West Village Housing Phases III & IV

Towson, Maryland

Mark Bland

Advisor | Dr. Aly Said

Structural Option

AE Senior Thesis

April 11, 2015

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

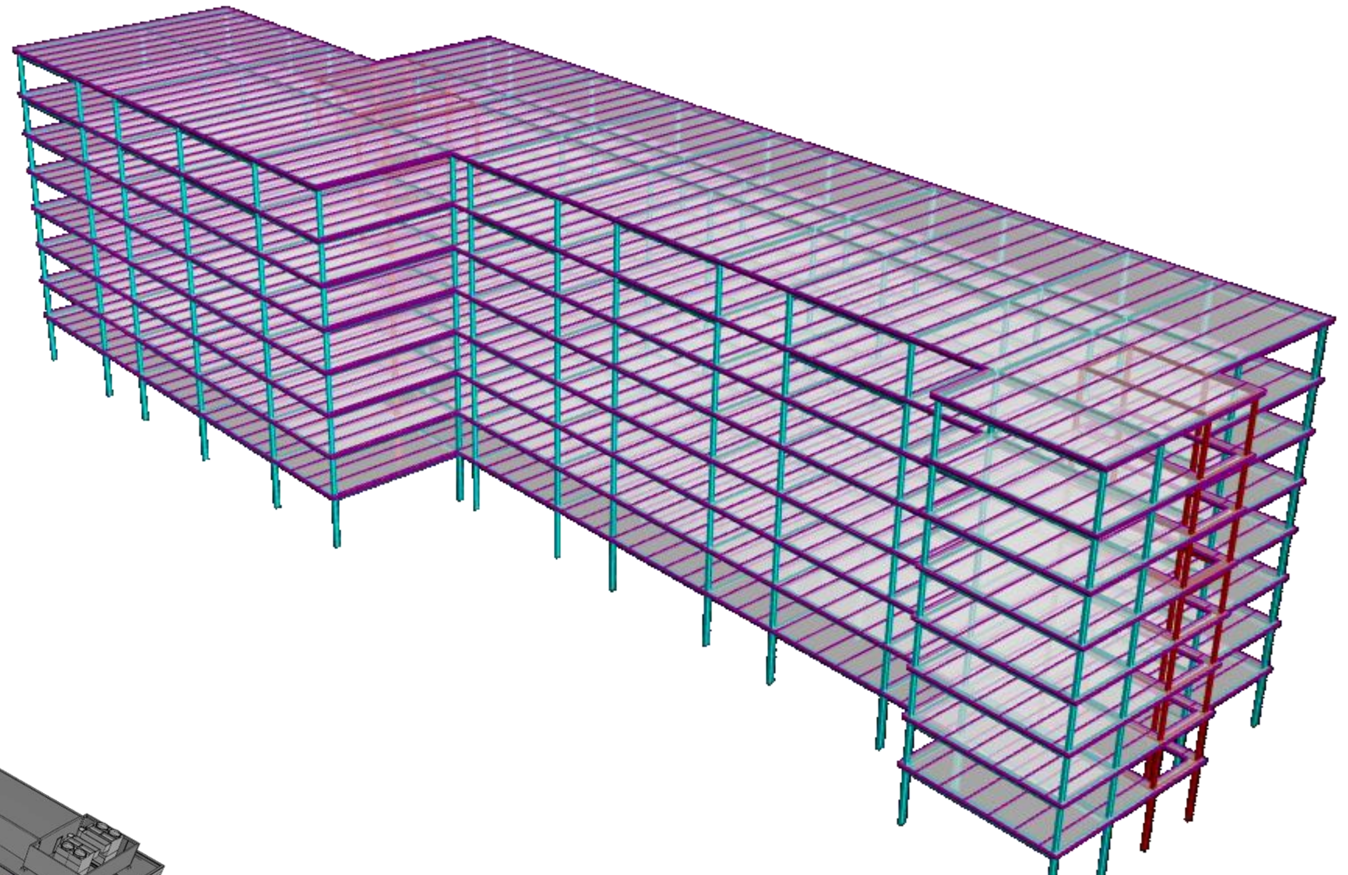
Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

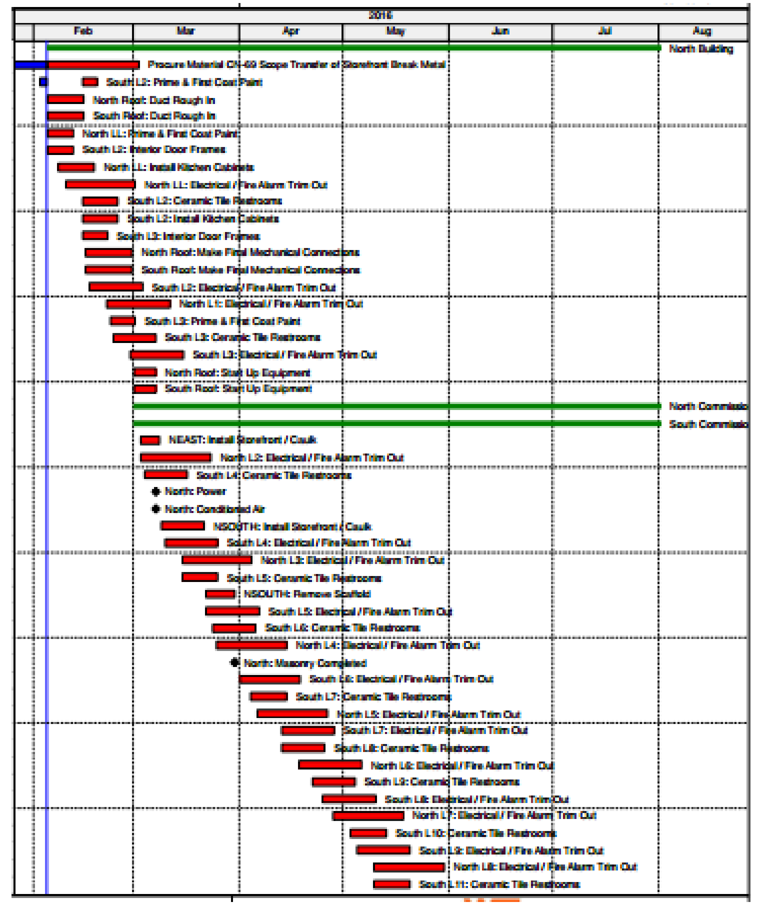
Conclusion
Comparison

Existing Design



Proposed System

Construction Breadth



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction

Site Plan | Existing Gravity | Existing Lateral

Proposal

Purpose | Solution

Redesigned Gravity System

Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System

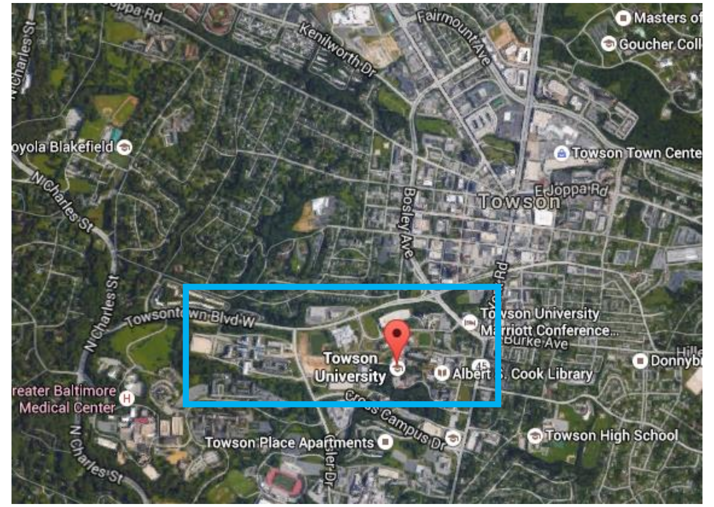
Buckling Restrained Braced Frames | COM/COR

Construction Breadth

Critical Path Schedule | Cost Analysis

Conclusion

Comparison



Use: Student Housing

Size: 170,000 sq. ft.

Stories: 9

Height: 87 ft.

Construction: September 2014 – July 2016

Towson University: **Owner**

Whiting Turner Contracting: **General Contractor and CM**

Ayers/Saint/Gross: **Architect**

Hope Furrer Associates: **Structural Engineer**

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction

Site Plan | Existing Gravity | Existing Lateral

Proposal

Purpose | Solution

Redesigned Gravity System

Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System

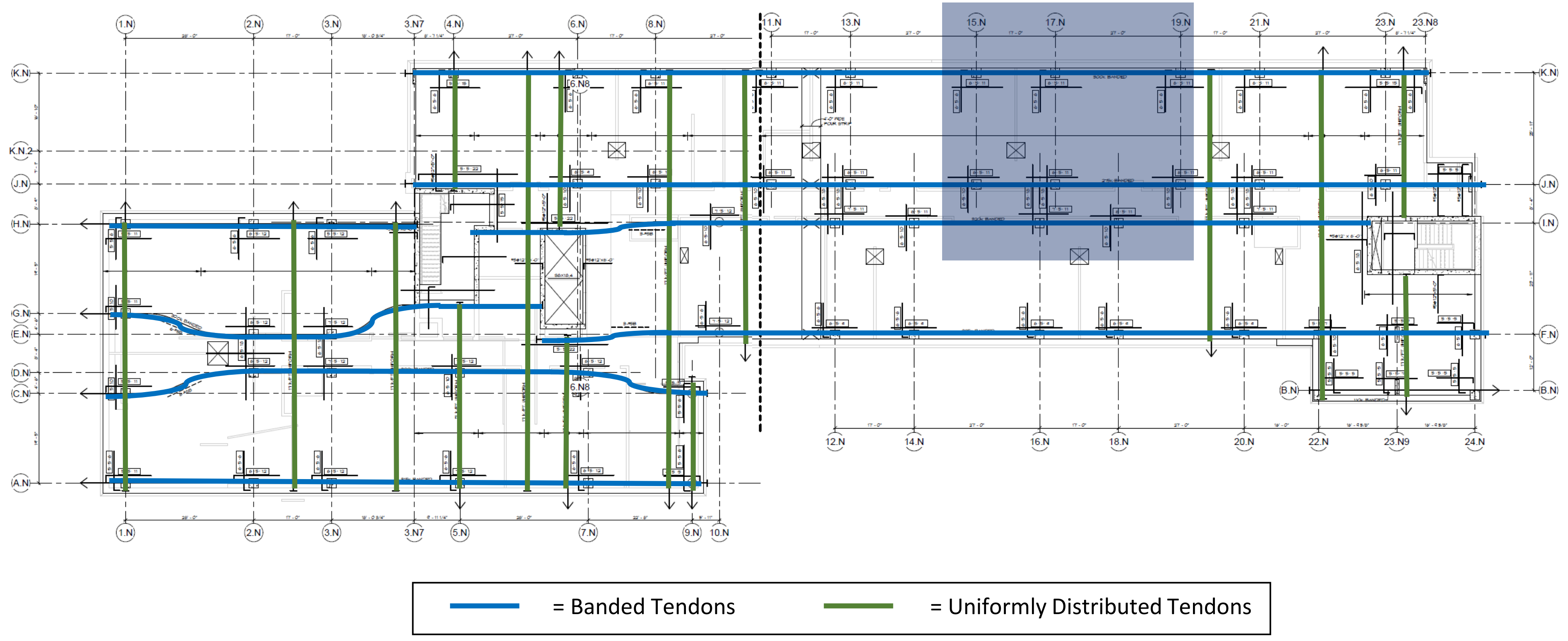
Buckling Restrained Braced Frames | COM/COR

Construction Breadth

Critical Path Schedule | Cost Analysis

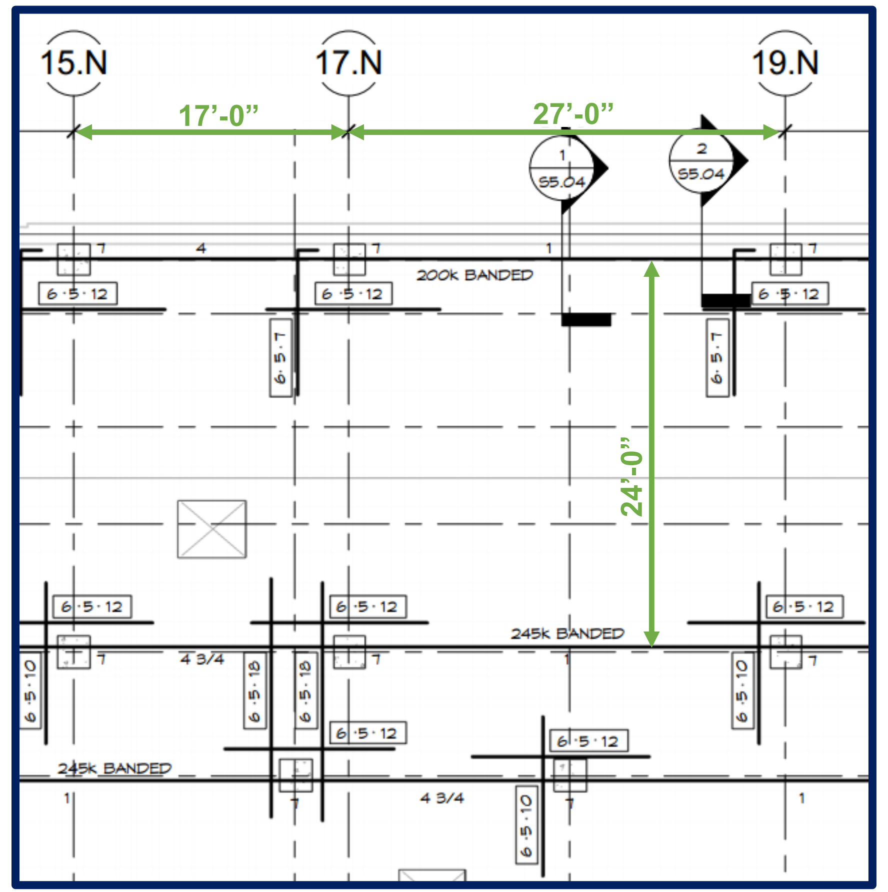
Conclusion

Comparison



Existing Gravity System

- 8" thick slab
- Two-way post-tensioned flat plate
- 24" x 24" Concrete columns



Typical Bay

Typical Loading

Loading	Typical Floor	Typical Roof	Penthouse
Dead Load	108	123	150
Live Load	55	30	100
Total Load	163	153	250

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction

Site Plan | Existing Gravity | Existing Lateral

Proposal

Purpose | Solution

Redesigned Gravity System

Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System

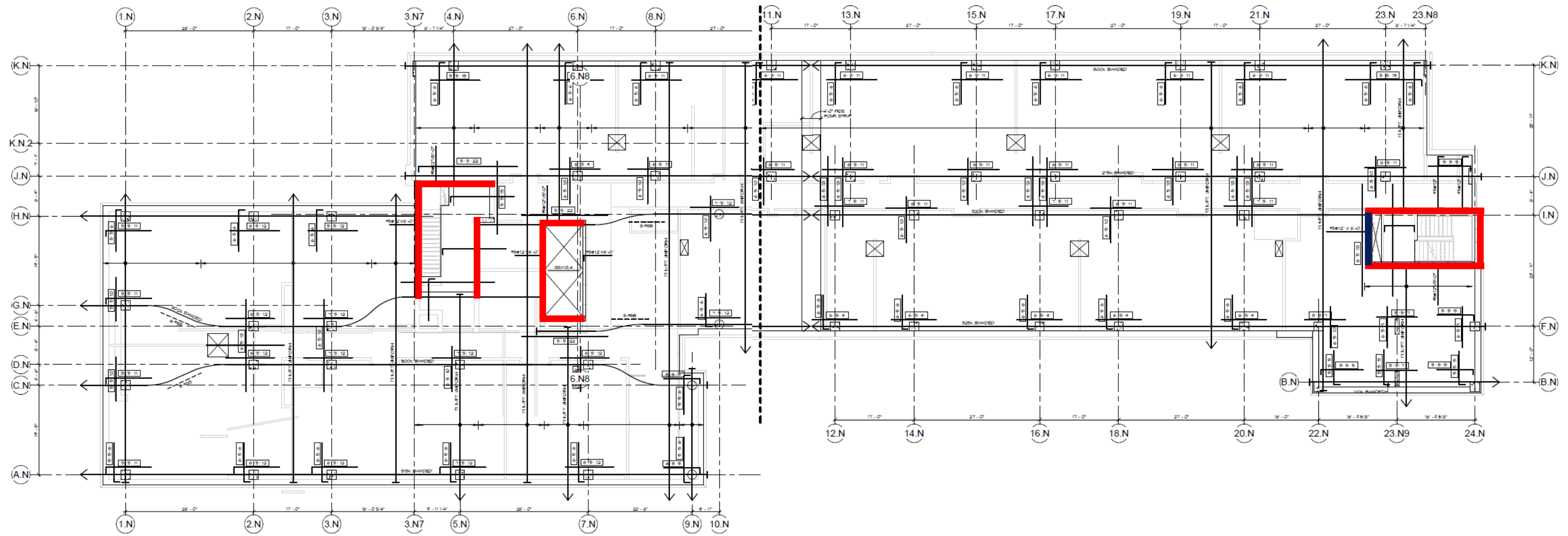
Buckling Restrained Braced Frames | COM/COR

