# UNIVERSITI TUN HUSSEIN ONN MALAYSIA

## FINAL EXAMINATION
## SEMESTER I
## SESSION 2009/2010

| | | |
|---|---|---|
| SUBJECT NAME | : | REINFORCED CONCRETE DESIGN 1 |
| SUBJECT CODE | : | BFC 3142 |
| COURSE | : | 3 BFF |
| EXAMINATION DATE | : | NOVEMBER 2009 |
| DURATION | : | 2 HOURS 30 MINUTES |
| INSTRUCTION | : | ANSWER **THREE (3)** QUESTION ONLY |

DESIGN SHOULD BE BASED ON:
BS 8110:PART 1:1997
BS 8110:PART 2:1985
BS 8110:PART 3:1985
BS 6399:PART 1:1996

THIS PAPER CONSIST OF FOURTEEN (14) PAGES

**Q1** (a) State **five (5)** factors to be considered in the design process.

(5 marks)

(b) Explain the concept of design for durability. State the **two (2)** limit states in reinforced concrete design according to BS8110.

(5 marks)

(c) With a sketch of a normal distribution curve, state the relationship between characteristic strength, mean strength, probability factor and standard deviation for materials used in the design of reinforced concrete structure.

(5 marks)

(d) Show mathematically the effect of the values of partial safety factor for steel reinforcement and concrete on the design formula according to BS8110:1985 and BS8110:1997.

(5 marks)

(e) Sketch and label the stress-strain curve for grade 60 concrete and high yield steel reinforcement.

(5 marks)

**Q2** (a) State the importances of structural analysis in design of reinforced concrete structures.

(2 marks)

(b) Figure **Q2(a)** shows a three spans continuous beam carrying the characteristic dead load (including selfweight) of 40 kN/m and characteristic imposed load of 32 kN/m for all spans. First span and third are 6 m while second span is 8 m. Analysis of the beam should involve 3 load cases as stated in clause 3.2.1.2.2 BS 8110 Part 1: 1997. The results of analysis of load case 2 and 3 are given in Figure **Q2(b)** and **Q2(c)**.

(i) Analyse the beam by applying maximum load on all beam spans (Load case 1). Use Moment Distribution Method with modified stiffeness.

(12 marks)

(ii) Draw the shear force and bending moment envelope by combining load case 1 obtained from Q2(b)(i) and Figure **Q2(b)** and Figure **Q2(c)**.

(8 marks)

(iii) Discuss the result obtained from Q2(b)(ii).

(3 marks)

**Q3** (a) State **five (5)** assumptions made in the design of reinforced concrete beams.

(5 marks)

(b) By using stress block diagram, prove:

$$z = d\left\{0.5 + \sqrt{0.25 - \frac{k}{0.9}}\right\}$$

(6 marks)

(c) Figure **Q3** shows a simply supported rectangular beam subjected to ultimate uniform distributed load, *w (kN/m)* and its cross section at the mid span. Given the characteristic strength of concrete, $f_{cu}$ and steel, $f_y$ are 30 N/mm$^2$ and 460 N/mm$^2$ respectively, and assumed the concrete cover is 25 mm.

(i) Calculate moment resistance of the section using stress block diagram.

(10 marks)

(ii) Based on the result obtained from Q3(c)(i), determine the maximum ultimate load, *w* can be supported by the beam.

(4 marks)

**Q4** (a) Calculate short term deflection for the 6 m span simply supported beam with cross section shown in Figure **Q4(a)**. The beam was designed to carry the dead load including selfweight of 15 kN/m and imposed load of 10 kN/m. The materials are grade 30 concrete and grade 460 reinforcement. Assumed $E_c$ and $E_s$ are 26 kN/mm$^2$ and 200 kN/mm$^2$ respectively. Use concrete cover 25 mm.

(12 marks)

(b) Figure **Q4(b)** shows a cross section of a rectangular beam subjected to the design moment of 150 kNm. Given the following data:

| | |
|---|---|
| $f_{cu}$ | = 30 N/mm$^2$ |
| Concrete cover, c | = 25 mm |
| $E_c$ | = 12.5 kN/mm$^2$ |
| $E_s$ | = 200 kN/mm$^2$ |

(i) Calculate the crack width at the bottom fibre of the beam.

(10 marks)

(ii) From the crack width obtained from Q4(b)(i), discuss your result if the required crack width is limitted to 0.2 mm.

