First Semester Examination
2017/2018 Academic Session

January 2018

EAS153 – Civil Engineering Materials
(*Bahan Kejuruteraan Awam*)

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of FIFTEEN (15) pages of printed material including appendix before you begin the examination.

[Sila pastikan bahawa kertas peperiksaan ini mengandungi LIMA BELAS (15) muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]

Instructions: *This paper contains* ***SEVEN (7)*** *questions. Answer* ***FIVE (5)*** *questions.*

[Arahan: *Kertas ini mengandungi* ***TUJUH (7)*** *soalan. Jawab* ***LIMA (5)*** *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 suitable cement is required for concreting massive foundations of a high rise building.

Satu simen yang sesuai diperlukan untuk mengkonkrit asas yang besar bagi sebuah bangunan tinggi.

(i). With justification, explain **TWO (2)** most desirable characteristics that the cement should have.

*Dengan justifikasi, terangkan **DUA (2)** ciri yang sangat diperlukan yang perlu ada pada simen berkenaan.*

(ii). Identify if the type of cement with oxide compositions given in **Table 1** suits the intended application. Use the given Bogue's equation.

*Kenal pasti jika simen dengan komposisi oksida di **Jadual 1** sesuai untuk aplikasi yang dicadangkan.*

[12 marks/*markah*]

Table 1: Oxide compositions of cement
***Jadual 1:** Komposisi oksida simen*

Oxide/ *Oksida*	**Content/ *Kandungan* (%)**
CaO	63.5
SiO_2	25.0
Al_2O_3	4.0
Fe_2O_3	4.3
MgO	0.5
Alkalis	0.5
SO_3	1.0
Insoluble residue/ *Sisa tidak terlarut*	0.4
Loss on ignition/ *Kehilangan semasa penyalaan*	0.3
Others/*Lain-lain*	0.5

Bogue's Equations/ *Rumus Bogue*

$C_3S = 4.07(CaO) – 7.60(SiO_2) – 6.72(Al_2O_3) – 1.43(Fe_2O_3) – 2.85(SO_3)$
$C_2S = 2.87(SiO_2) – 0.754(3CaO.SiO_2)$
$C_3A = 2.65(Al_2O_3) – 1.69(Fe_2O_3)$
$C_4AF = 3.04(Fe_2O_3)$

(b). A big precast concrete producer requires a suitable cement to enable quicker turnaround of formwork in order to increase rate of production of its precast concrete components.

Sebuah pengeluar konkrit pra-tuang yang besar memerlukan simen yang sesuai untuk membolehkan acuan dibuka dan digunakan semula dengan cepat bagi meningkatkan kadar pengeluaran komponen konkrit pra-tuangnya.

(i). Describe the most desirable characteristic of the cement to be used by the precast industry mentioned above.

Perihalkan ciri yang paling diperlukan yang perlu ada pada simen yang akan digunakan oleh kilang konkrit pra-tuang untuk tujuan yang dinyatakan di atas.

(ii). Explain **TWO (2)** strategies that can be employed in the production of cement to achieve the desirable characteristic in 1(b)(i).

*Terangkan **DUA (2)** strategi yang boleh digunakan dalam penghasilan simen untuk mencapai ciri yang diperlukan dalam 1(b)(i).*

[8 marks/*markah*]

2. (a). The construction of a two-storey reinforced concrete community center has been proposed in a remote area of Lahat Datu, Sabah where domestic water supply is not available. Nonetheless, there is a natural pond not far from the proposed location where the water could be used as concrete mixing water. A limited test has been performed to ascertain the suitability of the pond water as concrete mixing water. The results of the test are given in **Table 2**. Justify if the pond water is suitable to be used as concrete mixing water based on the limited test results.

*Pembinaan sebuah pusat komuniti dua tingkat daripada konkrit bertetulang telah dicadangkan di satu kawasan terpencil di Lahat Datu, Sabah di mana tiada sumber air domestik. Namun begitu, terdapat tasik semula jadi tidak jauh dari kawasan yang dicadangkan yang mana airnya boleh digunakan sebagai air bancuhan konkrit. Satu ujian terhad telah dijalankan untuk memastikan kesesuaian air tasik berkenaan sebagai air bancuhan konkrit. Keputusan ujian diberikan di **Jadual 2**. Berikan justifikasi sekiranya air tasik berkenaan boleh digunakan sebagai air bancuhan konkrit berdasarkan keputusan ujian.*

[4 marks/*markah*]

Table 2: Test for Suitability of Water as Concrete Mixing Water
Jadual 2: *Ujian untuk Kesesuaian Air Sebagai Air Bancuhan Konkrit*

Source of Water / *Sumber Air*	Initial Setting Time of Cement Paste/ *Masa Pemejalan Awal Adunan Simen* (min)	Final Setting Time of Cement Paste/ *Masa Pemejalan Akhir Adunan Simen* (min)	28-day Compressive Strength of Mortar/ *Kekuatan Mampatan 28-hari Mortar* (MPa)
Distilled Water / *Air Suling*	80	480	30
Pond Water / *Air Tasik*	105	840	21

(b). The gradation of samples of sand from two different sources is shown in **Table 3** in term of the mass retained on each sieve used. Determine the fineness modulus for both sand samples. Based on the fineness modulus values, explain which sand will require greater water content when used in concrete, assuming the quantity and characteristics of other materials to be used being the same.

