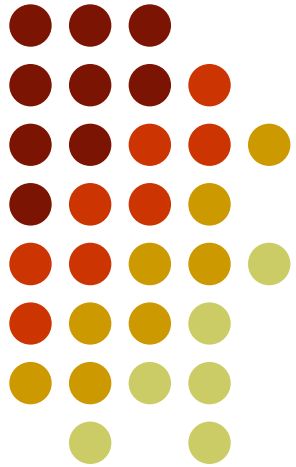
Plain & Reinforced Concrete-1

Sixth Term
Civil Engineering

CE-314

Lecture # 20

Analysis and Design of Slabs



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Solution: (contd…)

Panel-1 (case # 4)

a) x- direction

$L_x = 4.5$ m d = 123 mm m = 0.65

$$M^+_{DL} = C^+_{x\,DL}(1.2q_d)L_x^2$$

$$= 0.063 \times 7.45 \times 4.5^2 = 9.51 kN-m$$

$$M^+_{LL} = C^+_{x\,LL}(1.2q_L)L_x^2$$

$$= 0.078 \times 3.14 \times 4.5^2 = 4.96 kN-m$$

$$M^+_u = 9.51 + 4.96 = 14.47 \text{kN} - \text{m}$$

$$M^-_u = C^-_x \times q_u \times L_x^2$$

$$M^-_u = 0.077 \times 10.59 \times 4.5^2 = 16.51 \text{kN} - \text{m}$$

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Solution: (contd…)

Panel-1 (case # 4)

For M⁺

$$w = 0.85\frac{f_c'}{f_y} = 0.0546 \qquad R = \frac{M^+_u}{bd^2} = \frac{14.47\times10^6}{1000\times123^2} = 0.96$$

$$\rho = \omega\left(1-\sqrt{1-\frac{2.614R}{f_c'}}\right) = 0.0039$$

$$A_s = \rho bd = 0.0039\times1000\times123$$

$$= 480 mm^2/m > A_{s\,min} \qquad \textbf{O.K.}$$

$$\boxed{\#10@140 mm c/c} \qquad \textbf{140 < 2h O.K.}$$

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Solution: (contd…)

Panel-1 (case # 4)

For M^-

$$R = \frac{M^+_u}{bd^2} = \frac{16.51\times10^6}{1000\times123^2} = 1.091$$

$$\rho = 0.0046$$

$$A_s = 566$$

$$A_s > A_{s\,min}$$ **O.K.**

Spacing will be decided at letter stage

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Solution: (contd…)

Panel-1 (case # 4)

a) y- direction

$L_y = 7.0\ m \qquad d = 112\ mm \qquad m = 0.65$

$$M^{+}_{DL} = C^{+}_{y\,DL}\left(1.2 w_d\right) L_y^{\,2}$$

$$M^{+}_{DL} = 0.011 \times 7.45 \times 7^2 = 4.02 kN-m$$

$$M^{+}_{LL} = C^{+}_{y\,LL}\left(1.2 w_L\right) L_y^{\,2}$$

$$M^{+}_{LL} = 0.014 \times 3.14 \times 7^2 = 2.16 kN-m$$

$$\boxed{M^{+}_{u} = 6.18 kN-m}$$

$$M^{-}_{u} = C^{-}_{y} \times w_u \times L_y^{\,2}$$

$$\boxed{M^{-}_{u} = 0.014 \times 10.59 \times 7^2 = 7.27 kN-m}$$

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Solution: (contd…)

Panel-1 (case # 4)

For M^+

$$w = 0.85\frac{f_c'}{f_y} = 0.0546 \qquad R = \frac{M^+_u}{bd^2} = \frac{6.18\times10^6}{1000\times112^2} = 0.49$$

$$\rho = 0.0025$$

$$A_s = 280 mm^2/m$$

$$A_s < A_{s\,min}$$ **NOT O.K.**

Provide minimum steel

$$A_{s\,min} = 300 mm^2/m \Rightarrow \boxed{\#10@225 mmc/c}$$ **225 < 2h O.K.**

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Solution: (contd…)

Panel-1 (case # 4)

