University of Technology
Building and Construction Eng. Dept.
Final Exam – 2012/2013

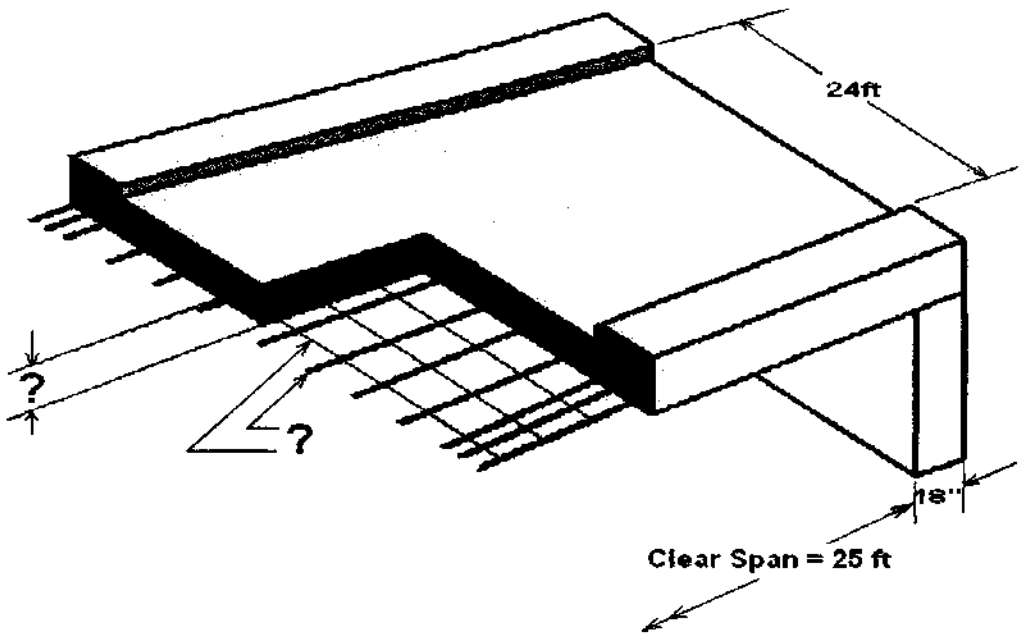
Branch :Roads & Bridges Eng. Class:4th
subject :Design of Concrete Bridges Time : 3 Hours
Examiner: Assist. Prof. Alaa Darwish Date : 17 / 06/ 2013

Open books and notes exam. Answer **4** questions only.
Start each answer with a new page. All questions will have similar evaluation degrees.

Q1: Design Slab thickness, main and secondary reinforcement of the slab bridge shown bellow. Taking into account that:-

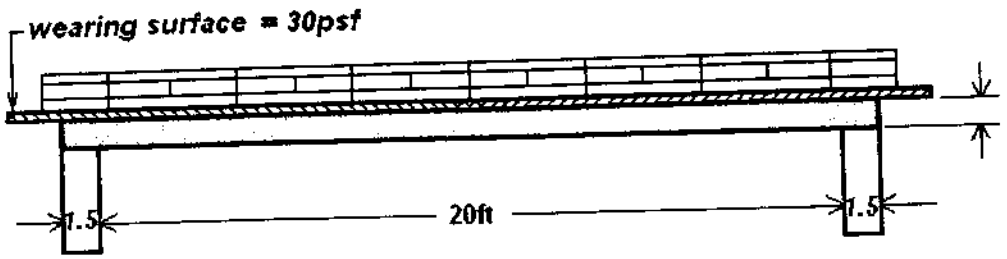
- Live loading Standard AASHTO Truck HS20.
- Clear Bridge Span = 25ft.
- f'_c = 4000psi.
- f_y = 50000psi.
- Wearing surface weight = 20psf.

Detailed drawing is required as a part of the complete answer.



Q2: Under the Military loading (Vehicle class 100), design the required thickness and Reinforcement of the Slab bridge shown below.

Use f'_c = 5000 psi and f_y = 60000 psi.

