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REINFORCED CONCRETE DESIGN 1

Shear Design (Examples and Tutorials)

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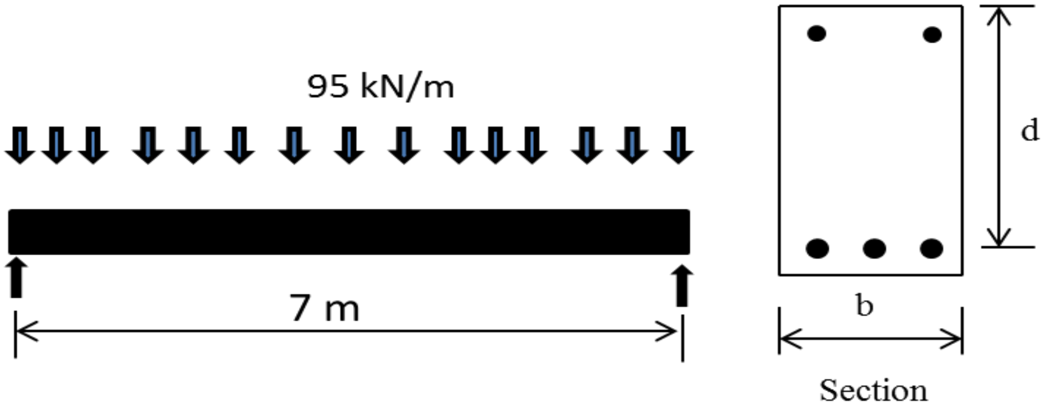
Example 1: Section requiring shear reinforcement design

A simply supported beam of 7 m span carries a uniform ultimate load of 95 kN/m. The beam dimensions are 200 x 450 mm (b x d) and the longitudinal reinforcement provided are 3H20 and 2H12 for tension and compression respectively. Design the shear reinforcement using vertical links. Use fck = 25 N/mm^2 and fyk = 500 N/mm^2.



Example 1: Section requiring shear reinforcement design

Design shear force,

$V_{ED} = wL / 2 \quad = 95 \times 7 / 2 \qquad = 332.5$ kN

Concrete strut capacity

$$V_{Rd,\,max} = \frac{0.36 b_w d f_{ck} (1 - f_{ck}/250)}{(\cot\theta + \tan\theta)}$$

= 251 kN -------- $\theta = 22$ deg $\cot\theta = 2.5$

= 364 kN -------- $\theta = 45$ deg $\cot\theta = 1.0$

$V_{Ed} > V_{Rd,\,max}$ $\cot\theta = 2.5$

$V_{Ed} < V_{Rd,\,max}$ $\cot\theta = 1.0$

Therefore angle $\theta > 22^0$

Example 1: Section requiring shear reinforcement design

$\theta = 0.5\sin^{-1} [V_{Ed}/0.18 b_w d f_{ck} (1 - f_{ck} / 250)]$

$= 0.5 \sin^{-1}[332.5 \text{ x} 103 / 0.18 \text{ x } 200 \text{ x } 450 \text{ x } 25$

$\text{x } (1-25/250)]$

$= 33^{o}$

Use : $\theta = 33^{o}$ tan $\theta = 0.65$, cot $\theta = 1.54$

Shear links

$A_{sw} / s = V_{Ed} / 0.78 f_{yk} d \cot \theta$

$= 332.5 \text{ x } 103/ (0.78 \text{ x } 500 \text{ x } 450 \text{ x } 1.54)$

$= 1.23$

Example 1: Section requiring shear reinforcement design

Try links: H8, A_{sw} = 101 mm2

Spacing, s = $A_{sw}/1.23$ < 0.75d

= 82 mm < 0.75 (450)

= 337.5 mm

Max. spacing, Use s_{max} = 75 mm

Provide: H8-75

Minimum links

$$A_{sw} / s = 0.08 f_{ck}^{1/2} b_w / f_{yk}$$

$$= (0.08 \times 25^{1/2} \times 200)/500$$

$$= 0.16$$

Example 1: Section requiring shear reinforcement design

Try links : H8, A_{sw} = 101 mm^2

Spacing, s = 101/0.16

= 631 mm < 0.75d

= 337 mm

Provide: H8-325

Shear resistance of minimum links

V_{min} = (A_{sw}/s) $(0.78 d f_{yk} \cot\theta)$

= (101/325) (0.78 x 400 x 500 x 2.5)

