MILITARY INSTITUTE OF SCIENCE AND TECHNOLOGY

Course Code : CE-316

DESIGN OF A DECK SLAB OF A CANTLEVER BRIDGE

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Design of a Cantilever Bridge

Design of Deck Slab

Given, Total span, $L = 300'$

$f_c' = 5$ ksi

$f_y = 60$ ksi

Let, No of Lane of bridge = 2 And minimum no of girder = 4

∴ Total width of bridge = $3.5' \times 2 + 12' \times 2 = 31'$

As the no of girder = 4; the spacing between them = 3

Let, Web width, $b_w = 18''$

$\therefore S_g = S = (31' - 3.5' \times 2 - \frac{18''}{12}) / 3 = 7.5'$

Slab thickness, $t_s = \frac{S_g}{12} = \frac{7.5 \times 12}{12} = 7.5'' \geq 7''$ ∴ OK.

Length Calculation:

$L = L_M + 2L_E = 1.4L_E + 2L_E = 3.4L_E$

$\Rightarrow 300 = 3.4L_E$

$\Rightarrow L_E = 88.2 \approx 90'$

$\therefore L_M = 1.4 L_E = 1.4 \times 90' = 126'$

$L_M = L_S + 2L_C = L_S + 2 \times 0.3 L_S = 1.6 L_S$

$\therefore L_S = 78.8' \approx 80'$

$\therefore L_C = 0.3 L_S = 0.3 \times 80' = 24'$

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$H = 0.07 L_s = 0.07 \times 80' = 5.6' = 67.2'' = 68''$

$H_p = 2H \quad [L < 350']$

$= 2 \times 68''$

$= 136''$

Load Calculation:

Slab thickness, $t_s = 7.5''$

$\therefore$ Self wt of slab, $W_{slab} = \frac{7.5''}{12} \times 150 = 93.75$ psf/ft width

$\pm M_{DL} = \pm \frac{W_{slab} \times S_g^2}{10} = \pm \frac{93.75 \times 7.5^2}{10} = 527.3$ lb-ft/ft

$\pm M_{WC} = \pm \frac{W_{WC} \times S_g^2}{10} = \pm \frac{30 \times 7.5^2}{10} = 168.8$ lb-ft/ft

$M_{LL} \rightarrow \frac{b_w}{2} = 9''$ [from table A4-1]

$+M_{LL} = 5.44$ K ft/ft

$-M_{LL} = 3.78$ K-ft/ft

$+M_{u\,service} = M_{DL} + M_{WC} + M_{LL} = \frac{527.3}{1000} + \frac{168.8}{1000} + 5.44 = 6.14$ Kft/ft

$\therefore + M_{u\,strength} = 1.25 M_{DC} + 1.5 M_{DW} + 1.75 M_{LL}$

$= 1.25 \times 527.3 + 1.5 \times 168.8 + 1.75 \times 5.44 \times 1000 = 10.43$ K-ft/ft

$\therefore - M_{u\,strength} = 1.25 M_{DC} + 1.5 M_{DW} + 1.75 M_{LL}$

$= 1.25 \times 527.3 + 1.5 \times 168.8 + 1.75 \times 3.78 \times 1000 = 7.58$ K-ft/ft

Control of Cracking Distribution of Reinforcement:

$d_c = 1 + \frac{5/8}{2} = 1.313''$ [Let, #5 bar is used]

$\beta_s = 1 + \frac{d_c}{.7(t_s - d_c)} = 1 + \frac{1.313}{.7(7.5 - 1.313)} = 1.303$

$f_{ss} = f_y \frac{M_{service}}{M_{strength}} = 60 \times \frac{6.14}{10.40} = 35.3$

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$$s \le \frac{700 \times \gamma_c}{\rho_s f_{ss}} - 2d_c = \frac{700 \times 1}{1.303 \times 35.3} - 2 \times 1.313 = 12.59'' \approx 12.5''$$

Reinforcement Calculation:

Positive Reinforcement:

$$A_s^+ = \frac{M^+_{strength}}{\phi f_y (d - a/2)} \quad ; \quad a = \frac{A_s f_y}{0.85 f_c' b}$$

$$= \frac{10.43 \times 12}{0.9 \times 60 \times (6 - \frac{a}{2})} \qquad = \frac{A_s \times 60}{0.85 \times 5 \times 12}$$

$$= 0.40 in^2 \qquad = 0.47 in$$

$d = 7.5 - 1.5 = 6''$

Spacing, $s = 12 \times .31 / 0.40 = 9.54'' \approx 9.5''$ c/c But we usually provide 6"~8" c/c

∴ #5 @ 7" c/c as positive bar.

Here $s = 7'' \le 12.5''$ ∴ Cracking Distribution is OK.

Negative Reinforcement:

$$A_s^- = \frac{M^-_{strength}}{\phi f_y (d - a/2)} \quad ; \quad a = \frac{A_s f_y}{0.85 \times f_c' b}$$

$$= \frac{7.53 \times 12}{0.9 \times 60 (6 - a/2)} \qquad = \frac{A_s \times 60}{0.85 \times 5 \times 12}$$

$$= 0.29 in^2 \qquad = 0.34 in$$

$d = 7.5 - 1.5 = 6''$

Spacing, $s = \frac{12 \times .31}{0.29} = 12.8'' \approx 12.5''$ c/c. But we usually provide 6"~8" c/c

∴ #5 @ 8" c/c as negative bar.

