UNIVERSITI SAINS MALAYSIA

First Semester Examination
2015/2016 Academic Session

December 2015 / January 2016

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 **ONE (1)** appendix before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi **ENAM BELAS (16)** muka surat yang bercetak termasuk **ONE (1)** 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] A new concrete dam is to be constructed in Sungai Padas, Sabah as part of the plan for generating hydroelectric to cater for the electricity demand of the surrounding area.

Sebuah empangan konkrit akan dibina di Sungai Padas, Sabah sebagai sebahagian daripada rancangan untuk menghasilkan hidro elektrik bagi menampung keperluan elektrik bagi kawasan sekitar.

[i] Describe the important characteristic of concrete that is required for the construction of the concrete dam, in addition to sufficient strength and high impermeability.

Jelaskan ciri utama konkrit yang diperlukan untuk pembinaan empangan konkrit di samping kekuatan yang mencukupi serta ketidakbolehtelapan yang tinggi.

[ii] Describe how the correct choice of cement type could contribute towards achieving the required characteristic of the concrete in [i].

Jelaskan bagaimana pemilihan jenis simen yang betul boleh menyumbang terhadap pencapaian ciri konkrit yang diperlukan di [i].

[iii] With justification, explain one type of EN 197-1 cement that you think suits the requirement for the construction of the dam.

Dengan justifikasi, terangkan sejenis simen EN 197-1 yang anda fikirkan sesuai dengan keperluan pembinaan empangan berkenaan.

[12 marks/*markah*]

[b] A leading cement producer has recently embarked on producing special cement for application in concrete repair as well as in precast concrete industry.

Sebuah pengeluar simen utama telah mengeluarkan simen khas untuk aplikasi dalam pembaikan konkrit dan dalam industri konkrit pra-tuang.

[i] State the most important characteristic of the cement for the intended applications.

Nyatakan ciri paling utama simen untuk tujuan aplikasi yang dikehendaki.

[ii] Discuss **TWO (2)** strategies that the cement plant could employ to produce cement with the stipulated characteristic in [i].

*Bincangkan **DUA (2)** strategi yang kilang simen boleh gunakan untuk menghasilkan simen dengan ciri yang ditetapkan di [i].*

[8 marks/*markah*]

2. [a] Two samples of granite coarse aggregates A and B have been tested for Ten Percent Fine Value (TPFV). The outcomes of the test show that the TPFV for aggregate A and B is 220 kN and 130 kN, respectively. By referring to the principle of the test as well as the recorded TPFV, provide explanation to show that one aggregate is better than the other in term of physical strength.

Dua sampel agregat kasar granit A dan B telah diuji untuk Nilai Hancur Sepuluh Peratus (TPFV). Dapatan ujian menunjukkan TPFV untuk agregat A dan B masing-masing adalah 220 kN dan 130 kN. Dengan merujuk kepada prinsip ujian dan nilai TPFV yang direkodkan, berikan penjelasan untuk menunjukkan bahawa satu agregat adalah lebih baik daripada yang satu lagi dari segi kekuatan fizikal.

[6 marks/*markah*]

[b] **Table 1** gives the grading of two samples of sand in term of mass retained on the relevant sieves. Determine the fineness modulus for each sand sample. 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 used being the same.

Jadual 1 *menunjukkan penggredan dua sampel pasir dalam bentuk jisim tertahan pada ayak-ayak yang berkaitan. Tentukan modulus kehalusan untuk tiap-tiap sampel pasir. Berdasarkan nilai modulus kehalusan, terangkan pasir mana akan memerlukan kandungan air yang tinggi bila digunakan di dalam konkrit, dengan anggapan kandungan dan ciri-ciri bahan yang lain adalah sama.*

Table 1: Grading of Sand
Jadual 1: *Penggredan Pasir*

Sieve Size/ ***Saiz Ayak***	**Mass Retained/** ***Jisim Tertahan*** **(g)**	
	Sand/*Pasir* A	**Sand/*Pasir* B**
10 mm	0.00	0.00
5 mm	0.00	10.00
2.36 mm	2.50	150.00
1.18 mm	7.50	107.00
600 µm	20.70	70.70
300 µm	270.20	140.20
150 µm	190.20	20.20
Pan	8.90	1.90
Total	500	500

[14 marks/*markah*]

