First Semester Examination
Academic Session 2018/2019

December 2018/January 2019

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

Duration : 3 hours
(Masa : 3 jam)

Please check that this examination paper consists of **SIXTEEN (16)** pages of printed material including appendix before you begin the examination.

*[Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM BELAS (16)** muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: *This paper contains **SIX (6)** questions. Answer **FIVE (5)** questions.*

[Arahan: *Kertas ini mengandungi **ENAM (6)** 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.]

...2/-

(1). (a). State the four major compound compositions of Portland cement.

Nyatakan empat komposisi sebatian utama simen Portland.

[2 marks/*markah*]

(b). A leading cement producer has recently embarked on producing special cement for application in concrete repair. Justify the most important characteristic that the cement should have so that it can be effectively used in concrete repair application. Explain the strategies that could be employed by the cement producer to produce cement with the required characteristic.

Sebuah pengeluar simen utama telah baru-baru ini bermula mengeluarkan simen khas untuk aplikasi di dalam pembaikan konkrit. Wajarkan ciri utama yang perlu ada pada simen yang dihasilkan supaya ia boleh digunakan secara efektif di dalam aplikasi pembaikan konkrit. Terangkan strategi-strategi yang boleh digunapakai oleh pengeluar simen untuk menghasilkan simen dengan ciri yang diperlukan.

[6 marks/*markah*]

(c). If the oxide compositions of the Portland cement produced by the cement producer in **(b)** are as given in **Table 1**, discuss the probable strength development and heat evolution characteristics of the cement. Comment on the suitability of the cement for concrete repair application.

Sekiranya komposisi oksida simen Portland yang dihasilkan oleh pengeluar simen di ***(b)*** *adalah seperti yang diberikan di dalam* ***Jadual 1****, bincangkan kemungkinan ciri pembentukan kekuatan dan pembebasan haba simen berkenaan. Komen kesesuaian simen tersebut untuk aplikasi pembaikan konkrit.*

[12 marks/*markah*]

Table 1: Oxide compositions of a Portland cement
Jadual 1: Komposisi oksida simen Portland

Oxide Compositions, (%)	
CaO	63
SiO_2	25.5
Al_2O_3	4.0
Fe_2O_3	4.3
MgO	0.5
SO_3	1
K_2O, Na_2O}	0.5
Insoluble residue	0.4
Loss on ignition	0.8
Others	0.5

$$C_3S = 4.07(CaO) – 7.60(SiO_2) – 6.72(Al_2O_3) – 1.43(Fe_2O_3) – 2.85(SO_3)$$

$$C_2S = 2.87(SiO_2) – 0.754(3CaO.SiO_2)$$

$$C_3A = 2.65(Al_2O_3) – 1.69(Fe_2O_3)$$

$$C_4AF = 3.04(Fe_2O_3)$$

(2). (a). Explain how the quantity of mixing water could affect the strength and durability performance of concrete.

Terangkan bagaimana kuantiti air bancuhan boleh memberi kesan terhadap kekuatan dan prestasi ketahanlasakan konkrit.

[5 marks/*markah*]

(b). Discuss the importance of considering the actual moisture condition of aggregates in concrete mix design.

Bincangkan kepentingan untuk mengambil kira keadaan lembapan sebenar bagi agregat di dalam rekabentuk campuran konkrit.

[5 marks/*markah*]

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(c). **Table 2** gives the grading of two samples of sand in term of weight retained on the relevant sieves. Determine the fineness modulus for each sand sample. Compare which sand will require greater water content when used in concrete to achieve comparable workability, assuming the quantity and characteristics of other materials used being the same.

