TAUBMAN COLLEGE
ARCHITECTURE & URBAN PLANNING
UNIVERSITY OF MICHIGAN

Arch324
STRUCTURES II

Winter 2024
Recitation

FACULTY: Prof. Peter von Bülow
GSI: Mohsen Vatandoost

Arch324: STRUCTURES II

Welcome to Recitation session 03/15

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mohsenv@umich.edu

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.

Welcome to Recitation session 03/15

Outline:

- Quick **Recap** of the week
- Provide the solution for the assignment **(Homework 8)**
- Answering student’s questions
- Lab: **Flexural Strain**
- **Tower Project:** Test date is **March 20**

Please feel free to ask questions.

Contact: Mohsenv@umich.edu

Recap of the week

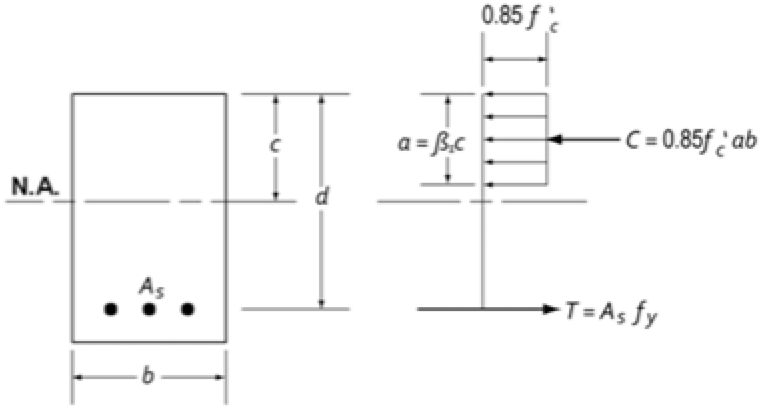
Rectangular Beam Analysis

Data:

- Section dimensions – b, h, (span)
- Steel area - As
- Material properties – f'c, fy

Required:

- Nominal Strength (of beam) Moment - Mn
- Required (by load) Design Moment – Mu
- Load capacity



$A_{s\,min}$:
greater of (a) and (b)

(a) $\frac{3\sqrt{f'_c}}{f_y} b_w d$

(b) $\frac{200}{f_y} b_w d$

1. Calculate d
2. Check As min
3. Calculate a
4. Determine c
5. Check that $\varepsilon_t \geq 0.005$ (tension controlled)
6. Find nominal moment, Mn
7. Calculate required moment, ϕ Mn ≥ Mu

   (if $\varepsilon_t \geq 0.005$ then $\phi = 0.9$)
8. Determine max. loading (or span)

$$c = \frac{a}{\beta_1}$$

$$\varepsilon_t = \frac{d-c}{c}0.003 \geq 0.005$$

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

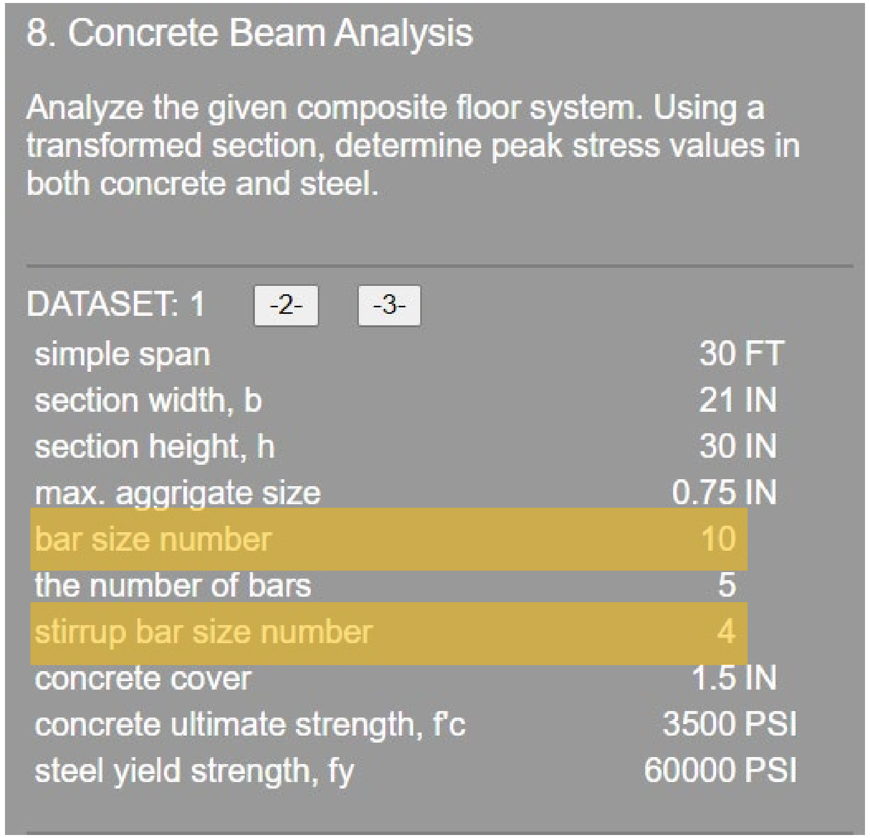
$$M_n = A_s f_y \left(d - \frac{a}{2}\right)$$

