

Arch 324

Structures II

Winter 2026 Recitation 004

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Recitation 004

Welcome to session 11!

- Quick Lecture Recap
- Homework #10 Composite Sections
- Tower Final Report + Course Evaluations
- Lab: Composite Sections

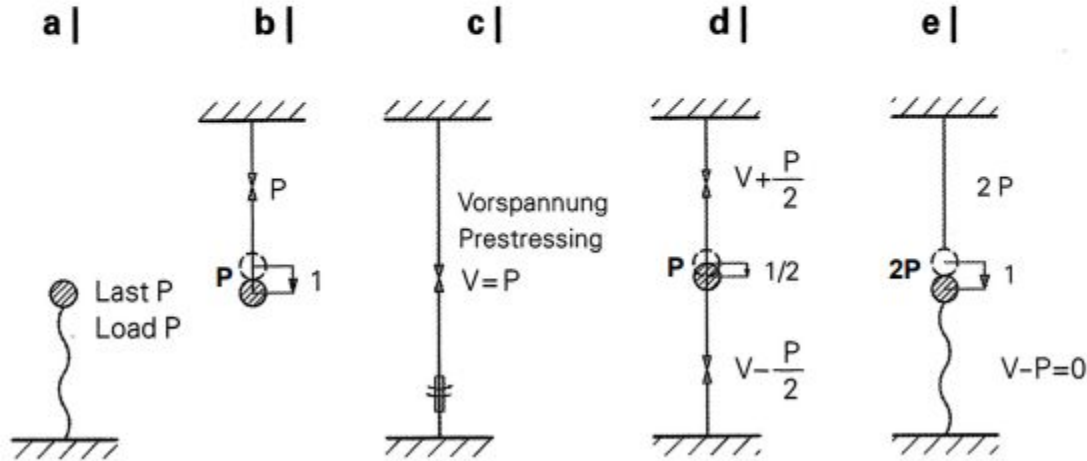
Feel free to ask questions anytime

Lecture: Pre-Stressed Structures (4/6)

Pre-stressing

Reducing deformation

(b) carries P and deflects 1
(e) carries $2P$ and deflects 1
what makes the difference?

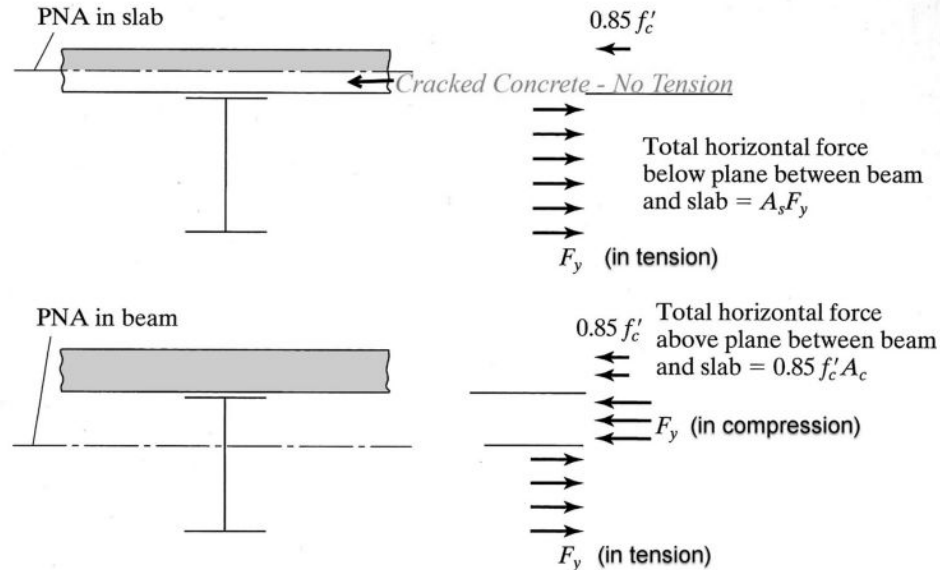


Lecture: Composite Sections (4/8)

Analysis Procedure (LRFD)

Case 1 – Plastic Neutral Axis (PNA) within slab

Case 2 – PNA within steel section



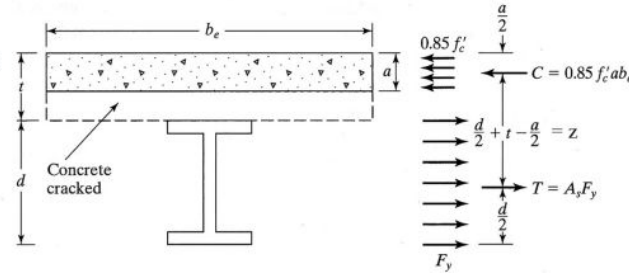
Lecture: Composite Sections (4/8)

Analysis Procedure (LRFD)

Case1 – PNA within slab

Given: Slab and beam geometry
W-section size and steel grade
(floor loads)

Find: pass/fail or capacities



1. Define effective flange width, b_e
2. Calculate the effective depth of the concrete stress block, a
3. If a is within concrete slab, the full steel section is in tension and:
 $M_p = T z$
 $M_n = M_p = A_s F_y (d/2 + t - a/2)$
4. $M_u \leq \phi M_n$

$$T = C$$

$$A_s f_y = 0.85 f'_c a b_e$$

$$z = \frac{A_s f_y}{0.85 f'_c b_e}$$

HW #10: Composite Sections

Analyze the given composite floor system. Determine the depth of the compression block, a . Find the floor live load capacity.

DATASET: 1

-2-

-3-

W-section

W16X77

span A

49 FT

span B

11 FT

slab thickness, t

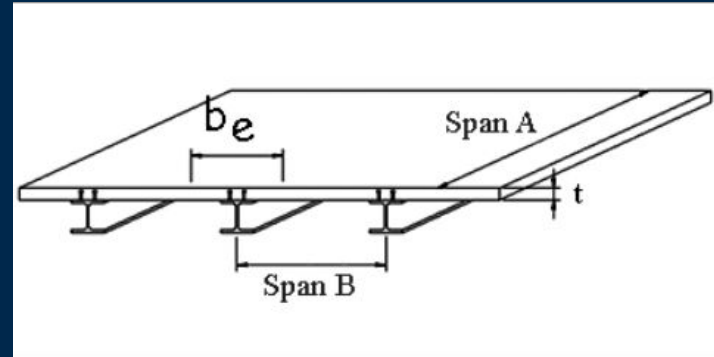
6 IN

steel yield stress, F_y

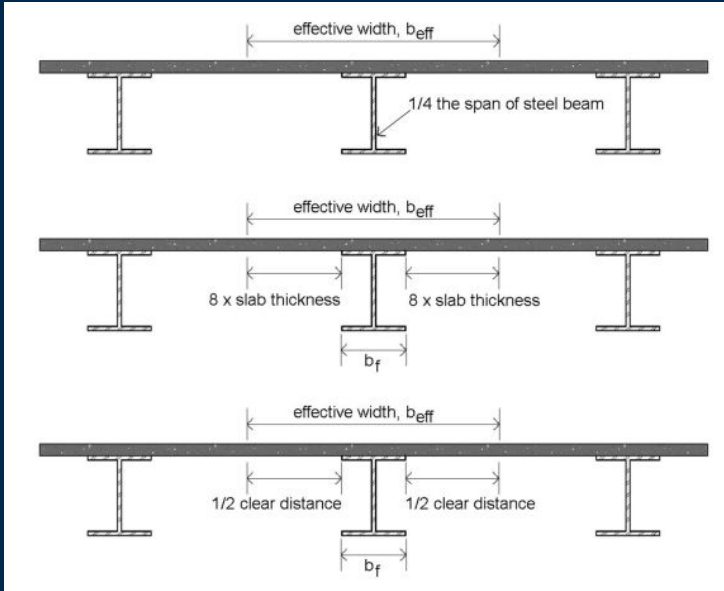
50 KSI

concrete ultimate stress, f_c

3 KSI



HW #10: Composite Sections



1. Effective width of the concrete flange

$\frac{1}{4}$ (span of steel beam) \leftarrow span A $\rightarrow \frac{1}{4} (49' \times 12'') = 174''$

MIN $\left\{ \begin{array}{l} b_f + 2(8 \times \text{slab thickness}) \rightarrow 10.3'' + 2(8 \times 6'') = \boxed{106.3''} \\ b_f + 2(\frac{1}{2} \text{ clear distance}) \rightarrow 10.3'' + 2(\frac{1}{2} \times 11 \times 12'') = \underline{142.3''} \end{array} \right.$