***Table 2** gives the grading of two samples of sand in term of weight retained on the relevant sieves. Determine the fineness modulus for each sand sample. Compare which sand will require greater water content when used in concrete to achieve comparable workability, assuming the quantity and characteristics of other materials used being the same.*

Table 2: Grading of Sand
Jadual 2: Penggredan Pasir

Sieve Size	Weight Retained (g)	
	Sand A	Sand B
10 mm	0	0
5 mm	0	0
2.36 mm	75.5	0
1.18 mm	139	3.6
600 µm	113.6	12.1
300 µm	74.9	260.1
150 µm	48.9	174.3
Pan	8.1	9.9
Total		

[10 marks/*markah*]

(3). You are required to propose concrete mixture proportions for the construction of two blocks of four storey school buildings in Nibong Tebal.

Anda perlu mencadangkan nisbah campuran konkrit untuk pembinaan dua blok bangunan sekolah empat tingkat di Nibong Tebal.

Using your vast knowledge and experience in concrete mix design, the guideline on “Design of Normal Concrete Mixes” (BRE Report, 1988 given in the attachment) and based on the data given below, determine the quantity of materials for a trial mix of 0.050 m^3. **Include the attachment used with your answer script.**

Menggunakan pengetahuan luas dan pengalaman anda dalam mereka bentuk campuran konkrit, menggunakan panduan “Design of Normal Concrete Mixes” (BRE Report, 1988 diberikan sebagai lampiran) dan berdasarkan data yang diberikan, tentukan kandungan bahan-bahan untuk campuran cubaan 0.050 m^3. ***Sertakan lampiran yang digunakan bersama skrip jawapan anda.***

Characteristic strength: 30 MPa
Kekuatan ciri: 30 MPa

Specified margin: 5 MPa
Margin yang ditetapkan: 5 MPa

Cement type: Ordinary Portland Cement
Jenis Simen: Simen Portland Biasa

Aggregates: Granite with moisture content of 0.8 %; and river sand with moisture content of 1.0 %

Agregat: Granit dengan kandungan lembapan 0.8 %; pasir sungai dengan kandungan lembapan 1.0 %

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

Slump: 100 mm
Penurunan: 100 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 describe its importance.

Berikan definasi kebolehkerjaan dan dan jelaskan kepentingannya.

[4 marks/*markah*]

(b). Select the most suitable combination of values of slump, compacting factor, vebe time and flow table to portray the effect of fly ash inclusion on the workability of the high strength concrete mix given in **Table 3**. Justify the answer that you select by referring to each test method. Discuss the characteristics of the fly ash which contribute towards the marked differences in the workability of the concrete mixes.

Pilih kombinasi nilai kebolehkerjaan yang paling sesuai berdasarkan nilai penurunan, faktor pemadatan, masa Vebe dan meja aliran untuk memaparkan kesan penggunaan abu terbang terhadap kebolehkerjaan campuran konkrit berkekuatan tinggi yang diberikan di dalam ***Jadual 3****. Berikan justifikasi untuk jawapan yang anda pilih dengan merujuk kepada setiap kaedah pengujian. Bincangkan ciri-ciri abu terbang yang menyumbang terhadap perbezaan yang jelas terhadap kebolehkerjaan kedua-dua campuran konkrit.*

[16 marks/*markah*]

Table 3: Concrete Mixture Proportions of High Strength Concrete
Jadual 3: Nisbah Campuran Konkrit Berkekuatan Tinggi

Concrete Mix	Portland Cement (kg/m^3)	Fly Ash (kg/m^3)	Sand (kg/m^3)	Granite (kg/m^3)	Water (kg/m^3)	SP (kg/m^3)
A	450	-	675	1125	126	12
B	315	135	675	1125	126	12

(i).

Concrete Mix	Slump (mm)	Compacting Factor	Vebe Time (sec)	Flow Table (mm)
A	100	0.90	5	600
B	150	0.99	10	650

(ii).

Concrete Mix	Slump (mm)	Compacting Factor	Vebe Time (sec)	Flow Table (mm)
A	100	0.95	10	550
B	220	0.99	5	650

(iii).

Concrete Mix	Slump (mm)	Compacting Factor	Vebe Time (sec)	Flow Table (mm)
A	100	0.95	10	550
B	150	0.99	15	600

(iv).