Here $s = 8'' \le 12.5''$ ∴ Cracking Distribution is OK.

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Shrinkage and Temperature Reinforcement:

$$\therefore A_{s,(Temp)} = \frac{1.3bt_s}{2(b+t_s)f_y} = \frac{1.3 \times 31 \times 12 \times 7.5}{2(31\times12+7.5)\times60} = 0.08\ in^2/ft$$

Limit: $0.11 \le A_s \le 0.6$ $\quad \therefore A_{s,Temp} = 0.11\ in^2/ft$

This reinforcement indicates the minimum steel needs to be provided.

Distribution Reinforcement:

$220/\sqrt{S_c} \le 67\%$ of main reinforcement (positive)

$$S_c = S_g - \frac{1}{2}b_w - \frac{1}{2}b_w = 7.5' - \frac{1}{2}\frac{18}{12} - \frac{1}{2}\frac{18}{12} = 6'$$

$220/\sqrt{S_c} = 220/\sqrt{6} = 89.8\% \le 67\%$ of $(+A_s)$

$$\therefore A_{s(Distribution)} = \frac{67}{100} \times 0.4\ in^2/ft = 0.27\ in^2/ft$$

$$\therefore \text{Spacing}, s = \frac{12\times0.2}{0.27} = 8.88 \approx 8.5''\ c/c$$

$\therefore$ #4 @ 8.5" c/c as distribution bar.

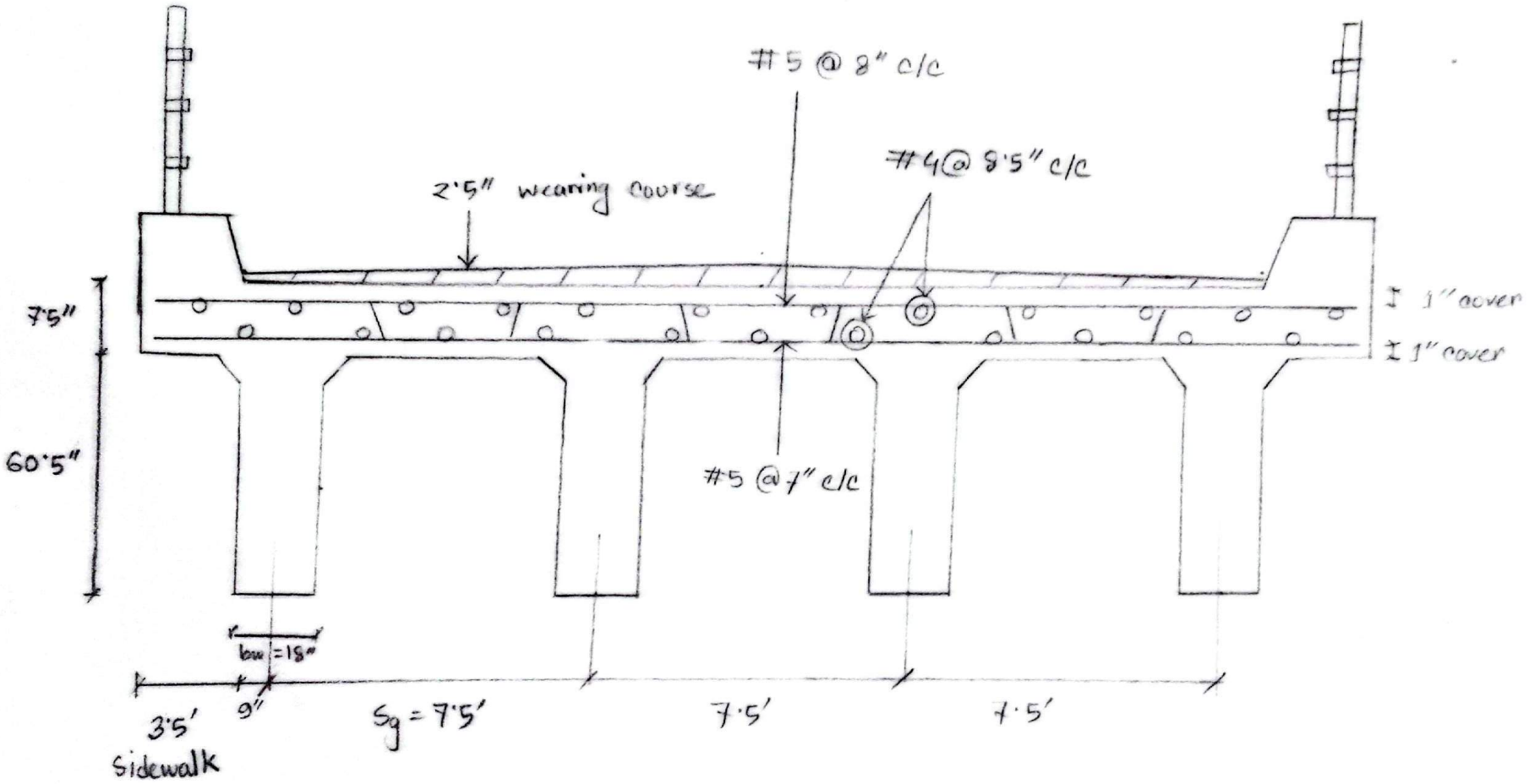


fig: Reinforcement detailing of deck slab