[ESS27]

UNIVERSITY OF BOLTON

SCHOOL OF ENGINEERING

BENG (HONS) CIVIL ENGINEERING

SEMESTER TWO EXAMINATION 2018/2019

MATHEMATICS & STRUCTURAL DESIGN

MODULE NO: CIE4012

Date: Thursday 23rd May 2019 **Time: 14:00 – 17:00**

INSTRUCTIONS TO CANDIDATES:

There are TWO sections: Sections A and B.

Section A: Answer BOTH questions

Section B: Answer BOTH questions

Marks for each question are shown.

Sketches should be neat and drawn to scale.

Answer books are provided.

All answers are to be written in the answer book or on the additional paper provided. Pre-prepared material will not be accepted.

Candidates should bring unmarked tables of steel design, extract from EC3, and concrete design to the examination.

Total 100 marks for the paper.

School of Engineering
BEng (Hons) Civil Engineering
Semester Two Examination 2018/2019
Mathematics & Structural Design
Module No: CIE4012

SECTION A: STRUCTURAL DESIGN (Total marks for Section A is 50 marks)
Question 1:

(a) List three factors that affect the design of column base plates. **(2 marks)**

(b) Figure Q1 shows a column base plate supporting an internal steel column with a size of: 305 × 305 × 118 UKC in S275 steel.

The design value of axial compressive load is N_{Ed} = 1750 kN.

Design of compressive strength of foundation concrete is f_{cd} = 20 N/mm^2.
Assume the column base plate is with steel grade S275.

<u>Column details</u>

Height of section	h	= 314.5 mm
Breadth of section	b	= 307.4 mm
Thickness of flange	t_f	= 18.7 mm
Thickness of web	t_w	= 12 mm
Cross sectional Area	A	= 150 cm^2
Section perimeter		= 1835 mm

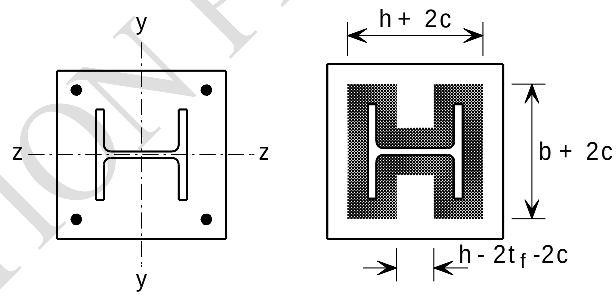


Figure Q1

(i) Use the effective area method (on page 3) to calculate the minimum thickness of the column base plate to resist the design axial compressive load. **(15 marks)**

(ii) What is the minimum size (*WidthxDepth*) of the column base plate? **(3 marks)**

(iii) Draw to a suitable scale, the cross-section of the base plate showing part of the column and the holding down bolts.

(5 marks)

Total 25 marks

Question 1 Effective Area Method over the page….

PLEASE TURN THE PAGE….

School of Engineering
BEng (Hons) Civil Engineering
Semester Two Examination 2018/2019
Mathematics & Structural Design
Module No: CIE4012

Question 1 continued….

<u>Effective Area Method</u>:

Effective area ≈ 4c² + (Column section perimeter) × c + Column section area
Where c is the cantilever outstand of the effective area, as shown in Figure Q1.

Effective area = N_{Ed}/f_{cd}

($Ac^2 + Bc + C = 0$) *where A =4, B = Column perimeter, C = (Column section area – Effective area)*

The value of *c* can be obtained by solving the above quadratic equation:

$$c = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$$

With no overlap: $h - 2t_f - 2c > 0$

The minimum thickness of base plate (t_p) is given by: $t_p \geq \dfrac{c}{\sqrt{f_{yp}/3f_{cd}}}$

f_{cd} is the design compressive strength of concrete
f_{yp} is the yield strength of the base plate