$b_f = \text{actual flange width}$ \leftarrow span B

Look up given section in code

Table 1-1 (continued)
W-Shapes
Dimensions

Shape	Area, A	Depth, d	Web		Flange		Distance								
			Thickness, t_w	t_w / Z	Width, b_f	Thickness, t_f	k	k		T	Workable Gage				
								k _{des}	k _{det}			in.	in.		
W16x100	29.4	17.0	17	0.585	⁹ / ₁₆	⁹ / ₁₆	10.4	10 ³ / ₁₆	0.985	1	1.39	1 ⁷ / ₈	1 ¹ / ₈	13 ³ / ₄	5 ¹ / ₂
x89	26.2	16.8	16 ³ / ₄	0.525	¹ / ₂	¹ / ₄	10.4	10 ³ / ₁₆	0.875	⁷ / ₈	1.28	1 ³ / ₄	1 ¹ / ₁₆		
x77	22.6	16.5	16 ¹ / ₂	0.455	⁷ / ₁₆	¹ / ₄	10.3	10 ¹ / ₄	0.760	³ / ₄	1.16	1 ⁵ / ₈	1 ¹ / ₁₆		
x67 ^c	19.6	16.3	16 ³ / ₈	0.395	³ / ₈	³ / ₁₆	10.2	10 ¹ / ₄	0.665	¹ / ₁₆	1.07	1 ⁹ / ₁₆	1		

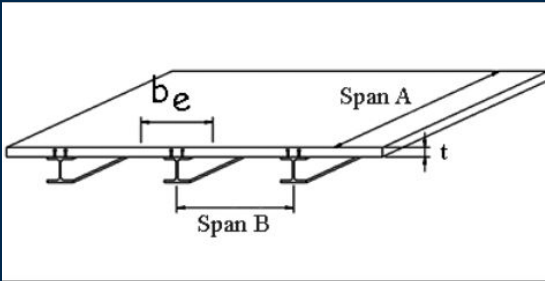
Given Section: W16 x 77
 $b_f = 10.3''$
 $A = 22.6 \text{ in}^2$
 $d = 16.5$

HW #10: Composite Sections

Analyze the given composite floor system. Determine the depth of the compression block, a . Find the floor live load capacity.

DATASET: 1 -2- -3-

W-section	W16X77
span A	49 FT
span B	11 FT
slab thickness, t	6 IN
steel yield stress, F_y	50 KSI
concrete ultimate stress, f_c	3 KSI



2. Depth of concrete stress block

$$a = \frac{A_s F_y}{0.85 F'_c b_e} = \frac{22.9 (50)}{0.85 (3) (106.3)} = \frac{1,145}{271.065} = \boxed{4.22"} < 6" \text{ within slab } \checkmark \text{ Q3}$$

4. Nominal bending moment

$$M_n = M_p = A_s F_y \left(\frac{d}{2} + t - \frac{a}{2} \right)$$

slab thickness #2

$$= 22.9 (50) \left(\frac{16.5}{2} + 6 - \frac{4.22}{2} \right)$$

section properties

$$= \boxed{13,900.3 \text{ k-in}}$$

5. Factored Bending Resistance

$$\phi M_n = 0.9 (13,900.3) = \boxed{12,510.27 \text{ k-in}}$$

6. Factored Design Moment

$$M_u \leq \phi M_n \rightarrow M_u = \phi M_n$$

#5

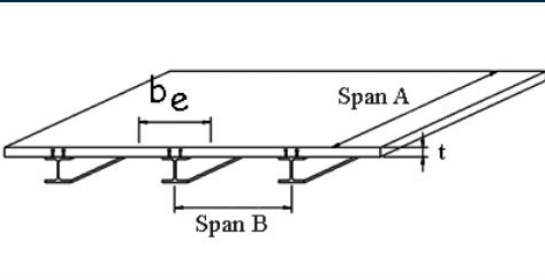
$$12,510.27 \times \frac{1}{12}$$

$$= \boxed{1,042.52 \text{ k-ft}}$$

HW #10: Composite Sections

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7. Total Factored Design Load

$$M_u = \frac{W_u L^2}{8}$$

$$W_u = \frac{8M_u}{L^2} = \frac{8(1,042.52)}{49^2} = \boxed{3.49 \text{ KLF}}$$

Span A

8. Selfweight of concrete slab

$$1 \text{ ft}^2 \rightarrow 150 \text{ lb} \rightarrow \frac{6}{12}(150) = ? = \boxed{75 \text{ PSF}}$$

