Calculation Procedure

The method used in this application is based on the formulae and guidelines as given in Limit State Design of Steel Structures by S K Duggal twelfth reprint 2013.

Design Procedure of Laterally Unsupported Rolled Beams:

- The design of a laterally supported beam consists of selecting a section on the basis of the modulus of section and checking it for shear capacity, high/low shear case, web buckling, web crippling and deflection.
- The service load expected on the beam are ascertained. The service loads are multiplied with the load factor γ_f to determine the factored loads.
- The maximum bending moment M and maximum shear force V are calculated for the beam. These are referred to as design forces. In the GUI of beam design the input required are these factored moments and factored shear.
- A trial plastic section modulus for the beam is worked out by the formula

$$Z_{pz\,req} = 1.3 \times \frac{M\gamma_{m0}}{f_y}$$

Where, M = design moment

f_y= yield stress of material

γ_{m0}=partial safety factor = 1.1

- Starting from ISLC 75 beams are checked for plastic section modulus greater than or equal to the worked out plastic section above.
- The classification of the section is checked and it is classified as plastic, compact or semi compact
- The trial section is checked for shear
- The design shear force V should be less than the design shear capacity V_d ,

$$V_d = \frac{f_y}{\sqrt{3}\gamma_{m0}} h t_w$$

Where h = overall depth of the section.

t_w = thickness of web.

- The beam is checked for high/low shear case.

If V<=0.6V_d, the case is of high shear and of low shear otherwise.

If any criteria is not matched the section is abandoned immediately and next higher section is chosen.

- The trial section is checked for design bending strength,

Rigidity modulus is calculated as

$$G = \frac{E}{2 \times (1 + \mu)}$$

Torsional Constant is calculated as

$$I_t = \sum b_i t_i^3 / 3$$

Warping constant is calculated as

$$I_w = (1 - \beta_f)\beta_f I_y h_f^2$$

Lateral torsional buckling moment is calculated as

$$M_{cr} = \frac{\pi^2 E I_y h_f}{2L_{LT}^2}\left[1 + \frac{1}{20}\left(\frac{L_{LT}/r_y}{h_f/t_f}\right)^2\right]^{0.5}$$

Non-Dimensional Slenderness ration is calculated as

$$\lambda_{LT} = \sqrt{\beta_b Z_p f_y / M_{cr}} \leq \sqrt{1.2\, Z_e f_y / M_{cr}}$$

Bending stress reduction factor is calculated as

$$\chi_{LT} = \frac{1}{\left\{\phi_{LT} + \left[{\phi_{LT}}^2 - {\lambda_{LT}}^2\right]^{0.5}\right\}} \leq 1.0$$

Where

$$\phi_{LT} = 0.5[1 + \alpha_{LT}(\lambda_{LT} - 0.2) + {\lambda_{LT}}^2]$$

Design bending compressive strength is calculated as

$$f_{bd} = \chi_{LT} f_y / \gamma_{m0}$$

Design Bending Capacity is calculated as

$$M_d = \beta_b Z_p f_{bd}$$

If any symbol is Unclear , assume its meaning as same as given in IS 800:2007.

- The trial section is checked for deflection. It should be less than (l/300) or the section is left and another section chosen. In the GUI calculation of deflection is very difficult as the number of possibilities of deflection depending on type and location of loads is very large. So the term excluding moment of inertia in the formula for calculation of deflection is asked and is to be input by the user as that part can be calculated by the user. It is then divided by moment of inertia of chosen section and compared with allowable deflection. It the criteria is not satisfied another beam is chosen.

- The trial section is checked for web buckling.
  The capacity of the section = $A_b f_{cd}$
  A_b = Area of web at neutral axis of the beam =Bt_w
  f_{cd} = Design compressive stress.

