INTRO: CLEVELAND

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Fast + Epp

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

Cleveland's First 9-Story Timber Tower

SKETCH: Hartshorne Plunkard Architecture

Where We Work

+ Vancouver | Canada
+ Edmonton | Canada
+ Calgary | Canada
+ Seattle | USA
+ New York | USA
+ Darmstadt | Germany

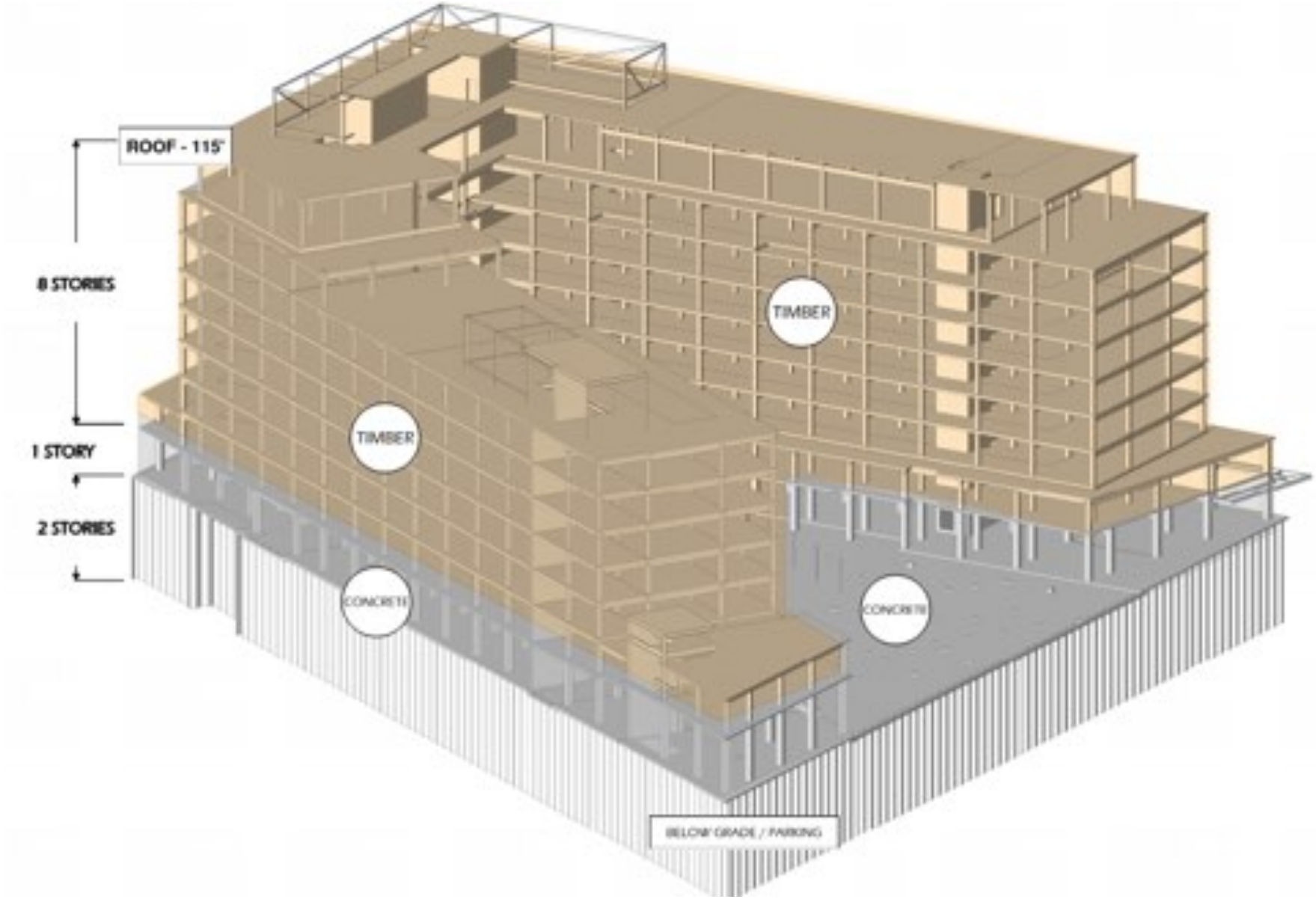
Who We Are

+ Structural engineers
+ Founded in 1985
+ 85 global staff
+ Work in all materials
+ Mass Timber expertise

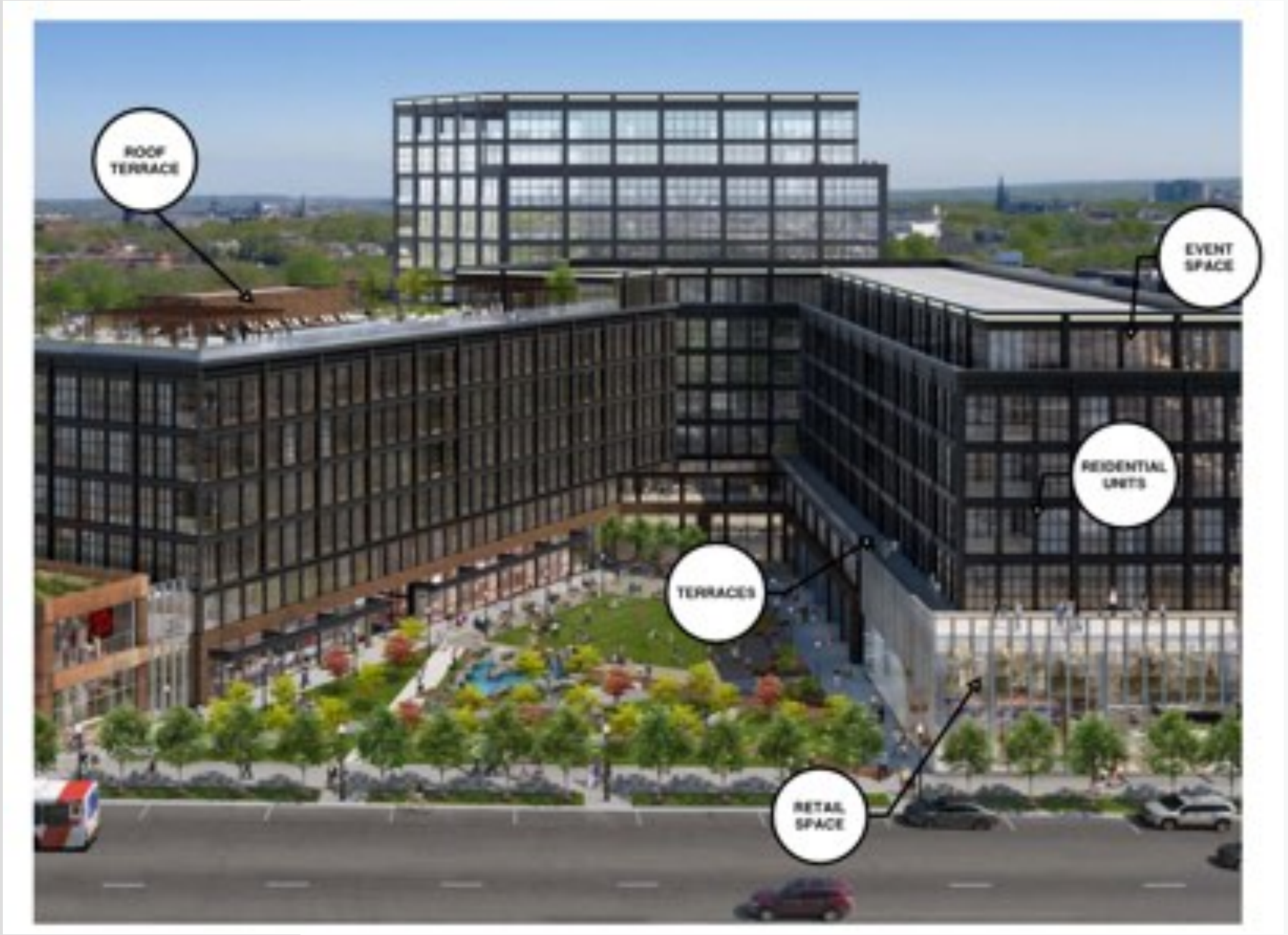
RENDERING: Hartshorne Plunkard Architecture

Design Team:

Harbor Bay Real Estate	Hartshorne Plunkard Architecture	Forefront Structural Engineers	Fast+Epp Structural Engineers