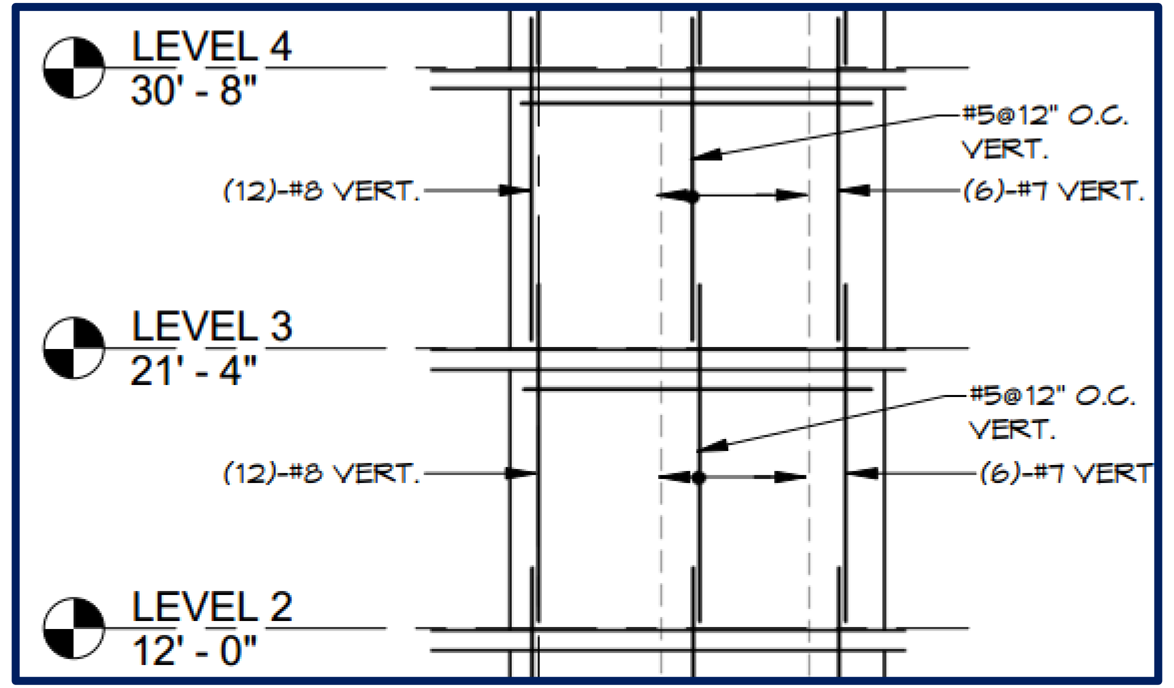
Construction Breadth

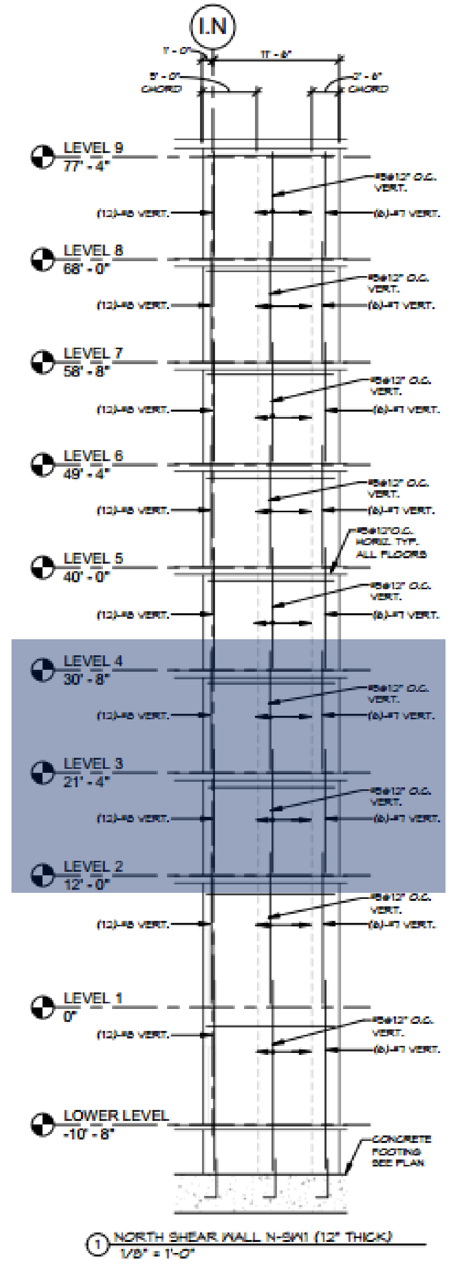
Critical Path Schedule | Cost Analysis

Conclusion

Comparison







Existing Lateral System

- (10) 12" thick concrete shear walls
- Located around stair and elevators
- Vary in height due to penthouse

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

Conclusion
Comparison

Three main questions

- What could be bettered with the project by changing the structural system?
- Is this alternative feasible?
- What are the impacts?
  - Benefits & repercussions

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction

Site Plan | Existing Gravity | Existing Lateral

Proposal

Purpose | Solution

Redesigned Gravity System

Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System

Buckling Restrained Braced Frames | COM/COR

Construction Breadth

Critical Path Schedule | Cost Analysis

Conclusion

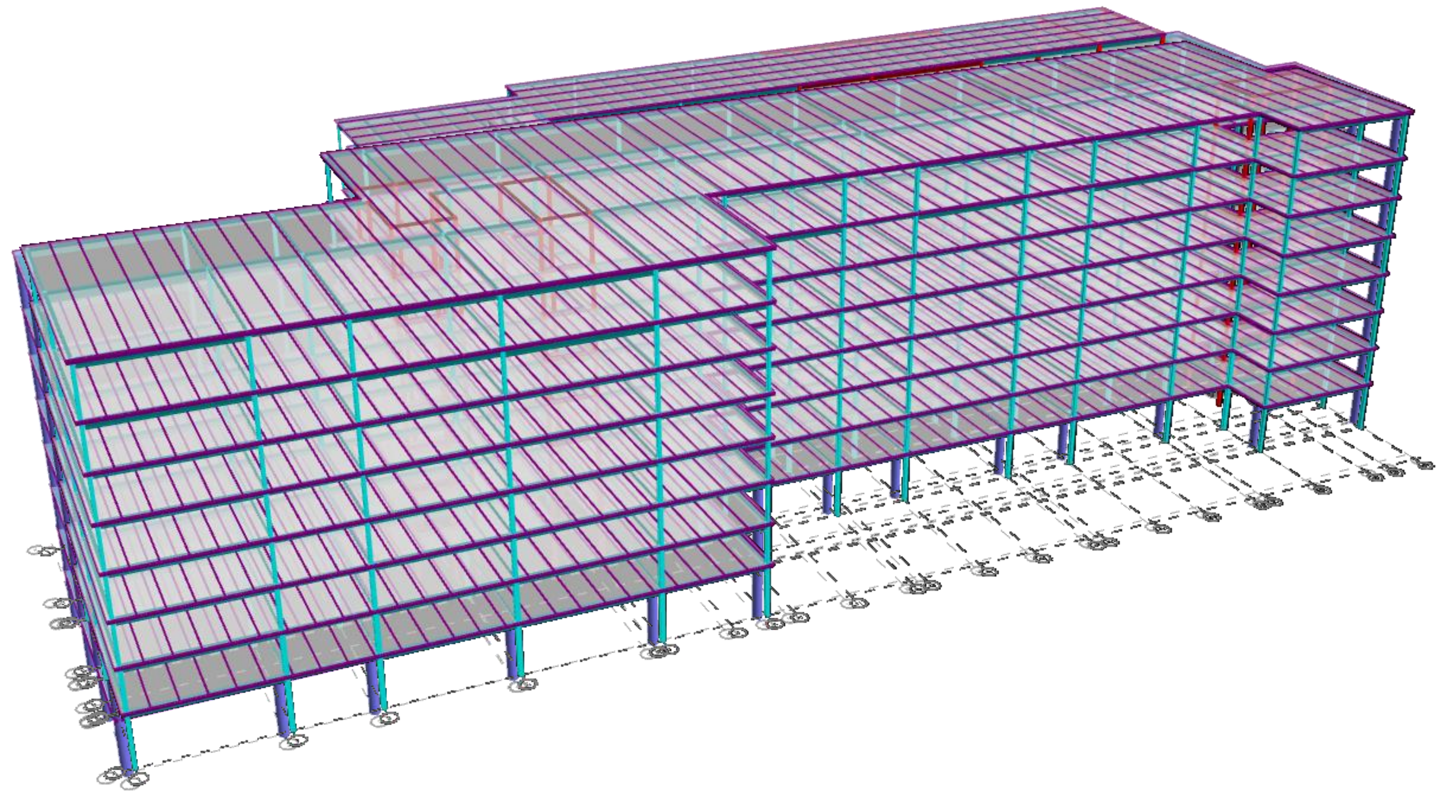
Comparison

Goals

- Reduce project schedule
- Cost efficient system

Proposed System

- Precast hollow core planks
- Non-composite steel
- Braced frames



West Village Housing Phases III & IV
Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

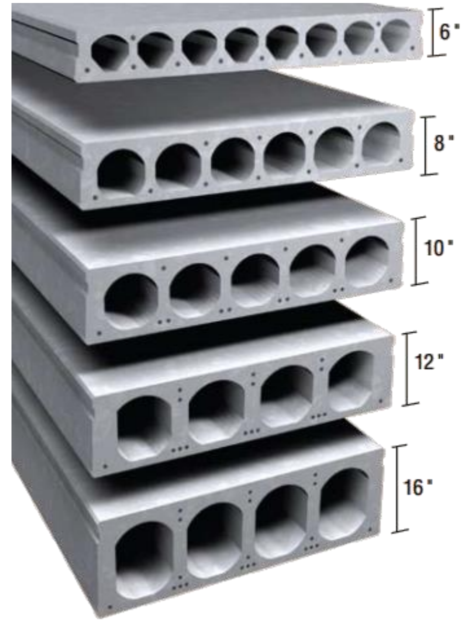
Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

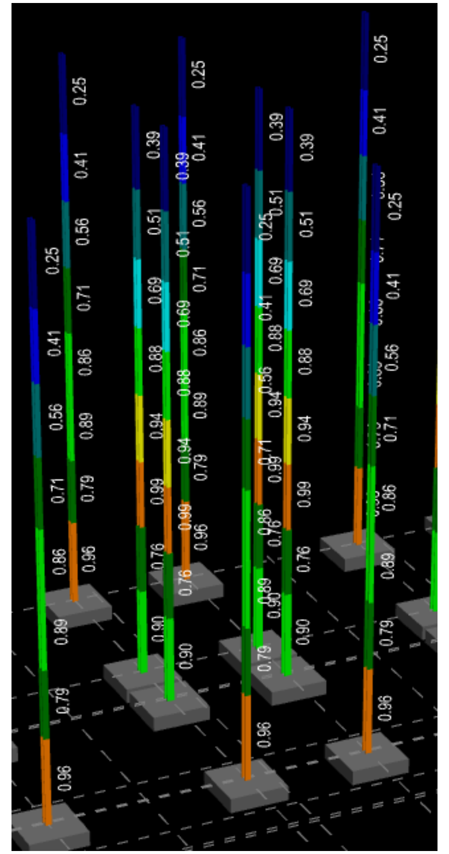
Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

Conclusion
Comparison

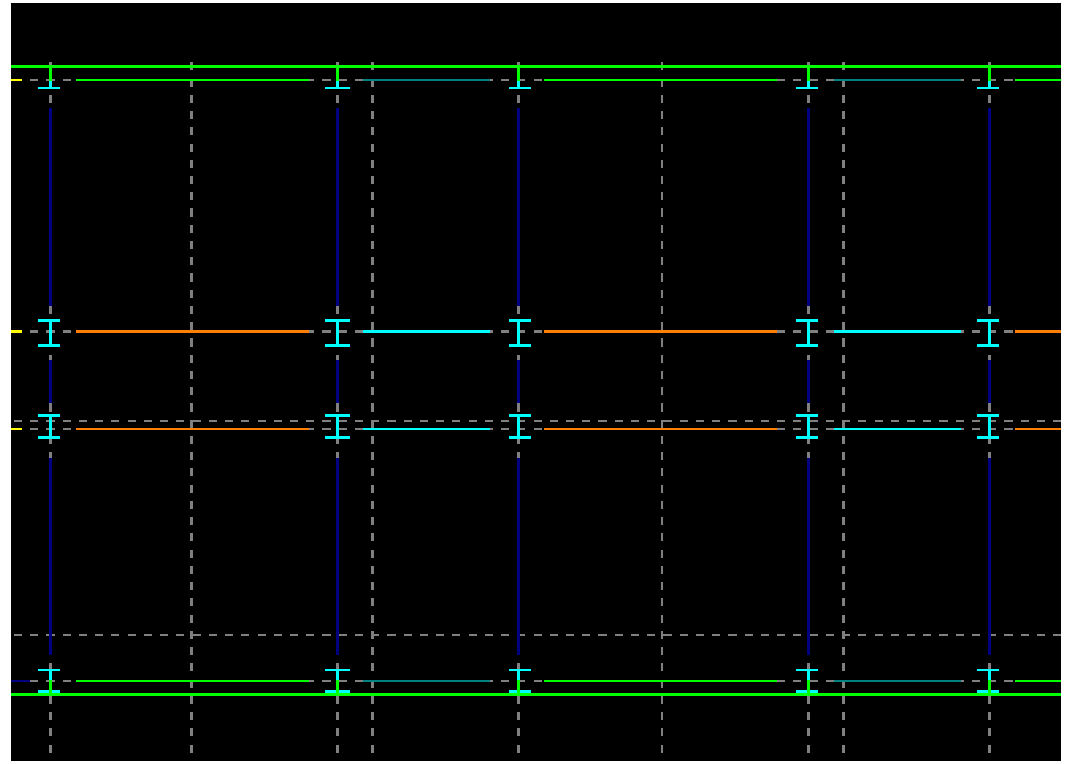
Hollow-Core Planks





Steel Columns

Non-Composite Beams



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

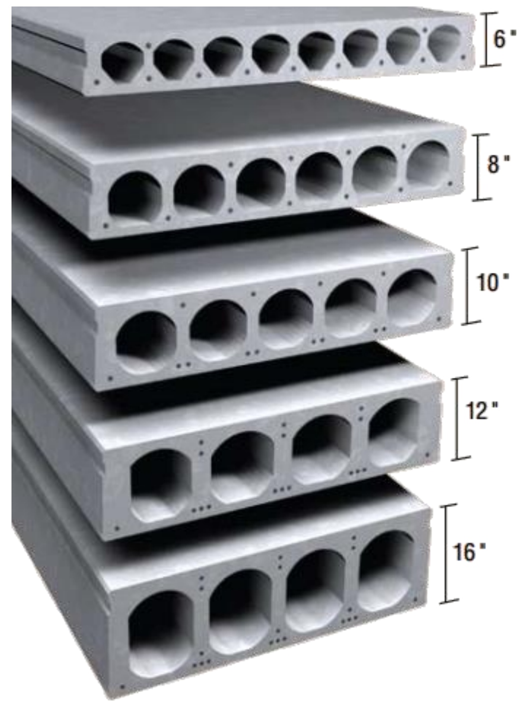
Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

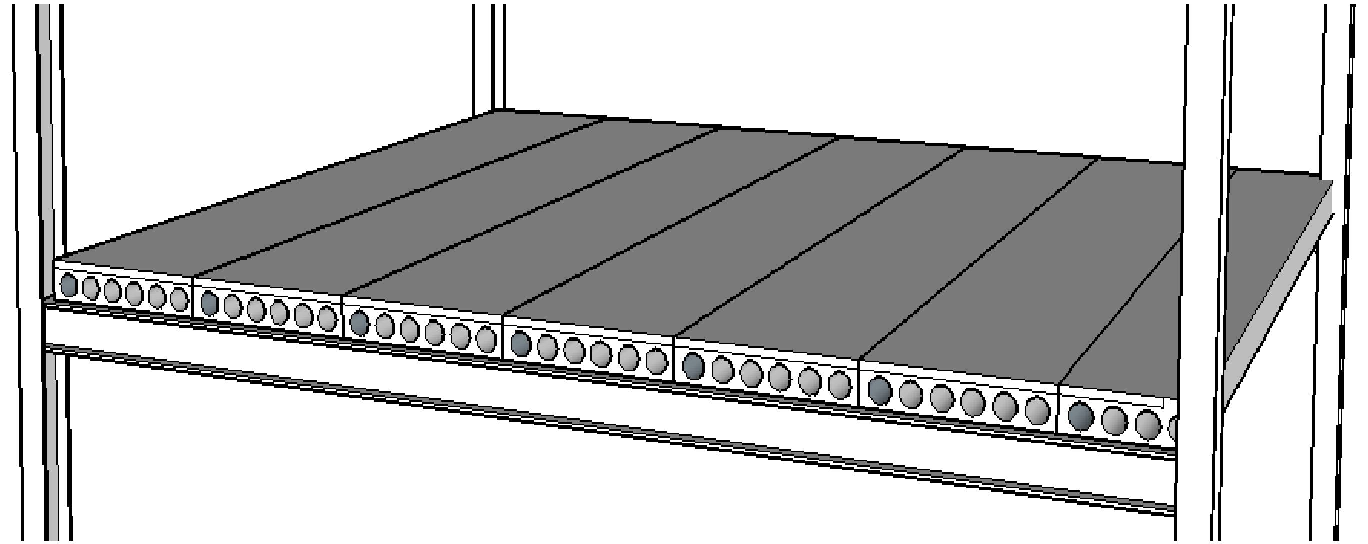
Conclusion
Comparison

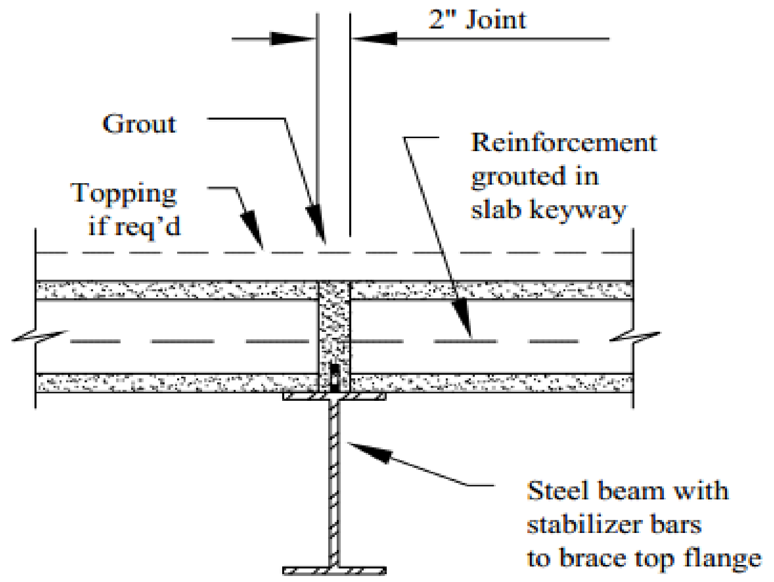


Courtesy of oldcastleprecast.com

Elematic precast hollow core planks

- 8” thick, 2” topping
- 4’ wide
- 5,000 psi concrete strength
- 79psf
  - Reduced from 108 psf





