First Semester Examination
2021/2022 Academic Session

February/March 2022

EAS457 – Structural Steel Design

Duration : 1 hour

Please ensure that this examination paper contains **FIVE (5)** printed pages before you begin the examination.

Instructions:

This paper contains **THREE (3)** questions. Answer **TWO (2)** questions.

All questions **MUST BE** answered on a new page.

The relevant standards, section properties and design data can be accessed in eLearn@USM portal.

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1. (a). Describe with the aid of diagrams

(i). **FIVE (5)** types of welds as described in EC3.

[20 marks]

(ii). **TWO (2)** types of shear failure of bolts.

[5 marks]

(b). A 305 x 165 x 54 UKB is to be connected to a 356 x 406 x 467 UKC as shown in the structural layout (**Figure 1**) using S275 steel. Several Class 6.8 M16 bolts are proposed to be connectors. The beam is welded to the end plate of 12 mm thick. The calculated shear resistance is 500 kN.

(i). Determine the number of bolts required.

[5 marks]

(ii). Estimate the bearing and shear resistance of one shear plane of the bolt group.

[20 marks]

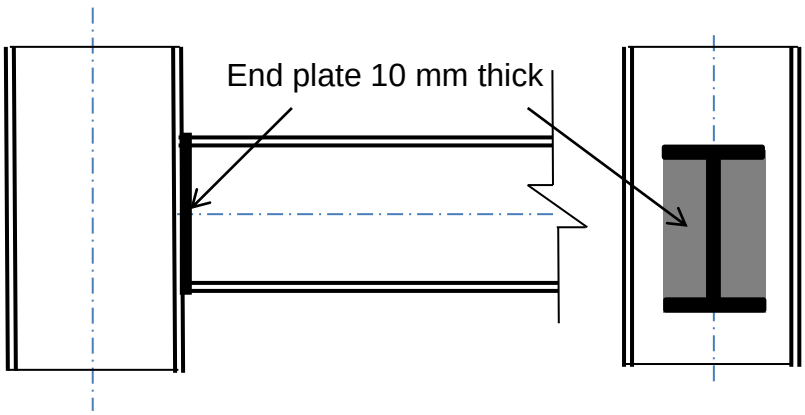


Figure 1 Structural layout

2. A tension member consists of a 150 × 90 × 12 single unequal angle with its ends are connected to gusset plates through the larger leg by a single row of four 22 mm bolts in 24 mm holes at 60 mm centres. Verify whether the size provided is suitable as a tension member when the design tension force, $N_{t,Ed}$ = 350 kN based on standard engineering assumptions. Assume the steel grade is S275. Discuss your verification.

[50 marks]

3. (a). A frame is said to be sensitive to the second order effect if the deflections are such that the effects of the axial load on the deflected shape are large enough to cause significant additional moments and further deflection.

(i). Identify the criteria when the second order effect can be ignored in frame elastic analysis.

[2 marks]

(ii). If second order effect is significant, describe the options available to take into account the second order effects in the design.

[4 marks]

(b). Initially, the column **C1** of a single portal frame (in **Figure 2 (b)**) with the size of $457 \times 191 \times 89\,\mathrm{kg/m}$ UKB S355 was designed by assuming no intermediate restraints between the haunch and the base. However, column **C1** failed in lateral-torsional buckling resistance condition.

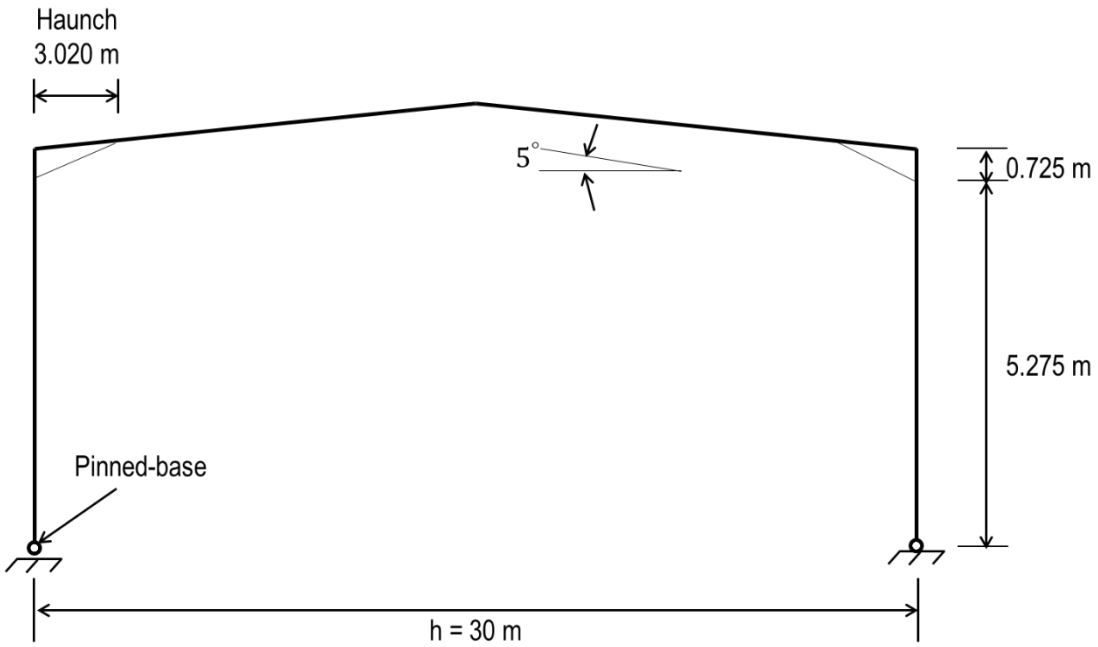
Hence, one torsional restraint was introduced at 1475 mm from the underside of the eave haunch (in **Figure 2 (c)**).

