

# Arch324

# **STRUCTURES II**

Winter 2024  
Recitation

FACULTY: Prof. Peter von Bülow  
GSI: Mohsen Vatandoost

# Arch324: STRUCTURES II

## Welcome to Recitation session 04/05

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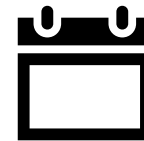
Office: Room 3104

hours:

Fri: 11:30 – 14:30

Mon, Wed: 11:00 - 12:00

walk-ins welcome!



[Click here to make an appointment](#)

Please feel free to ask questions.

# Arch324: STRUCTURES II

## Welcome to Recitation session 04/05

### Outline:

- Quick **Recap** of the week
- Provide the solution for the assignment (**Homework 10**)
- Answering student's questions
- Lab: **Composite Section**
- **Tower Project:** Final report by **April 12**

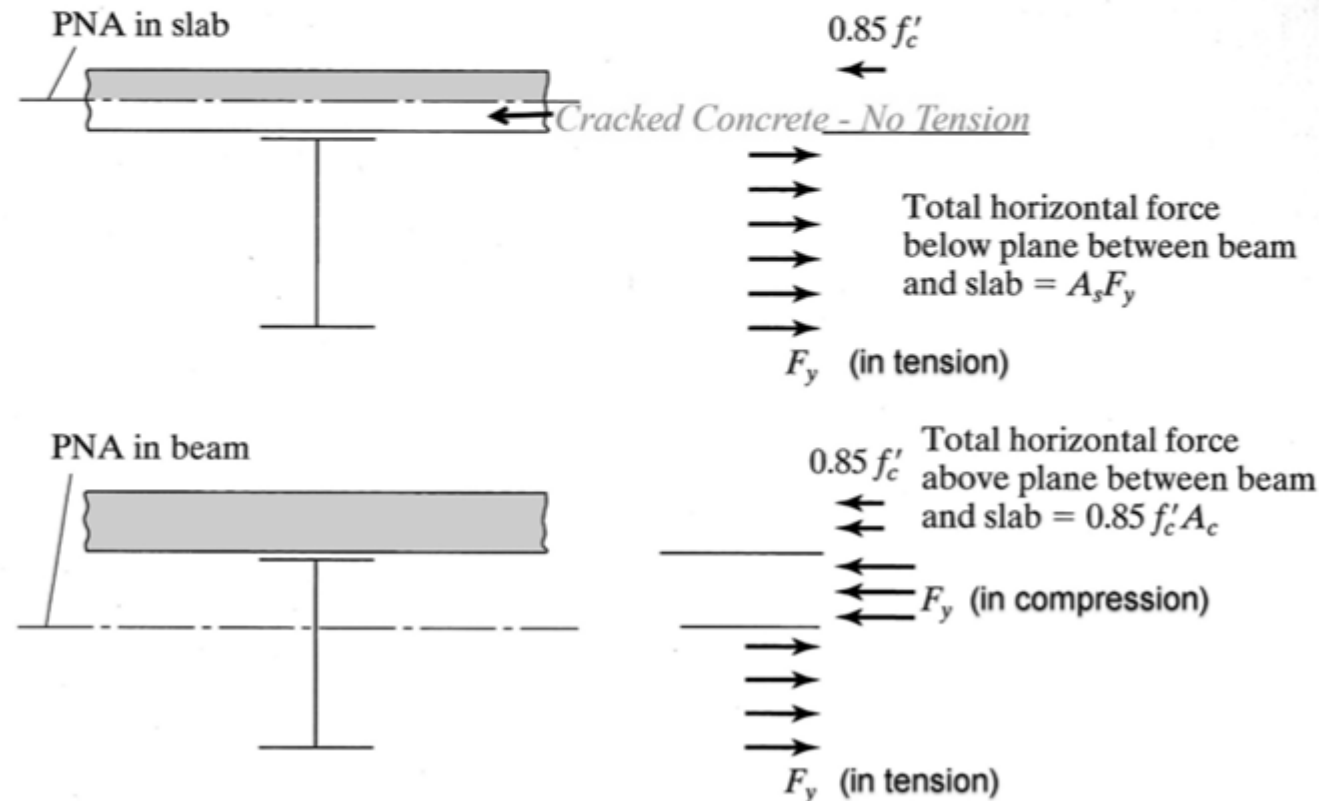
Please feel free to ask questions.