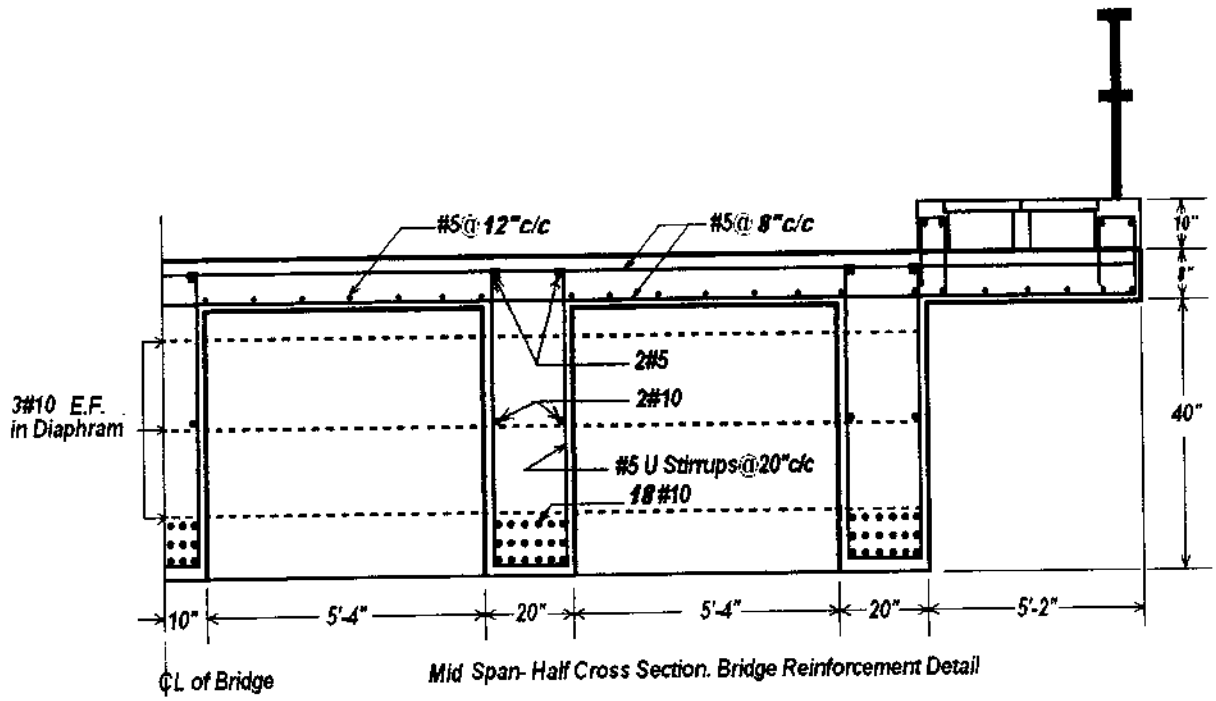


Q3: Redraw the half cross section of the Deck- Girder Bridge shown below after changing the reinforcement as follows:

1- The main and the secondary deck slab reinforcement from #5 to #4.

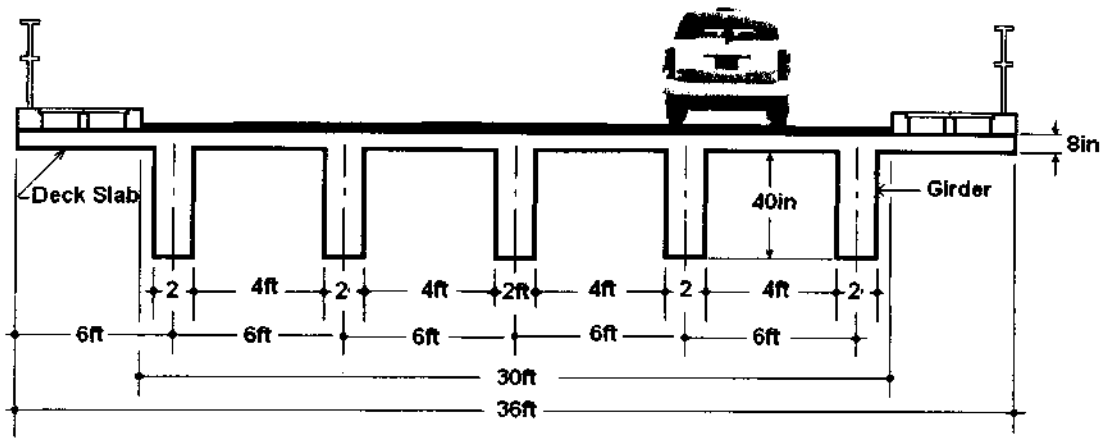
2- The main reinforcement of the Girder from # 10 to # 14.

3- The Shear reinforcement of the Girder from #5 to #3.

