WoodWorks™
WOOD PRODUCTS COUNCIL

Breaking Convention with Timber Offices

Offering Distinct Alternatives to the Monotony of Our Current Workplace Infrastructure

Presented by
WoodWorks for Non-residential Construction

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Questions related to specific materials, methods, and services will be addressed at the conclusion of this presentation.

Course Description

Great solutions often lie beyond convention. Consider that most offices in the U.S. could be built with a wood structure yet this option goes largely unexplored. Many designers assume they're limited to concrete and steel for workplace environments—because that's the common default—but, in fact, wood construction can accommodate the space and performance needs of office occupancies, while providing advantages such as speed, cost savings, and reduced environmental impact. Focusing on common design considerations (e.g., layout flexibility, land-use constraints, and market classification) this presentation will examine the potential for light-frame and heavy timber structural solutions. Topics will include building code opportunities related to fire and life safety, structural design and layout, and cost.

Learning Objectives

1. Review building code opportunities related to fire and life safety, with emphasis on construction types, fire resistance, and interior/exterior finish requirements.
2. Explore a variety of suitable structural layouts for light-frame and heavy timber solutions, demonstrating how to achieve flexibility of both space and function.
3. Evaluate the cost and value proposition of a class A heavy timber office solution using successful built examples.
4. Assess the cost and value proposition of a class B light-frame office solution using successful built examples.

OUTLINE

- Design Considerations for Offices
- Review Fire and Life Safety Opportunities/Challenges
- Layout Discussion
- Understanding Cost & Value
  - Class B/C Light Frame Wood Office Solution
  - Class A Mass Timber Office Solution

When asked why they didn't typically design offices in wood, Architects responded...

- "Does the building code even allow offices to be built in wood?"
- "Can wood accommodate the grid spacing needed for adaptable office floor plans?"
- "Is it possible to achieve high performance expectations …affordably?"

Classifications of Office Space

Class A

- New / Newly Renovated
- Prime / Central location
- On-site parking
- High Tech Building Systems (HVAC, elevators, utilities)
- High quality upkeep / maintenance
- Significant in size
- Contemporary Design

PROJECT: Federal Center South, Building 1202 – Seattle, WA
ARCHITECT: ZGF Architects LLP
ENGINEER: KPFF Consulting Engineers
PHOTO CREDIT: Benjamin Benschneider

Ownership / Intended Tenant

Custom

- Core and Shell and fit up
- Productive Environment
- Reflective of Company Culture
- Minimize Long Term Costs
- Accommodates current and future needs

VS'

Speculative

- Core and Shell
- Attractive
- Distinctive
- Maximize ROI
- Maximum Flexibility

Location and Scale

Urban/ Metro Area

Conditions:
- Smaller Sites
- Increased Density

Likely:
- Mid-High Rise
- Regular Footprint

Sub Urban/ Rural

Conditions:
- Larger Sites
- Reduced Density

Likely:
- Low-Mid Rise
- Irregular Footprint

David and Lucile Packard Foundation

- Location: Los Altos, CA
- 2 story, Type VB
- 49,000 sf
- Custom, Sub-Urban, Low-rise, Irregular Footprint

ARCHITECT: EHDD
ENGINEER: Tipping Mar
PHOTO CREDIT: Jeremy Bittermann, courtesy EHDD

The Radiator

- Location: Portland, OR
- 5 story, Type IIIB
- 36,000 sf
- Speculative, Urban, Mid-rise, Regular Footprint

FLOORS 2-4 + TENANT IMPROVEMENT

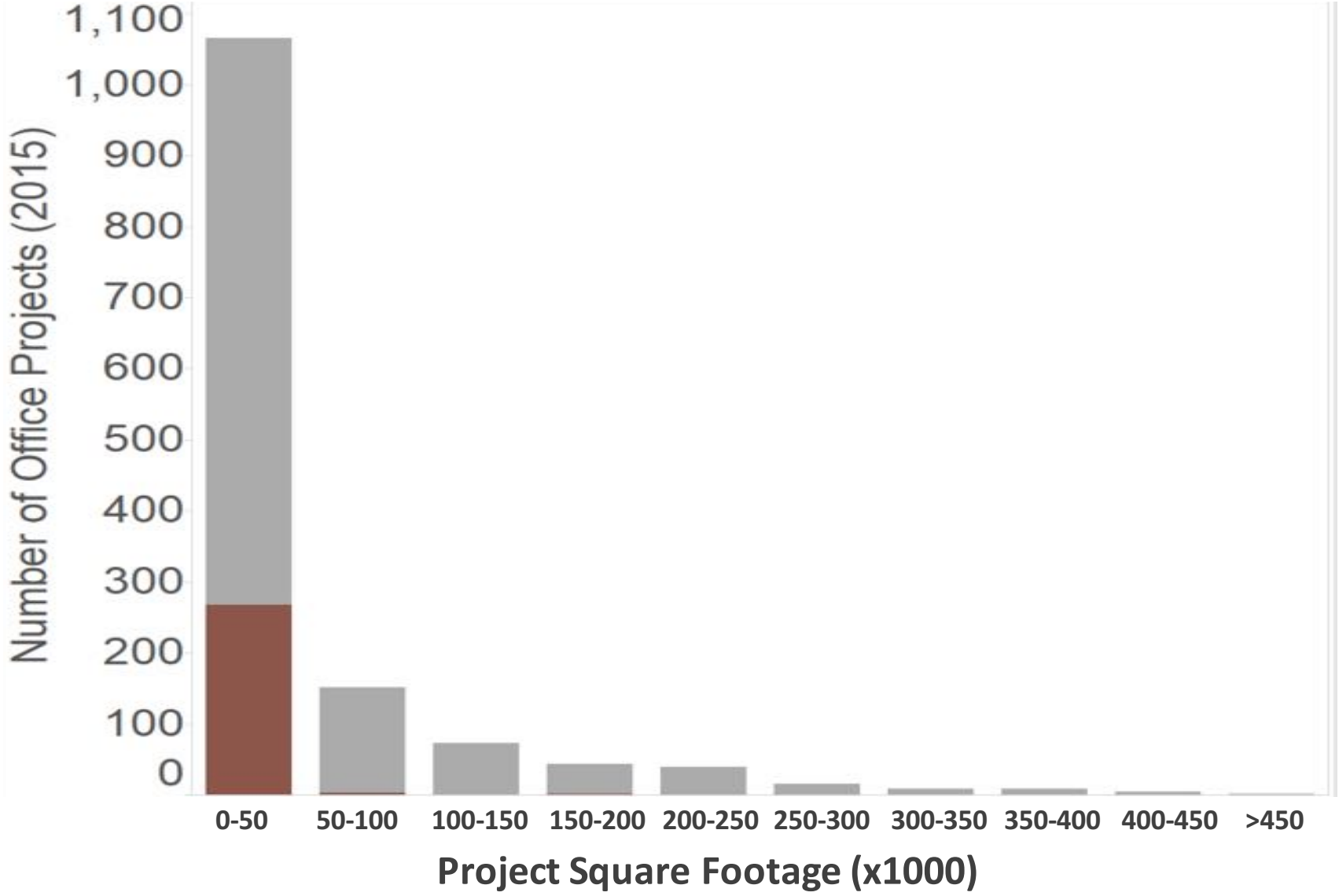
ARCHITECT: PATH Architecture
ENGINEER: Munzing Structural Engineering
PHOTO CREDIT: Josh Partee & Caitlin Murray

“Does the building code even allow offices to be built in wood?”

PREFACE: 2015 WoodWorks Market Analysis

Wood is under utilized in office construction:

- Nearly 75% of offices are less than 50k sf in total building area

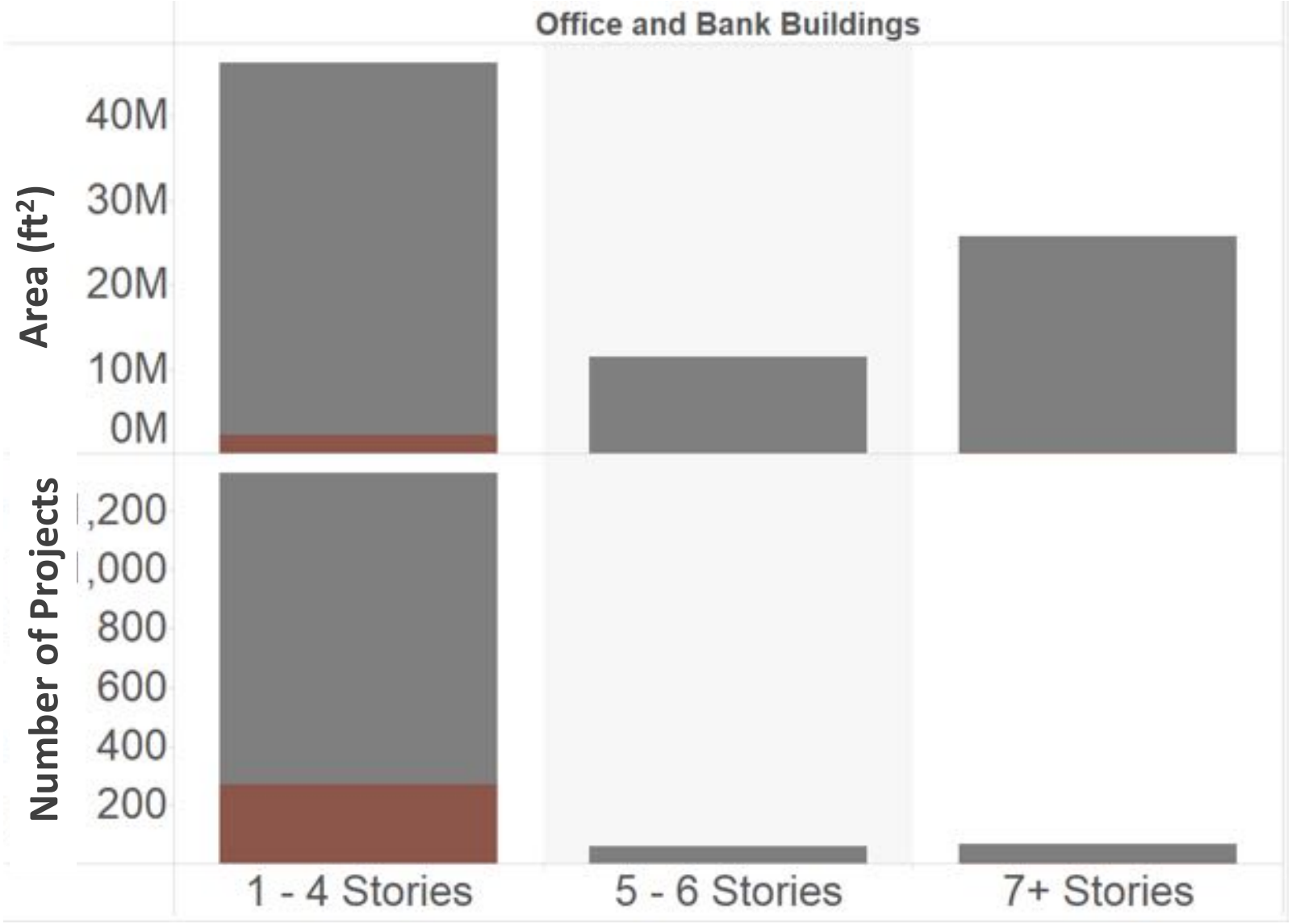


PREFACE: 2015 WoodWorks Market Analysis

Wood is under utilized in office construction:

- Nearly 75% of offices buildings are less than 50k sf in total building area
- More than 85% of office projects are 4 stories or less

Most Office Projects Could Be Wood Construction



Heights and Areas

Multi Story Business Occupancy (B)

Based on IBC 2012 Table 503 w/ allowable increases

Height and Area (With Allowable Increases)	IIB	IIIB	VA	VB
Stories[1]	4	4	4	3
Height[1] (ft)	75	75	70	60
Max Story Area[2] (ft^2)	69k	57k	54k	27k
Total Building Area[3] (ft^2)	207k	171k	162k	81k

[1] Assumes NFPA 13 sprinklers throughout (IBC 504.2)
[2] Assumes NFPA 13 sprinklers throughout (IBC 506.3)
[3] Assumes 3 or more number of stories (IBC 506.4)

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

Heights and Areas

Multi Story Business Occupancy (B)

Based on IBC 2012 Table 503 w/ allowable increases

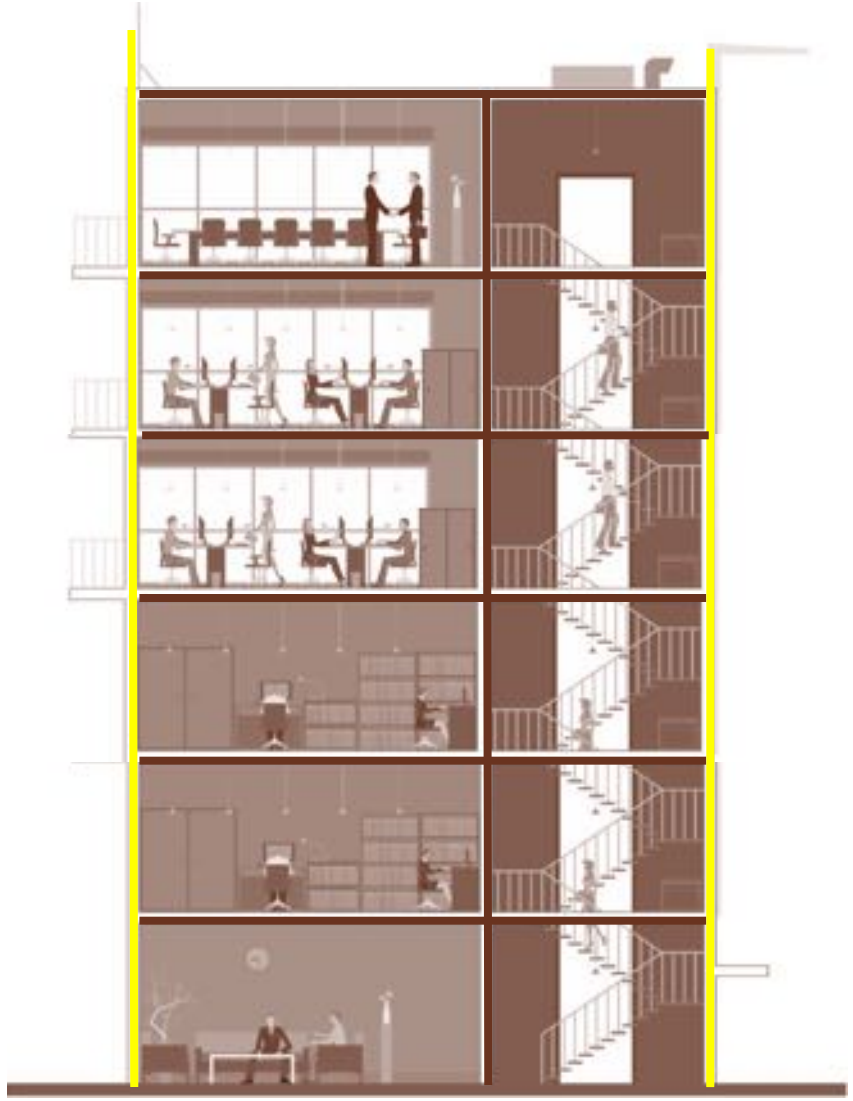
Construction Type	IIA	IIIA	IV
Stories[1]	6	6	6
Height[1](ft)	85	85	85
Story Area[2] (ft^2)	112.5k	85.5k	108k
Total Building Area[3] (ft^2)	337.5k	256.5k	324k

[1] Assumes NFPA 13 sprinklers throughout (IBC 504.2)
[2] Assumes NFPA 13 sprinklers throughout (IBC 506.3)
[3] Assumes 3 or more number of stories (IBC 506.4)

**ASCE7 12.2-1 limits wood shear wall seismic systems to 65' in height in SDC D,E,F

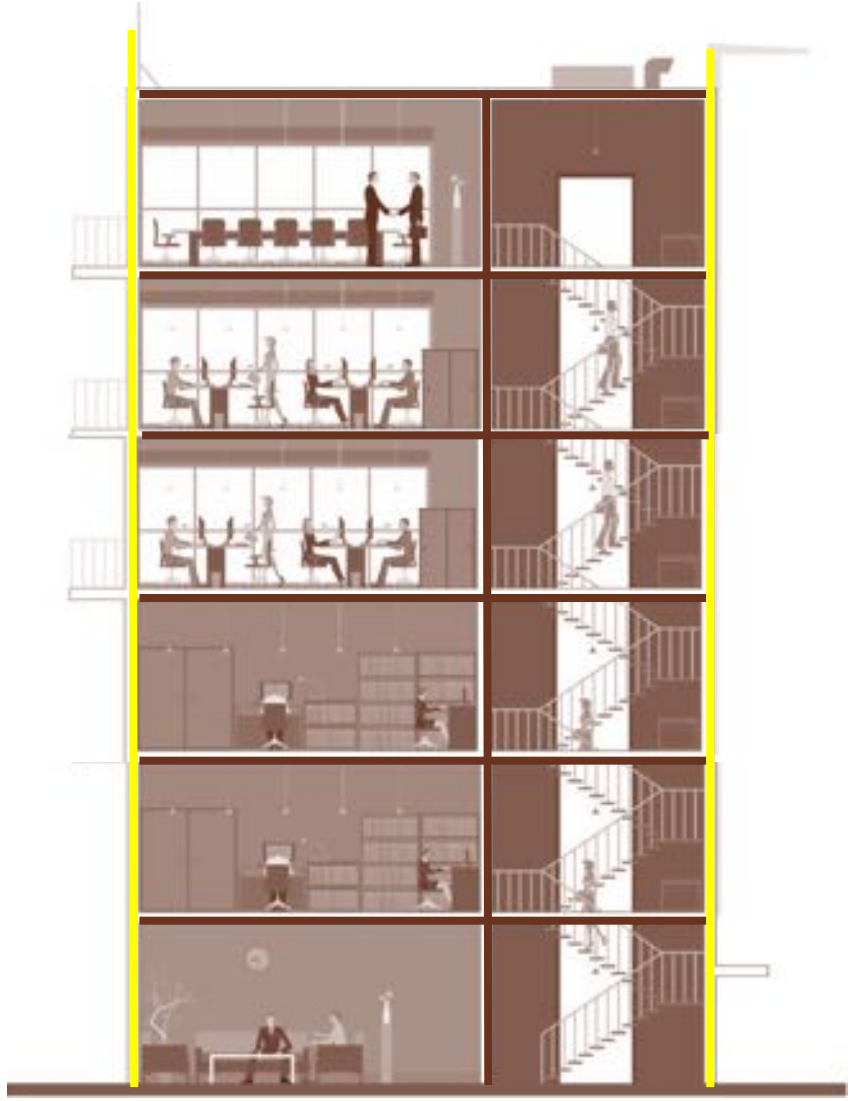
Type III Construction

- Exterior walls are of noncombustible materials.
- Fire Retardant Treated (FRT) wood is permitted in exterior walls of 2hr fire rating or less.
- Interior building elements are of any material permissible by code.



Type IV Construction

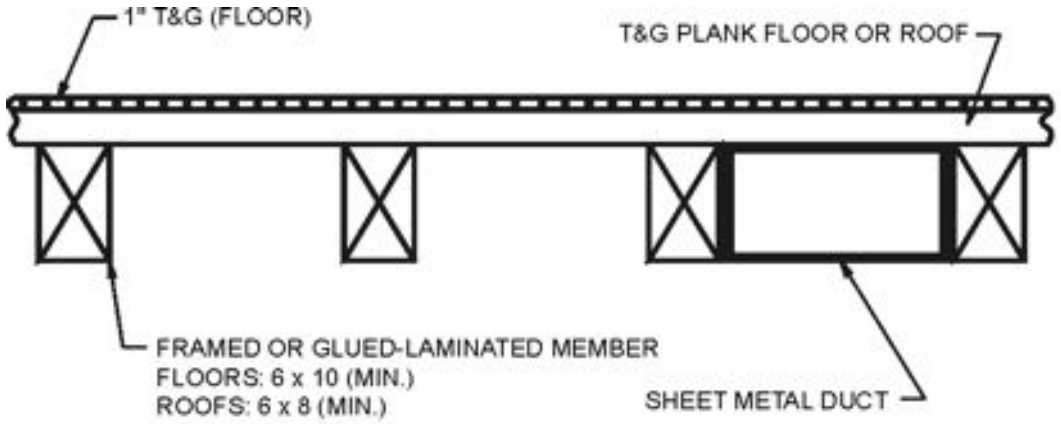
- Exterior walls are of noncombustible materials.
- Fire Retardant Treated (FRT) wood is permitted in exterior walls of 2hr fire rating or less.
- Interior building elements are of solid or laminated wood without concealed spaces.
- Interior elements have required minimum sizes.
- Partitions are of solid wood OR of 1hr fire-resistance



Type IV Construction

Element	Minimum Size/ Description
Roof Decking	• 1-1/8" Wood Structural Panel • 2x thick nominal (solid sawn or glulam planks) • 15/32” WSP over 3x wide min on edge solid • other w/equivalent fire resistance
Roof Framing	4x6 beam
Floor Decking	• 1x T&G flooring or 15/32” WSP over 3x min sawn or glulam planks, splined or tongue and grooved • 15/32” WSP over min 4x wide on edge well spiked w/no continuous joints except at support
Floor Framing	6x10 beam/ 8x8 timber truss
Column	• 8x8 supporting floor • 6x8 supporting roof only
Partitions	• (2) Layers of 1” boards • 4” thick laminated construction • 1hr rated assembly
Exterior Members	With 20’ min of separation, above sizes apply

Type IV Construction – Concealed Spaces



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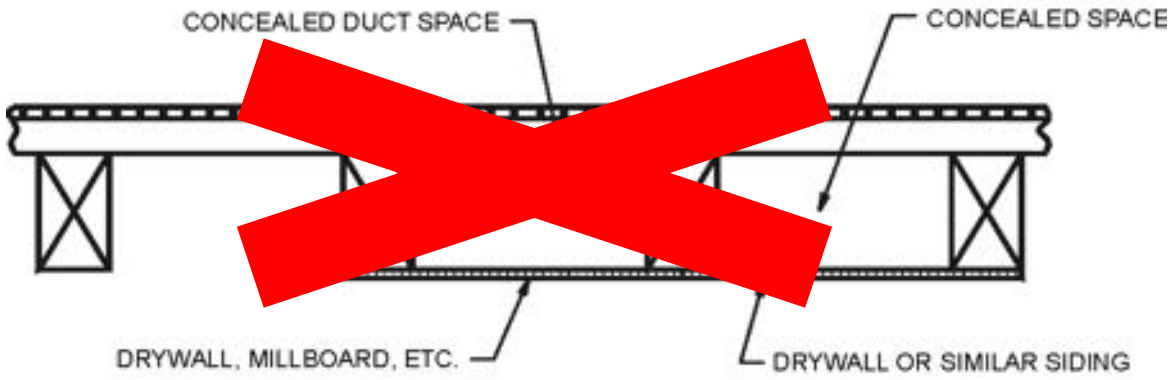

PROHIBITED INSTALLATION

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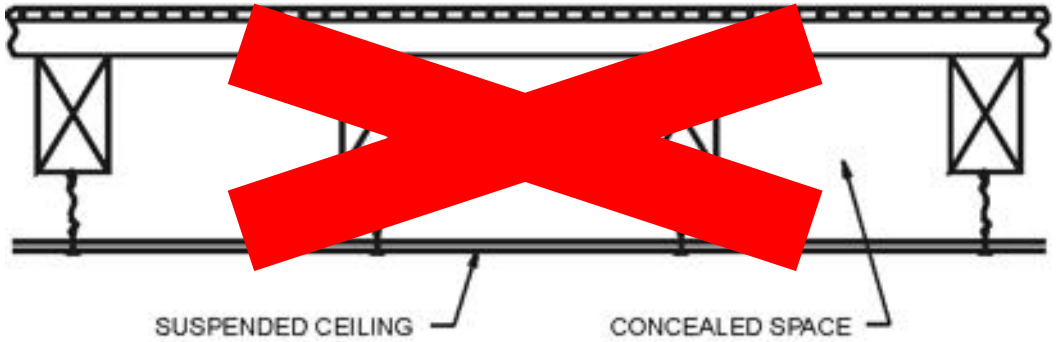


PROHIBITED INSTALLATION

Comparing Other Construction Type Distinctions

Fire Rating of Structural Elements	IIA	IIB
IBC Table 601		
Exterior bearing walls (hrs)	1	0
Interior bearing walls (hrs)	1	0
All other elements (hrs)	1	0
IBC Table 602		
X < 10 ft	1	1
10 ft ≤ X < 30 ft	1	0
X ≥ 30 ft	0	0
IBC Chapter 7		
Shaft Walls (IBC 713.4)[1]	2 max	2 max
Fire Walls (706.4) – B Occupancy	2	2

[1] Shaft Walls are constructed as Fire Barriers (707.3.1). Shaft Enclosures require a 2hr rating when connecting 4 stories or more (1hr for less than 4 stories).

3hr fire-resistance rating
2hr fire-resistance rating
1hr fire-resistance rating

Comparing Other Construction Type Distinctions

Fire Rating of Structural Elements	IIIA	IIIB	IV
IBC Table 601			
Exterior bearing walls (hrs)	2	2	2
Interior bearing walls (hrs)	1	0	1/HT
All other elements (hrs)	1	0	HT
IBC Table 602 (Exterior Non-bearing walls)			
X < 10 ft	1	1	1
10 ft ≤ X < 30 ft	1	1	1
X ≥ 30 ft	0	0	0
IBC Chapter 7			
Shaft Walls (IBC 713.4)[1]	2 max	2max	2 max
Fire Walls (706.4) – B Occupancy	3	3	3

[1] Shaft Walls are constructed as Fire Barriers (707.3.1). Shaft Enclosures require a 2hr rating when connecting 4 stories or more (1hr for less than 4 stories).

3hr fire-resistance rating
2hr fire-resistance rating
1hr fire-resistance rating

Exterior Walls (IBC 705)

705.5 Fire Resistance Ratings.

Exterior walls shall be fire-resistance rated in accordance with Tables 601 and 602 and this section. The required fire-resistance rating of exterior walls with a fire separation distance of greater than 10 feet (3048 mm) shall be rated for exposure to fire from the inside. The required fire-resistance rating of exterior walls with a fire separation distance of less than or equal to 10 feet (3048 mm) shall be rated for exposure to fire from both sides.

Example: Type IIIB or Type IV building

- Non-Bearing @ 20 ft
  - 1hr rated from inside exposure
- Non-Bearing @ 5 ft
  - 1hr rated from exposure on both sides

Sprinkler Requirements in Buildings

Advantages:

- Increased height
  - Additional 20ft
  - Additional Story
- Increased area by up to 4x
  - Additional 2x for multi-story
  - Additional 3x for single story
- If not needed for height and area, can be used as a substitute for 1hr rating of floor/roof **(not under 2015 IBC)**

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[d]	B	A[d]	B	HT	A[d]	B
Primary structural frame[g] (see Section 202)	3[a]	2[a]	1	0	1	0	HT	1	0
Bearing walls									
Exterior[f, g]	3	2	1	0	2	2	2	1	0
Interior	3[a]	2[a]	1	0	1	0	1/HT	1	0
Nonbearing walls and partitions Exterior				See Table 602					
Nonbearing walls and partitions Interior[e]	0	0	0	0	0	0	See Section 602.4.6	0	0
Floor construction and associated secondary member (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and associated secondary members (see Section 202)	$1^1/_2$[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

d. An approved automatic sprinkler system in accordance with Section 903.3.1.1 shall be allowed to be substituted for 1-hour fire-resistance-rated construction, provided such system is not otherwise required by other provisions of the code or used for an allowable area increase in accordance with Section 506.3 or an allowable height increase in accordance with Section 504.2. The 1-hour substitution for the fire resistance of exterior walls shall not be permitted.

Exposing Framing – Heavy/Mass Timber

Fire Rating of Structural Elements	IIB	IIIB	IV
IBC Table 601			
Exterior bearing walls (hrs)	0	2	2
Interior bearing walls (hrs)	0	0	1/HT
All other elements (hrs)	0	0	HT
IBC Table 602			
X < 10 ft	1	1	1
10 ft ≤ X < 30 ft	0	1	1
X ≥ 30 ft	0	0	0
IBC Chapter 7			
Shaft Walls (IBC 713.4)[1]	2 max	2 max	2 max
Fire Walls (706.4) – B Occupancy	2	3	3

[1] Shaft Walls are constructed as Fire Barriers (707.3.1). Shaft Enclosures require a 2hr rating when connecting 4 stories or more (1hr for less than 4 stories).

For up to 4 stories….

Protection not typically required:

- Floors/Ceilings
- Columns
- IIIB Interior Walls

Could be protected by calculated fire resistance:

- Exterior Walls
- Shaft walls

Exposing Framing – Heavy/Mass Timber

Fire Rating of Structural Elements	IIA	IIIA	IV
IBC Table 601			
Exterior bearing walls (hrs)	1	2	2
Interior bearing walls (hrs)	1	1	1/HT
All other elements (hrs)	1	1	HT
IBC Table 602			
X < 10 ft	1	1	1
10 ft ≤ X < 30 ft	1	1	1
X ≥ 30 ft	0	0	0
IBC Chapter 7			
Shaft Walls (IBC 713.4)[1]	2 max	2 max	2 max
Fire Walls (706.4) – B Occupancy	2	3	3

[1] Shaft Walls are constructed as Fire Barriers (707.3.1). Shaft Enclosures require a 2hr rating when connecting 4 stories or more (1hr for less than 4 stories).

For up to 6 stories….

<u>Could be protected by calculated fire resistance :</u>

- Floors/Ceilings (for IIIA)
- Exterior Walls
- Shaft walls

The difference in allowances for concealed spaces in floor/ceilings commonly has designers classifying as III for offices.

Exposing Framing – Heavy/Mass Timber

IBC 703.3 Alternate Methods for determining fire resistance

- Prescriptive designs per IBC 721.1
- Calculations in accordance with IBC 722
- Fire-resistance designs documented in sources
- Engineering analysis based on a comparison
- Alternate protection methods as allowed by 104.11

IBC 722 Calculated Fire Resistance

"…The calculated *fire resistance* of exposed wood members and wood decking shall be permitted in accordance with Chapter 16 of ANSI/AF&PA *National Design Specification for Wood Construction (NDS)*."

NDS Chapter 16 Fire Design of Wood Members

Limited to calculating fire resistance up to 2 hours.

Char rate varies based on endurance required, product type and lamination thickness. Equations and tables provided.

TR10 and NDS commentary are helpful in implementing permitted calculations.

