ELIZADE UNIVERSITY

**DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING**

**B.Eng (Civil and Environmental Engrg.) Degree 1st Semester Examination 2020/2021 Session**

**CVE 407: Design of Structures II** **Units: 3** **Time Allowed: 3Hrs**

**INSTRUCTION: Answer Four Questions. Each carries 25 marks**

HOD'S SIGNATURE

## Question 1

(a) A simply supported 406 x 178 x 74 UB is required to span 4.5 m and carry an ultimate design load of 40 kN/m. Check the suitability of the section with respect to shear.
Sectional properties: t = 9.6mm; D = 412.8mm d = 360.4mm, $P_y$ = 275N/mm² (9 marks)

(b) Explain the terms limit state design, ultimate limit state and serviceability limit state. (10 marks)

(c) Mention five main categories of steel produced from blast furnace. (6 marks)

## Question 2

(a) A single span beam of 8. 0 m span supporting two factored point loads is shown in Figure 1. Assuming lateral and torsional restraint to the compression flange at the ends and points of application of the loads only, check the suitability of a 406 x 140 x 39 UB with respect to bending. Neglect self-weight, i.e. the beam is not loaded between adjacent lateral restraints.

Sectional properties: u = 0.858, $P_y$ = 275N/mm², $r_{yy}$ = 28.7 mm, Pb = 131N/mm², $S_{xx}$ = 724 cm² (12 marks)

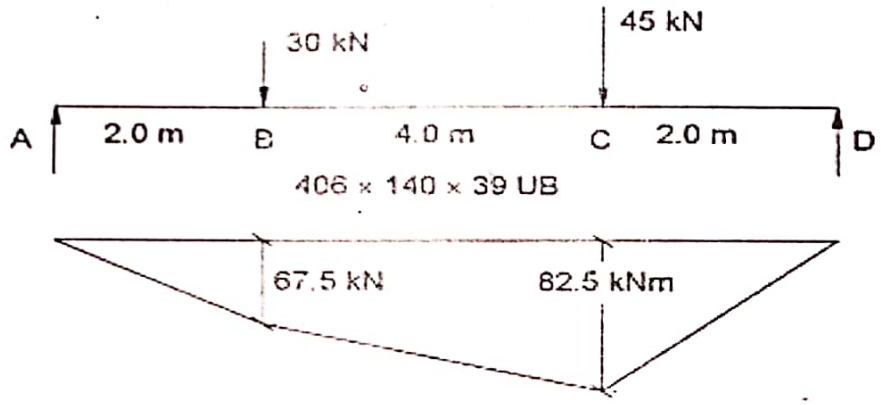



Figure 1

(b) Briefly explain the process of producing steel from blast furnace (13 marks)

**Question 3**

(a) Structural sections are classified into four sections namely: plastic, compact, semi-compact and slender sections. Explain all the sections. (10 marks)

(b) What are the four factors responsibly for deformation of compression flange of beam? (4 marks)

(c) A 406 x 178 x 54 UB is simply supported and carries factored loading as shown in Figure 2. Assuming lateral restraints to the compression flange at A, B, C and D as in Example 2.2, check the suitability of the section with respect to bending. (11 marks)