Concrete Mix	Slump (mm)	Compacting Factor	Vebe Time (sec)	Flow Table (mm)
A	100	0.95	10	600
B	75	0.85	5	550

(5). **Table 4** gives the profiles of two species of wood from strength groups of SG1 and SG5.

***Jadual 4** memberikan profil dua sepsis kayu daripada kumpulan kekuatan SG1 dan SG5.*

Table 4: Wood Profile
Jadual 4: Profil Kayu

Species	Botanical Name	Family	Density (kg/m^3)	Strength Group
Mengkulang	Heritiera	Sterculiaceae	625-895	SG5
Penaga	Mesua ferrea	Calophyllaceae	945-1185	SG1

(a). Explain the differences between SG1 and SG5 in term of its texture and air drying condition.

Terangkan perbezaan diantara SG1 dan SG5 dari aspek tekstur kayu dan kondisi pengeringan udara.

[6 marks/*markah*]

(b). Based on **Table 4**, explain the advantages of using wood from SG1 and SG5 in terms of construction method, aesthetics value and structure.

*Berdasarkan **Jadual 4**, terangkan kelebihan menggunakan kayu SG1 dan SG5 dari aspek kaedah pembinaan, nilai estatika dan struktur.*

[8 marks/*markah*]

(c). As an engineer, will you suggest Mengkulang timber to be used as a train railway sleeper. Give your justification.

Sebagai seorang jurutera, adakah anda akan mencadangkan penggunaan kayu Mengkulang sebagai pelapik landasan keretapi. Berikan jusfikasi anda.

[6 marks/*markah*]

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(6). The construction material that is being used as a partition wall between two houses either fired clay brick or concrete masonry unit, must be a fire-resistant material. The reason is to protect the neighboring houses from the potential spreading fire. In load bearing masonry system, there is a vertical steel reinforcement embedded inside the wall to resist horizontal load. However, during a the fire event, this steel reinforcement can yield and it will reduce the tensile strengh.

Bahan pembinaan yang digunakan sebagai dinding sekatan antara dua buah rumah sama ada bata tanah liat bakar atau bata konkrit, mestilah bahan yang tahan kalis api. Tujuannya adalah untuk melindungi rumah bersebelahan dari potensi penyebaran api. Dalam sistem pembinaan batu bata yang menanggung beban, terdapat tetulang besi yang dimasukkan ke dalam dinding untuk menahan beban melintang. Walaubagaimanapun, ketika kebakaran berlaku, tetulang besi boleh teralah dan ianya akan mengurangkan kekuatan tegangan.

(a). List **FIVE (5)** qualities that are needed from brick in construction of a partition wall other than fire resistance.

*Senaraikan **LIMA (5)** kualiti bahan binaan bata yang diperlukan dalam pembinaan dinding sekatan selain daripada ketahanan api*.

[5 marks/*markah*]

(b). In load bearing masonry system, give **FIVE (5)** important properties of the steel reinforcement use as construction material.

*Dalam sistem batu bata yang menanggung beban, berikan **LIMA (5)** ciri-ciri penting tetulang besi yang digunakan sebagai bahan pembinaan.*

[5 marks/*markah*]

(c). **Table 5** shows the data of applied force against elongation of a steel before and after fire event. Based on the given data, plot a graph and determine the yield stress and the ultimate stress of the steel. The area of steel before and after the firing event is 88.39 mm^2 and 70.33 mm^2, respectively. Give your opinion whether the steel after the firing event can still be used or not.

Jadual 5 *menunjukkan data daya yang dikenakan melawan pemanjangan daripada besi sebelum dan selepas kebakaran. Berdasarkan data yang diberikan, plotkan graf dan tentukan tegasan alahan dan tegasan muktamad. Keluasan besi sebelum dan selepas kebakaran adalah masing-masing 88.39 mm^2 dan 70.33 mm^2. Berikan pendapat anda sama ada besi ini masih boleh digunakan atau tidak*.

