©2025 TVET CDACC

073206T4CEN

CIVIL ENGINEERING LEVEL 6

CON/OS/CET/CR/05/6/A

Design Engineering Structures

November/December 2025

TVET CURRICULUM DEVELOPMENT, ASSESSMENT AND CERTIFICATION COUNCIL (TVET CDACC)

WRITTEN ASSESSMENT

Time: 3 HOURS

INSTRUCTIONS TO CANDIDATE

1. This paper consists of **TWO** sections: **A** and **B**.
2. Answer **ALL** questions in section A and **ANY THREE** (3) questions in section B.
3. Marks for each question are indicated in the brackets.
4. Candidates are provided with a separate answer booklet

Do not write on the question paper

This paper consists of SIX (6) printed pages

Candidates should check the question paper to ascertain that all pages are printed as indicated and that no questions are missing.

SECTION A (40 MARKS)

Answer ALL the questions in this section.

1. In structural design, engineers must consider various forces acting on a building. Name FOUR types of loads commonly used in building design. (4 Marks)
2. A simply supported slab of 4 m × 3 m carries a dead load of 5 KN/m² and a live load of 3 KN/m². Calculate the ultimate design load per square meter and the total load on the slab. (5 Marks)
3. The strength of a reinforced concrete column depends on several parameters. List FOUR factors that influence the load capacity of a column. (4 Marks)
4. A square column of 300 mm × 300 mm is reinforced with 4 bars of 16 mm diameter. Calculate the total steel reinforcement area provided. (4 Marks)
5. Different types of codes are used when conducting structural design in civil engineering structures. List THREE codes of practice used in structural design. (3 Marks)
6. Foundations are critical in transferring loads to the ground. Outline FOUR types of foundations used in building construction. (4 Marks)
7. A rectangular beam 300 mm wide × 500 mm deep is subjected to a bending moment of 120 KN-m. Calculate the maximum bending stress induced in the beam section. (4 Marks)
8. A key challenge in structural engineering is optimizing designs for economy while maintaining safety standards. State FOUR effective cost-saving measures a designer can implement during the structural design phase. (4 Marks)
9. Effective reinforcement detailing is fundamental to the performance and longevity of a concrete slab. Outline FOUR key reasons why it is critically important. (4 Marks)
10. The design of modern structures is governed by the limit state philosophy to ensure both safety and usability. Differentiate between the Ultimate Limit State (ULS) and the Serviceability Limit State (SLS). (4 Marks)

SECTION B (60 MARKS)

Answer THREE Questions in This Section

11. Timber is widely used in structural works such as beams, trusses and flooring systems due to its strength-to-weight ratio and ease of construction. Proper design ensures safety and durability under applied loads.

    a. Timber column 100 x 100mm square end is restrained both in position and not direction. Assuming that the actual height of the column is 3.75m. Using table 1. calculate the maximum axial load a long-term load that the column can carry using the data below:

        - Grade stress in compression parallel to grains = 6.8 N/mm^2
        - E_{min} = 5.8 KN/m^2

        (12 Marks)

    b. Timber used in structural works is often affected by defects that reduce its strength, durability and appearance**.** Explain FOUR common defects in timber. (8 Marks)

12.

    a. Columns in reinforced concrete design are classified as short or long depending on their slenderness ratio. Differentiate between short columns and long columns under the following aspects.

        i. Slenderness ratio. (2 Marks)
        ii. Failure mode. (2 Marks)
        iii. Load carrying capacity. (2 Marks)
        iv. Design considerations. (4 Marks)