(3 marks)

**Q5** Figure **Q5(a)** shows a beam ABC supported at A and B. The whole span of the beam carrying the characteristic dead load of 20 kN/m (excluding the beam selfweight) and characteristic imposed load of 10 kN/m. A point load acting at C consist of characteristic dead load of 50 kN and characteristic imposed load of 20 kN. The cross section of the beam is shown in Figure **Q5(b)**. Given the following data:

| | |
|---|---|
| $f_{cu}$ | = 30 N/mm$^2$ |
| $f_y$ | = 460 N/mm$^2$ |
| $f_{yv}$ | = 250 N/mm$^2$ |
| Concrete cover | = 30 mm |
| Diameter of main bar | = 25 mm |
| Diameter of compression bar | = 16 mm |
| Diameter of shear link | = 10 mm |

(a) Calculate the design load carried by the beam ABC and sketch the shear force and bending moment diagrams by showing the important values.

(5 marks)

(b) Design all required longitudinal reinforcement of the beam. Use effective width of 1300 mm.

(6 marks)

(c) Design the shear reinforcement of the whole span beam.

(6 marks)

(d) Check the deflection of span AB.

(3 marks)

(e) Draw the detailing of the beam ABC for longitudinal section and cross section.

(5 marks)

**Q6** Figure **Q6** shows the layout plan of an office building. Given the following data:

| | | |
|---|---|---|
| Slab thickness | = | 175 mm |
| Finishes (tiles) | = | 2.0 kN/m$^2$ |
| Grade concrete | = | C30 |
| Grade steel | = | 460 |
| Concrete cover | = | 30 mm |
| Main bar sizes | = | 10 mm |
| Imposed load | = | Refer BS 6399 |

(a) Calculate the design load on slab.

(2 marks)

(b) Design all the reinforcement required for slab C-D/1-3.

(18 marks)

(c) Check the deflection and cracking for slab C-D/1-3. Propose the solution if the checking are failed.

(5 marks)

**S1** (a) Nyatakan **lima (5)** faktor yang perlu dipertimbangkan dalam proses rekabentuk.

(5 markah)

(b) Terangkan konsep rekabentuk bagi ketahanlasakan. Nyatakan **dua (2)** keadaan had dalam rekabentuk konkrit bertetulang menurut BS8110.

(5 markah)

(c) Dengan lakaran lengkung taburan normal, nyatakan hubungan antara kekuatan ciri, kekuatan purata, faktor kebarangkalian dan sisihan piawai bagi bahan yang digunakan dalam rekabentuk struktur konkrit bertetulang.

(5 markah)

(d) Tunjukkan secara matematik kesan nilai faktor keselamatan separa untuk tetulang keluli dan konkrit ke atas formula rekabentuk menurut BS8110:1985 and BS8110:1997.

(5 markah)

(e) Lakarkan dan and label lengkung tegasan-terikan bagi konkrit gred 60 dan tetulang keluli alah tinggi.

(5 markah)

**S2** (a) Nyatakan kepentingan analisis struktur di dalam rekabentuk struktur konkrit bertetulang.

(2 markah)

(b) Rajah **Q2(a)** menunjukkan satu rasuk selanjar tiga rentang yang menanggung beban mati ciri (termasuk berat sendiri) 40 kN/m dan beban kenaan ciri 32 kN/m untuk semua rentang. Rentang pertama dan ketiga adalah 6 m manakala rentang kedua adalah 8 m. Analisis ke atas rasuk perlu melibatkan 3 kes pembebanan seperti yang dinyatakan pada fasal 3.2.1.2.2 BS 8110 Part 1: 1997. Keputusan analisis bagi kes pembebanan 2 dan 3 diberikan pada Rajah **Q2(b)** dan **Q2(c)**.

(i) Analisis rasuk berkenaan dengan mengaplikasikan susunan beban maksimum pada semua rentang (Kes pembebanan 1). Gunakan Kaedah Agihan Momen dengan kekukuhan terubahsuai.

(12 markah)

(ii) Lukiskan liputan gambarajah daya ricih dan momen lentur dengan menggabungkan kes pembebanan 1 yang diperolehi daripada S2(b)(i) dan Rajah **Q2(b)** dan Rajah **Q2(c)**.

(8 markah)

(iii) Bincangkan keputusan yang diperolehi daripada S2(b)(ii).

(3 markah)

S3 (a) Nyatakan **lima (5)** anggapan yang dibuat dalam rekabentuk struktur konkrit bertetulang.

