Index of Appendices

Building Code Data (Existing)

- International Building Code 2000
- Business – Group B Occupancy (§304, page 24)

- Type of Construction, Type IIIB, Sprinklered
  - 4 Story Office Building
  - Max. Height | 75’-0” (Table 503, page 71)
  - Max. Stories | 5 (Table 503, page 71)
  - Max Allowable Area Per Floor | 53,438 SF
  - 0 hour fire rating required

Similar results for existing classified in IBC 2009

Building Code Data (Redesign)
[with glulam perimeter]

- International Building Code 2009
- Business – Group B Occupancy

- Type of Construction, Type IV (HT) §602.4
  - 4 Story Office Building
  - Max. Height | 65’-0”
  - Max. Stories | 5
  - Max Allowable Area Per Floor | 36,000 SF
  - Minimum width and depth used for HT

“Floors shall be without concealed spaces.”

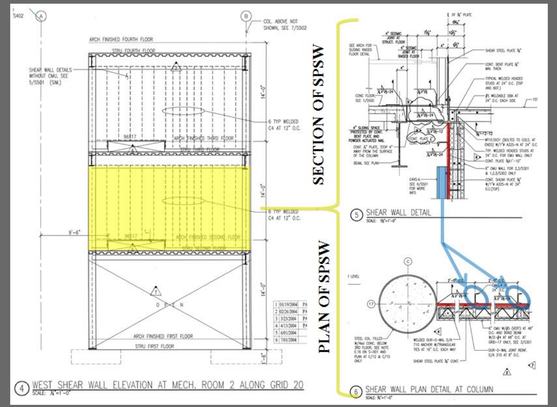
Building Code Data (Redesign)
[Alternative with steel perimeter]

- International Building Code 2009
- Business – Group B Occupancy

- Type of Construction, Type IIIB §602.3
  - 4 Story Office Building
  - Max. Height | 75’-0”
  - Max. Stories | 4
  - Max Allowable Area Per Floor | 60,648 SF
  - 0 hour fire rating required

“…the exterior walls are of noncombustible materials and the interior building elements are of any material permitted by this code.”

EXISTING SPSW LATERAL DESIGN



C4x5.4 at 24” O.C.

3/8” Continuous Shear Steel Plate

FIRE RATING – COMPOSITE DECK

- 4 ½” of NW on unprotected deck required for a 2 hour fire rating
- Construction Type IIIB requires no floor construction fire resistance

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 secondary members (see Section 202)	2	2	1	0	1	0	HT	1	0
Roof construction and secondary members (see Section 202)	1½[b]	1[b,c]	1[b,c]	0[c]	1[b,c]	0	HT	1[b,c]	0

FLOOR-CEILING ASSEMBLIES WITH COMPOSITE DECK

Vulcraft Decks have been tested by Underwriters Laboratories Inc. for their Fire Resistance Ratings. In as much as new listings are continually being added, please contact the factory if your required design is not listed below. The cellular decks listed comply with U.L. 209 for use as Electrical Raceways.

Restrained Assembly Rating	Type of Protection	Concrete Thickness & Type (1)	U.L. Design No. (2,3,4)	Classified Deck Type		Unrestrained Beam Rating
				Fluted Deck	Cellular Deck (5)	
¾ Hr.	Unprotected Deck	2 ½" LW	D914 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1 Hr.
			D916 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
1 Hr.	Exposed Grid	2 ½" NW	D216 +	1.5VL,1.5VLI,2VLI,3VLI	2VLP, 3VLP	2,3 Hr.
	Cementitious	2" NW&LW	D743 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
		2 ½" NW&LW	D703 *	1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1.5 Hr.
			D712 *	3VLI	3VLP	2 Hr.
			D722 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2 Hr.
			D739 *	1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3,4 Hr.
			D759	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
	Sprayed Fiber	2" NW&LW	D859 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
		2 ½" NW&LW	D832 *	1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D847 *	2VLI,3VLI	3VLP	1,1.5,3 Hr.
			D858 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,4 Hr.
			D871 *	2VLI,3VLI	2VLP, 3VLP	1,1.5,2,3 Hr.
	Unprotected Deck	2 ½" LW	D902 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D914 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1 Hr.
			D916 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D918 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D919 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
		3 ½" NW	D902 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D916 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5,2,3 Hr.
			D918 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
			D919 #	1.5VL,1.5VLI,2VLI,3VLI	1.5VLP, 2VLP, 3VLP	1,1.5 Hr.
	Gypsum Board	2 ½" NW	D502 *	1.5VL,1.5VLI,2VLI,3VLI	2VLP, 3VLP	1,1.5,2 Hr.

Existing Design - Dead Loads

Dead Loads	
Occupancy or Use	**Load (psf)**
Floors (typical)	95
Roof	30

Breakdown of Floor Dead Loads	
Occupancy or Use	**Load (psf)**
Concrete and steel deck	63
Concrete ponding	8
Computers	12
Lights	4
Mechanical	4
Sprinkler	3
Miscellaneous	1

Provided by Cromwell Architects Engineers, Inc.

