UNIVERSITI SAINS MALAYSIA

$2^{nd.}$ Semester Examination
2004/2005 Academic Session
Peperiksaan Semester Kedua
Sidang Akademik 2004/2005

March 2005

EAS 181/2 – Concrete Technology
EAS 181/2– Teknologi Konkrit

Duration: 2 hours
Masa : 2 jam

Instructions to candidates:
Arahan kepada calon:

1. Ensure that this paper contains **THIRTEEN (13)** printed pages included attachment.
Sila pastikan kertas peperiksaan ini mengandungi TIGA BELAS (13) muka surat bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.

2. This paper contains **FIVE (5)** questions. Answer **FOUR (4)** questions only. Marks will be given to the **FIRST FOUR (4)** questions put in order on the answer script and **NOT** the **BEST FOUR (4)**
Kertas ini mengandungi LIMA (5) soalan. Jawab EMPAT (4) soalan sahaja. Markah hanya akan dikira bagi EMPAT (4) jawapan PERTAMA yang dimasukkan di dalam buku mengikut susunan dan bukannya EMPAT (4) jawapan terbaik.

3. All questions **CAN BE** answered in English or Bahasa Malaysia or combination of both languages.
Semua soalan boleh dijawab dalam Bahasa Inggeris atau Bahasa Malaysia ataupun kombinasi kedua-dua bahasa.

4. All question **MUST BE** answered on a new sheet.
Semua jawapan MESTILAH dijawab pada muka surat yang baru.

5. 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) Dengan berbantukan graf yang sesuai, jelaskan peranan empat komposisi sebatian utama simen terhadap kekuatan.

(a) With the aid of an appropriate graph, explain the role of the four main compound compositions of cement towards strength.

(8 markah)

Jadual 1.0 - Komposisi Oksida Simen Portland

Komposisi Oksida, (%)	
CaO	63
SiO_2	20
Al_2O_3	3.5
Fe_2O_3	3.8
MgO	1.5
SO_3	2
K_2O, Na_2O}	1
Others	1
Loss on ignition	2
Insoluble residue	0.5

(b) Dengan menggunakan data di Jadual 1.0, dan persamaan-persamaan Bogue di bawah, tentukan komposisi sebatian bagi simen Portland di atas. Berdasarkan komposisi sebatian yang anda dapati, nyatakan kemungkinan jenis simen Portland di atas; berikan justifikasi yang sesuai.

(b) Using the data in Table 1.0, and the Bouge's equations below, calculate the compound compositions of the Portland cement. Based on the compound compositions obtained, state the probable type of the above Portland cement; give your justification.

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

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

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

$C_4AF = 3.04(Fe_2O_3)$

(8 markah)

(c) Jelaskan perbezaan-perbezaan di antara simen Portland biasa, simen Portland tahan sulfat dan simen Portland cepat keras dari aspek komposisi sebatian, kehalusan dan penggunaan.

(c) Explain the differences between ordinary Portland cement, Sulphate Resisting Portland cement and Rapid Hardening Portland cement in term of compound compositions, fineness and usage.

(9 markah)

2. (a) Dengan menggunakan lakaran-lakaran yang sesuai, jelaskan **EMPAT (4)** keadaan lembapan yang mungkin bagi agregat. Dengan merujuk lakaran-lakaran yang sama, jelaskan apakah yang dimaksudkan dengan penyerapan air dan kandungan lembapan.

   (a) By using appropriate sketches, explain the ***FOUR (4)*** *probable moisture conditions of aggregate. Referring to the same sketches, explain the meaning of water absorption and moisture content.*

   (10 markah)

   (b) Tentukan modulus kehalusan bagi agregat halus daripada data analisis ayakan yang diberikan di Jadual 2.0. Daripada nilai modulus kehalusan yang didapati, berikan komen anda tentang penggredan agregat halus berkenaan.

   (b) Determine the fineness modulus of the fine aggregate from the sieve analysis data given in Table 2.0. From the fineness modulus obtained, give your comment regarding the grading of the fine aggregate.