$$\varphi M_n \geq M_u$$

$$M_u = \frac{(1.2w_{DL} + 1.6w_{LL})l^2}{8}$$

$$1.6w_{LL} = \frac{M_u 8}{l^2} - 1.2w_{DL}$$

Provide the solution for the assignment – **HW8**

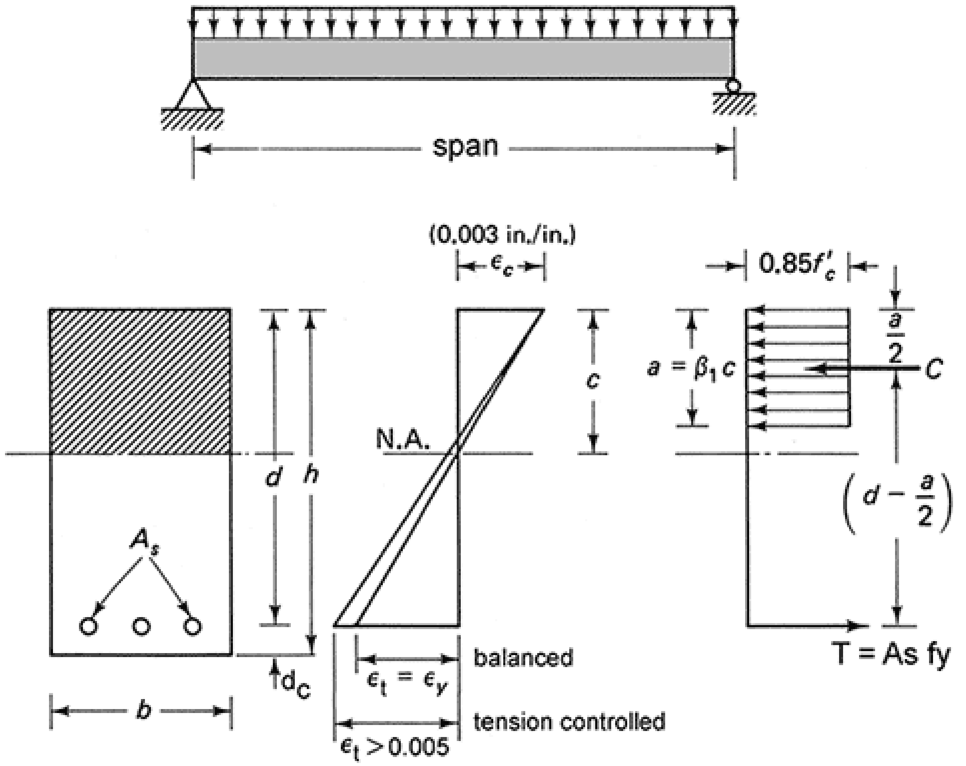


8. Concrete Beam Analysis

Analyze the given composite floor system. Using a transformed section, determine peak stress values in both concrete and steel.

DATASET: 1 -2- -3-

simple span	30 FT
section width, b	21 IN
section height, h	30 IN
max. aggrigate size	0.75 IN
bar size number	10
the number of bars	5
stirrup bar size number	4
concrete cover	1.5 IN
concrete ultimate strength, f'c	3500 PSI
steel yield strength, fy	60000 PSI



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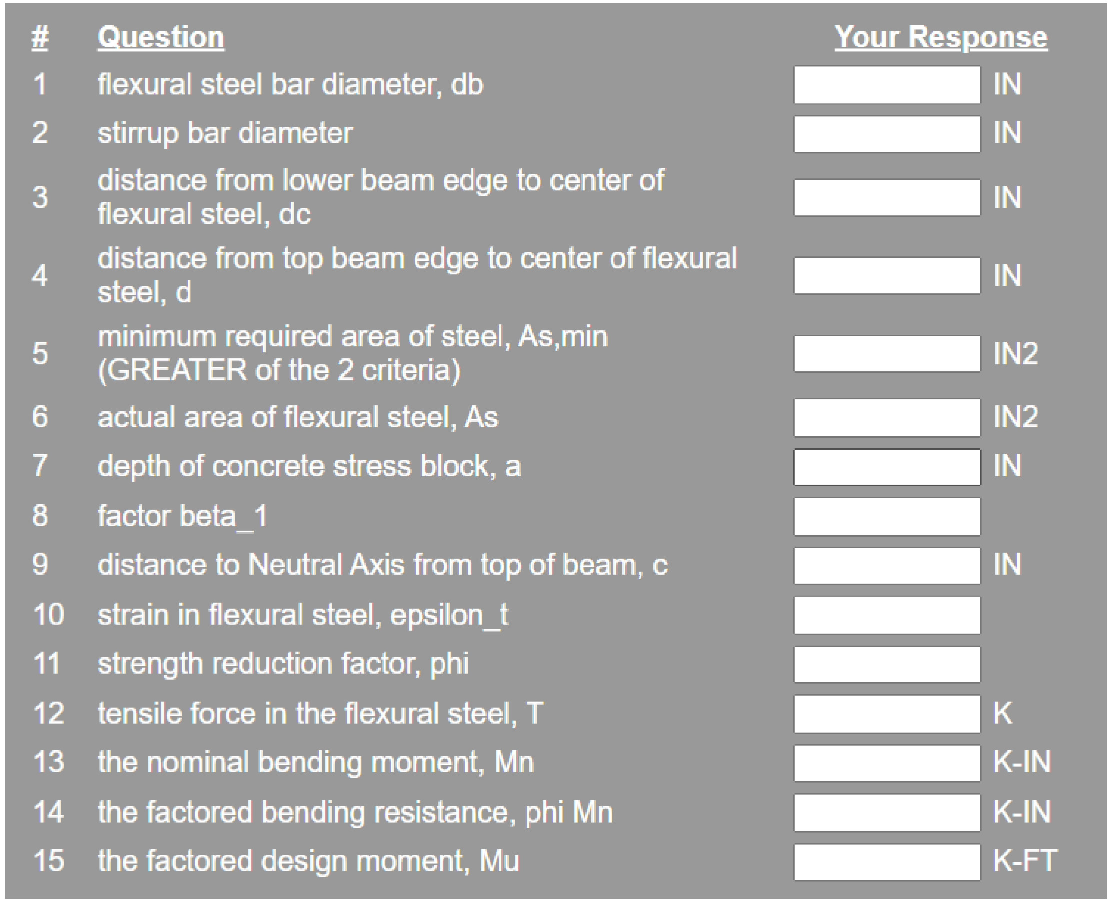
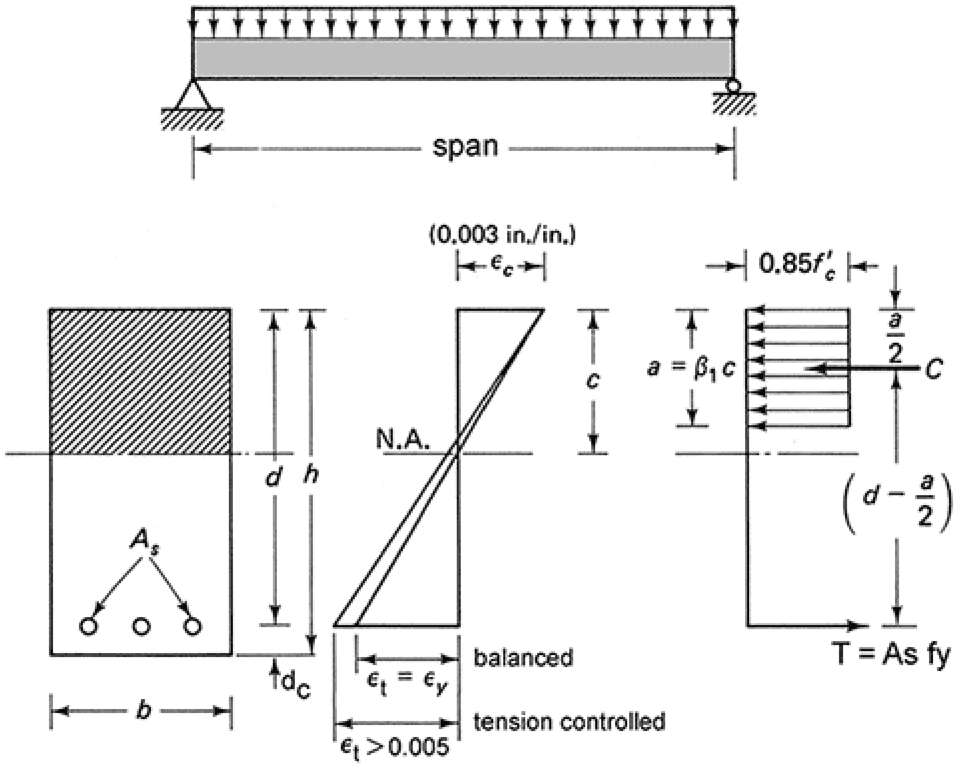