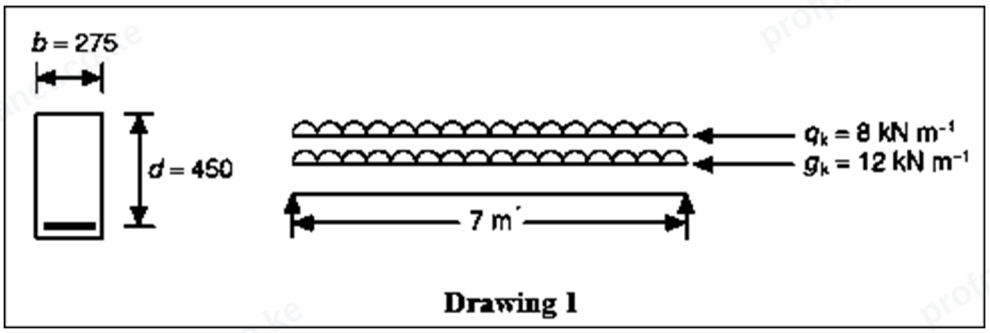
    b. As a structural engineer designing a multi-storey building, you must select suitable materials that can withstand applied loads and environmental conditions. Explain FIVE properties of steel that are considered in structural design. (10 Marks)

13.

    a. Drawing 1 shows a simply supported rectangular beam of 7 m span carries characteristic dead (including self-weight of beam), gk, an imposed, *q*k, loads of 12 kNm^{-1} and 8 kNm^{-1} . The beam dimensions are breadth, *b*, 275 mm and effective depth, *d*, 450 mm. Assuming the following material strengths, using Table 3 calculate the area of reinforcement required.

        $f$cu = 30 Nmm^{-2}

        fy = 500 Nmm^{-2}

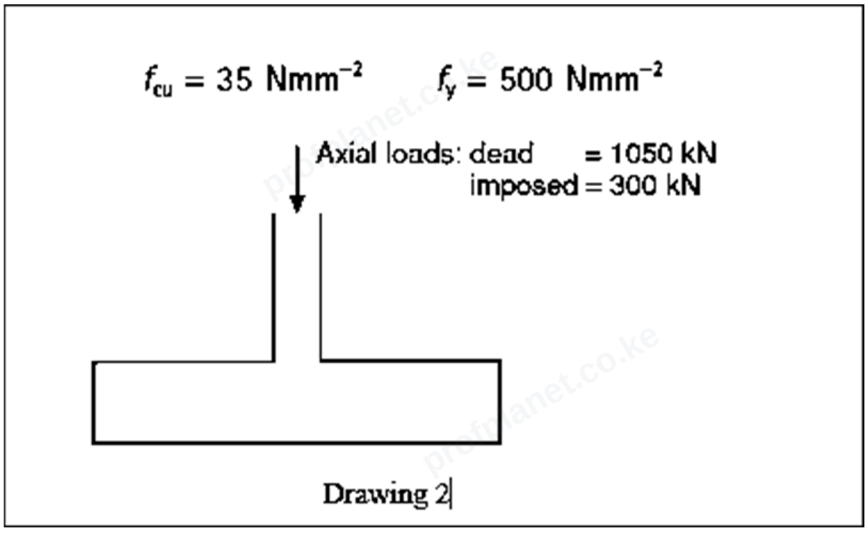


Drawing 1

(10 Marks)

b. Concrete is the most commonly used construction material in structural engineering due to its versatility and reliability. Explain FIVE properties of concrete considered in structural design. (10 Marks)

14. Drawing 2 shows a 400 mm square column carries a dead load (GK) of 1050 KN and imposed load (QK) of 300 KN. The safe bearing capacity of the soil is 170 kNm−2. Using Table 3 and 4, design a square pad footing to resist the loads assuming the following material strengths by.



Drawing 2

a. Calculate:

i. Factored loading. (5 Marks)

ii. Bending Moments. (5 Marks)

iii. Area of reinforcement. (7 Marks)

b. Draw a structure detail of reinforcement showing key details. (3 Marks)

