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**Natural aggregates for concrete**

*Granulats pour béton*

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# Contents

	Page
<b>Foreword</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Symbols and abbreviated terms</b> .....	<b>3</b>
<b>5 Geometrical requirements</b> .....	<b>3</b>
5.1 General.....	3
5.2 Aggregate sizes.....	3
5.3 Grading.....	4
5.3.1 General.....	4
5.3.2 Coarse aggregates.....	4
5.3.3 Fine aggregates.....	5
5.3.4 All-in aggregates.....	5
5.3.5 Special use aggregates and declared grading categories.....	6
5.3.6 Grading for filler aggregate.....	6
5.3.7 Natural graded 0/8 mm aggregates.....	6
5.4 Fines content.....	7
5.5 Fines quality.....	7
5.6 Particle shape of coarse and all-in aggregates — Flakiness index and shape index.....	7
5.7 Shell content of coarse and all-in aggregates.....	8
<b>6 Physical requirements</b> .....	<b>8</b>
6.1 General.....	8
6.2 Resistance to fragmentation.....	8
6.3 Resistance to wear.....	8
6.4 Particle density and water absorption.....	8
6.4.1 Particle density.....	8
6.4.2 Water absorption.....	8
6.5 Bulk density.....	8
6.6 Resistance to polishing for surface courses.....	8
6.7 Resistance to surface abrasion.....	9
6.8 Resistance to abrasion from studded tyres to be used for surface courses.....	9
<b>7 Chemical requirements</b> .....	<b>9</b>
7.1 General.....	9
7.2 Petrographic description.....	9
7.3 Sulfur containing compounds.....	9
7.3.1 Acid-soluble sulfate.....	9
7.3.2 Total sulfur.....	9
7.4 Chlorides.....	10
7.5 Constituents which alter the rate of setting and hardening of concrete.....	10
<b>8 Durability</b> .....	<b>11</b>
8.1 General.....	11
8.2 Soundness of coarse aggregates.....	11
8.3 Freeze-thaw resistance.....	11
8.3.1 Water absorption as a screening test for freeze-thaw resistance.....	11
8.3.2 Resistance to freezing and thawing.....	12
8.3.3 Resistance to freezing and thawing in the presence of salt (extreme conditions).....	12
8.4 Volume stability — Drying shrinkage.....	13
8.5 Alkali-silica reactivity.....	13
<b>9 Evaluation of conformity</b> .....	<b>13</b>
<b>10 Designation</b> .....	<b>14</b>

10.1	Designation and description.....	14
10.2	Additional information for the description of an aggregate.....	14
<b>11</b>	<b>Marking and labelling.....</b>	<b>14</b>
<b>Annex A</b>	<b>(informative) Guidance on the description of coarseness/fineness of fine aggregates.....</b>	<b>15</b>
<b>Annex B</b>	<b>(informative) Guidance on the effects of some chemical constituents of aggregates on the durability of concrete in which they are incorporated.....</b>	<b>16</b>
<b>Bibliography</b>	<b>.....</b>	<b>18</b>

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see the following URL: [www.iso.org/iso/foreword.html](http://www.iso.org/iso/foreword.html).

This document was prepared by Technical Committee ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 3, *Concrete production and execution of concrete structures*.

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# Natural aggregates for concrete

## 1 Scope

This document specifies the properties and requirements of aggregates obtained by processing natural materials and mixtures of these aggregates for use in concrete. It is applicable to aggregates with an oven-dried particle density greater than 2,00 Mg/m<sup>3</sup> (2 000 kg/m<sup>3</sup>) in accordance with ISO 22965 (all parts).

This document incorporates a general requirement that natural aggregates are not intended to release any harmful substances in excess of the maximum permitted levels specified for the material or permitted in the national regulations of the place in use.

National provisions, preferably given in a national annex or a project specification, can specify additional or deviating requirements.

NOTE Requirements for the end use of aggregates in concrete are specified in ISO 22965 (all parts).