   (10 markah)

Jadual 2.0 - Penggredan Agregat Halus

Saiz Ayak	Berat Tertahan (g)
10 mm	0
5 mm	0
2.36 mm	0
1.18 mm	2.8
600 μm	10.1
300 μm	259.2
150 μm	173.1
Pan	8.9

   (c) Jelaskan **DUA (2)** faktor yang selalunya menjadi had kepada saiz maksima agregat yang boleh digunakan di dalam konkrit.

   (c) Explain ***TWO (2)*** *limiting factors that govern the maximum size of aggregate that can be used in concrete.*

   (5 markah)

3. (a) Jelaskan apakah yang dimaksudkan dengan "bahan pozzolan".

(a) Explain what is meant by "pozzolanic material".

(4 markah)

(b) Senaraikan **EMPAT (4)** bahan tambah kimia yang selalu digunakan di dalam kerja pengkonkritan. Bagi tiap-tiap bahan tambah kimia, jelaskan peranan masing-masing.

*(b) List **FOUR (4)** commonly used chemical admixtures in concrete. For each chemical admixture, explain its role.*

(8 markah)

(c) Penggunaan abu terbang (*fly ash*) selalunya dikaitkan dengan kesan pengurangan keperluan air bancuhan konkrit sehingga 15 %.

i. Jelaskan bagaimana kesan ini boleh berlaku.

ii. Satu campuran konkrit dengan kandungan simen Portland biasa; 370 kg/m^3 dan nisbah air/simen; 0.6 memberikan nilai penurunan 75 mm. Sekiranya 30 % daripada kandungan simen digantikan dengan abu terbang, tentukan kandungan air bagi bancuhan konkrit berkenaan untuk mendapatkan nilai penurunan yang sama (75 mm). Anggapkan bahawa pada tahap penggantian 30 %, keperluan air berkurangan sebanyak 15%.

iii. Sekiranya nisbah air simen yang sama (0.6) dikekalkan bagi campuran konkrit yang mengandungi 30 % abu terbang, jelaskan kesan yang anda jangkakan kepada kebolehkerjaan.

(c) The use of fly ash is normally associated with a reduction in water demand of concrete up to about 15 %.

i. Explain how this effect could occur.

ii. A concrete mixture containing ordinary Portland cement; 370 kg/m^3 and water/cement ratio; 0.6 exhibits a slump value of 75 mm. If 30 % of the cement content is replaced with fly ash, determine the water content for the concrete mixture to give constant workability (75 mm slump). Assume that at 30 % replacement level, water requirement reduces by 15 %.

iii. If the same water/binder ratio of 0.6 is maintained for the concrete containing 30 % fly ash, explain the expected effect to workability.

(9 markah)

(d) Jelaskan apakah yang dimaksudkan dengan kesan penghalusan liang atau kesan pengisian liang yang selalunya dikaitkan dengan penggunaan bahan tambah mineral.

(d) Explain what is meant by pore refinement effect or pore filling effect that is normally associated with the use of mineral admixture.

(4 markah)

4. 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 0.035 m^3.

Kekuatan ciri: 25 MPa at 28 days
Peratus kecacatan: 5 %
Sisihan Piawai: 4 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: 60 – 180 mm
Saiz maksima agregat: 20 mm
Ketumpatan relatif agregat (SSD): 2.7
Peratusan pasir melepasi ayak 600 µm: 60 %

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 0.035 m^3.

Characteristic strength: 25 MPa at 28 days
Proportion defective: 5 %
Standard deviation: 4 MPa
Cement type: Ordinary Portland cement
Aggregate type (coarse): Granite; Aggregate type (fine): river sand
Maximum free water/cement ratio: 0.50
Slump: 60 -180 mm
Maximum aggregate size: 20 mm
Relative density of aggregate (SSD): 2.7
Percentage passing 600 µm sieve: 60 %

(25 markah)

5. (a) Jelaskan secara ringkas apakah yang dimaksudkan dengan ciri-ciri konkrit segar berikut:

   i. Kebolehkerjaan
   ii. Pengasingan
   iii. Kejelekitan
   iv. Penjujuhan
   v. Kehilangan penurunan