#	Question	Your Response	
1	flexural steel bar diameter, db		IN
2	stirrup bar diameter		IN
3	distance from lower beam edge to center of flexural steel, dc		IN
4	distance from top beam edge to center of flexural steel, d		IN
5	minimum required area of steel, As,min (GREATER of the 2 criteria)		IN2
6	actual area of flexural steel, As		IN2
7	depth of concrete stress block, a		IN
8	factor beta_1		
9	distance to Neutral Axis from top of beam, c		IN
10	strain in flexural steel, epsilon_t		
11	strength reduction factor, phi		
12	tensile force in the flexural steel, T		K
13	the nominal bending moment, Mn		K-IN
14	the factored bending resistance, phi Mn		K-IN
15	the factored design moment, Mu		K-FT



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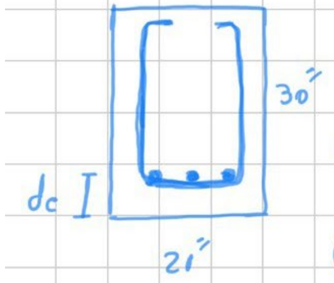


① Steel bar diameter, $d_b = \overset{\#10}{1.270}$ in (Table A.2)

② stirrups bar diameter = $\underset{\#4}{0.5}$ in

③ distance from lower beam edge to center of flexural steel, d_c

$$= \text{cover} + \text{stirrups diameter} + \frac{\text{flexural bar diameter}}{2}$$