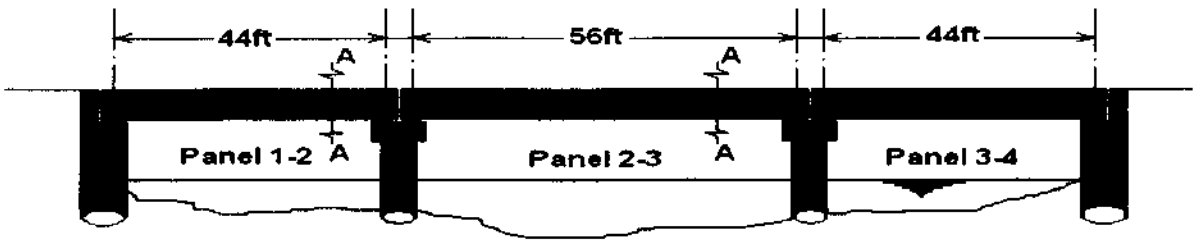


Mid Span- Half Cross Section. Bridge Reinforcement Detail

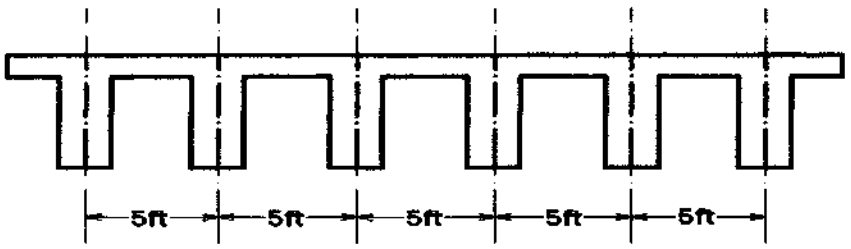
- Q4: Calculate the weight of the super structure of the deck girder bridge shown in the figure below, taking into account that the total length of the bridge is 30m and the Wearing surface weight is 25 psf.



Q5: Design the first panel (1-2) of the deck girder bridge shown below. Taking into account that; it should sustain the abnormal Loading of the military vehicle class 100. Use materials having the following properties: 1- Concrete of an ultimate compressive strength of f'_c = 6,000 psi. 2- Steel of a yield strength of f_y = 60,000 psi. Detailed drawings are required as a part of the complete answer.



Longitudinal Section



Cross Section AA

Deck- Girder Bridge

الاجوبة النموذجية - الامتحان النهائي - 2013

A1) Assume slab thickness = 16 in

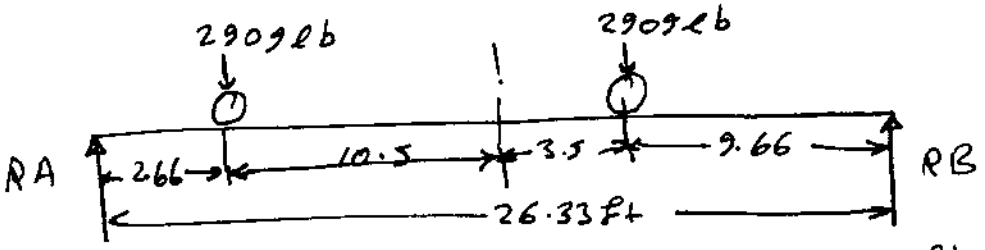
$D_L = 150 \times \frac{16}{12} + 20 = 220$ psf

Effective span $= 25 + \frac{16}{12} = 26.33$ ft

$M_{DL} = 220 \times (26.33)^2/8 = 19065$ ft.lb

$E = 16000/5.5 = 2909$ lb

M_L, Either $= 2909 \times 26.33/4 = 19150$ ft.lb or



$26.33\,RB = 2909(2.66 + 16.66) \Rightarrow RB = 2135$ lb

$M_L = 2135 \times 9.66 = 20620$ ft.lb

$M_T = 19065 + 1.3 \times 20620 = 45870$ ft.lb

$$d_{req} = \sqrt{\frac{2 \times 45870 \times 12}{1600 \times 0.338 \times 0.887 \times 12}} = 13.83 \text{ in}$$

$d_{eff} = 16 - 1.5 = 14.5$ in ✓ O.K.

$$A_s = \frac{45870 \times 12}{25000 \times 0.887 \times 14.5} = 1.72 \text{ in}^2/\text{ft}$$

