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Construction Standard CS3:2013 – Aggregates for Concrete

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Outline

1. Background
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6. Chemical Requirements
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1. Background

Reasons

- Migration to Eurocodes (BS 882:1992 replaced by BS EN 12620:2002+A1:2008)
- Aggregates are local products
- Request for a local construction standard for aggregates by industry

1. Background

History

- SCCT agreed to form a drafting committee to develop a local construction standard for aggregates used in concrete (CS3) in October 2009.
- The membership of the working group (WG) for drafting of CS3 was confirmed and endorsed by SCCT in April 2010.
- The first WG meeting was held in June 2010 and the drafting works was completed in March 2013.
- SCCT endorsed the final version of CS3 in late March 2013.

1. Background

Membership of WG includes:

- Works Departments (CEDD, HyD, ArchSD, DSD and WSD)
- Housing Department
- Building Department
- Innovation and Technology Commission

1. Background

The following organizations that have contributed on the drafting of CS3 are:

- The Concrete Producers Association of Hong Kong Ltd.
- The Hong Kong Contract Quarry Association
- The Institute of Quarrying (Hong Kong Branch)
- The Import Aggregates Suppliers Association Ltd.
- The Association of Construction Materials Laboratories Ltd.
- The University of Hong Kong

1. Background

The Drafting Committee have reviewed the following specification, technical circular and standards:

- Section 16 of General Specification for Civil Engineering Works, 2006 Edition (**GS 16**)
- WBTC No. 12/2002 – Specifications Facilitating the Use of Recycled Aggregates (**WBTC 12**)

1. Background

- British Standards (BS)

  BS 882: 1992, incorporating amendment no. 1 **(BS 882)**

  BS 812: Part 2:1995

  BS 812: Part 100:1990

  BS 812: Part 102:1989

  BS 812: Section 103.1:1985

  BS 812: Section 105.1:1989

  BS 812: Section 105.2:1990

  BS 812: Part 109:1990

  BS 812: Part 111:1990

  BS 812: Part 112:1990

  BS 812: Part 117:1988

  BS 812: Part 118:1988

  BS 812: Part 120:1989

1. Background

- British Standards (BS), cont'

  BS 812: Part 121:1989

  BS 1881: Part 124:1988

  BS 7943:1999

- European Standards adopted as British Standards (BS EN)

  BS EN 12620: 2002+A1:2008 **(BS EN 12620)**

  BS EN 932-5:2000

  BS EN 933-9:2009

  BS EN 1015-4:1999

  BS EN 1015-11:1999

  BS EN 1744-1:2009

1. Background

- National Standard of the People's Republic of China (GB)

  GB/T 14684-2011

- Réunion Internationale des Laboratoires et Experts des Materiaux, systèmes de construction et ouvrages (RILEM)

  RILEM AAR-1

- ASTM International Standards

  ASTM C131-96

  ASTM C294-12

  ASTM C295-08

- Building Research Establishment (BRE)

  BRE Digest 433

2. Contents

Specification

2. Contents

General Testing Requirements

Section 7 – General requirements for common equipment and calibration

Section 8 – Methods for sampling

Petrographic Examination

Section 9 – Method for petrographic examination of aggregates

2. Contents

Tests for Geometrical Properties

Section 10 – Methods for determination of particle size distribution, sieve tests

Section 11 – Method for determination of flakiness index

Section 12 – Method for determination of elongation index

Section 13 – Method for determination of methylene blue value

2. Contents

Tests for Physical and Chemical Properties

Section 14 – Method for determination of Los Angeles Value

Section 15 – Methods for determination of aggregate impact value

Section 16 – Methods for determination of ten per cent fines value

Section 17 – Methods for determination of particle density and water absorption

Section 18 – Methods for determination of moisture content

Section 19 – Method for determination of soundness

2. Contents

Tests for Physical and Chemical Properties , cont'

Section 20 – Method for determination of drying shrinkage

Section 21 – Methods for determination of chemical properties

Section 22 – Method for determination of effect of organic substances by mortar method

3. Scope

- Specifies the property requirements, quality control requirements and testing methods of aggregates for use in production of concrete.

- Covers coarse and fine natural aggregates and coarse recycled aggregates having an oven-dried particle density not less than 2,000 kg/m^3.

- Does not cover lightweight aggregates, heavyweight aggregates and all-in aggregates.

- Coarse recycled aggregate used in concrete in accordance with WBTC No. 12/2002

4. Geometrical Requirements

Grading of Coarse Aggregates

Sieve size (mm)	Percentage by mass passing test sieves (%)							
	Nominal size of graded aggregates (mm)			Nominal size of single-sized aggregate (mm)				
	40 to 5	20 to 5	14 to 5	40	20	14	10	5
50	100	-	-	100	-	-	-	-
37.5	90-100	100	-	85-100	100	-	-	-
20	35-70	90-100	100	0-25	85-100	100	-	-
14	25-55	40-80	90-100	-	0-70	85-100	100	-
10	10-40	30-60	50-85	0-5	0-25	0-50	85-100	100
5	0-5	0-10	0-10	-	0-5	0-10	0-25	45-100
2.36	-	-	-	-	-	-	0-5	0-30

NOTE: *For coarse recycled 20 mm and 10 mm single-sized aggregates, the percentage by mass passing 4 mm test sieve shall not exceed 5%.*

4. Geometrical Requirements

Grading of Fine Aggregates

Sieve size	Percentage by mass passing test sieves (%)			
	Overall limits	Limits for declared grading		
		C	M	F
10 mm	100	-	-	-
5 mm	89-100	-	-	-
2.36 mm	60-100	60-100	65-100	80-100
1.18 mm	30-100	30-90	45-100	70-100
600 µm	15-100	15-54	25-80	55-100
300 µm	5-70	5-40	5-48	5-70
150 µm	0-20	-	-	-

4. Geometrical Requirements

Grading of Fine Aggregates, cont'

- The grading (i.e. C, M or F) of fine aggregates shall be declared and documented by the aggregate producer or supplier.
- The grading shall comply with both the overall limits and the limits for the declared grading in the table.
- Not more than one in ten consecutive samples shall have a grading outside the limit for the declared grading.

4. Geometrical Requirements

Shape of Coarse Aggregates

- Flakiness index

  of coarse natural aggregate, ≤ 30

  of coarse recycled aggregate, ≤ 40

- Elongation index

  of coarse natural aggregate, ≤ 35

Shell Content

- Free of shell

4. Geometrical Requirements

Fines Content

Aggregate type		Maximum percentage by mass passing 75 μm test sieve (%)
Coarse aggregates		4
Fine natural aggregate	Class I	10
	Class II	>10 and ≤14

NOTE : 1. *For heavy duty floor finishes, Class I fine natural aggregate should be used.*
2. *For Class II fine natural aggregate, the methylene blue value, determined in accordance with Section 13 of this Standard, shall be ≤ 1.4.*

The aggregate producer or supplier shall declare the class (i.e. Class I or II) of the fine natural aggregate.

4. Geometrical Requirements

Foreign Materials in Coarse Recycled Aggregate

Type of foreign materials	Maximum percentage by mass (%)
Wood and other material less dense than water	0.5
Other foreign materials (e.g. metals, plastics, clay lumps, asphalt and tar, glass etc.)	1.0

The content of foreign materials shall be determined by manual sorting in accordance with BRE Digest 433.

5. Physical Requirements

Resistance to Fragmentation

- Los Angeles value of coarse natural aggregate, $\leq 30\%$ loss
- Ten per cent fines value of coarse aggregates, ≥ 100 kN
- Aggregate impact value of coarse natural aggregate, $\leq 30\%$

5. Physical Requirements

Particle Density and Water Absorption

- Oven-dried particle density of aggregates, $\geq 2{,}000\ kg/m^3$

- Water absorption

  of coarse natural aggregate, $\leq 0.8\%$

  of coarse recycled aggregate, $\leq 10\%$

5. Physical Requirements

Durability

- Magnesium sulphate soundness value
  of coarse natural aggregate, $\geq 94\%$
- Drying shrinkage
  of natural aggregates, $\leq 0.075\%$
- Potential alkaline-reactivity of aggregates
  for mortar bar test, Table 10 of CS1
  for concrete prism test, Table 13 of CS1

6. Chemical Requirements

Chlorides

- The chloride ion contents of combined natural aggregates for four categories of concrete

Type and use of concrete	Chloride ion content expressed as percentage by mass of combined natural aggregates (%)
Prestressed concrete and heat-cured concrete containing embedded metal	0.01
Concrete containing embedded metal and made with cement complying with BS 4027	0.03
Concrete containing embedded metal and made with cement complying with BS EN 197-1 or combinations with ground granulated blastfurnace slag (GGBS) or pulverized-fuel ash (PFA)	0.05
Other concrete	No limit

6. Chemical Requirements

Chlorides, cont'

- The chloride ion content of natural aggregates and coarse recycled aggregate when combined in use, $\leq$ 0.05% by mass

- The water-soluble chloride ion content shall be determined for natural aggregates and the acid-soluble chloride ion content shall be determined for coarse recycled aggregate.

6. Chemical Requirements

Suphur Containing Compounds

- Acid-soluble suphate content

  of natural aggregates, $\leq 0.8\%$ by mass

  of coarse recycled aggregate, $\leq 1\%$ by mass

- Total sulphur content

  of natural aggregates, $\leq 1\%$ by mass

6. Chemical Requirements

Organic Substances

- The aggregate producer or supplier shall demonstrate that the supplied aggregate is free of organic substances or alternatively the presence of organic substances does not affect the stiffening or hardening of mortar.

- The presence of humus shall be determined by colour comparison method; if positive, its effect shall be assessed on the following:

  (i) the increase in stiffening time of mortar test specimens, $\leq$ 120 min

  (ii) the decrease in 28-day compressive strength of mortar test specimens, $\leq$ 20%

7. Quality Control

Quality Control Under ISO 9001

- The aggregate producer and supplier shall establish and maintain a quality assurance system certified to ISO 9001 standard.

- The aggregate producer and supplier shall undertake routine control and laboratory testing to ensure that the aggregate product conforms to CS3 and is traceable throughout the process (production, supply, storage and delivery).

- All tests shall be performed by a HOKLAS accredited laboratory and the test results shall be presented in HOKLAS endorsed test reports.

7. Quality Control

Quality Control Under ISO 9001, cont'

- When requested, the aggregate producer or supplier shall provide the data including test results/certificates of aggregates.

7. Quality Control

Quality Control Under A Third Party Product Certification System (Alternative System)

- Quality assurance of the aggregate production and supply may rely on a third party certification of product conformity based on testing and continuous product surveillance and on the quality assurance system of the aggregate producer and supplier.

- A product certification scheme is required to be developed for Hong Kong to cover the production, supply, testing, handling, storage, transportation, etc. of the aggregate.

7. Quality Control

Quality Control Under A Third Party Product Certification System (Alternative System), cont'

- The certification scheme shall be reviewed by a certification body accredited by HKAS or its MLA partner(s) for product certification.

8. Comparison

Geometrical Requirements

Geometrical Requirements	CS3:2013			GS 16		WBTC 12	BS 882	
	CNA	FNA	CRA	CNA	FNA	CRA	CNA	FNA
Grading	Table 3.1 of CS3	Table 3.2 of CS3	Table 3.1 of CS3	(Table 3)	Table 4 of BS 882 omitted Note	Table 3 of BS 882:1992	Table 3	Table 4
Flakiness index (max)	30	-	40	30	-	40	40	-
Elongation index (max)	35	-	-	35	-	-	-	-
Shell content	Free	-	-	Free	-	-	20%, 8%	-
Fines content (max)	4%	10% for Class I, >10% and <=14% for Class II	4%	(4%)	(16%)	4%	4%	16%
Sand content (max)	-	-	5% (<4mm)	-	-	5% (<4mm)	-	-
Foreign materials Content (max)	-	-	0.5% (< water); 1.0% (> water)	-	-	0.5% (< water); 1.0% (> water)	-	-

CNA = coarse natural aggregate, FNA = fine natural aggregate, CRA = coarse recycled aggregate

8. Comparison

Physical Requirements

Physical Requirements	CS3:2013			GS 16		WBTC 12	BS 882	
	CNA	FNA	CRA	CNA	FNA	CRA	CNA	FNA
Los Angeles value (max)	30% loss	-	-	30% loss	-	-	-	-
Aggregate impact value (max)	30%	-	-		-	-	30%	-
Ten per cent fines value (min)	100 kN	-	100 kN	100 kN	-	100 kN	100 kN	-
Ove-dried Particle density (min)	2,000 kg/m^3	2,000 kg/m^3	2,000 kg/m^3	-	-	2,000 kg/m^3	Appendix A, the test result when required, no criteria	
Water absorption (max)	0.8%	-	10%	0.8%	-	10%	-	-
Magnesium sulphate soundness value (min)	94%	-	-	6% loss	-	-	-	-
Drying shrinkage (max)	0.075%	0.075%	-	-	-	-	Appendix A, test result when requested, 0.05% set for time for data required	
Alkali-silica reactivity	CS1	CS1	CS1	CS1	CS1	-	-	-

CNA = coarse natural aggregate, FNA = fine natural aggregate, CRA = coarse recycled aggregate

2,000 kg/m^3 and 0.075% from BS EN 12620

8. Comparison

Chemical Requirements

Chemical Requirements	CS3:2013			GS 16		WBTC 12	BS 882	
	CNA	FNA	CRA	CNA	FNA	CRA	CNA	FNA
Chloride ion content (max, combined)*	0.01%(PresC), 0.03%(SulfRC), 0.05%(PC, GGBS,PFA)		-	[0.01%(PresC), 0.03%(SulfRC), 0.05%(PC, GGBS,PFA)]		-	0.01%(PresC), 0.03%(SulfRC), 0.05%(PC, GGBS,PFA)	
Acid-soluble chloride ion content (max, combined)	0.05%			-		0.05%	-	
Acid-soluble sulphate content (max)	0.8%	0.8%	1%	-	-	1%	Test result when requested, no criteria	-
Total sulphur content (max)	1%	1%	-	-	-	-	-	-
Organic materials	Free of humus; if not, use mortar test (i) increase in stiffening time ≤ 120min, (ii) decrease in 28-day compressive strength ≤ 20%				-	-	-	-

CNA = coarse natural aggregate, FNA = fine natural aggregate, CRA = coarse recycled aggregate

* - The water-soluble chloride ion content shall be determined for natural aggregates and the acid-soluble chloride ion content shall be determined for coarse recycled aggregate.

0.8%, 1% and organic materials from BS EN 12620

End of Presentation

Thank You