(5 markah)

(b) Dengan menggunakan gambarajah blok tegasan, buktikan;

$$z = d\left\{0.5 + \sqrt{0.25 - \frac{k}{0.9}}\right\}$$

(6 markah)

(c) Rajah **Q3** menunjukkan rasuk segiempat sokong mudah yang dikenakan beban teragih seragam muktamad, $w$ (kN/m) dan keratan rentas di pertengahan rentang. Diberikan kekuatan ciri konkrit, $f_{cu}$ dan keluli, $f_y$ adalah masing-masing 30 N/mm$^2$ dan 460 N/mm$^2$, dan anggap penutup konkrit 25 mm.

(i) Kirakan momen rintangan bagi keratan menggunakan gambarajah blok tegasan.

(10 marks)

(ii) Berdasarkan keputusan yang diperolehi daripada S3(c)(i), tentukan beban maksimum muktamad, $w$ yang boleh ditanggung oleh rasuk.

(4 markah)

S4 (a) Kirakan pesongan jangka pendek bagi rasuk sokong mudah yang mempunyai rentang 6 m dan mempunyai keratan rentas rasuk seperti Rajah **Q4(a)**. Rasuk berkenaan telah direkabentuk untuk menanggung beban mati termasuk berat sendiri 15 kN/m dan beban kenaan 10 kN/m. Bahan-bahan adalah terdiri daripada konkrit gred 30 dan tetulang keluli gred 460. Anggap $E_c$ dan $E_s$ adalah masing-masing 26 kN/mm$^2$ dan 200 kN/mm$^2$. Gunakan penutup konkrit 25 mm.

(12 markah)

(b) Rajah **Q4(b)** menunjukkan keratan rentas bagi rasuk segiempat yang menanggung momen rekabentuk 150 kNm. Diberikan data berikut:

| | |
|---|---|
| $f_{cu}$ | = 30 N/mm$^2$ |
| Penutup konkrit, c | = 25 mm |
| $E_c$ | = 12.5 kN/mm$^2$ |
| $E_s$ | = 200 kN/mm$^2$ |

(i) Kirakan lebar retak yang berlaku di permukaan bawah rasuk.

(10 markah)

(ii) Daripada lebar retak yang diperolehi daripada S4(b)(i), bincangkan keputusan anda sekiranya keperluan lebar retak dihadkan pada 0.2 mm.

(3 markah)

S5 Rajah **Q5(a)** menunjukkan rasuk ABC yang disokong di A dan B. Keseluruhan panjang rasuk menanggung beban mati ciri 20 kN/m (tidak termasuk berat sendiri rasuk) dan beban kenaan ciri 10 kN/m. Satu beban tumpu bertindak di C dengan beban mati ciri 50 kN dan beban kenaan ciri 20 kN. Keratan rentas rasuk adalah seperti yang ditunjukkan di dalam Rajah **Q5(b)**. Diberikan data-data berikut:

| | |
|---|---|
| $f_{cu}$ | = 30 N/mm$^2$ |
| $f_y$ | = 460 N/mm$^2$ |
| $f_{yv}$ | = 250 N/mm$^2$ |
| Penutup konkrit | = 30 mm |
| Diameter tetulang utama | = 25 mm |
| Diameter tetulang mampatan | = 16 mm |
| Diameter tetulang perangkai | = 10 mm |

(a) Kirakan beban rekabentuk yang ditanggung oleh rasuk ABC dan lakarkan gambarajah daya ricih dan momen lentur dengan menunjukkan nilai-nilai penting.

(5 markah)

(b) Rekabentuk semua tetulang memanjang yang diperlukan oleh rasuk. Gunakan lebar berkesan 1300 mm.

(6 markah)

(c) Rekabentuk tetulang ricih untuk keseluruhan rentang rasuk.

(6 markah)

(d) Semak pesongan pada rentang AB.

(3 markah)

(e) Lukiskan perincian rasuk ABC pada keratan memanjang dan keratan rentas.

(5 markah)

S6 Rajah **Q6** menunjukkan pelan lantai bagi sebuah bangunan pejabat. Diberi data berikut :

| | | |
|---|---|---|
| Tebal papak | = | 175 mm |
| Kemasan (jubin) | = | 2.0 kN/m$^2$ |
| Gred konkrit | = | C30 |
| Gred keluli | = | 460 |
| Penutup konkrit | = | 30 mm |
| Saiz tetulang utama | = | 10 mm |
| Beban kenaan | = | Rujuk BS 6399 |

(a) Kira beban rekabentuk bagi papak.

(2 markah)

(b) Rekabentuk semua tetulang yang diperlukan pada papak C-D/1-3.

(18 markah)

(c) Semak pesongan dan keretakan untuk papak C-D/1-3. Cadangkan perkara yang perlu dilakukan jika semakan yang dibuat didapati gagal.

