



**JARAMOGI OGINGA ODONGA UNIVERSITY OF SCIENCE AND
TECHNOLOGY**

SCHOOL OF ENGINEERING AND TECHNOLOGY

**UNIVERSITY EXAMINATIONS FOR THE DIPLOMA IN CIVIL
ENGINEERING**

2ND YEAR 1ST SEMESTER 2024 - 2025 ACADEMIC YEAR

CENTRE: MAIN CAMPUS

COURSE CODE: TDE 2224

COURSE TITLE: DESIGN OF ENGINEERING STRUCTURES

EXAM VENUE:

STREAM: DIP CIV ENG

DATE:

EXAM SESSION:

DURATION: 2 HOURS

Instructions

- 1. Answer section A (Compulsory) and ANY other two questions from section B**
- 2. Candidates are advised not to write on question paper**
- 3. Candidates must hand in their answer booklets to the invigilator while in the examination room**

SECTION A: 30 Marks Answer all the questions QUESTION ONE (10 Marks)

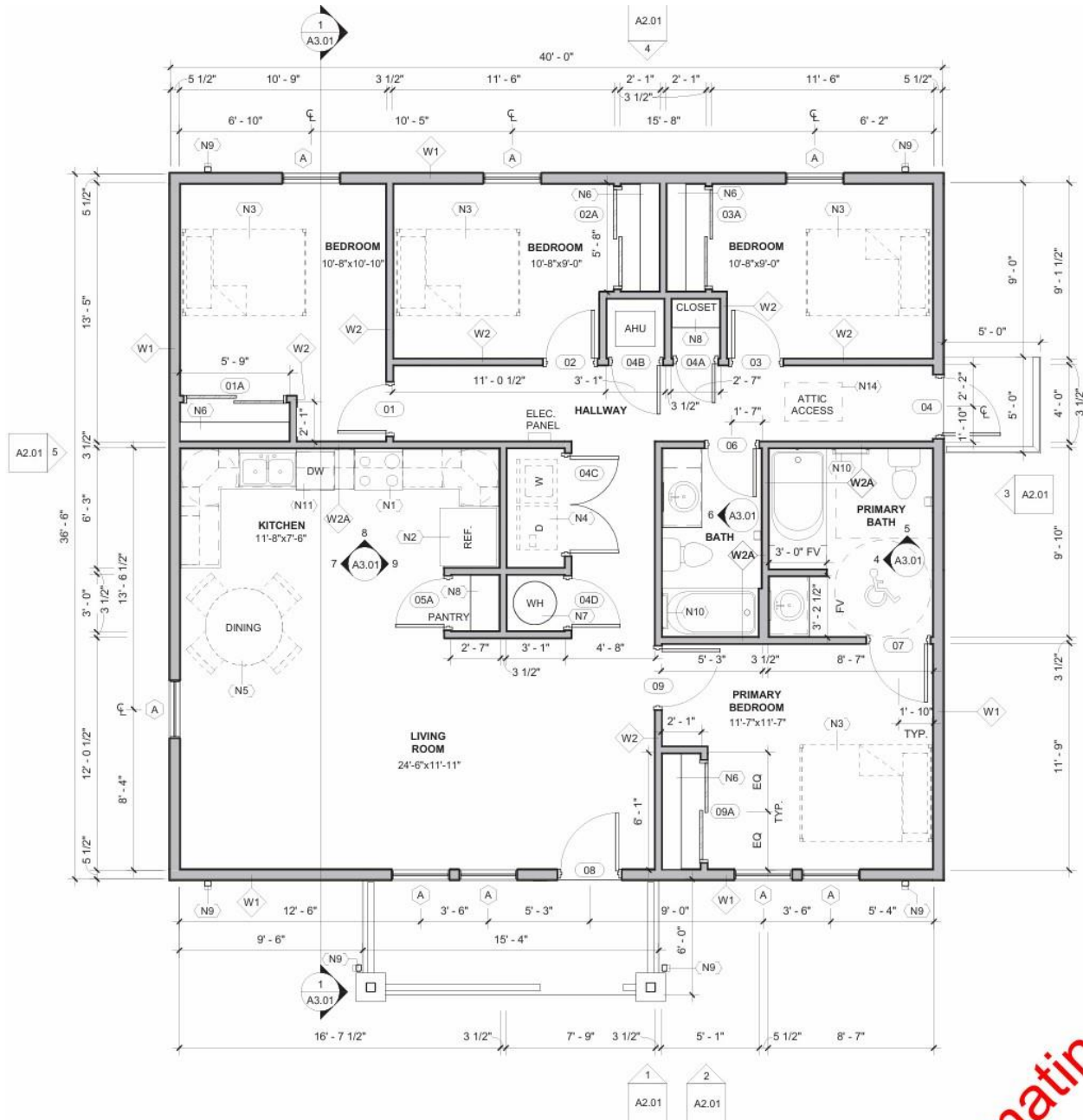
- a) The following are various types of structural layouts except **ONE**;
a) Foundation layout b) Beam layout c) Floor plan d) Column layout
- b) Structural loads are of various categories, select the odd **ONE** out.
a) Dead load b) Rain load c) Live load d) Wind load
- c) Of the following which **ONE** is not a structural design element?
a) Train b) Truss c) Arch d) Cables
- d) From below which structural design software has the highest rating
a) AutoCAD b) Prokon c) Revit d) Miniso
- e) Select a design method which is not cost effective
a) Free Software b) Spreadsheets c) Hand calculation d) Charged software
- f) From below, choose the odd one out
a) Topology optimization b) Constraints c) Design parameters d) Object function
- g) The following are factors which influence design optimization except **ONE**, which one?
a) Design variable choice b) Structure type c) Dimensionality of structure d) Shape
- h) The following are design constraints except which **ONE**
a) Deflection b) Weight c) Buckling d) Stress
- i) In which stage of a project is the modification of structural designs relevant.
a) Project conception b) Construction stage c) Detailed design stage d) Preliminary design stage
- j) Modification of preliminary designs to suite site conditions should conform to?
a) An educated guess b) Code of practice standards c) Profits of the project d) Personal interest only

