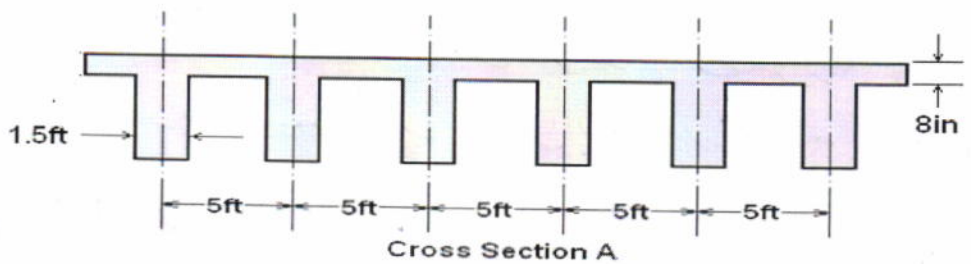
University Of Technology
Building & Construction Eng. Dept.
Final Exam – 2013/ 2014

Branch : Roads & Bridges Eng. **Class:** 4
subject : Design of Concrete Bridges **Time :** 3 Hours
Examiner: Assist. Prof. Alaa Darwish **Date :** 02/ 06/ 2014

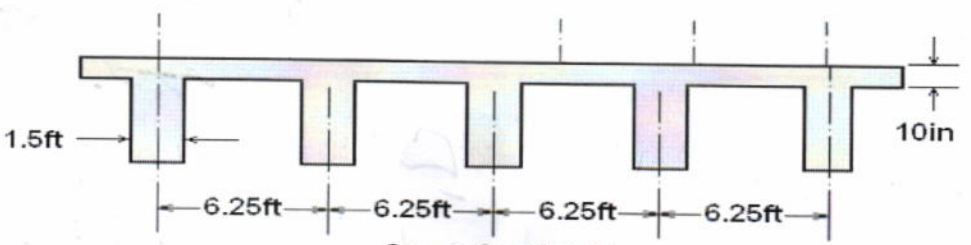
Open books and notes exam
Answer 3 questions only
Start the answer of each question with a new page

Q1: It is required to design a Deck-Girder Bridge of an effective span of 60 ft. The first designer suggests the use of 6 supporting girders whereas the Second prefers to use 5 girders only. To reach the final decision it is required to **design the main and the secondary reinforcement for the Deck Slab** of the two cases shown below.

Live Loading AASHTO Standard Truck HS20
Wearing Surface = 30 psf
f_c = 5000 psi
f_y = 60000 psi



