5.2.2.4 Design Shear Capacity of a Web

Designers must ensure that the design shear force (V^*) ≤ ϕV_v along the beam. RHS and SHS generally have non-uniform shear stress distributions along their webs. Consequently, the design shear capacity of a web (ϕV_v) for most RHS/SHS in the Tables are primarily determined from Clauses 5.11.3 and 5.11.4 of AS 4100 and is calculated as the *lesser* of:

$$\phi V_v = \phi V_w \qquad \text{(Clause 5.11.4 of AS 4100)}$$

and
$$\phi V_v = \frac{2\phi V_u}{0.9 + \left(\frac{f^*_{vm}}{f^*_{va}}\right)} \qquad \text{(Clause 5.11.3 of AS 4100)}$$

Also, for CHS: $\phi V_v = 0.36 f_y A_e$ (Clause 5.11.4 of AS 4100)

where ϕ = 0.9 (Table 3.4 of AS 4100)

$V_w = 0.6 f_y (d - 2t) 2t$

$V_u = V_w$ for $\frac{d_1}{t}\sqrt{\left(\frac{f_y}{250}\right)} \leq 82$ and applies for most RHS/SHS in the Tables

$= \alpha_v V_w$ for $\frac{d_1}{t}\sqrt{\left(\frac{f_y}{250}\right)} > 82$ for 150x50x2.0RHS in Grades C350/C450

f^*_{va} = average design shear stress in the web

f^*_{vm} = maximum design shear stress in the web

f_y = yield stress used in design

A_e = effective section area

= A_g (ie gross cross section of CHS *provided* there are no holes larger than those required for fasteners, or that the net area is greater than 0.9 times the gross area)

d = full depth of section

t = thickness of section

$d_1 = d - 2t$

The ratio of maximum to average design shear stress in the web (f^*_{vm} / f^*_{va}) for bending about the x-axis is calculated [5.3] using:

$$\frac{f^*_{vm}}{f^*_{va}} = \frac{3\,(2b + d)}{2\,(3b+d)}$$

where d = full depth of section

b = full width of section

Note: For bending about the y-axis, b and d are interchanged in the calculation of the maximum to average design web shear stress ratio. Non-uniform shear stress governs when $d / b > 0.75$.

For calculating the web area, the web depth has been taken as $d - 2t$ (or $b - 2t$ when appropriate) for RHS/SHS and 0.6 times the gross cross-section area (0.6 A_g) for CHS.

5.2.2.5 Design Web Bearing Capacities

Designers must ensure that the design bearing force (R^*) $\leq \phi R_b$ at all locations along a beam where bearing forces are present.

The design bearing capacity (ϕR_b) is calculated in accordance with Clause 5.13 of AS 4100 and taken as the lesser of:

ϕR_{by} = $\phi 2\alpha_p b_b t f_y$

and ϕR_{bb} = $\phi 2\alpha_c b_b t f_y$

where ϕ = 0.9 (Table 3.4 of AS 4100)

ϕR_{by} = design web bearing yield capacity (Clause 5.13.3 of AS 4100)

ϕR_{bb} = design web bearing buckling capacity (Clause 5.13.4 of AS 4100)

t = thickness of section

f_y = yield stress used in design

(a) For **interior bearing** such that $\boldsymbol{b_d \geq 1.5 d_5}$ (see Figure 5.2(b))

b_b = $b_s + 5r_{ext} + d_5$

b_s = actual length of bearing (see Figure 5.2(b))

d_5 = flat width of web (see Figure 5.2(a))

r_{ext} = outside corner radius (see Section 3.2.1.2)

$$\alpha_p = \frac{0.5}{k_s}\left[1+\left(1-\alpha_{pm}^2\right)\left(1+\frac{k_s}{k_v}-\left(1-\alpha_{pm}^2\right)\frac{0.25}{k_v^2}\right)\right]$$

$$\alpha_{pm} = \frac{1}{k_s} + \frac{0.5}{k_v}$$

$$k_s = \frac{2r_{ext}}{t} - 1$$

$$k_v = \frac{d_5}{t}$$

α_c = member slenderness reduction factor determined from Clause 5.13.4 of AS 4100. This is equal to the design axial compression capacity of a member with area $t_w b_b$ with $\alpha_b = 0.5$, $k_f = 1.0$ and modified slenderness ratio, $L_e/r = 3.5d_5/t$.