   (a) Explain briefly what is meant by the following characteristics of fresh concrete:

   i. Workability
   ii. Segregation
   iii. Cohesiveness
   iv. Bleeding
   v. Slump loss

(10 markah)

   (b) Bincangkan bagaimana faktor-faktor berikut boleh meningkatkan kekuatan dan ketahanlasakan konkrit konkrit:

   i. Nisbah air/pengikat
   ii. Penggunaan bahan tambah mineral

   (b) Discuss how the following factors could enhance strength and durability of concrete:

   i. Water/binder ratio
   ii. The use of mineral admixture

(10 markah)

   (c) Beberapa spesimen konkrit yang telah di salut (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. Tuliskan ungkapan yang sesuai untuk rayapan bagi spesimen-spesimen konkrit yang terlibat.

   ii. Sekiranya jumlah terikan yang diukur pada umur t, $\varepsilon = 398 \times 10^{-6}$, $\sigma_0 = 12$ N/mm^2, E = 35.6 GPa, kenaikan suhu = 25 °C, dan pekali pengembangan haba = 8×10^{-6}/°C, tentukan terikan rayapan.

...7/-

(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 ($t > t_0$).*

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

ii. *If the total measured strain at the age of t, $\varepsilon = 398 \times 10^{-6}$, $\sigma_0 = 12$ N/mm^2, E = 35.6 GPa, temperature rise = 25 °C, and coefficient of thermal expansion = 8×10^{-6}/°C, determine the creep strain.*

(5 markah)

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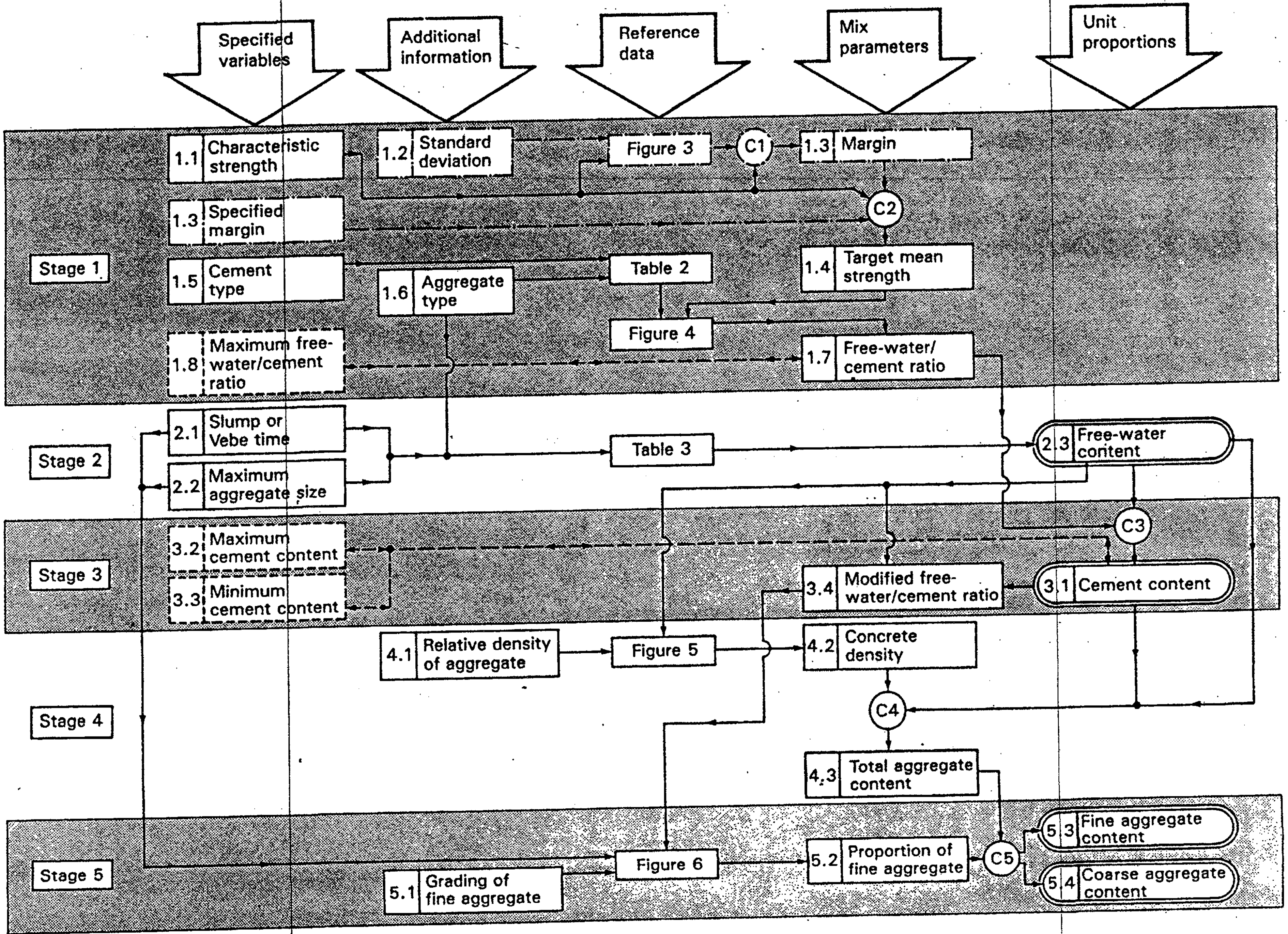