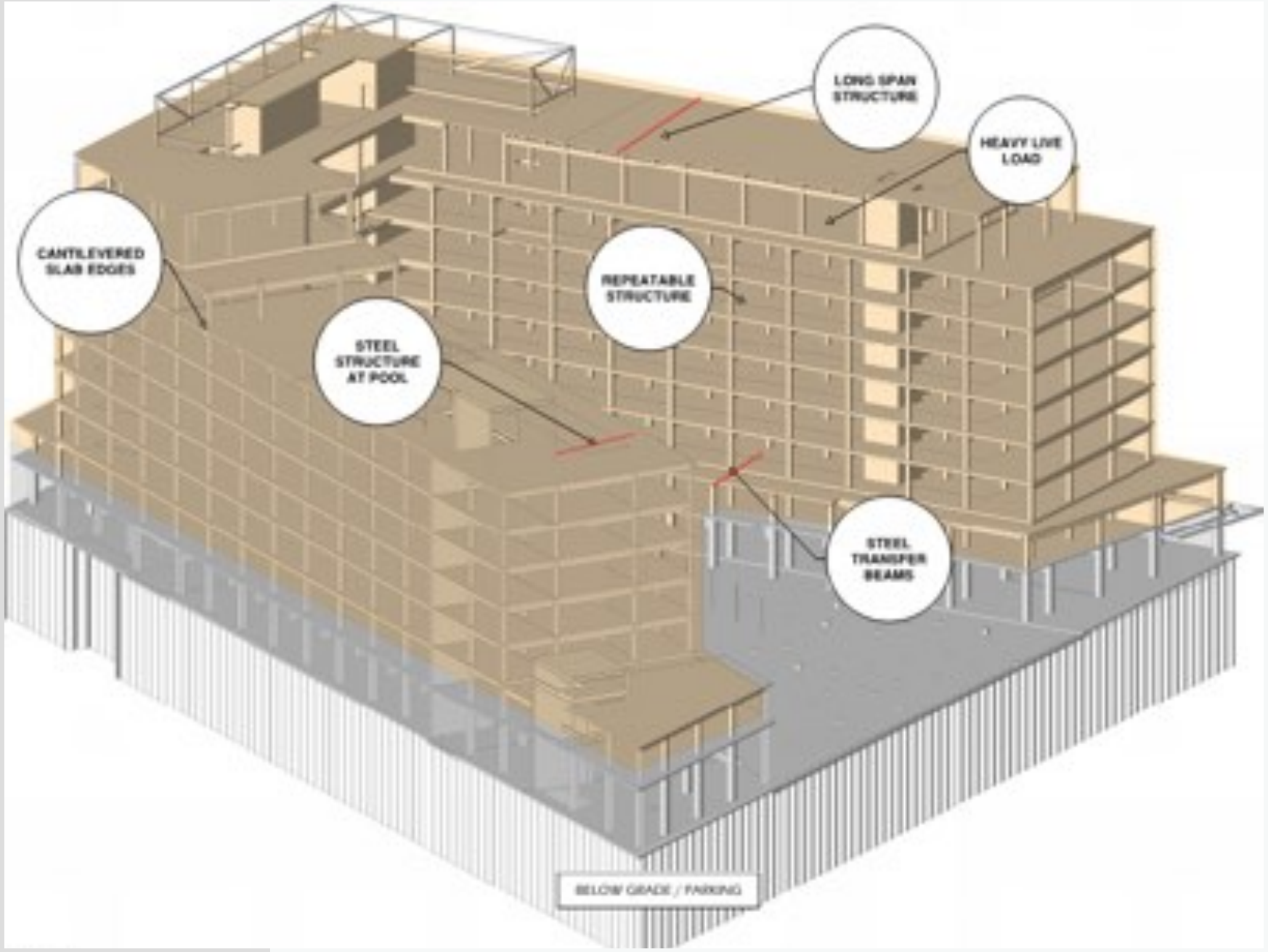

ROOF - 115'
8 STORIES
1 STORY
2 STORIES
TIMBER
TIMBER
CONCRETE
CONCRETE
BELOW GRADE / PARKING

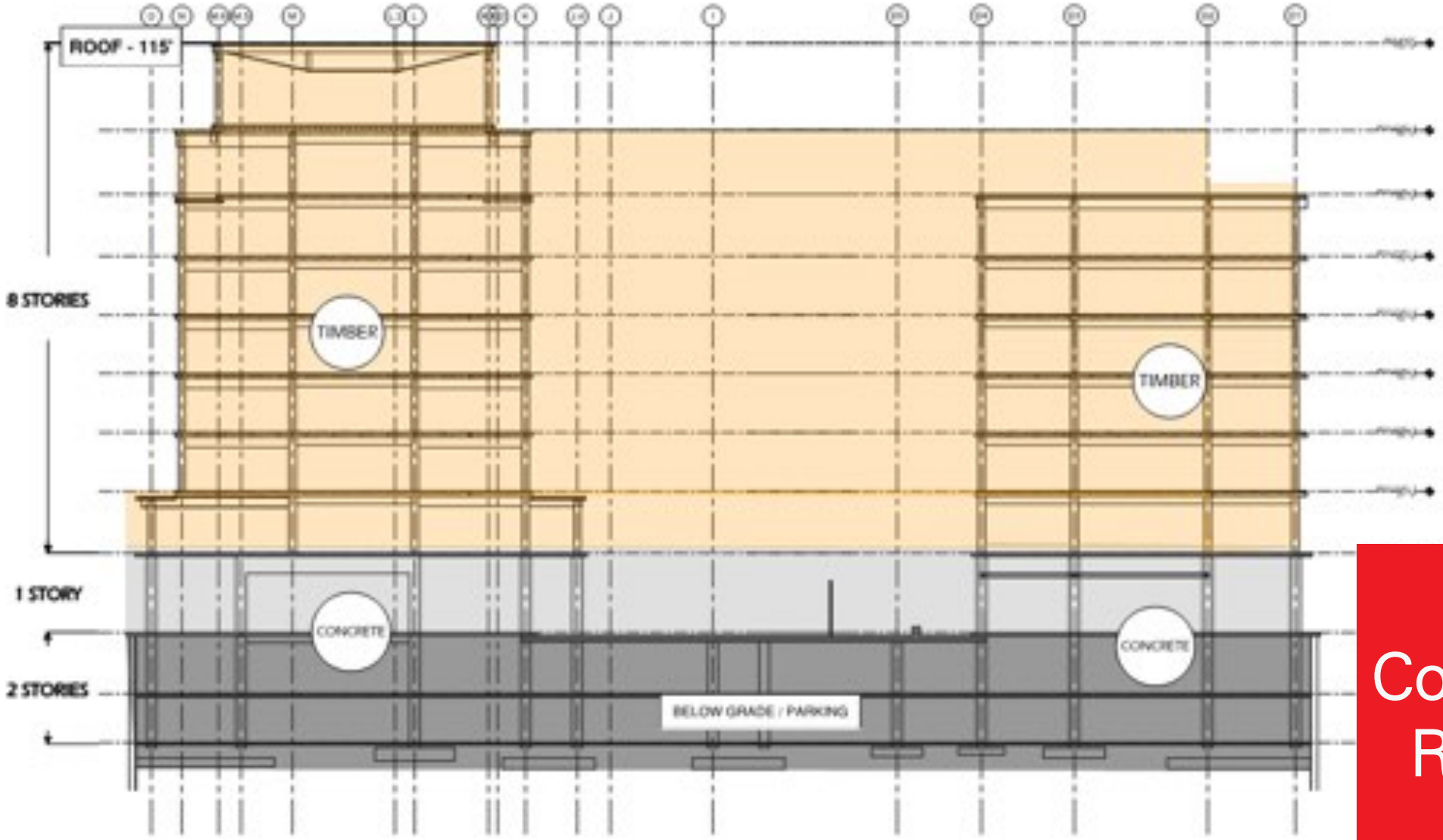
Key Features



RENDERING: Hartshorne Plunkard Architecture

Key Features





Code Recognition

ALLOWABLE BUILDING HEIGHT

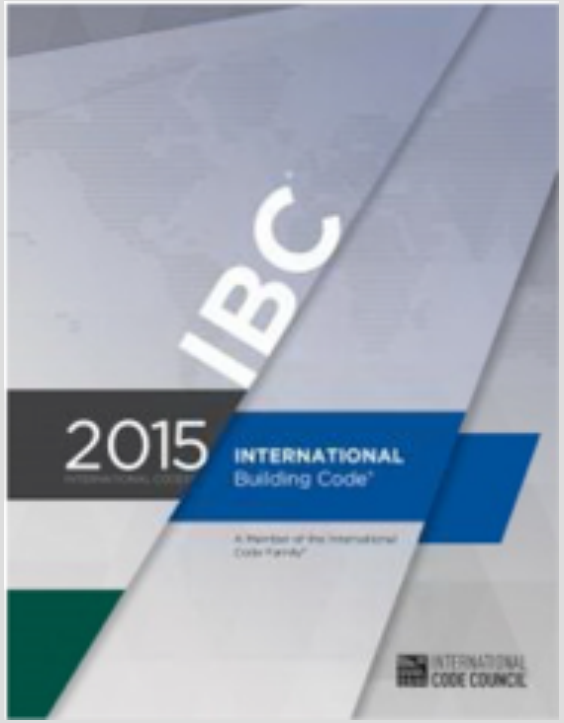


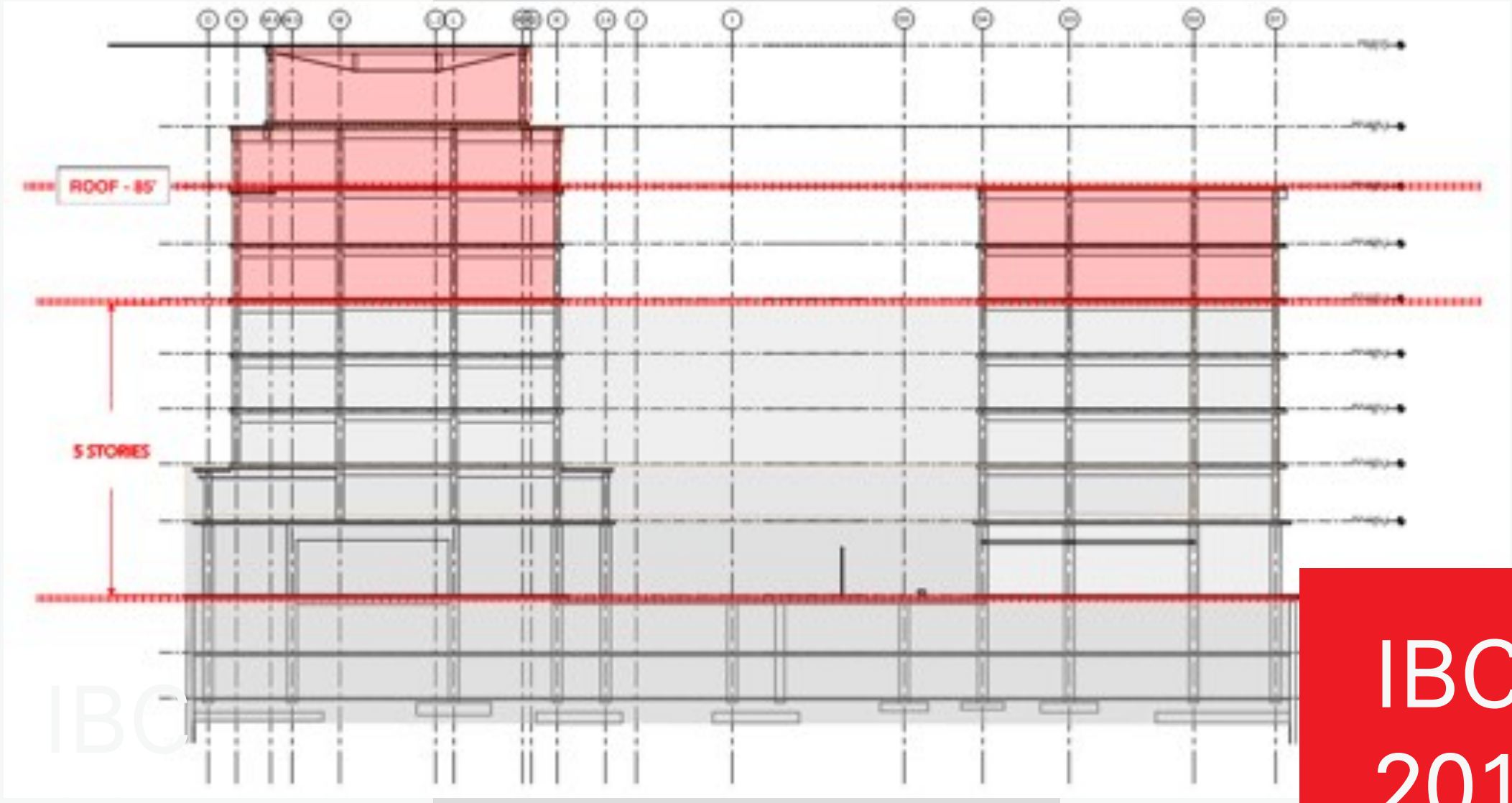
TABLE 504.3
ALLOWABLE BUILDING HEIGHT IN FEET ABOVE GRADE PLANE[a]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
R[b]	NS[d]	UL	160	65	55	65	55	65	50	40
	S13D	60	60	60	60	60	60	60	50	40
	S13R	60	60	60	60	60	60	60	60	60
	S	UL	180	85	75	85	75	85	70	60

TABLE 504.4—continued
ALLOWABLE NUMBER OF STORIES ABOVE GRADE PLANE[a, b]

OCCUPANCY CLASSIFICATION	SEE FOOTNOTES	TYPE OF CONSTRUCTION								
		TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
		A	B	A	B	A	B	HT	A	B
R-1[b]	NS[d]	UL	11	4	4	4	4	4	3	2
	S13R	4	4						4	3
	S	UL	12	5	5	5	5	5	4	3
R-2[b]	NS[d]	UL	11	4	4	4	4	4	3	2
	S13R	4	4	4					4	3
	S	UL	12	5	5	5	5	5	4	3

ALLOWABLE BUILDING STORIES



IBC 2015

2017 Ohio Building Code

AED

alternatively engineered design required

CLT not a recognized material

Accepted Based On:

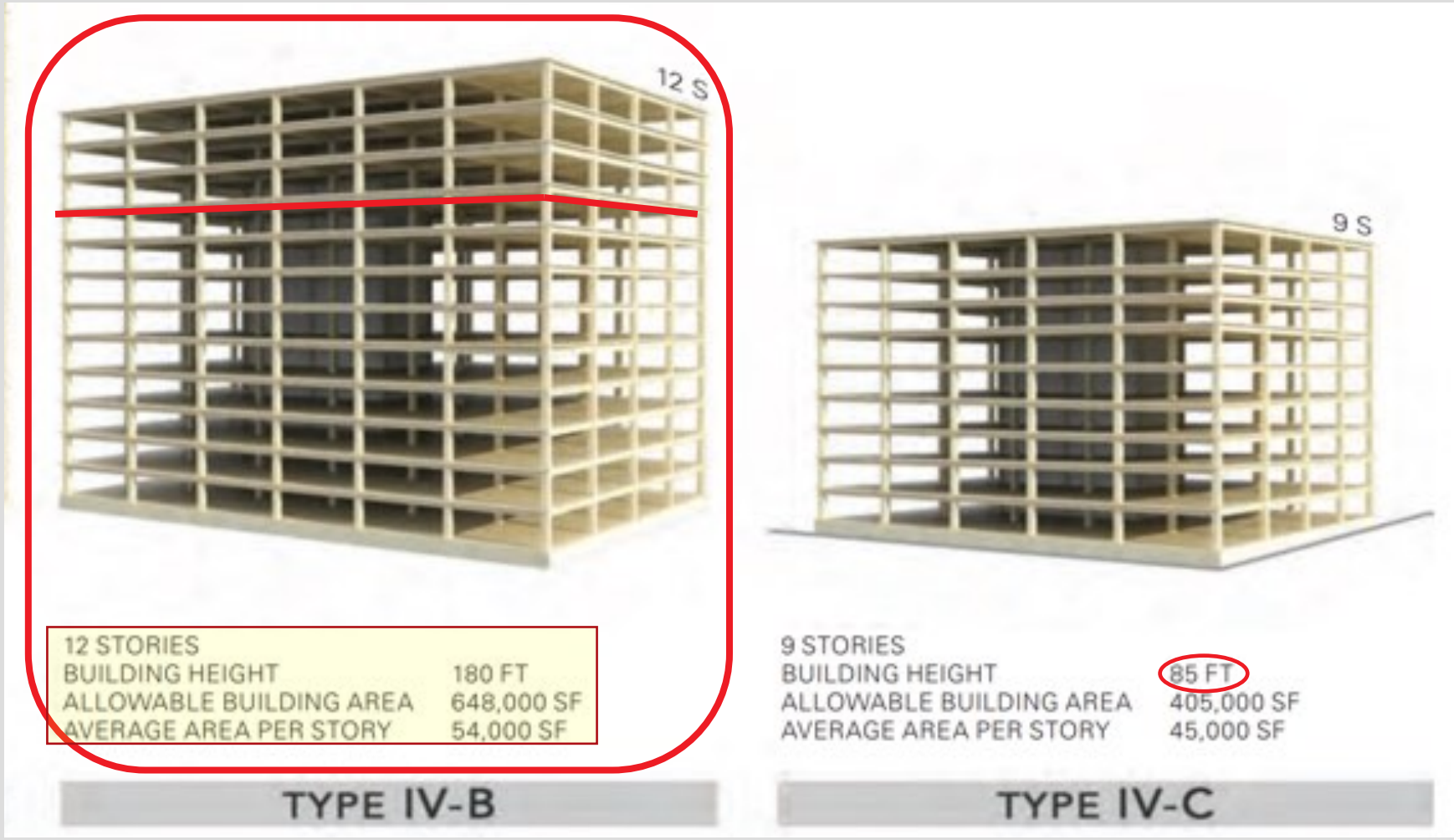
- language adopted by

  ICC Ad Hoc Committee on Tall Wood Buildings for 2021 IBC

- Data from USDA tests
- Additional code compliance for fire protection

2021 IBC
Tall Wood Provisions

Breneman, S; Timmers, M; Richardson, D*; Tall Wood Buildings in the 2021 IBC Up to 18 Stories of Mass Timber*; 2019; Woodworks Wood Products Council
Image Courtesy atelierjones, LLC



Breneman, S; Timmers, M; Richardson, D*; Tall Wood Buildings in the 2021 IBC Up to 18 Stories of Mass Timber*; 2019; Woodworks Wood Products Council
Image Courtesy atelierjones, LLC

01 FIRE RATING

What is the required fire rating (mins) or the building type

02 COVERAGE

How much timber can be exposed / how much must be covered?

03 PROTECTION

What satisfies the coverage requirement

To Note:

IBC tables that are most often referenced typically call out **Allowable Building Height, # of Stories, and Allowable Area,** The new 2021 code also has some key information for engineers to be aware of when looking into type 4 construction

01

FIRE RATING

02

COVERAGE

602.4.2.2.2 Protected area. All interior faces of all mass timber elements shall be protected in accordance with Section 602.4.2.2.1, including the inside face of exterior mass timber walls and mass timber roofs.

Exceptions: Unprotected portions of mass timber ceilings and walls complying with Section 602.4.2.2.4 and the following:

1. Unprotected portions of mass timber ceilings, including attached beams, shall be permitted and shall be limited to an area equal to 20% of the floor area in any dwelling unit or fire area; or
2. Unprotected portions of mass timber walls, including attached columns, shall be permitted and shall be limited to an area equal to 40% of the floor area in any dwelling unit or fire area; or
3. Unprotected portions of both walls and ceilings of mass timber, including attached columns and beams, in any dwelling unit or fire area shall be permitted in accordance with section 602.4.2.2.3.
4. Mass timber columns and beams which are not an integral portion of walls or ceilings, respectively, shall be permitted to be unprotected without restriction of either aggregate area or separation from one another.

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV				TYPE V	
	A	B	A	B	A	B	A	B	C	HT	A	B
Primary structural frame[f] (see Section 202)	3[a, b]	2[a, b]	1[b]	0	1[b]	0	3[a]	2[a]	2[a]	HT	1[b]	0
Bearing walls Exterior[e, f] Interior	3 3[a]	2 2[a]	1 1	0 0	2 1	2 0	3 3	2 2	2 2	2 1/HT	1 1	0 0

722.7

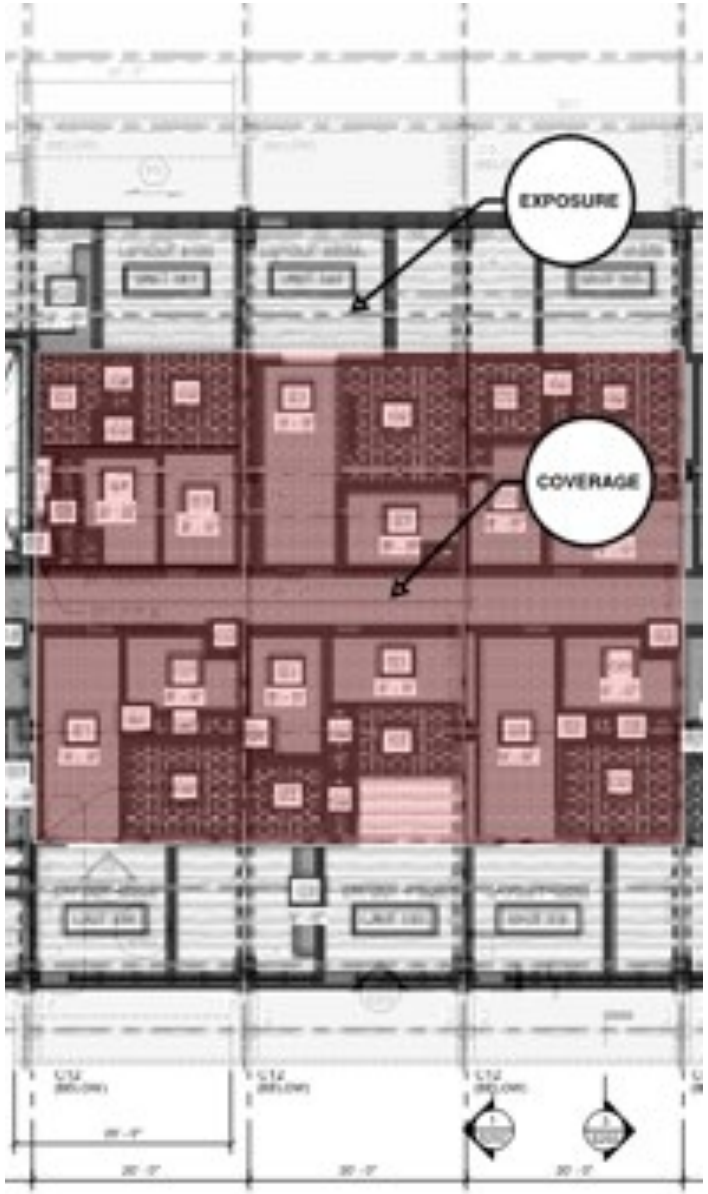
Required Fire Resistance Rating of Building Element per Tables 601 and 602 (hours)	Minimum Protection Required from Noncombustible Protection (minutes)
1	40
2	80
3 or more	120

Noncombustible Protection	Protection Contribution (minutes)
1/2 inch Type X Gypsum Board	30
5/8 inch Type X Gypsum Board	40

03

PROTECTION

IBC 2021



FIRE PROTECTION

SCHEMATIC DESIGN

- MATERIAL AND SUPPLY
- FIRE DESIGN
- GRID SPACING
- VOLUME ANALYSIS

SUPPLIER + MATERIAL

BINDERHOLZ - SUPPLIER

WOOD SPECIES

EUROPEAN SPRICE

PANEL SIZE

4’ WIDTH

40’ LENGTH

SHIPPING

BARGE

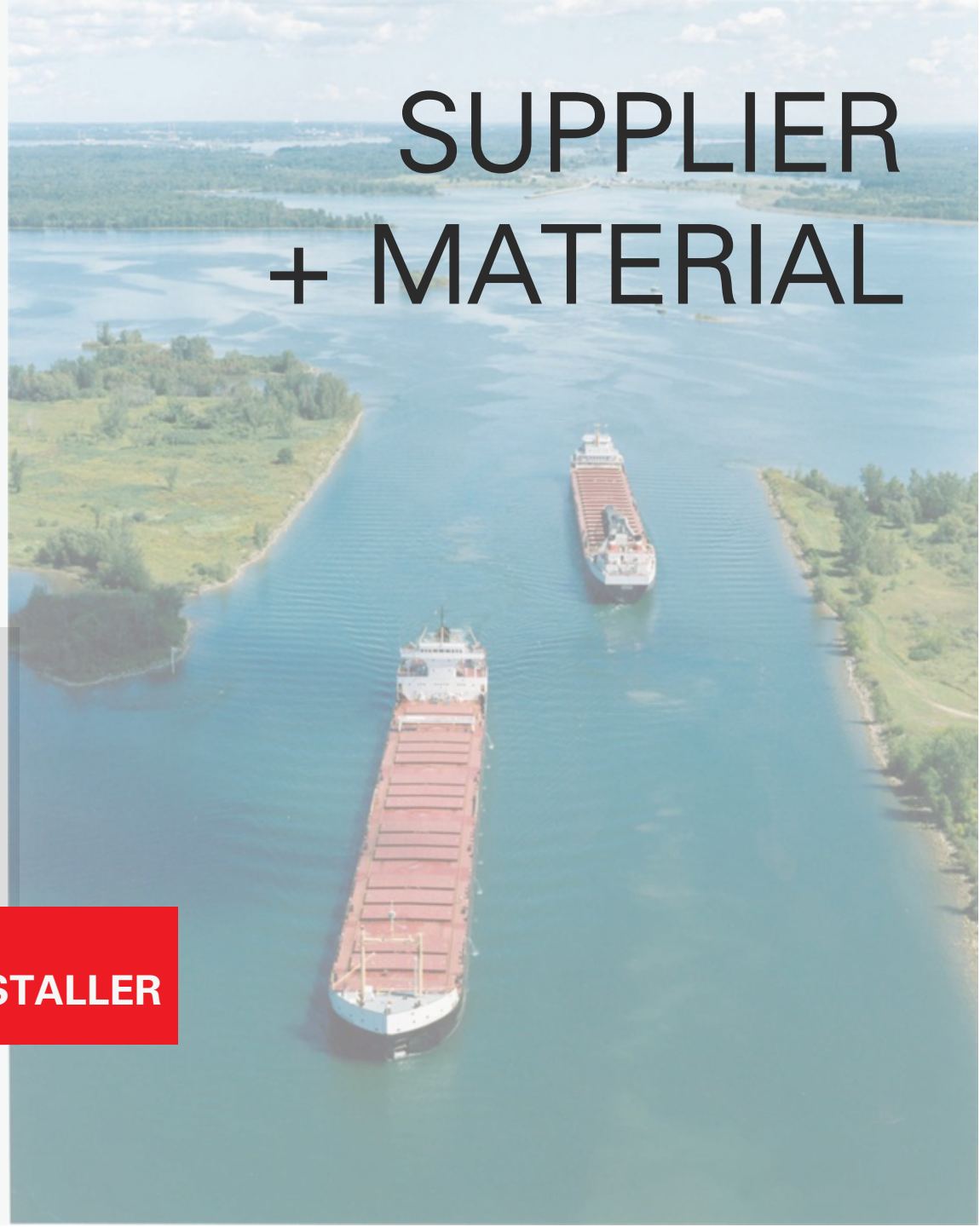
ST. LAWRENCE SEAWAY

TO PORT OF CLEAVLAND

APPROVALS

PRG 320

SEAGATE - INSTALLER



Supplier and Material

EC5 Characteristic Values:

$f_{m,k}$	30	N/mm^2
$f_{t,0,k}$	24	N/mm^2
$f_{t,90,k}$	0.5	N/mm^2
$f_{c,0,k}$	30	N/mm^2
$f_{c,90,k}$	2.5	N/mm^2
$f_{v,k}$	3.5	N/mm^2
$f_{r,k}$	1.2	N/mm^2

NDS2015 Reference Design Values:

$F_{NDS} = 145\ f_{EC5,k}\ k_{mod} / \gamma_M / \phi_{NDS} / K_F$

$k_{mod} = 1.00$

F_b	**1550**	psi
F_t	**1239**	psi
$F_{t\perp}$	**26**	psi
F_c	**1549**	psi
$F_{c\perp}$	**186**	psi
F_v	**181**	psi

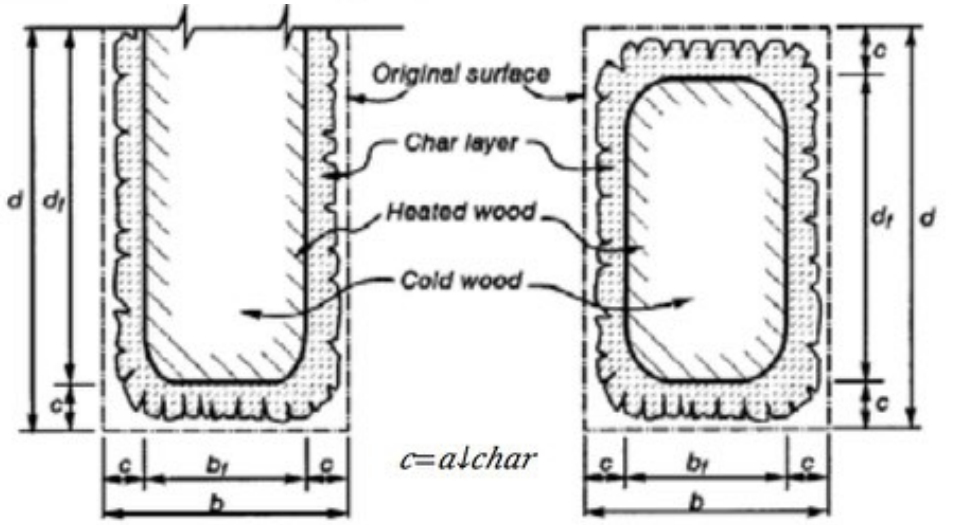
Fire Design

Table 16.2.1A Char Depth and Effective Char Depth (for β_n = 1.5 in./hr.)