(b) For **end bearing** such that $\boldsymbol{b_d < 1.5 d_5}$ (see Figure 5.2(c))

$$b_b = b_s + 2.5r_{ext} + \frac{d_5}{2}$$

$$\alpha_p = \sqrt{2 + k_s^2} - k_s$$

α_c = member slenderness reduction factor determined from Clause 5.13.4 of AS 4100. This is equal to the design axial compression capacity of a member with area $t_w b_b$ with $\alpha_b = 0.5$, $k_f = 1.0$ and modified slenderness ratio, $L_e/r = 3.8d_5/t$.

Tables 5.2-1 to 5.2-4 list values ϕR_{by} and ϕR_{bb} in terms of $\phi R_{by}/b_b$ and $\phi R_{bb}/b_b$ respectively for RSH/SHS. In both the interior and end bearing cases, the critical web bearing failure mode (i.e. web bearing yield design capacity or web bearing buckling design capacity) is shown in **bold**. Additionally, the terms $5r_{ext}$ (=2 x $2.5r_{ext}$ for interior bearing), $2.5r_{ext}$ (for end bearing), b_{bw} (see Figures 5.2 (b) and (c)) and L_e/r are also listed in these tables. For the same section range, the RHS listings in this table series consider shear and bearing forces for flexure about the x-axis (the (A) series tables) which is then immediately followed by the (B) series table for flexure about the y-axis.

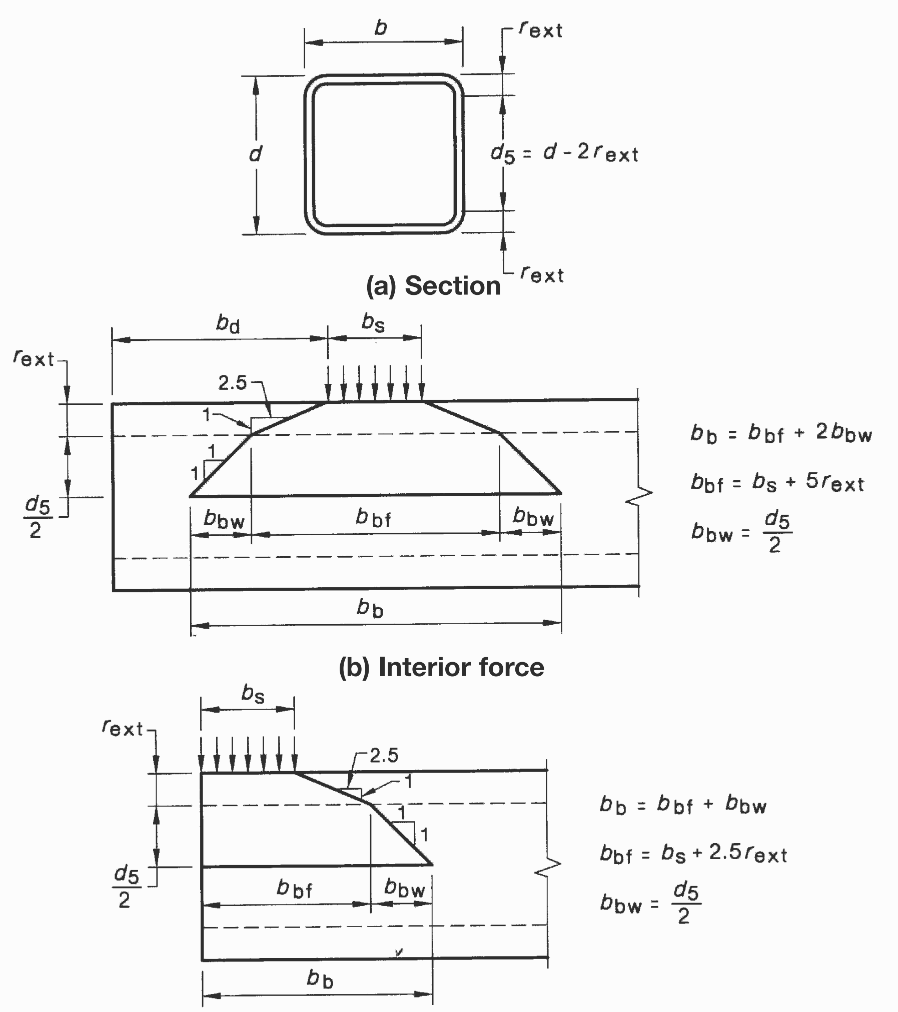

Figure 5.2: Dispersion of force through flange, radius and web of RHS/SHS

5.2.3 Example – Web Bearing

For an interior bearing location, a 150x100x4.0RHS – Grade C450 section has a design concentrated force of 150 kN bearing over the full width of the RHS for a length of 100 mm along the RHS (see Figure 5.3). Check the bearing capacity of the beam.

