UNIVERSITI SAINS MALAYSIA

First Semester Examination
2014/2015 Academic Session

December 2014/January 2015

EAS 153/3 – 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 **TWO (2) APPENDICES** before you begin the examination.

[*Sila pastikan bahawa kertas peperiksaan ini mengandungi* ***ENAM BELAS (16)*** *muka surat yang bercetak termasuk* ***DUA (2) LAMPIRAN*** *sebelum anda memulakan peperiksaan ini.*]

[Instructions: This paper contains ***SEVEN (7)*** questions. Answer ***FIVE (5)*** questions only.
[***Arahan****: Kertas ini mengandungi* ***TUJUH (7)*** *soalan. Jawab* ***LIMA (5)*** *soalan sahaja.*

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

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 new cement plant has just started its operation for a few months. In order to ensure the quality and consistency of the cements produced, the plant regularly carries out relevant tests and analyses on the cements. A sample of cement from the plant has been analyzed for oxide compositions as shown in **Table 1**.

Sebuah kilang simen baru saja memulakan operasi untuk beberapa bulan. Bagi memastikan kualiti dan konsistensi simen yang dihasilkan, kilang tersebut menjalankan ujian dan analisa berkala terhadap simen-simen keluarannya. Satu sampel simen daripada kilang berkenaan telah dianalisa untuk menentukan komposisi oksida seperti di ***Jadual 1****.*

Table 1: Oxide compositions of cement

Jadual 1: *Komposisi oksida simen*

Oxide	**Content (%)**
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	0.4
Loss on ignition	0.3
Others	0.5

(a) Using the oxide compositions, determine the major compound compositions of the cement.

Dengan menggunakan komposisi oksida, tentukan komposisi sebatian utama simen.

[4 marks/markah]

(b) Based on the major compound compositions obtained in (a), and assuming that the cement has similar specific surface area with that of ASTM Type I cement, discuss the probable strength development, heat evolution as well as sulphate resistance characteristics of the cement in comparison to ASTM Type I cement. Comment on the suitability of the analyzed cement for concrete repair application, in particular for the repair of a highway bridge.

Berdasarkan komposisi sebatian utama yang didapati di (a), dan dengan menganggapkan simen berkenaan mempunyai luas permukaan tentu yang sama dengan simen ASTM Jenis I, bincangkan kemungkinan ciri-ciri pembentukan kekuatan, pembebasan haba dan juga ketahanan sulfat simen berkenaan berbanding simen ASTM Jenis I. Komen kesesuaian simen yang dianalisa untuk aplikasi pembaikan konkrit, terutamanya untuk pembaikan jambatan lebuh raya.

[16 marks/markah]

2. Using the guideline on “Design of Normal Concrete Mixes” (BRE Report, 1988) and based on the data given below, determine the quantity of materials for a trial mix of 0.075 m^3. Use the attached mix design forms (Appendix B: pages 12-16) pages 11 and **include the attachment used with your answer script.**

*Menggunakan garis panduan mengenai "rekabentuk campuran untuk konkrit biasa" (BRE Report, 1988) dan berdasarkan data yang diberikan di bawah, tentukan kuantiti bahan-bahan untuk satu campuran cubaan 0.075 m^3. Gunakan jadual rekabentuk campuran yang dilampirkan (Lampiran B: mukasurat 12-16) dan **sertakan lampiran yang digunakan bersama kertas jawapan anda.***

Characteristic strength: 30 MPa at 28 days
Specified Margin: 5 MPa
Cement type: Ordinary Portland cement
Aggregate type (coarse): Granite with moisture content of 0.75 %; Aggregate type (fine): river sand with moisture content of 1.0 %
Maximum free water/cement ratio: 0.50
Slump: 100 mm
Maximum aggregate size: 20 mm
Relative density of aggregate (SSD): 2.6
Percentage passing 600 μm sieve: 40 %