$$= 1.5 + 0.5 + \frac{1.270}{2} = 2.635 \text{ in}$$

④ distance from top beam edge to center of flexural steel, d

$$d = h - d_c = 30 - 2.635 = 27.365 \text{ in}$$

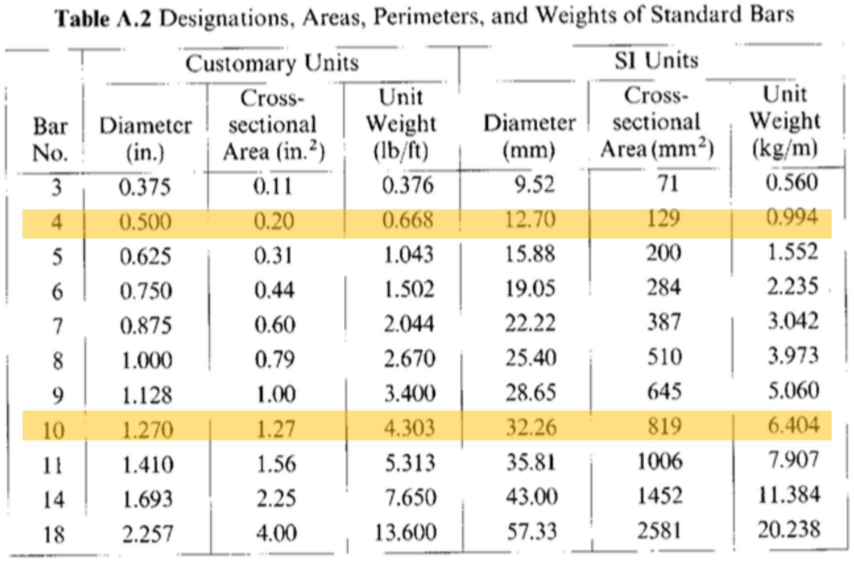
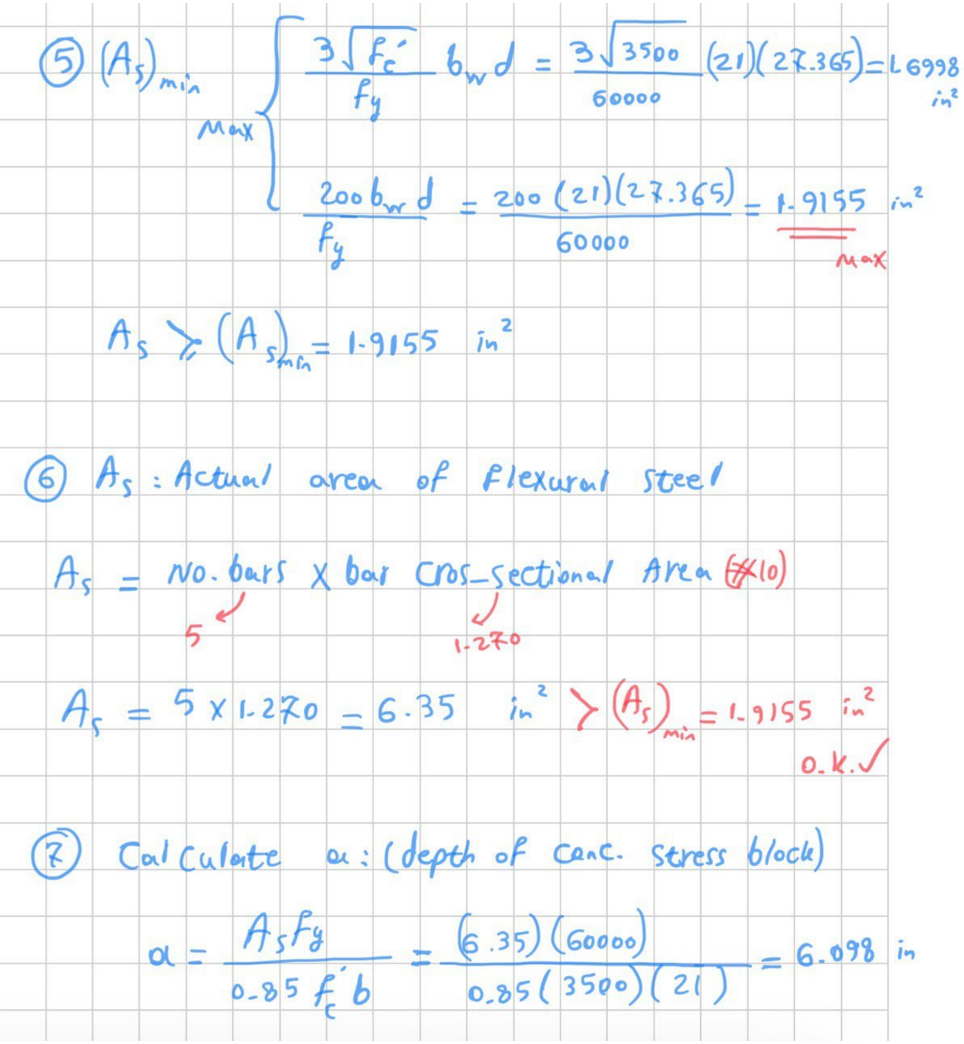


Table A.2 Designations, Areas, Perimeters, and Weights of Standard Bars

	Customary Units			SI Units		
Bar No.	Diameter (in.)	Cross-sectional Area (in.^{2})	Unit Weight (lb/ft)	Diameter (mm)	Cross-sectional Area (mm^2)	Unit Weight (kg/m)
3	0.375	0.11	0.376	9.52	71	0.560
4	0.500	0.20	0.668	12.70	129	0.994
5	0.625	0.31	1.043	15.88	200	1.552
6	0.750	0.44	1.502	19.05	284	2.235
7	0.875	0.60	2.044	22.22	387	3.042
8	1.000	0.79	2.670	25.40	510	3.973
9	1.128	1.00	3.400	28.65	645	5.060
10	1.270	1.27	4.303	32.26	819	6.404
11	1.410	1.56	5.313	35.81	1006	7.907
14	1.693	2.25	7.650	43.00	1452	11.384
18	2.257	4.00	13.600	57.33	2581	20.238

Provide the solution for the assignment – **HW8**



⑤ $(A_s)_{min}$ Max $\begin{cases} \dfrac{3\sqrt{f_c'}}{f_y} b_w d = \dfrac{3\sqrt{3500}}{60000}(21)(27.365) = 1.6998 \text{ in}^2 \\ \dfrac{200 b_w d}{f_y} = \dfrac{200(21)(27.365)}{60000} = \underline{\underline{1.9155}} \text{ in}^2 \end{cases}$

max

$A_s \geq (A_s)_{min} = 1.9155 \text{ in}^2$

⑥ A_s : Actual area of flexural steel

A_s = No. bars x bar cross_sectional Area (#10)

