THE PAPUA NEW GUINEA UNIVERSITY OF TECHNOLOGY

DEPARTMENT OF CIVIL ENGINEERING – 3RD YEAR DEGREE

SECOND SEMESTER EXAMINATIONS - 2022

CE 322 – CONCRETE STRUCTURES

DATE: FRIDAY, 28TH OCTOBER 2022 – 12:50 P.M

VENUE: STRUCTURES LECTURE THEATRE (SLT)

TIME ALLOWED: 3 HOURS

INFORMATION FOR CANDIDATES

1. You have 10 minutes to read the paper before the examination starts. You must **not** begin writing during this time.
2. **There are SEVEN (7) Questions in this paper. Answer any 4 Questions.**
3. Use only ink. Do not use pencils for writing except for drawings and sketches.
4. Only Calculator is allowed in the examination room. MOBILE PHONE is not allowed (**Switch your Mobile Phones OFF**). Notes and textbooks are not allowed.
5. Start each question on a new page and show all your calculations in the answer book provided. No other material will be accepted.
6. **Write your NAME and Student NUMBER clearly on the front page.**
   <u>Do it now</u>.
7. <u>**Marking Scheme**</u>: All Questions carry equal marks.

Question One   [Concrete Manufacturing]   (25 Marks)

Write short notes on the following properties/parameters of concrete.

- (i) Workability
- (ii) Shrinkage
- (iii) Creep Define the lever arm and moment of resistance constants with relevant figures
- (iv) Hardening
- (v) Role of water cement ration in manufacturing and strength of concrete.

Question Two   [General Definitions]   (25 Marks)

1. Describe what is meant by a Compression failure of a reinforced concrete section.
2. Describe why a compression failure is dangerous.
3. Describe what is meant by a Tension failure of a reinforced concrete section.
4. Describe an advantage of a tension failure.
5. Segregation of concrete

Question Three   [Singly Reinforced Sections]   (25 Marks)

a) Express your opinion on the following statement:

   "the depth of a singly reinforced beam can be increased to any extent". (5 Marks)

b) A singly reinforced rectangular beam with width 305 mm and overall depth (D) 400 mm is reinforced with three (3) 16 mm diameter steel bars at bottom. Determine whether the section is balanced or under reinforced or over reinforced. Also, determine the ultimate moment of resistance (Mu) of the section using limit state method. M$_{20}$ concrete with f'c = 20 N/mm^2 and Fe415 grade of steel with fy = 415 N/mm^2 are to be used.

   Assume effective cover d' = 25 mm   (20 Marks)

   For limit state method,

   Depth of neutral axis is given by the formula, (Xu/d) = (0.87fy Ast)/(0.36fck.b.d) [IS 456:2000, p96]
   For Fe415, (Xu,max)/d = 0.48 (page 70, IS 456: 2000).

   Hints:

   1) If $\dfrac{Xu}{d} = \dfrac{Xu,max}{d}$ ⟹ Balanced

And for balanced section,

$$M.R. = Mu, lim = 0.36 * \frac{Xu, max}{d} *$$
$$(1 - 0.42 \frac{Xu, max}{d}) b * d^2 * fck$$

For under reinforced section,

$$M.R. = Mu.lim = 0.36 * \frac{Xu, max}{d} *$$
$$(1 - 0.42 \frac{Xu, max}{d}) b * d^2 * fck$$

OR

$$M.R. = Mu = 0.87 * fy * Ast * d *$$
$$(1 - 0.42 \frac{Xu}{d})$$

And over reinforced section is prohibited by the code.

Question Four   [Doubly Reinforced Sections]   (25 Marks)

a) Can you reduce the depth of a section of a doubly reinforced beam? Why or why not? (5 Marks)

b) Which material between mild steel and stainless high-grade steel will you prefer to design a doubly reinforced concrete section and why? (5 Marks)

c) Determine the ultimate moment of resistance of the beam section shown in the Figure below. M_{20} concrete and f_y = 415 MPa (i.e., Fe415) steel are to be used.   (15 Marks)
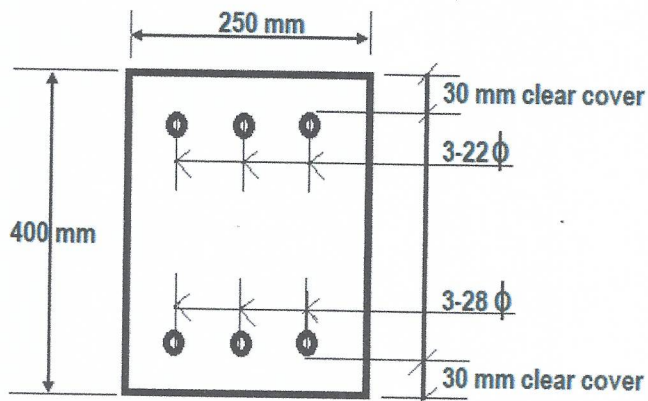

250 mm

30 mm clear cover

3-22 ⌀

400 mm

3-28 ⌀

30 mm clear cover

Fig No:)

For Fe415, (Xu,max)/d = 0.48 (page 70, IS 456: 2000).

Assume, design stress in compression in steel in this case as f_{sc} = 412 N/mm^2 ; A_{st2} = area of steel in tension zone to balance the compression reinforcement Asc = (fsc.Asc)/(0.87fy) [p 96, IS 456]. A_{st} = A_{st1} + A_{st2}, and (Xu/d) = (0.87fy A_{st1})/(0.36fck.b.d).

$$Mu = \text{M.R.} = Mu.\lim = 0.36 * \frac{Xu, max}{d} *$$
$$(1 - 0.42 \frac{Xu, max}{d}) b * d^2 * fck$$

Question Five   [General Definitions]   (25 Marks)

1. Describe what the purpose of tension reinforcement in an RC beam section? (5 Marks)
2. Describe what the purpose of compression reinforcement in an RC beam section? (5 Marks)
3. Describe what the purpose of lateral reinforcement in an RC beam section? (7 Marks)
4. Will you prefer smaller or bigger diameter of steel bar in RC slab design? Minimum diameter of bar available in the market is 6 mm. Justify your answer. (8 marks)

Question Six   [One-way Slab]   (25 Marks)

A simply supported *one–way* slab has an effective span of 3.5 meters. It is 150 mm thick, and is reinforced with 10 mm φ bars @ 200 mm spacing located at an effective depth of 125 mm. Assuming M 20 concrete and Fe 415 steel, determine the superimposed service load (in kN/m^2) that the slab can safely carry by:

    (i)   Working stress method of design (WSM), and

    (ii)   Limit state method (LSM) of design (assuming a load factor of 1.5). Assume any relevant data needed for the design.

Question Seven   [One-way Slab]   (25 Marks)

Determine (a) the allowable moment (at service load) and (b) the ultimate moment of resistance of a 100 mm thick slab, reinforced with 8 mm φ bars at 200 mm spacing located at an effective depth of 75 mm. Assume M20 concrete and Fe415 steel.