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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]*

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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 (gypsum) 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)

*(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  $\text{Ca}(\text{OH})_2$  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  $1686 \text{ kg/m}^3$  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  $1686 \text{ kg/m}^3$  dan graviti tentu dalam keadaan permukaan kering tepu adalah 2.65, tentukan kandungan lompong.*

*(3 markah)*

3. (a) Give the appropriate definition for admixture according to ASTM. (5 marks)

*Berikan definisi 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;  $370 \text{ kg/m}^3$  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;  $370 \text{ kg/m}^3$  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 ketahanan lasakan 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  $0.065 \text{ m}^3$ . 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 600 $\mu\text{m}$  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  $0.065 \text{ m}^3$ . 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  $\mu\text{m}$ : 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  $1 \text{ m}^3$  and for the trial mix of  $0.065 \text{ m}^3$ .

(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  $1 \text{ m}^3$  dan untuk campuran cubaan  $0.065 \text{ m}^3$ .*

(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. Penjujukan
- (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 berbantuan rajah, terangkan secara ringkas lengkung 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 berbantuan rajah.* (8 markah)

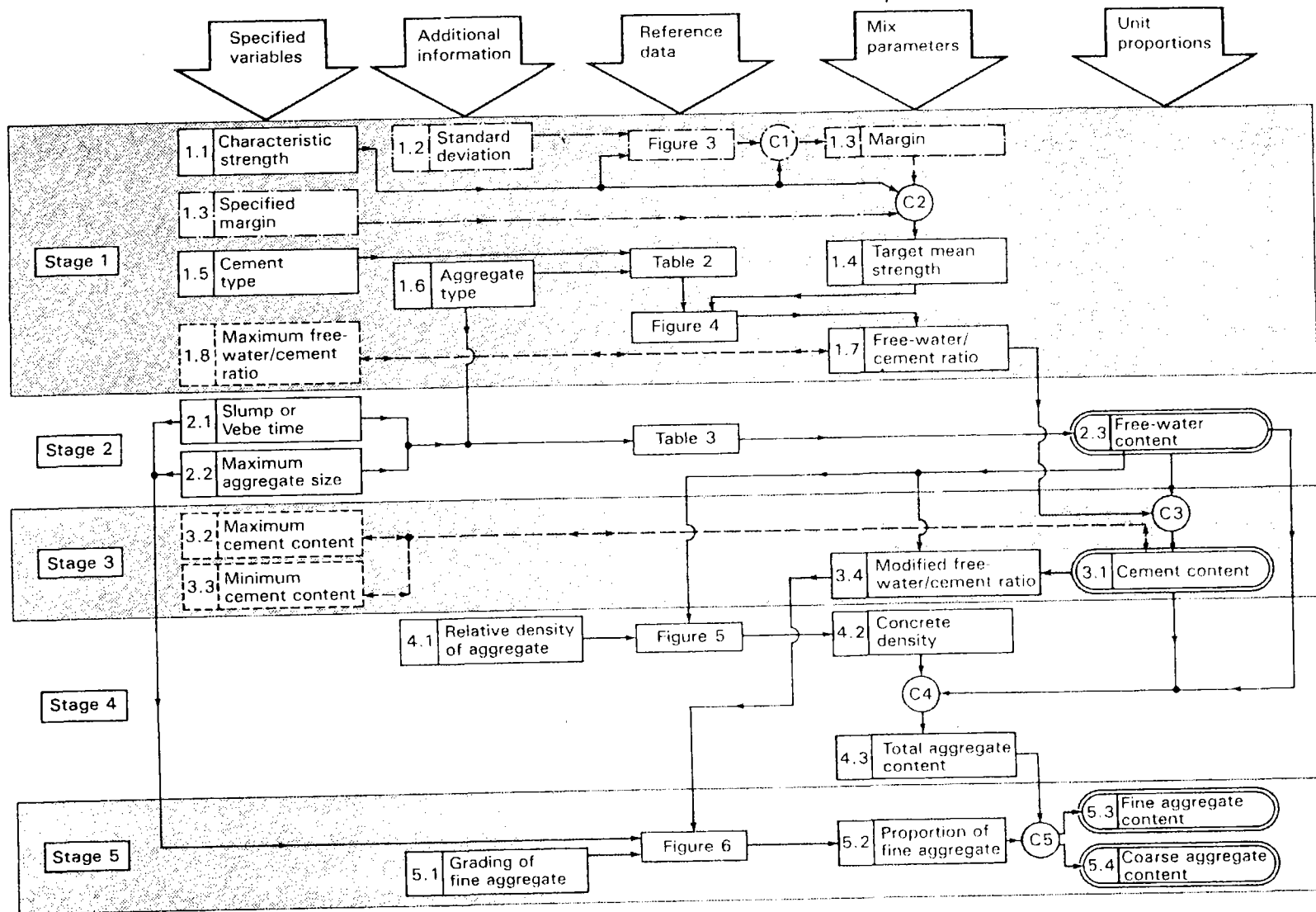


Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation  
Items in chain-dotted boxes are alternatives

...8/-

Concrete mix design form

Job title .....

Stage	Item	Reference or calculation	Values
1	1.1 Characteristic strength	Specified	_____ N/mm <sup>2</sup> at _____ days Proportion defective _____ %