Table 5 : Force vs Elongation
Jadual 5: Daya vs *Pemanjangan*

	Before Fire		After Fire	
	Force *Daya* (kN)	Elongation *Pemanjangan* (mm)	Force *Daya* (kN)	Elongation *Pemanjangan* (mm)
1	0.0000	0.0000	0	0
2	10.0018	1.9053	8.0054	8.3520
3	30.0042	5.2585	20.6503	11.1251
4	40.0706	6.9787	22.7801	11.6670
5	41.4015	7.5120	21.3520	14.2367
6	40.4168	7.8338	20.2591	25.6572
7	40.5825	8.5185	25.5441	41.2547
8	41.3448	27.6783	26.3331	55.1985
9	44.6637	40.0574	15.2143	57.2152
10	45.3930	52.0900		
11	31.0027	58.1634		

[10 marks/*markah*]

APPENDIX 1/*LAMPIRAN 1*

DOE CONCRETE MIX DESIGN FORM / BORANG REKABENTUK CAMPURAN DOE

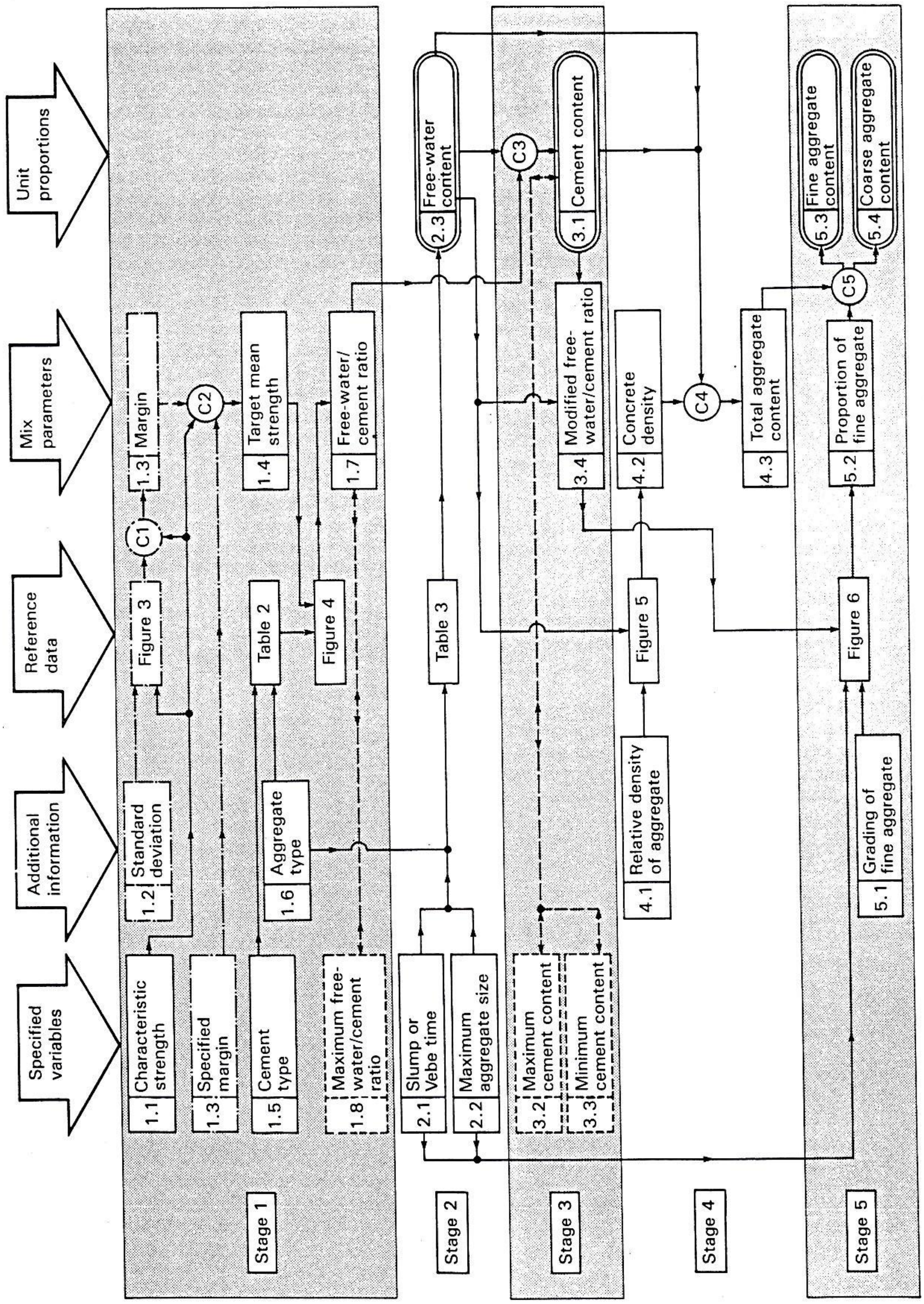

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

ANGKA GILIRAN/*INDEX NO*:____________

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	______ } Use the lower value [ ]
	1.8	*Maximum free-water/cement ratio*	*Specified*	______
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**

Maximum size aggregate (mm)	Type of aggregate	Slump (mm) 0-10 / Vebe time(s) >12	10-30 / 6-12	30-60 / 3-6	60-180 / 0-3
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

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

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:

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

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:

$$\text{Total aggregate content} = D - C - W \quad ...C4$$

(saturated and surface-dry)

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.