©2025 TVET CDACC

DESIGN TABLES TO BRITISH STANDARD DESIGN CODE

TABLE 1: Modification factor K12 for compression member

$E/\sigma_{c,\parallel}$	Value of K_{12}																						
	Values of slenderness ratio $\lambda (= L_e/i)$																						
	<5	5	10	20	30	40	50	60	70	80	90	100	120	140	160	180	200	220	240	250			
	Equivalent L_e/b (for rectangular sections)																						
	<1.4	1.4	2.9	5.8	8.7	11.6	14.5	17.3	20.2	23.1	26.0	28.9	34.7	40.5	46.2	52.0	57.8	63.6	69.4	72.3			
400	1.000	0.975	0.951	0.896	0.827	0.735	0.621	0.506	0.408	0.330	0.271	0.225	0.162	0.121	0.094	0.075	0.061	0.051	0.043	0.040			
500	1.000	0.975	0.951	0.899	0.837	0.759	0.664	0.562	0.466	0.385	0.320	0.269	0.195	0.148	0.115	0.092	0.076	0.063	0.053	0.049			
600	1.000	0.975	0.951	0.901	0.843	0.774	0.692	0.601	0.511	0.430	0.363	0.307	0.226	0.172	0.135	0.109	0.089	0.074	0.063	0.058			
700	1.000	0.975	0.951	0.902	0.848	0.784	0.711	0.629	0.545	0.467	0.399	0.341	0.254	0.195	0.154	0.124	0.102	0.085	0.072	0.067			
800	1.000	0.975	0.952	0.903	0.851	0.792	0.724	0.649	0.572	0.497	0.430	0.371	0.280	0.217	0.172	0.139	0.115	0.096	0.082	0.076			
900	1.000	0.976	0.952	0.904	0.853	0.797	0.734	0.665	0.593	0.522	0.456	0.397	0.304	0.237	0.188	0.153	0.127	0.106	0.091	0.084			
1 000	1.000	0.976	0.952	0.904	0.855	0.801	0.742	0.677	0.609	0.542	0.478	0.420	0.325	0.255	0.204	0.167	0.138	0.116	0.099	0.092			
1 100	1.000	0.976	0.952	0.905	0.856	0.804	0.748	0.687	0.623	0.559	0.497	0.440	0.344	0.272	0.219	0.179	0.149	0.126	0.107	0.100			
1 200	1.000	0.976	0.952	0.905	0.857	0.807	0.753	0.695	0.634	0.573	0.513	0.457	0.362	0.288	0.233	0.192	0.160	0.135	0.116	0.107			
1 300	1.000	0.976	0.952	0.905	0.858	0.809	0.757	0.701	0.643	0.584	0.527	0.472	0.378	0.303	0.247	0.203	0.170	0.144	0.123	0.115			
1 400	1.000	0.976	0.952	0.906	0.859	0.811	0.760	0.707	0.651	0.595	0.539	0.486	0.392	0.317	0.259	0.214	0.180	0.153	0.131	0.122			
1 500	1.000	0.976	0.952	0.906	0.860	0.813	0.763	0.712	0.658	0.603	0.550	0.498	0.405	0.330	0.271	0.225	0.189	0.161	0.138	0.129			
1 600	1.000	0.976	0.952	0.906	0.861	0.814	0.766	0.716	0.664	0.611	0.559	0.508	0.417	0.342	0.282	0.235	0.198	0.169	0.145	0.135			
1 700	1.000	0.976	0.952	0.906	0.861	0.815	0.768	0.719	0.669	0.618	0.567	0.518	0.428	0.353	0.292	0.245	0.207	0.177	0.152	0.142			
1 800	1.000	0.976	0.952	0.906	0.862	0.816	0.770	0.722	0.673	0.624	0.574	0.526	0.438	0.363	0.302	0.254	0.215	0.184	0.159	0.148			
1 900	1.000	0.976	0.952	0.907	0.862	0.817	0.772	0.725	0.677	0.629	0.581	0.534	0.447	0.373	0.312	0.262	0.223	0.191	0.165	0.154			
2 000	1.000	0.976	0.952	0.907	0.863	0.818	0.773	0.728	0.681	0.634	0.587	0.541	0.455	0.382	0.320	0.271	0.230	0.198	0.172	0.160			

TABLE 3: Area of reinforcement

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 4: Cross-sectional area per meter width for various bar spacing (mm2)

Table 3.22 Cross-sectional area per metre width for various bar spacing (mm^2)

Bar size (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