(5 markah)

**FINAL EXAMINATION**

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| SEMESTER/SESSION | : SEM 1 / 2009/20010 | COURSE | : 3 BFF |
| SUBJECT | : STRUCTURAL CONCRETE DESIGN 1 | SUBJECT CODE | : BFC 3142 |

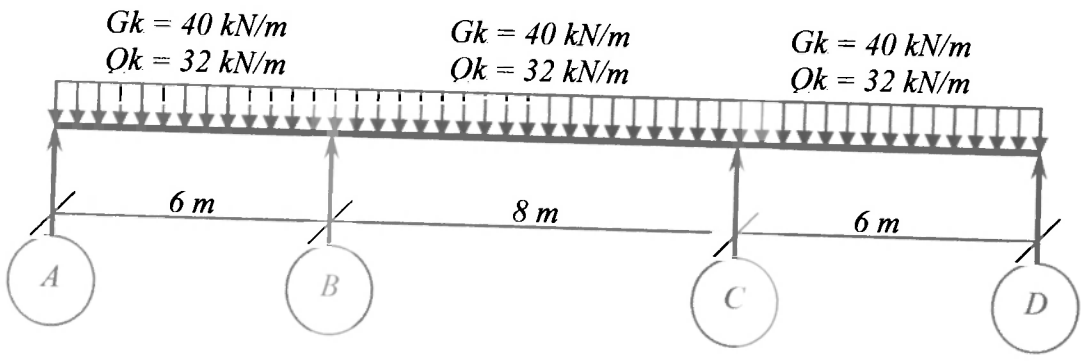


**FIGURE Q2(a)**

LOAD CASE 2