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

Concrete mix design form **LAMPIRAN**

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.

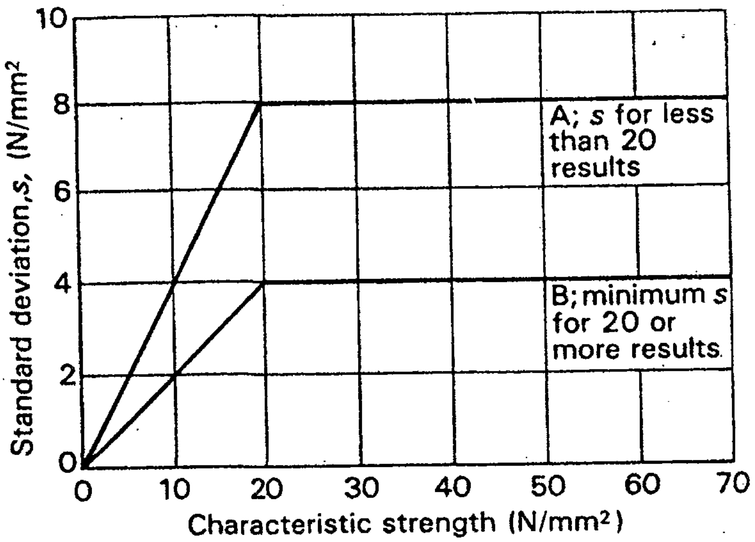

Figure 3 Relationship between standard deviation and characteristic strength

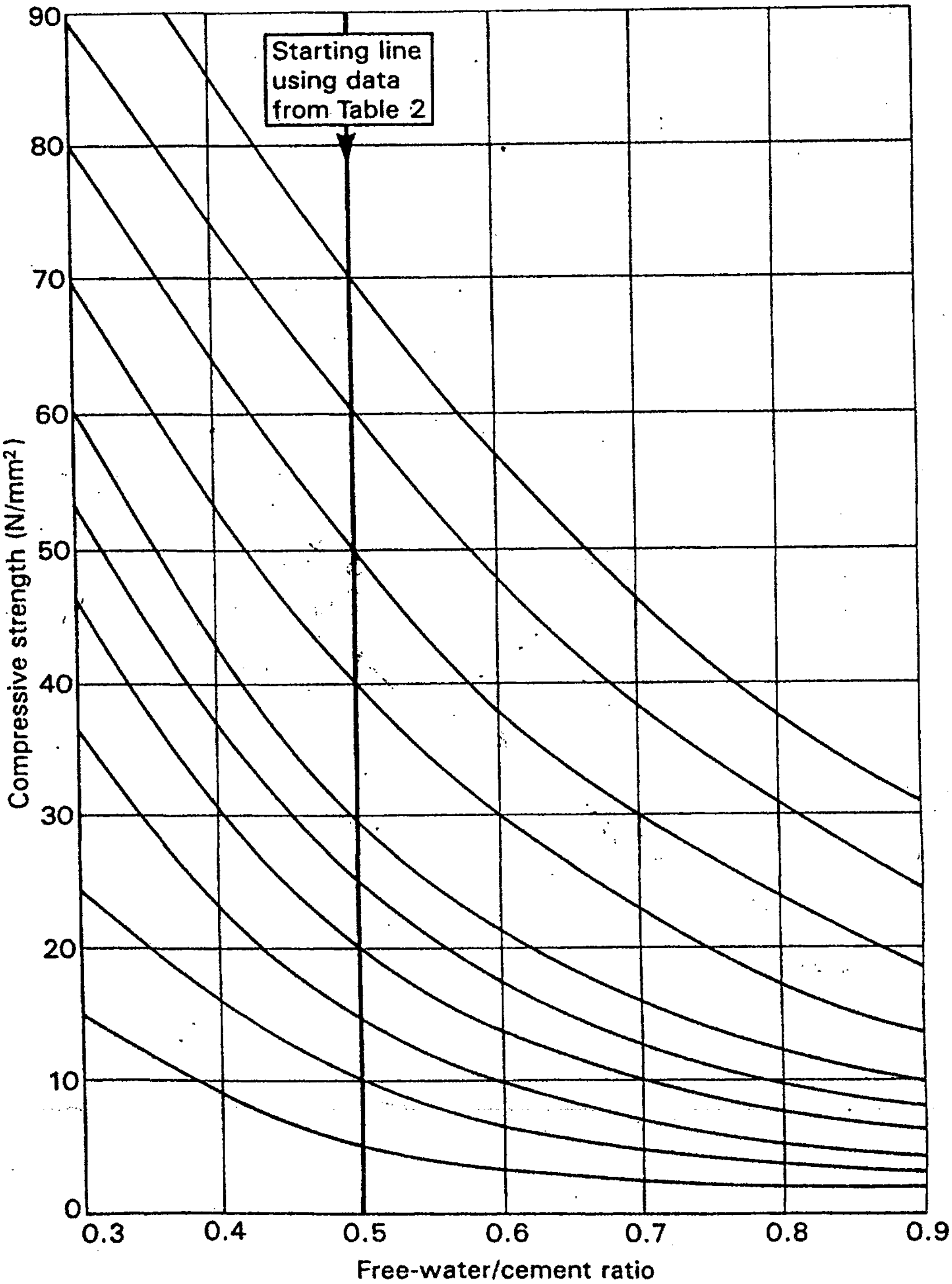

Figure 4 Relationship between compressive strength and free-water/cement ratio

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:

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

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/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.

