UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2016/2017 Academic Session

June 2017

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 **ELEVEN (11)** pages of printed materials including **ONE (1)** appendix before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **SEBELAS (11)** muka surat bercetak termasuk **SATU (1)** lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **FIVE (5)** questions. Answer **FOUR (4)** questions only.
*[**Arahan**: Kertas ini mengandungi **LIMA (5)** soalan. Jawab **EMPAT (4)** soalan sahaja.]*

All questions **MUST BE** answered on a new page.
*[Semua soalan **MESTILAH** dijawab pada muka surat baru.]*

Write the answered question numbers on the cover sheet of the answer script.
Tuliskan nombor soalan yang dijawab di luar kulit buku jawapan anda.

You may answer the question either in Bahasa Malaysia or English.
[Anda dibenarkan menjawab soalan sama ada dalam Bahasa Malaysia atau Bahasa Inggeris.]

In the event of any discrepancies, the English version shall be used.
[Sekiranya terdapat percanggahan pada soalan peperiksaan, versi Bahasa Inggeris hendaklah diguna pakai.]

1. [a] In a structural inspection task involving the failure of a building situated very near to the coastal area, you are given the opportunity to analyse the deep foundation system. The typical cross-section of the 1000 mm diameter bored pile used for construction is shown in **Figure 1**. The terms of reference for the project stated that the structural design of all piles must be in accordance to BS EN 1992-1-1, 50 years design life and factor of safety = 2.0. If the allowable pile working load is 3800 kN, evaluate the structural integrity and the detailing of the previous design. Take minimum clear distance between longitudinal bars as 100 mm.

Dalam satu tugasan penyiasatan struktur yang melibatkan kegagalan satu bangunan terletak sangat hampir dengan kawasan pantai, anda telah diberi peluang untuk menganalisis sistem asas dalam. Keratan asas tipikal cerucuk tegerek bergarispusat 1000 mm yang telah digunakan untuk pembinaan ditunjukkan di ***Rajah 1****. Terma rujukan untuk projek tersebut menyatakan semua rekabentuk struktur cerucuk mesti mengikut BS EN 1992-1-1, 50 tahun hayat rekabentuk dan faktor keselamatan = 2.0. Sekiranya beban kerja asas yang dibenarkan adalah 3800 kN, sediakan penilaian terhadap integriti struktur dan perincian rekabentuk terdahulu. Ambil jarak kelegaaan minimum di antara tetulang sebagai 100 mm.*

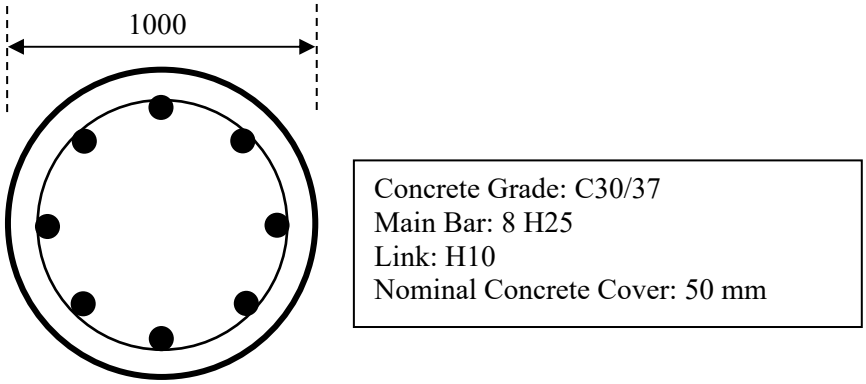

Figure 1: (all dimensions in mm)/*Rajah 1: (semua ukuran dalam mm)*

[10 marks/*markah*]

[b] The foundation system of a proposed 8-storey hotel project needs to be designed using micro piles. In order to stabilize the drilling hole and avoid necking along the pile shaft, a temporary casing shall be installed. If the allowable pile working load is 450 kN, design the structural capacity of a 250 mm micro pile considering grout strength = 25 N/mm^2, E_{grout} = 14 GPa, reinforcement size = 16 mm diameter, f_{yk} = 500 N/mm^2 and E_{steel} = 200 GPa. The maximum reinforcement is limited to 3% of the pile cross sectional area and the Factor of Safety is taken as 2.0. Ignore the requirement for bond length. Provide relevant detailing and justify the method to calculate the structural capacity of the micro pile.

Sistem asas dalam untuk satu cadangan projek hotel 8-tingkat perlu direkabentuk menggunakan cerucuk mikro. Untuk menstabilkan lubang gerek dan mengelakkan penyempitan disepanjang aci cerucuk, satu selongsong sementara akan dipasang. Jika keupayaan kerja cerucuk yang dibenarkan adalah 450 kN, rekabentuk keupayaan struktur satu cerucuk mikro bergarispusat 250 mm dengan mempertimbangkan kekuatan turap = 25 N/mm^2, E_{turap} = 14 GPa, saiz tetulang = 16 mm diameter, f_{yk} = 500 N/mm^2 and E_{keluli} = 200 GPa. Had penggunaan tetulang maksimum adalah 3% daripada luas keratan rentas cerucuk dan Faktor Keselamatan diambil sebagai 2.0. Abaikan keperluan panjang ikatan. Sediakan perincian yang berkaitan dan wajarkan pemilihan kaedah pengiraan keupayaan struktur cerucuk mikro.

[15 marks/*markah*]

2. [a] Checking the final capacity of a pile or a pile group can be part of the deep foundation design. This requirement is applied to ensure that none of the pile will suffer from excessive compression or tension force. 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 satu atau sekumpulan cerucuk boleh menjadi sebahagian daripada rekabentuk asas dalam. Keperluan ini digunakan untuk memastikan tiada cerucuk yang akan mengalami lebihan daya mampatan atau tegangan. Bincangkan dengan jelas **DUA (2)** situasi dimana keperluan untuk melakukan semakan keupayaan cerucuk dianggap sebagai wajib. Bezakan kesan setiap situasi keatas keupayaan cerucuk. Gunakan lakaran yang sesuai.*

[9 marks/*markah*]

[b] **Figure 2** shows part plan of the piling layout for a 4 pile group superimposed with the location of Column C1. The actual pile spacing is supposed to be 1600 mm center to center with respect to the reference axes (x-x and y-y). However, due to poor site coordination, it can be seen that pile P2 and P4 deviated -200 mm from the y-axis. Meanwhile, Column C1 deviated -75 mm and -100 mm from the x-axis and y-axis, respectively. If the pile working capacity is set at 500 kN, evaluate the capacity distribution for each pile.

Rajah 2 *menunjukkan sebahagian pelan susunatur cerucuk untuk kumpulan empat cerucuk yang ditindih bersama lokasi tiang C1. Jarak selaan sebenar cerucuk sepatutnya adalah 1600 mm pusat ke pusat berpandukan kepada paksi rujukan (x-x dan y-y). Namun demikian, disebabkan oleh kelemahan penyelasaran ditapak bina, dapat dilihat cerucuk P2 dan P4 telah tersisih sebanyak 200 mm dari paksi-y. Sementara itu, tiang C1 pula tersisih 75 mm dan 100 mm, masing-masing dari paksi-x dan paksi-y. Jika keupayaan kerja cerucuk ditetapkan pada 500 kN, buat penilaian terhadap agihan keupayaan untuk setiap cerucuk.*

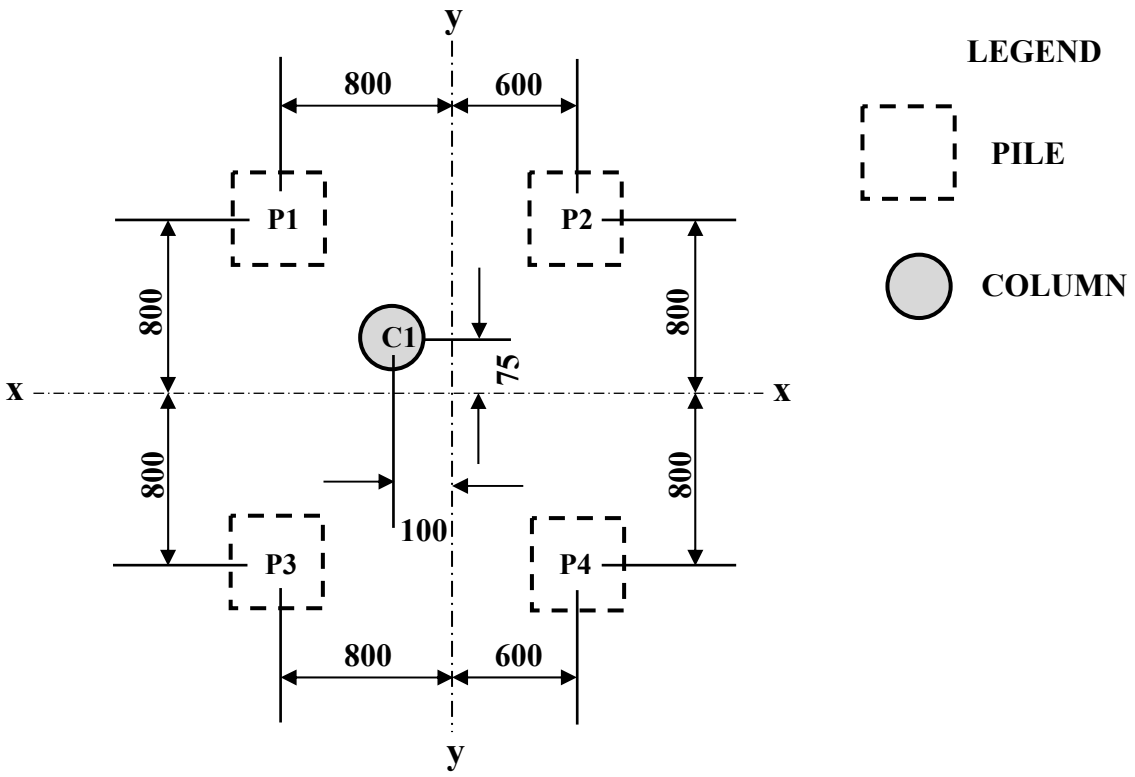

Figure 2: (all dimensions in mm)/*Rajah 2: (semua ukuran dalam mm)*

[16 marks/*markah*]

3. A pile cap with four pile group is required to support a column load with G_k = 2600 kN and Q_k = 1000 kN. The centroid of the pile cap and the rectangular column coincide with each other as shown in **Figure 3**. If the overall depth of the pile cap is 900 mm, design and provide relevant detailing considering that the f_{ck} = 35 N/mm^2, f_{yk} = 500 N/mm^2, concrete cover = 40 mm and pile embedded length = 75 mm. Use reinforcement H20. Ignore the check for maximum shear resistance at the column face and the anchorage length.

*Satu tetopi cerucuk dengan sekumpulan empat cerucuk diperlukan untuk menanggung beban tiang dengan G_k = 2600 kN, Q_k = 1000 kN. Sentroid tetopi cerucuk dan tiang segiempat tepat adalah bertindan di antara satu sama lain seperti yang ditunjukkan di **Rajah 3**. Jika kedalaman keseluruhan tetopi cerucuk adalah 900 mm, rekabentuk dan sediakan perincian yang berkaitan dengan mempertimbangkan f_{ck} = 35 N/mm^2, f_{yk} = 500 N/mm^2, penutup konkrit = 40 mm and panjang tertanam cerucuk = 75 mm. Gunakan tetulang H20. Abaikan semakan rintangan ricih pada permukaan tiang dan panjang tambatan.*

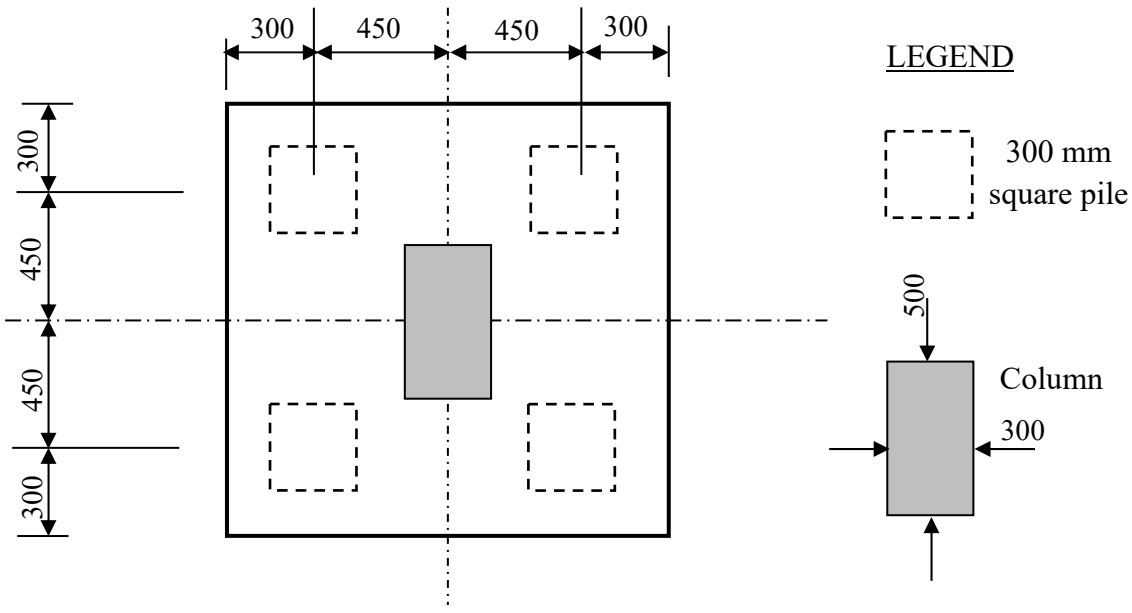

Figure 3: (all dimensions in mm)/*Rajah 3*: *(semua ukuran dalam mm)*

[25 marks/*markah*]

4. A flat slab construction is required for a housing project. The part plan of the internal layout for the slab is shown in **Figure 4**. The slab should be 225 mm thick together with 2.4 m × 2.4 m × 300 mm drop panels. If the ultimate design load = 10 kN/m^2, design the flat slab and check the punching shear requirements within the drop panel only. Provide typical sectional details along the column strip and middle strip. 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 is taken as 1000 mm and 25 mm, respectively. Assume Q_k= 2.5 kN/m^2 and reinforcement spacing = 200 mm.

Pembinaan lantai rata adalah diperlukan untuk satu projek perumahan. Sebahagian pelan susun atur dalaman untuk lantai rata ditunjukkan di ***Rajah 4****. Lantai tersebut mestilah 225 mm tebal dan mempunyai panel jatuhan 2.4 m × 2.4 m × 300 mm. Jika beban rekabentuk muktamad = 10 kN/m^2, rekabentuk lantai rata tersebut dan semak keperluan ricih tebukan dilingkungan panel jatuhan sahaja. Sediakan perincian tipikal disepanjang jalur tiang dan jalur tengah. 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 Q_k = 2.5 kN/m^2 dan selaan tetulang = 200 mm.*

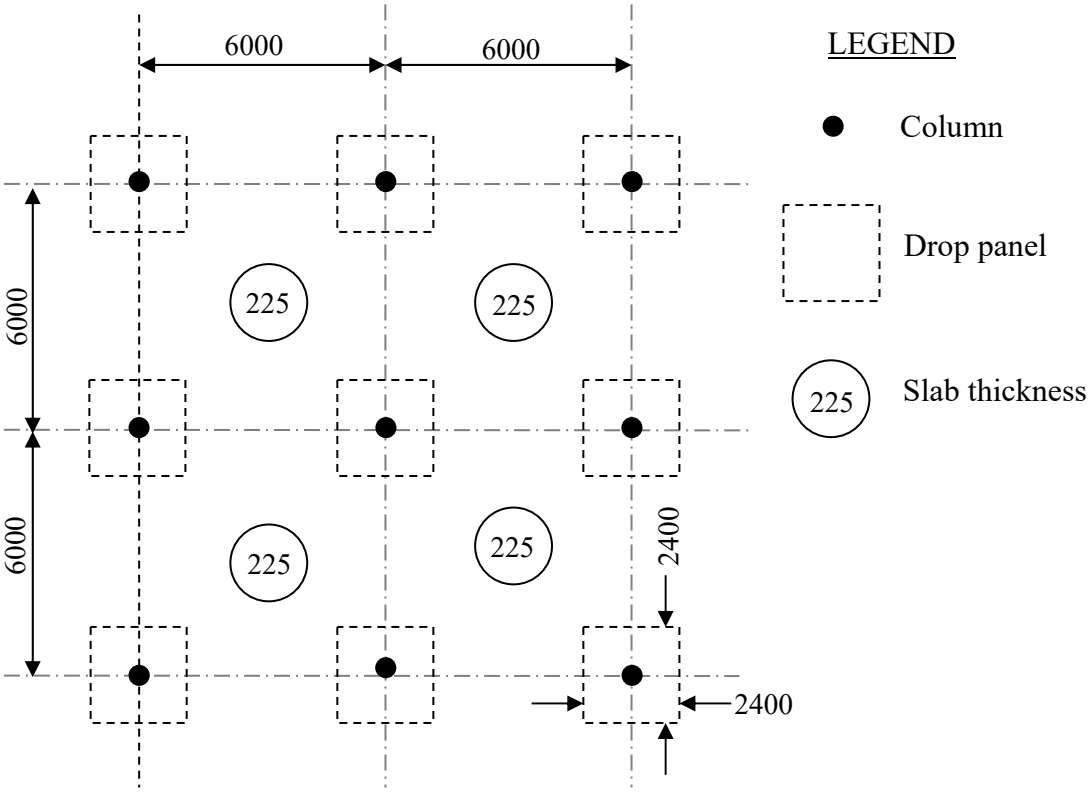

Figure 4: (all dimensions in mm)/*Rajah 4: (semua ukuran dalam mm)*

[25 marks/*markah*]

5. Design a cantilever wall as shown in **Figure 5** to retain earth with horizontal backfill and surcharge load of 10 kN/m^2. The top of the wall is 4.0 m above the ground level, and the foundation depth may be taken as 0.9 m below ground level, with the safe bearing capacity of 170 kN/m^2. Assume the backfill has a unit weight of 19 kN/m^3 and an angle of shearing resistance of 35˚. The coefficient of friction between soil and concrete is 0.45. Use concrete grade 30 (f_{ck} = 30 N/mm^2), H12 reinforcement (f_{yk} = 500 kN/m^2) and nominal concrete cover as 45 mm.

Rekabentuk sebuah dinding julur seperti yang ditunjukkan pada ***Rajah 5*** *untuk menahan beban kambus balik melintang dan beban surcaj 10 kN/m^2. Bahagian atas dinding adalah 4.0 m diatas aras bumi dan kedalaman asas adalah 0.9 m dibawah aras bumi dengan keupayaan galas selamat 170 kN/m^2. Pekali geseran diantara tanah dan konkrit adalah 0.45. Gunakan konkrit gred 30((f_{ck} = 30 N/mm^2), tetulang H12 (f_{yk} = 500 kN/m^2) dan penutup konkrit nominal adalah 45 mm.*

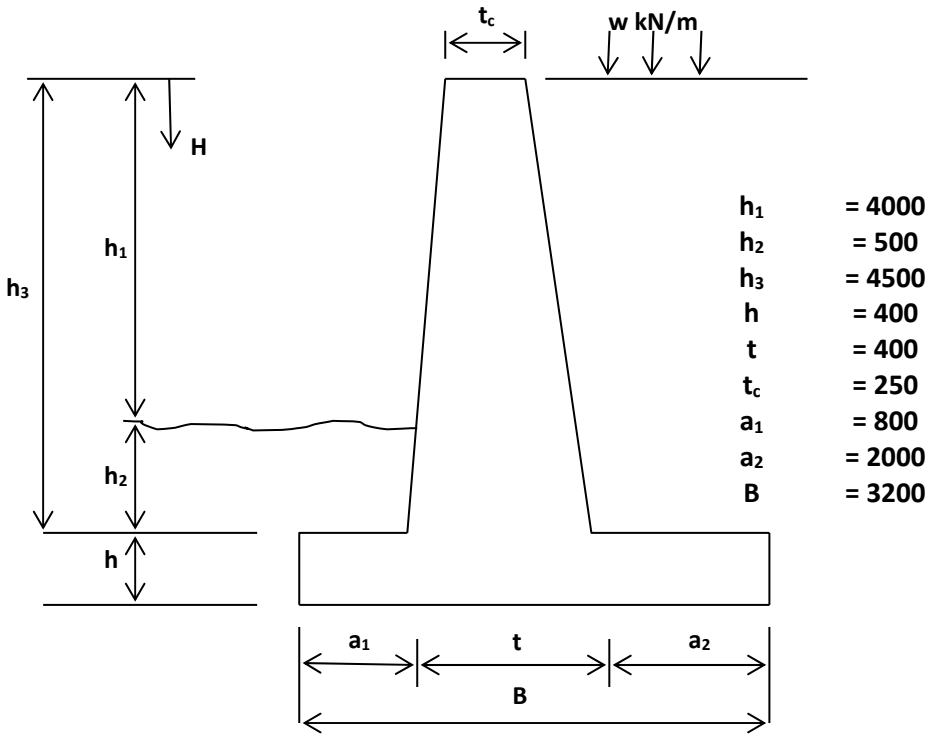

Figure 5: (all dimensions in mm)/*Rajah 5: (semua ukuran dalam mm)*

[25 marks/*markah*]

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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