QUESTION TWO 20 Marks

- a) Briefly explain the following:
 - i. Structural analysis (2 Marks)
 - ii. Structural design (2 Marks)
- b) Answer the following
 - i. What is the basic objective of structural analysis and design process (2 Marks)
 - ii. What is the primary purpose of a structure (2 Marks)
- c) Outline the project development stages you know (3 Marks)
- d) List any four factors which may lead to failure of a concrete structure (4 Marks)
- e) Answer the following
 - i. What is a code of practice (1 Mark)
 - ii. Name any three codes of practice and areas where they are applied (3 Marks)

SECTION B: 40 Marks; Answer any two questions QUESTION THREE 20 marks

- a) Differentiate between architectural plan and structural layout (2 Marks)
- b) What is the purpose of a building structural layout? (3 Marks)
- c) What factors would you consider in producing a building structural layout? (5 marks)
- d) Use the floor plan given to create a structural plan assuming the structure is a two story building. Ignore the dimensions and concentrate on the walls given to guide you. (10 marks)



QUESTION FOUR (20 Marks)

Outline detailed steps which you would follow to design a singly reinforced beam using the guidelines given in BS 8110-1

QUESTION FIVE (20 Marks)

A reinforced concrete structure should be designed to satisfy the intended purpose for its entire life based on adequate safety in terms of strength and stability, adequate serviceability in terms of its durability and reasonable economy. All designed structures must be safe, serviceable and economical for the entire life span. Mostly the design of structures and structural elements are based upon theoretical methods. Briefly discuss the following common methods of designing RCC structures (**general description, advantages, disadvantages**)

- a) Working Stress Method (WSM) (6 marks)
- b) Ultimate Load Method (ULM) (6 marks)
- c) Limit State Method (LSM) (8 marks)

QUESTION SIX (20 Marks)

A simply supported reinforced rectangular beam of 8 m span carries uniformly distributed characteristic dead load, which includes an allowance for self-weight of **7 kN/m** and characteristic imposed load of **5 kN/m**. The breadth **b=250 mm**. Design the beam as a singly reinforced at mid-span section for tension reinforcement required. Use **grade 30** concrete and **high yield steel reinforcement, $f_y = 460 \text{ N/mm}^2$** . (20 marks)

RELEVANT DESIGN FORMULAE WHICH MAY BE NEEDED

- Eurocode
- BS 8110

; compression reinforcement not required
 ; compression reinforcement required, hence doubly reinforced
 Provided $M_d \leq M_u$ or $K \leq K'$, only tension reinforcement is required. Where

; When $d = d_{min}$, compression reinforcement not require
 Using this value of d,

$$z = d \{0.5 + \sqrt{(0.25 - k/0.9)}\} \leq 0.95d$$

APPLICABLE DESIGN TABLES AND FIGURES

Table 3.9 — Basic span/effective depth ratio for rectangular or flanged beams (bs 8110)

Support conditions	Rectangular section	Flanged beams with $\frac{b_w}{b} \leq 0.3$
Cantilever	7	5.6
Simply supported	20	16.0
Continuous	26	20.8

Table 3.4 Values of γ_f for various load combinations (based on Table 2.1, BS 8110)

Load combination	Load type				
	Dead, G_k		Imposed, Q_k		Wind, W_k
	Adverse	Beneficial	Adverse	Beneficial	
1. Dead and imposed	1.4	1.0	1.6	0	–
2. Dead and wind	1.4	1.0	–	–	1.4
3. Dead and wind and imposed	1.2	1.2	1.2	1.2	1.2

Table 8.2 Concrete strength classes and properties (based Table 3.1, EC 2)