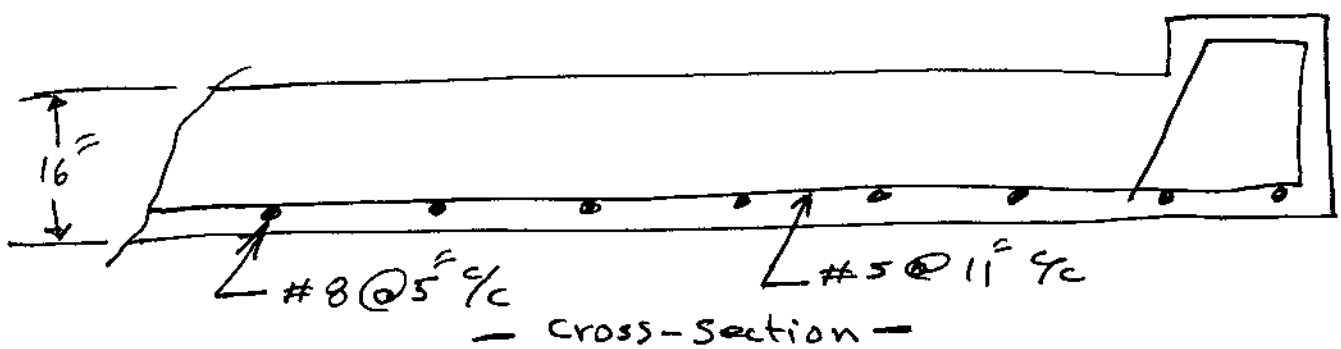
Spacing $= 0.79/1.72 = 0.46$ ft $\Rightarrow 5.5$ in

Use #8@5" c/c

$\frac{A_s}{\sqrt{26.33}} = 0.335$ in²/ft

spacing $= 0.31/0.335 = 0.925$ ft $= 11.1$ in

Use #5@11" c/c



— Cross-Section —

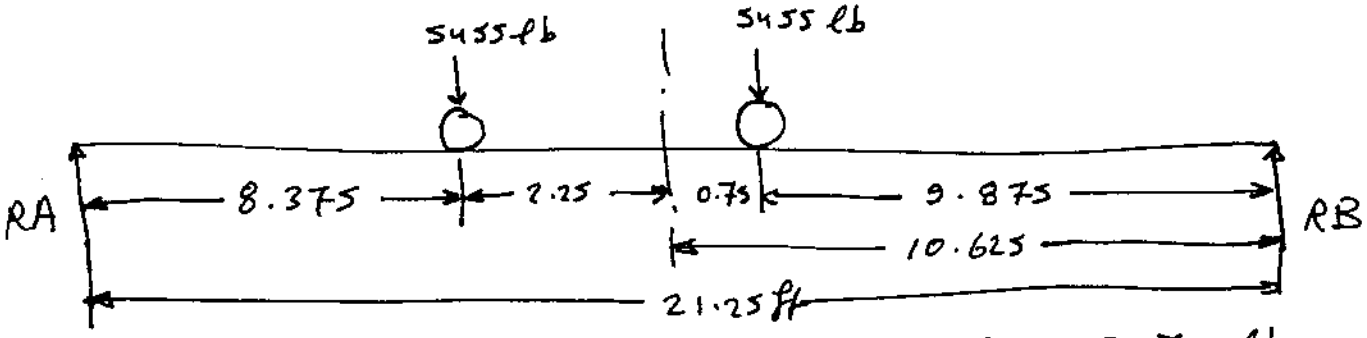
A2) Assume slab thickness = 15 in

DL = $150 \times \frac{15}{12} + 30 = 217.5$ psf

Effective span = $20 + \frac{15}{12} = 21.25$ ft

Md = $217.5 \times (21.25)^2/8 = 12277$ ft.lb

E = $30000/5.5 = 5455$ lb



$21.25\,RB = 5455(8.375 + 11.375) \longrightarrow RB = 5070$ lb

ML = $5070 \times 9.875 = 50066$ ft.lb

MT = $12277 + 1.37 \times 50066 = 80867$ ft.lb

$n = \frac{29\,000\,000}{57000\sqrt{5000}} = 7.2$

$f_s = 0.75 \times 60000 = 45000$ psi

$f_c = 0.73 \times 5000 = 3650$ psi

$r = \frac{45000}{3650} = 12.33$

$k = \frac{7.2}{7.2 + 12.33} = 0.37$

$j = 1 - \frac{0.37}{3} = 0.877$

$d_{req} = \sqrt{\frac{2 \times 80867 \times 12}{3650 \times 0.37 \times 0.877 \times 12}} = 11.7$ in

$d_{eff} = 15 - 1.5 = 13.5$ in ✓ O.k.... [Thickness = 15 in]

