Shear Terms

$\phi V_n = \phi V_c + \phi V_s = V_u$

$\phi = 0.75$

V_c = Shear strength of concrete

V_s = Shear " " steel

V_n = Normal shear strength $= V_c + V_s$

V_u = Required Shear strength

Always #3 or #4 Stirrup

Shear Design

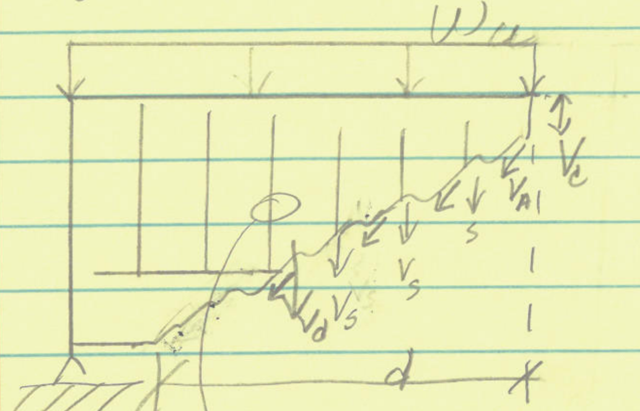
- Terms
- Mechanism
  - V_c
  - V_s
  - Stirrup Spacing
  - Example

Test 1 back

HW 6 — Oct 13
8.8, 8.12, 8.14, 8.16

HW 7 — Oct 18
handout

Shear Mechanism



A_s = Area of Stirrup

* Stirrups Normally have 2 legs

$\therefore A_v = 2A_{bar}$

2 bars each Stirrup x times # of Stirrups

V_{cz} = Shear carried by uncracked concrete

V_A = Shear carried by aggregate interlock

V_D = Shear carried by dowel action of Flextural Steel

V_s = Shear carried by stirrups

Shear Strength of Concrete

$V_c = V_{CZ} + V_A + V_D$

But there is an easier way

$V_c = 2\sqrt{f'_c}\, b_w\, d$ [ACI Eqn 11-3]

f'_c = concrete strength, psi
b_w = web width, inches
d = depth, inches

V_s Shear Strength of Stirrups

$$V_s = \frac{A_v f_y d}{s}$$ [ACI Eqn 11-15]

A_v = Area of stirrup, in^2
f_y = yield strength of Stirrups, psi
d = depth, in
s = stirrup spacing, in.

$V_s \leq 8\sqrt{f'_c}\, b_w\, d$ [11.4.7.9]

When are Stirrups required

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

Except [11.4.6.1]

- Slabs donot
- Footings
- beams with
  - $h < 10''$
  - $h < 2.5 h_f$ (flange)
  - $h < \frac{1}{2} b_w$

} $V_n > \phi V_c$,

Stirrups Spacing Requirements

$S_{max} = \min \begin{cases} d/2 \\ 24 in \end{cases}$ (when ⊥ to longitudinal axis)

[11.4.5.1]

If $V_s > 4\sqrt{f'_c}\, b_w\, d$

$S_{max} \begin{cases} d/4 \\ 12 in. \end{cases}$ [11.4.5.3]

Determination of Stirrup Spacing 15.2

If spacing is needed:

$$S = \frac{A_v f_y d}{\left(\frac{V_u}{\phi} - V_c\right)}$$ Varies as dictated by V_u

term = V_s

If sizing is needed

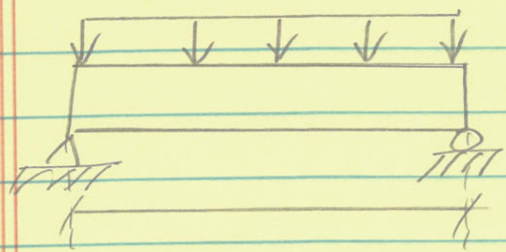
$$A_v = \frac{\left(\frac{V_u}{\phi} - V_c\right) S}{f_y d}$$

After determining S, Check $A_{v,min}$ [11.4.6.3]

$$A_{v,min} = 0.75\sqrt{f'_c}\ \frac{b_w S}{f_{y,transverse}} > \frac{50\, b_w S}{f_{y\,transverse}}$$

Hand out

$W_u = 4.4$ k/ft

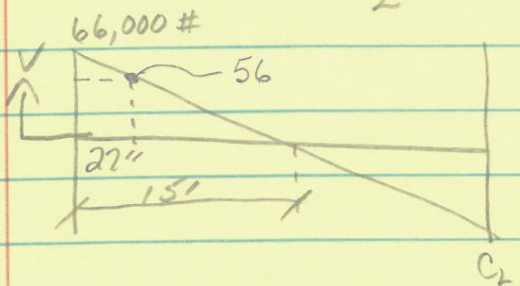


① Calculate factored loads

$W_u = 4.4$ k/ft

② Draw Shear Diagrams

$V_u = \frac{W_u l}{2} = \frac{4.4(30)}{2} = 66k$



③ Determine V_u @ "d" from support

- critical location for shear [11.1.3]