Required Fire Resistance (hr.)	Char Depth, a_{char} (in.)	Effective Char Depth, a_{eff} (in.)
1-Hour	1.5	1.8
1½-Hour	2.1	2.5
2-Hour	2.6	3.2

Table 16.2.1B Effective Char Depths (for CLT with β_n = 1.5in./hr.)

Required Fire Resistance (hr.)	Effective Char Depths, a_{eff} (in.)								
	lamination thicknesses, h_{lam} (in.)								
	5/8	3/4	7/8	1	1-1/4	1-3/8	1-1/2	1-3/4	2
1-Hour	2.2	2.2	2.1	2.0	2.0	1.9	1.8	1.8	1.8
1½-Hour	3.4	3.2	3.1	3.0	2.9	2.8	2.8	2.8	2.6
2-Hour	4.4	4.3	4.1	4.0	3.8	3.8	3.6	3.6	3.6



NDS – National Design Specification for Wood

FIRE DESIGN

+

Table 16.2.2 Adjustment Factors for Fire Design[1]

			ASD					
			Design Stress to Member Strength Factor	Size Factor [2]	Volume Factor [2]	Flat Use Factor [2]	Beam Stability Factor [3]	Column Stability Factor [3]
Bending Strength	F_b	x	2.85	C_F	C_V	C_{fu}	C_L	-
Beam Buckling Strength	F_{bE}	x	2.03	-	-	-	-	-
Tensile Strength	F_t	x	2.85	C_F	-	-	-	-
Compressive Strength	F_c	x	2.58	C_F	-	-	-	C_P
Column Buckling Strength	F_{cE}	x	2.03	-	-	-	-	-

Table 5.3.1 Applicability of Adjustment Factors for Structural Glued Laminated Timber

	ASD only	ASD and LRFD										LRFD only		
	Load Duration Factor	Wet Service Factor	Temperature Factor	Beam Stability Factor [1]	Volume Factor [1]	Flat Use Factor	Curvature Factor	Stress Interaction Factor	Shear Reduction Factor	Column Stability Factor	Bearing Area Factor	Format Conversion Factor	Resistance Factor	Time Effect Factor
												K_F	ϕ	
$F_b' = F_b$ x	C_D	C_M	C_t	C_L	C_V	C_{fu}	C_c	C_i	-	-	-	2.54	0.85	λ
$F_t' = F_t$ x	C_D	C_M	C_t	-	-	-	-	-	-	-	-	2.70	0.80	λ
$F_v' = F_v$ x	C_D	C_M	C_t	-	-	-	-	-	C_{vr}	-	-	2.88	0.75	λ
$F_{rt}' = F_{rt}$ x	C_D	C_M^2	C_t^2	-	-	-	-	-	-	-	-	2.88	0.75	λ
$F_c' = F_c$ x	C_D	C_M	C_t	-	-	-	-	-	-	C_P	-	2.40	0.90	λ
$F_{c\perp}' = F_{c\perp}$ x	-	C_M	C_t	-	-	-	-	-	-	-	C_b	1.67	0.90	-

NDS – National Design Specification for Wood

CLT CHAR +

Table 8 Layups for Binderholz BBS CLT panels with five layers and five laminations

CLT Grade	Layup Designation	Thickness [mm]	Lamination actual Thickness [mm]				
			=	⊥	=	⊥	=
BBS 125 and BBS XL	100-5s	100	20	20	20	20	20
	120-5s	120	20	30	20	30	20
	140-5s	140	40	20	20	20	40
	150-5s	150	40	20	30	20	40
	160-5s	160	40	20	40	20	40
	180-5s	180	40	30	40	30	40
	200-5s	200	40	40	40	40	40

VARIED LAYER THICKNESS

EQUAL LAYER THICKNESS

16.2.1.3 For cross-laminated timber manufactured with laminations of equal thickness, the char depth, a_{char}, shall be calculated as follows:

$$a_{char} = n_{lam}\, h_{lam} + \beta_t \left(t - \left(n_{lam}\, t_{gi} \right) \right)^{0.813} \qquad (16.2\text{-}3)$$

5.4 BBS 125 – 220-5s (20-40-30-40-30-40-20)

Major Strength Direction

Grid Dimension: 9m

Grid Dimension: 9m

Number of Purlins: 3

Building Stories: 6

Panel Type: CLT

Loading: Residential

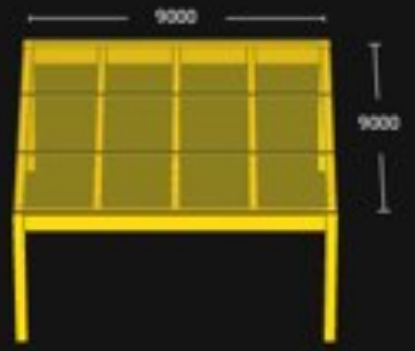
Fire Resistance: 0 min

Purlin Width: 215mm

Girder Width: 265mm

FAST + EPP

Show dimensions



Bay Data

Panel Size:
87V CLT (3PLY)

Girder Size:
265w x 608h

Purlin Size:
215w x 456h

Column Size:
342w x 315h

Total Structural Depth:
695mm

Column Spacing:
9000mm x 9000mm

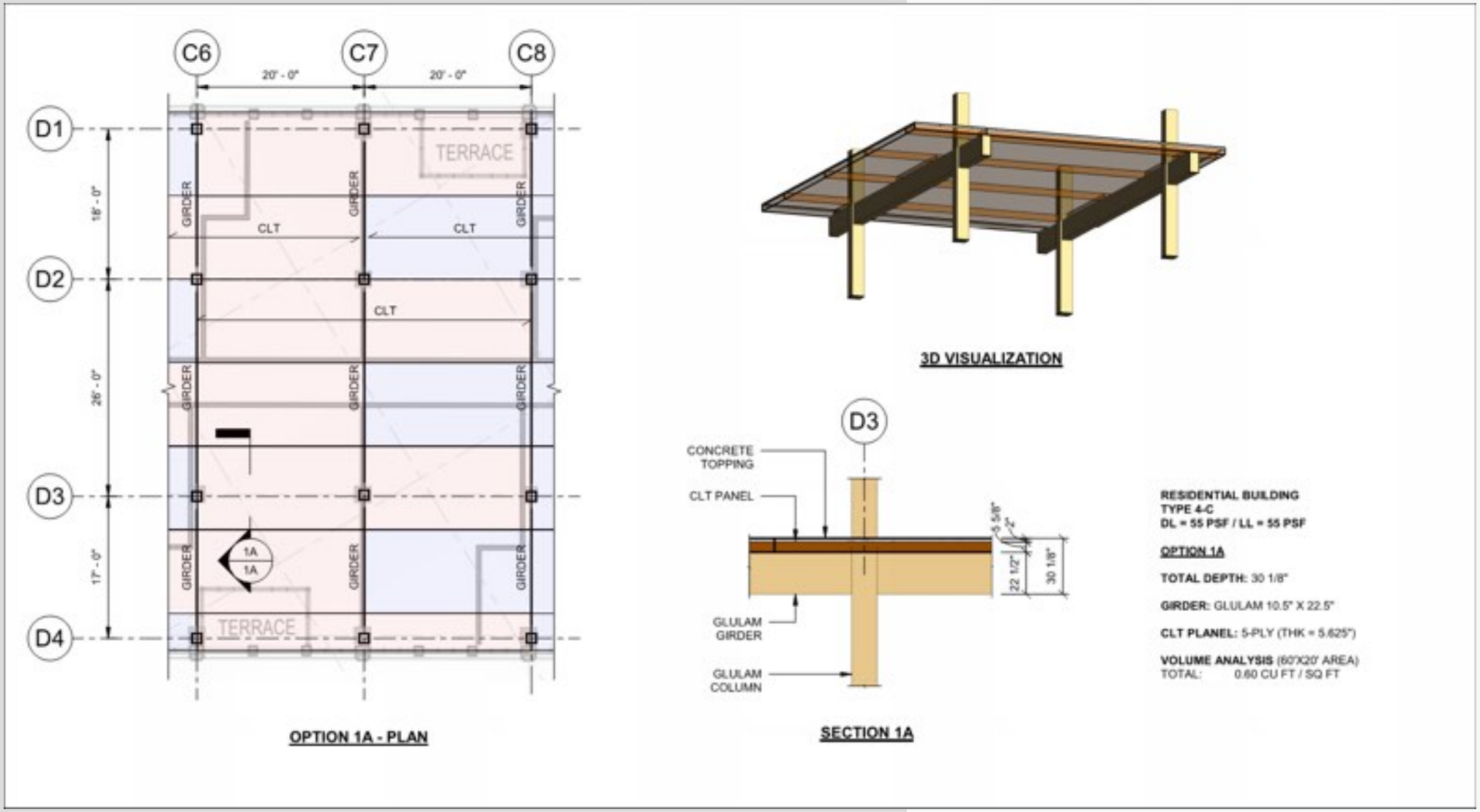
Material Volume

Glulam Volume:
0.075m³/m²

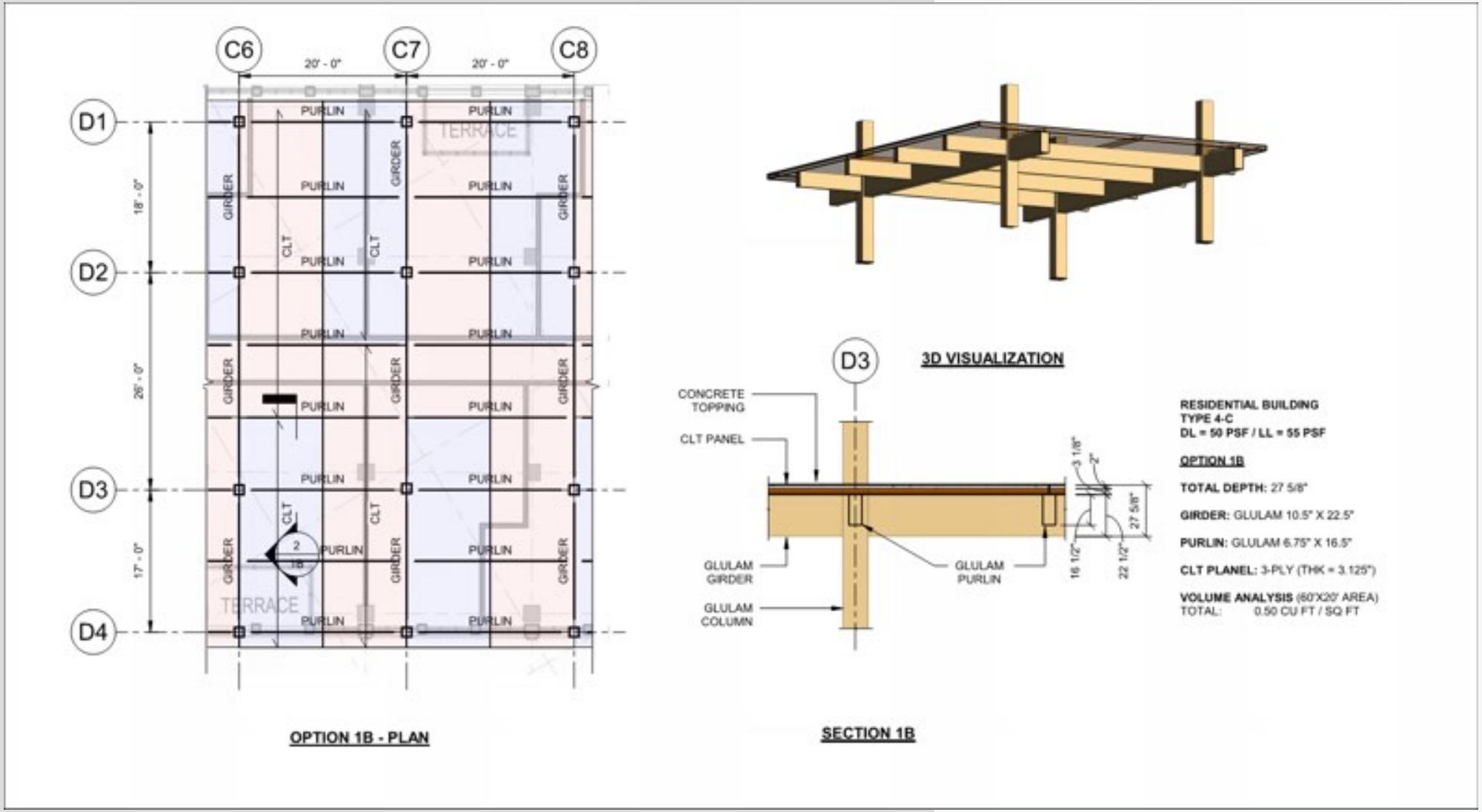
Panel Volume:
0.087m³/m²

Total Timber Volume:
0.162m³/m²

Bay Studies

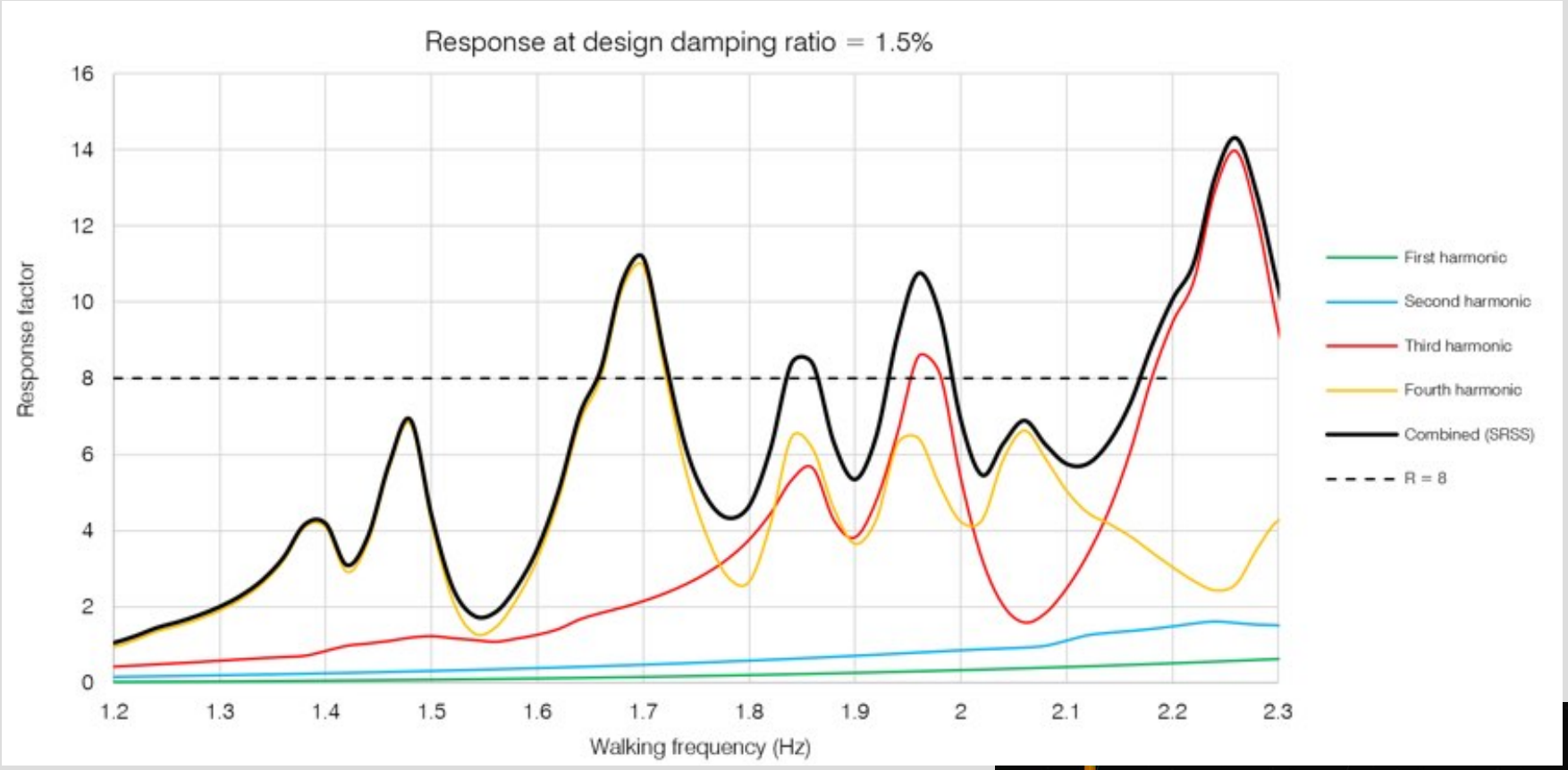

C6
C7
C8
20' - 0"
20' - 0"
D1
D2
D3
D4
16' - 0"
26' - 0"
17' - 0"
TERRACE
GIRDER
CLT
1A
1A
TERRACE
OPTION 1A - PLAN
3D VISUALIZATION
D3
CONCRETE TOPPING
CLT PANEL
GLULAM GIRDER
GLULAM COLUMN
5 5/8"
2"
22 1/2"
30 1/8"
SECTION 1A
RESIDENTIAL BUILDING
TYPE 4-C
DL = 55 PSF / LL = 55 PSF
OPTION 1A
TOTAL DEPTH: 30 1/8"
GIRDER: GLULAM 10.5" X 22.5"
CLT PLANEL: 5-PLY (THK = 5.625")
VOLUME ANALYSIS (60'X20' AREA)
TOTAL: 0.60 CU FT / SQ FT

