Contribution of Concrete to Shear Strength for beams with webs well reinforced in shear

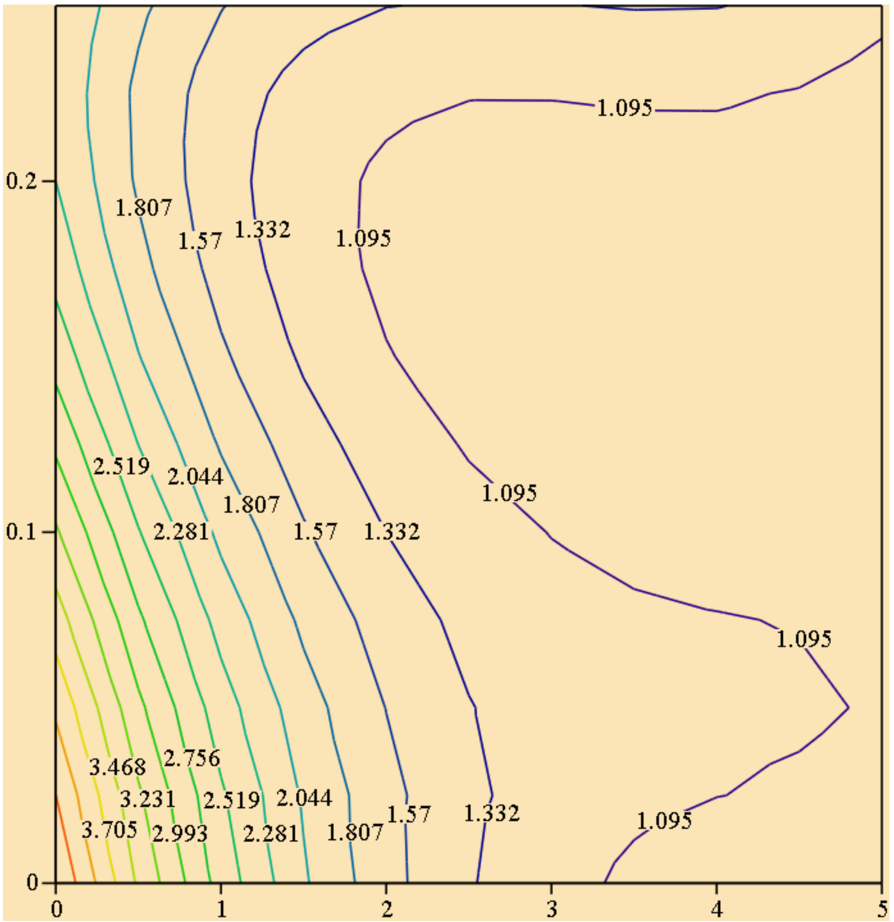
Don't use for slabs, mats or joists not reinforced in shear

The following serves to interpolate values in Table 7-3 of Collins & Mitchell 1997 p. 361 to the purpose of calculating concrete contribution to shear strength in sections that have at least minimum shear reinforcement as to warrant typical crack separations to be lesser than 30 cm. See in the text the general conditions that apply. Note that shear field action as here implied is a 2-D affair and so you sholdn't rely in this sheet to properly cover 3-D cases such 2-way mats where there are tensile stresses in 2 orthogonal directions which can cause more reduction in the concrete shear contribution than the 2-D case. For these cases still go code. Uncollapse area to see calculations.

$\phi_s := 0.85$

shear strength reduction factor

Shear - tensile strain interaction for well reinforced in shear beams, as per Table 7-3 in Collins & Mitchell 1997, p. 361



ββ

Enable by right-click in the graph, Flying menu... Format...Special...Numbered to see values

- Enter in abscissas with longitudinal strain ε_x in thousandths. Top value charted is $5 \cdot 10^{-3}$ or 0.005 then. For compressive strains enter 0. To be generally conservative the longitudinal strain should be from factored loads and read where it is maximum and affecting shear, and this can't be other place than the main tensile reinforcement level, be it from positive or negative moments (it does not matter, since we are charting interaction with a tensile strain, whichever its position). However this stance may be overly conservative, and it can be more reasonable (see p. 357 in the text) to use the strain at the center of gravity level, which is acceptable for beams with shear reinforcement. Don't use this chart if there is not shear reinforcement, so don't use for slabs or mats not reinforced in shear.

- Enter in ordinates with the ratio of shear on effective (web) shear section (bounded by effective mechanical arm) to specified concrete strength, that is $\dfrac{\dfrac{V_u}{b_w \cdot mech_{arm}}}{f_c}$
- Read within the chart the β value to be used in the evaluation of shear strength.

Example of use of the chart

$f_c := 35 \cdot MPa$

Factored shear close but not over one support where

(Over or at face of supports strut and tie analysis is better)

$\varepsilon_x := 0.0001$

You obtain ε_x by some compatibility of deformation analysis of the section under bending. It may be at the most tensile reinforcement level (negatives or positives, whichever it is) (conservative but recommended by authors, maybe due to some restrictions observed while building the table) or at center of gravity of the section level (usual, were not for the authors recommendation).

input in abscissas, where 1 means 0.001 or ten times our input value

$sr := 0.1$ this is $\dfrac{\dfrac{V_u}{b_w \cdot mech_{arm}}}{f_c}$ shear stress to compressive stress ratio, enter it in ordinates

We read in the table β to be $\beta := 3.2$

Then **concrete** contribution to shear strength is

$\phi_s \cdot \beta \cdot \sqrt{\dfrac{f_c}{psi}} \cdot psi = 1.34\,MPa$

limit concrete shear strength contribution at the section to be compared with factored shears on $b_w \cdot mech_{arm}$

$\phi_s \cdot \beta \cdot \sqrt{\dfrac{f_c}{psi}} \cdot psi = 193.79\,psi$

$\phi_s \cdot \beta \cdot \sqrt{\dfrac{f_c}{psi}} \cdot psi = 13.63\,\dfrac{kgf}{cm^2}$

When the web is to be taken enough reinforced in shear for the above procedure be apt for use

Whichever your positive result with the concrete contribution to shear strength be, your web **MUST** respect the inferior limits for shear reinforcement established in ACI 318.

Alternatively, for your web be properly reinforced in shear you must have (criteria taken from Rangan et al.)

$$\rho_{t\_min} := \frac{0.06 \cdot \sqrt{\frac{f_c}{MPa}}}{\frac{f_y}{MPa}} \qquad \rho_{t\_min} = 0.000887 \qquad f_y \text{ of stirrups}$$

This geometrical capacity must be less than $\frac{A_{sv}}{b_w \cdot s}$

where A_{sv} is total area in planes of stirrups at s separation, and b_w the web width

$f_c := 20 \cdot MPa$ $\quad b_w := 150 \cdot cm$ $\quad h := 100 \cdot cm$ $\quad d := 0.9 \cdot h$

$V_u := 1200 \cdot kN$ $\quad mech_{arm} := 0.8 \cdot h$

$$\frac{\frac{V_u}{b_w \cdot mech_{arm}}}{f_c} = 0.05$$

read $\beta := 2.3$

$$V_c := b_w \cdot d \cdot \left(\phi_s \cdot \beta \cdot \sqrt{\frac{f_c}{psi}} \cdot psi \right)$$

$V_c = 980.06\,kN$