UNIVERSITI SAINS MALAYSIA

Second Semester Examination
2010/2011 Academic Session

April/May 2011

EAS 181/2 – Concrete Technology
[*Teknologi Konkrit*]

Duration : 2 hours
[*Masa : 2 jam*]

Please check that this examination paper consists of **SIXTEEN (16)** pages of printed material including appendices before you begin the examination.
[*Sila pastikan bahawa kertas peperiksaan ini mengandungi* ***ENAM BELAS (16)*** *muka surat yang bercetak termasuk lampiran sebelum anda memulakan peperiksaan ini.*]

Instructions : This paper contains **SIX (6)** questions. Answer **FOUR (4)** questions.
[***Arahan*** *: Kertas ini mengandungi* ***ENAM (6)*** *soalan. Jawab* ***EMPAT (4)*** *soalan.*

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*].

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. As a technical manager for a cement production plant, you are responsible to ensure the smooth running of the cement plant and the compliance of the cements produced with all the relevant requirements which could differ from one type of cement to another. Parts of the parent company's recent transformation plans are to reduce the carbon footprint of the cement plant, to reduce the consumption of the non-renewable natural resources required for producing cement, to reduce the price of cement without compromising quality, as well as to ensure sustainability of the concrete industry. One of the key strategies to realize the agenda is to maximize the production of blended cement by using suitable waste or by-product materials. One of the by-products that you would consider is blast-furnace slag, a by-product obtained from the production of iron from iron oxide in a blast-furnace.

   (a) Explain the whole production process of the blended blast-furnace slag cement, use appropriate flowchart to aid your explanation. Describe how the process is different from the typical production of ordinary Portland cement.

   [12 marks]

   (b) Discuss the main characteristic of the blended cement produced in (a) that makes it ideal to be used for concreting involving mass concrete such as in the construction of dam.

   [8 marks]

   (c) Explain other technique that can be utilized by cement producers to produce cement having similar characteristic as explained in (b).

   [5 marks]

2. (a) A construction of a school building involving reinforced concrete has been proposed in a remote area where domestic water supply system is not available. Water sample from a nearby pond has been obtained and tested to assess its suitability as mixing water for concrete and the test results are given in Table 1. Based on the test results, discuss the suitability of the water sample as concrete mixing water.

Table 1: Results of tests performed on water

	28-day Compressive strength of standard mortar (MPa)		Initial setting time of cement (minutes)	
	Distilled water	Lake water	Distilled water	Lake water
Test 1	30	23	72	105
Test 2	31	20	78	122
Test 3	30	21	68	112
Mean	30.5	21.5	73	113

[8 marks]

(b) Two major roles of water are for chemical reaction with cement; i.e. to enable cement to hydrate; and to provide adequate workability to concrete to enable placing and compaction of concrete without undue bleeding and segregation. Nonetheless, pure cement paste requires only about 23 % water to undergo complete hydration. In reality, for a typical structural concrete, normally water content in excess of 50 % is used. Discuss the potential influence of the excess water than requires by cement for hydration on strength and durability performance of concrete.

[8 marks]

(c) Give the appropriate definition of admixture according to ASTM.

[4 marks]

(d) Explain how the use of superplasticiser could bring about positive effects on strength and durability performance of concrete.

[5 marks]

3. (a) As a technical manager for a ready mix concrete producer, you have to propose suitable concrete mix proportions for the construction of a school hall. 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 0.05 m^3. **Include the attachment used with your answer script.**

Characteristic strength: 35 MPa at 28 days
Specified margin: 5 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 μm sieve: 40 %

[20 marks]

(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 $1m^3$ and for the trial mix of 0.05 m^3.

[5 marks]

4. (a) Describe **THREE (3)** different classes of aggregates based on their bulk density.

[3 marks]

(b) In concrete mix design, the terms free water content and free water/cement ratio are used. Aggregates are always considered to be in saturated and surface dry (SSD) condition. Nonetheless, in reality, it is difficult to ensure that the aggregates are always in SSD condition. Discuss the potential influence of aggregates moisture conditions on water content of concrete and describe the measures that should are taken in concrete mix design practices if the moisture conditions of the aggregates are not SSD so that the terms free water content and free water/cement ratio remain accurate and relevant.

