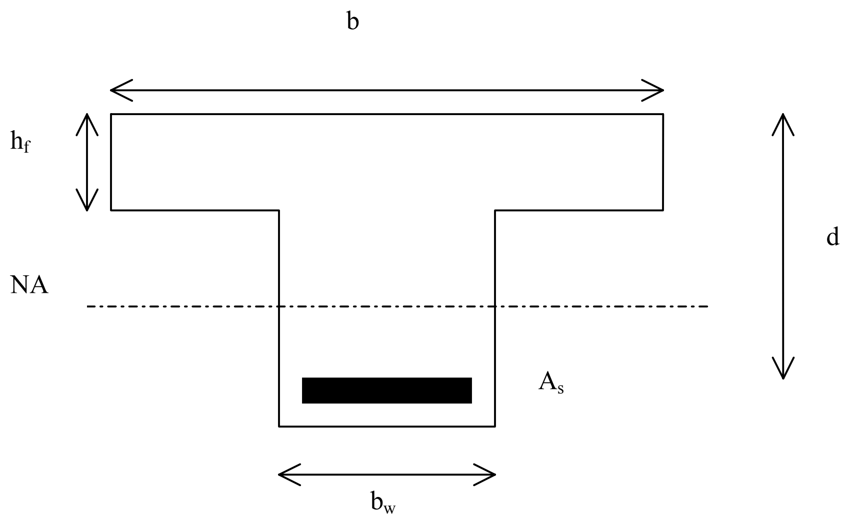
RECITATION 3

Example 1 (Evaluate Stirrup Spacing for Different Shear Loads)



Given $f_c^{'} = 3000$ psi
$f_y = 60{,}000$ psi
$A_v = 0.22\ in^2$ (#3 stirrup) → $\Pi(3/8)^2/4$ x 2 legs

b = 30”
d = 16.5”
b_w = 10”
$\phi = 0.85$ for shear design

Case 1: $V_u = 12$ kips
Case 2: $V_u = 36$ kips
Case 3: $V_u = 42$ kips

Equations to be used:

$$V_c = 2\sqrt{f_c^{'}}b_w d$$

$$s = d/2; \quad s = \frac{A_w f_y}{50 b_w}$$

$$V_s = \frac{V_u}{\phi} - V_c$$

$V_c = 2\,(3000)^{1/2}.10.(16.5) = 18.1$ kips

$\phi V_c/2 = 0.85$ x 18.1 / 2 = 7.7 kips

Case 1

$V_u > \phi V_c/2$; since 12 > 7.7
But
$V_u < \phi V_c$ since 12 < 15.4

Therefore, use minimum reinforcement, spacing is the smallest of

s = d/2 = 16.5/2 = 8.25”, $s = A_v f_y/(50 b_w)$ = 0.22 (60000) / (50 x 10) = 26.4”, s = 24”

Choose s = 8.25” → theoretical

Provide s = 8” → practical

Case 2

$V_u > \phi V_c$ since 36 > 15.4

$V_s = V_u/\phi - V_c = 36/0.85 – 18.1 = 24.3$ kips

and

$s = A_v f_y d/V_s = 0.22 \times 60 \times 16.5 / 24.3 = 8.96$”

But need to check if $V_s \le 4\sqrt{f_c'}\, b_w d = 4\,(3000)^{1/2} . 10 . (16.5) = 36.1$ kips > 24.3

Therefore, $s_{max} = A_v f_y/50 b_w = 26.4$” or $s_{max} = d/2 = 8.25$” < 24”

→ s = 8.25”

Therefore, provide s = 8” as before

For V_u = 12 or 36 kips
Provide the same stirrup arrangement!!!

Case 1: For safety reason
Case 2: For need-based reason

Case 3

V_u = 42 kips

$V_s = V_u/\phi - V_c = 42/0.85 – 18.1 = 31.3$ kips < $4\sqrt{f_c'}\, b_w d = 36.1$ kips

Therefore, provide $s = \frac{A_v f_y d}{V_s} = \frac{0.22 \times 60 \times 16.5}{31.3} = 6.96''$

Need to check

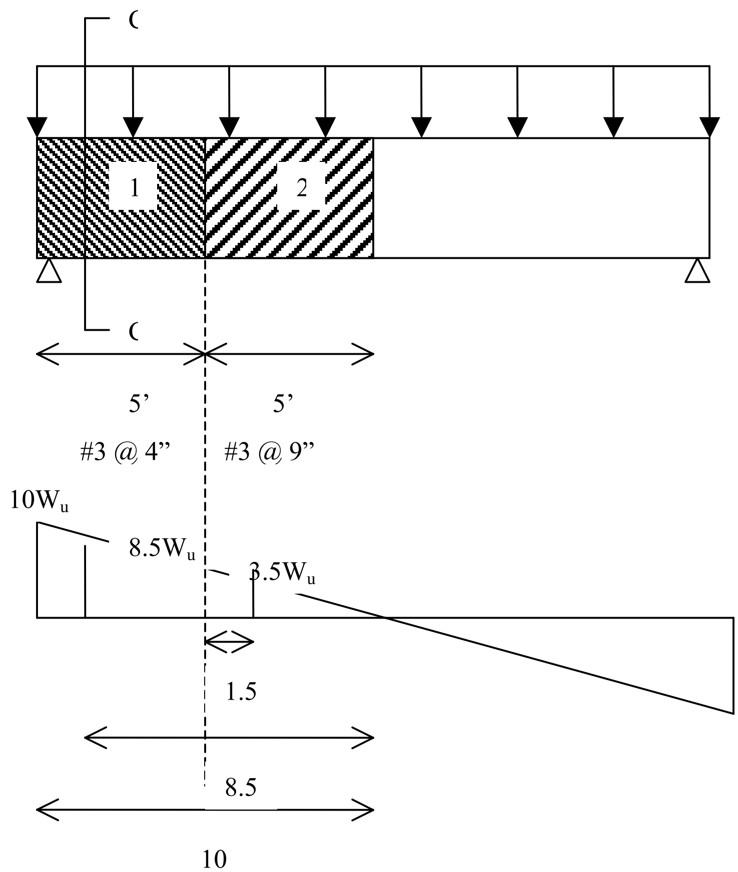
$$s_{\max} = \frac{A_v f_y}{50 b_w} \; or \; \frac{d}{2} \; or \; 24''$$

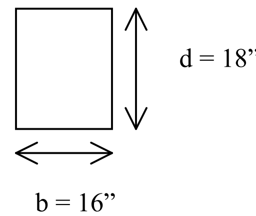
Therefore, s = 6.96" controls

Provide s = 6.5"

Example 2 (Determine Maximum Load Based on Shear Design)

Given:





L = 20'
f_y = 60,000 psi
f_c' = 3000 psi
C-C = critical section (next to support with compression)

$\phi = 0.85$

Region 1

Check V_c

$V_c = 2\sqrt{f_c'}\ b_w d = 2 \times (3000)^{1/2}\ 16\ .\ 18 = 31.55$ kips

Find V_s

$V_s = A_v f_y d / s = 0.22\ (60)\ (18) / 4 = 59.4$ kips

Find V_u

$V_u = \phi\ (V_c + V_s) = 0.85\ (31.55 + 59.4) = 77.3$ kips

Find W_u allowed

At the critical section $V_u = 8.5\ W_u$
Therefore, $W_u = 77.3 = 9.1$ kips/ft

Region 2

$V_c = 31.55$ kips (same)

$V_s = A_v f_y d / s = 59.4 \;.\; (4/9) = 26.4$ kips

$V_u = \phi\ (V_c + V_s) = 0.85\ (31.55 + 26.4) = 49.3$ kips

Find W_u allowed

At the transition, the interface will be taken care of by the last stirrup in Region (1). Therefore, consider d from the interface.