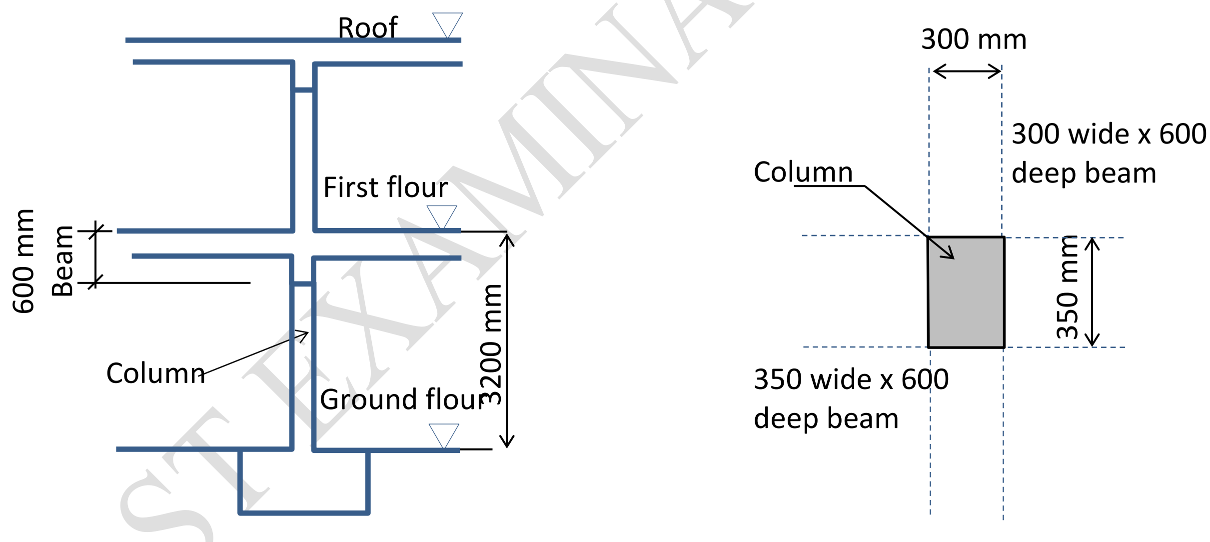
School of Engineering
BEng (Hons) Civil Engineering
Semester Two Examination 2018/2019
Mathematics & Structural Design
Module No: CIE4012

Question 2: Concrete Column Design

Figures Q2 (a) and (b) show a reinforced concrete column supporting the first floor and roof of an office building. The column is supported on a base that is designed to resist moments. The plan dimensions of the column are 300mm x 350mm, and it is to be in C25/30 concrete with 40mm cover to all bars. Both of the beams framing into the column are 600mm deep. The beam widths are 300mm and 350mm and align with the plan dimensions of the column as shown in Figure Q2(b). The thickness of the slab supported by the beams is 275mm. Floor to floor height is 3200mm.

In your calculations, assume that longitudinal bars are H25 and ties are H8. In your final design, you may use different bars. It is necessary to design the column for bending and axial loads.

At ultimate limit state (ULS), the column supports an axial load of 1444 kN and framing action applies a factored bending moment of 45 kNm in the direction of the 350 mm dimension (Column's strong axis). You may ignore the nominal moments in the weak axis of the column.



(a) Sectional Elevation (NTS)

(b) Plan view of column (NTS)

Figure Q2

Question 2 continues over the page….

PLEASE TURN THE PAGE….

Question 2 continued….

Answer the following questions:

(a) Show that the column is stocky and calculate the design bending moment applied to the column.

(7 marks)

(b) State which column design chart(s) should be used to design the reinforcement in the column and justify your choice.

(5 marks)

(c) Calculate the amount of longitudinal reinforcement and ties required for the column to support its design loads.

(8 marks)

(d) Draw an annotated transverse section through the column at around mid-height showing longitudinal reinforcement and ties (use a scale of 1:10)

(5 marks)

Total 25 marks

END OF SECTION A

PLEASE TURN THE PAGE….

School of Engineering
BEng (Hons) Civil Engineering
Semester Two Examination 2018/2019
Mathematics & Structural Design
Module No: CIE4012

SECTION B: MATHEMATICS (Total marks for Section B is 50 marks)

Question 3

(a) With the aid of a sketch, find the area under the curve $y = x^2 - 3x$ between $x = 0$ and $x = 5$

(6 marks)

(b) In Fig 3 below, find the area of the shaded region A.