For M^-

$$R = \frac{M^-_u}{bd^2} = \frac{7.27\times10^6}{1000\times112^2} = 0.58$$

$$\rho = 0.0025$$

$$A_s = 280 mm^2/m$$

$$A_s < A_{s\,min} \qquad \textbf{NOT.O.K.}$$

Provide $A_{s\,min} = 300 mm^2/m$

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Solution: (contd…)

Panel-2 (case # 9)

a) x- direction

$L_x = 6.0$ m d = 123 mm m = 0.85

$$M^+_{DL} = C^+_{x\,DL}\left(1.2 w_d\right) L_x^{\,2}$$

$$M^+_{DL} = 0.035 \times 7.45 \times 6.0^2 = 9.39 \text{kN} - \text{m}$$

$$M^+_{LL} = C^+_{x\,LL}\left(1.2 w_L\right) L_x^{\,2}$$

$$M^+_{LL} = 0.049 \times 3.14 \times 6.0^2 = 5.54 \text{kN} - \text{m}$$

$$\boxed{M^+_u = 14.93 \text{kN} - \text{m}}$$

$$M^-_u = C^-_x \times w_u \times L_x^{\,2}$$

$$\boxed{M^-_u = 0.065 \times 10.59 \times 6.0^2 = 24.78 \text{kN} - \text{m}}$$

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Solution: (contd…)

Panel-2 (case # 9)

For M^+

$$\omega = 0.85\frac{f_c'}{f_y} = 0.0546 \qquad R = 0.99$$

$$\rho = 0.0042$$

$$A_s = 517 mm^2/m$$

$$A_s > A_{s\,min}$$ **O.K.**

$$\boxed{\#10@130mmc/c}$$ **130 < 2h O.K.**

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Solution: (contd…)

Panel-2 (case # 9)

For M⁻

$$R = \frac{M^-_u}{bd^2} = 1.64$$

$$\rho = 0.0070$$

$$A_s = 861 mm^2 / m$$

$$A_s > A_{s\,min}$$ **O.K.**

Spacing will be decided at letter stage

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Solution: (contd…)

Panel-2 (case # 9)

b) y- direction

$L_y = 7.0\ m \qquad d = 112\ mm \qquad m = 0.85$

$$M^{+}_{DL} = C^{+}_{y\,DL}\left(1.2 w_d\right) L_y^{\,2}$$

$$M^{+}_{DL} = 0.016 \times 7.45 \times 7^2 = 5.84 kN-m$$

$$M^{+}_{LL} = C^{+}_{y\,LL}\left(1.2 w_L\right) L_y^{\,2}$$

$$M^{+}_{LL} = 0.025 \times 3.14 \times 7^2 = 3.85 kN-m$$

$$\boxed{M^{+}_{u} = 9.69 kN-m}$$

$$M^{-}_{u} = C^{-}_{y} \times w_u \times L_y^{\,2}$$

$$\boxed{M^{-}_{u} = 0.019 \times 10.59 \times 7^2 = 9.86 kN-m}$$

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Solution: (contd…)

Panel-2 (case # 9)

For M^+

$$\omega = 0.85\frac{f_c'}{f_y} = 0.05464 \qquad R = 0.77$$

$$\rho = 0.0032$$

$$A_s = 359 mm^2/m$$

$$A_s > A_{s\,min} \qquad \textbf{O.K.}$$

$$\boxed{\#10@190 mm c/c} \qquad \textbf{190 < 2h O.K.}$$

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Solution: (contd…)

Panel-2 (case # 9)

For M^-

$$R = 0.79$$

$$\rho = 0.0033$$

$$A_s = 370 mm^2 / m$$

$$A_s > A_{s\,min}$$ **O.K.**

Spacing will be decided at letter stage

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Solution: (contd…)

