Second Semester Examination
2020/2021 Academic Session

July/August 2021

EAS356 – Reinforced Concrete Structural Design II

Duration : 2 hours

Please ensure that this examination paper contains **NINE (9)** printed pages including appendix before you begin the examination.

Instructions: This paper contains **FIVE (5)** questions. Answer **FOUR (4)** questions.

All questions **MUST BE** answered on a new page.

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1. (a). The structural investigation of the pile for a structure situated very near to the coast revealed some of the bored piles were cracked. Having the floor plan examined, it is estimated that the 800 mm diameter bored pile (refer **Figure 1**) is supporting 3800 kN unfactored column load. The design report showed that the structural capacity governed the pile working load. The structural design of all piles was in accordance to BS EN 1992-1-1 and 50 years design life. Evaluate the structural integrity and the detailing of the previous design.

[15 marks]

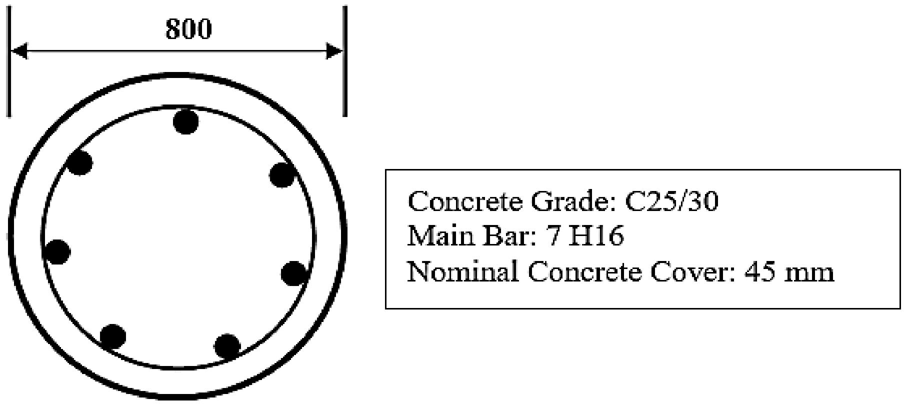


Figure 1 (all dimensions in mm)

(b). The construction of 250 mm diameter micro piles for an elevated water tank structure requires the use of permanent casing. This technique will increase the construction cost. If the allowable pile working capacity = 600 kN, provide the most economical design using H16 reinforcement to compensate the use of permanent casing. Take grout strength = 25 N/mm^2, E (steel) = 200 kN/mm^2 and E (grout) = 16 kN/mm^2 and FOS = 2.0. Assume the minimum and maximum percentage of reinforcement allowed is 1% and 6% of the cross-sectional area of the pile, respectively.

[10 marks]

2. Design and provide relevant detailing for the 6 PG pile cap as shown in **Figure 2** if the column load is taken to be G_k = 2500 kN and Q_k = 1200 kN. Take the overall depth of the pile cap = 1000 mm, f_{ck} = 30 N/mm^2, f_{yk} = 500 N/mm^2, main reinforcement = H25, secondary reinforcement = H16, concrete cover = 50 mm, z = 0.95d and pile embedded length = 75 mm. Neglect the design for anchorage length, reinforcement spacing and checking of the maximum shear at column face.

[25 marks]