Kekuatan ciri: 30 MPa pada 28 hari
Jidar yang ditetapkan: 5 MPa
Jenis simen: Simen Portland biasa
Jenis agregat (kasar): Granit dengan kandungan lembapan 0.75 %: Jenis agregat (halus): pasir sungai dengan kandungan lembapan 1.0 %
Niasbah air/simen maksima dibenarkan: 0.50
Penurunan: 100 mm
Saiz maksima agregat: 20 mm
Ketumpatan relatif agregat (SSD): 2.6
Peratusan melepasi ayak 600 μm: 40 %

[20 marks/*markah*]

3. (a) Describe the roles of concrete mixing water. Discuss the importance of ensuring the quality and suitability of water to be used as concrete mixing water.

Jelaskan fungsi air bancuhan konkrit. Bincangkan kepentingan memastikan kualiti dan kesesuaian air untuk diguna pakai sebagai air bancuhan konkrit.

[6 marks/markah]

(b) Explain how the mechanical strength of coarse aggregates could be assessed based on the aggregate crushing value test.

Terangkan bagaimana kekuatan mekanikal agregat kasar boleh ditentukan berdasarkan ujian nilai kehancuran agregat.

[5 marks/markah]

(c) By using suitable sketches, explain the probable moisture conditions of aggregates. Discuss why aggregates are assumed to be in saturated and surface dry (SSD) condition in concrete mix design.

Dengan menggunakan lakaran yang sesuai, terangkan keadaan lembapan yang mungkin bagi agregat. Bincangkan kenapa agregat dianggap berada di dalam keadaan permukaan kering tepu (SSD) di dalam rekabentuk campuran konkrit.

[9 marks/markah]

4. (a) Describe the term workability. Explain with the aid of appropriate sketch how the compacting factor test could provide assessment of workability of concrete.

Jelaskan terminologi kebolehkerjaan. Terangkan dengan bantuan lakaran bagaimana ujian faktor pemadatan boleh memberikan anggaran kebolehkerjaan konkrit.

[10 marks/markah]

(b) Describe the term bleeding. Explain the negative consequences of bleeding.

Jelaskan terminologi penjujuhan. Terangkan akibat-akibat negatif penjujuhan.

[7 marks/markah]

(c) Explain the importance of curing of concrete.

Terangkan kepentingan pengawetan konkrit.

[3 marks/markah]

5. (a) Discuss the influence of water/binder ratio and the use of mineral admixtures on strength and durability performance of concrete.

Bincangkan pengaruh nisbah air/pengikat dan penggunaan bahan tambah mineral terhadap kekuatan dan prestasi ketahanlasakan konkrit.

[10 marks/markah]

(b) Describe the following time dependent characteristics of concrete:
Jelaskan ciri-ciri ubah bentuk bersandar masa konkrit yang berikut:

i) Plastic shrinkage
Pengecutan plastik

ii) Autogenous shrinkage
Pengecutan autogenous

iii) Drying shrinkage
Pengecutan kering

iv) Creep
Rayapan

[6 marks/markah]

(c) Several concrete specimens which were sealed (no moisture movement) and subjected to a constant compressive stress, σ_0 from the age of t_0, have been subjected to elevated temperature at the age of t ($t > t_0$).

Beberapa spesimen konkrit yang telah disalut (tiada pergerakan lembapan) dan dikenakan tegasan mampatan yang malar, σ_0 daripada umur t_0, telah didedahkan kepada suhu yang tinggi pada umur t ($t > t_0$).

i) Write an expression for creep strain of the concrete specimens involved.

Tuliskan ungkapan yang sesuai untuk rayapan bagi spesimen-spesimen konkrit yang terlibat.

ii) If the total measured strain at the age of t, $\varepsilon = 412 \times 10^{-6}$, $\sigma_0 = 10$ N/mm^2, E = 32 GPa, temperature rise = 30 °C, and coefficient of thermal expansion = 9×10^{-6}/°C, determine the creep strain.

