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 Supported 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

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

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 adequacy of the section is checked. Adding the factored self-weight of the beam to the total load acting and re calculating the plastic section modulus of the beam. It should be less than the plastic section modulus of the beam chosen else the beam is abandoned and next beam is chosen to repeat the process.
- 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,

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

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,

For low shear case Md > M

Where Md is the design bending strength
M is the design bending moment.

The design bending strength,

$$M_d = \beta_b Z_p \frac{f_y}{\gamma_{m0}} \leq 1.2\, Z_e \frac{f_y}{\gamma_{m0}}$$

$$where\ \beta_b = 1.0\ for\ plastic\ and\ compact\ sections$$

For high shear case $M_{dv} \geq M$ for plastic and compact sections,

$M_d \geq M$ for semi-compact sections.

Where M_{dv} = Design bending strength of plastic or compact sections,

M_d= Design bending strength of semi-compact sections.

$$= Z_e \frac{f_y}{\gamma_{m0}}$$

$$M_{dv} = M_d - \beta\left(M_d - M_{fd}\right) \leq 1.2\, Z_e \frac{f_y}{\gamma_{m0}}$$

$$\beta = (2\frac{V}{V_d} - 1)^2$$

M_{fd} = Plastic design strength of the area of the cross section excluding the shear area

$$= Z_{fd} \frac{f_y}{\gamma_{m0}}$$

$Z_{fd} = Z_p - A_w\, y_w$

A_w = Area of the web = ht_w

$y_w = \frac{h}{4}$

- 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.