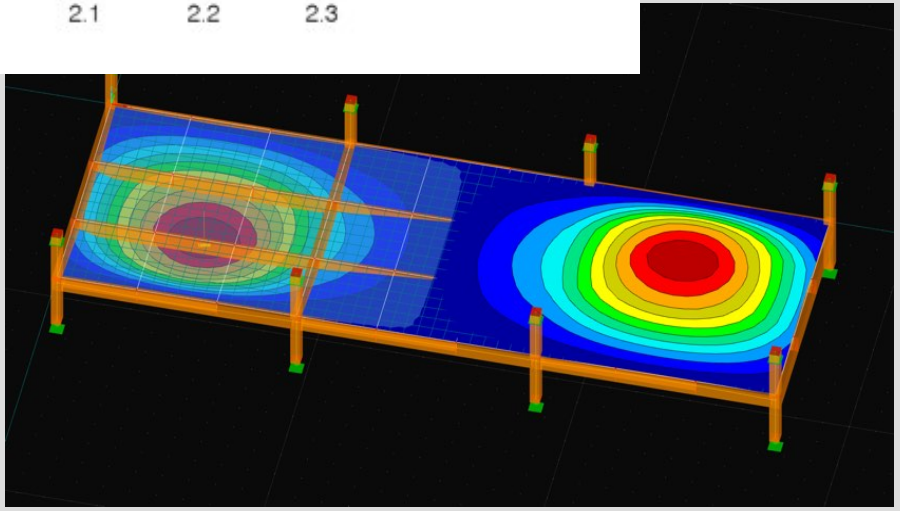
Bay Studies


C6
C7
C8
20' - 0"
20' - 0"
D1
D2
D3
D4
18' - 0"
26' - 0"
17' - 0"
PURLIN
GIRDER
CLT
TERRACE
OPTION 1B - PLAN
3D VISUALIZATION
CONCRETE TOPPING
CLT PANEL
GLULAM GIRDER
GLULAM COLUMN
GLULAM PURLIN
3 1/8"
2"
27 5/8"
16 1/2"
22 1/2"
RESIDENTIAL BUILDING
TYPE 4-C
DL = 50 PSF / LL = 55 PSF
OPTION 1B
TOTAL DEPTH: 27 5/8"
GIRDER: GLULAM 10.5" X 22.5"
PURLIN: GLULAM 6.75" X 16.5"
CLT PLANEL: 3-PLY (THK = 3.125")
VOLUME ANALYSIS (60'X20' AREA)
TOTAL: 0.50 CU FT / SQ FT
SECTION 1B