3. In a proposed project for the construction of a multi-storey car park, concrete mix with characteristic strength of 35 MPa at 28 days will be used. Other stipulated requirements of the concrete include a workability of 150 mm based on slump value and a maximum water/cement ratio of 0.5. Using the extract from "Design of Normal Concrete Mixes" (BRE Report, 1988 given in the **Appendix**) and based on the data given in **Table 2**, determine the quantity of materials for a trial mix of 0.04 m^3. If both the river sand and granite have moisture content of 1.2% and 0.8%, respectively, determine the mix proportions for 1 m^3 and for the trial mix of 0.04 m^3. Use the attached mix design forms and **include the appendix used with your answer script.**

Dalam satu cadangan projek untuk membina sebuah tempat letak kereta bertingkat, konkrit dengan kekuatan ciri 35 MPa akan digunakan. Keperluan lain konkrit yang ditetapkan termasuk kebolehkerjaan 150 mm berdasarkan nilai penurunan dan nisbah air/simen maksima 0.5. Menggunakan ekstrak daripada "Rekabentuk Campuran Untuk Konkrit Biasa" (BRE Report, 1988 dalam ***Lampiran****) dan berdasarkan data yang diberikan dalam* ***Jadual 2****, tentukan kuantiti bahan untuk satu campuran cubaan 0.04 m^3. Jika kedua-dua pasir sungai dan granit masing-masing mempunyai kandungan lembapan 1.2% dan 0.8%, tentukan kuantiti bahan untuk 1 m^3 dan juga campuran cubaan 0.04 m^3. Gunakan jadual rekabentuk campuran yang dilampirkan dan* ***sertakan lampiran yang digunakan bersama kertas jawapan anda.***

Table 2: Mix design data
Jadual 2: *Data rekabentuk campuran*

Specified margin/ ***Jidar yang ditetapkan***	**5 MPa**
Cement type/ *Jenis simen*	Ordinary Portland cement/ *Ordinary Portland cement*
Coarse aggregate type/ Jenis agregat kasar	Granite/ *Granit*
Fine aggregate type/ Jenis agregat halus	River sand/ *Pasir sungai*
Maximum aggregate size/ *Saiz maksima agregat*	20 mm
Relative density of aggregate (SSD)/ *Ketumpatan relatif agregat (SSD)*	2.65
Percentage passing 600 µm sieve/ *Peratusan melepasi ayak 600 µm*	40%

[20 marks/*markah*]

4. [a] Most of the supplementary cementitious materials used in the concrete industry are pozzolanic in nature. Their use can normally improve the properties and performance of concrete. Explain the term pozzolan.

Kebanyakan bahan penyimenan suplemen yang digunakan dalam industri konkrit adalah bersifat "pozzolan". Penggunaan mereka selalunya meningkatkan sifat dan prestasi ketahanlasakan konkrit. Terangkan terminologi "pozzolan".

[4 marks/*markah*]

[b] Limited tests have been performed to assess the suitability of unknown water sourced from a pond as concrete mixing water. The results of the tests are given in **Table 3**. Based on the results of the tests, explain the suitability of the pond water as concrete mixing water.

Ujian yang terhad telah dijalankan untuk menilai kesesuaian air yang didapati dari sebuah tasik sebagai air bancuhan konkrit. Keputusan ujian diberikan dalam

***Jadual 3**. Berdasarkan keputusan ujian, terangkan kesesuaian air tasik berkenaan sebagai air bancuhan konkrit.*

Table 3: Results of Tests on Initial Setting Time and Compressive Strength

***Jadual 3:** Keputusan Ujian Masa Pemejalan Awal dan Kekuatan Mampatan*

Test/Ujian	**Source of Water/*Sumber Air***	
	Distilled Water/ *Air Suling*	**Pond Water/ *Air Tasik***
Initial setting time of cement paste/ *Masa pemejalan awal adunan simen* (Minutes/*Minit*)	150	162
7th day Compressive strength of mortar/ *Kekuatan mampatan 7 hari mortar* (MPa)	23	21

[4 marks/*markah*]

[c] Chemical admixtures namely superplasticizer, retarder and accelerator are commonly used in the concrete industry. For each chemical admixture, explain one situation in the concrete industry where its use may be required.