Design the lateral-torsional buckling resistance of column **C1** by considering the introduced intermediate restraint.

Assume column **C1** is a **Class 1** section and use the following critical moment (M_{cr}) in the design. The characteristics of **C1** is given in **Figure 2(a)**.

$$M_{cr} = C_1 \frac{\pi^2 EI_z}{L^2} \sqrt{\frac{I_w}{I_z} + \frac{L^2 GI_T}{\pi^2 EI_z}}$$

[44 marks]



(a) Single portal frame

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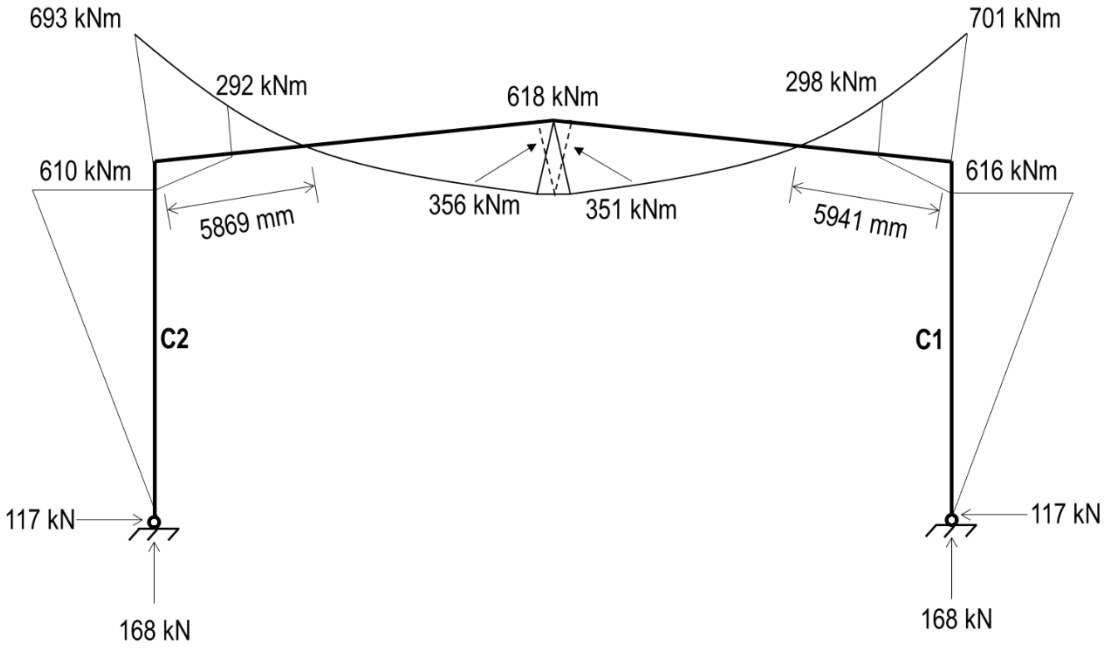
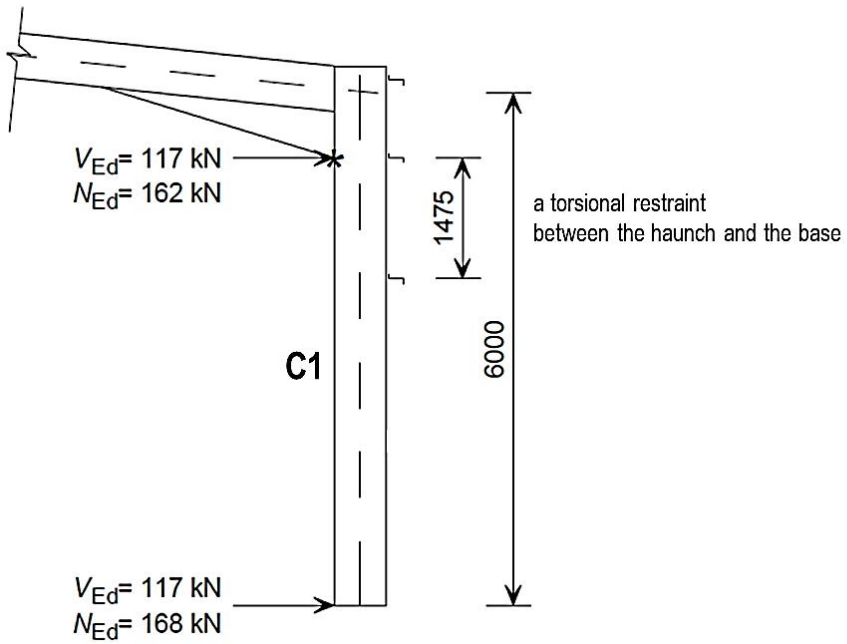


(b) Bending moment diagram (include EHF)



(Unit: mm)

(c) Column C1

Figure 2

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