## 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 6274, *Concrete — Sieve analysis of aggregates*

ISO 6782, *Aggregates for concrete — Determination of bulk density*

ISO 6783, *Coarse aggregates for concrete — Determination of particle density and water absorption — Hydrostatic balance method*

ISO 7033, *Fine and coarse aggregates for concrete — Determination of the particle mass-per-volume and water absorption — Pycnometer method*

## 3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— IEC Electropedia: available at <http://www.electropedia.org/>

— ISO Online browsing platform: available at <http://www.iso.org/obp>

### 3.1

#### **aggregate**

granular material of natural, manufactured or recycled origin used in construction

### 3.2

#### **natural aggregate**

aggregate from mineral sources which has been subjected to nothing more than mechanical processing, such as crushing, washing and sieving

### 3.3

#### **aggregate size**

designation of aggregate in terms of lower (d) and upper (D) sieve sizes expressed as d/D

Note 1 to entry: This designation accepts the presence of some particles which are retained on the upper sieve (oversize) and some which pass the lower sieve (undersize).

Note 2 to entry: Other designations may be used where specified in a national standard.

### 3.4

#### **grading**

particle size distribution expressed as the percentages by mass passing a specified set of sieves

### 3.5

#### **fines**

particle size fraction of an aggregate that passes the 0,063 mm sieve

Note 1 to entry: The 0,075 mm sieve may be used where specified in a national standard.

### 3.6

#### **coarse aggregate**

designation given to the larger aggregate sizes with D greater than 4 mm and d greater than or equal to 1 mm

Note 1 to entry: Aggregates that do not fit the definitions for fine or coarse (1 mm to 3 mm or 2 mm to 4 mm) are treated as coarse aggregate.

Note 2 to entry: Coarse aggregate may be separated by other sizes where specified in a national standard.

### 3.7

#### **fine aggregate**

designation given to the smaller aggregate sizes with D less than or equal to 4 mm and  $d = 0$

Note 1 to entry: Fine aggregate can be produced from natural disintegration of rock or gravel and/or by the crushing of rock or gravel or processing of manufactured aggregates.

Note 2 to entry: Fine aggregate may be separated by other sizes where specified in a national standard.

### 3.8

#### **all-in aggregate**

aggregate consisting of a mixture of coarse and fine aggregates and fines with D greater than 4 mm and  $d = 0$

Note 1 to entry: It can be produced without separating into coarse and fine fractions or it can be produced by combining coarse and fine aggregates.

### 3.9

#### **filler aggregate**

aggregate, most of which passes a 0,063 mm sieve, which can be added to construction materials to provide certain properties

Note 1 to entry: Other sieve sizes, as the 0,075 mm sieve, may be used where specified in a national standard.

### 3.10

#### **declared value**

value declared and documented by a manufacturer, which is derived from measured values under specified conditions and rules, for identification of performance requirements

## 4 Symbols and abbreviated terms

Symbol	Description
<i>AAV</i>	resistance to surface abrasion — aggregate abrasion value
<i>AN</i>	resistance to abrasion from studded tyres — Nordic abrasion value
<i>AS</i>	acid soluble sulfate content
<i>F</i>	resistance to freezing and thawing — percentage loss of mass
<i>f</i>	finer content
<i>F<sub>EC</sub></i>	resistance to freezing and thawing in the presence of salt (extreme conditions) — percentage loss of mass
<i>FI</i>	particle shape of coarse and all-in aggregates — flakiness index
<i>LA</i>	resistance to fragmentation — Los Angeles coefficient
<i>MB</i>	finer quality — methylene method
<i>MD</i>	resistance to wear — micro-Deval coefficient
<i>MS</i>	magnesium sulfate value
<i>PSV</i>	resistance to polishing of surface courses — polished stone value
<i>S</i>	total sulfur content
<i>SC</i>	shell content of coarse and all-in aggregates
<i>SE</i>	finer quality — sand equivalent method
<i>SI</i>	particle shape of coarse and all-in aggregates — shape index
<i>SS</i>	sodium sulfate value
<i>SZ</i>	resistance to fragmentation — impact value
<i>WA</i>	water absorption value after 24 h

## 5 Geometrical requirements

### 5.1 General

The necessity for testing and declaring all properties specified in this clause shall be limited according to the particular application at end use or origin of the aggregate. When required, the aggregates shall be tested as specified in this clause to determine the relevant geometrical properties.

NOTE Guidance on selection of appropriate categories for specific applications can be found in national provisions in the place of use of the aggregate.

### 5.2 Aggregate sizes

All aggregates shall be described in terms of aggregate sizes using the designations  $d/D$  and shall conform to the grading requirements specified in 5.3, except for aggregates added as fillers, which shall be specified as filler aggregate.

Aggregate sizes shall be specified using a pair of sieve sizes selected from one of the basic sets given in Table 1. The basic sets are based on the R 20 series in ISO 565.

Other sieves specified in national standards may be used.