	1.2 Standard deviation	Fig 3	_____ N/mm <sup>2</sup> or no data _____ N/mm <sup>2</sup>
	1.3 Margin	C1 or Specified	(k = _____) _____ × _____ = _____ N/mm <sup>2</sup> _____ N/mm <sup>2</sup>
	1.4 Target mean strength	C2	_____ + _____ = _____ N/mm <sup>2</sup>
	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 <input type="text"/>
1.8 <i>Maximum free-water/cement ratio</i>	<i>Specified</i>	_____ } _____ } Use the lower value <input type="text"/>	
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 <sup>3</sup> <input type="text"/>
	3.1 Cement content	C3	_____ + _____ = _____ kg/m <sup>3</sup>
3.2 <i>Maximum cement content</i>	<i>Specified</i>	_____ kg/m <sup>3</sup>	
3.3 <i>Minimum cement content</i>	<i>Specified</i>	_____ kg/m <sup>3</sup> use 3.1 if ≤ 3.2 use 3.3 if > 3.1	
3.4 Modified free-water/cement ratio		_____ <input type="text"/>	
4	4.1 Relative density of aggregate (SSD)		_____ known/assumed
	4.2 Concrete density	Fig 5	_____ kg/m <sup>3</sup>
	4.3 Total aggregate content	C4	_____ - _____ - _____ = _____ kg/m <sup>3</sup>
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 <sup>3</sup>
	5.4 Coarse aggregate content		_____ - _____ = _____ kg/m <sup>3</sup>

Quantities	Cement (kg)	Water (kg or L)	Fine aggregate (kg)	Coarse aggregate (kg)		
				10 mm	20 mm	40 mm
per m <sup>3</sup> (to nearest 5 kg)	_____	_____	_____	_____	_____	_____
per trial mix of _____ m <sup>3</sup>	_____	_____	_____	_____	_____	_____

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

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

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

**Table 3** Approximate free-water contents (kg/m<sup>3</sup>) required to give various levels of workability

Slump (mm)	0-10	10-30	30-60	60-180	
Vebe time(s)	>12	6-12	3-6	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:

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

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:

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

(saturated and surface-dry)

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

\*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.