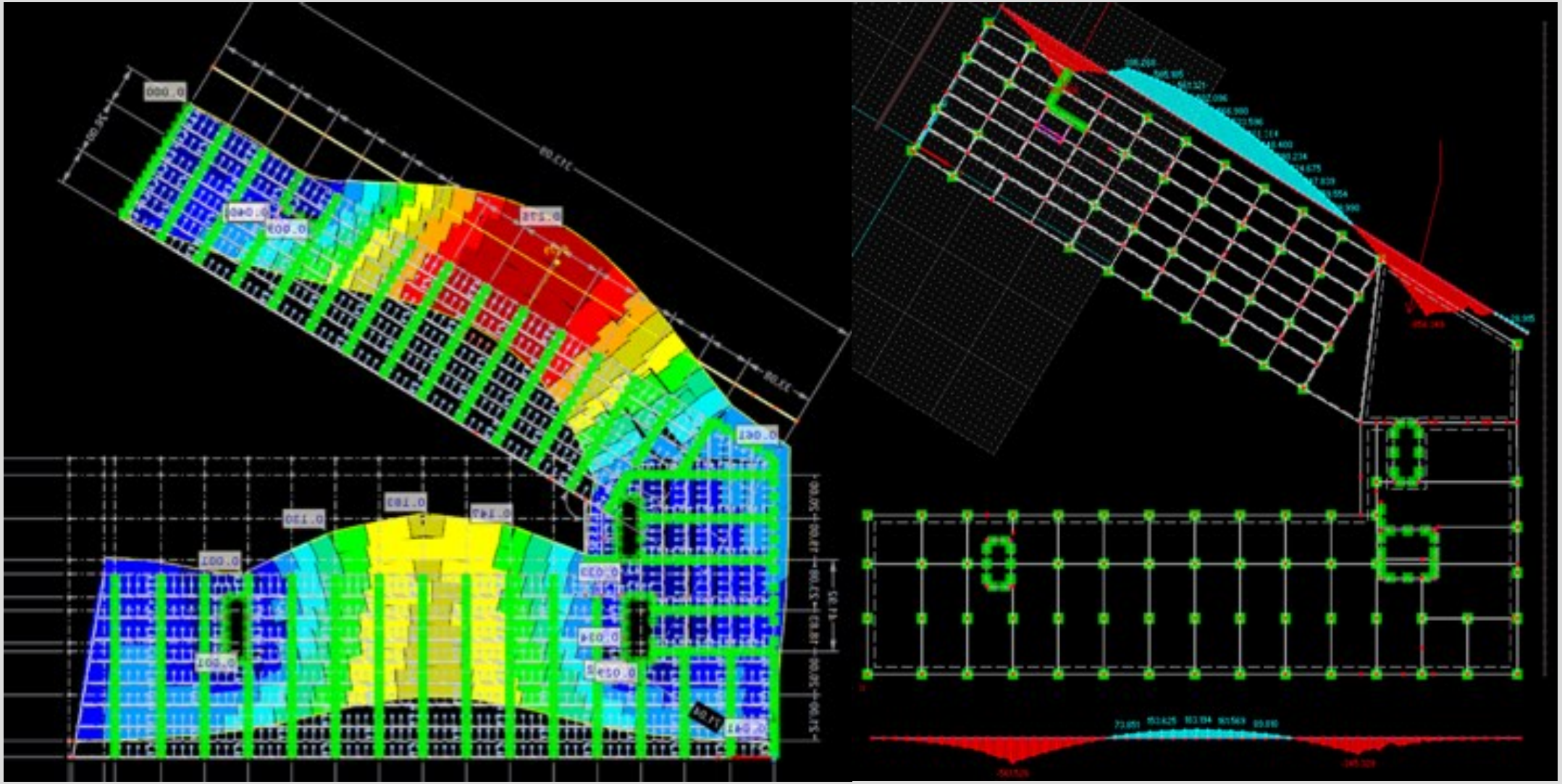
DETAILED DESIGN

- VIBRATION
- LATERAL
- CONNECTIONS
- COORDINATION

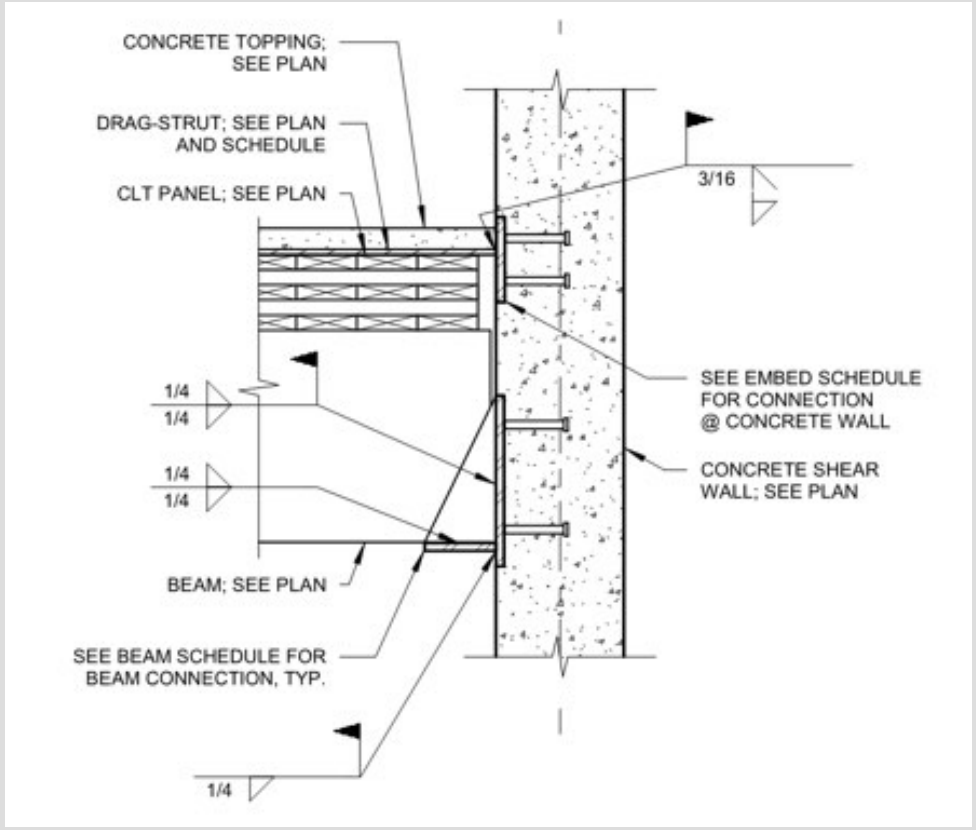


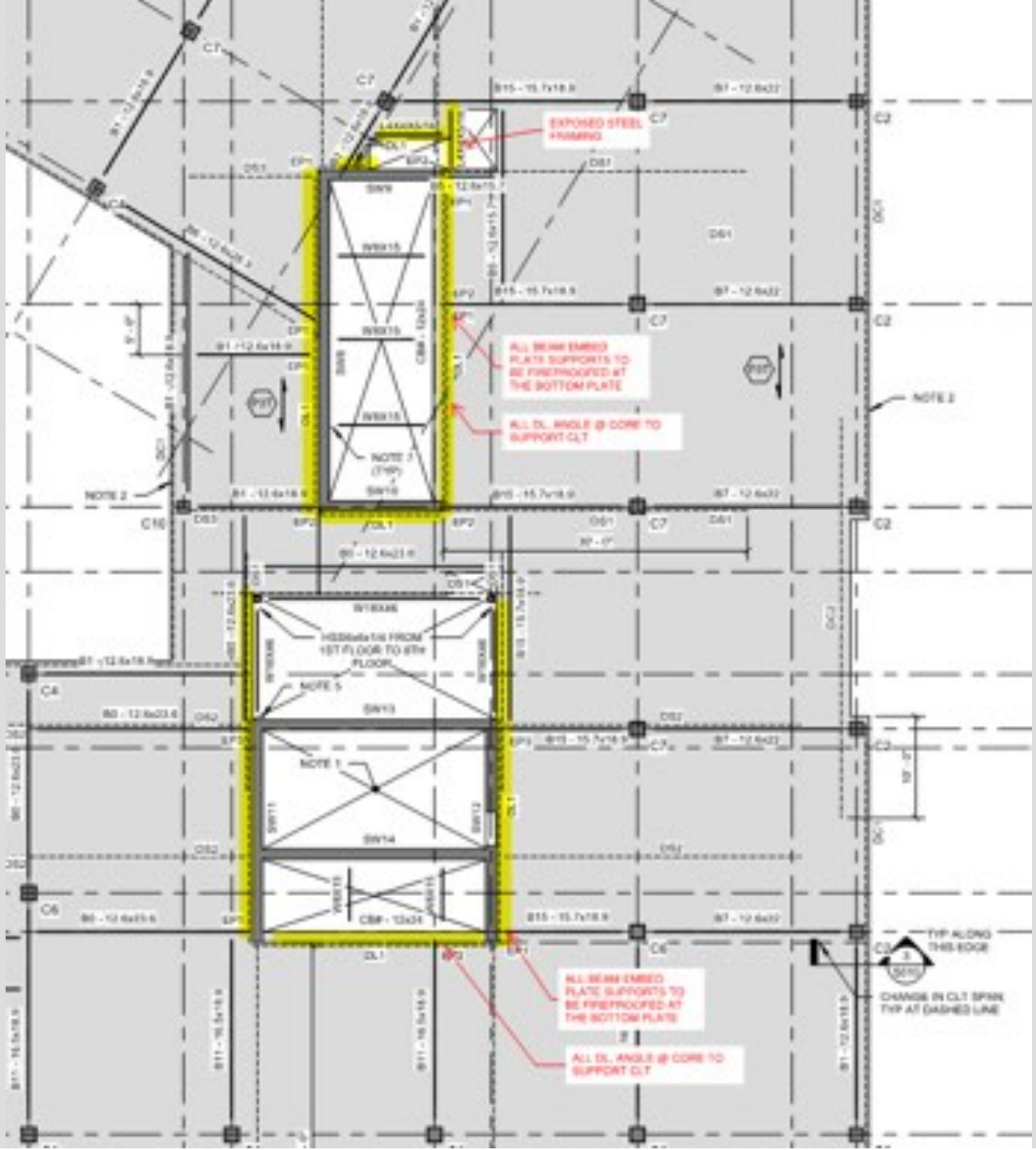


+ Vibration Design

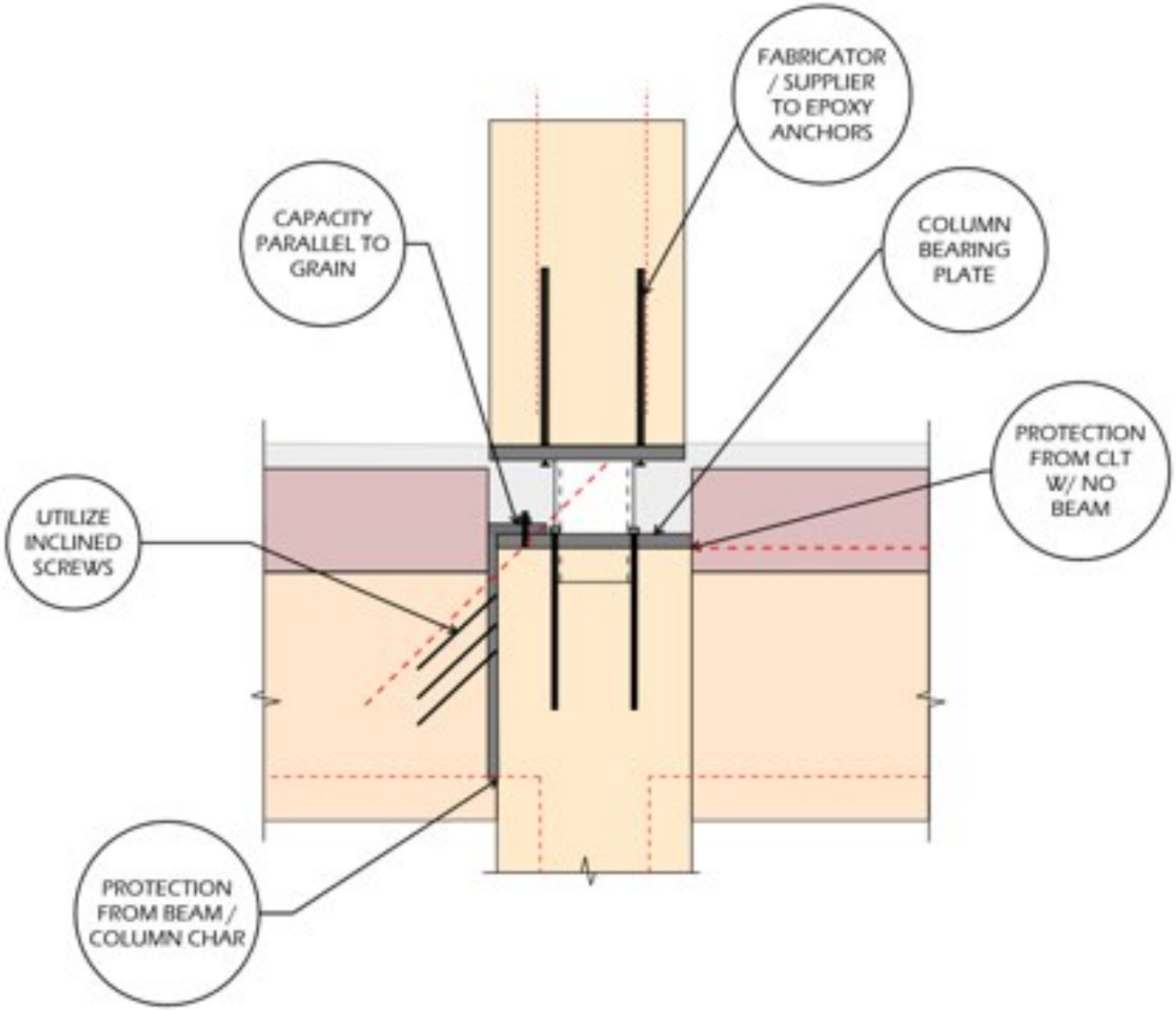


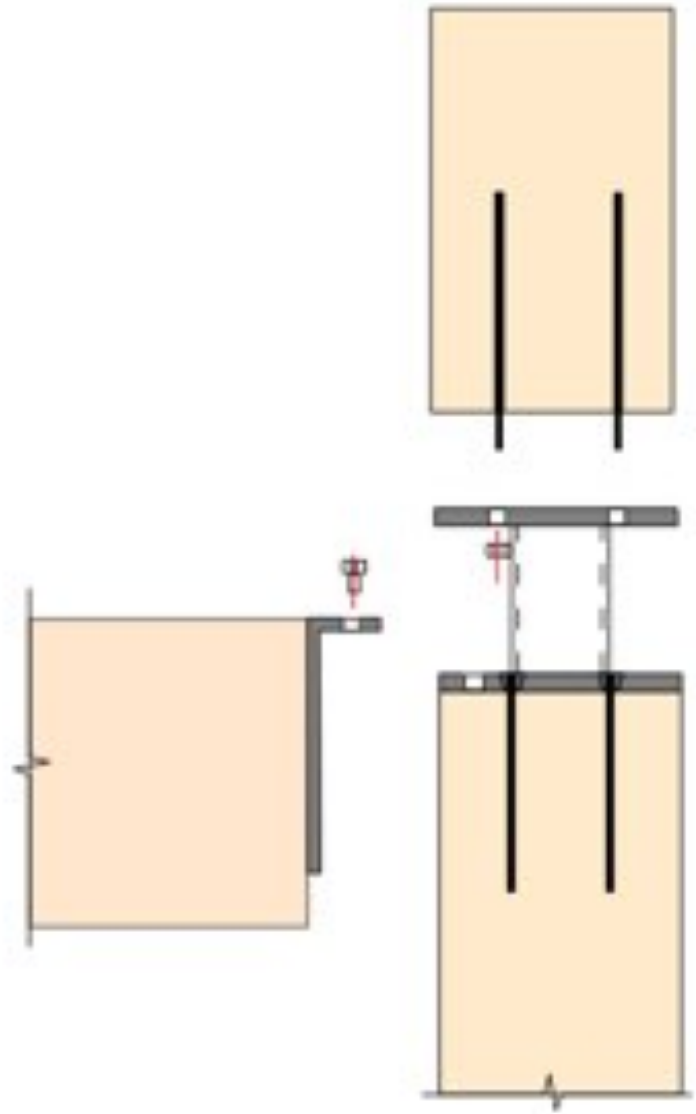
LATERAL DESIGN

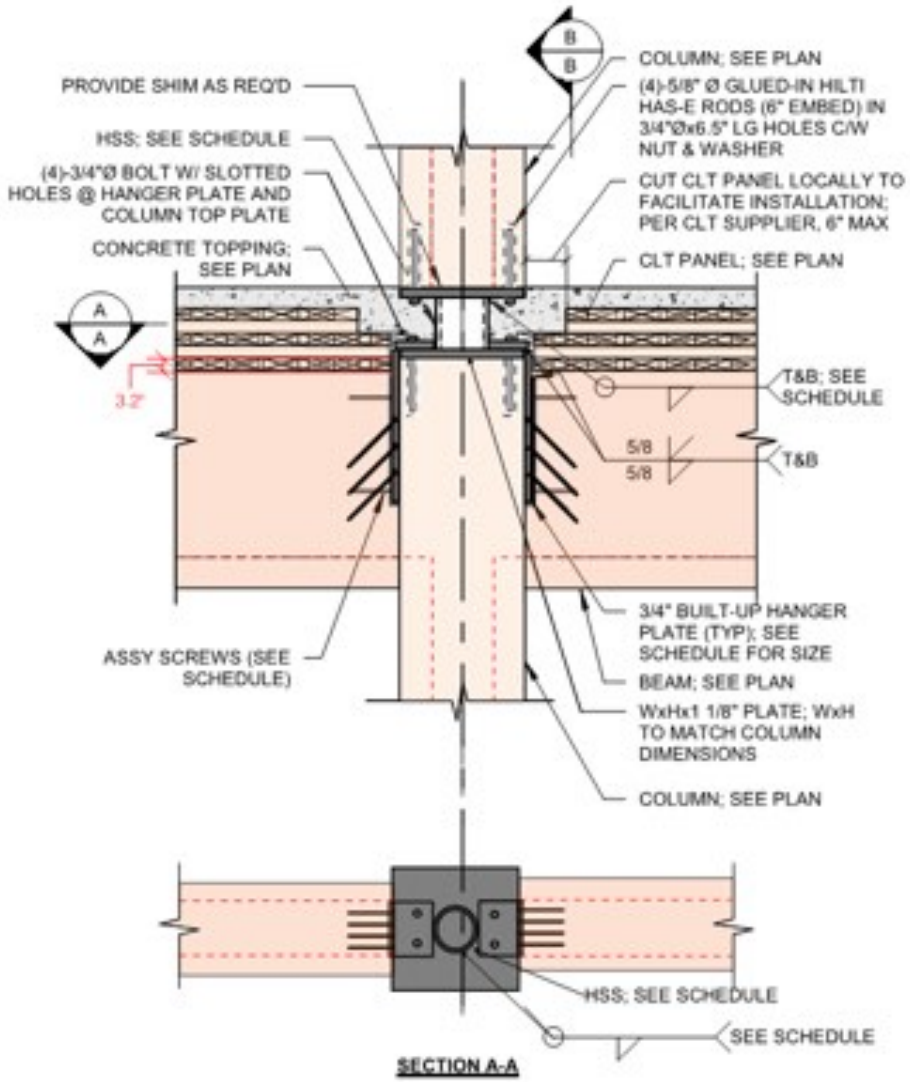




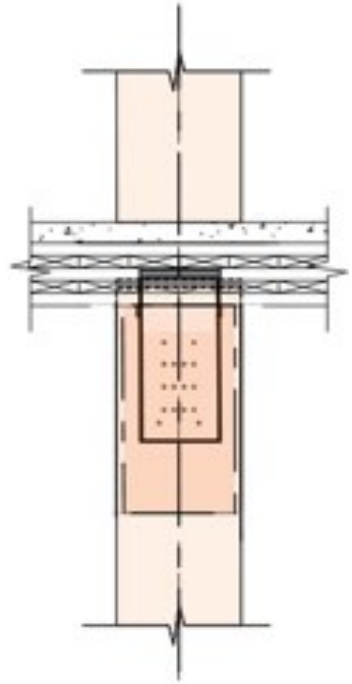
+ LATERAL DESIGN


FABRICATOR / SUPPLIER TO EPOXY ANCHORS
CAPACITY PARALLEL TO GRAIN
COLUMN BEARING PLATE
PROTECTION FROM CLT W/ NO BEAM
UTILIZE INCLINED SCREWS
PROTECTION FROM BEAM / COLUMN CHAR

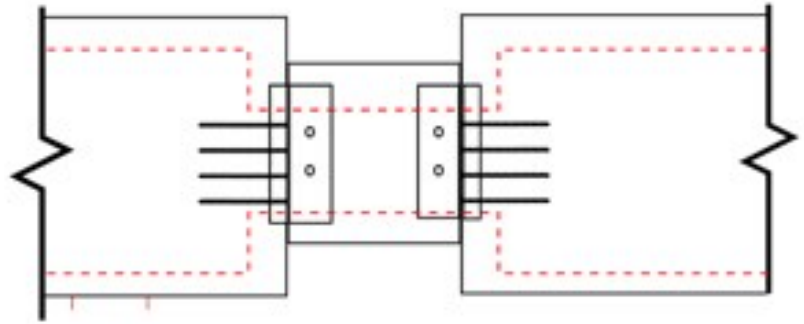


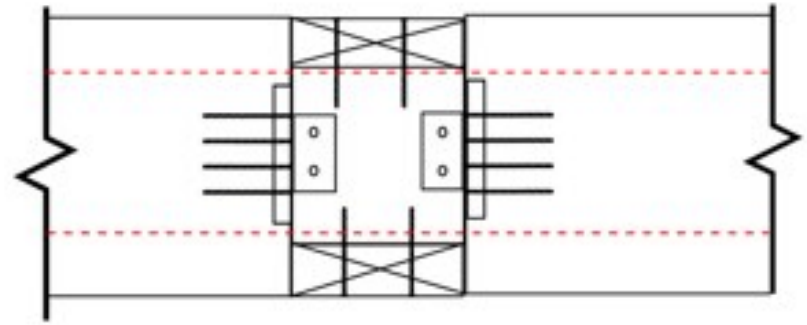


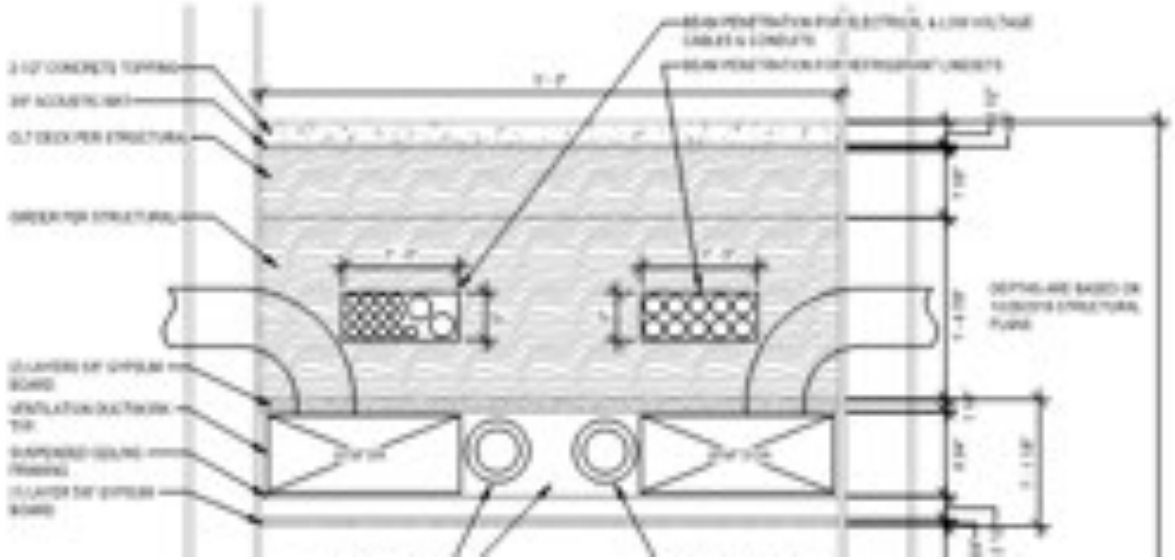
SECTION A-A



SECTION B-B





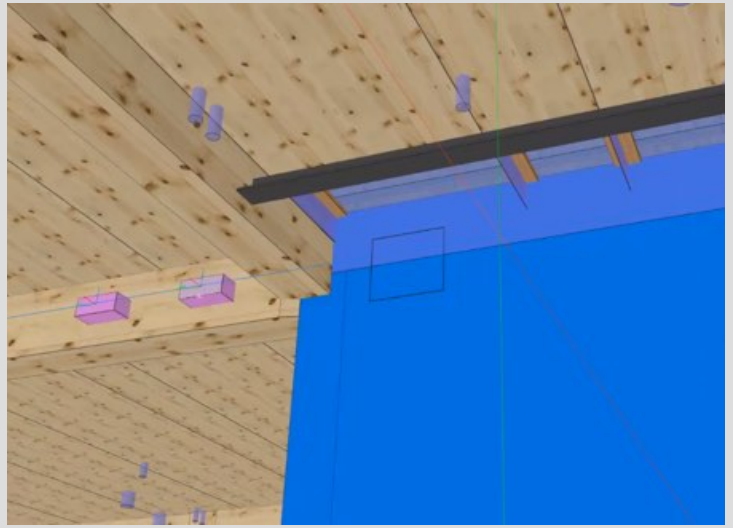


MEP

MEP COORD

CENTRAL BEAM PENETRATIONS

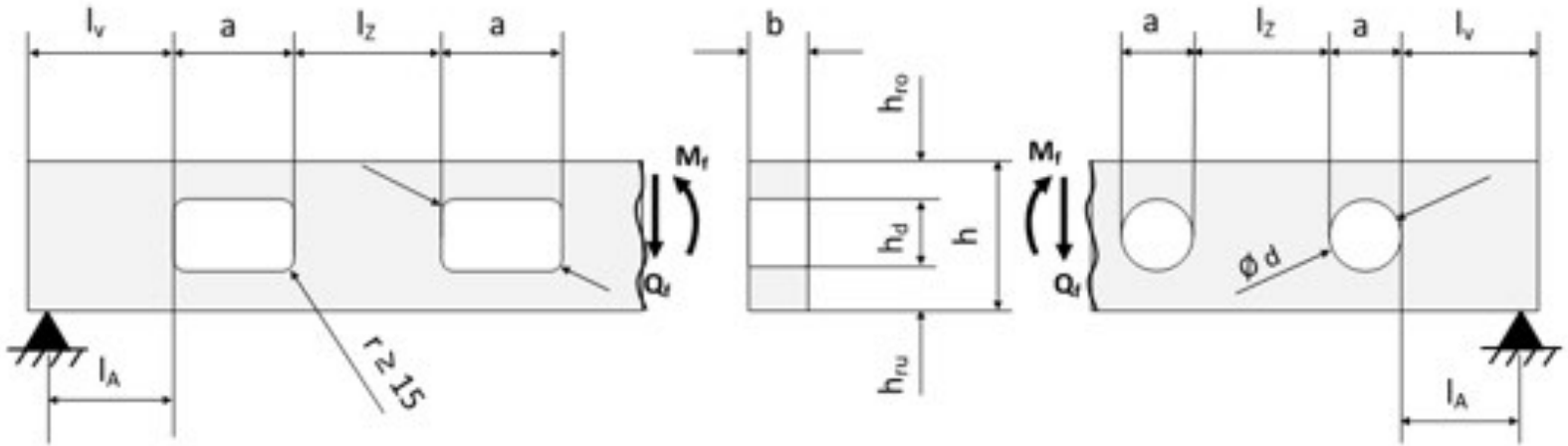
CLT HOLES

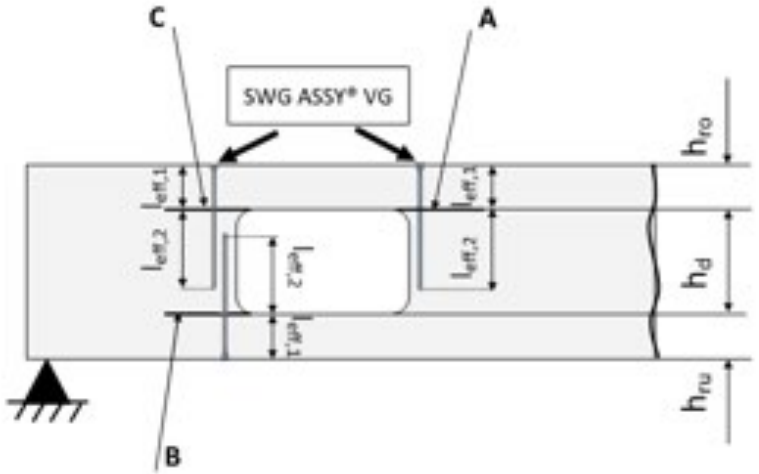


MODEL: **Lignum Design**

MyTiCon Timber Connectors White Paper

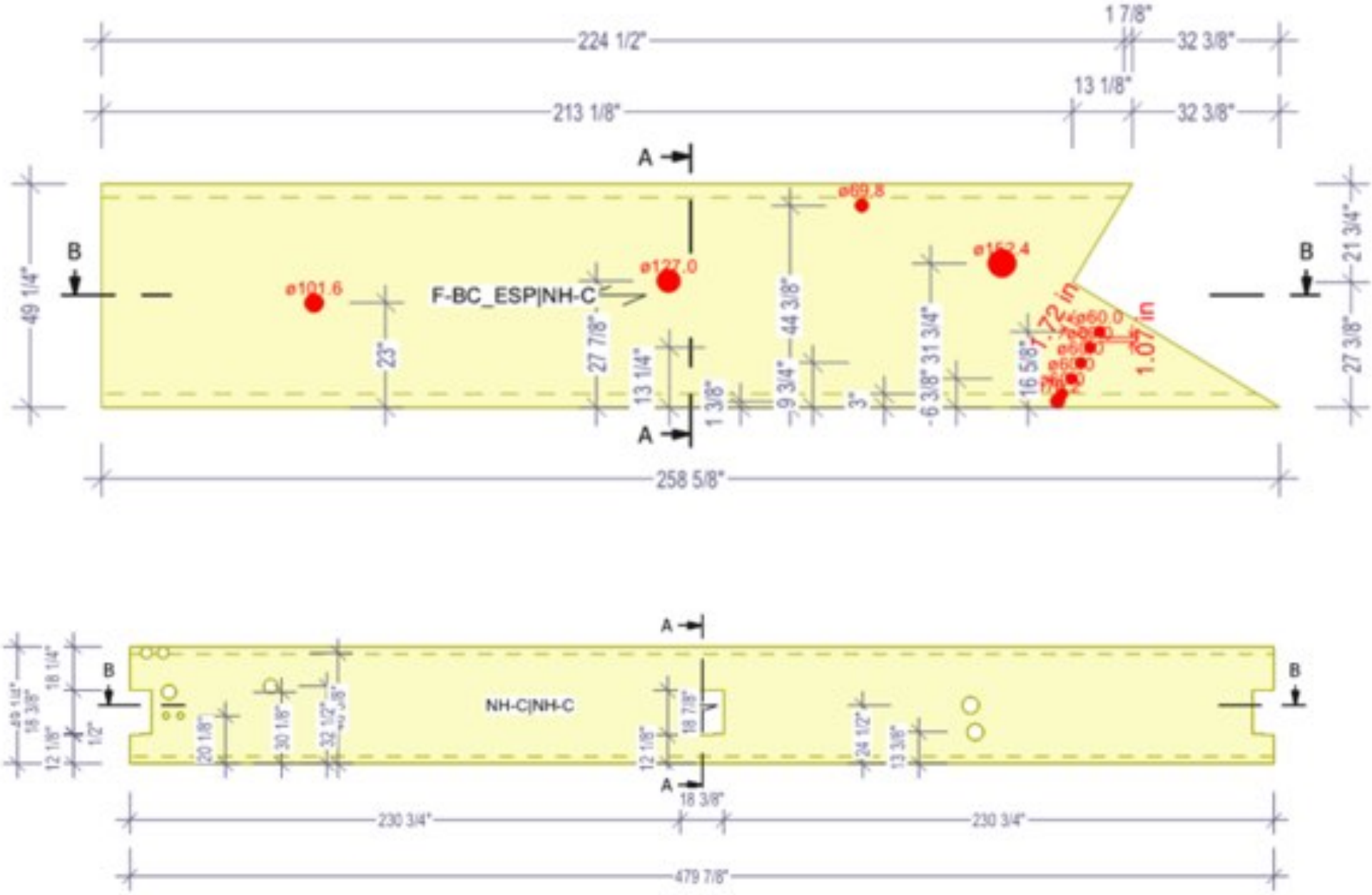
Full thread SWG ASSY® Screws as Reinforcement