[8 marks]

(c) Representative sand sample from Sungai Perak has been delivered to USM, Concrete Laboratory for testing. The sample weighs 1015 g and 970 g in as received and oven-dried conditions, respectively. From sieve analysis, the calculated fineness modulus is 3.2. If the absorption capacity of the sand is 1.5 %, determine the percentage of free moisture. Explain the probable water requirement characteristic based on the calculated fineness modulus.

[6 marks]

(d) Discuss the principles behind the "aggregate ten percent fines value" and "aggregate impact value" tests which are often used as parts of aggregates compliance testing.

[8 marks]

5. A builder is constructing a multi-storey building at Nibong Tebal. A ready-mix concrete of 30MPa is used to construct the structural members of the multi-storey building. Before using the ready-mixed concrete in the construction activities, the concrete must be assessed by the site engineer.

(a) Explain how the workability could be assessed by the engineer before using the ready-mixed concrete. Sketch the different forms of slump.

[12 marks]

(b) Discuss the dominating factors which could affect the workability of fresh concrete.

[8 marks]

(c) List out the necessary measures to be taken when placing the concrete.

[5 marks]

6. (a) Explain briefly the need of *"green concrete technology"* in the construction industry.

[6 marks]

(b) Explain briefly how the slump loss could occur.

[5 marks]

(c) With the aid of flow chart, state the factors which could affect the strength of hardened concrete.

[4 marks]

(d) With the aid of appropriate diagram, explain the stress-strain behavior of concrete.

[10 marks]

1. *Sebagai pengurus teknikal bagi sebuah kilang simen, anda bertanggungjawap memastikan perjalanan lancar operasi kilang and pematuhan simen-simen yang dihasilkan terhadap keperluan-keperluan yang berkaitan yang mungkin berbeza dari satu jenis simen ke simen yang lain. Sebahagian daripada pelan transfomasi syarikat utama adalah mengurangkan jejak karbon kilang simen, mengurangkan pengambilan dan kebergantungan terhadap sumber alam yang tidak boleh diperbaharui untuk menghasilkan simen, mengurangkan harga simen tanpa menjejaskan kualiti dan juga memastikan kelestarian industri konkrit. Salah satu strategi penting untuk merealisasikan agenda ini adalah dengan memaksimakan penghasilan simen campuran (simen komposit) dengan menggunakan bahan sisa atau oleh-produk. Salah satu bahan oleh-produk yang anda akan pertimbangkan adalah jermang relau bagas, oleh-produk daripada proses pengeluaran besi daripada oksida besi menggunakan relau bagas.*

   (a) *Terangkan keseluruhan proses penghasilan simen campuran jermang relau bagas, gunakan carta alir yang sesuai untuk membantu penerangan anda. Jelaskan bagaimana proses penghasilannya berbeza daripada proses penghasilan simen Portland biasa.*

   [12 markah]

   (b) *Bincangkan ciri utama simen campuran yang dihasilkan seperti di (a) yang menjadikan ia ideal untuk digunakan dalam kerja konkrit yang melibatkan konkrit pukal seperti di dalam pembinaan empangan.*

   [8 markah]

   (c) *Terangkan teknik lain yang boleh digunakan oleh pengilang simen untuk menghasilkan simen dengan ciri-ciri yang sama seperti yang diterangkan di (b).*

   [5 markah]

2. (a) *Pembinaan sebuah sekolah melibatkan konkrit bertetulang telah dicadangkan di satu kawasan pedalaman di mana tidak terdapat sistem bekalan air domestik. Sampel air daripada sebuah kolam telah diperolehi dan diuji untuk menilai kesesuaian sebagai air bancuhan konkrit, dan keputusan ujian diberikan di Jadual 1. Berdasarkan keputusan-keputusan ujian yang telah dilakukan, bincangkan kesesuaian sampel air berkenaan sebagai air bancuhan konkrit.*