Panel-3 (case # 8)

a) x- direction

$L_x = 3.5\ m \qquad d = 123\ mm \qquad m = 0.60$

$$M^{+}_{DL} = C^{+}_{x\,DL}\left(1.2 w_d\right) L_x^{\,2}$$

$$M^{+}_{DL} = 0.06 \times 7.45 \times 3.5^2 = 5.48\,kN-m$$

$$M^{+}_{LL} = C^{+}_{x\,LL}\left(1.2 w_L\right) L_x^{\,2}$$

$$M^{+}_{LL} = 0.081 \times 3.14 \times 3.5^2 = 3.12\,kN-m$$

$$\boxed{M^{+}_{u} = 8.60\,kN-m}$$

$$M^{-}_{u} = C^{-}_{x} \times w_u \times L_x^{\,2}$$

$$\boxed{M^{-}_{u} = 0.072 \times 10.59 \times 3.5^2 = 9.34\,kN-m}$$

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Solution: (contd…)

Panel-3 (case # 8)

For M⁺

$$\omega = 0.85\frac{f_c'}{f_y} = 0.05464 \qquad R = 0.57$$

$$\rho = 0.0025$$

$$A_s = 308 mm^2/m$$

$$A_s < A_{s\,min}$$ **NOT O.K.**

$A_s = 300 mm^2/m$ $\boxed{\#10@225mmc/c}$ **225 < 2h O.K.**

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Solution: (contd…)

Panel-3 (case # 8)

For M^-

$$R = \frac{M^-_u}{bd^2} = 0.62$$

$$\rho = 0.0026$$

$$A_s = 320 mm^2 / m$$

$$A_s < A_{s\,min}$$ **Not O.K.**

$$A_s = 300 mm^2 / m$$

Spacing will be decided at letter stage

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Solution: (contd…)

Panel-3 (case # 8)

b) y- direction

$L_y = 6.0\ m \qquad d = 112\ mm \qquad m = 0.60$

$$M^{+}_{DL} = C^{+}_{y\,DL}\left(1.2 w_d\right) L_y^{\,2}$$

$$M^{+}_{DL} = 0.009 \times 7.45 \times 6^2 = 2.41 kN-m$$

$$M^{+}_{LL} = C^{+}_{y\,LL}\left(1.2 w_L\right) L_y^{\,2}$$

$$M^{+}_{LL} = 0.011 \times 3.14 \times 6^2 = 1.24 kN-m$$

$$\boxed{M^{+}_{u} = 3.65 kN-m}$$

$$M^{-}_{u} = C^{-}_{y} \times w_u \times L_y^{\,2}$$

$$\boxed{M^{-}_{u} = 0.016 \times 10.59 \times 6^2 = 6.10 kN-m}$$

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Solution: (contd…)

Panel-3 (case # 8)

For M^+

$$\omega = 0.85\frac{f_c'}{f_y} = 0.05464 \qquad R = 0.29$$

$$\rho = 0.0025$$

$$A_s = 280 mm^2/m$$

$$A_s < A_{s\min} \qquad \textbf{NOT O.K.}$$

$A_{s\min}$ $\#10@225mmc/c$

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Solution: (contd…)

Panel-3 (case # 8)

For M^-

$$R = 0.49$$

$$\rho = 0.0025$$

$$A_s = 280 mm^2 / m$$

$$A_s < A_{s\,min}$$ **NOT.O.K.**

$$A_s = 300 mm^2 / m$$

Spacing will be decided at letter stage

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Solution: (contd…)

Panel-4 (case # 2)

a) x & y- direction

$L_x = L_y = 6.0$ m d = 112 mm (smaller) m = 1.0

$$M^+_{DL} = C^+_{x\,DL}\left(1.2 w_d\right) L_x^{\,2}$$

$$M^+_{DL} = 0.023 \times 7.45 \times 6.0^2 = 6.17 \text{kN} - \text{m}$$

$$M^+_{LL} = C^+_{x\,LL}\left(1.2 w_L\right) L_x^{\,2}$$

$$M^+_{LL} = 0.034 \times 3.14 \times 6.0^2 = 3.84 \text{kN} - \text{m}$$

$$\boxed{M^+_u = 10.01 \text{kN} - \text{m}}$$

$$M^-_u = C^-_x \times w_u \times L_x^{\,2}$$

$$\boxed{M^-_u = 0.041 \times 10.59 \times 6.0^2 = 15.63 \text{kN} - \text{m}}$$

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Solution: (contd…)