Table 1 — Sieve sizes for specifying aggregate sizes

Basic set 1 mm	Basic set 2 mm	Basic set 3 mm	Basic set 4 mm
0	0	0	0
1	1	1	1,25 (1,2)
2	2	2	2,5
4	4	4	-
—	5,6 (5)	—	5,0
—	—	6,3 (6)	—
8	8	8	—
—	—	10	10
—	11,2 (11)	—	—
—	—	12,5 (12)	—
—	—	14	—
16	16	16	—
—	—	20	20
—	22,4 (22)	—	—
31,5 (32)	31,5 (32)	31,5 (32)	31,5 (30)
—	—	40	40
—	45	—	—
—	56	—	50
63	63	63	63 (60)
80	80	80	80
100	100	100	100

NOTE Rounded sizes shown in parentheses can be used as simplified descriptions of aggregate sizes.

## 5.3 Grading

### 5.3.1 General

The grading of the aggregate shall be determined in accordance with ISO 6274 and shall conform to the requirements of [5.3.2](#) to [5.3.5](#) as appropriate to its aggregate size  $d/D$ .

Aggregates may comprise single sizes, all-in aggregates or combinations of two or more sizes.

Aggregates supplied as a mixture of different sizes or types should be uniformly blended. When aggregates of significantly different density are blended, caution is necessary to avoid segregation.

Where the specification requires the use of sieves which are a fraction of the upper sieve size (e.g.  $D/2$  or  $D/1,4$ ) the sieve chosen shall be the next nearest from basic set plus set 1 or basic set plus set 2.

NOTE When a sieve size of the ISO 565 R 20 series is closer to the calculated  $d/2$ ,  $D/1,4$  or  $D/2$  size, the producer can choose to use this R 20 size.

### 5.3.2 Coarse aggregates

Coarse aggregates shall conform to the general requirements specified in [Table 2](#), appropriate to their size designation  $D/d$ .

Table 2 — Overall limits and tolerances for coarse aggregate

Coarse aggregate			
Property	Requirement		
	Tolerance class 1	Tolerance Class 2	Tolerance Class 3
Particle distribution (grading): — percentage > d/2 — percentage > d — percentage > mid sieve, if D > 2d — percentage > D — percentage < 2D	Declared value ± 7,0 % Declared value ± 5,0 % Declared value ± 20,0 %  Declared value ± 15,0 % 100 %	Declared value ± 5,0 % Declared value ± 10,0 % Declared value ± 15,0 %  Declared value ± 10,0 % 100 %	Declared value ± 3,0 % Declared value ± 7,0 % Declared value ± 12,0 %  Declared value ± 7,0 % 100 %
Fines	Declared value ± 3,0 %	Declared value ± 2,0 %	Declared value ± 1,0 %
Particle density	Declared value ± 0,09 Mg/m <sup>3</sup>	Declared value ± 0,07 Mg/m <sup>3</sup>	Declared value ± 0,05 Mg/m <sup>3</sup>
Water absorption	Declared value ± 0,5 %	Declared value ± 0,3 %	Declared value ± 0,2 %
Particle shape (flakiness index)	Declared value ± 9	Declared value ± 7	Declared value ± 5

### 5.3.3 Fine aggregates

Fine aggregates shall conform to the general requirements of [Table 3](#), appropriate to their upper sieve size D.

National standards specifying other sieve sizes may be used where available.

NOTE Guidance on the description of coarseness/fineness of fine aggregates is given in [Annex A](#).

Table 3 — Overall limits and tolerances for fine aggregate

Fine aggregate			
Property	Requirement		
	Tolerance class 1	Tolerance Class 2	Tolerance Class 3
Particle distribution (grading): — percentage > 0,125 mm — percentage > 0,5 mm — percentage > 2 mm — percentage > D	Declared value ± 5,0 % Declared value ± 8,0 % Declared value ± 15,0 % Declared value ± 9,0 %	Declared value ± 3,0 % Declared value ± 5,0 % Declared value ± 10,0 % Declared value ± 7,0 %	Declared value ± 2,0 % Declared value ± 3,0 % Declared value ± 7,0 % Declared value ± 6,0 %
Fines	Declared value ± 5,0 %	Declared value ± 3,0 %	Declared value ± 2,0 %
Particle density	Declared value ± 0,05 Mg/m <sup>3</sup>	Declared value ± 0,03 Mg/m <sup>3</sup>	Declared value ± 0,02 Mg/m <sup>3</sup>
Water absorption	Declared value ± 0,5 %	Declared value ± 0,3 %	Declared value ± 0,2 %

### 5.3.4 All-in aggregates

All-in aggregates shall conform to the general requirements of [Table 4](#), appropriate to their upper sieve size D.