Jadual 1 : Keputusan ujian ke atas sampel air

	Kekuatan mampatan mortar piawai – 28 hari (MPa)		*Masa pemejalan awal simen (minit)*	
	Air suling	*Air tasik*	*Air suling*	*Air tasik*
Ujian 1	*30*	*23*	*72*	*105*
Ujian 2	*31*	*20*	*78*	*122*
Ujian 3	*30*	*21*	*68*	*112*
Purata	*30.5*	*21.5*	*73*	*113*

[8 markah]

(b) *Dua peranan utama air adalah untuk tindakbalas kimia dengan simen; iaitu untuk membolehkan simen menghidrat; dan untuk memberikan kebolehkerjaan yang sesuai kepada konkrit bagi membolehkan perletakan dan pemadatan konkrit tanpa mengalami penjujuhan dan pengasingan. Namun, adunan simen asli memerlukan kurang lebih 23 % air untuk membolehkan penghidratan berlaku dengan sempurna. Realitinya, bagi konkrit yang tipikal untuk struktur, kandungan air melebihi 50 % selalunya digunakan. Bincangkan kemungkinan pengaruh lebihan air daripada yang diperlukan oleh simen untuk menghidrat terhadap kekuatan dan prestasi ketahanlasakan konkrit.*

[8 markah]

(c) *Berikan definasi yang sesuai untuk bahan tambah berdasarkan ASTM.*

[4 markah]

(d) *Terangkan bagaimana penggunaan bahan super-pemplastikan (superplasticizer) boleh membawa kesan-kesan positif ke atas kekuatan dan prestasi ketahanlasakan konkrit.*

[5 markah]

3. (a) *Sebagai pegurus teknikal kepada pengeluar konkrit siap campur, anda bertanggungjawab untuk mencadangkan campuran konkrit yang sesuai bagi pembinaan sebuah dewan sekolah. 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 0.05 m^3.* ***Sertakan lampiran yang digunakan bersama kertas jawapan anda.***

Kekuatan ciri: 35 MPa at 28 days
Jidar: 5 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) *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 0.05m^3.*

[5 markah]

4. (a) *Jelaskan **TIGA (3)** kelas agregat yang berbeza berdasarkan ketumpatan pukal.*

[3 markah]

(b) *Dalam rekabentuk campuran konkrit, terminologi kandungan air bebas dan nisbah air/simen bebas digunakan. Agregat dianggapkan berada dalam keadaan permukaan kering tepu (SSD). Namun, secara realiti, adalah sukar untuk memastikan semua agregat berada dalam keadaan SSD. Bincangkan potensi pengaruh keadaan lembapan agregat terhadap kandungan air konkrit dan jelaskan langkah-langkah yang diambil dalam praktis rekabentuk campuran konkrit sekiranya keadaan lembapan agregat berbeza dari SSD, untuk memastikan terminologi kandungan air bebas dan nisbah air/simen bebas kekal tepat dan relevan.*

[8 markah]

(c) *Sampel pasir daripada Sungai Perak telah dihantar ke Makmal Konkrit, USM untuk ujian makmal. Sampel pasir berkenaan mempunyai jisim 1015 g dan 970 g, masing-masing untuk keadaan seperti diterima dan kering (oven-dried). Daripada analisa ayakan, modulus kahalusan yang ditentukan adalah 3.2. Sekiranya kapasiti penyerapan pasir adalah 1.5 %, tentukan peratusan lembapan bebas. Terangkan kemungkinan ciri-ciri keperluan air pasir berkenaan berdasarkan nilai modulus kehalusan.*

[6 markah]

(d) *Bincangkan prinsip-prinsip ujian "nilai hancur sepuluh peratus" dan "nilai hentaman agregat" yang selalunya digunakan sebagai sebahagian daripada ujian pematuhan agregat.*

[8 markah]

5. *Satu syarikat pembinaan sedang membina sebuah bangunan berbilang tingkat di Nibong Tebal. Konkrit siap campur 30 MPa digunakan untuk membina anggota struktur bangunan berkenaan. Sebelum menggunakan konkrit siap campur di dalam aktiviti pembinaan, konkrit tersebut perlu dinilai oleh jurutera tapak.*