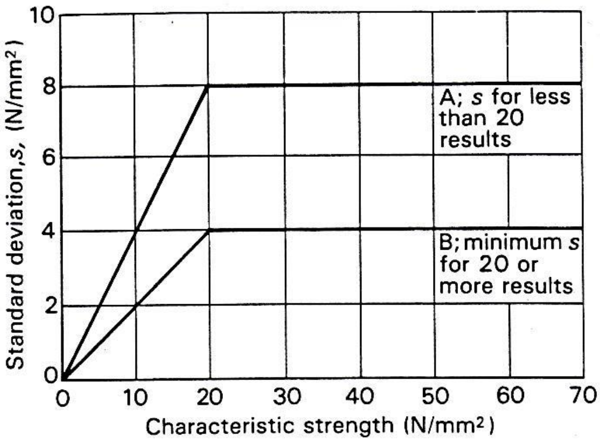

Figure 3 Relationship between standard deviation and characteristic strength

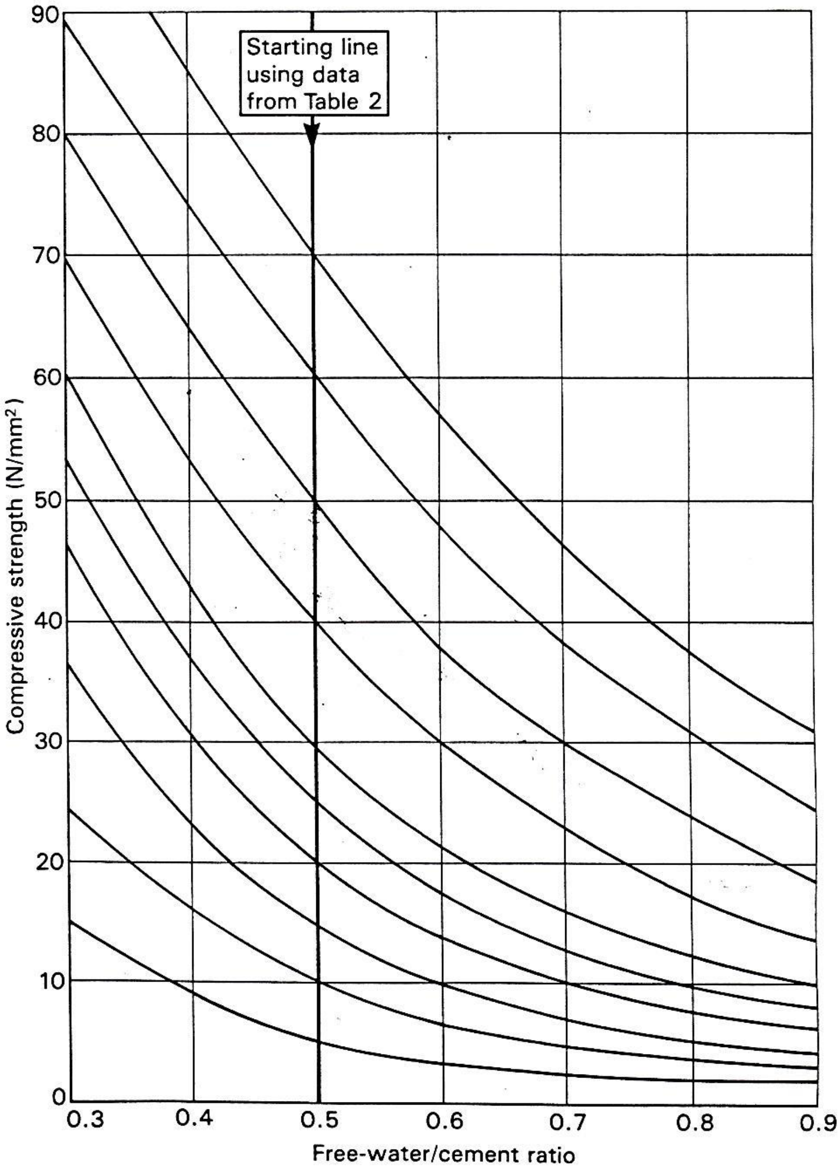