Existing Design - Live Loads

Live Loads	
Occupancy or Use	**Load (psf)**
Floors (typical)	80
Balcony	100
Stairs	100
Mechanical	150
Sidewalk	250
Roof Minimum	20
Snow Load	10
Ground Snow Load	10

Redesign - Dead Loads

Breakdown of Floor Dead Loads	
Occupancy or Use	**Load (psf)**
Concrete and steel deck	51
Carpet	1.5
Computers	12
SDL (MEP+LTG+Sprinkler)	10
Framing	10

SAP2000 Queen Post Model

Original Model

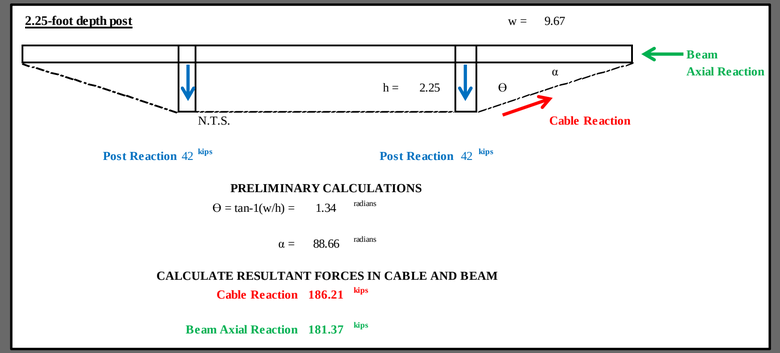
Member Releases

Point Loads

Distributed Self Weight

Axial Load Results

Member	Force	Percent Error (from actual)
Cable	172.97	7.1%
Cable	168.14	9.7%
Cable	172.97	7.1%
Post	-40.586	3.4%
Post	-40.586	3.4%

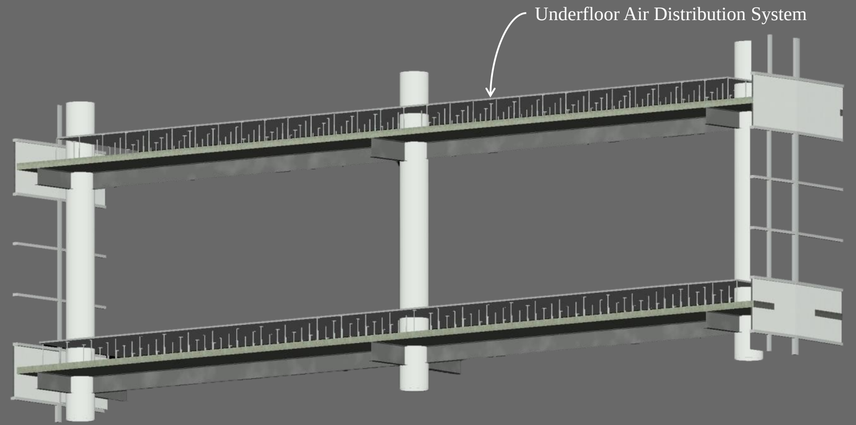


Floor System Comparison

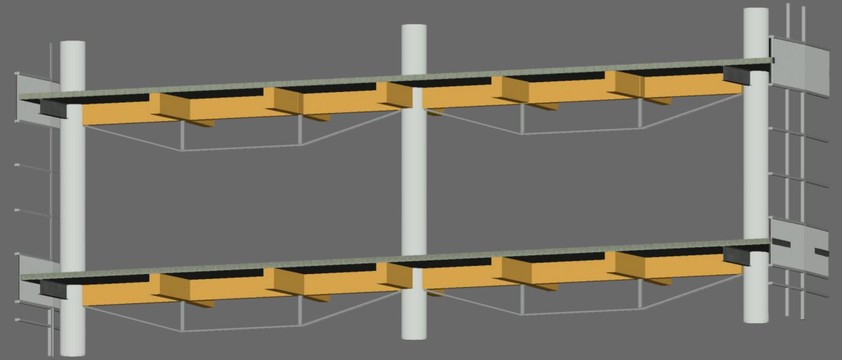
Potential Floor System	Advantages and Disadvantages
Tongue and groove wood plank	✓ Spacing will be an issue
Concrete floor system	✓ Additional weight may be of concern ✓ Would not match architectural style of building
Composite concrete and wood system	✓ Intricate calculations required
Steel decking and concrete system	✓ In use in existing building ✓ Would match redesign of building
Post tensioned slab	✓ Not an economical solution ✓ Would have to span in the short distance thus decreasing the utility of the post tensioning