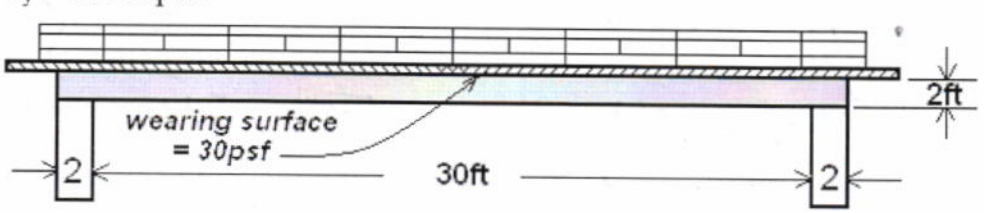
Cross Section A



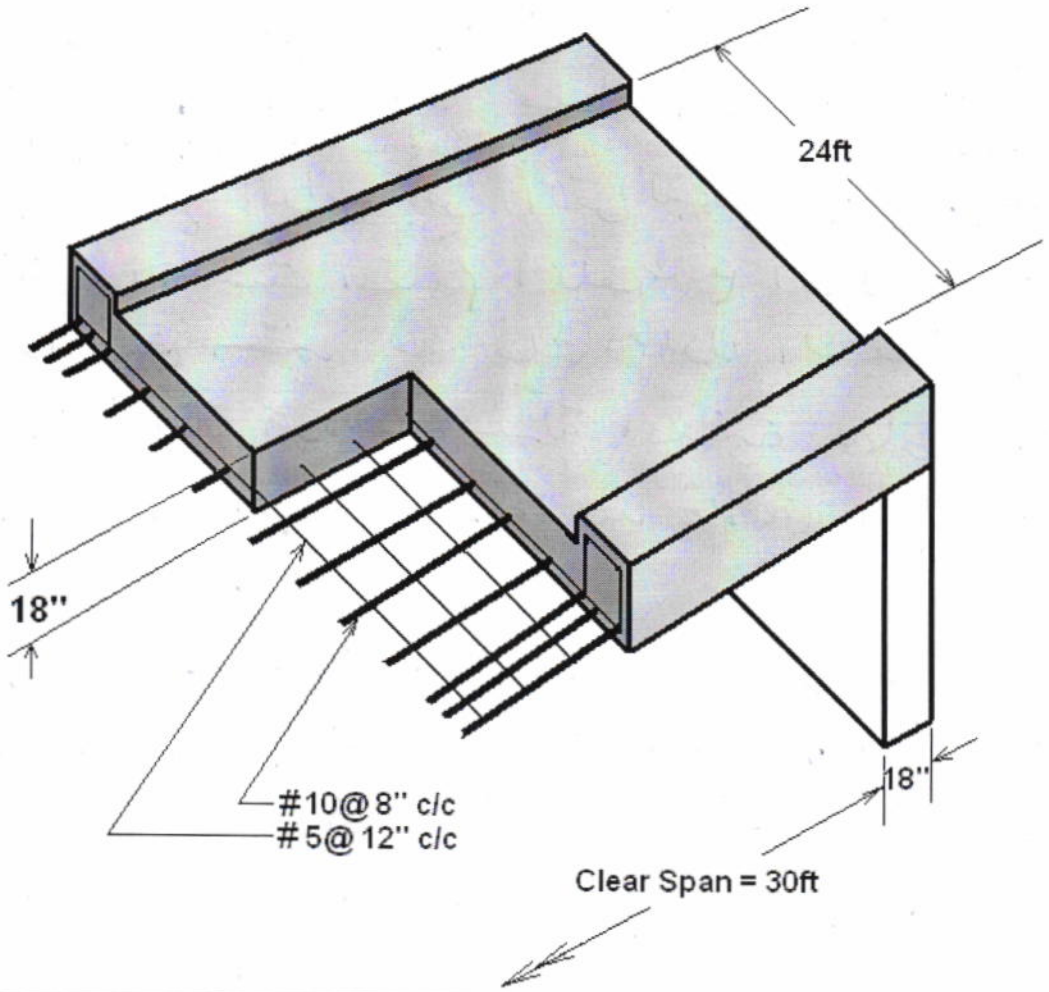
Cross Section B

Q2: Design the required main reinforcement for the slab bridge shown below, taking into account that:

- Live loading HS20 Standard Truck.
- Clear width 22ft
- f'_c = 5000psi.
- f_y = 60000psi.

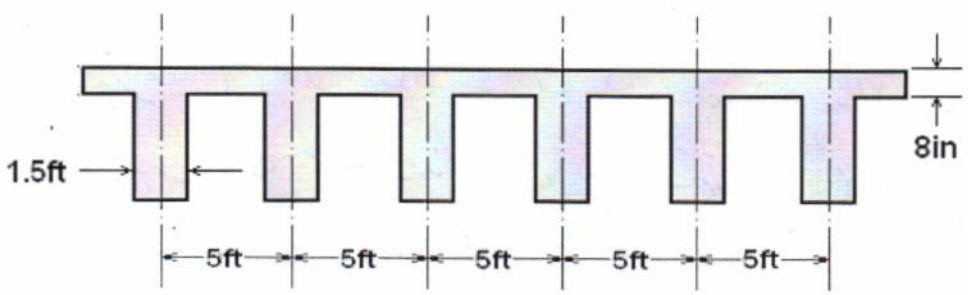


Q3: Redesign the main reinforcement of the slab bridge shown in the Figure bellow. Taking into account that steel bars #8 should be used instead of bars #10 & #4 instead of bars #5.



