

# Structural Calculations

For: Kermit the Frog's Maniacal headquarters  
1234 Gonzo Ave  
Animal, Pennsylvania

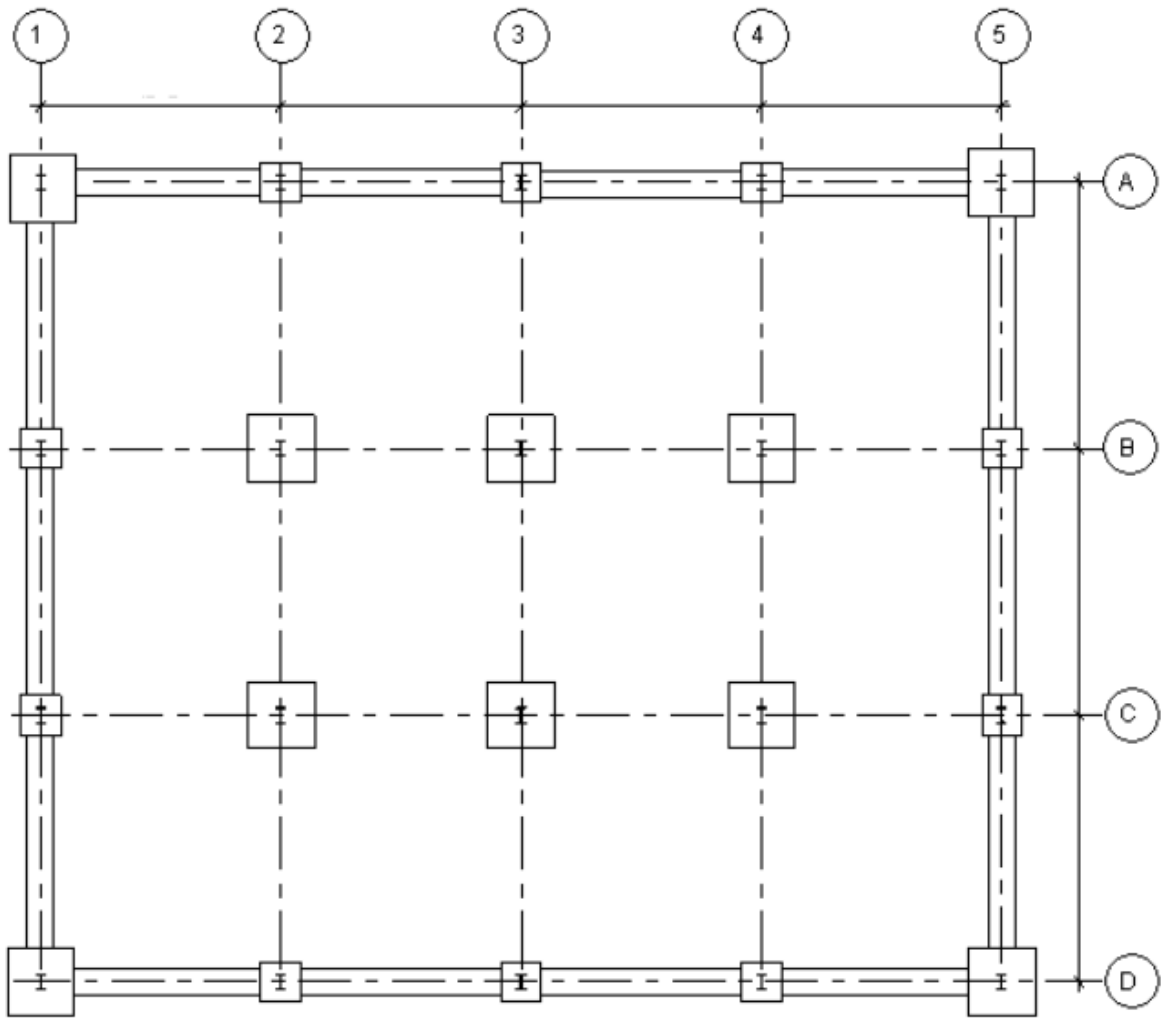
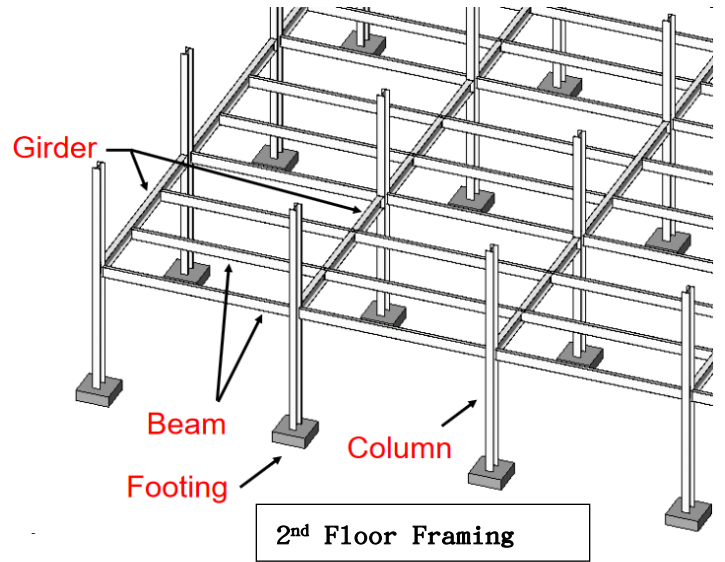
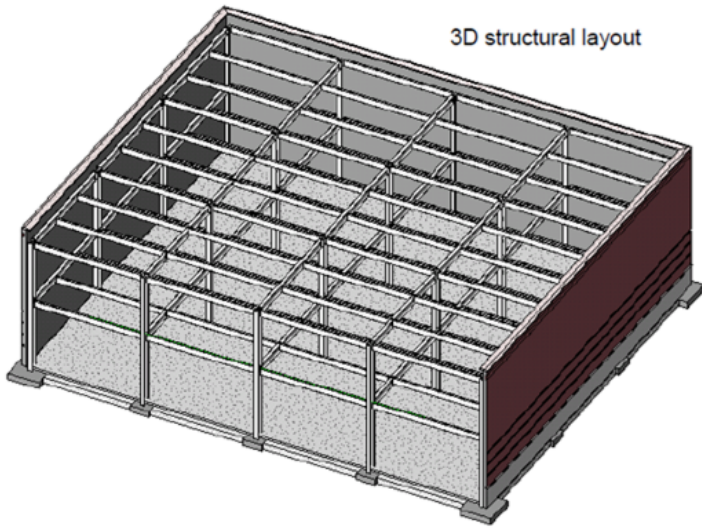
Architect: Jimmy & Bubba  
123 Carrot Lane  
Suite 95  
Garden, CA 95261