$A_s = \frac{80867 \times 12}{45000 \times 0.877 \times 13.5} = 1.8214$ in²/ft

Spacing = $0.79/1.8214 = 0.434$ ft = 5.2 in

Use #8 @ 5" c/c ---------- [Main Reinforcement]

$\frac{A_s}{\sqrt{21.25}} = 0.3952$ in²/ft

Spacing = $0.31/0.3952 = 0.784$ ft = 9.4 in

Use #5 @ 9" c/c ---------- [Secondary Reinforcement]

A3) 1-) $\text{Spacing} = \frac{Ab}{As} \Longrightarrow As = \frac{Ab}{\text{spacing}}$

Area of secondary Rein $= \frac{0.31}{12/12} = 0.31 \text{ in}^2/\text{ft}$

New spacing $= \frac{0.2}{0.31} = 0.645 \text{ ft} = 7.7 \text{ in}$

$\therefore$ Use #4 @ 7" c/c

Area of Main Rein. $= \frac{0.31}{8/12} = 0.465 \text{ in}^2/\text{ft}$

New spacing $= \frac{0.2}{0.465/12} = 5.16 \text{ in}$

$\therefore$ Use #4 @ 5" c/c

2-) The Area of Main Rein of the Girder $= 18 \times 1.27 = 22.86 \text{ in}^2$

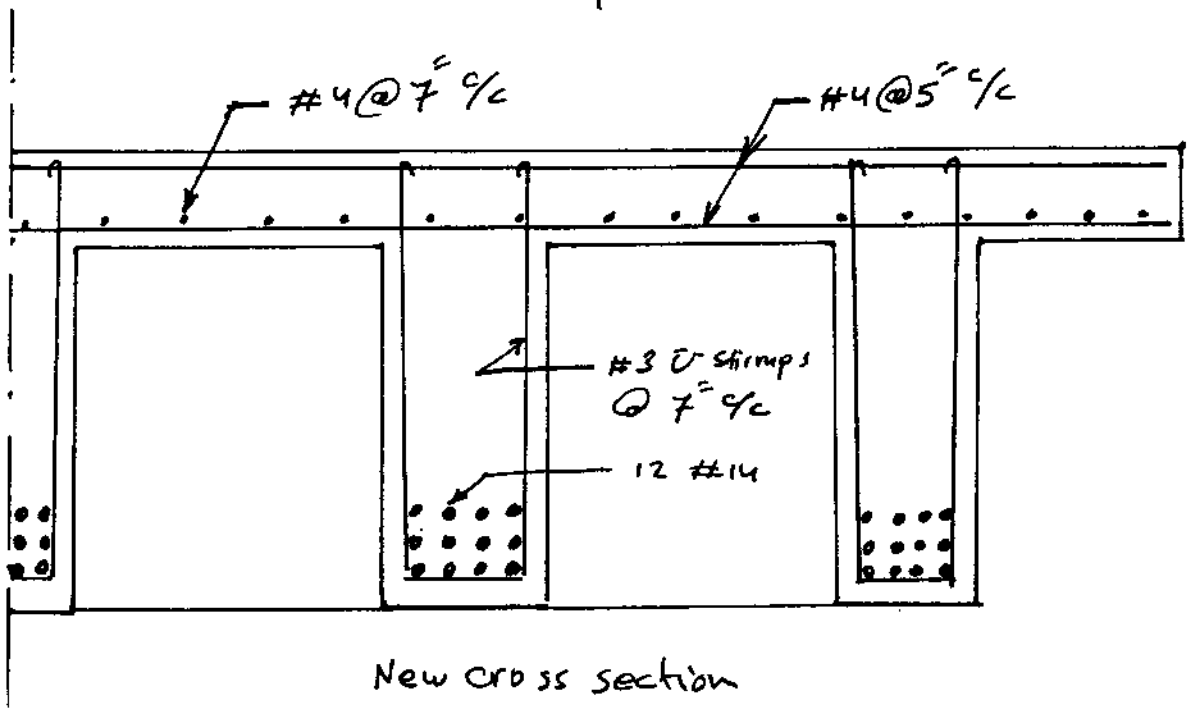
New Number of #14 bars $= \frac{22.86}{2.25} = 10.16 \text{ bars}$

$\therefore$ Use 12 #14

3-) New spacing of shear Rein of the Girder is

$\frac{0.11}{0.31} \times 20 = 7.1 \text{ in}$

$\therefore$ Use #3 U stirrups @ 7" c/c



New cross section

A4)

1 ft = 0.3048 m

30m = 98.425 ft

1- Wearing surface weight :