Bahan tambah kimia iaitu superpemplastikan, pelambat dan pemecut selalu digunakan dalam industri konkrit. Untuk setiap bahan tambah kimia, terangkan satu situasi dalam industri konkrit dimana penggunaannya mungkin diperlukan.

[6 marks/*markah*]

[d] Discuss how the quantity of mixing water could affect the strength and durability performance of concrete.

Bincangkan bagaimana kuantiti air bancuhan boleh memberi kesan kepada kekuatan dan prestasi ketahanlasakan konkrit.

[6 marks/*markah*]

5. [a] [i] Compliance to workability requirement is important in concrete practice. Give the definition of workability of concrete.

Pematuhan terhadap keperluan kebolehkerjaan adalah penting dalam amalan kerja konkrit. Berikan definasi kebolehkerjaan konkrit.

[ii] A vee-bee time test has been performed on two concrete samples C and D. Concrete C registers a vee-bee time of 20 seconds, while concrete D records a value of 3 seconds. Considering the principle of the test and the recorded vee-bee times, provide explanation to show that one concrete mix has greater workability than the other.

Ujian masa vee-bee telah dijalankan terhadap dua sampel konkrit C dan D. Konkrit C merekodkan bacaan masa vee-bee 20 saat, manakala konkrit D merekodkan nilai 3 saat. Dengan mengambil kira prinsip ujian dan bacaan masa vee-bee yang direkodkan, berikan penerangan untuk menunjukkan bahawa satu campuran konkrit mempunyai kebolehkerjaan yang lebih tinggi daripada campuran yang satu lagi.

[9 marks/*markah*]

[b] Several concrete samples have been subjected to a constant compressive stress, σ_0 from the age of t_0, while being exposed to uniform temperature and low relative humidity. The samples were then subjected to elevated temperature at the age of t ($t > t_0$). Write an appropriate expression representing the creep strain for the concrete samples.

Beberapa sampel konkrit telah dikenakan tegasan mampatan yang malar, σ_0 daripada umur t_0, dan pada masa yang sama sampel konkrit berkenaan didedahkan kepada suhu yang seragam serta kelembapan relatif yang rendah. Kemudiannya, sampel konkrit berkenaan telah didedahkan kepada suhu yang tinggi pada umur t ($t > t_0$). Tuliskan ungkapan yang sesuai yang mewakili terikan rayapan sampel-sampel konkrit yang terlibat.

[3 marks/*markah*]

[c] Creep and shrinkage tests have been performed on cylindrical concrete specimens (diameter, Ø = 120 mm, length, L = 300 mm) which have been cured in water until the age of 28 days. For the creep test, the samples have been subjected to compressive load of 30% of the compressive strength of the concrete. If the average failure load for similar concrete samples tested in compression at the age of 28 days is 510 kN, and based on the recorded data in **Table 4**, determine:

- Compressive strength of the concrete at 28 days
- Initial elastic strain
- Elastic Modulus
- Drying shrinkage after 3 months
- Creep after being loaded for 6 months

*Ujian rayapan dan pengecutan telah dijalankan ke atas spesimen-spesimen konkrit berbentuk selinder (garispusat, Ø = 120 mm, panjang, L = 300 mm) yang telah diawet di dalam air sehingga 28 hari. Bagi ujian rayapan, spesimen telah dikenakan beban mampatan 30% daripada kekuatan mampatan konkrit tersebut. Jika beban gagal purata (average failure load) bagi selinder-selinder konkrit yang diuji secara mampatan pada umur 28 hari adalah 510 kN dan berdasarkan data-data cerapan di dalam **Jadual 4**, tentukan:*

- *Kekuatan mampatan konkrit pada 28 hari*
- *Terikan anjal mula*
- *Modulus keanjalan*
- *Pengecutan kering selepas 3 bulan*
- *Rayapan selepas 6 bulan dibebankan*

Table 4: Average demec gauge reading ($x10^{-6}$)
Jadual 4: *Purata bacaan tolok terikan (*x *10^{-6})*