Gravity System Side-by-Side Comparison

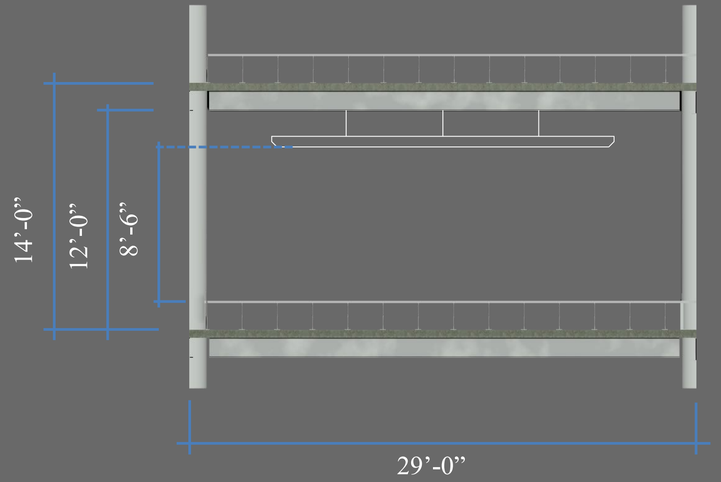
Existing System

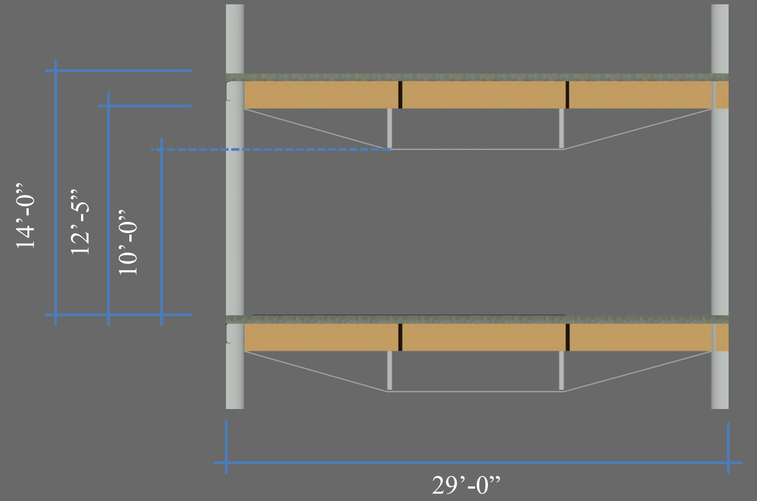


Redesigned System



Floor-to-Floor Height Comparison

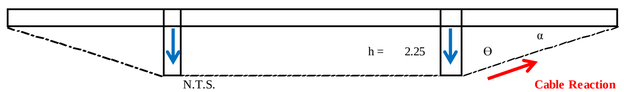




MACALLOY BAR & CABLE SYSTEMS

2.25-foot depth post

w = 9.67



Post Reaction 42 kips

Post Reaction 42 kips

PRELIMINARY CALCULATIONS

Θ = tan-1(w/h) = 1.34 radians

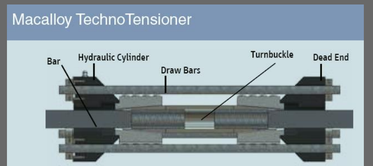
α = 88.66 radians

CALCULATE RESULTANT FORCES IN CABLE AND BEAM

Cable Reaction 186.21 kips

Beam Axial Reaction 181.37 kips

Macalloy TechnoTensioner



Macalloy 460 Bar System

Table 1 - Tendon Capacities for Carbon Macalloy 460

Thread		M10 3/8	M12 1/2	M16 5/8	M20 3/4	M24 1	M30 1 1/4	M36 1 3/8	M42 1 5/8	M48 2	M56 2 1/4	M64 2 1/2	M76 3	M85 3 3/8	M90 3 1/2	M100 4
Nominal Bar Dia.	mm	10	11	15	19	22	28	34	39	45	52	60	72	82	87	97
	inch	0.39	0.43	0.59	0.75	0.87	1.1	1.34	1.54	1.77	2.05	2.36	2.83	3.23	3.43	3.82
Min. Yield Load	kN	25	36	69	108	156	249	364	501	660	912	1204	1756	2239	2533	3172
	kip	5.6	8.1	15.5	24.3	35.1	56	81.8	112.6	148.4	205	270.7	394.7	503.3	569.4	713.1
Min. Break Load	kN	33	48	91	143	207	330	483	665	875	1209	1596	2329	2969	3358	4206
	kip	7.4	10.8	20.5	32.1	46.5	74.2	108.6	149.5	196.7	271.8	358.8	523.6	667.4	754.9	945.5
Design Resistance to EC3	kN	24	35	66	103	149	238	348	479	630	870	1149	1677	2138	2418	3029
	kip	5.4	7.87	14.84	25.16	33.5	53.5	78.23	107.7	141.63	195.58	258.31	377	480.64	543.59	680.95
Nominal Bar Weight	(kg/m)	0.5	0.75	1.4	2.2	3	4.8	7.1	9.4	12.5	16.7	22.2	32	41.5	46.7	58
	(lb/ft)	0.34	0.5	0.94	1.48	2.02	3.23	4.77	6.32	8.4	11.22	14.92	21.5	27.89	31.38	38.97

