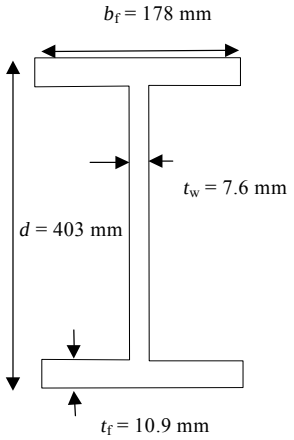
Steel Structures 1

Tutorial Set 3 - Bending

1) OneSteel are planning to introduce a new ***heavily welded*** I section which is shown on the right. The steel has a yield stress f_y = 320 MPa.



Geometric properties:

I_x $= 7.6\times(403-2\times10.9)^3/12+2\times(178\times10.9^3/12+178\times10.9\times\{(403-10.9)/2\}^2)$
$= 184\times10^6 mm^4$

Z_x $= I_x/(d/2) = 184\times10^6/(403/2) = 914\times10^3\ mm^3$

S_x $= 2\times\{(403-2\times10.9)/2 \times 7.6 \times (403-2\times10.9)/4 + 178\times10.9\times(403-10.9)/2$
$= 1040\times10^3\ mm^3$

Determine the following:

- Effective section modulus (Z_{ex}) and the design section moment capacity (φM_{sx}) for major axis bending.
- Design shear capacity (φV_v).
- Design member moment capacity (φM_{bx}) assuming an effective length in bending L_{eb} = 4.0 m, and that the bending moment results from a simply supported beam with a central point load.

Note that this section has the same dimensions as a 410UB53.7, but the answer should be different to the value of Z_{ex} = 1060 × 10^3 mm^3 (Compact) given in the OneSteel Section Handbook. Suggest some reasons for the discrepancy.

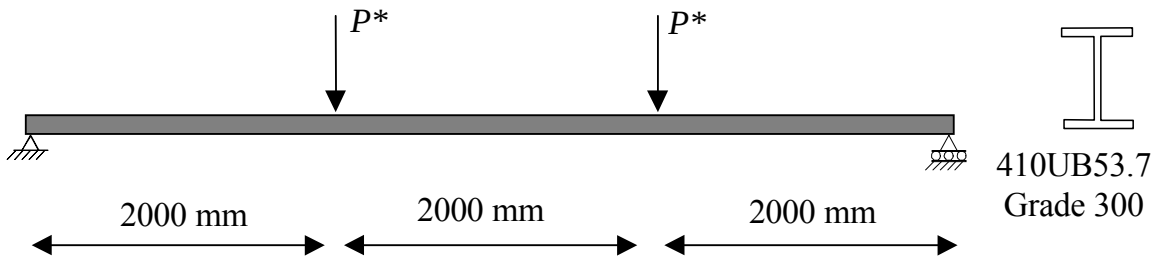
2) The beam shown below is a 410UB53.7 in Grade 300 steel. The beam is subjected to two point loads, P^*, acting on the top flange of the beam.

a) Draw the bending moment diagram and shear force diagram. Is the beam bending about the *x*-axis or *y*-axis?

b) What is the maximum value of P^* in each of the following cases:

i. The beam has full lateral restraint along its entire length,
ii. There is full restraint at both supports and both load points, or
iii. There is full restraint at both supports only.

In each case, the values of M_s, L_e, α_m, α_s, and M_b should be clearly indicated (when relevant).



3) An 8 m long 310UB46.2 in Grade 300 steel forms part of a roof system. The connections at the end of the beam to the columns are simple, flexible connections, providing full restraint (F) to both flanges at the end of the beams only but not providing lateral rotation restraint. The beam is oriented so that the web of the UB is vertical and there are purlins on the top flange at a yet undetermined spacing which provide restraint to the top flange but not the bottom flange.

- Assuming downwards gravity loads (live + dead) act as a UDL on the top flange, what would be the maximum purlin spacing to ensure that the beam could be considered to have full lateral restraint for gravity loads (*Hint: Cl 5.3.2.4)*? What is moment capacity in this case, and what is the maximum UDL the beam could support?

- Consider an upwards UDL due to wind uplift. What is moment capacity in this case, and what is the maximum UDL the beam could support? What, if anything, could be done to increase this capacity?

4) Consider the 410UB53.7 section in Grade 300 steel in Question 3. At the load points near the middle of the beam, the point loads act on the top flange via a stiff bearing length of 150 mm, and the beam overhangs the support by 150 mm. **What is the maximum load, *P**, that the beam can resist in bearing?** (It can be assumed that shear and bending capacity are adequate). Clearly indicate the values of b_b, b_{bf}, ϕR_{bb}, and ϕR_{by}. Draw a picture that clearly indicates b_s, b_b, b_{bf}.

5) Spreadsheet question: Calculation of the member capacity in bending can be time consuming. Create a spreadsheet that will calculate the ϕM_{sx} & ϕM_{bx} for any given values of effective length. What input data is required? Feel free to use whatever information is available in the OneSteel property tables. This may be of assistance in the subsequent design exercise on frame design.

6) Spreadsheet question: Consider a simply supported beam with length L, subject to a UDL of 12 kN/m. Increase the length of the beam in 500 mm intervals from 3 m to 20 m.
   - Consider two cases: either with full lateral restraint, or without restraint (where $L_e = L$)
   - For each length, determine minimum size UB or WB that can be used.
   - Plot L/d vs L as L varies (d – beam depth).
   - Plot m vs L (m = mass per unit length).
   - *Hint:* Excel lookup tables will prove useful.

It is anticipated that students should be able to complete most of these tutorial questions during the allocated tutorial time.

In the exam only annotated versions of the Standard AS 4100 and the BHP/OneSteel section properties are permitted. Hence it is good practice to attempt these questions using just the standard AS 4100 and not referencing the lecture notes.

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