(a) *Terangkan bagaimana tahap kebolehkerjaan boleh dinilai oleh jurutera sebelum menggunakan konkrit siap campur berkenaan. Lakarkan bentuk-bentuk runtuhan yang berlainan.*

[12 markah]

(b) *Bincangkan faktor-faktor utama yang boleh mempengaruhi kebolehkerjaan konkrit segar.*

[8 markah]

(c) *Senaraikan langkah-langkah yang perlu diambil semasa meletakkan konkrit.*

[5 markah]

2. (a) *Terangkan dengan ringkas keperluan "teknologi konkrit hijau" di dalam industri pembinaan.*

[6 markah]

(b) *Terangkan secara ringkas bagaimana kehilangan kebolehkerjaan boleh berlaku.*

[5 markah]

(c) *Dengan berbantukan carta alir, nyatakan faktor-faktor yang boleh mempengaruhi kekuatan konkrit.*

[4 markah]

(d) *Dengan berbantukan diagram yang sesuai, terangkan perlakuan tegasan-terikan konkrit.*

[10 markah]

Appendix 1
Lampiran 1

DOE CONCRETE MIX DESIGN

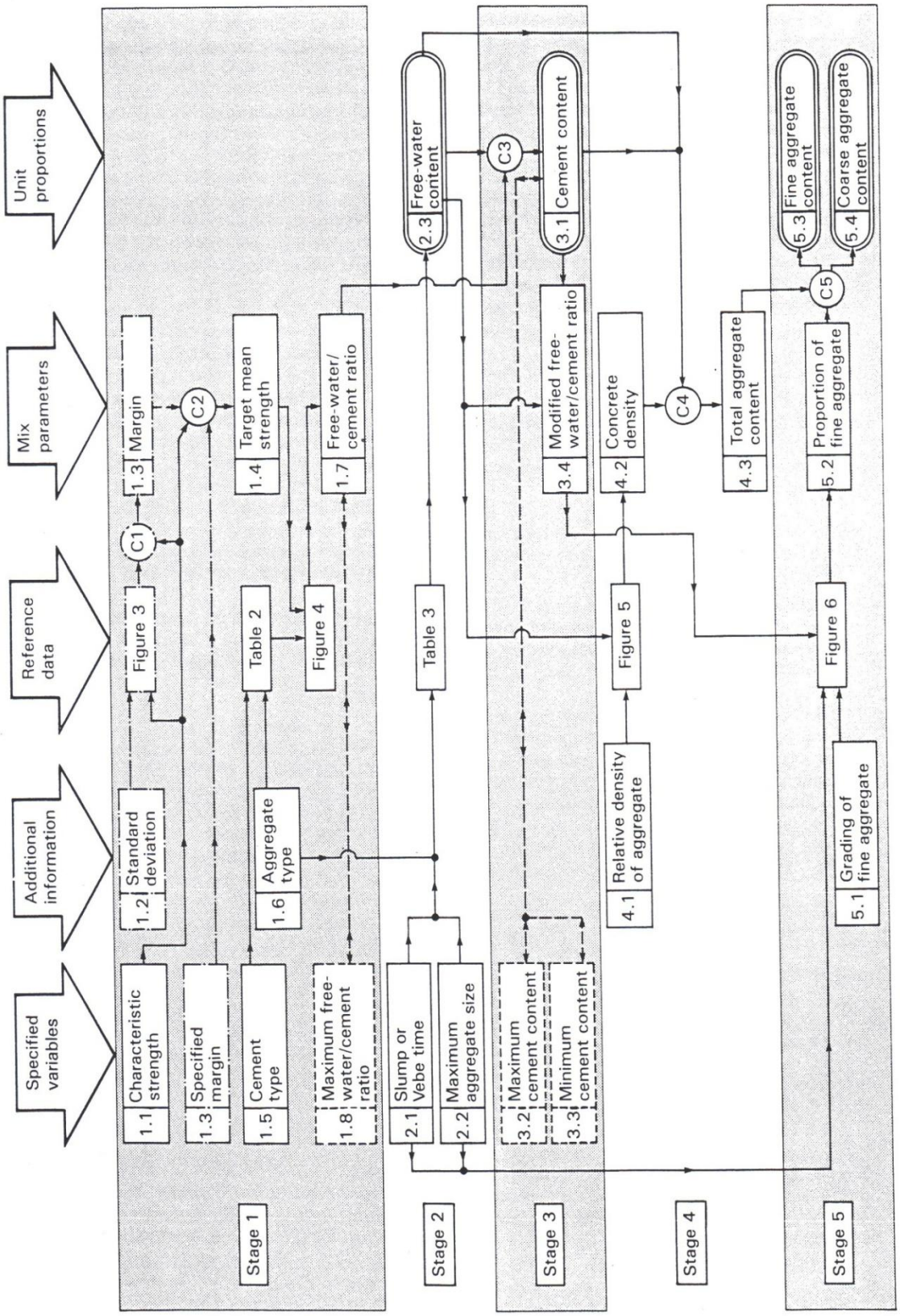

Figure 2 Flow chart of mix design procedure. Items in dashed boxes and with two-way arrows are optional limiting values that may be specified. C = calculation
Items in chain-dotted boxes are alternatives

Appendix 2
Lampiran 2

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.

Appendix 3
Lampiran 3

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.