Figure 4 Relationship between compressive strength and free-water/cement ratio

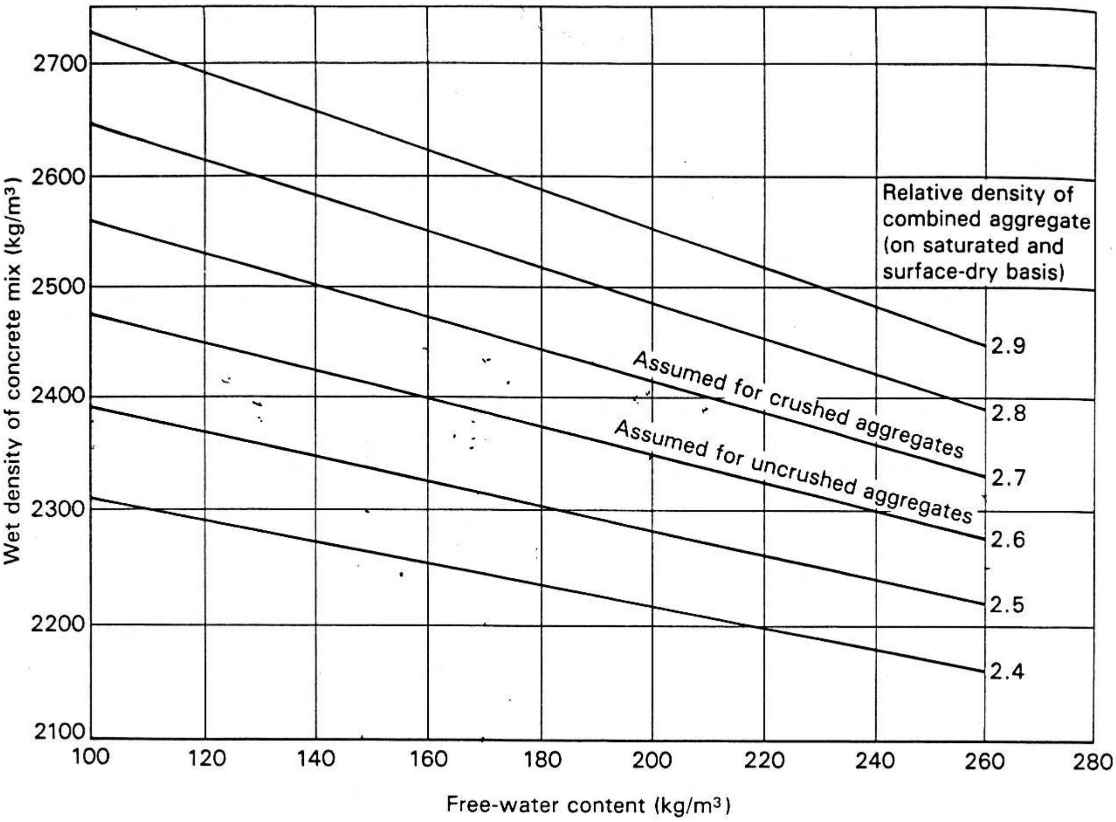

Figure 5 Estimated wet density