Panel-4 (case # 2)

For M^+

$$\omega = 0.85\frac{f_c'}{f_y} = 0.05464 \qquad R = 0.80$$

$$\rho = 0.0034$$

$$A_s = 381 mm^2/m$$

$$A_s > A_{s\,min}$$ **O.K.**

$$\boxed{\#10@180mmc/c}$$ **180 < 2h O.K.**

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Solution: (contd…)

Panel-4 (case # 2)

For M^-

$$R = \frac{M^-_u}{bd^2} = 1.25$$

$$\rho = 0.0053$$

$$A_s = 594 mm^2 / m$$

$$A_s > A_{s\,min}$$ **O.K.**

Spacing will be decided at letter stage

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Solution: (contd…)

Support-A & B

Top A_s is larger of 566mm^2 & 861 mm^2

$$\mathbf{A_s = 861\ mm^2}$$

Some steel is already present in the form of bent-up bars. So we need to subtract the already present steel.

$A_s = 861 - (\#\ 10 @ 140\ c/c)/2 - (\#\ 10 @ 130\ c/c)/2$

$A_s = 335\ mm^2$

$\#\ 13 @ 350\ mm^2$

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Solution: (contd…)

Support-C

Top A_s is larger of 300mm^2 & 594 mm^2

$$\mathbf{A_s = 594mm^2}$$

Some steel is already present in the form of bent-up bars. So we need to subtract the already present steel.

A_s = 594 – (# 10 @ 225 c/c)/2 - (# 10 @ 190 c/c)/2

A_s = 249 mm^2

10 @ 275 mm^2

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Solution: (contd…)

Support-D

$$\mathbf{A_s = 594mm^2}$$

Some steel is already present in the form of bent-up bars. So we need to subtract the already present steel.

$A_s = 594 - (\#\ 10 @ 190\ c/c)/2 - (\#\ 10 @ 190\ c/c)/2$

$A_s = 220\ mm^2$

$\#\ 10 @ 300\ mm^2$

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Solution: (contd…)

Support-E & G

Top A_s is larger of 300mm^2 & 320 mm^2

A_s = 320mm^2

Some steel is already present in the form of bent-up bars. So we need to subtract the already present steel.

A_s = 320 – (# 10 @ 225 c/c)/2 - (# 10 @ 225 c/c)/2

A_s = 4

Almost no steel is needed

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Solution: (contd…)

Support-F & H

Top A_s is larger of 370mm^2 & 594 mm^2

$$\mathbf{A_s = 594mm^2}$$

Some steel is already present in the form of bent-up bars. So we need to subtract the already present steel.

$A_s = 594 - (\#\ 10 @ 190\ c/c)/2 - (\#\ 10 @ 180\ c/c)/2$

$A_s = 210\ mm^2$

$\#\ 10 @ 300\ mm^2$

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Solution: (contd…)

	Bent-up for discontinuous end	Bent-up for continuous end + top additional for discontinuous end	Top additional	Extended bent-up
L_n	$L_n/7$	$L_n/5$	$0.22L_n$	$0.3L_n$
7000	1000	1400	1540	2100
6000	860	1200	1320	1800
4500	640	900	990	1350
3500	500	700	770	1050

