

Arch324

STRUCTURES II

Winter 2026
Recitation

FACULTY: Prof. Peter von Bülow
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Arch324: STRUCTURES II

Welcome to Recitation session 02/13

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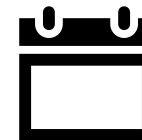
Office: Room 3128

hours:

Fri: 11:30 – 12:30

Mon, Wed: 11:00 - 12:00

walk-ins welcome!



[Click here to make an appointment](#)

Please feel free to ask questions.

Where can you find me?



Parking Lot (Fuller Road)

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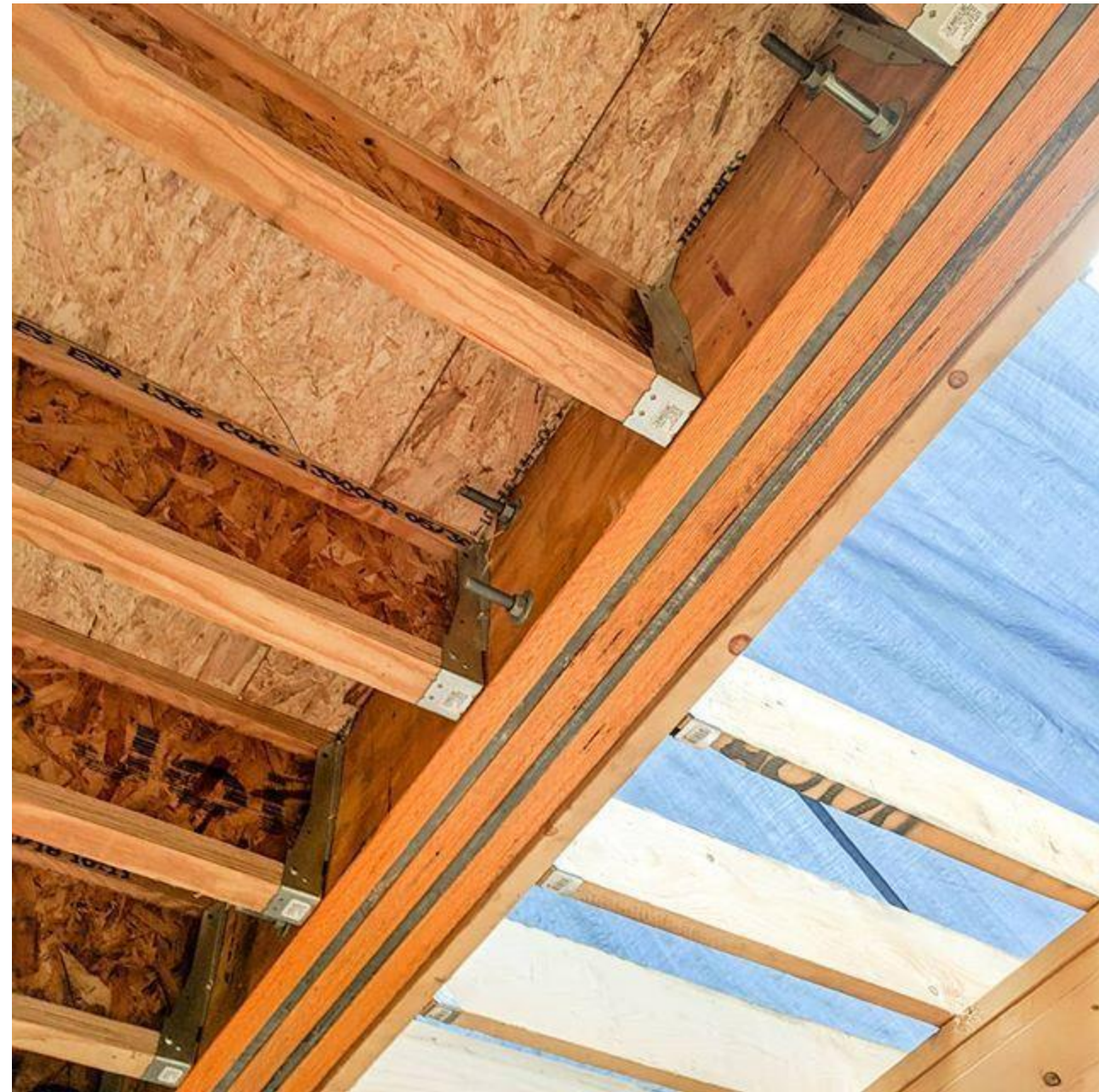
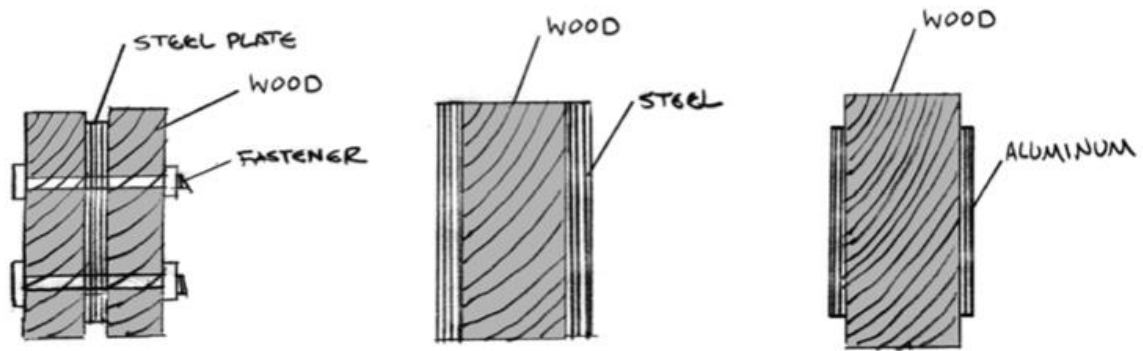
Outline:

- Quick **Recap** of the week
- Provide the solution for the assignment (**Homework 5**)
- Answering student's questions
- Lab: **Steel beam**
- **Tower Project:** due date is extended! Feb 16

Please feel free to ask questions.

Recap of the week

Fitched Beams & Scab Plates



Recap of the week

Steel Beam **Design** Procedure (zone 1)

1. Use the maximum moment equation, and solve for the ultimate moment, M_u .
2. Set $\phi M_n = M_u$ and solve for M_n
3. Assume Zone 1 to determine Z_x required
4. Select the lightest beam with a Z_x greater than the Z_x required from AISC table
5. Determine if $h/t_w < 59$
(case 1, most common)
6. Determine A_w :
 $A_w = d t_w$
7. Calculate V_n :
 $V_n = 0.6 F_y A_w$
8. Calculate V_u for the given loading
 $V_u = w_u L / 2$ (e.g. unif. load)
9. Check $V_u < \phi V_n$
 ϕ for $V = 1.0$
10. Check deflection

Provide the solution for the assignment – HW5

- Problem:

5. Steel Beam Design

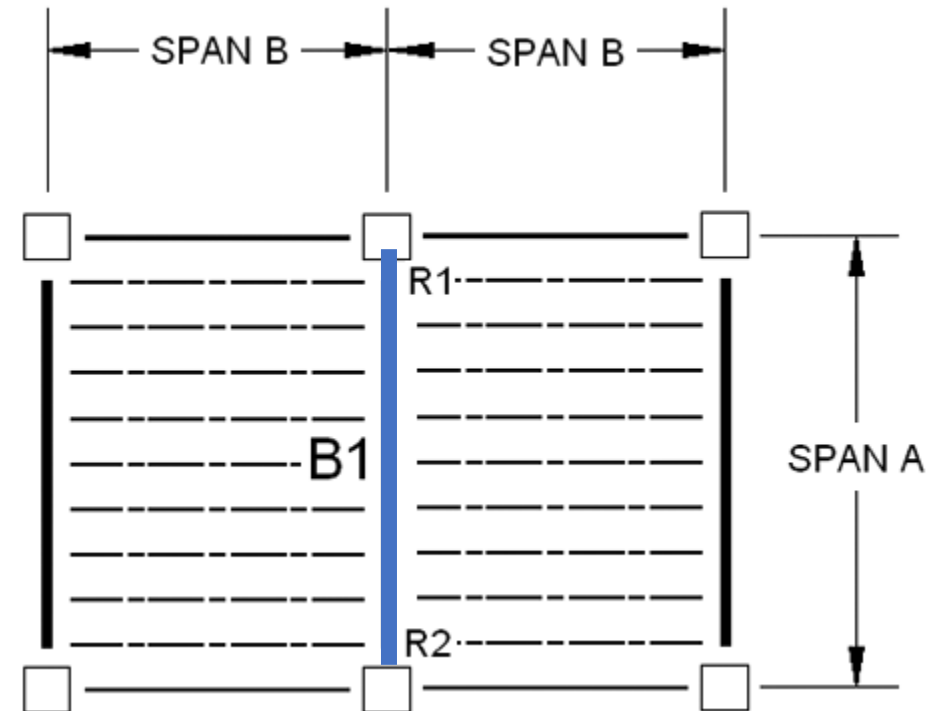
Choose the lightest steel W-section to support the applied dead and live floor loads on Beam B1. Choose a steel W-section from AISC Table 3-2 (posted on Canvas). For the selection of the beam, neglect selfweight (for loads marked with *). After selecting the lightest section from Table 3-2, revise the DL to include the beam selfweight. Check that the final M_u including selfweight is less than the beam strength, ϕM_n . Assume the beam is fully braced, $L_b < L_p$. (Zone 1)

DATASET: 1

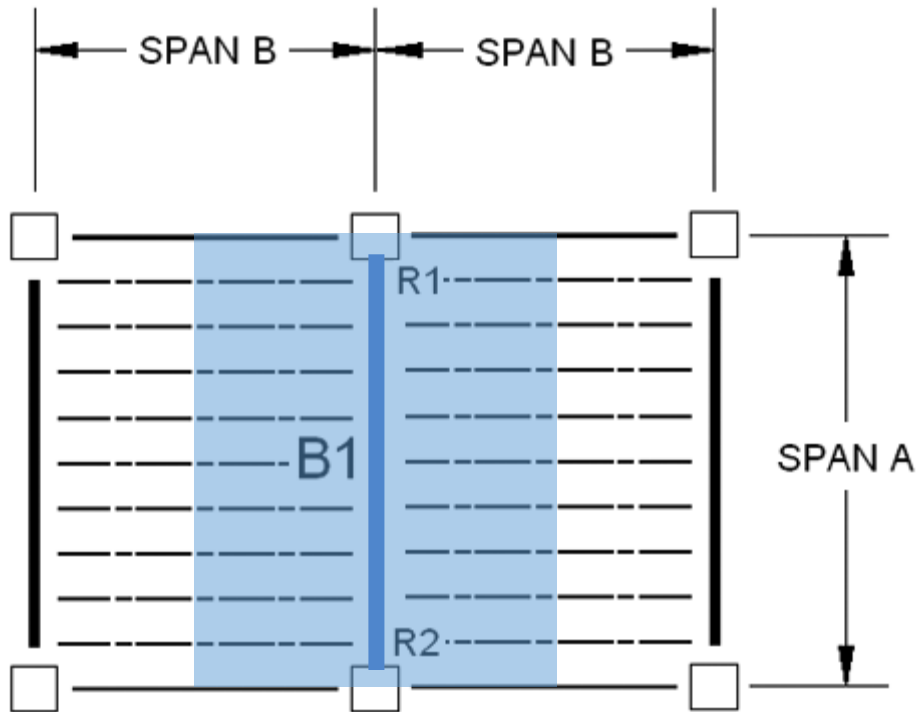
-2-

-3-

Fy	50 KSI
Span A	33 FT
Span B	15 FT
Floor Dead Load	18 PSF
Floor Live Load	80 PSF



Provide the solution for the assignment – HW4



#	Question	Your Response
1	The unfactored floor dead load on beam B1 (neglecting selfweight), w_{DL}^*	<input type="text"/> PLF
2	The unfactored floor live load on the beam, w_{LL}	<input type="text"/> PLF
3	The total factored design load on the beam (neglecting selfweight), w_u^*	<input type="text"/> KLF
4	The factored design moment (neglecting selfweight), M_u^*	<input type="text"/> K-FT
5	The nominal bending moment (neglecting selfweight), M_n^*	<input type="text"/> K-IN
6	The plastic modulus of the section (neglecting selfweight), Z_x^*	<input type="text"/> IN3
7	The nominal depth of the lightest passing W-section from Z_x table (include selfweight)	<input type="text"/> IN
8	The weight of the lightest passing W-section from Z_x table	<input type="text"/> PLF
9	The plastic modulus of the section for the chosen section, Z_x	<input type="text"/> IN3
10	The revised unfactored dead load on the beam (including selfweight), w_{DL}	<input type="text"/> PLF
11	The total factored design load on the beam (including selfweight), w_u	<input type="text"/> KLF
12	The factored design moment (including selfweight), M_u in KIP-FT	<input type="text"/> K-FT
13	The factored design moment (including selfweight), M_u in KIP-IN	<input type="text"/> K-IN
14	The nominal factored bending moment for the chosen section, ϕM_n	<input type="text"/> K-IN

Provide the solution for the assignment – HW5

un factored floor dead load on beam B1:

$$w_D = 18 \text{ PSF} \times 2 \left(\frac{\text{span } B}{2} \right) = 270 \text{ PLF}$$

Q1

Live load :

$$w_L = 80 \times 15 = 1200 \text{ PLF}$$

Q2

w_u (Total factored design load):

$$w_u = 1.2 w_D + 1.6 w_L$$

$$w_u = 1.2 (270) + 1.6 (1200) = 2294 \text{ PLF} \times \frac{1}{1000} = 2.294 \text{ KLF}$$

Q3

Provide the solution for the assignment – HW5

Design moment

$$M_u = \frac{w_u L^2}{8}$$
$$= \frac{2.249 \times 33^2}{8} = 305.4645 \text{ K-FT}$$

Q4

nominal bending moment:

$$M_u \leq \phi M_n$$

Assumption: $M_u = \phi M_n \rightarrow$

Nominal bending moment

$$M_n = \frac{M_u}{\phi=0.9} = \frac{305.4645}{0.9} = 339.405 \text{ K-FT} \times 12 = 4072.86 \text{ K-IN}$$

unit conversion

Q5

Provide the solution for the assignment – HW5

The plastic modulus of the section

problem Assumption: fully braced (Zone 1)

$$M_n = Z_x F_y$$

4072.86 = $Z_x \cdot (50)$ → Required $Z_x = 81.4572 \text{ in}^3$ **Q6**

look up in the table:
 From the bott go upward and find nearest Z
 (Choose Bold row) → lightest + strongest in the series

W21x44 → weight **Q8**
 height depth → $Z = 95.4 \text{ in}^3$ **Q9**

Q7

Z_x Table 3-2 (continued) **W-Shapes** Selection by Z_x **F_y = 50 ksi**

Shape	Z _x in. ³	M _{px} /Ω _b		M _{rx} /Ω _b		BF/Ω _b		L _p ft	L _r ft	I _x in. ⁴	V _{nx} /Ω _v	
		ASD kip-ft	LRFD kip-ft	ASD kip-ft	LRFD kip-ft	ASD kips	LRFD kips				kips	kips
W21x44	95.4	238	358	143	214	11.1	16.8	4.45	13.0	843	145	217
W16x50	92.0	230	345	141	213	7.69	11.4	5.62	17.2	659	124	186
W18x46	90.7	226	340	138	207	9.63	14.6	4.56	13.7	712	130	195
W14x53	87.1	217	327	136	204	5.22	7.93	6.78	22.3	541	103	154
W12x58	86.4	216	324	136	205	3.82	5.69	8.87	29.8	475	87.8	132
W10x68	85.3	213	320	132	199	2.58	3.85	9.15	40.6	394	97.8	147
W16x45	82.3	205	309	127	191	7.12	10.8	5.55	16.5	586	111	167
W18x40	78.4	196	294	119	180	8.94	13.2	4.49	13.1	612	113	169
W14x48	78.4	196	294	123	184	5.09	7.67	6.75	21.1	484	93.8	141
W12x53	77.9	194	292	123	185	3.65	5.50	8.76	28.2	425	83.5	125
W10x60	74.6	186	280	116	175	2.54	3.82	9.08	36.6	341	85.7	129
W16x40	73.0	182	274	113	170	6.67	10.0	5.55	15.9	518	97.6	146
W12x50	71.9	179	270	112	169	3.97	5.98	6.92	23.8	391	90.3	135
W8x67	70.1	175	263	105	159	1.75	2.59	7.49	47.6	272	103	154
W14x43	69.6	174	261	109	164	4.88	7.28	6.68	20.0	428	83.6	125
W10x54	66.6	166	250	105	158	2.48	3.75	9.04	33.6	303	74.7	112
W18x35	66.5	166	249	101	151	8.14	12.3	4.31	12.3	510	106	159
W12x45	64.2	160	241	101	151	3.80	5.80	6.89	22.4	348	81.1	122
W16x36	64.0	160	240	98.7	148	6.24	9.36	5.37	15.2	448	93.8	141
W14x38	61.5	153	231	95.4	143	5.37	8.20	5.47	16.2	385	87.4	131
W10x49	60.4	151	227	95.4	143	2.46	3.71	8.97	31.6	272	68.0	102
W8x58	59.8	149	224	90.8	137	1.70	2.55	7.42	41.6	228	89.3	134
W12x40	57.0	142	214	89.9	135	3.66	5.54	6.85	21.1	307	70.2	105
W10x45	54.9	137	206	85.8	129	2.59	3.89	7.10	26.9	248	70.7	106
W14x34	54.6	136	205	84.9	128	5.01	7.55	5.40	15.6	340	79.8	120
W16x31	54.0	135	203	82.4	124	6.86	10.3	4.13	11.8	375	87.5	131
W12x35	51.2	128	192	79.6	120	4.34	6.45	5.44	16.6	285	75.0	113
W8x48	49.0	122	184	75.4	113	1.67	2.55	7.35	35.2	184	68.0	102
W14x30	47.3	118	177	73.4	110	4.63	6.95	5.26	14.9	291	74.5	112
W10x39	46.8	117	176	73.5	111	2.53	3.78	6.99	24.2	209	62.5	93.7
W16x26*	44.2	110	166	67.1	101	5.93	8.98	3.96	11.2	301	70.5	106
W12x30	43.1	108	162	67.4	101	3.97	5.96	5.37	15.6	238	64.0	95.9

ASD LRFD * Shape does not meet the h/t_w limit for shear in AISC Specification Section G2.1(a) with F_y = 50 ksi; therefore, φ_v = 0.90 and Ω_v = 1.67.

Ω_b = 1.67 φ_b = 0.90
 Ω_v = 1.50 φ_v = 1.00

Provide the solution for the assignment – HW5

revise the dead load and include self weight:

$$w_D = 270 \text{ PLF} + 44 \text{ PLF} = 314 \text{ PLF} \quad \text{Q10}$$

$$w_u = 1.2(314) + 1.6(1200) = 2296.8 \text{ PLF} \times \frac{1}{1000} = 2.2968 \text{ KLF} \quad \text{Q11}$$

Design moment

$$M_u = \frac{w_u L^2}{8} = \frac{2.2968 \times 33^2}{8} = 312.6519 \text{ K-FT} \quad \text{Q12}$$

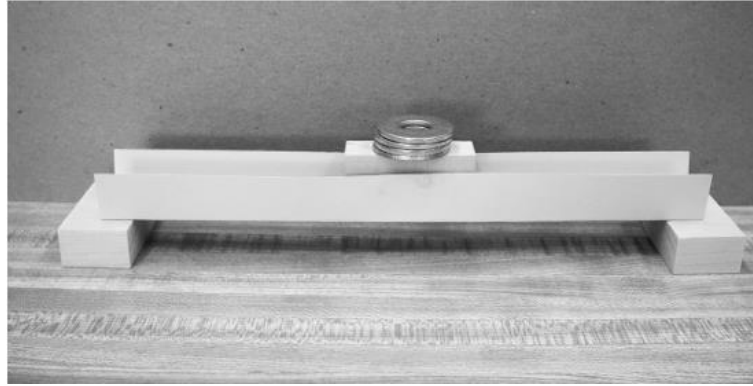
$$\times 12 = 3751.8228 \text{ K-IN} \quad \text{Q13}$$

unit conversion

$$\phi M_n = \phi Z F_y = 0.9(95.4)(50) = 4293 \text{ K-IN} \quad \text{Q14}$$

$$4293 > 3751.82 \quad \text{O.K.} \checkmark$$

Lab: Steel Beam Analysis



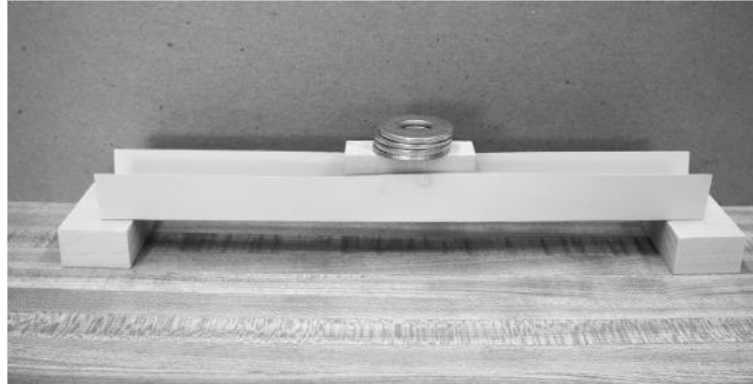
Description

This project uses observation to understand how unbraced compression edges and lateral torsional buckling reduce the ultimate load capacity of steel beams.

Goals

To observe the behavior of unbraced section edges in compression vs tension.
To measure capacity loss due to lateral torsional buckling.

Lab: Steel Beam Analysis



Procedure

1. Position the U shaped section with the free edges on the upper side of the span.
2. Test how many washers the section can support at mid span. Use a wood block to position the load. Observe the mode (how) it fails.
3. Repeat the procedure with the section inverted and the free edges downward.
4. Compare the load level carried by each orientation of the paper beam and describe the behavior under load.

Tower Project: How to start

Criteria

- The tower is to be made of wood. Either **linear wood** (sticks) or **wood panels** (sheets) can be used. **Glue** can be used to connect the elements. **Gusset plates** at the joints are allowed and can also be glued. But no steel pins or fasteners may be used.
- Wood: **any species.** maximum cross-sectional dimension = 1/4".
- **NO** paper, mylar or plastic or string or dental floss.
- If a member is made by **laminating multiple pieces** together, the maximum cross-sectional dimension or thickness still cannot exceed 1/4".
- The **height of the tower = 48".**
- The tower **must hold at least 50 lbs.**
- The entire tower **can weigh no more than 4 oz.**
- The top of the tower must be loadable. The weights will be stacked on top of the tower, but you may optionally use a loose piece of MDF or plywood as a tray under the weights. (It will not be counted in either weight or load)
- Towers will be graded on their low weight, high load-carrying capacity, and the load/weight ratio. The evaluation formula is:
$$(4/\text{weight in OZ}) + (\text{load in LBS}/50) + (\text{load LBS}/\text{weight OZ}) \times 1.5$$
- The score will be normalized to a range of 50 to 100. It is used together with report scores to assess your project (a detailed evaluation form is given separately).

Tower Project: How to start

Scoring	
Preliminary Report	40 pts
Testing	60 pts
Final Report	150 pts

Procedure

1. Develop a structural concept for a tower meeting the above criteria.
2. Analyze the design concept with **either** hand calculations or a computer program (e.g. Dr. Frame)
3. Determine the capacity of the major members and of the overall tower (total capacity in LBS)
4. Estimate your expected score using the formula above.
5. Write the preliminary report.
6. Construct the structural model.
7. Test the model. 5-pound steel bars will be placed on top of the model, until the model fails. (bar size: 1 1/2" x 2" x 5 13/16").
8. Produce final report documenting requirements and process. See also score sheet.

Use NDS approach

Find load P and stress F'_c for each member

Use 1.0 for all factors except C_p

Analysis

$$f_c = \frac{P}{A} \leq F'_c$$

Capacity

$$P = F'_c A$$

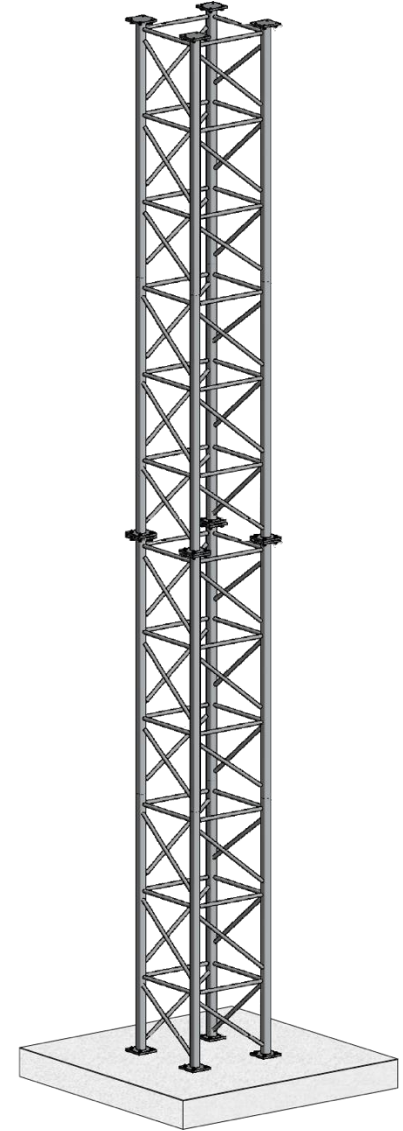
Design

$$A = \frac{P}{F'_c}$$

Tower Project – Preliminary Report Requirements

Explanation – describe how the design was developed, the basis of the structural concept, and how the principles of column behavior influenced the design decisions.

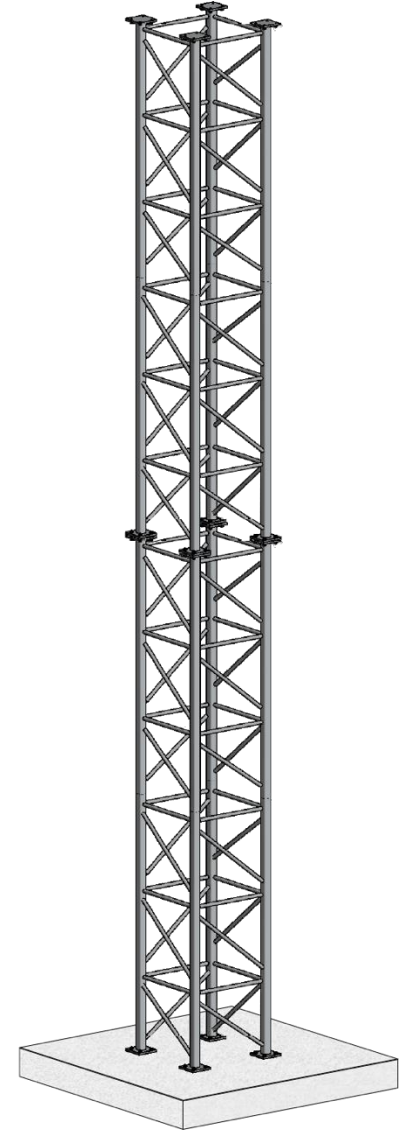
Illustration – include diagrams/drawings that describe the structure in its entirety. **At least a horizontal cross-section and an elevation of the tower are required.** Dimensions are to be included and the member sizes labeled.



Tower Project: Prelim Report Guidelines 2024

The report should include the following:

- Choose **wood type** and stress properties
- Determine the **cross-sectional area** of each member
(Find the axial force P and the allowable stress F'_c .)
Then size the members based on the force in each member.
- Predict the **total weight** of the tower.
The total weight should be under **4 OZ**.
- Predict **Capacity**
 - **Construct a table**, for each member type
(e.g. main vertical, horizontal tie, diagonal brace)
 - **calculate the ratio of f_c/F'_c**
(This ratio should be below 1.0 for all members.)
- Calculate the **buckling capacity** of the tower as a whole.
This is done by treating the tower as one column loaded at the top



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Thank you.

Any question?

Please feel free to ask questions.