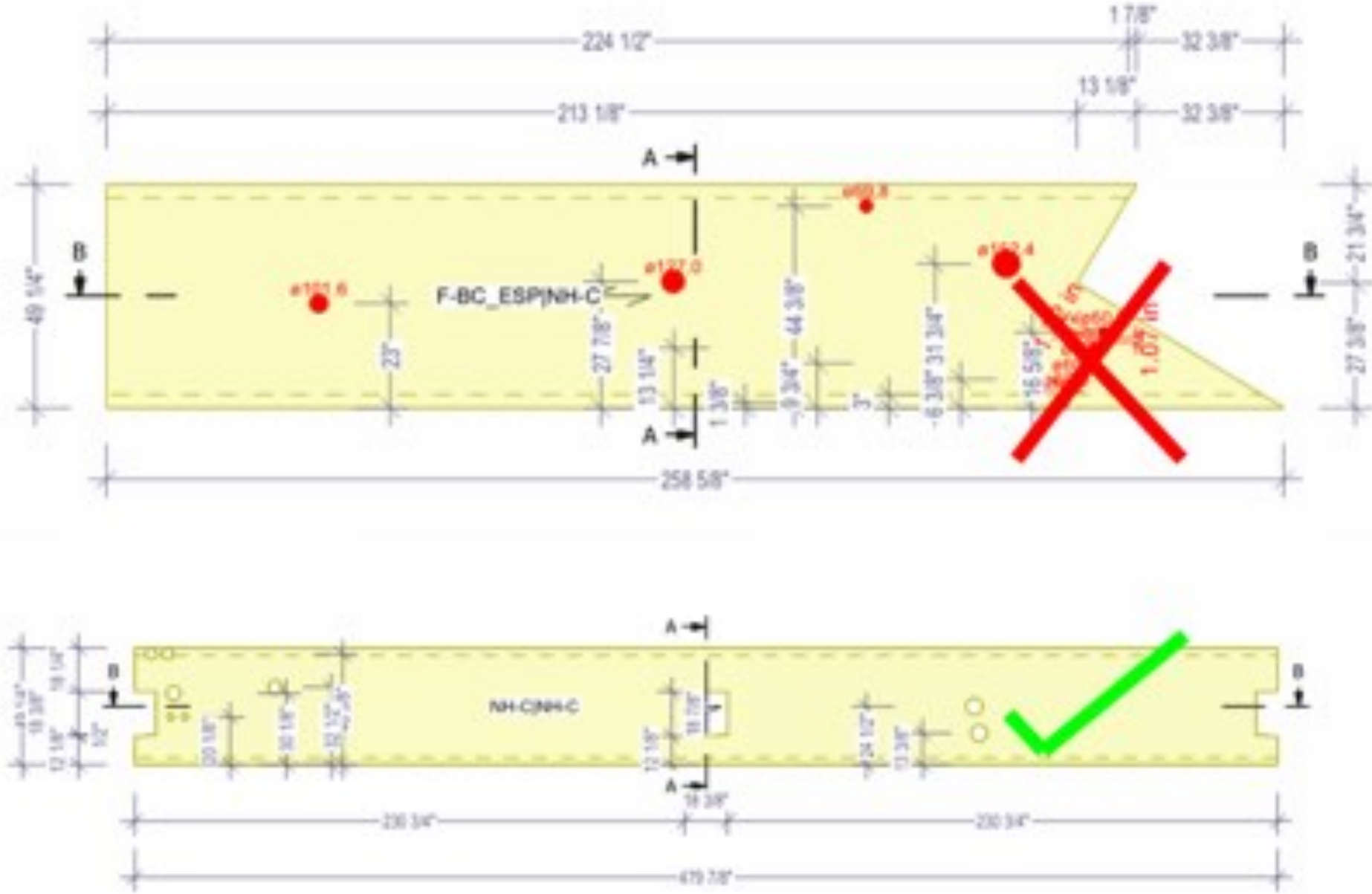




TECHNICAL NOTE

Effect of Large Diameter Horizontal Holes on the Bending and Shear Properties of Structural Glued Laminated Timber


224 1/2"
1 7/8"
32 3/8"
213 1/8"
13 1/8"
32 3/8"
A
B
ø69.8
ø127.0
ø101.6
F-BC_ESP|NH-C
ø152.4
49 1/4"
23"
27 7/8"
13 1/4"
1 3/8"
44 3/8"
9 3/4"
3"
31 3/4"
6 3/8"
16 5/8"
1.72 in
1.07 in
21 3/4"
27 3/8"
258 5/8"
NH-C|NH-C
18 1/4"
18 3/8"
12 1/8"
1/2"
20 1/8"
30 1/8"
32 1/2"
18 7/8"
24 1/2"
13 3/8"
18 3/8"
230 3/4"
479 7/8"


224 1/2"
1 7/8"
32 3/8"
13 1/8"
213 1/8"
32 3/8"
A
B
#102 6
#127 0
#102 3
#102 4
F-BC_ESP|NH-C
49 1/4"
23"
27 7/8"
13 1/4"
1 3/8"
9 3/4"
44 3/8"
3"
6 3/8"
31 3/4"
16 5/8"
1.0" min
21 3/4"
27 3/8"
258 5/8"
NH-C|NH-C
230 3/4"
479 7/8"

Cleveland's First 9-Story Timber Tower

PHOTO: Hartshorne Plunkard Architecture


THANK YOU!

JANUARY 13, 2021

Ascent

Alejandro Fernandez
Senior Project Engineer
Woodworks

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

Thornton Tomasetti

WHO ARE WE?

Thornton Tomasetti

1500
ENGINEERS, ARCHITECTS, SCIENTISTS AND OTHER PROFESSIONALS

PROJECTS IN
50 COUNTRIES

50+
OFFICES

5
CONTINENTS

WHO ARE WE?