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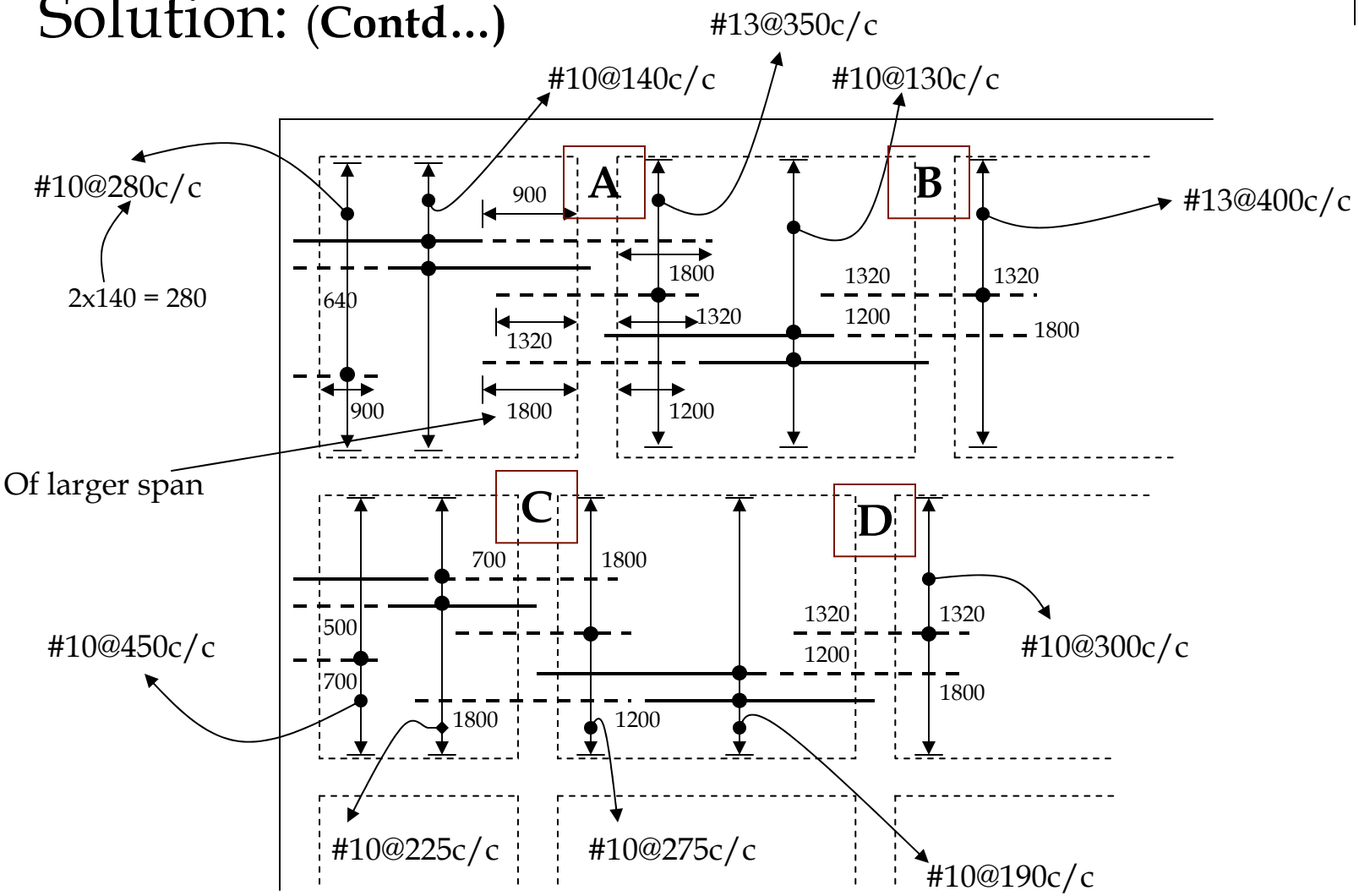
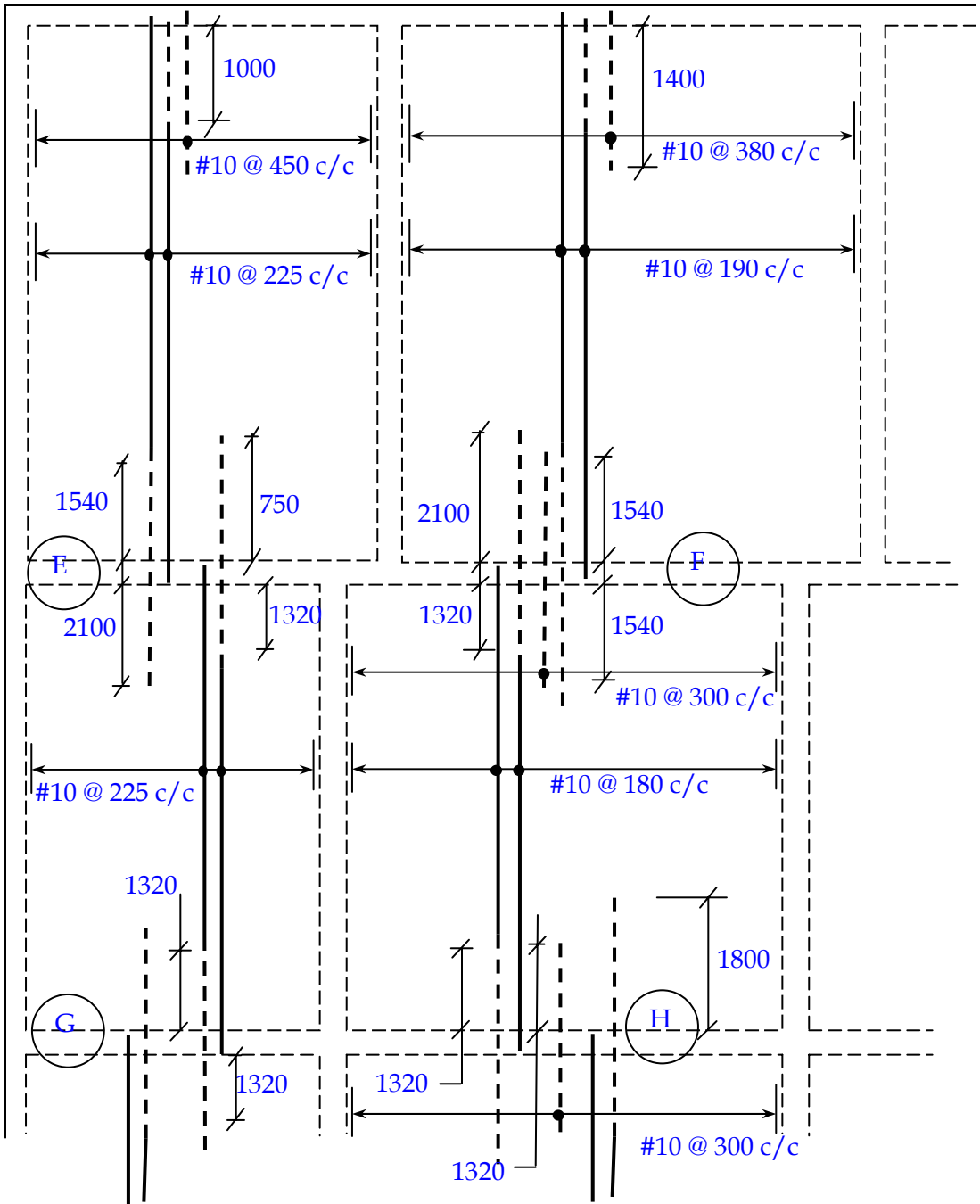