Q4: Design the required main reinforcement for the interior girders of the Deck-Girder Bridge shown below. Taking into account that:

- Live loading HS20 Standard Truck, Wearing Surface = 30 psf.
- Clear Span 65ft.
- $f'_c = 6000$psi.
- $f_y = 60000$psi.



Typical Answers
Design of R.C. Bridges – 4th year

A1: Design of the first Deck-Girder slab.

Slab span = $5 - 1.5 = 3.5$ ft

$DL = 150 \times \frac{8}{12} + 30 = 130$ psf

$M_{dl} = \frac{130 \times 3.5^2}{10} = 160$ ft.lb

$M_L = 0.8 \frac{3.5+2}{32} \times 16000 = 2200$ ft.lb

$M_T = 160 + 1.3 \times 2200 = 3020$ ft.lb

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

$r = \frac{30\,000}{2000} = 15$

$k = \frac{7.2}{7.2+15} = 0.324$

$j = 1 - \frac{0.324}{3} = 0.9$

$d_{req.} = \sqrt{\frac{2 \times 3020 \times 12}{2000 \times 0.324 \times 0.9 \times 12}} = 3.2$ in $\Longrightarrow$ O.K.

$d_{ava.} = 8 - 1 - \frac{5}{16} - 1 = 5.6$ in

$A_s = \frac{3020 \times 12}{30000 \times 0.9 \times 5.6} = 0.24$ in^2/ft

Spacing $= \frac{0.31}{0.24} = 1.29$ ft $= 15.5$ in

Use #5 @ 15" c/c, T & B.

Design of the Second Deck-Girder slab.

slab span = $6.25 - 1.5 = 4.75$ ft

$DL = 150 \times \frac{10}{12} + 30 = 155$ psf

$Md = \frac{155 \times 4.75^2}{10} = 350$ ft.lb

$ML = 0.8 \frac{4.75 + 2}{32} \times 16000 = 2700$ ft.lb

$MT = 350 + 1.3 \times 2700 = 3860$ ft.lb

$n = 7.2$, $r = 15$, $k = 0.324$, $j = 0.9$

$d_{req.} = \sqrt{\frac{2 \times 3860 \times 12}{2000 \times 0.324 \times 0.9 \times 12}} = 3.65$ in $\Rightarrow$ o.k.

$d_{ava.} = 10 - 1 - \frac{5}{16} - 1 = 7.6$ in

$A_s = \frac{3860 \times 12}{30000 \times 0.9 \times 7.6} = 0.226$ in^2/ft

Spacing $= \frac{0.31}{0.226} = 1.37$ ft $= 16.46$ in

Use #5@16" c/c, T&B.

A2: Clear span = 30 ft

Effective span = 32 ft

$DL = 150 \times \frac{24}{12} + 30 = 330$ psf

$Md = \frac{330 \times 32^2}{8} = 42240$ ft.lb

Wheel load = 16000 lb

$E = 4 + 0.06 \times 32 = 5.92$ ft

$L.L/ft = \frac{16000}{5.92} = 2702$ lb

$ML = 900 S = 900 \times 32 = 28800$ ft.lb

$I = \frac{50}{32+125} = 0.31 \Rightarrow$ Use 0.3

$MT = 42240 + 1.3 \times 28800 = 79680$ ft.lb

$n = 7.2$, $r = 15$, $K = 0.324$, $j = 0.9$

$$d = \sqrt{\frac{2 \times 79680 \times 12}{2000 \times 0.324 \times 0.9 \times 12}} = 16.5 \text{ in} \Rightarrow \text{O.K.}$$