Strength Classes for Concrete	C20/25	C25/30	C28/35	C30/37	C32/40	C35/45	C40/50	C45/55	C50/60
f_{ck}	20	25	28	30	32	35	40	45	50
$f_{ck,cube}$	25	30	35	37	40	45	50	55	60
f_{ctm}	$f_{ctm} = 0.3 \times f_{ck}^{(2/3)} \text{ N mm}^{-2} \quad (8.1)$								
$f_{ctk,0.05}$	$f_{ctk,0.05} = 0.7 \times f_{ctm} \text{ N mm}^{-2} \quad (8.2)$								

Table 3.2 Strength of reinforcement (Table 3.1, BS 8110)

Reinforcement type	Characteristic strength, f_y (Nmm^{-2})
Hot rolled mild steel	250
High-yield steel (hot rolled or cold worked)	500

Table 2.3 Bending moments, shear forces and deflections for various standard load cases

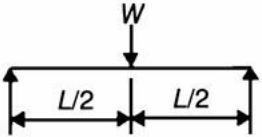
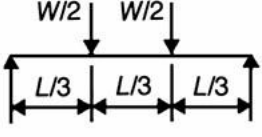
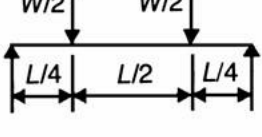
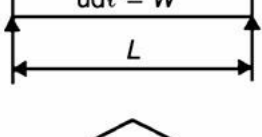
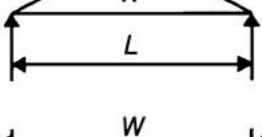
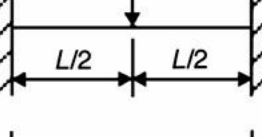
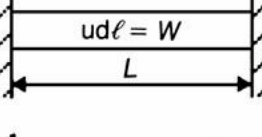
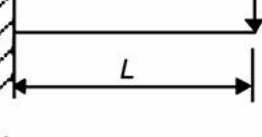
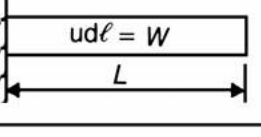
<i>Loading</i>	<i>Maximum bending moment</i>	<i>Maximum shearing force</i>	<i>Maximum deflection</i>
	$\frac{WL}{4}$	$\frac{W}{2}$	$\frac{WL^3}{48EI}$
	$\frac{WL}{6}$	$\frac{W}{2}$	$\frac{23WL^3}{1296EI}$
	$\frac{WL}{8}$	$\frac{W}{2}$	$\frac{11WL^3}{768EI}$
	$\frac{WL}{8}$	$\frac{W}{2}$	$\frac{5WL^3}{384EI}$
	$\frac{WL}{6}$	$\frac{W}{2}$	$\frac{WL^3}{60EI}$
	$\frac{WL}{8}$ (at supports and at midspan)	$\frac{W}{2}$	$\frac{WL^3}{192EI}$
	$\frac{WL}{12}$ at supports $\frac{WL}{24}$ at midspan	$\frac{W}{2}$	$\frac{WL^3}{384EI}$
	WL	W	$\frac{WL^3}{3EI}$
	$\frac{WL}{2}$	W	$\frac{WL^3}{8EI}$

Table 8.4 Partial safety factors for materials (based on Table 2.1N, EC 2)

Limit state	γ_c for concrete	γ_s for reinforcing and prestressing steel
Ultimate	1.5	1.15
Serviceability	1.0	1.0

Table 3.10 Cross-sectional areas of groups of bars (mm²)

Bar size (mm)	Number of bars									
	1	2	3	4	5	6	7	8	9	10
6	28.3	56.6	84.9	113	142	170	198	226	255	283
8	50.3	101	151	201	252	302	352	402	453	503
10	78.5	157	236	314	393	471	550	628	707	785
12	113	226	339	452	566	679	792	905	1020	1130
16	201	402	603	804	1010	1210	1410	1610	1810	2010
20	314	628	943	1260	1570	1890	2200	2510	2830	3140
25	491	982	1470	1960	2450	2950	3440	3930	4420	4910
32	804	1610	2410	3220	4020	4830	5630	6430	7240	8040
40	1260	2510	3770	5030	6280	7540	8800	10100	11300	12600

Table 3.23 Minimum Steel areas

	Percentage	$f_y=250$ N/ mm ²	$f_y=460$ N/ mm ²
Tension reinforcement			
Rectangular beam	$100A_s/A_c$	0.24	0.13
Flanged beam—Web in tension: $b_w/b < 0.4$	$100A_s/b_w h$	0.32	0.18
Flanged beam—Web in tension: $b_w/b \geq 0.4$	$100A_s/b_w h$	0.24	0.13
Compression reinforcement			
Rectangular beam	$100A_{sc}/A_c$	0.2	0.2
Flanged beam—flange in compression:	$100A_{sc}/b_w h_f$	0.2	0.2

A_c =total area of concrete, A_s =minimum area of reinforcement, A_{sc} =area of steel in compression, b, b_w, h_f =dimensions.

Table 3.25 — Minimum percentages of reinforcement (section 3.12.5.4)

The maximum area of both tension and compression reinforcement in beams is specified in BS8110: Part 1, clause 3.12.6.1. Neither should exceed 4% of the gross cross-sectional area of the concrete.