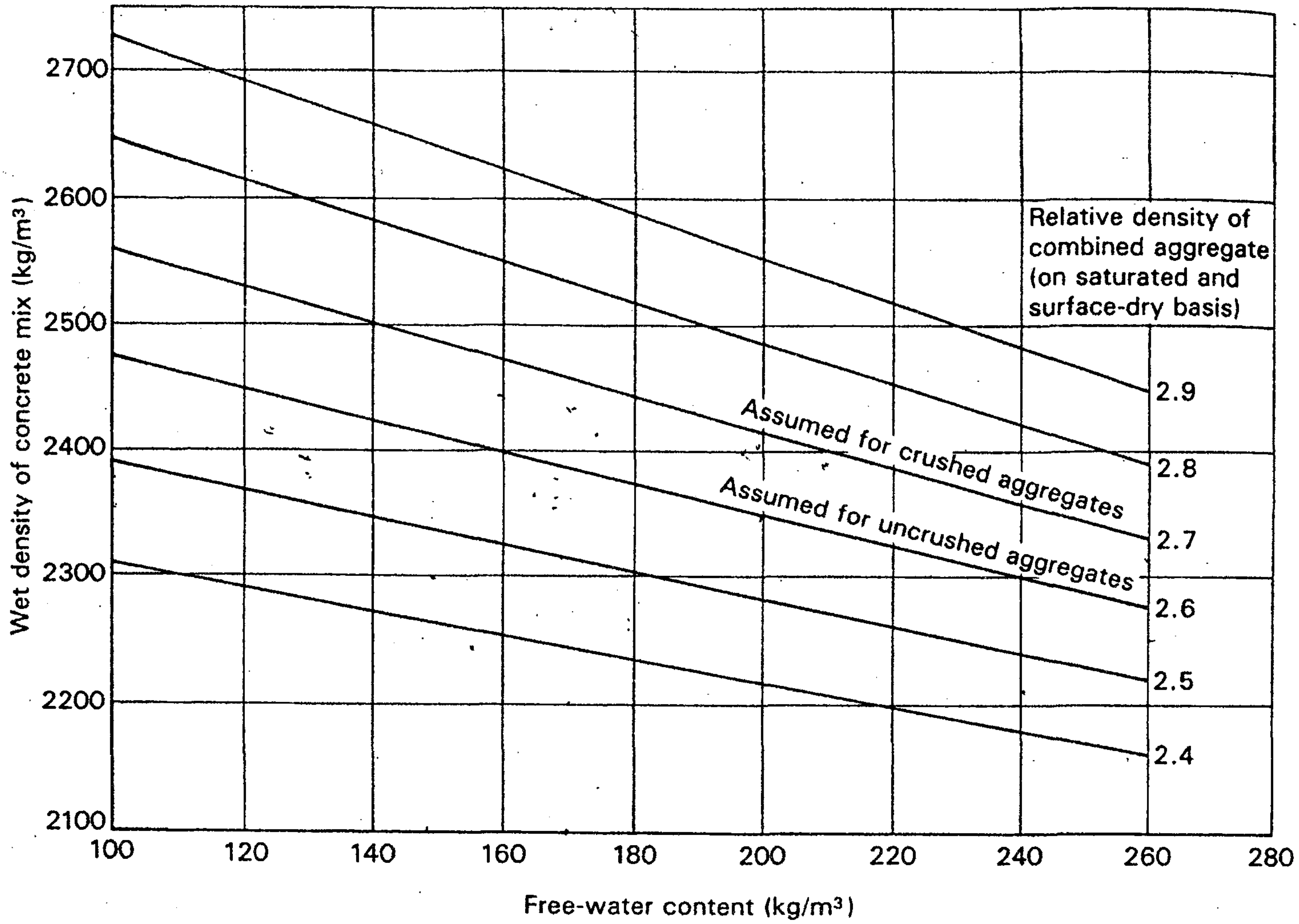

Figure 5 Estimated wet density of fully compacted concrete