Recording Time / *Masa Cerapan*	**Loaded Sample / *Sampel Terbeban* (Creep/*Rayapan*)**	**Unloaded Sample / *Sampel Tidak Terbeban* (Shrinkage/*Pengecutan*)**
Before loading/ *Sebelum dibebankan*	1420	1376
Immediately after loading/ *Sebaik sahaja selepas dibebankan*	1040	1376
1 day after loading/ *1 hari selepas dibebankan*	924	1342
3 days after loading/ *3 hari selepas dibebankan*	838	1284
7 days after loading/ *7 hari selepas dibebankan*	726	1224
14 days after loading/ *14 hari selepas dibebankan*	643	1184
28 days after loading/ *28 hari selepas dibebankan*	544	1132
3 months after loading/ *3 bulan selepas dibebankan*	362	1030
6 months after loading/ *6 bulan selepas dibebankan*	276	968

[8 marks/*markah*]

6. [a] Fired clay brick is a fire resistant material that is normally used for building construction such as external, internal and partition walls. The quality of bricks can be influenced by the forming and firing processes. As an engineer that supervise the material quality on site, explain **FIVE (5)** characteristics that are required from the fired clay brick in the construction of wall for building in addition to fire resistance.

*Bata tanah liat bakar merupakan bahan binaan yang tahan api yang biasa digunakan untuk pembinaan bangunan seperti dinding luar, dalam dan dinding pemisah. Kualiti bata dipengaruhi oleh proses pembentukan dan pembakaran. Sebagai seorang jurutera yang menjaga kualiti bahan di tapak pembinaan, terangkan **LIMA (5)** ciri yang diperlukan dari bahan binaan bata tanah liat bakar dalam pembinaan dinding bangunan selain daripada ketahanan api.*

[10 marks/*markah*]

[b] In Malaysia, the old wooden houses are carved with different patterns to form unique and attractive building structures. Using the latest technology, local timber products are processed with modern methods which make them more durable. Explain the advantages of using timber in terms of structural requirements, aesthetic values and as a construction method.

Di Malaysia, rumah kayu lama yang diukir dengan pelbagai corak untuk menghasilkan sebuah struktur binaan yang unik dan menarik. Menggunakan teknologi terkini, produk kayu tempatan diproses dengan kaedah moden menjadikannya lebih tahan lasak. Terangkan kelebihan menggunakan kayu dari aspek keperluan struktur, nilai estatika dan sebagai satu kaedah pembinaan.

[10 marks/*markah*]

7. [a] Asbestos has two types of fibers namely crocidolite and amosite which are harmful to human health but they are still being used in the construction industry. The usage of asbestos has been replaced by other building materials that are safer to human being. List **FIVE (5)** building components where asbestos is commonly used in a house and suggest **FIVE (5)** other suitable materials that can replace this construction material.

*Asbestos mempunyai dua jenis gentian yang sangat berbahaya iaitu amosit dan krosidolit yang berbahaya kepada kesihatan manusia tetapi masih digunakan dalam industri pembinaan. Penggunaan asbestos telah digantikan dengan bahan binaan lain yang lebih selamat kepada pengguna. Senaraikan **LIMA (5)** bahan binaan yang biasa menggunakan asbestos dan cadangkan **LIMA (5)** bahan lain yang sesuai digunakan untuk menggantikan bahan binaan tersebut*

.

[10 marks/*markah*]

[b] Ferrous iron is an important material used in the construction industry. Explain **FIVE (5)** important properties of ferrous iron that make it suitable to be used as a structural member.

Besi ferus merupakan bahan binaan penting dalam industri pembinaan. Terangkan ***LIMA (5)*** *sifat penting besi ferus yang menjadikannya sesuai digunakan sebagai anggota struktur.*

[10 marks/*markah*]

APPENDIX / *LAMPIRAN*
ANGKA GILIRAN:_____

Extract from "Design of Normal Concrete Mixes (BRE Report, 1988)"

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		_____	− _____ = [ ] 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.