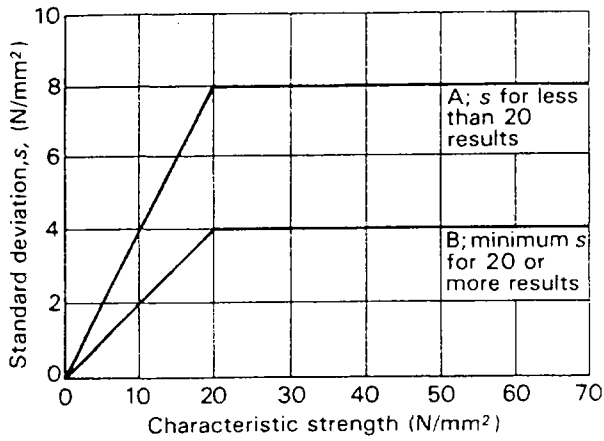


Figure 3 Relationship between standard deviation and characteristic strength

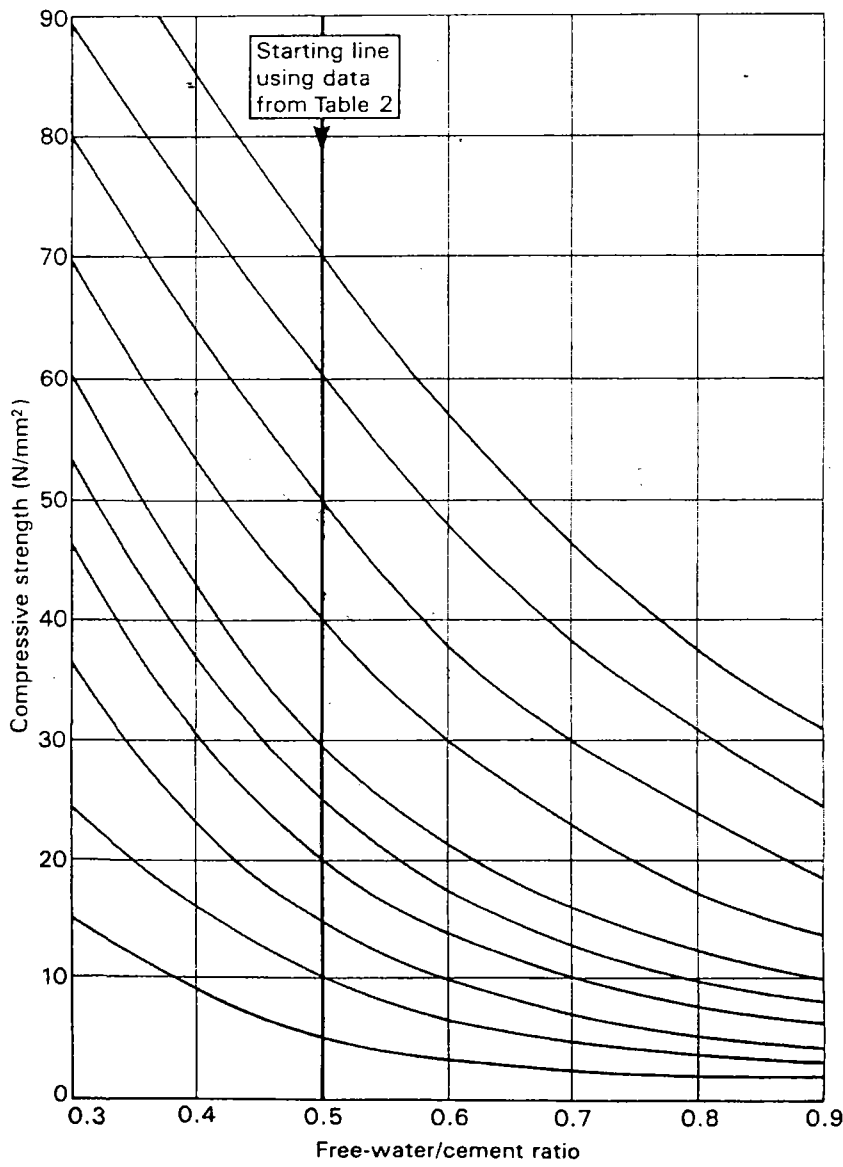


Figure 4 Relationship between compressive strength and free-water/cement ratio