slab thickness

9. Total unfactored dead load

$$\text{selfweight (concrete + steel)}$$

$$11(75) + 77 = 902 \times \frac{1}{1000} = \boxed{0.902 \text{ KLF}}$$

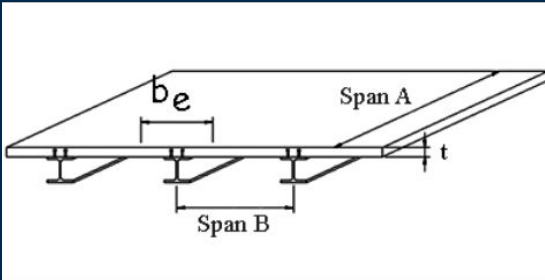
Span B - tributary area width

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10. Actual unfactored live load

$$W_u = 1.2W_{DL} + 1.6W_{LL}$$

$$3.47 = 1.2(0.902) + 1.6W_{LL}$$

$$2.3876 = 1.6W_{LL}$$

$$\boxed{\frac{1.49}{KLF}} = W_{LL}$$

11. Actual floor live load

$$\frac{W_{LL}}{\text{span B}} = \frac{1.49}{11} = 0.136 \times 1000 = \boxed{135.66 \text{ PSF}}$$

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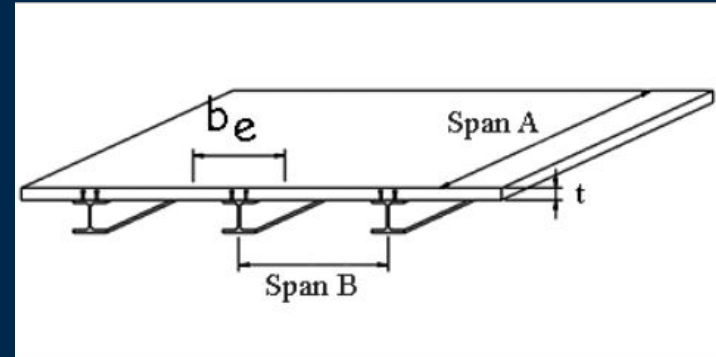
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3 KSI



Final Tower Report :P

- Due April 19
- See scoring sheet!!
- Remember to attach annotated preliminary report to final submission
- See Final Report Guidelines for Additional expectations

PRELIMINARY REPORT (re-submit with final report)	40	
TESTING		
Tower weight ≤ 4 oz (15 pts); height = 48" (5 pts); holds ≥ 50 lbs (5 pts)	30	
Correct Materials (5 pts) (scaled if doesn't meet requirements)		
Efficiency $(4/\text{weight OZ}) + (\text{load LBS}/50) + (\text{load LBS}/\text{weight OZ}) \times 1.5$ (scaled based on class rank)	30	
FINAL REPORT REQUIREMENTS		
Preliminary Design Development	20	
How cross-sectional design of preliminary tower was chosen	4	
How elevation of preliminary tower was developed (e.g. bracing, taper, etc.)	4	
Why/how cross-section was or was not adjusted from preliminary report	4	
Why/how elevation of tower was or was not adjusted from preliminary report	4	
Discussion of how basic principles of columns supported these decisions	4	
Revised/Tested Tower Design Analysis [SHOW WORK AND UNITS!]		
Calculated/modeled axial forces and derivation of required member cross-sectional areas from axial forces (consider both crushing and buckling)	10	
Estimated weight calculation using actual member sizes used – include weight from members, glue, and gussets, etc.	7	
Member properties table: A, r, L, slenderness ratio (L/r), utilization ratio (actual load / allowable load)	7	
Indicate critical member (largest utilization ratio)	8	
Tower stability (as a whole) - buckling calculation	8	
Prediction of capacity of tower and mode of failure	10	
Illustration of Final/Tested Design		
20		
Cross-section and elevations(s) of tower	5	
Perspective(s) or isometric of tower (no screenshots!)	5	
Overall dimensions labeled (height, width, etc.) with units	5	
Member sizes labeled (cross-sectional area, length of vertical members and cross-bracing) with units	5	
Testing Results		
30		
Final weight and height of tower	6	
Tested capacity of tower	6	
Observations of testing (loading, any buckling observed, etc.)	6	
Description of mode of failure	6	
Images of failure	6	
Post-Testing Analysis		
30		
Comparison of testing results with predicted capacity and modes of failure	10	
Discussion of discrepancies between results	10	
Suggested improvements for future designs with reasoning discussed	10	
FINAL GRADE	250	

Course Evals!! Bonus pts!!

Lab: Composite Sections