Penggredan sampel pasir daripada dua sumber ditunjukkan dalam ***Jadual 3*** *dalam bentuk jisim tertahan dalam setiap ayak. Tentukan modulus kehalusan untuk kedua-dua sampel pasir. Berdasarkan nilai modulus kehalusan, terangkan pasir yang mana akan memerlukan kandungan air yang lebih besar apabila digunakan di dalam konkrit, dengan menganggapkan kuantiti dan ciri-ciri bahan yang lain yang digunakan adalah sama.*

[10 marks/*markah*]

Table 3: Gradation of Sand from Different Sources
Jadual 3: *Penggredan Pasir daripada Sumber yang Berbeza*

Sieve Size / *Saiz Ayak*	Mass Retained/*Jisim Tertahan (gram)*	
	Source/*Sumber A*	Source/*Sumber B*
10 mm	0	0
5 mm	0	10
2.36 mm	2.5	150
1.18 mm	7.5	117
600 µm	20.7	60.7
300 µm	260.2	140.2
150 µm	200.2	20.2
Pan	8.9	1.9
Total	500	500

(c). The mixture proportions of two concrete mixes are given in compressive **Table 4**. Explain the expected differences in workability and 3-day strength between the two concrete mixes.

*Nisbah campuran dua bancuhan konkrit diberikan dalam **Jadual 4**. Terangkan perbezaan yang dijangkakan untuk kebolehkerjaan dan kekuatan mampatan 3-hari di antara kedua-dua campuran konkrit.*

[6 marks/*markah*]

Table 4: Mixture Proportions of Concrete (kg/m^3)
***Jadual 4:** Nisbah Campuran Konkrit (kg/m^3)*

Concrete Mix / *Campuran Konkrit*	Cement I/ *Simen I*	Pulverised Fuel Ash/ *Abu Terbang*	Water/ *Air*	Sand/ *Pasir*	Granite/ *Granit*
Mix A/ *Campuran A*	360	-	205	700	1135
Mix B/ *Campuran B*	215	145	205	700	1135

3. You are required to propose concrete mixture proportions for the construction of 4 storey commercial and office building in Parit Buntar.

Using your vast knowledge and experience in concrete mix design, the guideline on “Design of Normal Concrete Mixes” (BRE Report, 1988 given in the appendix) and based on the given data, determine the quantity of materials for a trial mix of 0.04 m^3. **Include the appendix used with your answer script.**

Anda perlu mencadangkan nisbah campuran konkrit untuk pembinaan bangunan komersial dan pejabat 4 tingkat di Parit Buntar.

*Menggunakan pengetahuan luas dan pengalaman anda dalam mereka bentuk campuran konkrit, panduan “Design of Normal Concrete Mixes” (BRE Report, 1988 diberikan sebagai lampiran) dan berdasarkan data yang diberikan, tentukan kandungan bahan-bahan untuk campuran cubaan 0.04 m^3. **Sertakan lampiran yang digunakan bersama skrip jawapan anda.***

Characteristic strength: 40 MPa
Kekuatan ciri: 40 MPa

Specified margin: 5 MPa
Margin yang ditetapkan: 5 MPa

Cement type: Cement I
Jenis Simen: Simen I

Aggregates: Granite with moisture content of 1.0 %; and river sand with moisture content of 0.8 %
Agregat: Granit dengan kandungan lembapan 1.0 %; pasir sungai dengan kandungan lembapan 0.8 %

Maximum allowable water/cement ratio: 0.55
Nisbah air/simen maksimum dibenarkan: 0.55

Slump: 150 mm
Penurunan: 150 mm

Maximum allowable aggregate size: 20 mm
Saiz agregat maksimum dibenarkan: 20 mm

Relative density of aggregate: 2.70
Ketumpatan relatif agregat: 2.70

Percentage passing 600 μm sieve: 60 %
Peratusan melepasi ayak 600 μm: 60 %

[20 marks/*markah*]

4. (a). Give the definition of workability and explain its importance.

Berikan definisi kebolehkerjaan dan terangkan kepentingannya.

[5 marks/*markah*]

(b). The workability of two high strength concrete mixes *A* and *B* has been evaluated using the slump and compacting factor tests. The mixture proportions together with the slump and compacting factor values are given in **Table 5.** Referring to the principle of the tests and based on the slump and compacting factor values, justify that one concrete mix has higher workability than the other one. Discuss the influence of silica fume on the water demand and the workability of the concrete.

*Kebolehkerjaan dua campuran konkrit berkekuatan tinggi A dan B telah dinilai menggunakan ujian penurunan dan faktor pemadatan. Nisbah campuran bersama dengan nilai penurunan dan faktor pemadatan diberikan di **Jadual 5**. Merujuk kepada prinsip kedua-dua ujian dan berdasarkan nilai penurunan dan faktor pemadatan, berikan justifikasi bahawa satu daripada campuran konkrit mempunyai kebolehkerjaan yang lebih tinggi daripada satu lagi campuran. Bincangkan pengaruh wasap silika terhadap keperluan air dan kebolehkerjaan konkrit.*

[12 marks/*markah*]

Table 5: Concrete Mixture Proportions and Workability of High Strength Concrete
Jadual 5: *Nisbah Campuran dan Kebolehkerjaan Konkrit Berkekuatan Tinggi*

Concrete Mix/ *Campuran Konkrit*	Portland Cement /*Simen Portland* (kg/m^3)	Silica Fume / *Wasap Silika* (kg/m^3)	Sand / *Pasir* (kg/m^3)	Granite /*Granit* (kg/m^3)	Water / *Air* (kg/m^3)	SP /Super *Pemplastik* (kg/m^3)	Slump / *Kebolehkerjaan* (mm)	Compacting Factor/ *Faktor Pemadatan*
A	450	-	675	1125	126	12	150	0.95
B	382.5	67.5	675	1125	126	12	75	0.88

(c). If the workability of one of the concrete mixes in (b) is not sufficient for effective placing and compaction, what could be done to further improve the workability?

Jika kebolehkerjaan campuran konkrit di (b) adalah tidak mencukupi untuk peletakan dan pemadatan yang efisien, apakah yang boleh dilakukan untuk meningkatkan lagi kebolehkerjaan?

[3 marks/*markah*]

5. (a). Discuss how water/binder ratio and mineral admixture could influence the strength and durability performance of concrete.

Bincangkan bagaimana nisbah air/simen dan bahan tambah mineral boleh mempengaruhi kekuatan dan prestasi ketahanlasakan konkrit.

[10 marks/*markah*]

(b). Explain the reversibility of elasticity, creep and shrinkage using suitable deformation-time curves.

Terangkan keboleh-balikan keanjalan, rayapan dan pengecutan konkrit menggunakan lengkung ubah bentuk-masa yang sesuai.

[10 marks/*markah*]

6. Steel is a versatile and sustainable material. In construction, steel is usually used as a reinforcement in concrete structure. There are two common types of steel used which are mild steel (usually non-ridges) and high tensile steel (ridges).

Keluli merupakan bahan versatil dan lestari. Dalam pembinaan, keluli biasanya digunakan sebagai tetulang dalam struktur konkrit. Terdapat dua jenis keluli yang biasa digunakan iaitu keluli lembut (biasanya tidak berbunga) dan keluli tegangan tinggi (berbunga).

(a). Explain the differences between mild steel and high tensile steel.

Terangkan perbezaan diantara keluli lembut dengan keluli tegangan tinggi.

[4 marks/*markah*]

(b). The reinforcing steel bar used in concrete structures have 'ridges' and 'non-ridges'. Explain the function and its application in construction industry. With the aid of sketches, show the ridges and non-ridges steel bar.

Tetulang keluli yang digunakan dalam struktur konkrit mempunyai bunga dan tidak berbunga. Terangkan fungsi dan kegunaannya dalam industri pembinaan. Dengan bantuan lakaran, tunjukkan keluli jenis berbunga dan tidak berbunga.

[6 marks/*markah*]

(c). **Table 6** shows the data of load and displacement from a testing conducted at the Structural Engineering Laboratory, School of Civil Engineering, USM. Plot a graph and include all the phases of elastic and plastic regions. Determine the yield stress and the ultimate stress. The area of steel is 75.81 mm^2. Justify either this is a mild steel or a high tensile steel.

Jadual 6 *menunjukkan data beban dan anjakan daripada ujian yang dijalankan di Makmal Kejuruteraan Stuktur, Pusat Pengajian Kejuruteraan Awam, USM. Plotkan graf dan tunjukkan semua fasa kawasan elastik dan plastik. Tentukan tegasan alahan dan tegasan muktamad. Saiz keluli adalah 75.81 mm^2. Justifikasikan sama ada keluli ini merupakan keluli lembut atau keluli tegangan tinggi.*

Table 6/*Jadual 6*

	Load/ *Beban* (kN)	Displacement/ *Anjakan* (mm)
1	0.0000	0.0000
2	10.0018	1.9053
3	30.0042	5.2585
4	40.0706	6.9787
5	41.4015	7.5120
6	40.4168	7.8338
7	40.5825	8.5185
8	41.3448	27.6783
9	44.6637	40.0574
10	45.3930	52.0900
11	31.0027	58.1634

[10 marks/*markah*]

7. Fired clay brick is a building material used as a partition wall between two units of terrace houses. The process of making fired clay brick starts from mining until storage and shipping to customer.

Bata tanah liat bakar merupakan bahan binaan yang digunakan sebagai dinding sekatan diantara dua unit rumah teres. Proses pembuatan bata tanah liat bakar bermula dari perlombongan sehingga penyimpanan dan penghantaran kepada pengguna.

(a). Describe using suitable flowchart the manufacturing process of making fired clay brick.

Terangkan menggunakan carta alir yang sesuai proses pembuatan bata tanah liat bakar.

[8 marks/*markah*]

(b). Justify any **THREE (3)** of the processes of making fired clay brick which influence the quality of the brick.

*Justifikasikan mana-mana **TIGA (3)** proses pembuatan bata tanah liat bakar yang mempengaruhi kualiti bata.*

[9 marks/*markah*]

(c). If the screening process of raw material had been removed from the manufacturing process, explain its effects to the quality of the brick produced.

Jika proses penyaringan bahan mentah dikeluarkan daripada proses pembuatan bata, terangkan kesan-kesannya terhadap kualiti bata yang dihasilkan.

[3 marks/*markah*]

APPENDIX 1/*LAMPIRAN 1*

DOE CONCRETE MIX DESIGN FORM / BORANG REKABENTUK CAMPURAN DOE

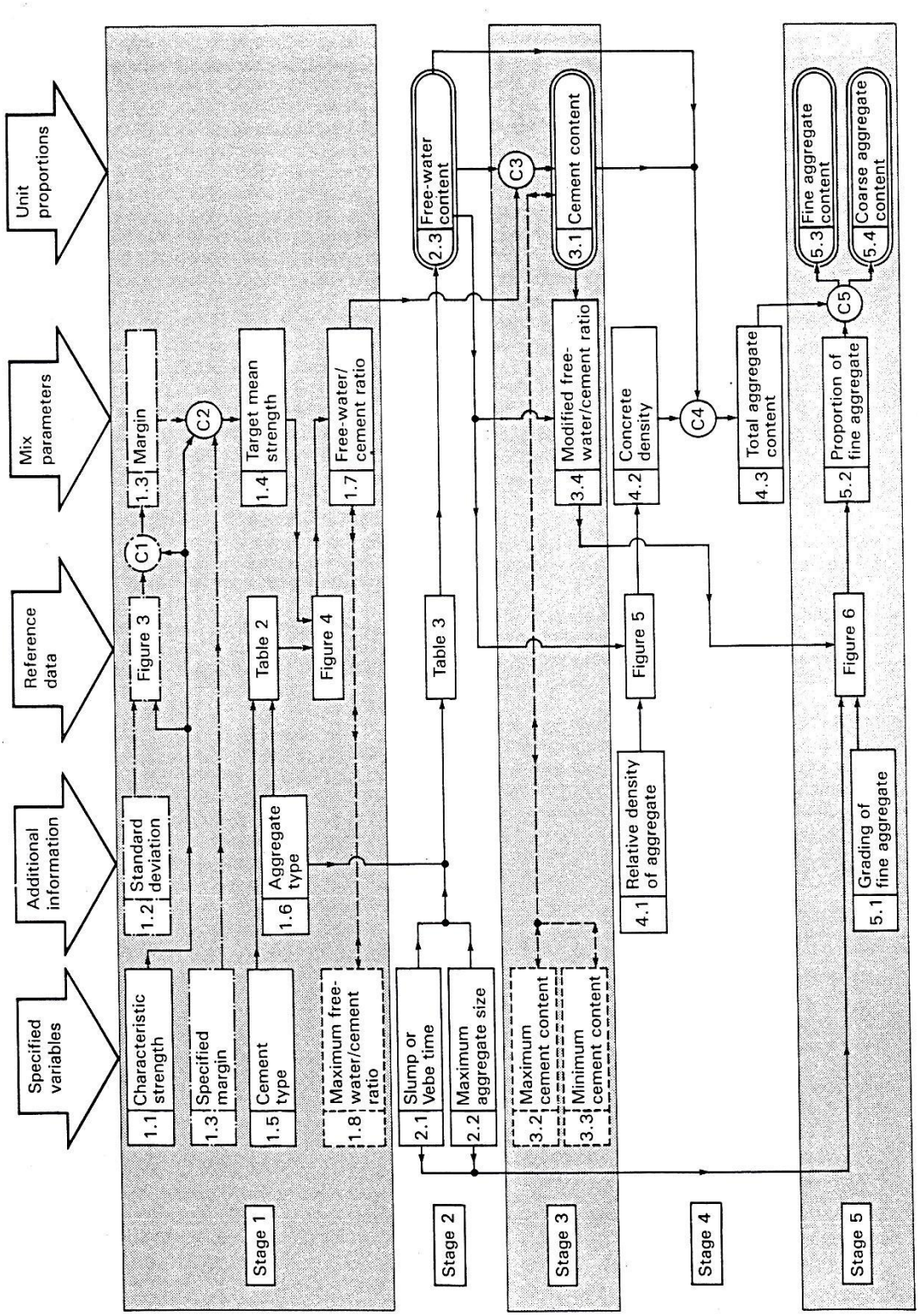

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

ANGKA GILIRAN:_____

Concrete mix design form

Job title .....

Stage	Item		Reference or calculation	Values
1	1.1	Characteristic strength	Specified	_____ N/mm² at _____ days Proportion defective _____ %
	1.2	Standard deviation	Fig 3	_____ N/mm² or no data _____ N/mm²
	1.3	Margin	C1 or Specified	(k = _____) _____ × _____ = _____ N/mm² _____ N/mm²
	1.4	Target mean strength	C2	_____ + _____ = _____ N/mm²
	1.5	Cement type	Specified	OPC/SRPC/RHPC
	1.6	Aggregate type: coarse Aggregate type: fine		Crushed/uncrushed Crushed/uncrushed
	1.7	Free-water/cement ratio	Table 2, Fig 4	_____
	1.8	*Maximum free-water/cement ratio*	*Specified*	_____ Use the lower value [ ]
2	2.1	Slump or Vebe time	Specified	Slump _____ mm or Vebe time _____ s
	2.2	Maximum aggregate size	Specified	_____ mm
	2.3	Free-water content	Table 3	_____ [ ] kg/m³
3	3.1	Cement content	C3	_____ ÷ _____ = _____ kg/m³
	3.2	*Maximum cement content*	*Specified*	_____ kg/m³
	3.3	*Minimum cement content*	*Specified*	_____ kg/m³
				use 3.1 if ⩽ 3.2 use 3.3 if > 3.1 [ ] kg/m³
	3.4	Modified free-water/cement ratio		_____ [ ]
4	4.1	Relative density of aggregate (SSD)		_____ known/assumed
	4.2	Concrete density	Fig 5	_____ kg/m³
	4.3	Total aggregate content	C4	_____ − _____ − _____ = _____ kg/m³
5	5.1	Grading of fine aggregate	Percentage passing 600 μm sieve	_____ %
	5.2	Proportion of fine aggregate	Fig 6	_____ %
	5.3	Fine aggregate content	C5	_____ × _____ = [ ] kg/m³
	5.4	Coarse aggregate content	C5	_____ − _____ = [ ] kg/m³

Quantities	Cement (kg)	Water (kg or *L*)	Fine aggregate (kg)	Coarse aggregate (kg) 10 mm	20 mm	40 mm
per m³ (to nearest 5 kg)						
per trial mix of _____ m³						

Items in italics are optional limiting values that may be specified (see Section 7)

1 N/mm² = 1 MN/m² = 1 MPa (see footnote to Section 3).
OPC = ordinary Portland cement; SRPC = sulphate-resisting Portland cement; RHPC = rapid-hardening Portland cement.
Relative density = specific gravity (see footnote to Para 5.4). SSD = based on a saturated surface-dry basis.

Table 2 Approximate compressive strengths (N/mm²) of concrete mixes made with a free-water/cement ratio of 0.5

Type of cement	Type of coarse aggregate	Compressive strengths (N/mm²) Age (days) 3	7	28	91
Ordinary Portland (OPC) or sulphate-resisting Portland (SRPC)	Uncrushed	22	30	42	49
	Crushed	27	36	49	56
Rapid-hardening Portland (RHPC)	Uncrushed	29	37	48	54
	Crushed	34	43	55	61

1 N/mm² = 1 MN/m² = 1 MPa (see footnote on earlier page).

Table 3 Approximate free-water contents (kg/m³) required to give various levels of workability

Slump (mm) / Vebe time(s)		0-10 >12	10-30 6-12	30-60 3-6	60-180 0-3
Maximum size aggregate (mm)	Type of aggregate				
10	Uncrushed	150	180	205	225
	Crushed	180	205	230	250
20	Uncrushed	135	160	180	195
	Crushed	170	190	210	225
40	Uncrushed	115	140	160	175
	Crushed	155	175	190	205

Note: When coarse and fine aggregates of different types are used, the free-water content is estimated by the expression

$$\frac{2}{3}W_f + \frac{1}{3}W_c$$

where W_f = free-water content appropriate to type of fine aggregate
and W_c = free-water content appropriate to type of coarse aggregate.

5.3 Determination of cement content (Stage 3)

The cement content is determined from calculation C3:

$$\text{Cement content} = \frac{\text{free-water content}}{\text{free-water/cement ratio}} \quad \ldots C3$$

The resulting value should be checked against any maximum or minimum value that may be specified. If the calculated cement content from C3 is below a specified minimum, this minimum value must be adopted and a modified free-water/cement ratio calculated which will be less than that determined in Stage 1. This will result in a concrete that has a mean strength somewhat higher than the target mean strength. Alternatively, the free-water/cement ratio from Stage 1 is used resulting in a higher free-water content and increased workability.

On the other hand, if the design method indicates a cement content that is higher than a specified maximum then it is probable that the specification cannot be met simultaneously on strength and workability requirements with the selected materials. Consideration should then be given to changing the type of cement, the type and maximum size of aggregate or the level of workability of the concrete, or to the use of a water reducing admixture.

5.4 Determination of total aggregate content (Stage 4)

Stage 4 requires an estimate of the density of the fully compacted concrete which is obtained from Figure 5 depending upon the free-water content and the relative density* of the combined aggregate in the saturated surface-dry condition (SSD). If no information is available regarding the relative density of the aggregate an approximation can be made by assuming a value of 2.6 for uncrushed aggregate and 2.7 for crushed aggregate. From this estimated density of the concrete the total aggregate content is determined from calculation C4:

$$\text{Total aggregate content (saturated and surface-dry)} = D - C - W \quad \ldots C4$$

where D = the wet density of concrete (kg/m³)
C = the cement content (kg/m³)
W = the free-water content (kg/m³).

*The internationally known term 'relative density' used in this publication is synonymous with 'specific gravity' and is the ratio of the mass of a given volume of substance to the mass of an equal volume of water.

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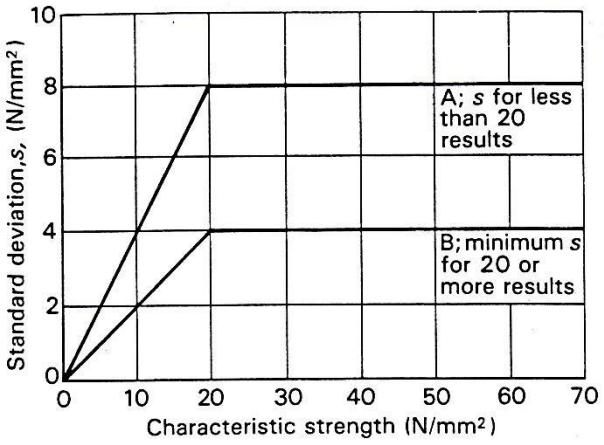

Figure 3 Relationship between standard deviation and characteristic strength

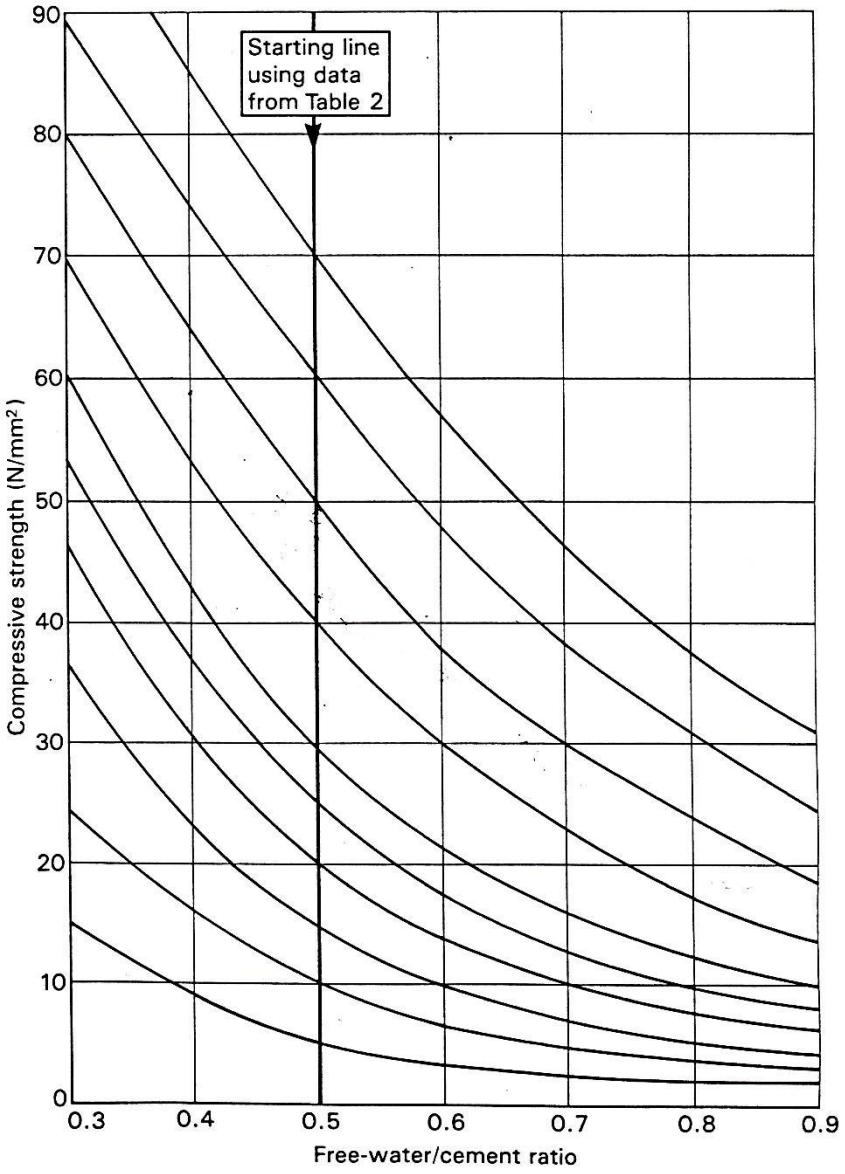

Figure 4 Relationship between compressive strength and free-water/cement ratio

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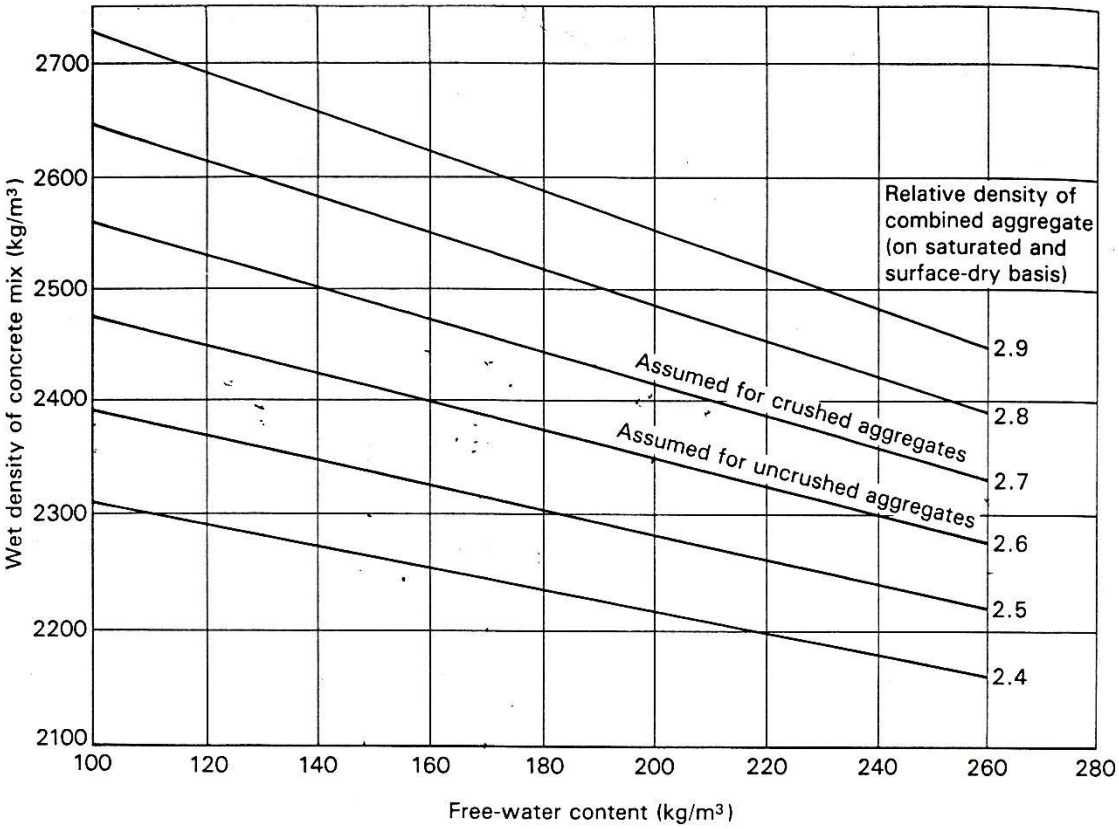