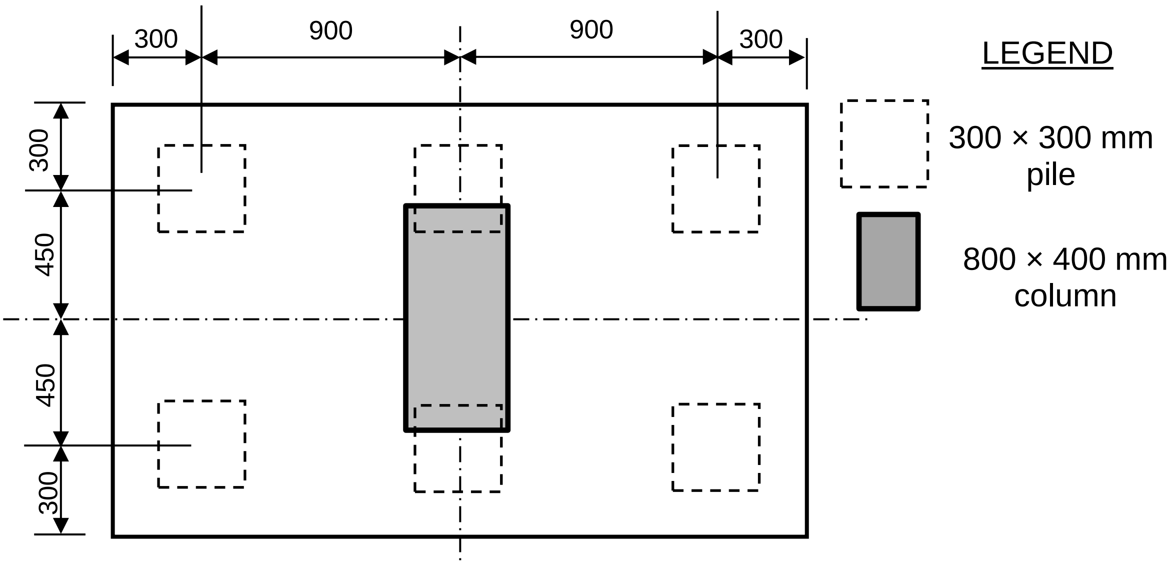


Figure 2 (all dimensions in mm)

3. The piling work for the construction of an office building has been completed. The contractor engaged a licensed land surveyor to prepare the As-Built piling drawing and to be submitted to the design office. Upon receiving the drawing, a structural engineer superimposed the given information with the construction drawing. The actual distance measured from the center of the piles to the respective axes is shown in **Figure 3**. The allowable pile working capacity is 800 kN. If the combined column load and selfweight of the pile cap are calculated to be 4500 kN, evaluate the pile capacity individually and as a group.

[25 marks]

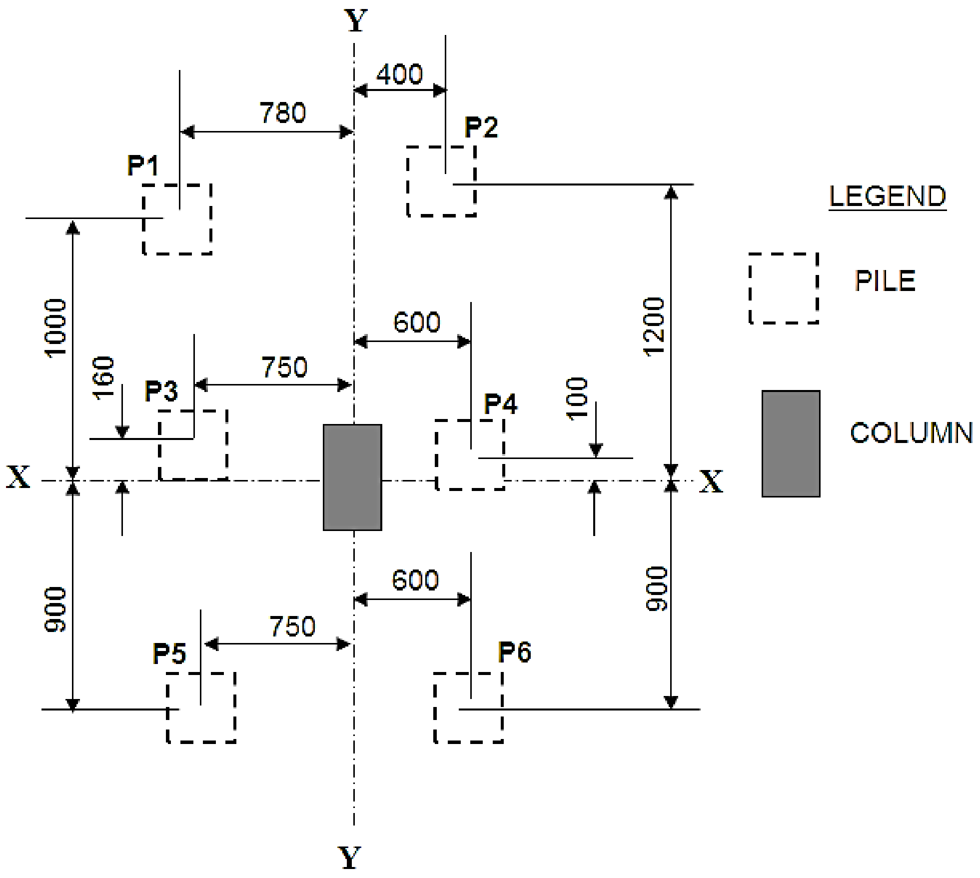


Figure 3: (all dimensions in mm)

4. (a). **Figure 4** shows a 4.5 m cantilever retaining wall to be designed. The surface of the backfill is subjected to surcharge of 10 kN/m^2. The size of the retaining wall has been proposed as shown in the figure.