Connection detail

- Transfers diaphragm forces
- Lateral bracing
- Grout adds stiffness

West Village Housing Phases III & IV

Towson, Maryland

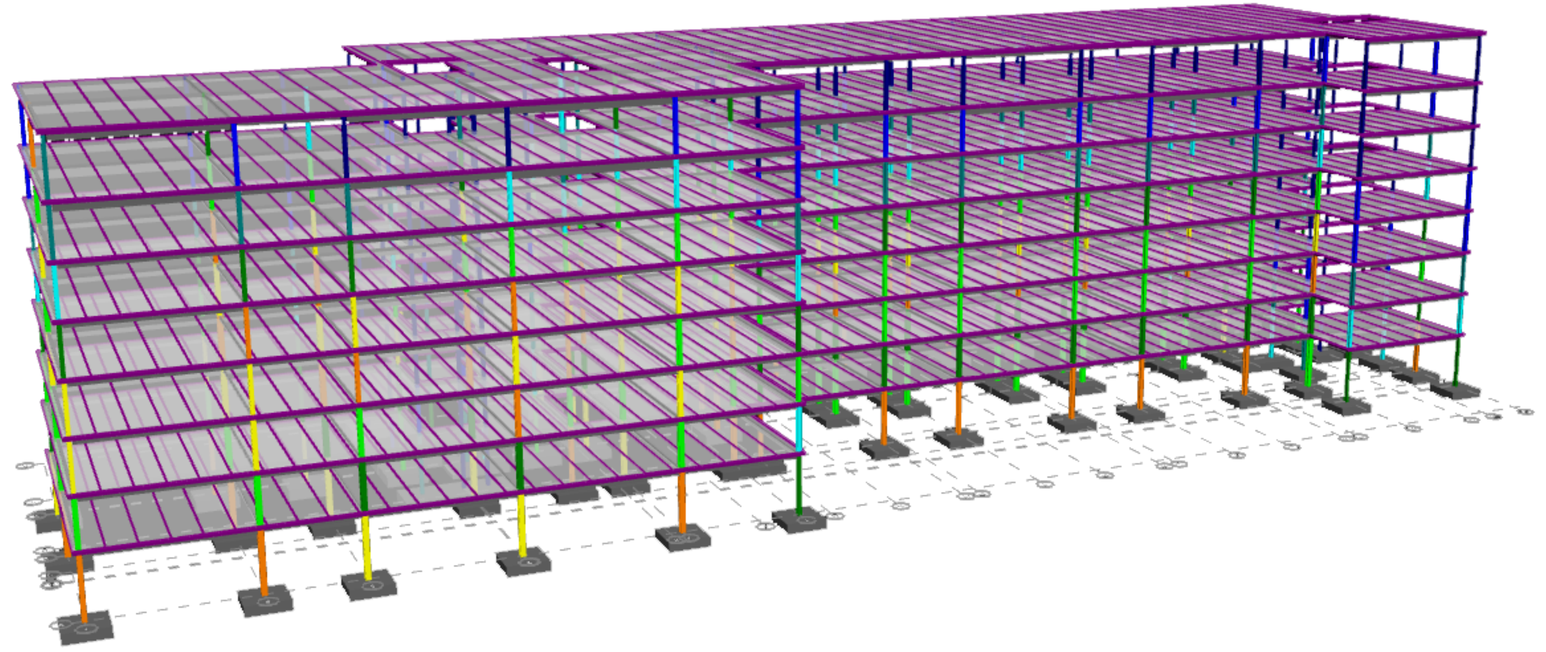
🟩 Proposed columns ▨ Existing columns

Shifting columns

- Optimizing steel performance
- Minimal architectural changes

Column sizes

- Column depth constant through building height
- Spliced every two floors
- Exterior: W 12x53, W 12x40
- Interior: W 12x65, W 12x53



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

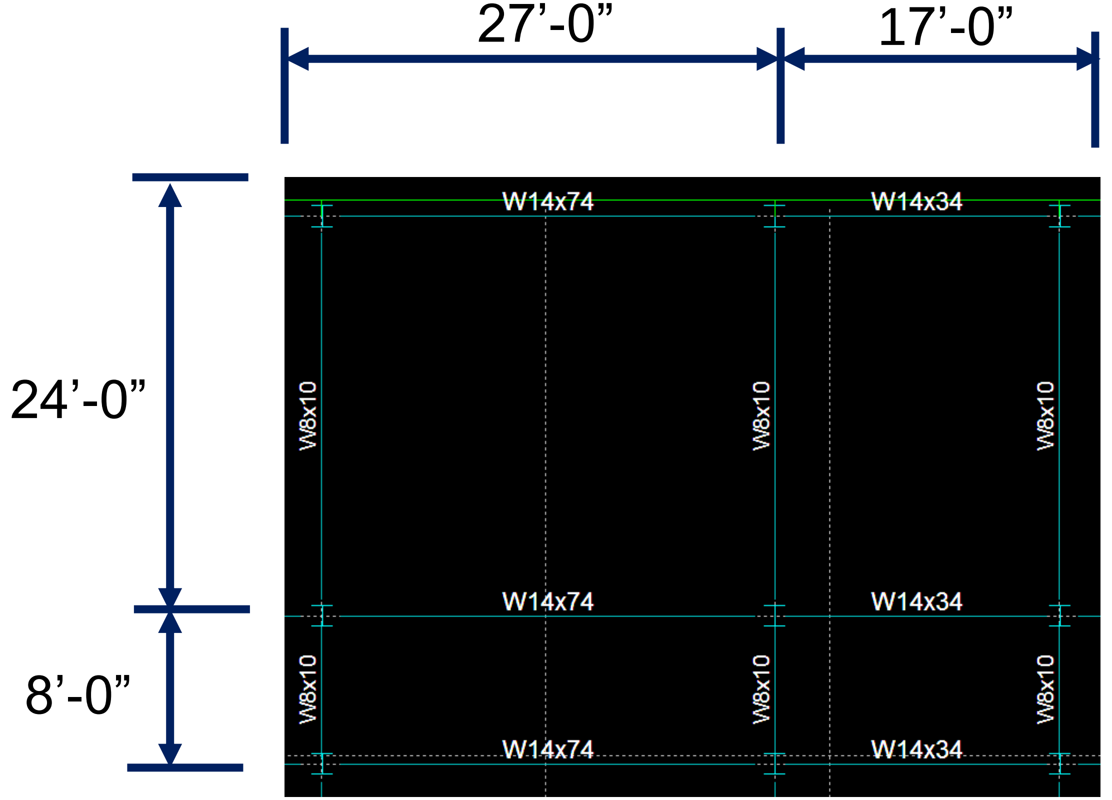
Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

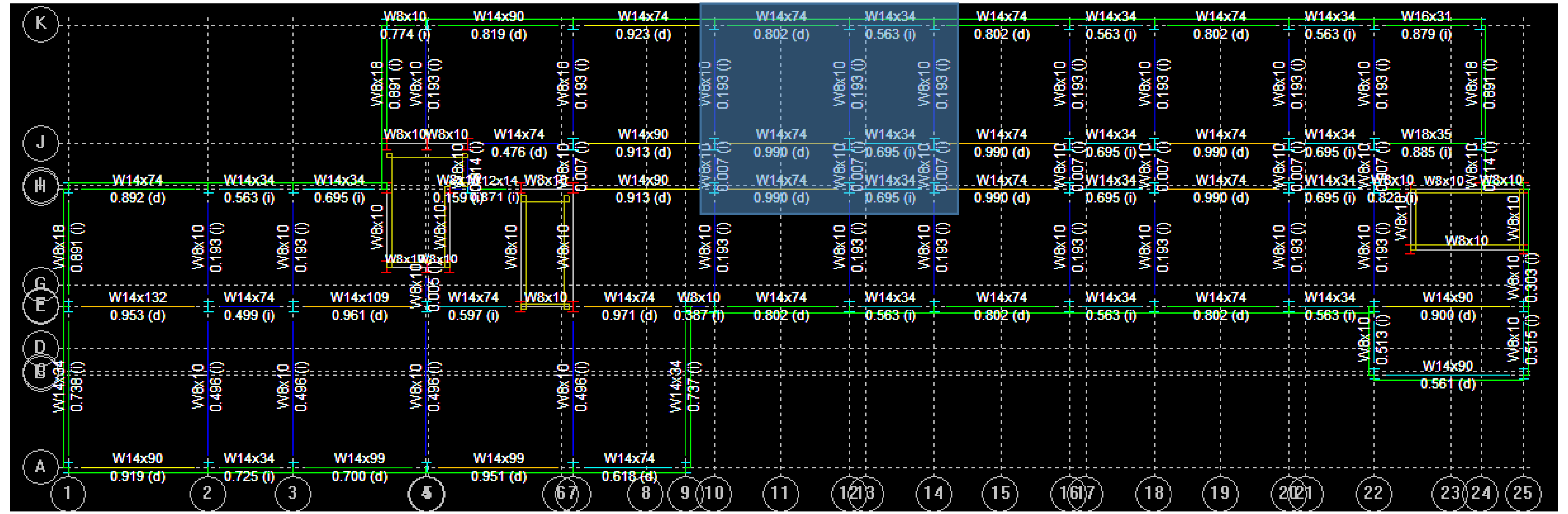
Conclusion
Comparison

Typical Bay

- Shifted columns eliminates transfer beams
- Beam depth 14” maintained throughout
- Deflection controlled majority of beam sizes
- Designed for 2 hour fire rating



Column sizes



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

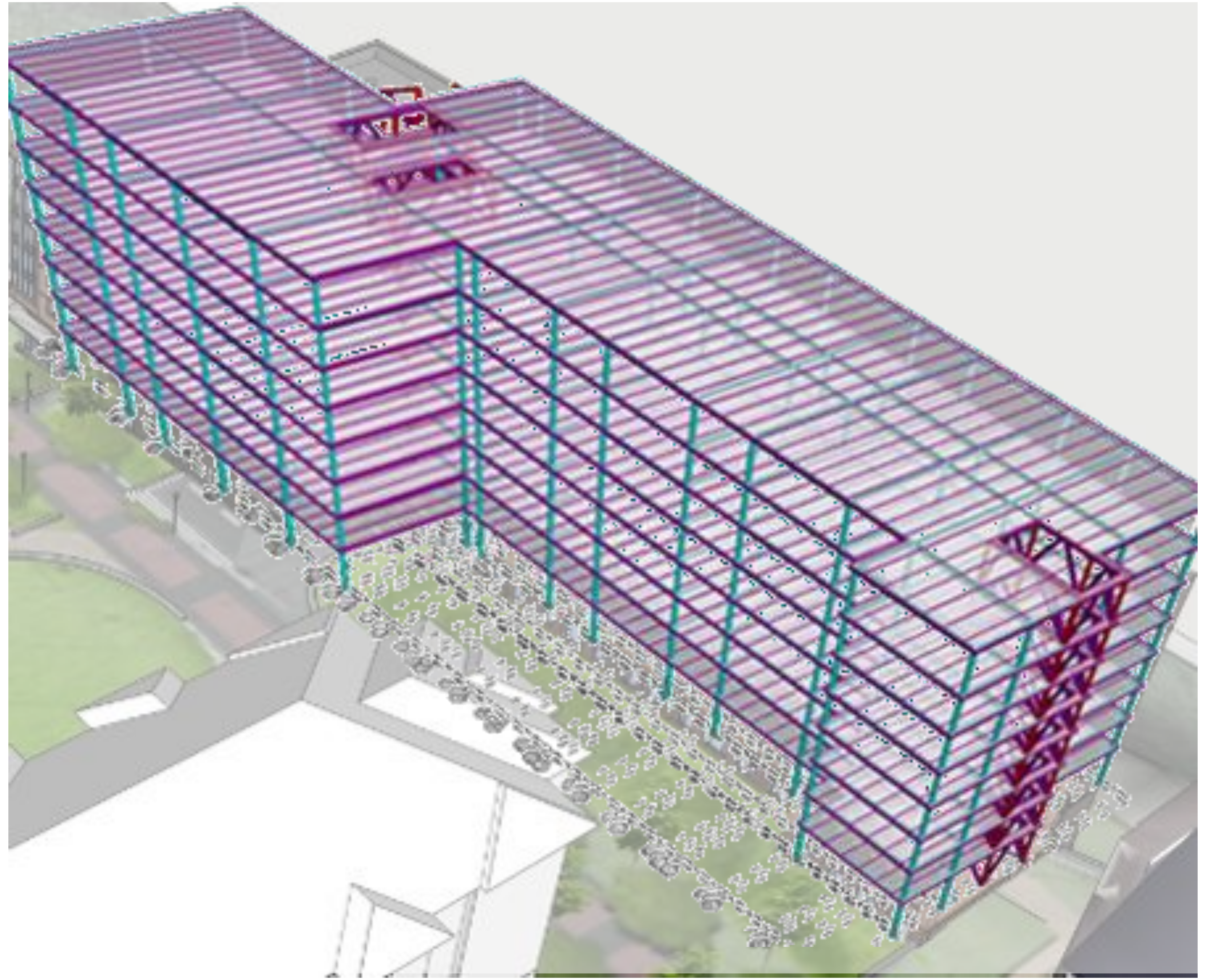
Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

Conclusion
Comparison



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

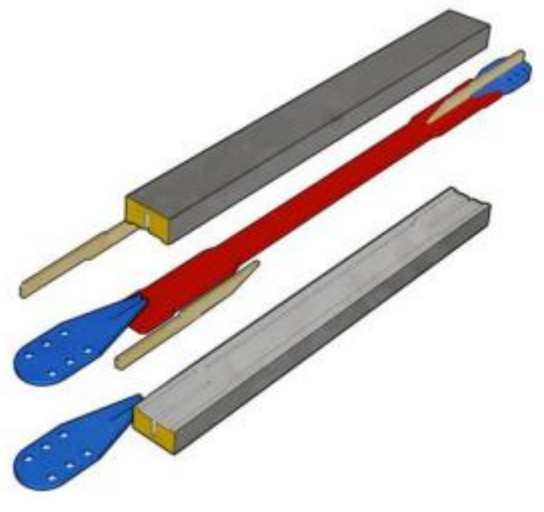
Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

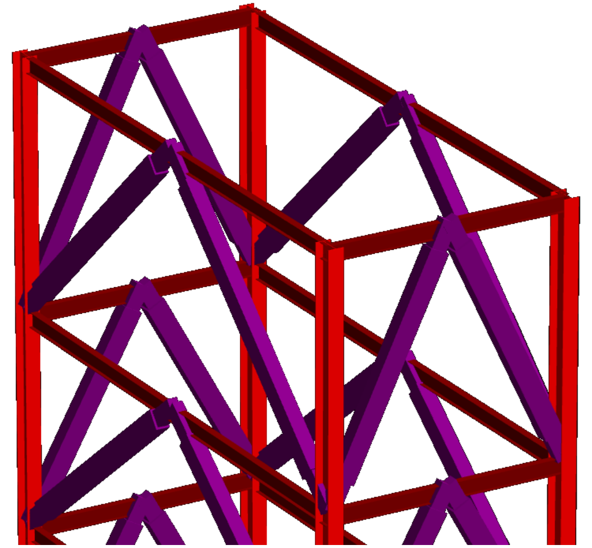
Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