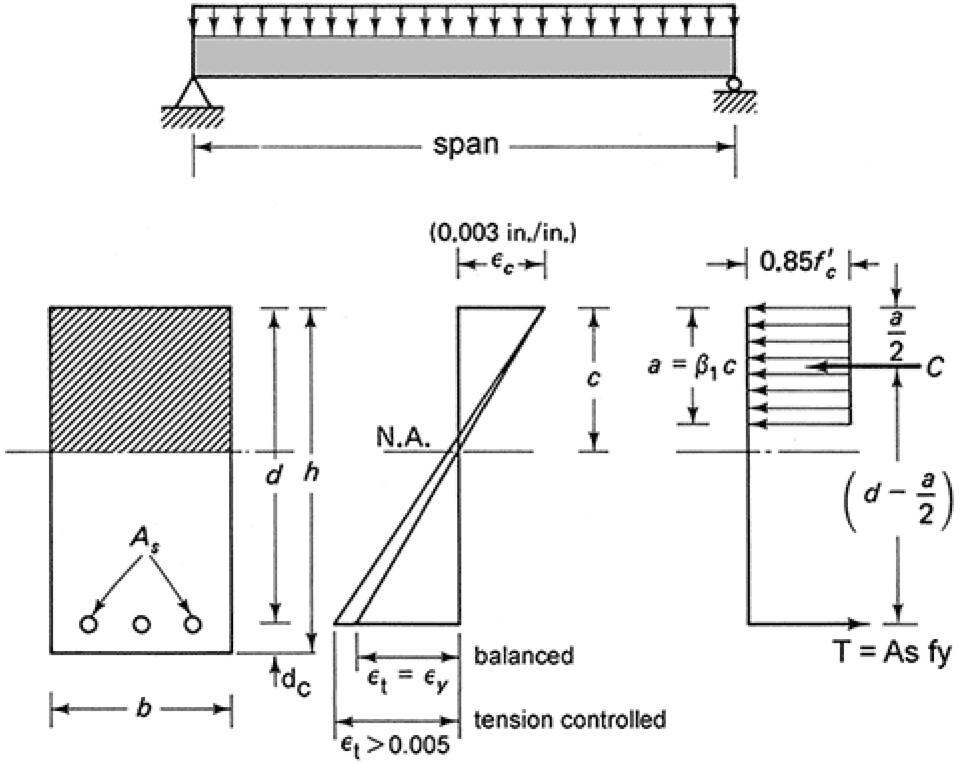
5 1.270

$A_s = 5 \times 1.270 = 6.35 \text{ in}^2 > (A_s)_{min} = 1.9155 \text{ in}^2$

o.k.✓

⑦ Calculate a : (depth of conc. stress block)

$$a = \frac{A_s f_y}{0.85 f_c' b} = \frac{(6.35)(60000)}{0.85(3500)(21)} = 6.098 \text{ in}$$



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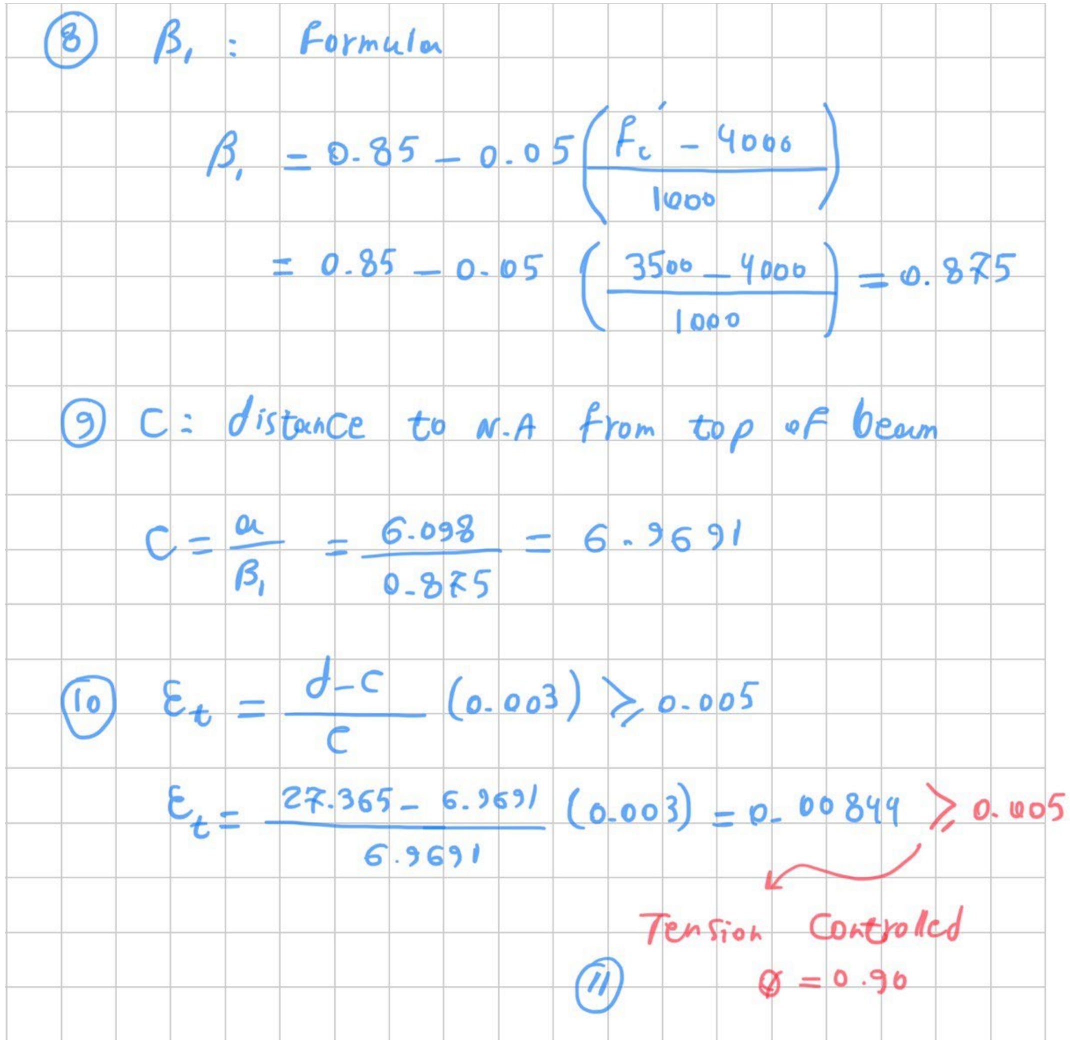