Exposing Framing – 2015 NDS

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

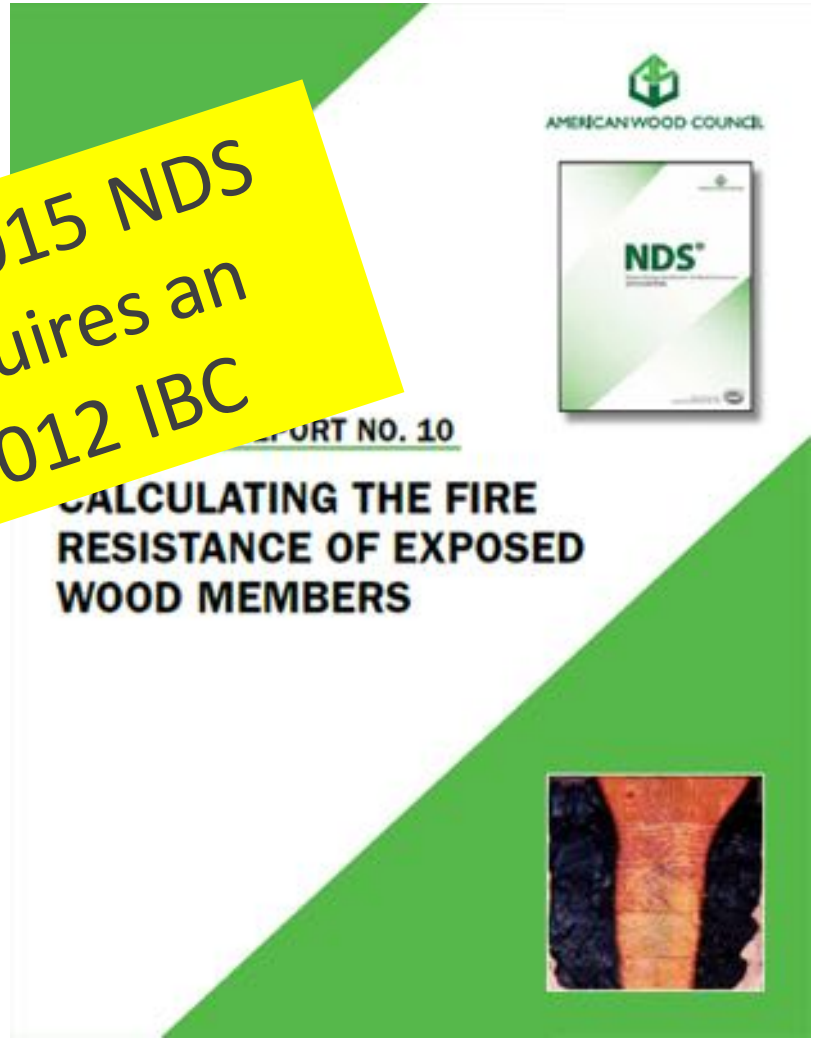
Required Fire Endurance (hr.)	Effective Char Rate, β_{eff} (in./hr.)	Effective Char Depth, a_{char} (in.)
1-Hour	1.8	1.8
1½-Hour	1.67	
2-Hour	1.58	

Table 16.2.1B Effect

with β_n

Required Fire Endurance (hr.)	Effecti…								
	lamination …icknesses, 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	3.9	3.8	3.6	3.6	3.6

NOTE: Reference the 2015 NDS and the 2015 IBC requires an AMMR under the 2012 IBC



Source: 2015 NDS Chapter 16
http://awc.org/pdf/codes-standards/publications/nds/AWC-NDS2015-ViewOnly-1411.pdf

http://awc.org/pdf/codes-standards/publications/tr/AWC-TR10-1510.pdf

Cobra Campus

- Location: Spokane, WA
- 1 story, Type V
- 11,500 sf
- Exposed Wood Roof Trusses and Decking

ARCHITECT: Uptic Studios
ENGINEER: DCI Engineers
PHOTO CREDIT: Oliver Irwin Photography

Green Office

- Location: Berkeley, CA
- 2 story, Type VB
- 15,200 sf
- Exposed Wood Roof Trusses and Decking

ARCHITECT: Marcy Wong Don Logan Architects
ENGINEER: Gregory P. Luth Associates
PHOTO CREDIT: Billy Hustace Photography

Exposing Framing - Interior Finishes

Wood Interior Finish (IBC 803.9)

- Building occupancy
- Location of the material in the building
- Sprinklers or no sprinklers

Flame Spread and Smoke-developed index

- ASTM E84 or UL 723 Test Method

PROJECT: TBWA/Chiat/Day Offices – San Francisco, CA
ARCHITECT: Marmol Radziner & Associates
ENGINEER: Tipping Mar and Associates
PHOTO CREDIT: Benny Chan

Class	Flame Spread Index*	Smoke Development Index
A	0 - 25	0 - 450
B	30 - 75	0 - 450
C	80 - 200	0 - 450

*DCA 1 explains that flame spread values are rounded to the nearest multiple of 5

Exposing Framing - Interior Finishes

AWC's DCA 1 lists Flame Spread and Smoke Developed Indices for a number of softwood lumber species

Species	Flame Spread Index	Smoke Developed Index	Flame Spread Class
Douglas-Fir	70	80	B
Hem-fir species group	60	70	B
Pine, Eastern White	70	110	B
Pine, Southern Yellow	70	165	B
Spruce, Black (4" thick, 3 layers of cross laminations)	35	55	B

http://www.awc.org/pdf/codes-standards/publications/dca/AWC-DCA1-FlameSpreadPerformance-1509.pdf

Exposing Framing - Interior Finishes

INTERIOR WALL AND CEILING FINISH REQIRMENTS FOR B OCCUPANCY (IBC Table 803.11)	FINISH CLASS
SPRINKLERED	
Interior exit stairways, ramps and exit passageways [1]	B
Corridors and enclosure for exit access stairways and ramps	C
Rooms and enclosed spaces	C
NONSPRINKLERED	
Interior exit stairways ramps and exit passageways [1]	A
Corridors and enclosure for exit access stairways and ramps	B
Rooms and enclosed spaces	C

[1] Buildings less than 3 stories above grade, Class B interior finish for nonsprinklered buildings and class C interior finish for sprinklered buildings shall be permitted in interior exit stairways and ramps.

PROJECT: Radiator – Portland, OR
ARCHITECT: Path Architecture
ENGINEER: Munzing Structural Engineering
PHOTO CREDIT: Josh Partee Photography

Heavy Timber Exemption (803.3) - Exposed portions of structural members complying with requirements of Type IV shall not be subject to interior finish requirements

Sprinklers in Floor Cavities – NFPA 13 Standard

- Floor cavities will require sprinklers when:
  - NFPA 13 sprinklers are required for Height & Area increases or as a substitute for fire rating (only under 2012 IBC)
  - Cavity does not contain fire stops partitioning space to a volume of 160 ft3 or less
    - 1” max furred ceiling and batt insulation provided at bottom flange
    - Fire stop is equal to material used in joist web
- Additional Sprinkler heads in floor cavities may increase the cost of NFPA 13 sprinklers system

8.15.1.2.6 *Concealed spaces formed by ceilings attached to composite wood joist construction either directly or onto metal channels not exceeding 1 in. (25 mm) in depth, provided the joist channels are firestopped into volumes each not exceeding 160 ft^3 (4.5 m^3) using materials equivalent to the web construction and at least 3-1/2 in. (90 mm) of batt insulation is installed at the bottom of the joist channels when the ceiling is attached utilizing metal channels, shall not require sprinkler protection.*

8.15.1.2.8 *Concealed spaces within wood joist construction and composite wood joist construction having noncombustible insulation filling the space from the ceiling up to the bottom edge of the joist of the roof or floor deck, provided that in composite wood joist construction the joist channels separated into volumes each not exceeding 160 ft^3 (4.5 m^3) to the full depth of the composite wood joist with material equivalent to the web construction, shall not require sprinkler protection.*

Sprinklers in Floor Cavities – How might this change design?

Without Sprinklers

Construction Type	IIIA	VA	IIIB	IV	VB
Stories	5	3	3	5	2
Height(ft)	65	50	55	65	40
Story Area[2] (ft^2)	28.5k	18k	19k	36k	9k
Total Building Area[3] (ft^2)	85.5k	54k	571k	108k	27k

With Sprinklers

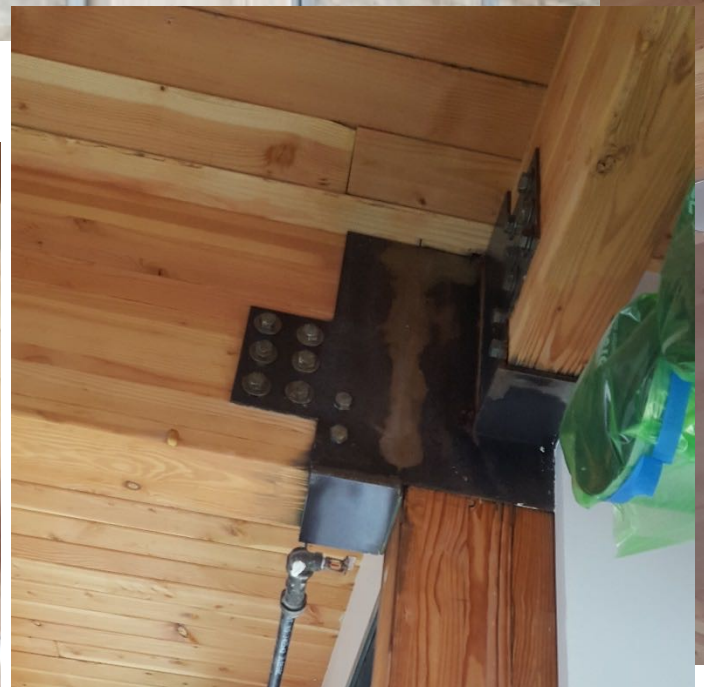
	CONCEALED SPACES		OPPORTUNITY TO EXPOSE		
Construction Type	IIIA	VA	IIIB	IV	VB
Stories	6	4	4	6	3
Height(ft)	85	70	75	85	60
Story Area[2] (ft^2)	85.5k	54k	57k	108k	27k
Total Building Area[3] (ft^2)	256.5k	162k	171k	324k	81k

[3] Assumes 3 or more number of stories (IBC 506.4)

Exposed Connections

No Protection Required if:

- Type IIIB, IV, VB based on primary frame* requirements of Table 601
- Not part of any assembly otherwise required to be fire rated



*primary frame does not apply to repetitive framing members typical in light frame and only applies to wood construction in post and beam applications

Exposed Connections

Protection required if:

- Type IIIA, VA based on primary frame requirements of Table 601
- Where connection is part of an assembly required to be fire resistance rated
  - Occupancy separation per 508.4
  - Elements are part of fire barriers, fire walls, fire partitions

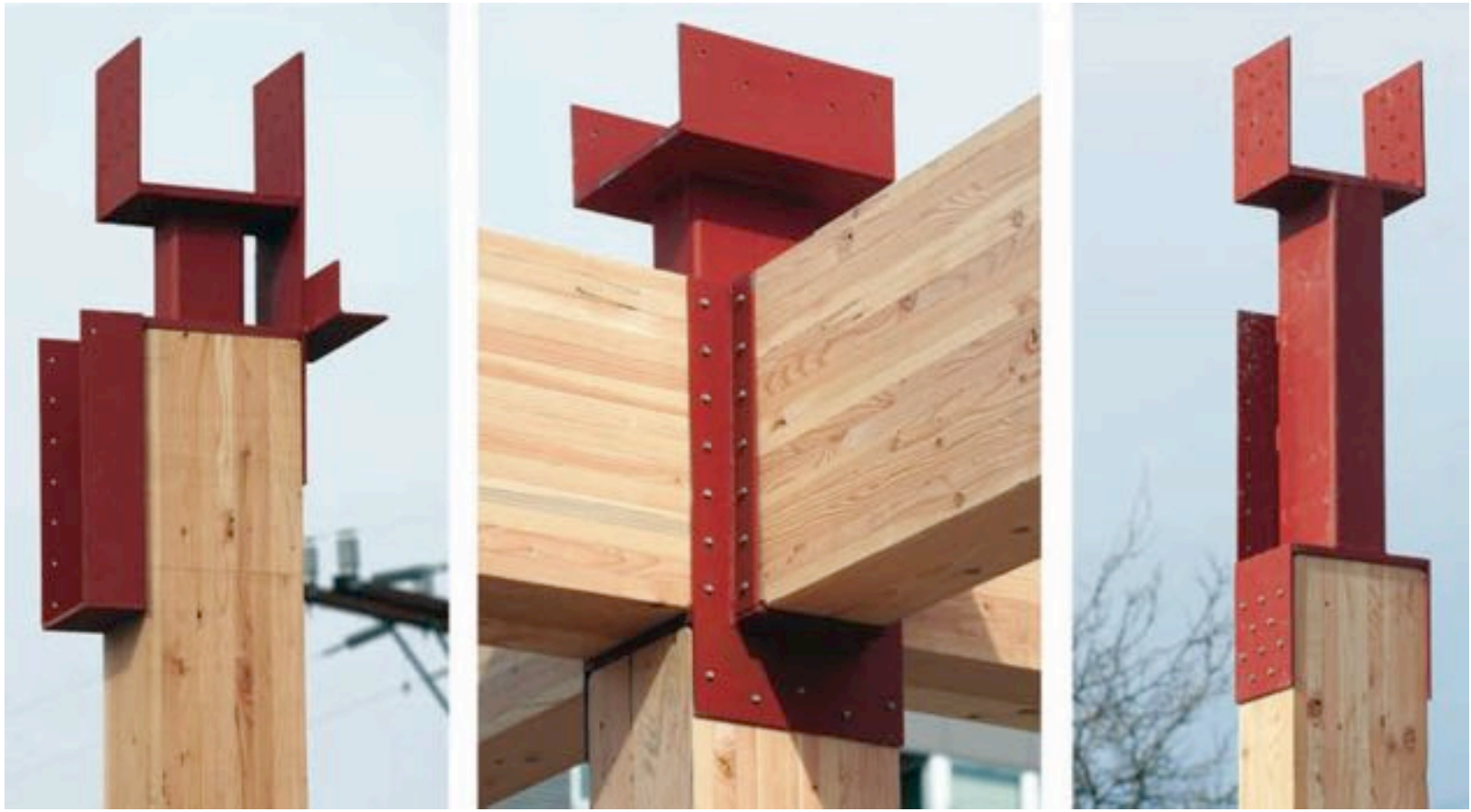
Protected Connection Options:

- Encapsulating connection in gypsum
- Concealing connection in the wood member can protect by calculated fire resistance of exposed wood
- Fire resistant coating or intumescent paint on the steel connector may be accepted by AHJ
- OR... be creative

Exposed Connections

Creative Connection:

- Allows full bearing
- Avoids crushing perpendicular to grain
- Addresses shrinkage
- Aids in constructability



PROJECT: Bullitt Center – Seattle, WA
ARCHITECT: Miller Hull Partnership
ENGINEER: PAE Consulting Engineers
PHOTO CREDIT: John Stamets

Exposing Framing – Light Frame

Fire Rating of Structural Elements	IIIB	VB
IBC Table 601		
Exterior bearing walls (hrs)	2	0
Interior bearing walls (hrs)	0	0
All other elements (hrs)	0	0
IBC Table 602		
X < 10 ft	1	1
10 ft ≤ X < 30 ft	1	0
X ≥ 30 ft	0	0
IBC Chapter 7		
Shaft Walls (IBC 713.4)[1]	2 max	2 max
Fire Walls (706.4) – B Occupancy	3	2

[1] Shaft Walls are constructed as Fire Barriers (707.3.1). Shaft Enclosures require a 2hr rating when connecting 4 stories or more (1hr for less than 4 stories).

Protection is not typically required:

- Floors/Ceilings
- Columns
- Interior walls
- VB Exterior Walls

Could be protected by calculated fire resistance :

- IIIB Exterior Walls
- Shaft walls

Exterior Finishes: IBC 1406

Combustible exterior wall coverings for Type I, II, III and IV construction shall be:

- Shall not exceed 10% of exterior wall surface where fire separation is 5 feet or less
- Shall be limited to 40 feet above grade plane
- If constructed of FRT shall not be limited in surface area where fire separation is 5 feet or less and shall be permitted up to 60 feet above grade

Wood finishes are not limited in Type V construction.

Note: Exterior weather exposure requires additional specification to address UV and moisture.

PROJECT: GSA Office Building – Albuquerque, NM
ARCHITECT: Page Southerland Page, LLP
ENGINEER: Walter P. Moore & Associates
PHOTO CREDIT: Patrick Coulie Photography

Exterior Finishes: IBC 1405.5

Wood Veneers on exterior walls of Type I, II, III and IV construction shall be:

- Shall be 1” nominal thick minimum OR .438” exterior hardboard OR .375 wood structural panel
- Shall not exceed 40’ in height above grade OR if FRT shall not exceed 60 feet above grade
- Attached to or furred from noncombustible backing (FRT exterior wall framing in Types III and IV construciton may comply with such noncombustible req.)
- Shall not project more than 24” from building

Wood or Wood-based products are exempt from NFPA 268 testing for ignition resistance.

Note: Exterior weather exposure requires additional specification to address UV and moisture.

PROJECT: One North
ARCHITECT: Holst Architecture | ENGINEER: Froelich Engineers

PROJECT: Radiator
ARCHITECT: PATH Architecture | ENGINEER: Munzing Structural Engineer
PHOTO CREDITS: Josh Partree Phtorapy & Catlin Murray

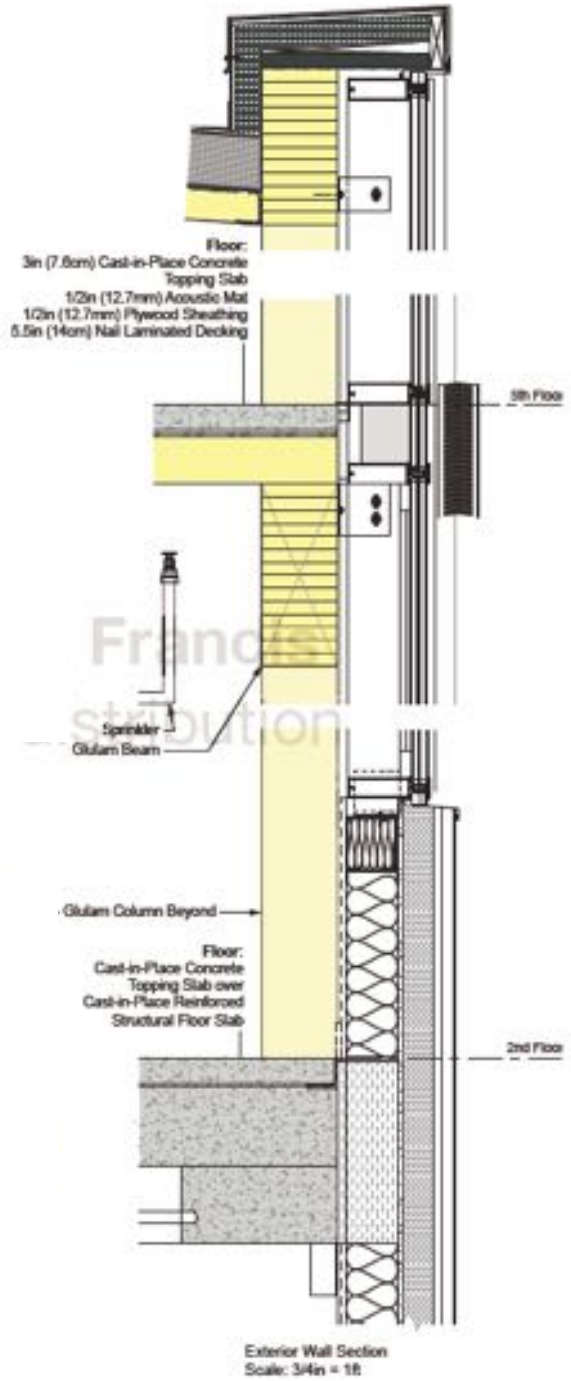
Nonbearing Exterior Walls

Curtain walls (ie. Non-Bearing Exterior Walls):

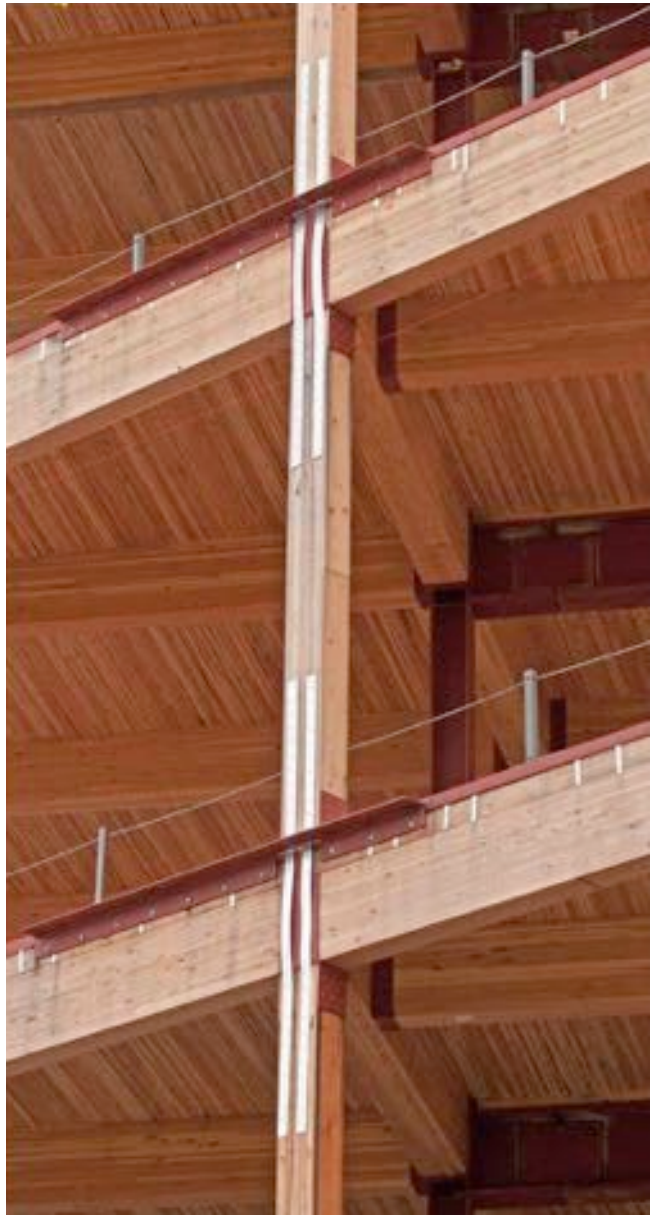
- Act primarily as a building envelope
- Enable an increased amount of glazing (natural light)
- Traditionally of lighter weight materials

The same curtain wall systems used on concrete/steel frames can be used on timber frames

PROJECT: SAC Federal Credit Union Headquarters
ARCHITECT: LEO A DALY
ENGINEER: LEO A DALY
PHOTO CREDIT: Brad Anderson

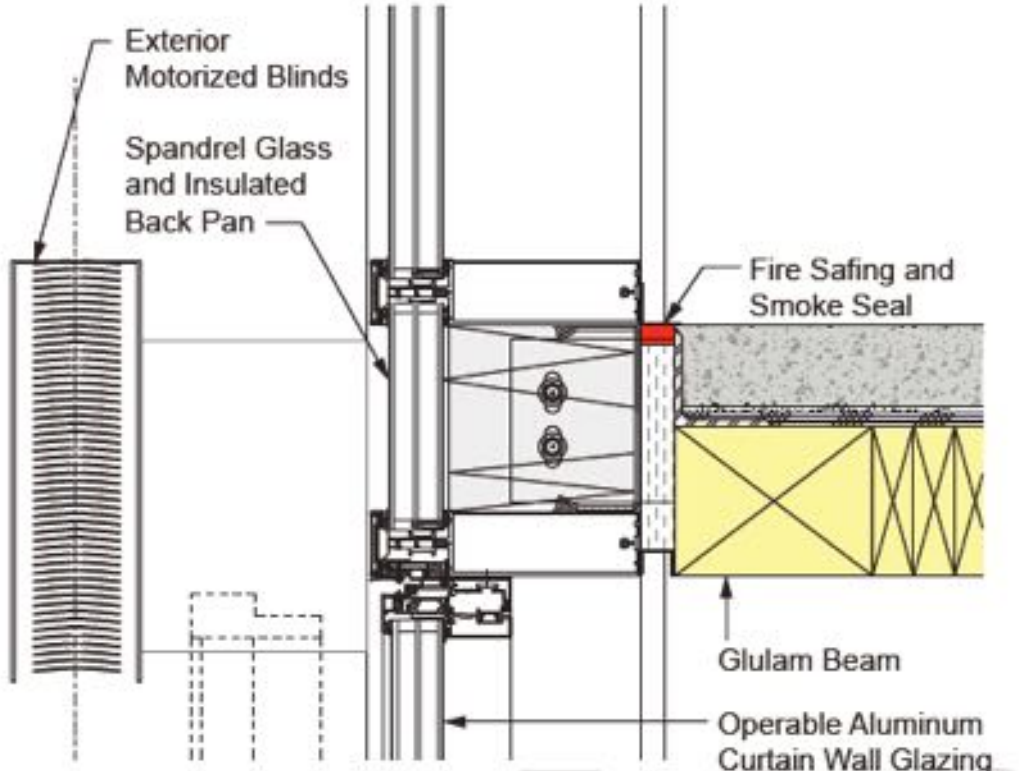


Exterior Wall Section
Scale: 3/4in = 1ft

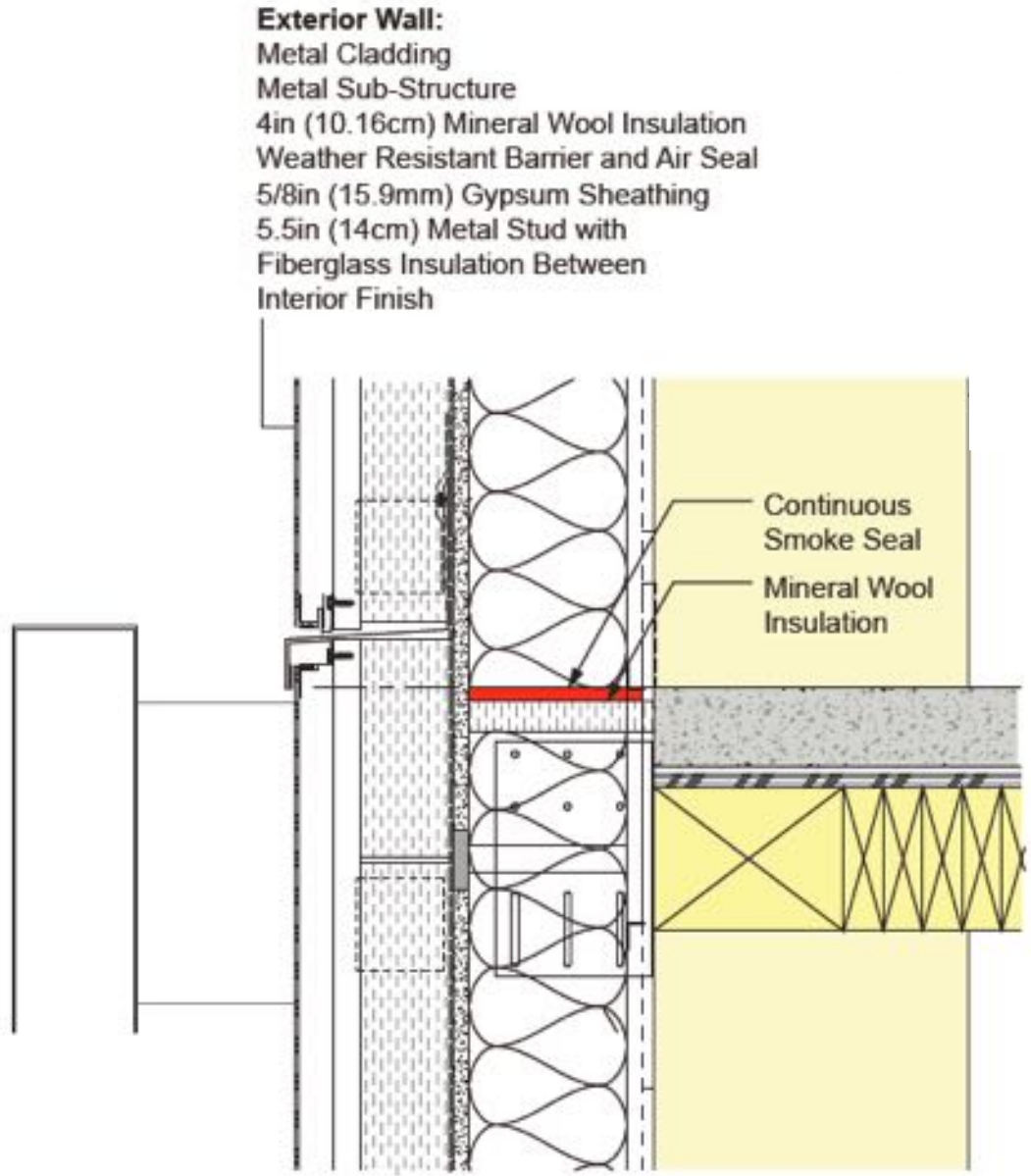


ARCHITECT: Miller Hull Architects
Source: Solid Wood, Mayo

Curtain Wall Detailing



Detail at Upper Level Curtain Wall Mullion and Floor Interface



Detail at Exterior Metal Wall Panel and Floor Interface

ARCHITECT: Miller Hull Architects
Source: Solid Wood, Mayo

Promega GMP Facility – client & staff reception area

- Location: Madison, WI.
- Type IV construction
- 2 stories of heavy timber and CLT
- 52,000 sf. Addition

ARCHITECT: Uihlein-Wilson Architects, EwingCole | ENGINEER: EwingCole
PHOTO CREDIT: Aitor Sanchez/Ewing Cole

Nonbearing Exterior Walls

FRT Wood Curtain walls in Type III and IV construction:

- Reduce the fire rating requirements for exterior walls
- Can enable increased levels of panelization
- May be more cost effective than traditional curtain wall systems

PROJECT: LCT One – Dornbirn, Austria
ARCHITECT: Hermann Kaufmann
ENGINEER: Merz Kley Partner
PHOTO CREDIT: CREE

Nonbearing Exterior Walls & Partitions

603.1 Allowable Materials

Combustible materials shall be permitted in buildings of Type I or II construction in the following applications in accordance with 603.1.1 through 603.1.3.

Fire-retardant-treated wood shall be permitted in:

1. Nonbearing partitions where the required fire resistance rating is 2 hrs or less
2. Nonbearing exterior walls where fire-resistance rated construction is not required
3. Roof construction including girders, trusses, framing and decking. (Exception in IA exceeding 2 stories where roof is not more than 20' from floor below)

Fire Rating of Structural Elements	IA	IB	IIA	IIB
IBC Table 601				
Nonbearing interior walls/partitions	0	0	0	0
IBC Table 602 (Nonbearing Exterior Walls)				
X < 10 ft	1	1	1	1
10 ft ≤ X < 30 ft	1	1	1	0
X ≥ 30 ft	0	0	0	0

Opportunity for FRT Wood Curtain Walls and Partitions in Types I and II construction

Broadstone Skyline (Building 1)

- Location: Houston, TX
- 5 stories of Type IIIA over 1 story IA podium
- Building 2 will be IIIB over IA podium
- 286K sf

ARCHITECT: EDI Architecture | DEVELOPER: Alliance Residential Group
ENGINEER: Sterling Engineering
PHOTO CREDIT: WoodWorks

“Can wood accommodate the grid spacing needed for adaptable office floor plans?”