# Recap of the week

## Analysis Procedure (LRFD)

Case 1 – Plastic Neutral Axis (PNA) within slab

Case 2 – PNA within steel section



# Recap of the week

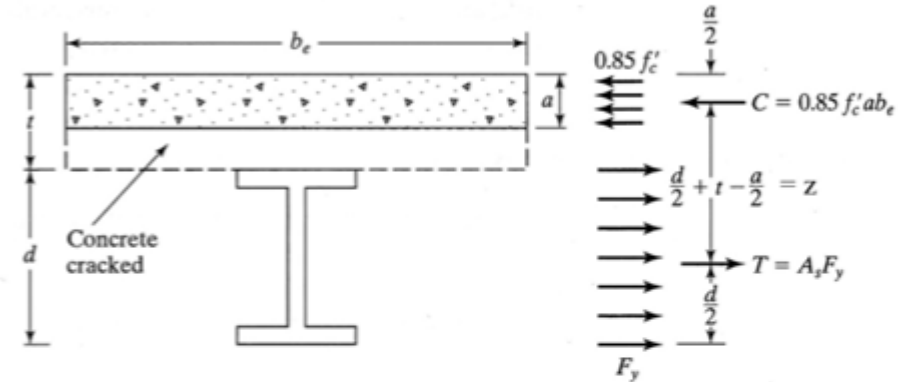
## Analysis Procedure (LRFD)

### 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.  $M_u \leq \phi M_n$



$$T = C$$

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

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

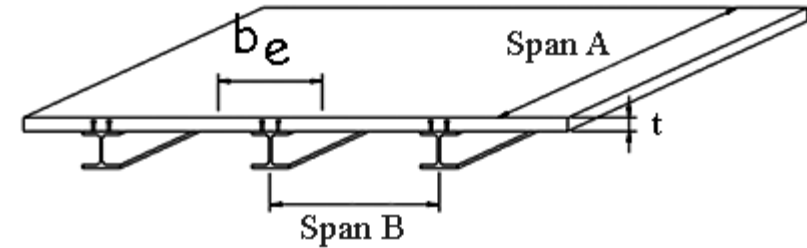
# Provide the solution for the assignment – HW10

## 10. Composite Sections

Using the strength method, determine the required amount of flexural steel reinforcement,  $A_s$ , for the simple span beam (shown in section). The beam carries a dead and live floor load from a one-way slab in addition to its own self weight at 150 PCF. For the given bar size, determine the number of bars to obtain the required  $A_s$ . Check  $A_{s,min}$  and  $\epsilon_{t}$ . Calculate the strength moment,  $M_n$  for the final beam design and check that  $\phi M_n$  is  $> M_u$ .

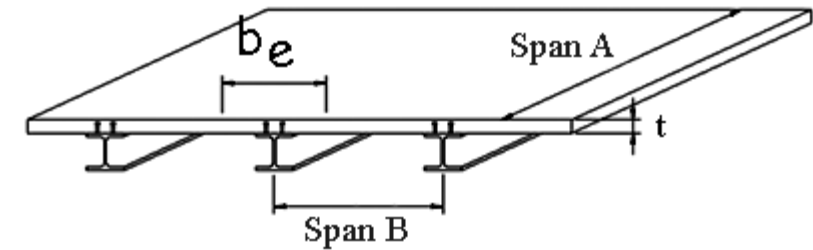
DATASET: 1    -2-    -3-

W-section	W21X166
span A	70 FT
span B	18 FT
slab thickness, $t$	9 IN
steel yield stress, $F_y$	50 KSI
concrete ultimate stress, $f'_c$	5 KSI



# Provide the solution for the assignment – HW10

#	Question	Your Response
1	Effective width of the concrete flange, $b_e$	<input type="text"/> IN
2	Depth of concrete stress block, $a$	<input type="text"/> IN
3	Is depth $a$ within the slab? 1=yes, 0=no	<input type="text"/>
4	The nominal bending moment, $M_n$	<input type="text"/> K-IN
5	The factored bending resistance, $\phi M_n$	<input type="text"/> K-IN
6	The factored design moment, $M_u$	<input type="text"/> K-FT
7	The total factored design load, $w_u$	<input type="text"/> KLF
8	The selfweight of the concrete slab	<input type="text"/> PSF
9	The total (steel+concrete) unfactored dead load on the beam, $w_{DL}$	<input type="text"/> KLF
10	The actual, unfactored beam live load (capacity), $w_{LL}$	<input type="text"/> KLF
11	The actual floor live load (floor capacity), $LL$	<input type="text"/> PSF



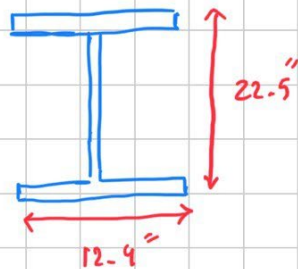
# Provide the solution for the assignment – HW10

①

effective width

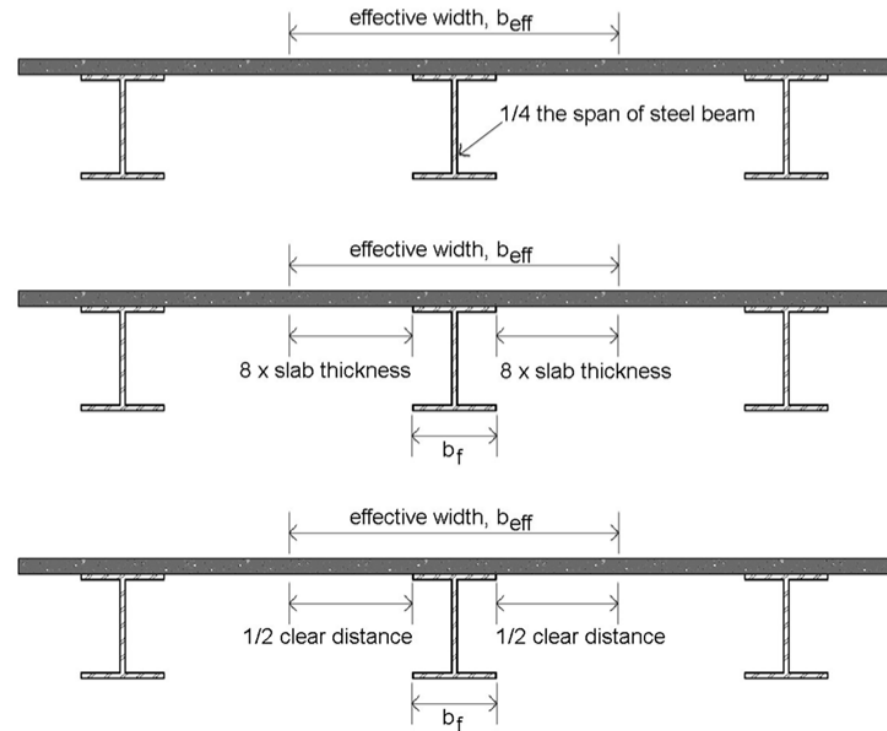
$$\text{Min} \left\{ \begin{array}{l} \frac{1}{4} (\text{span of steel beam}) \\ \frac{1}{4} (70 \times 12) = 210'' \\ b_f + 2(8 \times \text{slab thickness}) \\ 12.4 + 2(8 \times 9) = \boxed{156.4''} \\ b_f + 2(\frac{1}{2} \text{ clear distance}) \\ 18 \times 12 = 216'' \end{array} \right.$$

W21 X166



$$A = 48.8 \text{ in}^2$$

$$w = 166 \frac{\text{lb}}{\text{ft}} \text{ (PLF)}$$





# Provide the solution for the assignment – HW10

② effective depth of concrete stress block,  $a$

$$a = \frac{A_s F_y}{0.85 F'_c b_e} = \frac{(48.8) (50)}{0.85 (5) (156.4)} = 3.6708'' < 9''$$

within slab

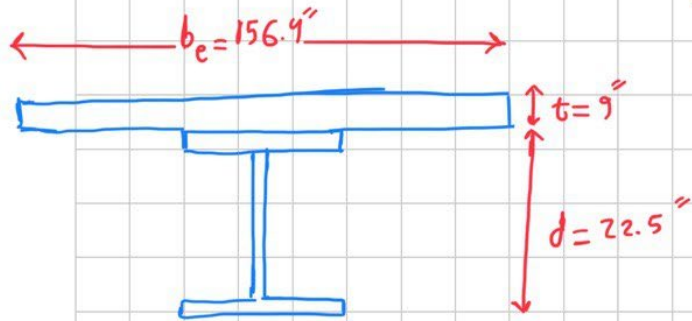
③

④ If  $a$  is within conc. slab, the full steel section is in tension:  
nominal bending moment:

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

*slab thickness* (pointing to  $t$ )  
*concrete stress block* (pointing to  $a$ )

$$= (48.8) (50) \left( \frac{22.5}{2} + 9 - \frac{3.6708}{2} \right) = 44931.62 \text{ K-in}$$



# Provide the solution for the assignment – HW10

$$\textcircled{5} \quad \phi M_n = 0.9 (44931.62) = 40438.45 \quad \text{k-in}$$

$$\textcircled{6} \quad M_u \leq \phi M_n \rightarrow M_u = \phi M_n$$
$$40438.45 \times \frac{1}{12} = 3369.87 \quad \text{k-ft}$$

$$\textcircled{7} \quad M_u = \frac{w_u L^2}{8} \rightarrow w_u = \frac{8 M_u}{L^2} = \frac{8 (3369.87 \text{ k-ft})}{(70)^2} = 5.5018 \quad \text{kLF}$$

$L^2$   
Span A

$\textcircled{8}$  Self-weight of concrete slab:

$$\frac{9}{12} \text{ ft}^3 \quad 150 \text{ lb} \rightarrow \frac{9}{12} \times 150 = 112.5 \text{ PSF}$$

# Provide the solution for the assignment – HW10

⑨ Total unfactored dead load:

Self weight (Concrete + steel)

$$\begin{aligned} 18(112.5) + 166 &= 2191 \text{ pLF} \\ &= 2.191 \text{ KLF} \end{aligned}$$

⑩ Actual unfactored live load,  $w_{LL}$

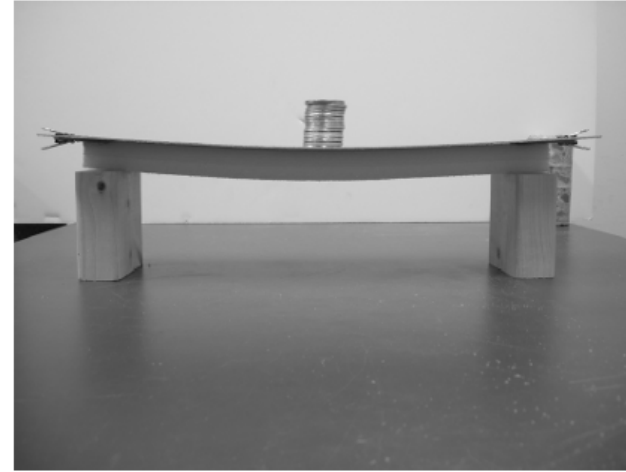
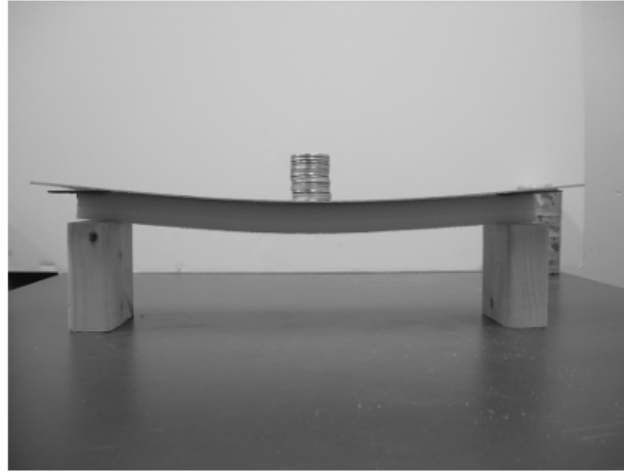
$$w_u = 1.2 w_{DL} + 1.6 w_{LL}$$

$$5.5018 \text{ KLF} = 1.2(2.191) + 1.6(w_{LL}) \rightarrow w_{LL} = 1.7953 \text{ KLF}$$

⑪ Actual floor live load:

$$\frac{w_{LL}}{\text{span}} = \frac{1.7953 \text{ KLF}}{18} = 0.0997388 \text{ KSF} \times 1000 = 99.7388 \text{ PSF}$$