Sekiranya jumlah terikan yang diukur pada umur t, $\varepsilon = 412 \times 10^{-6}$, $\sigma_0 = 10$ N/mm^2, E = 32 GPa, kenaikan suhu = 30 °C, dan pekali pengembangan haba = 9×10^{-6}/°C, tentukan terikan rayapan.

[4 marks/markah]

6. (a) Brick is the oldest building material that has been used for century. During the process of producing it and during its service life, it will undergo some physical changes. Explain **FIVE (5)** defects that can happen to brick as a material for construction.

*Bata merupakan bahan binaan tertua yang telah digunakan berabad lama. Ketika proses penghasilan bata dan semasa hayat perkhidmatannya, bata akan mengalami perubahan fizikal. Terangkan **LIMA (5)** kecacatan yang boleh berlaku pada bata sebagai bahan untuk pembinaan.*

[10 marks/*markah*]

(b) In other countries, timber is still being used as building material. The engineered wood products like 'glulam' have certain advantages in construction process. Describe **FIVE (5)** advantages of using structural timber in construction.

*Di negara-negara lain, kayu masih digunakan sebagai bahan binaan. Produk kayu terekabentuk seperti 'glulam' pasti mempunyai kelebihan dalam proses pembinaan. Jelaskan **LIMA (5)** kelebihan menggunakan kayu struktur dalam pembinaan.*

[10 marks/*markah*]

7. (a) Materials in construction can be classified into different types. They are ferrous metal, non-ferrous metal, ceramic, polymer, and bitumen. Explain these **FIVE (5)** types with suitable example.

*Bahan dalam pembinaan boleh diklasifikasikan kepada jenis yang berbeza. Mereka adalah besi ferus, besi bukan ferus, seramik, polimer dan bitumen. Terangkan **LIMA (5)** jenis ini dengan contoh yang sesuai.*

[10 marks/*markah*]

(b) Building a bungalow in suburban area sometimes require special materials. Explain the following **FIVE (5)** special materials:

- geosynthetic
- water proofing material
- heat insulation material
- adhesive
- sound insulation material

Pembinaan sebuah banglo di kawasan subbandar adakalanya memerlukan bahan yang khusus. Terangkan ***LIMA (5)*** *bahan khusus berikut:*

- *Geosintetik*
- *bahan kalis air*
- *bahan penebat haba*
- *bahan pelekat*
- *bahan penebat bunyi*

[10 marks/*markah*]

