Second Semester Examination
2018/2019 Academic Session

June 2019

EAS356– Reinforced Concrete Structural Design II
(Rekabentuk Struktur Konkrit Bertetulang II)

Duration : 2 hours
(Masa : 2 jam)

Please check that this examination paper consists of **TEN (10)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **SEPULUH (10)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

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

*[**Arahan** : Kertas ini mengandungi **LIMA (5)** soalan. Jawab **EMPAT (4)** soalan.]*

In the event of any discrepancies, the English version shall be used.

[Sekiranya terdapat sebarang percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah digunapakai.]

(1). (a). A structural engineer designed a 1000 mm diameter bored pile using BS EN 1992-1-1 for working life of 100 years. The pile is required to support unfactored load of 6000 kN. In the detailing part, the engineer proposed to use 12 H25 longitudinal reinforcement, grade 35 concrete and 50 mm concrete cover. Considering that the piles will be placed in a tidal zone (as the foundation of a marine structure), evaluate the adequacy of the proposed bored pile design and provide your technical comments.

Seorang jurutera struktur telah merekabentuk satu cerucuk tergerek bergarispusat 1000 mm menggunakan BS EN 1992-1-1 untuk jangka hayat kerja 100 tahun. Cerucuk tersebut perlu menanggung beban tidak difaktor sebanyak 6000 kN. Untuk bahagian perincian, jurutera tersebut mencadangkan penggunaan tetulang melintang 12 H25, konkrit gred 35 dan 50 mm penutup konkrit. Dengan mempertimbangkan cerucuk tersebut akan berada di zon pasang surut (sebagai asas satu struktur marin), buat penilaian terhadap kecukupan cadangan cerucuk tergerek tersebut dan sediakan komen teknikal anda.

[15 marks/*markah*]

(b). Determine the minimum number of H12 reinforcement required for a 250 mm micro pile in order to achieve 600 kN allowable pile working load. In order to stabilize the drilling hole and avoid necking along the pile shaft, a permanent casing shall be installed. Take the grout strength = 25 N/mm^2, E_{grout} = 16 GPa, f_{yk} = 500 N/mm^2 and E_{steel} = 200 GPa. The maximum area of reinforcement is limited to 4% of the pile cross sectional area. Take Factor of Safety = 2.0. Justify the selected method to calculate the structural capacity of the micro pile.

Tentukan bilangan minimum tetulang H12 yang diperlukan untuk cerucuk mikro bergarispusat 250 mm supaya mencapai keupayaan kerja dibenarkan sebanyak 600 kN. Untuk menstabilkan lubang gerek dan mengelakkan penyempitan di sepanjang aci cerucuk, satu selongsong kekal akan dipasang. Ambil kekuatan turap = 25 N/mm^2, E_{turap} = 16 GPa, f_{yk} = 500 N/mm^2 dan E_{keluli} = 200 GPa. Luas maksimum tetulang adalah dihadkan kepada 4% daripada luas keratan rentas cerucuk. Ambil Faktor Keselamatan = 2.0. Sediakan justifikasi terhadap pemilihan kaedah pengiraan keupayaan struktur cerucuk mikro tersebut.

[10 marks/*markah*]

(2). (a). The proposed plan view of a square pile cap with four pile group for a building project is shown in **Figure 1**. The pile cap is required to support unfactored column load with G_k = 2000 kN and Q_k = 600 kN. If the overall depth of the pile cap is taken as 700 mm, provide the design and the full detailing. Take f_{ck} = 30 N/mm^2, f_{yk} = 500 N/mm^2 and pile embedded length = 75 mm. Use H16 as the main reinforcement. Ignore the check for the maximum shear resistance at the column face, the reinforcement spacing and the anchorage length (sketch only the anchorage length for detailing purposes).

Cadangan pandangan pelan tetopi cerucuk segiempat sama dengan sekumpulan empat cerucuk untuk projek bangunan adalah seperti di ***Rajah 1****. Tetopi cerucuk tersebut diperlukan untuk menanggung beban tiang tidak terfaktor G_k = 2000 kN, Q_k = 600 kN. Jika kedalaman keseluruhan tetopi cerucuk adalah 700 mm, sediakan rekabentuk dan perincian penuh. Ambil f_{ck} = 30 N/mm^2, f_{yk} = 500 N/mm^2 dan panjang tertanam cerucuk = 75 mm. Gunakan tetulang H16 sebagai tetulang utama. Abaikan semakan rintangan ricih maksimum pada permukaan tiang, selaan tetulang dan panjang tambatan (hanya lakarkan panjang tambatan bagi tujuan perincian).*