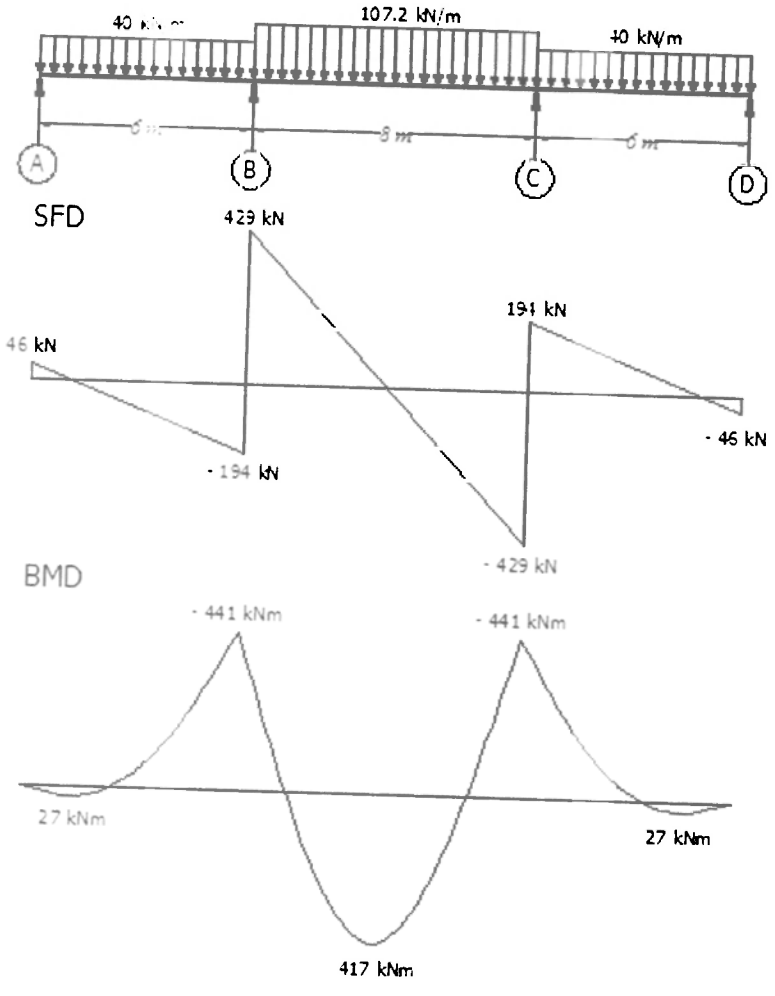


**FIGURE Q2(b)**

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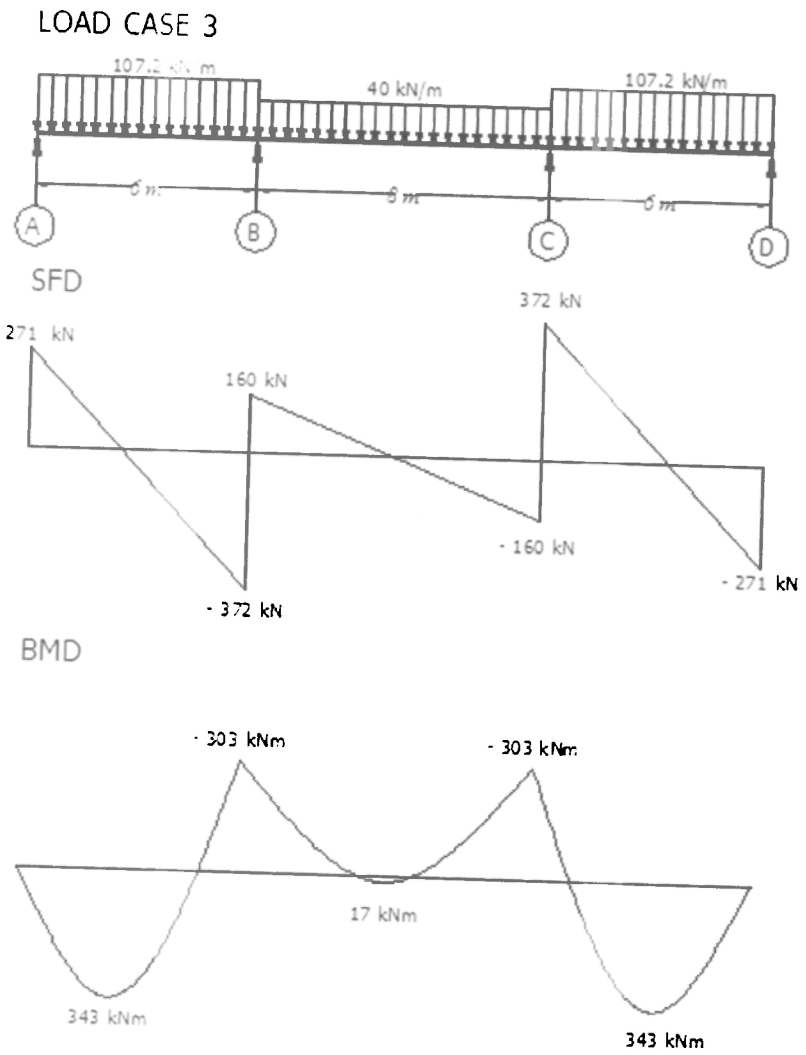


**FIGURE O2(c)**

**FINAL EXAMINATION**

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| SUBJECT | : STRUCTURAL CONCRETE DESIGN 1 | SUBJECT CODE | : BFC 3142 |