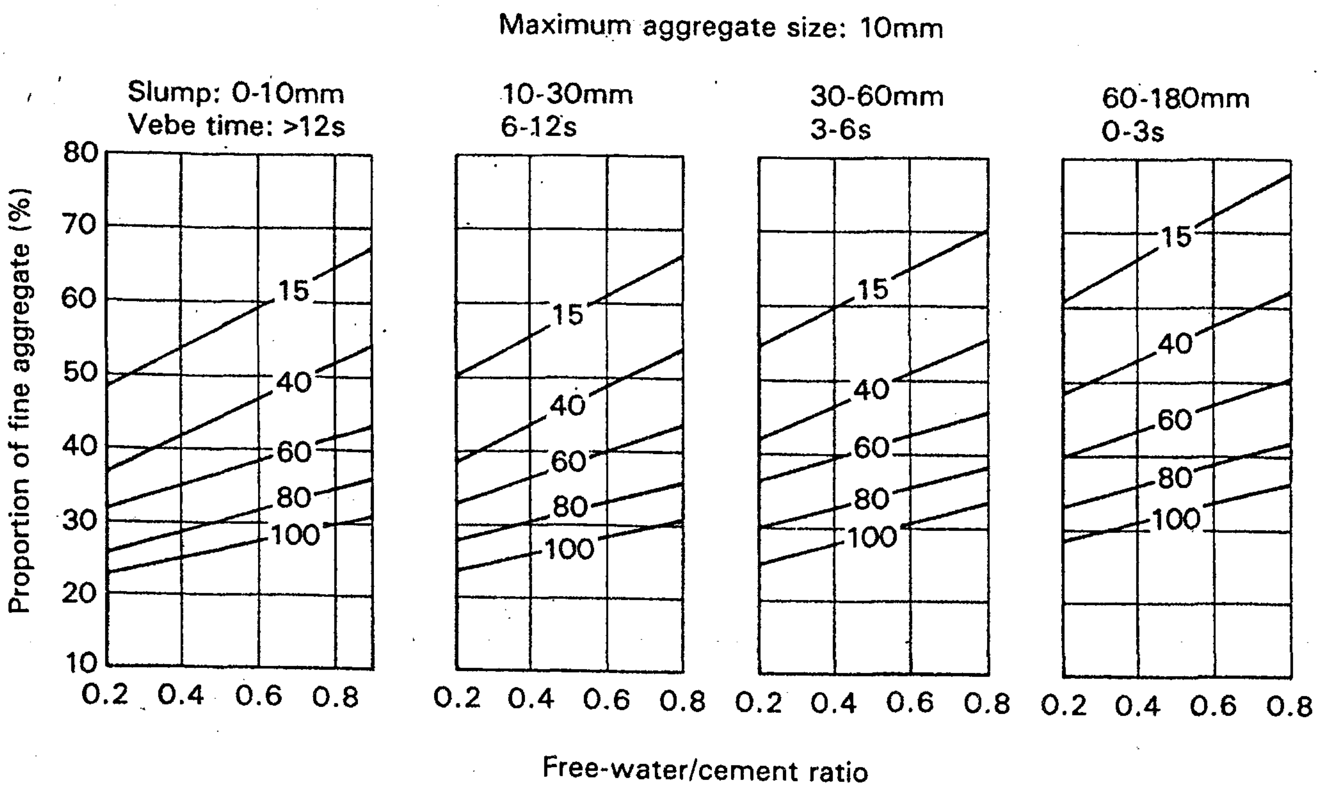

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

