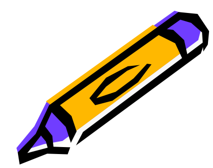
Shear in Beams

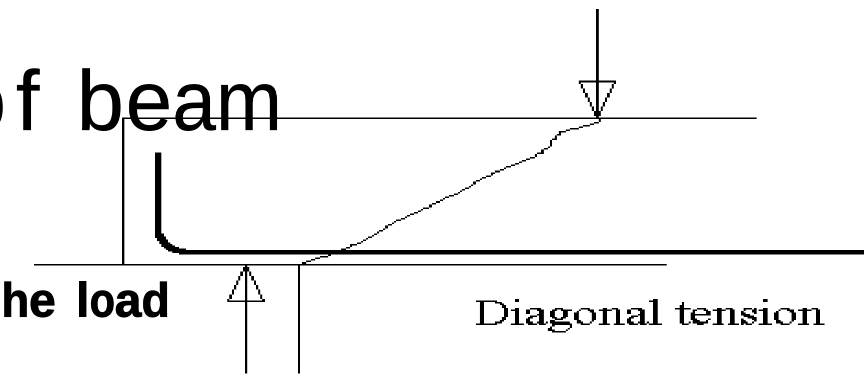
Lesson 4



Introduction to shear

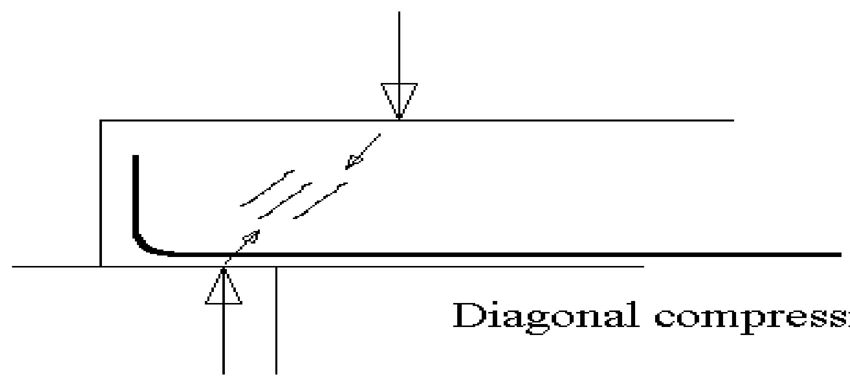
- Beam failure may occur in bending and shear.
- Shear failure of beam

Result due to gradual increase in the load



Diagonal tension

Occurs under the action of large shear forces near the support



Diagonal compression

Diagonal Tension/Compression

- **Diagonal tension -** prevented by the provision of **shear reinforcement or shear links**
- **Diagonal compression** - avoided by limiting the maximum shear stress to 5N/mm^2 or $0.8\sqrt{f_{cu}}$ whichever is the lesser.

Design shear stress, *v*

$$v = V/bd$$

V: shear force at ULS

In order to determine whether shear reinforcement is required, it is necessary to calculate the shear resistance **also termed as design concrete shear stress**.

Design concrete shear stress, v_c

- Depends on:
  - Concrete in the compression zone
  - Aggregate interlock across the cracked zone
  - Dowel action of the tension reinforcement
- Based on the above, a look up table has been devised.