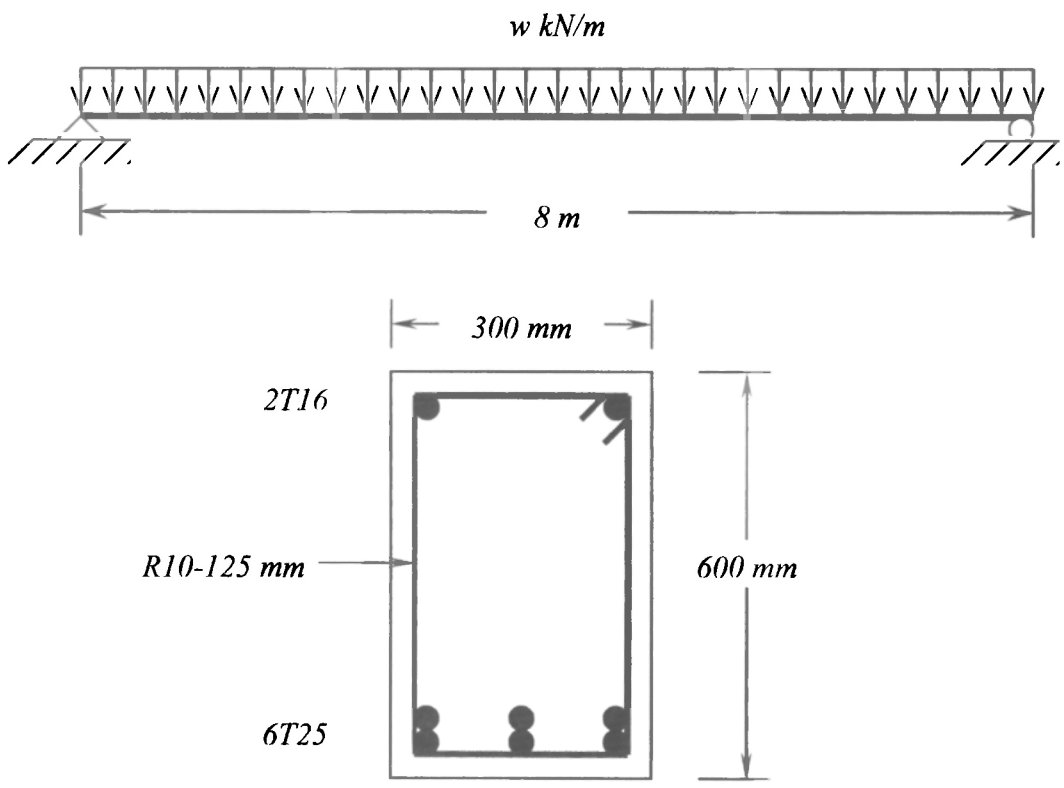


**FIGURE O3**

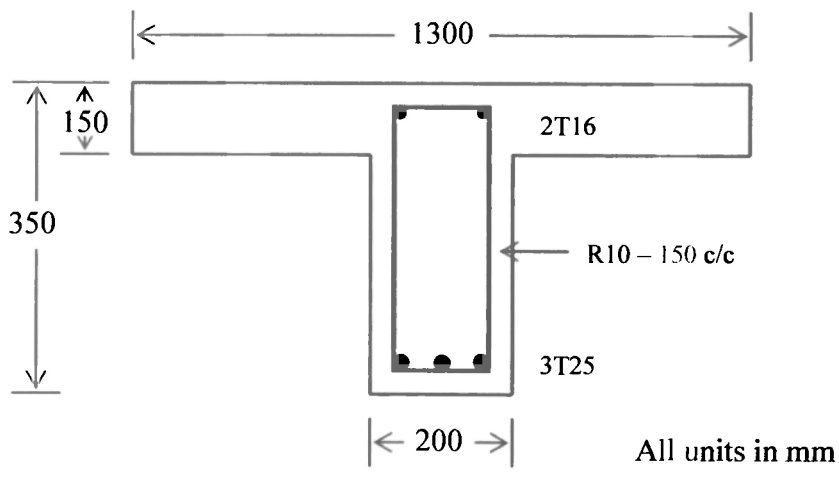


**FIGURE O4(a)**

**FINAL EXAMINATION**

| | | | |
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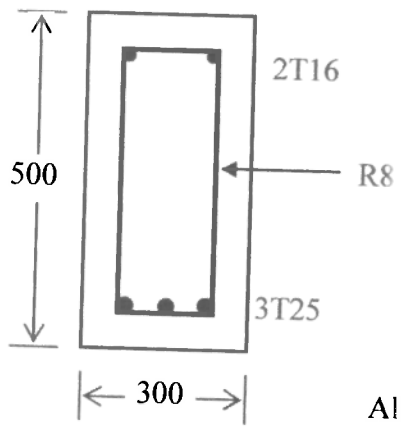
| SEMESTER/SESSION | : SEM 1 / 2009/20010 | COURSE | : 3 BFF |
| SUBJECT | : STRUCTURAL CONCRETE DESIGN 1 | SUBJECT CODE | : BFC 3142 |




All units in mm

**FIGURE Q4(b)**

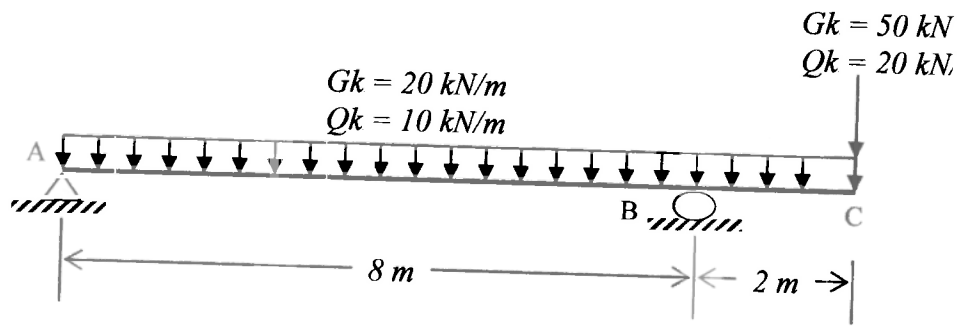
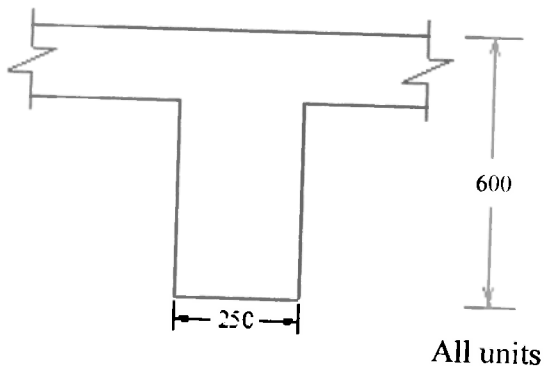



**FIGURE Q5(a)**




All units in mm

**FIGURE Q5(b)**

**FINAL EXAMINATION**

| | | | |
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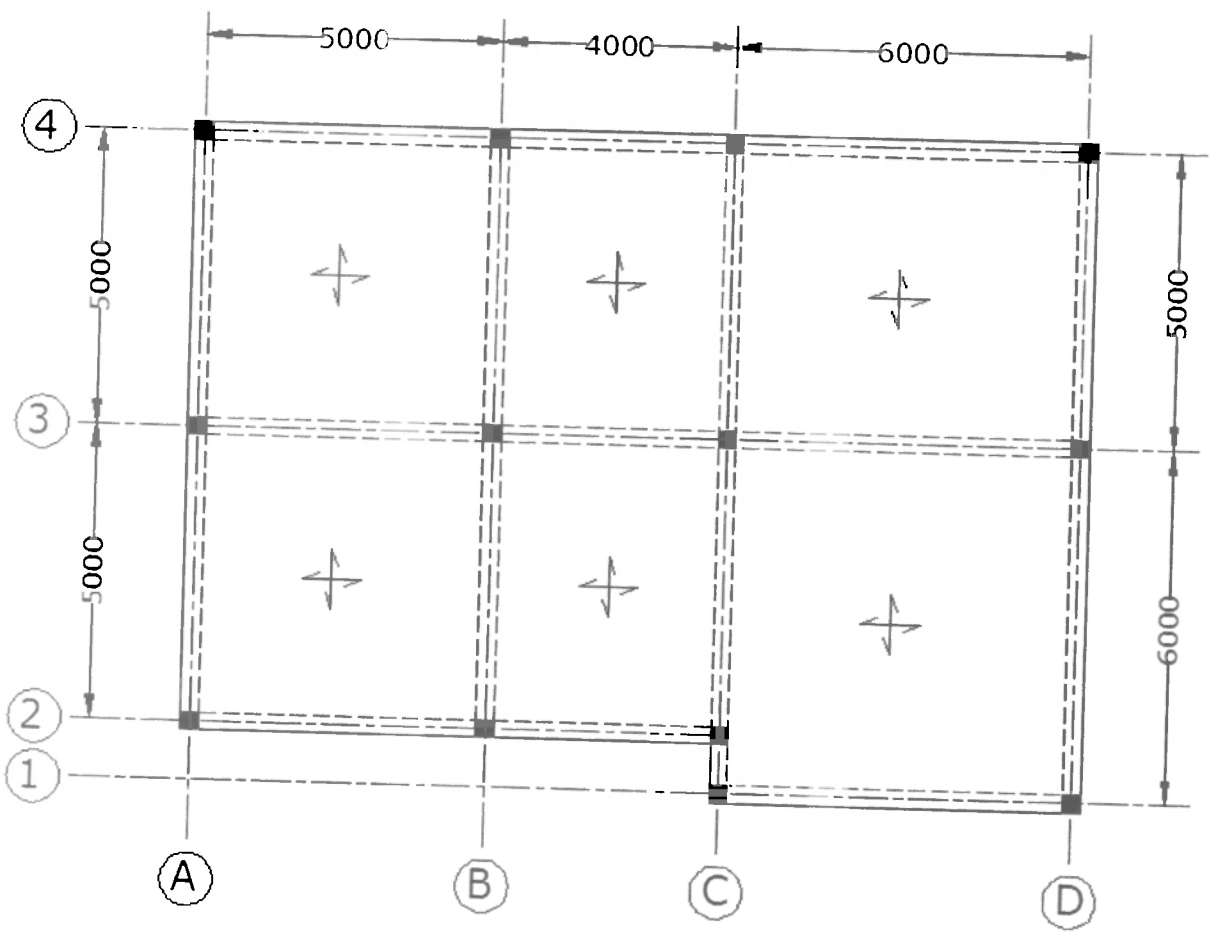
| SEMESTER/SESSION | : SEM I / 2009/20010 | COURSE | : 3 BFF |
| SUBJECT | : STRUCTURAL CONCRETE DESIGN I | SUBJECT CODE | : BFC 3142 |