$V_u@d = V_u@support - \frac{d}{12}(w_u) = 66,000 - \frac{27}{12}(4400) = 56K$

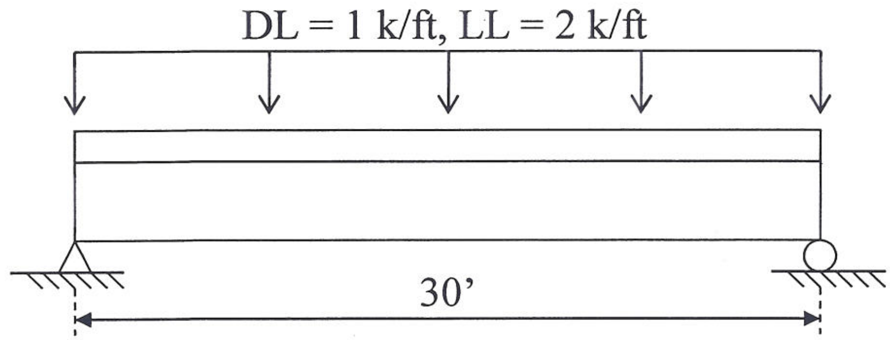
④ Calculate ΦV_c

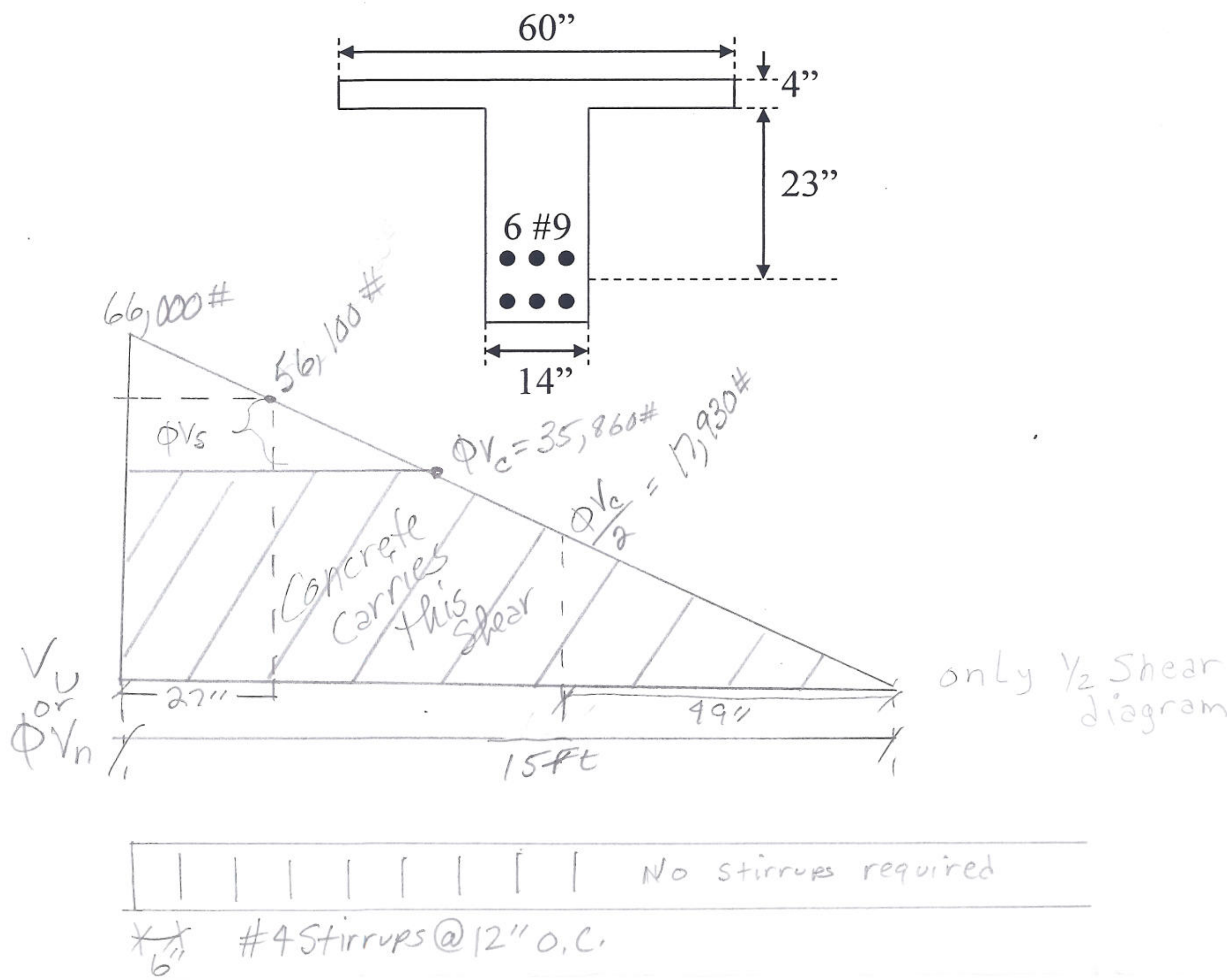
$\Phi V_c = \Phi 2\sqrt{f'_c}\, b_w d = 0.75\sqrt{4000}(14)(27) = 35,860$ #