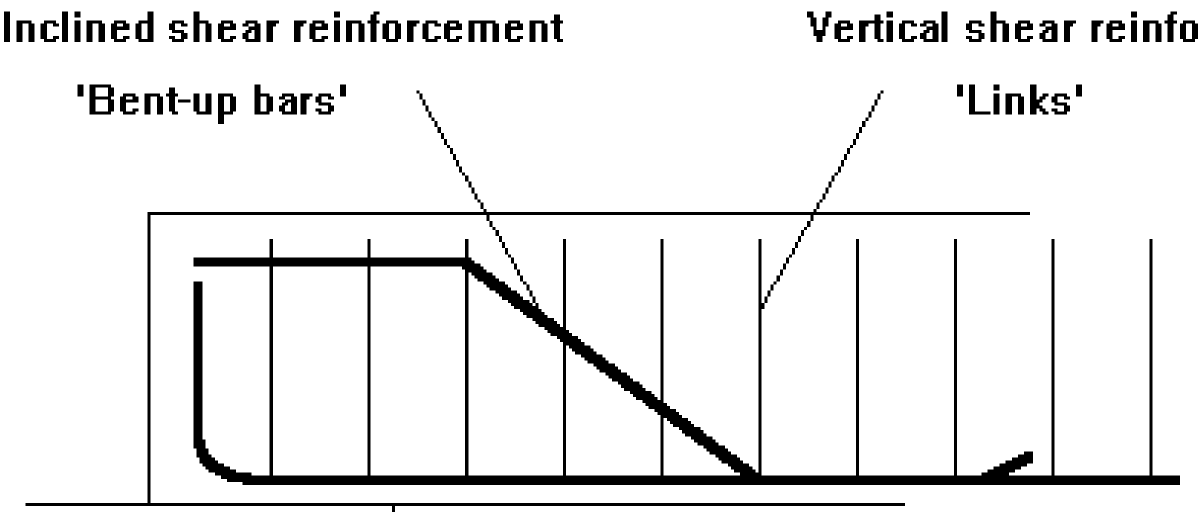
Design concrete shear stress, v_c

$100A_s/bd$	Effective Depth (mm)							
	125	150	175	200	225	250	300	>=400
<=0.15	0.45	0.43	0.41	0.40	0.39	0.38	0.36	0.34
.25	0.53	0.51	0.49	0.47	0.46	0.45	0.43	0.4
.5	0.67	0.64	0.62	0.6	0.58	0.56	0.54	0.5
.75	0.77	0.73	0.71	0.68	0.66	0.65	0.62	0.57
1.0	0.84	0.81	0.78	0.75	0.73	0.71	0.68	0.63
1.5	0.97	0.92	0.89	0.86	0.83	0.81	0.78	0.72
2	1.06	1.02	0.98	0.95	0.92	0.89	0.86	0.8
=3.0	1.22	1.16	1.12	1.08	1.05	1.02	0.98	0.91

Design concrete shear stress, v_c

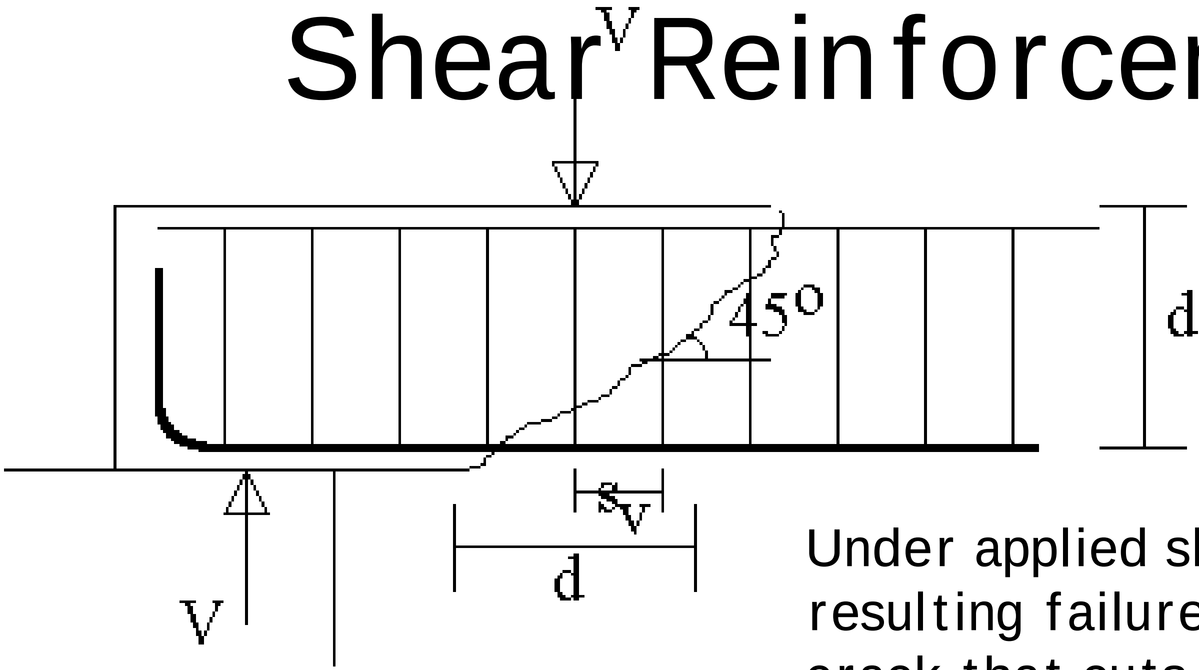
- Table is based upon a concrete of **Grade C25**, for alternative characteristic strengths the given values must be factored by $\sqrt[3]{f_{cu}/25}$.