[20 marks/*markah*]

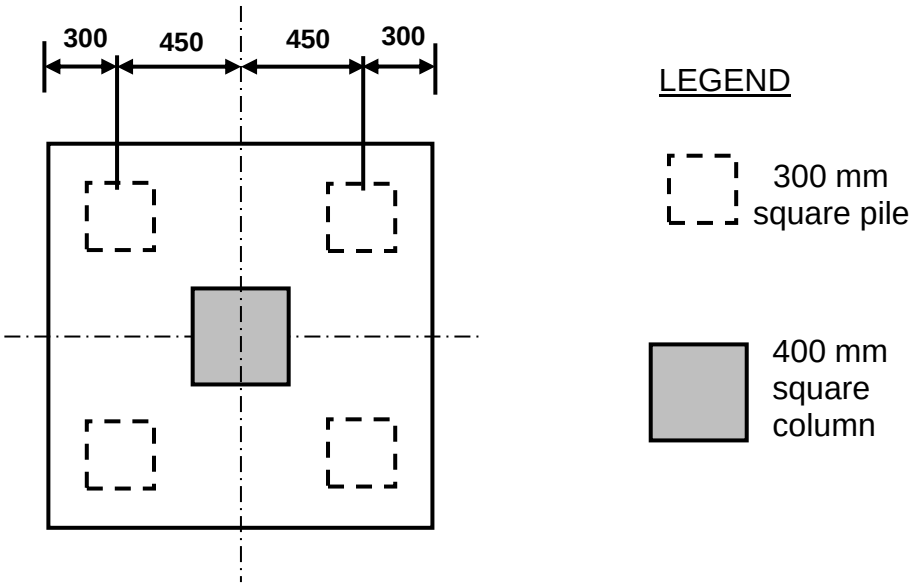

Figure 1 (all dimensions in mm)/*Rajah 1 (semua ukuran dalam mm)*

(b). The client for the project accepted the proposed piling size and pile cap details. However, in order to reduce the cost for excavation and concrete, the client appreciated if your design office could reduce the overall depth of the pile cap. One of your colleagues suggested compensating the reduction in the overall pile cap depth by using high concrete grade. Evaluate his suggestion. Without the need to perform any calculation, propose and justify another **ONE (1)** approach that has the potential to overcome the issue.

*Klien kepada projek tersebut bersetuju dengan cadangan saiz cerucuk dan perincian tetopi cerucuk. Namun demikian, untuk mengurangkan kos pengorekan dan konkrit, klien tersebut menghargai sekiranya kedalaman tetopi cerucuk dapat dikurangkan. Salah seorang rakan kerja anda mencadangkan penggunaan konkrit bergred tinggi untuk mengimbal kepada pengurangan kedalaman tetopi cerucuk. Buat penilaian terhadap cadangan beliau. Cadang dan berikan justifikasi **SATU (1)** lagi pendekatan yang berpotensi untuk mengatasi isu tersebut.*

[5 marks/*markah*]

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(3). (a). The plan and sectional views of a six pile group together with the associated loading arrangement are shown in **Figure 2**. The pile cap is supported by four vertical piles and two raked piles (1:5), spaced at 450 mm centre to centre. If the allowable pile working load is 200 kN, evaluate the capacity distribution of the pile (individual and group).

Pandangan pelan dan keratan satu tetopi cerucuk dengan sekumpulan enam cerucuk beserta susunan beban adalah seperti di ***Rajah 2****. Tetopi cerucuk tersebut di tanggung oleh empat cerucuk pugak dan dua cerucuk sadak (1:5), pada selaan 450 mm jarak pusat ke pusat. Jika keupayaan kerja dibenarkan untuk cerucuk adalah 200 kN, buat penilaian terhadap agihan keupayaan cerucuk (individu dan kumpulan).*

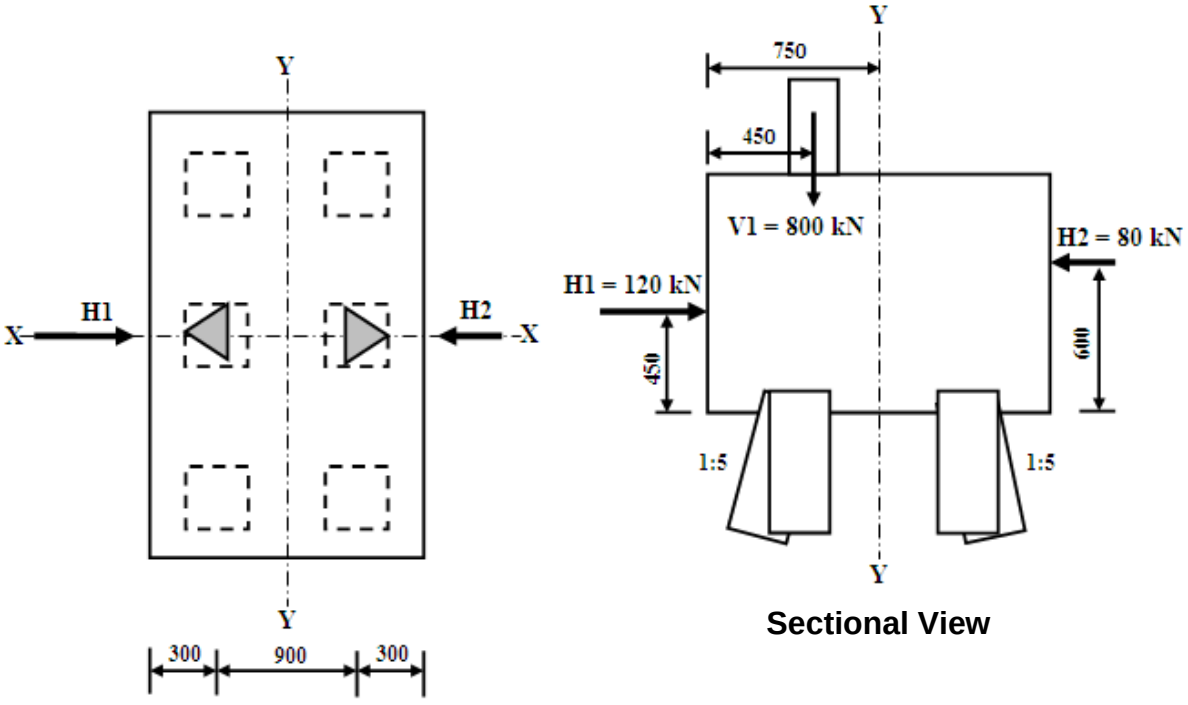

Figure 2 (all dimensions in mm)/*Rajah 2 (semua ukuran dalam mm)*

[15 marks/*markah*]

(b). Checking the final capacity of a pile group can be part of the deep foundation design. This approach is applied to ensure that none of the pile will suffer from excessive compression or tension force that can cause failure. Clearly discuss **TWO (2)** situations where the need to perform the pile capacity check on deep foundation system are deemed compulsory. Differentiate the effect of each situation on the pile capacity. Use relevant sketches.

*Pemeriksaan terhadap keupayaan muktamad sekumpulan cerucuk boleh menjadi sebahagian daripada rekabentuk asas dalam. Kaedah ini digunakan untuk memastikan tiada cerucuk yang akan mengalami daya mampatan atau tegangan yang berlebihan sehingga boleh menyebabkan kegagalan. Bincangkan dengan jelas **DUA (2)** situasi dimana keperluan untuk melakukan semakan keupayaan cerucuk dianggap sebagai satu kewajipan. Bezakan kesan setiap situasi ke atas keupayaan cerucuk. Gunakan lakaran yang sesuai.*

[10 marks/*markah*]

(4). **Figure 3** shows the part plan for the internal layout of a slab of a commercial building where the use of flat slab has been proposed. The slab thickness should be 225 mm together with drop panels of dimension 2200×2200×300 mm. Given that the ultimate design load is 10 kN/m^2, design the flat slab and check the punching shear requirements within the drop panel only. Use H12 reinforcement (f_{yk} = 500 N/mm^2) and grade 30 concrete (f_{ck}= 30 N/mm^2). The diameter of the column head (h_c) and the concrete cover are to be taken as 1000 mm and 25 mm, respectively. Assume variable load, Q_k as 2.5 kN/m^2. Provide typical sectional details along the column strip and middle strip.

Rajah 3 *menunjukkan sebahagian pelan susun atur dalaman untuk satu lantai bangunan komersial di mana penggunaan lantai rata telah dicadangkan. Tebal lantai tersebut mestilah 225 mm dengan panel jatuhan berukuran 2200×2200×300 mm. Diberi beban rekabentuk muktamad adalah 10 kN/m^2, rekabentuk lantai rata tersebut dan semak keperluan ricih tebukan di lingkungan panel jatuhan sahaja. Gunakan tetulang H12 (f_{yk} = 500 N/mm^2) dan konkrit gred 30 (f_{ck}= 30 N/mm^2). Garis pusat kepala tiang (h_c) dan penutup konkrit masing-masing diambil sebagai 1000 mm dan 25 mm. Anggap beban berubah, Q_k sebagai 2.5 kN/m^2 . Sediakan perincian tipikal di sepanjang jalur tiang dan jalur tengah.*

