CIV102 - STRUCTURES and MATERIALS

Topic: Shear Design + Example

1) Shear Design

Shear Force → SFD
↳ Use max |Shear| value
↳ $V_{applied}$

$V_{applied} \leq V_{safe}$

$$V_{applied} \leq \frac{V_c}{FOS} + \frac{V_s}{FOS} \leq \frac{V_{max}}{FOS}$$

V_c: FOS ↳ 2.0 — Sliding on concrete crack
V_s: FOS ↳ 1.67 — yielding of stirrups
V_{max}: FOS ↳ 2.0 — Crushing of concrete

How to design for shear in RC

i) Need $V_{applied}$ — SFD
ii) Given info f_c', f_y, b_w, b, shape of cross section, A_s
iii) Check $V_{max} = 0.25 f_c' \cdot b_w \cdot j \cdot d$ if $V_{applied} < \frac{V_{max}}{2.0}$ <u>ok</u>
iv) Assume we do not need shear reinforcement

$$V_c = \frac{230\sqrt{f_c'}}{1000 + 0.9d} b_w \cdot j \cdot d$$

if $V_{applied} < \frac{V_c}{2.0} \rightarrow$ ok
if not, add stirrups

V) You do need shear reinforcement

$$V_c = 0.18\sqrt{f_c'} \cdot b_w \cdot j \cdot d$$

(this will only be correct if you have at least a minimum quantity of stirrups)

Check spacing (S_1) to get minimum shear steel

$$\frac{A_v \cdot f_y}{b_w \cdot S_1} \geq 0.06\sqrt{f_c'}$$

(Solve for S_1 to exactly match the minimum)

Also check that resulting meets the general limit

$$S_2 \leq 0.7\, j d$$

Take $\min\{S_1, S_2\} = S$

$$V_s = \frac{A_v \cdot f_y \cdot j \cdot d}{S} \cot\theta \quad \theta = 35^\circ$$

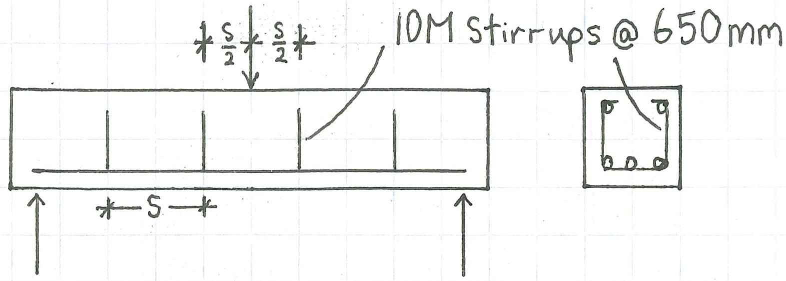
Check $\quad V_{applied} \leq \frac{V_c}{2.0} + \frac{V_s}{1.67}$ $\quad$ if yes $\longrightarrow$ done
if no $\longrightarrow$ Select new, smaller S

Calculate required value of S

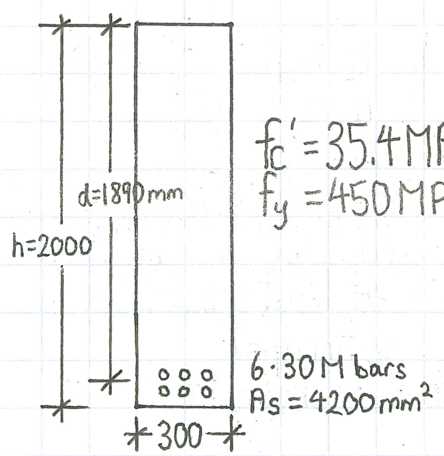
$$V_{applies} = \frac{V_c}{2.0} + \frac{1}{1.67} \cdot \frac{A_v \cdot f_y \cdot j \cdot d}{S} \cdot \cot 35^\circ$$

Solve for S. Round down value of S to nearest say 25 mm.

vi) Draw a sketch



2) Example 1



$f_c' = 35.4\,MPa$
$f_y = 450\,MPa$

$j \cdot d = 1715\,mm$ from flexural safety check of f_c, f_s

What is predicted failure shear

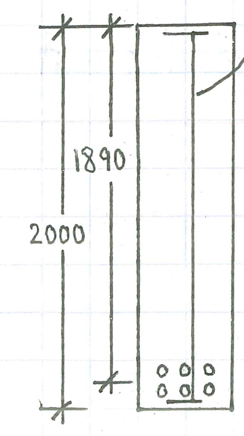
$$V_{max} = 0.25 \cdot f_c' \cdot b_w \cdot j \cdot d = 4553\,kN$$

$$V_c = \frac{230\sqrt{35.4}}{1000 + 0.9 \cdot 1890} \cdot 300 \cdot 1715 = 261\,KN < V_{max}$$

estimate

Test Strength = 256KN <u>ok</u>

3) Example 2



US #4 bar @ 590mm Spacing
Area of a US#4 = $129\,mm^2$
∵ Only one leg in beam
$A_v = A_{bar} = 129\,mm^2$

f_y Stirrup = 468MPa

$b_w = 300$
$f_c' = 36.6$

Do we have min shear reinforcement?

$$\frac{A_v \cdot f_y}{b_w \cdot S} \geq 0.06\sqrt{f_c'}$$

$0.341 \geq 0.363$
for us, close enough

$V_c + V_s = 811\,KN < V_{max} = 4553\,KN$

$V_{test} = 674\,KN$
84% of predicted

$$V_c = 0.18\sqrt{f_c'}\, b_w \cdot j \cdot d = 560\,KN$$

$$V_s = \frac{A_v \cdot f_y \cdot j \cdot d}{S} \cot 35 = 251\,KN$$