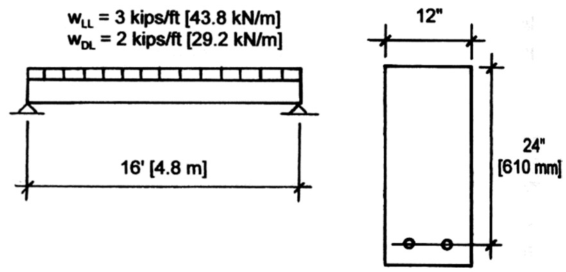
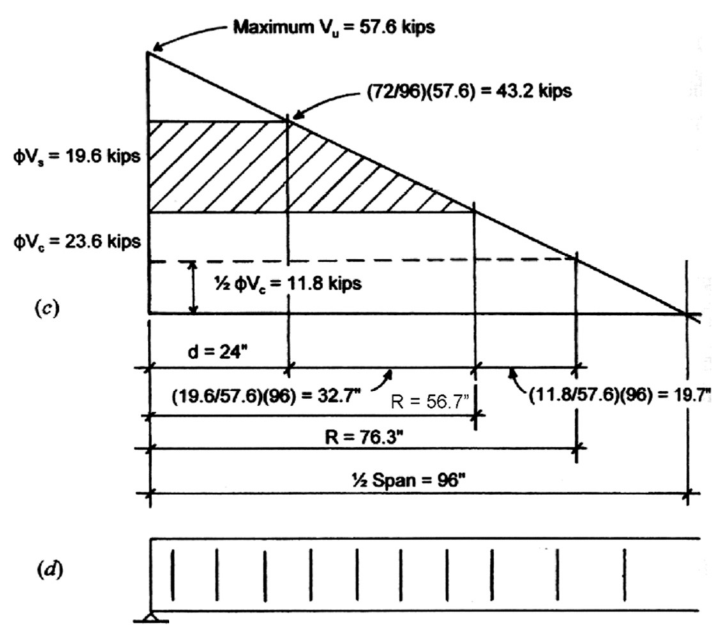
Example 12

Example 7. Design the required shear reinforcement for the simple beam shown in Figure 13.18. Use $f'_c = 3$ ksi [20.7 MPa] and $f_y = 40$ ksi [276 MPa] and single U-shaped stirrups.





Example 13

For the simply supported concrete beam shown in Figure 5-61, determine the stirrup spacing (if required) using No. 3 U stirrups of Grade 60 (f_y = 60 ksi). Assume f'_c = 3000 psi.

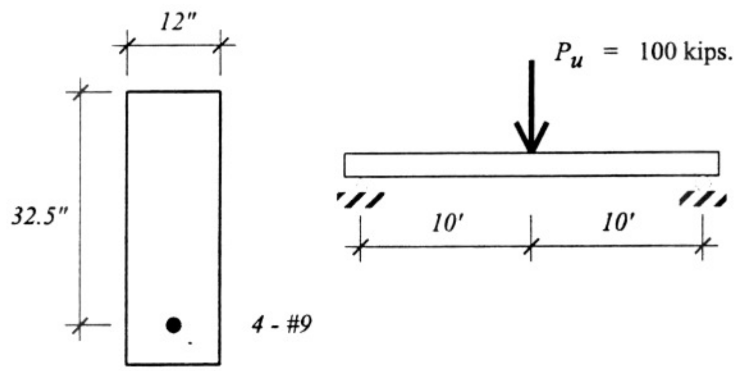


Figure 5-61: Simply supported concrete beam for Example 5-15.

f'_c = 3000 psi. For #3 bars, A_s = 0.11 in.^{2},
F_y = 60 ksi. with 2 legs, then A_v = 0.22 in.^{2}

Solution:

V_u = 50 kips (neglecting weight of the beam)

$$\phi V_c = \phi\lambda 2\sqrt{f'_c}\, b_w d$$

$$= \frac{(0.75)(1)2\sqrt{3000}(12)(32.5)}{1000} = 32.0 \text{ kips} < V_u \quad \therefore \text{Need Stirrups}$$

Note: If $V_u = \frac{1}{2}\varphi V_c$, minimum stirrups would still be required.

$$V_u \le \phi V_c + \phi V_s$$

$$\therefore \phi V_s = V_u - \phi V_c = 50 - 32.0 = 18.0 \text{ kips} \qquad (<\phi 4\sqrt{f'_c}\, b_w d = 64.1 \text{ kips})$$

$$s_{req'd} \le \frac{\phi A_v F_y d}{\phi V_s} = \frac{(0.75)(0.22in^2)(60ksi)(32.5in)}{18.0k}$$

$$= 17.875 \text{ in.}$$

$$s_{max} = \frac{d}{2} = \frac{32.5}{2} = 16.2 \text{ in.} \quad \text{☚ controls}$$

$$= 24 \text{ in.}$$

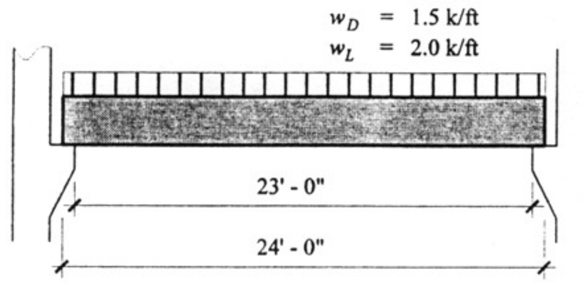
$$s_{req'd} \le \frac{A_v F_y}{50 b_w} = \frac{(0.22)(60{,}000)}{50(12)} = 22.0 \text{ in.}$$, but 16" (d/2) would be the maximum as well.