APPENDIX A/*LAMPIRAN A*

Bogue's Equations

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

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

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

$C_4AF = 3.04(Fe_2O_3)$

APPENDIX B/*LAMPIRAN B*
DOE CONCRETE MIX DESIGN

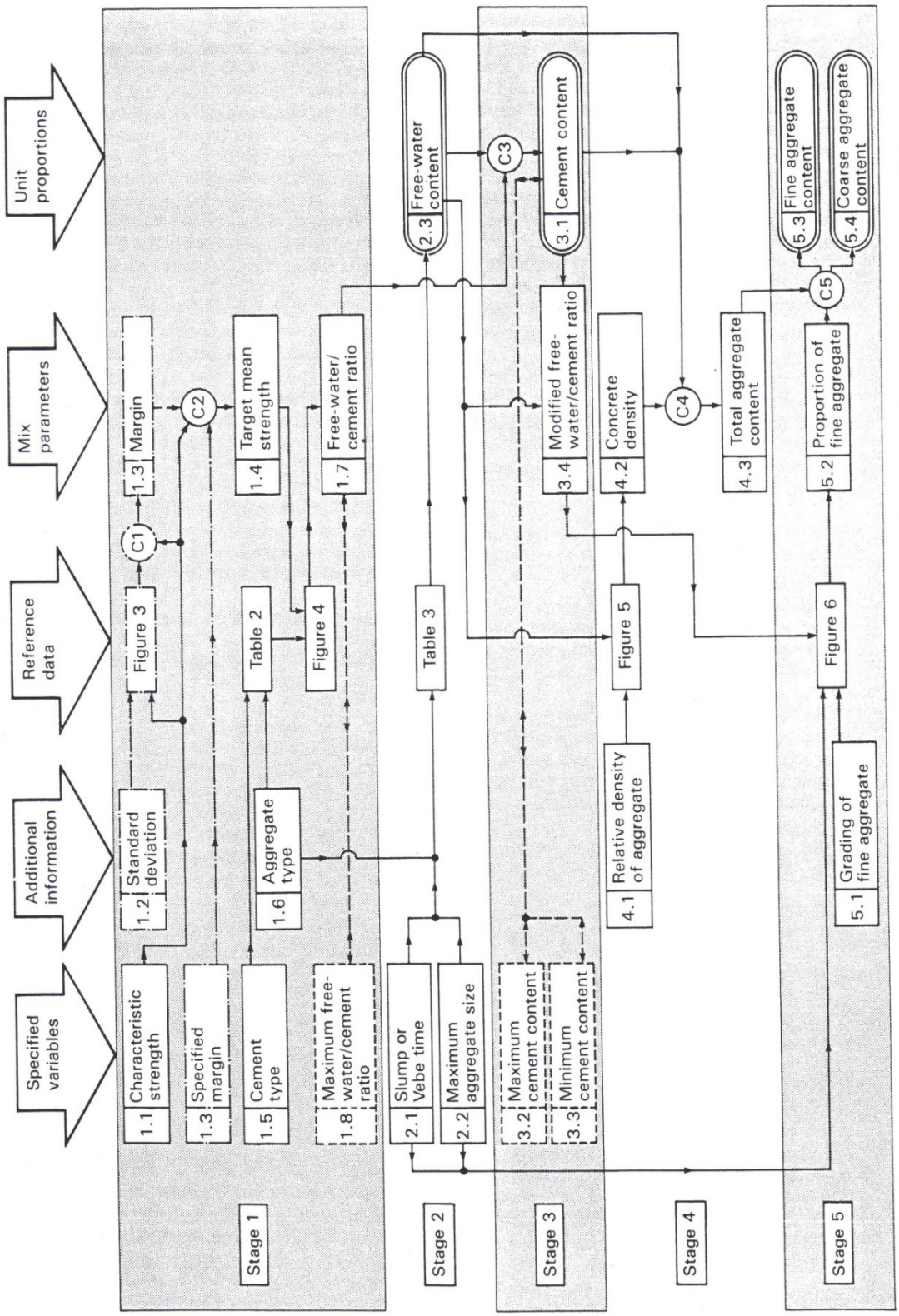

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

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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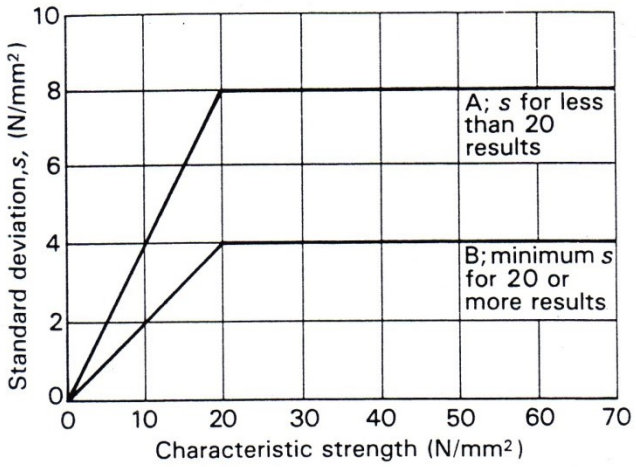