⑧ β_1 : Formula

$$\beta_1 = 0.85 - 0.05\left(\frac{f_c' - 4000}{1000}\right)$$

$$= 0.85 - 0.05\left(\frac{3500 - 4000}{1000}\right) = 0.875$$

⑨ C: distance to N.A from top of beam

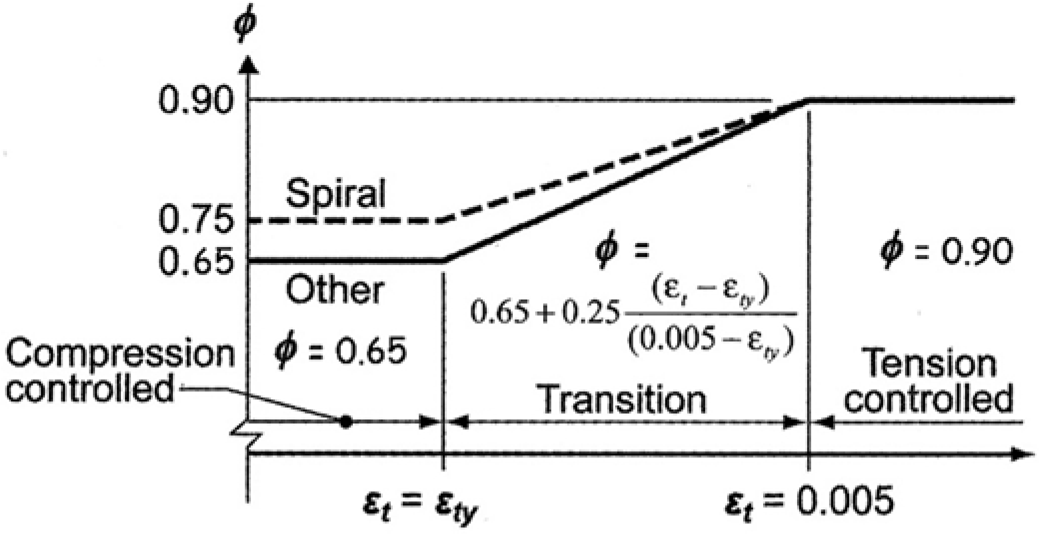
$$C = \frac{a}{\beta_1} = \frac{6.098}{0.875} = 6.9691$$

⑩ $\varepsilon_t = \frac{d-c}{c}(0.003) \geq 0.005$

$$\varepsilon_t = \frac{27.365 - 6.9691}{6.9691}(0.003) = 0.00844 \geq 0.005$$

Tension Controlled

⑪ $\emptyset = 0.90$



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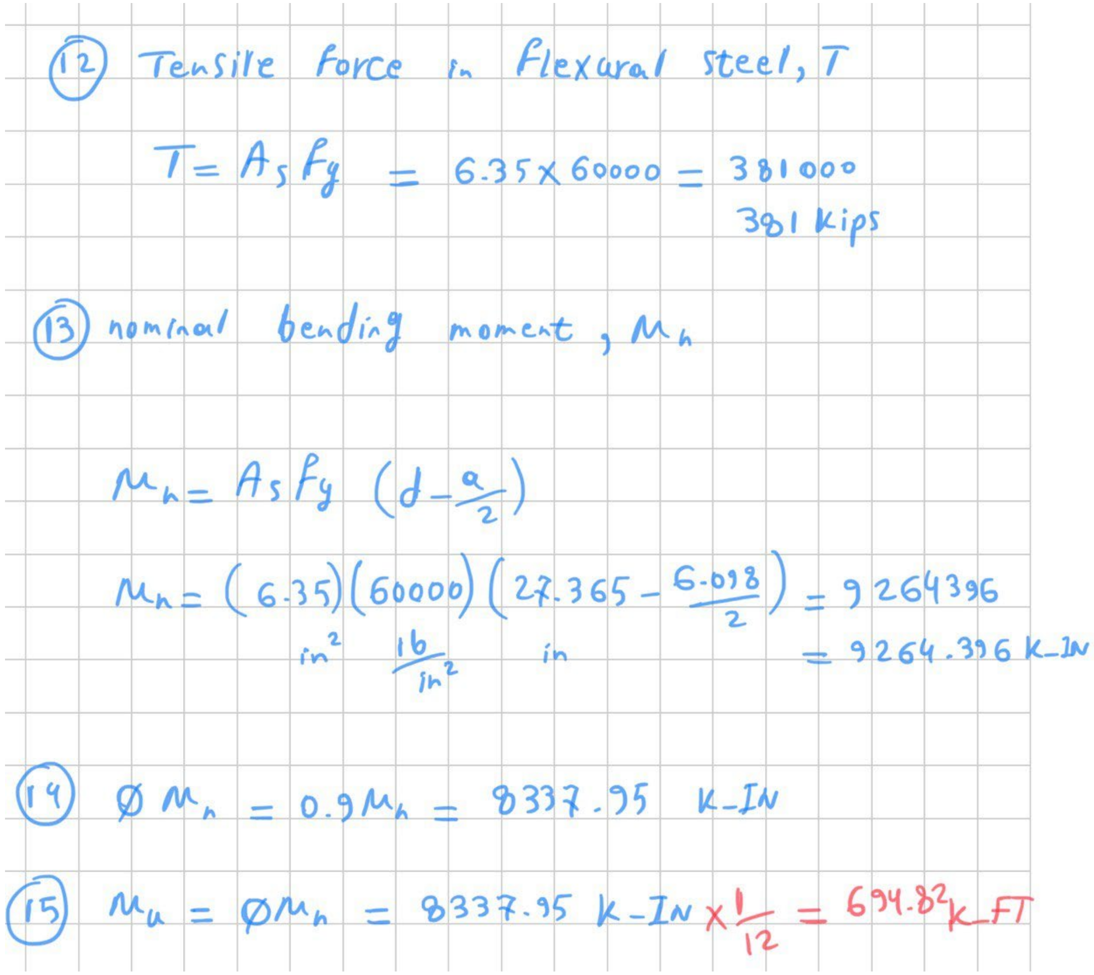