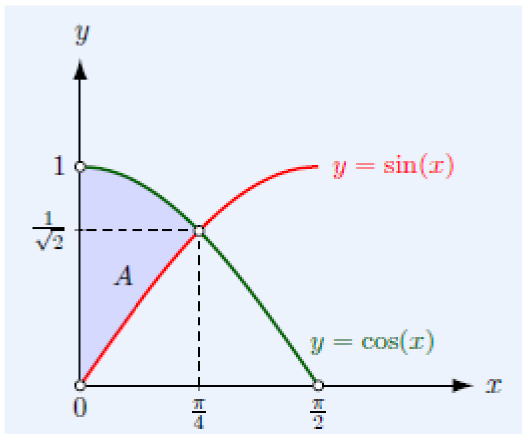


Fig 3

(6 marks)

(c) Find the particular solutions of the following differential equations:

(i) $\frac{d^2y}{dx^2} = x^2 + 2$ given that $y = 0$ and $\frac{dy}{dx} = 0$ at $x = 0$

(6 marks)

(ii) $\frac{d^2y}{dx^2} = \sin(x) + 1$ given that $y = 0$ at $x = 0$ and $x = 1$

(7 marks)

Total 25 marks

PLEASE TURN THE PAGE….

School of Engineering
BEng (Hons) Civil Engineering
Semester Two Examination 2018/2019
Mathematics & Structural Design
Module No: CIE4012

Question 4

a) Evaluate the following definite integrals:

i. $\int_0^1 (x^2 - 5x + 3)\, dx$ **(3 marks)**

ii. $\int_0^{\pi} (\sin(2x) - \cos(3x))\, dx$ **(4 marks)**

iii. $\int_1^2 \left(\frac{1}{x} + \sqrt{x}\right) dx$ (correct to 2 decimal places) **(5 marks)**

b) Using suitable integration techniques, determine the following indefinite integrals:

i. $\int x\cos(4x)dx$ **(6 marks)**

ii. $\int 2x^2 e^{2x} dx$ **(7 marks)**

Total 25 marks

END OF QUESTIONS

Formula and equation sheet over the page….

PLEASE TURN THE PAGE….

FORMULA AND EQUATION SHEET

$f(x)$	$\int f(x)\,\mathrm{d}x$	
k, any constant	$kx + c$	
x	$\frac{x^2}{2} + c$	
x^2	$\frac{x^3}{3} + c$	
x^n	$\frac{x^{n+1}}{n+1} + c$	$n \neq -1$
$x^{-1} = \frac{1}{x}$	$\ln\lvert x\rvert + c$	
e^x	$\mathrm{e}^x + c$	
e^{kx}	$\frac{1}{k}\mathrm{e}^{kx} + c$	
$\cos x$	$\sin x + c$	
$\cos kx$	$\frac{1}{k}\sin kx + c$	
$\sin x$	$-\cos x + c$	
$\sin kx$	$-\frac{1}{k}\cos kx + c$	
$\tan x$	$\ln(\sec x) + c$	$-\frac{\pi}{2} < x < \frac{\pi}{2}$
$\sec x$	$\ln(\sec x + \tan x) + c$	$-\frac{\pi}{2} < x < \frac{\pi}{2}$
$\operatorname{cosec} x$	$\ln(\operatorname{cosec} x - \cot x) + c$	$0 < x < \pi$
$\cot x$	$\ln(\sin x) + c$	$0 < x < \pi$
$\cosh x$	$\sinh x + c$	
$\sinh x$	$\cosh x + c$	
$\tanh x$	$\ln\cosh x + c$	
$\coth x$	$\ln\sinh x + c$	$x > 0$
$\frac{1}{x^2+a^2}$	$\frac{1}{a}\tan^{-1}\frac{x}{a} + c$	$a > 0$
$\frac{1}{x^2-a^2}$	$\frac{1}{2a}\ln\frac{x-a}{x+a} + c$	$\lvert x\rvert > a > 0$
$\frac{1}{a^2-x^2}$	$\frac{1}{2a}\ln\frac{a+x}{a-x} + c$	$\lvert x\rvert < a$
$\frac{1}{\sqrt{x^2+a^2}}$	$\sinh^{-1}\frac{x}{a} + c$	$a > 0$
$\frac{1}{\sqrt{x^2-a^2}}$	$\cosh^{-1}\frac{x}{a} + c$	$x \geqslant a > 0$
$\frac{1}{\sqrt{x^2+k}}$	$\ln(x + \sqrt{x^2+k}) + c$	
$\frac{1}{\sqrt{a^2-x^2}}$	$\sin^{-1}\frac{x}{a} + c$	$-a \leqslant x \leqslant a$

Integration by Parts Formula

$$\int u\frac{dv}{dx}dx = uv - \int v\frac{du}{dx}dx$$

END OF PAPER