Figure 3 Relationship between standard deviation and characteristic strength

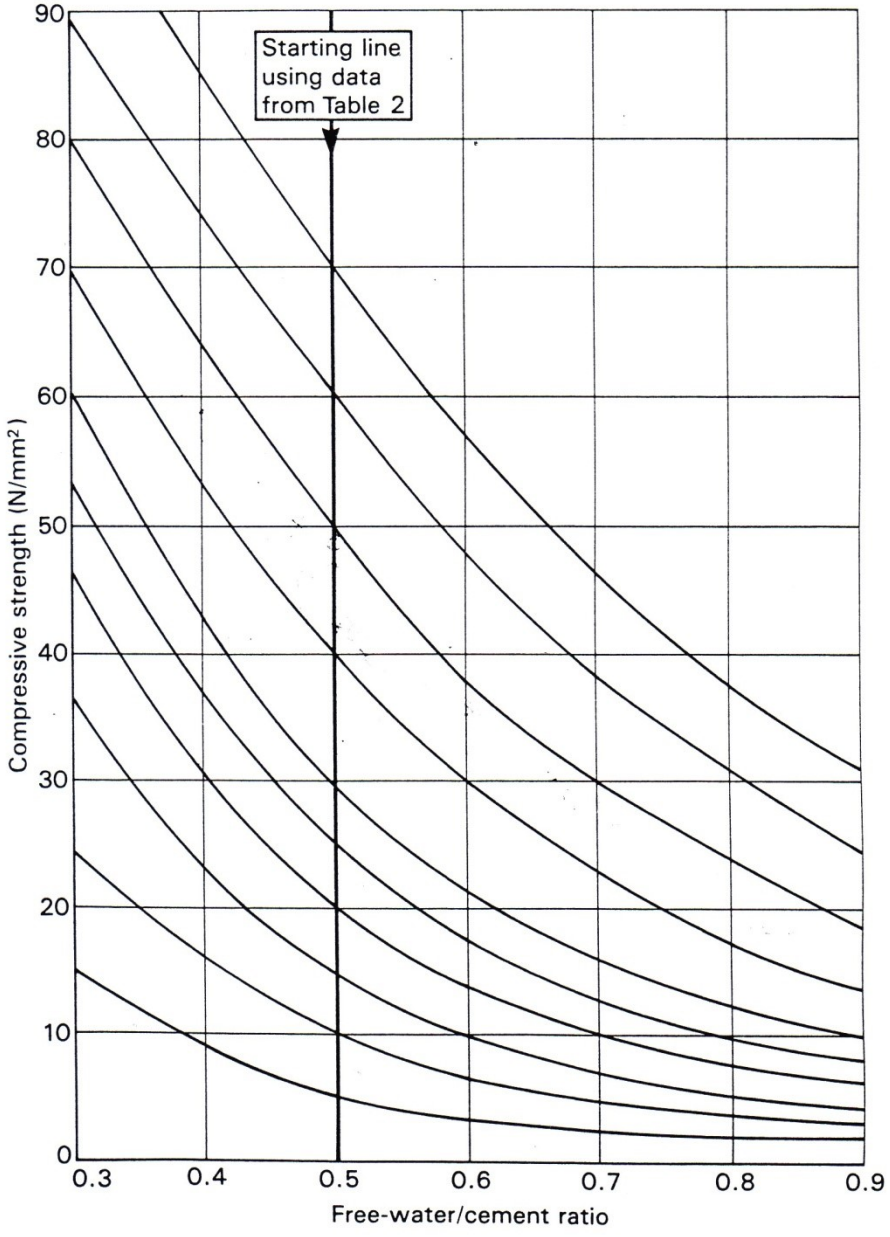

Figure 4 Relationship between compressive strength and free-water/cement ratio

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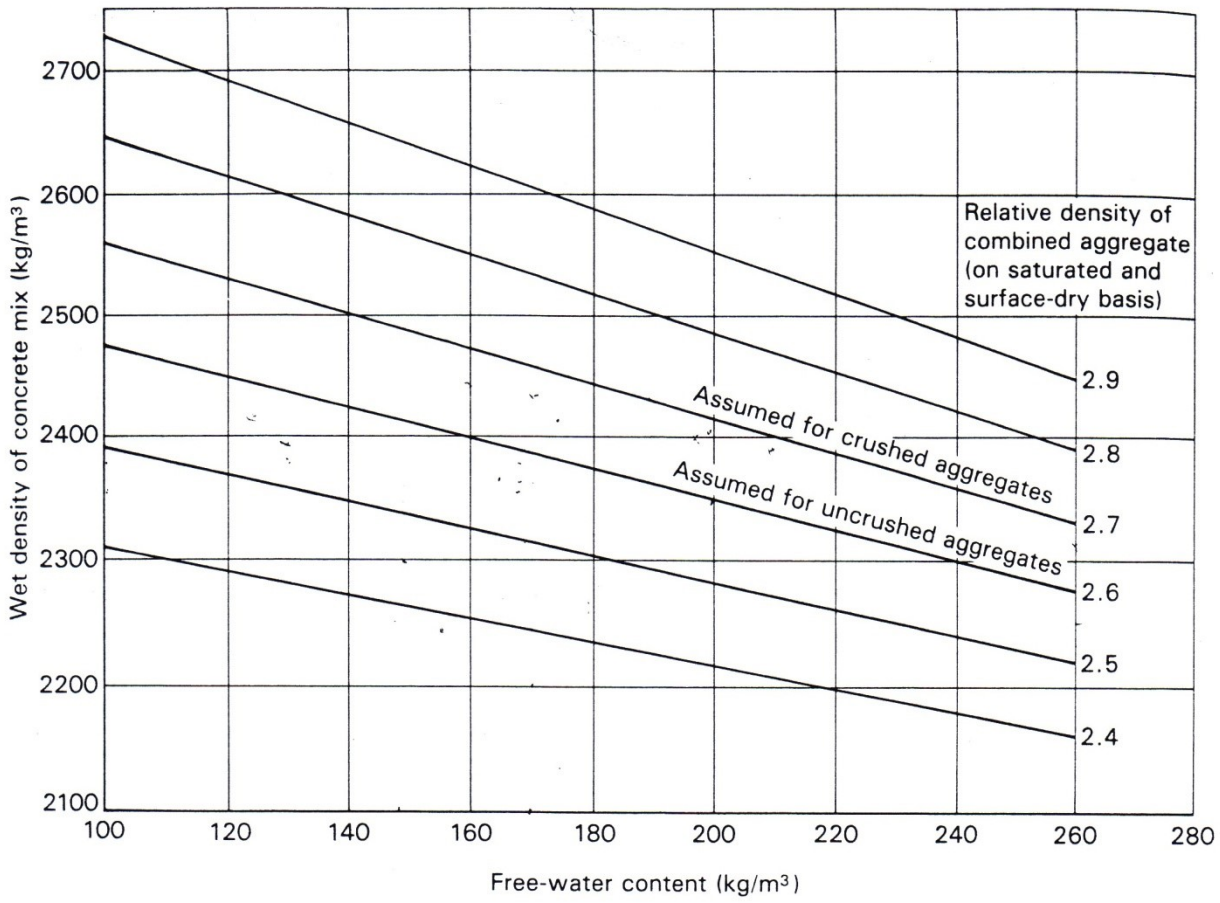