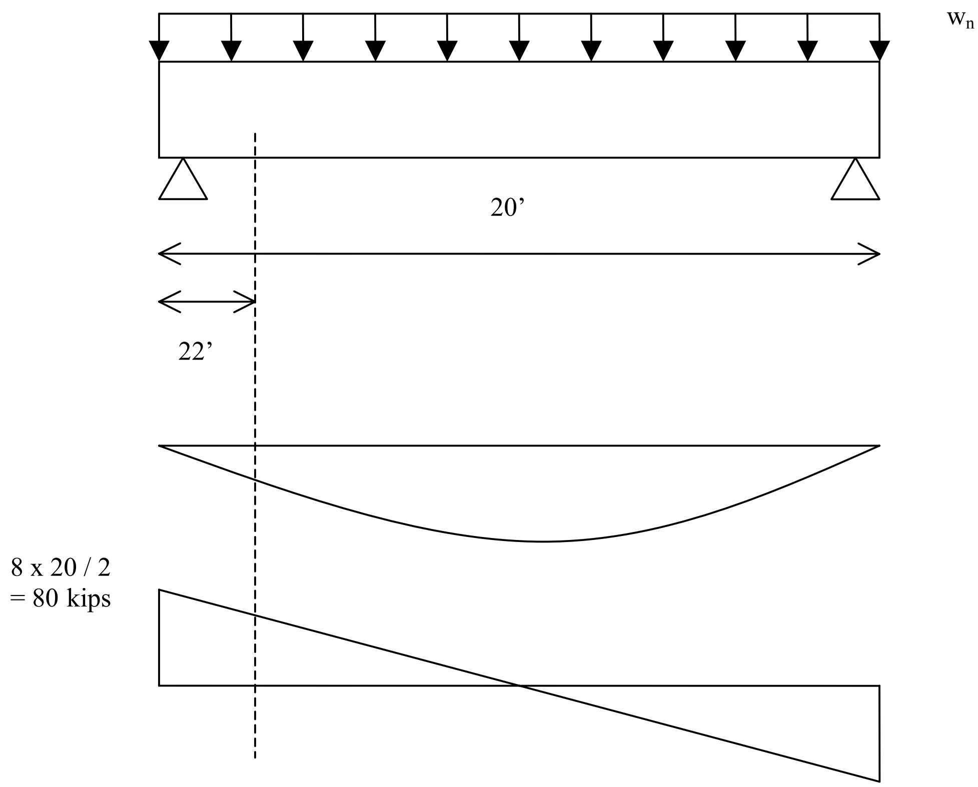
$V_u = 3.5W_u = 49.3$
$W_u = 14.1$ kips/ft

Obviously Region (1) controls

W_u (max) = 9.1 kips/ft

Example 3 (Design of Stirrups with Moment-Shear Coupling Consideration)

Given:



DL = 1.45 kips/ft (Include Self-Weight)
LL = 3.5 kips/ft
A_s = 6.06 in^2
f_c' = 2500 psi
f_y = 50,000 psi
b = 16"
d = 22"

1. Compute factored load

W_u = 1.4 DL + 1.7 LL = 1.4 x 1.45 + 1.7 x 3.5 = 7.98

Use W_u = 8.0 kips/ft

2. Compute M_u, V_u at critical section, d from the support

d = 22' = 22/12
V_u = 80 – 8(22/12) = 65.3 kips
M_u = (80 + 65.3)/2 . (22/12) = 133.19 kips.ft

3. Compute nominal shear strength

$$V_c = \left(1.9\sqrt{f_c^{'}} + 2500\rho_w \frac{V_u d}{M_u}\right) b_w d \leq 3.5\sqrt{f_c^{'}} b_w d$$

Therefore, $V_u d/M_u$ = 65.3 x 22 / (133.19 x 12) = 0.9 < 1.0; **OKAY!**

$\rho_w = A_s / b_w d$ = 6.06 / (16 x 22) = 0.0172

V_c = 47.06 kips

Check $3.5\sqrt{f_c'}\, b_w d$ = 61.6 kips > V_c; **OKAY!**

4. Stirrup provision

$\phi V_c/2$ = 0.85 (47.06) / 2 = 20 kips < V_u

Thus, need stirrups

$V_s = V_u/\phi - V_c$ = 65.3/0.85 – 47.06 = 29.76 kips

$s = A_v f_y d / V_s$ = 0.22 x 50 x 22 / 29.76 = 8.13"

Check s_{max}

i. $d/2$ = 11 in.

ii. $4\sqrt{f_c'} b_w d$ = 70.4 kips > V_s

$s_{max} = A_v f_y / 50 b_w$ or d/2 or 24"

= 0.22 x 50,000/(50 x 16)

= 13.75

Therefore, s = 8.13" controls

Use s = 8"

5. Determine where to terminate by computing V_c and check against $\phi V_c/2$