(a) Check the stability of the retaining wall.

(b) Design for bending reinforcement of the retaining wall

[25 marks]

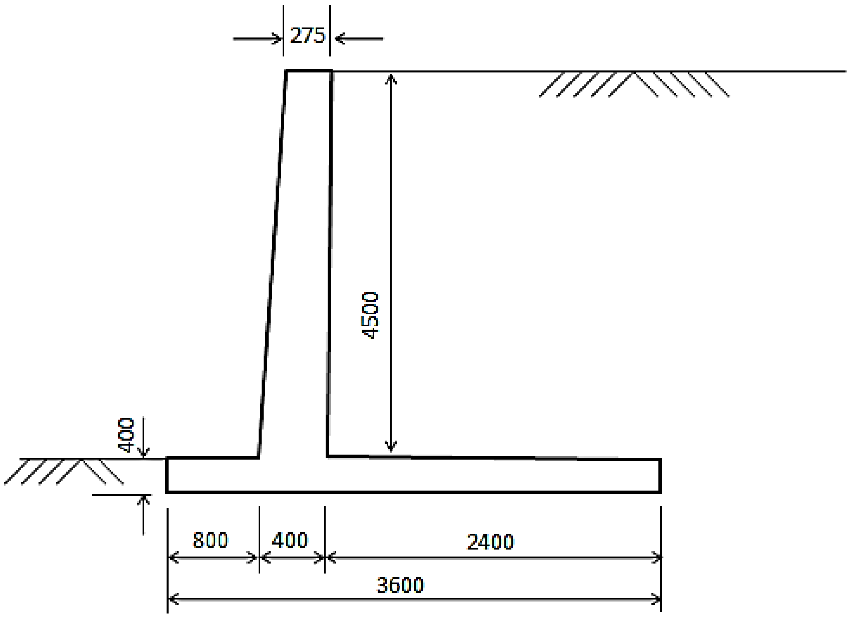


Figure 4 (all dimensions in mm)

Design data are given as follows:

Backfill soil:

granular material with self-weight, γ_s = of 17 kN/m^3

angle of internal friction, ϕ = 30^0

Foundation soil:

safe bearing pressure, q = 175 kN/m^2

coefficient of friction between soil and concrete, μ = 0.45

Retaining wall:

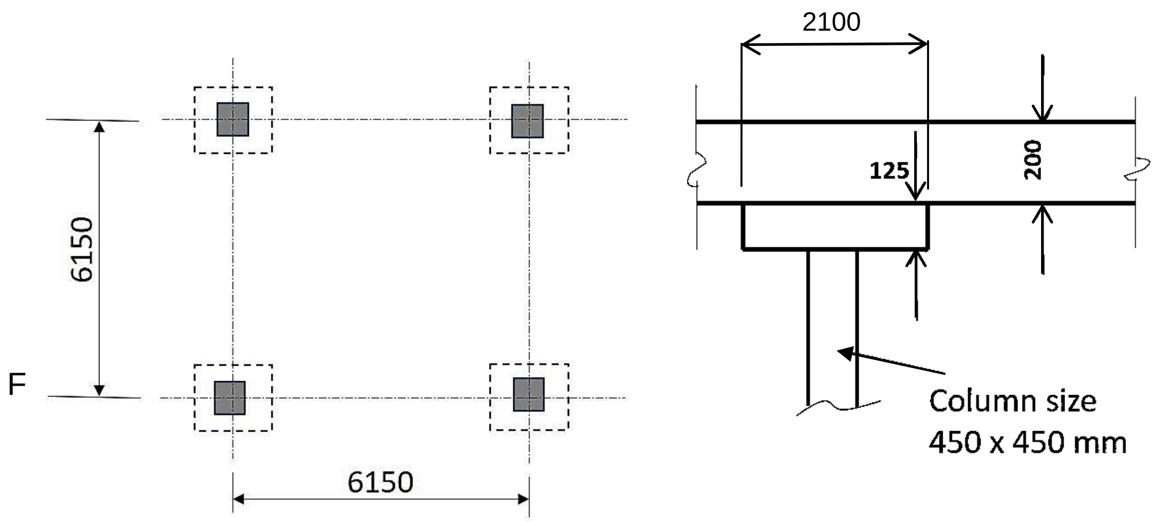
concrete class C30/37

unit weight of concrete, γ_c = 25 kN/m^3

steel rebars, f_{yk} = 500 N/mm^2

5. **Figure 5** shows an internal panel of a flat slab with panel size of 6150 mm. The thickness of the slab is 200 mm and size of drop panel is 2100 × 2100 × 125 mm. The slab is designed to carry a variable load with characteristic value of 4 kN/m^2. The characteristic material strength for concrete f_{ck} and steel f_{yk} are 25 N/mm^2 and 500 N/mm^2, respectively. Design for the flexural reinforcement of the flat slab. Use cover of 25 mm and reinforcement size of 12 mm. Check also the sufficiency of the flat slab with respect to punching shear at basic perimeter u_1. Provide the sketch of reinforcement layout. Checking of maximum spacing of flexural reinforcement and design for shear reinforcement are not needed.

[25 marks]



Plan view Cross-section

Figure 5 (all dimensions in mm)

APPENDIX

1. Pile capacity check:

$$P_n = \frac{P}{N} \pm \frac{M_{xx}\, y_n}{I_{xx}} \pm \frac{M_{yy}\, x_n}{I_{yy}}$$

2. Design shear resistance:

$$V_{Rd,c} = 0.12k(100\rho_1 f_{ck})^{\frac{1}{3}}\, bd$$

3. Minimum area of reinforcement:

$$A_{s,min} 0.26 \left(\frac{f_{ctm}}{f_{yk}}\right) bd$$

4. Ultimate bending moment in one-way spanning slabs

Ultimate bending moment and shear force in one way spanning slabs		
	Middle interior spans	Interior supports
Moment	0.063 *Fl*	0.063 *Fl*
F = is the total design load (1.35 *Gk* + 1.5 *Qk*) in kN; *l* = effective span		

5. Distribution of design moments in panel of flat slabs

Design moment	**Apportionment between column and middle strip expressed as percentage of the total negative or positive design moment**	
	Column strip %	**Middle strip %**
Negative	75	25
Positive	55	45
NOTE: For the case where the width of the column strip is taken as equal to that of the drop, and the middle strip is thereby increased in width, the design moments to be resisted by the middle strip should be increased in proportion to its increased width. The design moments to be resisted by the column strip may be decreased by an amount such that the total positive and the total negative design moments resisted by the column strip and middle strip together are unchanged.		

Table 3: Steel stress (under quasi-permanent loading)

f_s	$= \dfrac{f_{yk}\,(G_k + 0.3Q_k)}{1.15(1.35G_k + 1.5Q_k)}\ x\ \dfrac{A_{s,req}}{A_{s,pro}}$

Bar Areas and Perimeters

Sectional areas of groups of bars (mm^2)

Bar Size (mm)	Number of bars							
	1	2	3	4	5	6	7	8
6	28.3	56.6	84.9	113	142	170	198	226
8	50.3	101	151	201	252	302	352	402
10	78.5	157	236	314	393	471	550	628
12	113	226	339	452	566	679	792	905
16	201	402	603	804	1010	1210	1410	1610
20	314	628	943	1260	1570	1890	2200	2510
25	491	982	1470	1960	2450	2950	3440	3930
32	804	1610	2410	3220	4020	4830	5630	6430

Sectional areas per metre width for various bar spacings (mm^2)

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

A_{sv}/s_v for varying stirrup diameter and spacing

Stirrup diameter (mm)	Number of bars										
	85	90	100	125	150	175	200	225	250	275	300
8	1.183	1.118	1.006	0.805	0.671	0.575	0.503	0.447	0.402	0.366	0.335
10	1.847	1.744	1.57	1.256	1.047	0.897	0.785	0.698	0.628	0.571	0.523
12	2.659	2.511	2.26	1.808	1.507	1.291	1.13	1.004	0.904	0.822	0.753
16	4.729	4.467	4.02	3.216	2.68	2.297	2.01	1.787	1.608	1.462	1.34

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