Figure 5 Estimated wet density of fully compacted concrete

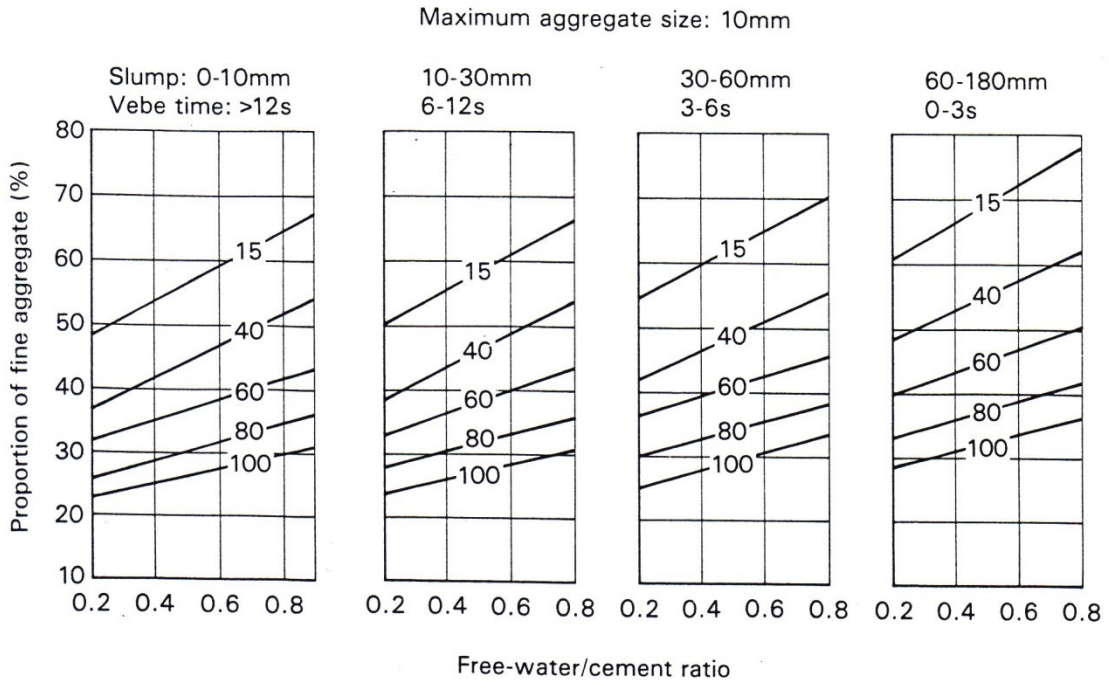

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

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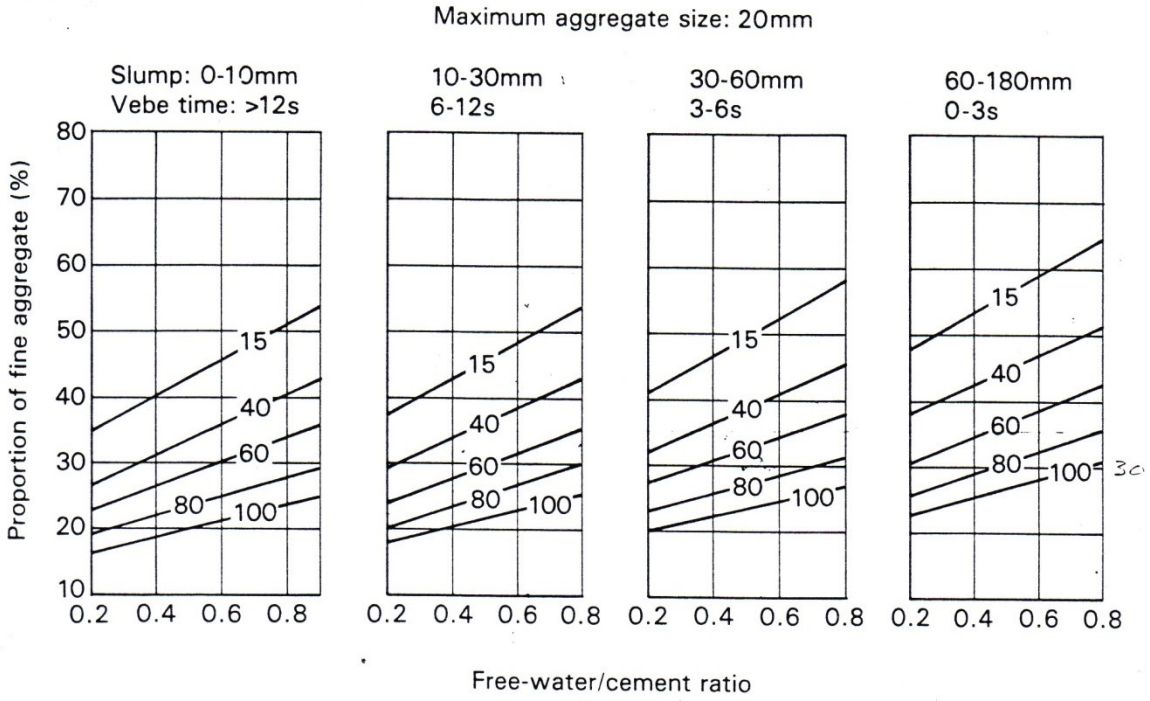