Conclusion
Comparison



Courtesy of CoreBrace.com



Buckling Restrained Braced Frame Advantages

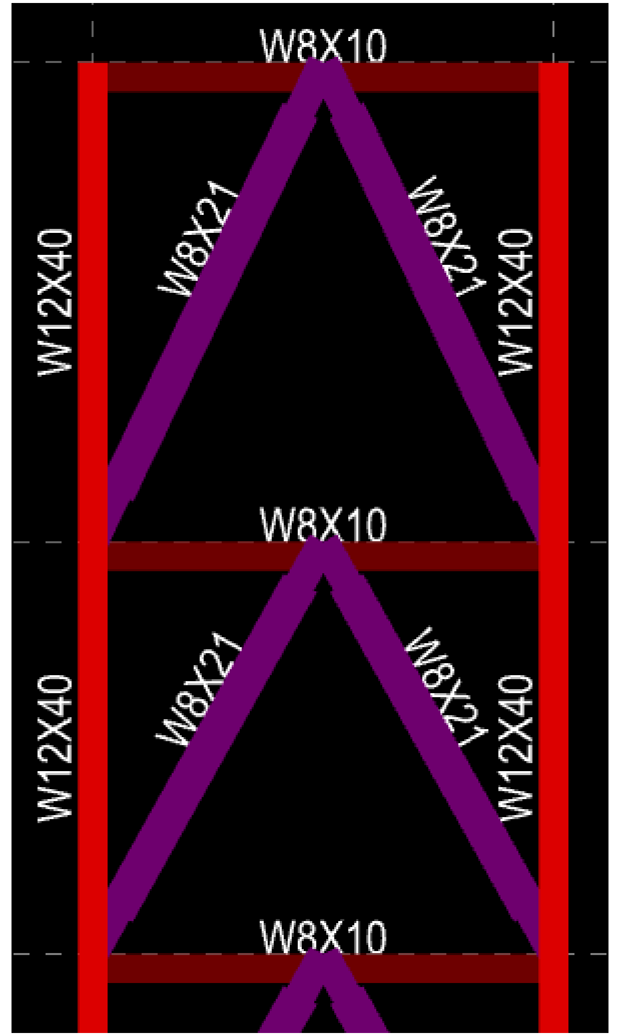
- Field tolerances
- Fast and efficient frame erection
- Response modification coefficient, R, of 8
- Provides member ductility
- Less imbalance of tension and compression forces

Selected Design

- Columns: W 12x40
- Beams: W 8x10
- Braces: W 8x21

CoreBrace

- Stiffness factors vary
- Bolted lug connection



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction

Site Plan | Existing Gravity | Existing Lateral

Proposal

Purpose | Solution

Redesigned Gravity System

Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System

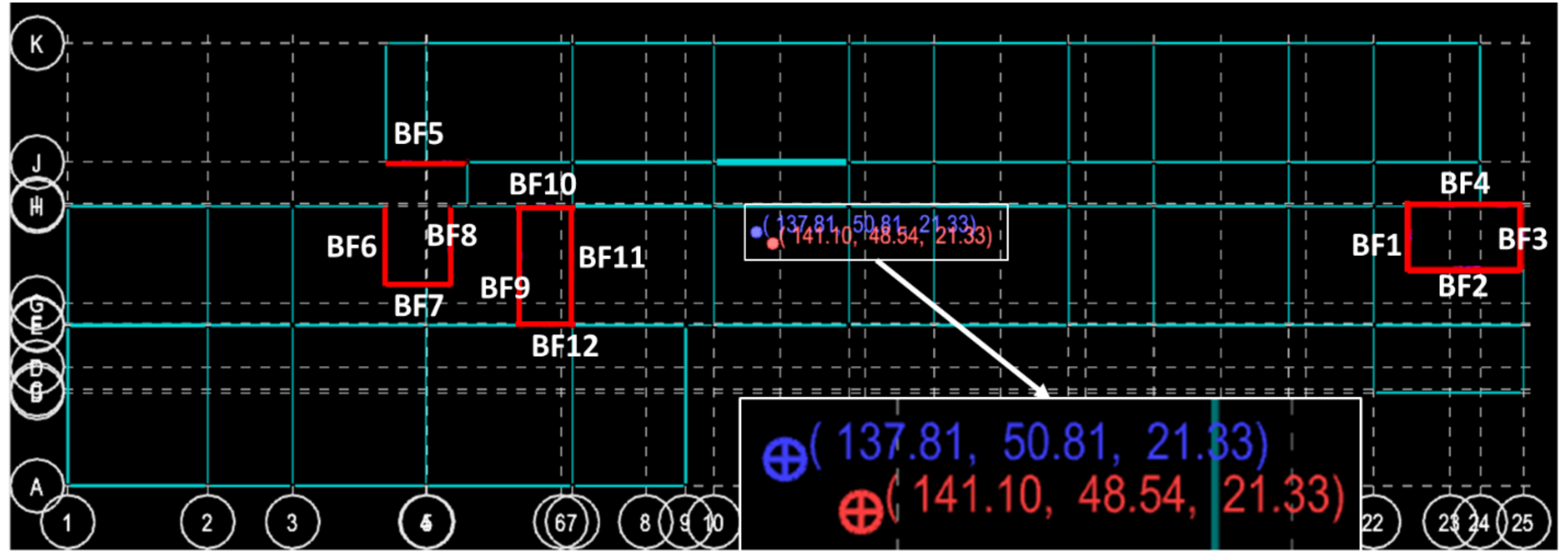
Buckling Restrained Braced Frames | **COM/COR**

Construction Breadth

Critical Path Schedule | Cost Analysis

Conclusion

Comparison



Lateral Brace Location

- COM/COR 4ft apart, x-direction
  - Reducing lateral torsion
- Appropriate stiffness

Construction Breadth

- Is the schedule reduced?
- Has money been saved?
- What else can be done?

Acoustical Breadth

- Has sound transmission been improved?
- How are residents effected?

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction

Site Plan | Existing Gravity | Existing Lateral

Proposal

Purpose | Solution

Redesigned Gravity System

Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System

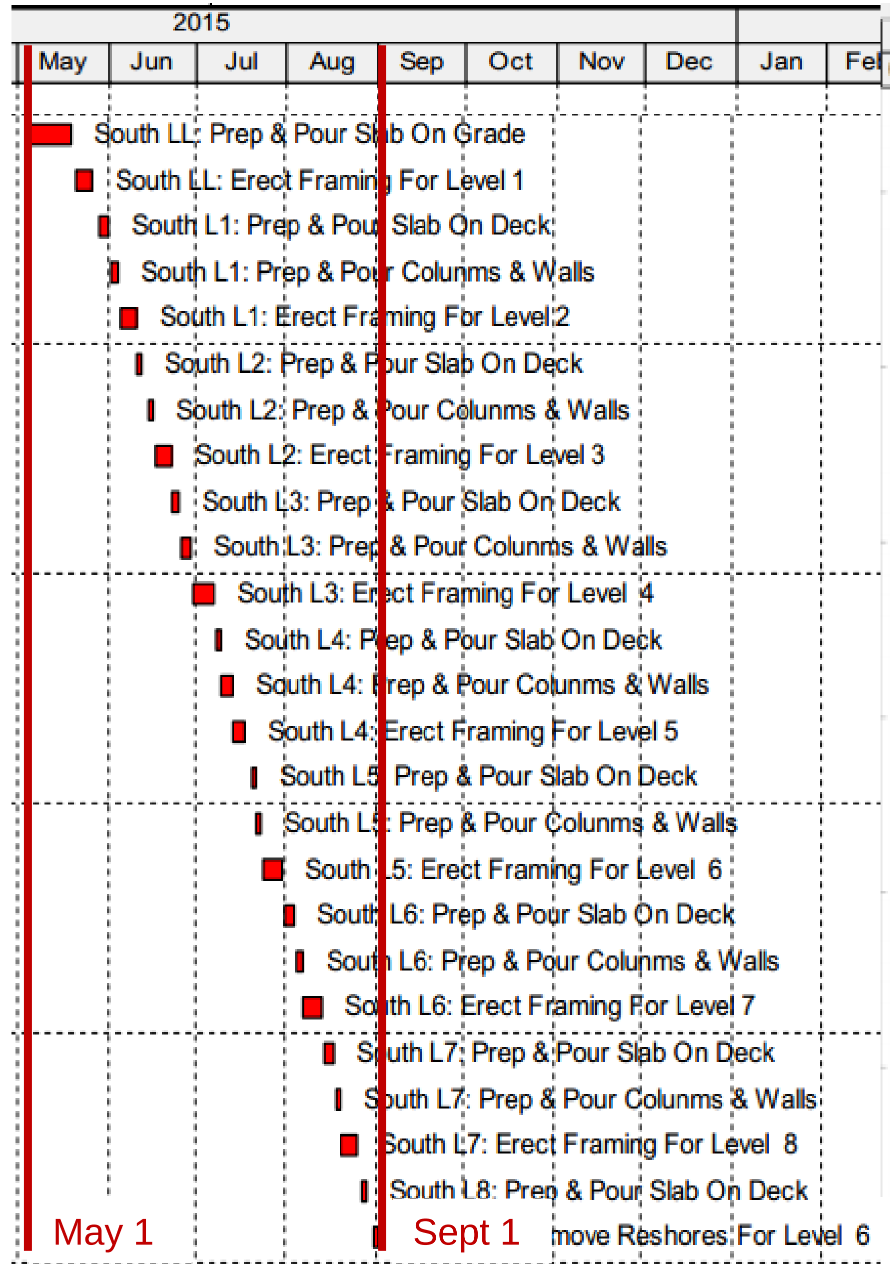
Buckling Restrained Braced Frames | COM/COR

Construction Breadth

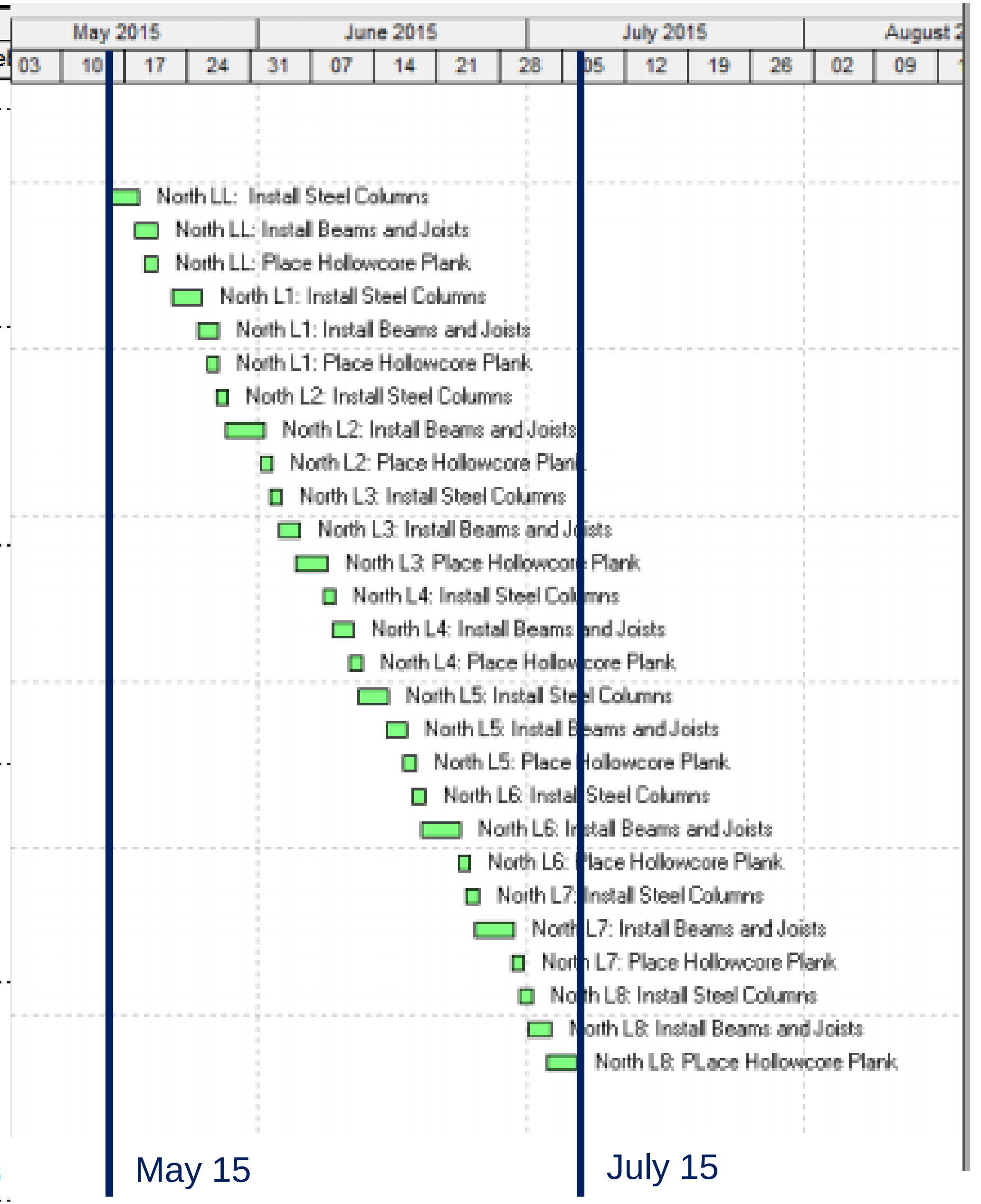
Critical Path Schedule | Cost Analysis

Conclusion

Comparison



South LL: Prep & Pour Slab On Grade
South LL: Erect Framing For Level 1
South L1: Prep & Pour Slab On Deck
South L1: Prep & Pour Columns & Walls
South L1: Erect Framing For Level 2
South L2: Prep & Pour Slab On Deck
South L2: Prep & Pour Columns & Walls
South L2: Erect Framing For Level 3
South L3: Prep & Pour Slab On Deck
South L3: Prep & Pour Columns & Walls
South L3: Erect Framing For Level 4
South L4: Prep & Pour Slab On Deck
South L4: Prep & Pour Columns & Walls
South L4: Erect Framing For Level 5
South L5: Prep & Pour Slab On Deck
South L5: Prep & Pour Columns & Walls
South L5: Erect Framing For Level 6
South L6: Prep & Pour Slab On Deck
South L6: Prep & Pour Columns & Walls
South L6: Erect Framing For Level 7
South L7: Prep & Pour Slab On Deck
South L7: Prep & Pour Columns & Walls
South L7: Erect Framing For Level 8
South L8: Prep & Pour Slab On Deck
move Reshores For Level 6



North LL: Install Steel Columns
North LL: Install Beams and Joists
North LL: Place Hollowcore Plank
North L1: Install Steel Columns
North L1: Install Beams and Joists
North L1: Place Hollowcore Plank
North L2: Install Steel Columns
North L2: Install Beams and Joists
North L2: Place Hollowcore Plank
North L3: Install Steel Columns
North L3: Install Beams and Joists
North L3: Place Hollowcore Plank
North L4: Install Steel Columns
North L4: Install Beams and Joists
North L4: Place Hollowcore Plank
North L5: Install Steel Columns
North L5: Install Beams and Joists
North L5: Place Hollowcore Plank
North L6: Install Steel Columns
North L6: Install Beams and Joists
North L6: Place Hollowcore Plank
North L7: Install Steel Columns
North L7: Install Beams and Joists
North L7: Place Hollowcore Plank
North L8: Install Steel Columns
North L8: Install Beams and Joists
North L8: PLace Hollowcore Plank

Critical Path Schedule Analysis

- Original structural system: **7 Months**
  - 8 work days per floor
- Proposed structural system: **3.5 Months**
  - 7 work days per floor
  - Multiple floors a day

West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

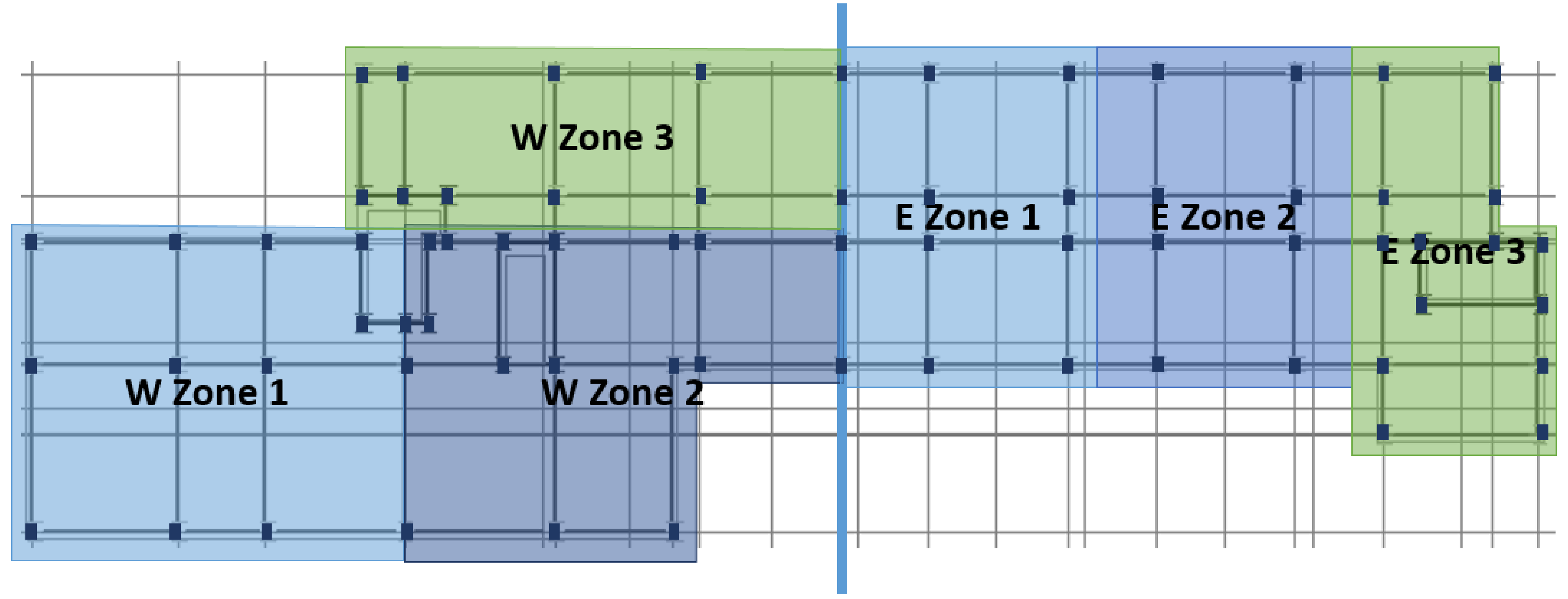
Construction Breadth
Critical Path Schedule | Cost Analysis