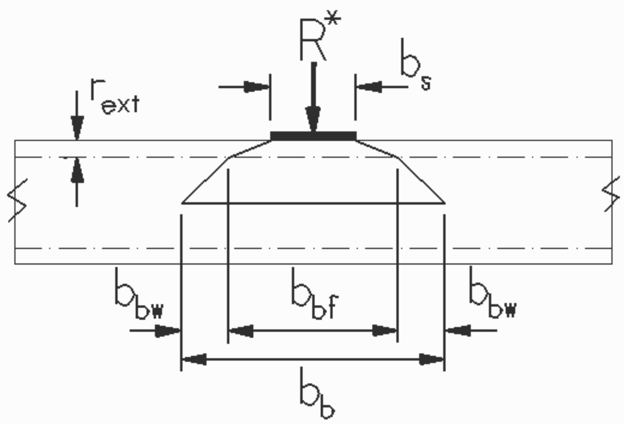

Figure 5.3: Web bearing design example

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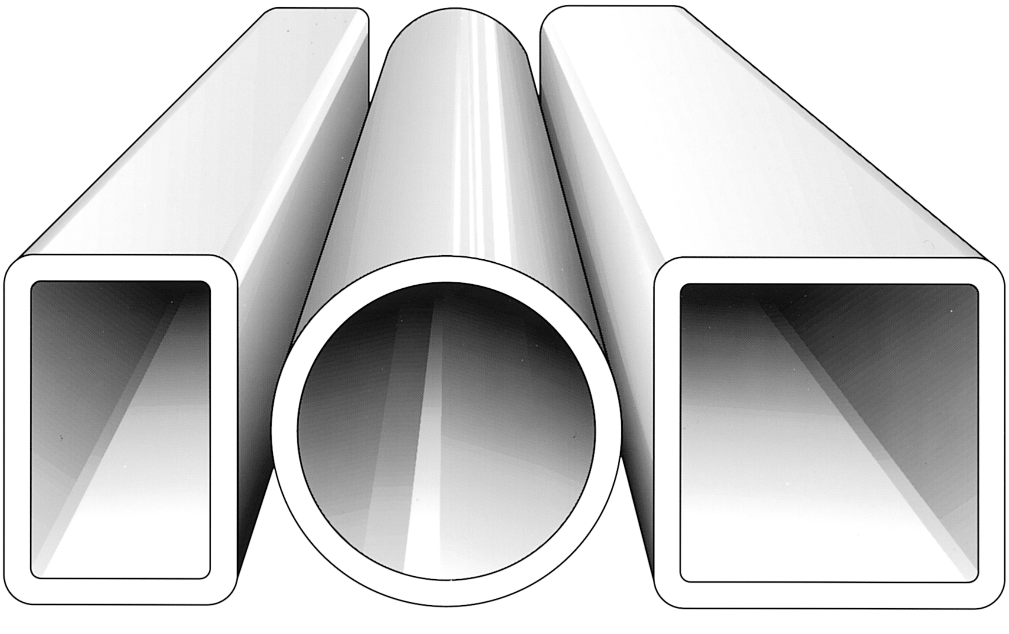

Volume 2: Hollow Sections

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CHS - Grade C250/C350 (to AS 1163)

RHS - Grade C350/C450 (to AS 1163)

SHS - Grade C350/C450 (to AS 1163)

LIMIT STATES EDITION TO AS 4100-1998 $S^* \leq \phi R_u$

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TABLES

NOTE: SEE SECTION 2.1 FOR THE SPECIFIC MATERAL STANDARD (AS 1163) REFERRED TO BY THE SECTION TYPE AND STEEL GRADE IN THESE TABLES