- The trial section is checked for web bearing

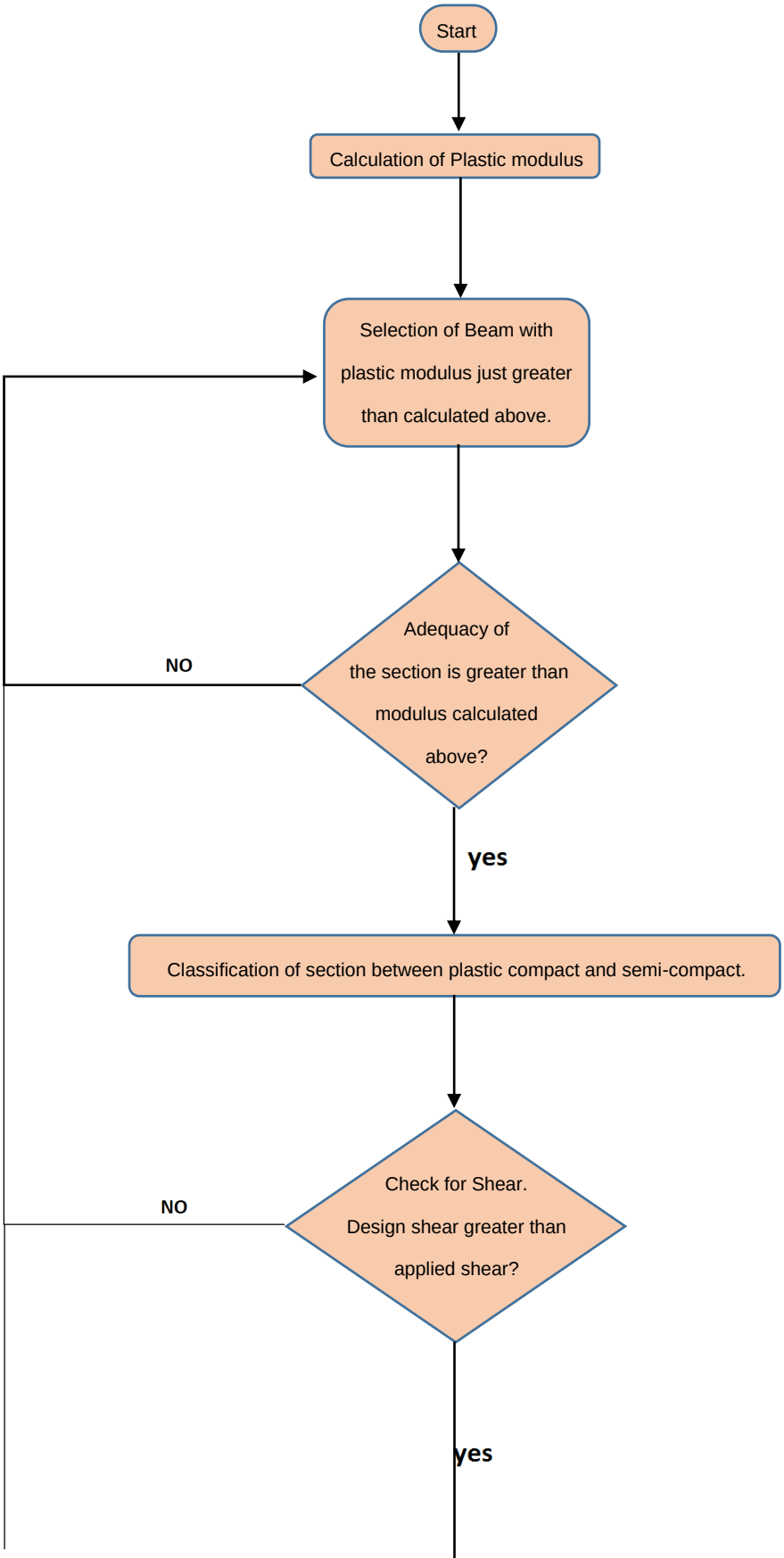
  $$F_w > V$$

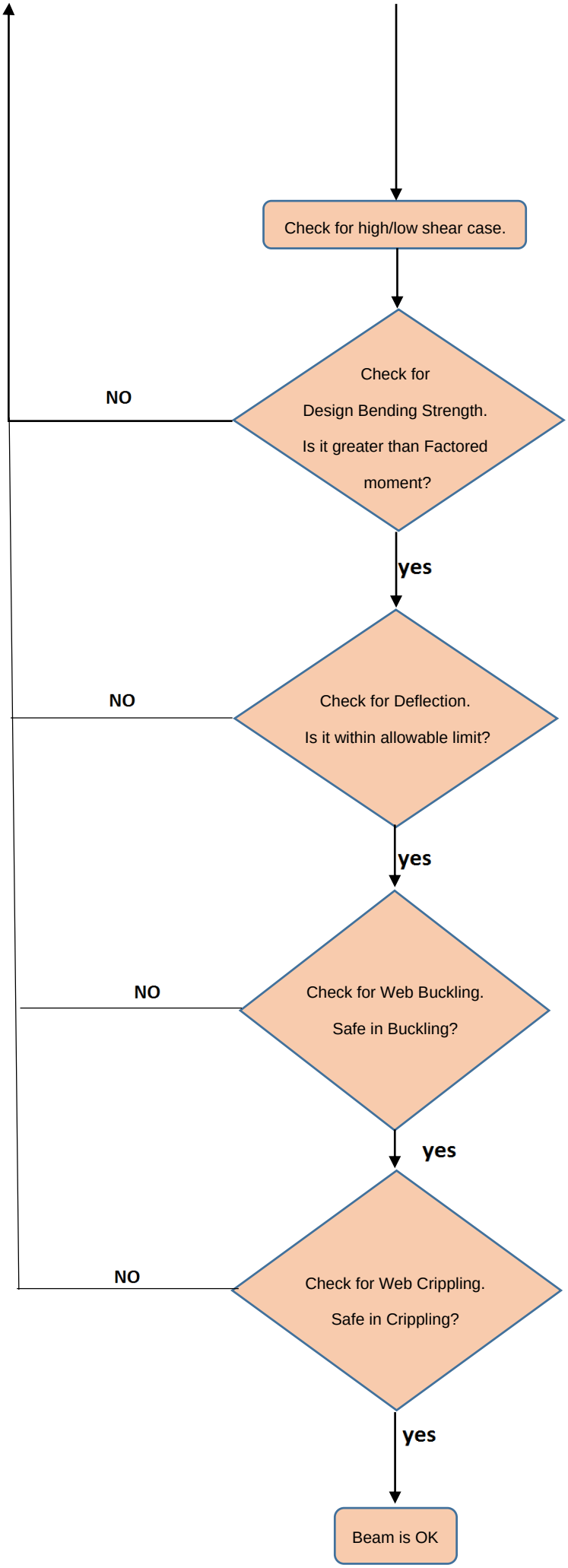
  Where F_w = web bearing strength

$= A_e \frac{f_{yw}}{\gamma_{m0}}$

Where A_e = [b+2.5(t_f+R_1)]t_w , f_{yw} = Yield stress of the web of the bearing section.

Flow Chart for Design of Laterally Supported Beams




Check for high/low shear case.
Check for
Design Bending Strength.
Is it greater than Factored
moment?
NO
yes
Check for Deflection.
Is it within allowable limit?
NO
yes
Check for Web Buckling.
Safe in Buckling?
NO
yes
Check for Web Crippling.
Safe in Crippling?
NO
yes
Beam is OK