$\frac{\Phi V_c}{2} = 17,930$ #

Shear Design of a T beam
ENCE 4359 Structural Concrete Design
Dr. Lamanna

For the beam shown, select the stirrup spacing if $f'_c = 4{,}000$ psi and $f_y = 60{,}000$ psi. The dead loads shown includes the beam weight. Assume #3 U stirrups.





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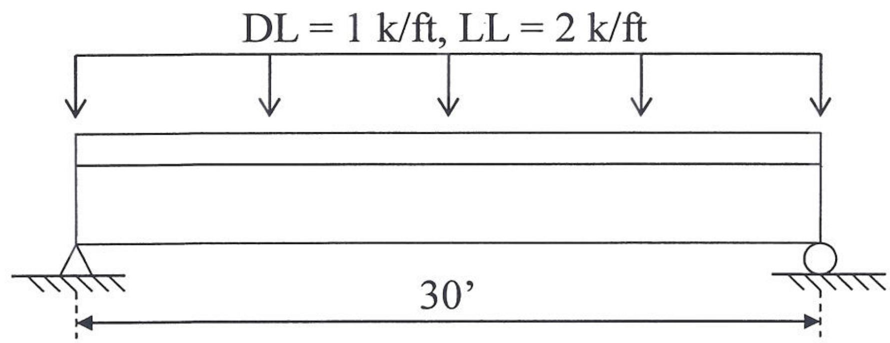

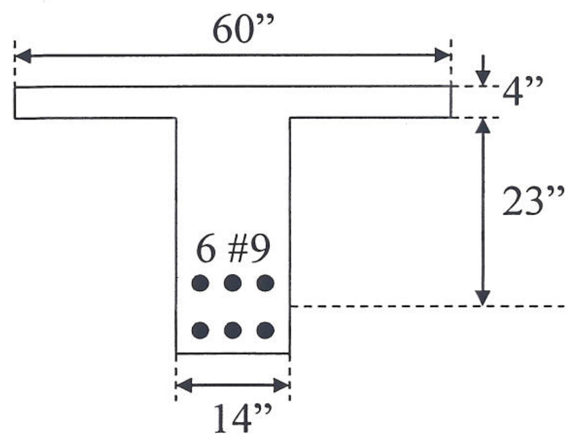

(5) Is Shear reinforcement required?

Is $V_u \geq \frac{\phi V_c}{2}$? YES → Stirrups required

location on diagnal

$\frac{66}{15} = \frac{17.93}{x} \Rightarrow$ solve $x = 4.075' = 49''$

(6) determine $V_{s,req}$; $V_{s,max}$

$V_u @ d = \phi V_c + \phi V_s$

$V_{s,req} = \frac{V_u@d - \phi V_c}{\phi} = \frac{56{,}100 - 35{,}860}{0.75} = 26{,}987\#$

$V_{s,max} = 4\sqrt{f'_c}\, b_w d = 4\sqrt{4000}(14)(27) = 95{,}627\#$

$V_{s,req} < V_{s,max}$

(7) determine max spacing

$S_{max} = \min \begin{cases} d/2 = 27/2 = 13.5 \text{ in} \\ 24'' \end{cases}$

(since $V_{s_{req}} < 4\sqrt{f'_c}\, b_w d$, max spacing is not reduced by 1/2

(8) Determine S @ critical section

$$S \leq \frac{A_v f_y d}{V_s} = \frac{(2)(0.11)(60{,}000)(27)}{\left(\frac{56{,}100 - 35860}{\phi}\right)} = 13.21''$$

or 26,987

use $s = 12''$

(9) Determine max S to provide $A_{v,min}$

$$A_{v,min} = 0.75\sqrt{f'_c}\,\frac{(b_w)S}{f_{y,t}}$$

$$\Rightarrow S_{max} = \frac{A_v f_{y,t}}{0.75\sqrt{f'_c}\, b_w} = \frac{2(0.11)(60{,}000)}{0.75\sqrt{4000}\; 14}$$

$S_{max} = 12 < 13.21$

(10) Place the 1st stirrup @ S/2

(11) Design the stirrups

from support: 1 @ 6" = 6"

11 @ 12" = 132"

138" — symetric @ ℄

-draw picture