Queen Post Fire Rating

- Building not required to have a fire rating
- Assume a fire occurs on four sides of the member
- Assume member acts purely in compression (a column)

$$t = 2.54 \cdot Z \cdot B\left[3 - \frac{B}{D}\right]$$

APA – The Engineered Wood Association

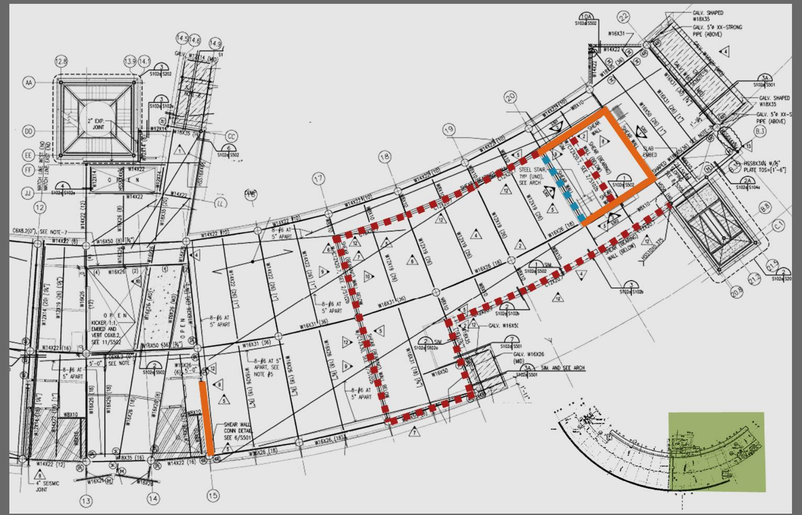
Fire rating of glulam is approximately
1 hour and 15 minutes

Lateral System Layout

Ground Level Only

First and Second Levels Only

All Levels



IRREGULARITY

Horizontal

- **Type 1a** — Torsional Irregularity ✗
- **Type 1b** — Extreme Torsional Irregularity ✓
- **Type 5** — Nonparallel System Irregularity ✓

§12.3.2, Table 12.3-1
ASCE 7-10

		East Side	West Side
x-direction	Type 1a	-	-
	Type 1b	Yes	Yes
y-direction	Type 1a	-	None
	Type 1b	Yes	-

§12.7.3	Structural Modeling ✓
§12.8.4.3	Amplification of Accidental Torsional Moment ✓
§12.12.1	Story Drift Limit ✓
Table 12.6-1	Equivalent Lateral Force Analysis Procedure ✓
§16.2.2	Structural Modeling ✓

$$\delta_{avg} = \frac{\delta_A + \delta_B}{2}$$

$$A_x = \left[\frac{\delta_{max}}{1.2\delta_{avg}}\right]^2$$

$$\Delta_a = 0.020h_x$$

Amplification Factor - West Side of Heifer International Center

X-direction Seismic Loading

Level	δ EX A + Ext. A (in)	δ EX B + Ext. B (in)	δ Average (in)	δ Maximum (in)	A_x	1.2(δ Average)	1.4(δ Average)	Irregularity Type 1a (Table 12.3-1)	Irregularity Type 1b (Table 12.3-
Story3	0.380	0.244	0.312	0.380	1.03	0.374	0.436	NA	Type 1b
Story2	0.218	0.145	0.180	0.218	1.03	0.216	0.252	NA	Type 1b
Story1	0.073	0.047	0.060	0.073	1.03	0.072	0.084	NA	Type 1b
Controlling Case	E5								

EX A @ (-156.198, -393.277), trace Location 1
EX B @ (-379.546, -319.250), trace Location 3

Level	A_x	V_x (kips)	e (ft)	M_x (k-ft)	V_{static} (kips
Story3	1.03	186.15	11.26	2162	191.97
Story2	1.02	293.64	11.26	3560	299.03
Story1	1.03	331.55	11.26	3840	341.03

Eccentricity calculated by RAM Frame

Shear only from x-direction of case E5, conservative assumption

IRREGULARITY

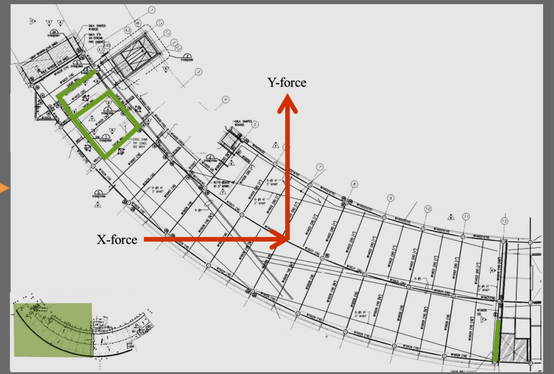
Horizontal

- **Type 1a** — Torsional Irregularity ✗
- **Type 1b** — Extreme Torsional Irregularity ✓
- **Type 5** — Nonparallel System Irregularity ✓

§12.3.2, Table 12.3-1
ASCE 7-10

"…lateral force resisting system not aligning with the orthogonal application for seismic forces."