Thornton Tomasetti

Weidlinger Transportation

Forensics

Sustainability

Weidlinger Applied Science

Façade Engineering

Renewal

Weidlinger Protective Design

Property Loss Consulting

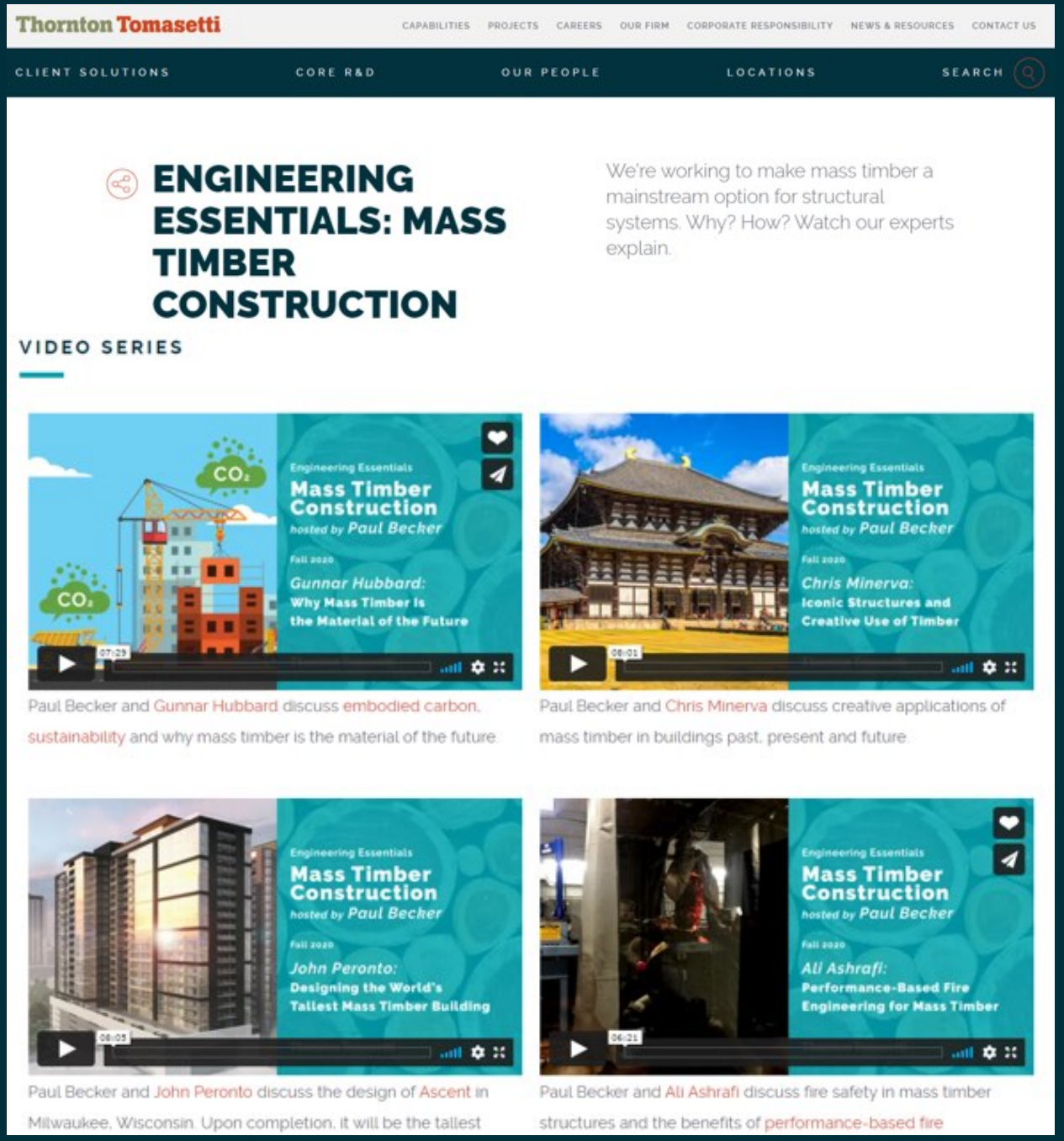
Construction Engineering

Structural Engineering

Thornton Tomasetti

MASS TIMBER SOLUTIONS

WWW.THORNTONTOMASETTI.COM/CAPABILITY/MASS-TIMBER-CONSTRUCTION



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CONTEXT

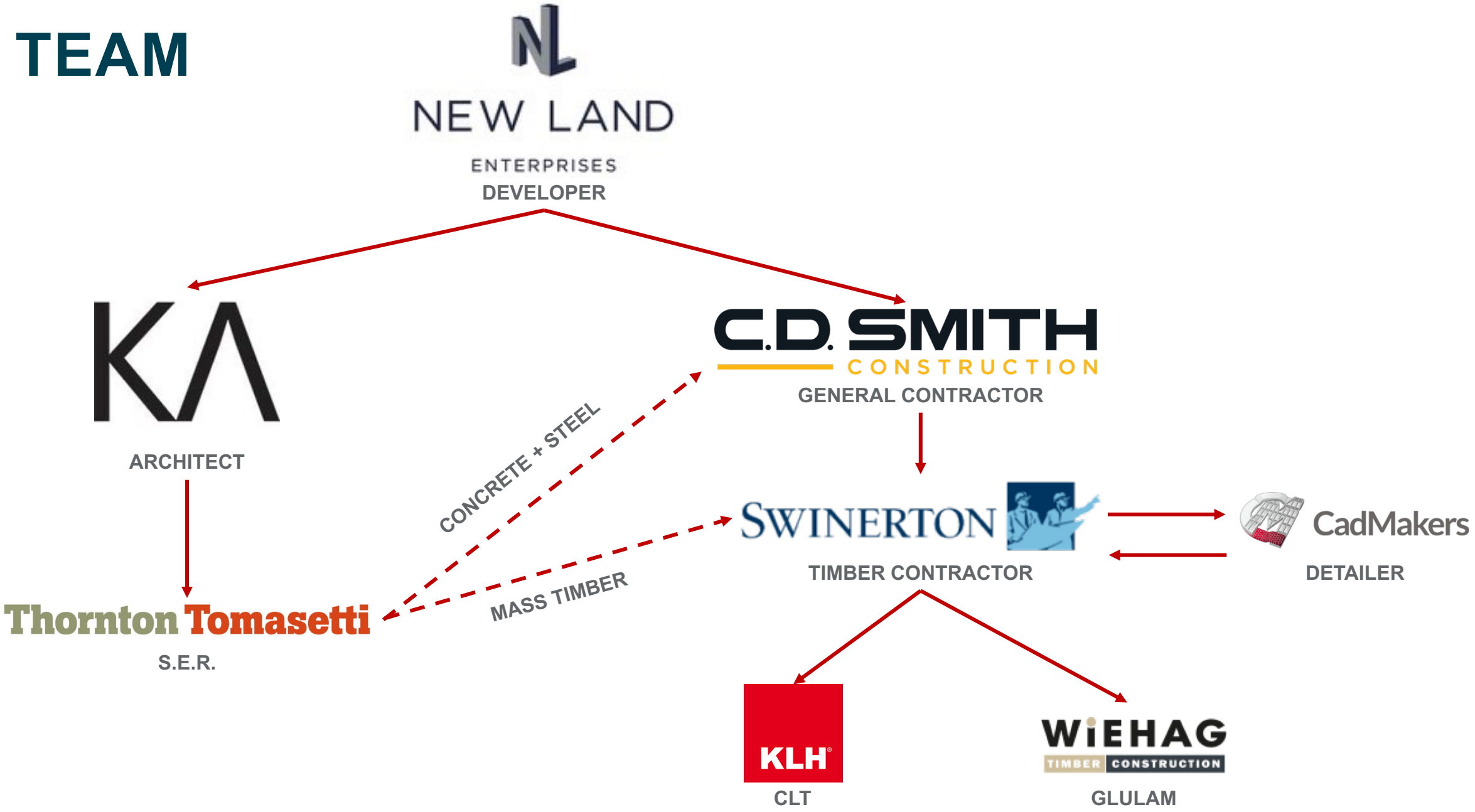

© Korb + Associates


LOWER EAST SIDE
SCHLITZ PARK
YANKEE HILL
EAST TOWN
Google
© Google

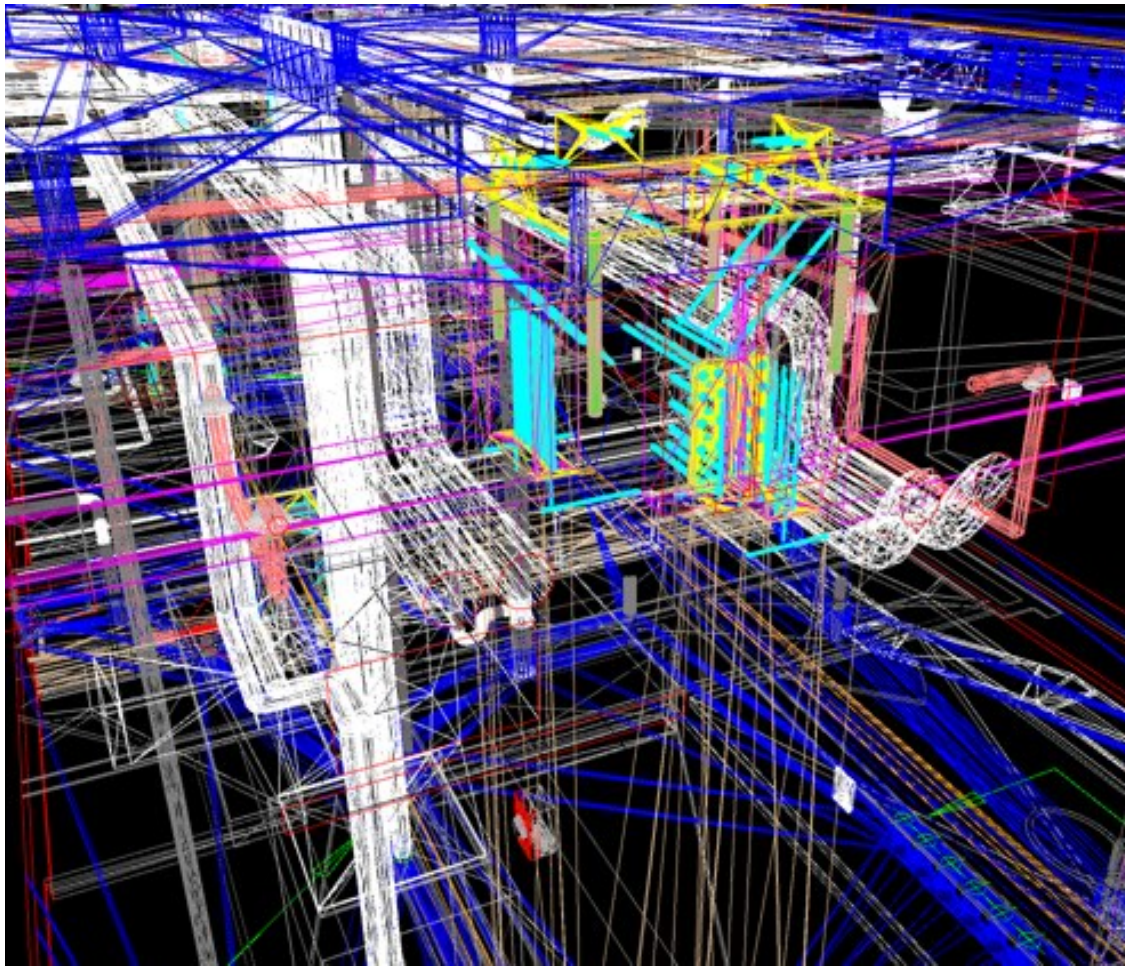
RIVER BEECH

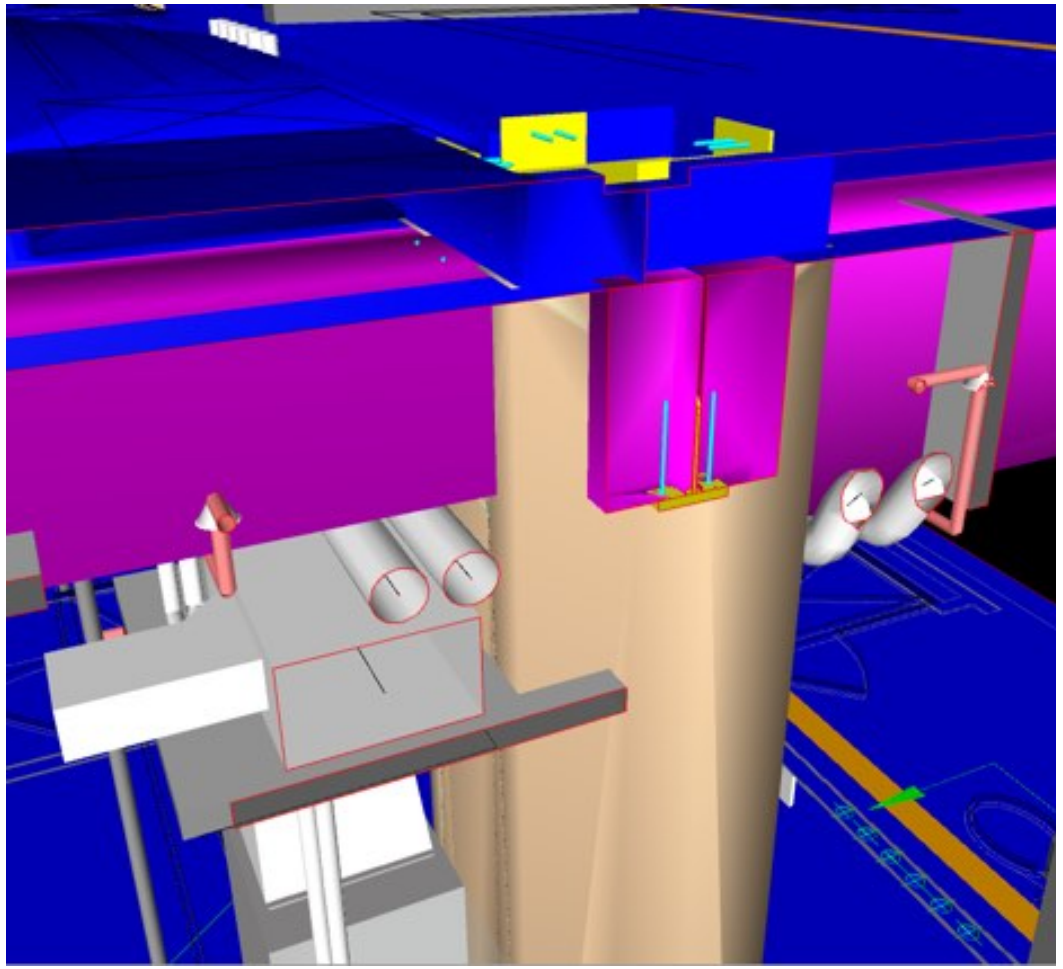
Chicago

TEAM


NEW LAND
ENTERPRISES
DEVELOPER
KA
ARCHITECT
C.D. SMITH
CONSTRUCTION
GENERAL CONTRACTOR
CONCRETE + STEEL
MASS TIMBER
SWINERTON
TIMBER CONTRACTOR
CadMakers
DETAILER
Thornton Tomasetti
S.E.R.
KLH
CLT
WIEHAG
TIMBER CONSTRUCTION
GLULAM

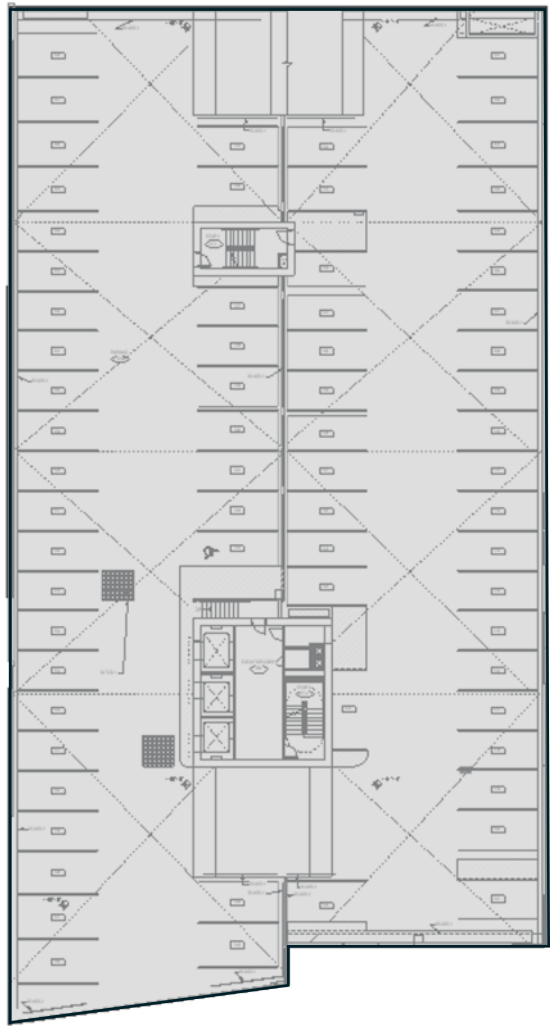
COORDINATION



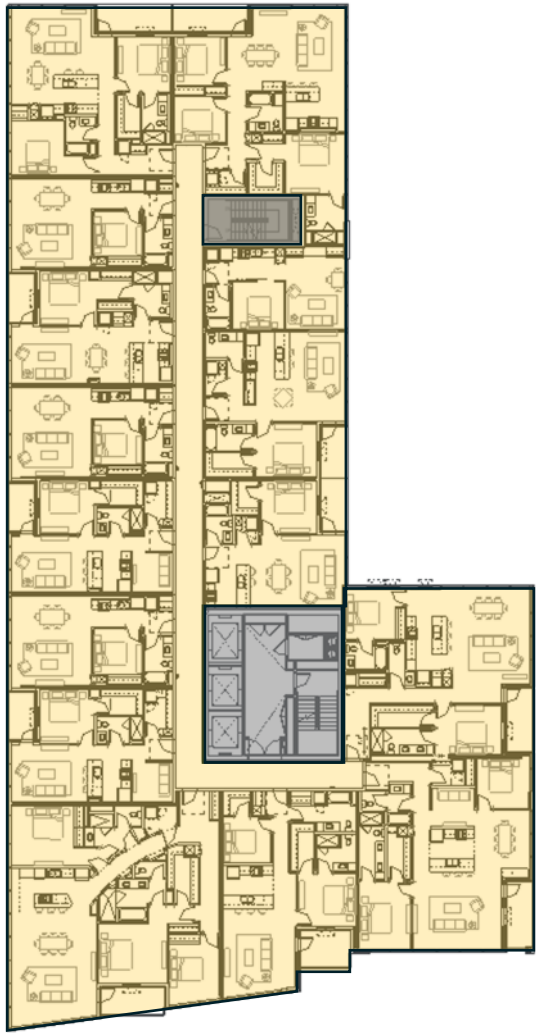


ARCHITECTURAL EXPRESSION

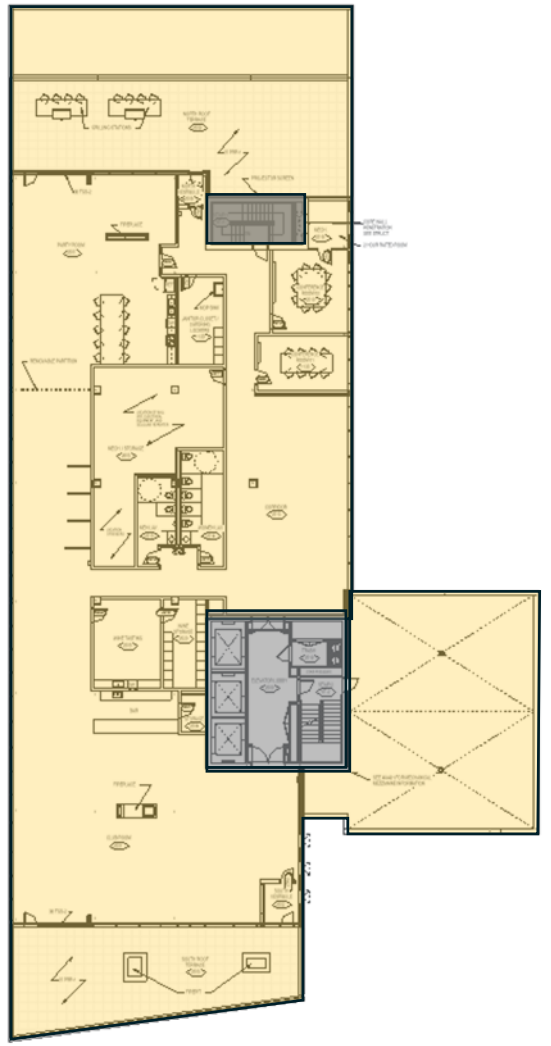
TYPICAL FLOOR PLANS



TYPICAL PARKING LEVEL

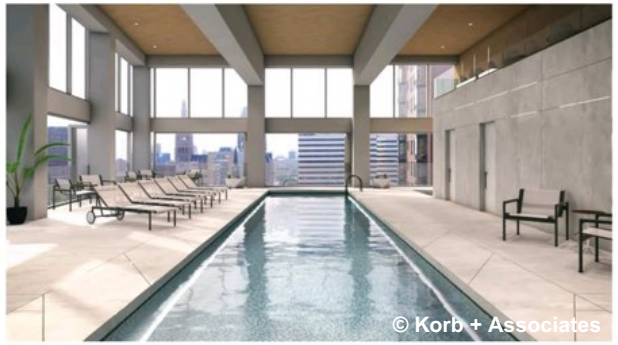


TYPICAL RESIDENTIAL LEVEL



AMENITIES LEVEL (L25)

CONNECTION TO NATURE



PERMITTING

Dates indicate
approved permit year

12 stories

25 stories

Framework (2017)
Portland, OR

Ascent (2020)
Milwaukee, WI

PERMITTING

TABLE 601
FIRE-RESISTANCE RATING REQUIREMENTS FOR BUILDING ELEMENTS (HOURS)

BUILDING ELEMENT	TYPE I		TYPE II		TYPE III		TYPE IV	TYPE V	
	A	B	A	B	A	B	HT	A	B
Primary structural frame[f] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls Exterior[e, f] Interior	3 3[a]	2 2[a]	1 1	0 0	2 1	2 0	2 1/HT	1 1	0 0
Nonbearing walls and partitions Exterior	See Table 602								
Nonbearing walls and partitions Interior[d]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

For SI: 1 foot = 304.8 mm.

a. Roof supports: Fire-resistance ratings of primary structural frame and bearing walls are permitted to be reduced by 1 hour where supporting a roof only.

b. Except in Group F-1, H, M and S-1 occupancies, fire protection of structural members shall not be required, including protection of roof framing and decking where every part of the roof construction is 20 feet or more above any floor immediately below. Fire-retardant-treated wood members shall be allowed to be used for such unprotected members.

c. In all occupancies, heavy timber shall be allowed where a 1-hour or less fire-resistance rating is required.

d. Not less than the fire-resistance rating required by other sections of this code.

e. Not less than the fire-resistance rating based on fire separation distance (see Table 602).

f. Not less than the fire-resistance rating as referenced in Section 704.10.

IBC 2015

Chapter SPS 361
ADMINISTRATION AND ENFORCEMENT

Subchapter I — Scope and Application

(6) Alternatives. Nothing in chs. SPS 361 to 366 is intended to prohibit or discourage the design and utilization of new building products, systems, components, or alternate practices, provided written approval from the department is obtained first.
Note: Chapter SPS 361, subch. VI contains requirements for approval of building products and alternate standards.

Subchapter VI — Product and Standard Review and Approval

SPS 361.50 Building product approvals.
(1) Voluntary approval.
(a) Materials, equipment, and products regulated under chs. SPS 361 to 366 may receive a written approval from the department indicating code compliance.
(b)
1. Approval of materials, equipment, and products shall be based on sufficient data, tests, and other evidence that prove the material, equipment, or product is in compliance with the standards specified in chs. SPS 361 to 366.
2. Tests, compilation of data, and calculations shall be conducted by a qualified independent third party.
(2) Alternate approval.
(a) Materials, equipment, and products that meet the intent of chs. SPS 361 to 366 and which are not approved under sub. (1) shall be permitted if approved in writing by the department.
(b)
1. Approval of materials, equipment, and products shall be based on sufficient data, tests, and other evidence that prove the material, equipment, or product meets the intent of the standards specified in chs. SPS 361 to 366.
2. Tests, compilation of data, and calculations shall be conducted by a qualified independent third party.

WISCONSIN COMMERCIAL BUILDING CODE

PERMITTING

ENR
Engineering News-Record

Milwaukee's 25-Story Ascent Stacks Up as Tall Timber Role Model

Fire officials accept the unprecedented use of the sustainable material in a 284-ft-tall wood and concrete frame

Approvals took two years for Ascent, an unprecedented 284-ft-tall wood and concrete tower under way in Milwaukee since September.

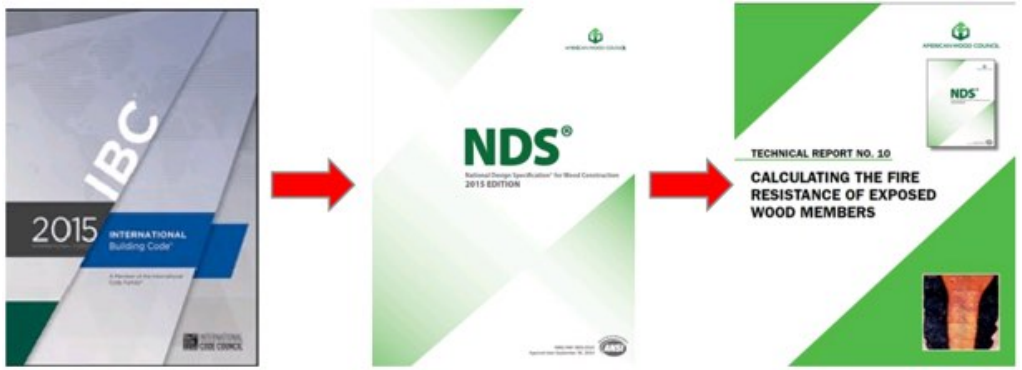
Montage by Scott Hilling for ENR—rendering by Thornton Tomasetti, photo courtesy C.D. Smith

https://www.enr.com/articles/50905-milwaukees-25-story-ascent-stacks-up-as-tall-timber-role-model

FIRE

Determining Fire Ratings:

- Char
  - Calculations (Char Method)
  - Full Scale (Global) Testing
  - Element (Member) Testing
  - Connection Testing
- Product Certificates
- Concealment
- Intumescent Paint (connections only)