Offices Need to be Flexible

- Space mobility
  - Change of tenant
  - Expanding/contracting/modifying spaces to meet existing tenant
- Electrical/Mechanical/IT adaptability
  - Power, voice and data
  - Lighting, space conditioning
- Multiplicity of function
  - Various sized groups at different times
  - Range of interactivity

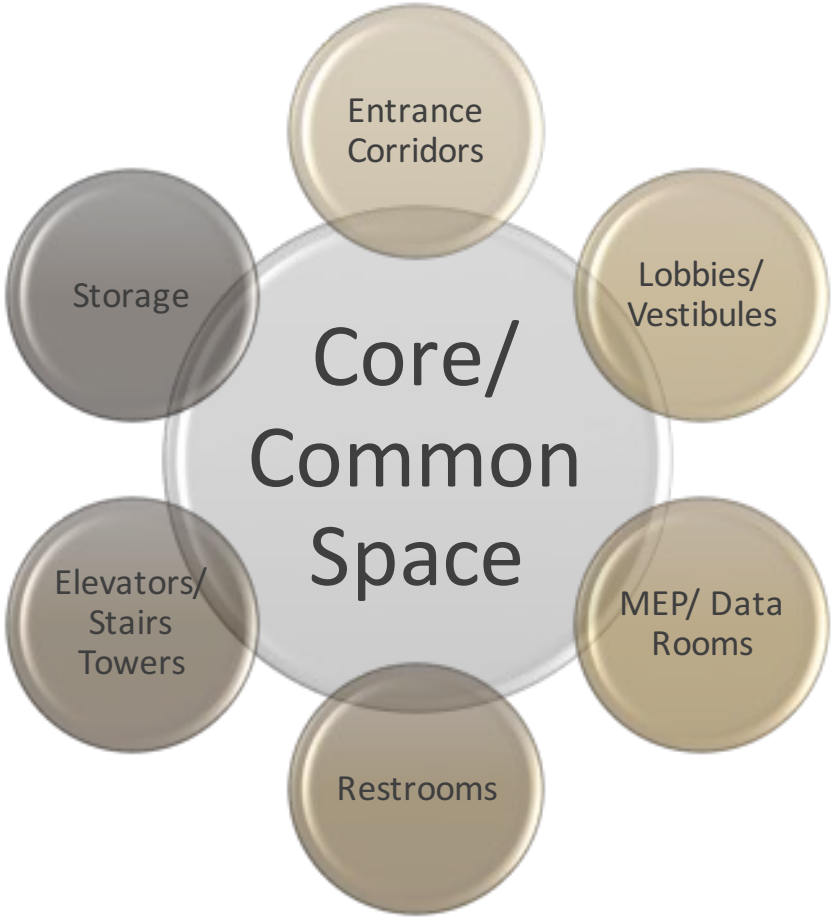
Achieving Flexibility

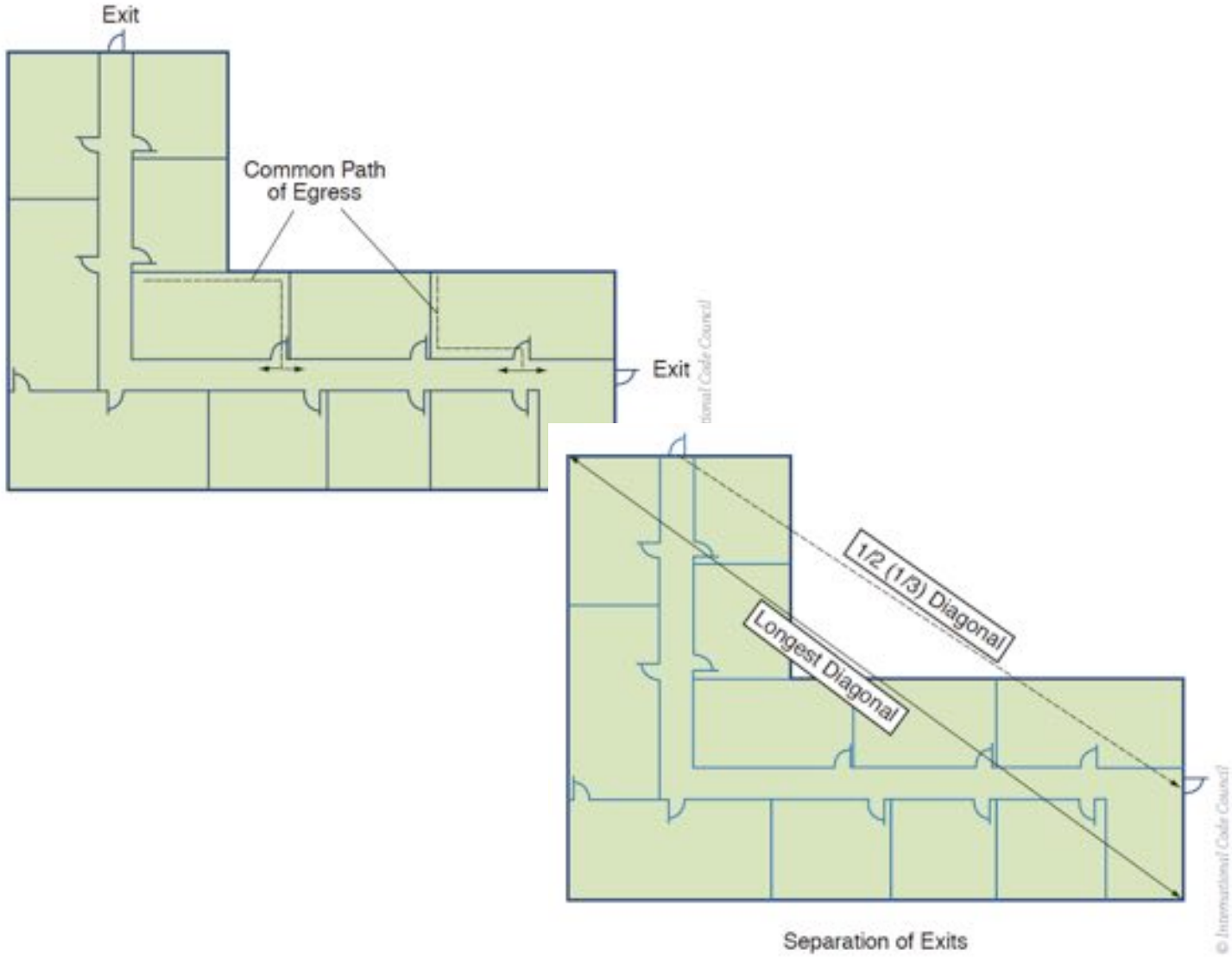
- Space mobility
  - Strategic placements;
  - Mobile workstations
- Electric/Mechanical/IT adaptability
  - Accessible, typically in ceiling or
  - Distributed vertical cores, closets, plenums, outlets/connections
- Multiplicity of function
  - Adaptable furnishings
  - Structure can accommodate changes in loading

Grid Spacing

Floor to Floor Depth

Office Building Layout & Size





Office Building Layout & Size

Conceptual Office Space "Rules of Thumb"	
Executive Offices	200-400 sf
Manager/ Supervisor Offices	120-200 sf (10'x12' minimum)
Open Office Workstation	40-80 sf
Conference Rooms	120 sf (4 person table) – 600 sf (20 person table)
Ancillary Space	~ 30% (with conference room)

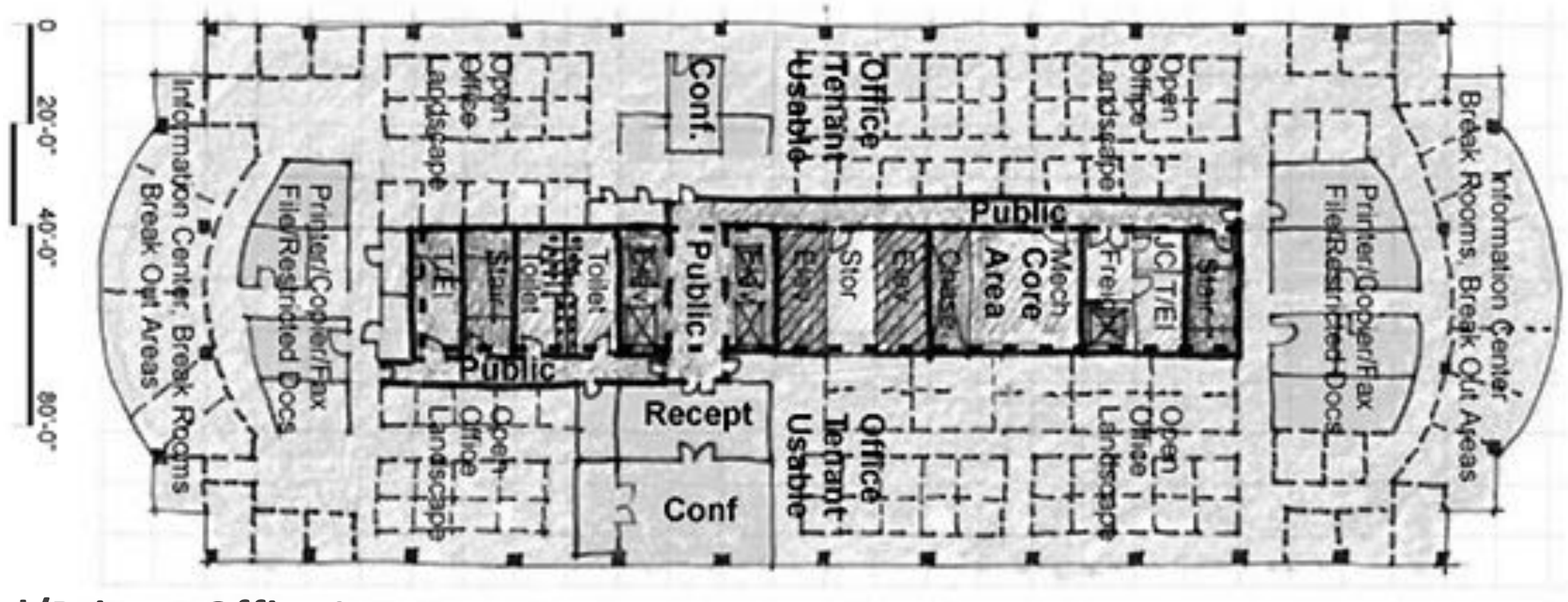
Source: Architectural Graphic Standards by AIA, NIBS Whole Building Design Guide

Office Building Layout & Size

Ancillary Office Spaces:

- Reception/Lobby
- Copy Room
- Break Room
- Server & UPS Rooms
- Record Storage

Open vs. Closed Offices



Closed/Private Office Layouts:

- More typical in narrower building footprint so more offices have windows
- Tenant profile is more "static" => Custom Office Bldg
- Same grid *can* accommodate an open office as well

Source: NIBS Whole Building Design Guide

Open Offices

PHOTO CREDIT: Benny Chan

Why?

- Creates interactive company culture
- Possibly fit more occupants in the space

Benefits:

- Provides for more space mobility
- Allows deeper penetration of daylight

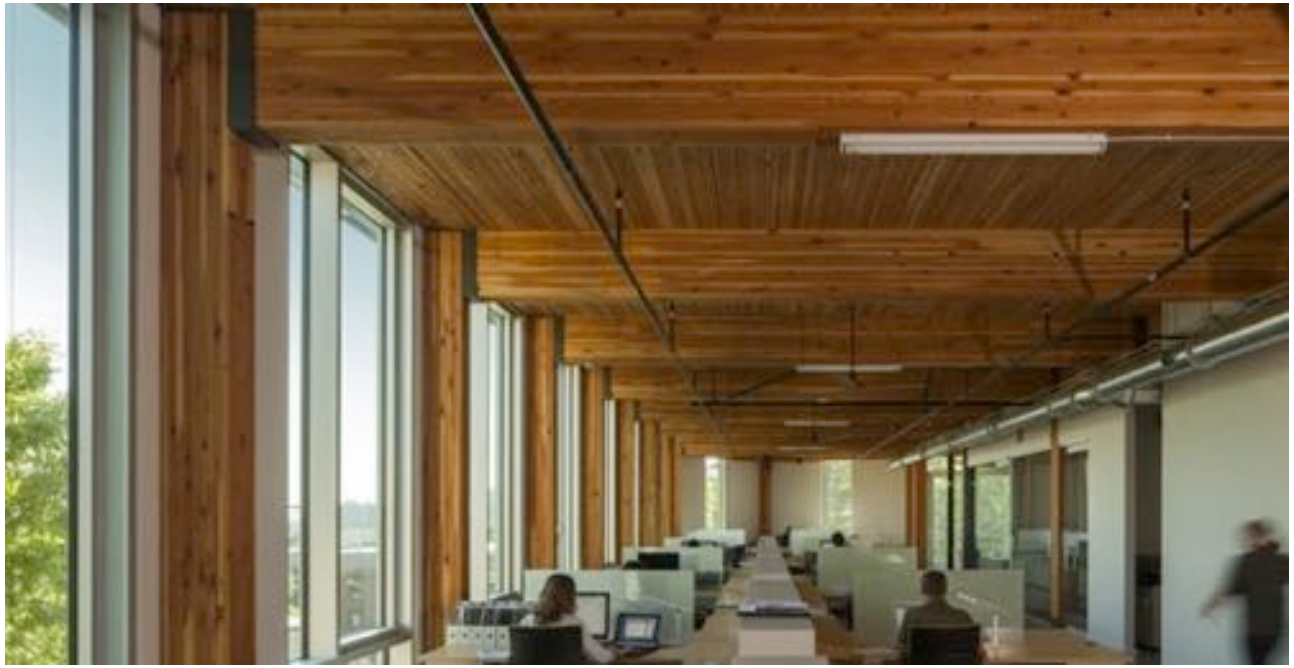
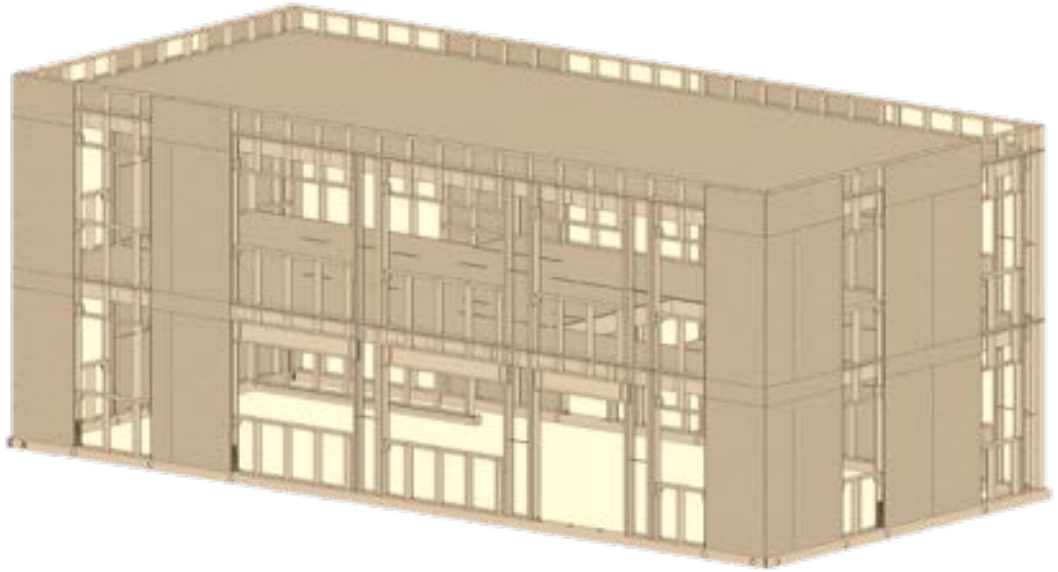


PHOTO CREDIT: John Stamets

Typical Lateral Systems:



Light Frame Diaphragms and Shearwalls:

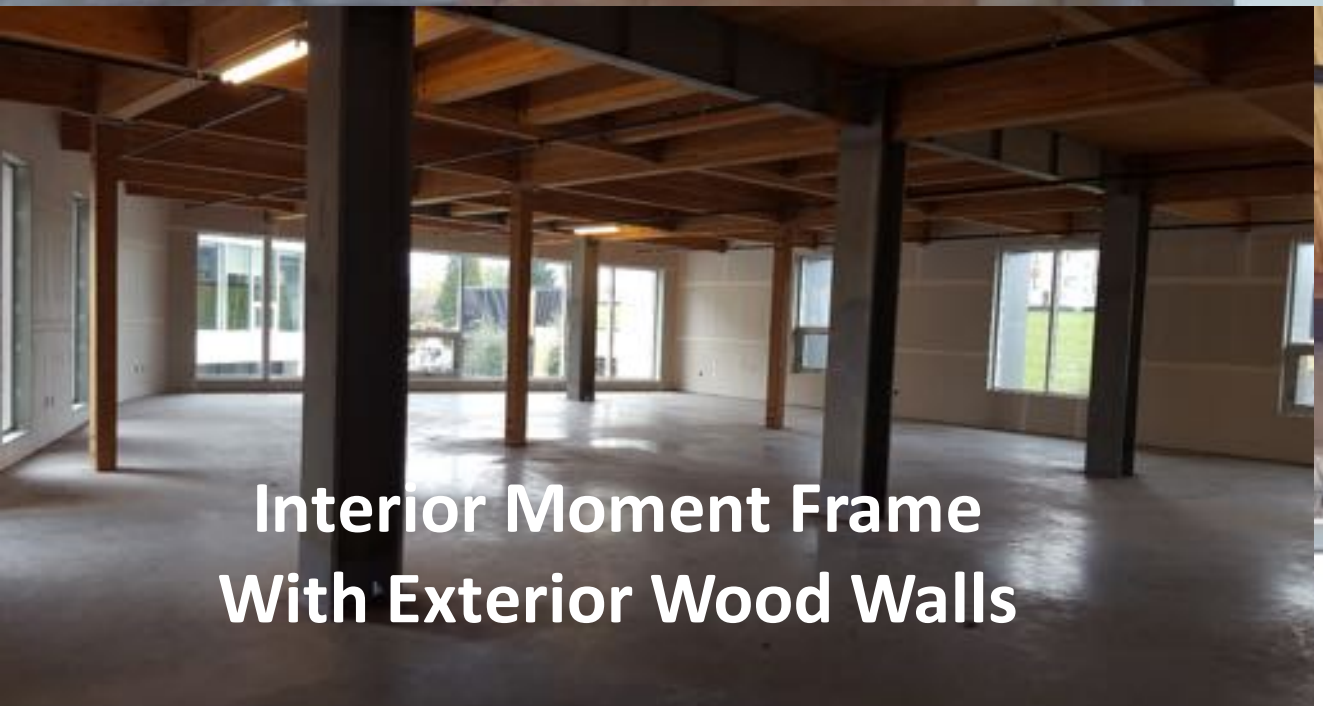
- Typical for 1-5 stories
- Typically assume flexible diaphragm
- Need ample wall at perimeter
- Very compatible with custom/private offices

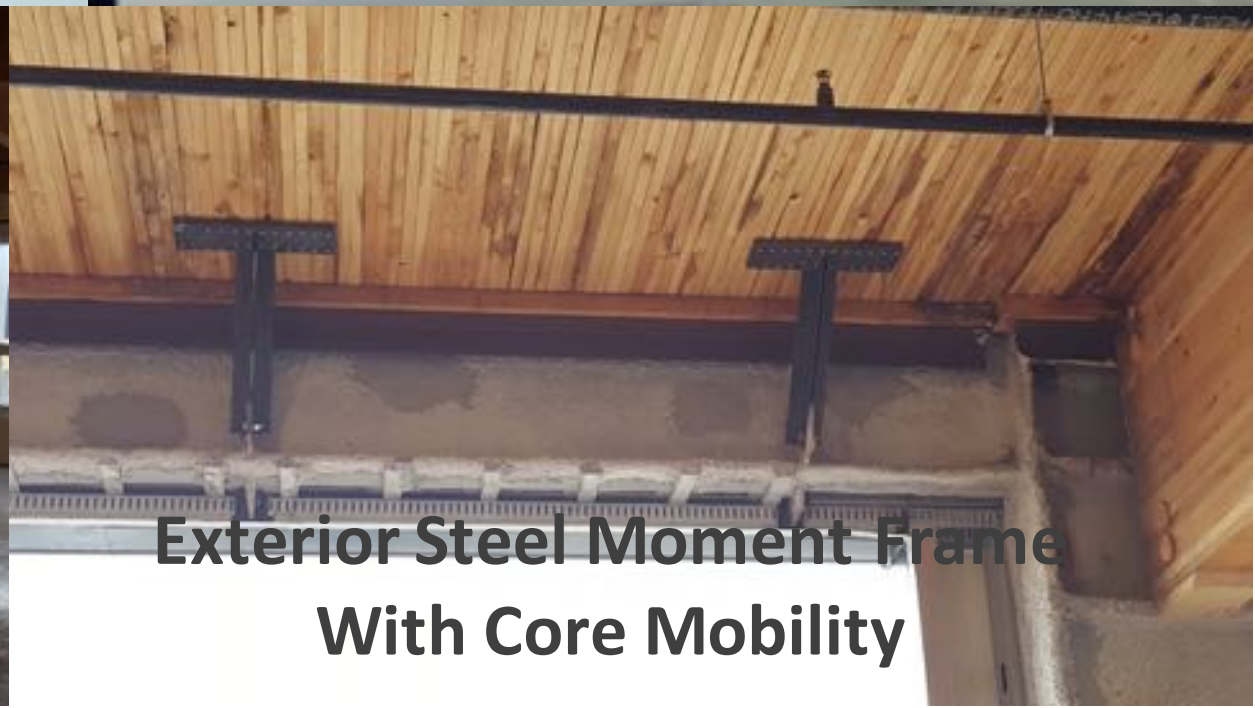
Lateral Core Resisting System:

- May be used in buildings over 3 stories
- Commonly used with glazing/curtain walls
- May use rigid or semi-rigid (if used with frames at exterior) analysis
- Very compatible with speculative/open offices


Interior Shear Walls
With Exterior Glazing Wall


Exterior Reinforced Brick Wall
(Barrier Wall and internal Insulation)


Interior Moment Frame
With Exterior Wood Walls


Exterior Steel Moment Frame
With Core Mobility

Office Floor Design Considerations

Fire Resistance

- Type IIIA/VA: 1hr
- Type IIIB/VB: NA
- Type IV requires prescriptive assemblies
- Occupancy Separation: 1hr w/sprinklers, 2hrs w/o sprinklers

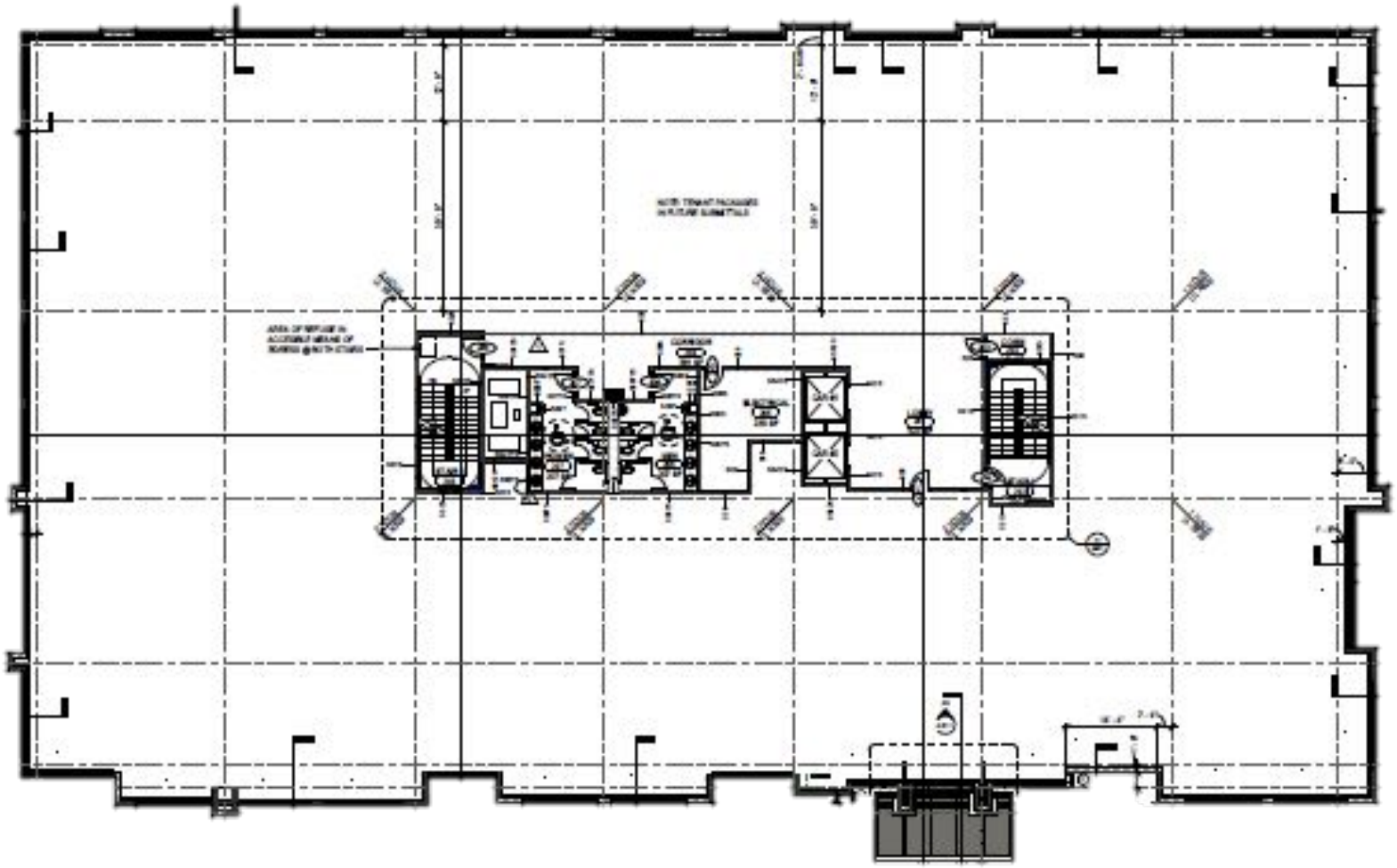
Structural

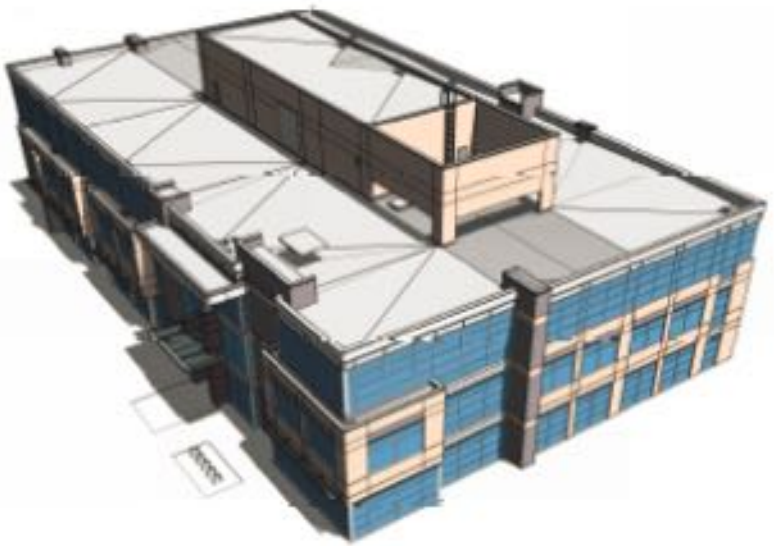
- Office Floor Live Load: 50 psf
- Partition Live Load: 15 psf
- Cooridor Above 1st Floor Live Load: 80 psf
- Common Wood Frame Floor Dead Load: 25-35 psf

Occupant Comfort

- No IBC Acoustic requirement
- GSA varies acoustic requirements based on class of space and open vs. private (STC 50)
- Reducing vibrations and deflection: L/600

Example
Urban, Regular Footprint, Speculative

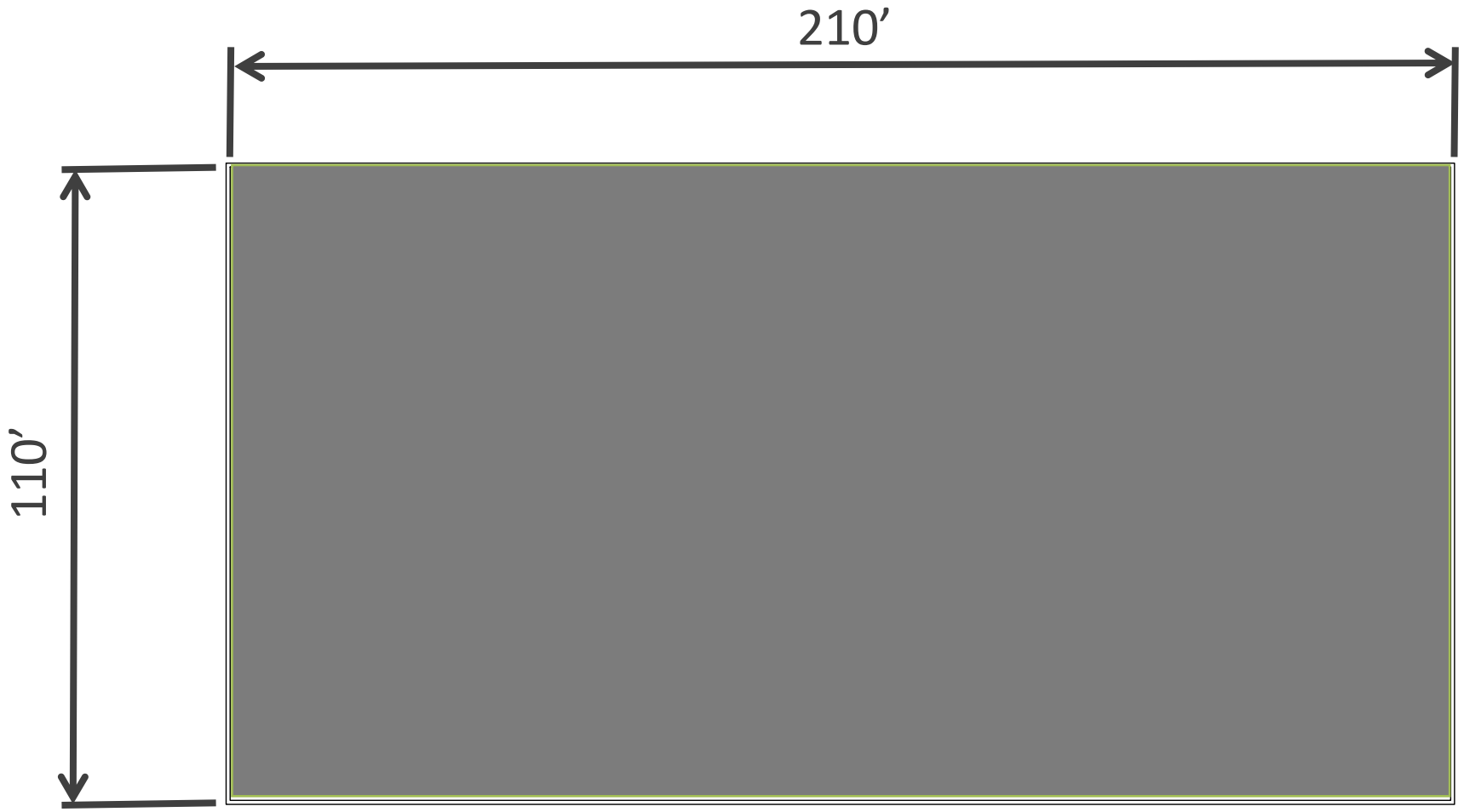




Courtesy of Arch Nexus

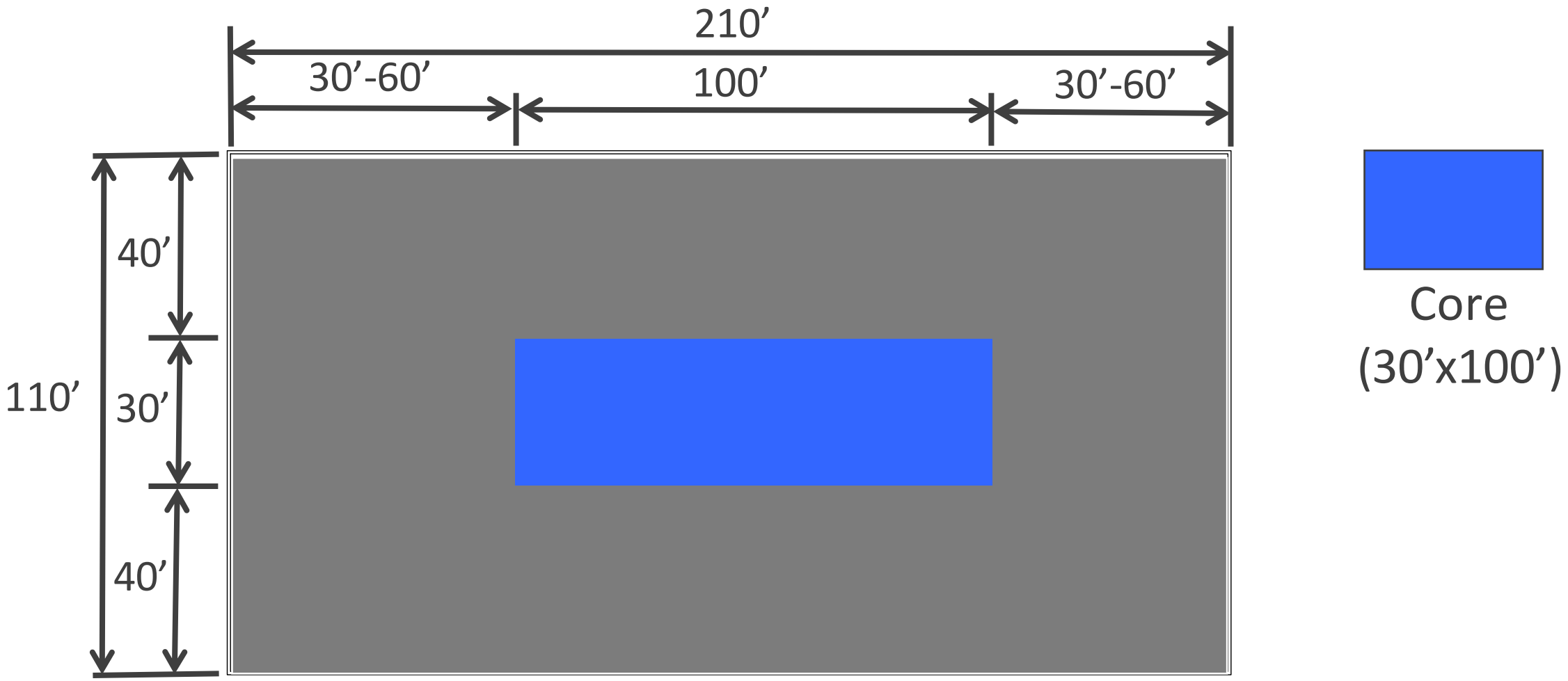
Open Office Building Layout

- Floor Plate: 25,000 sf



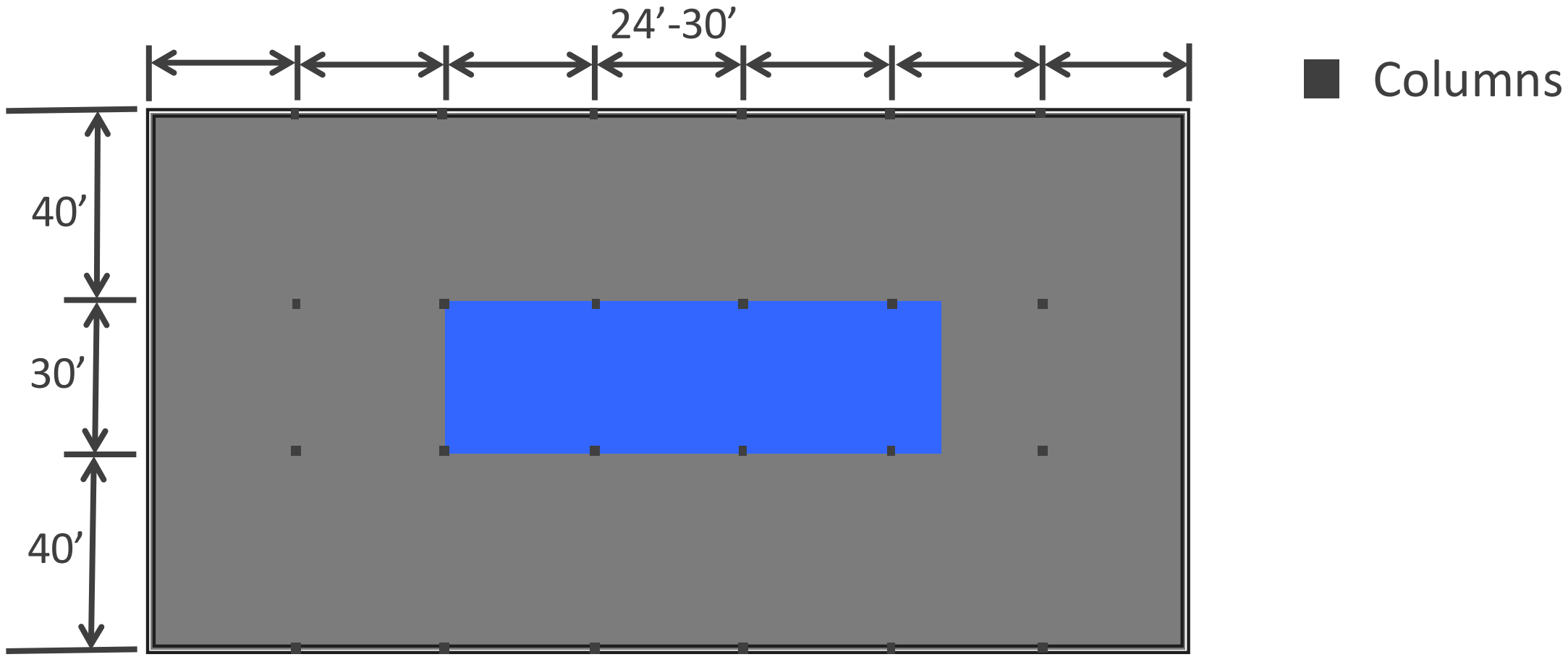
Open Office Building Layout

- Centralized core is fixed



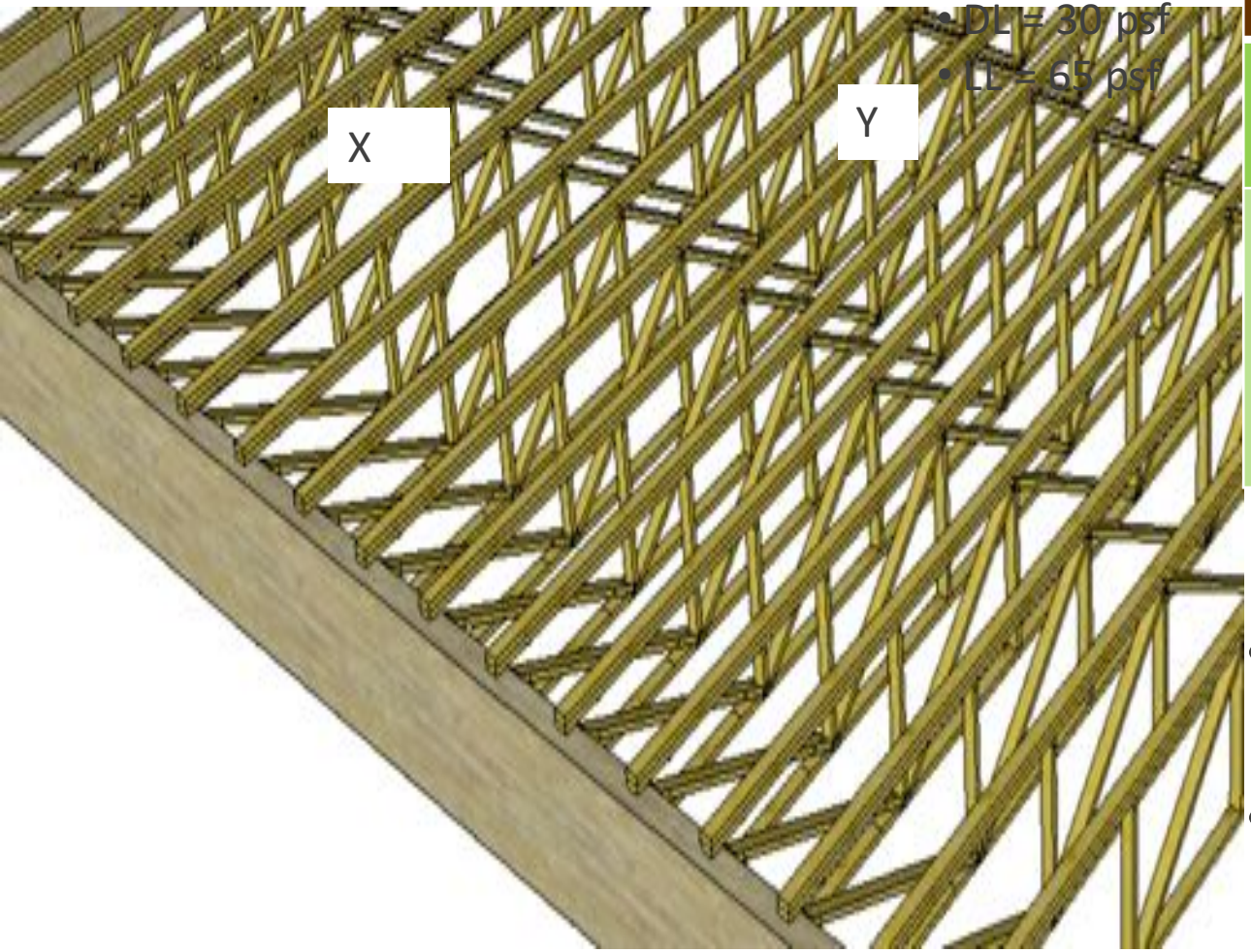
Open Office Building Layout

- Clear span from exterior to core => maximum flexibility
- Common span for steel grid ~ 40 ft



Rectangular Grid

Assumptions:
- DL = 30 psf
- LL = 65 psf



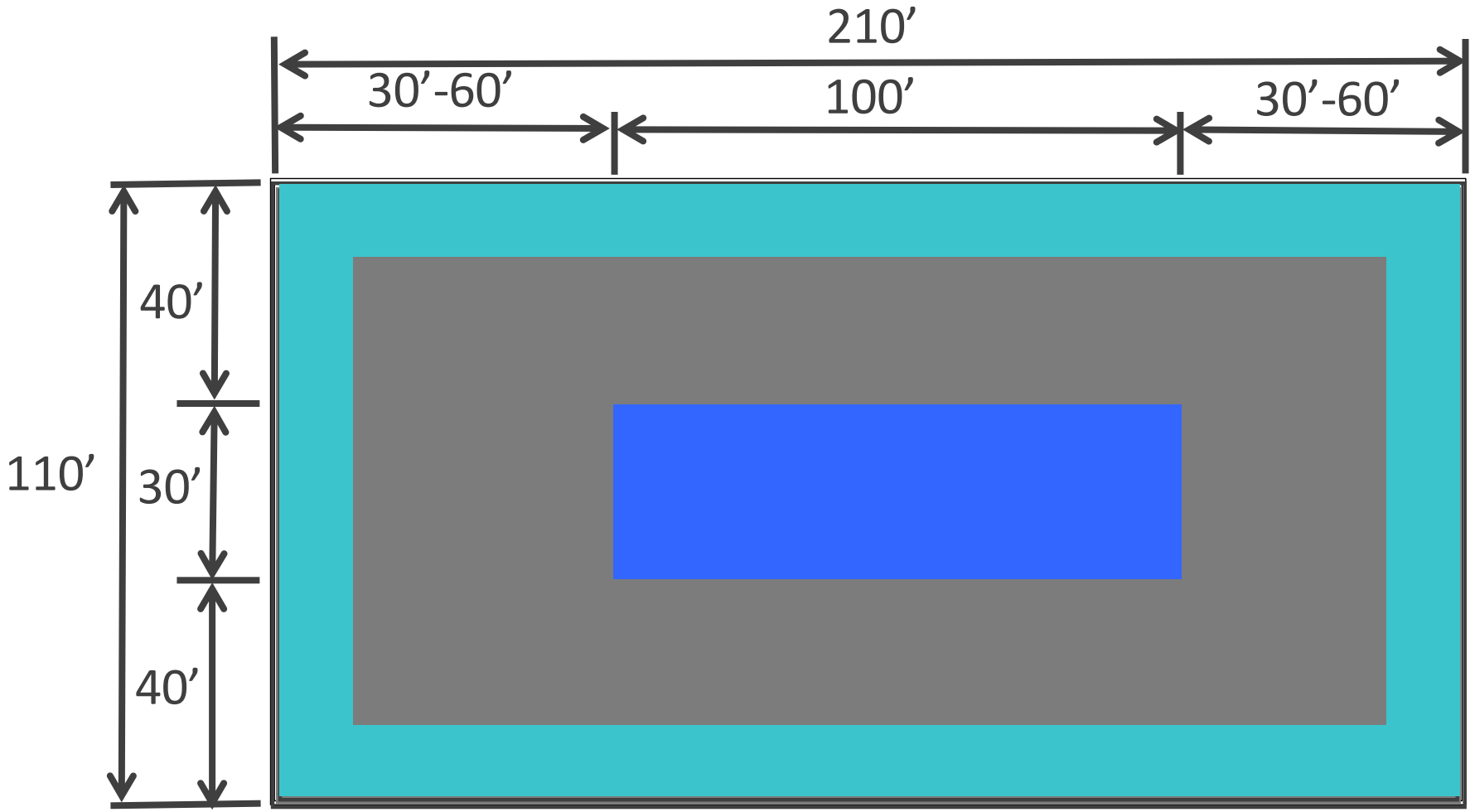
Approximate Member Sizes – Office Floor Framing			
X	Joist Depth	Y	Glulam Girder Size *Assume beams support framing on both sides
40’	38-46” Pinned or Plated Truss	24’	8 ¾”x33” 24F-V4
		30’	10 ¾”x 39” 24F-V4

Note: All member sizing needs to be confirmed by a licensed engineer for conditions of your project.

- Steel Structure Rule of Thumb ~ 1”/depth per 1’/span
- Adapting from a square to rectangular grid, depth of system can be matched

Semi-Open Office Building Layout

- Likely that there will be some private offices

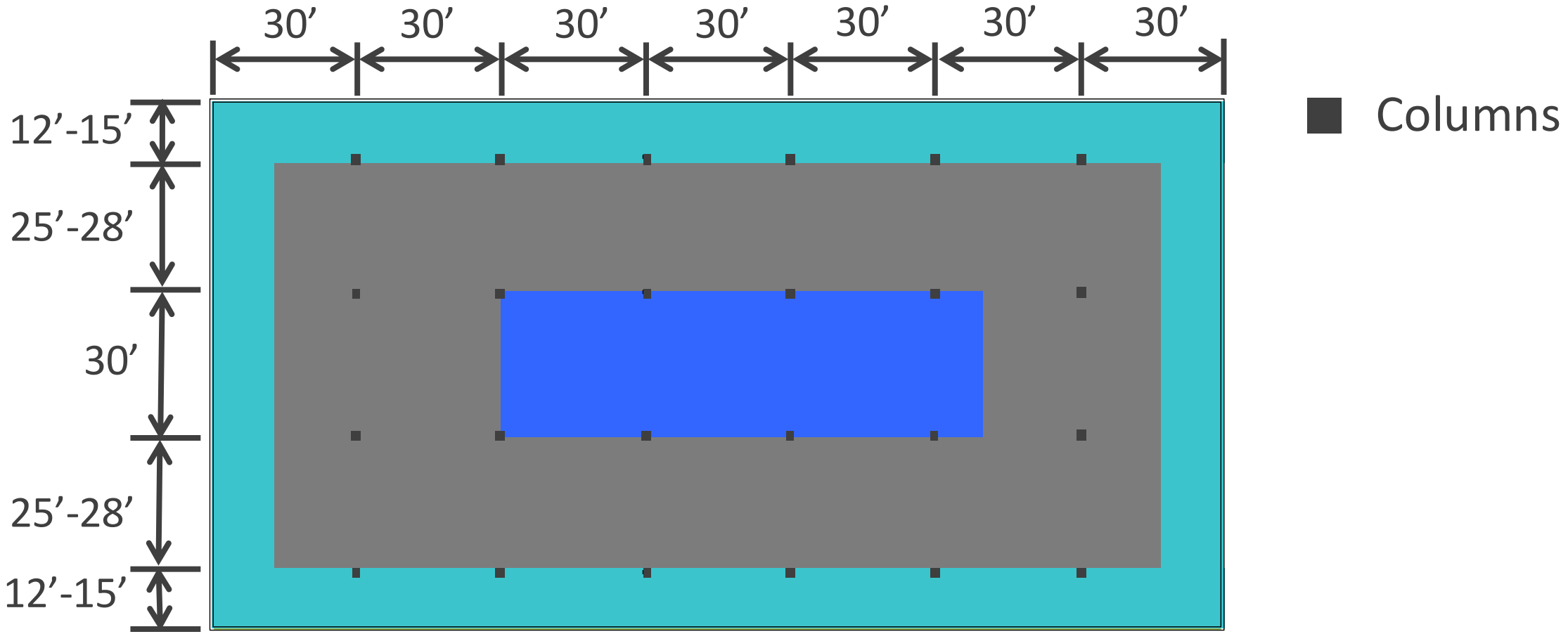


Core
(30’x100’)

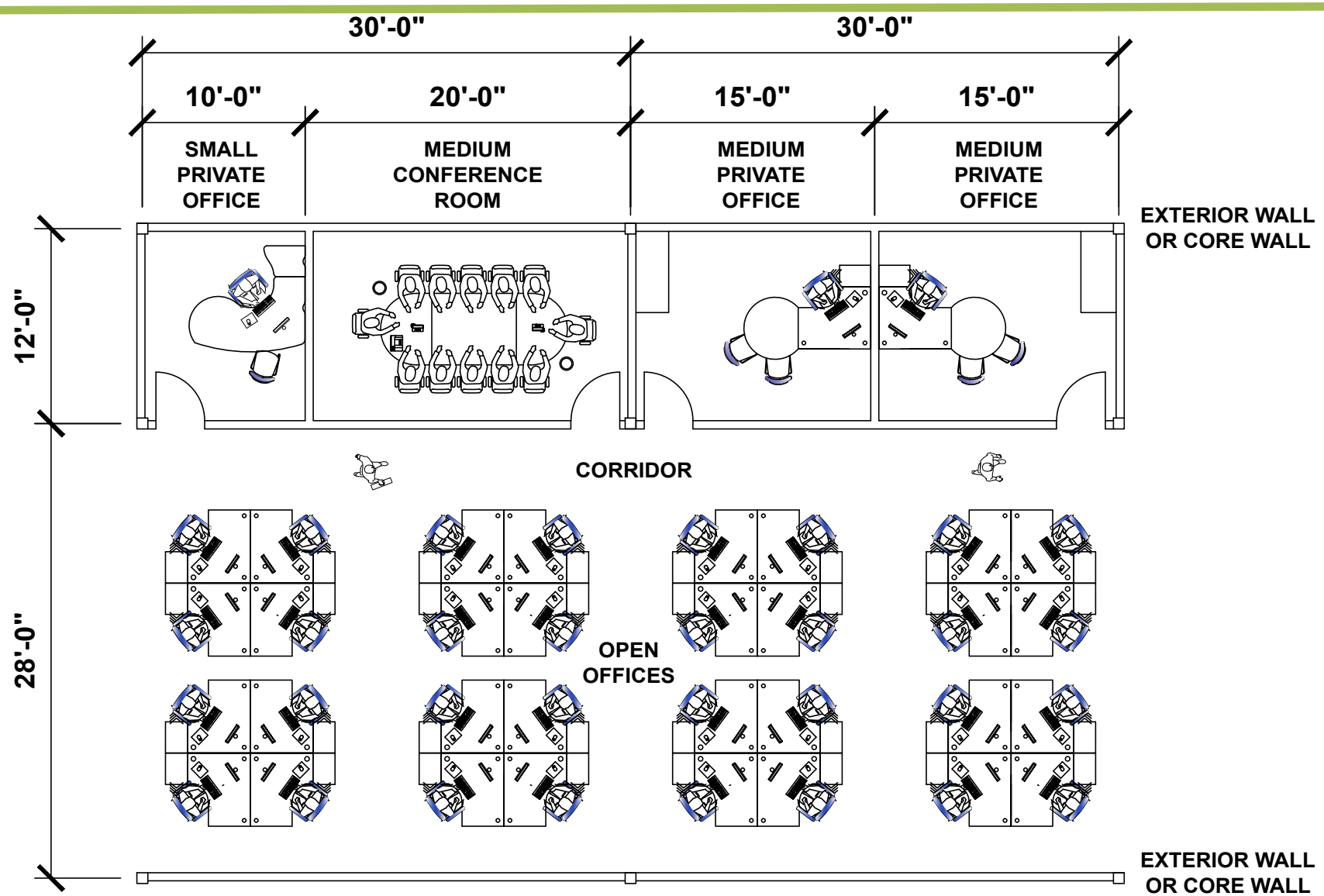
Private Offices
(12’x10’ to
12’x20’)

Semi-Open Office Building Layout

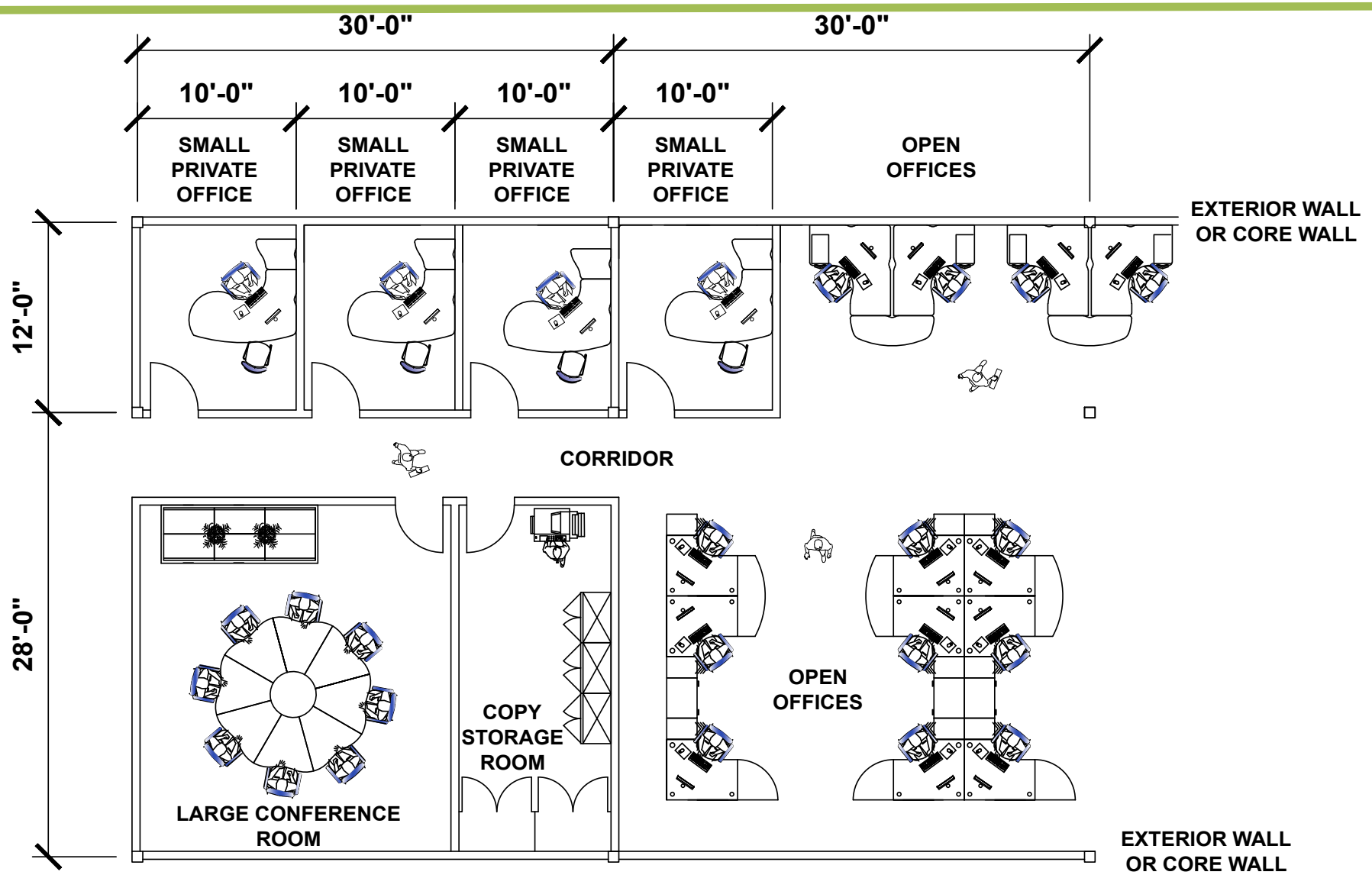
- Layout will follow structural constraints
- Important that constraints are not overly limiting



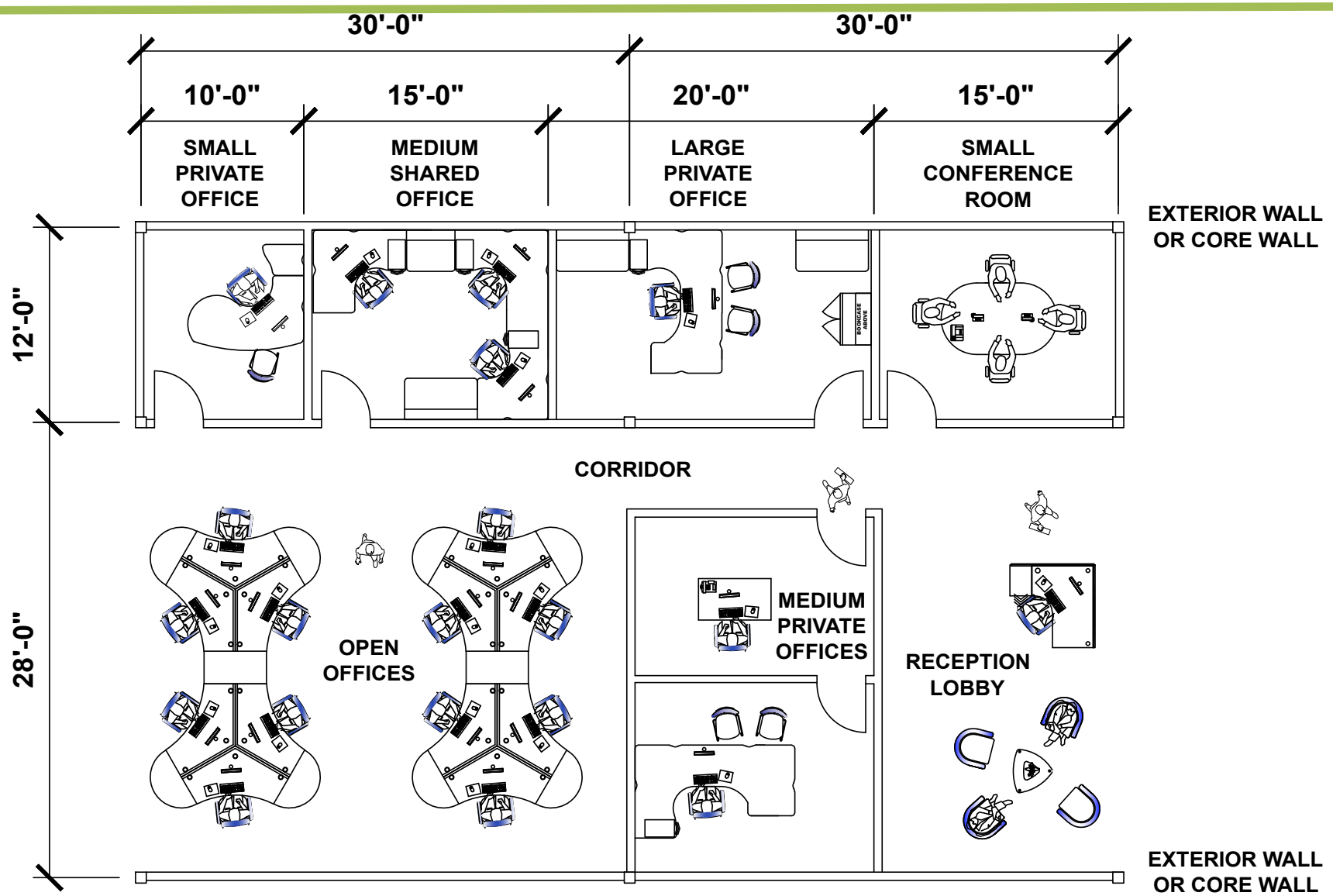
Semi-Open Office Building Layout



Semi-Open Office Building Layout

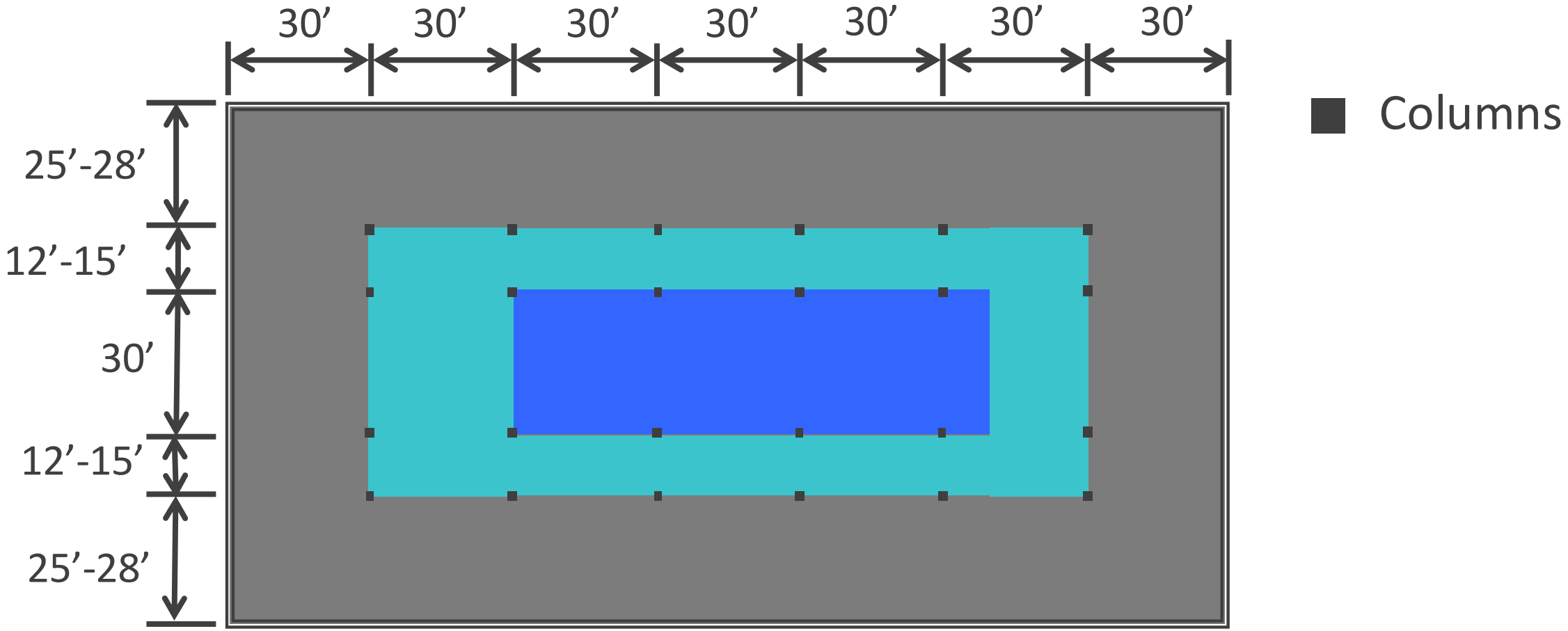


Semi-Open Office Building Layout



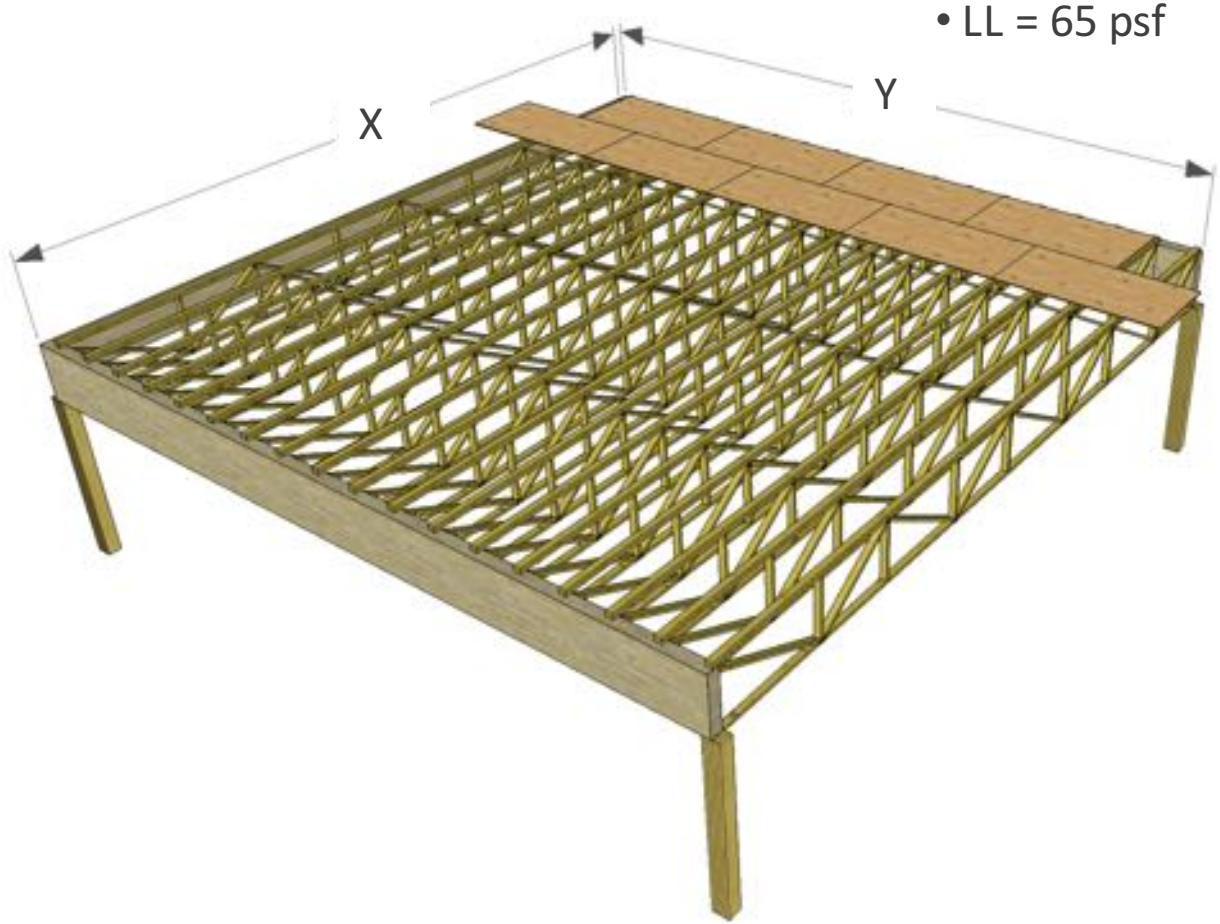
Semi-Open Office Building Layout

- Same concept can be inverted for increased daylight penetration
- Ancillary spaces work well near central core



Joist and Beam Layout

Assumptions:
- DL = 30 psf
- LL = 65 psf



Approximate Member Sizes – Office Floor Framing			
X	Joist Depth	Y	Glulam Girder Size *Assume beams support framing on both sides
30’	28-30” I-Joist or 24-34” Pinned or Plated Truss	12’	3-1/8”x22 ½” 24F-V4 or 5-1/8”x18” 24F-V4
		28’	8 ¾”x 34 ½” 24F-V4 Or 10 ¾”x31 ½” 24F-V4

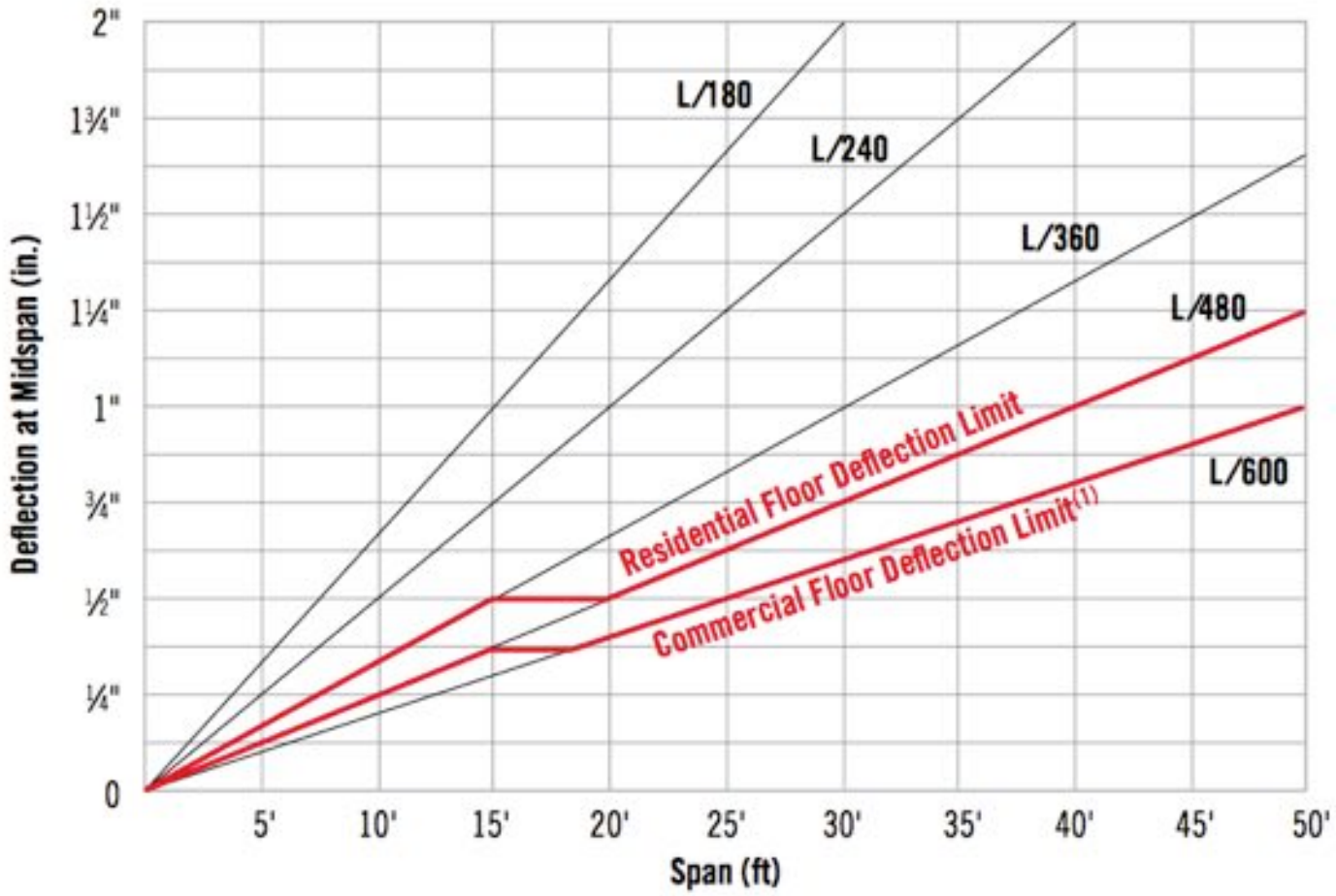
Note: All member sizing needs to be confirmed by a licensed engineer for conditions of your project.

Office Floor Design Considerations

Avoiding Bouncy Floors → Vibration & Deflection Control

Long spans (25’-40’ range)

- Often governed by vibration and/or deflection
- Consider limiting deflection as low as L/600
- However, L/600 limit has potential to increase member size and may be unnecessary in many scenarios



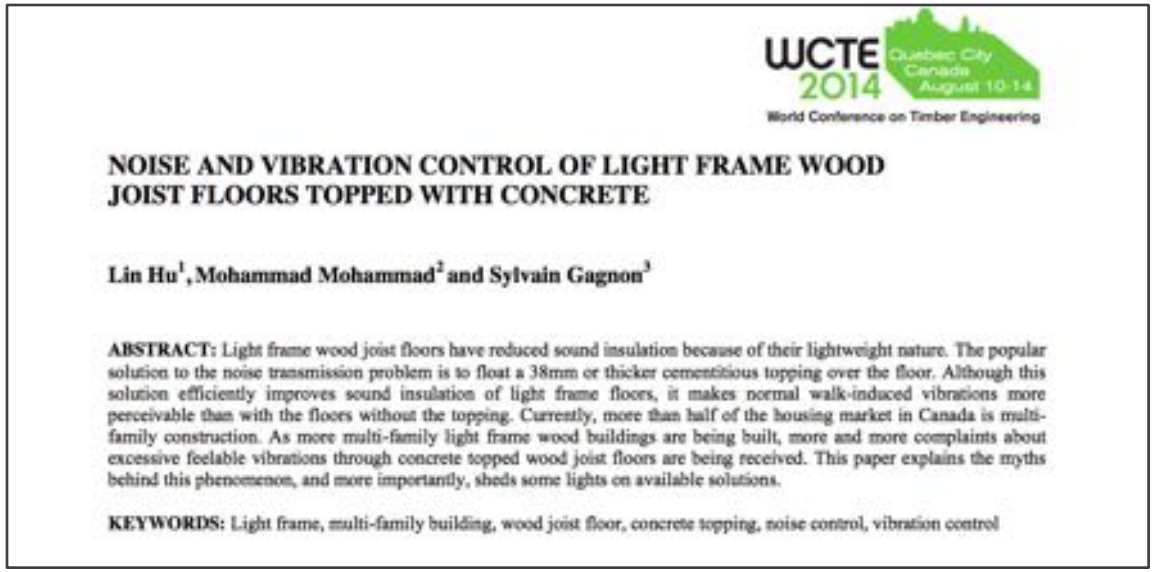
Total Load Deflection Chart: courtesy, Redbuilt

Office Floor Design Considerations

Tools available to designers:

Vibration Analysis: FP Innovations

(Spreadsheet available upon request)



WCTE 2014 Quebec City Canada August 10-14
World Conference on Timber Engineering

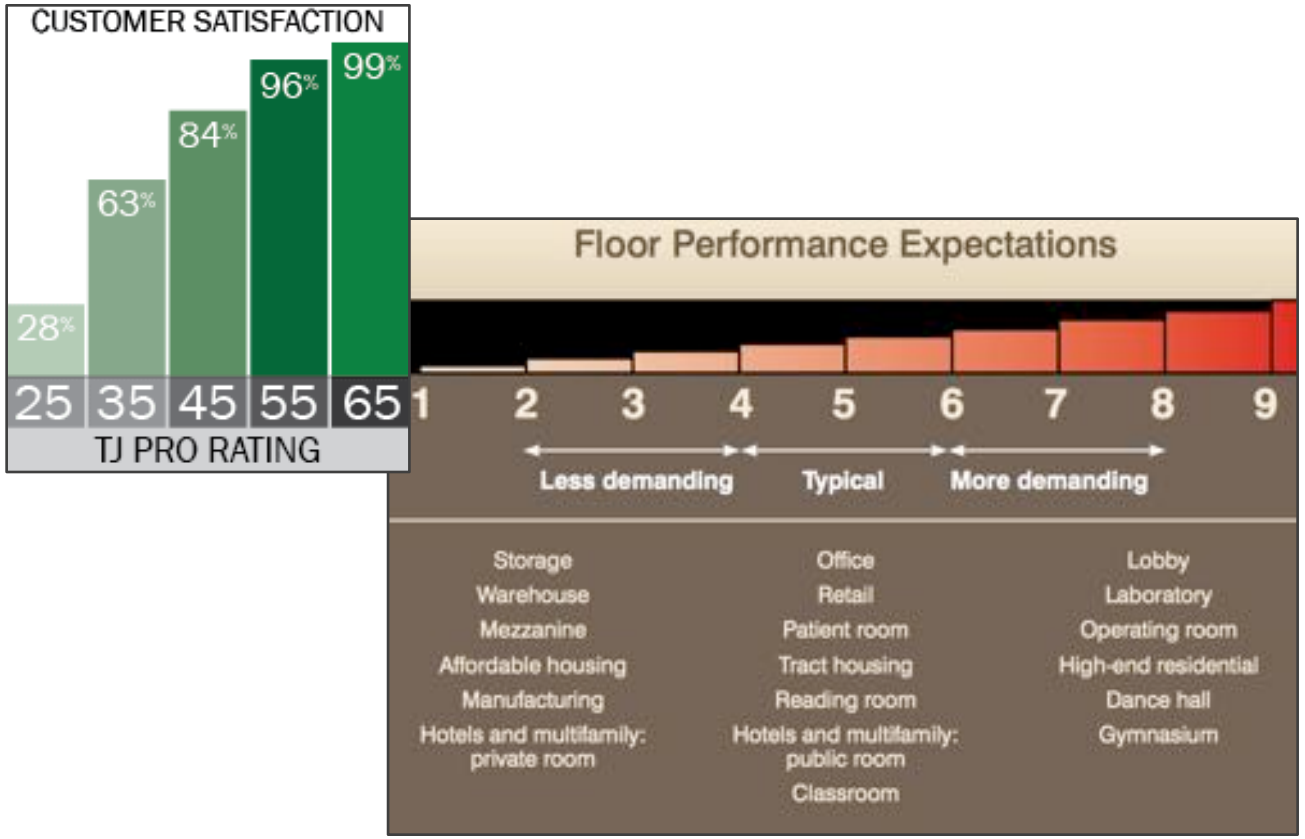
NOISE AND VIBRATION CONTROL OF LIGHT FRAME WOOD JOIST FLOORS TOPPED WITH CONCRETE

Lin Hu[1], Mohammad Mohammad[2] and Sylvain Gagnon[3]

ABSTRACT: Light frame wood joist floors have reduced sound insulation because of their lightweight nature. The popular solution to the noise transmission problem is to float a 38mm or thicker cementitious topping over the floor. Although this solution efficiently improves sound insulation of light frame floors, it makes normal walk-induced vibrations more perceivable than with the floors without the topping. Currently, more than half of the housing market in Canada is multi-family construction. As more multi-family light frame wood buildings are being built, more and more complaints about excessive feelable vibrations through concrete topped wood joist floors are being received. This paper explains the myths behind this phenomenon, and more importantly, sheds some lights on available solutions.

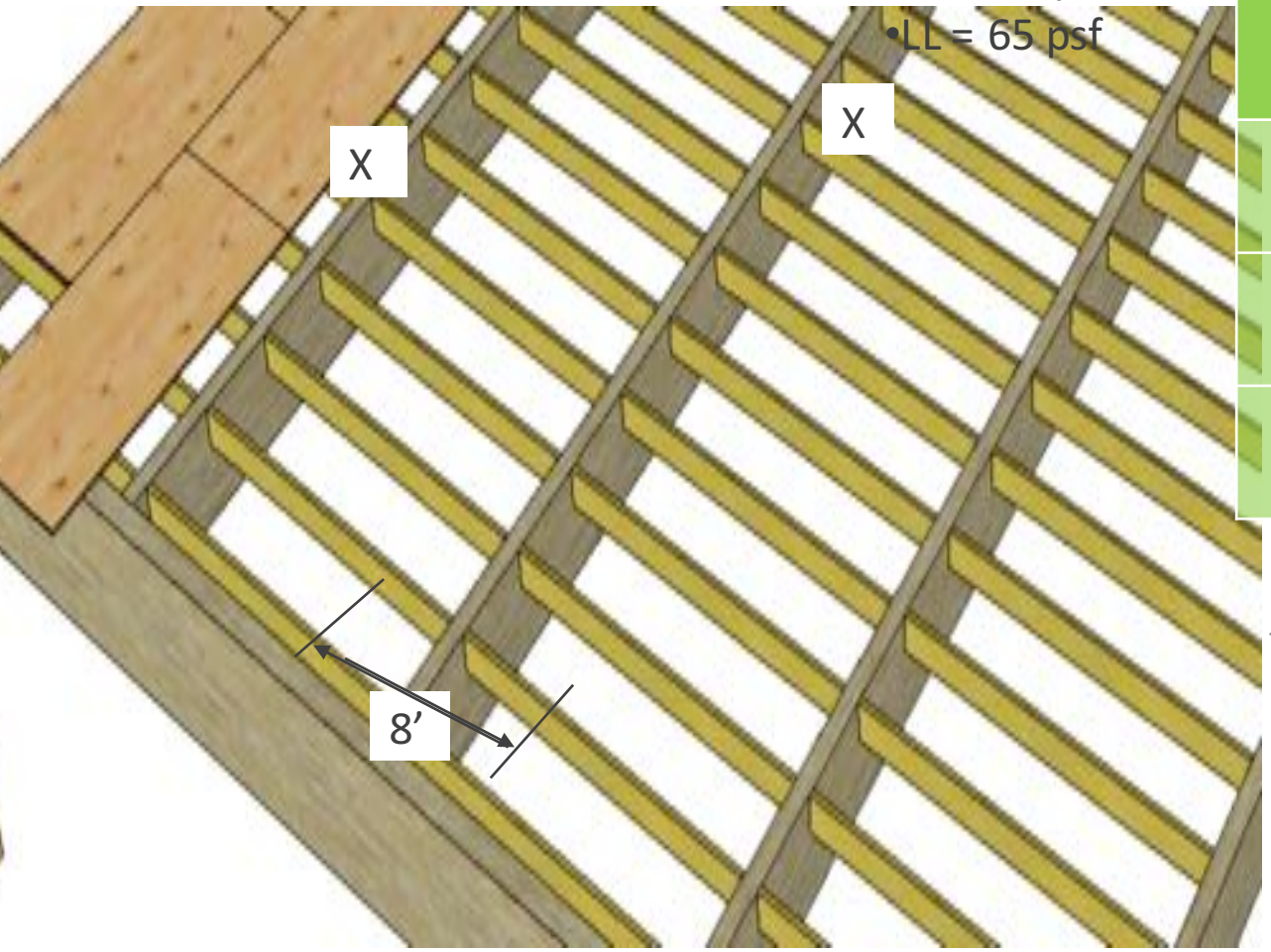
KEYWORDS: Light frame, multi-family building, wood joist floor, concrete topping, noise control, vibration control

Floor manufacturer's Rating Systems



Sub-purlin/Pulin/Girder Layout

Assumptions:
•DL = 30 psf
•LL = 65 psf

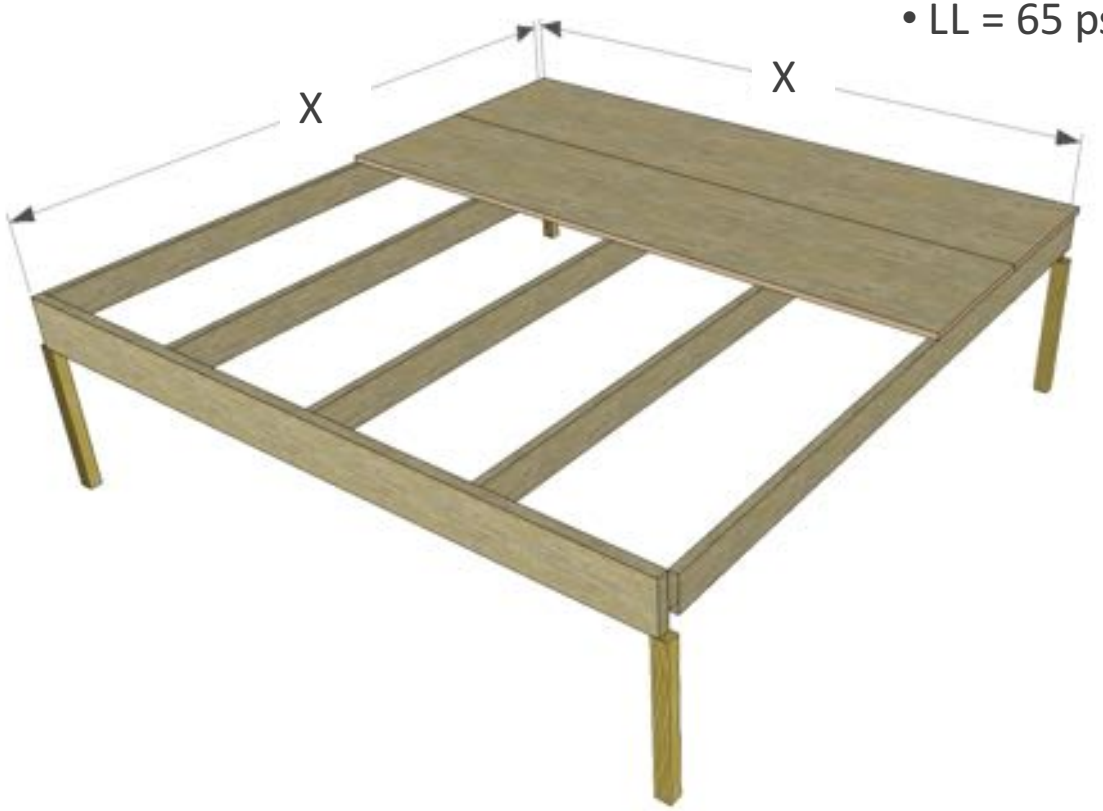


Approximate Member Sizes – Office Floor Framing			
X	2x Sub-Purlin *Assuming Bay Spacing of 8’	Purlin @ 8’ oc	Glulam Girder Size *Assume beams support framing on both sides
22’	2x8 @ 16”	5-1/8”x18” 24F-V4	6-3/4”x25 ½” 24F-V4
24’	2x8 @ 16”	5-1/8”x19 ½” 24F-V4	6-3/4”x28 ½” 24F-V4
28’	2x8 @ 16”	5-1/8”x22 ½” 24F-V4	8-3/4”x33” 24F-V4

Note: All member sizing needs to be confirmed by a licensed engineer for conditions of your project.

Solid Wood Layout

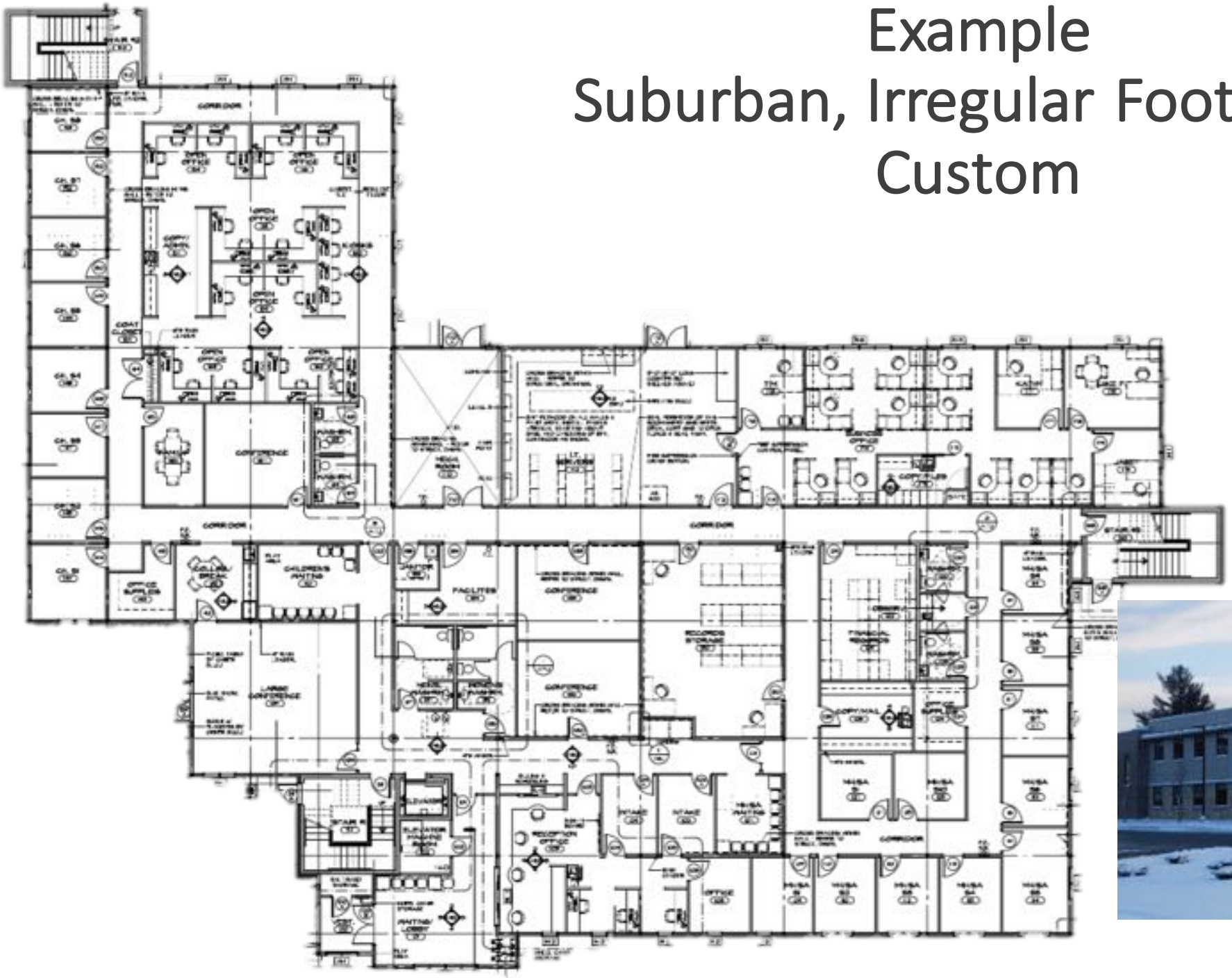
Assumptions:
- DL = 30 psf
- LL = 65 psf



Approximate Member Sizes – Office Floor Framing			
X	Mass Timber Panel	Glulam Purlin	Glulam Girder
20’	2x8 NLT or 7-PLY CLT	None	5-1/8”x24” 24F-V4
25’	2x6 NLT or 5-PLY CLT	5-1/8”x24” @ 12.5’ oc	6-3/4”x30” or 8-3/4”x27” 24F-V4
30’	2x6 NLT or 3-PLY CLT	5-1/8”x28-1/2” @ 10’ oc	8-3/4”x36” or 10-3/4”x33” 24F-V4

Note: All member sizing needs to be confirmed by a licensed engineer for conditions of your project.

Example
Suburban, Irregular Footprint, Custom



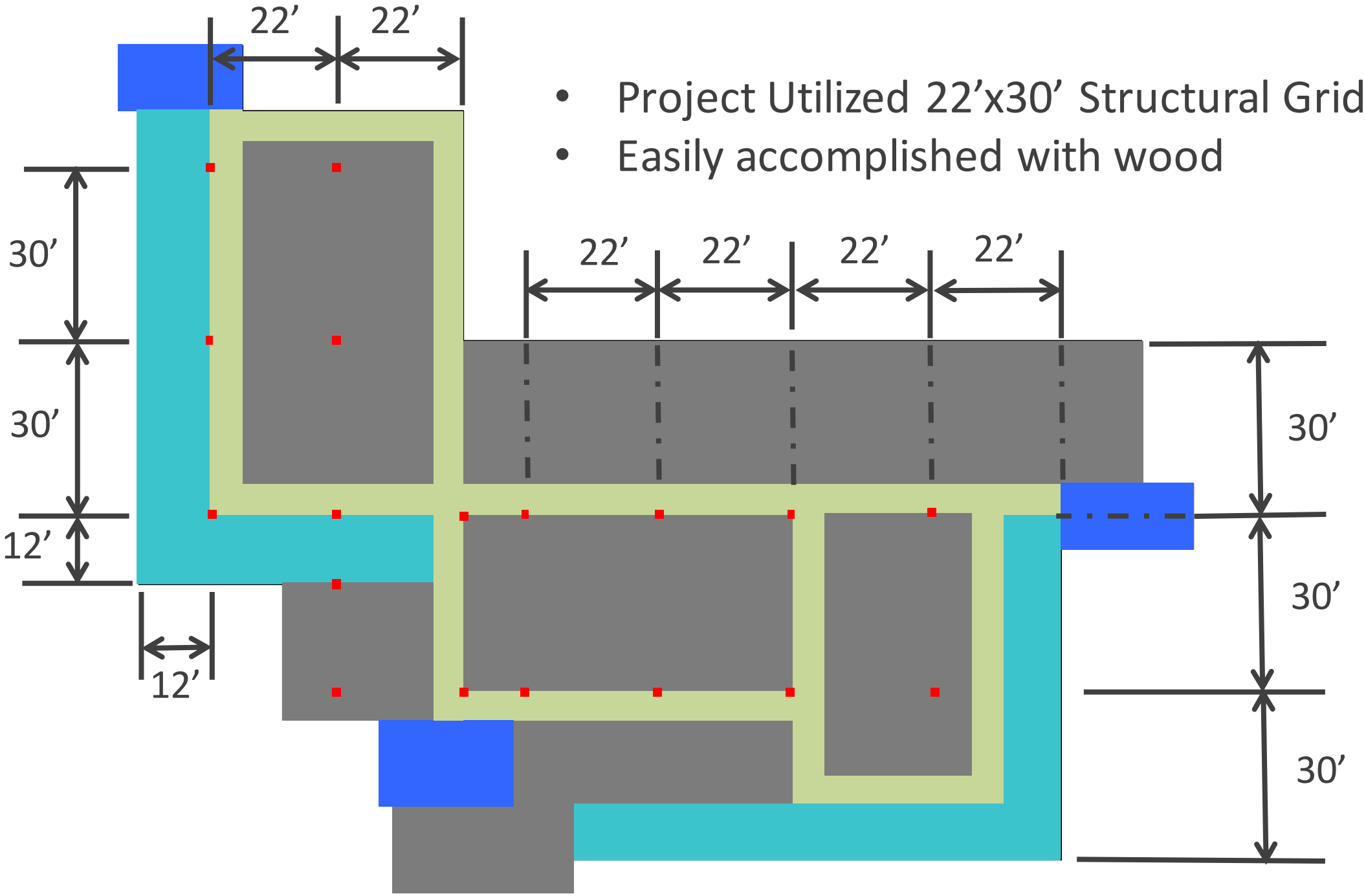
- 2 Stories
- 16k sf Per Floor

- 2 Stories
- 16k sf Per Floor

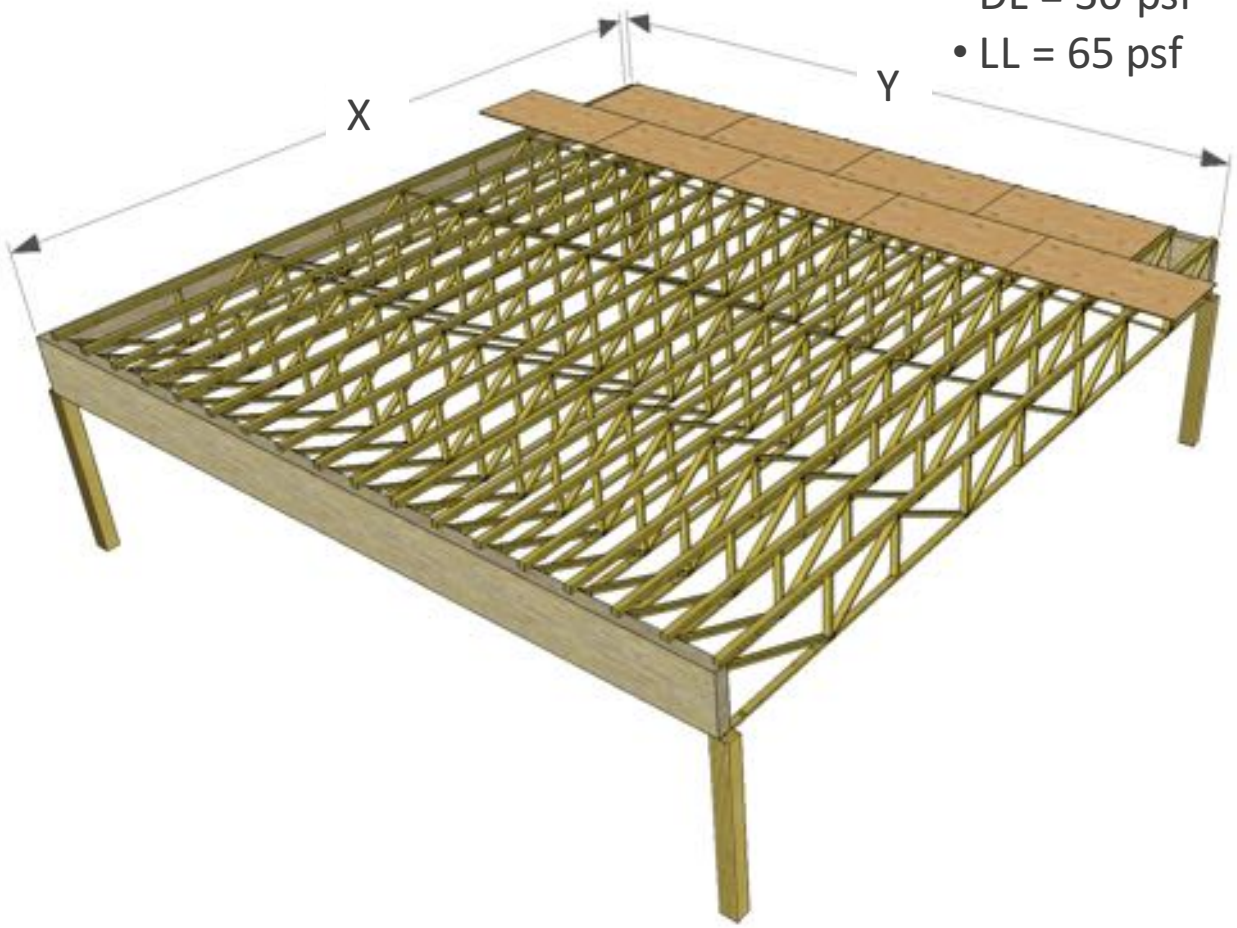
Stairs and/or Elevators


• 2 Stories
• 16k sf Per Floor
Stairs and/or Elevators
Private Offices
(10’x12’)
Corridors
(5’ Wide)
Open Office/
Shared Space

- Project Utilized 22’x30’ Structural Grid
- Easily accomplished with wood



Joist and Beam Layout



Assumptions:
- DL = 30 psf
- LL = 65 psf

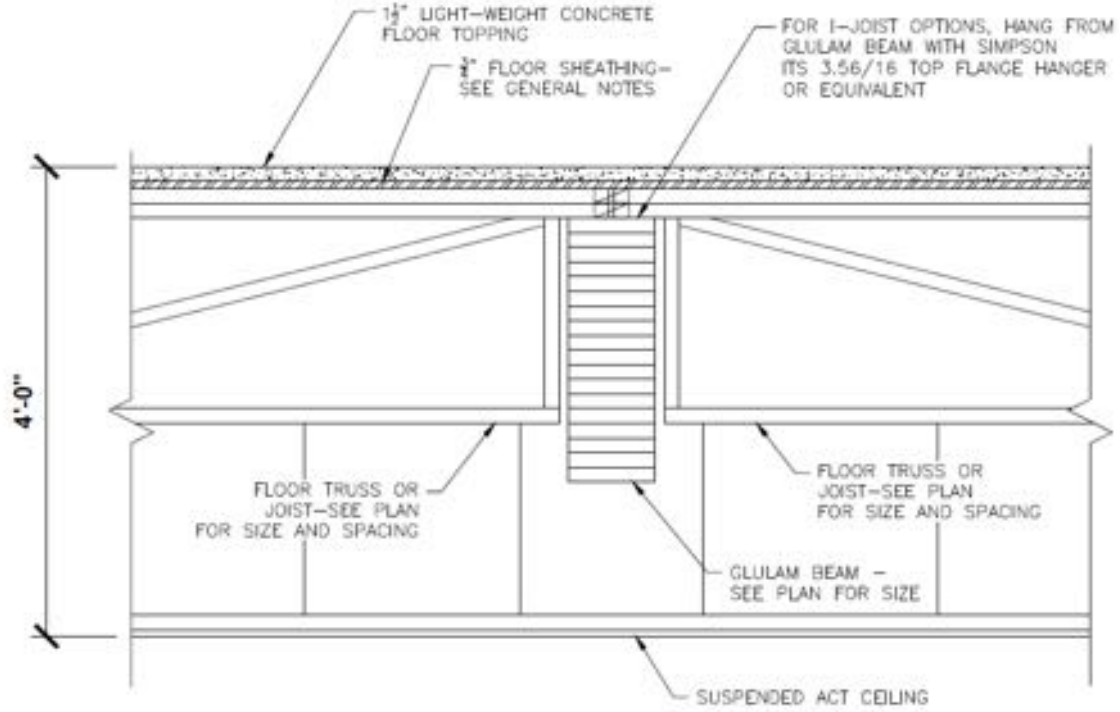
Approximate Member Sizes – Office Floor Framing			
X	Joist Depth	Y	Glulam Girder Size *Assume beams support framing on both sides
22’	16” I-Joist or 18” Plated Truss	30’	6 ¾“x34 ½“ or 8 ¾”x31 ½” 24F-V4
30’	28-30” I-Joist or 24-34” Pinned or Plated Truss	22’	6 ¾“x30“ or 8 ¾”x27” 24F-V4

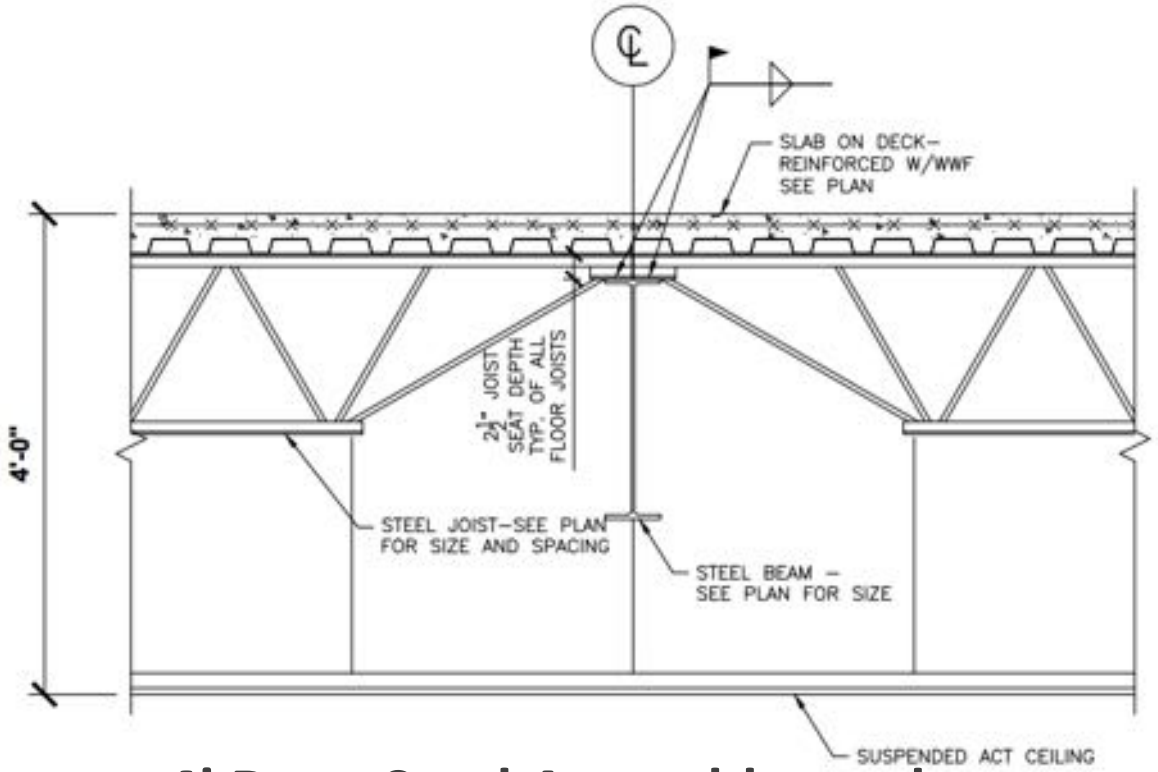
Note: All member sizing needs to be confirmed by a licensed engineer for conditions of your project.

Floor Assembly

4’ Deep Wood Assembly:

- 1 ½” Gypsum over ¾” sheathing
- 24” trusses
- 27” Beam
- 15.75” Drop Ceiling





4’ Deep Steel Assembly used:

- 4” concrete slab deck
- 18” bar Joists
- 24” Beam
- 17.5” Drop Ceiling

Floor to Floor Height

Design Constraints that might limit overall height:

- Zoning height limitations
- Construction Type height limitation
- High-rise limitations
- Cost of exterior curtain wall/façade

If overall height is limited and floor to ceiling height is maximized then depth of floor assembly is important.

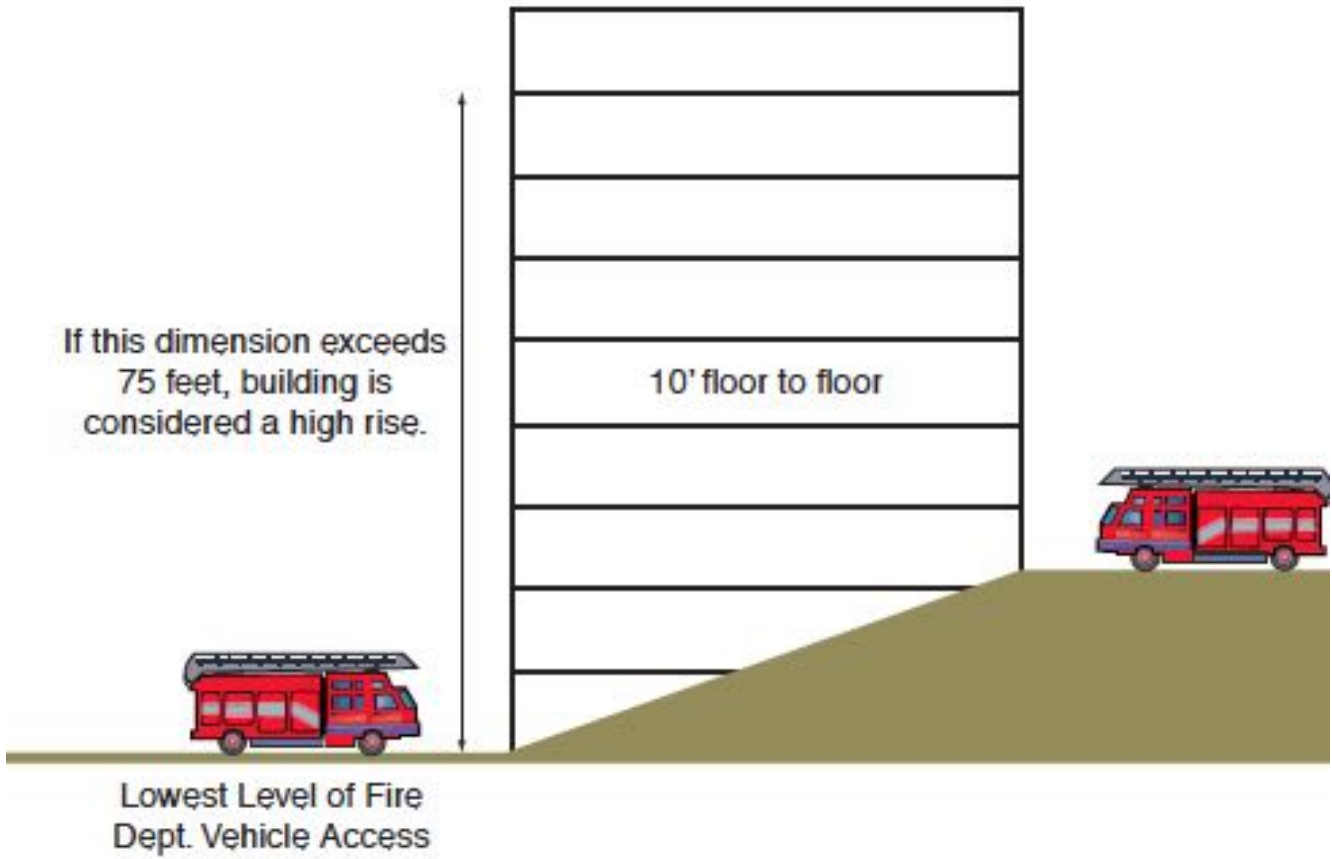


FIGURE 6-6 Determination of high-rise building

Floor to Floor Height

Electrical/Data can be accommodated by running:

- Through joist cavity
- Below joists in drop ceiling
- Above joists in raised floor

If wood floor assembly is slightly deeper than for Steel/Concrete, options are:

1. Raise height of building
2. Reduce floor to ceiling height
3. Reduce girder spans

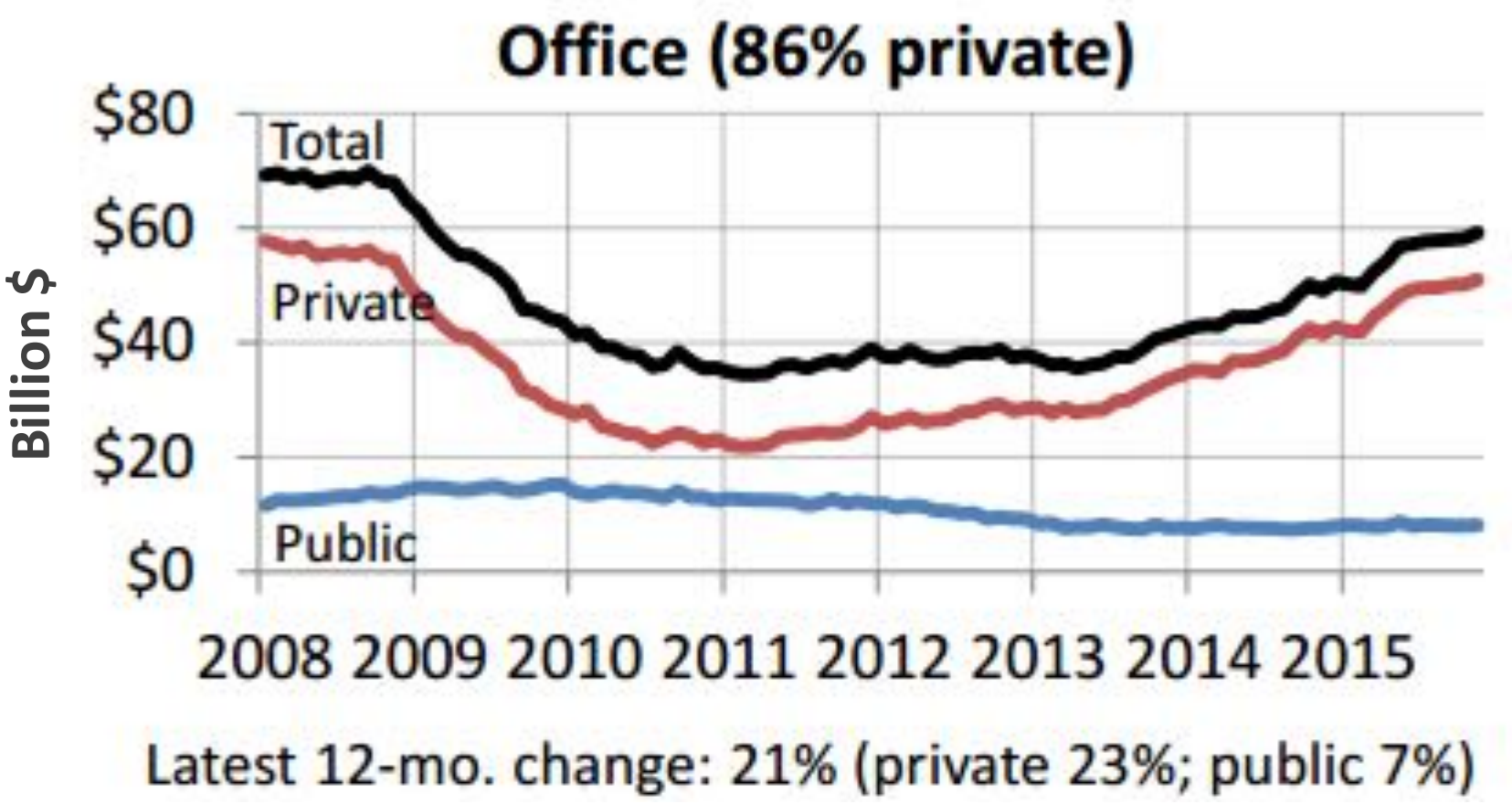
“Is it possible to achieve the high performance expectations … affordably?”

2016 Office Construction Outlook – AGC of America

Key points in Office Construction:

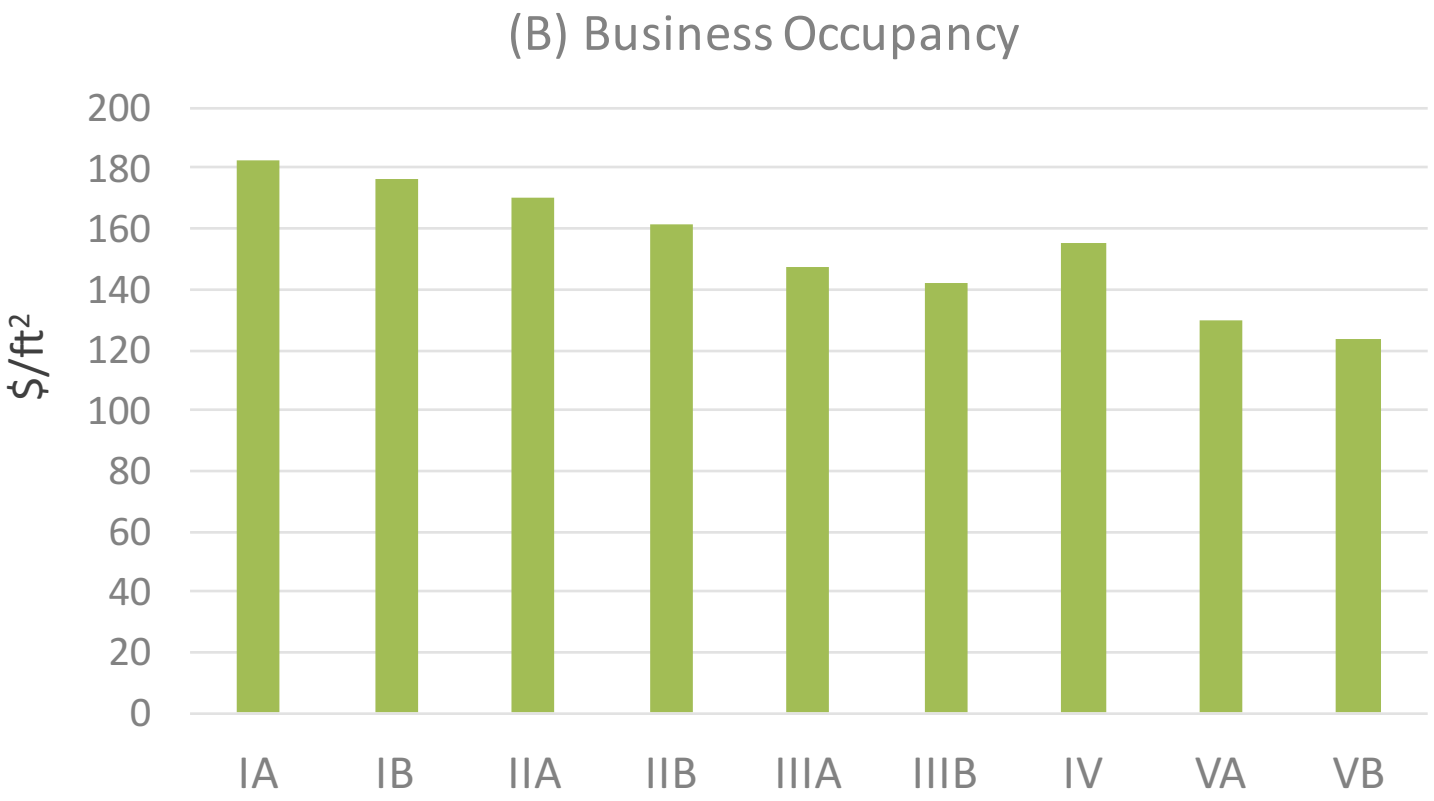
- Employment sets records each month but office space per employee keeps shrinking
- Growth is mainly in cities and renovations, not suburban office parks
- Largely privately funded

US Construction Spending



Source: AGC of America, Constriction Spending, Labor & Materials Outlook, Jan. 2016, Census Bureau construction spending reports

Office Construction Costs – ICC Building Valuation



"..where wood frame construction is allowed, depending on location and occupancy, this would help to keep costs lower. In areas that are restricted to non-flammable construction, price per square foot will go up."

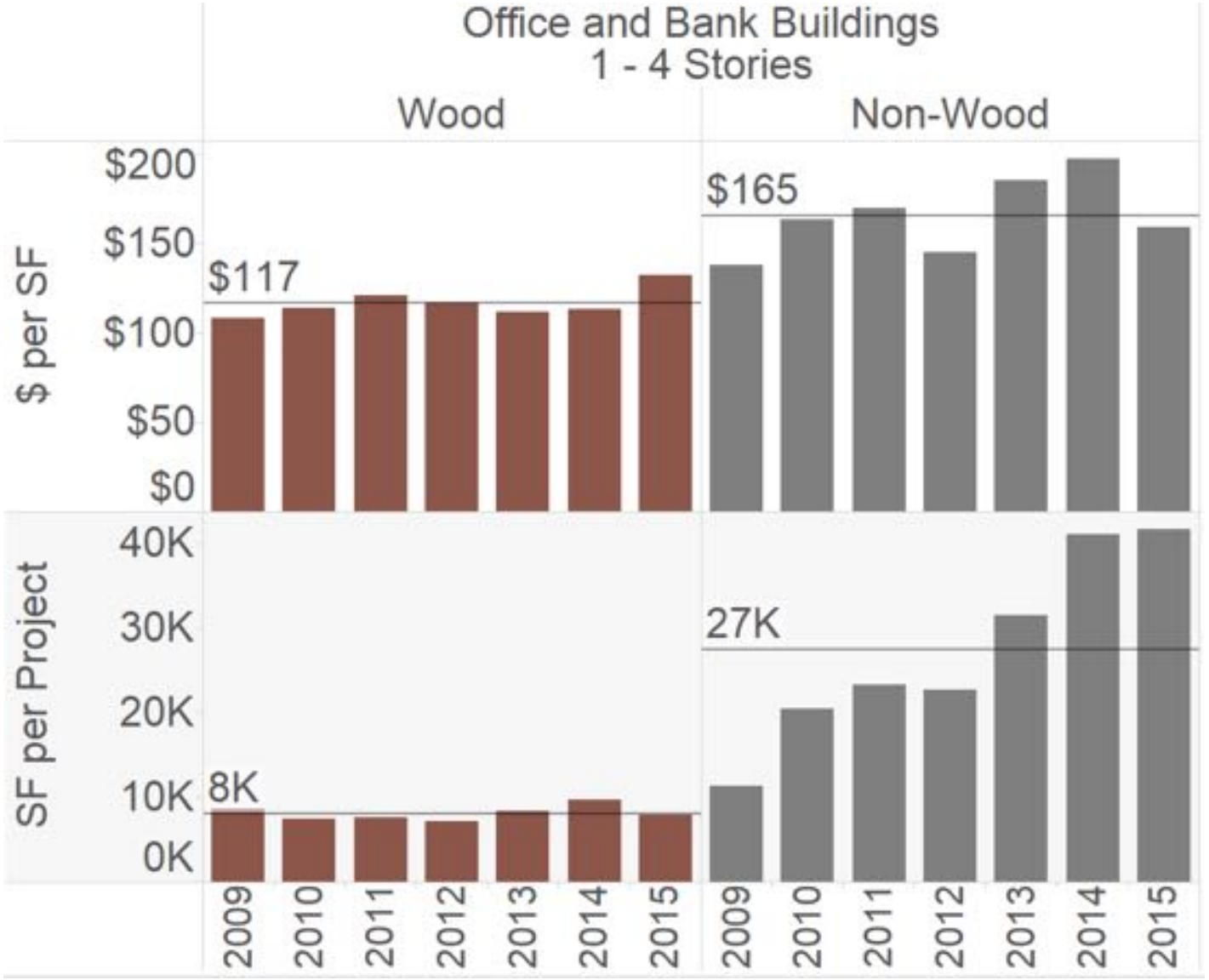
-EV Studio Article
(full service Design firm)

Source: ICC Building Valuation Data, Aug 2015
http://evstudio.com/construction-cost-per-square-foot-for-office-buildings/construction-cost-office-building-2-to-4-stories-2/

1-4 Story Office Construction Costs – Built National Average

1-4 Story Offices in US:

- wood offices are 20-30% less expensive per square foot than non-wood office
- average square foot per project for a wood office was 18-80% smaller than a non-wood office



Data Source: Dodge Analytics Data

2-4 Story RSMeans Cost Estimates –Estimated National Average

OFFICE & WAREHOUSE SQUARE FOOT COST ESTIMATES

The following estimate assumes face brick with concrete block back-up / wood joists, using 2013 RSMeans data.

National Cost Estimate (Union Labor)	% of Total	Cost Per SF
Construction Total		$$134.78
Contractor Fees (GC,Overhead,Profit)	25%	$$33.69
Architectural Fees	6%	$$8.09
Total Building Cost		**$$176.56**

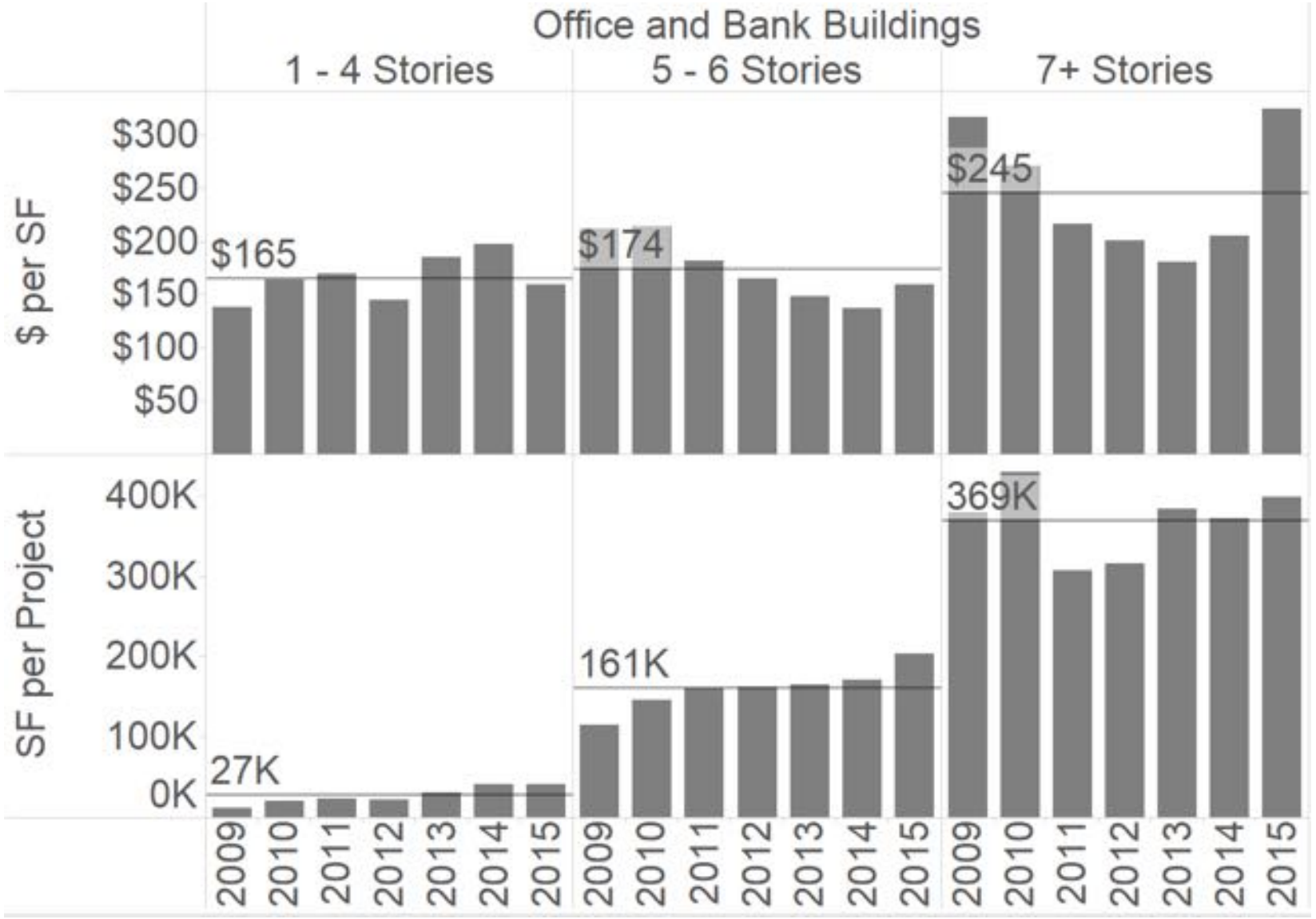
OFFICE, 2-4 STORY SQUARE FOOT COST ASSUMING BRICK VENEER / WOOD FRAME

Cost Estimate (Union Labor)	% of Total	Cost Per SF
Total		$$119.40
Contractor Fees (GC,Overhead,Profit)	25%	$$29.85
Architectural Fees	7%	$$10.45
Total Building Cost		**$$159.70**

Source: RS Means Cost per Square Foot Models

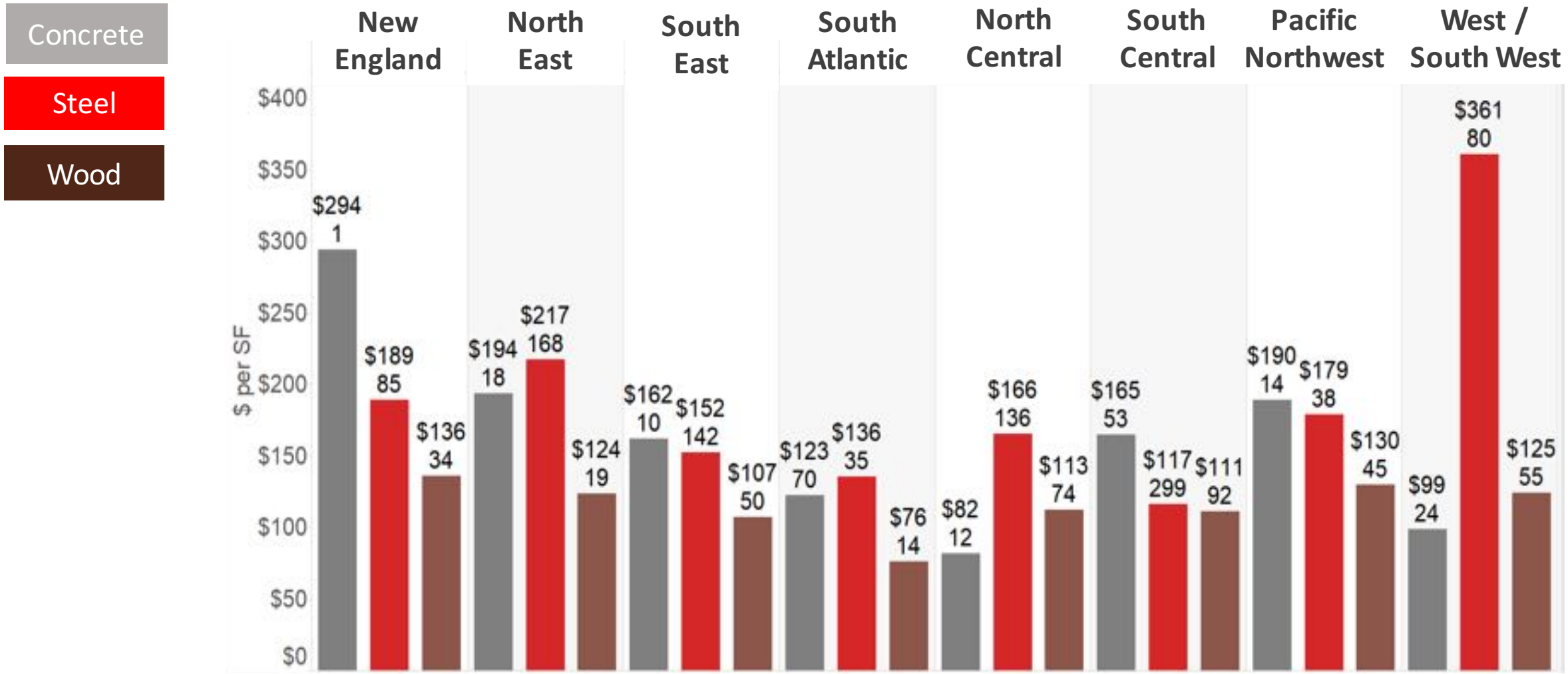
5-10 Story Office Construction Costs – Built National Average

- RSMeans data suggests ~4% ($6-10/sf) savings by increasing stories*
- Based on Dodge Data, perhaps economies of scale do not always exist
- Wood is not an architype for offices of this height so cost data is not available



* Source: 2012 Reed Construction Data
Graph Data Source: Dodge Analytics Data

Regional Variation of Construction Cost– Built Projects 2013-2015



Data source: Dodge Analytics Data


Heavy/Mass Timber provides great solutions for:
❑Market Distinction
❑Larger Scale
❑Open Layout
Marcus Kauffman, ODF

Bullitt Center

- Location: Seattle, WA.
- Type IV construction
- 4 stories of wood over a 2 story concrete podium
- 52,000 sf

ARCHITECT: Miller Hull Partnership
ENGINEER: PAE Consulting Engineers
PHOTO CREDIT: John Stamets, Nic Lehoux

Bullitt Center (Cont.)

- Construction cost $18.5 M, $355/sf
- Net Zero Building
- Goal- 250 year life expectancy
- First Living Building Challenge Certified Office Building
- 80% Energy reductions
- PV array provides energy for building

ARCHITECT: Miller Hull Partnership
ENGINEER: PAE Consulting Engineers
PHOTO CREDIT: John Stamets, Nic Lehoux

Volume of wood used:
24,526 cubic feet

U.S. and Canadian forests grow this much wood in:
2 minutes

Carbon stored in the wood:
545 metric tons of CO_2

Avoided greenhouse gas emissions:
1,158 metric tons of CO_2

TOTAL POTENTIAL CARBON BENEFIT:
1,703 metric tons of CO_2

EQUIVALENT TO:

325 cars off the road for a year

Energy to operate a home for 145 years

Source: US EPA

Estimated by the Wood Carbon Calculator for Buildings, based on research by Sarthre, R. and J. O'Connor, 2010, A Synthesis of Research on Wood Products and Greenhouse Gas Impacts, FPInnovations. Note: CO_2 on this chart refers to CO_2 equivalent.

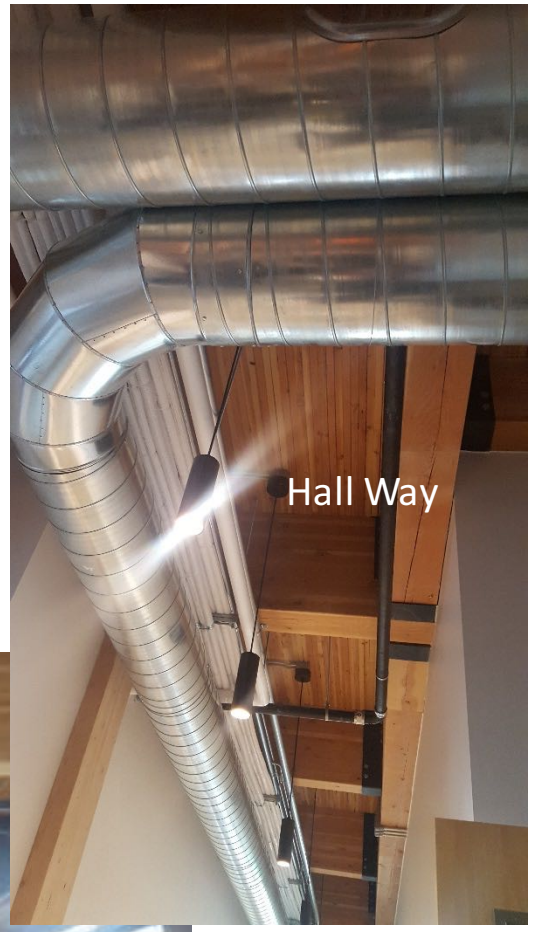
Hudson Building

- Location: Vancouver, WA.
- 3 stories, Type VB, 45,000 sf
- Cost more than steel and approx. the same as PT Concrete
- Gets $7/sf more in rent than similar (non-wood) office building next door

ARCHITECT: Mackenzie
ENGINEER: Mackenzie
DEVELOPER: Killian Pacific and Mackenzie
PHOTO CREDIT: Columbian

Hudson Building (Cont.)

- ~25’x25’ Grid
- 15’-18’ floor to floor heights
- Composite floor: 2x4 and 2x6 NLT floor panels with 3 ½” reinforced concrete topping
- All MEP exposed
- Reinforced Brick as exterior bearing shearwall system



ARCHITECT: Mackenzie
ENGINEER: Mackenzie
DEVELOPER: Killian Pacific and Mackenzie
PHOTO CREDIT: WoodWorks

Clay Creative

- Location: Portland, OR
- 5 stories of Type IIIA over 1 story of Type IA, 72,000 sf
- Deck on upper level
- Under Construction (Complete May 16, 2016)
- Net cost: ~$300-$350/sf of rentable space
- Received a $300K transit oriented development grant
- ~12 month construction duration

DEVELOPER: Killian Pacific and Mackenzie
IMAGE CREDIT: WoodWorks, Next Portland

Clay Creative (Cont.)

- ~8’ finished floor to bottom of beam
- 25’x30’ at perimeter
- 30’x30’ bays at center
- 1.5” gypsum o/ WSP o/ 2x6 NLT floor panels stitched together with 12” screws
- Raised floor system for mechanical, data and acoustics
- Exterior steel moment frame keeps core area more versatile

“This is a terrific building that echoes the historic character of the workspaces in the Central Eastside, but takes it a step further with this incredible wood construction.”

-Portland Metro Councilor
Bob Stacey

DEVELOPER: Killian Pacific and Mackenzie
PHOTO CREDIT: WoodWorks

Albina Yard

- Location: Portland, OR
- 4 stories, Type VA/IIIB, 16,000 sf
- Green Roof
- Under Construction (Dec 2015)

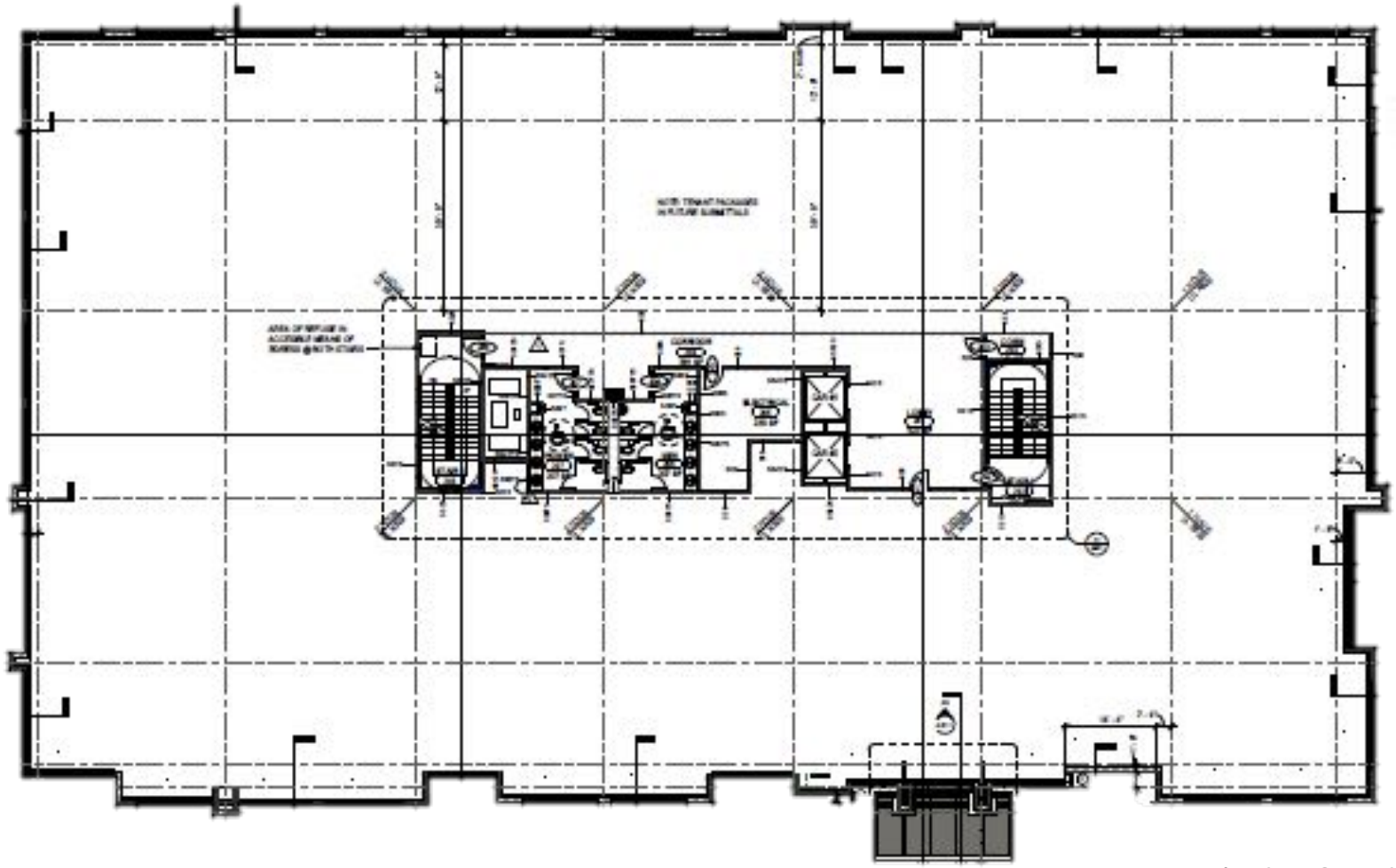
ARCHITECT: Lever Architecture
IMAGE CREDIT: Lever Architecture

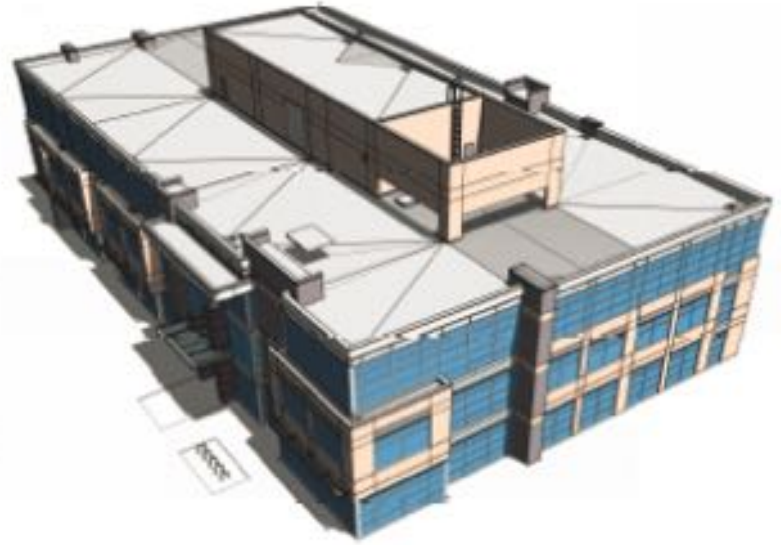
Albina Yard (Cont.)

- ~20’x20’ Grid
- CLT floor panels with electrical conduit poured into light weigh gypsum topping
- Wood shearwall core with open front design for glazing wall

ARCHITECT: Lever Architecture
IMAGE CREDIT: WoodWorks

Exploring Costs
For Heavy Timber Office





Timber Fabricator Assumptions:

- Aspen, CO*
- 30’x40’ Grid
- 3 stories
- 70K sf
- 14’ Floor to floor height

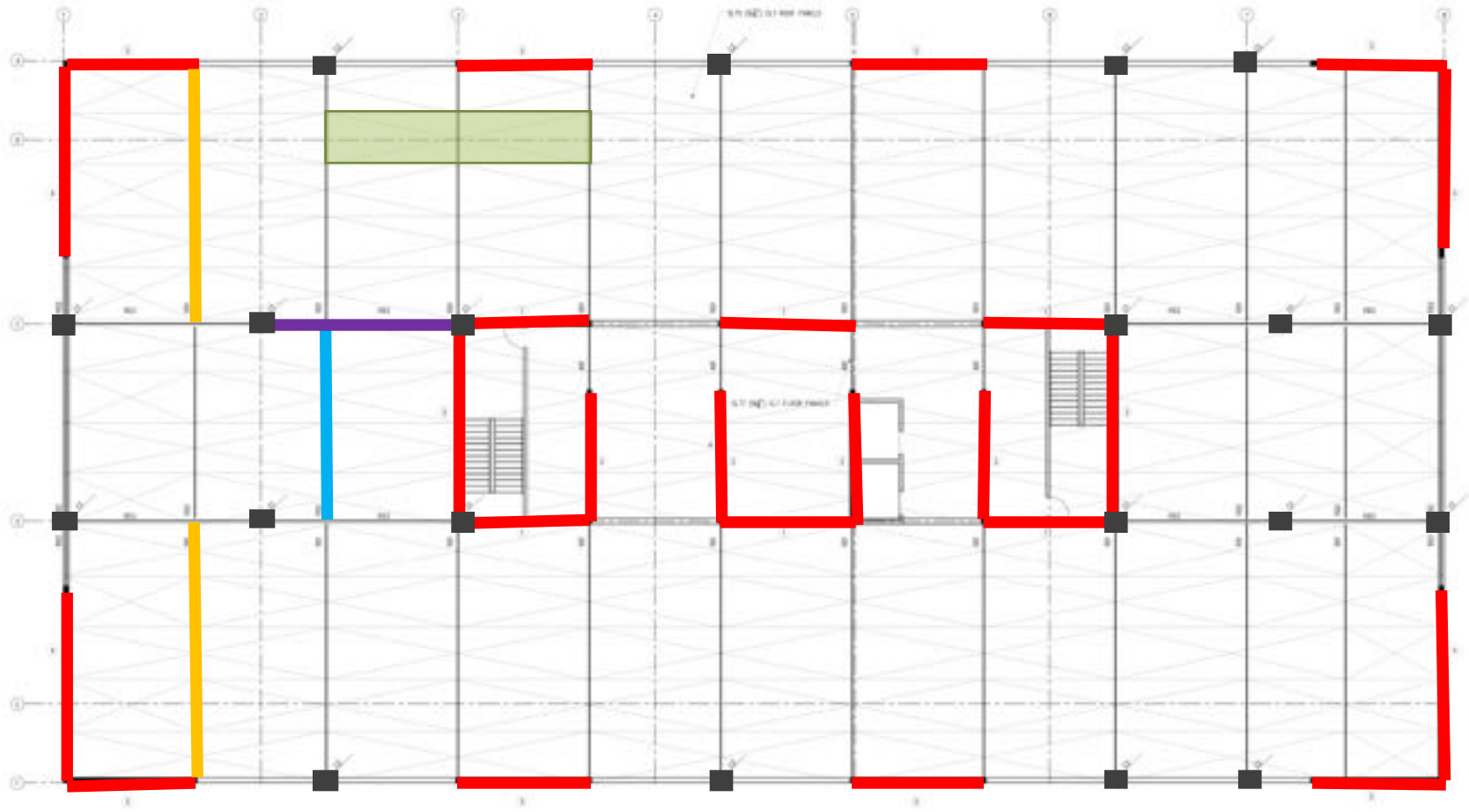
Courtesy of Arch Nexus

*Labor for 3 local workers and 4 from Fabricator HQ. Includes costs for accommodation and per diem expenses in CO.

Cost Estimate – Heavy Timber Specialist

Assumed Materials for Design:

1. **Bearing Shearwalls: 5 ply CLT at all levels**
2. **Floor Girders: 10 ½"x43 ½"**
3. **Floor Beams: 10 ½"x31 ½" (interior bays)**
4. **Floor Beams: 10 ½"x40 ½" (exterior bays)**
5. **Columns: 8 ½"x9" – 10 ½"x 10 ½"**
6. **Floor Deck: 7 ply CLT**
7. Roof Beams: 8 ¾"x27" GLB
8. Roof Deck: 5 ply CLT



Steel and Concrete - RSMeans Square Foot Cost Models

RS Means Square Foot Cost Model
Assumptions:

- Los Angeles, CA
- 8 Story Office
- 80K sf
- **25’x25’ bays**
- **12’ floor to floor height**
- 2016 Q2 Cost Data
- 3 reinforced concrete frame solutions
- 3 steel frame solutions

Exploring Structural System Cost Comparison

Structural System	Class A **Heavy Timber Frame** (Western Wood Structures)	Typical **Steel Frame** (RSMeans 5-10 Story Office Square Foot Module)	Typical **Reinforced Concrete Frame** (RSMeans 5-10 Story Office Square Foot Module)
	Up to $55/sf	Up to $48/sf	Up to $60/sf
Includes	• 30'x40' Grid • Materials • Labor • Equipment • Connections • Delivery • No wall Insulation	• 25'x25' Grid • Materials • Labor • Equipment • Connections • Delivery • Insulation on wall	• 25'x25' Grid • Materials • Labor • Equipment • Connections • Delivery • Insulation on wall
Does not include	• Infill and partition walls • Foundation or site work • Design fees • Roof and wall Insulation • Building envelope	• Infill and partition walls • Foundation or site work • Design fees • Roof Insulation • Building Envelope	• Infill and partition walls • Foundation or site work • Design fees • Roof Insulation • Building Envelope

Additional Value of a Heavy Timber Structure

Potential Tangible Value:

- Reduced foundation size due to structure weight
- Improved construction schedule
- Less on-site labor
- Fewer finishes leading to reduction in cost, schedule and environmental impact

Intangible Value:

- Lower involuntary stress environment (Bio-philia)
- Unique Aesthetic
- Reduced Carbon Footprint
- Lower Environmental Impacts

When asked what the value is in building a timber office, developers say…..

- “Creates market distinction”
- “Offers a warm rustic aesthetic young firms are looking for”
- “It’s the new class A office”


Light frame wood provides great solutions for:
✓ Low-rise (1-4 stories)
✓ Custom
✓ Irregular in footprint

Bonner General Health

- Location: Sandpoint, ID
- Complete: 2015
- 3 stories, 50,000 sf
- 32’ floor spans
- 28” deep I-joists w/ topping
- Originally to be steel
- Poor soils needed lighter structure
- Wood framing brought project in budget

ARCHITECT: John Eixenberger
PHOTO CREDIT: RedBuilt

"Not only did wood give us a more economical structure, but we could more easily source our labor needs with wood framing, too."

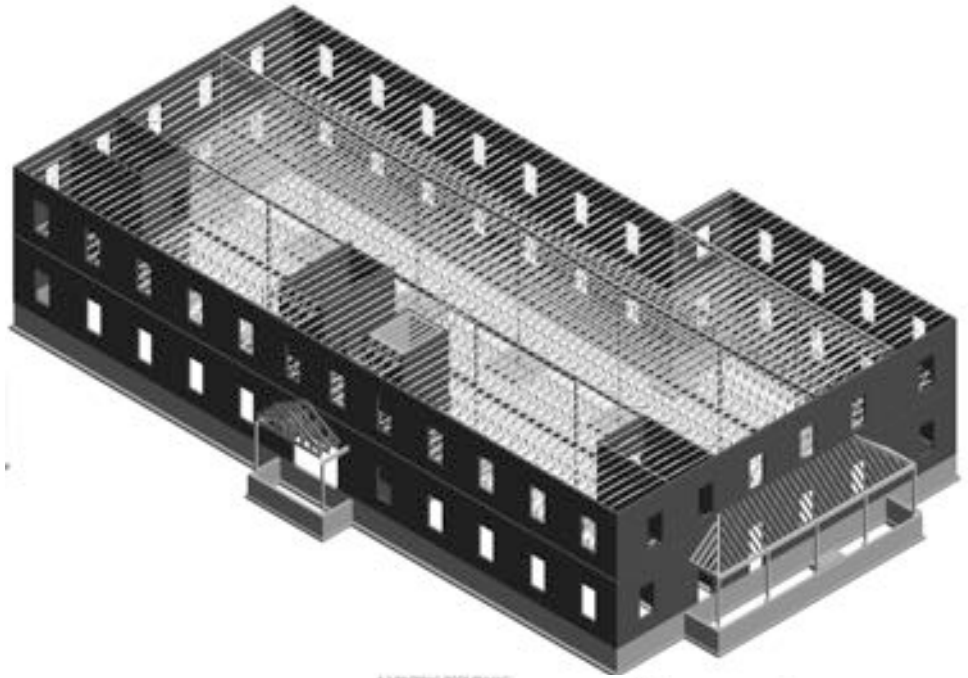
-Construction Manager
Jim Williamson

PROJECT: Bonner General Health Office
ARCHITECT: John Eixenberger
PHOTO CREDIT: RedBuilt

575 Stonecutters Way Office Building

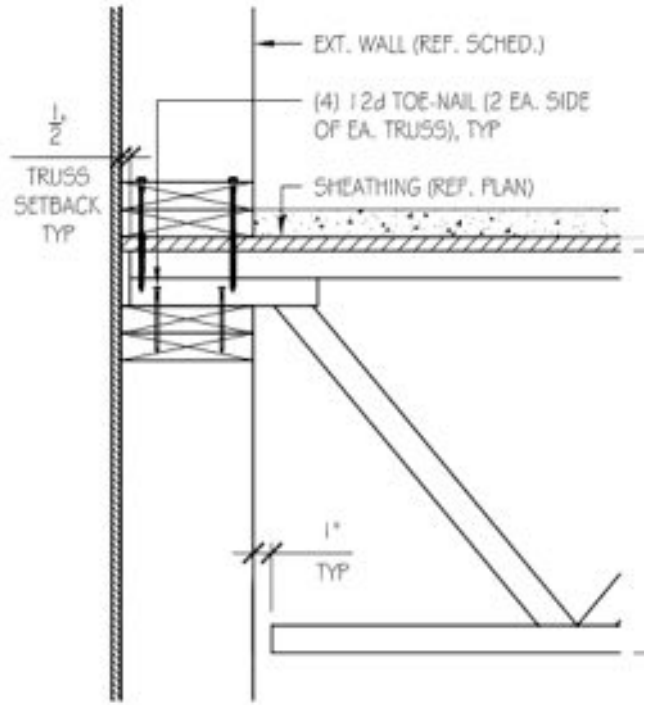
- Location: Montpelier, VT
- Completed: Fall 2012
- 2 stories, Type VB, 20,000 sf
- Prefabricated walls
- High R-value walls and roof

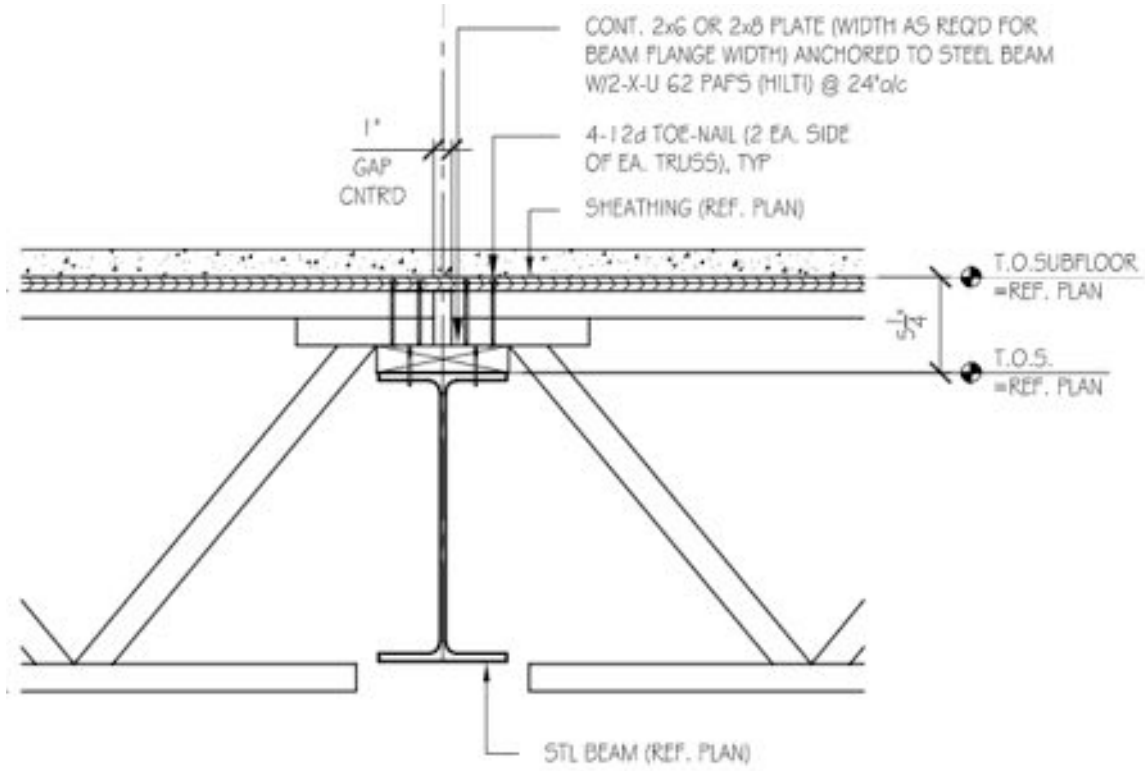
ARCHITECT: Connor Contracting
PHOTO CREDIT: Connor Contracting



575 Stonecutters Way Office Building (Cont.)

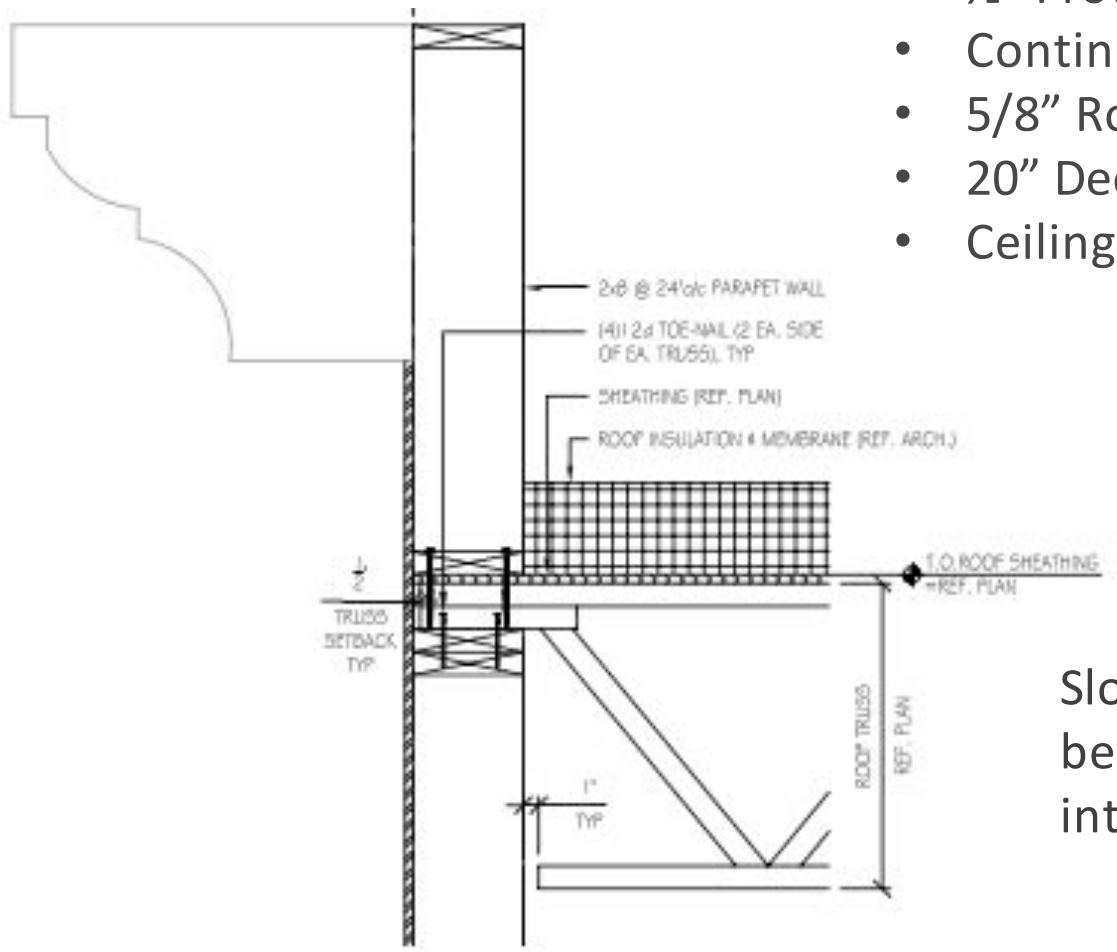
- Floor to Floor Height: 14’-0”
- Typical Floor Truss Span: 24’-0”
- 1-1/2” Lightweight Concrete Topping
- ¾” Floor Sheathing
- 24” Deep Pre-fab Wood Trusses @ 24” o.c.
- Gypsum Ceiling





Detailing Options for Wood Framed Office

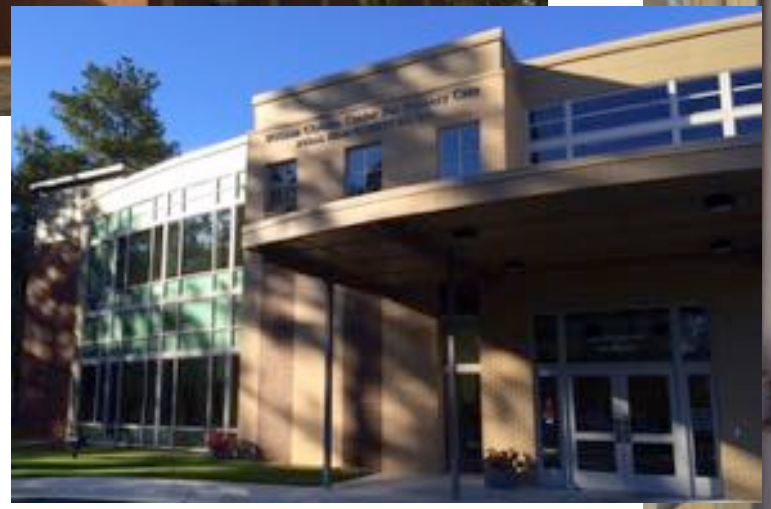
Typical Roof Truss Span: 24’-0”



Roof Construction:

- Roofing Membrane
- ½” Protection Board
- Continuous Insulation
- 5/8” Roof Sheathing
- 20” Deep Pre-fab Wood Trusses @ 24” o.c.
- Ceiling

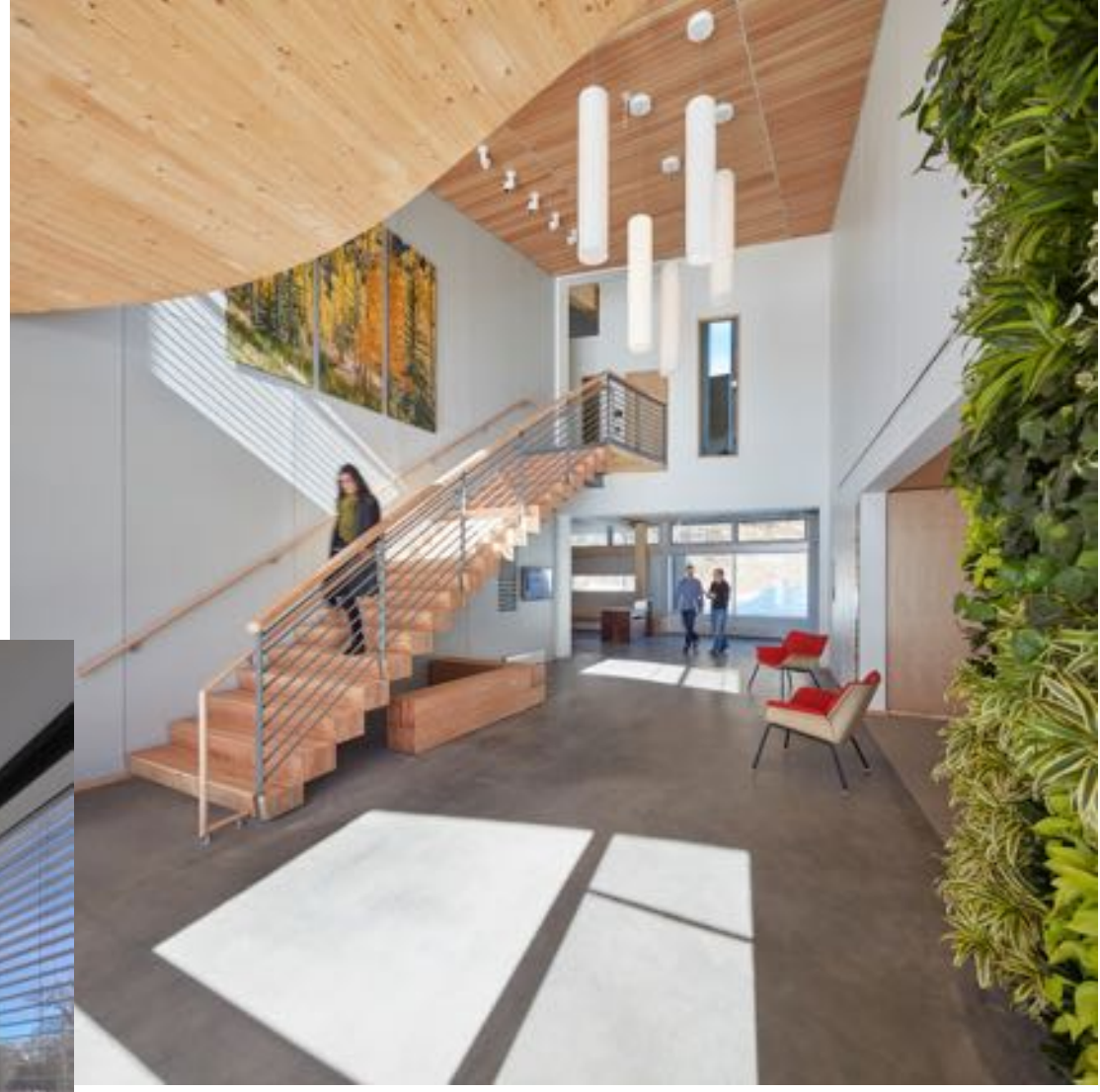
Sloping internal roof support beams created low-slope, internally drained roof



William Clyburn Center for Primary Care

- Location: Aiken, SC
- Completed: Nov, 2014
- 2 stories, Type VB, 26,600 sf
- Wood bearing walls with I-joists
- Total Construction Cost: $4M
- Approx. $150/sf

ARCHITECT: Hughes, Beattie, O'Neal, Law & Associates
ENGINEER: J.E. Stewart Engineering, Inc.
PHOTO CREDIT: Hughes, Beattie, O'Neal, Law & Associates



Rocky Mountain Institute Innovation Center

- Location: Basalt, CO
- Type VB, 2 stories
- 15,600 sf
- Goal- 100 year design life

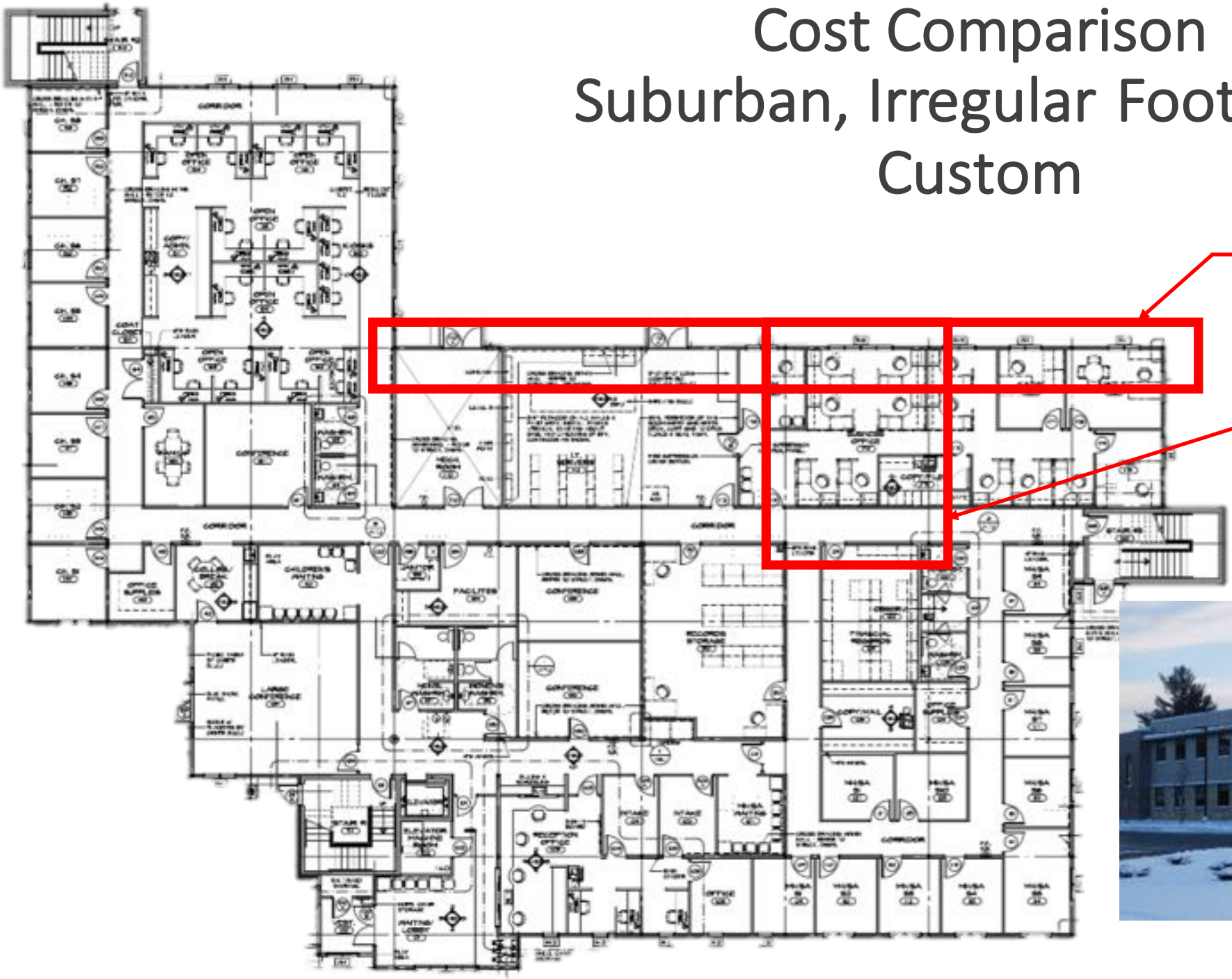
ARCHITECT: ZGF Architects
ENGINEER: KPFF Consulting Engineers
PHOTO CREDIT: Tim Griffith

Rocky Mountain Institute Innovation Center (Cont.)

- SIP panel exterior walls and roof
- Targeting net zero energy
- Cross-laminated timber used for floor structure utilizes beetle-kill lumber from British Columbia.
- Use of CLT allowed structure depth to be minimized, allowing natural daylight to penetrate further into building

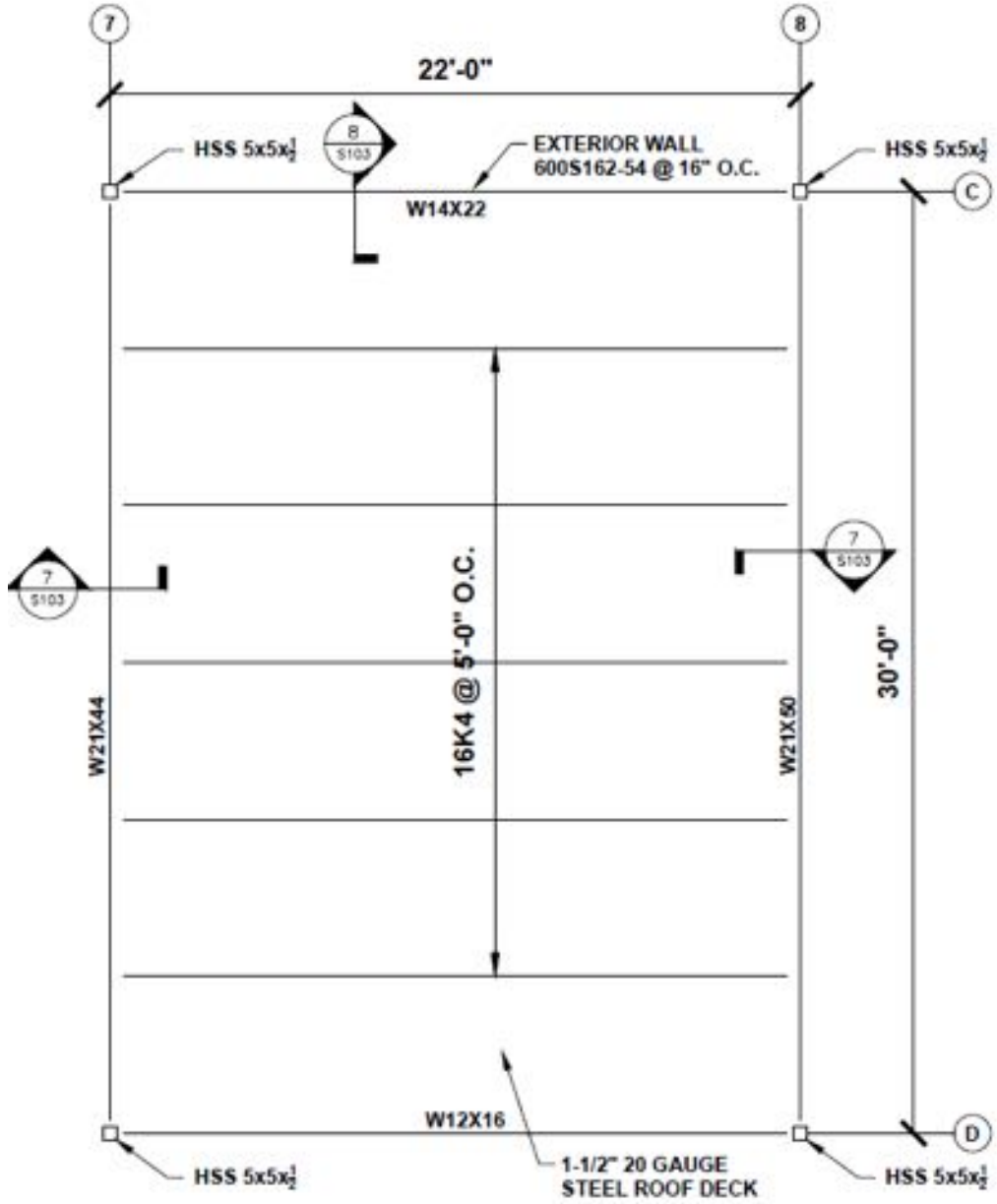
ARCHITECT: ZGF Architects
ENGINEER: KPFF Consulting Engineers
PHOTO CREDIT: Structurlam, RMI, Aspen Times

Cost Comparison
Suburban, Irregular Footprint, Custom

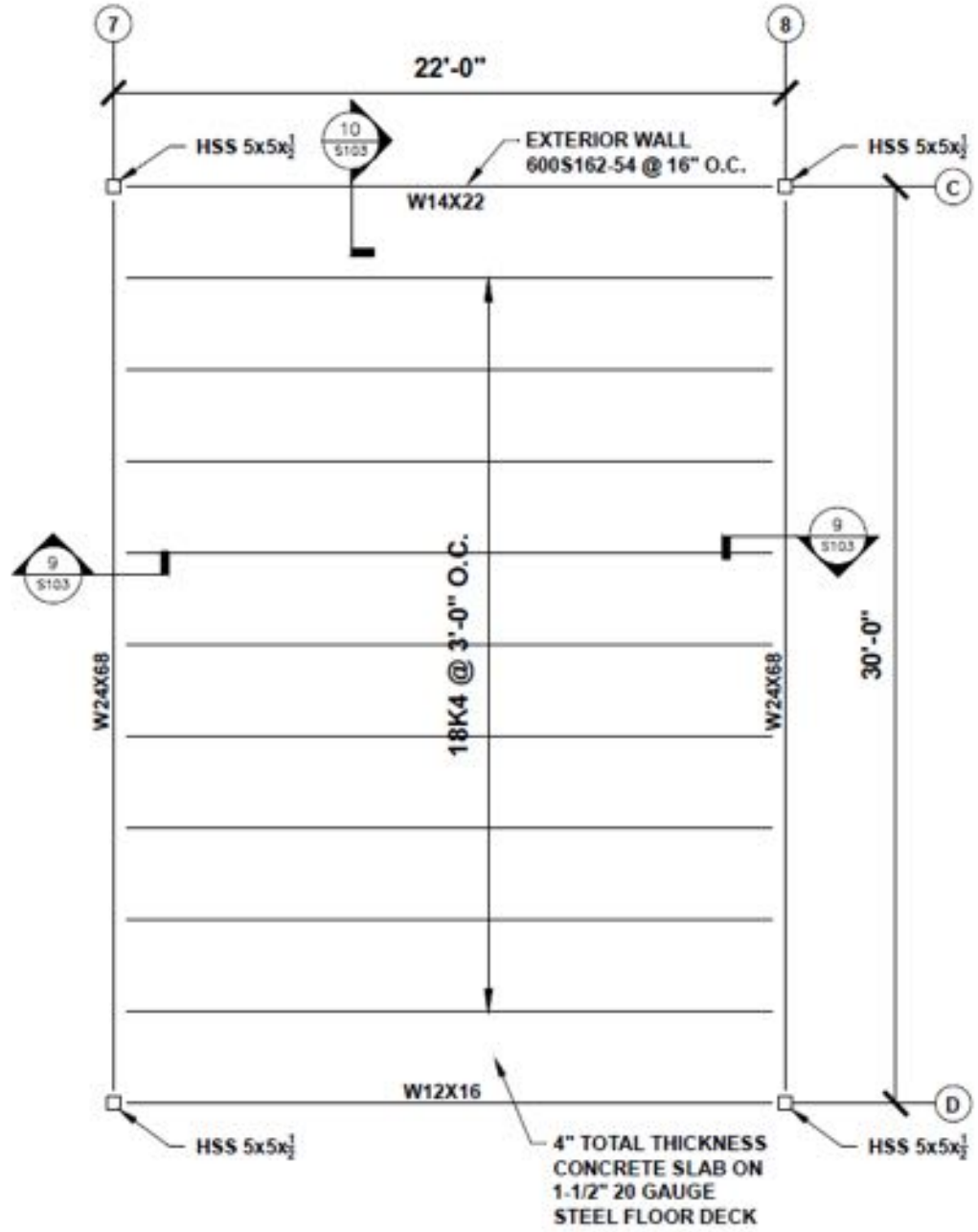


Lateral line:
- Steel braced frame
- Wood shear wall

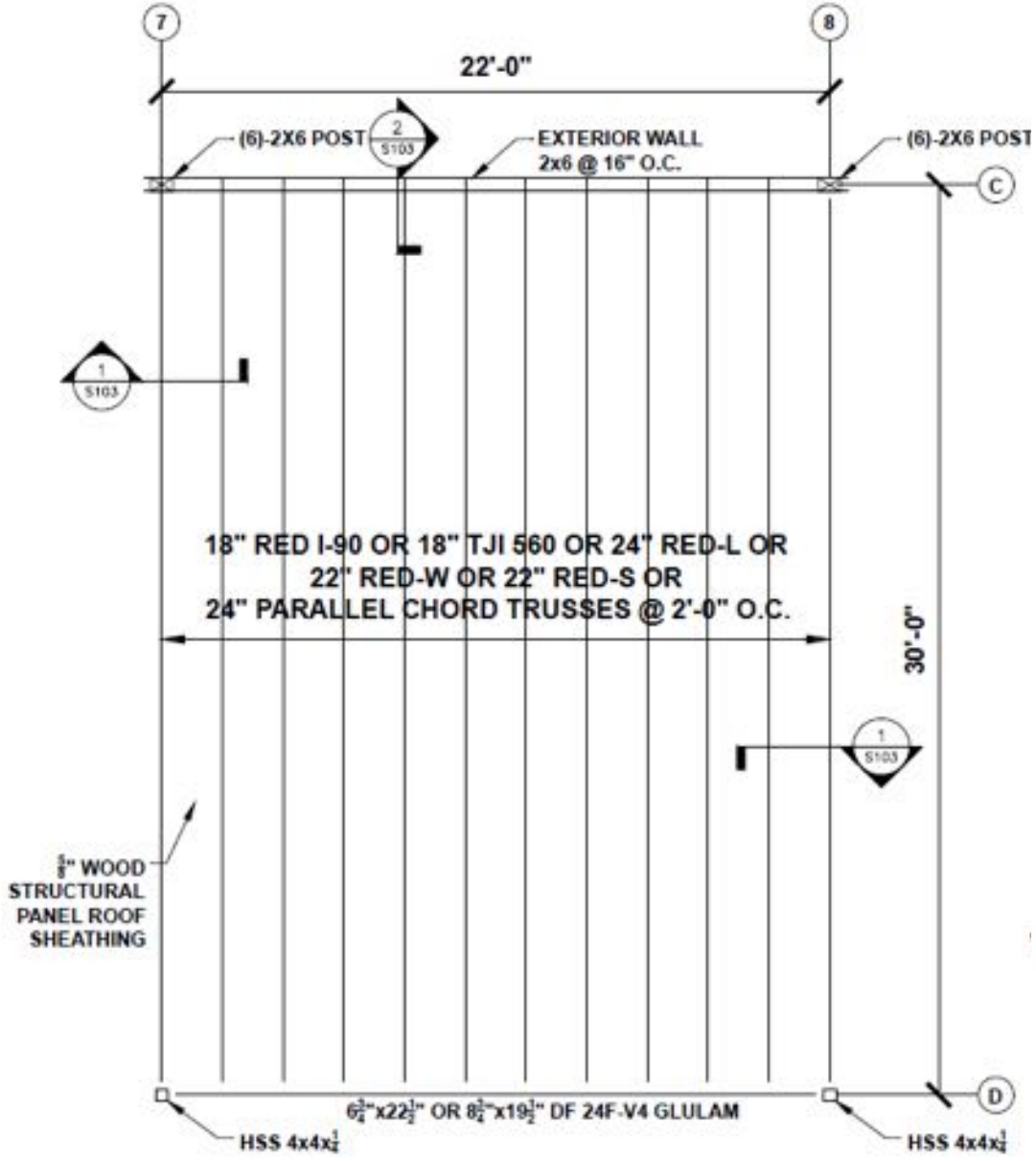
Single floor grid:
- Steel joist
- Wood shear wall



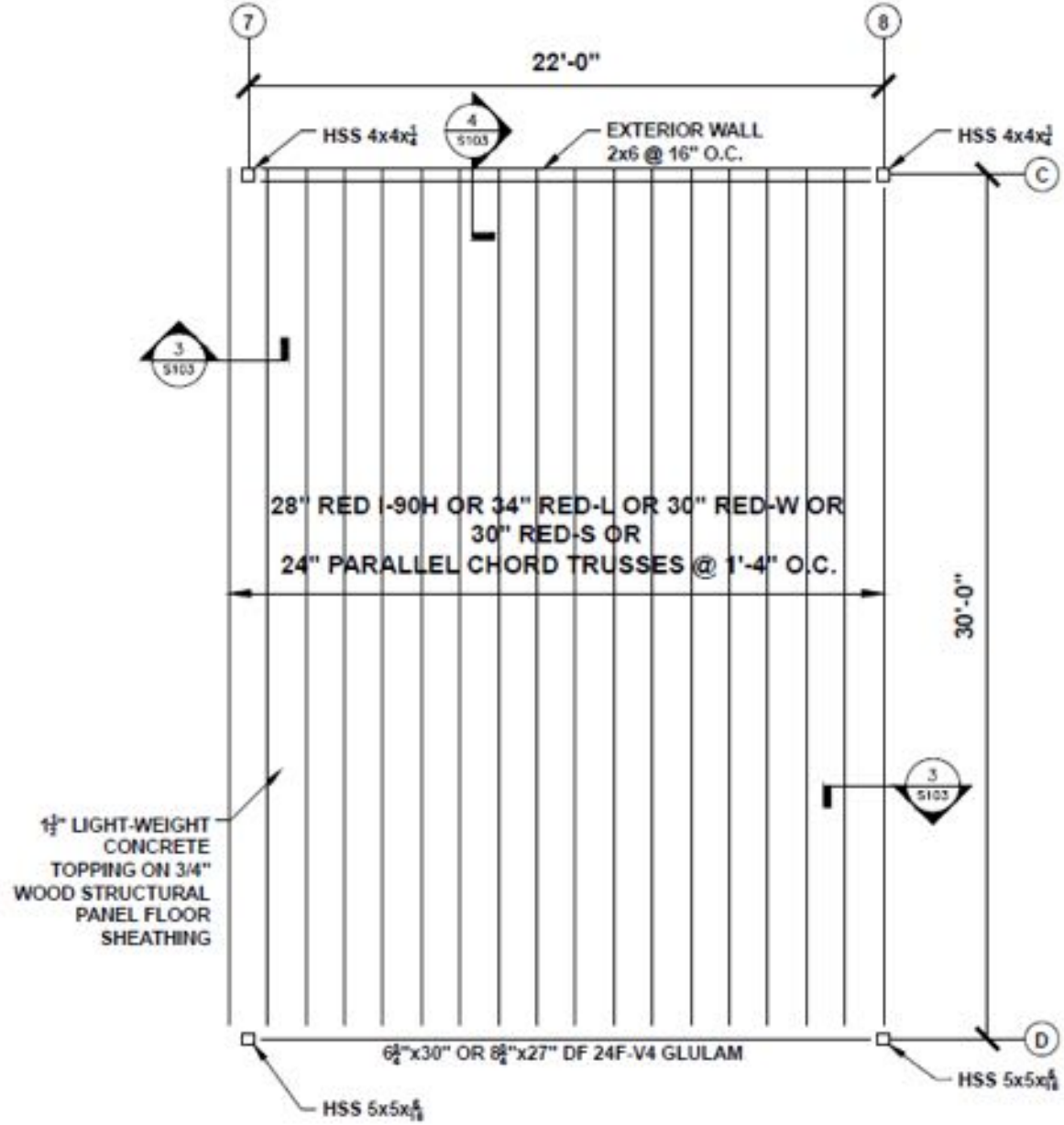
STEEL BUILDING ROOF FRAMING PLAN



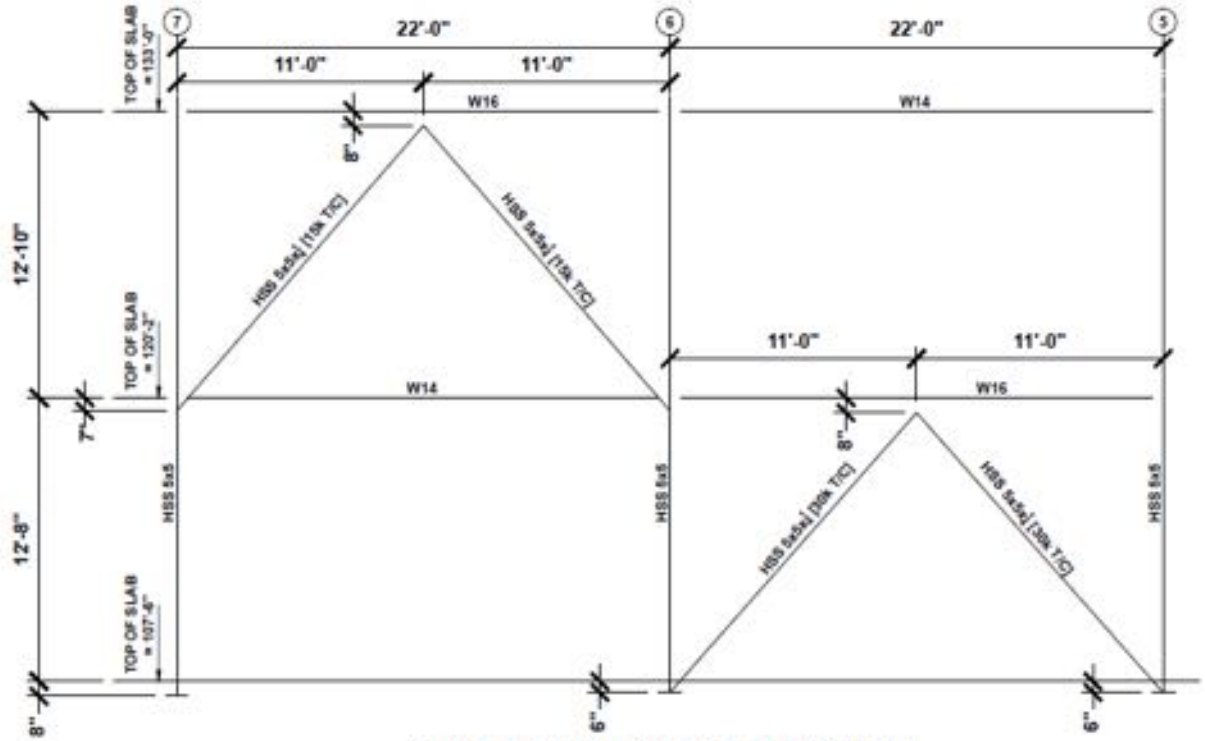
STEEL BUILDING 2ND FLOOR FRAMING PLAN



WOOD BUILDING ROOF FRAMING PLAN

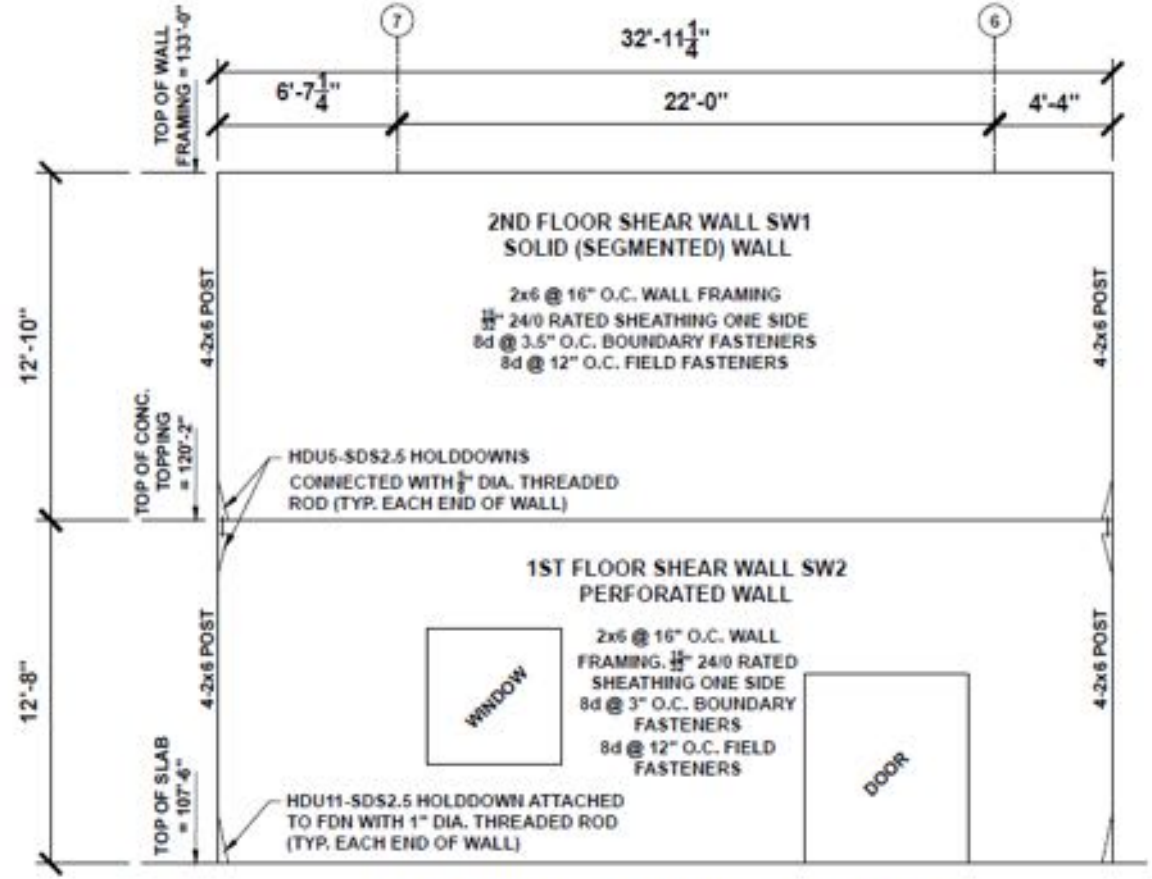


WOOD BUILDING 2ND FLOOR FRAMING PLAN



LINE C STEEL BRACE ELEVATION

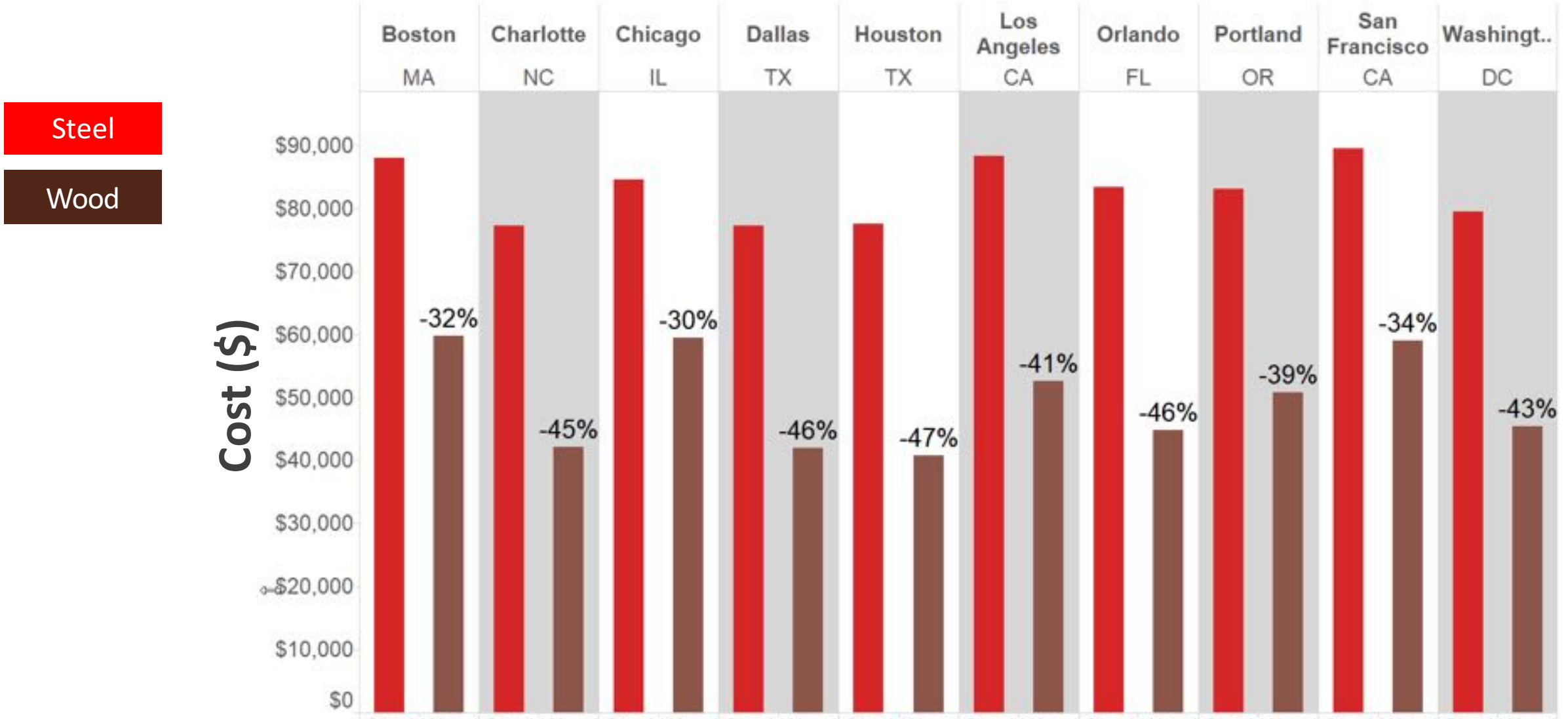
SCALE: $\frac{3}{32}$" = 1'-0"



LINE C SHEAR WALL ELEVATION

SCALE: $\frac{3}{32}$" = 1'-0"

Cost Comparison: 22’x30’ Grid

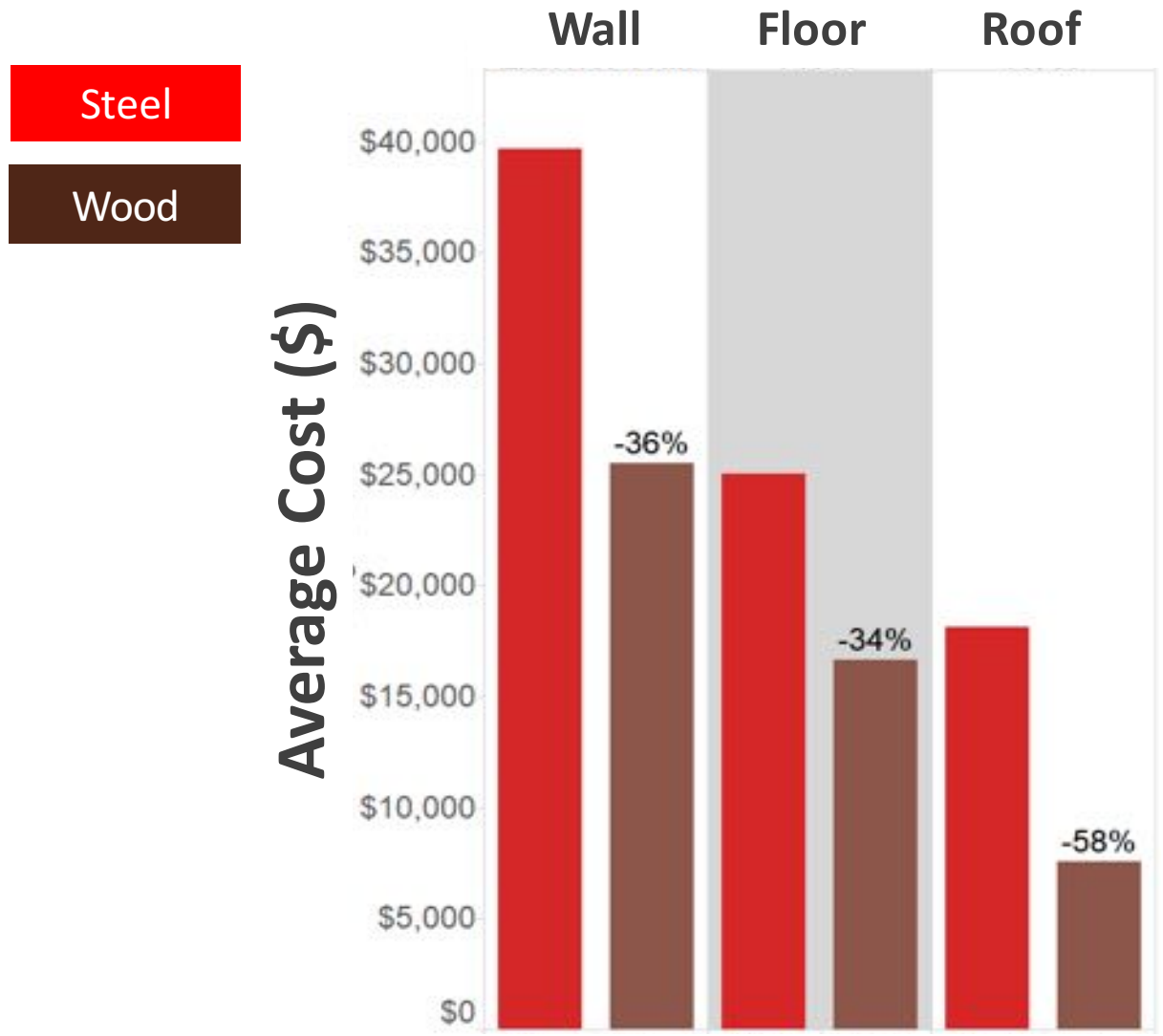


Source: ESQ Consultants, RSMeans 2016 Q2

Cost Comparison: 22’x30’ Grid

Cost Savings by System:

- Average overall savings of 40% on structure
- Structure makes up 15-30% of overall building cost
- Largest Cost Savings in the Roof
- Included were all secondary assembly items that differed between a steel and roof structural system



Source: ESQ Consultants, RSMeans 2016 Q2

Architects largely agree that timber construction offers:

- Cost Effectiveness
- Large Labor Pool
- Readily Available Material
- Speed of Erection
- Low Carbon Footprint

But what is often missed is……

It can be done more often than you thought!

“Any more questions?”