Shear reinforcement



If design shear stress **>** than the design concrete shear stress enhancement of the shear resistance is gained by the provision of shear reinforcement: **either links** or **a combination of links and bent up bars** as illustrated above.

Shear Reinforcement



Under applied shear force *V*, the resulting failure will give rise to a crack that cuts across any links as shown

Shear reinforcement

$$V \le V_{conc} + V_{link}$$

$$\le v_c bd + \left({}^{d}\!/_{s_v} \right) A_{sv} 0.87 f_{yv}$$

dividing both sides by the area of the section

$$V/bd \le v_c + \left(1/bs_v \right) A_{sv} 0.87 f_{yv}$$

where the LHS is now the nominal shear stress

on the cross section

$$v \le v_c + \left(1/bs_v \right) A_{sv} 0.87 f_{yv}$$

Which may be rearranged to leave the

unknowns on the LHS

$$\frac{A_{sv}}{s_v} = \frac{b(v - v_c)}{0.87 f_{yv}}$$

All 0.87fy should be changed to 0.95fy

Shear links

- When *(v - vc)* is less than 0.4N/mm2 links should be provided according to:

$$\frac{A_{sv}}{s_v} = \frac{0.4b}{0.87 f_{yv}}$$

All 0.87fy should be changed to 0.95fy

Shear links

Table 3.7 — Form and area of shear reinforcement in beams

Value of v N/mm²	**Form of shear reinforcement to be provided**	**Area of shear reinforcement to be provided**
Less than $0.5v_c$ throughout the beam	See NOTE 1	—
$0.5v_c < v < (v_c + 0.4)$	Minimum links for whole length of beam	$A_{sv} \geq 0.4 b_v s_v / 0.95 f_{yv}$ (see NOTE 2)
$(v_c + 0.4) < v < 0.8\sqrt{f_{cu}}$ or 5 N/mm²	Links or links combined with bent-up bars. Not more than 50 % of the shear resistance provided by the steel may be in the form of bent-up bars (see NOTE 3)	Where links only provided: $A_{sv} \geq b_v s_v (v - v_c)/0.95 f_{yv}$ Where links and bent-up bars provided: see **3.4.5.6**

NOTE 1 While minimum links should be provided in all beams of structural importance, it will be satisfactory to omit them in members of minor structural importance such as lintels or where the maximum design shear stress is less than half v_c.

NOTE 2 Minimum links provide a design shear resistance of 0.4 N/mm².

NOTE 3 See **3.4.5.5** for guidance on spacing of links and bent-up bars.

Shear links

- Limitation - maximum spacing should be less than ***0.75d***, which is obviously necessary to avoid a failure plane forming which misses the links altogether.

Shear reinforcement Calculation

- ***Design and detail*** a simply supported beam from the following design data:
- Beam dimensions: 200mm wide and 450mm high inclusive of a 150mm thick slab.
- Span of beam = 5m
- Dead load inclusive of beam's self-weight = 10.8kN/m
- Imposed load on beam = 10kN/m
- Characteristic strength of concrete = 30N/mm2
- Characteristic strength of high tensile steel = 460N/mm2
- Characteristic strength of mild steel = 250N/mm2
- Exposure condition = Mild
- Fire resistance = 1.5hours.
- Diameter of tensile steel may be assumed = 25mm.