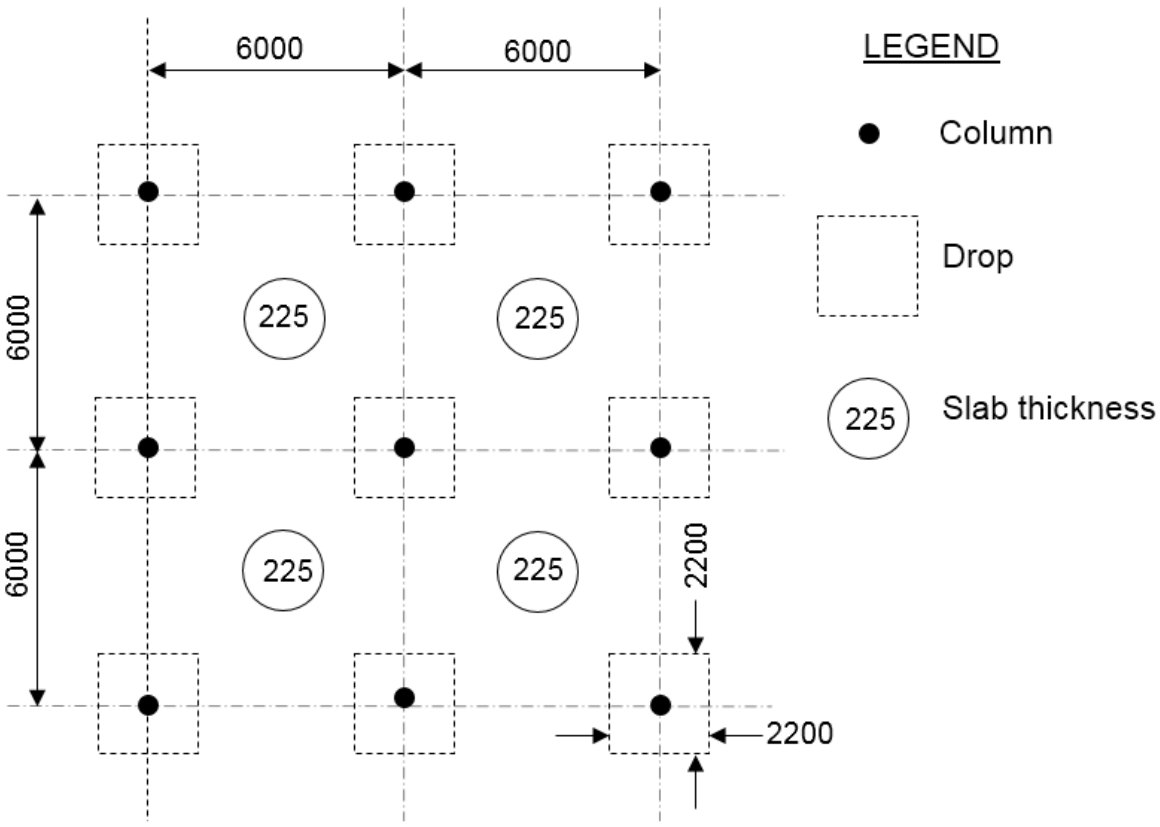

Figure 3 (all dimensions in mm)/*Rajah 3 (semua ukuran dalam mm)*

[25 marks/*markah*]

(5). **Figure 4** shows a cantilever wall for retaining horizontal earth backfill which is subjected to surcharge of 10 kN/m^2. The height of the wall is 4.5 m above ground level and the depth of foundation is 0.4 m below ground level. Given that the safe bearing capacity of the foundation soil is 170 kN/m^2, unit weight of backfill is 19 kN/m^3, angle of shearing resistance of soil is 35˚ and coefficient of friction between soil and concrete is 0.45, design and provide the relevant detailing for the cantilever wall. Use concrete grade 30 (f_{ck} = 30 N/mm^2), H12 reinforcement (f_{yk} = 500 kN/m^2) and nominal concrete cover of 45 mm.

Rajah 4 *menunjukkan satu dinding julur untuk menahan beban kambus balik tanah melintang yang dikenakan beban tambahan 10 kN/m^2. Ketinggian dinding adalah 4.5 m di atas paras tanah dan kedalaman asas adalah 0.4 m di bawah paras tanah. Diberi bahawa keupayaan galas selamat tanah adalah 170 kN/m^2, berat unit kambus balik adalah 19 kN/m^3, sudut rintangan ricih tanah adalah 35˚ dan pekali geseran diantara tanah dan konkrit adalah 0.45, rekabentukkan dan sediakan perincian yang bersesuaian untuk dinding julur berkenaan. Gunakan konkrit gred 30 (f_{ck} = 30 N/mm^2), tetulang H12 (f_{yk} = 500 kN/m^2) dan penutup konkrit nominal sebesar 45 mm.*

[25 marks/*markah*]

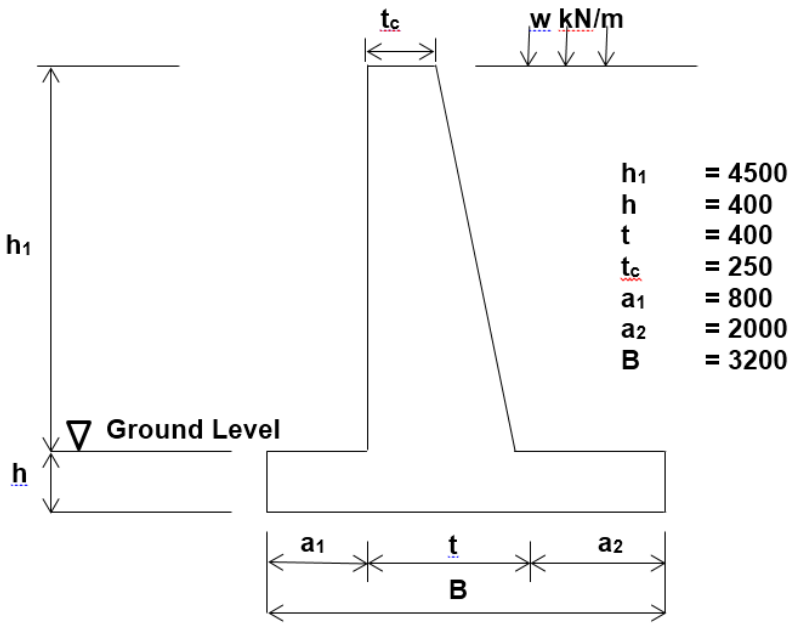

Figure 4 (all dimensions in mm)/*Rajah 4 (semua ukuran dalam mm)*

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APPENDIX/ *LAMPIRAN*

1. Pile capacity: $$P_n = \frac{P}{N} \pm \frac{M_{xx}\, y_n}{I_{xx}} \pm \frac{M_{yy}\, x_n}{I_{yy}}$$

2. Design shear resistance: $$V_{Rd,c} = 0.12k(100\rho_1 f_{ck})^{\frac{1}{3}}\, bd$$

3. Minimum area of reinforcement: $$A_{s,min} = 0.26 \left(\frac{f_{ctm}}{fyk}\right) bd$$

4. Maximum area of reinforcement: $$A_{s,max} = 0.04\ A_c$$

5. Minimum shear resistance: $$V_{min} = 0.035\, k^{\frac{3}{2}}\, f_{ck}^{\frac{1}{2}}$$

6. Steel stress (quasi-permanent loading): $$\sigma_s = 0.55 \left(\frac{f_k}{1.15}\right)\left(\frac{A_{s,req}}{A_{s,pro}}\right)$$

7. Ultimate bending moment and shear forces 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		

8. Distributions 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.		

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9. Reinforcement data (area and spacing)

Diameter of link bars (mm)	Spacing of bars (s_v) (mm)									
	75	100	125	150	175	200	225	250	275	300
8	1.34	1.005	0.804	0.67	0.574	0.503	0.447	0.402	0.366	0.335
10	2.094	1.571	1.257	1.047	0.898	0.785	0.698	0.628	0.571	0.524
12	3.016	2.262	1.81	1.508	1.293	1.131	1.005	0.905	0.823	0.754
16	5.362	4.021	3.217	2.681	2.298	2.011	1.787	1.608	1.462	1.34

No of bars	Bar Diameter (mm)							
	6	8	10	12	16	20	25	32
1	28	50	79	113	201	314	491	804
2	57	101	157	226	402	628	982	1608
3	85	151	236	339	603	942	1473	2413
4	113	201	314	452	804	1257	1963	3217
5	141	251	393	565	1005	1571	2454	4021
6	170	302	471	679	1206	1885	2945	4825
7	198	352	550	792	1407	2199	3436	5630
8	226	402	628	905	1608	2513	3927	6434
9	254	452	707	1018	1810	2827	4418	7238
10	283	503	785	1131	2011	3142	4909	8042

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