Sectional properties: $S_{xx}$ = 1055 cm$^2$, $P_b$ = 182.5 N/mm$^2$

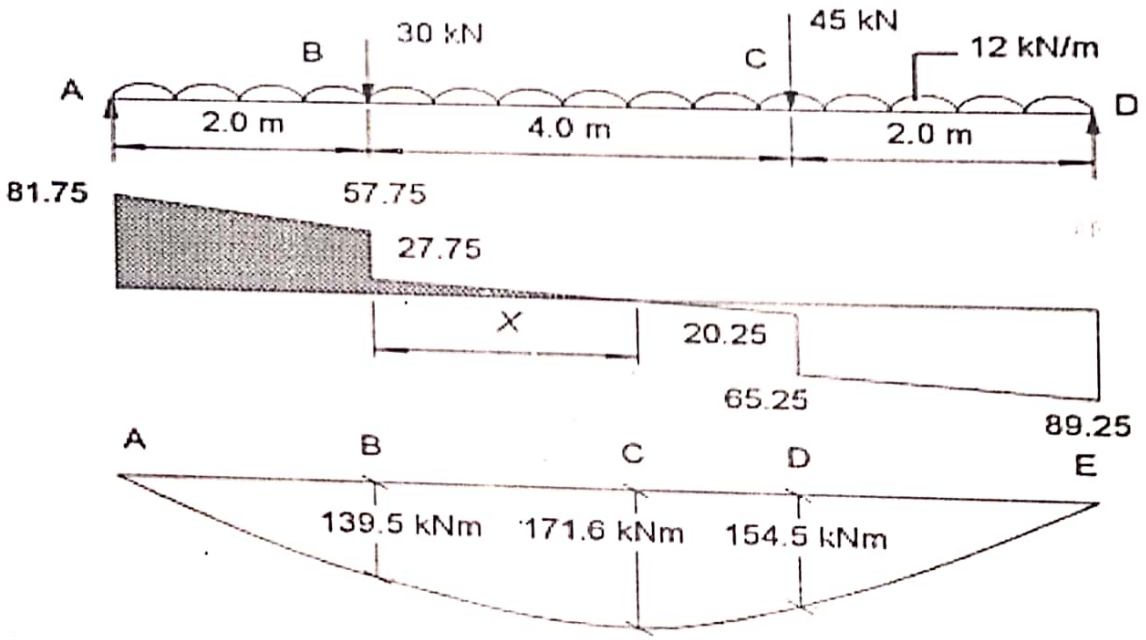
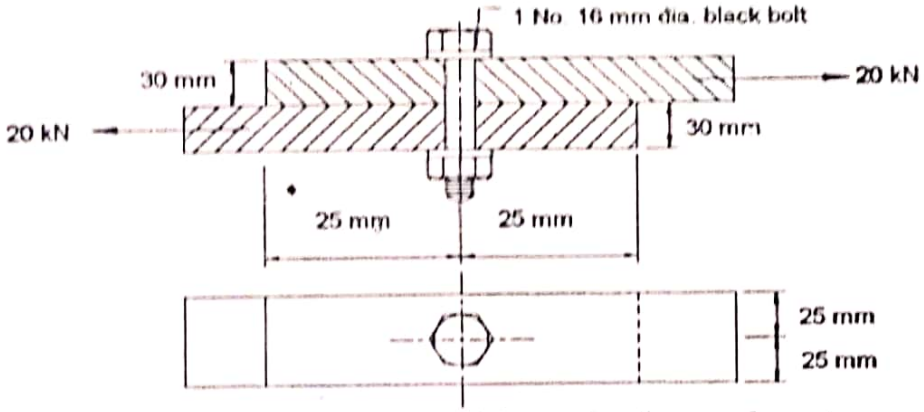



Figure 2

**Question 4**

(a) A lap joint is shown in Figure 3 in which a single Grade 4. 6 16 mm diameter black bolt is used. There is one shear interface and it is assumed that this passes through the threaded portion of the bolt. Check the minimum and maximum edge and end distances. Determine the shear capacity of the connection with respect to:
(i) bolt shear,
(ii) bolt bearing,
(iii) plate bearing, and
(iv) plate tension capacity.
Sectional properties: for 16mm bolt, edge/end distance = 25mm, $P_s$ = 160kN/mm$^2$, As = 157mm$^2$, $P_{bb}$ = $P_{bc}$ = 460N/mm$^2$ (19 marks)




• It is desirable to adopt the minimum edge distance +5 mm to accommodate any enlargement which may be necessary on site.