$30 \times 98.425 \times 25 = 73819$ lb

2- Weight of Deck-Slab :

$\frac{8}{12} \times 36 \times 98.425 \times 150 = 354330$ lb

3- Weight of Girders :

$5 \times 2 \times \frac{40}{12} \times 98.425 \times 150 = 492125$ lb

∴ Total Weight = 73819 + 354330 + 492125

= 920274 lb

A5) Assume Girder width = 15 in and slab thickness = 7 in

$S_s = 5 - 1.25 = 3.75$ ft

$DL = 150 \times \frac{7}{12} + 15 = 103$ psf

$M_{dl} = (103 \times 3.75^2)/10 = 145$ ft.lb

$M_L = 0.8 \frac{3.75+2}{32} \times 30000 = 4313$ ft.lb

Impact factor $I = 0.346$

$M_T = 145 + 1.346 \times 4313 = 5925$ ft.lb

$f_s = 45000$ psi & $f_c = 0.73 \times 6000 = 4380$ psi

$n = 6.57$ & $r = 10.27$ & $k = 0.39$ & $j = 0.87$

$$d_{req.} = \sqrt{\frac{2 \times 5925 \times 12}{4380 \times 0.39 \times 0.87 \times 12}} = 2.83 \text{ in}$$

$d_{ava.} = 7 - 1 - 1 - \frac{5}{16} = 4.6$ in $\Longrightarrow$ O.K.

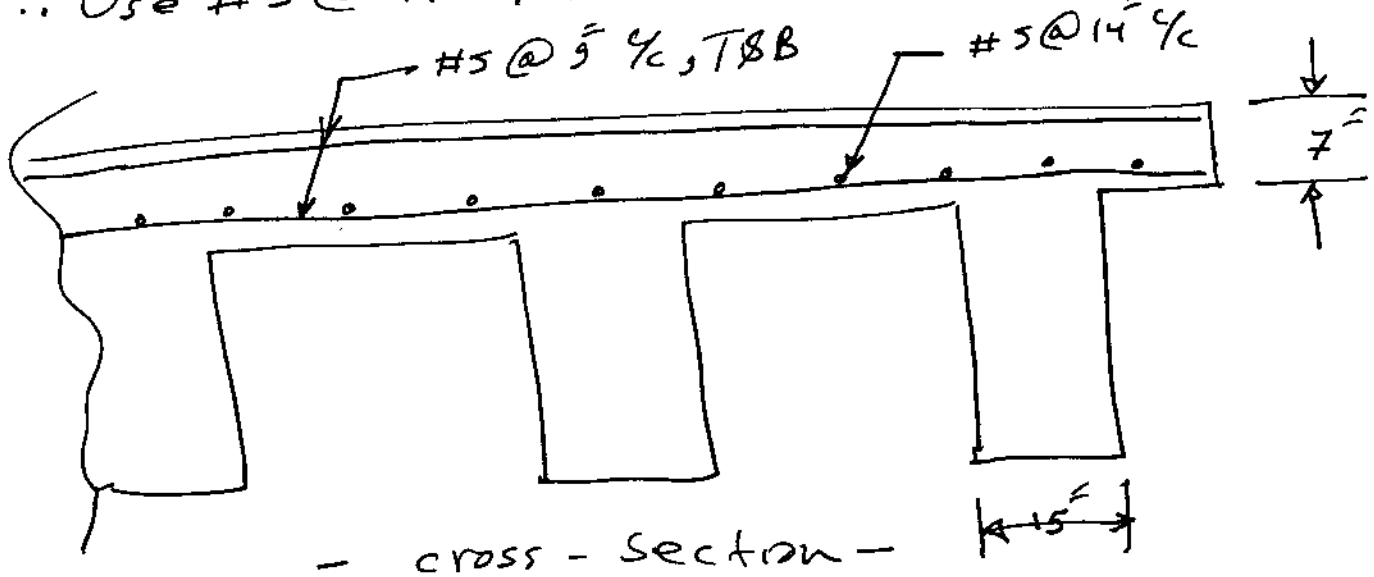
$$A_s = \frac{5925 \times 12}{45000 \times 0.87 \times 4.6} = 0.4 \text{ in}^2/\text{ft}$$

$$\text{Spacing} = \frac{0.31}{0.4} = 0.775 \text{ ft} = 9.3 \text{ in}$$

∴ Use #5 @ 9" c/c, T & B.

For secondary Rein. use 67 %:

∴ Use #5 @ 14" c/c



– cross - section –