

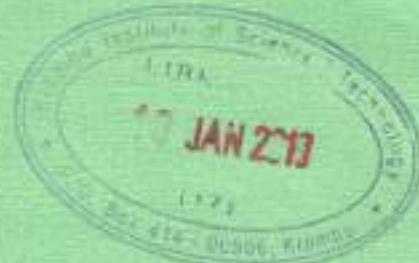
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**STRUCTURES II, GEOTECHNOLOGY II  
AND CONCRETE TECHNOLOGY II**

Oct/Nov. 2018

Time: 3 hours

**THE KENYA NATIONAL EXAMINATIONS COUNCIL****DIPLOMA IN BUILDING TECHNOLOGY****DIPLOMA IN CIVIL ENGINEERING****DIPLOMA IN ARCHITECTURE****MODULE II****STRUCTURES II, GEOTECHNOLOGY II AND CONCRETE TECHNOLOGY II****3 hours****INSTRUCTIONS TO CANDIDATES***You should have the following for this examination:**answer booklet;**scientific calculator/ mathematical tables;**drawing instruments.**This paper consists of EIGHT questions in THREE sections, A, B and C.**Answer TWO questions from section A, TWO questions from section B and ONE question from section C in the answer booklet provided.**All questions carry equal marks.**Maximum marks for each part of a question are as indicated.**Candidates should answer the questions in English.***This paper consists of 9 printed pages.****Candidates should check the question paper to ascertain that all the pages are printed as indicated and that no questions are missing.**

## SECTION A: STRUCTURES II

*Answer TWO questions from this section.*

1. (a) Using Mohr's theorems, derive equations for maximum deflection and maximum slope for a simply supported beam of span  $\ell$  carrying a uniform distributed load unit length over the entire span. (10 marks)
- (b) **Figure 1** shows a loaded cantilever beam. Using Macauley's method, determine the slope and deflection at the free end of the beam (point B). Take  $EI = \text{constant}$ . (10 marks)

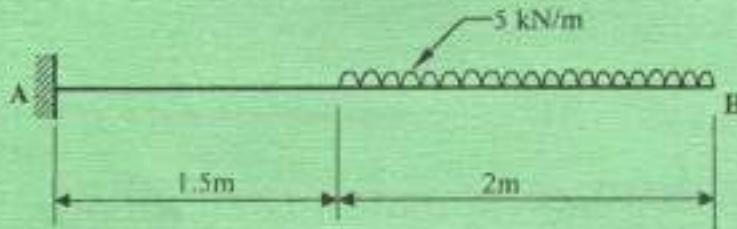


Fig. 1

2. (a) With the aid of sketches, explain any four modes of failure in masonry retaining walls. (10 marks)
- (b) **Figure 2** shows a cross-section of a column transmitting the load to the base. Determine the extreme stresses at points A, B, C and D. (10 marks)