All units in mm

**FIGURE O6**

**FINAL EXAMINATION**

| | | | | | |
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| SEMESTER/SESSION | : | SEM I / 2009/20010 | COURSE | : | 3 BFF |
| SUBJECT | : | STRUCTURAL CONCRETE DESIGN 1 | SUBJECT CODE | : | BFC 3142 |

**Table 1:** Cross Sectional Area ($mm^2$) according to Size and Numbers of Bar

| Bar Size (mm) | Number of bar | | | | | | | | Perimeter (mm) |
|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | |
| 6 | 28.3 | 56.6 | 84.9 | 113 | 141 | 170 | 198 | 226 | 18.9 |
| 8 | 50.3 | 101 | 151 | 201 | 251 | 302 | 352 | 402 | 25.1 |
| 10 | 78.6 | 157 | 236 | 314 | 393 | 471 | 550 | 629 | 31.4 |
| 12 | 113 | 226 | 339 | 453 | 566 | 679 | 792 | 905 | 37.7 |
| 16 | 201 | 402 | 603 | 805 | 1006 | 1207 | 1408 | 1609 | 50.3 |
| 20 | 314 | 629 | 943 | 1257 | 1571 | 1886 | 2200 | 2514 | 62.9 |
| 25 | 491 | 982 | 1473 | 1964 | 2455 | 2946 | 3438 | 3929 | 78.6 |
| 32 | 805 | 1609 | 2414 | 3218 | 4023 | 4827 | 5632 | 6437 | 100.6 |
| 40 | 1257 | 2514 | 3771 | 5029 | 6286 | 7543 | 8800 | 10057 | 125.7 |

**Table 2:** Cross Sectional Area ($mm^2$) for every meter width at distance between bar

| Bar Size (mm) | Distance between Bar (mm) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 50 | 75 | 100 | 125 | 150 | 175 | 200 | 250 | 300 |
| 6 | 566 | 377 | 283 | 226 | 189 | 162 | 141 | 113 | 94 |
| 8 | 1006 | 670 | 503 | 402 | 335 | 287 | 251 | 201 | 168 |
| 10 | 1571 | 1048 | 786 | 629 | 524 | 449 | 393 | 314 | 262 |
| 12 | 2263 | 1509 | 1131 | 905 | 754 | 647 | 566 | 453 | 377 |
| 16 | 4023 | 2682 | 2011 | 1609 | 1341 | 1149 | 1006 | 805 | 670 |
| 20 | 6286 | 4190 | 3143 | 2514 | 2095 | 1796 | 1571 | 1257 | 1048 |
| 25 | 9821 | 6548 | 4911 | 3929 | 3274 | 2806 | 2455 | 1964 | 1637 |
| 32 | 16091 | 10728 | 8046 | 6437 | 5364 | 4598 | 4023 | 3218 | 2682 |
| 40 | 25143 | 16762 | 12571 | 10057 | 8381 | 7184 | 6286 | 5029 | 4190 |

**FINAL EXAMINATION**

| | | | |
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***Short term deflection***

Depth of neutral axis, x can be found by taking moment the *x-x* axis to give the equation:

$$0.5bx^2 + \alpha_e As'(x-d) - \alpha_e As(d-x) = 0$$

Moment of Inertia about *x-x* axis

$$I_{xx} = 0.34bx^3 + \alpha_e As'(x-d)^2 + \alpha_e As(d-x)^2$$

The stress at outer fiber of concrete

$$fct = \frac{1.0(h-x)}{(d-x)}$$

The force in concrete in tension

$$Fct = 0.5 f_{ct} b \frac{(h-x)}{(d-x)}$$

The moment resistance of concrete in tension

$$M_c = F_{ct} \frac{2}{3}(h-x)$$

***Crack width of flexural member***

Depth of neutral axis, *x*

$$x = \left[-\alpha_e.\rho + \sqrt{\alpha_e.\rho(2+\alpha_e.\rho}\right]d$$

Surface strain, $\varepsilon_1$

$$\varepsilon_1 = \left(\frac{h-x}{d-x}\right)\varepsilon_s$$

Strain due to stiffening effect, $\varepsilon_2$

$$\varepsilon_2 = \frac{1.0b_t(h-x)(a'-x)}{3E_s As(d-x)}$$

Crack width, *w*

$$w = \frac{3a_{cr}\varepsilon_m}{1+2\left(\frac{a_{cr}-c_{\min}}{h-x}\right)}$$