Conclusion
Comparison

Techniques to fast track schedule

- Utilize sequencing to advance schedule
- Zoning assures an efficient work environment
- Constructability

Proposed Zoning Diagram



West Village Housing Phases III & IV

Towson, Maryland

Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

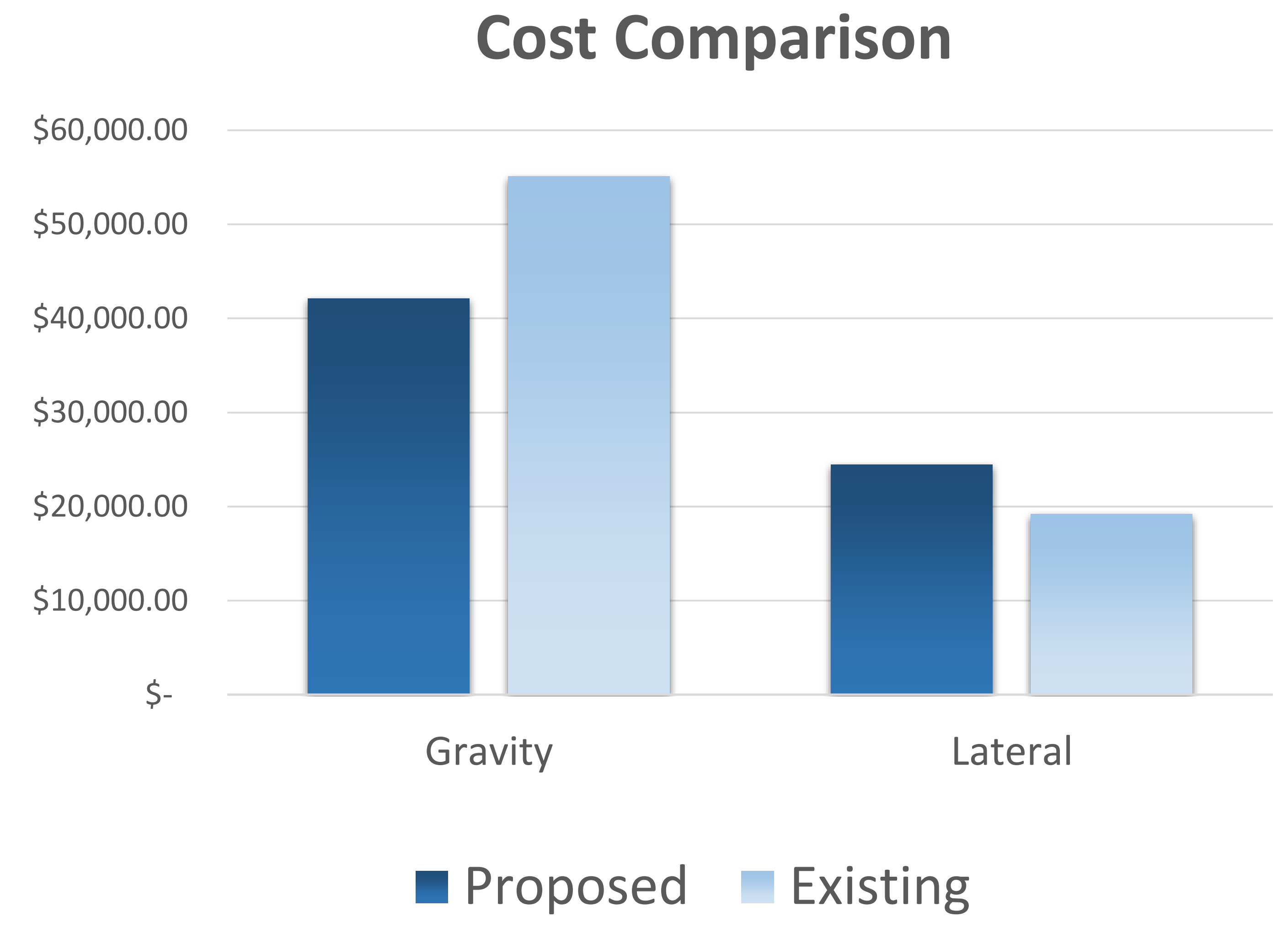
Construction Breadth
Critical Path Schedule | **Cost Analysis**

Conclusion
Comparison

Area Under Analysis	Sq. Ft.	Lateral Element
	Gravity	Lateral
% Savings	23.5	-
% Increase	-	21.5

Net Savings
15%

Additional Savings
- Early Student Move-in
- Summer semester tuition



Building Introduction
Site Plan | Existing Gravity | Existing Lateral

Proposal
Purpose | Solution

Redesigned Gravity System
Hollow Core Plank | Steel Columns | Steel Beams

Redesigned Lateral System
Buckling Restrained Braced Frames | COM/COR

Construction Breadth
Critical Path Schedule | Cost Analysis

Conclusion
Comparison

Benefits	Repercussions
Quick installation	Lateral brace cost
Off site production	Fire proofing
Structural integrity	Shifting architecture
Acoustical performance	

Resulting answers

- Lighter weight structure
- Stiffer lateral elements
- Schedule/cost reduction
- Reduced column sizes

- Efficient
- Constructability

- Pros and Cons

Acknowledgments

A very special thanks to:

- Dr. Aly Said, Thesis Advisor
- Professor Kevin Parfitt, AE Advisor
- Hope Furrer and the entire HFA staff
- Mr. R Timothy Sandruck, Towson University Construction Serviced
- My friends and family

HOLLOW CORE SLABS

NEAREST MANUFACTURER → OLDCASTLE PRECAST, EDGEWOOD MD

↳ USES ELEMATIC PLANKS

SECTION E8"x48" WITH 2" TOPPING

- SPAN: 24'-3"

LOADING: S.I. DL = 10PSF
LL ROOMS = 40 PSF
LL corridors = 15PSF
65PSF <

- (6) 7/16" Lo LAX STRANDS
- 25' span, 139 psF ✓
- 4' WIDE PLANKS

- PROPERTIES:
  - PLANK + TOPPING = 54 + 25 = 79 PSF

$f'c = 5000\,psi$ $f'_{ci} = 3000\,psi$ $A = 207\,in^2$ $E_s = 29{,}000\,Ksi$

$f_{pu} = 270{,}000\,psi$ $I_c = 3{,}072\,in^4$ $b_w = 10\,in$

* CALCULATIONS REFERENCED FROM PCI MANUAL

LOSS OF PRESTRESS

- ELASTIC SHORTENING

- $A_{ps} f_{pu} = 0.115(270) = 31.05\ ^{K}/_{STRAND}$
- $P_i = 0.6(6)(31.05) = 111.78K$
- $M_g = \frac{(24.25)^2}{8}(0.054)(4)' = 190.5\,in\text{-}K$
- $f_{cir} = K_{cir}\left(\frac{P_i}{A} + \frac{P_i e^2}{I}\right) - \frac{M_g e}{I}$

$$= 0.9\left(\frac{111.78}{207} + \frac{111.78(3)^2}{3{,}072}\right) - \frac{190.5(3)}{3072} = 0.59\,Ksi$$

- $ES = K_{es}\frac{E_s}{E_{ci}} f_{cir}$

$$= (1.0)\frac{29000}{3250}(0.59)$$

$$= \underline{5.26\,Ksi}$$

- CONCRETE CREEP

- $M_{sd} = \frac{(24.25)^2}{8}(0.025 + 0.01)(4)^{\times 12} = 123.5\,K\text{-}in$
- $f_{cds} = \frac{M_{sd} e}{I} = \frac{123.5(3)}{3072} = 0.12\,Ksi$
- $CR = K_{cr}\frac{E_s}{E_c}(f_{cir} - f_{cds})$

$$= (2.0)\left(\frac{29000}{4300}\right)(0.59 - 0.12) = \underline{6.34\,Ksi}$$

- SHRINKAGE OF CONCRETE

- $\frac{V}{S} = \frac{AREA}{PERIMETER} = \frac{207\,in^2}{2(48+8)} = 1.85$
- USE RH = 70% (FIG 2.2.3.1)
- $SH = 8.2\times10^{-6} K_{sh} E_s\left(1 - 0.06\frac{V}{S}\right)\times(100 - RH)$

$$= 8.2\times10^{-6}(1.0)(29000)(1 - 0.06(1.85))(100 - 70) = \underline{6.34\,Ksi}$$

- STEEL RELAXATION

- $K_{re} = 5000$ $J = 0.04$ (TABLE 2.2.3.1)
- $f_{si}/f_{pu} \rightarrow C = 0.53$
- $RE = [K_{re} - J(SH + CR + ES)]\,C$

$$= \left[\frac{5000}{1000} - 0.04(6.34 + 6.34 + 5.26)\right]0.53 = 2.27\,Ksi$$

- TOTAL LOSS AT MIDSPAN

$= 5.26 + 6.34 + 6.34 + 2.27 = 20.21\,Ksi$

$$\% = \frac{20.21}{(0.6)(270)}(100) = \boxed{12.5\%}$$

SERVICE LOAD STRESS

ACCOUNT FOR LOSSES

- $A_{ps} f_{se} = 0.6(6)(31.05)(1 - 0.125) = 97.8K$
- $M_{non\ comp} = \frac{(24.25)^2}{8}(0.079)12 = 69.7\,in\text{-}^{K}/_{ft}$

$M_{comp} = \frac{(24.25)^2}{8}(0.065)12 = 57.34\,in\text{-}^{K}/_{ft}$

- Top of Topping

$$f_{top} = \frac{57.34(4)(13 - 5.41)}{3024}\left(\frac{3605}{4696}\right) = 0.44\,Ksi$$

- TOP OF PLANK

$$f_{top} = \frac{97.8}{207} - \frac{97.8(3)(3.97)}{1580} + \frac{69.7(4)(3.97)}{1580} + \frac{57.34(4)(10 - 5.41)}{3024}$$

$$= 0.781\,Ksi$$

- BOTTOM OF PLANK

$$f_{bot} = 0.47 + 0.737 - 0.7 - \frac{57.34(4)(5.41)}{3024} = 0.09\,Ksi$$

PERMISSIBLE COMPRESSION

$0.45f'c = 0.45(5000) = 2.25\,Ksi > 0.44\,Ksi$ ✓

$0.6f'c = 0.6(5000) = 3.0\,Ksi > 0.781\,Ksi$ ✓

PERMISSIBLE TENSION

$7.5\sqrt{f'c} = 7.5\sqrt{5000} = .53\,Ksi > 0.09\,Ksi$ ✓

FLEXURAL STRENGTH

$w_u = 1.2(0.079 + 0.01) + 1.6(0.055) = 0.195\,KSF$

$M_u = \frac{24.25^2}{8}(0.195) = 14.3\,ft\text{-}^{K}/_{ft} = 57.3\,ft\,^{K}/_{slab}$

- $\beta_1 = 0.85 - \left(\frac{5000 - 3000}{1000}\right)0.05 = 0.775$
- $\rho_p = \frac{A_{ps}}{b d_p} = \frac{6(0.115)}{48(7)} = 0.0021$
- $\gamma_p = 0.28$ (Low lax)
- $f_{ps} = 270\left[1 - \frac{0.28}{0.775}\left(0.0021\frac{270}{5}\right)\right] = 258.9\,Ksi$

- $\omega_p = \frac{\rho_p f_{ps}}{f'c} = \frac{0.0021(258.9)}{5} = 0.109 < 0.36\beta_1$ ✓
- $a = \frac{A_{ps} f_{ps}}{0.85 f'c\, b} = \frac{6(0.115)(258.9)}{0.85(5)(48)} = 0.88"$ ✓
- $\phi M_n = 0.9(6)(0.115)(258.9)\left(7 - \frac{0.88}{2}\right) = 101.31\ ft\text{-}^{K}/_{slab}$

$M_u = 57.3 < 101.3$ ✓

- $\phi M_n \geq 1.2 M_{cr}$

$$f_{bot} = \frac{97.8}{196} + \frac{97.8(3)(5)}{1580} = 1.42\,Ksi$$

$$M_{cr} = \frac{3024}{5.41}\left(1.42 + \frac{7.5\sqrt{5000}}{1000}\right) = 90.85\,ftK$$

SHEAR

use ≤ 1

$$V_c = \min_{of}\begin{cases}\left[0.6\sqrt{f'c} + 700\frac{V_u d_p}{M_u}\right]b_w d_p & = \left[0.6\sqrt{5000} + 700(1)\right]\frac{(10)(7)}{12} \\ \left[0.6\sqrt{f'c} + 700\right]b_w d_p & = 4330.8\,Kip \\ 5\sqrt{f'c}\,b_w d_p & = 5\sqrt{5000}\frac{(10)(7)}{12} = 2062.4\,Kip\end{cases}$$

$V_u = w\left(\frac{l}{2} - x\right)$

$w = [1.2(54 + 10) + 1.6(55)]4' = 659.2\,^{lb}/_{ft}$

$$V_u = \frac{wl}{2} = \frac{0.6592(24)}{2} = 7.9\,Kip$$

$V_u < V_c$ ✓

Initial camber

$$\frac{P_o l^2}{8E_s I} - \frac{5 w_s l^4}{384EI}$$

$$\frac{(1 - 0.125)(111.78)(3)(24.25\times12)^2}{8(3250)(3024)} - \frac{5(3.5)(0.079)(24.25)^4(1728)}{384(3250)(3024)}$$

$= 0.316" - 0.218" = 0.098$

LONG TERM CAMBER

(table 2.4.1)

$2.2(0.316) - 2.4(0.218) = 0.172"$ ∴ 1/4" camber

DEFLECTION

$P = A_{topping}(strain)(modulus)$

$= 48"(2")(0.00025)(3605)$

$= 86.52K$

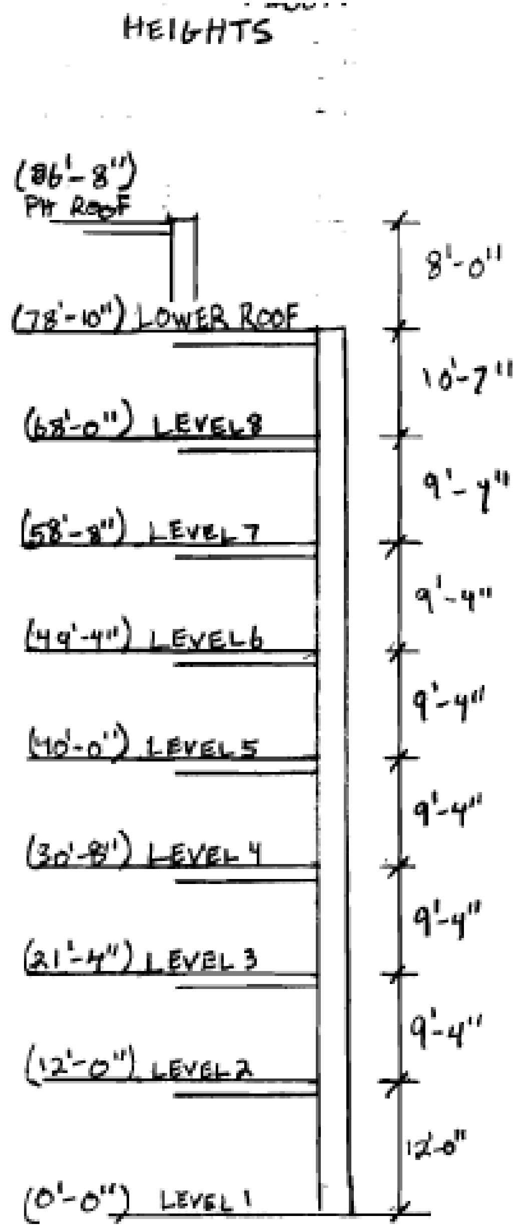
$P = \frac{86.52}{2.3} = 37.6K$ (TABLE 2.4.1)