§12.5.3	Orthogonal Combination Procedure (30%/100%) ✓
§12.7.3	Structural Modeling ✓
Table 12.6-1	Equivalent Lateral Force Analysis Procedure ✓
§16.2.2	Structural Modeling ✓



IRREGULARITY

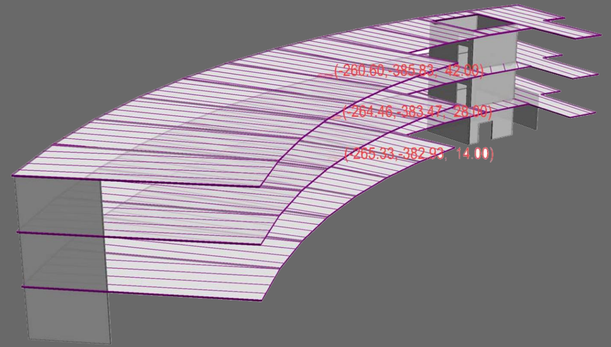
Vertical

– Type 4 In-Plane Discontinuity in Vertical LFR Element Irregularity

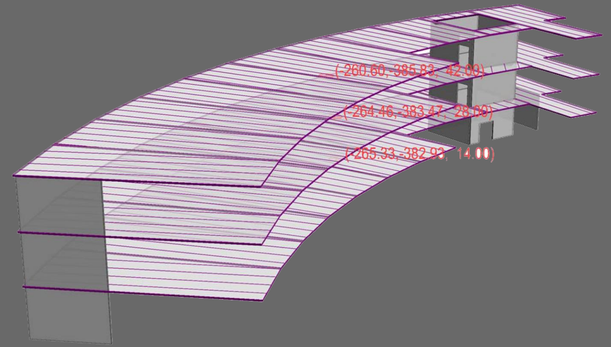
– Type 5b Discontinuity in Lateral Strength-Extreme Weak Story Irregularity

§12.3.2, Table 12.3-2
ASCE 7-10

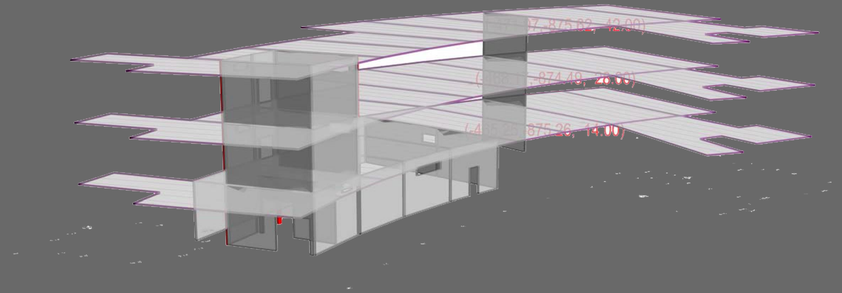
Center of Mass – West Side



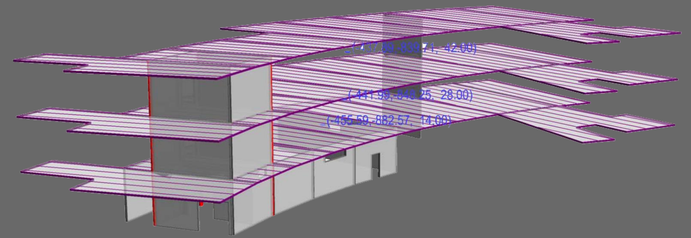
Center of Rigidity – West Side



Center of Mass – East Side



Center of Rigidity – East Side



Seismic Forces

Seismic Shear Summary - West End		
Level	V_x (kips)	V_y (kips)
Level 3	191.97	185.64
Level 2	290.03	282.97
Level 1	341.03	331.21

Seismic Shear Summary - East End		
Level	V_x (kips)	V_y (kips)
Level 3	221.73	180.16
Level 2	329.23	274.77
Level 1	347.62	325.55

Wind Forces

Wind Shear Summary - West End		
Level	V_x (kips)	V_y (kips)
Level 3	35.04	53.91
Level 2	67.36	103.94
Level 1	63.31	98.15

Wind Shear Summary - East End		
Level	V_x (kips)	V_y (kips)
Level 3	35.04	47.25
Level 2	67.36	91.1
Level 1	63.31	86.02

MECHANICAL DUCTWORK SIZING

TRANE Ductulator® Duct Sizing from Air Handling Units (AHU)