National Standards specifying other sieve sizes may be used where available.

**Table 4 — Tolerances on declared typical grading for all-in aggregate**

All-in aggregate			
Property	Requirement		
	Tolerance class 1	Tolerance Class 2	Tolerance Class 3
Particle distribution (grading):			
— percentage > 0,063 mm	Declared value $\pm$ 7,0 %	Declared value $\pm$ 5,0 %	Declared value $\pm$ 3,0 %
— percentage > 0,250 mm	Declared value $\pm$ 25,0 %	Declared value $\pm$ 25,0 %	Declared value $\pm$ 20,0 %
— percentage > D/2	Declared value $\pm$ 25,0 %	Declared value $\pm$ 20,0 %	Declared value $\pm$ 10,0 %
— percentage > D	Declared value $\pm$ 7,5 %	Declared value $\pm$ 5,0 %	Declared value $\pm$ 5,0 %
— percentage < 2D	100 %	100 %	100 %
Fines	Declared value $\pm$ 3,0 %	Declared value $\pm$ 2,0 %	Declared value $\pm$ 1,0 %
Particle density	Declared value $\pm$ 0,09 Mg/m <sup>3</sup>	Declared value $\pm$ 0,07 Mg/m <sup>3</sup>	Declared value $\pm$ 0,05 Mg/m <sup>3</sup>
Water absorption	Declared value $\pm$ 0,5 %	Declared value $\pm$ 0,3 %	Declared value $\pm$ 0,2 %
Particle shape (flakiness index)	Declared value $\pm$ 9	Declared value $\pm$ 7	Declared value $\pm$ 5

### 5.3.5 Special use aggregates and declared grading categories

When special aggregates gradings are required for a particular end use, or to define a specific source, special grading envelopes shall be defined using the appropriate sieves from [Table 1](#). The general principles of this clause shall be applied using appropriate requirements at 2D, 1,4D, D, d, d/2. The aggregate shall conform to the grading requirements specified.

NOTE This recognizes that size designations and grading categories are essentially categories of convenience and different sizes and grading categories can be used by agreement between supplier and purchaser.

### 5.3.6 Grading for filler aggregate

The grading shall conform to the values specified in [Table 5](#).

National Standards specifying other sieve sizes may be used where available.

**Table 5 — Grading requirements for filler aggregate**

Sieve size mm	Percentage passing by mass	
	Overall range for individual results	Producer's maximum declared range <sup>a</sup>
2	100	
0,125	85 to 100	10
0,063	70 to 100	10

<sup>a</sup> Declared grading range on the basis of the last 20 values. 90 % of the results shall be within this range, but all the results shall be within the overall grading range.

### 5.3.7 Natural graded 0/8 mm aggregates

Natural graded 0/8 mm aggregates shall conform to the general requirements specified in [Table 6](#).

National Standards specifying other sieve sizes may be used where available.

Table 6 — Grading requirements for 0/8 mm natural graded aggregates

Natural graded aggregate (d = 0 mm and D < 8 mm)			
Property	Requirement		
	Tolerance class 1	Tolerance Class 2	Tolerance Class 3
Particle distribution (grading):			
— percentage > 0,125 mm	Declared value ± 50 %	Declared value ± 3,0 %	Declared value ± 2,0 %
— percentage > 0,250 mm	Declared value ± 8,0 %	Declared value ± 5,0 %	Declared value ± 3,0 %
— percentage > 2 mm	Declared value ± 15,0 %	Declared value ± 10,0 %	Declared value ± 7,0 %
— percentage > D	Declared value ± 9 %	Declared value ± 7,0 %	Declared value ± 6,0 %
Fines	Declared value ± 5,0 %	Declared value ± 3,0 %	Declared value ± 2,0 %
Particle density	Declared value ± 0,05 Mg/m <sup>3</sup>	Declared value ± 0,03 Mg/m <sup>3</sup>	Declared value ± 0,02 Mg/m <sup>3</sup>
Water absorption	Declared value ± 0,5 %	Declared value ± 0,3 %	Declared value ± 0,2 %

#### 5.4 Fines content

When required, the fines content shall be determined and the results declared using the designation  $f_{\text{Declared}}$ .

