UNIVERSITI SAINS MALAYSIA

Second Semester Examination
Academic Session 2007/2008

April 2008

EAS 181/2 – Concrete Technology
[Teknologi Konkrit]

Duration: 2 hours
[Masa : 2 jam]

Please check that this examination paper consists of **TWELVE (12)** printed pages including appendices before you begin the examination.
*[Sila pastikan kertas peperiksaan ini mengandungi **DUA BELAS (12)** muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.]*

Instructions: This paper consists of **FIVE (5)** questions. Answer **FOUR (4)** questions only. All questions carry the same marks.

*[**Arahan**: Kertas ini mengandungi **LIMA (5)** soalan. Jawab **EMPAT (4)** soalan sahaja. Semua soalan membawa jumlah markah yang sama.]*

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

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.]

1. (a) List the **FOUR (4)** major compound compositions of cement. Briefly describe in general (not referring to a specific compound composition) the influence of the proportions of the compound compositions on the characteristics of cement.

(5 marks)

*Senaraikan **EMPAT (4)** komposisi sebatian utama simen. Jelaskan dengan ringkas (tanpa merujuk kepada komposisi sebatian tertentu) pengaruh kadar komposisi sebatian terhadap ciri-ciri simen.*

(5 markah)

(b) A newly built cement factory has recently started its operation. During its first trial run production, the plant operator did not include calcium sulphate (gypsum) to the cement clinker. Describe the probable setting characteristic of the cement produced. Explain briefly the suitability of the cement for the production of concrete.

(5 marks)

Sebuah kilang simen yang baru dibina telah memulakan operasinya. Semasa pengeluaran ujian dilakukan, kalsium sulfat (gipsum) tidak ditambah kepada batu hangus (clinker) simen. Jelaskan kemungkinan ciri-ciri pemejalan simen yang dihasilkan. Terangkan secara ringkas kesesuaian simen berkenaan untuk menghasilkan konkrit.

(5 markah)

(c) Explain the principle behind the maximum limit of the tricalcium aluminate (C_3A) content in the specification for Sulphate Resisting Portland cement (SRPC) or equivalent ASTM Type V cement.

(5 marks)

Terangkan prinsip di sebalik had maksima kandungan "tricalcium aluminate" (C_3A) di dalam spesifikasi bagi simen Portland Penahan Sulfat (SRPC) atau simen Jenis V ASTM.

(5 markah)

(d) An analysis performed on a fully hydrated hardened cement paste shows that the relative proportions of calcium silicate hydrate (C-S-H) is greater and $Ca(OH)_2$ is smaller than those typically found in Ordinary Portland cement. With justifications, state the most probable type of the cement analysed. Explain the characteristics of the cement in term of rate of strength development and heat evolved during hydration. State **ONE (1)** potential application of this cement.

(10 marks)

*Analisa yang dilakukan terhadap adunan simen terkeras yang telah terhidrat sepenuhnya menunjukkan kadar relatif "calcium silicate hydrate" (C-S-H) yang tinggi dan kadar relatif $Ca(OH)_2$ adalah rendah berbanding nilai tipikal untuk simen Portland Biasa. Dengan memberikan justifikasi-justifikasi yang sesuai, nyatakan kemungkinan jenis simen yang dianalisa. Terangkan ciri-ciri simen berkenaan dari aspek kadar pembentukan kekuatan dan pembebasan haba semasa penghidratan. Nyatakan **SATU** (1) potensi kegunaan untuk simen ini.*

(10 markah)

2.(a) Explain the **FOUR** (4) probable state of moisture conditions of aggregate. Use appropriate sketches to aid your explanation.

(12 marks)

*Terangkan **EMPAT** (4) kemungkinan keadaan lembapan agregat. Gunakan lakaran-lakaran yang sesuai untuk membantu penerangan anda.*

(12 markah)

(b) A sample of sand weighs 505g and 480g in "as received" and "oven-dried" condition, respectively. If the absorption capacity of the sand is 1.5%, determine the percentage of free moisture.

(5 marks)

Satu sampel pasir mempunyai jisim 505g dan 480g masing-masing dalam keadaan seperti diterima dan kering (oven dried). Sekiranya kapasiti penyerapan pasir berkenaan adalah 1.5%, tentukan peratusan lembapan bebas.

(5 markah)

(c) Two types of sand A and B has a fineness modulus of 1.86 and 3.25, respectively. Explain which sand will require greater water content when used in concrete, assuming the quantity and characteristics of other materials used being the same.

(5 marks)

Dua jenis pasir A dan B masing-masing mempunyai modulus kehalusan 1.86 dan 3.25. Terangkan pasir yang mana akan memerlukan kandungan air yang lebih tinggi bila digunakan di dalam konkrit, dengan anggapan kuantiti dan ciri-ciri bahan-bahan yang lain adalah sama.

(5 markah)

(d) If the bulk density of a coarse aggregate is 1686 kg/m^3 and its specific gravity in saturated and surface dry condition is 2.65, determine the voids content.

(3 marks)

Sekiranya ketumpatan pukal untuk suatu agregat kasar adalah 1686 kg/m^3 dan graviti tentu dalam keadaan permukaan kering tepu adalah 2.65, tentukan kandungan lompang.

(3 markah)

3. (a) Give the appropriate definition for admixture according to ASTM.

(5 marks)

Berikan definasi yang sesuai untuk bahan tambah berdasarkan ASTM.

(5 markah)

(b) The use of fly ash is normally associated with reduction in water demand of concrete. Explain how this phenomenon occurs.

(5 marks)

Penggunaan abu terbang selalunya dikaitkan dengan pengurangan keperluan air konkrit. Terangkan bagaimana fenomena ini berlaku.

(5 markah)

(c) A concrete mixture containing ordinary Portland cement; 370 kg/m^3 and water/cement ratio; 0.52 exhibits a slump value of 80 mm. If 30 % of the cement content is replaced with fly ash, determine the water content, water/binder ratio and water/cement ratio for the concrete mixture to give constant workability (80 mm slump). Assume that at 30 % replacement level, water requirement reduces by 15 %. If the same water/binder ratio of 0.52 is maintained for the concrete containing 30 % fly ash, describe the expected effect to workability.

(6 marks)

Satu bancuhan konkrit yang mengandungi simen Portland biasa; 370kg/m^3 dan nisbah air/simen; 0.52 menunjukkan nilai penurunan sebanyak 80mm. Sekiranya 30% daripada kandungan simen digantikan dengan abu terbang, tentukan kandungan air, nisbah air/pengikat dan nisbah air/simen untuk bancuhan konkrit berkenaan untuk mencapai kebolehkerjaan malar (penurunan 80mm). Anggapkan bahawa pada 30% tahap gatian, keperluan air menurun sebanyak 15%. Jika nisbah air/pengikat yang sama (0.52) dikekalkan untuk konkrit yang mengandungi 30% abu terbang, jelaskan kesan yang boleh dijangkakan kepada kebolehkerjaan.

(6 markah)

(d) Discuss the potential influences of fly ash at 30% replacement level as in (c) on strength development and durability performance of concrete.

(9 marks)

Terangkan potensi pengaruh-pengaruh abu terbang pada tahap gantian 30% seperti di (c) terhadap pembentukan kekuatan dan prestasi ketahanlasakan konkrit.

(9 markah)

4. (a) Using 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 0.065 m^3. Include the attachment used with your answer script.

Characteristic strength: 35 MPa at 28 days
Proportion defective: 5 %
Standard deviation: 6 MPa
Cement type: Ordinary Portland cement
Aggregate type (coarse): Granite; Aggregate type (fine): river sand
Maximum free water/cement ratio: 0.50
Slump: 100 mm
Maximum aggregate size: 20 mm
Relative density of aggregate (SSD): 2.6
Percentage passing 600μm sieve: 40 %

(20 marks)

Dengan menggunakan kaedah rekabentuk campuran untuk konkrit biasa (BRE Report, 1988 seperti di lampiran) dan berdasarkan kepada data-data yang diberikan di bawah, tentukan kuantiti bahan-bahan untuk satu campuran cubaan dengan isipadu 0.065 m^3. Sertakan lampiran yang digunakan bersama kertas jawapan anda.

Kekuatan ciri: 35 MPa at 28 days
Peratus kecacatan: 5 %
Sisihan Piawai: 6 MPa
Jenis simen: Simen Portland biasa
Jenis agregat (Agregat kasar): Batuan granit
Jenis agregat (Agregat halus): Pasir sungai
Nisbah air/simen bebas maksima: 0.50
Penurunan: 100 mm
Saiz maksima agregat: 20 mm
Ketumpatan relative agregat (SSD): 2.6
Peratusan pasir melepasi ayak 600 μm: 40 %

(20 markah)

(b) If the sand used in (a) is moist with moisture content of 1.25% and the granite coarse aggregate is dry with water absorption of 0.5%, determine the mix proportions for 1 m^3 and for the trial mix of 0.065 m^3.

(5 marks)

Sekiranya pasir yang digunakan di (a) adalah basah dengan kandungan lembapan 1.25% dan agregat kasar granit yang digunakan adalah kering dengan penyerapan air 0.5%, tentukan nisbah bancuhan untuk 1m^3 dan untuk campuran cubaan 0.065 m^3.

(5 markah)

5. (a) What properties are desired in fresh or plastic concrete?

(3 marks)

Sifat-sifat apakah yang dikehendaki pada konkrit segar ?

(3 markah)

(b) Explain briefly the following terms:

i. Segregation
ii. Cohesiveness
iii. Bleeding

(6 marks)

Terangkan dengan ringkas terminologi-terminologi berikut:
i. Pengasingan
ii. Kejelekitan
iii. Penjujuhan

(6 markah)

(c) With the aid of diagram, briefly explain the stress-strain curve for concrete. Write down an expression to determine the modulus of elasticity of the concrete.

(8 marks)

Dengan berbantukan rajah, terangkan secara ringkas lengkuk tegasan-terikan konkrit. Tuliskan ungkapan untuk menentukan modulus keanjalan konkrit.

(8 markah)

(d) Why a slump test is used? Explain the test procedures to perform a slump test with the aid of diagram.

(8 marks)

Kenapa ujian penurunan digunakan? Terangkan langkah-langkah untuk menjalankan ujian penurunan dengan berbantukan rajah.

(8 markah)

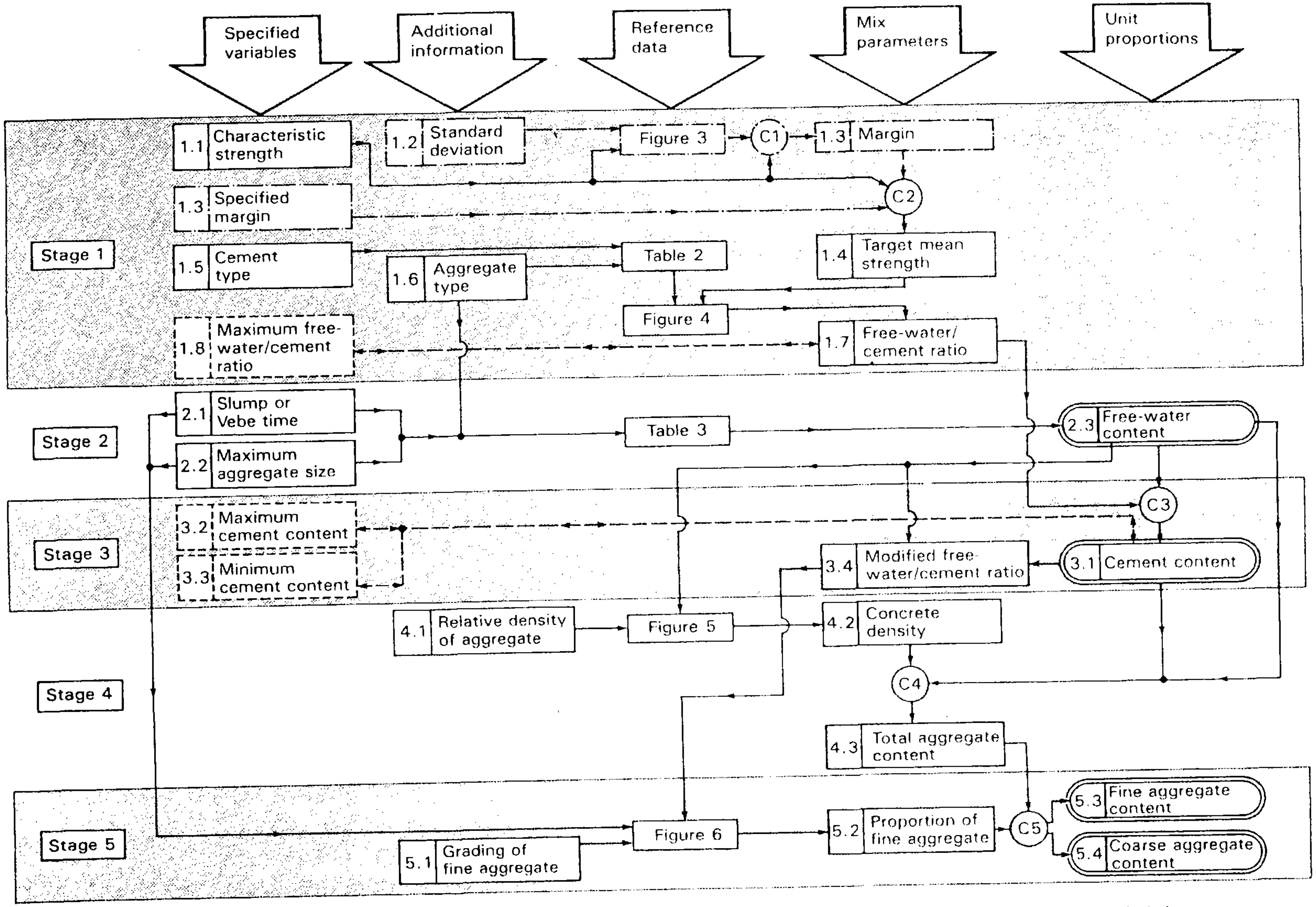

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

APPENDIX/LAMPIRAN

Concrete mix design form

Job title ....

Stage	Item	Reference or calculation	Values
1	1.1 Characteristic strength	Specified	______ N/mm^2 at ______ days; Proportion defective ______ %
	1.2 Standard deviation	Fig 3	______ N/mm^2 or no data ______ N/mm^2
	1.3 Margin	C1 or Specified	(k = ______) ______ × ______ = ______ N/mm^2; ______ N/mm^2
	1.4 Target mean strength	C2	______ + ______ = ______ N/mm^2
	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/m^3
3	3.1 Cement content	C3	______ ÷ ______ = ______ kg/m^3
	3.2 *Maximum cement content*	*Specified*	______ kg/m^3
	3.3 *Minimum cement content*	*Specified*	______ kg/m^3
			use 3.1 if ≤ 3.2 use 3.3 if > 3.1 [ ] kg/m^3
	3.4 Modified free-water/cement ratio		______ [ ]
4	4.1 Relative density of aggregate (SSD)		______ known/assumed
	4.2 Concrete density	Fig 5	______ kg/m^3
	4.3 Total aggregate content	C4	______ − ______ − ______ = ______ kg/m^3
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/m^3
	5.4 Coarse aggregate content	C5	______ − ______ = [ ] kg/m^3

Quantities	Cement (kg)	Water (kg or *L*)	Fine aggregate (kg)	Coarse aggregate (kg) 10 mm	20 mm	40 mm
per m^3 (to nearest 5 kg)	______	______	______	______	______	______
per trial mix of ______ m^3	______	______	______	______	______	______

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

1 N/mm^2 = 1 MN/m^2 = 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/mm^2) of concrete mixes made with a free-water/cement ratio of 0.5

Type of cement	Type of coarse aggregate	Compressive strengths (N/mm^2) 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/mm^2 = 1 MN/m^2 = 1 MPa (see footnote on earlier page).

Table 3 Approximate free-water contents (kg/m^3) 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

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

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:

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

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:

Total aggregate content = D − C − W ...*C4*
(saturated and surface-dry)

where D = the wet density of concrete (kg/m^3)
C = the cement content (kg/m^3)
W = the free-water content (kg/m^3).

*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.

APPENDIX/LAMPIRAN

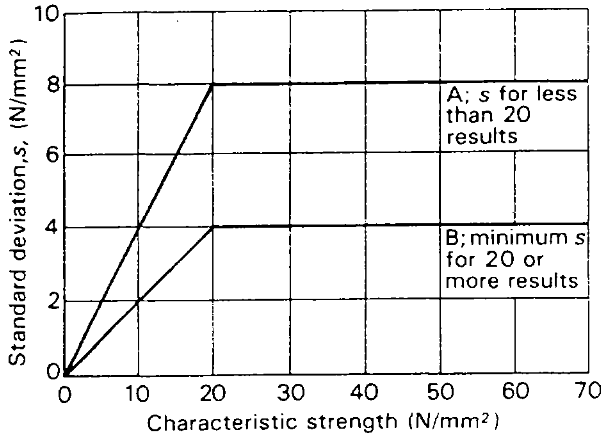

Figure 3 Relationship between standard deviation and characteristic strength

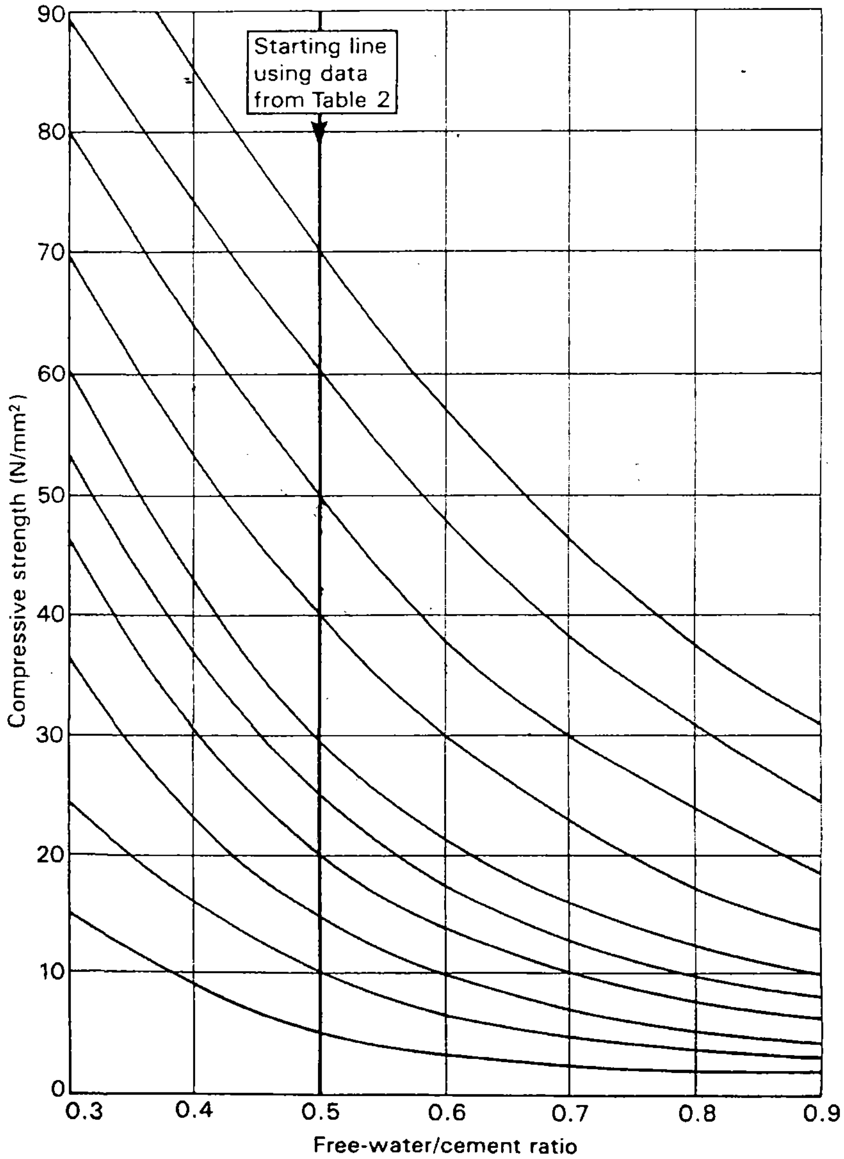

Figure 4 Relationship between compressive strength and free-water/cement ratio

APPENDIX/LAMPIRAN

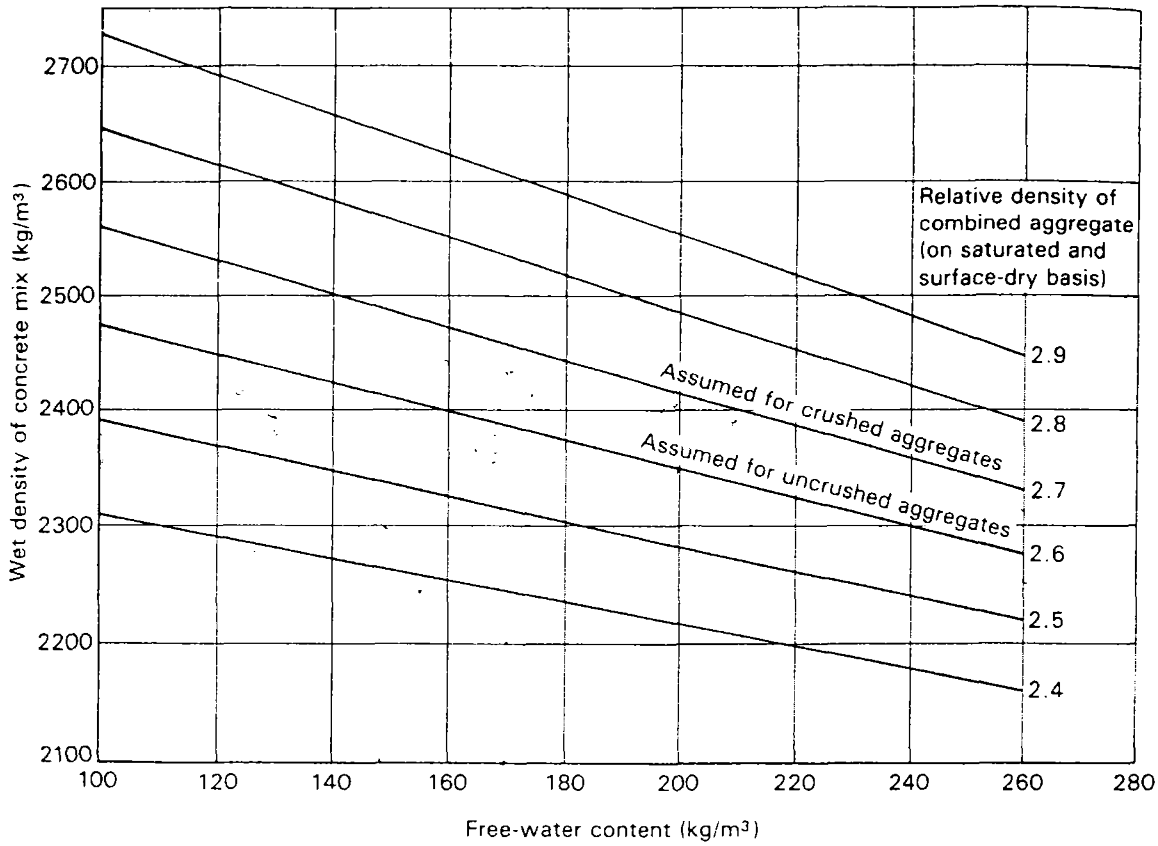

Figure 5 Estimated wet density of fully compacted concrete

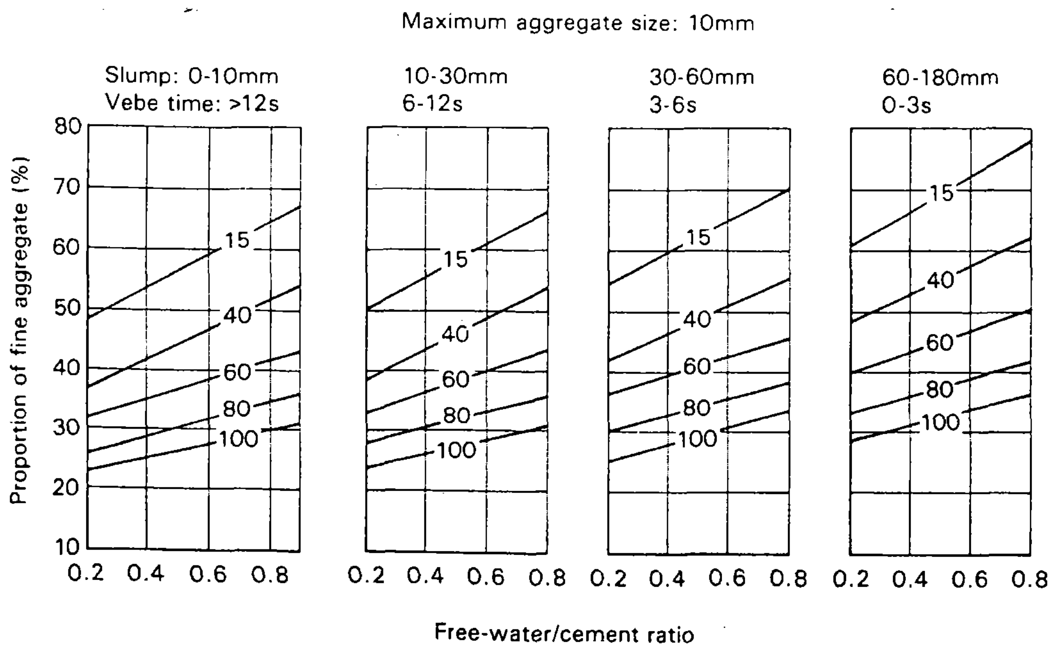

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

APPENDIX/LAMPIRAN

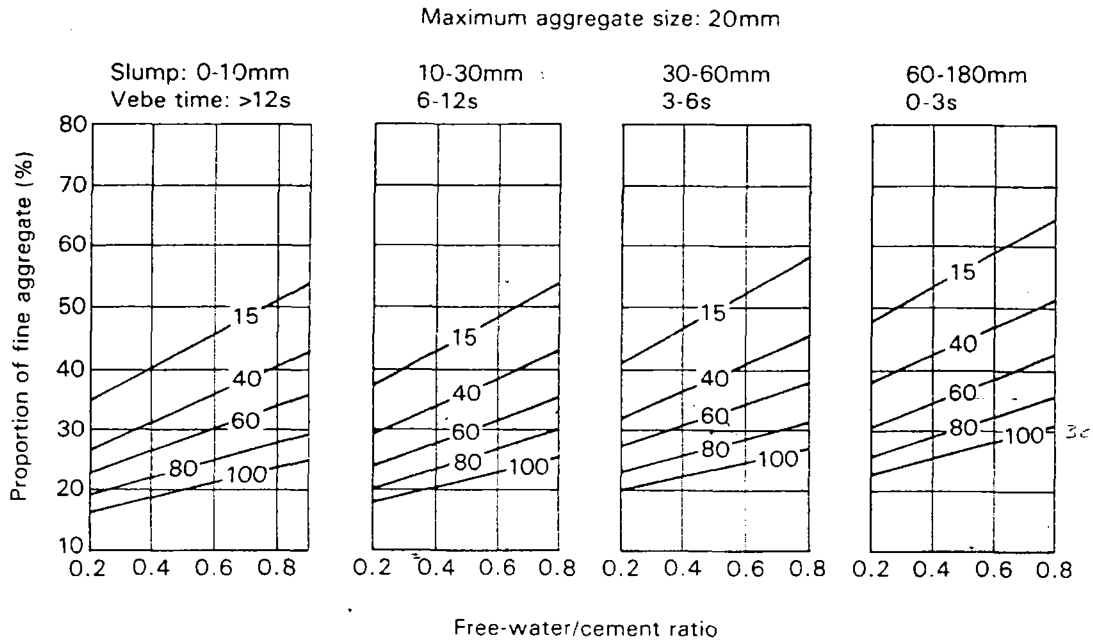

Figure 6 *(continued)*

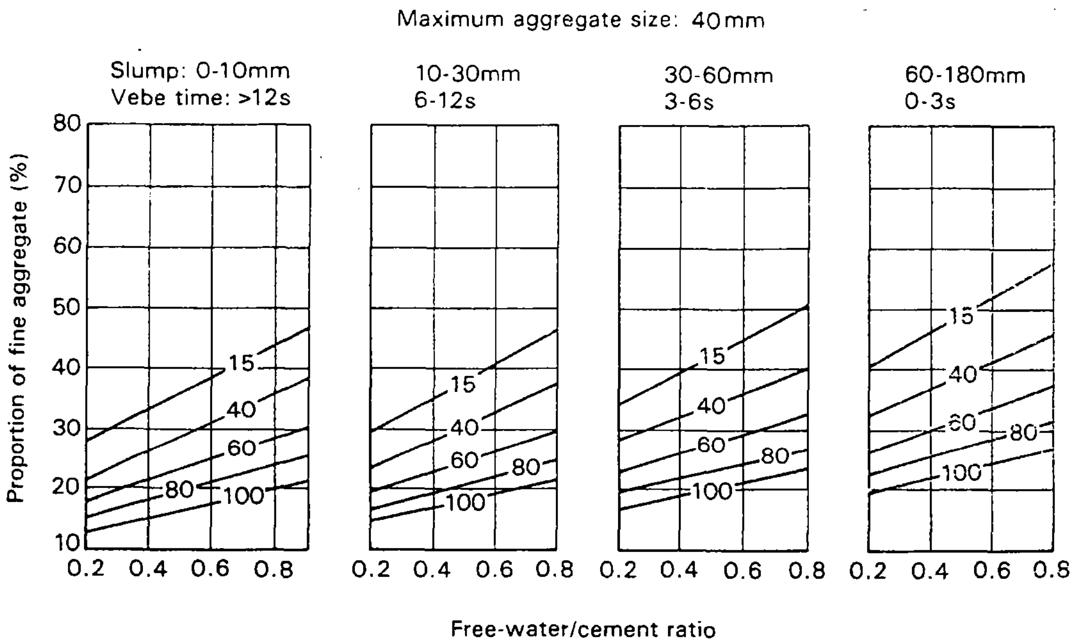

Figure 6 *(continued)*

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