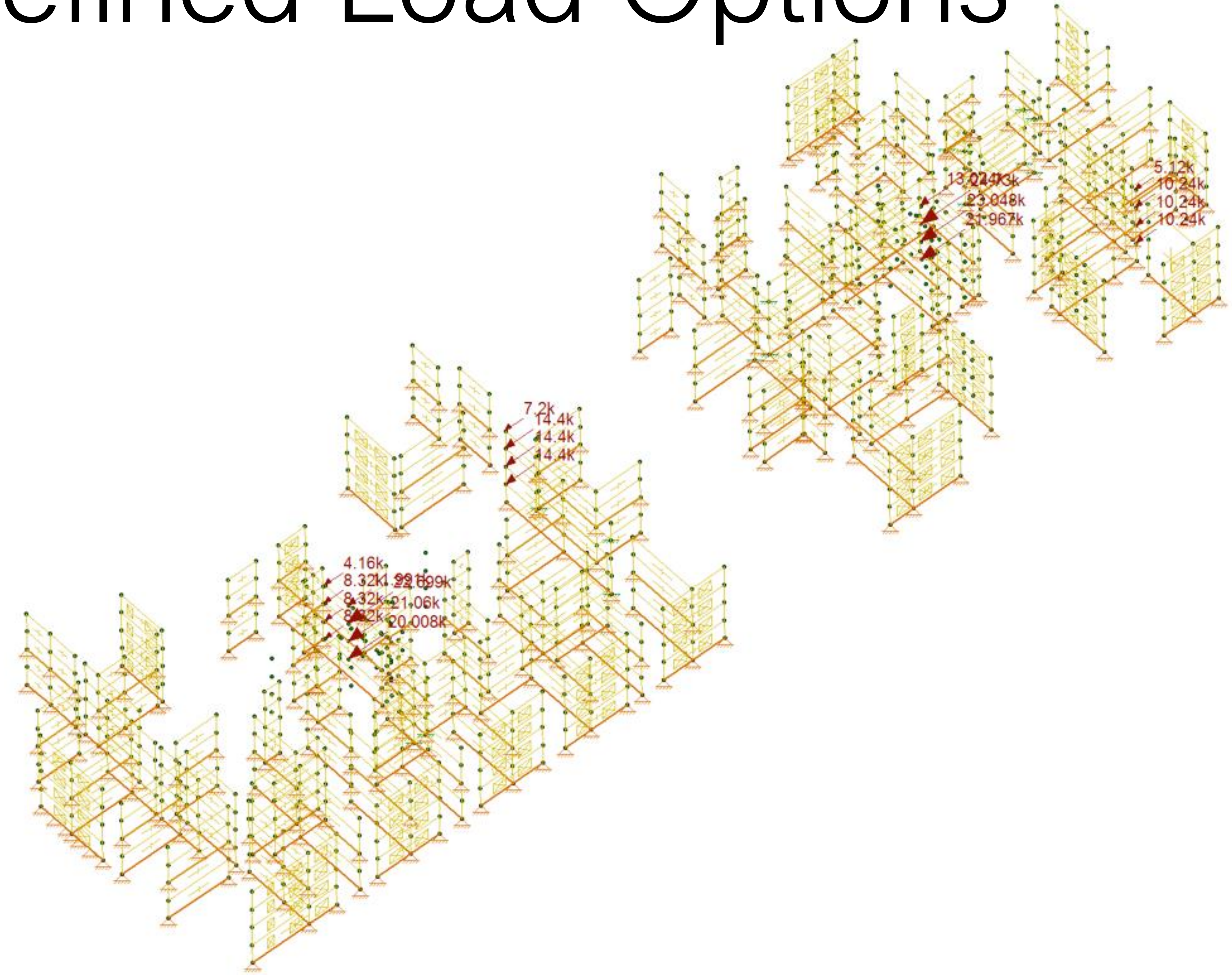
Verify Loads - User Defined Load Options

- What do you do when the load generator is close, but needs supplemental loads to be added
  - Can supplemental loads be added to generated loads?



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Wind	Auto exposure edges? Allow Modifications?	User defined exposure areas	Combine with user defined loads?	Parapets
RISA 3D	yes | no		yes	
RSS (FRAME) RAM Elements	yes | yes			yes
ETABS	yes | yes	lateral walls	yes	yes
SCIA		load panels	yes	yes
TEKLA Structural Designer		wall panels	yes	yes
IES VisualAnalysis		areas	yes	yes

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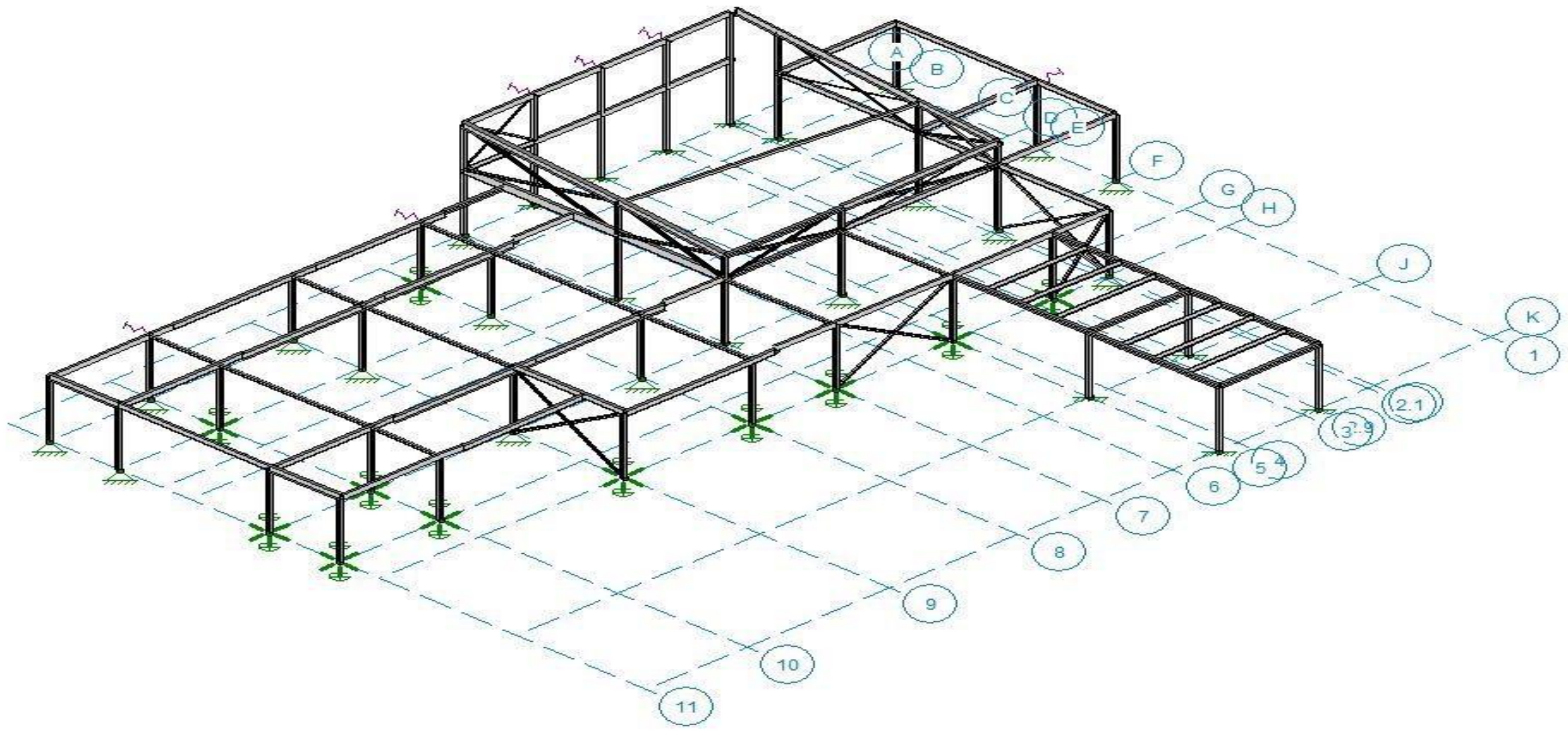

QA/QC for Loading

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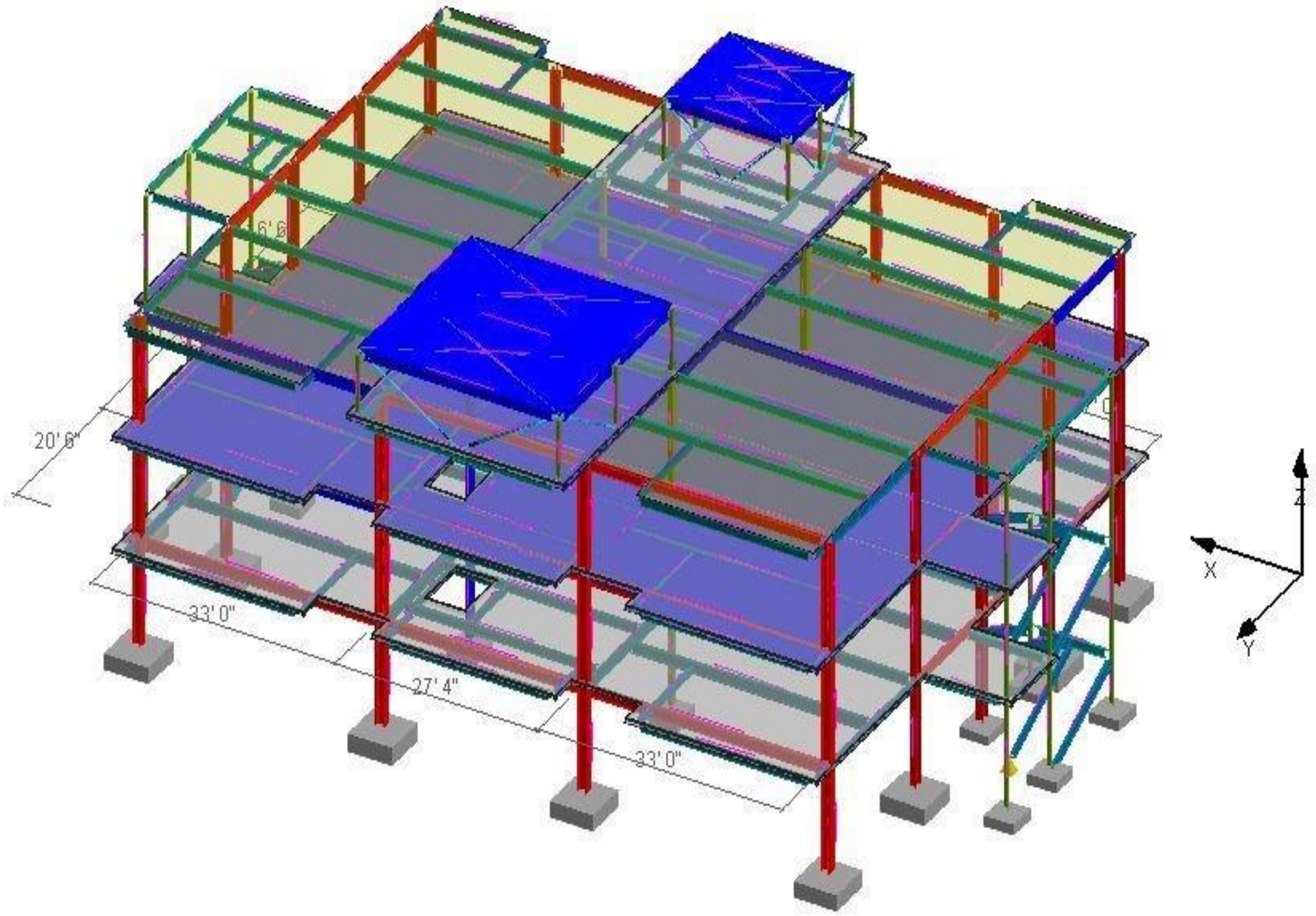
QA/QC

- Peer review of model is essential
- Loads in = Loads out
  - Does resulting base shear = applied lateral load?
- Wind Load Code Check:
  - If factored wind loads are applied per ASCE 7-10, confirm LRFD design is applied



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Verify analysis results

- Start with simple models to approximate results
  - Simple micro models
  - Simple macro models
- Work in complex elements to overall model
- Verify final model matches behavior of simple model
- Understand software capability/limitations of analysis

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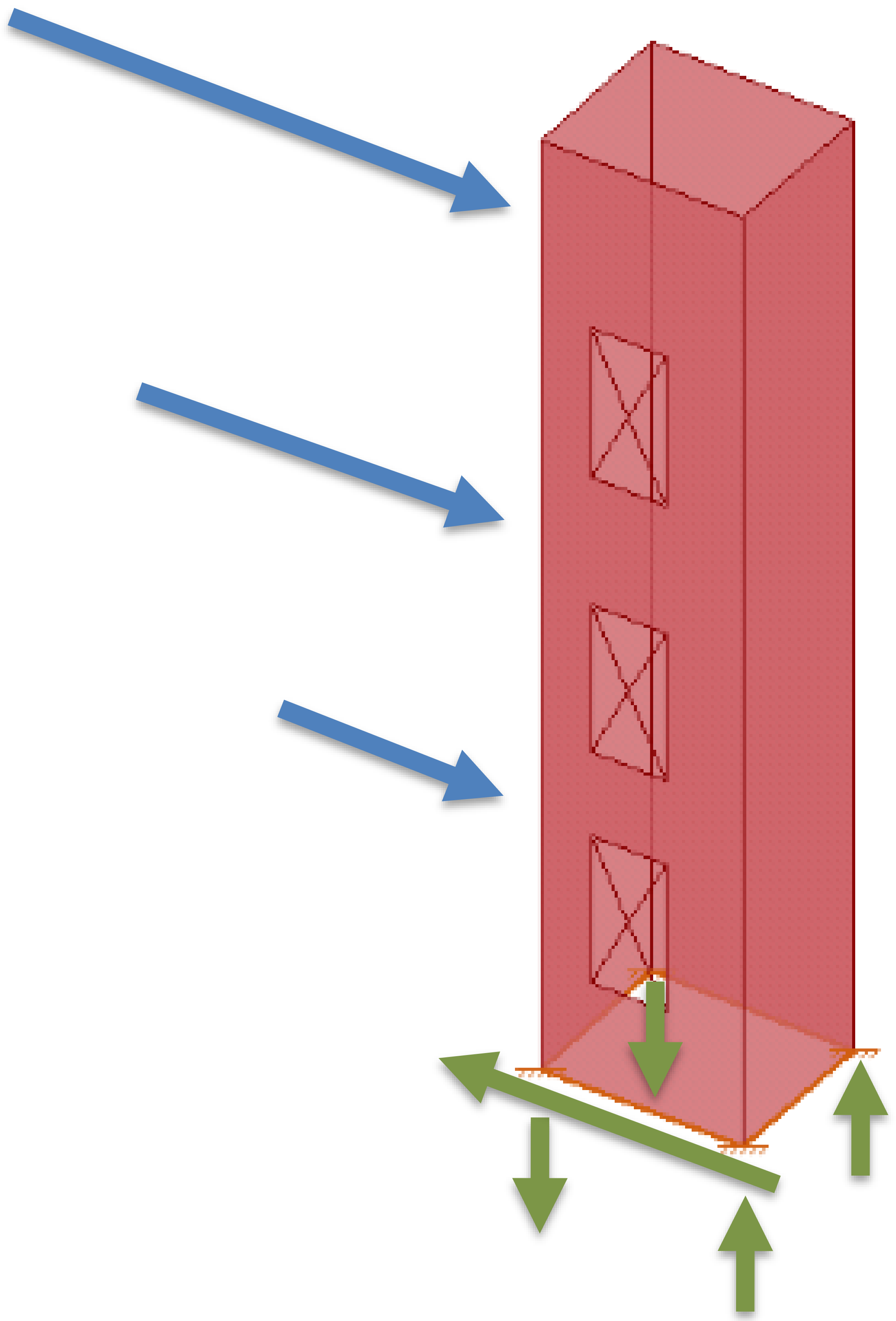
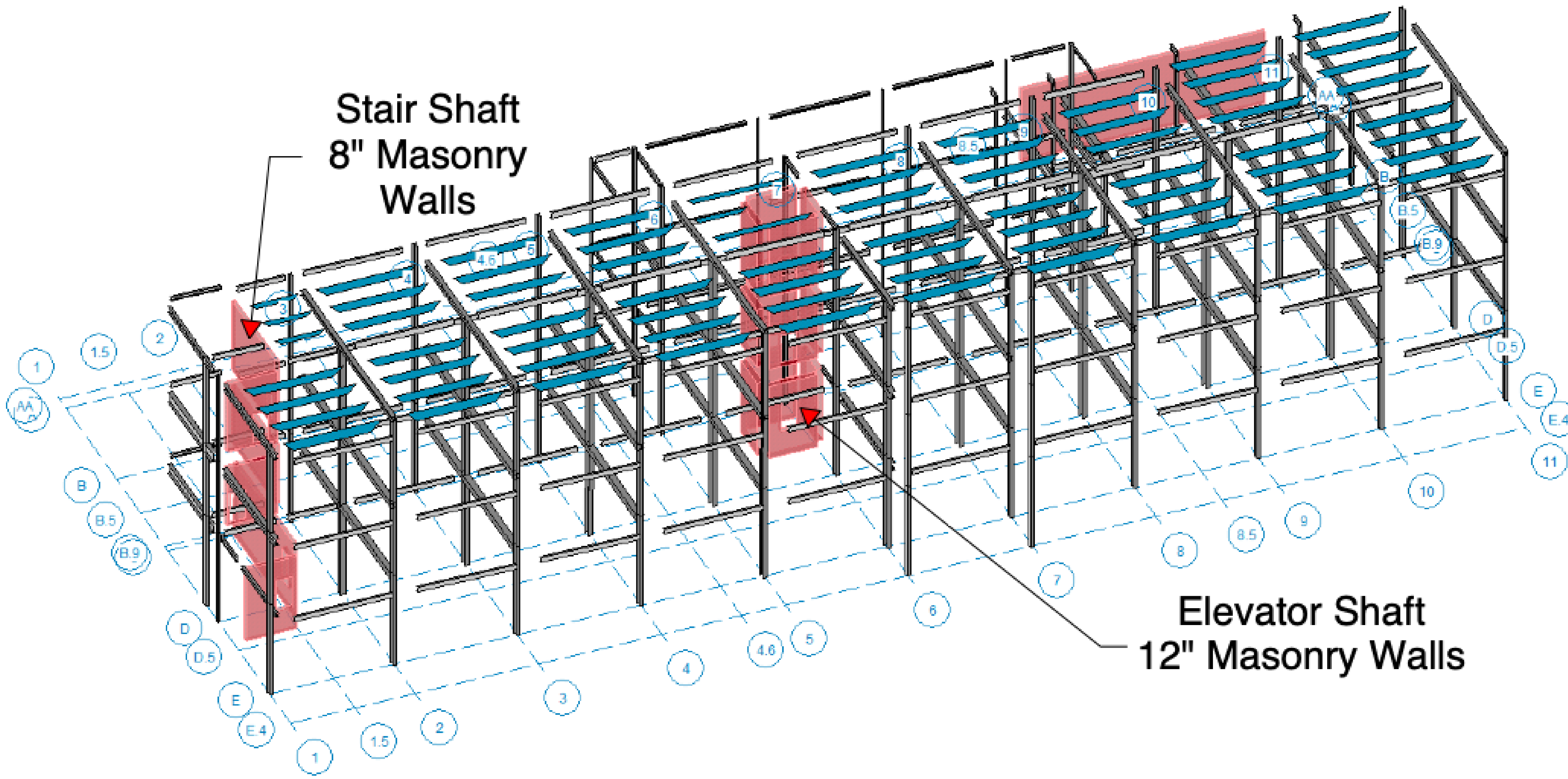
Estimate Behavior Before Hitting Analyze



- Estimate load
- Determine Shear for group
- Determine corner up/down reactions as estimate

Estimate Behavior Before Hitting Analyze

- Simple to complex
  - Lose the ability to do this wh
    we import complex models f
    BIM models
- Counter intuitive behavior?
  - Real or not real???



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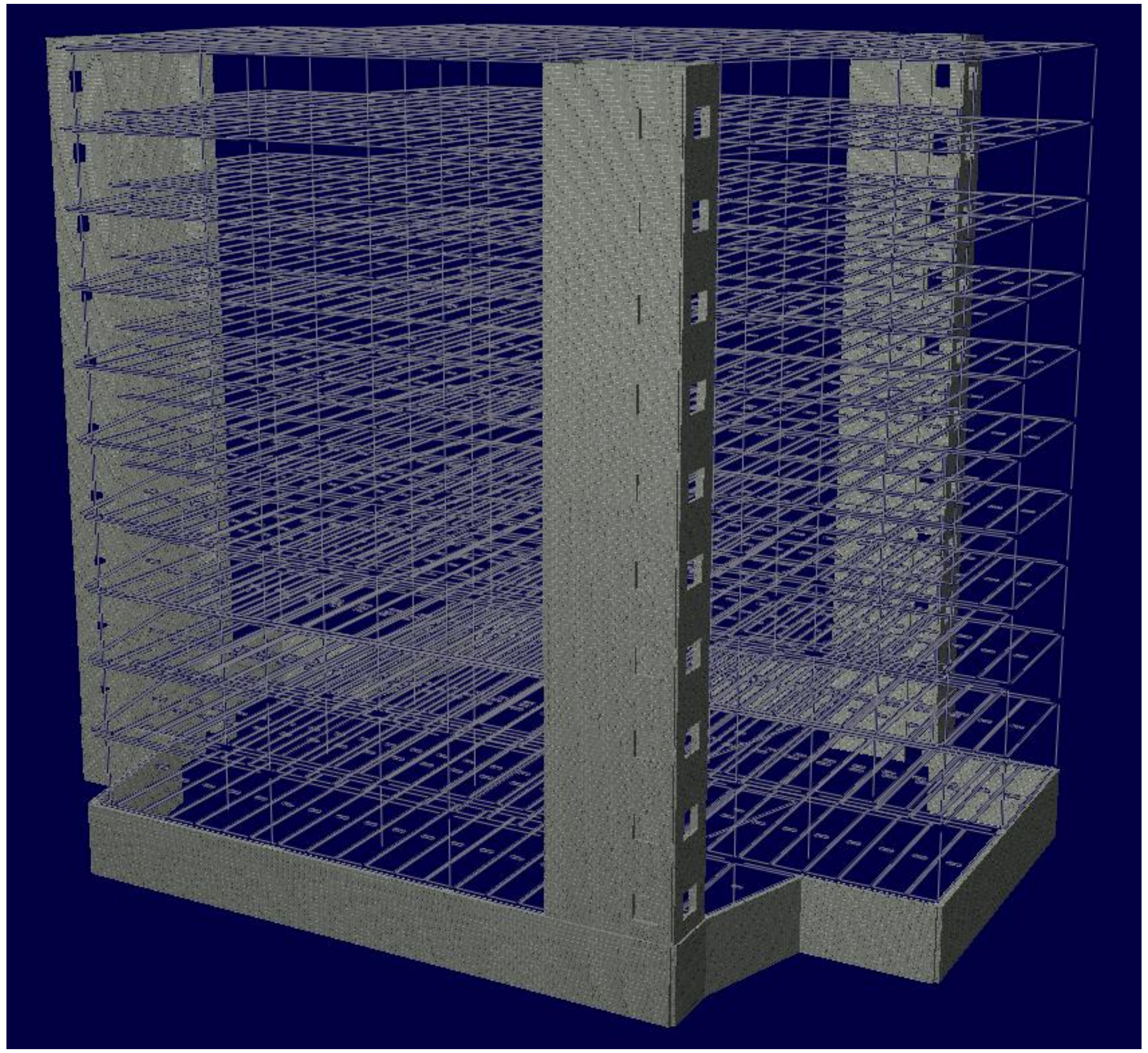
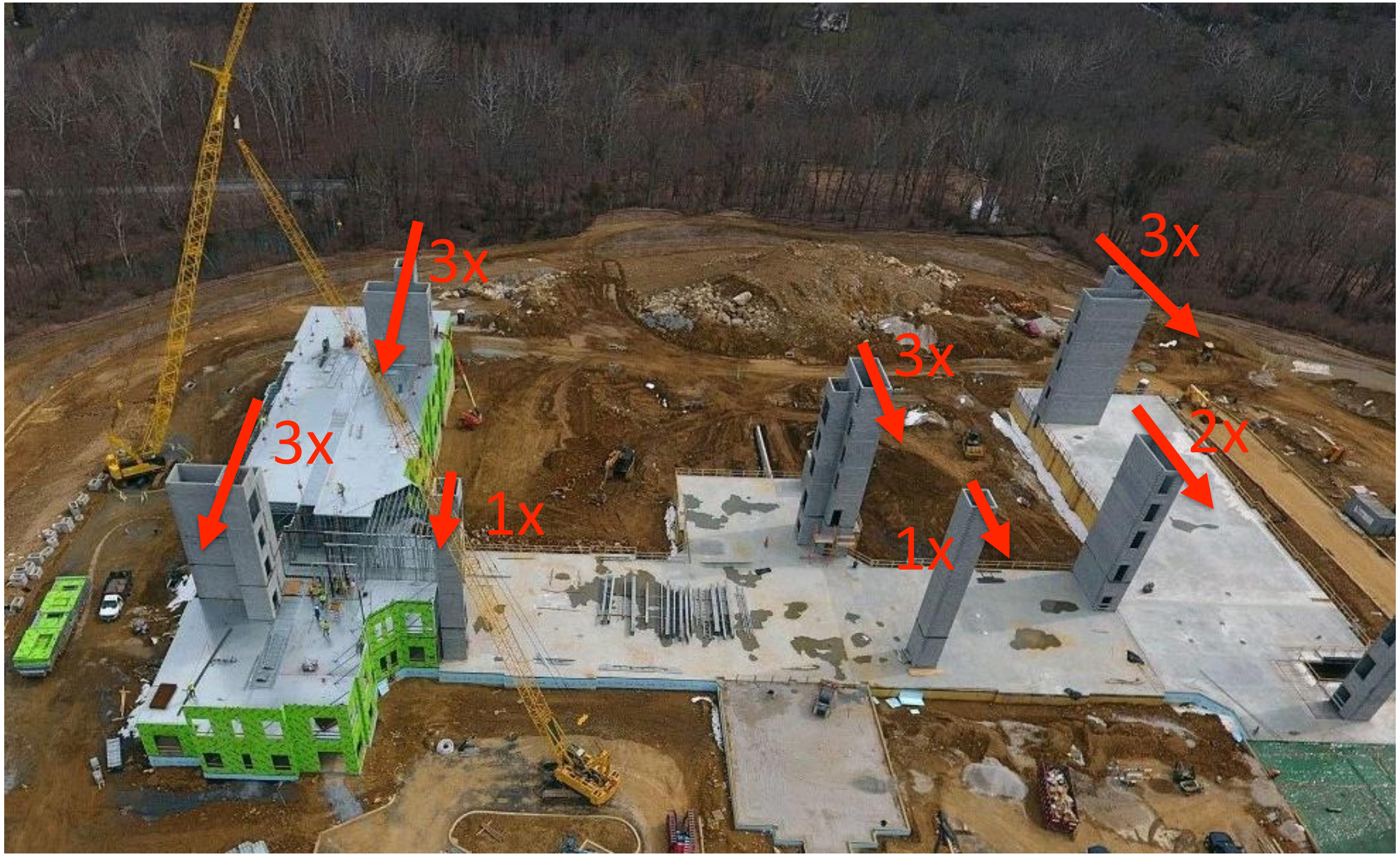
What Happens at First Floor?

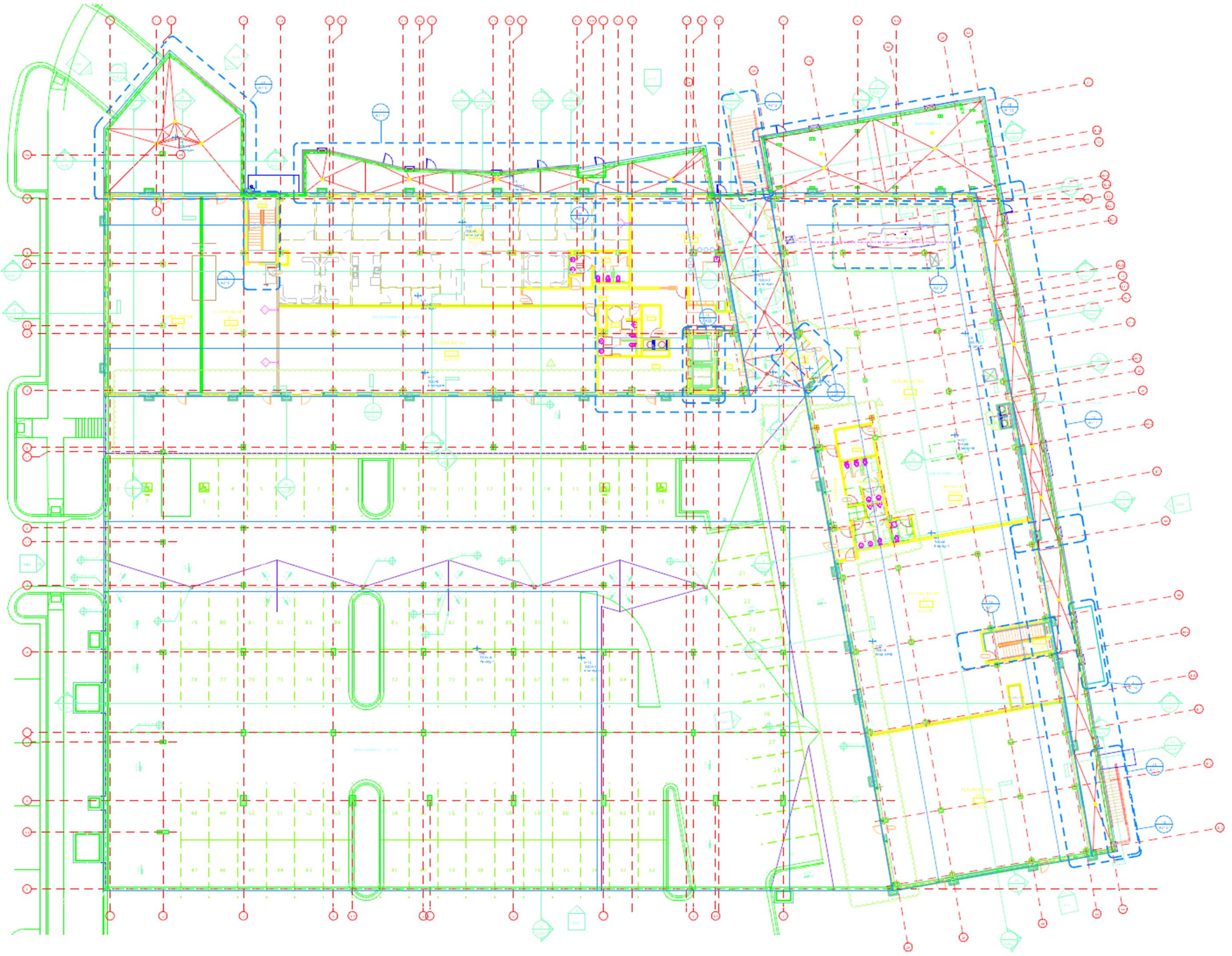
- Can load really reverse in towers?
  - created by rigid diaphragms
- More realistic with Semi-rigid
  - still need to check ability to get load out of wall groups, into diaphragm, then into new walls at foundation



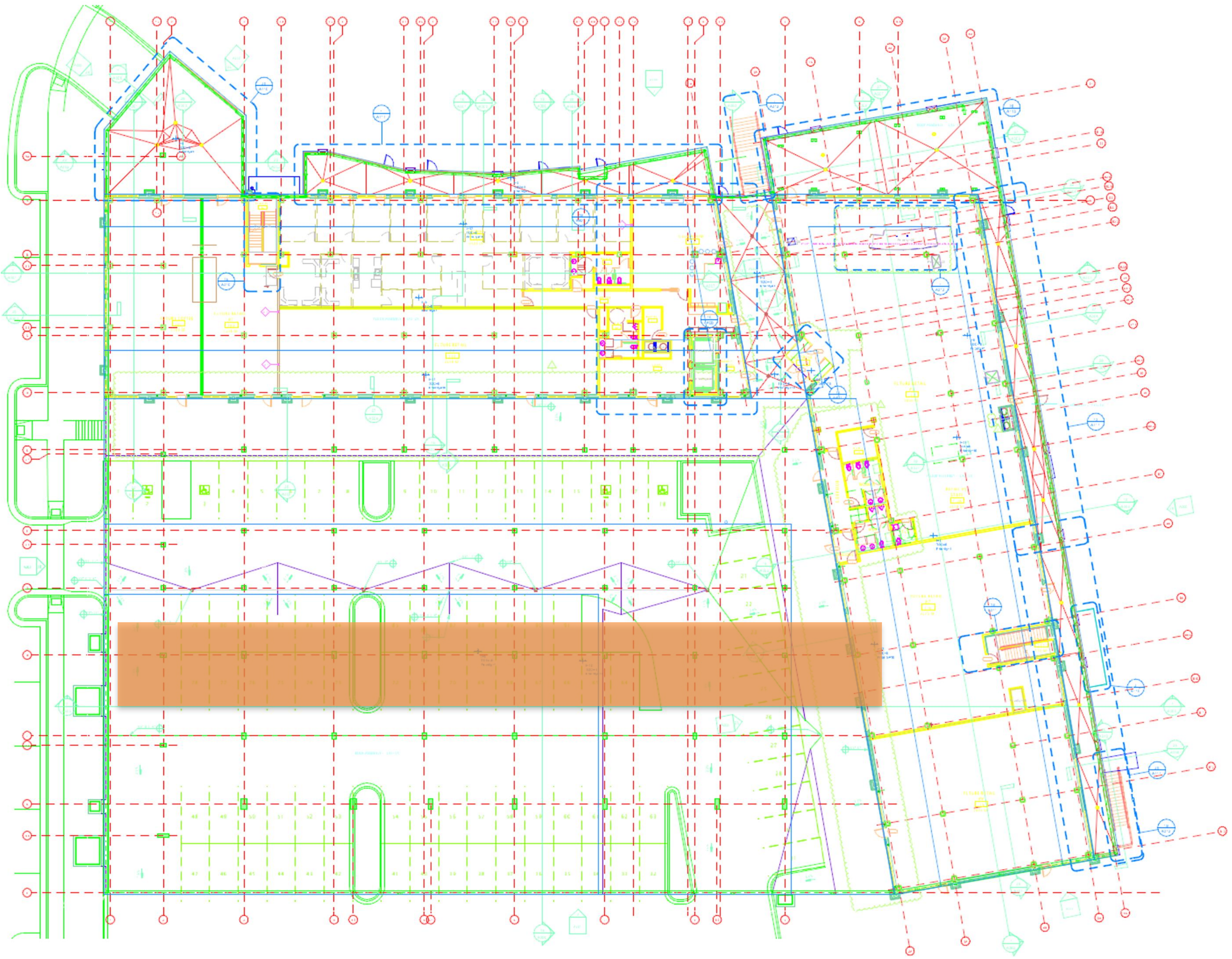
Estimate Load Distribution



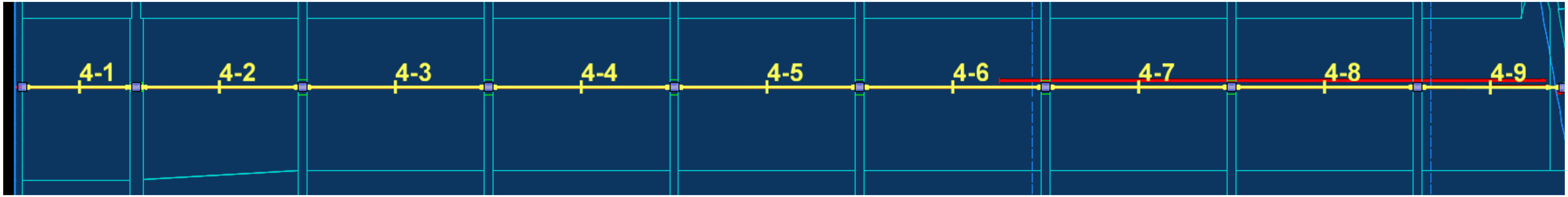
Before We Take on This…



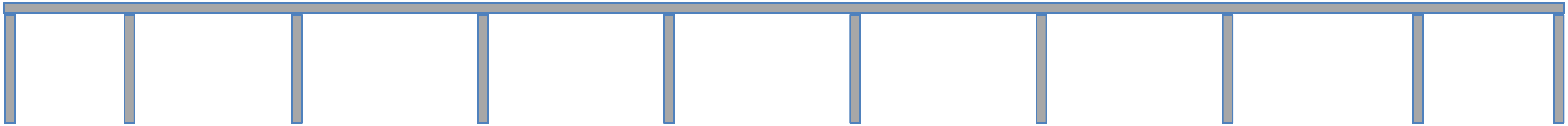
Work on Understanding Individual Area



Work on Understanding Individual Area



PLAN



SECTION

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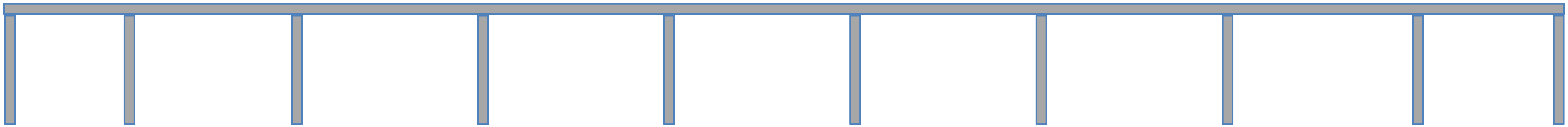
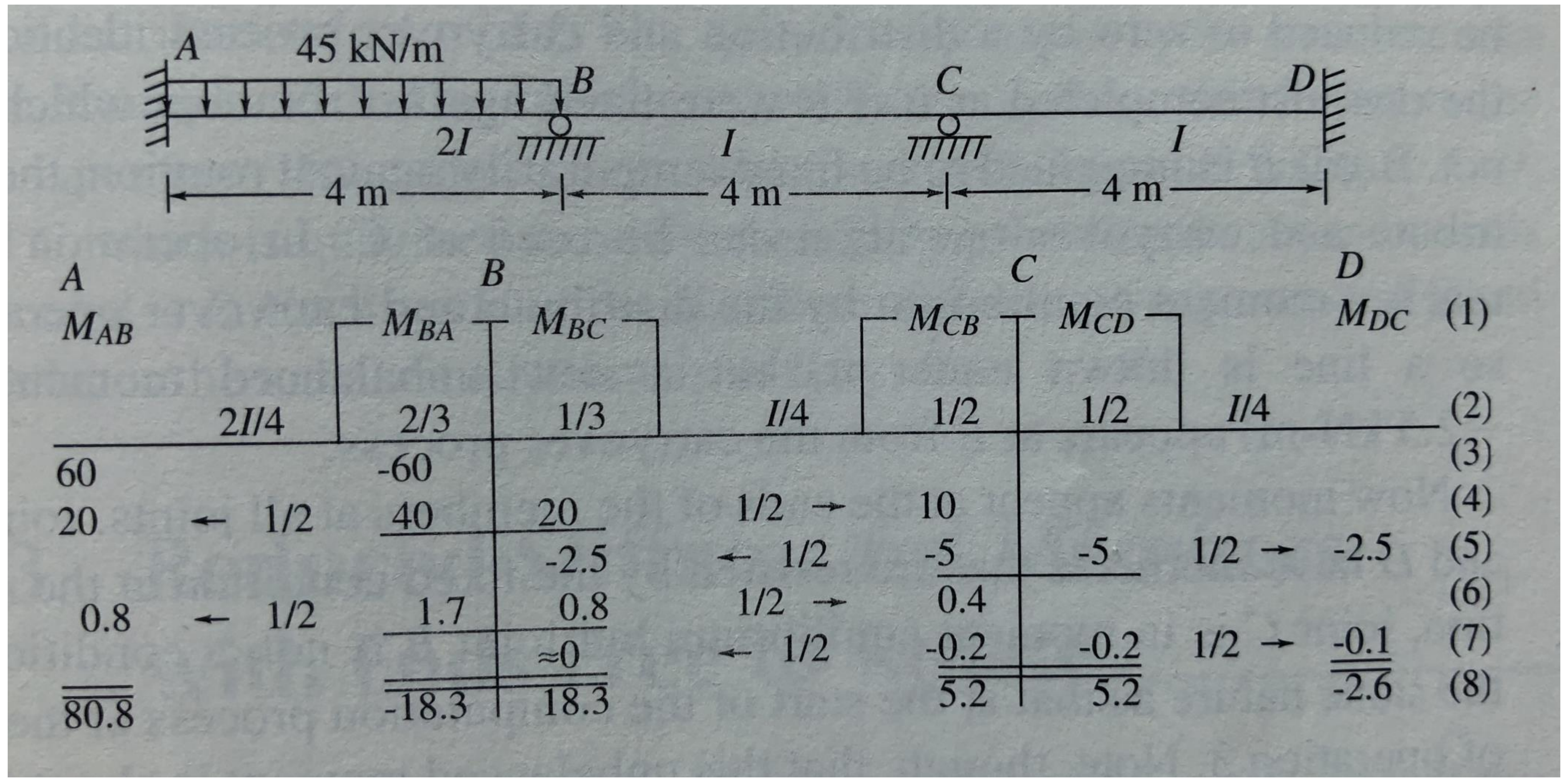
Use hand calcs to estimate



SECTION

Indeterminate Structures

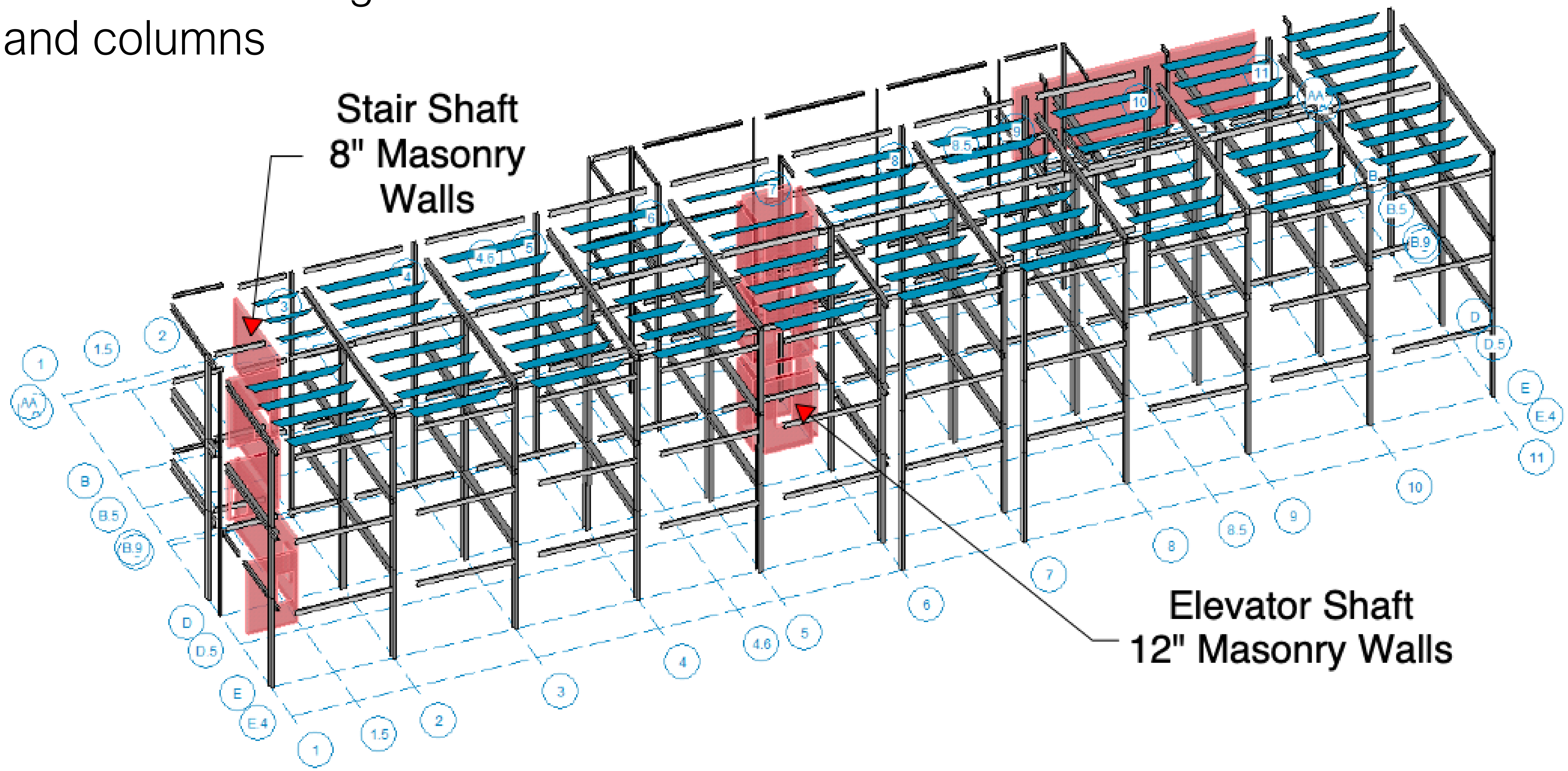
- Slope Deflection
- Moment Distribution



Moment Distribution Example from “ANALYSIS AND BEHAVIOR OF STRUCTURES”

Verify All Elements are Modeled

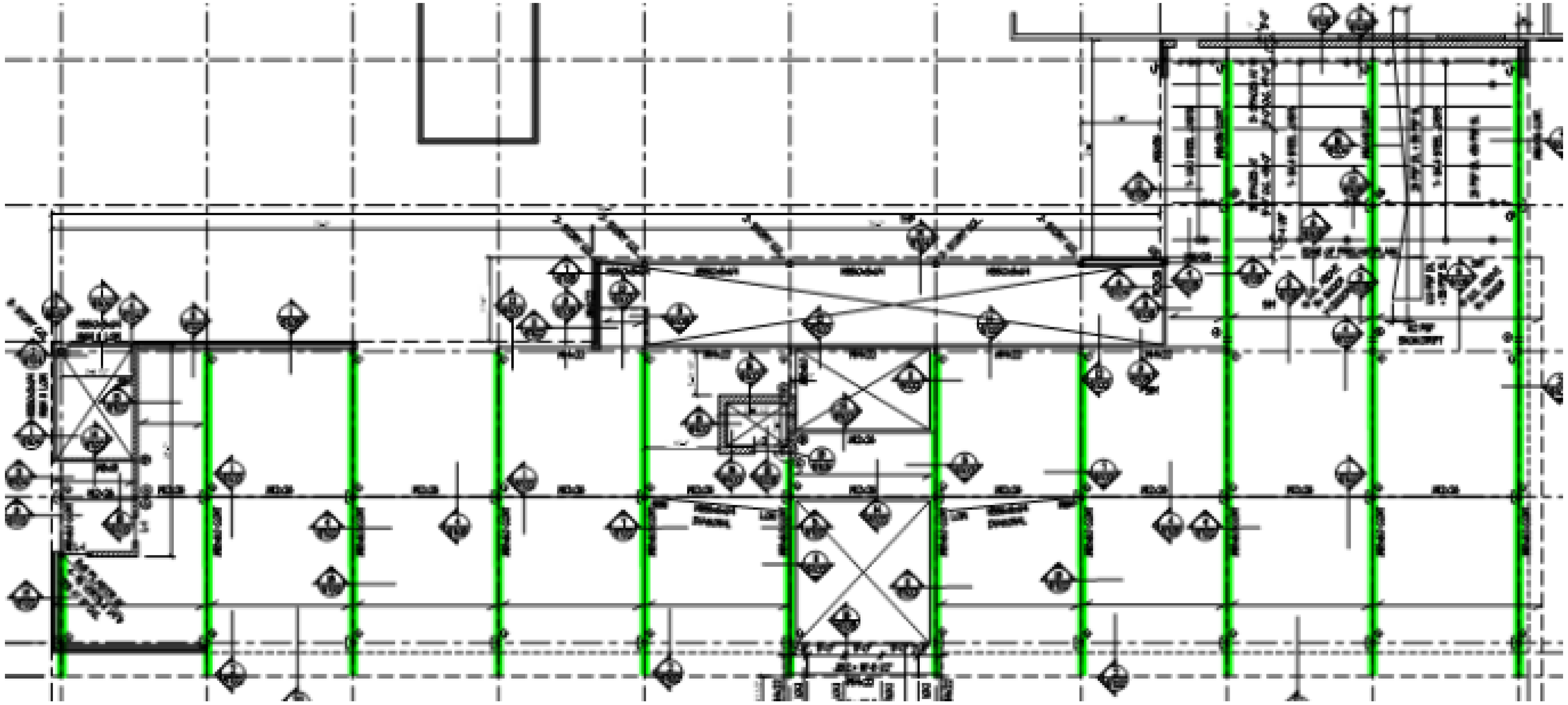
- 3 story structure
- Masonry stair and elevator shaft walls
- Steel floor framing and columns
- Semi-rigid diaphragms at Level 1 and 2
- Flexible diaphragm at roof



Verify All Elements are Modeled

Steel Lateral System

- Steel beams, roof joists, and columns
- 11 Moment Frames in the N-S direction

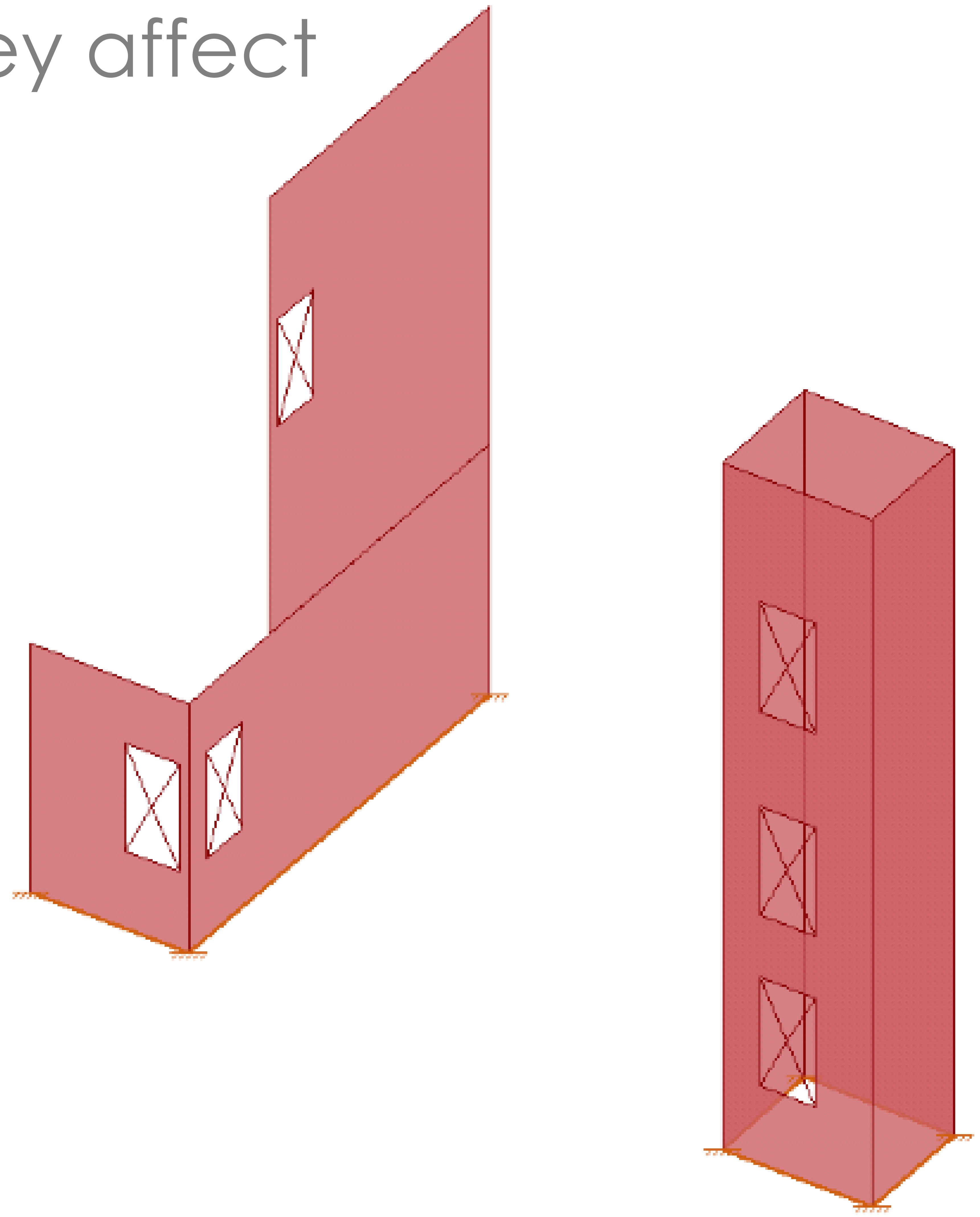


Verify All Elements are Modeled

Forgotten Elements - how will they affect behavior?

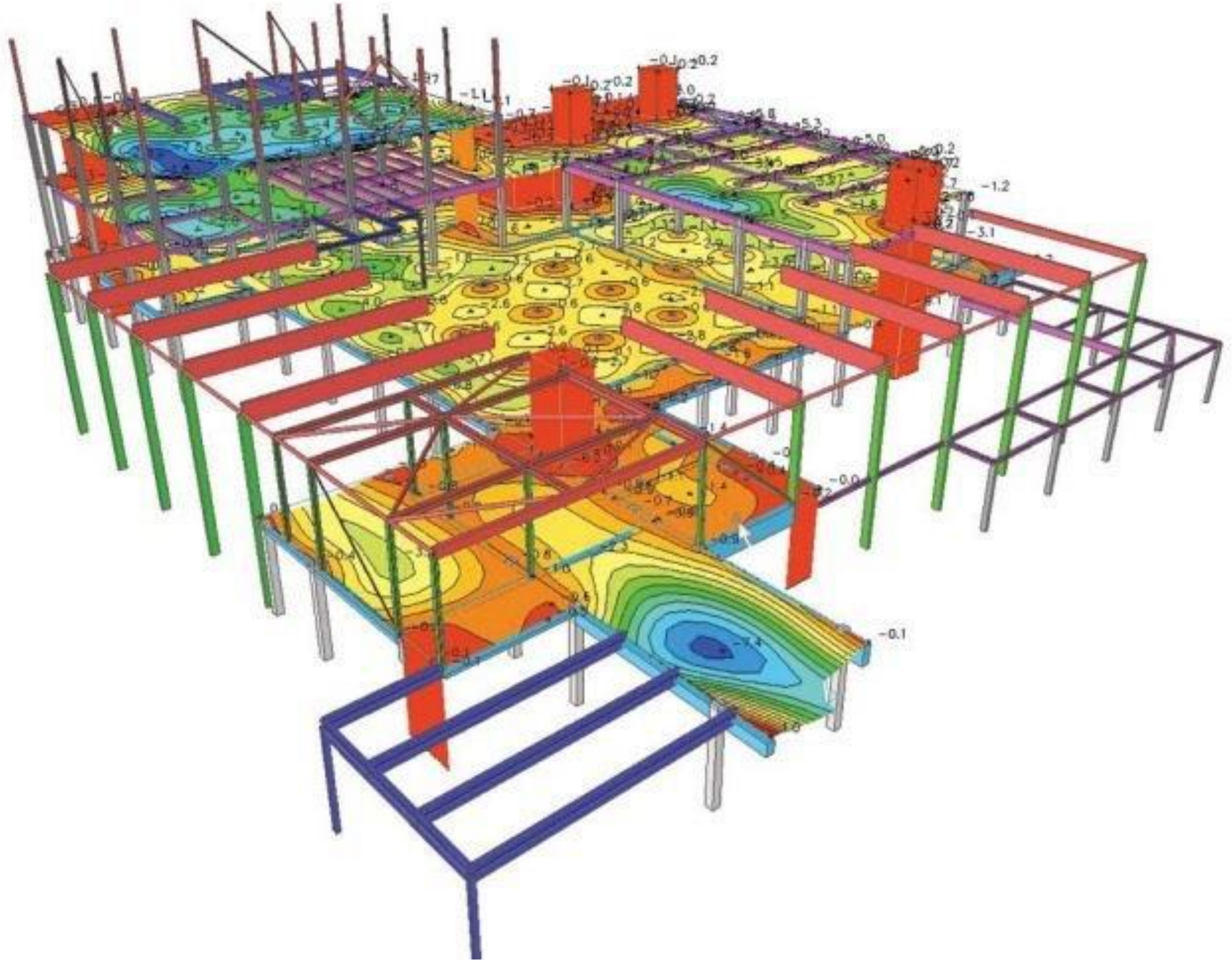
<u>Masonry System</u>

- Stairs: 8” masonry walls with #5@24” o.c. vertical reinf
- Elevators: 12” walls with #5@24” o.c. vertical reinforcement
- Capable of carrying all lateral load without steel moment frames



Moving Away From Simplicity

- Previously with limited software, slower computers, or no software and computers, we simplified reality with conservative “approximations”
- Large difference between all "lateral" and "gravity/lateral" member modeling
  - How can members be ignored from lateral system?



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Understand Software Capability/Limitations of Analysis

- Beam, Column, and Wall Properties
- Diaphragm Properties
- Diaphragm connection to lateral support system

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Beams and Columns

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Beams and Columns

- Member properties - boundary conditions
  - Strong axis - pinned or moment connected
    - Maybe semi-rigid?
  - Weak axis and torsion being checked?
  - Concrete
    - Does FEA consider cracked sections?

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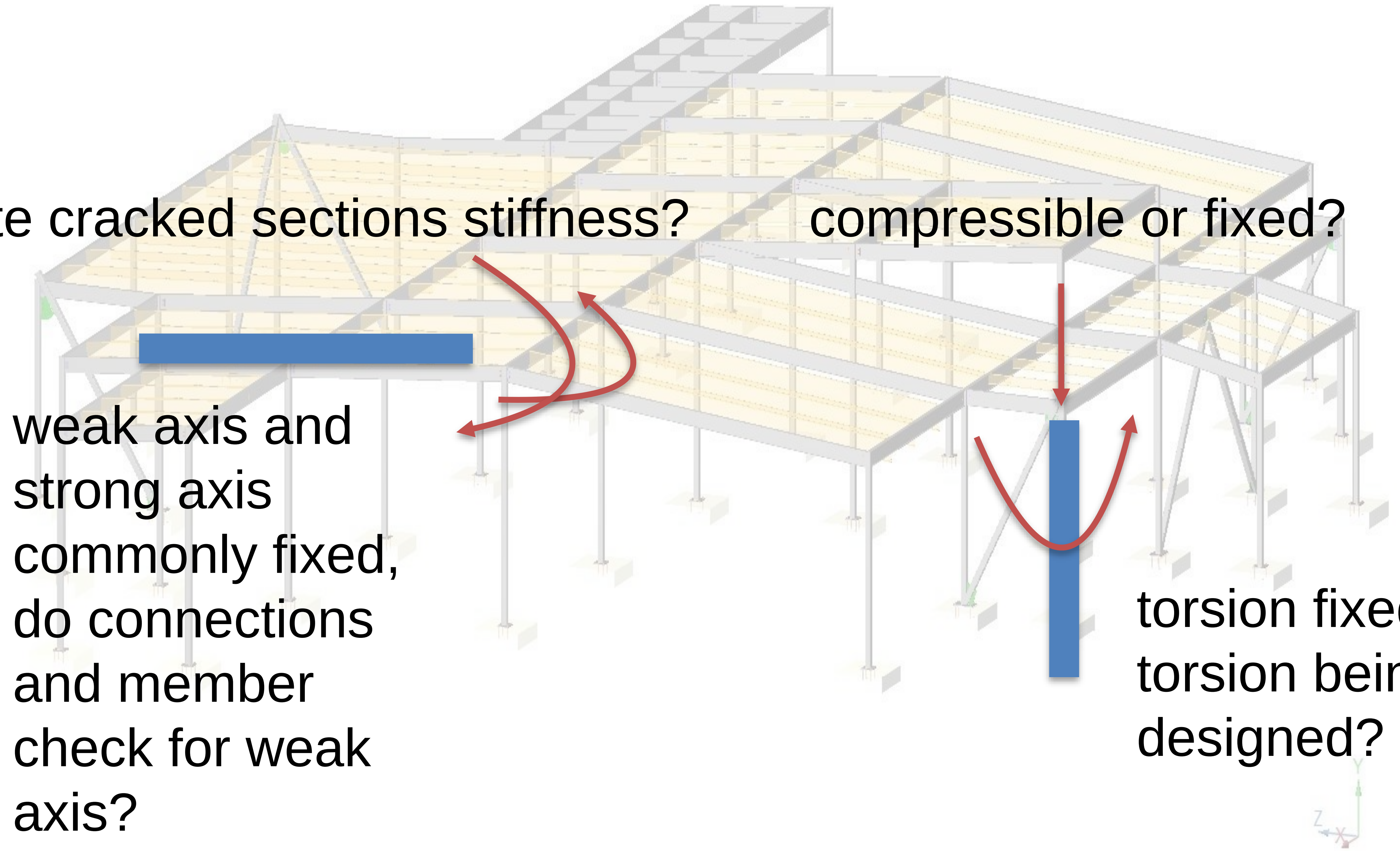
Beams and Columns

- Member properties - boundary conditions
  - End zone
  - Rigid end offsets
  - Pinned, fixed or spring support?

Beams and Columns

- Member properties - type of finite element
  - Wide concrete beam
    - When should it be considered a plate instead of line element (4 node instead of 2)?
  - Large “deep column” or ‘short wall”
    - Remember, “columns” are 1-D finite elements that connect to plates at a single point

Beams and Columns



concrete cracked sections stiffness?

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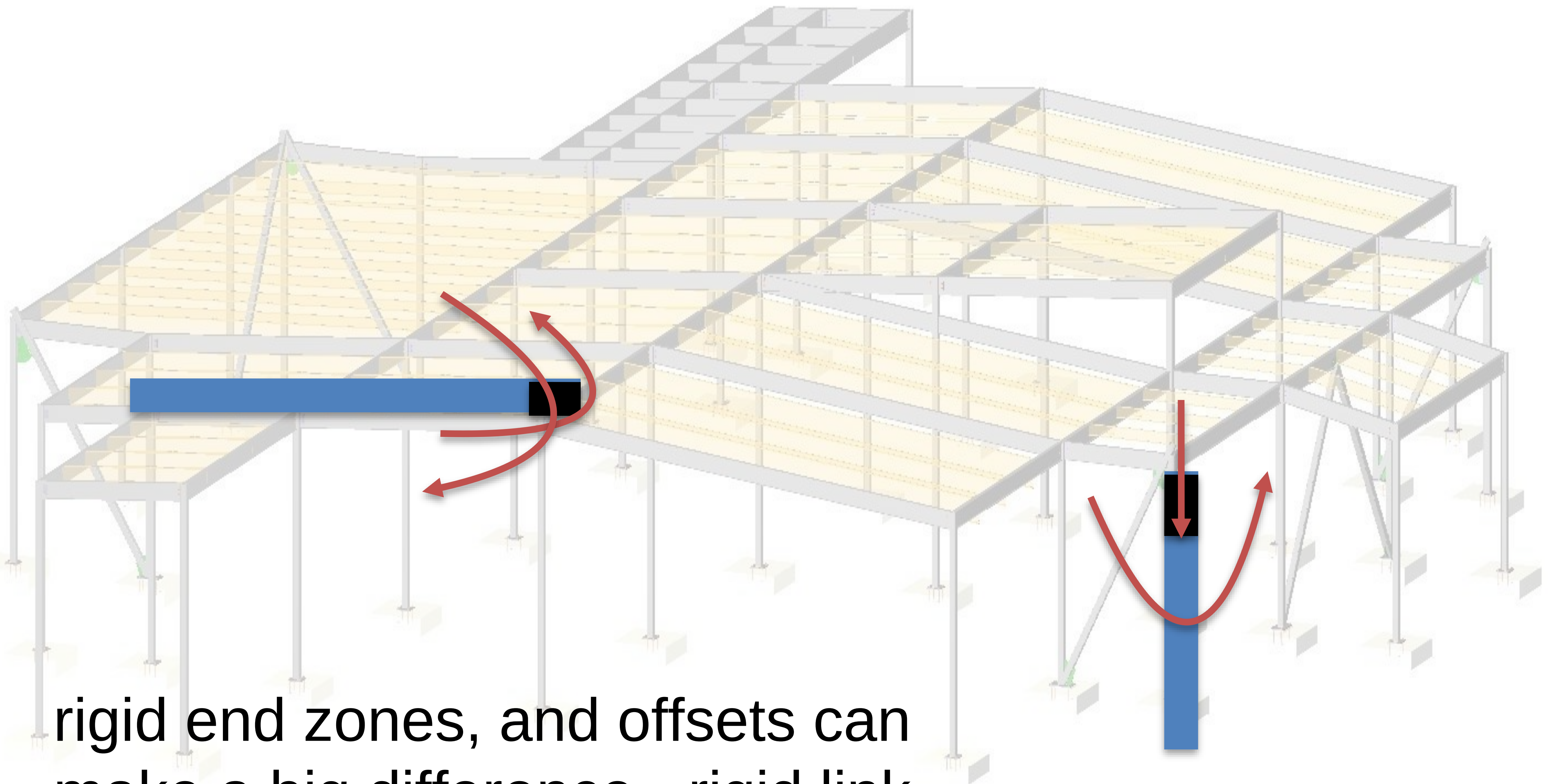
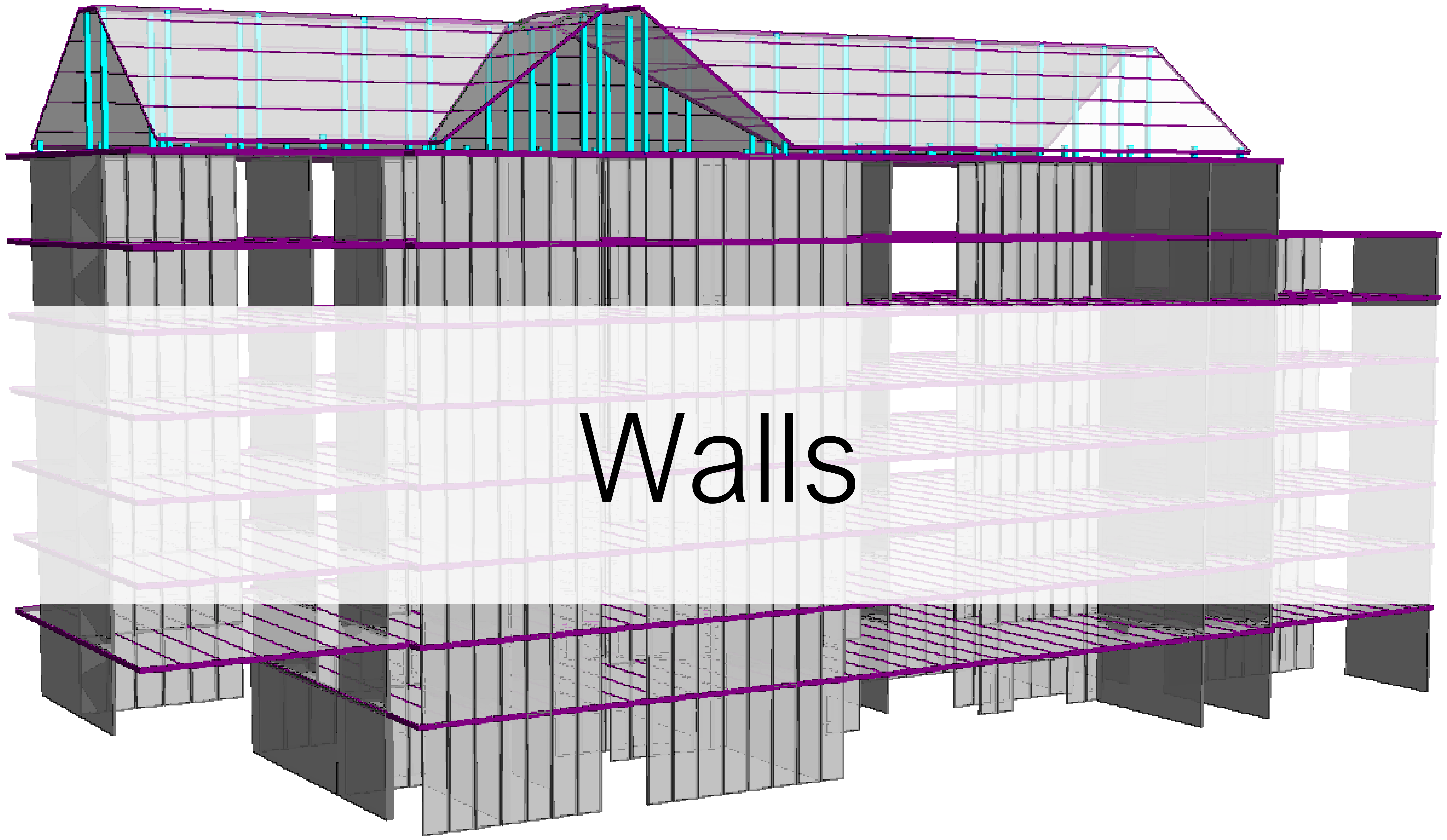


rigid end zones, and offsets can make a big difference - rigid link between the end of the member and end node

Walls



Walls

- Wall properties, boundary conditions
  - Is there weak axis bending? torsional?
  - Horizontal and vertical bending? both being checked?
  - Does FEA consider cracked sections
  - Wall node releases

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Walls

- Wall modeling
  - Masonry wall stiffness based on partial or full grout
  - “True” long walls vs. short segments
    - Gap or no gap
  - Openings

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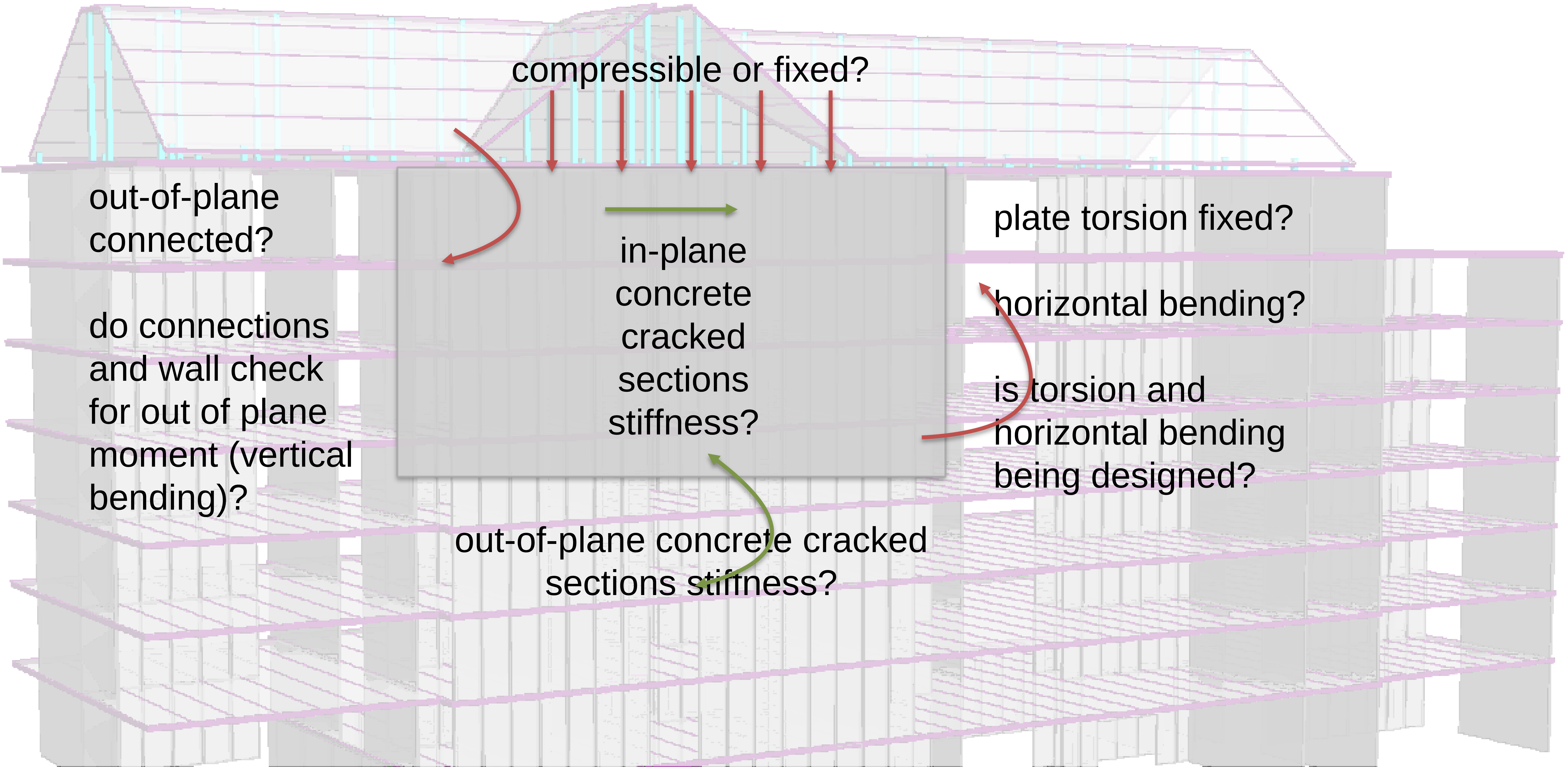
Walls

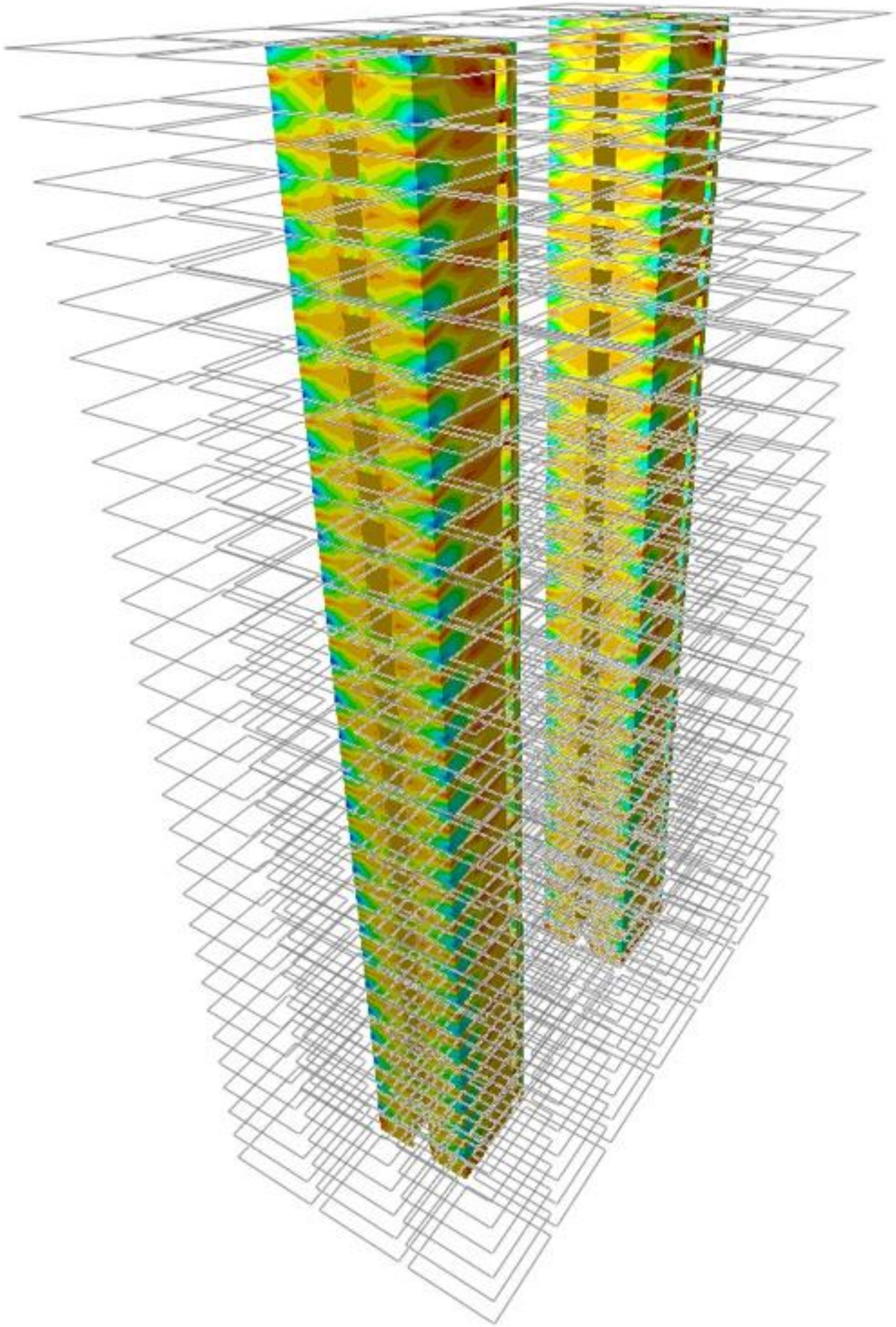

compressible or fixed?
out-of-plane
connected?
do connections
and wall check
for out of plane
moment (vertical
bending)?
in-plane
concrete
cracked
sections
stiffness?
plate torsion fixed?
horizontal bending?
is torsion and
horizontal bending
being designed?
out-of-plane concrete cracked
sections stiffness?

Effective Stiffness for Modeling Reinforced Concrete Structures

By John-Michael Wong, Ph.D., S.E., Angie Sommer, S.E., Katy Briggs, S.E. and Cenk Ergin, P.E.

STRUCTURE MAGAZINE in Articles, Structural Analysis, January 2017

	Elements	Property Modifier for Modeling Elements												
		ACI 318-11 10.10.4.1 ACI 318-14 6.6.3.1.1	ASCE 41-13 Table 10-5	PEER TBI Guidelines Service Level	LATBSDC MCE-Level Non Linear Models (2014)	LATBSDC Servicability & Wind (2014)	FEMA 356 Table 6-5	NZS 3101: Part 2:2006 Ultimate Limit State (fy=300Mpa)	NZS 3101: Part 2:2006 Servicability Limit State (μ=3) (Note 3)	CSA A23.3-14	EuroCode	TS 500-2000	Paulay & Priestley (1992)	Priestly, Calvi & Kowalsky (2007)
Beams	Conventional Beams (L/H > 4)	0.35Ig	0.30Ig	0.50Ig	0.35Ig	0.70Ig	0.50Ig	0.40Ig (rectangular) 0.35Ig (T and L beams)	0.70Ig (rectangular) 0.60Ig (T and L beams)	0.35Ig	0.50Ig	0.40Ig	0.40Ig	0.17Ig-0.44Ig
	Prestressed Beams (L/H > 4)	n/a	1.00Ig	1.00Ig	n/a	n/a	1.00Ig	n/a	n/a				n/a	n/a
	Coupling Beams (L/H ≤ 4)		n/a	n/a	0.20Ig	0.30Ig	n/a	0.60Ig (diagonally reinforced)	0.75Ig				(9)	n/a
Columns	Columns - Pu ≥ 0.5Agf'c	0.70Ig	0.70Ig	0.50Ig	0.70Ig	0.90Ig	0.70Ig	0.80Ig	1.00Ig	0.70Ig	0.50Ig	0.80Ig (Note 6)	0.80Ig	0.12Ig-0.86Ig
	Columns - Pu ≤ 0.3Agf'c						0.50Ig	0.55Ig	0.80Ig				0.60Ig	
	Columns - Pu ≤ 0.1Agf'c		0.30Ig		n/a	n/a		0.40Ig	0.70Ig			0.40Ig	(9)	
	Columns - tension			n/a				n/a	n/a			n/a		
Walls (4)	Walls - uncracked	0.70Ig	n/a	0.75Ig	n/a	n/a	0.80Ig	n/a	n/a	0.7Ig	0.50Ig	n/a	(9)	n/a
	Walls - cracked	0.35Ig	0.50Ig		1.00Ec (1)	0.75Ig	0.50Ig	0.32Ig-0.48Ig	0.50Ig-0.70Ig	0.35Ig	0.50Ig	0.40Ig - 0.80Ig (Note 6)		0.20Ig-0.30Ig
	Walls - shear	n/a	0.40EcAw (10	n/a	0.50Ag	1.00Ag	n/a	n/a	n/a	n/a	n/a	n/a	(9)	n/a
Slabs	Conventional flat plates and flat slabs	0.25Ig	See 10.4.4.2	0.50Ig	0.25Ig	0.50Ig	n/a	n/a	n/a	0.25Ig	0.50Ig	n/a	(9)	n/a
	Post tensioned flat plates and flat slabs	n/a	See 10.4.4.2									n/a	n/a	
	In-plane Shear	n/a	n/a	n/a	0.25Ag	0.80Ag	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Notes		(5)	(2)	(2)	(2)				(3)				(7)	



Mixing Materials
… in the same frame

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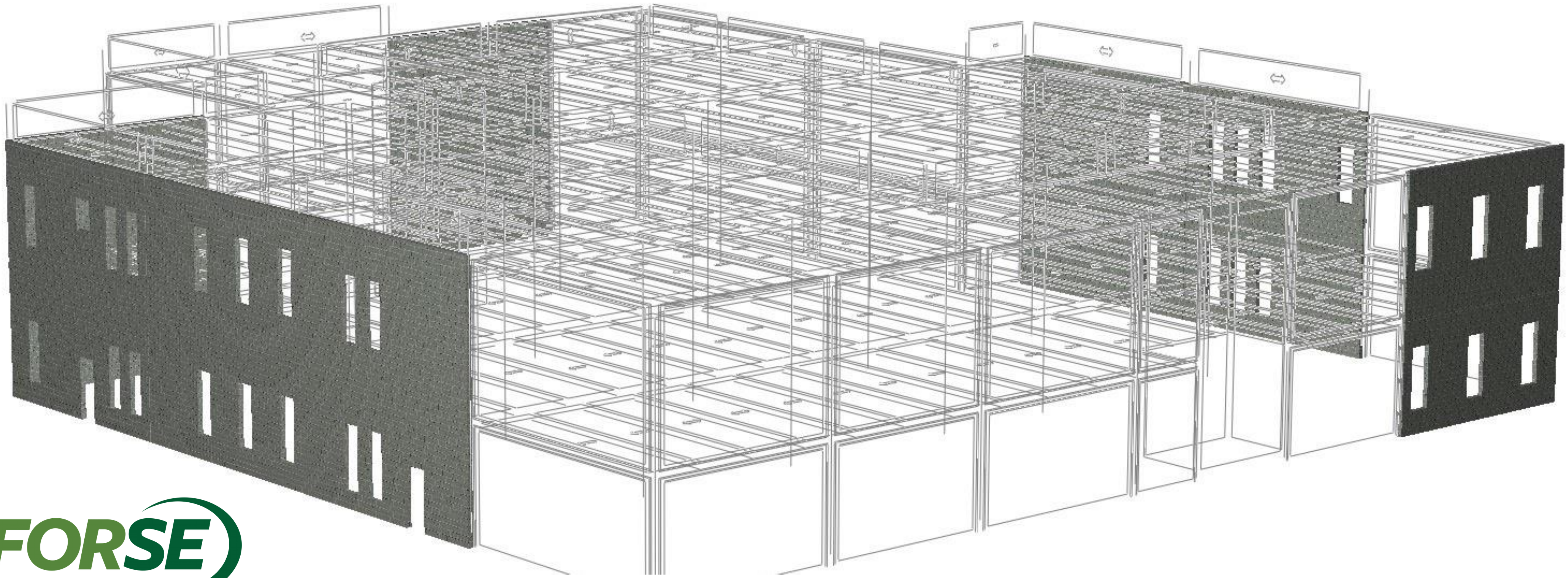
Steel Frames Connected to Perforated Masonry Shear Walls



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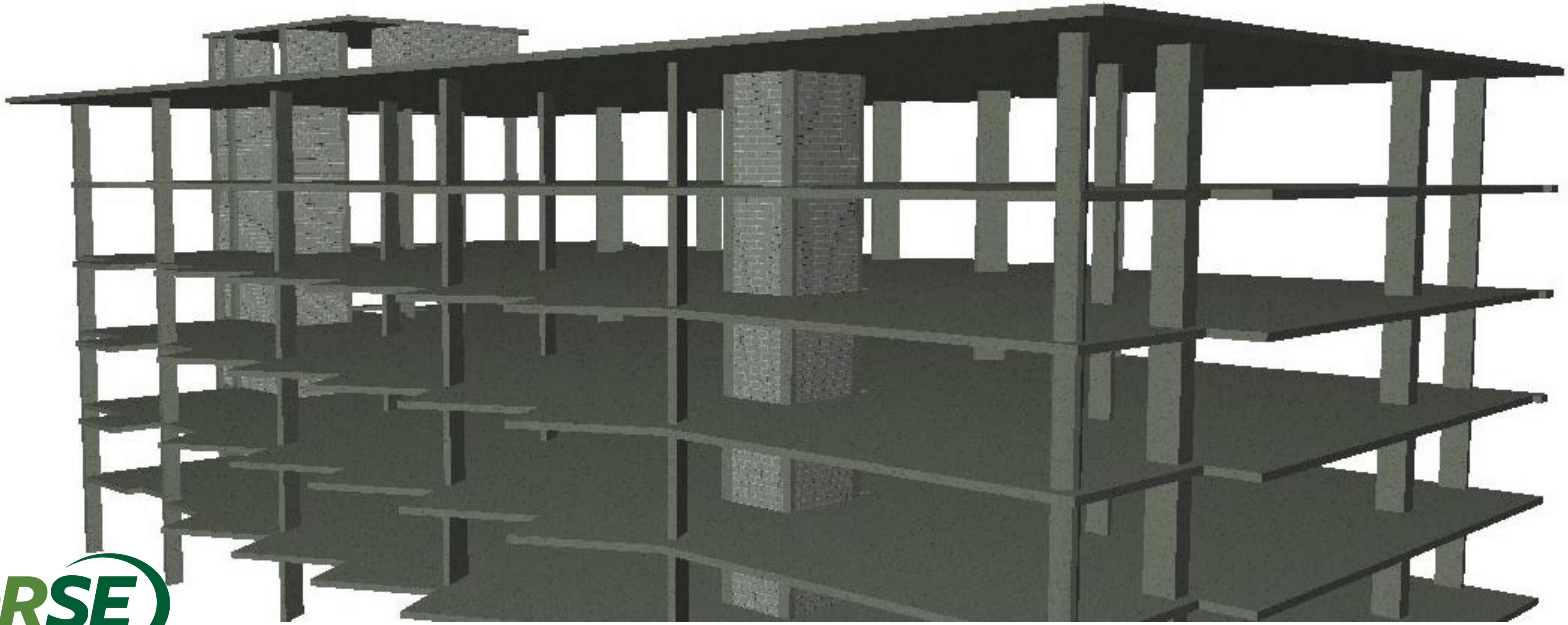
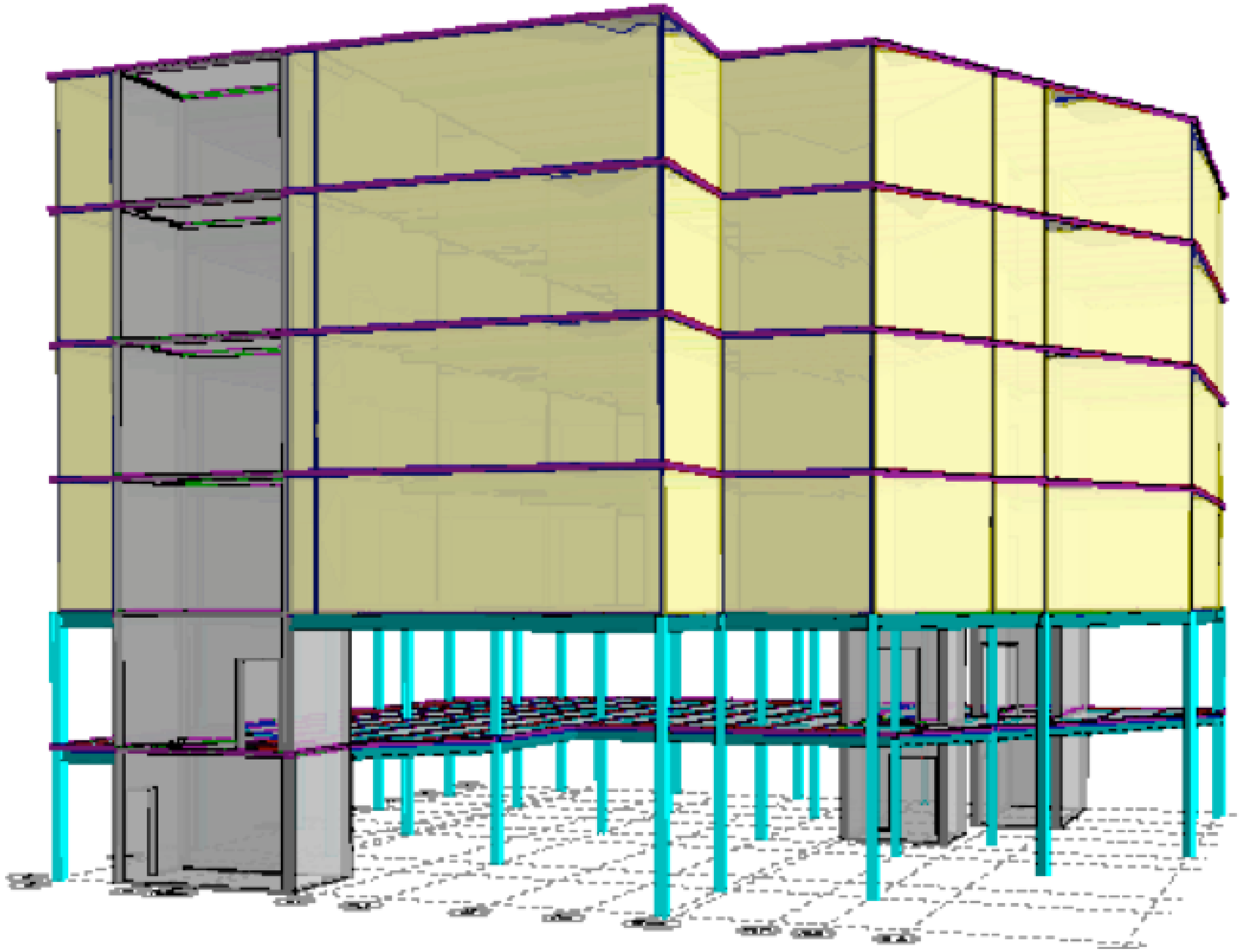
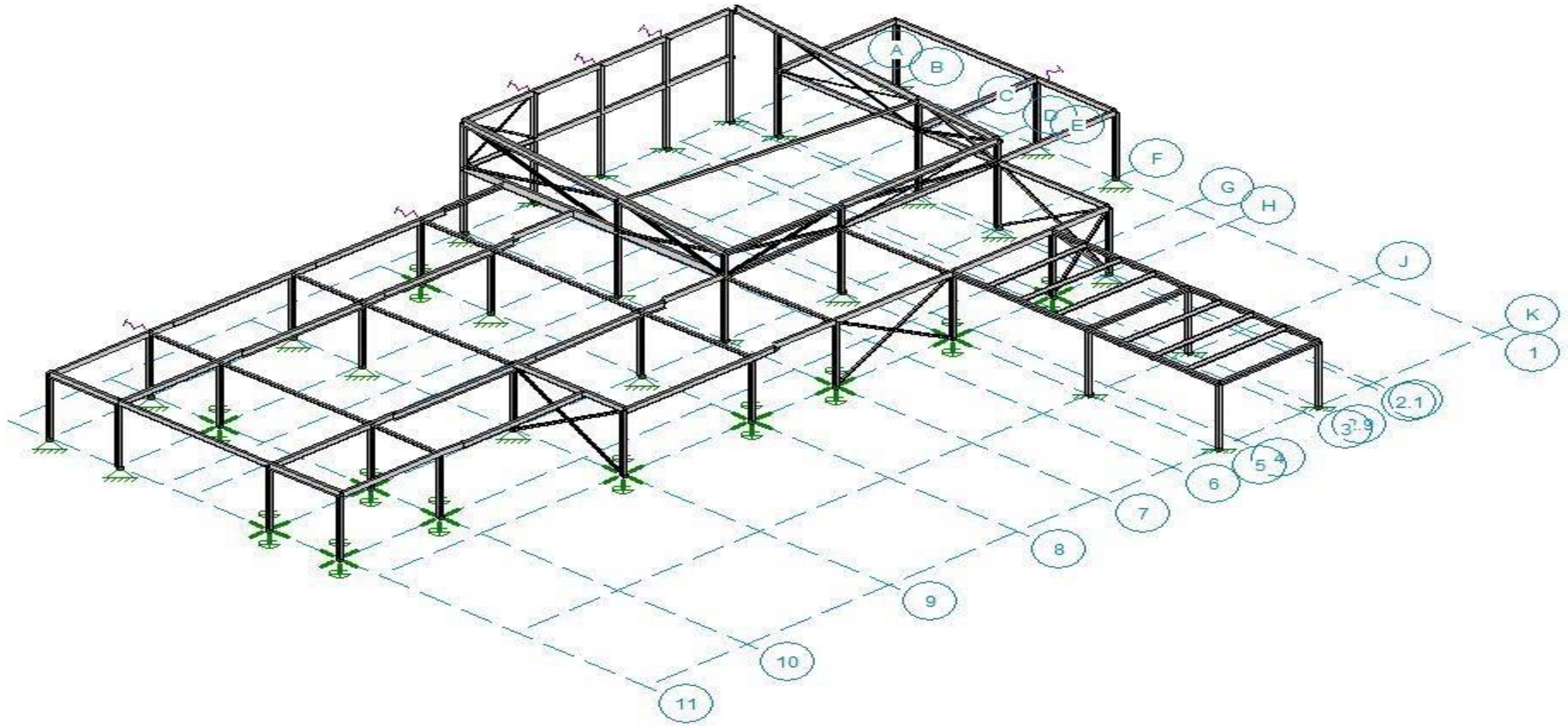
Post-Tensioned Concrete Frame with Masonry Walls



Multiple Material Lateral: Wood - Masonry - Steel





QA/QC for Member Results

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QA/QC

- What are residual forces/stresses?
  - Examples
    - Torsional load in wide flange?
    - Horizontal bending in walls?
    - Axial forces in connections?
    - Diaphragm forces in floors?

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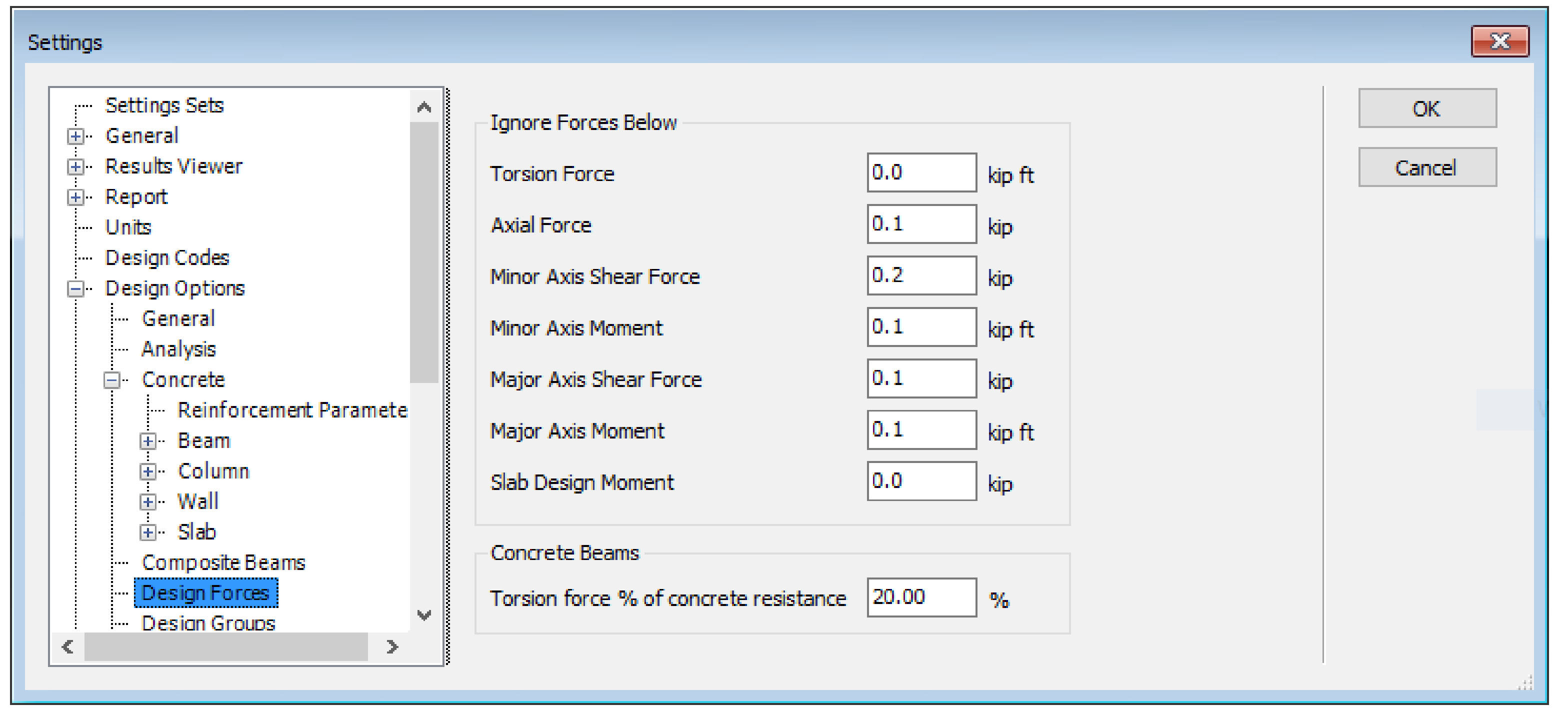
QA/QC

- Do you have a way to check for unaccounted for residual forces/stresses?
- Or do you have a means to make sure the magnitude of the load is below a certain threshold to ignore?



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QA/QC

VIEW THE DEFLECTED SHAPE - ANIMATE

QA/QC

- Check drift - inter-story and overall drifts
- Check the animated shapes as well
  - tells a story of the buildings response

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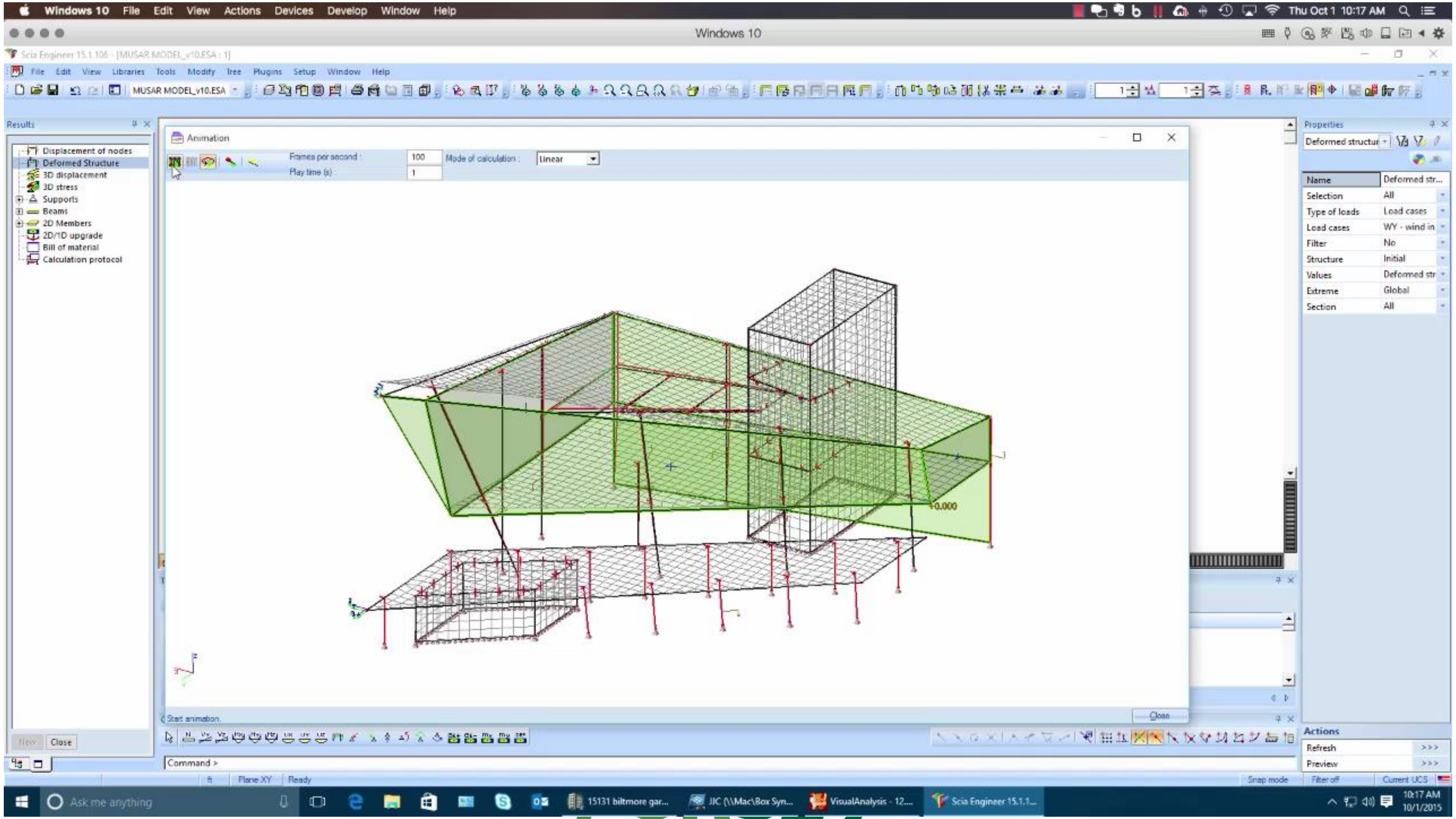
Windows 10
File
Edit
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Develop
Window
Help
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Windows 10
Results
Displacement of nodes
Deformed Structure
3D displacement
3D stress
Supports
Beams
2D Members
2D/1D upgrade
Bill of material
Calculation protocol
Animation
Frames per second :
100
Mode of calculation :
Linear
Play time (s) :
1
Start animation.
Close
Properties
Name
Deformed str...
Selection
All
Type of loads
Load cases
Load cases
WY - wind in
Filter
No
Structure
Initial
Values
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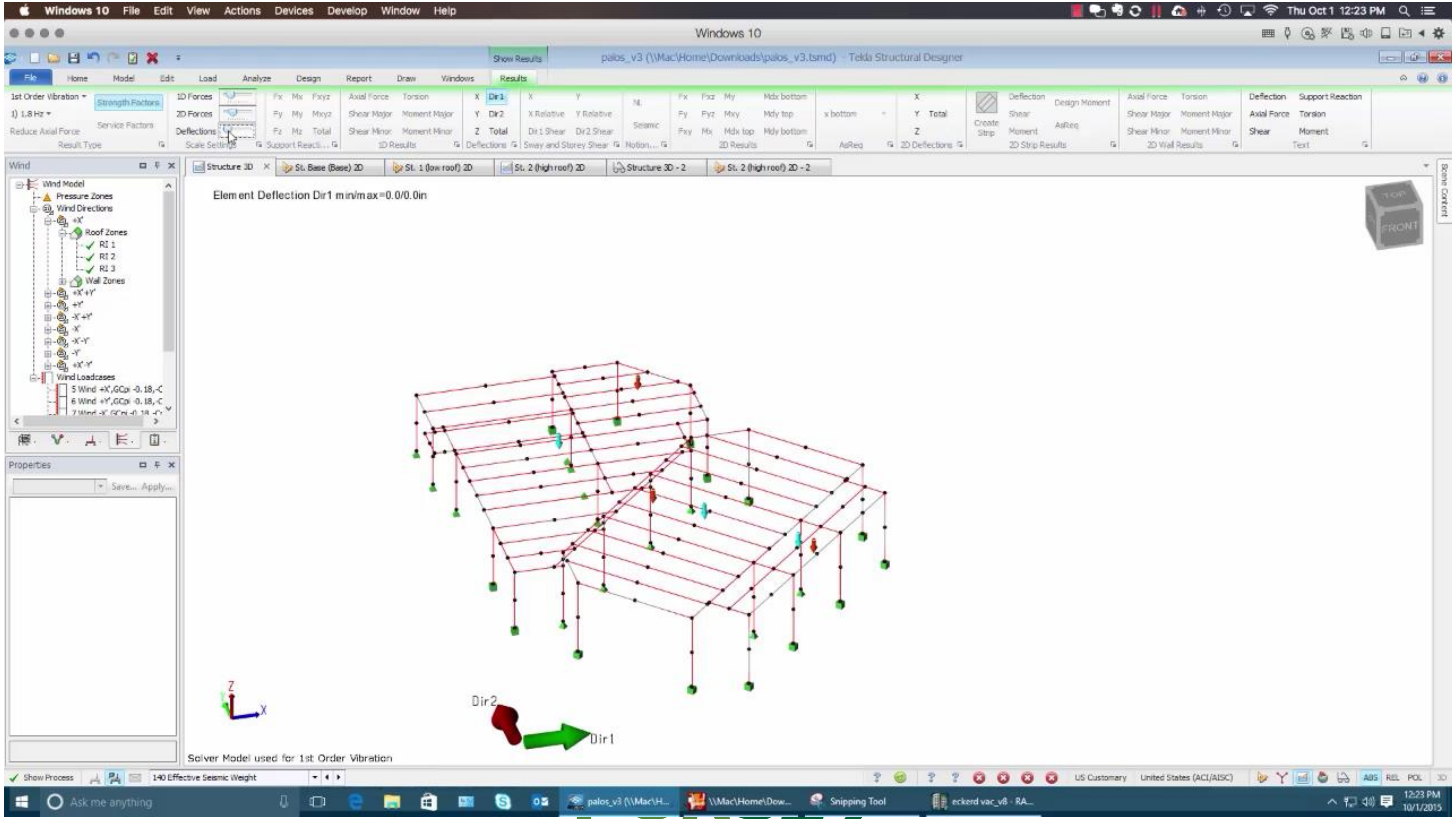
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Show Results
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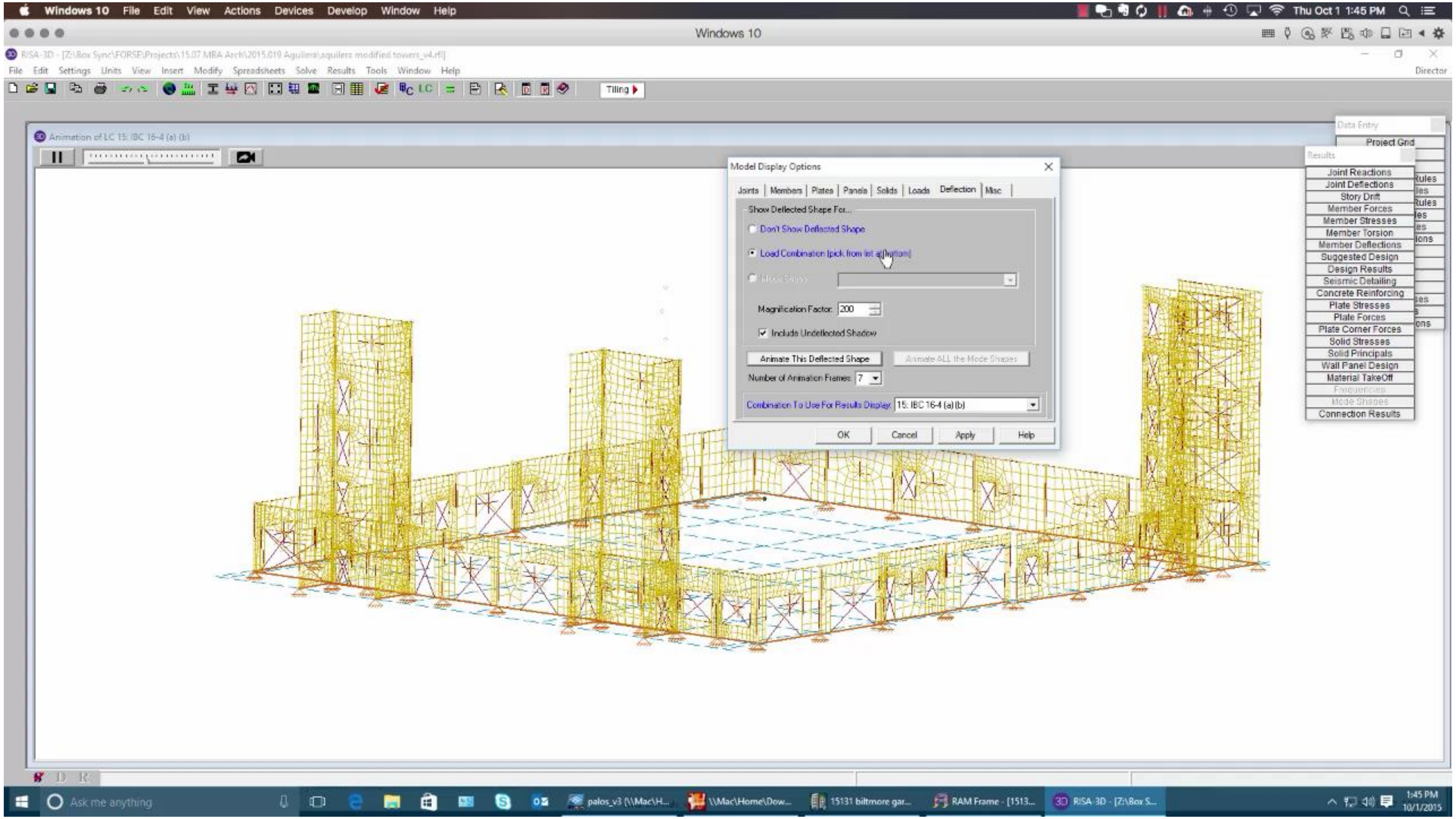
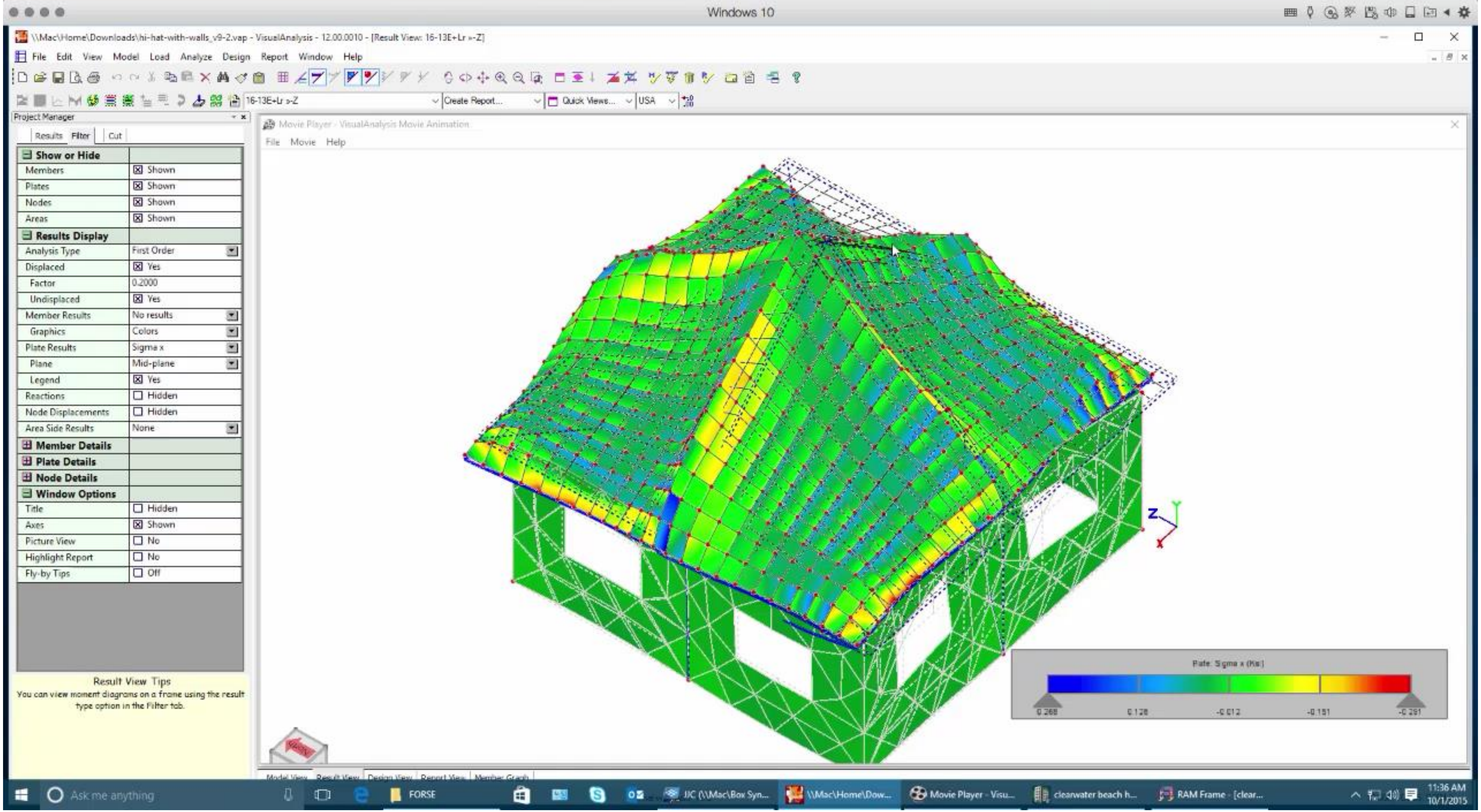
File Home Model Edit Load Analyze Design Report Draw Windows Results
1st Order Vibration
1) 1.8 Hz
Reduce Axial Force
Strength Factors
Service Factors
Result Type
1D Forces
2D Forces
Deflections
Scale Settings
Support Reacti...
1D Results
Deflections
Sway and Storey Shear
2D Results
2D Deflections
2D Strip Results
2D Wall Results
Text
Wind
Wind Model
Pressure Zones
Wind Directions
Roof Zones
Wall Zones
Wind Loadcases
Properties
Structure 3D
St. Base (Base) 2D
St. 1 (low roof) 2D
St. 2 (high roof) 2D
Structure 3D - 2
St. 2 (high roof) 2D - 2
Element Deflection Dir1 min/max=0.0/0.0in
Dir2
Dir1
Solver Model used for 1st Order Vibration
Show Process
140 Effective Seismic Weight
US Customary
United States (ACI/AISC)
Ask me anything
Snipping Tool
12:23 PM
10/1/2015


Windows 10 File Edit View Actions Devices Develop Window Help
Thu Oct 1 1:45 PM
Windows 10
File Edit Settings Units View Insert Modify Spreadsheets Solve Results Tools Window Help
Tiling
Director
Animation of LC 15: IBC 16-4 (a) (b)
Model Display Options
Joints Members Plates Panels Solids Loads Deflection Misc
Show Deflected Shape For...
Don't Show Deflected Shape
Load Combination (pick from list at bottom)
Magnification Factor 200
Include Undeflected Shadow
Animate This Deflected Shape
Animate ALL the Mode Shapes
Number of Animation Frames 7
Combination To Use For Results Display 15: IBC 16-4 (a) (b)
OK Cancel Apply Help
Data Entry
Project Grid
Results
Joint Reactions
Joint Deflections
Story Drift
Member Forces
Member Stresses
Member Torsion
Member Deflections
Suggested Design
Design Results
Seismic Detailing
Concrete Reinforcing
Plate Stresses
Plate Forces
Plate Corner Forces
Solid Stresses
Solid Principals
Wall Panel Design
Material TakeOff
Frequencies
Mode Shapes
Connection Results
Ask me anything
RAM Frame - [1513...
RISA-3D - [Z:\Box S...
1:45 PM
10/1/2015


Windows 10
\\Mac\Home\Downloads\hi-hat-with-walls_v9-2.vap - VisualAnalysis - 12.00.0010 - [Result View: 16-13E+Lr »-Z]
File Edit View Model Load Analyze Design Report Window Help
16-13E+Lr »-Z
Create Report...
Quick Views...
USA
Project Manager
Results Filter Cut
Show or Hide
Members Shown
Plates Shown
Nodes Shown
Areas Shown
Results Display
Analysis Type First Order
Displaced Yes
Factor 0.2000
Undisplaced Yes
Member Results No results
Graphics Colors
Plate Results Sigma x
Plane Mid-plane
Legend Yes
Reactions Hidden
Node Displacements Hidden
Area Side Results None
Member Details
Plate Details
Node Details
Window Options
Title Hidden
Axes Shown
Picture View No
Highlight Report No
Fly-by Tips Off
Result View Tips
You can view moment diagrams on a frame using the result type option in the Filter tab.
Movie Player - VisualAnalysis Movie Animation
File Movie Help
Z
Y
X
Ask me anything
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JJC (\\Mac\Box Syn...
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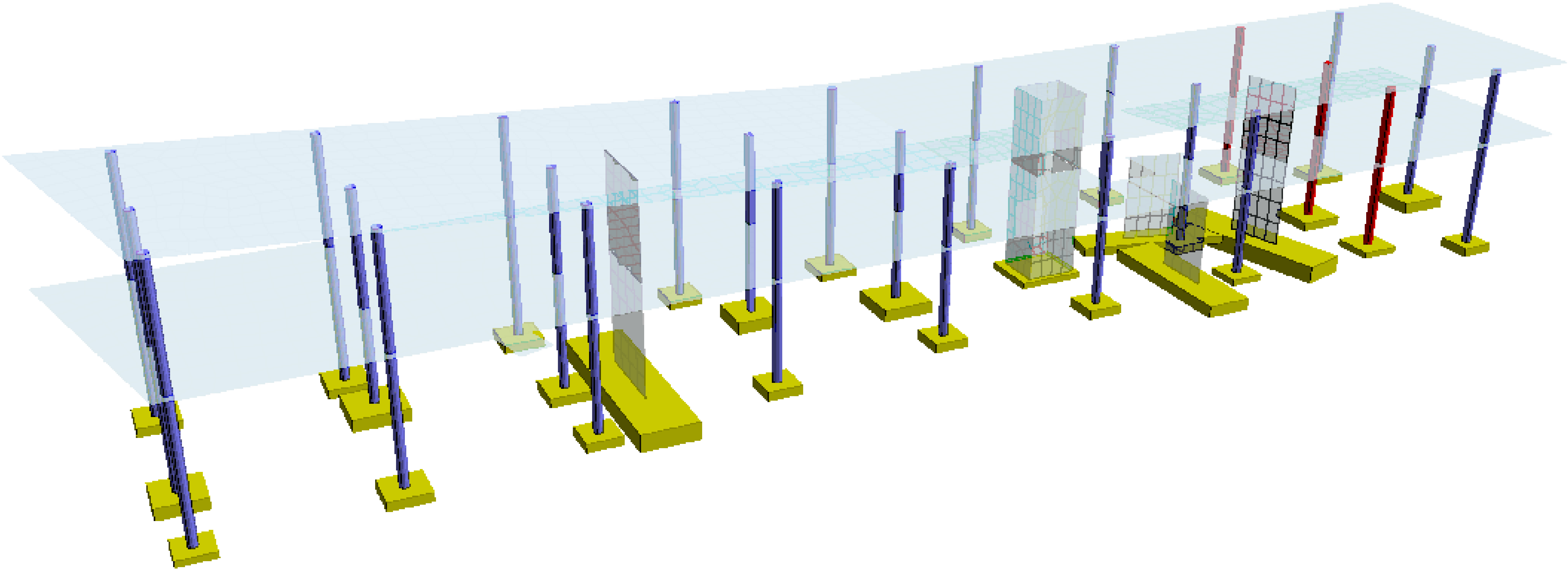
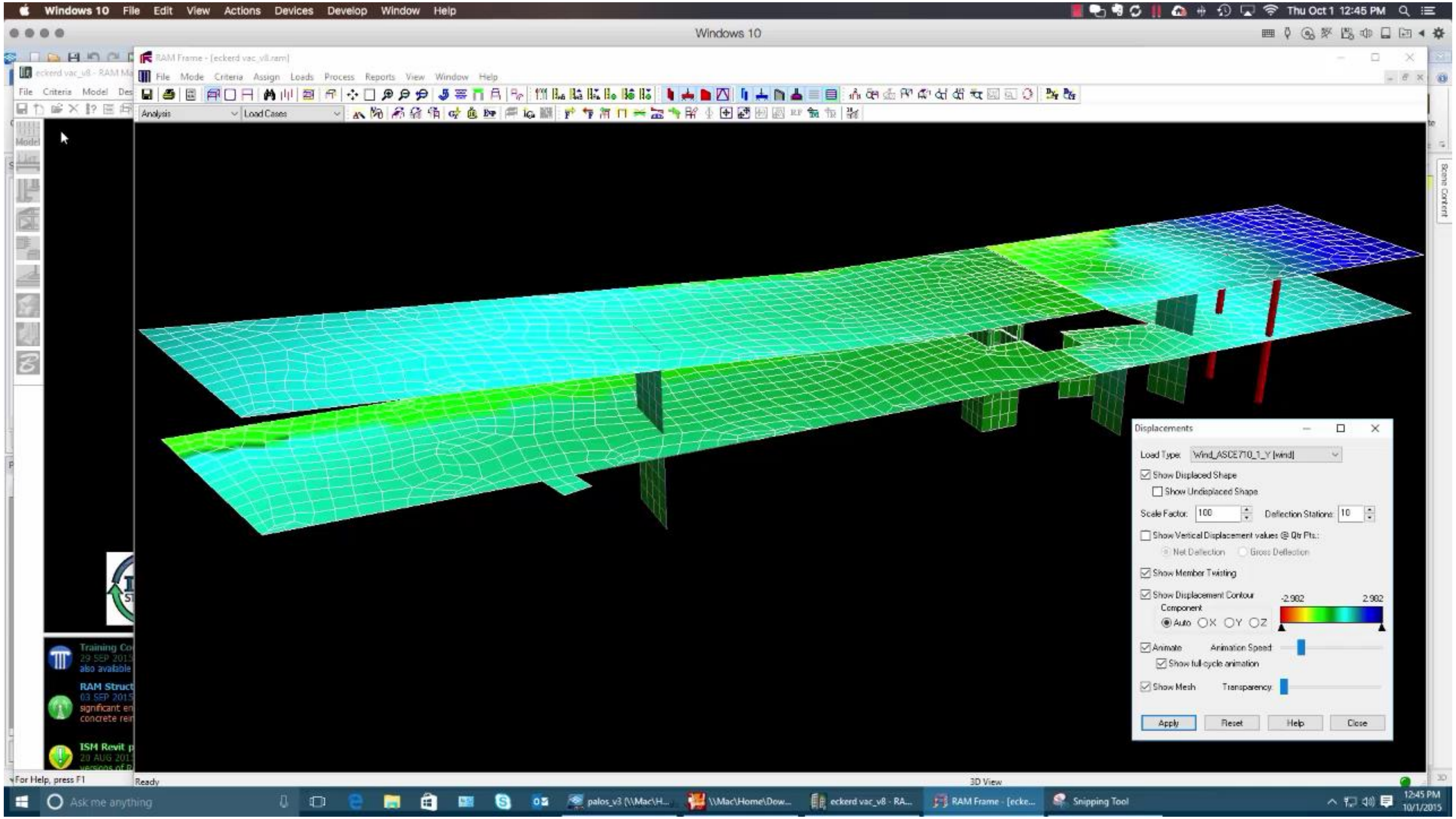
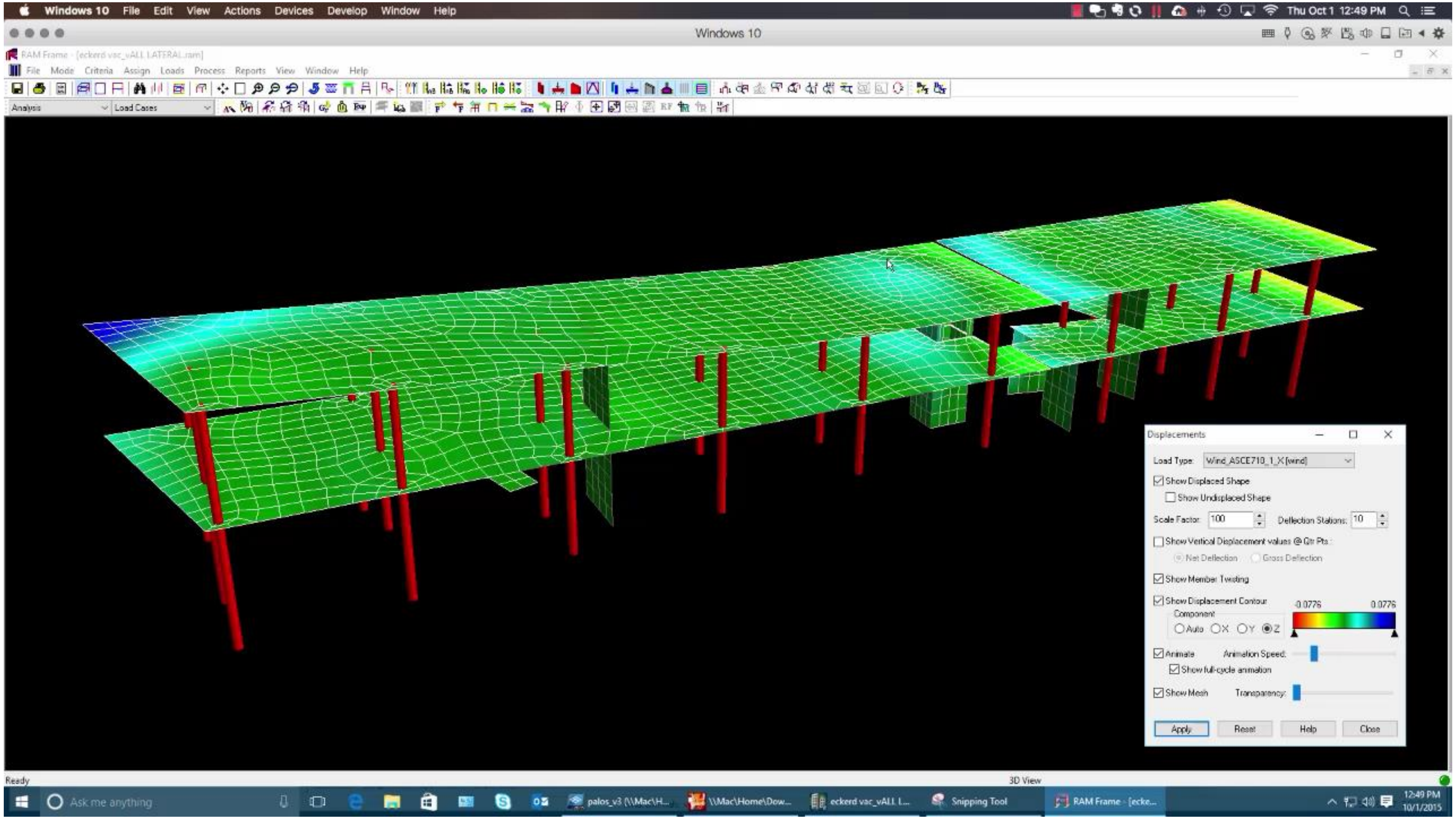
Movie Player - Visu...
clearwater beach h...
RAM Frame - [clear...
11:36 AM
10/1/2015





Windows 10
RAM Frame - [eckerd vac_v8.ram]
Displacements
Load Type: Wind_ASCE710_1_Y [wind]
Show Displaced Shape
Show Undisplaced Shape
Scale Factor: 100
Deflection Stations: 10
Show Vertical Displacement values @ Qtr Pts.:
Net Deflection
Gross Deflection
Show Member Twisting
Show Displacement Contour
-2.902
2.902
Component
Auto X Y Z
Animate
Animation Speed
Show full-cycle animation
Show Mesh
Transparency
Apply
Reset
Help
Close
For Help, press F1
Ready
3D View



Windows 10 File Edit View Actions Devices Develop Window Help
Thu Oct 1 12:49 PM
Windows 10
RAM Frame - [eckerd vac_vALL LATERAL.ram]
File Mode Criteria Assign Loads Process Reports View Window Help
Analysis
Load Cases
Displacements
Load Type: Wind_ASCE710_1_X [wind]
Show Displaced Shape
Show Undisplaced Shape
Scale Factor: 100
Deflection Stations: 10
Show Vertical Displacement values @ Qtr Pts :
Net Deflection
Gross Deflection
Show Member Twisting
Show Displacement Contour
-0.0776
0.0776
Component
Auto X Y Z
Animate
Animation Speed:
Show full-cycle animation
Show Mesh
Transparency:
Apply
Reset
Help
Close
Ready
3D View
Ask me anything
palos_v3 (\\Mac\H...
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Snipping Tool
RAM Frame - [ecke...
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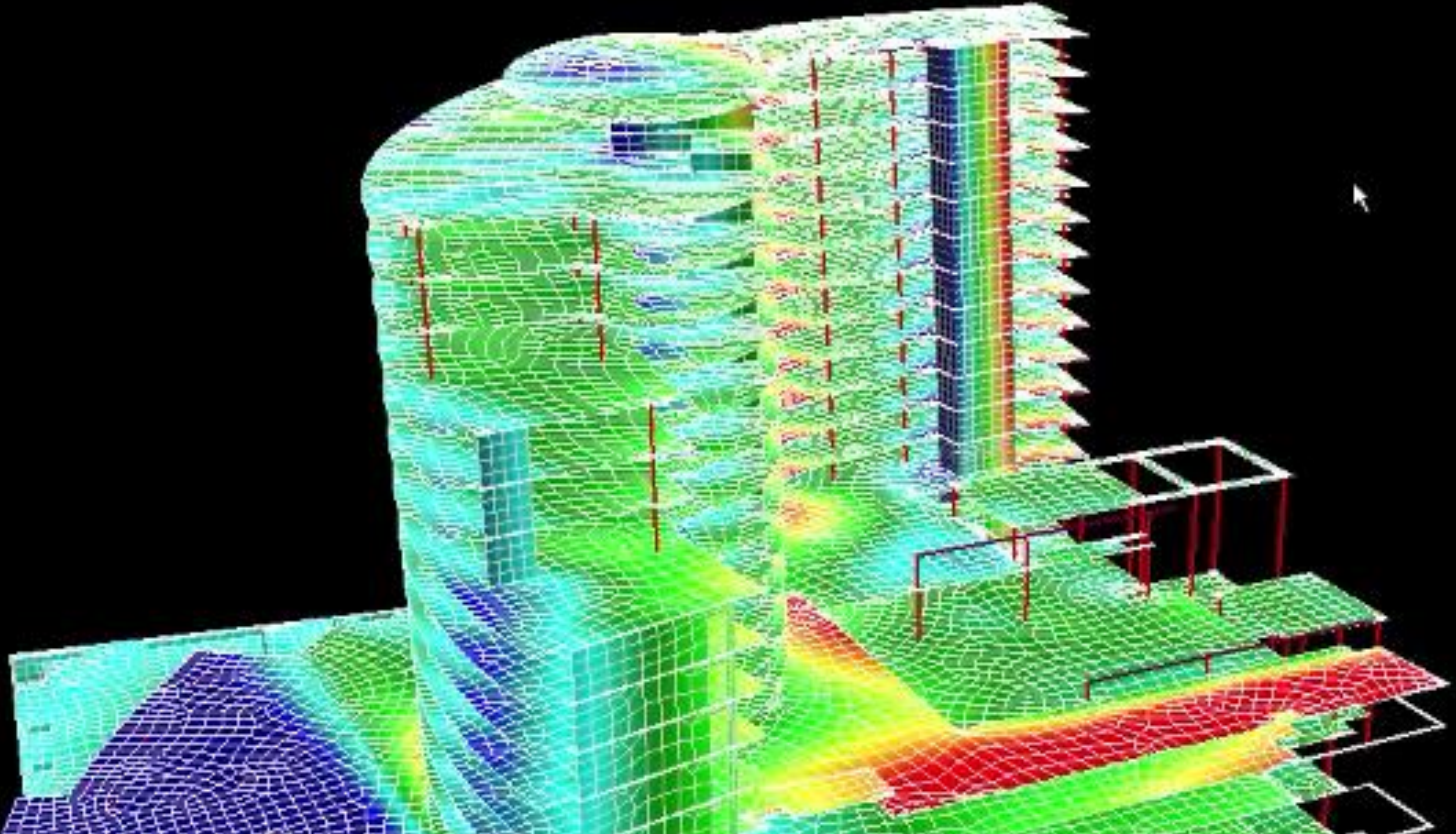

Verify design checks

Never **go from analysis to design check without validating results first**

- Understand software capability/limitations of design checks
  - Note: (obvious) not all programs run the same checks
- start with simple models to understand design checks
  - Note: (obvious) reading the manual is imperative
- be sure design check is comparing the right analysis results against member capabilities

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Examples: Floor Vibration Calculations

- structural steel software review
  - all these programs do floor vibration checks
  - do they agree with your hand calcs
  - what to do when things get more complicated

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Dynamic Analysis for Steel Floor Vibrations
Simple Software Solution

XXXX	By: XXX	Date: 3/2/2011
0000 0000.00	Checked By:	Date:

SHEET

Floor Vibrations - Due to Human Activity — **AISC - Steel Design Guide Series 11**

Chapter 4 - Design for Walking Excitation

Design Criteria

Concrete Slab and Deck Properties

Concrete Thickness

Deck, t_{DECK} = 2.00 in — f'_c = 4000 psi

Concrete, t_{CONC} = 3.25 in — γ_{CONC} = 145.0 pcf

Overall, t_{TOTAL} = 5.25 in — E_{CONC} = 3492 ksi

Normal Weight Concrete — E_{CONC} (dynamic) = 1.35 * E_{CONC}

Loads for Vibration Analysis

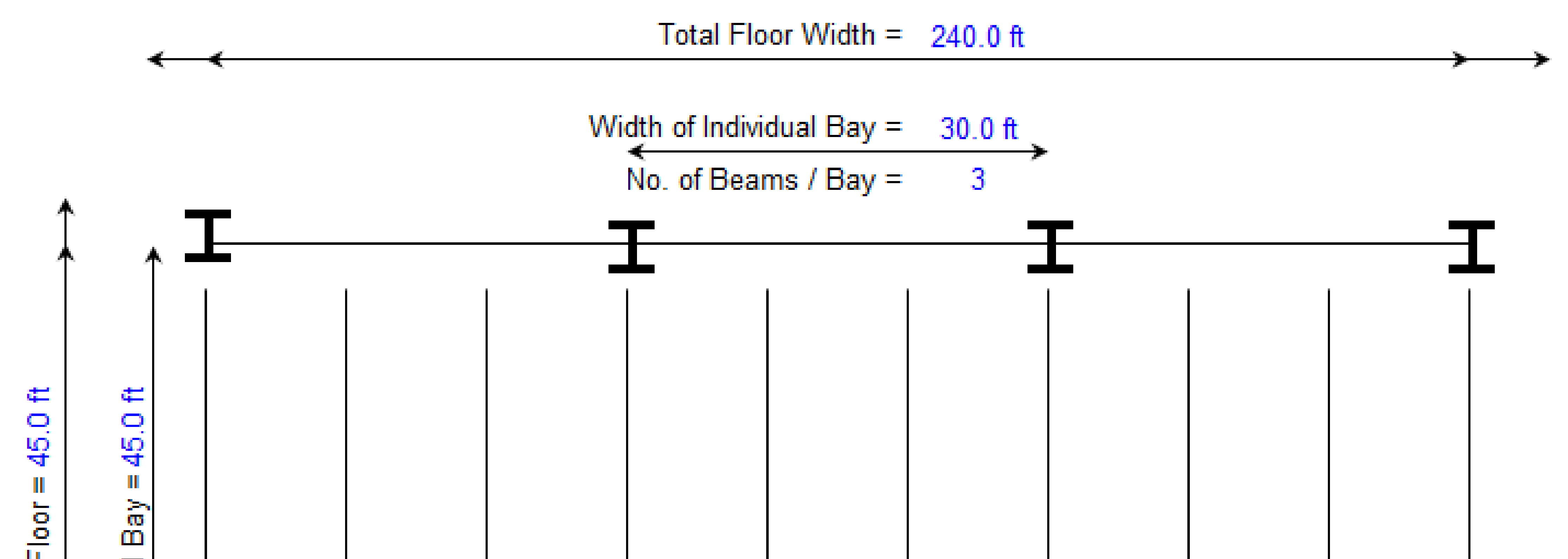
DL (slab) =	51.0 psf
DL (deck) =	2.0 psf
DL (mech &misc) =	4.0 psf
Total DL =	57.0 psf
LL (for vibration analysis) =	11.0 psf

Steel Section Properties

Steel Beam Section W18x50 — F_Y = 50 ksi

Steel Girder Section W24x55 — E_{STEEL} = 29000 ksi

Modular Ratio, n = E_{STEEL} / E_{CONC} (dynamic 6.15



Dynamic Analysis for Steel Floor Vibrations Simple Software Solution

Combined Mode Properties

If L_G is less than B_J, the combined mode is restricted and the system is effectively stiffened.

$\Delta_G = (L_G / B_J) * \Delta_G'$ 0.186 in

Otherwise

$\Delta_G = \Delta_G' =$ N/A

Floor Fundamental Frequency

$f_N = 0.18 * \sqrt{(g / (\Delta_J + \Delta_G))} =$ 3.49 Hz

Effective Panel Mode Panel Weight

$W = \Delta_J / (\Delta_J + \Delta_G) * W_J + \Delta_G / (\Delta_G + \Delta_J) * W_G =$ 124.0 k

$\Delta_J / (\Delta_J + \Delta_G) * W_J =$ 111.70 k

$\Delta_G / (\Delta_G + \Delta_J) * W_G =$ 12.29 k

Indicate the appropriate occupancy by selecting from the categories below:

Offices, Residences, and Churches with non-structural components and furnishings

Use the following Parameters from Table 4.1

Constant Force, $P_0 =$ 65.0 lb

Damping Ratio, $\beta =$ 0.03

Acceleration Limit, $a_0/g =$ 0.50% of g

Floor Fundamental Natural Frequency

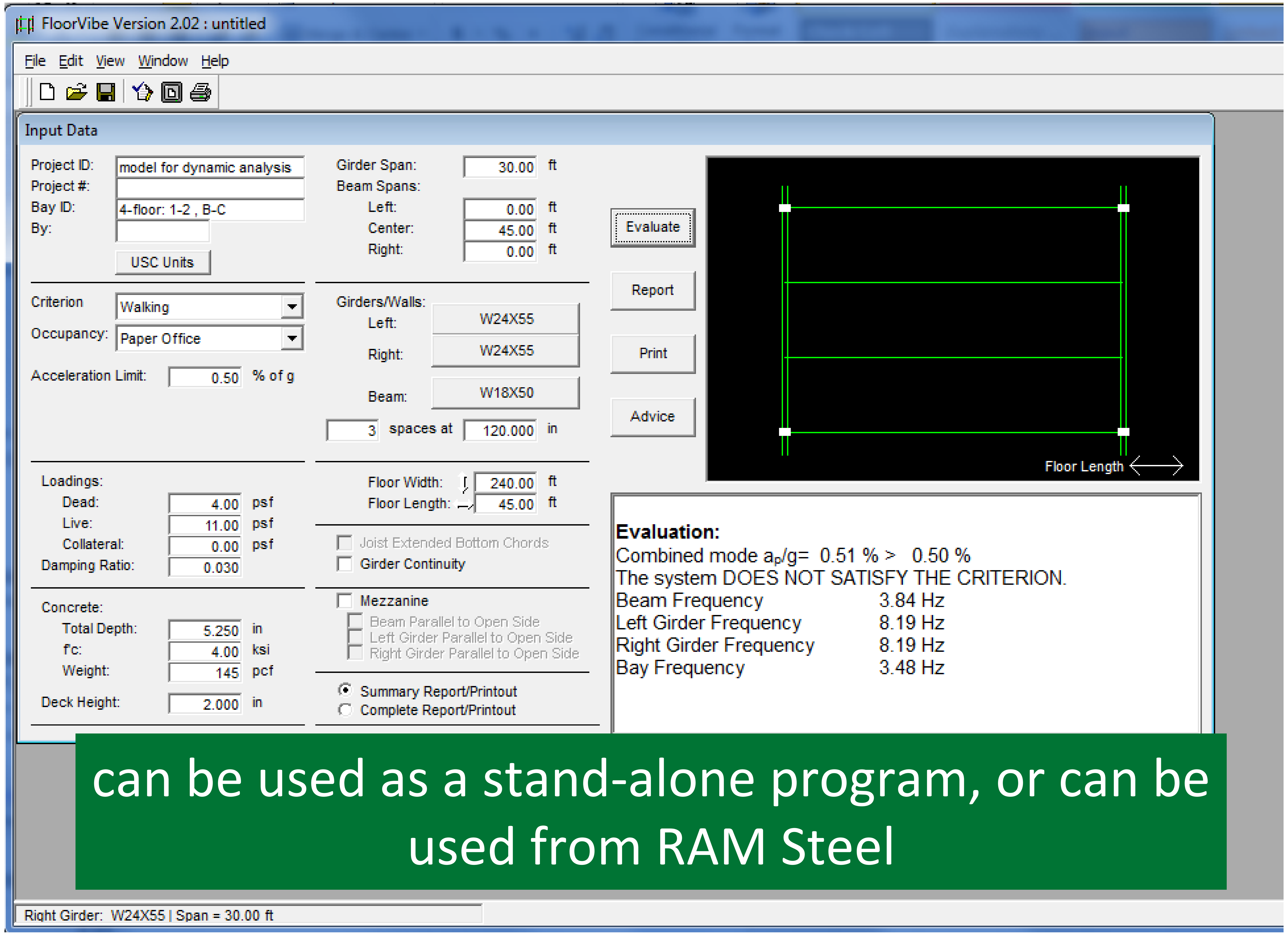
$a_P/g = P_0 * \exp(-0.35 * f_N) / (\beta * W)$

Individual Beam $a_B/g =$ **0.41% of g** **OK, <0.5% of g**

Individual Girder $a_G/g =$ **0.28% of g** **OK, <0.5% of g**

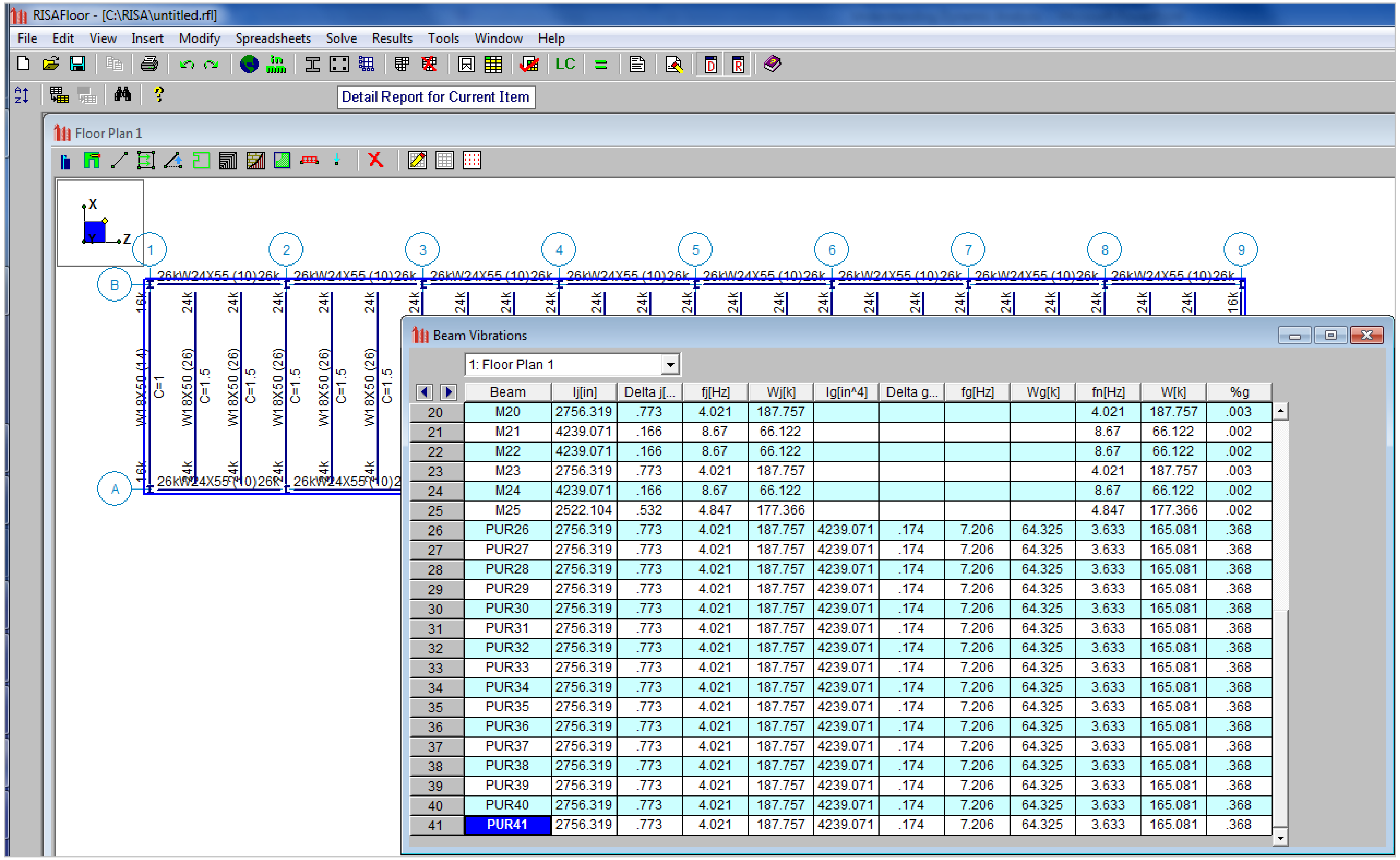
Combined Panel $a_P/g =$ **0.52% of g** **NG, >0.5% of g**

Dynamic Analysis for Steel Floor Vibrations Floorvibe



can be used as a stand-alone program, or can be used from RAM Steel

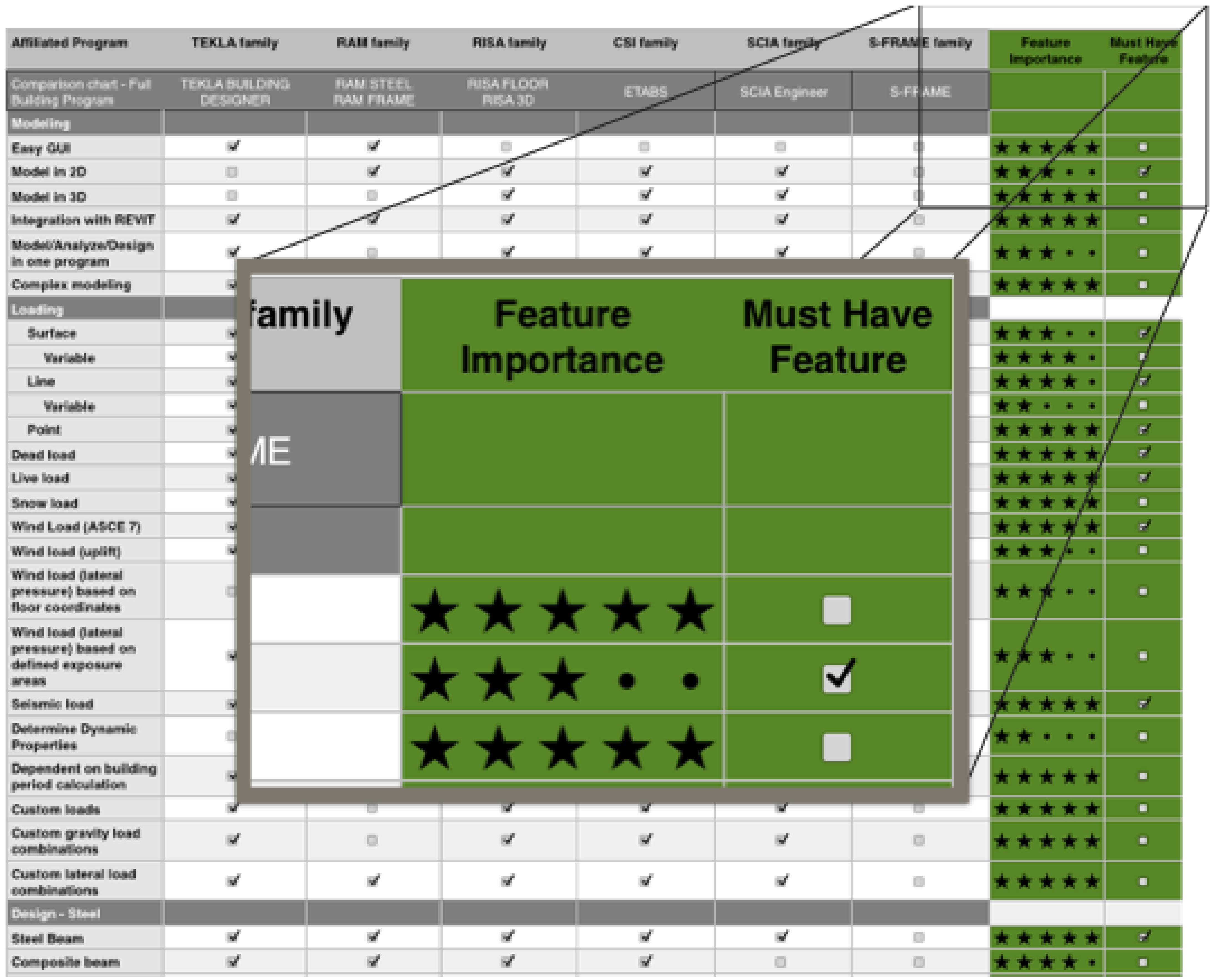
Dynamic Analysis for Steel Floor Vibrations RISA Floor



	Beam	Ij[in]	Delta j[...	fj[Hz]	Wj[k]	Ig[in^4]	Delta g...	fg[Hz]	Wg[k]	fn[Hz]	W[k]	%g
20	M20	2756.319	.773	4.021	187.757					4.021	187.757	.003
21	M21	4239.071	.166	8.67	66.122					8.67	66.122	.002
22	M22	4239.071	.166	8.67	66.122					8.67	66.122	.002
23	M23	2756.319	.773	4.021	187.757					4.021	187.757	.003
24	M24	4239.071	.166	8.67	66.122					8.67	66.122	.002
25	M25	2522.104	.532	4.847	177.366					4.847	177.366	.002
26	PUR26	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
27	PUR27	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
28	PUR28	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
29	PUR29	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
30	PUR30	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
31	PUR31	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
32	PUR32	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
33	PUR33	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
34	PUR34	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
35	PUR35	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
36	PUR36	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
37	PUR37	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
38	PUR38	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
39	PUR39	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
40	PUR40	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368
41	PUR41	2756.319	.773	4.021	187.757	4239.071	.174	7.206	64.325	3.633	165.081	.368

Develop Your Checklist

Design features vary between programs, know what the differences are.



In Conclusion

- Get to know your software, develop means to verify by hand
- Get to know the code, and how it's been implemented in each software you use
- Always know capabilities, and more importantly <u>limitations</u>
- Always, always check with hand calculations

Remember software is a tool, your the engineer!

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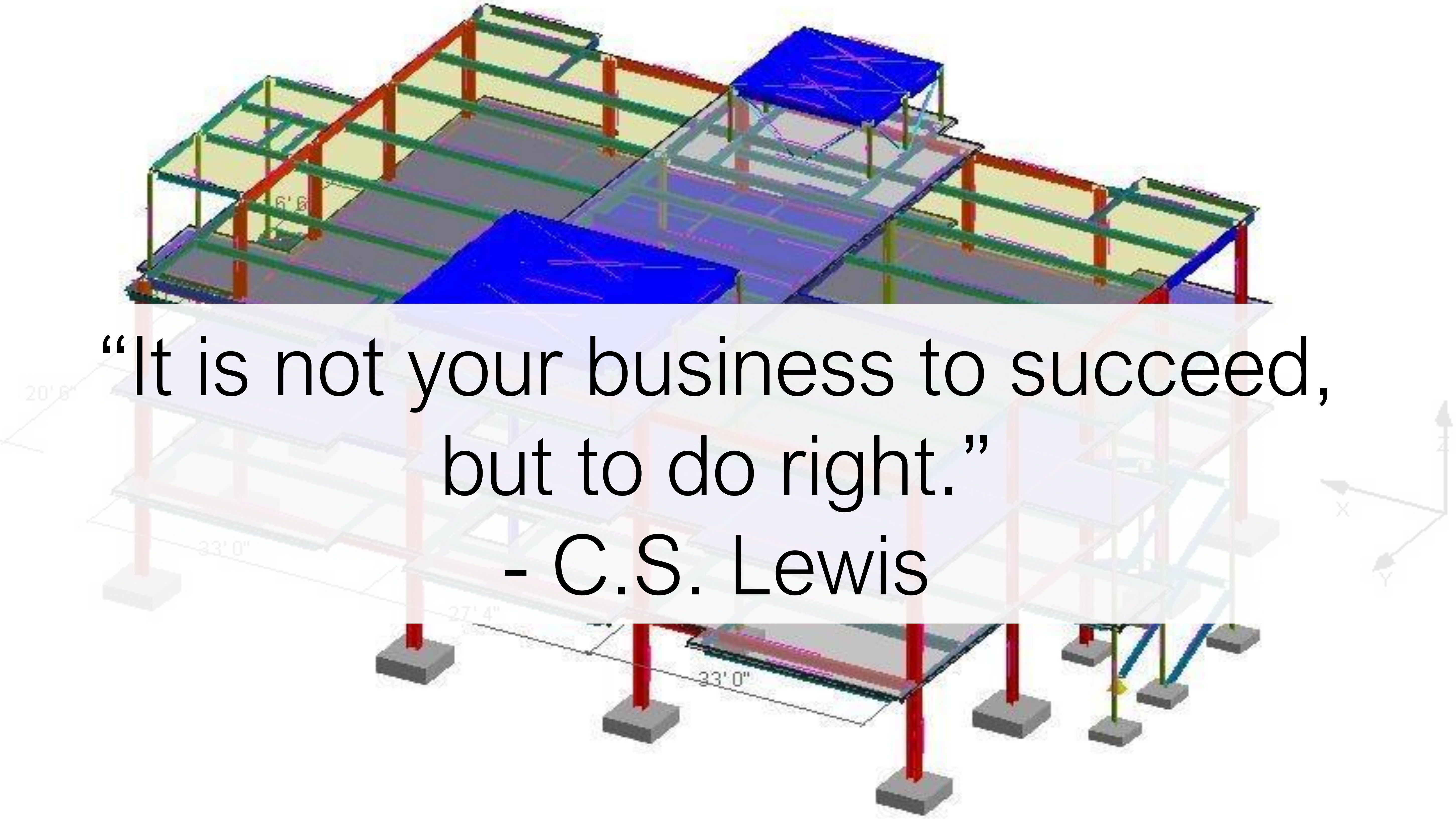

