ENGINEERING TRIPOS PART IIB

Tuesday 1 May 2012 2.30 to 4

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.*

Unless otherwise indicated, in all questions the given loads are already factored and no partial material factors need to be applied, and self-weight can be ignored.

Attachments: Special datasheets (9 pages).

STATIONERY REQUIREMENTS	SPECIAL REQUIREMENTS
Single-sided script paper	Engineering Data Book
	CUED approved calculator allowed

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

KAS03

1 A composite floor carries 5.0 kN m^{-2} of imposed load in addition to 2.5 kN m^{-2} of permanent services. Load factors of 1.35 and 1.5 apply to the permanent and imposed loads, respectively. The floor consists of a 100 mm thick concrete slab, of design strength $f_{cd} = 25$ N mm^{-2}, cast onto the profiled steel sheeting shown in Fig. 1(a). The slab acts compositely with a 10 m span simply-supported secondary beam, of section 457 × 152 × 52 kg m^{-1} UB in S275 structural steel, laid at right angles to the troughs and placed at 3 m centres. The concrete has a density of 2400 kg m^{-3}.

(a) Will the slab need to be propped during in-situ casting of the concrete if the sheeting has a thickness of 0.9 mm? [10%]

(b) Show that the floor can carry the specified loads. [50%]

(c) Calculate the number of 13 mm × 65 mm shear studs needed in each UB to achieve full composite action. [10%]

(d) The end of each secondary composite beam is connected to a primary beam by the bolt group detail shown in Fig. 1(b). What size of grade 8.8 bolt is needed if the span is assumed to be simply supported between the centre-lines of the primary beams? [30%]

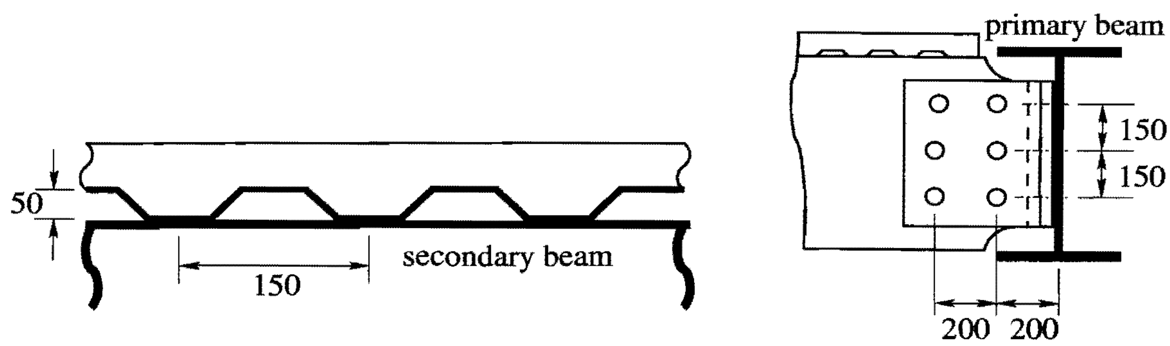

Fig. 1

2 A 10 m column is made from a $381 \times 102 \times 55$ kg m^{-1} channel section in S355 structural steel. The column is pin-supported at its ends and effective lateral restraint against minor axis flexural buckling is provided by bracing at intervals along its length, as shown in Fig. 2(a).

(a) Calculate the effective cross-section of the channel for axial loading. [20%]

(b) Check that the column is capable of supporting an axial load of 900 kN applied with no eccentricity. [50%]

(c) The intermediate bracing against minor axis buckling is attached to the web of the channel by a joint containing a class F detail. How many complete load cycles can be carried under the loading cycle indicated in Fig. 2(b)? [30%]