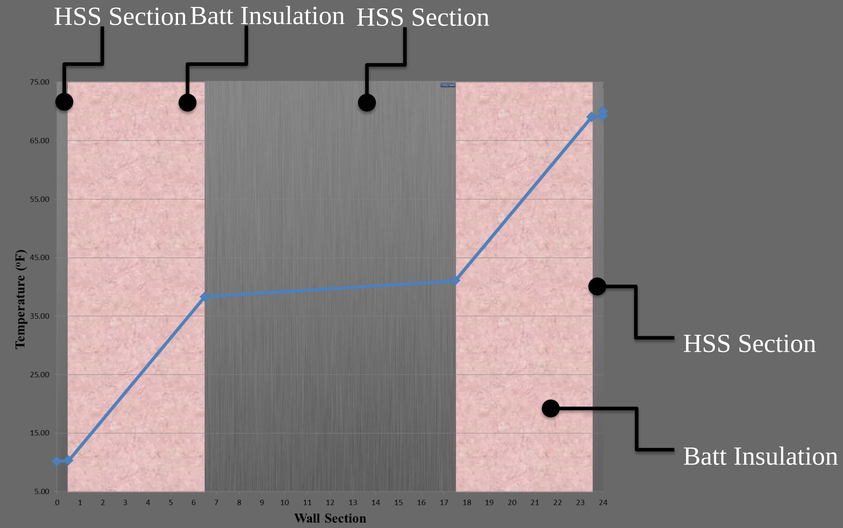
Mark	Location	Services	Type	Max Supply (CMU)	Min Outside Air (CMU	Return Air (CMU)	Rounded Max Supp	Ductulator® Size (in)	Alternative Ductulator® Size (in)
AHU-1E	1st	East	HOR2	6544	2452	4092	7000	25x30	20x38
AHU-1W	1st	West	HOR2	8920	1715	7205	9000	25x36	20x48
AHU-2E	2nd	East	HOR2	11122	1655	9467	11000	25x42	20x55
AHU-2W	2nd	West	HOR2	14403	2839	11564	14000	25x50	20x70
AHU-3E	3rd	East	HOR2	11400	1655	9745	11000	25x42	20x55
AHU-3W	3rd	West	HOR2	14842	2839	12003	15000	25x55	20x75
AHU-4E	4th	East	HOR2	10355	2620	7736	10000	25x40	20x50
AHU-4W	4th	West	HOR2	12503	2811	9692	13000	25x50	20x65
OSA-1E	-	East	HOR2	8400	8400	-	8000	25x32	20x42
OSA-1W	-	West	HOR2	10200	10200	-	10000	25x40	20x50

Thermal Bridge Elimination

Redesigned HSS Envelope

Material	Depth (in)	R (BTU-in/h-ft^2-^{o}F)	U (1/R)
Outside Air Film	-	0.17	5.88
Aluminum Composite	0.5	0.06	15.86
Batt Insulation	3	11.45	0.09
Aluminum Composite	0.5	0.06	15.86
Inside Air Film	-	0.68	1.47
	Sum	12.43	0.08

[1] Thermal Batt FIBERGLAS® Insulation (Owens Corning Insultating Systems, LLC, 2007)
[2] Almaxco ACP Mechanical Properties (Almaxco, 2012)

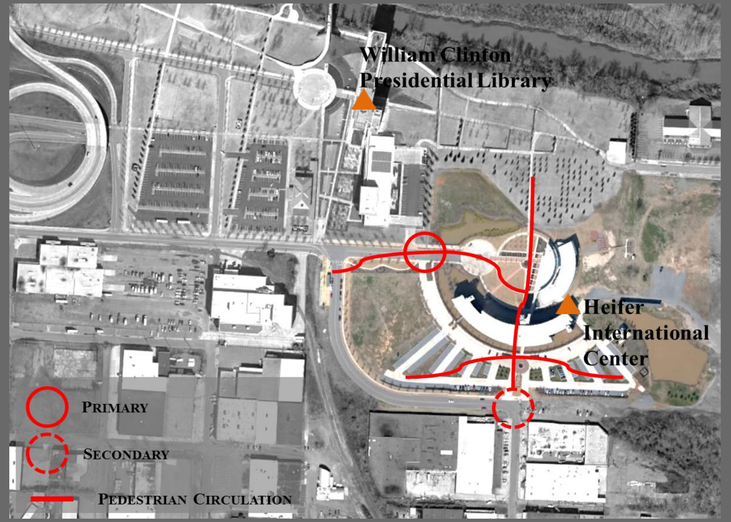


Architectural Guideline

- History of Heifer International
- Character of the Campus
  - Site Circulation
  - Movement on the Site
- Character of Buildings
- Character of the Interior Space

In all my travels around the world, the important decisions were made where people sat in a circle, facing each other as equals. – Dan West