= 121 kN

Example 1: Section requiring shear reinforcement design

Additional longitudinal reinforcement
Additional tensile force,

F_{td} = $0.5\ V_{Ed} \cot\theta$
= 0.5 x 332.5 x 1.54
= 256 kN

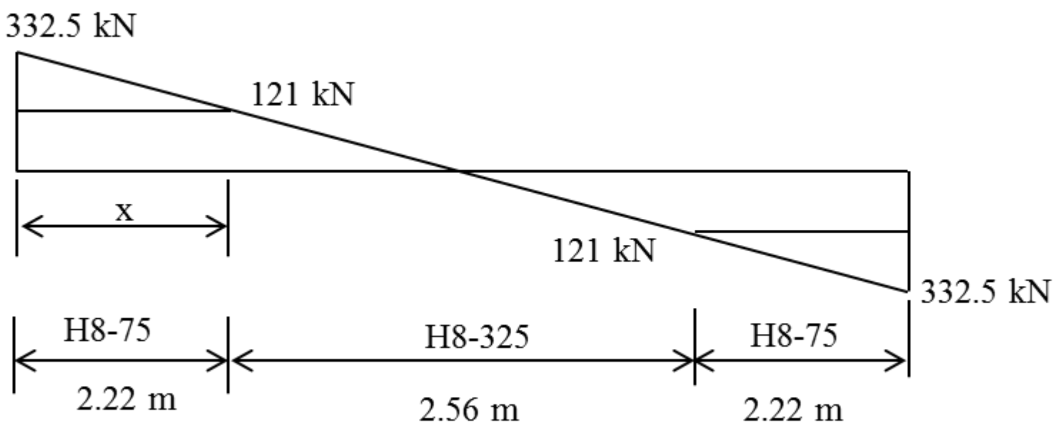
Additional tension reinforcement,

A_s = $Ft_d / 0.87\ f_{yk}$
= $256 \times 10^3 / (0.87 \times 500)$
= $588\ mm^2$

Use: 2H20 ($A_s = 626\ mm^2$)

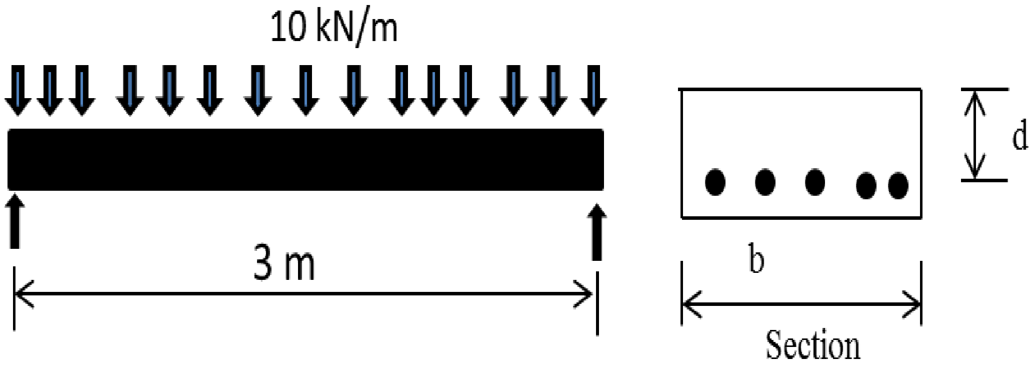
To be added to As for flexure support (after curtailment)

Example 1: Section requiring shear reinforcement design



x = (332.5-121)/95 = 2.22 m

Example 2: Section not requiring shear reinforcement design



A 3 m span simply supported slab with effective depth *d* = 125 mm carries an ultimate action of 10 kN/m per m width. The provided tension reinforcement steel is H8-150 bar. Use f_{ck} = 25 N/mm^2 and f_{yk} = 500 N/mm^2. Verify shear reinforcement for this section.

Example 2: Section not requiring shear reinforcement design

Span, L = 3.0 m

Size, b x d = 1000 x 125 mm

Design load, w = 10 kN/m per m width

Characteristic strength of concrete, $f_{ck} = 25\ N/mm^2$

Characteristic strength of steel, $f_{yk} = 500\ N/mm^2$

Tension steel : **H8 – 150** , As = 335 mm/m^2

Example 2: Section not requiring shear reinforcement design

Design shear force, V_{Ed}

$V_{Ed} = wL/2 \quad = 10 \times 3 / 2 = 15$ kN

Concrete shear resistance

$V_{Rdc} = [0.12\ k\ (100\rho_1 f_{ck})^{1/3}]\ b_w d$

$= 1 + (200/d)^{1/2} \leq 2.0$

$= 2.26 \leq 2.0$

$\rho_1 = (A_{sl} / b_w d) \leq 0.02$

$= 0.0027 \leq 0.02$

Example 2: Section not requiring shear reinforcement design

V_{Rdc} = $[0.12 \times 2.0 \times (100 \times 0.0027 \times 25)^{1/3}]\ 1000 \times 125$
= 56.7 kN

V_{min} = $[0.035k^{3/2} f_{ck}^{½}]\ b_w d$
= $[0.035 \times 2.0^{3/2} \times 25^{½}]\ 1000 \times 125$
= 61.87 kN

So, V_{Rdc} = 61.87 > V_{ed} = 15

Therefore, shear check pass. No shear reinforcement is required!

Tutorial

A rectangular reinforced concrete beam for a simply supported beam has a size of 150 mm width and 225 mm effective depth. If the beam is 3.3 m carrying a uniform distributed load of 10 kN/m^2, calculate the area of steel required for shear reinforcement of this beam. Consider f_{ck} = 25 N/mm^2 and f_{yk} = 500 N/mm^2.

Examples and Tutorial