of fully compacted concrete

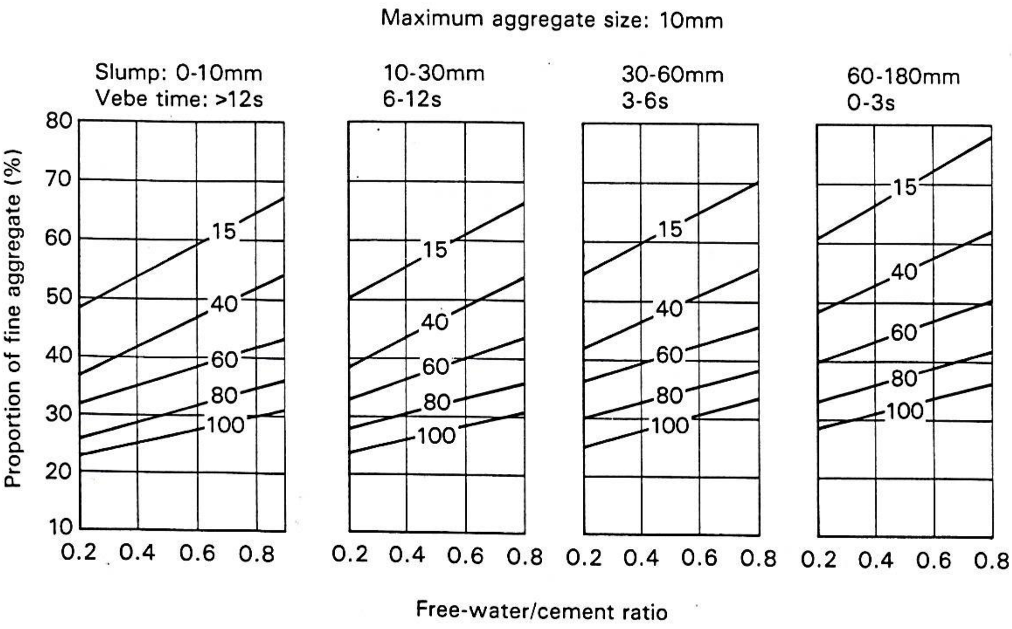

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

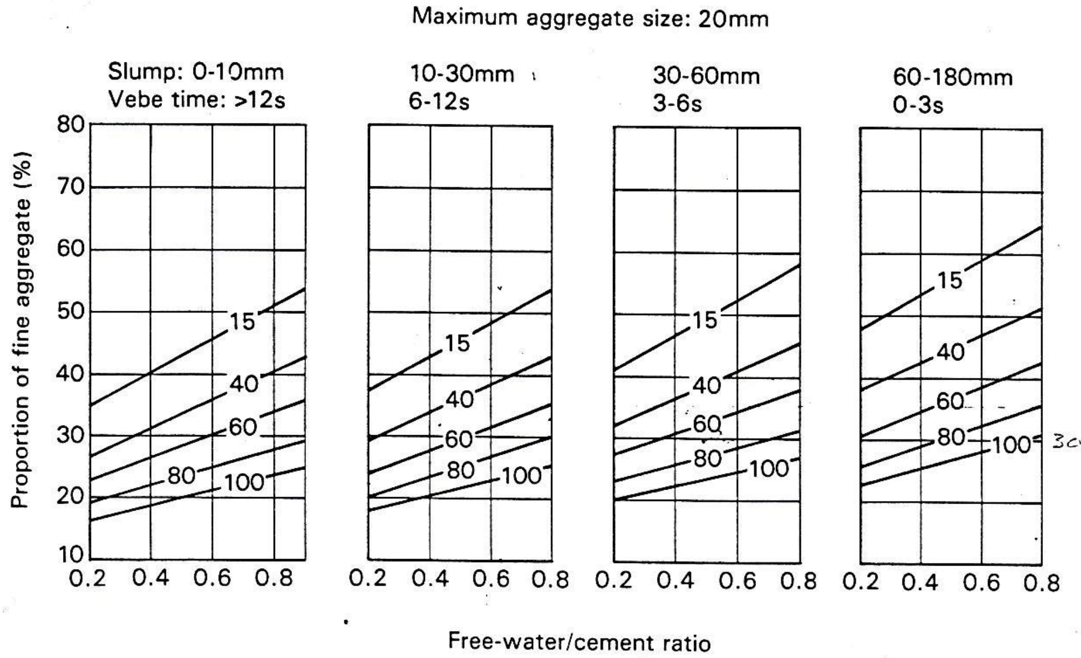