⑫ Tensile force in flexural steel, T

$$T = A_s f_y = 6.35 \times 60000 = 381000$$

381 kips

⑬ nominal bending moment, M_n

$$M_n = A_s f_y \left(d - \frac{a}{2}\right)$$

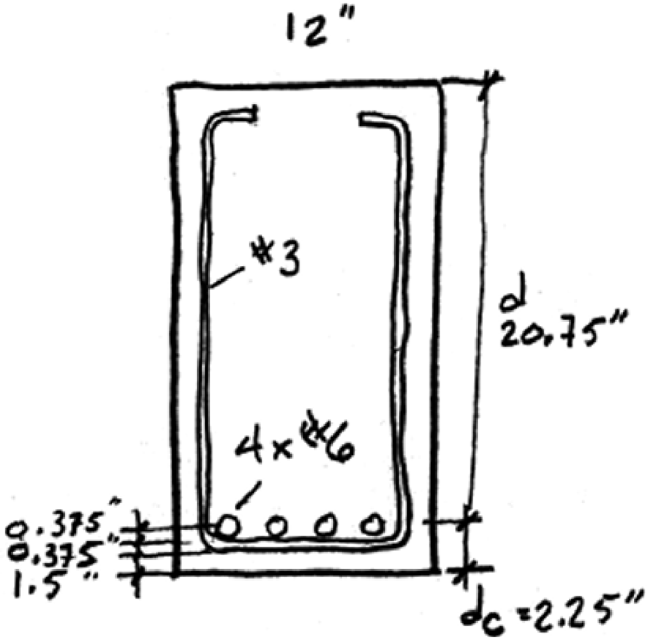
$$M_n = \underset{in^2}{(6.35)} \underset{\frac{lb}{in^2}}{(60000)} \left(\underset{in}{27.365} - \frac{6.098}{2}\right) = 9264396$$

$$= 9264.396 \text{ K-IN}$$

⑭ $\varnothing M_n = 0.9 M_n = 8337.95 \text{ K-IN}$

⑮ $M_u = \varnothing M_n = 8337.95 \text{ K-IN} \times \frac{1}{12} = 694.82 \text{ K-FT}$

Lab : Flexural Strain



Description

This project produces a graphic representation of the strain diagram for a tension controlled concrete beam.

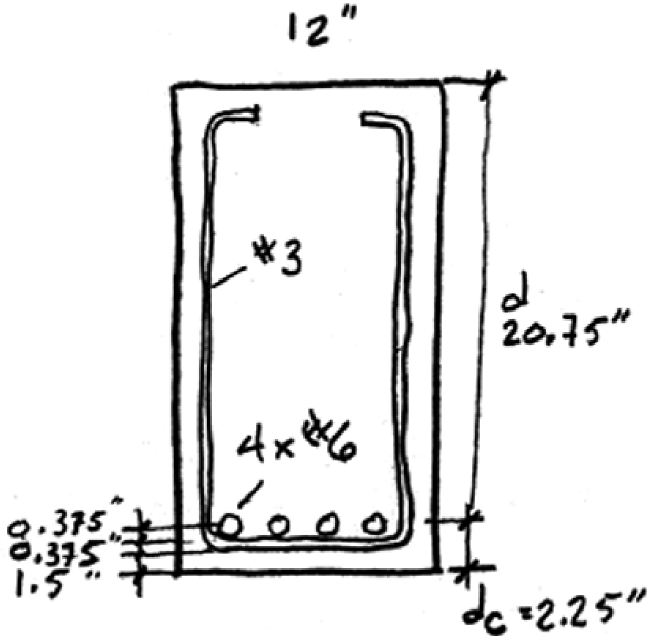
Goals

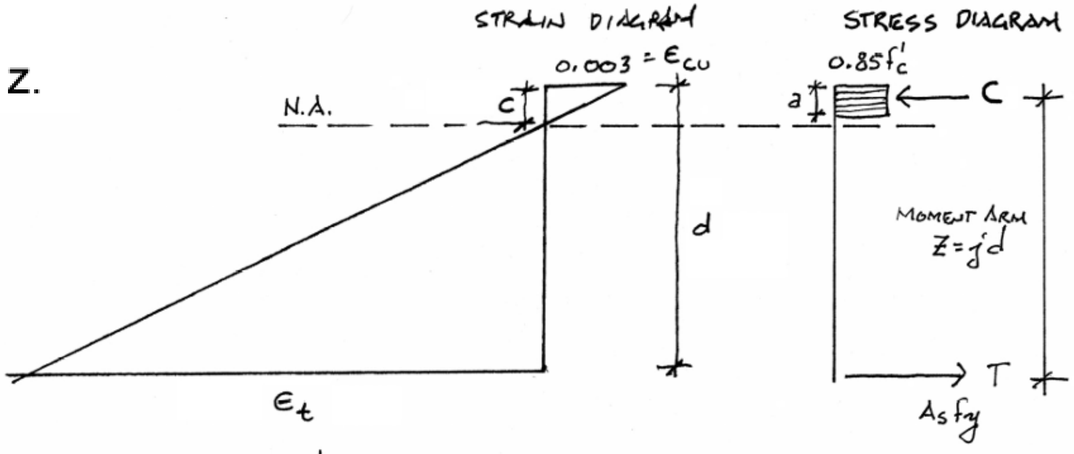
To plot the compression and tension strain levels in a concrete beam
To graphically determine the neutral axis.
To draw the ACI "Whitney" stress block showing C and T forces.
To compare plotted and calculated results.