when $\phi V_c > V_u > \frac{\phi V_c}{2}$

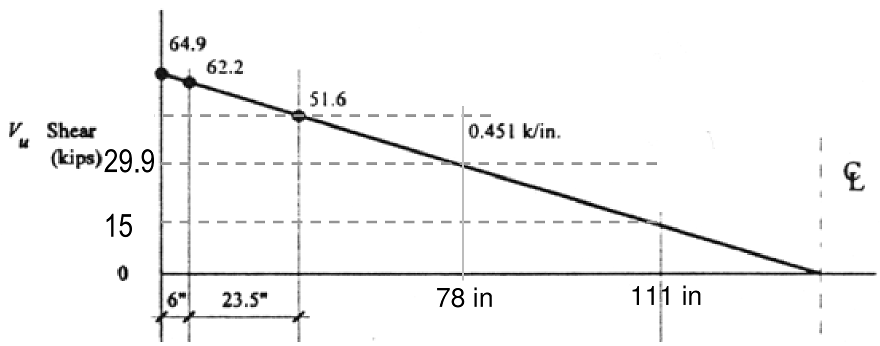
∴ Use #3 U @ 16" max spacing

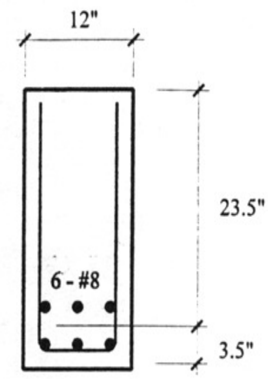
Example 14

Design the shear reinforcement for the simply supported reinforced concrete beam shown with a dead load of 1.5 k/ft and a live load of 2.0 k/ft. Use 5000 psi concrete and Grade 60 steel. Assume that the point of reaction is at the end of the beam.



SOLUTION:





Shear diagram:

Find self weight = 1 ft x (27/12 ft) x 150 lb/ft^3 = 338 lb/ft = 0.338 k/ft

w_u = 1.2 (1.5 k/ft + 0.338 k/ft) + 1.6 (2 k/ft) = 5.41 k/ft (= 0.451 k/in)

$V_{u\,(max)}$ is at the ends = $w_u L/2$ = 5.41 k/ft (24 ft)/2 = 64.9 k

$V_{u\,(support)}$ = $V_{u\,(max)}$ – w_u(distance) = 64.9 k – 5.4 1k/ft (6/12 ft) = 62.2 k

V_u for design is d away from the support = $V_{u\,(support)}$ – w_u(d) = 62.2 k – 5.41 k/ft (23.5/12 ft) = 51.6 k

Concrete capacity:

We need to see if the concrete needs stirrups for strength or by requirement because $V_u \le \phi V_c + \phi V_s$ (design requirement)

$\phi V_c = \phi 2\lambda\sqrt{f'_c}\, b_w d$ = 0.75 (2)(1.0)$\sqrt{5000}$psi (12 in) (23.5 in) = 299106 lb = 29.9 kips (< 51.6 k!)

Locating end points:

29.9 k = 64.9k – 0.451 k/in x (a)
a = 78 in

15 k = 64.9k – 0.451 k/in x (b)
b = 111 in.

Stirrup design and spacing

We need stirrups: $A_v = V_s s/f_y d$

$\phi V_s \ge V_u - \phi V_c$ = 51.6 k – 29.9 k = 21.7 k

Spacing requirements are in Table 3-8 and depend on $\phi V_c/2$ = 15.0 k and $2\phi V_c$ = 59.8 k

2 legs for a #3 is 0.22 in^2, so $s_{req'd} \le \phi A_v f_{yt} d/\phi V_s$ = 0.75(0.22 in^2)(60 ksi)(23.5 in)/21.7 k = 10.72 in Use s = 10"

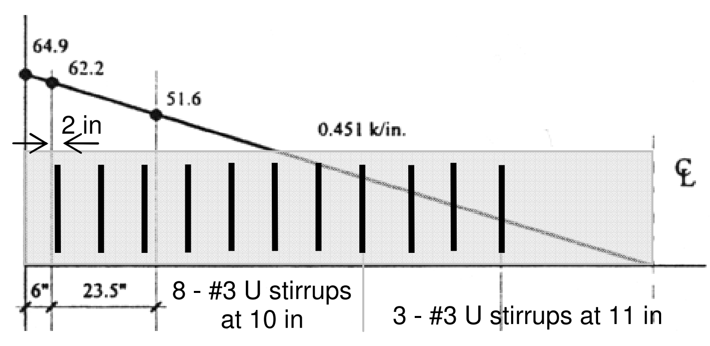
our maximum falls into the d/2 or 24", so d/2 governs with 11.75 in Our 10" is ok.

This spacing is valid until $V_u = \phi V_c$ and that happens at (64.9 k – 29.9 k)/0.451 k/in = 78 in

We can put the first stirrup at a minimum of 2 in from the support face, so we need 10" spaces for (78 – 2 - 6 in)/10 in = 7 even (8 stirrups altogether ending at 78 in)

After 78" we can change the spacing to the required (but not more than the maximum of d/2 = 11.75 in ≤ 24in);

$s = A_v f_{yt} / 50 b_w$ = 0.22 in^2 (60,000 psi)/50 (12 in) =
22 in ≤ $A_v f_{yt}/0.75\sqrt{f'_c}\, b_w$ =
0.22 in^2 (60,000 psi)/[0.75$\sqrt{5000}$psi(12 in)] = 20.74 in



We need to continue to 111 in, so (111 – 78 in)/ 11 in = 3 even