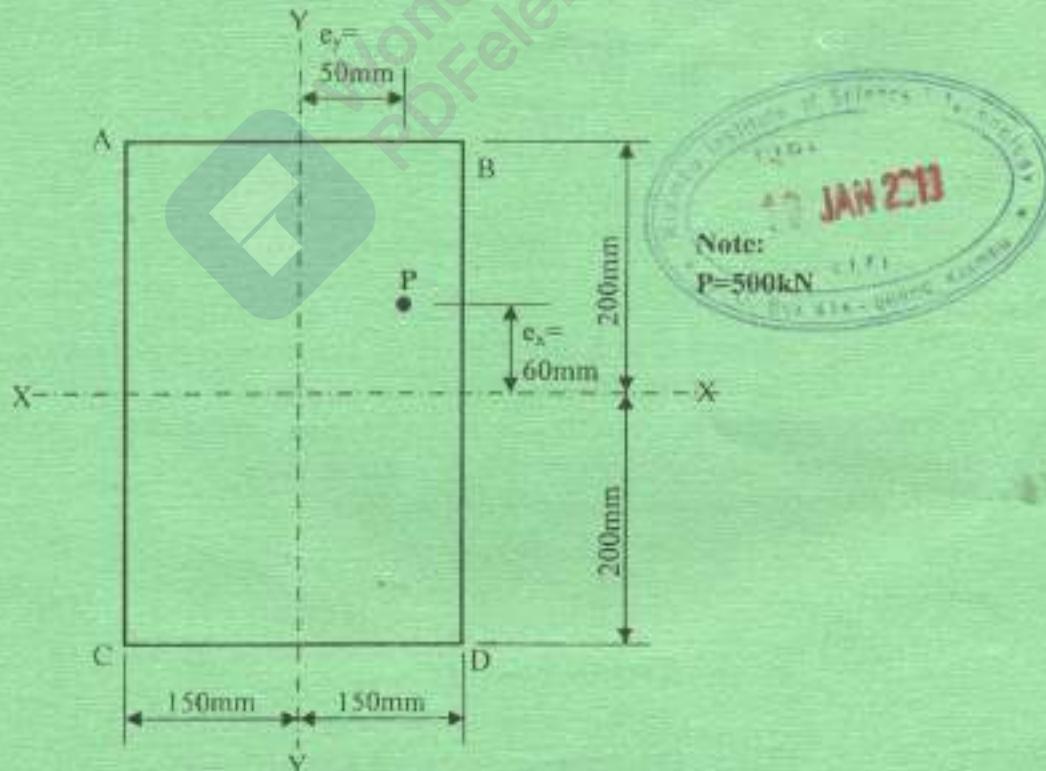


Fig. 2

3. Figure 3 shows a slab restrained in the four sides (slab casted monolithically with beam). Design the slab given the following information:

**Information:**

- imposed load =  $4.0 \text{ kN/m}^2$ ,
- finishes =  $0.6 \text{ kN/m}^2$ ,
- concrete mix = 1:2:4,
- characteristic material strengths,

$$f_{cu} = 30 \text{ N/mm}^2$$

$$f_s = 460 \text{ N/mm}^2$$

- thickness of slab = 200 mm
- exposure condition is moderate
- use design tables 1 - 9 attached.



(20 marks)

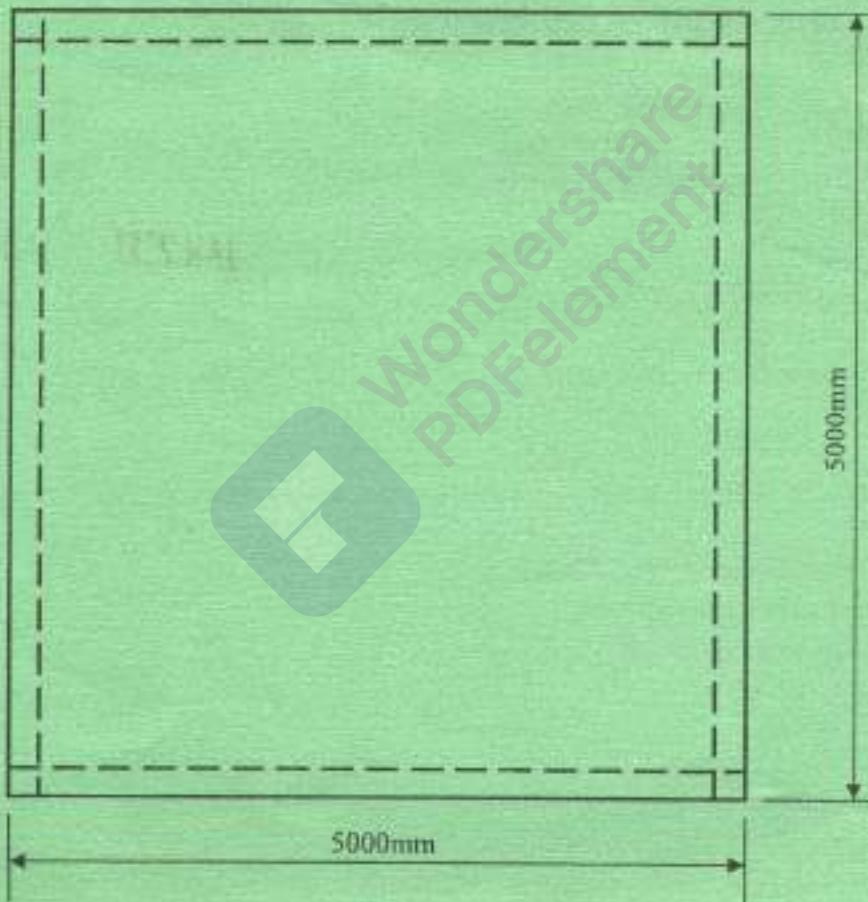


Fig. 3

## SECTION B: GEOTECHNOLOGY II

*Answer TWO questions from this section.*

4. (a) (i) Outline two negative and two positive effects of geological faulting in Kenya.  
 (ii) With the aid of sketches, describe three causes of geological faulting. (10 marks)
- (b) Outline each of the following weathering processes:  
 (i) physical weathering;  
 (ii) chemical weathering. (3 marks)
- (c) (i) Define Geological maps.  
 (ii) Explain each of the following types of maps:  
 (I) isopachyte maps;  
 (II) geophysical maps;  
 (III) structural contour maps. (7 marks)
5. (a) (i) State two functions of a dam.  
 (ii) Name four types of dams. (4 marks)
- (b) Explain each of the following as used in dams and reservoirs:  
 (i) storage capacity and head;  
 (ii) foundation conditions;  
 (iii) conceptual design;  
 (iv) conveyances. (8 marks)
- (c) State four environmental hazards caused by quarrying of stones. (4 marks)
- (d) Explain each of the following methods of quarrying stones:  
 (i) extraction;  
 (ii) dressing of stone. (4 marks)

6. (a) State five factors considered before tunnelling operation commences. (5 marks)
- (b) Explain the purpose of ventilation in tunnel construction. (3 marks)
- (c) With the aid of sketches, describe each of the following methods of tunnelling:  
 (i) open cut method;  
 (ii) pre-deck method;  
 (iii) immersed tube system. (12 marks)



### SECTION C: CONCRETE TECHNOLOGY II

*Answer ONE question from this section.*

7. (a) Describe the architectural precast stone class of the precast concrete. (5 marks)
- (b) Explain how large - panel precast concrete units are fixed under each of the following:  
 (i) wet joints;  
 (ii) dry joints;  
 (iii) groove joints. (6 marks)
- (c) With aid of a sketch, describe an expansion joint. (9 marks)
8. (a) State eight precautions to be taken when concreting in hot weather. (8 marks)
- (b) Describe the post-tensioning method of prestressing concrete. (6 marks)
- (c) Describe the hand-fed tilting drum mixer. (6 marks)

**Table 1 — Nominal cover to all reinforcement (including links) to meet durability requirements (see NOTE 1)**

| Conditions of exposure<br>(see 3.3.4)       |      | Nominal cover<br>Dimensions in millimetres |                 |                 |                 |
|---|------|--|-----------------|-----------------|-----------------|
| Mild  | 25   | 20   | 20 <sup>a</sup> | 20 <sup>a</sup> | 20 <sup>a</sup> |
| Moderate                                    | —    | 35   | 30              | 25              | 20              |
| Severe                                      | —    | —  | 40              | 30              | 25              |
| Very severe                                 | —    | —  | 50 <sup>b</sup> | 40 <sup>b</sup> | 30              |
| Most severe                                 | —    | —  | —               | —               | 50              |
| Abrasive                                    | —    | —  | —               | See NOTE 3      | See NOTE 3      |
| Maximum free water/cement ratio             | 0.65 | 0.60                                       | 0.55            | 0.50            | 0.45            |
| Minimum cement content (kg/m <sup>3</sup> ) | 275  | 300  | 325             | 350             | 400             |
| Lowest grade of concrete                    | C30  | C35  | C40             | C45             | C50             |

NOTE 1 This table relates to normal-weight aggregate of 20 mm nominal size. Adjustments to minimum cement contents for aggregates other than 20 mm nominal maximum size are detailed in Table 8 of BS 5328-1:1997.

NOTE 2 Use of sulfate resisting cement conforming to BS 4027. These cements have lower resistance to chloride ion migration. If they are used in reinforced concrete in very severe or most severe exposure conditions, the covers in Table 3.3 should be increased by 10 mm.