Figure 3

(c) Briefly discuss two most widely use applications of structural steel work in buildings.
(6 marks)

**Question 5**

(a) An industrial unit comprises a series of braced rectangular frames as shown in Figure 4 .8. A travelling crane is supported on a runner beam attached to the underside, at the mid-span point of the rafters. Using the design data provided, check the suitability of a 203 x 133 x 25 UB for the column of a typical internal frame, using the simplified approach.
(20 marks)

Sectional properties: $P_y = 275 N/mm^2$

Section Properties: 203 × 133 × 25 UB

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| $D$ = 203.2 mm | $B$ = 133.2 mm | $T$ = 7.8 mm | $Z_{xx}$ = 230 cm$^2$ | $d/t$ | = | 30.2 |
| $A$ = 3200 mm$^2$ | $d$ = 172.4 mm | $t$ = 5.7 mm | $S_{xx}$ = 258 cm$^2$ | $b/T$ | = | 8.54 |
| $r_{yy}$ = 31.0 mm | $r_{xx}$ = 85.6 mm | $u$ = 0.877 | $x$ = 25.6 | | | |

**Design Data:**

| | |
|---|---|
| Characteristic dead load due to the sheeting, purlins and services | 0.5 kN/m$^2$ |
| Characteristic imposed load | 0.75 kN/m$^2$ |
| Characteristic dead load due to side sheeting | 0.3 kN/m$^2$ |
| Characteristic dead load due to crane | 5.0 kN |
| Characteristic imposed load | 25.0 kN |
| Ignore wind loading | |

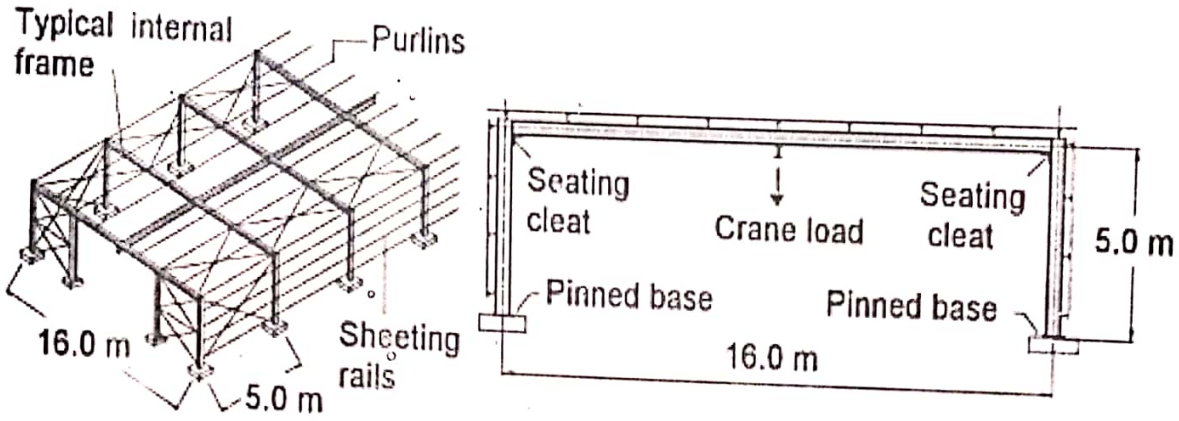



Figure 4

(b) List five aims or objectives of designing structures. (5 marks)

**Question 6**

(a) The uniform rectangular portal frame shown in Figure 5 is subjected to loading which induces moments and shear forces at the knee joint as given in the data below. Using this data, determine a suitable size of H.S.F.G. bolt for the connection between the column and the roof beam. (12 marks)

**Design Data:**

| | |
|---|---|
| Column / Beam Section | 610 × 305 × 149 UB |
| Ultimate Design Moment at the knee joint | 540 kNm |
| Ultimate Design Shear Force at the knee joint | 380 kN |