Maximum aggregate size: 20mm

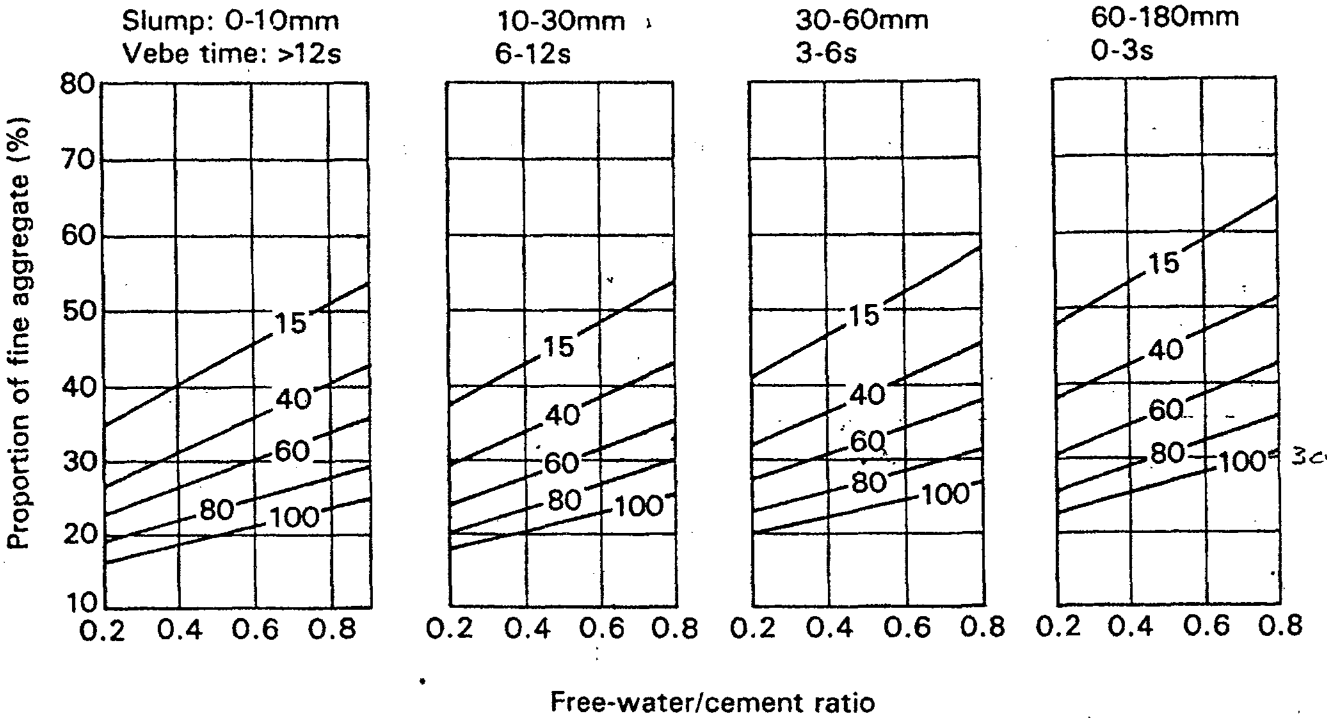

Figure 6 *(continued)*

