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Hong Kong Institute

of

Vocational Education

香港專業教育學院

HD in Civil Engineering

(EG314101)

Steelwork Design

( C O N 4 3 3 4 )

AY 2014/15

Semester Two Examination

12 May 2015

1:30 pm – 3:30 pm

Notes :

1. The result of this examination will not be counted if you do not meet the minimum attendance requirement governed by the General Academic Regulations of your programme unless approval from the Campus Principal has been granted.
2. This paper consists of SIX (6) pages including this cover page.
3. **There are two sections in this paper. Section A contains compulsory questions with a total of 40 marks. Section B is comprised of choice questions and carries a total of 60 marks.**
4. **Answer ALL questions in Section A. Answer ANY TWO (2) questions in Section B.**
5. All symbols have their usual meaning unless otherwise defined.
6. All dimensions are in millimeter unless otherwise stated.
7. All figures are NOT necessary to scale.
8. Examination Data:

   THIRTY-FIVE (35) pages of examination data are provided for reference.

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## SECTION A: COMPULSORY QUESTION (40%)

**AQ.1 (a)** A structural plan layout comprising of steel beams and concrete one-way slabs for a storage area is shown in ***Figure Q1***. Compression flanges of the steel beams (Beam B1-B3) are fully restrained from lateral torsional buckling by concrete slabs. The concrete slabs are 150 mm thick with additional finishes load of 1.0 kN/m$^2$. The live load being supported by the slabs is 2.0 kN/m$^2$. All steel beams are of Grade S355 and simply supported at their ends. Unit weight of concrete is assumed to be 24.5 kN/m$^3$. All the beams are carrying brittle finishes.

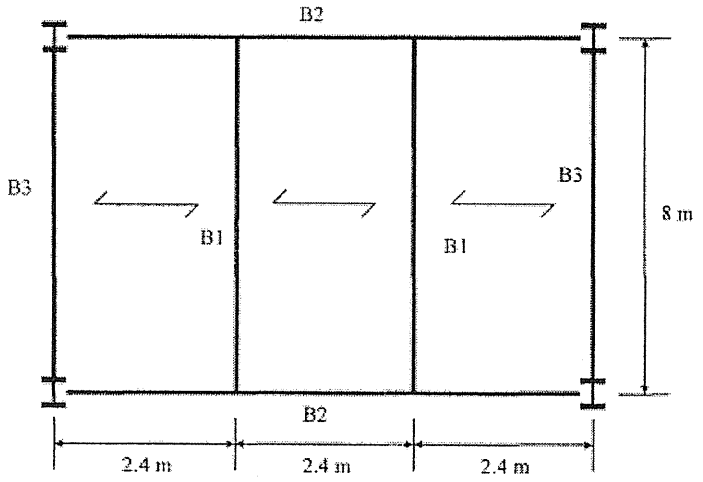
(i) Determine the factored load intensity (in kPa) carried by the slabs. (4 marks)

(ii) With consideration of beam self-weight, calculate the maximum factored shear forces and bending moments of Beam B1 and Beam B2. (8 marks)

(iii) Find the section classes of the steel beam B1 and B2. (4 marks)

(iv) Check the adequacy of steel beam B1 against shear, bending and deflection. (10 marks)

(v) Check the adequacy of steel beam B2 against shear, bending and deflection. (10 marks)




Beam B1: 305 x 165 x 40 kg/m UB
Beam B2: 356 x 171 x 51 kg/m UB

**Figure Q1**

**(b)** ***Ultimate Limit States (ULS)*** represent those limit states beyond which collapse of or irreparable damage to the structure may take place and a high load factor is used, while ***Serviceability Limit States (SLS)*** represent those limit states beyond which the structure becomes unfit for its intended use in service. State **TWO (2)** examples of each type of limit states relevant to steel structures. (4 marks)

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**Section B – Answer any TWO questions in this Section.**

**BQ.2** (a) Two 12 mm thick steel plates are bolted to the flanges of a 203 x 203 x 71 kg/m UC to form a bracket as shown in ***Figure Q2(a)***. All steel members and bolts are of Grade S355 and Grade 8.8 respectively. The point load P has a 250 mm eccentricity from centreline of the steel column. The preliminary setting out of the bolts is shown in ***Figure Q2(a)***. The end distance and edge distance for the bolts are 30 mm and 53 mm respectively.

(i) Determine the design load and design torsional moment on **ONE** plate of the bracket. (2 marks)

(ii) Determine the resultant load on the maximum loaded bolt. (10 marks)

(iii) Determine the size of grade 8.8 bolts required. Assume all the holes for the bolts are standard holes. Checking of the structural adequacy for the steel plate is NOT required. (10 marks)

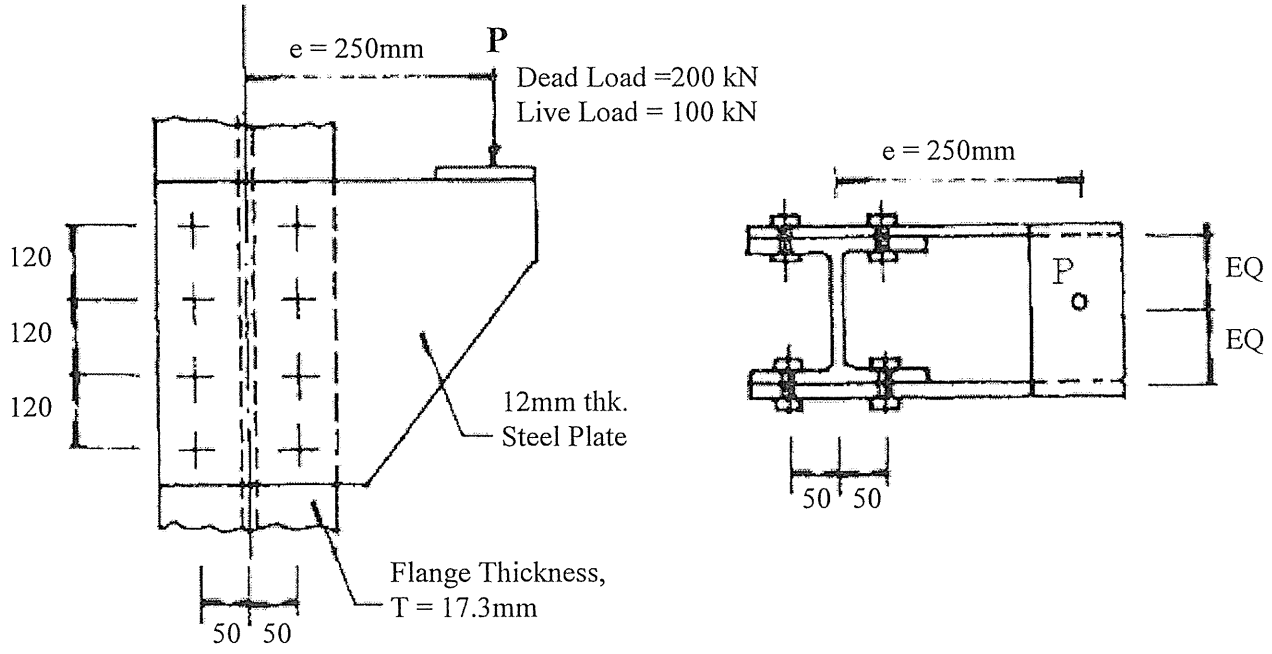



*Figure Q2(a)*

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(b) Two cover plates at both sides of two main plates are connected together by using welded connection as shown in Figure Q2(b) below, subjected to an ultimate tensile force of 750 kN. Check the adequacy of the length of weld provided for the connection with the following data:

Data: Fillet weld - Class 42 Electrode
Steel - Grade S355 steel
Cover plate thickness $t_1$ = 12 mm
Main plate thickness $t_2$ = 24 mm

(8 marks)

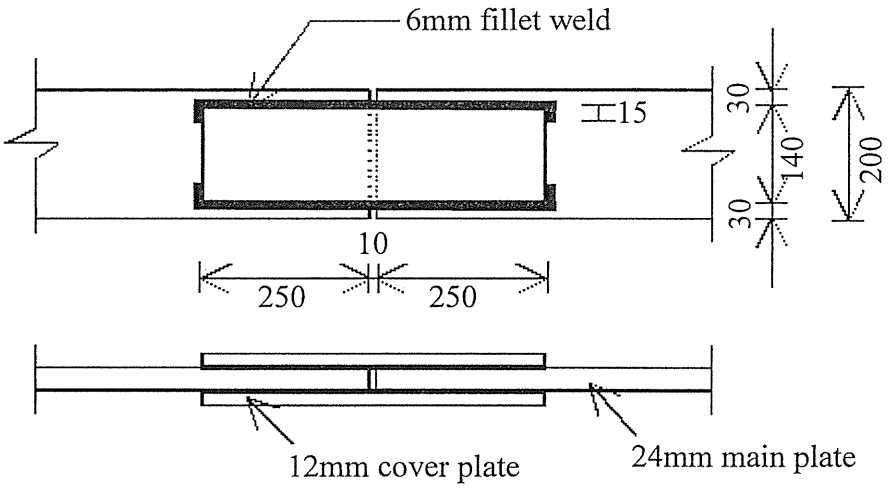



**Figure Q2(b)** ***(dimension in mm)***

**BQ.3** A steel column with effective length of 6 m is subjected to factored end loads as shown below. Check the adequacy of the column section if a 254 x 254 x 107 kg/m UC section (Grade S355) is being used.

Loadings:
Factored axial compression = 1200 kN

Factored moment about x-x axis, $\mathbf{M_{x\text{-}x}}$, **at top** of column = +100 kNm
Factored moment about x-x axis, $\mathbf{M_{x\text{-}x}}$, **at bottom** of column = +50 kNm
Amplification factor for P-Δ-δ effect in x-x axis = 1.2

Factored moment about y-y axis, $\mathbf{M_{y\text{-}y}}$, **at top** of column = +50 kNm
Factored moment about y-y axis, $\mathbf{M_{y\text{-}y}}$, **at bottom** of column = -25 kNm
Amplification factor for P-Δ-δ effect in y-y axis = 1.1

Ultimate moment amplified for P-Δ-δ effect governing $M_b$, $\mathbf{M_{LT}}$ = +100 kNm

Note: (+ve for clockwise moment, -ve for anti-clockwise moment)

(30 marks)

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**BQ.4** A simply supported steel beam with brittle finishes and a span of 6 m is subjected to a uniformly distributed load. The maximum factored loadings are calculated as follows. **Lateral restriants on the compression flange of the steel beam are provided at the end supports only.** Sectional dimensions of the beam are 457 x 152 x 52 kg/m UB (Grade S355).

- Design Moment = 160 kNm
- Design Shear Force = 80 kN

(a) Determine the class of the steel beam section. (4 marks)

(b) Determine the shear capacity of the steel beam and confirm the adequacy of shear resistance for the steel beam section. (5 marks)

(c) Check the adequancy of buckling moment resistance of the steel beam by using accurate values of parameters $u$ and $v$ in the calculation of $\lambda_{LT}$. (16 marks)

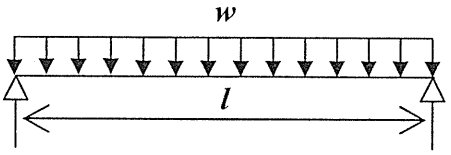
(d) Check the deflection of the beam if the beam is under a uniformly imposed load of 5 kN/m. (5 marks)

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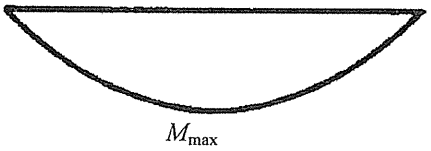
## Useful Equations:

**1) for UDL**



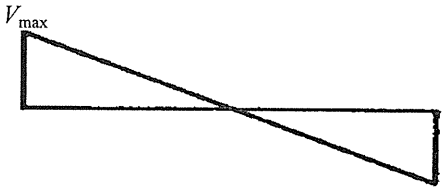

**Bending moment equation:**

$$M_{max} = \frac{wl^2}{8}$$



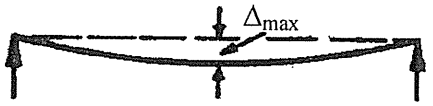

**Shear force equation:**

$$V_{max} = \frac{wl}{2}$$

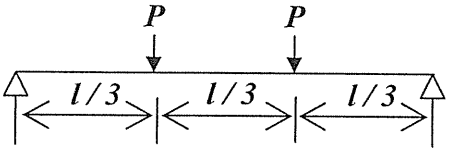



**Deflection equation**

$$\Delta_{max} = \frac{5}{384}\frac{wl^4}{EI}$$

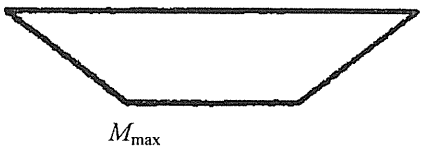



**2) for point loads at 1/3 and 2/3 of span**



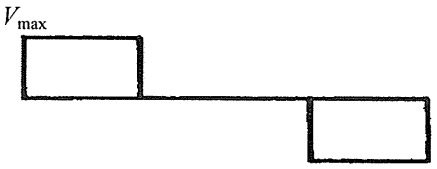

**Bending moment equation:**

$$M_{max} = \frac{Pl}{3}$$




**Shear force equation:**

$$V_{max} = P$$




**Deflection equation**

$$\Delta_{max} = \frac{23}{648}\frac{Pl^3}{EI}$$

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