[Include With Your Answer Script]

Extract from "Design of Normal Concrete Mixes (BRE Report, 1988)"

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

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

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:

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

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:

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

[Include With Your Answer Script]

Extract from "Design of Normal Concrete Mixes (BRE Report, 1988)"

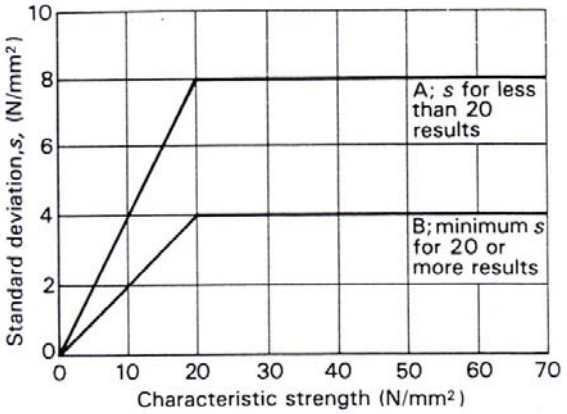

Figure 3 Relationship between standard deviation and characteristic strength

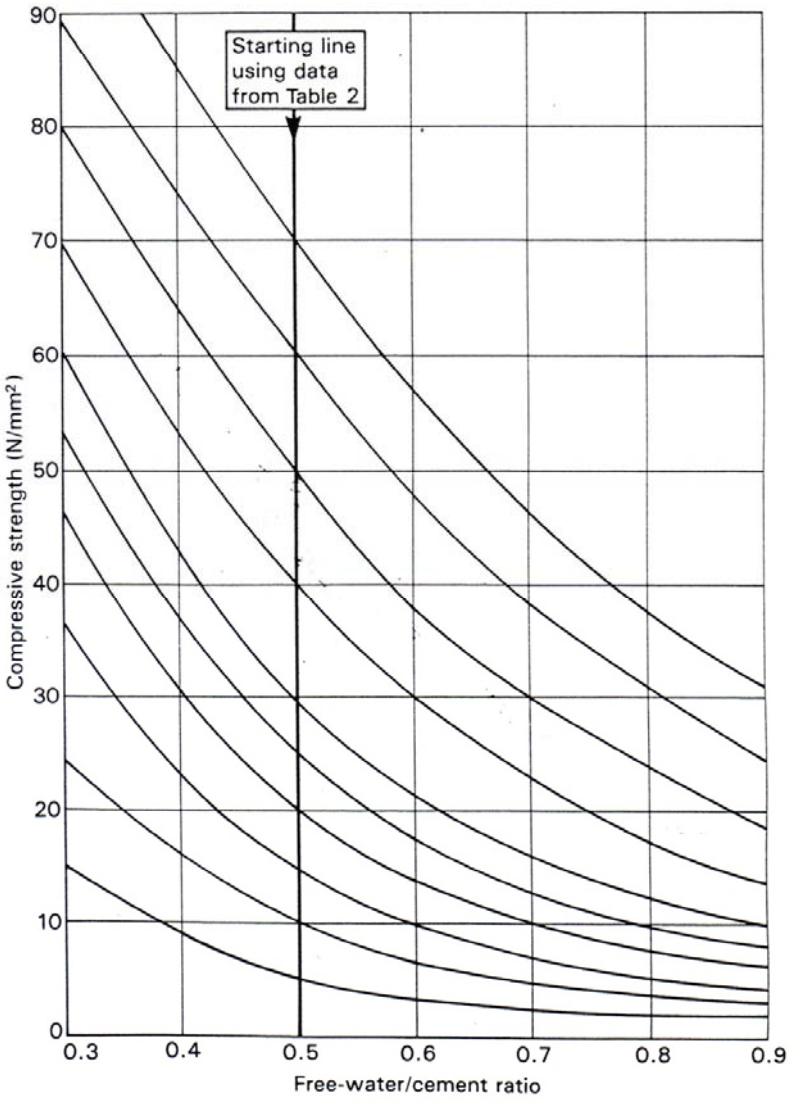

Figure 4 Relationship between compressive strength and free-water/cement ratio

[Include With Your Answer Script]

Extract from "Design of Normal Concrete Mixes (BRE Report, 1988)"