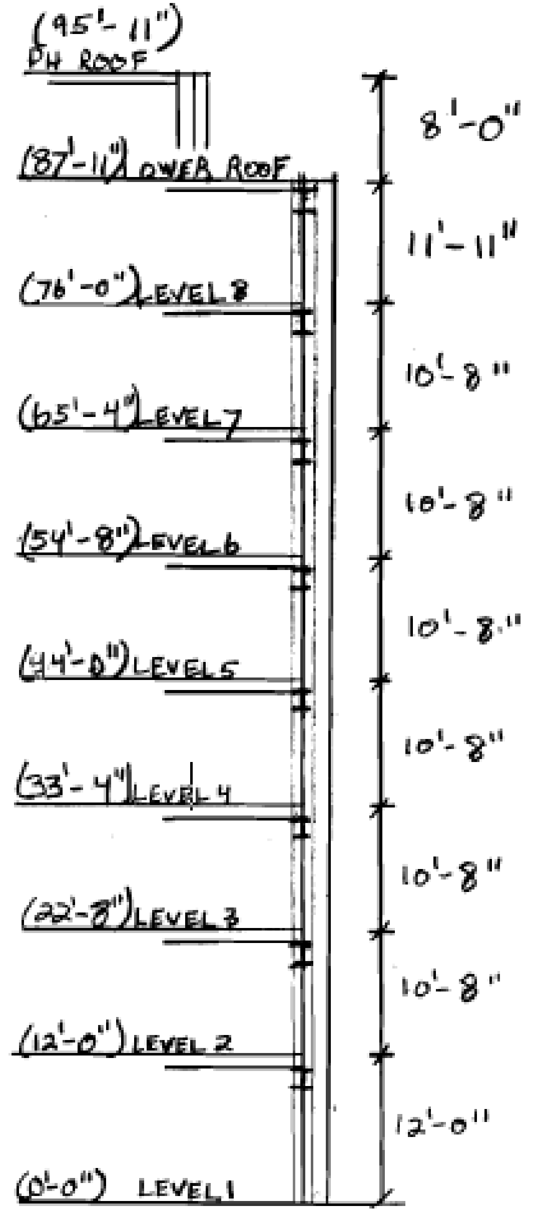
$e = 9" - 4 = 5"$

$M = Pe = (37.6)(5) = 188.1\,Kin$

$$\downarrow\Delta = \frac{Ml^2}{8EI} = \frac{188.1(24.25\times12)^2}{8(4696)(3024)} = 0.14"$$

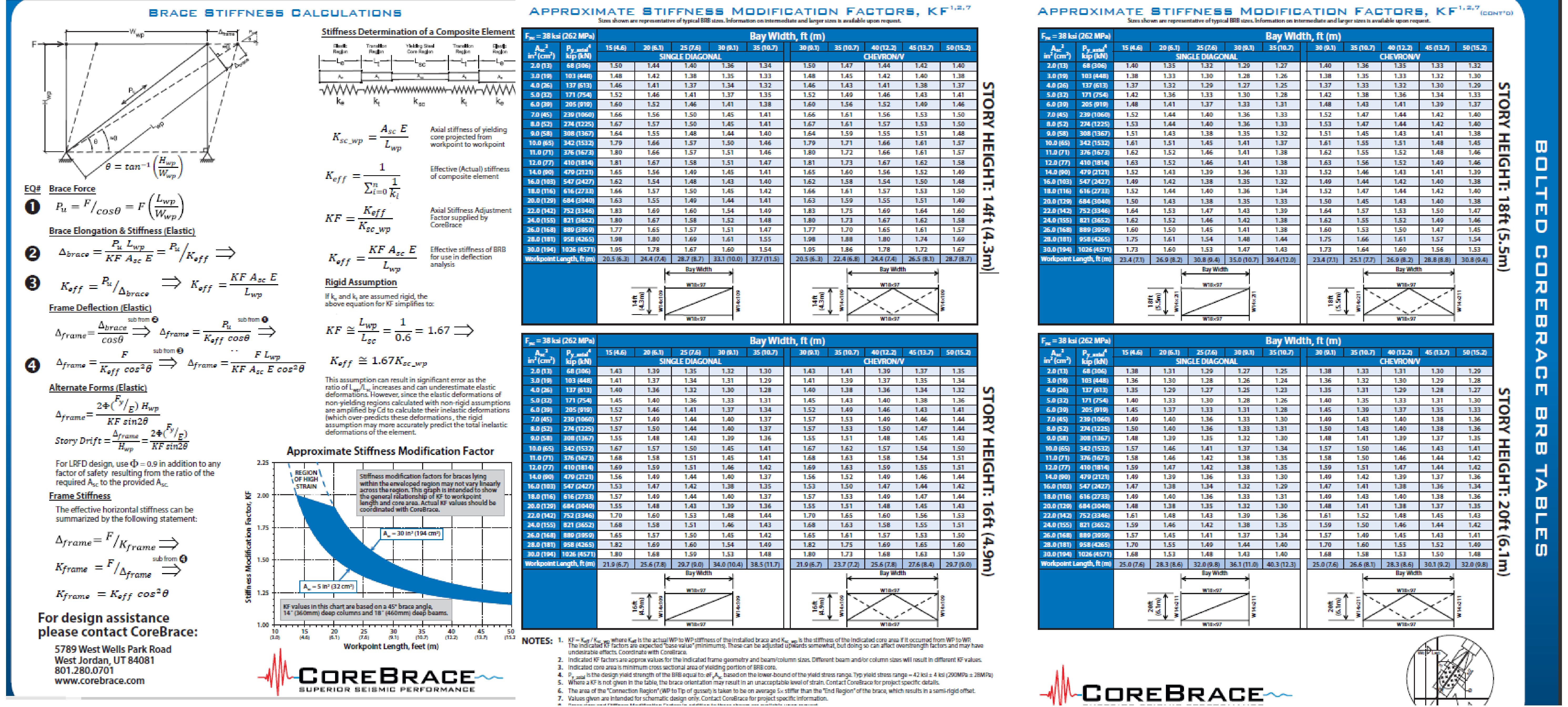
$$\frac{L}{360} = \frac{24.25\times12}{360} = 0.81" > 0.14"$$ ✓


HEIGHTS
(86'-8") PH ROOF
(78'-10") LOWER ROOF
(68'-0") LEVEL 8
(58'-8") LEVEL 7
(49'-4") LEVEL 6
(40'-0") LEVEL 5
(30'-8") LEVEL 4
(21'-4") LEVEL 3
(12'-0") LEVEL 2
(0'-0") LEVEL 1
8'-0"
10'-7"
9'-4"
9'-4"
9'-4"
9'-4"
9'-4"
9'-4"
12'-0"


(95'-11") PH ROOF
(87'-11") LOWER ROOF
(76'-0") LEVEL 8
(65'-4") LEVEL 7
(54'-8") LEVEL 6
(44'-0") LEVEL 5
(33'-4") LEVEL 4
(22'-8") LEVEL 3
(12'-0") LEVEL 2
(0'-0") LEVEL 1
8'-0"
11'-11"
10'-8"
10'-8"
10'-8"
10'-8"
10'-8"
10'-8"
12'-0"

BRBF Design procedure

- Define appropriate BRB modeling
- Determine required brace strength
- Check drift
- Determine brace displacements
- Conduct tests and add stiffness factors
- Calculate required strength of columns, beams and connections based on BRB strengths



BRACE STIFFNESS CALCULATIONS

$$\theta = tan^{-1}\left(\frac{H_{wp}}{W_{wp}}\right)$$

EQ# **Brace Force**

❶ $$P_u = {}^{F}/_{cos\theta} = F\left(\frac{L_{wp}}{W_{wp}}\right)$$

Brace Elongation & Stiffness (Elastic)

❷ $$\Delta_{brace} = \frac{P_u\ L_{wp}}{KF\ A_{sc}\ E} = {}^{P_u}/_{K_{eff}} \Longrightarrow$$

❸ $$K_{eff} = {}^{P_u}/_{\Delta_{brace}} \Longrightarrow K_{eff} = \frac{KF\ A_{sc}\ E}{L_{wp}}$$

Frame Deflection (Elastic)

$$\Delta_{frame} = \frac{\Delta_{brace}}{cos\theta} \overset{\text{sub from ❷}}{\Longrightarrow} \Delta_{frame} = \frac{P_u}{K_{eff}\ cos\theta} \overset{\text{sub from ❶}}{\Longrightarrow}$$

❹ $$\Delta_{frame} = \frac{F}{K_{eff}\ cos^2\theta} \overset{\text{sub from ❸}}{\Longrightarrow} \Delta_{frame} = \frac{F\ L_{wp}}{KF\ A_{sc}\ E\ cos^2\theta}$$

Alternate Forms (Elastic)

$$\Delta_{frame} = \frac{2\Phi({}^{F_y}/_{E})\ H_{wp}}{KF\ sin2\theta}$$

$$Story\ Drift = \frac{\Delta_{frame}}{H_{wp}} = \frac{2\Phi({}^{F_y}/_{E})}{KF\ sin2\theta}$$

For LRFD design, use Φ = 0.9 in addition to any factor of safety resulting from the ratio of the required A_{sc} to the provided A_{sc}.

Frame Stiffness

The effective horizontal stiffness can be summarized by the following statement:

$$\Delta_{frame} = {}^{F}/_{K_{frame}} \Longrightarrow$$

$$K_{frame} = {}^{F}/_{\Delta_{frame}} \overset{\text{sub from ❹}}{\Longrightarrow}$$

$$K_{frame} = K_{eff}\ cos^2\theta$$

Stiffness Determination of a Composite Element

$$K_{sc\_wp} = \frac{A_{sc}\ E}{L_{wp}}$$ Axial stiffness of yielding core projected from workpoint to workpoint

$$K_{eff} = \frac{1}{\sum_{i=0}^{n}\frac{1}{k_i}}$$ Effective (Actual) stiffness of composite element

$$KF = \frac{K_{eff}}{K_{sc\_wp}}$$ Axial Stiffness Adjustment Factor supplied by CoreBrace

$$K_{eff} = \frac{KF\ A_{sc}\ E}{L_{wp}}$$ Effective stiffness of BRB for use in deflection analysis

Rigid Assumption

If k_e and k_t are assumed rigid, the above equation for KF simplifies to:

$$KF \cong \frac{L_{wp}}{L_{sc}} = \frac{1}{0.6} = 1.67 \Longrightarrow$$

$$K_{eff} \cong 1.67 K_{sc\_wp}$$

This assumption can result in significant error as the ratio of L_{wp}/L_{sc} increases and can underestimate elastic deformations. However, since the elastic deformations of non-yielding regions calculated with non-rigid assumptions are amplified by Cd to calculate their inelastic deformations (which over-predicts these deformations, the rigid assumption may more accurately predict the total inelastic deformations of the element.

Approximate Stiffness Modification Factor

Stiffness modification factors for braces lying within the enveloped region may not vary linearly across the region. This graph is intended to show the general relationship of KF to workpoint length and core area. Actual KF values should be coordinated with CoreBrace.

KF values in this chart are based on a 45° brace angle, 14" (360mm) deep columns and 18" (460mm) deep beams.

Workpoint Length, feet (m)	10 (3.0)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)

For design assistance please contact CoreBrace:

5789 West Wells Park Road
West Jordan, UT 84081
801.280.0701
www.corebrace.com

APPROXIMATE STIFFNESS MODIFICATION FACTORS, KF[1,2,7]

Sizes shown are representative of typical BRB sizes. Information on intermediate and larger sizes is available upon request.

STORY HEIGHT: 14ft (4.3m)

F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}[2] in² (cm²)	P_{y_axial}[4] kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	1.50	1.44	1.40	1.36	1.34	1.50	1.47	1.44	1.42	1.40
3.0 (19)	103 (448)	1.48	1.42	1.38	1.35	1.33	1.48	1.45	1.42	1.40	1.38
4.0 (26)	137 (613)	1.46	1.41	1.37	1.34	1.32	1.46	1.43	1.41	1.38	1.37
5.0 (32)	171 (754)	1.52	1.46	1.41	1.37	1.35	1.52	1.49	1.46	1.43	1.41
6.0 (39)	205 (919)	1.60	1.52	1.46	1.41	1.38	1.60	1.56	1.52	1.49	1.46
7.0 (45)	239 (1060)	1.66	1.56	1.50	1.45	1.41	1.66	1.61	1.56	1.53	1.50
8.0 (52)	274 (1225)	1.67	1.57	1.50	1.45	1.41	1.67	1.61	1.57	1.53	1.50
9.0 (58)	308 (1367)	1.64	1.55	1.48	1.44	1.40	1.64	1.59	1.55	1.51	1.48
10.0 (65)	342 (1532)	1.79	1.66	1.57	1.50	1.46	1.79	1.71	1.66	1.61	1.57
11.0 (71)	376 (1673)	1.80	1.66	1.57	1.51	1.46	1.80	1.72	1.66	1.61	1.57
12.0 (77)	410 (1814)	1.81	1.67	1.58	1.51	1.47	1.81	1.73	1.67	1.62	1.58
14.0 (90)	479 (2121)	1.65	1.56	1.49	1.45	1.41	1.65	1.60	1.56	1.52	1.49
16.0 (103)	547 (2427)	1.62	1.54	1.48	1.43	1.40	1.62	1.58	1.54	1.50	1.48
18.0 (116)	616 (2733)	1.66	1.57	1.50	1.45	1.42	1.66	1.61	1.57	1.53	1.50
20.0 (129)	684 (3040)	1.63	1.55	1.49	1.44	1.41	1.63	1.59	1.55	1.51	1.49
22.0 (142)	752 (3346)	1.83	1.69	1.60	1.54	1.49	1.83	1.75	1.69	1.64	1.60
24.0 (155)	821 (3652)	1.80	1.67	1.58	1.52	1.48	1.80	1.73	1.67	1.62	1.58
26.0 (168)	889 (3959)	1.77	1.65	1.57	1.51	1.47	1.77	1.70	1.65	1.61	1.57
28.0 (181)	958 (4265)	1.98	1.80	1.69	1.61	1.55	1.98	1.88	1.80	1.74	1.69
30.0 (194)	1026 (4571)	1.95	1.78	1.67	1.60	1.54	1.95	1.86	1.78	1.72	1.67
Workpoint Length, ft (m)		20.5 (6.3)	24.4 (7.4)	28.7 (8.7)	33.1 (10.0)	37.7 (11.5)	20.5 (6.3)	22.4 (6.8)	24.4 (7.4)	26.5 (8.1)	28.7 (8.7)

STORY HEIGHT: 16ft (4.9m)

F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}[2] in² (cm²)	P_{y_axial}[4] kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	1.43	1.39	1.35	1.32	1.30	1.43	1.41	1.39	1.37	1.35
3.0 (19)	103 (448)	1.41	1.37	1.34	1.31	1.29	1.41	1.39	1.37	1.35	1.34
4.0 (26)	137 (613)	1.40	1.36	1.32	1.30	1.28	1.40	1.38	1.36	1.34	1.32
5.0 (32)	171 (754)	1.45	1.40	1.36	1.33	1.31	1.45	1.43	1.40	1.38	1.36
6.0 (39)	205 (919)	1.52	1.46	1.41	1.37	1.34	1.52	1.49	1.46	1.43	1.41
7.0 (45)	239 (1060)	1.57	1.49	1.44	1.40	1.37	1.57	1.53	1.49	1.46	1.44
8.0 (52)	274 (1225)	1.57	1.50	1.44	1.40	1.37	1.57	1.53	1.50	1.47	1.44
9.0 (58)	308 (1367)	1.55	1.48	1.43	1.39	1.36	1.55	1.51	1.48	1.45	1.43
10.0 (65)	342 (1532)	1.67	1.57	1.50	1.45	1.41	1.67	1.62	1.57	1.54	1.50
11.0 (71)	376 (1673)	1.68	1.58	1.51	1.45	1.41	1.68	1.63	1.58	1.54	1.51
12.0 (77)	410 (1814)	1.69	1.59	1.51	1.46	1.42	1.69	1.63	1.59	1.55	1.51
14.0 (90)	479 (2121)	1.56	1.49	1.44	1.40	1.37	1.56	1.52	1.49	1.46	1.44
16.0 (103)	547 (2427)	1.53	1.47	1.42	1.38	1.35	1.53	1.50	1.47	1.44	1.42
18.0 (116)	616 (2733)	1.57	1.49	1.44	1.40	1.37	1.57	1.53	1.49	1.47	1.44
20.0 (129)	684 (3040)	1.55	1.48	1.43	1.39	1.36	1.55	1.51	1.48	1.45	1.43
22.0 (142)	752 (3346)	1.70	1.60	1.53	1.48	1.44	1.70	1.65	1.60	1.56	1.53
24.0 (155)	821 (3652)	1.68	1.58	1.51	1.46	1.43	1.68	1.63	1.58	1.55	1.51
26.0 (168)	889 (3959)	1.65	1.57	1.50	1.45	1.42	1.65	1.61	1.57	1.53	1.50
28.0 (181)	958 (4265)	1.82	1.69	1.60	1.54	1.49	1.82	1.75	1.69	1.65	1.60
30.0 (194)	1026 (4571)	1.80	1.68	1.59	1.53	1.48	1.80	1.73	1.68	1.63	1.59
Workpoint Length, ft (m)		21.9 (6.7)	25.6 (7.8)	29.7 (9.0)	34.0 (10.4)	38.5 (11.7)	21.9 (6.7)	23.7 (7.2)	25.6 (7.8)	27.6 (8.4)	29.7 (9.0)

NOTES:

1. KF = K_{eff} / K_{sc_wp} where K_{eff} is the actual WP to WP stiffness of the installed brace and K_{sc_wp} is the stiffness of the indicated core area if it occurred from WP to WP. The indicated KF factors are expected "base value" (minimums). These can be adjusted upwards somewhat, but doing so can affect overstrength factors and may have undesirable effects. Coordinate with CoreBrace.
2. Indicated KF factors are approx values for the indicated frame geometry and beam/column sizes. Different beam and/or column sizes will result in different KF values.
3. Indicated core area is minimum cross sectional area of yielding portion of BRB core.
4. P_{y_axial} is the design yield strength of the BRB equal to: ø$F_y A_{sc}$ based on the lower-bound of the yield stress range. Typ yield stress range = 42 ksi ± 4 ksi (290MPa ± 28MPa)
5. Where a KF is not given in the table, the brace orientation may result in an unacceptable level of strain. Contact CoreBrace for project specific details.
6. The area of the "Connection Region" (WP to Tip of gusset) is taken to be on average 5x stiffer than the "End Region" of the brace, which results in a semi-rigid offset.
7. Values given are intended for schematic design only. Contact CoreBrace for project specific information.
8. [illegible]

APPROXIMATE STIFFNESS MODIFICATION FACTORS, KF[1,2,7] (CONT'D)

Sizes shown are representative of typical BRB sizes. Information on intermediate and larger sizes is available upon request.