Appendix 4
Lampiran 4

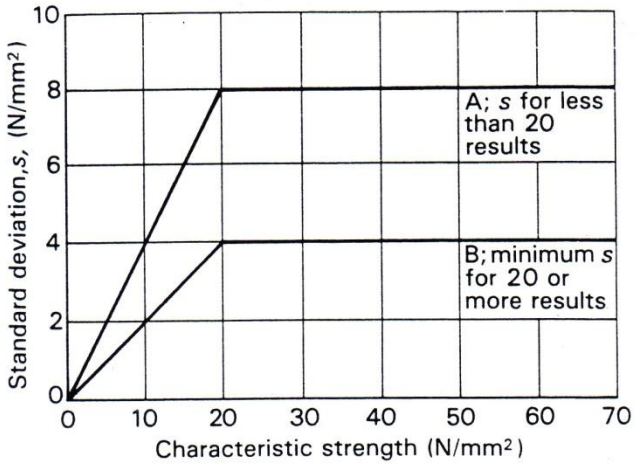

Figure 3 Relationship between standard deviation and characteristic strength

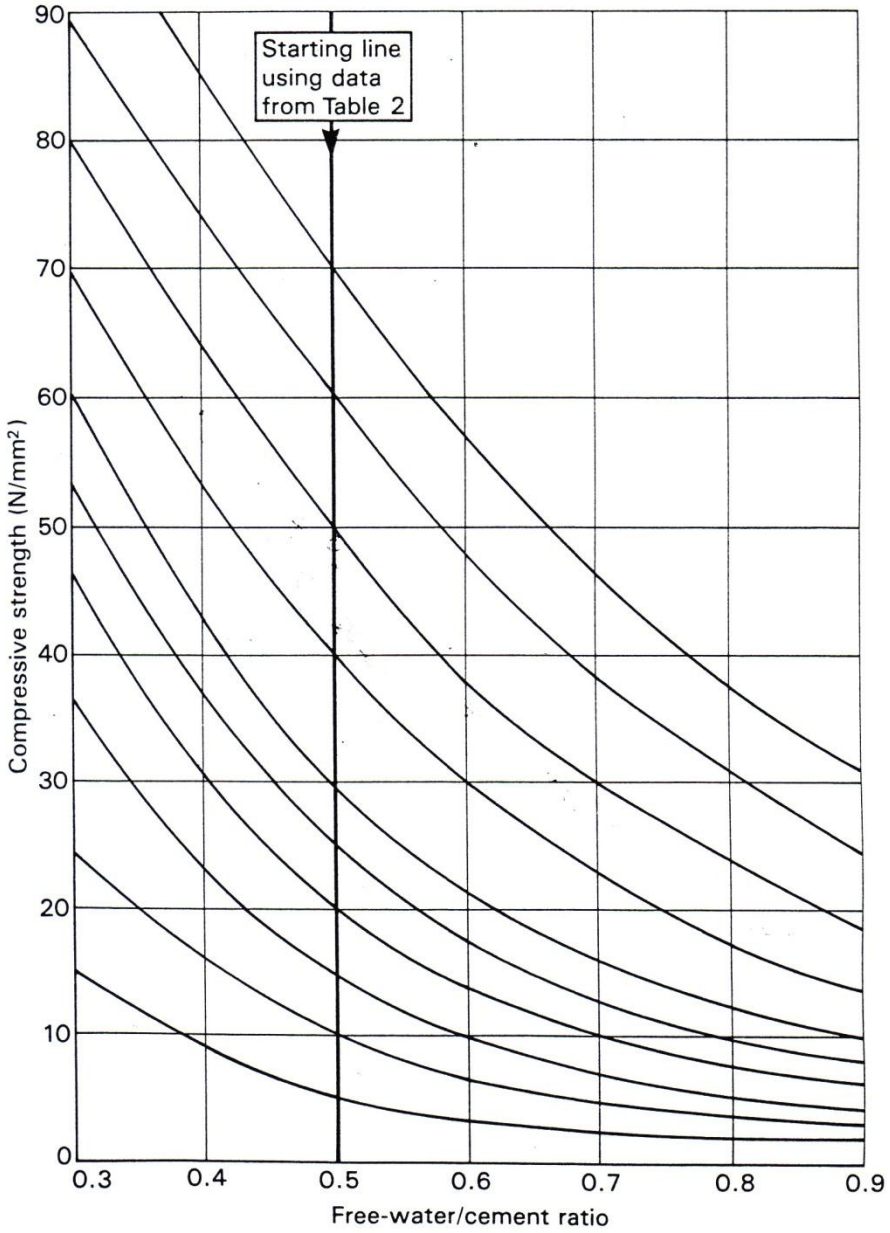