Maximum aggregate size: 40mm

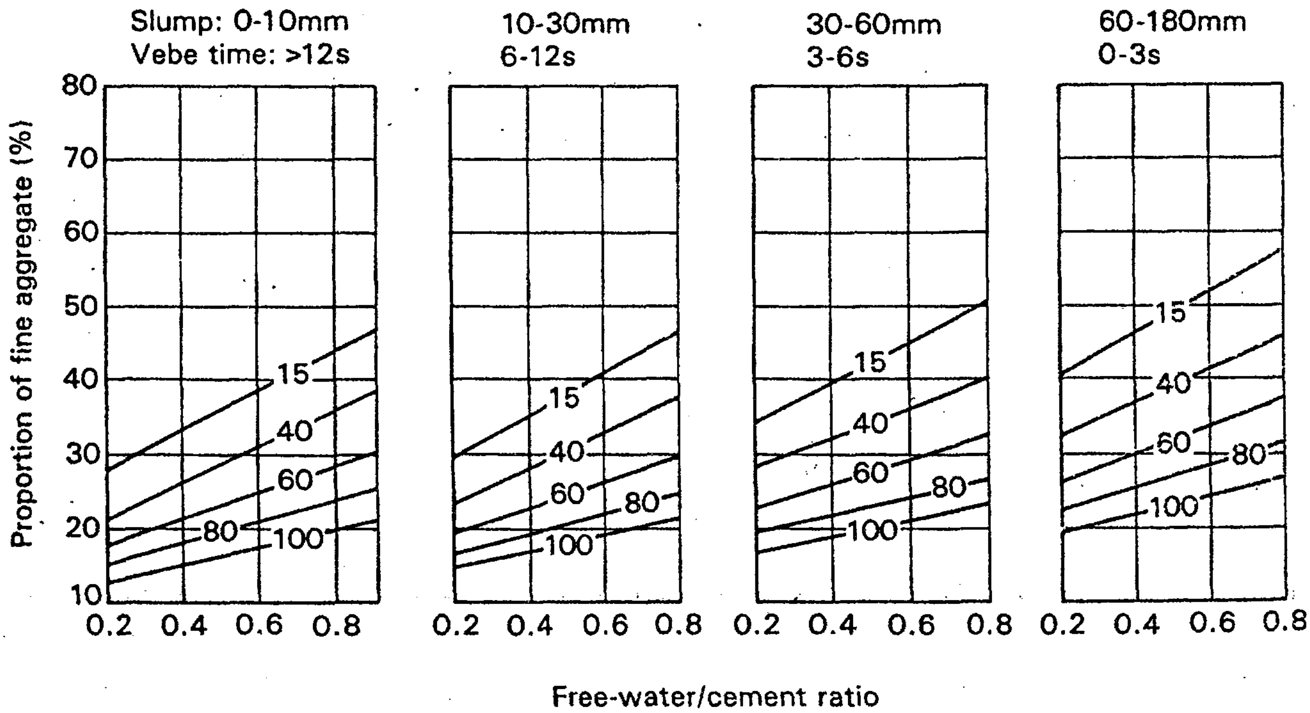

Figure 6 *(continued)*