Figure 6 *(continued)*

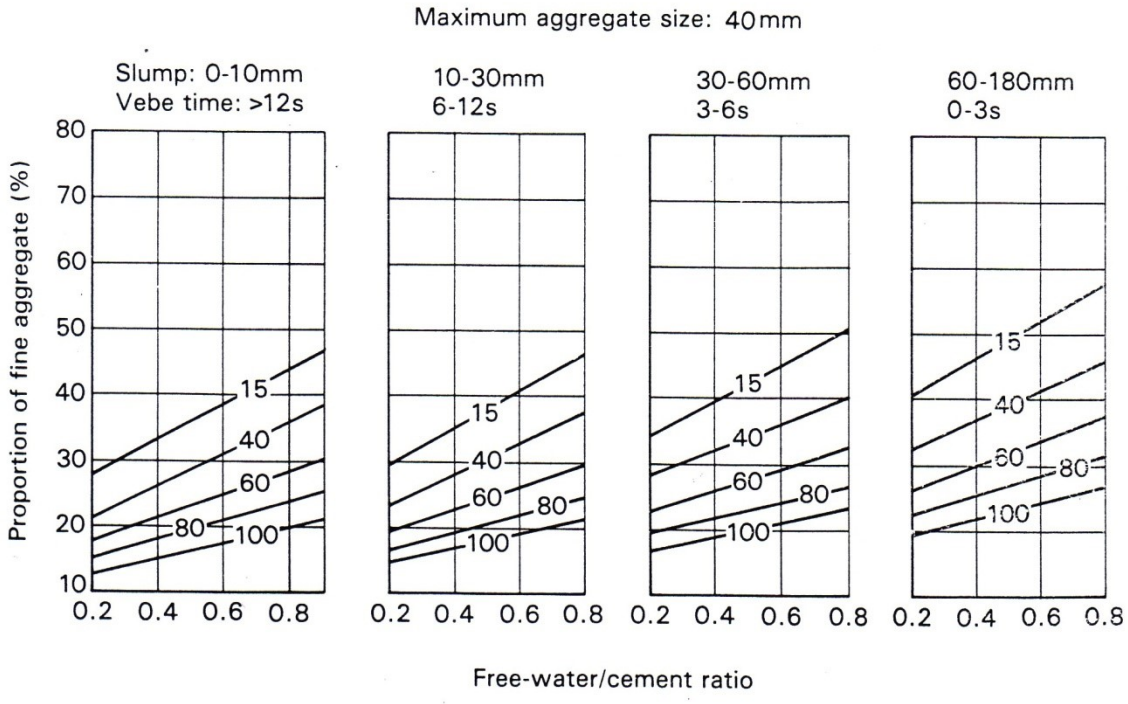

Figure 6 *(continued)*

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