Lab : Flexural Strain

Procedure

1. For the tension controlled beam analysis discussed in lecture, construct the strain diagram with ϵ_{cu} = 0.003 and ϵ_t as calculated.
2. Use f'c = 6000 psi and fy = 60000 psi
3. Graphically determine the c distance from the top to the N.A on your diagram.
4. Make a second diagram to show the relationship of C & T forces to the strains.
5. Draw the ACI – Whitney stress block at "a" distance from the top.
6. Show the moment arm and calculate j using jd = z.





$$\frac{\epsilon_t}{\epsilon_{cu}} : \frac{d-c}{c}$$

Lab : Flexural Strain

$f_y = 60000$ $f'_c = 6000$ psi $\varepsilon_{cu} = 0.003$

① $a = \dfrac{A_s f_y}{0.85 f'_c b}$

② $\beta_1 = 0.85 - 0.05\left(\dfrac{f'_c - 4000}{1000}\right)$

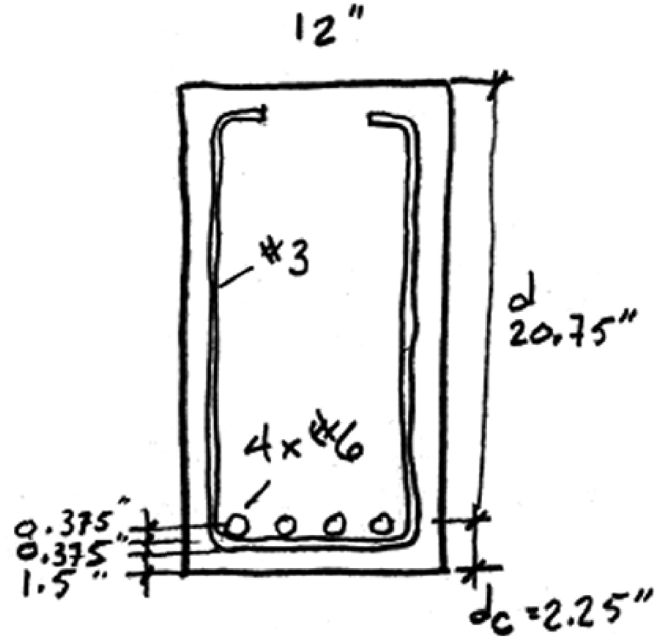
③ $c = \dfrac{a}{\beta_1}$

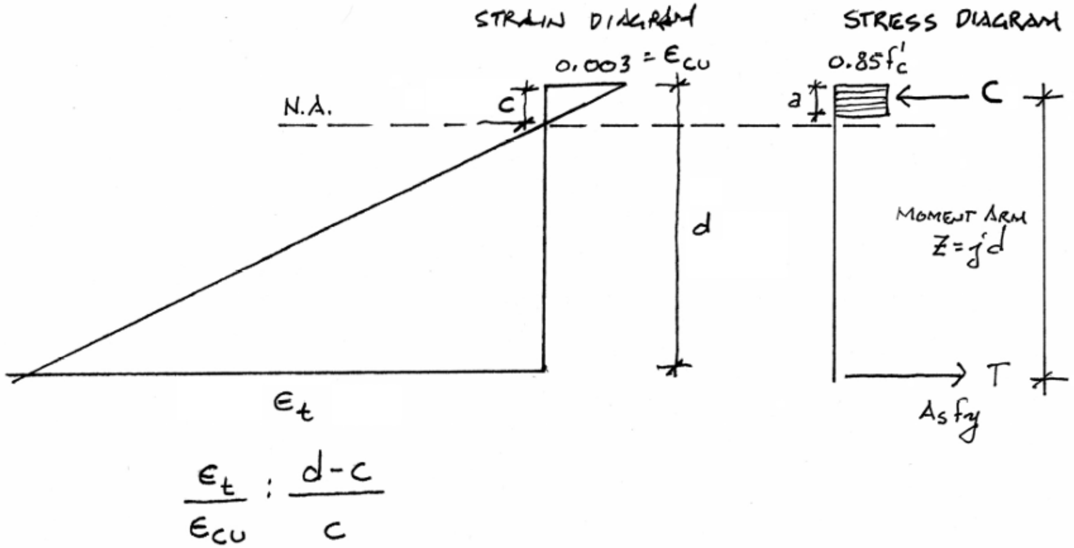
④ $\varepsilon_t \longrightarrow \dfrac{\varepsilon_t}{\varepsilon_{cu}} = \dfrac{d-c}{c}$

⑥ Moment arm: $d - \dfrac{a}{2}$

$T = A_s f_y$

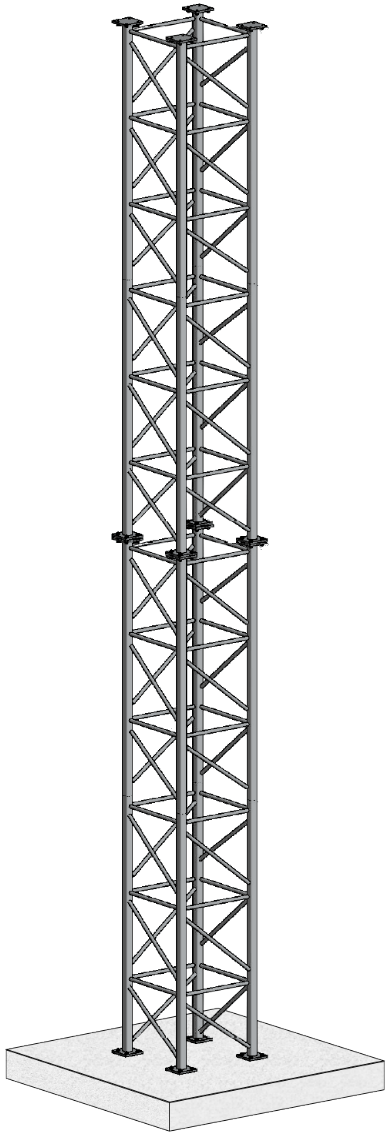
$M_n = T\left(d - \dfrac{a}{2}\right)$





$$\frac{\varepsilon_t}{\varepsilon_{cu}} : \frac{d-c}{c}$$

Tower Project:



Tower Test : March 20

Please sign up and schedule time.

Thank you.

Any question?

Please feel free to ask questions.

Contact: Mohsenv@umich.edu