Figure 4 Relationship between compressive strength and free-water/cement ratio

Appendix 5
Lampiran 5

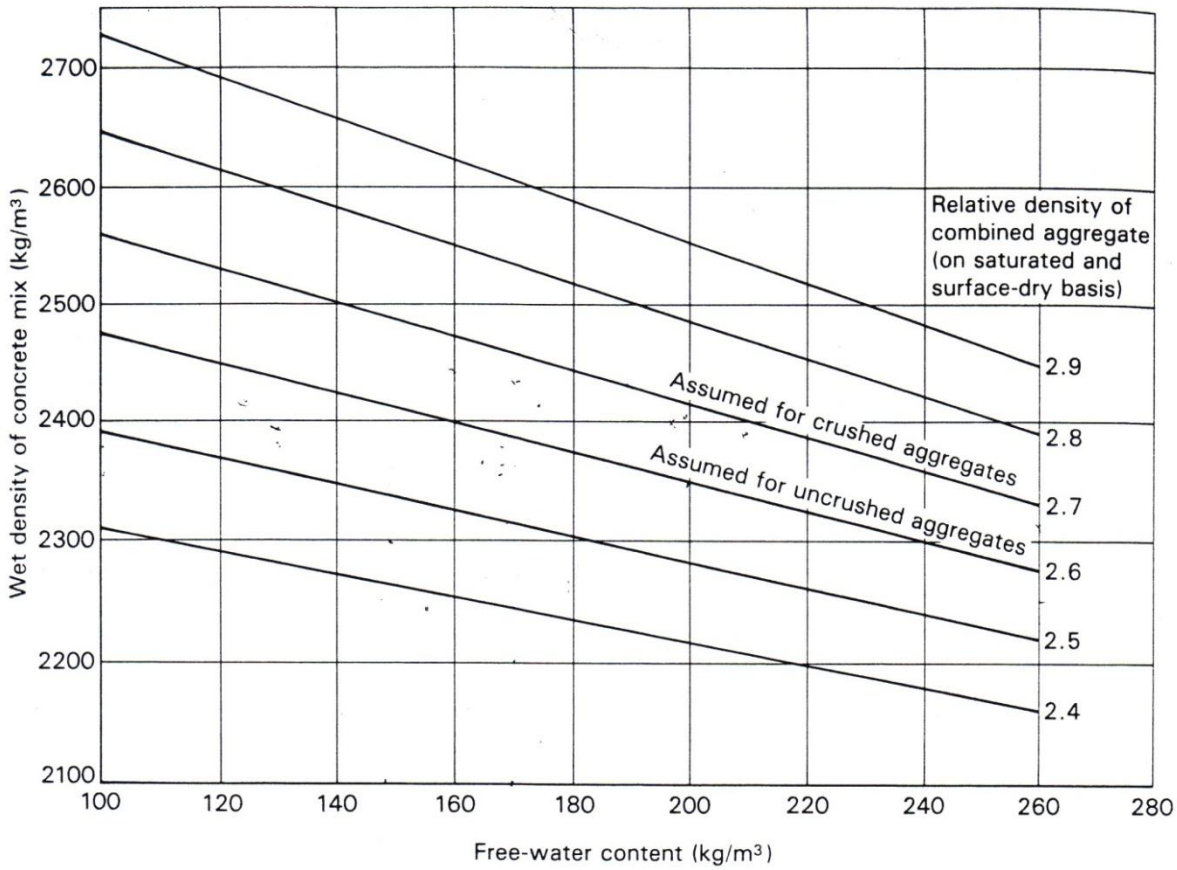

Figure 5 Estimated wet density of fully compacted concrete