Figure 6 *(continued)*

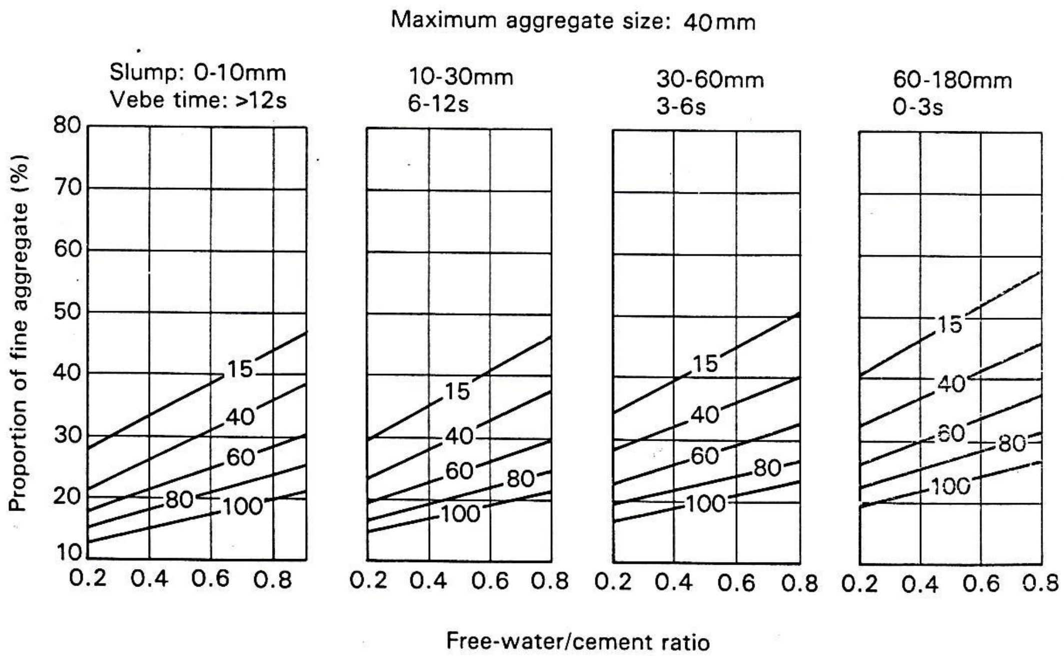

Figure 6 *(continued)*

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