“It is not your business to succeed,
but to do right.”
- C.S. Lewis

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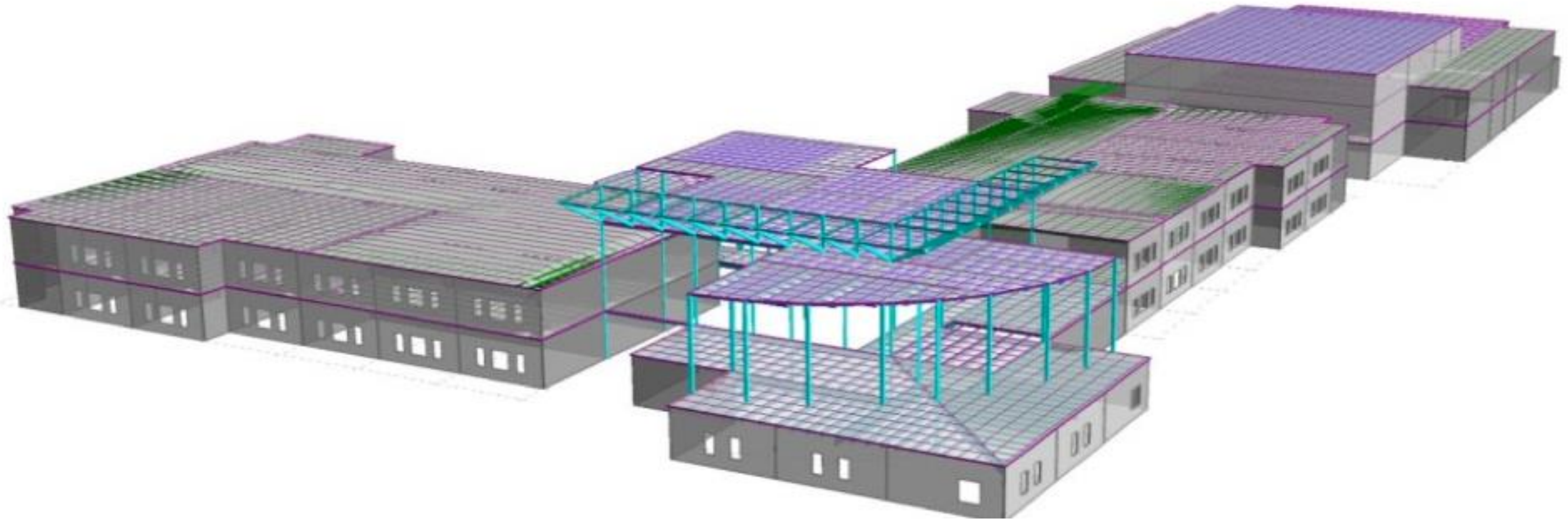
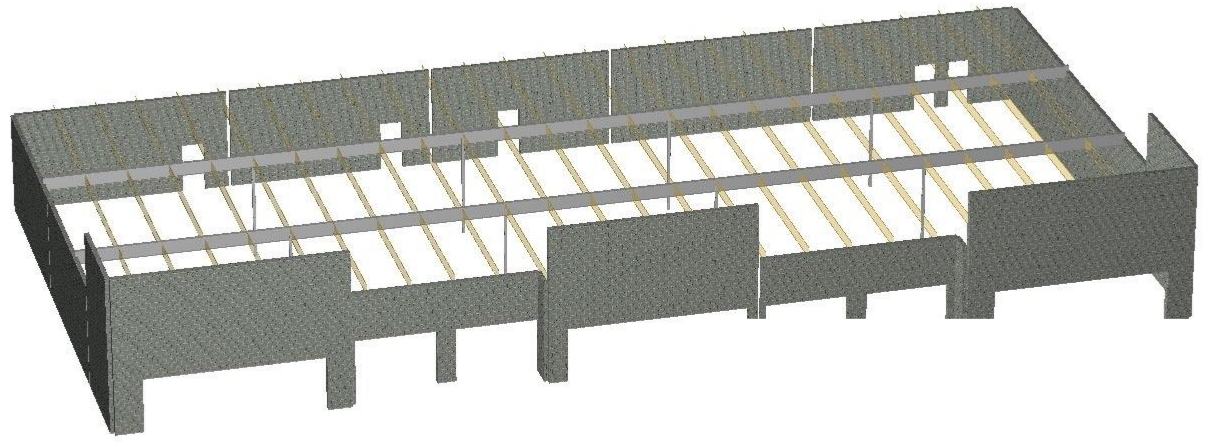
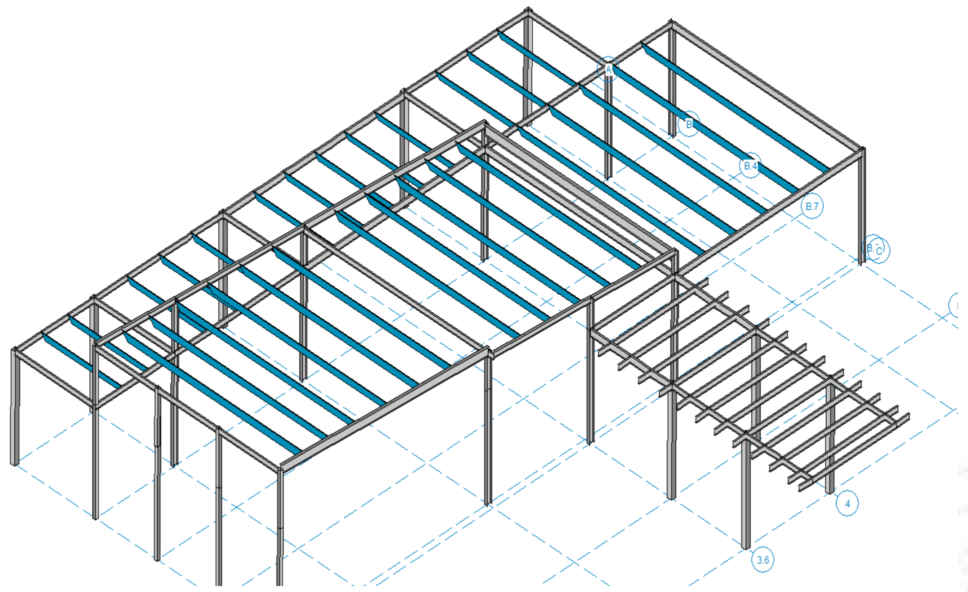
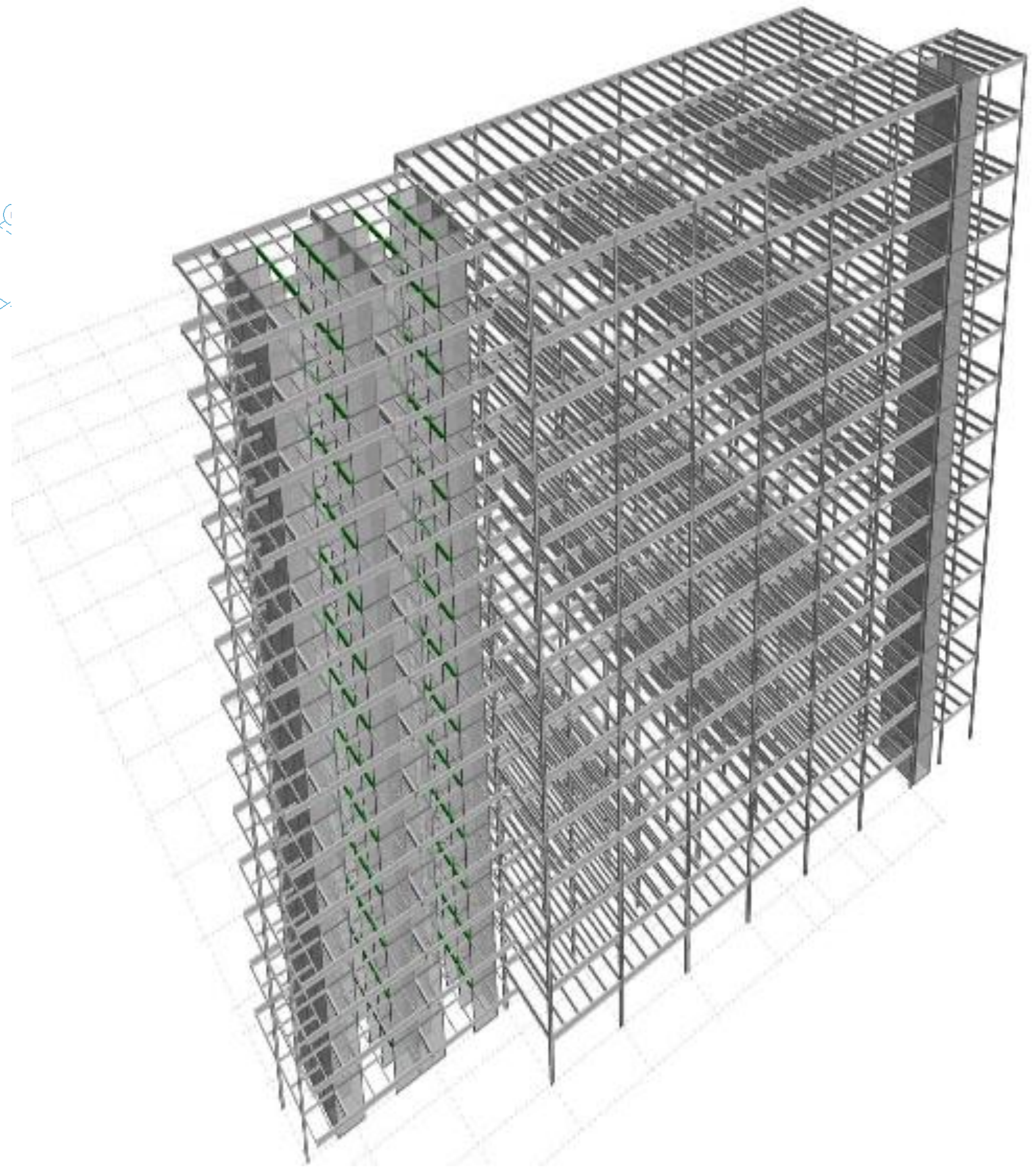
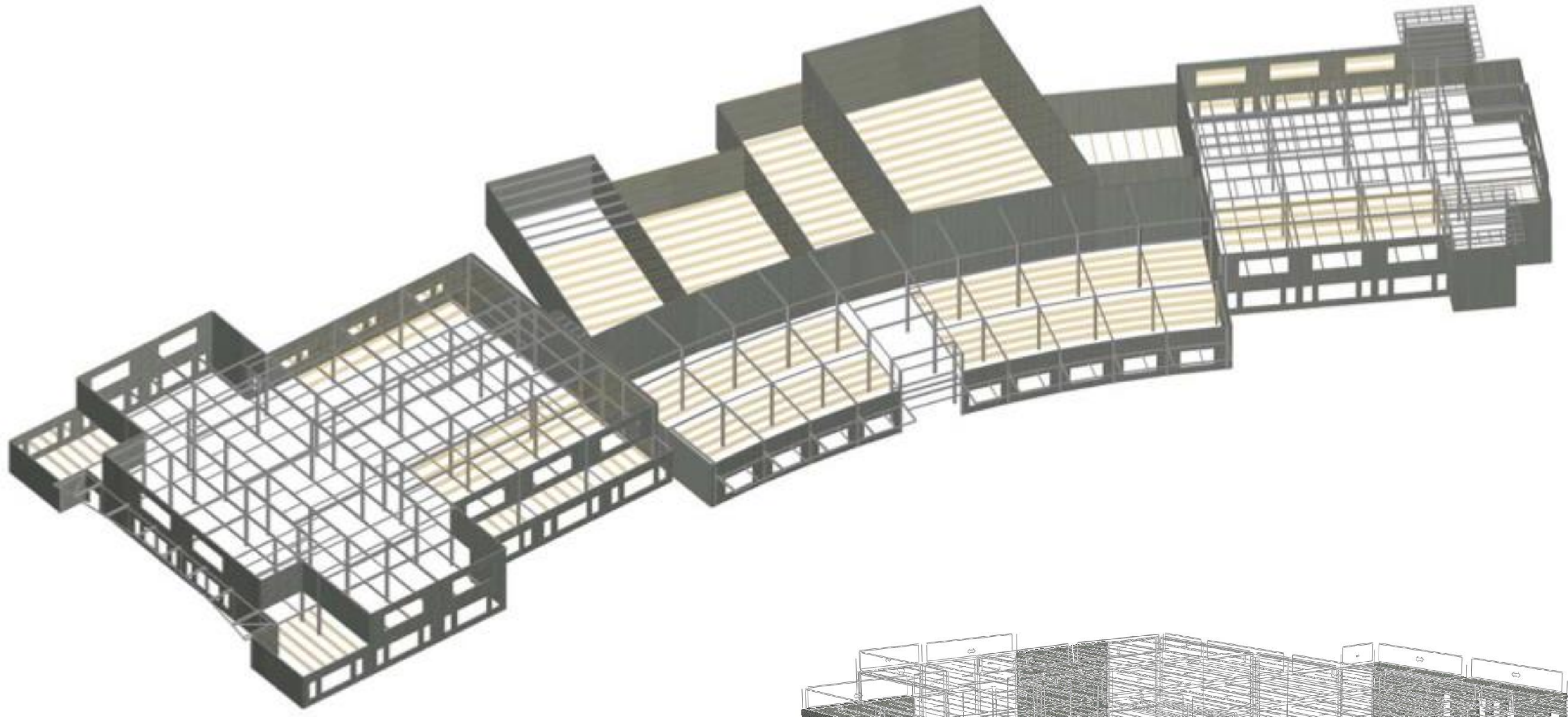
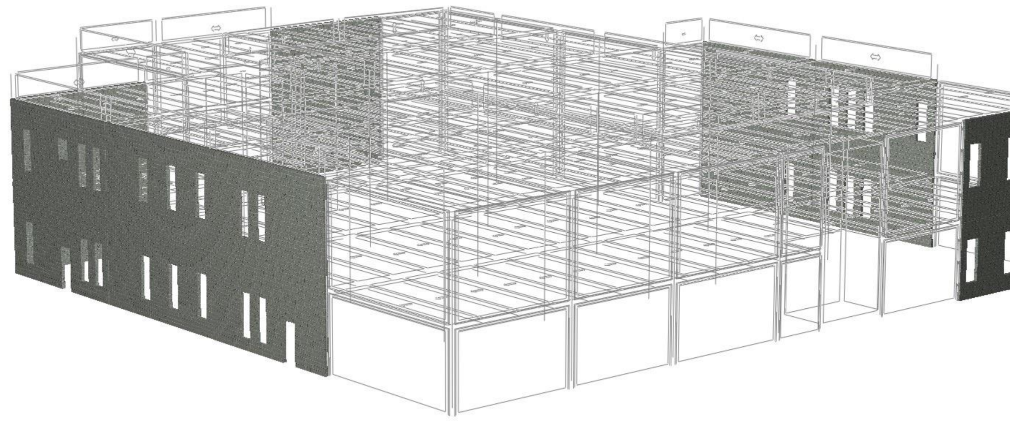
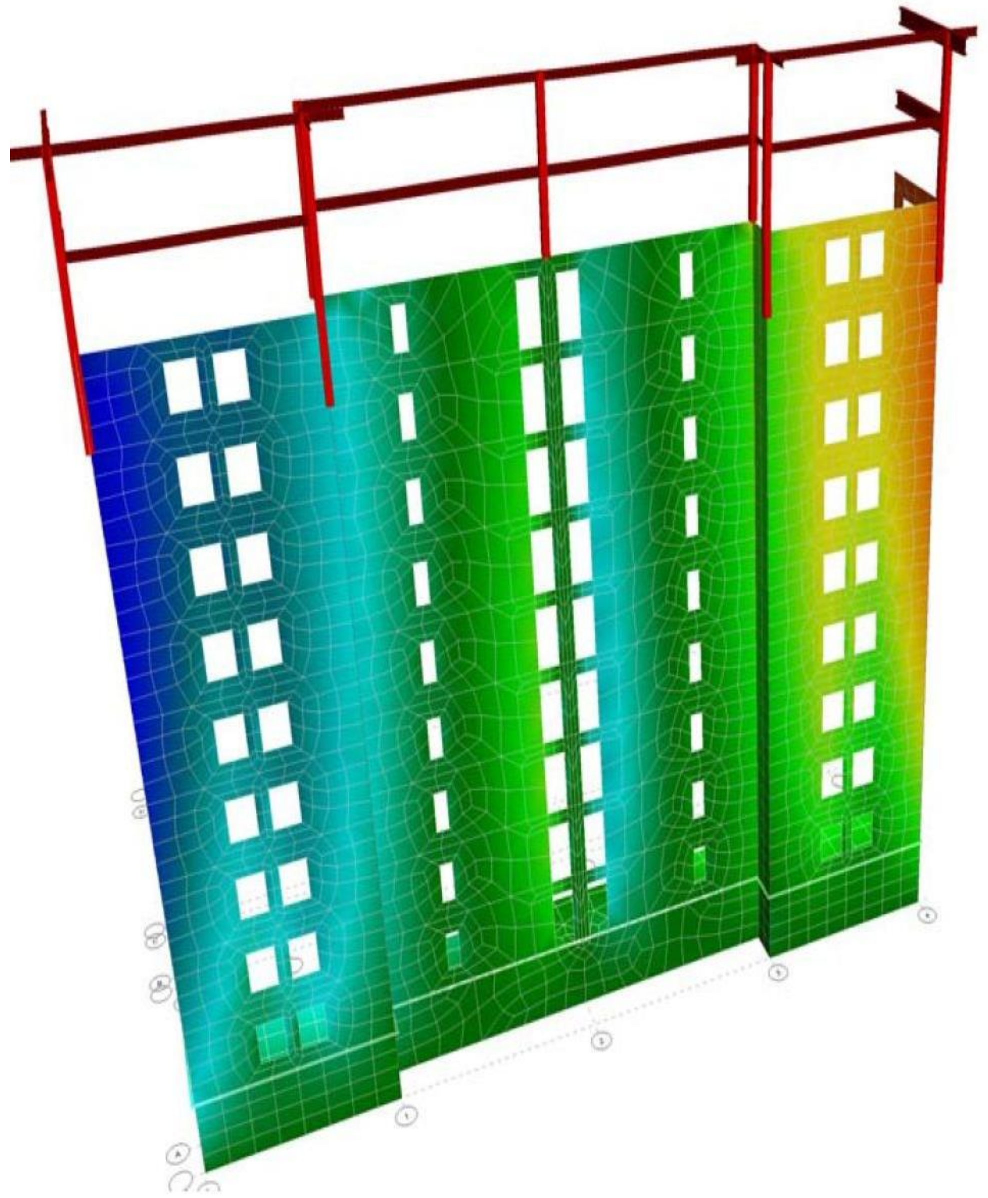
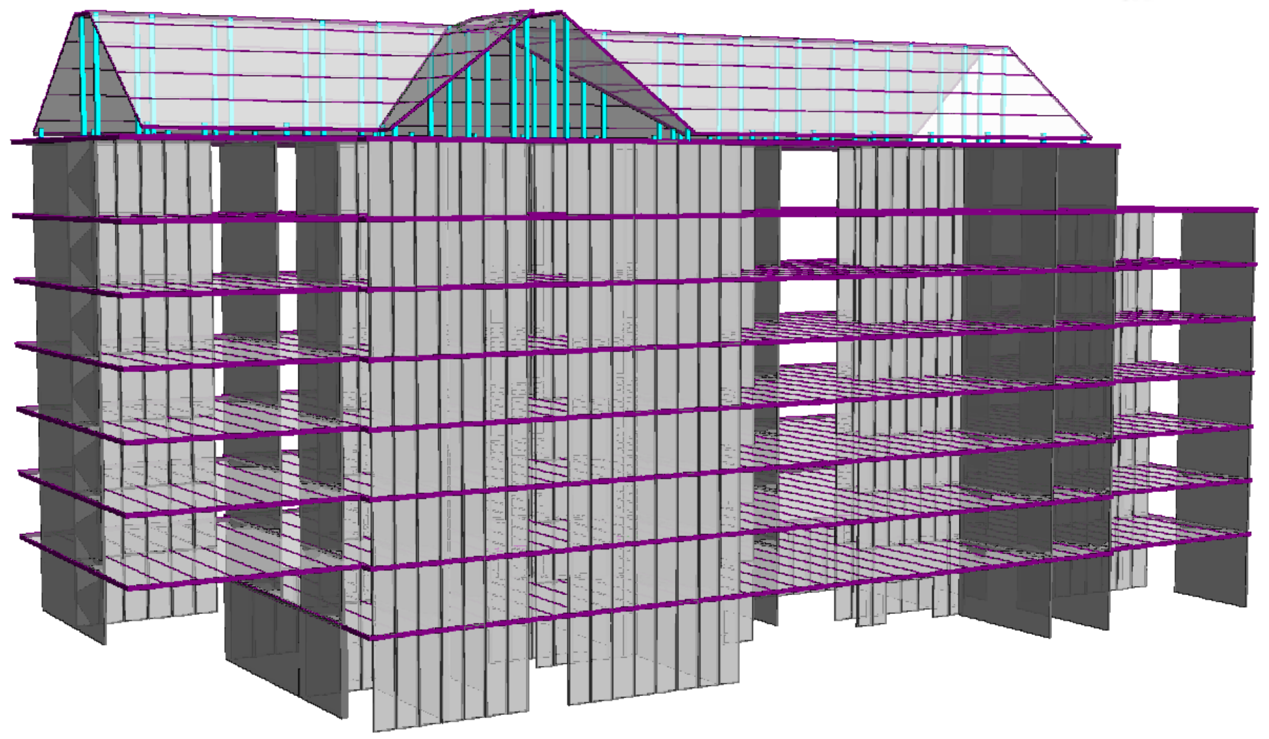
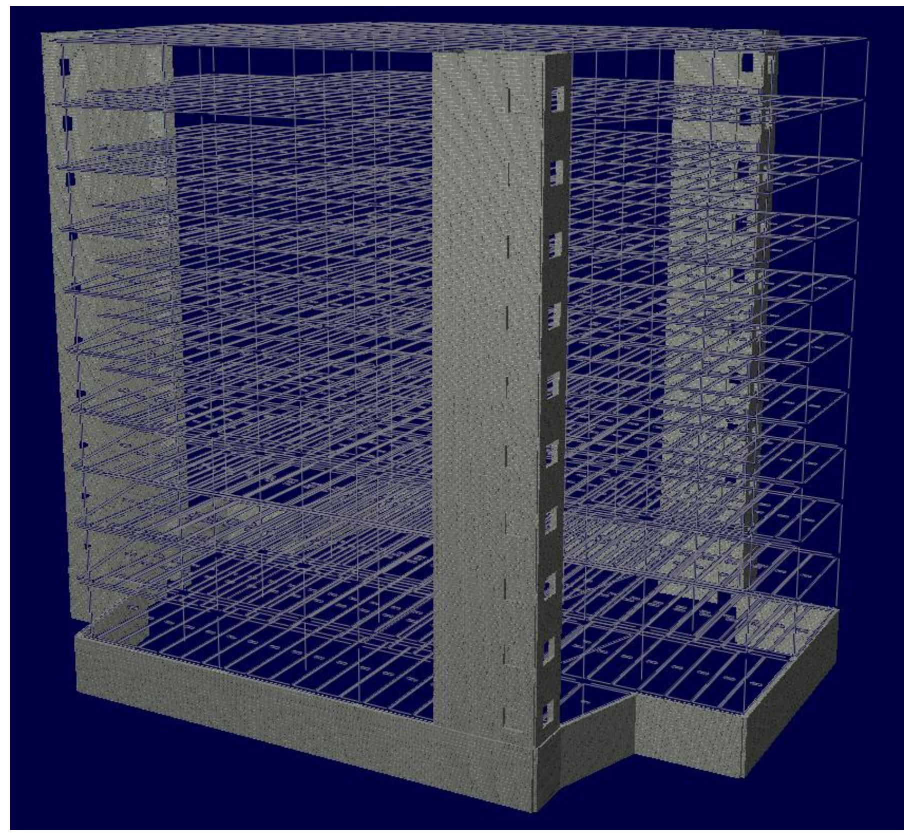

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