Architectural Guideline



Architectural Guideline



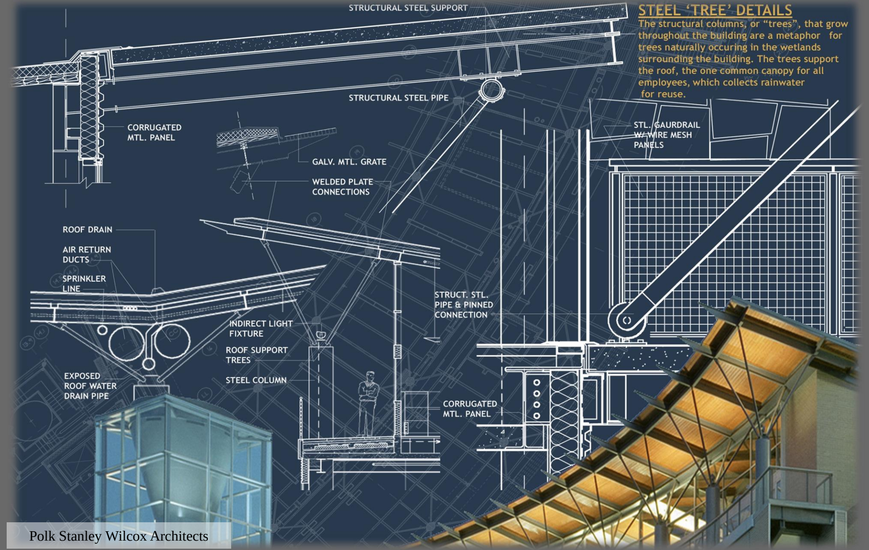








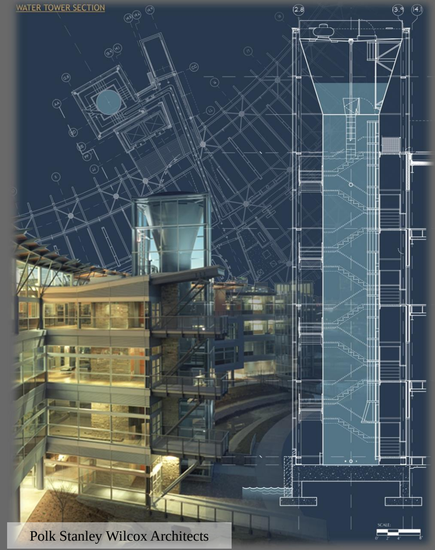

ARCHITECTURAL GUIDELINE



STEEL 'TREE' DETAILS

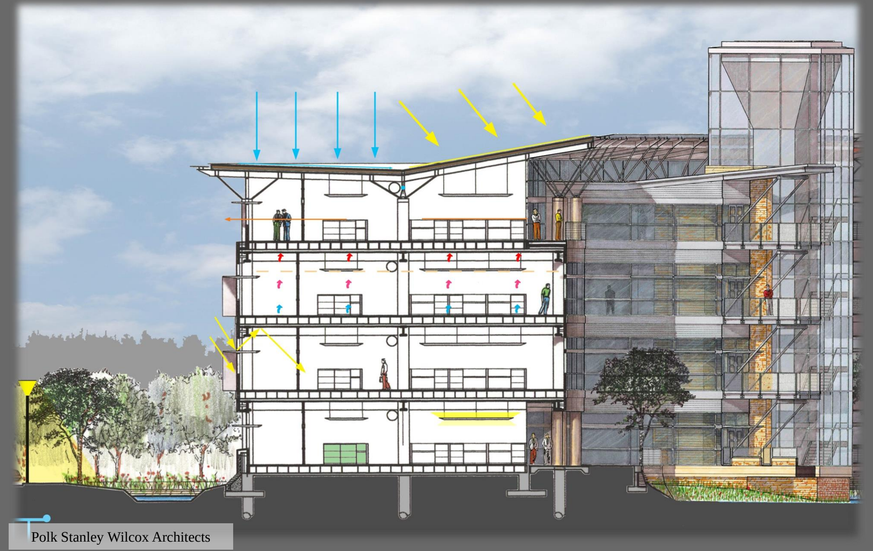
The structural columns, or "trees", that grow throughout the building are a metaphor for trees naturally occuring in the wetlands surrounding the building. The trees support the roof, the one common canopy for all employees, which collects rainwater for reuse.