Date: 05/23/2024

BB&C Job No.: 456

Bugs Bunny & Co.  
Structural, Martian, Civil, and Not So Civil Engineers  
8526 Carrot Drive - Suite 100 - Rabbit, Pennsylvania 98745





Foundation Plan

## Beam Calculations

### Dead load

$$\begin{aligned} \text{Concrete: } 4'' \times 240 \text{ ft}^2 \times 150 \text{ lb/ft}^3 &= 12000 \text{ lb} \\ \text{Tile and mortar} &= 2500 \text{ lb} \\ \text{Interior Walls} &= 2000 \text{ lb} \\ \text{Drop Ceilings} &= 500 \text{ lb} \\ \text{HVAC} &= 2500 \text{ lb} \\ \text{Beam @ } 100 \text{ lb/ft} &\approx 2500 \text{ lb} \\ \text{DL} &= 22000 \text{ lb} \end{aligned}$$

### Live load

$$80 \text{ lb/ft}^2 \times 240 \text{ ft}^2 = 20000 \text{ lb}$$

### Total load

$$\text{DL} + \text{LL} \rightarrow 22000 + 20000 = 42000 \text{ lb}$$

### Factor of safety (FOS) = 5

$$(\text{FOS})(\text{TL}) \rightarrow 5 \times 42000 = 210000 \text{ lb}$$

### Moment

$$wL^2/8 \rightarrow w = 210000 \text{ lb} / 240 \text{ ft}^2 \rightarrow 875 \text{ lb/ft}^2$$

$$\rightarrow w = 875 \text{ lb/ft}^2 \times 10 \text{ ft} = 8750 \text{ lb/ft}$$

$$L^2 = 24^2 = 576 = 576 \text{ ft}^2$$

$$M = \frac{(8750 \text{ lb/ft})(576 \text{ ft}^2)}{8} = 630000 \text{ lb-ft}$$

### Section Modulus

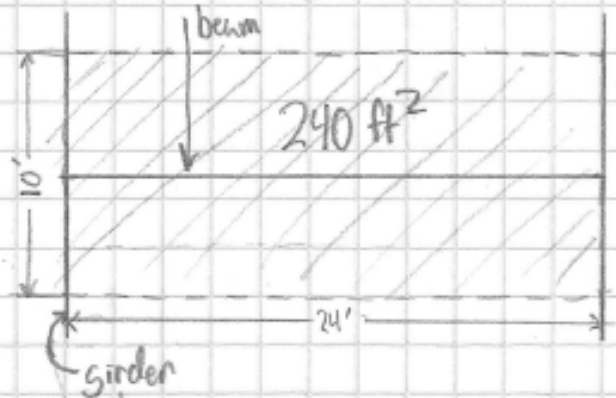
$$S = M / F_y \rightarrow 630000 \text{ lb-ft} / 30000 \text{ lb/in}^2$$

$$S = 630000 \text{ lb-ft} / 36000 \text{ lb/in}^2 = 210 \text{ in}^3$$

### Beam Selection

$$\text{Use W14 x 106 } S = 204 \text{ in}^3$$

### Floor diagram



## Girder Calculations

### Dead load

$$\begin{aligned} & \text{Beam DL} \times 3 + \text{Girder weight} \\ & (22000 \text{ lb}) \times 3 + (200 \text{ lb/ft}) \times (30 \text{ ft}) \\ & 66000 \text{ lb} + 6000 \text{ lb} \end{aligned} = 72000 \text{ lb}$$

### Live load

$$80 \text{ lb/ft}^2 \times 720 \text{ ft}^2 = 57600 \text{ lb}$$

### Total load

$$\text{DL} + \text{LL} \rightarrow 72000 \text{ lb} + 57600 \text{ lb} = 129600 \text{ lb}$$

### Factor of Safety (FOS) = 5

$$\text{FOS} \times \text{TL} \rightarrow 5 \cdot 129600 \text{ lb} = 648000 \text{ lb}$$

### Moment

$$wL^2/8 \rightarrow w = 648000 \text{ lb} / 720 \text{ ft}^2 \rightarrow$$

$$w = 900 \text{ lb/ft}^2 \times 24 \text{ ft} = 21600 \text{ lb/ft}$$

$$L^2 = (30 \text{ ft})^2 = 900 \text{ ft}^2$$

$$M = \frac{(21600 \text{ lb/ft}) \times (900 \text{ ft}^2)}{8} = 2430000 \text{ lb-ft}$$

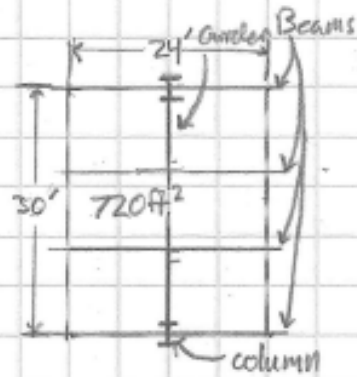
### Section Modulus

$$S = M/F_y$$

$$S = 2430000 \text{ lb-ft} / 30000 \text{ lb/in}^2 = 810 \text{ in}^3$$

### Girder Selection

$$W27 \times 281, S = 814 \text{ in}^3$$



## Column Calculations

Roof load

$$35 \text{ lb/ft}^2$$

$$720 \text{ ft}^2 \cdot 35 \text{ lb/ft}^2$$

$$= 25200 \text{ lb}$$

2nd floor load

= Girder TL

$$= 129600 \text{ lb}$$

Total Load (TL)

$$25200 \text{ lb} + 129600 \text{ lb}$$

$$= 154800 \text{ lb}$$

Factor of Safety (FOS) = 5

$$5 \cdot 154800 \text{ lb}$$

$$= 774000 \text{ lb}$$

Slenderness Ratio

$$\lambda = L_c / r$$

$\lambda$

$$\leq 100$$

$$L_c = (12 \text{ ft}) \cdot (12 \text{ m/ft})$$

$$= 144 \text{ m}$$

$r$

$$\geq 1.44 \text{ m}$$

Column Selection

Allowable =

$$= 42000 \text{ lb/in}^2$$

Factual = TL + Column weight / Area  $\rightarrow$

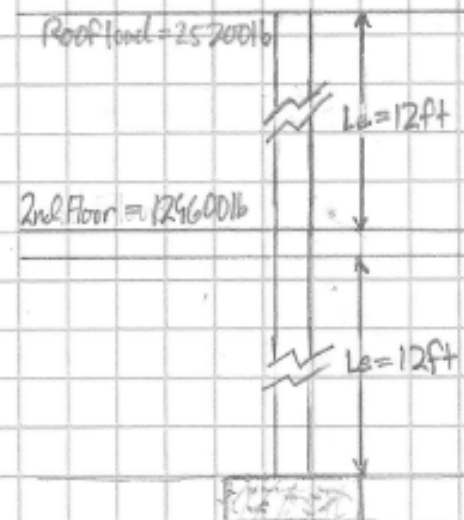
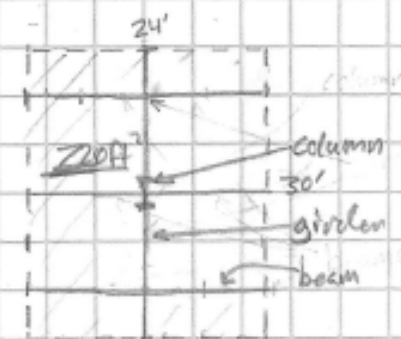
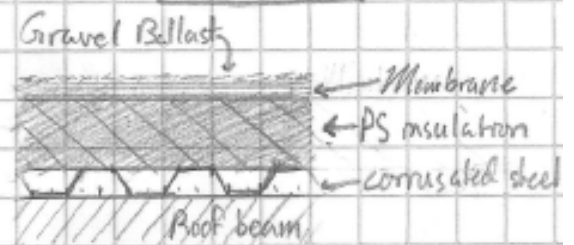
$$\text{Factual} = 774000 \text{ lb} + 5064 \text{ lb} / 62.2 \text{ m}^2 = 12525 \text{ lb/m}^2$$

$$42000 \text{ psi} > 12525 \text{ psi}$$

$$= \checkmark$$

Use W30X211,  $r = 3.44 \text{ m}$

## Roof Diagram



### Footings Calculations

Total load (TL)

$$TL = \text{Column TL} = 774000 \text{ lb}$$

Group Pressure (GP)

$$GP = 3000 \text{ lb/ft}^2$$

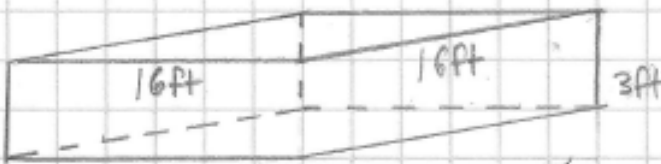
Area

$$A = TL/GP \rightarrow 774000 \text{ lb} / 3000 \text{ lb/ft}^2 = 258 \text{ ft}^2$$

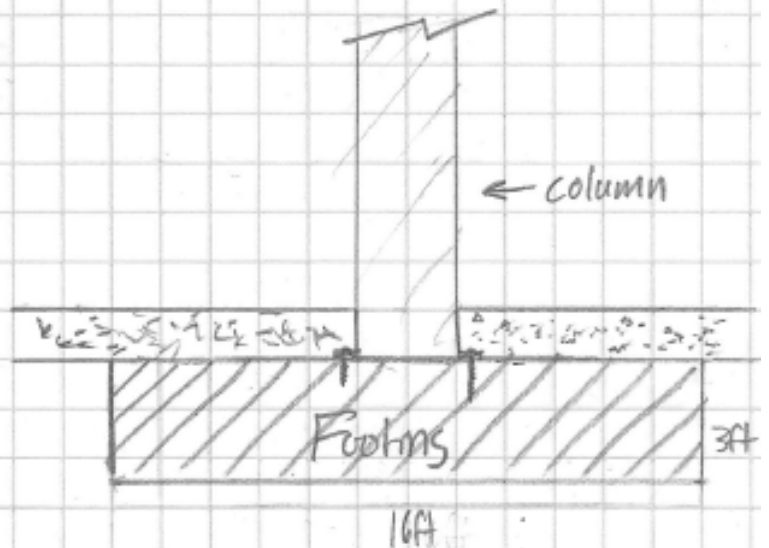
Footings size

16ft x 16ft x 3ft concrete

$$V = 16 \text{ ft} \times 16 \text{ ft} \times 3 \text{ ft} = 768 \text{ ft}^3$$



Footings dimension



## Cost Estimate

### Cost steel skeleton

Q	Member type	weight (lb)
(36)	Beams 2544/b	→ 91584
(15)	Girders 8430/b	→ 126450
(20)	Column 5064/b	→ 101280
Roof:		
(36)	Beams 2544/b	→ 91584
(15)	Girders 8430/b	→ 126450
<u>537348 lb</u>		

$$537348 \text{ lb} \times 201 \text{ USD/lb}$$

$$= \boxed{\$1080069.48}$$

### Cost concrete Footings

$$\begin{aligned} & 768 \text{ ft}^3 \times 20 \\ & (15360 \text{ ft}^3) \left( \frac{1 \text{ yd}^3}{3 \text{ ft}^3} \right) \\ & 5120 \text{ yd}^3 \times 150 \text{ USD/yd}^3 \end{aligned}$$

$$= 15360 \text{ ft}^3$$

$$= 5120 \text{ yd}^3$$

$$= \boxed{\$768,000}$$

# STRUCTURAL CALCULATIONS

For: **Johanson K. Industries**  
**4618 Monongahela St.**  
**San Diego, CA**

Architect: **Norman Foster**  
**425 Park Avenue**  
**New York, NY**

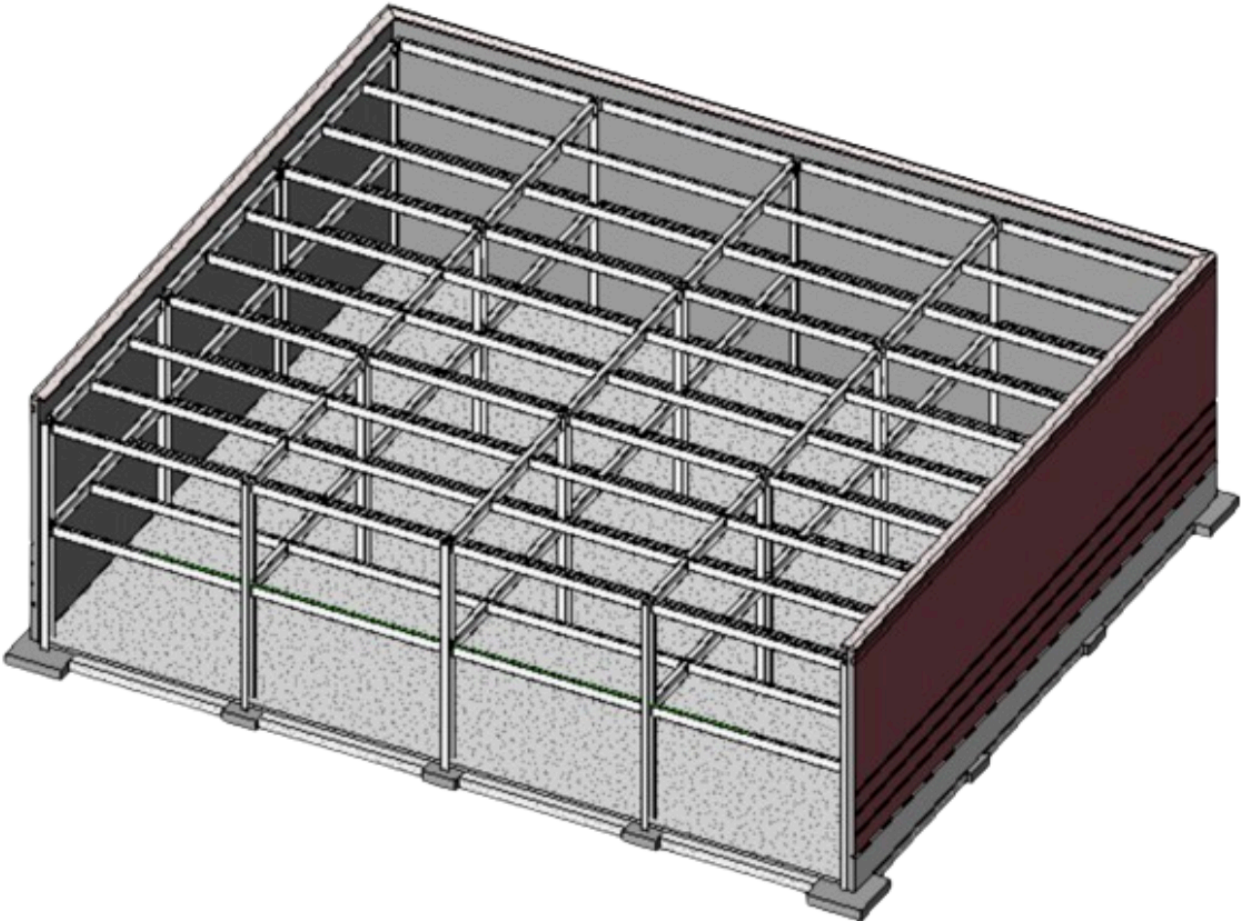
Date: **5/17/24**

CPC Job No.: **254359 XH**





# Retail Building Project - Final Exam



3D Structural Layout

# BEAMS



# STIRLING ENGINEERING

STRUCTURAL - SEISMIC - CIVIL

12854 LUISENO ST ♦ POWAY 92104 ♦ SAN DIEGO, CA  
PHONE (619) 972-2236 ♦ STIRLINGENGINEERING.COM

Job: JKI - Retail Building Project

Sheet No.: 1 - Beams

Calculated By: Sol S.

Date: 5-21-24

Beams - 27 Beams

$$A B 3 = 24' \times 10' = 240 \text{ ft}^2 \text{ AREA}$$

Floor covering = tile

$$12 \text{ lbs/ft}^2$$

$$240$$

$$\times 12$$

$$\underline{2,880 \text{ lbs}}$$

Humans = LL (Live load)

$$\approx 80 \text{ lbs per square ft}$$

$$240$$

$$\times 80$$

$$\underline{19,200}$$

Drop/Hanging Ceiling

$$2 \frac{1}{2} \text{ in}^2 \times 240 \text{ ft}^2 = 480 \text{ in}^2$$

S is in  $\text{in}^3$

$$S = \left( \frac{12,960,000}{180,000} \right) (12)$$

(MOI solids to final Moment)

$$\underline{864 \text{ in}^3}$$



USE W24 x 335 for all Beams

$$\text{Beam itself} \approx 1,000 \text{ lb}$$

$$\text{Moment} = 12,960,000$$

$$\underline{40 \text{ lb/ft}^2} \times 240 \text{ ft}^2$$

$$\text{HVAC Duct} = 500 \text{ lb/ft}^2$$

$$\text{Concrete} = 150 \text{ lbs per cubic inch}$$

$$150 \times 80 \text{ cubic feet} = 12,000 \text{ lbs}$$

21
12,880 - Tile
12,000 - concrete
480 - ceiling
500 - HVAC Duct
1,000 - Beam
$\times 19,200$ - Live Load
<u>36,060</u> - Load (final)

\* multiply by safety factor of 5\*

$$180,000 \text{ lbs}$$

$$\text{Section Modulus } S = \frac{\text{Moment}}{\text{yield strength}}$$

1-16 BEAMS = W24 x 335

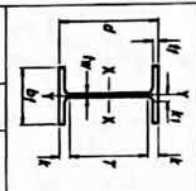


Table 1-1 (continued) W Shapes Dimensions

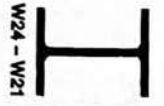
Shape	Area, A	Depth, d	Web		Flange		Distance		Work-able Gage	
			Thickness, t <sub>w</sub>	h	Width, b <sub>f</sub>	Thickness, t <sub>f</sub>	k	h <sub>1</sub>		T
W24x100	36.4	28.0	1/2	13.7	2.72	2/1	3.22	11.4	20 3/4	5 1/2
W24x112	41.2	31.0	1/2	14.3	2.98	2/1	3.48	12.1	21 1/4	5 1/2
W24x132	50.4	35.0	1/2	15.7	3.29	2/1	3.81	13.0	22 1/4	5 1/2
W24x150	58.1	38.0	1/2	16.9	3.58	2/1	4.09	13.9	23 1/4	5 1/2
W24x176	70.2	43.0	1/2	18.5	3.97	2/1	4.53	15.0	25 1/4	5 1/2
W24x200	80.7	47.0	1/2	19.9	4.35	2/1	4.93	16.1	26 3/4	5 1/2
W24x225	91.8	51.0	1/2	21.2	4.71	2/1	5.31	17.2	28 1/4	5 1/2
W24x250	103.0	55.0	1/2	22.5	5.07	2/1	5.68	18.3	29 3/4	5 1/2
W24x275	115.0	59.0	1/2	23.7	5.43	2/1	6.04	19.4	31 1/4	5 1/2
W24x300	127.0	63.0	1/2	24.9	5.79	2/1	6.40	20.5	32 3/4	5 1/2
W24x335	141.0	67.0	1/2	26.1	6.14	2/1	6.75	21.6	34 1/4	5 1/2

1-17 DIMENSIONS AND PROPERTIES

Table 1-1 (continued) W Shapes Properties

Shape	I <sub>x</sub>	I <sub>y</sub>	S <sub>x</sub>		S <sub>y</sub>		r <sub>x</sub>	r <sub>y</sub>	J							
			S <sub>x</sub>	c <sub>x</sub>	S <sub>y</sub>	c <sub>y</sub>			J	C <sub>p</sub>						
W24x100	390	25.1	14.2	13.40	9.57	11.1	11.30	11.80	170	3.27	2.87	3.92	25.3	201	1.86	1000
W24x112	450	28.8	15.6	14.70	10.8	12.2	11.90	12.60	180	3.52	3.08	4.27	28.0	239	2.11	1100
W24x132	540	33.7	17.7	16.70	12.4	13.4	12.70	13.40	210	3.87	3.41	4.82	32.1	279	2.36	1200
W24x150	630	39.6	19.8	18.80	14.1	14.7	13.60	14.20	240	4.22	3.74	5.37	36.2	320	2.61	1300
W24x176	770	47.0	22.7	21.70	16.1	16.1	14.70	15.20	280	4.68	4.18	5.92	40.3	363	2.86	1400
W24x200	900	55.8	26.4	25.50	18.3	17.6	15.80	16.30	320	5.14	4.64	6.47	44.4	407	3.11	1500
W24x225	1050	65.5	30.9	30.00	20.8	19.0	16.90	17.40	360	5.60	5.10	7.02	48.5	452	3.36	1600
W24x250	1210	76.3	36.2	35.40	23.7	21.7	18.00	17.90	400	6.06	5.56	7.57	52.6	497	3.61	1700
W24x275	1390	88.1	41.8	41.30	26.9	24.6	19.10	18.00	450	6.52	6.02	8.12	56.7	542	3.86	1800
W24x300	1580	101.0	48.1	48.10	30.7	28.2	20.20	19.10	500	7.00	6.50	8.67	60.8	587	4.11	1900
W24x335	1800	116.0	55.8	55.80	35.2	32.4	21.30	20.20	560	7.50	7.00	9.22	64.9	632	4.36	2000

S = 864 MATCH



# **GIRDERS**



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Job: JKI - Retail Design Building

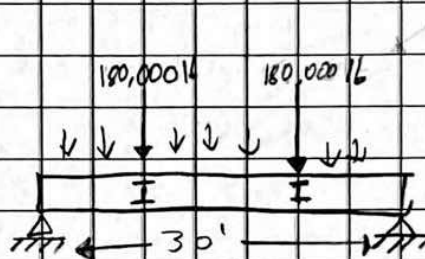
Sheet No.: 2 - Girders

Calculated By: Sol S

Date: 5/21/24

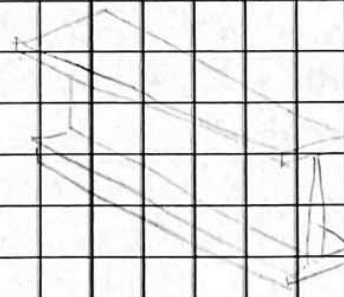
Girders - 27 Girders

Dimensions = 24' x 30' → Area = 720 ft<sup>2</sup>/ft



MD SOLIDS =  $M = 40,500,000 \text{ lb} \cdot \text{ft}$

$S = \frac{(40,500,000)(12)}{(360,000)} = 1350 \text{ in}^3 \rightarrow \boxed{W36 \times 361}$  for all 27 Girders



Girders: W36x362

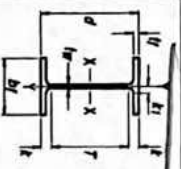


Table 1-1 (continued)  
W Shapes  
Dimensions

Table 1-1 (continued) W Shapes Dimensions. Columns include Shape, Area (A), Depth (d), Thickness (t), Flange Width (b), Flange Thickness (t\_f), Distance from web centerline to flange tip (k), and Workable Flange Length (L). Rows list various W-shape sizes from W30x80 to W36x362.

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Table 1-1 (continued)  
W Shapes  
Properties  
S = 1350  
Match



Table 1-1 (continued) W Shapes Properties. Columns include Weight (lb/ft), Compact Section Criteria (b/t\_f, d/t\_w), and various section properties (I\_x, I\_y, S\_x, S\_y, r\_x, r\_y, etc.) for W-shape sizes W30x80 to W36x362.

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# COLUMNS





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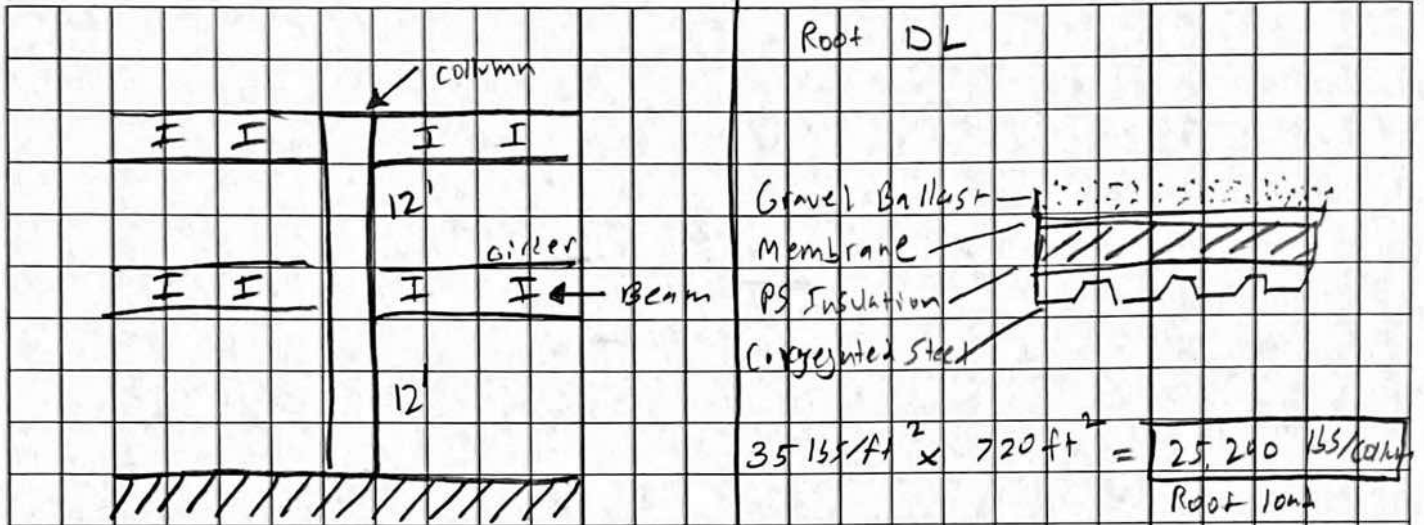
12854 LUISENO ST ♦ POWAY 92014 ♦ SAN DIEGO, CA  
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Job: JKI - Retail Design Building

Sheet No: 3 - Columns / Roofing

Calculated By: SG/S

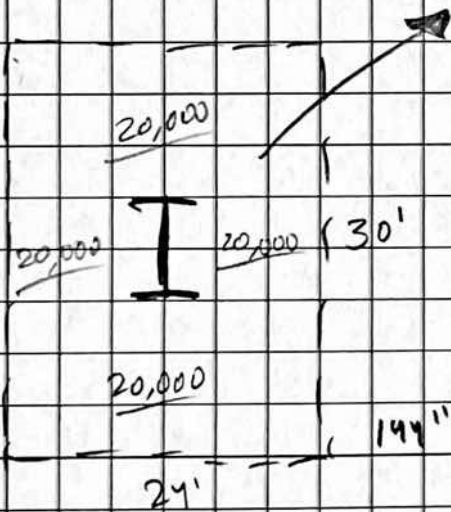
Date: 5/22/24



Interior

Column

$P = 80,000 \text{ lbs}$  tributary load



$80,000$  - 2nd floor

$P = 25,200$  - Roof

$105,200 \text{ lbs}$

$\times 5$  - safety factor

$526,000$

slenderness ratio target = 100

try **W18 x 258**

$F_c = 526,000 = 54,435$

$8.85 \text{ in}^2$   
(AISC Table)

$600 \checkmark$



**FLOORING & ADDITIONAL  
DRAWINGS**



# STIRLING ENGINEERING

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Job: JKI - Retail Design Building

Sheet No.: 4 - Flooring Plans

Calculated By: SJS

Date: 5/22/24