# Lab : Composite Sections



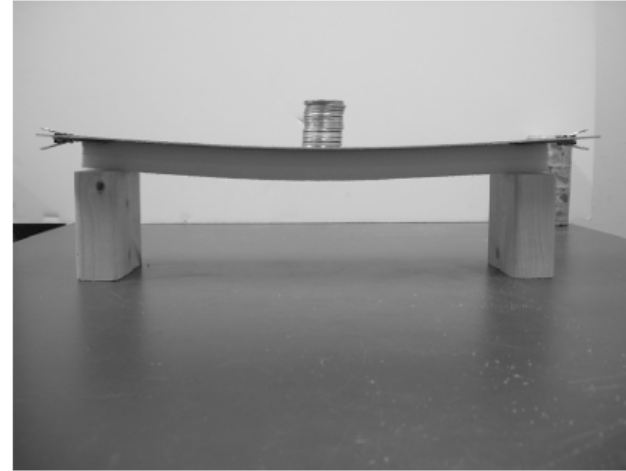
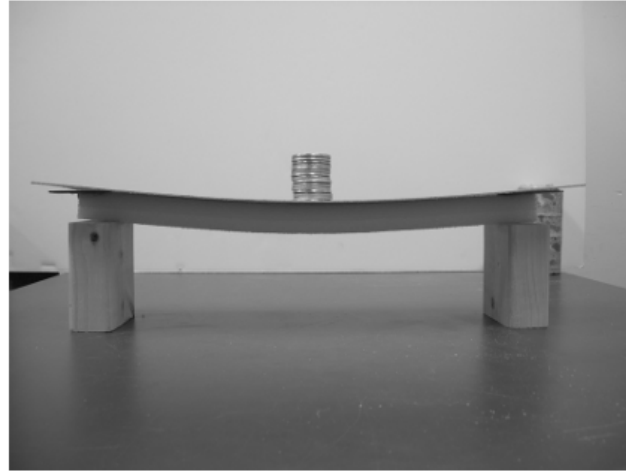
## Description

This project allows the students to observe the difference in stiffness between Composite and Non-Composite beam slab combinations.

## Goals

- To observe the bending behavior of non-connected beams and slabs
- To observe the bending behavior of a composite section.
- To compare the deflection of the two systems.

# Lab : Composite Sections



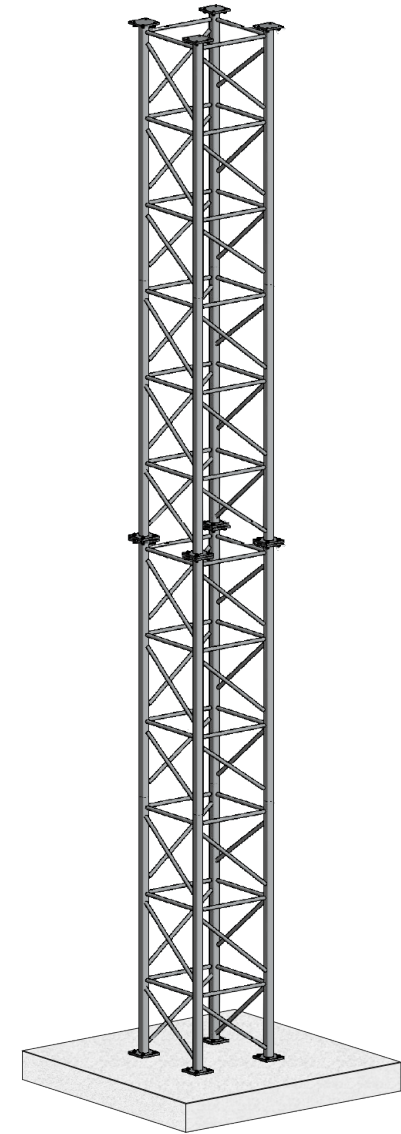
## Procedure

1. Place the chipboard slab on the foam beam but do not attach the end clips.
2. Place the 10 washer weights in the center and measure the deflection.
3. Repeat the procedure but now with the ends of the slab and the beam clipped together.
4. Again, measure the deflection.
5. Compare the deflections of the two systems.

# Tower Project:

Tower Project final report:

April, 12



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Thank you.

Any question?

Please feel free to ask questions.