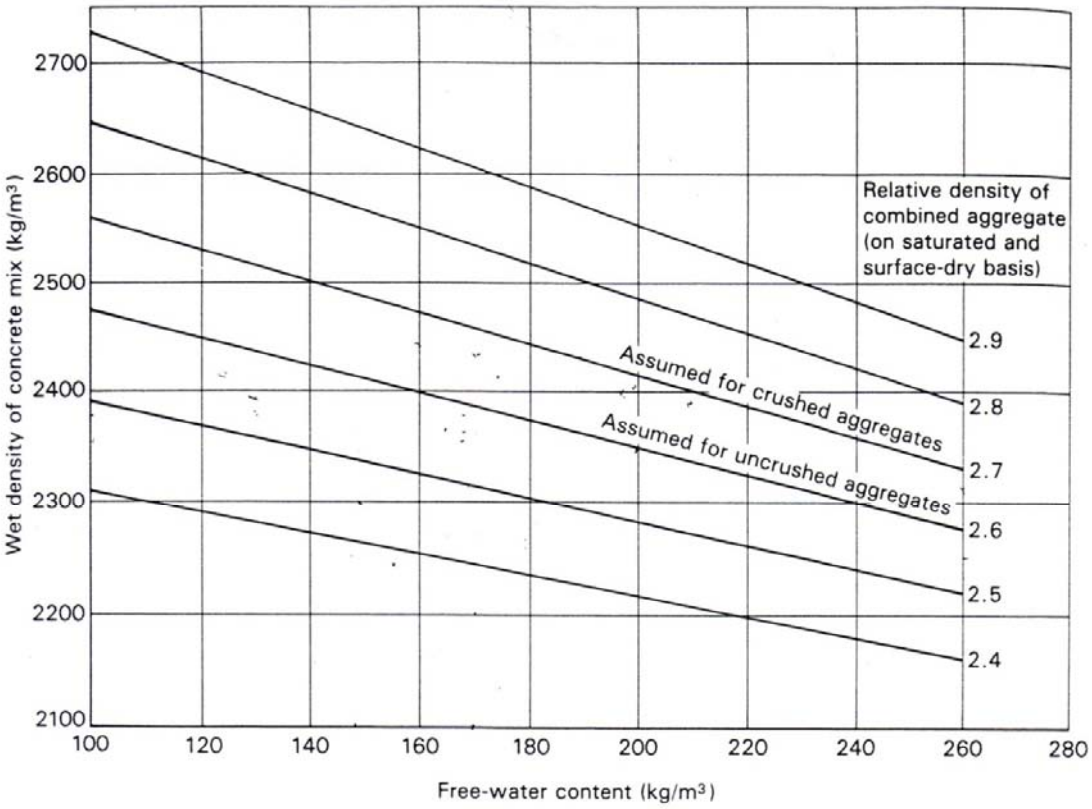

Figure 5 Estimated wet density of fully compacted concrete

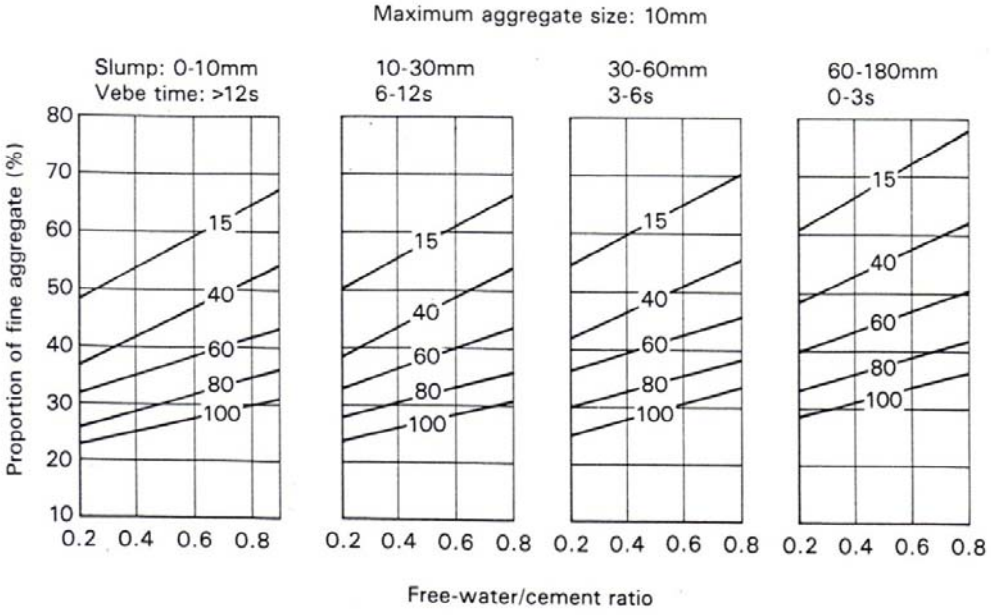

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

[Include With Your Answer Script]

Extract from "Design of Normal Concrete Mixes (BRE Report, 1988)"

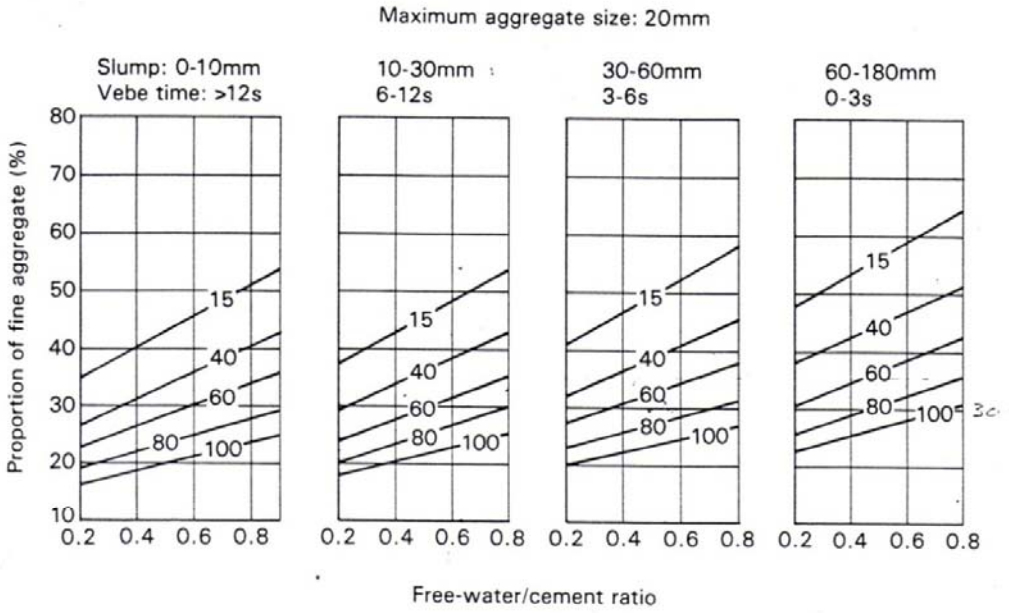

Figure 6 *(continued)*

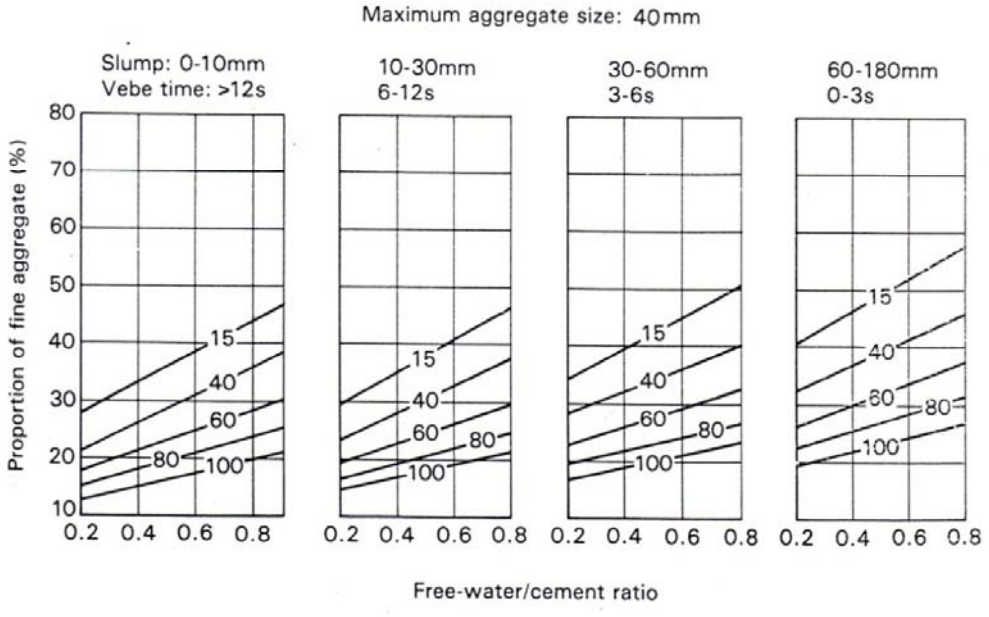

Figure 6 *(continued)*

[Include With Your Answer Script]

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