Polk Stanley Wilcox Architects



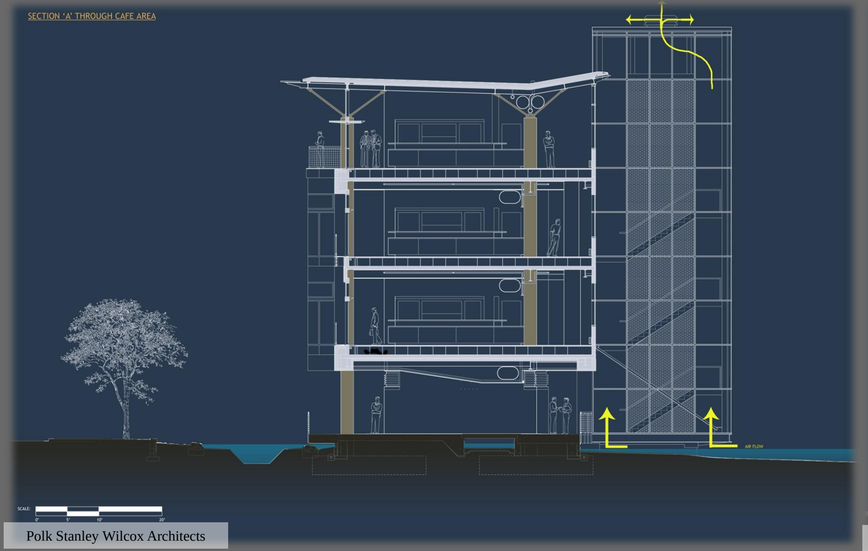
Polk Stanley Wilcox Architects

Architectural Guideline

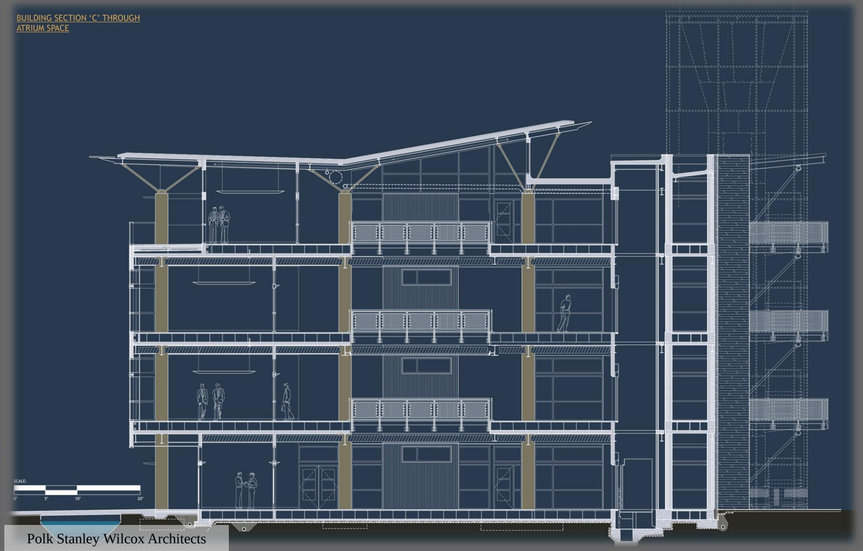


Polk Stanley Wilcox Architects

Architectural Guideline



Polk Stanley Wilcox Architects



Polk Stanley Wilcox Architects

Timber-Concrete Composite

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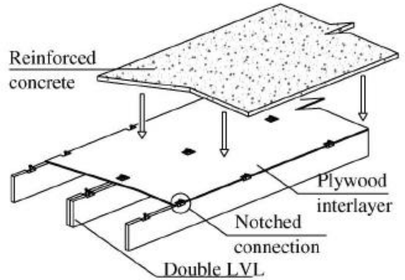
Antii Bilund, The Vihantasalmi Bridge of Finland



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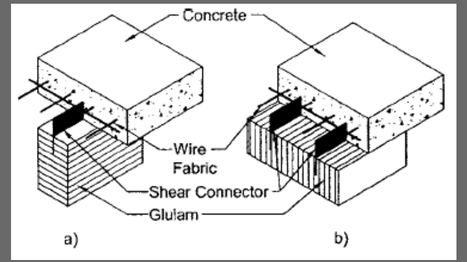
Timber-Concrete Composite

Shear Connector and Wire Mesh



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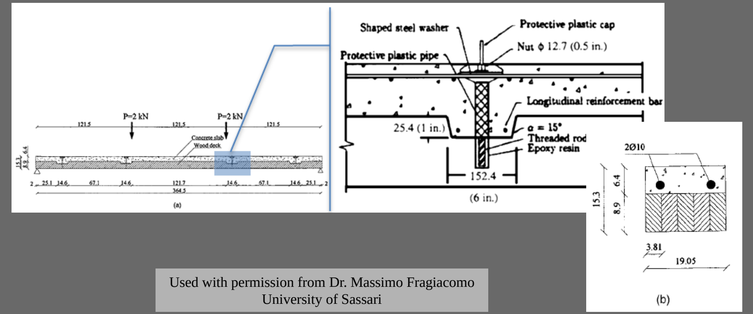
Shear Key Connection



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Hilti and Shear Key Connection

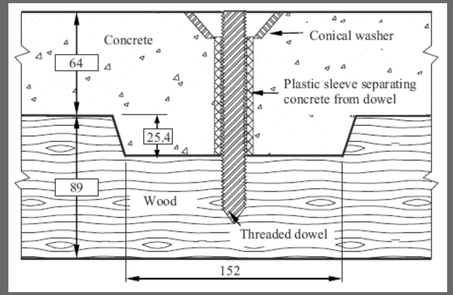
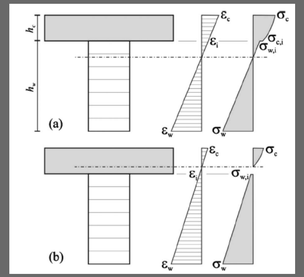


Figure from Gutkowski et al. 2010

Timber-Concrete Composite

Glued Composite Members



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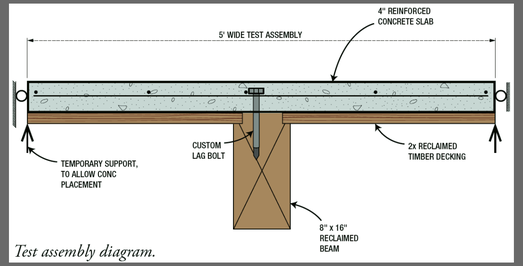
Custom Lag Bolt System



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