#### 5.5 Fines quality

When required, the fines quality shall be determined in accordance with EN 933-8 or EN 933-9 and evaluated and declared as follows.

When the fines content in the fine aggregate is not greater than 3 %, or any other value according to the provisions valid in the place of use of the aggregate, no further testing is required.

If the fines content is greater than 3 %, the fines of fine aggregate shall be considered non-harmful (e.g. swelling of clay) when one of the two following conditions applies:

- The sand equivalent value ( $SE$ ), when tested in accordance with EN 933-8, and declared value  $SE_{\text{Declared}}$  is higher than a specified limit;
- The methylene blue value ( $MB$ ) on the 0/2 mm fraction, when tested in accordance with EN 933-9, and declared value  $MB_{\text{Declared}}$  is lower than a specified limit.

The compliance requirements for the sand equivalent test and the methylene blue test should normally be expressed with a probability of 90 %.

NOTE If the fines content is greater than 3 % by mass and there is documented evidence of satisfactory use, further testing might not be necessary.

#### 5.6 Particle shape of coarse and all-in aggregates — Flakiness index and shape index

When required, the shape shall be determined in accordance with EN 933-3 in terms of the flakiness index, and the results declared using the designation  $FI_{\text{Declared}}$ .

The flakiness index shall be the reference test for the determination of the shape.

For all-in aggregates the flakiness index shall be measured on the fraction 4/D.

When required, the shape index shall be determined in accordance with EN 933-4 and the results declared using the designation  $SI_{\text{Declared}}$ .

## 5.7 Shell content of coarse and all-in aggregates

When required, the shell content of coarse and all-in aggregates shall be determined in accordance with EN 933-7 and the results declared using the designation  $SC_{\text{Declared}}$ .

For all-in aggregates the shell content has to be measured on the fraction 4/D.

## 6 Physical requirements

### 6.1 General

The necessity for testing and declaring all properties specified in this clause shall be limited according to the particular application at end use or origin of the aggregate. When required, the aggregates shall be tested as specified in this clause to determine the relevant physical properties.

### 6.2 Resistance to fragmentation

When required, the resistance to fragmentation shall be determined in accordance with EN 1097-2 in terms of the Los Angeles coefficient. The Los Angeles test method shall be the reference test for the determination of resistance to fragmentation. For all-in aggregates the test shall be carried out on the coarse aggregate fraction. The Los Angeles coefficient shall be using the designation  $LA_{\text{Declared}}$ .

When required, the impact value shall be determined and the results declared using the designation  $SZ_{\text{Declared}}$ .

### 6.3 Resistance to wear

When required, the resistance to wear [micro-Deval coefficient ( $MD$ )] shall be determined in accordance with EN 1097-1 and the results declared using the designation  $MD_{\text{Declared}}$ .

### 6.4 Particle density and water absorption

#### 6.4.1 Particle density

When required, the particle density shall be determined in accordance with ISO 6783 or ISO 7033 (apparent particle density) and the results declared.

#### 6.4.2 Water absorption

When required, the water absorption shall be determined in accordance with ISO 6783 or ISO 7033 depending upon the size of the aggregate, and the results declared.

### 6.5 Bulk density

When required, the bulk density shall be determined in accordance with ISO 6782 and the results declared.

### 6.6 Resistance to polishing for surface courses

When required, the resistance to polishing for surface course aggregate [polished stone value ( $PSV$ )] shall be determined in accordance with EN 1097-8 and the results declared using the designation  $PSV_{\text{Declared}}$ .

## 6.7 Resistance to surface abrasion

When required, the resistance to surface abrasion [aggregate abrasion value (AAV)] shall be determined in accordance with EN 1097-8 and the results declared using the designation  $AAV_{\text{Declared}}$ .

## 6.8 Resistance to abrasion from studded tyres to be used for surface courses

When required, the resistance to abrasion from studded tyres [Nordic abrasion value (AN)] shall be determined in accordance with EN 1097-9 and the results declared using the designation  $AN_{\text{Declared}}$ .

# 7 Chemical requirements

## 7.1 General

The necessity for testing and declaring all properties specified in this clause shall be limited according to the particular application at end use or origin of the aggregate. When required, the aggregates shall be tested in accordance with EN 1744-1 as specified in this clause to determine the relevant chemical properties.

When the value of a property is required but not defined by specified limits, the value should be declared as an  $XX_{\text{Declared}}$  category, e.g. a value of say 1,2 % by mass for the acid-soluble sulfate content of air-cooled blast furnace slag corresponds to  $AS_{1,2}$  (declared value).