Figure 5 Estimated wet density of fully compacted concrete

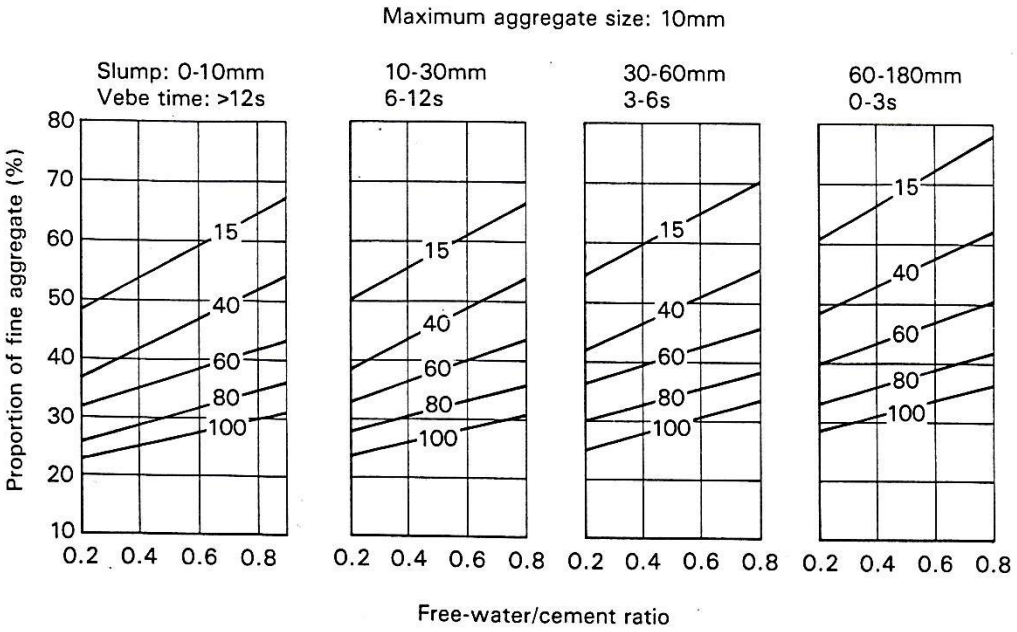

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

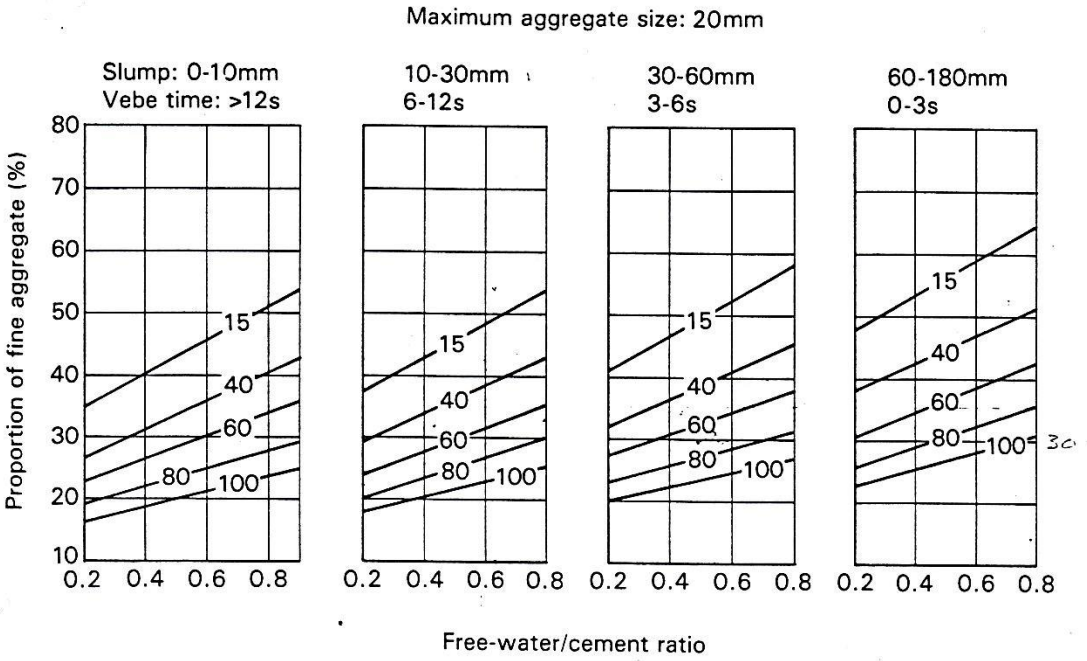

Figure 6 *(continued)*

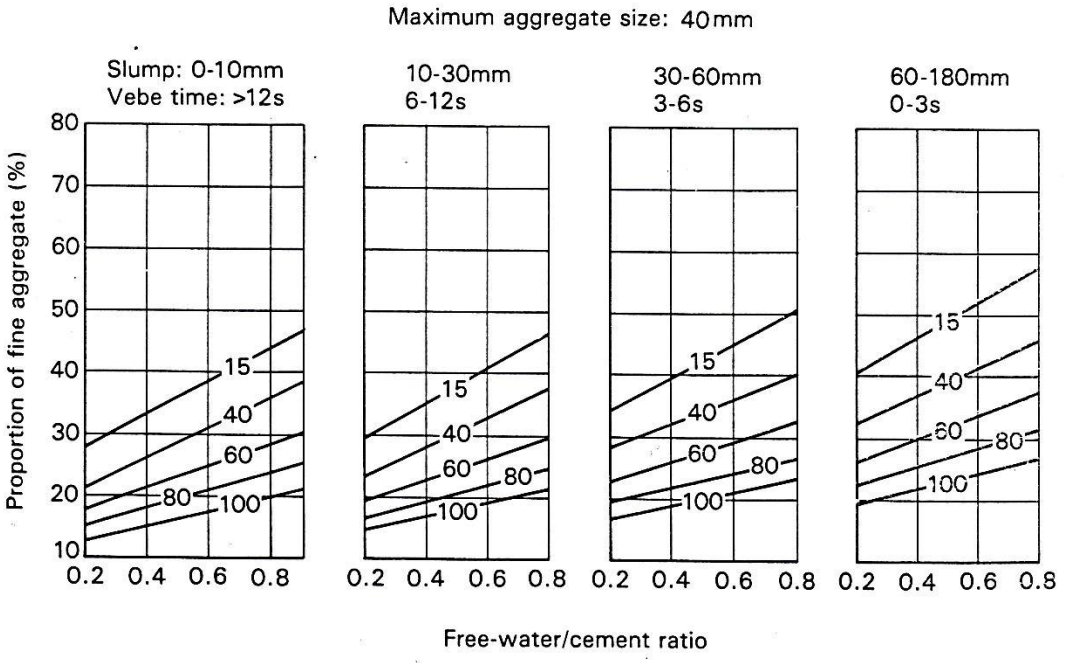

Figure 6 *(continued)*

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