EGT3
ENGINEERING TRIPOS PART IIB

Thursday 1 May 2014   2 to 3.30

Module 4D10

STRUCTURAL STEELWORK

*Answer not more than **three** questions.*

All questions carry the same number of marks.

*The **approximate** percentage of marks allocated to each part of a question is indicated in the right margin.*

*Write your candidate number **not** your name on the cover sheet.*

STATIONERY REQUIREMENTS
Single-sided script paper

SPECIAL REQUIREMENTS TO BE SUPPLIED FOR THIS EXAM
CUED approved calculator allowed
Attachment: 4D10 Structural Steelwork Data Sheets (9 pages).
Engineering Data Book

You may not start to read the questions printed on the subsequent pages of this question paper until instructed to do so.

1 (a) Explain briefly the rationale behind the Perry-Robertson approach to the flexural buckling resistance of steel columns. [15%]

(b) Explain briefly how Eurocode EC3 applies the Perry-Robertson rationale to lateral-torsional buckling of beams and to residual stress effects. [15%]

(c) A simply-supported 10 m long 305 × 127 UB 42 beam of S275 steel is shown in Fig. 1. Lateral deflections and twist rotations are prevented at the ends and at midspan by lateral bracing.

(i) Determine whether the beam is adequate to carry a central point load of 50 kN coexistent with an end moment of 80 kNm as shown. (These are ultimate design loads that already include all load factors and an allowance for self-weight.) [50%]

(ii) Is the beam adequate to carry just the central 50 kN point load when the 80 kNm end moment is removed? [10%]

(iii) Suggest a reason as to why your calculations for lateral-torsional buckling in part (i) might be somewhat conservative. [10%]

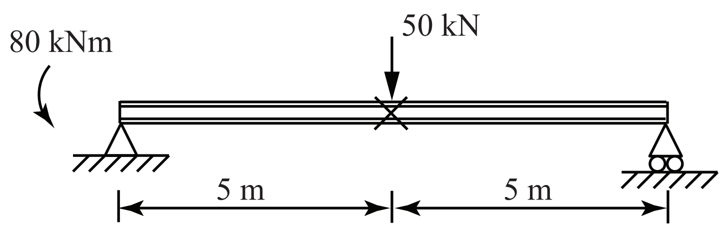


Fig. 1

2 A 457×191 UB 82 beam column of S355 steel is 10 m long. It is simply supported at its ends with respect to major axis flexure.

There are lateral braces at its ends and at midspan. Each brace prevents lateral movement due to minor axis flexure and twist rotation of the section at which it connects.

The beam column will be loaded with some combination of axial compression N and equal-and-opposite major axis end moments M.

In the following calculations you may assume that all components are at least Class 2 (compact).

(a) Using the bilinear "half web fraction" approximation, construct the local plastic capacity envelope on an (M,N) diagram. [20%]

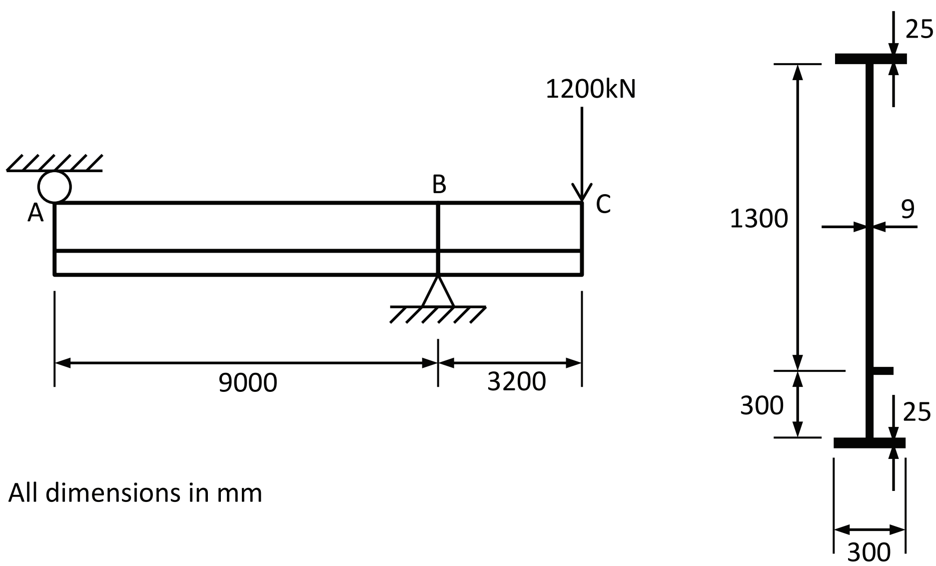
(b) On your (M,N) diagram, also construct two strength envelopes associated with global behaviour, one concerning major and the other minor axis flexure, each of which may interact with lateral-torsional buckling and plasticity effects. You may assume that each envelope is linear between points on the M and N axes. [80%]

3 The uniform plate girder ABC shown in Fig. 2 (a), of total length 12.2 m, is simply supported at points A and B and loaded vertically at point C. The girder has the cross-section shown in Fig. 2 (b), and is fabricated by welding together plates of grade S355 steel. The web is reinforced by a longitudinal stiffener over its full length and by vertical stiffeners at A, B and C.

It may be assumed that all stiffeners are properly designed, and that lateral torsional buckling is prevented. Ignore self-weight.

(a) Determine whether the girder design is adequate to support the load of 1200 kN applied at C. If the girder design is not adequate, suggest, without further calculation, how it might be modified to carry the load safely. [70%]

(b) Estimate the number of loading cycles to cause fatigue failure in the fillet welds attaching the longitudinal stiffener to the web, for repeated applications of the 1200 kN load. [30%]



(a) (b)

Fig. 2

4 A composite floor carries 1 kPa of permanent services and 6 kPa of imposed load. The load factors for permanent and imposed load are 1.35 and 1.5 respectively. The floor consists of a solid concrete slab, of thickness 100 mm, and of grade 30 concrete whose design strength f_{cd} may be assumed to be 30 MPa. It acts compositely with $457 \times 191 \times 89$ Universal Beams of grade S355 steel, each of simply-supported 12 m span, placed at 3.5 m centres. Assume the density of concrete to be 2400 kg m^{-3}.

(a) Check the floor strength at ultimate limit state. [50%]

(b) Calculate the total number of 65×13 mm shear studs needed for each UB. [20%]

(c) Estimate the central deflection under short term application of the imposed load. [30%]

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ANSWERS:

Q1: c) 93 kNm > 85 kNm. OK. d) 93 kNm < 125 kNm. FAIL

Q2: a) 3692 kN, 650 kNm, (760kN). b) 3138 kN, 1218 kN, 319 kNm

Q3: a) FAIL (instability of top web panel over support) b) 470,000 cycles

Q4: a) 1191 kNm > 878 kNm OK b) 172 studs(13 by 65) c) 23.5 mm