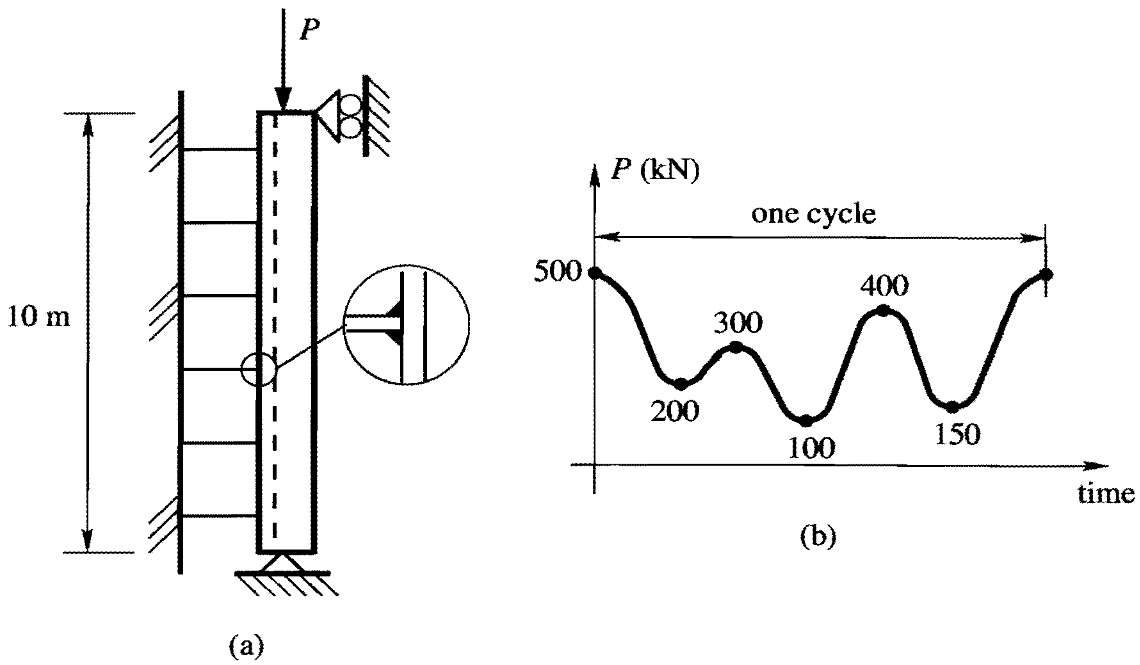

Fig. 2

3 (a) Show that the lowest root $\sigma = \sigma_L$ of the Perry-Robertson equation

$$(\sigma_y - \sigma)(\sigma_E - \sigma) = \eta \sigma \sigma_E$$

may be expressed as

$$\sigma_L = \frac{\sigma_y}{\Phi + \sqrt{\Phi^2 - \lambda^2}}$$

where $\Phi = (1 + \eta + \lambda^2)/2$ and $\lambda = \sqrt{\sigma_y/\sigma_E}$. [30%]

(b) Describe briefly the rationale behind using the Perry-Robertson equation for;

(i) flexural buckling,

(ii) lateral torsional buckling,

stating any assumptions or shortcomings. [20%]

(c) A beam-column has a length of 2.8 m, and it is simply supported about both major and minor axes. At each end it is restrained from twisting and is free to warp. It is made from a $203 \times 203 \times 60$ kg m^{-1} UC section in S275 structural steel. You may assume that all components of the section are at least Class 2 (compact), and any reduction of moment capacity due to shear effects may be ignored.

Assuming that there are no applied minor axis moments, construct the interaction diagrams that bound the permissible combinations of applied axial forces and equal-and-opposite major axis end moments. For the local plastic capacity interaction diagram you may use the bi-linear approximation based on half the web-fraction, and for the global interaction diagrams you may use the linear approximations that correspond to all "*k*-factors" being equal to unity. [50%]

4 Figure 3 shows a simply-supported 15 m long beam ABCD braced at intermediate points B and C. It is made from a 406 × 178 × 74kg m^{-1} UB section in S275 structural steel. The web is in the plane of the diagram. Lateral deflection and twist rotation are prevented at points A, B, C and D. You may ignore self-weight, and you may assume that all components of the section are at least Class 2 (compact), and any reduction of moment capacity due to shear effects may be ignored.

(a) Factored point loads of 35 kN and 70 kN are to be carried simultaneously at B and C respectively, as shown. Determine if the member is adequate. [70%]

(b) The loads at B and C are now changed. Determine if the beam is adequate to carry a factored point load combination of -175 kN at B and +175 kN at C. [30%]

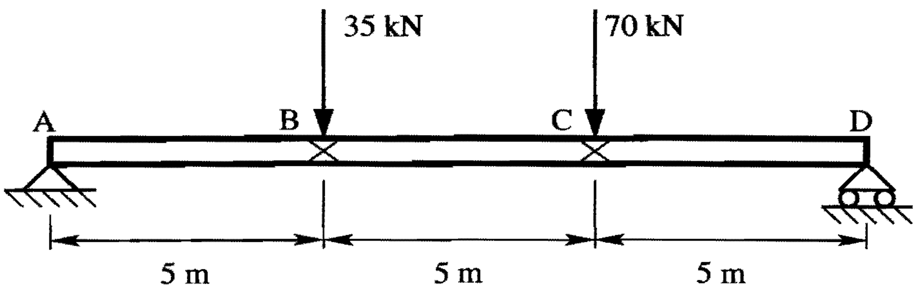

Fig. 3

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