NOTE 3 Cover should be not less than the nominal value corresponding to the relevant environmental category plus any allowance for loss of cover due to abrasion.

<sup>a</sup> These covers may be reduced to 15 mm provided that the nominal maximum size of aggregate does not exceed 15 mm.

<sup>b</sup> Where concrete is subject to freezing whilst wet, air-entrainment should be used (see 5.3.3 of BS 5328-1:1997) and the strength grade may be reduced by 5.

**Table 2 — Nominal cover to all reinforcement (including links) to meet specified periods of fire resistance (see NOTE 1 and NOTE 2)**

| Fire resistance<br>h | Nominal cover             |                  |                           |                  |                           |                  |                            |
|----------------------|---------------------------|------------------|---------------------------|------------------|---------------------------|------------------|----------------------------|
|                      | Beams <sup>a</sup>        |                  | Floors                    |                  | Ribs                      |                  | Columns <sup>b</sup><br>mm |
|                      | Simply<br>supported<br>mm | Continuous<br>mm | Simply<br>supported<br>mm | Continuous<br>mm | Simply<br>supported<br>mm | Continuous<br>mm |                            |
| 0.5                  | 20 <sup>b</sup>           | 20 <sup>b</sup>  | 20 <sup>b</sup>           | 20 <sup>b</sup>  | 20 <sup>b</sup>           | 20 <sup>b</sup>  | 20 <sup>b</sup>            |
| 1                    | 20 <sup>b</sup>           | 20 <sup>b</sup>  | 20                        | 20               | 20                        | 20 <sup>b</sup>  | 20 <sup>b</sup>            |
| 1.5                  | 20                        | 20 <sup>b</sup>  | 25                        | 20               | 35                        | 20               | 20                         |
| 2                    | 40                        | 30               | 35                        | 25               | 45                        | 35               | 25                         |
| 3                    | 60                        | 40               | 45                        | 35               | 55                        | 45               | 25                         |
| 4                    | 70                        | 50               | 55                        | 45               | 65                        | 55               | 25                         |

NOTE 1 The nominal covers given relate specifically to the minimum member dimensions given in Figure 3.2. Guidance on increased covers necessary if smaller members are used is given in section 4 of BS 8110-2:1985.

NOTE 2 Cases that lie below the bold line require attention to the additional measures necessary to reduce the risks of spalling (see section 4 of BS 8110-2:1985).

<sup>a</sup> For the purposes of assessing a nominal cover for beams and columns, the cover to main bars which would have been obtained from Tables 4.2 and 4.3 of BS 8110-2:1985 has been reduced by a notional allowance for stirrups of 10 mm to cover the range 8 mm to 12 mm (see also 3.3.6).

<sup>b</sup> These covers may be reduced to 15 mm provided that the nominal maximum size of aggregate does not exceed 15 mm (see 3.3.1.3).

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**Table 3 — Values of  $v_s$ , design concrete shear stress**

| $\frac{100A_s}{b_y d}$ | Effective depth<br>mm |                   |                   |                   |                   |                   |                   |                   |
|------------------------|-----------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
|                        | 125                   | 150               | 175               | 200               | 225               | 250               | 300               | ≥ 400             |
|                        | N/mm <sup>2</sup>     | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> | N/mm <sup>2</sup> |
| ≤ 0.15                 | 0.45                  | 0.43              | 0.41              | 0.40              | 0.39              | 0.38              | 0.36              | 0.34              |
| 0.25                   | 0.53                  | 0.51              | 0.49              | 0.47              | 0.46              | 0.45              | 0.43              | 0.40              |
| 0.50                   | 0.67                  | 0.64              | 0.62              | 0.60              | 0.58              | 0.56              | 0.54              | 0.50              |
| 0.75                   | 0.77                  | 0.73              | 0.71              | 0.68              | 0.66              | 0.65              | 0.62              | 0.57              |
| 1.00                   | 0.84                  | 0.81              | 0.78              | 0.75              | 0.73              | 0.71              | 0.68              | 0.63              |
| 1.50                   | 0.97                  | 0.92              | 0.89              | 0.86              | 0.83              | 0.81              | 0.78              | 0.72              |
| 2.00                   | 1.06                  | 1.02              | 0.98              | 0.95              | 0.92              | 0.89              | 0.86              | 0.80              |
| ≥ 3.00                 | 1.22                  | 1.16              | 1.12              | 1.08              | 1.05              | 1.02              | 0.98              | 0.91              |