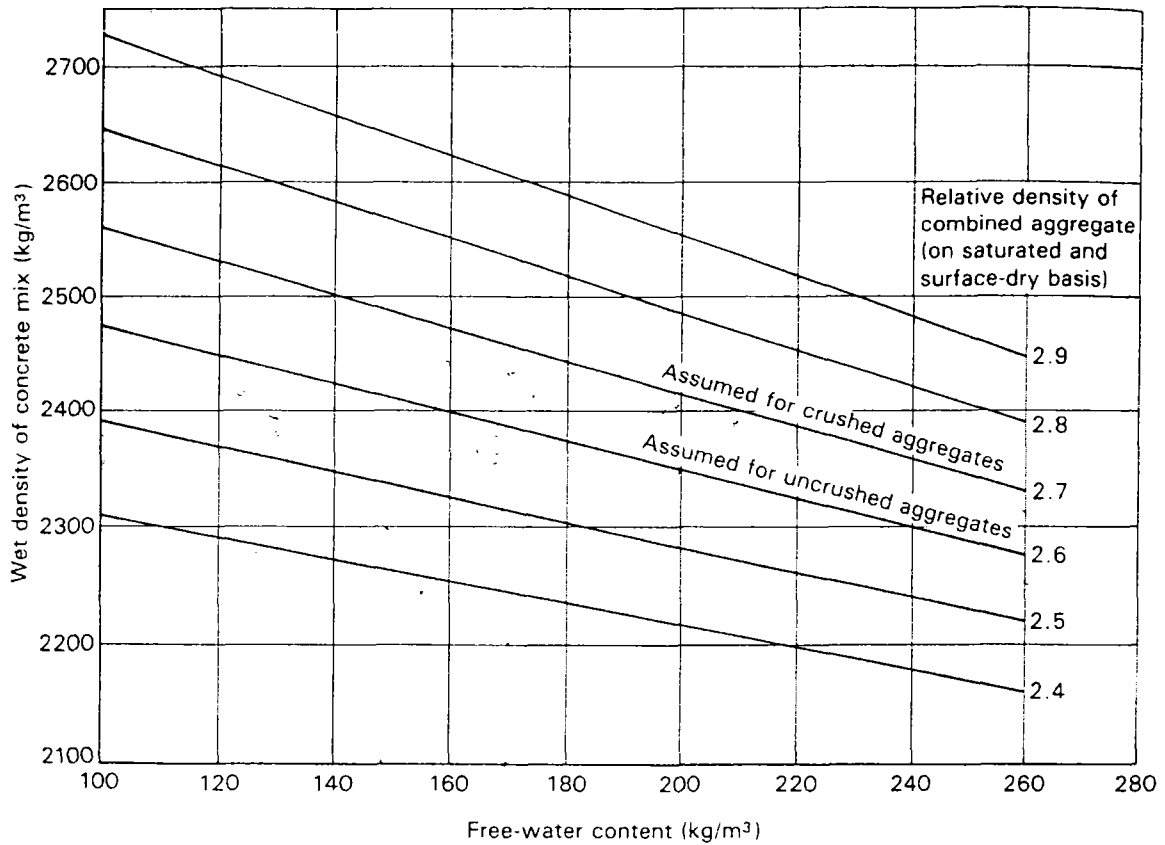


Figure 5 Estimated wet density of fully compacted concrete

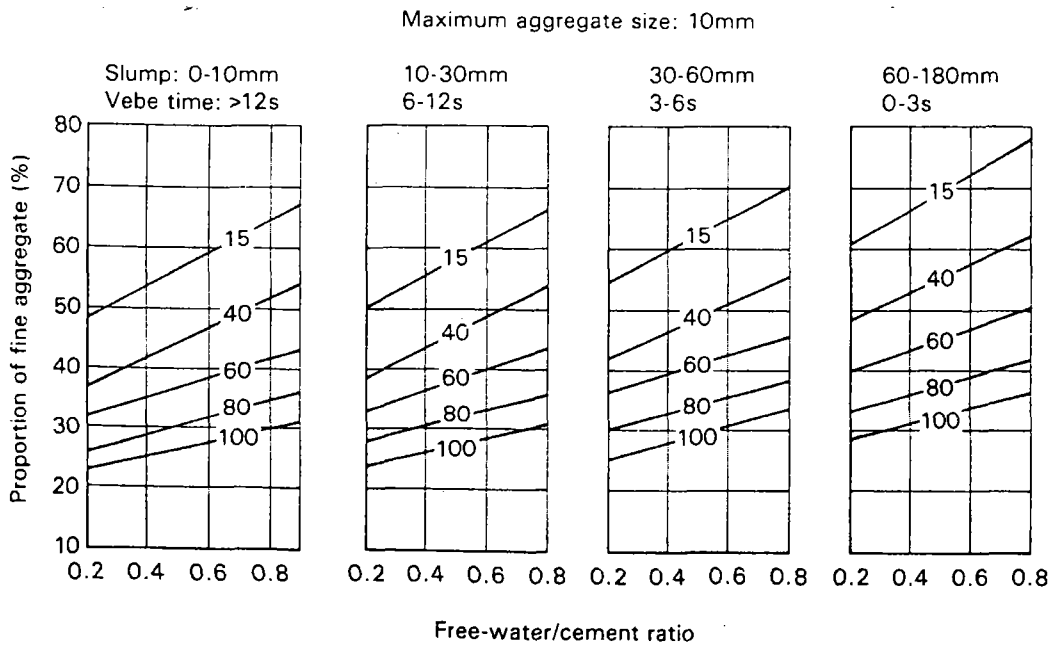


Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve