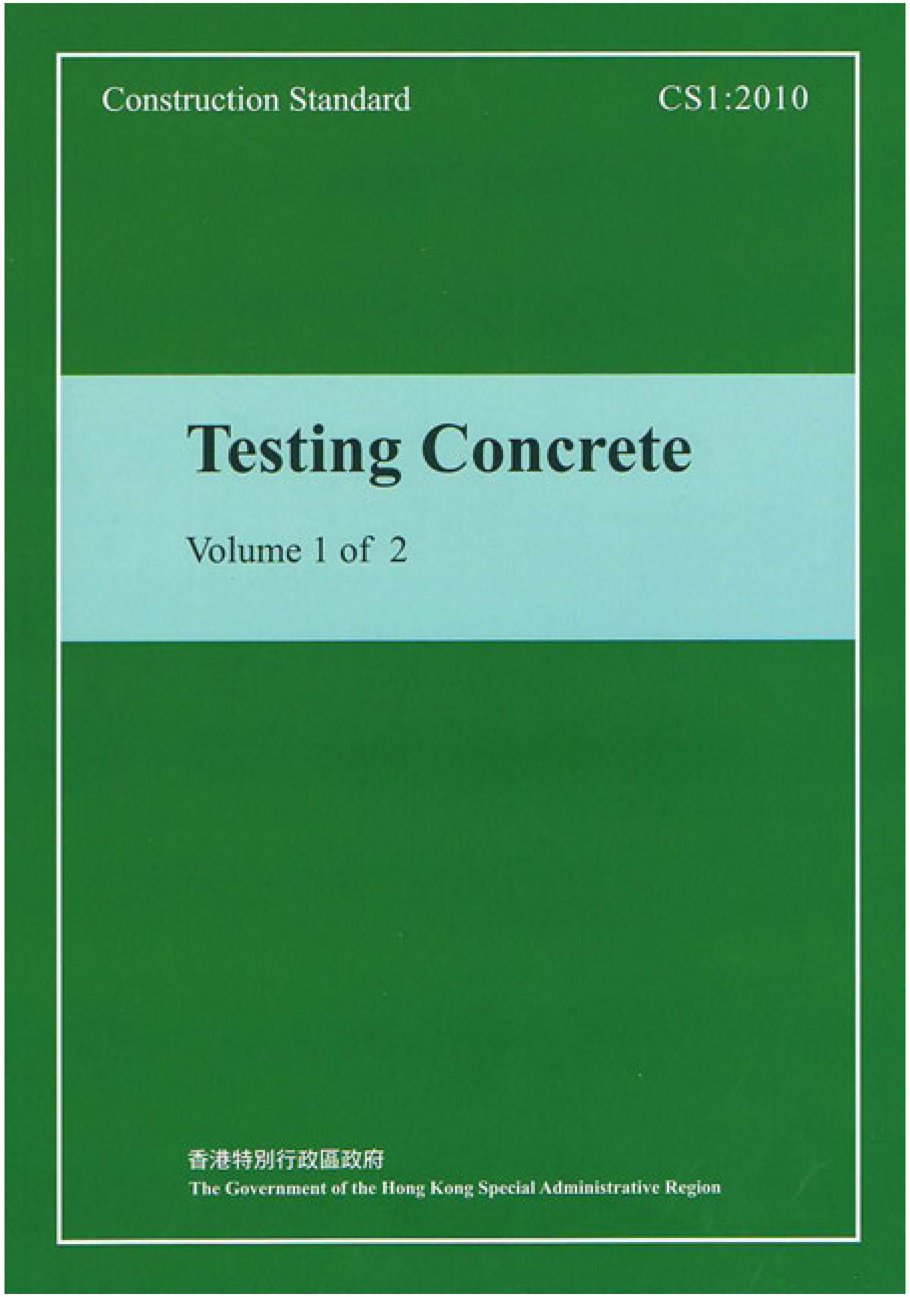
CS1 : 2010 Testing Concrete and Quality Scheme for the Production & Supply of Concrete

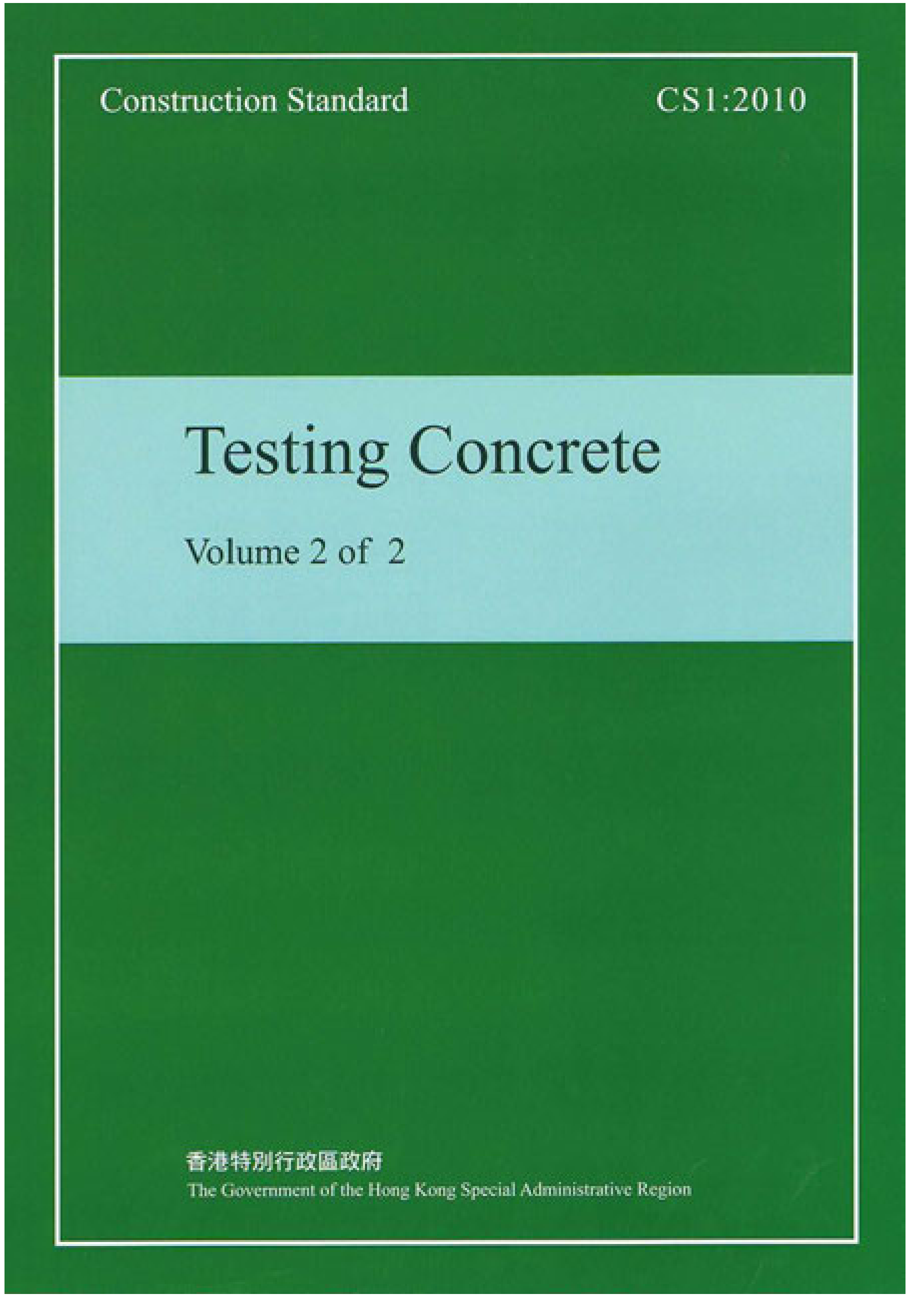
Ir C K Cheung
Civil Engineering & Development Department


Construction Standard CS1:2010

Testing Concrete

Volume 1 of 2

香港特別行政區政府
The Government of the Hong Kong Special Administrative Region


Construction Standard CS1:2010

Testing Concrete

Volume 2 of 2

香港特別行政區政府
The Government of the Hong Kong Special Administrative Region

BRITISH STANDARD

BS EN 206-1:2000

Incorporating Corrigenda Nos. 1 and 2 and Amendments Nos. 1 and 2

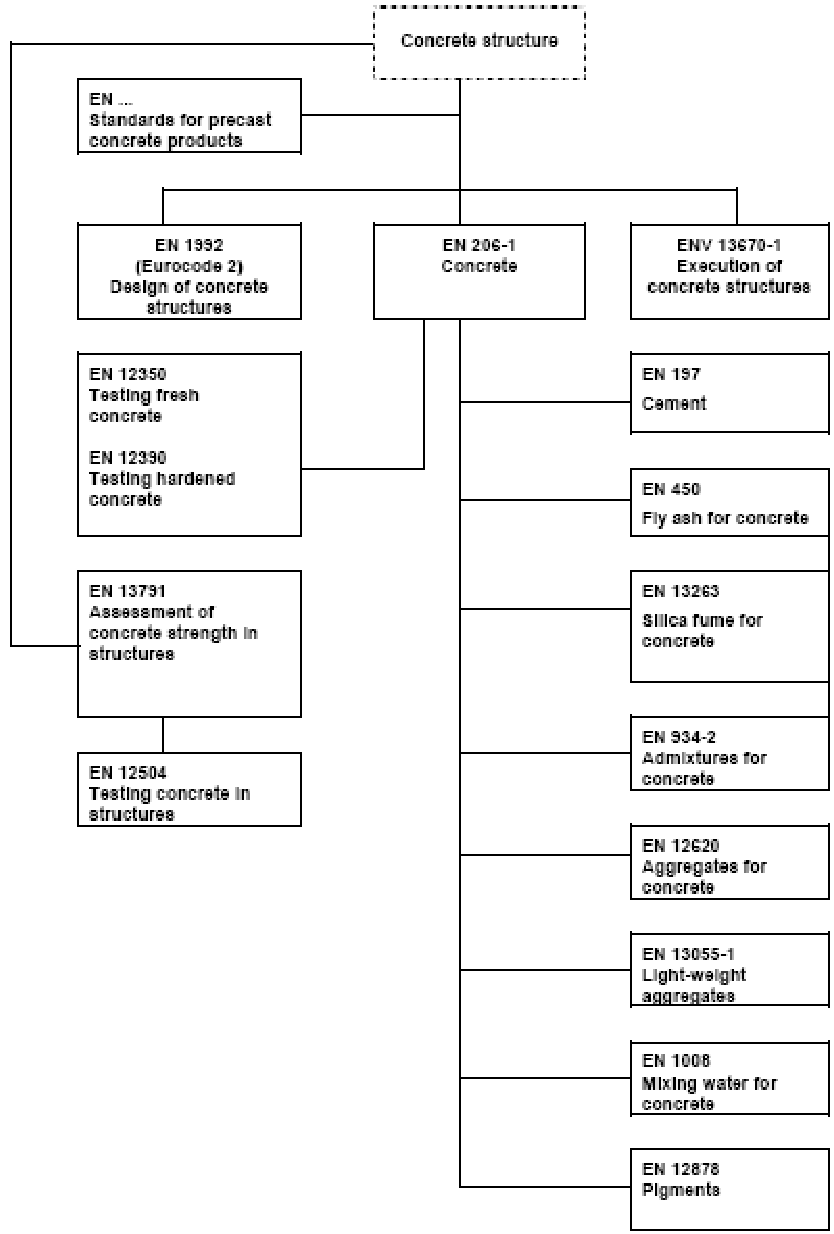
Concrete —

Part 1: Specification, performance, production and conformity

The European Standard EN 206-1:2000, with the incorporation of amendment A1:2004, has the status of a British Standard

ICS 91.100.30

British Standards



CS1:1990
Based on old BS 1881

BS 1881 : Part 1 to 6 :1970
BS 1881 : Part 101 : 1983
BS 1881 : Part 102 : 1983
BS 1881 : Part 103 : 1983
BS 1881 : Part 104 : 1983
BS 1881 : Part 106 : 1983
BS 1881 : Part 107 : 1983
BS 1881 : Part 108 : 1983
BS 1881 : Part 109 : 1983
BS 1881 : Part 110 : 1983
BS 1881 : Part 111 : 1983
BS 1881 : Part 114 : 1983
BS 1881 : Part 115 : 1986
BS 1881 : Part 116 : 1983
BS 1881 : Part 117 : 1983
BS 1881 : Part 118 : 1983
BS 1881 : Part 120 : 1983
BS 1881 : Part 121 : 1983
BS 1881 : Part 124 : 1983
BS 1881 : Part 125 : 1986

CS1:2010
Based on various New test standards

BS 1881:Part 124:1988
BS 1881:Part 103:1993
BS EN 12350-1 to 3 & 5 to 7:2009
BS EN 12390-1:2000
BS EN 12390-2 to 3:2009
BS EN 12390-4:2000
BS EN 12390-5:2009
BS EN 12390-6:2000
BS EN 12390-7 & 8:2009
BS EN 12504-1:2009
BS EN 13294:2002
ISO 1920-2:2005(E)
RILEM TC 106-2 & 3:2000
ASTM C1202-97

CS1 Stakeholders Consultation

The contribution from the following organizations on the drafting of the Construction Standard is gratefully acknowledged:

The Hong Kong Institution of Engineers
The Concrete Producers Association of Hong Kong Ltd.
The Association of Construction Materials Laboratories Ltd.
The Hong Kong Construction Association Ltd.
The Mass Transit Railway Corporation Ltd.

New Tests added in CS1:2010

(1) Slump flow test for designed flow values between 340 mm and 600 mm;

(2) Determination of stiffening time;

(3) Determination of depth of penetration of water under pressure;

(4) Determination of concrete's ability to resist chloride ion penetration;

(5) Determination of alkali silica reaction potential by ultra-accelerated mortar bar test; and

(6) Determination of alkali silica reaction potential by concrete prism test.

Major changes in the test procedures and testing machine

(1) Calibration of testing machines – the CS1:2010 adopts the requirements of BS EN 12390 as compared to that of BS 1610 in CS1:1990;

(2) The requirements of HOKLAS Supplementary Criteria No. 36 has been included in CS1:2010;

(3) In CS1:2010, the loading rates for determining the compressive strength of concrete cubes or tensile splitting strength have been increased to 0.6 ± 0.2 MPa/s. In CS1:1990, the loading rates were in the range of 0.2 to 0.4 MPa/s; and

(4) In CS1:2010, the loading rates for determining the compressive strength of concrete cores shall be in the range of 0.2 MPa/s to 1.0 MPa/s. In CS1:1990, the corresponding range of loading rates was 0.2 MPa/s to 0.4 MPa/s.

Classification of concrete tests in CS1: 2010

Workability tests

Strength tests

Durability tests

Workability Tests in CS1:2010

(1) Slump test for slump between 20 mm to 175 mm;

(2) Compactor factor;

(3) Vebe time;

(4) Flow table;

(5) Slump flow test for designed flow values between 340 mm and 600 mm

(6) Stiffening time

Strength Tests in CS1:2010

(1) Compressive strength of cubes

(2) Tensile splitting strength;

(3) Flexure strength;

(4)Concrete core strength; and

(5) Static modulus of elasticity.

Durability Tests in CS1:2010

(1) Determination of depth of penetration of water under pressure;

(2) Determination of concrete’s ability to resist chloride ion penetration;

(3) Determination of alkali silica reaction potential by ultra-accelerated mortar bar test; and

(4) Determination of alkali silica reaction potential by concrete prism test.

Workability Tests in CS1:2010

SECTION 2

DETERMINATION OF WORKABILITY AND CONSISTENCY OF CONCRETE

PART I - DETERMINATION OF SLUMP

PART II - DETERMINATION OF COMPACTING FACTOR

PART III - DETERMINATION OF VEBE TIME

PART IV - FLOW TABLE TEST

PART V – SLUMP FLOW TEST

PART I - DETERMINATION OF SLUMP

This Section describes the method of determining the slump of concrete made with aggregate having a nominal maximum size not exceeding 40 mm.

The slump test is sensitive to changes in the consistency of concrete which correspond to designed slumps between 20 mm and 175 mm. Beyond these extremes the measurement of slump can be unsuitable and other methods of determining the consistency should be considered.

The test is only valid if it yields a true slump, this being a slump in which the concrete remains substantially intact and symmetrical as shown in Figure 1(a). If the specimen shears, as shown in Figure 1(b) and Figure 2, another sample shall be taken and the procedure repeated. The slump shall be recorded to the nearest 5 mm.

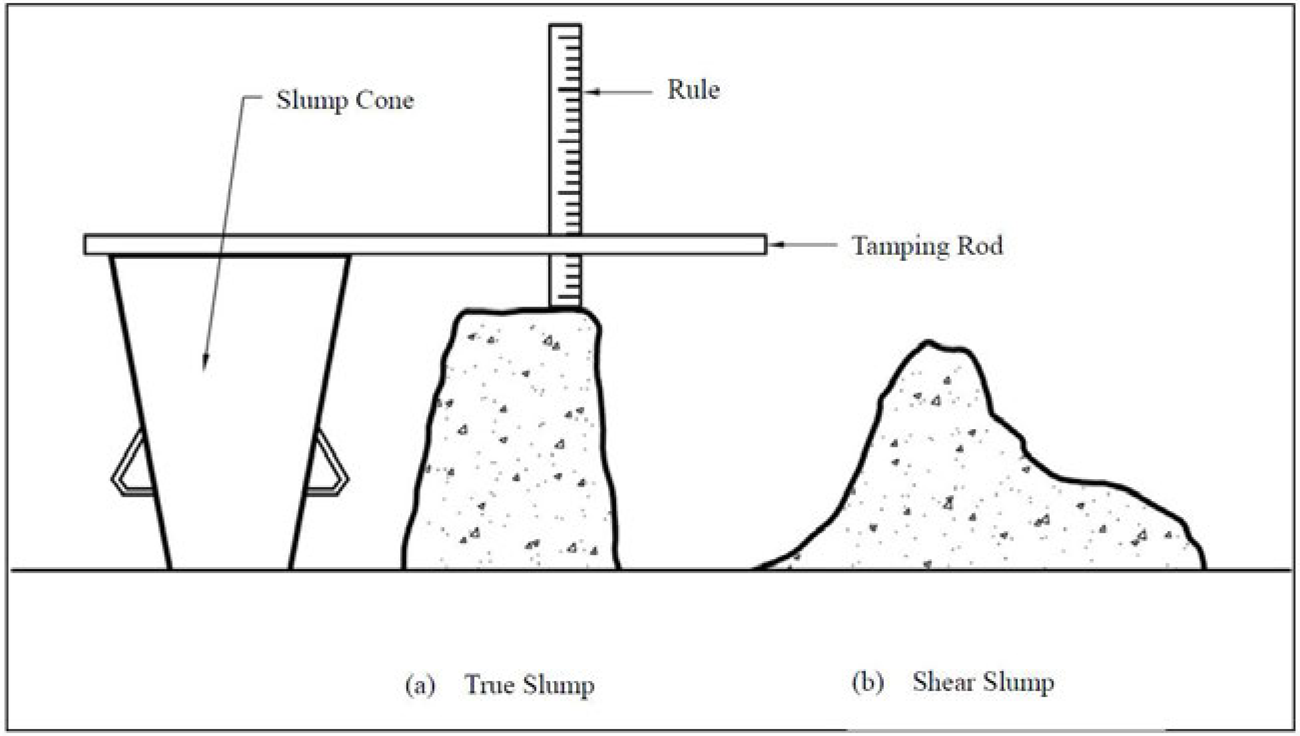


Figure 1 - Forms of Slump (Slump test)

Figure 2 - Photograph of Shear Slump

PART II - DETERMINATION OF COMPACTING FACTOR

The compacting factor shall be calculated from the equation:

$$\text{compacting factor} = \frac{m_p}{m_f} \qquad \text{----- } \mathbf{(2.2 - 1)}$$

where

m_p is the mass of the partially-compacted concrete

m_f is the mass of the fully compacted concrete

The results shall be expressed to two decimal places.

PART IV - FLOW TABLE TEST

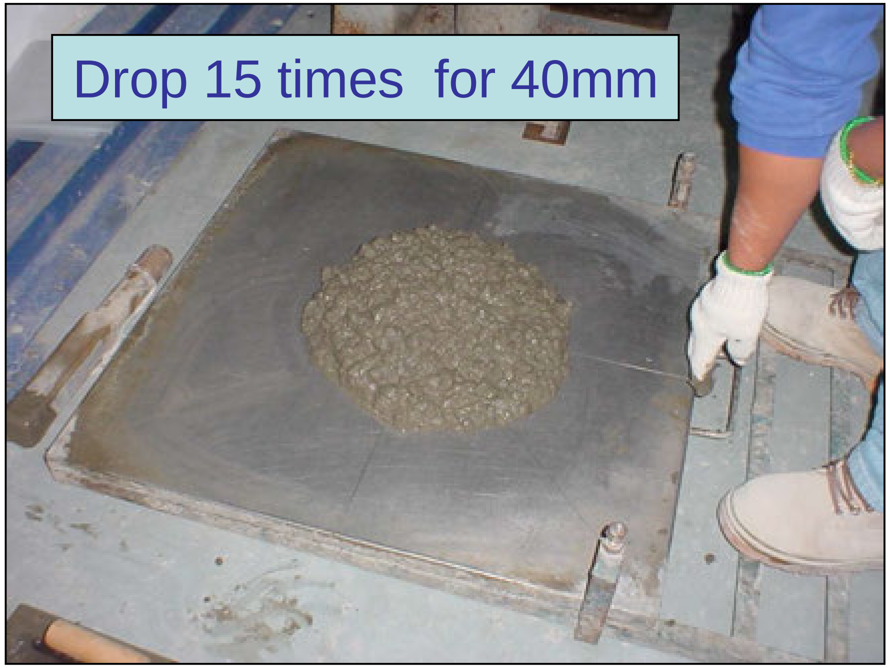
This flow table test determines the consistency of fresh concrete by measuring the spread of concrete on a flat plate which is subjected to jolting. This test is suitable for concrete mix corresponding to designed flow values between 340 mm and 600 mm. Other methods of determining the consistency should be considered if the designed flow values are beyond these extremes.

Slump < 175mm use slump cone

Tremie concrete Slump > 175mm Use flow table

Collapse slump ?


2 layer 10 times


Drop 15 times for 40mm


Measure mean diameter as flow value

Make sure no segregation when using flow table

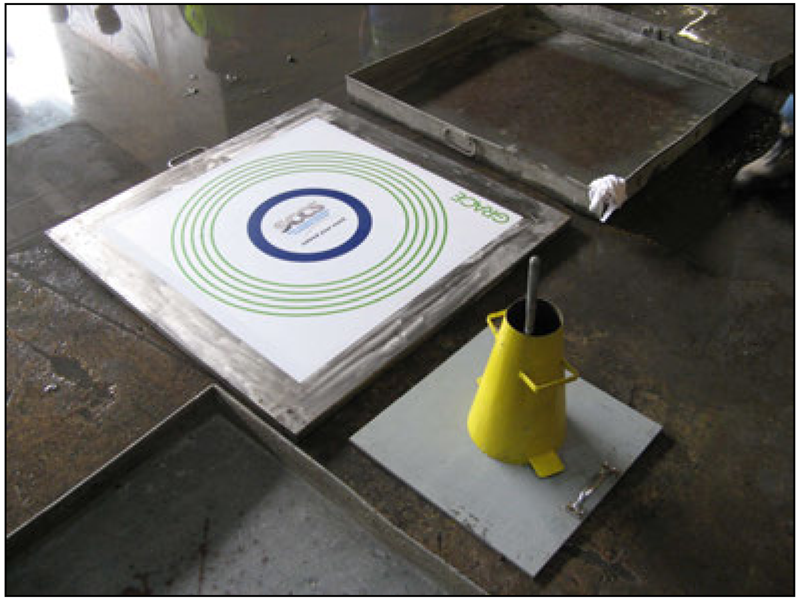
Normal

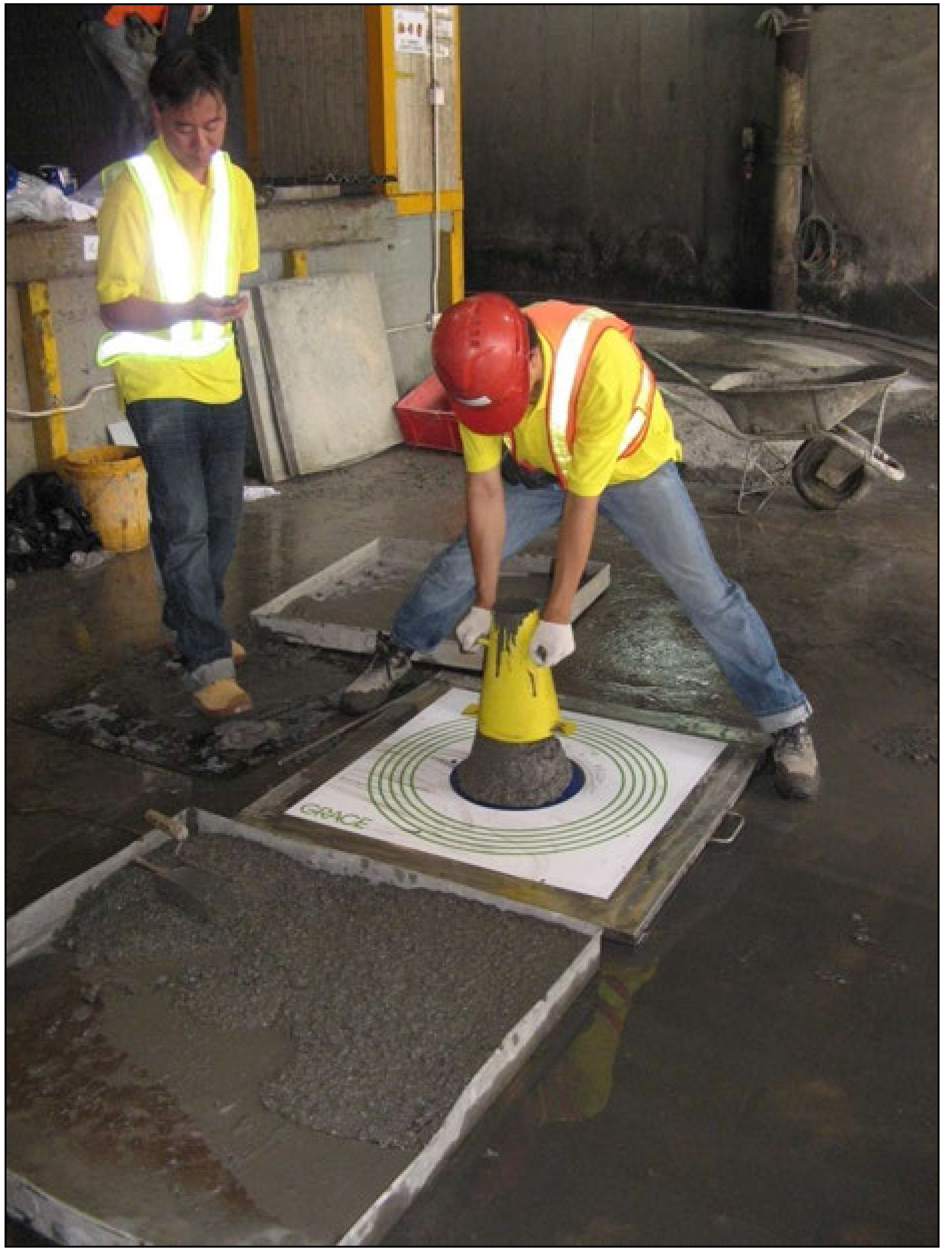
Segregation

Figure 8 – Photograph of Segregation

PART V – SLUMP FLOW TEST

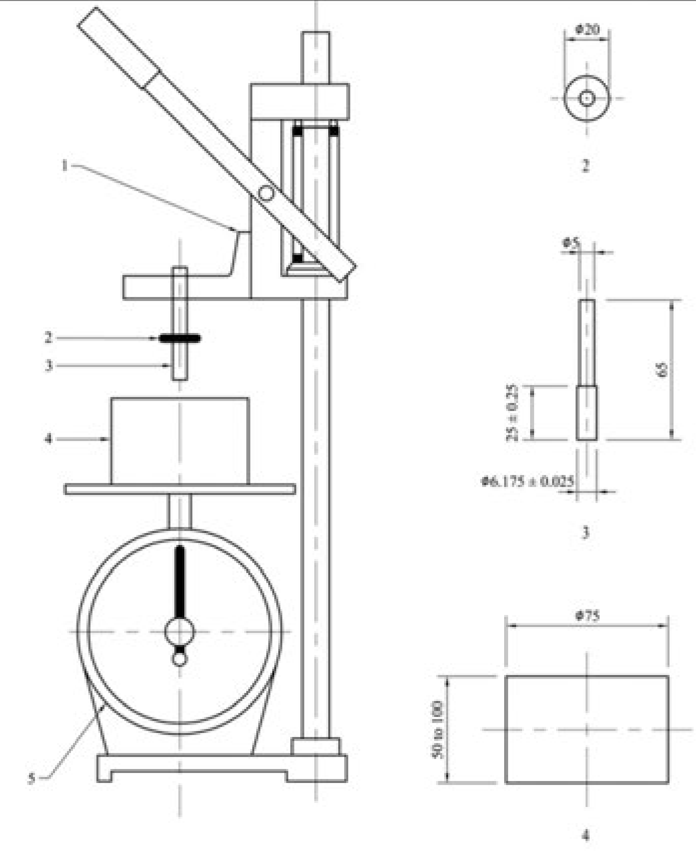
This slump flow test determines the consistency of fresh concrete by measuring the spread of concrete on a flat plate, the time for the concrete to flow to a diameter of 500 mm, and the time to end-of-flow.


GRACE


GRACE

SECTION 3

DETERMINATION OF STIFFENING TIME



Key
1 Drill stand (lever type)
2 Washer
3 Penetration rod
4 Container
5 Scale (preferably with a tare device) reading to at least 15 kg with graduations not greater than 100 g

Figure 10 - Stiffening Time Apparatus

3.5.1 Calculation of resistance to penetration

The resistance to penetration (in N/mm^2), at various test times, shall be calculated from the following from the equation:

$$\text{resistance to penetration} = \frac{10\,s}{a_r} \qquad \text{----- (3 - 1)}$$

where

s is the scale reading (in kg) or the corrected scale reading (in kg) where applicable

a_r is the end area of the penetration rod (in mm^2)

3.5.2 Determination of stiffening time

The stiffening time is the period from the completion of mixing of concrete until a resistance to penetration of 0.5 N/mm^2 (initial) and 3.5 N/mm^2 (final) is achieved.

The times to each resistance to penetration of 0.5 N/mm^2 (initial) and 3.5 N/mm^2 (final) shall be estimated by interpolation between the results immediately above and below these values. The results shall be reported to the nearest 15 min.

Strength Tests in CS1:2010

SECTION 12

DETERMINATION OF COMPRESSIVE STRENGTH OF CONCRETE CUBES

12.5 CALCULATION AND EXPRESSION OF RESULTS

The cross-sectional area of the cube shall be calculated from the measured dimensions. The compressive strength of the cube shall be calculated by dividing the maximum load by the cross-sectional area. The result shall be expressed to the nearest 0.1 MPa. The density of the specimen shall be calculated using the measured dimensions or the volume obtained from the water displacement method.


DHR2000
UNIT TEST
UTS
1
2
3
Explosive Failures
Note. All four exposed faces are cracked approximately equally, generally with little damage to faces in contact with the platens.
Satisfactory Failures

SECTION 13

DETERMINATION OF TENSILE SPLITTING STRENGTH

Tensile splitting strength is the theoretical maximum indirect tensile stress obtained by splitting the specimen under a concentrated compressive line load.

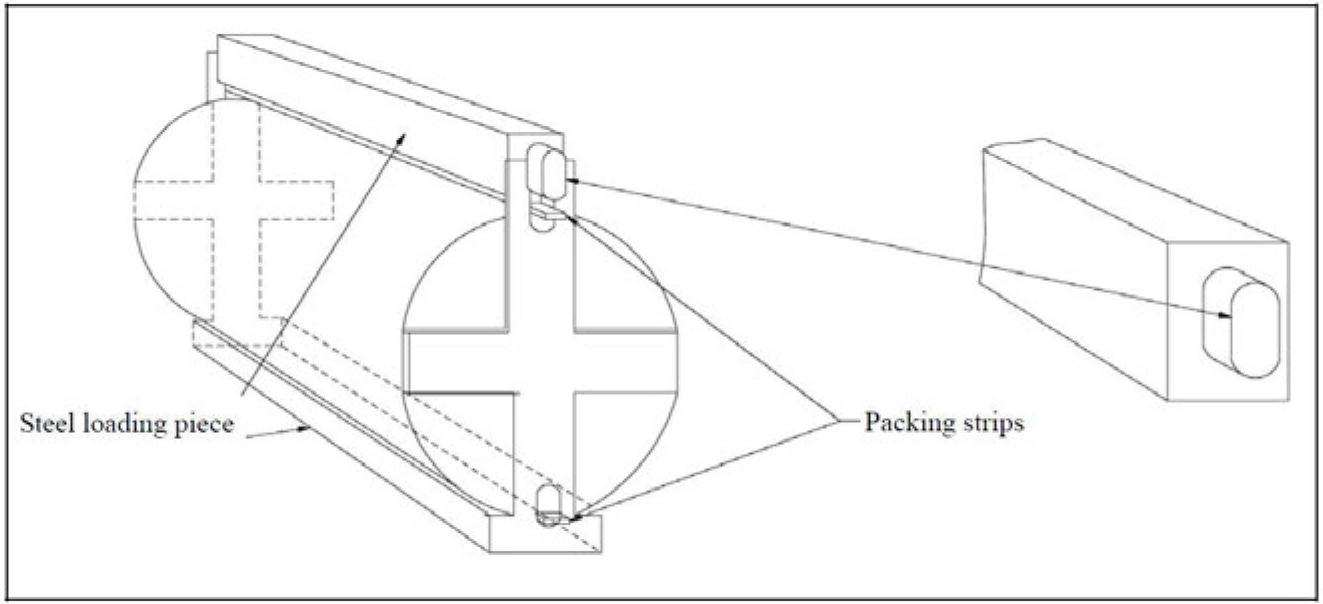


Figure 14 - Jig for Tensile Splitting Strength Test

13.6 CALCULATION AND EXPRESSION OF RESULTS

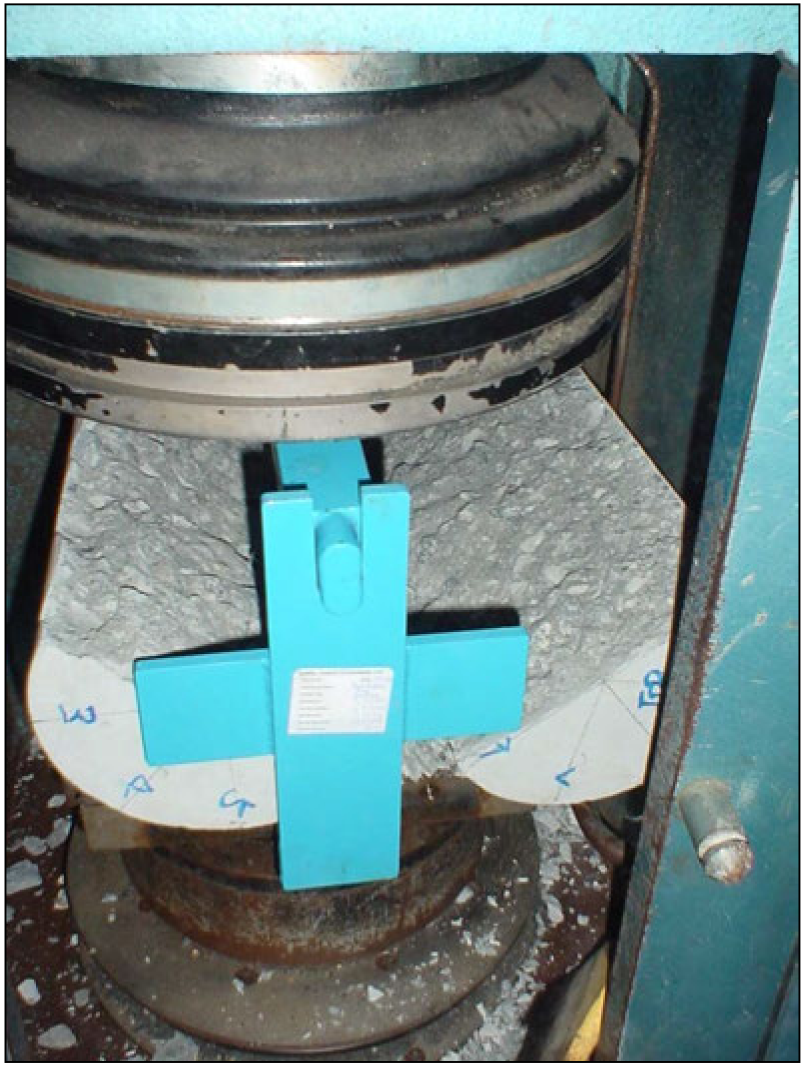
The tensile splitting strength f_{ct} in MPa is given by the equation:

$$f_{ct} = \frac{2F}{\pi \times L \times d} \qquad \textbf{----- (13 - 2)}$$

where

F	is the maximum load (in N)
L	is the average measured length (in mm)
d	is the average measured diameter (in mm)

The tensile splitting strength shall be expressed to the nearest 0.05 MPa.



Concrete Tensile Splitting test

Concrete Tensile Splitting sample after test

SECTION 14

DETERMINATION OF FLEXURAL STRENGTH

Flexural strength is the theoretical maximum tensile stress reached in the bottom fibre of a test beam during a flexural strength test.

14.6 CALCULATION AND EXPRESSION OF RESULTS

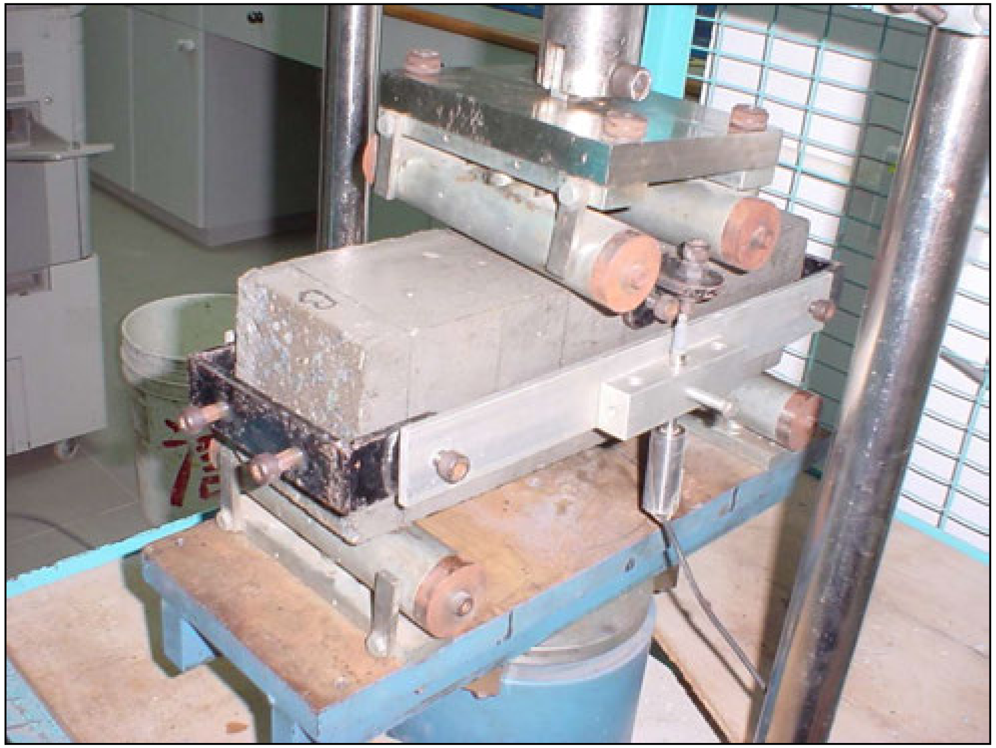
The flexural strength f_{cf} (in MPa) is given by the equation:

$$f_{cf} = \frac{450 \times F}{d_1 \times d_2^2} \qquad \text{----- (14 - 1)}$$

where

F	is the maximum load (in N)
d_1 & d_2	are the width and depth of the specimen respectively (in mm) (see Figure 15).

The flexural strength shall be expressed to the nearest 0.1 MPa.



SECTION 15

OBTAINING CORE SAMPLES AND DETERMINATION OF THE COMPRESSIVE STRENGTH OF CONCRETE CORES

This Section describes the method of taking a core from concrete, preparing it for testing, determining its compressive strength and calculating the estimated in-situ cube strength.

15.3.1 Size of cores

The test specimen shall preferably be of 100 mm diameter and in no case shall it be less than 75 mm diameter. The ratio of diameter to the maximum aggregate size shall be not less than 3. The length of core shall be sufficient to give the required length/diameter ratio after end preparation.

Concrete core from bored pile


TP0677

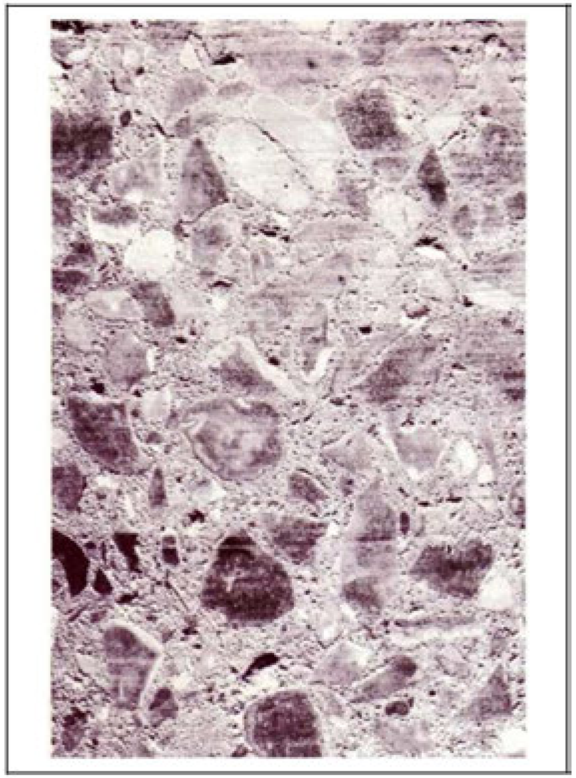


Figure 16 (a) Excess voidage = 0

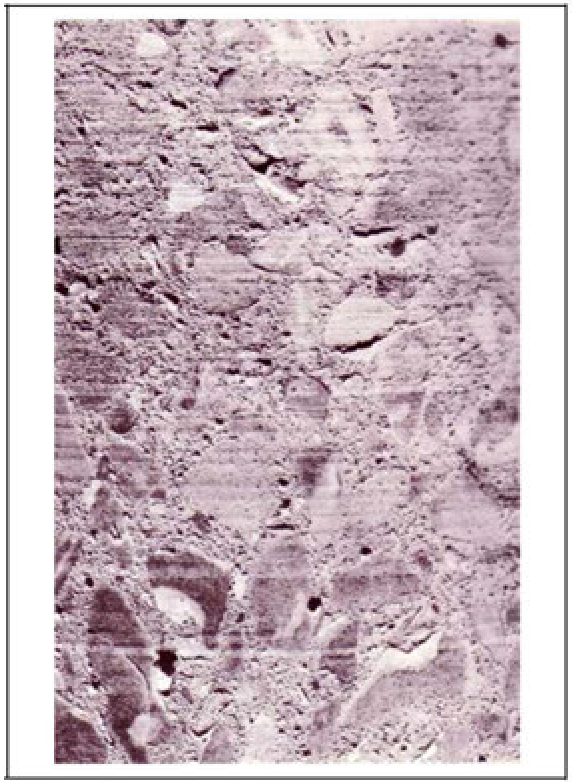


Figure 16 (b) Excess voidage = 0.5 %

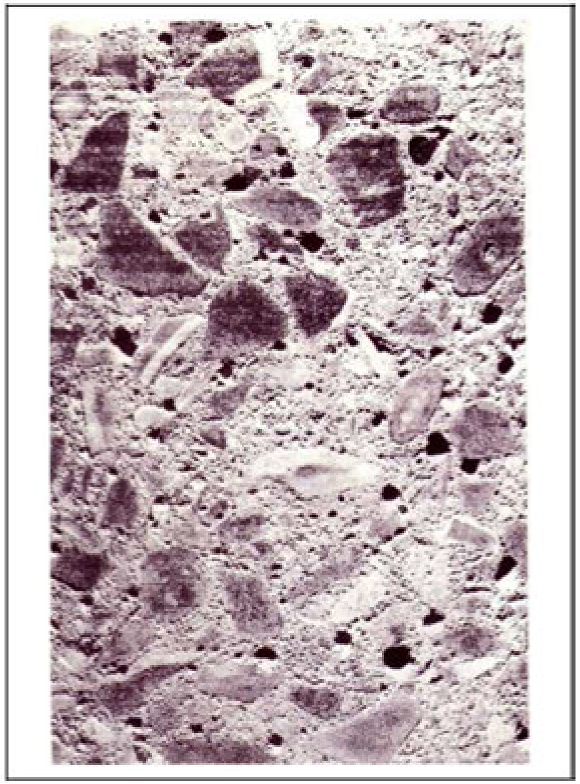


Figure 16 (c) Excess voidage = 1.5 %

Table 4 - Assessment of Excess Voidage

Figure No.	Excess Voidage (%)
16 (a)	0
16 (b)	0.5
16 (c)	1.5
16 (d)	3.0
16 (e)	13.0

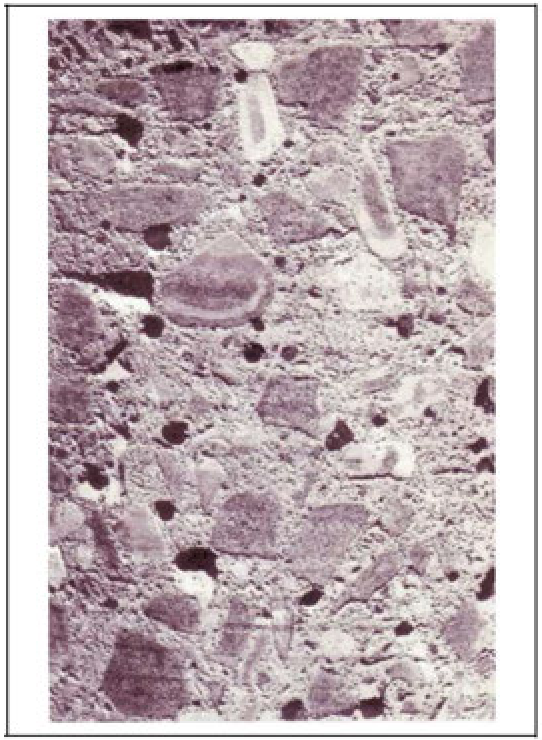


Figure 16 (d) Excess voidage = 3.0 %

Figure 16 (e) Excess voidage = 13.0 %

Table 4 - Assessment of Excess Voidage

Figure No.	Excess Voidage (%)
16 (a)	0
16 (b)	0.5
16 (c)	1.5
16 (d)	3.0
16 (e)	13.0

Table 4 of CS1:1990 Section 15

Table 4 of CS1:1990 Section 15

Table 4 - Classification of the Extent of Voids

Extents of Voids	Number of voids per 100 000 mm^2 of curved face (approx. 150 mm dia.x 200 mm long core)		
	Small voids	Medium voids	Large voids
Negligible	Less than 40	Less than 4	---------
Few	40-150	4-15	Less than 2
Considerable	151-400	16-75	2-15
Numerous	More than 400	More than 75	More than 15

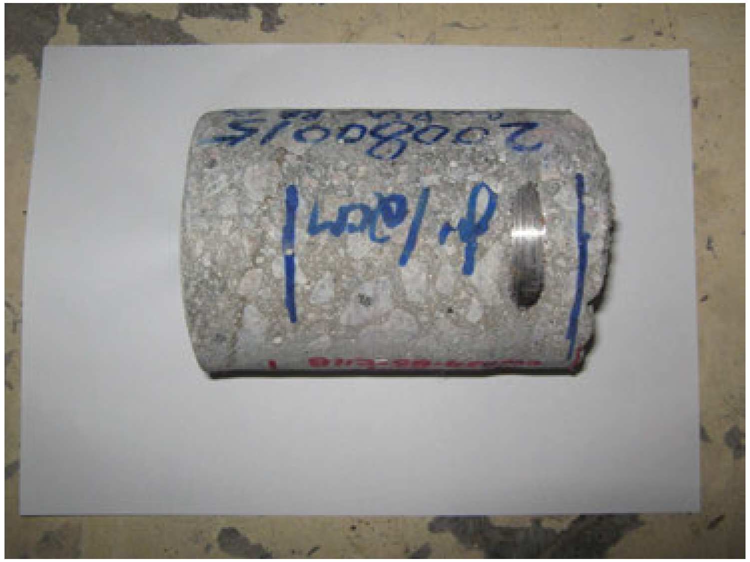
15.7.1 Compressive strength of core

The compressive strength of the core shall be calculated by dividing the maximum load by the cross-sectional area as calculated from the average diameter. The results shall be expressed to the nearest 0.1 MPa.

15.7.2 Estimated in-situ cube strength

For cores free of reinforcement, the estimated in-situ cube strength, F_{ce} shall be calculated to the nearest 0.5 MPa from the equation:

$$F_{ce} = \frac{D}{1.5 + \frac{1}{\alpha}} \times \begin{array}{l}\text{measured}\\ \text{compressive}\\ \text{strength of core}\\ \text{(to nearest 0.1 MPa)}\end{array} \qquad \text{---- (15 - 1)}$$



For cores with reinforcement perpendicular to the core axis, the estimated in-situ cube strength shall be calculated by multiplying the strength of core obtained from equation (15 - 1) by the following factors:

(a) for cores containing a single bar:

$$1.0 + 1.5 \frac{\varphi_r \, d}{\varphi_c \, L} \qquad \textbf{----- (15 - 2)}$$

(b) for specimens containing two bars no further apart at their closest point than the diameter of the larger bar, only the bar corresponding to the higher value of ϕ_rd need be considered. If the bars are further apart, their combined effect should be assessed by using the factor:

$$1.0 + 1.5 \frac{\sum \varphi_r \, d}{\varphi_c \, L} \qquad \textbf{----- (15 - 3)}$$

SECTION 17

DETERMINATION OF STATIC MODULUS OF ELASTICITY IN COMPRESSION

Static modulus of elasticity in compression, E_c, is the ratio between compressive stress and strain, expressed in terms of the secant modulus. The secant modulus in MPa is calculated from the equation:

$$E_c = \frac{\Delta_\sigma}{\Delta_\varepsilon} \qquad \text{----- (17 - 1)}$$

Where Δ_σ and Δ_ε are the differences in stress and strain respectively, between a basic loading level of 0.5 MPa and an upper loading level of one-third of the compressive strength of the concrete.

Durability Tests in CS1:2010

SECTION 18

DETERMINATION OF DEPTH OF PENETRATION OF WATER UNDER PRESSURE

This Section describes the method of determining the depth of penetration of water under pressure in hardened concrete which has been water cured.

The test specimen shall be cubes or cylinders of length of edge, or diameter, not less than 150 mm.


PROKLEAN
WATER PURIFIER
21

SECTION 19

DETERMINATION OF CONCRETE'S ABILITY TO RESIST CHLORIDE ION PENETRATION

This method sets out the procedure for determination of electrical conductance of concrete to provide a rapid indication of its resistance to penetration of chloride ions.

19.3 REAGENTS

(a) Sodium chloride (NaCl) solution shall be 3.0 % by mass (reagent grade) in distilled water.

(b) Sodium hydroxide (NaOH) solution shall be 0.3 N (reagent grade) in distilled water.

19.7.2 Calculation

The area underneath the curve plotted in clause 19.7.1 shall be integrated in order to obtain the ampere-seconds, or coulombs, of charge passed during the 6-h test period.

The following formula, based on the trapezoidal rule, can be used to obtain the ampere-seconds, or coulombs, of charge passed during the 6-hour test period. Alternatively, if automatic data processing equipment is used to perform the integration during or after the test and to display the coulomb value, the total charge passed is a measure of the electrical conductance of the concrete during the period of the test.

$$Q = 900\ (I_0 + 2I_{30} + 2I_{60} \ldots + 2I_{300} + 2I_{330} + I_{360}) \quad \textbf{----- (19 - 1)}$$

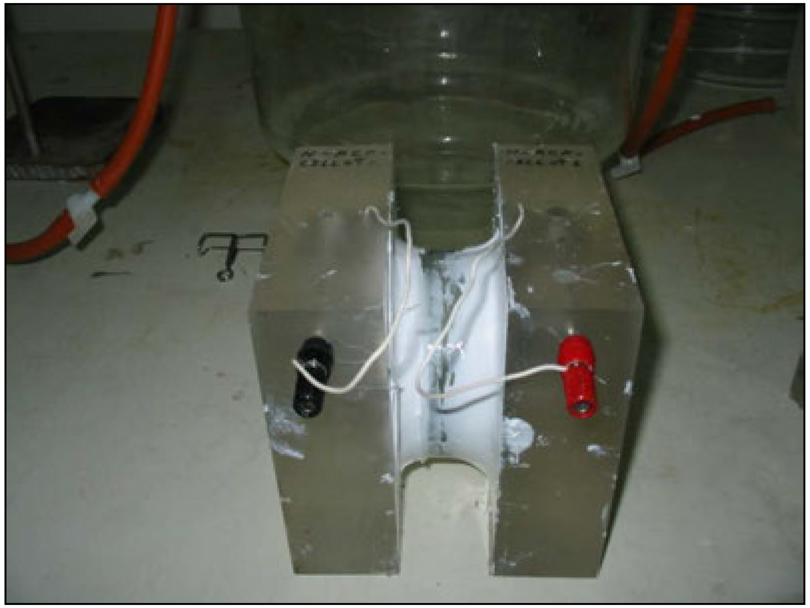
where

Q is the charge passed (coulombs)
I_0 is the current (amperes) immediately after voltage is applied
I_t is the current (amperes) at t min after voltage is applied

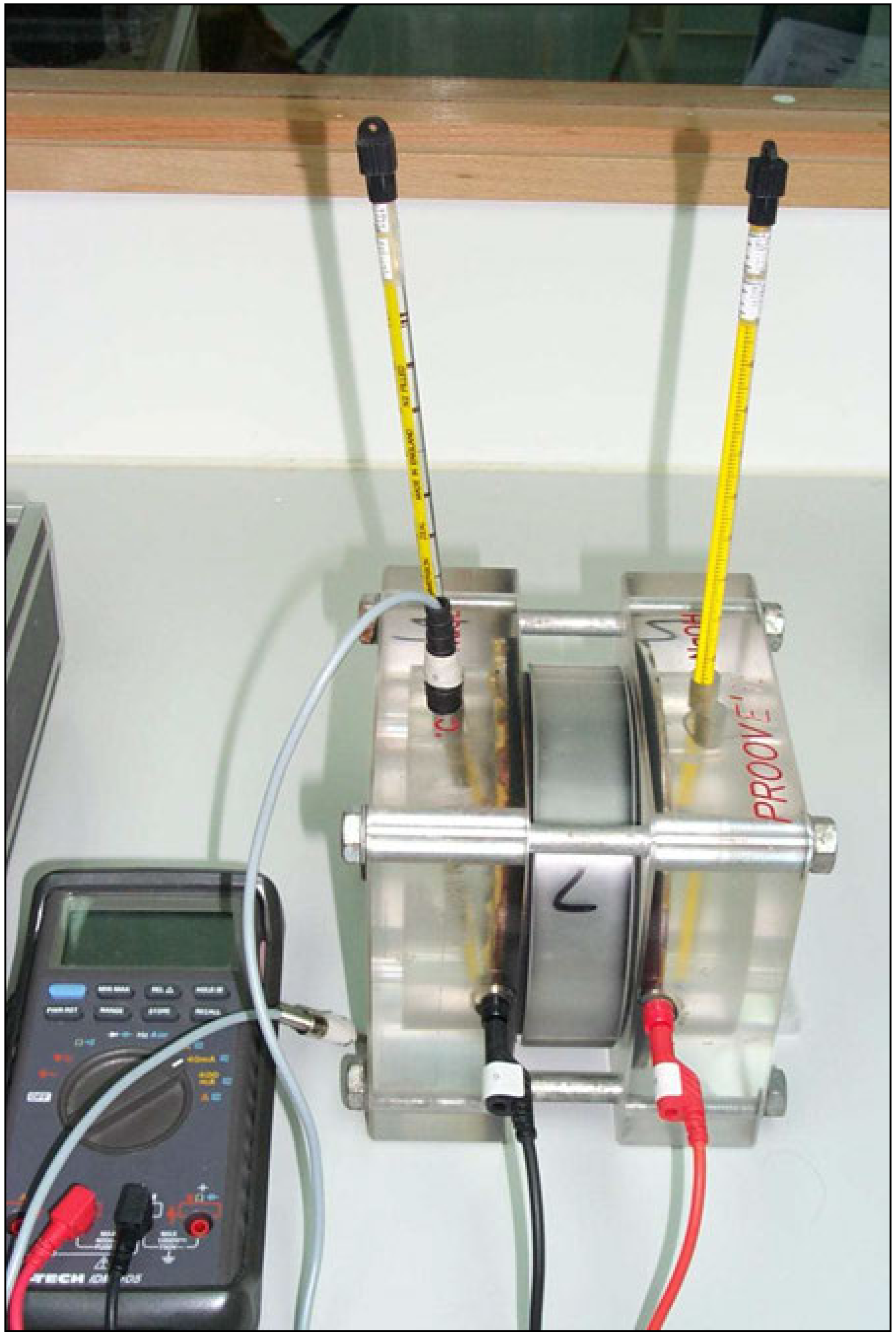
Table 5 - Chloride Ion Penetrability Based on Charge Passed

Charge Passed (Coulombs)	Chloride Ion Penetrability
>4000	High
2,000-4,000	Moderate
1,000-2,000	Low
100-1,000	Very Low
<100	Negligible


PC-51

NaOH



NaCl

60V

Every 30min measure Current for 6 hr


Map Cracking
ASR on concrete
Alkali-Aggregate Reaction (ASR)

Petrographic Examination of ASR

Map Cracking on concrete column – ASR

SECTION 22

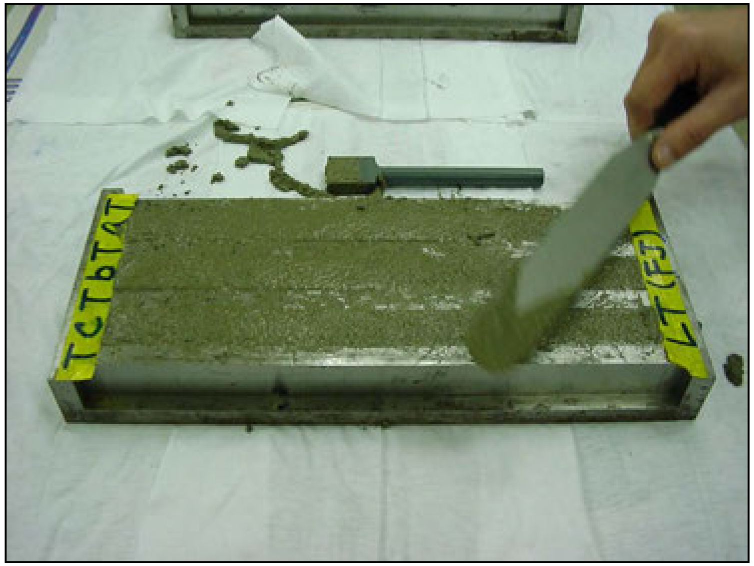
DETERMINATION OF ALKALI SILICA REACTION POTENTIAL BY ULTRA-ACCELERATED MORTAR BAR TEST

This test method is intended to determine rapidly the potential alkali-reactivity of aggregates that forms the main constituents of concrete through the evaluation of the expansion of mortar-bars immersed in NaOH solution at elevated temperature, as specified in the method. The test may also be used in experiments to assess the pessimum behaviour of reactive aggregates.


MA230115-5
20mm


Aggregate


MORTAR MIXER
STOP
ON-OFF




3/1 CE101488
3/1 CE101488 A
3/1 CE101488 B

Immerse in NaOH at 80 degree for 14 days

22.8.3.2 Subsequent measurement (L_n)

Subsequent measurements (L_n) of the specimen shall be taken periodically, with a reading after 24 hours of immersion in the NaOH solution and at least three intermediate readings before the final reading at 14 days of immersion in NaOH solution. If so desired, measurement may be taken at 24-hour intervals and may be continued beyond 14 days. All measurements should be taken at approximately the same time each day. The measuring procedure is identical to that described in clause 22.8.2.3 and the specimens shall be returned to their container after each measurement.

Table 10 - Potential Alkali-reactivity of Aggregate for Mortar Bar Test

Expansion After 14 Days of Immersion in NaOH solution (%)	Potential Reactivity
< 0.10	Non-reactive
0.10 to 0.20	Potentially reactive
> 0.20	Reactive

SECTION 23

DETERMINATION OF ALKALI SILICA REACTION POTENTIAL BY CONCRETE PRISM TEST

The method covers the measurement of expansion of concrete produced by alkali-silica reaction. It enables the effect of specific combinations of aggregates to be investigated.

Table 13 - Potential Alkali-reactivity of Aggregate for Concrete Prism Test

Expansion After 52 Weeks (%)	Potential Reactivity
< 0.05	Non-reactive
0.05 to 0.10	Potentially reactive
> 0.10	Reactive

23.9.1 Expansion

The increase in length and weight for each prism for each period of measurement from the difference between the initial comparator or weight measurement (L_0, W_0) and the comparator or weight measurement after that period (L_t , W_t) shall be calculated.

Each increase as a percentage of the initial length or weight of the corresponding prism to the nearest 0.01 % shall be calculated.

For example, at 52 weeks the percentage length change E_{52} of a prism is given by :

$$E_{52}\,(\%) = 100 \times (L_{52} - L_0)/L \qquad \textbf{----- (23 - 1)}$$

where

L_{52} is the comparator measurement at 52 weeks age

L_0 is the initial comparator measurement of the prism

L is the gauge length of that prism (in mm)

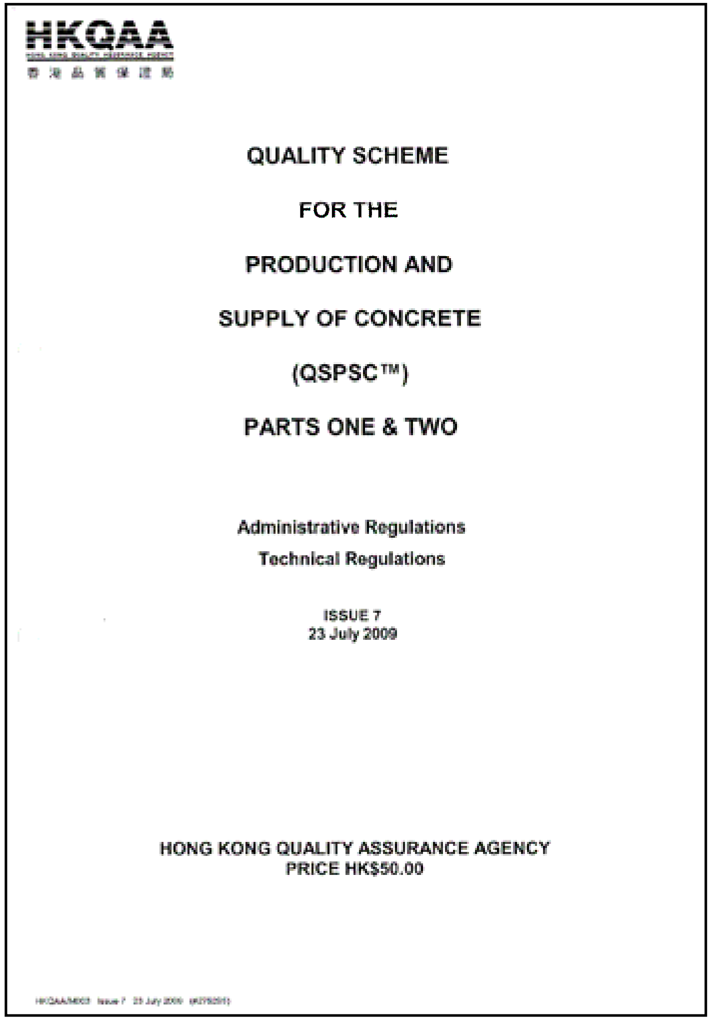

9
06/01/2011

9
06/01/2011

9
06/01/2011

9
06/01/2011

Quality Scheme for the Production and Supply of Concrete


HKQAA
香港品質保證局

QUALITY SCHEME

FOR THE

PRODUCTION AND

SUPPLY OF CONCRETE

(QSPSC™)

PARTS ONE & TWO

Administrative Regulations
Technical Regulations

ISSUE 7
23 July 2009

HONG KONG QUALITY ASSURANCE AGENCY
PRICE HK$50.00

ETWB TC (Works) 57/2002

香港特別行政區政府

The Government of the Hong Kong Special Administrative Region

政府總部
環境運輸及工務局
運輸及工務科
香港花園道美利大廈

Environment, Transport and Works Bureau
Government Secretariat
Transport and Works Branch
Murray Building, Garden Road, Hong Kong

Ref : ETWB(W) 825/83/04
Group : 5,7

31 December 2002

Environment, Transport and Works Bureau Technical Circular (Works) No. 57/2002

Quality Assurance for Structural Concrete

Scope

This Circular sets out the policy and quality assurance requirement for structural concrete used in public works projects.

2. The Director of Agriculture, Fisheries and Conservation, Director of Home Affairs, Director of Housing and Director of Lands have agreed to the content of this circular.

Effective Date

3. This Circular shall apply to public works contracts for which tenders are invited on or after 1 January 2003.

Effective on Existing Circulars

4. This Circular supersedes WBTC No. 3/94, which is hereby cancelled.

Policy

7. Structural concrete for all public works contracts must be obtained from concrete suppliers who are certified under the QSPSC, except for those located at remote areas (such as outlying islands) or where the volume of structural concrete involved is less than $50m^3$. Even for these "exceptional" projects, structural concrete should be obtained from a supplier operating a quality system approved by the Architect/Engineer.

11. The QSPSC is currently administered by the HKQAA. In future, all certification bodies including HKQAA will be accredited by the Hong Kong Accreditation Service (HKAS) to administer the QSPSC. Further enquiries on the certification bodies other than the HKQAA should be directed to the HKAS (Attn: Senior Accreditation Officer, tel: 2829 4870) or the Environment, Transport and Works Bureau (Attn: Principal Assistant Secretary (Works)3).

(W S Chan)
Deputy Secretary for the Environment
Transport and Works (Transport and Works) W2

Category of existing source/new source of aggregate based on AMBT

AMBT Expansion results:

(a) < 0.1%: innocuous

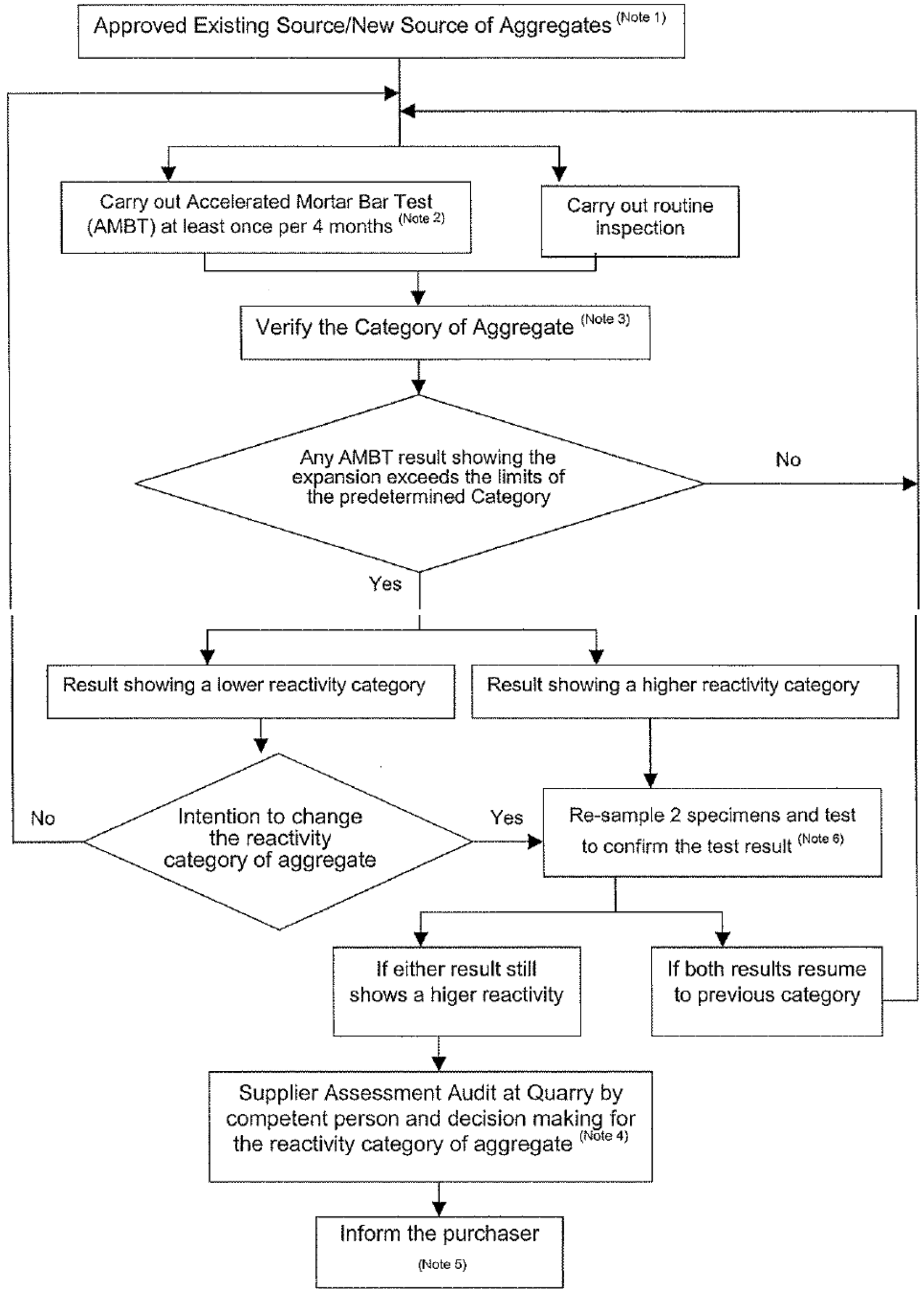
(b) > 0.1% but < 0.2%: potentially reactive

(c) > 0.2%: reactive

the aggregate shall be classified to fall in the lowest category (highest reactivity) of the aggregates.

Appendix E

- **A Framework for Monitoring the Alkaline Reactivity of Aggregates by Accelerated Mortar Bar Test**



Conclusions

- CS1:2010 provides a set of new standard methods for testing the workability, strength and durability of concrete. In particular
- (a) The slump flow provides a test for concrete mix of very high workability
- (b) The chloride penetration test provides a test for measuring the durability of concrete against chloride attack
- (c) The AMBT provides a test for measuring the ASR of aggregates used for our concrete mix

End of the Talk

Thank You