**Section Data:** 610 × 305 × 149 UB

| | | |
|---|---|---|
| $D$ = 609.6 mm | $d$ = 537.2 mm | $I_{xx}$ = 124.7 × 10$^3$ cm$^4$ |
| $B$ = 304.8 mm | $b/T$ = 7.74 | $I_{yy}$ = 9.308 × 10$^3$ cm$^4$ |
| $t$ = 11.9 mm | $d/t$ = 45.1 | $r_{xx}$ = 25.6 cm |
| $T$ = 19.7 mm | $r_{yy}$ = 6.99 cm | $u$ = 0.886 |
| $x$ = 32.5 | $A$ = 190 cm$^2$ | |

$K_s$ = 1.0 and $\mu$ = 0.45

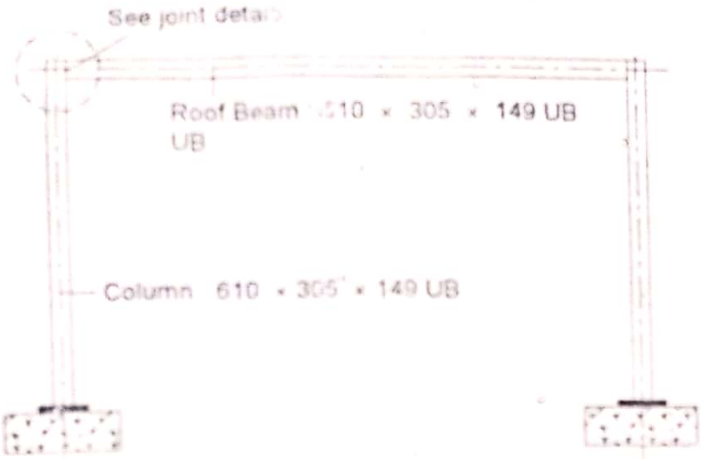



Figure 5

(b) An industrial frame building supports a light electric overhead travelling crane on brackets bolted to the main columns as shown in Figure 6 below. Using the design data given determine a suitable size of H.S.F.G. bolt to connect the brackets to the columns. (13 marks)

Sectional properties: for 20mm HSFG bolts $P_s$ = 71.3kN and $P_t$ = 130kN

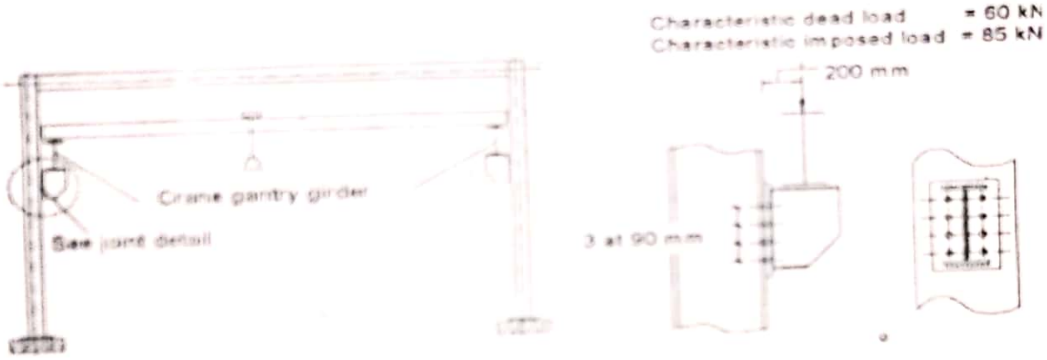



Figure 6

A lap joint is shown in Figure 4.15 in which a single Grade 4. 6 16 mm diameter black bolt is used. There is one shear interface and it is assumed that this passes through the threaded portion of the bolt.

(a) Check the minimum and maximum edge and end distances.

(b) Determine the shear capacity of the connection with respect to:

(i) bolt shear,

(ii) bolt bearing,

(iii) plate bearing, and

(iv) plate tension capacity.

Sectional properties: for 16mm bolt, edge/end distance = 25mm, Ps = 160kN/mm2, As = 157mm2, Pbb = Pbc = 460N/mm2