STORY HEIGHT: 18ft (5.5m)

F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}[2] in² (cm²)	P_{y_axial}[4] kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	1.40	1.35	1.32	1.29	1.27	1.40	1.36	1.35	1.33	1.32
3.0 (19)	103 (448)	1.38	1.33	1.30	1.28	1.26	1.38	1.35	1.33	1.32	1.30
4.0 (26)	137 (613)	1.37	1.32	1.29	1.27	1.25	1.37	1.33	1.32	1.30	1.29
5.0 (32)	171 (754)	1.42	1.36	1.33	1.30	1.28	1.42	1.38	1.36	1.34	1.33
6.0 (39)	205 (919)	1.48	1.41	1.37	1.33	1.31	1.48	1.43	1.41	1.39	1.37
7.0 (45)	239 (1060)	1.52	1.44	1.40	1.36	1.33	1.52	1.47	1.44	1.42	1.40
8.0 (52)	274 (1225)	1.53	1.44	1.40	1.36	1.33	1.53	1.47	1.44	1.42	1.40
9.0 (58)	308 (1367)	1.51	1.43	1.38	1.35	1.32	1.51	1.45	1.43	1.41	1.38
10.0 (65)	342 (1532)	1.61	1.51	1.45	1.41	1.37	1.61	1.55	1.51	1.48	1.45
11.0 (71)	376 (1673)	1.62	1.52	1.46	1.41	1.38	1.62	1.55	1.52	1.48	1.46
12.0 (77)	410 (1814)	1.63	1.52	1.46	1.41	1.38	1.63	1.56	1.52	1.49	1.46
14.0 (90)	479 (2121)	1.52	1.43	1.39	1.36	1.33	1.52	1.46	1.43	1.41	1.39
16.0 (103)	547 (2427)	1.49	1.42	1.38	1.35	1.32	1.49	1.44	1.42	1.40	1.38
18.0 (116)	616 (2733)	1.52	1.44	1.40	1.36	1.34	1.52	1.47	1.44	1.42	1.40
20.0 (129)	684 (3040)	1.50	1.43	1.38	1.35	1.33	1.50	1.45	1.43	1.40	1.38
22.0 (142)	752 (3346)	1.64	1.53	1.47	1.43	1.39	1.64	1.57	1.53	1.50	1.47
24.0 (155)	821 (3652)	1.62	1.52	1.46	1.42	1.38	1.62	1.55	1.52	1.49	1.46
26.0 (168)	889 (3959)	1.60	1.50	1.45	1.41	1.38	1.60	1.53	1.50	1.47	1.45
28.0 (181)	958 (4265)	1.75	1.61	1.54	1.48	1.44	1.75	1.66	1.61	1.57	1.54
30.0 (194)	1026 (4571)	1.73	1.60	1.53	1.47	1.43	1.73	1.64	1.60	1.56	1.53
Workpoint Length, ft (m)		23.4 (7.1)	26.9 (8.2)	30.8 (9.4)	35.0 (10.7)	39.4 (12.0)	23.4 (7.1)	25.1 (7.7)	26.9 (8.2)	28.8 (8.8)	30.8 (9.4)

STORY HEIGHT: 20ft (6.1m)

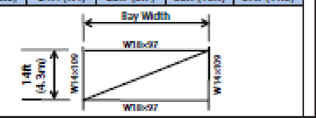
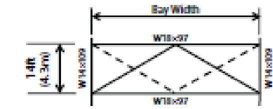
F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}[2] in² (cm²)	P_{y_axial}[4] kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	1.38	1.31	1.29	1.27	1.25	1.38	1.33	1.31	1.30	1.29
3.0 (19)	103 (448)	1.36	1.30	1.28	1.26	1.24	1.36	1.32	1.30	1.29	1.28
4.0 (26)	137 (613)	1.35	1.29	1.27	1.25	1.23	1.35	1.31	1.29	1.28	1.27
5.0 (32)	171 (754)	1.40	1.33	1.30	1.28	1.26	1.40	1.35	1.33	1.31	1.30
6.0 (39)	205 (919)	1.45	1.37	1.33	1.31	1.28	1.45	1.39	1.37	1.35	1.33
7.0 (45)	239 (1060)	1.49	1.40	1.36	1.33	1.30	1.49	1.43	1.40	1.38	1.36
8.0 (52)	274 (1225)	1.50	1.40	1.36	1.33	1.31	1.50	1.43	1.40	1.38	1.36
9.0 (58)	308 (1367)	1.48	1.39	1.35	1.32	1.30	1.48	1.41	1.39	1.37	1.35
10.0 (65)	342 (1532)	1.57	1.46	1.41	1.37	1.34	1.57	1.50	1.46	1.43	1.41
11.0 (71)	376 (1673)	1.58	1.46	1.42	1.38	1.35	1.58	1.50	1.46	1.44	1.42
12.0 (77)	410 (1814)	1.59	1.47	1.42	1.38	1.35	1.59	1.51	1.47	1.44	1.42
14.0 (90)	479 (2121)	1.49	1.39	1.36	1.33	1.30	1.49	1.42	1.39	1.37	1.36
16.0 (103)	547 (2427)	1.47	1.38	1.34	1.32	1.29	1.47	1.41	1.38	1.36	1.34
18.0 (116)	616 (2733)	1.49	1.40	1.36	1.33	1.31	1.49	1.43	1.40	1.38	1.36
20.0 (129)	684 (3040)	1.48	1.38	1.35	1.32	1.30	1.48	1.41	1.38	1.37	1.35
22.0 (142)	752 (3346)	1.61	1.48	1.43	1.39	1.36	1.61	1.52	1.48	1.45	1.43
24.0 (155)	821 (3652)	1.59	1.46	1.42	1.38	1.35	1.59	1.50	1.46	1.44	1.42
26.0 (168)	889 (3959)	1.57	1.45	1.41	1.37	1.34	1.57	1.49	1.45	1.43	1.41
28.0 (181)	958 (4265)	1.70	1.55	1.49	1.44	1.40	1.70	1.60	1.55	1.52	1.49
30.0 (194)	1026 (4571)	1.68	1.53	1.48	1.43	1.40	1.68	1.58	1.53	1.50	1.48
Workpoint Length, ft (m)		25.0 (7.6)	28.3 (8.6)	32.0 (9.8)	36.1 (11.0)	40.3 (12.3)	25.0 (7.6)	26.6 (8.1)	28.3 (8.6)	30.1 (9.2)	32.0 (9.8)

BOLTED COREBRACE BRB TABLES

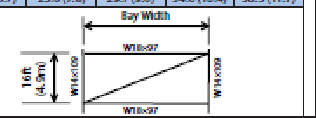
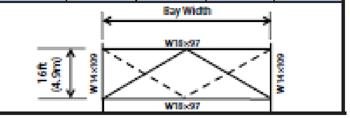
APPROXIMATE CASING SIZES$^{1-8}$ IN (MM)

Sizes shown are representative of typical BRB sizes. Information on intermediate and larger sizes is available upon request.

STORY HEIGHT: 14ft (4.3m)

F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}^{2} in^2 (cm^2)	P_{y_axial}^{4} kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	t6 (t152.4)	t6 (t152.4)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t6 (t152.4)	t6 (t152.4)	t6 (t152.4)	t8 (t203.2)	t8 (t203.2)
3.0 (19)	103 (448)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
4.0 (26)	137 (613)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
5.0 (32)	171 (754)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
6.0 (39)	205 (919)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t12 (t304.8)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
7.0 (45)	239 (1060)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
8.0 (52)	274 (1225)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
9.0 (58)	308 (1367)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
10.0 (65)	342 (1532)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
11.0 (71)	376 (1673)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
12.0 (77)	410 (1814)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
14.0(90)	479 (2121)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
16.0 (103)	547 (2427)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
18.0 (116)	616 (2733)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
20.0 (129)	684 (3040)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
22.0 (142)	752 (3346)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
24.0 (155)	821 (3652)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
26.0 (168)	889 (3959)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
28.0 (181)	958 (4265)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
30.0 (194)	1026 (4571)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
Workpoint Length, ft (m)		20.5 (6.3)	24.4 (7.4)	28.7 (8.7)	33.1 (10.1)	37.7 (11.5)	20.5 (6.3)	22.4 (6.8)	24.4 (7.4)	26.5 (8.1)	28.7 (8.7)
t = square tube (round pipe casing also available)											

STORY HEIGHT: 16ft (4.9m)

F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}^{2} in^2 (cm^2)	P_{y_axial}^{4} kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	t6 (t152.4)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t6 (t152.4)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
3.0 (19)	103 (448)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
4.0 (26)	137 (613)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
5.0 (32)	171 (754)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
6.0 (39)	205 (919)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t12(t304.8)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
7.0 (45)	239 (1060)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
8.0 (52)	274 (1225)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
9.0 (58)	308 (1367)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
10.0 (65)	342 (1532)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
11.0 (71)	376 (1673)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
12.0 (77)	410 (1814)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
14.0(90)	479 (2121)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
16.0 (103)	547 (2427)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
18.0 (116)	616 (2733)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
20.0 (129)	684 (3040)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
22.0 (142)	752 (3346)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
24.0 (155)	821 (3652)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
26.0 (168)	889 (3959)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
28.0 (181)	958 (4265)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
30.0 (194)	1026 (4571)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
Workpoint Length, ft (m)		21.9 (6.7)	25.6 (7.8)	29.7 (9.0)	34.0 (10.4)	38.5 (11.7)	21.9 (6.7)	23.7 (7.2)	25.6 (7.8)	27.6 (8.4)	29.7 (9.0)
t = square tube (round pipe casing also available)											

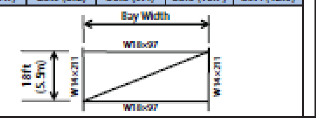
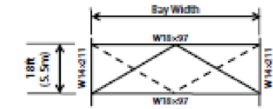
NOTES:

1. CoreBrace BRB Casing Sizes are approx square minimums for the indicated frame geometry and beam/column sizes. Different beam/column sizes will affect brace length and possibly casing size. More economical sizes may be used unless specifically required otherwise. Round casings of similar size are also available.
2. Indicated core area is minimum cross sectional area of yielding portion of BRB core.
3. P_{y_axial} is the calculated yield force of the BRB equal to: øF_yA_{sc} based on the lower-bound of the yield stress range. Typ yield stress range = 42 ksi ±4 ksi (290 MPa ±28MPa).
4. Where casing size is controlled by fit up, alternate core configurations (width × thickness) may allow for reduced casing sizes, on a project specific basis. Contact CoreBrace for details.
5. Casing buckling checks include a FS of 1.3 accounting for code prescribed phi factors and casing initial out-of-straightness. Where casing size is controlled by buckling, alternate casing configurations must maintain the same min moment of inertia about the core critical axis. Contact CoreBrace for assistance with alternate configurations.
6. Brace and casing sizes other than those shown are available upon request.
7. This table was created by considering overstrength at 2% story drift as required by AISC 341-10. For other story drifts, values may be different.
8. Casing sizes in table are intended for schematic design only. Contact CoreBrace for project specific sizes.

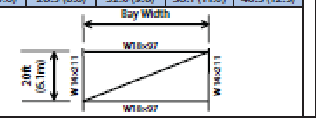
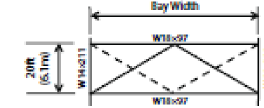
APPROXIMATE CASING SIZES$^{1-8}$ IN (MM) (CONT'D)

Sizes shown are representative of typical BRB sizes. Information on intermediate and larger sizes is available upon request.

STORY HEIGHT: 18ft (5.5m)

F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}^{2} in^2 (cm^2)	P_{y_axial}^{4} kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
3.0 (19)	103 (448)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
4.0 (26)	137 (613)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
5.0 (32)	171 (754)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)
6.0 (39)	205 (919)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t12 (t304.8)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
7.0 (45)	239 (1060)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
8.0 (52)	274 (1225)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
9.0 (58)	308 (1367)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
10.0 (65)	342 (1532)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
11.0 (71)	376 (1673)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
12.0 (77)	410 (1814)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
14.0 (90)	479 (2121)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
16.0 (103)	547 (2427)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
18.0 (116)	616 (2733)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)
20.0 (129)	684 (3040)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t10 (t304.8)	t14 (t355.6)
22.0 (142)	752 (3346)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
24.0 (155)	821 (3652)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
26.0 (168)	889 (3959)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t16 (t406.4)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
28.0 (181)	958 (4265)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
30.0 (194)	1026 (4571)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
Workpoint Length, ft (m)		23.4 (7.1)	26.9 (8.2)	30.8 (9.4)	35.0 (10.7)	39.4 (12.0)	23.4 (7.1)	25.1 (7.7)	26.9 (8.2)	28.8 (8.8)	30.8 (9.4)
t = square tube (round pipe casing also available)											

STORY HEIGHT: 20ft (6.1m)

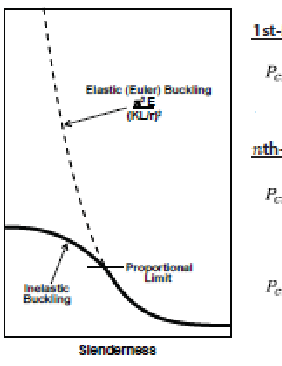
F_{ysc} = 38 ksi (262 MPa)		Bay Width, ft (m)									
A_{sc}^{2} in^2 (cm^2)	P_{y_axial}^{4} kip (kN)	15 (4.6)	20 (6.1)	25 (7.6)	30 (9.1)	35 (10.7)	30 (9.1)	35 (10.7)	40 (12.2)	45 (13.7)	50 (15.2)
		SINGLE DIAGONAL					CHEVRON/V				
2.0 (13)	68 (306)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
3.0 (19)	103 (448)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
4.0 (26)	137 (613)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)
5.0 (32)	171 (754)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t8 (t203.2)	t8 (t203.2)	t8 (t203.2)	t10 (t254.0)	t10 (t254.0)
6.0 (39)	205 (919)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t12 (t304.8)	t12 (t304.8)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
7.0 (45)	239 (1060)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t12 (t304.8)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)	t10 (t254.0)
8.0 (52)	274 (1225)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
9.0 (58)	308 (1367)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
10.0 (65)	342 (1532)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
11.0 (71)	376 (1673)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
12.0 (77)	410 (1814)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
14.0 (90)	479 (2121)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
16.0 (103)	547 (2427)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)
18.0 (116)	616 (2733)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)
20.0 (129)	684 (3040)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t12 (t304.8)	t14 (t355.6)
22.0 (142)	752 (3346)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
24.0 (155)	821 (3652)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t16 (t406.4)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
26.0 (168)	889 (3959)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t16 (t406.4)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)	t14 (t355.6)
28.0 (181)	958 (4265)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
30.0 (194)	1026 (4571)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)	t16 (t406.4)
Workpoint Length, ft (m)		25.0 (7.6)	28.3 (8.6)	32.0 (9.8)	36.1 (11.0)	40.3 (12.3)	25.0 (7.6)	26.6 (8.1)	28.3 (8.6)	30.1 (9.2)	32.0 (9.8)
t = square tube (round pipe casing also available)											

For design assistance please contact CoreBrace:

5789 West Wells Park Road
West Jordan, UT 84081
801.280.0701
www.corebrace.com

CoreBrace
SUPERIOR SEISMIC PERFORMANCE

BOLTED LUG BRACE AND CASING INFORMATION



1st-Mode Euler Buckling

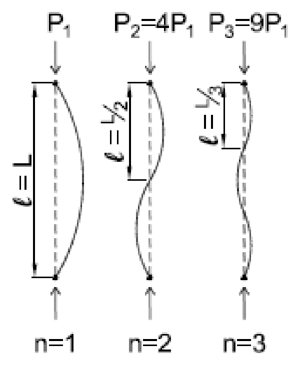
$$P_{cr} = \frac{\pi^2 EI}{(KL)^2} \qquad F_{cr} = \frac{\pi^2 E}{\left(\frac{KL}{r}\right)^2}$$

nth-Mode Euler Buckling

$$P_{cr\_n} = \frac{\pi^2 EI}{(K\ell)^2} = \frac{\pi^2 EI}{\left(\frac{KL}{n}\right)^2} = n^2 \frac{\pi^2 EI}{(KL)^2} = n^2 P_{cr}$$

where $\ell = L/n$

$$P_{cr\_n} = n^2 P_{cr} \qquad F_{cr\_n} = n^2 F_{cr}$$



Casing Demands

$$I_{req'd} = \frac{FS_B P_u (KL_g)^2}{\pi^2 E}$$

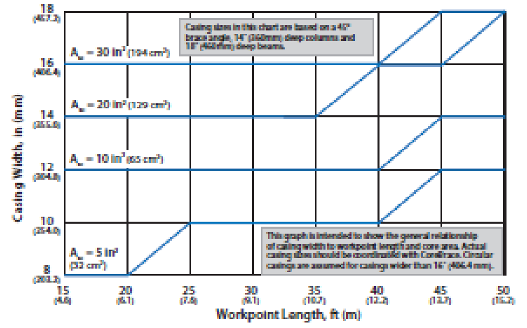
Adjusted Brace Strength Determination

$$P_c = \beta \omega F_y A_{sc} \quad (compression)$$

$$P_t = \omega F_y A_{sc} \quad (tension)$$

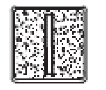
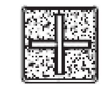
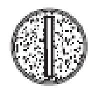
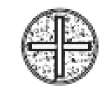
F_y of material used to fabricate brace yielding cores to be established based on coupon testing of individual plates. In such cases, R_y may be taken as equal to 1.0 in the above equations. (See AISC 341)

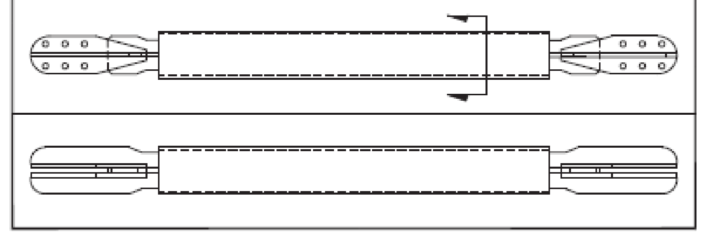
Approximate Casing Size



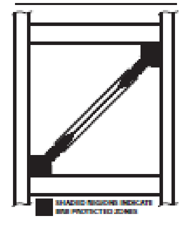
Casing sizes in this chart are based on a 45° brace angle, 14" (360mm) deep columns and 18" (460mm) deep beams.