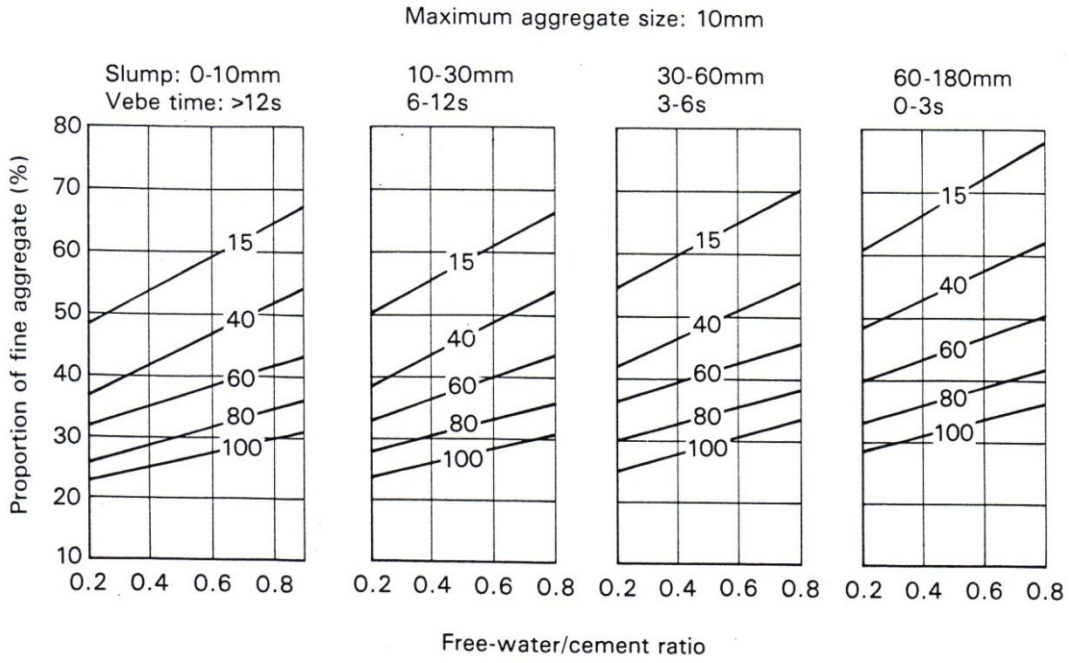

Figure 6 Recommended proportions of fine aggregate according to percentage passing a 600 μm sieve

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