**Table 4 — Basic span/effective depth ratio for rectangular or flanged beams**

| Support conditions | Rectangular section | Flanged beams with<br>$\frac{b_e}{b} > 0.1$ |
|--------------------|---------------------|---|
| Cantilever         | 7                   | 5.6   |
| Simply supported   | 20                  | 16.0  |
| Continuous         | 26                  | 20.8  |



**Table 5 — Modification factor for tension reinforcement**

| Service stress | $M/bd^2$ |      |      |      |      |      |      |      |      |
|----------------|----------|------|------|------|------|------|------|------|------|
|                | 0.50     | 0.75 | 1.00 | 1.50 | 2.00 | 3.00 | 4.00 | 5.00 | 6.00 |
| $(f_y = 250)$  | 2.00     | 2.00 | 2.00 | 1.86 | 1.63 | 1.36 | 1.19 | 1.08 | 1.01 |
|                | 2.00     | 2.00 | 1.98 | 1.69 | 1.49 | 1.25 | 1.11 | 1.01 | 0.94 |
|                | 2.00     | 2.00 | 1.91 | 1.63 | 1.44 | 1.21 | 1.08 | 0.99 | 0.92 |
|                | 2.00     | 1.95 | 1.76 | 1.51 | 1.35 | 1.14 | 1.02 | 0.94 | 0.88 |
|                | 1.90     | 1.70 | 1.55 | 1.34 | 1.20 | 1.04 | 0.94 | 0.87 | 0.82 |
|                | 1.60     | 1.44 | 1.33 | 1.16 | 1.06 | 0.93 | 0.85 | 0.80 | 0.76 |
| $(f_y = 460)$  | 3.07     | 1.56 | 1.41 | 1.30 | 1.14 | 1.04 | 0.91 | 0.84 | 0.79 |
|                |          |      |      |      |      |      |      |      | 0.76 |

NOTE 1 The values in the table derive from the equation:

$$\text{Modification factor} = 0.55 + \frac{(477 - f_y)}{120 \left( 0.9 + \frac{M}{bd^3} \right)} \leq 2.0 \quad \text{equation 7}$$

where

 $M$  is the design ultimate moment at the centre of the span or, for a cantilever, at the support.

NOTE 2 The design service stress in the tension reinforcement in a member may be estimated from the equation:

$$f_t = \frac{2f_y A_{s, \text{min}}}{3A_{s, \text{max}}} \times \frac{1}{\rho_y} \quad \text{equation 8}$$

NOTE 3 For a continuous beam, if the percentage of redistribution is not known but the design ultimate moment at mid-span is obviously the same as or greater than the elastic ultimate moment, the stress  $f_u$  in this table may be taken as  $2/f_y$ .**Table 6 — Bending moment coefficients for slabs spanning in two directions at right angles, simply-supported on four sides**

| $I_y/I_z$     | 1.0   | 1.1   | 1.2   | 1.3   | 1.4   | 1.5   | 1.75  | 2.0   |
|---------------|-------|-------|-------|-------|-------|-------|-------|-------|
| $\alpha_{xx}$ | 0.062 | 0.074 | 0.084 | 0.093 | 0.099 | 0.104 | 0.113 | 0.118 |
| $\alpha_{yy}$ | 0.062 | 0.061 | 0.059 | 0.055 | 0.051 | 0.046 | 0.037 | 0.029 |

**Table 7 Cross-sectional areas of groups of bars (mm)**

| Bar<br>Diameter<br>(mm) | Number of bars |      |      |      |      |      |      |       |       |       |
|-------------------------|----------------|------|------|------|------|------|------|-------|-------|-------|
|                         | 1              | 2    | 3    | 4    | 5    | 6    | 7    | 8     | 9     | 10    |
| 6                       | 28             | 57   | 85   | 113  | 141  | 170  | 198  | 226   | 254   | 283   |
| 8                       | 50             | 101  | 151  | 201  | 251  | 302  | 352  | 402   | 452   | 503   |
| 10                      | 79             | 157  | 236  | 314  | 393  | 471  | 550  | 628   | 707   | 785   |
| 12                      | 113            | 226  | 339  | 452  | 565  | 679  | 792  | 905   | 1017  | 1131  |
| 16                      | 201            | 402  | 603  | 804  | 1005 | 1206 | 1407 | 1608  | 1809  | 2011  |
| 20                      | 314            | 628  | 942  | 1257 | 1571 | 1885 | 2199 | 2513  | 2827  | 3142  |
| 25                      | 491            | 982  | 1473 | 1963 | 2454 | 2945 | 3436 | 3927  | 4418  | 4909  |
| 32                      | 804            | 1608 | 2412 | 3216 | 4021 | 4825 | 5629 | 6433  | 7237  | 8042  |
| 40                      | 1256           | 2513 | 3769 | 5026 | 6283 | 7539 | 8796 | 10050 | 11310 | 12570 |

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**Table 8 — Form and area of shear reinforcement in solid slabs**

| Value of $v$<br>N/mm <sup>2</sup>                                 | Form of shear reinforcement<br>to be provided   | Area of shear reinforcement to be provided   |
|---|---|--|
| $v \leq v_c$  | None required   | None   |
| $v_c < v < (v_c + 0.4)$   | Minimum links in areas<br>where $v > v_c$   | $A_{sv} \geq 0.4bs_v/0.95f_yv$   |
| $(v_c + 0.4) \leq v < 0.8\sqrt{f_{cu}}$<br>or 5 N/mm <sup>2</sup> | Links and/or bent-up bars<br>in any combination (but<br>the spacing between links<br>or bent-up bars need not<br>be less than $s$ ) | Where links only provided:<br>$A_{sv} \geq bs_v(v - v_c)/0.95f_yv$<br>Where bent-up bars only provided:<br>$A_{sb} \geq bs_b(v - v_c)/[0.95f_yv(\cos \alpha + \sin \alpha \times \cot \beta)]$ (see 3.4.5.7) |

NOTE 1 It is difficult to bend and fix shear reinforcement so that its effectiveness can be assured in slabs less than 200 mm deep. It is therefore not advisable to use shear reinforcement in such slabs.

NOTE 2 The enhancement in design shear strength close to supports described in 3.4.5.8, 3.4.5.9 and 3.4.5.10 may also be applied to solid slabs.

**Table 9 Cross-sectional area per metre width for various bar spacing (mm<sup>2</sup>)**

| Bar size<br>(mm) | Spacing of bars |       |       |       |      |      |      |      |      |
|------------------|-----------------|-------|-------|-------|------|------|------|------|------|
|                  | 50              | 75    | 100   | 125   | 150  | 175  | 200  | 250  | 300  |
| 6                | 566             | 377   | 283   | 226   | 189  | 162  | 142  | 113  | 94.3 |
| 8                | 1010            | 671   | 503   | 402   | 335  | 287  | 252  | 201  | 168  |
| 10               | 1570            | 1050  | 785   | 628   | 523  | 449  | 393  | 314  | 262  |
| 12               | 2260            | 1510  | 1130  | 905   | 754  | 646  | 566  | 452  | 377  |
| 16               | 4020            | 2680  | 2010  | 1610  | 1340 | 1150 | 1010 | 804  | 670  |
| 20               | 6280            | 4190  | 3140  | 2510  | 2090 | 1800 | 1570 | 1260 | 1050 |
| 25               | 9820            | 6550  | 4910  | 3930  | 3270 | 2810 | 2450 | 1960 | 1640 |
| 32               | 16100           | 10700 | 8040  | 6430  | 5360 | 4600 | 4020 | 3220 | 2680 |
| 40               | 25100           | 16800 | 12600 | 10100 | 8380 | 7180 | 6280 | 5030 | 4190 |

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