This graph is intended to show the general relationship of casing width to workpoint length and core area. Actual casing sizes should be coordinated with CoreBrace. Circular casings are assumed for casings wider than 16" (406.4 mm).

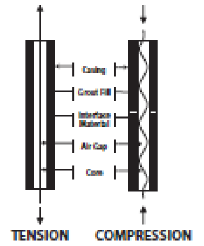
	FLAT	CRUCIFORM	MATERIAL SPECS
SQUARE CASING			CORE PL: A36 CONTROLLED YIELD STIFFENER PL: A36 (F_y = 249 MPa) LUG PL: A572 GR-50 (F_y = 345 MPa) CASING: A500 GR-B (F_y = 318 MPa) GUSSET/REPAD PL: A572 GR-50 (F_y = 345 MPa) BOLTS: A490/F2280 (F_u = 1035 MPa)
ROUND CASING			CORE PL: A36 CONTROLLED YIELD STIFFENER PL: A36 (F_y = 249 MPa) LUG PL: A572 GR-50 (F_y = 345 MPa) CASING: ROUND HSS: A500 GR-B (F_y = 290 MPa) PIPE: A53 GR-B (F_y = 242 MPa) GUSSET/REPAD PL: A572 GR-50 (F_y = 345 MPa) BOLTS: A490/F2280 (F_u = 1035 MPa)



BRB Protected Zones



Schematic BRB Behavior



WBS Task	Sub-task Description	Qty.	Units	Production Rate	Crew hours	Crew Cost / hr	# workers on crew	total labor hours
Overhead rough-in	Domestic Water	100	LF	0.25	25	$98.30	2	50
Precast Slab Planks	Hollow, 8" thick	1056	S.F.	0.023	24.288	235.45	1	24.288
Finishing Floors	Integral topping and finish, 2" thick	1056	S.F.	0.08	84.48	189.05	1	84.48
Structural Steel Members	Beam, W 14 x 82	88	L.F.	0.078	6.864	135.5	1	6.864
Structural Steel Members	Beam, W 8 x 10	72	L.F.	0.093	6.696	172	1	6.696
Columns Structural	W shape, 12 x 40	9.33	L.F.	0.054	0.50382	102.5	1	0.50382
Columns Structural	W shape, 12 x 53	77.3	L.F.	0.057	4.4061	135.5	1	4.4061
Structural Steel Members	Beam, W 8 x 10	181	L.F.	0.093	16.8051		1	16.8051

Existing Gravity System

Building Element	Quantity	Unit	Unit Cost	Total Cost
Prestressing Steel - 200' span, 300 kip	232.05	Lb	4.12	956.05
Reinforcing in Place - Elevated slabs, #4 - #7	10.974938	Ton	2025	22224.25
Normal Weight Concrete - 5000 psi	202.94267	C.Y.	120	24353.12
Placing Concrete - 6"-10" thick, pumped	202.94267	C.Y.	28.5	5783.87
Concrete in Place - Columns, square (4000psi), 24"x24" average reinforcing	1.3836048	C.Y.	1275	1764.10
			Total $	55081.38

Proposed Gravity System

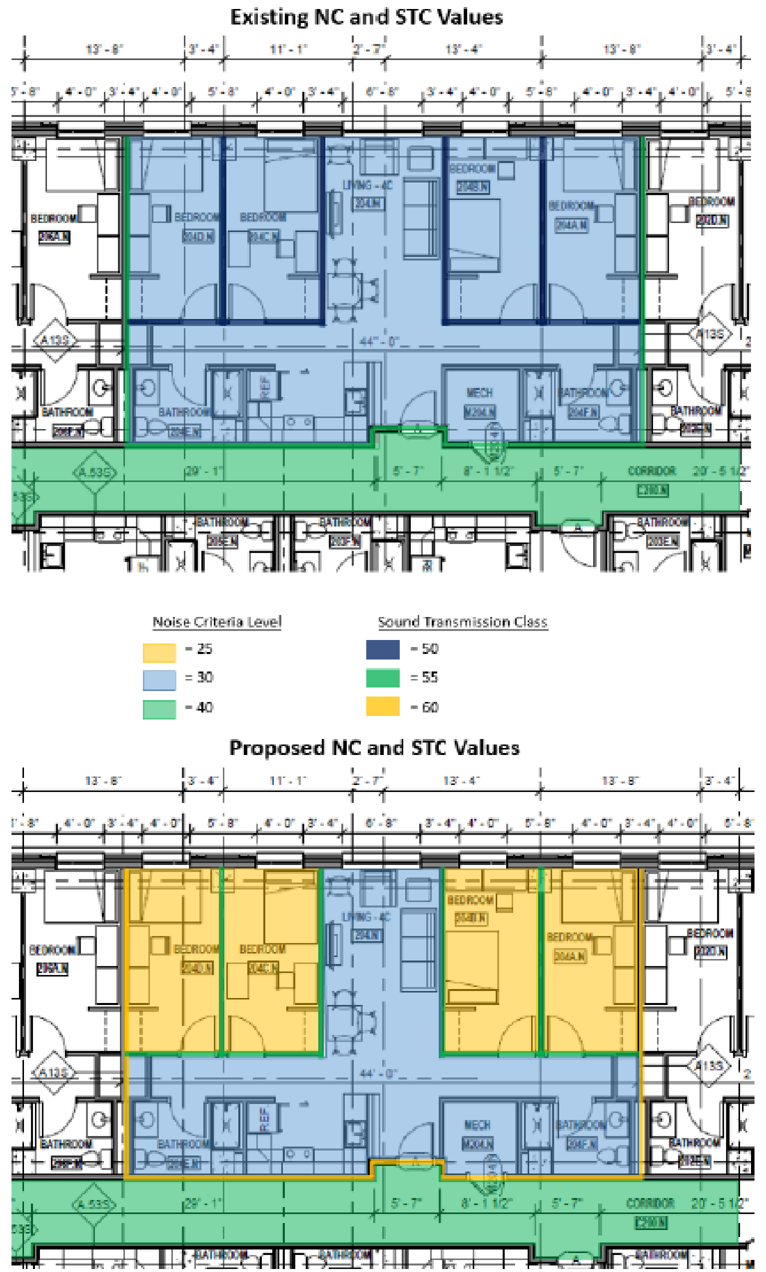
Building Element	Quantity	Unit	Unit Cost	Total Cost
Precast Slab Planks - Hollow, 8" thick	1056	S.F.	10.35	10929.6
Finishing Floors - Integral topping and finish, 2" thick	1056	S.F.	6.55	6916.8
Structural Steel Members - Beam, W 14 x 82	88	L.F.	201	17688
Structural Steel Members - Beams, W 8 x 10	72	L.F.	27	1944
Columns Structural - W Shape, 12 x 40	9.33	L.F.	86.5	807.045
			Total $	42113.99

Existing Lateral System

Building Element	Quantity	Unit	Unit Cost	Total Cost
Placing Concrete - walls, 8" thick	129.30859	C.Y.	96.5	12478.28
Reinforcing in Place - Columns, #3 - #7	1.37676	Ton	2750	3786.09
Forms In Place, Walls - job-build plywood, over 8' 3 use	210.0219	SFCA	13.95	2929.81
				0.00
			Total $	19194.17

Proposed Lateral System

Building Element	Quantity	Unit	Unit Cost	Total Cost
Columns Structural - W Shape, 12 x 53	77.3	L.F.	146	11285.8
Structural Steel Members - Beams, W 8 x 10	180.664	L.F.	27	4877.928
Braces - Star Seismic BRBF bolted lug connection				11000
				0
			Total $	24447.36



Existing NC and STC Values

Proposed NC and STC Values

Figure 39: NC and STC values for both systems

Existing Apartment Partitions

Partition	Label	Room #'s	Description	STC Value
Apartment demising wall	A12/A23	Apartment-Apartment	Two layers 1/2" GB each side of 3-5/8" studs 16" O.C. plus 1-1/2" FG	55
Corridor wall	A12/A23	Apartment-Apartment	Two layers 1/2" GB each side of 3-5/8" studs 16" O.C. plus 1-1/2" FG	55
Bedroom wall	A.53	Bedroom-Bedroom-Living Area	One layer 5/8" GB 3-5/8" studs 16" O.C. plus 1-1/2" FG	50
Exterior wall	Type 1	Apartment-Outside	4" masonry, 2 1/2" stone wool/acoustical insulation, 5/8" GB	60
Floor/Ceiling Assembly	S5.00	Apartment-Apartment	8" PT slab, ceiling tiles, carpeting	58

Proposed Apartment Partitions

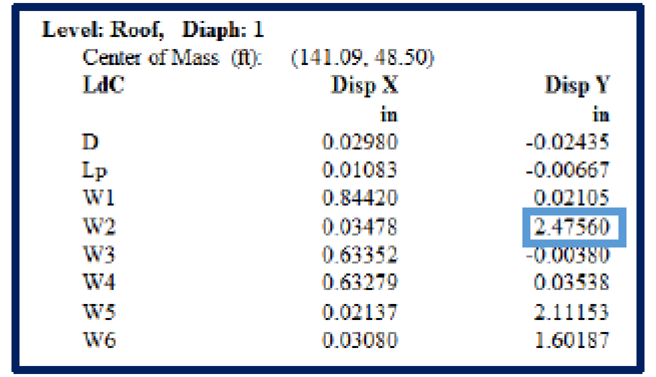
Partition	Label	Room #'s	Description	STC Value
Apartment demising wall	NA	Apartment-Apartment	Three layers 1/2" GB each side of 3-5/8" studs 16" O.C. plus 3" FG	61
Corridor wall	NA	Apartment-Apartment	Three layers 1/2" GB each side of 3-5/8" studs 16" O.C. plus 3" FG	61
Bedroom wall	NA	Bedroom-Bedroom-Living Area	One layer 5/8" GB 3-5/8" studs 16" O.C. plus 1-1/2" FG	50
Exterior wall	Type 1	Apartment-Outside	4" masonry, 2 1/2" stone wool/acoustical insulation, 5/8" GB	60
Floor/Ceiling Assembly	NA	Apartment-Apartment	8" hollow core plank 2" topping, acousitcal ceiling tiles	59

Wind Force Determination N-S						
Building Level	Height above ground level z (ft)	K_z	q_z	$P_{z(W)}$	$P_{h(L)}$	Total (psf)
Level 1	0.0	0.575	16.54	10.66	-11.18	21.84
Level 2	12.0	0.575	16.54	10.66	-11.18	21.84
Level 3	22.7	0.647	18.61	11.99	-11.18	23.17
Level 4	33.3	0.722	20.78	13.39	-11.18	24.57
Level 5	44.0	0.782	22.49	14.49	-11.18	25.67
Level 6	54.7	0.832	23.93	15.42	-11.18	26.60
Level 7	65.3	0.875	25.18	16.23	-11.18	27.41
Level 8	76.0	0.914	26.29	16.94	-11.18	28.12
Lower Roof	87.9	0.953	27.41	17.66	-11.18	28.84
PH Roof	95.9	0.977	28.10	18.11	-11.18	29.29

Wind Force Determination E-W						
Building Level	Height above ground level z (ft)	K_z	q_z	$P_{z(W)}$	$P_{h(L)}$	Total (psf)
Level 1	0.0	0.575	16.54	11.18	-4.69	15.87
Level 2	12.0	0.575	16.54	11.18	-4.69	15.87
Level 3	22.7	0.647	18.61	12.58	-4.69	17.27
Level 4	33.3	0.722	20.78	14.04	-4.69	18.73
Level 5	44.0	0.782	22.49	15.20	-4.69	19.89
Level 6	54.7	0.832	23.93	16.18	-4.69	20.87
Level 7	65.3	0.875	25.18	17.02	-4.69	21.71
Level 8	76.0	0.914	26.29	17.77	-4.69	22.46
Lower Roof	87.9	0.953	27.41	18.53	-4.69	23.22
PH Roof	95.9	0.977	28.10	19.00	-4.69	23.69

Base Shear Determination N-S				
Building Level	Height above ground level z (ft)	Tributary Height (ft)	Total Pressure (psf)	Total Lateral Story Force (kip)
Level 1	0.0	6.00	21.84	39.31
Level 2	12.0	11.34	21.84	74.26
Level 3	22.7	10.67	23.17	74.14
Level 4	33.3	10.67	24.57	78.60
Level 5	44.0	10.67	25.67	82.18
Level 6	54.7	10.67	26.60	85.11
Level 7	65.3	10.67	27.41	87.68
Level 8	76.0	11.30	28.12	95.29
Lower Roof	87.9	9.96	28.84	86.18
PH Roof	95.9	4.00	29.29	35.15
			Total Base Shear (kips) =	**737.90**

Base Shear Determination E-W				
Building Level	Height above ground level z (ft)	Tributary Height (ft)	Total Pressure (psf)	Total Lateral Story Force (kip)
Level 1	0.0	6.00	15.87	5.81
Level 2	12.0	11.34	15.87	10.97
Level 3	22.7	10.67	17.27	11.24
Level 4	33.3	10.67	18.73	12.19
Level 5	44.0	10.67	19.89	12.95
Level 6	54.7	10.67	20.87	13.58
Level 7	65.3	10.67	21.71	14.13
Level 8	76.0	11.30	22.46	15.48
Lower Roof	87.9	9.96	23.22	14.11
PH Roof	95.9	4.00	23.69	5.78
			Total Base Shear (kips) =	**116.22**



```
Level: Roof,   Diaph: 1
     Center of Mass (ft):    (141.09, 48.50)
     LdC                          Disp X         Disp Y
                                      in             in
     D                           0.02980       -0.02435
     Lp                          0.01083       -0.00667
     W1                          0.84420        0.02105
     W2                          0.03478        2.47560
     W3                          0.63352       -0.00380
     W4                          0.63279        0.03538
     W5                          0.02137        2.11153
     W6                          0.03080        1.60187
```

Name	Value	Reference
site class	C	per geotechnical report
S_S	0.175	USGS app
S_1	0.051	USGS app
F_a	1.2	table 11.4.1
F_v	1.7	table 11.4.2
S_{MS}	0.21	
S_{M1}	0.0867	
S_{DS}	0.1400	
S_{D1}	0.0578	
Occupancy Cat.	II	table 1-1
Importance Factor	1.00	table 11.5-1
Design Cat. Based on S_{DS}	A	table 11.6-1
Design Cat. Based on S_{D1}	B	table 11.6-2
design method	equivalent lateral force	section 12.8
R	8	table 12.2-1
C_s	0.018	eq. 12.8-2
W=	15139.6	kips
Ta=	0.000	eq 12.8-7
k=	0.750	12.8.3
Seismic Base Shear	264.943	kips

LEVEL	h_x (ft)	W_x (k)	$W_x h_x^k$	C_{vx}	F_x (k)	V_x (k)	OVERTURNING MOMENT (ft-k)
Level 1	0.00	**1767**	0	0.000	0.00	**264.9**	0.00
Level 2	12.00	**1936**	25287	0.040	10.66	**264.9**	127.87
Level 3	21.3	**1888**	44638	0.071	18.81	**254.3**	400.67
Level 4	30.67	**1889**	65097	0.104	27.43	**235.5**	841.34
Level 5	40	**1888**	85614	0.136	36.08	**208.0**	1443.11
Level 6	49.3	**1888**	106314	0.169	44.80	**172.0**	2208.68
Level 7	58.67	**1460**	98379	0.156	41.46	**127.2**	2432.28
Level 8	68	**1481**	116279	0.185	49.00	**85.7**	3332.01
Lower Roof	78.83	**844**	77167	0.123	32.52	**36.7**	2563.41
PH Roof	86.67	**99**	9944	0.016	4.19	**4.2**	363.19
TOTAL		15140	628717	1.0000	264.94		**13712.55**