$d_{ava.} = 24 - 1 - \frac{1}{2} = 22.5$ in

$$A_s = \frac{79680 \times 12}{30000 \times 0.9 \times 22.5} = 1.574 \text{ in}^2/\text{ft}$$

$$\text{Spacing} = \frac{0.79}{1.574} = 0.5 \text{ ft} = 6.0 \text{ in}$$

Use #8 @ 6" c/c

A3: Main Reinforcing Area = $\frac{Ab}{spacing}$

$$= \frac{1.27}{\left(\frac{8}{12}\right)} = 1.9 \text{ in}^2/\text{ft}$$

By using #8 bars, the spacing will be:

$$\frac{0.79}{1.9} = 0.415 \text{ ft} = 4.98 \text{ ft}$$

Use #8 @ 4" c/c instead of
#10 @ 8" c/c

Secondary Reinforcing Area

$$= \frac{0.31}{1} = 0.31 \text{ in}^2/\text{ft}$$

By using #4 bars, the secondary spacing will be:

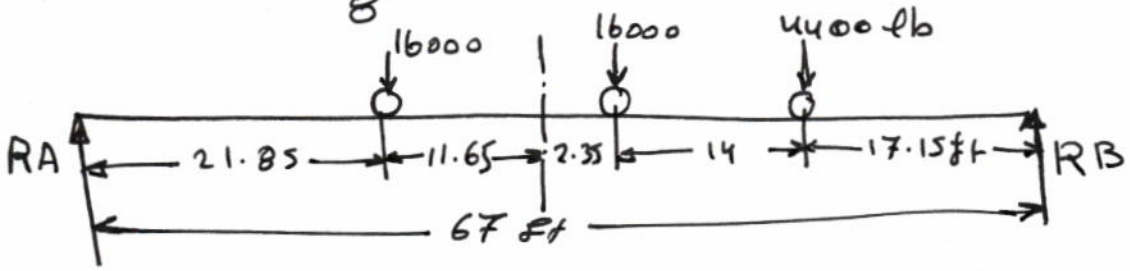
$$\frac{0.2}{0.31} = 0.645 \text{ ft} = 7.74 \text{ in}$$

Use #4 @ 7" c/c instead of
#5 @ 12" c/c.

A4: Girder Span = 65 + 2 = 67 ft

$DL = (1 \times 5\frac{8}{12} + 1.5 \times 1 \times 3) \times 150 + 30 \times 5 = 1325$ lb/ft

$M_d = \frac{1325 \times 67^2}{8} = 743490$ ft.lb



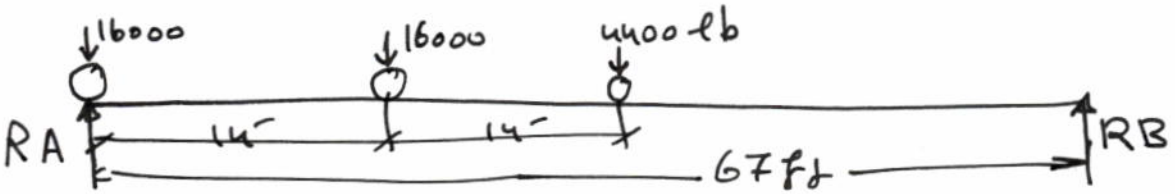
$RB = \frac{16000(21.85 + 35.85) + 4400 \times 49.85}{67} = 17053$ lb

$M_{L\max} = 17053 \times 31.15 - 4400 \times 14 = 469600$ ft.lb

$I = \frac{50}{67 + 125} = 0.26$

$M_T = 743490 + 1.26 \times 469600 = 1,335,381$ ft.lb

$V_{d\max} = 1327 \times \frac{67}{2} = 44388$ lb



$V_{L\max} = RA = \frac{16000 \times 67 + 16000 \times 53 \times 4400 \times 39}{67} = 31218$ lb

$V_{T_{max}} = 44388 + 1.26 \times 31218 = 83722$ lb

$v = 2.95\sqrt{6000} = 228$ psi

$b_w = 18$ in

$d_{req.} = \frac{367}{18} = 20.4$ in

$h_{req.} = 20.4 + \frac{9}{16} + 2 + \frac{9}{8} + 2.5 = 26.6$ in

$d_{ava.} = 43 - 2.5 - \frac{9}{8} - 2 - \frac{9}{16} = 36$ in

$A_s = \frac{1335381 \times 12}{30000(36 - 7/2)} = 16.5$ in^2

Use 18 #9, Three layers.