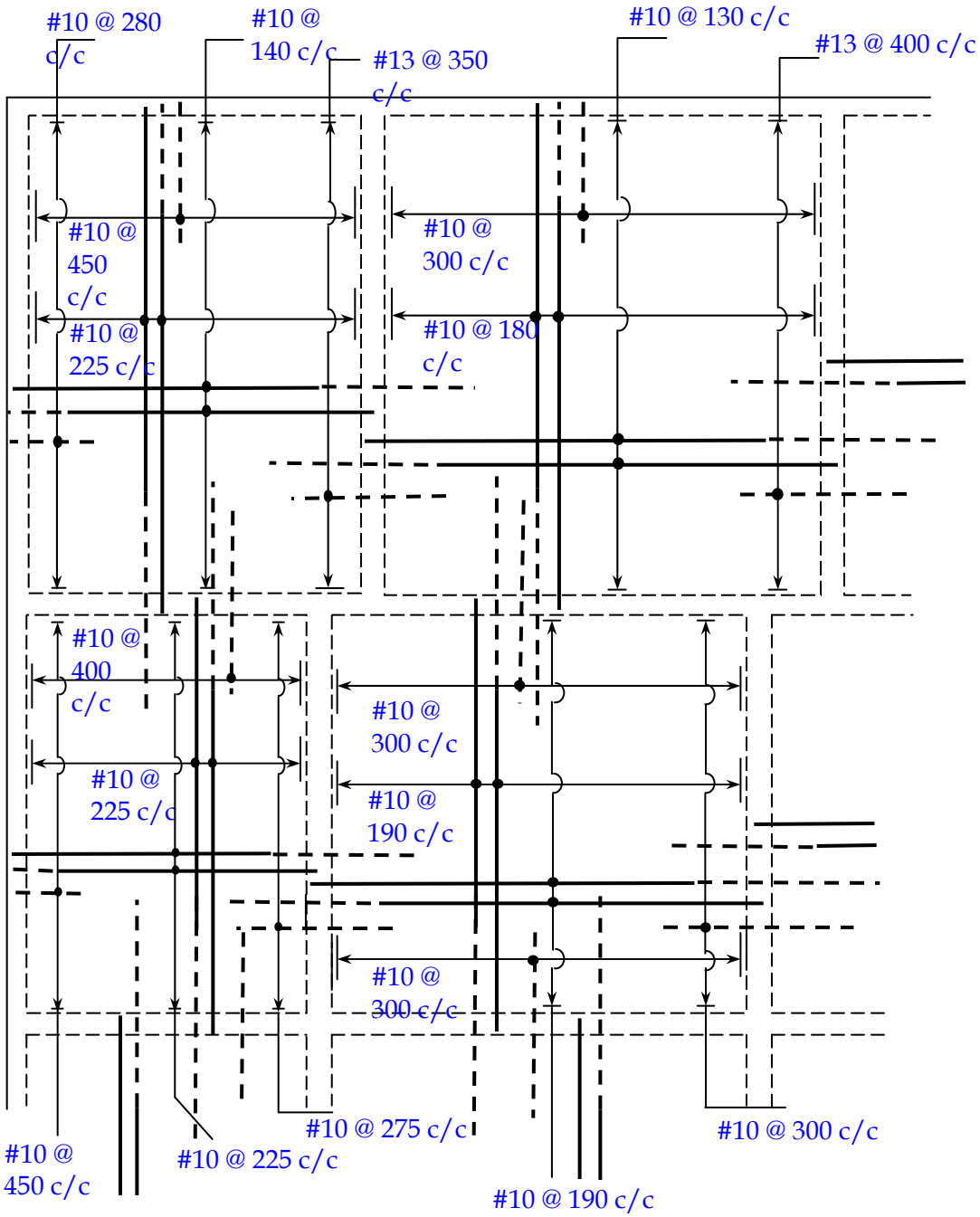
Solution: (Contd...)




1000
#10 @ 450 c/c
#10 @ 225 c/c
1400
#10 @ 380 c/c
#10 @ 190 c/c
1540
750
2100
E
1320
2100
1540
F
1320
1540
#10 @ 300 c/c
#10 @ 225 c/c
#10 @ 180 c/c
1320
1800
G
H
1320
1320
1320
#10 @ 300 c/c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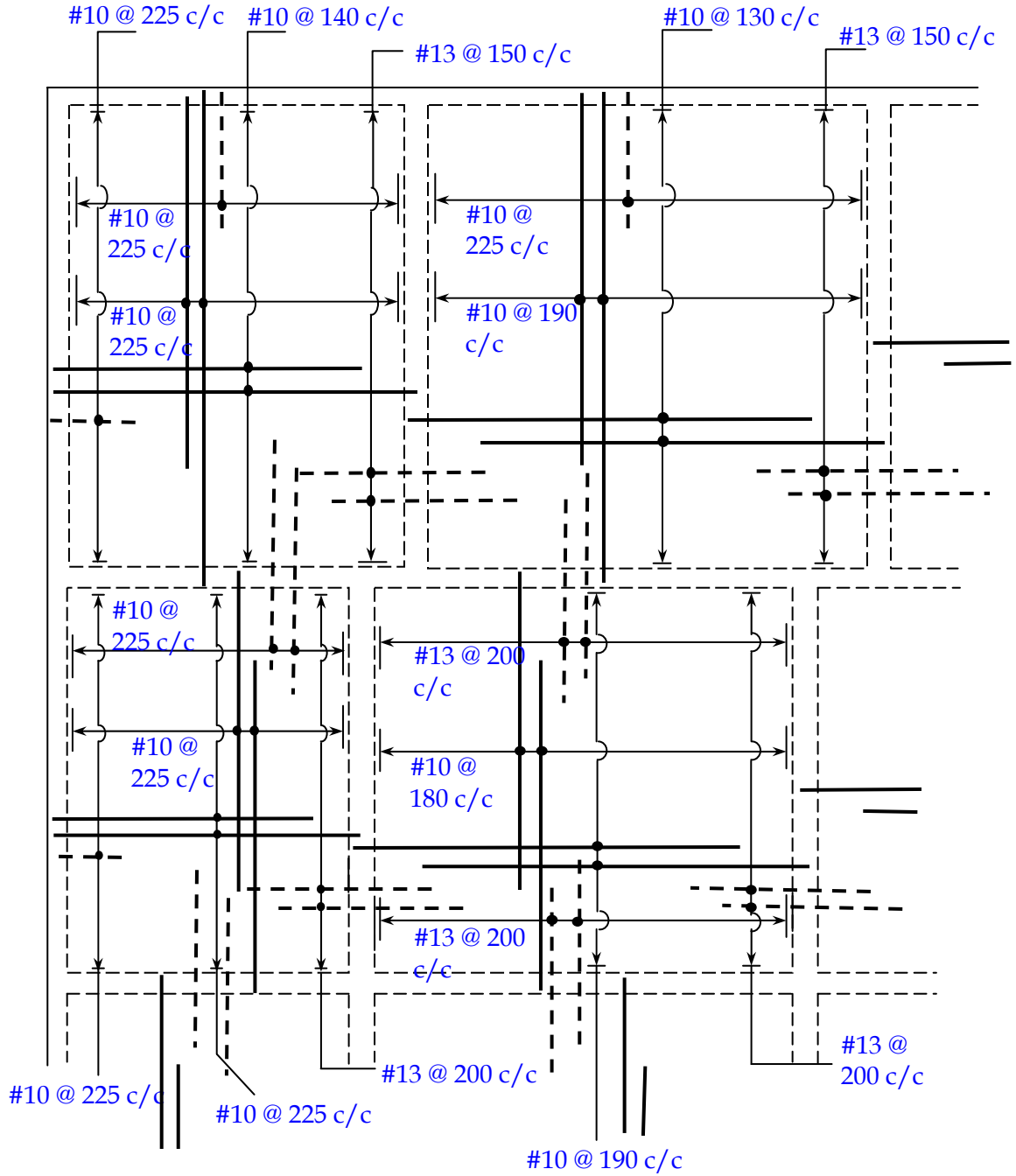
#13 @ 350 c/c
#10 @ 130 c/c
#13 @ 400 c/c
#10 @ 450 c/c
#10 @ 225 c/c
#10 @ 300 c/c
#10 @ 180 c/c
#10 @ 400 c/c
#10 @ 225 c/c
#10 @ 300 c/c
#10 @ 190 c/c
#10 @ 300 c/c
#10 @ 450 c/c
#10 @ 225 c/c
#10 @ 275 c/c
#10 @ 190 c/c
#10 @ 300 c/c


#10 @ 225 c/c
#10 @ 140 c/c
#13 @ 150 c/c
#10 @ 130 c/c
#13 @ 150 c/c
#10 @ 225 c/c
#10 @ 225 c/c
#10 @ 225 c/c
#10 @ 190 c/c
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#10 @ 225 c/c
#10 @ 180 c/c
#13 @ 200 c/c
#13 @ 200 c/c
#10 @ 225 c/c
#10 @ 225 c/c
#13 @ 200 c/c
#13 @ 200 c/c
#10 @ 190 c/c

Prof. Dr. Zahid Ahmad Siddiqi and Dr. Azhar Saleem

Assignment – Problems Chapter 6