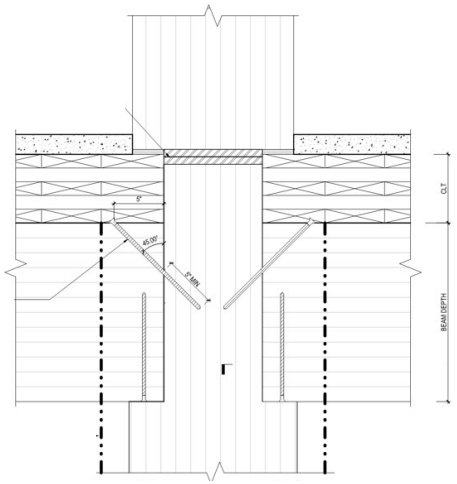


IBC NDS TR-10

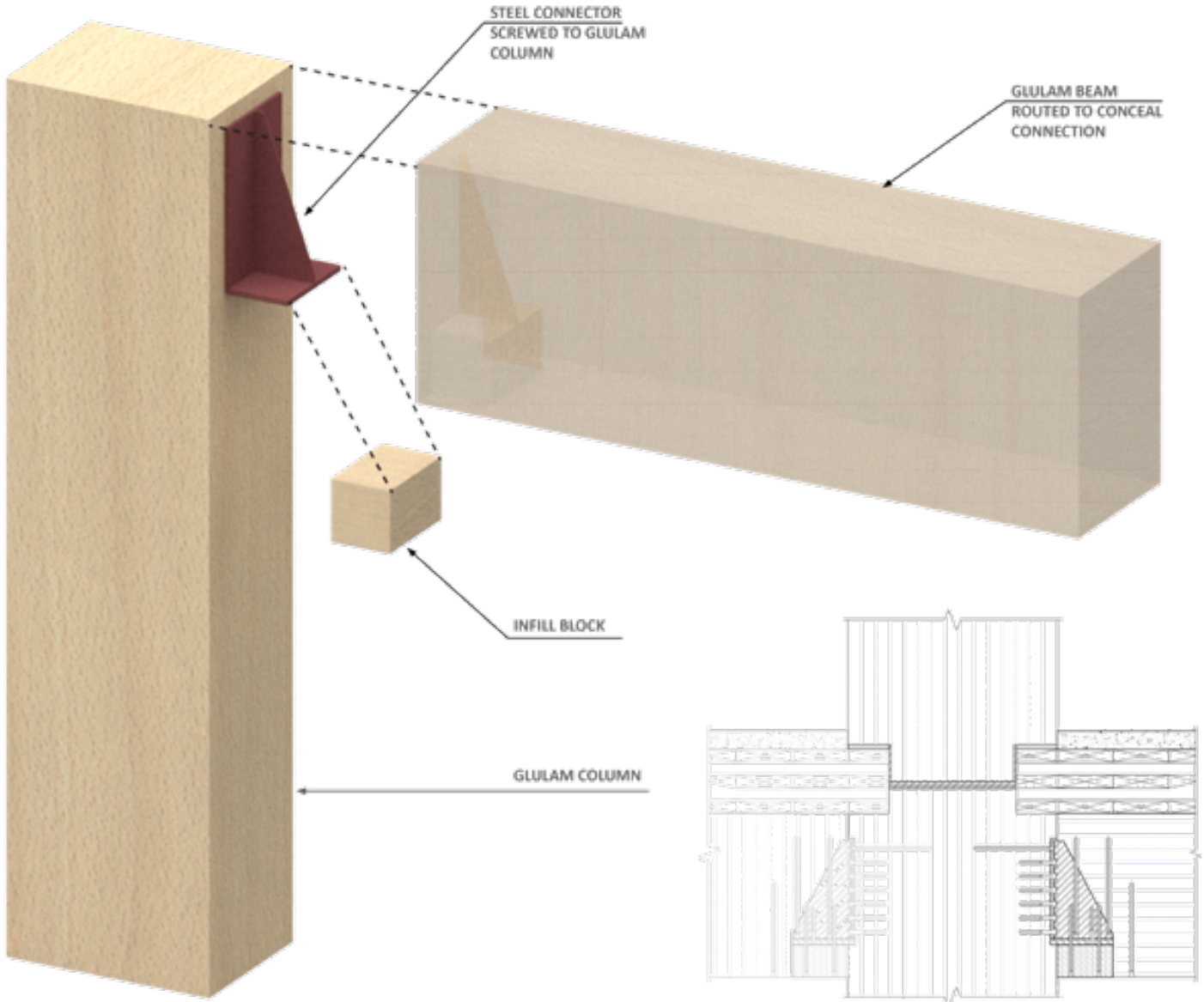
FIRE

3 HOURS TEST

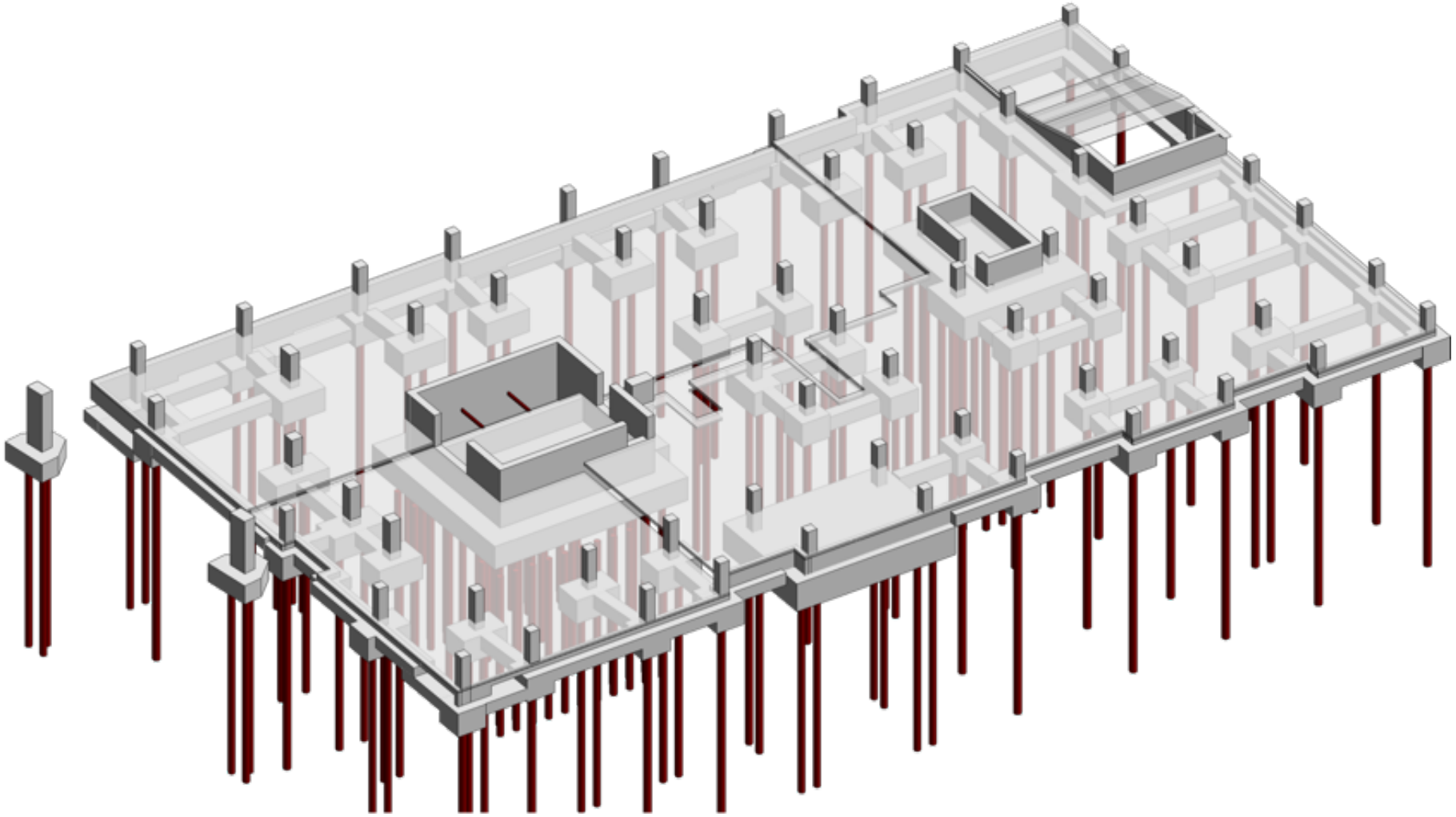
CONNECTIONS



CONNECTIONS



FOUNDATION

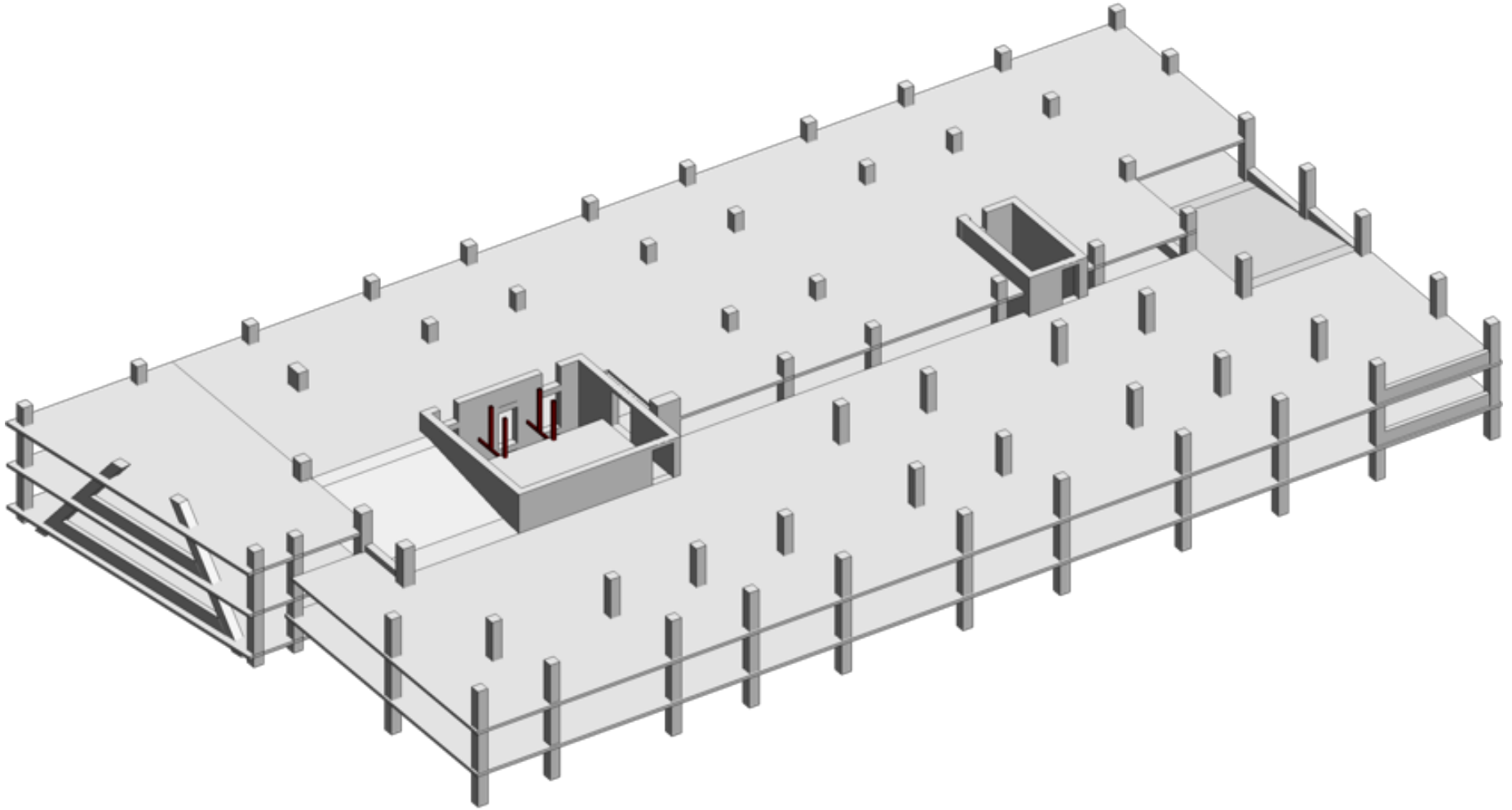


FOUNDATION

STATIC TESTING

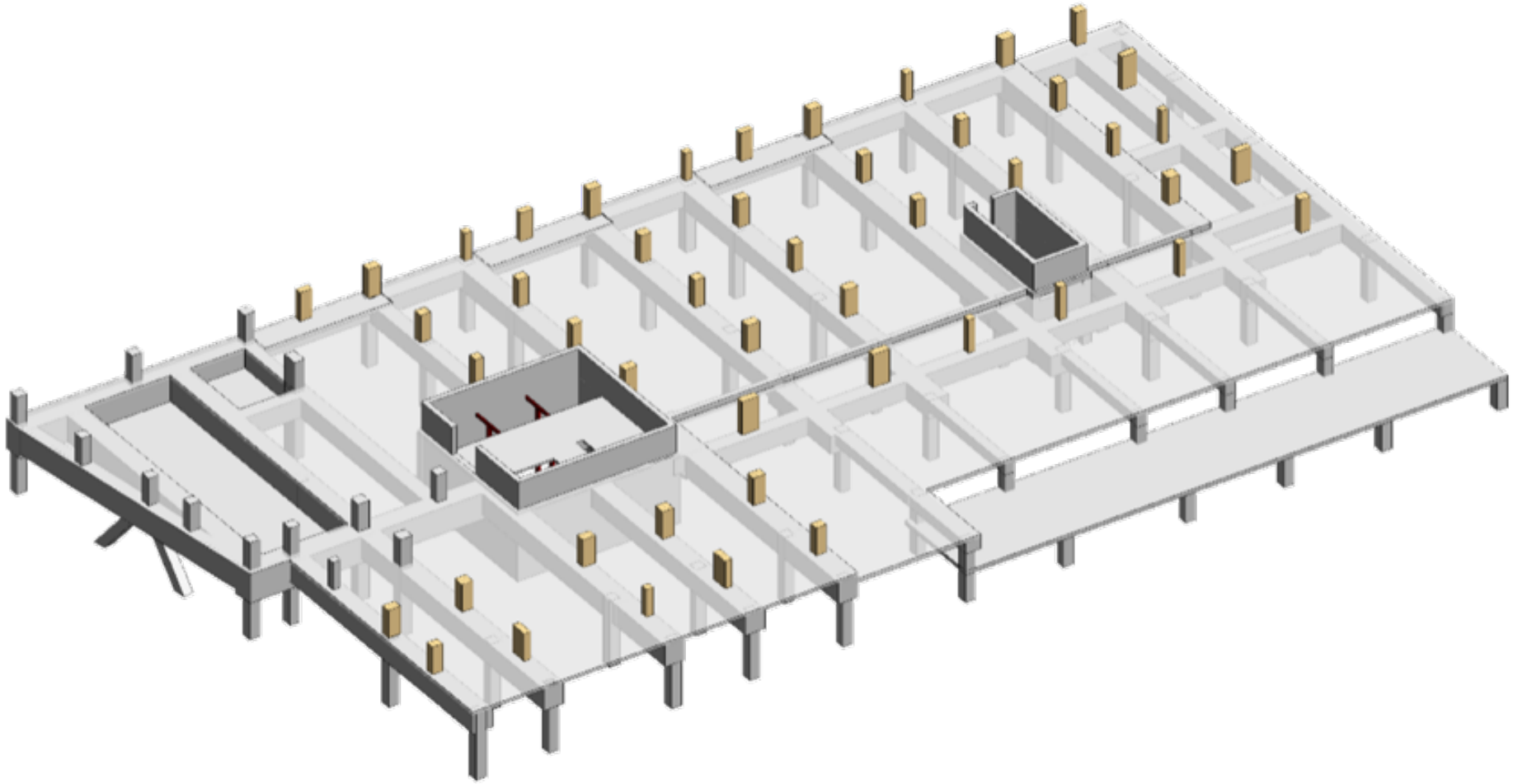
ASCENT

TYPICAL PARKING LEVEL



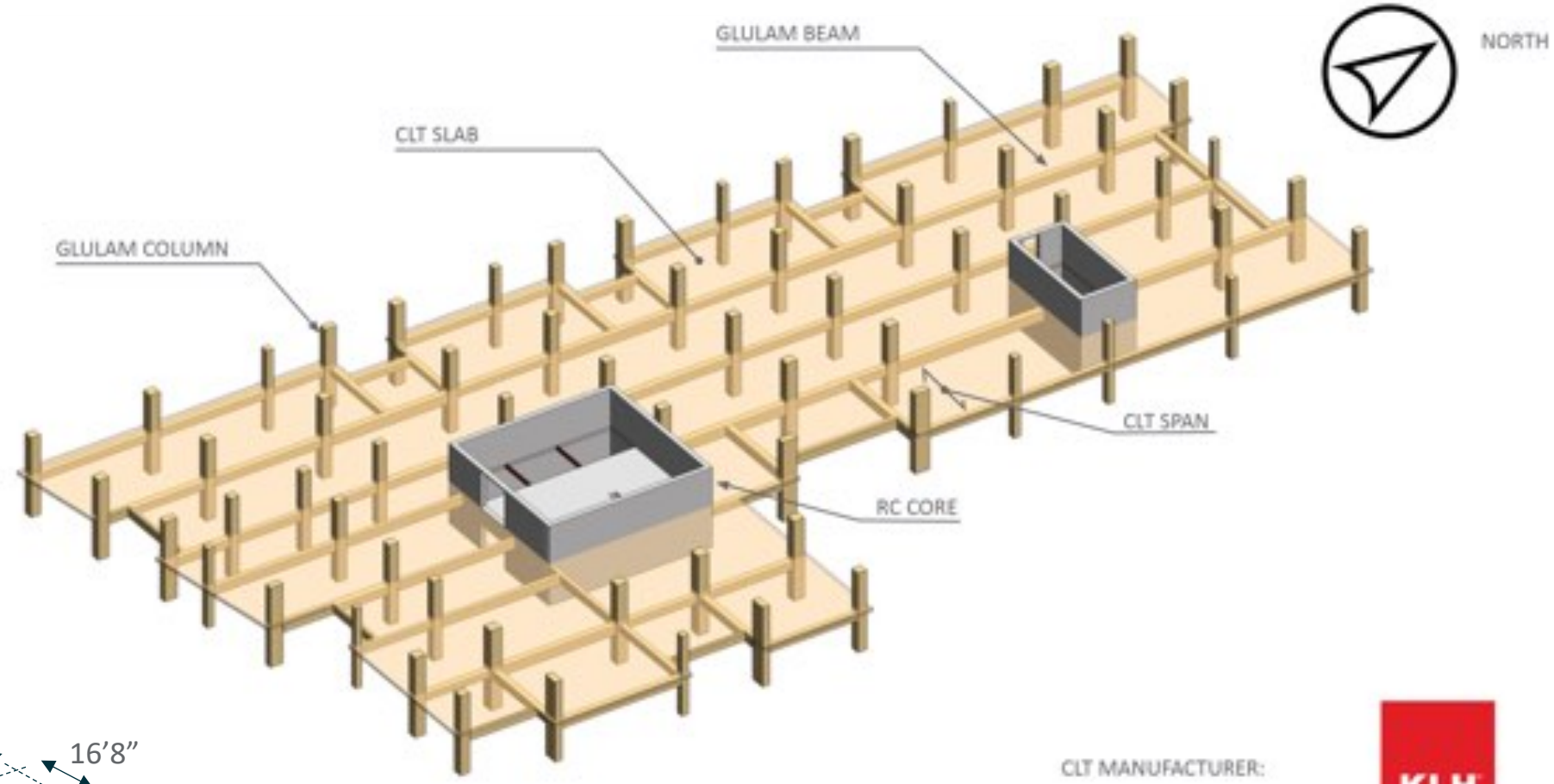
ASCENT

TRANSFER LEVEL

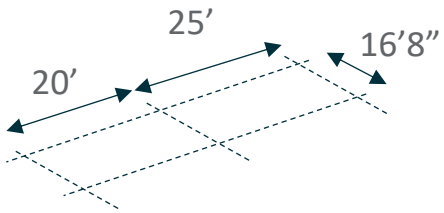


ASCENT

TYPICAL TIMBER LEVEL



TYPCAL GRID



CLT MANUFACTURER: KLH

GLULAM MANUFACTURER: WIEHAG

CONSTRUCTION SEQUENCE

ASCENT

DEC 3, 2020

This concludes The American Institute of Architects Continuing Education Systems Course

THANK YOU

Contact info

afernandez@ThorntonTomasetti.com

Thornton Tomasetti

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