NOTE 1 Guidance on selection of appropriate values for specific applications can be found in provisions in the place of use of the aggregate.

NOTE 2 Guidance on the effects of chemical constituents in aggregates, including alkali-silica reactivity and lightweight organic contaminators related to the durability and surface properties of the concrete in which they are incorporated, is given in [Annex B](#).

## 7.2 Petrographic description

When required, the petrographic description of the aggregate shall be determined in accordance with EN 932-3 and described.

## 7.3 Sulfur containing compounds

### 7.3.1 Acid-soluble sulfate

When required the acid-soluble sulfate content of the aggregates for concrete shall be determined and the results declared in accordance with the relevant category specified in [Table 7](#).

**Table 7 — Categories for maximum values of acid-soluble sulfate content**

Aggregate	Acid soluble sulfate content Percentage by mass	Category $AS$
Natural aggregates	$\leq 0,2$	$AS_{0,2}$
	$0,2 > AS \leq 0,8$	$AS_{0,8}$
	$> 0,8$	$AS_{\text{Declared}}$
	No requirement	$AS_{\text{NR}}$

### 7.3.2 Total sulfur

When required, the total sulfur content shall be determined and the results declared in accordance with the relevant category specified in [Table 8](#).

**Table 8 — Categories for maximum values of total sulfur content**

Aggregate	Total sulfur content %	Category <i>S</i>
Natural aggregates	≤1	<i>S</i> <sub>1</sub>
	>1	<i>S</i> <sub>Declared</sub>
	No requirement	<i>S</i> <sub>NR</sub>

Special precautions are necessary if pyrrhotite, an unstable form of iron sulfide (FeS), is present in the aggregate. If this mineral is known to be present, a maximum total sulfur content of 0,1 % as *S* shall apply.

#### 7.4 Chlorides

When required, the water-soluble chloride ion content of aggregates for concrete shall be determined and the results declared.

NOTE If the water-soluble chloride ion content of the combined aggregates is known to be 0,01 % or lower (e.g. for aggregates extracted from most inland quarries), this value can be used in the calculation of the chloride content of concrete.

#### 7.5 Constituents which alter the rate of setting and hardening of concrete

When required, the presence of organic matter shall be determined (presence of humus test). If the results indicate the presence of high humic acid, the presence of fulvo acids shall be determined. If the supernatant liquid in these tests is lighter than the standard colours, the aggregates should be considered to be free from organic matter.

NOTE 1 Some inorganic compounds which discolour the supernatant liquid in the sodium hydroxide test do not adversely affect the setting and hardening of concrete.

Sugars do not affect the colour of the supernatant liquid in the humus content test or the fulvo acid test. If it is suspected that sugars or sugar type materials are present, the aggregate should be tested using the mortar test. The stiffening time and compressive strength requirements shown in a) and/or b) should apply.

Fine aggregates and filler aggregates that contain organic or other substances in proportions that alter the rate of setting and hardening of concrete shall be assessed for the effect on stiffening time and compressive strength.

The proportions of such materials shall be such that they do not

- a) increase the stiffening time of mortar test specimens by more than 120 min, and/or
- b) decrease the compressive strength of mortar test specimens by more than 20 % at 28 days.

When required, the presence of lightweight organic contaminators shall be tested and the results declared.

Two screening tests for the presence of organic matter are in common use:

- sodium hydroxide test;
- fulvo acid test.

Both tests may be applied to recycled aggregates. If the supernatant liquid in these tests is lighter than the standard colours, the aggregates may be considered to be free from organic matter.

Sugars do not affect the colour of the supernatant liquid in the sodium hydroxide or the fulvo acid test. If it is suspected that sugars or sugar type materials are present, the aggregate should be tested using the water extract test. The requirements for the influence on setting time shown in a) and/or b) should apply.

## 8 Durability

### 8.1 General

The necessity for testing and declaring all properties specified in this clause shall be limited according to the particular application at end use or origin of the aggregate. When required, the aggregates shall be tested as specified in this clause to determine the relevant durability properties.

### 8.2 Soundness of coarse aggregates

When required, the resistance to weathering of coarse aggregates shall be determined in accordance with EN 1367-2 or ASTM C88 the magnesium sulfate soundness test or the sodium sulfate test using five cycles, and the results shall be declared in accordance with the relevant category specified in [Table 9](#).

**Table 9 — Categories for maximum sulfate soundness**

Magnesium sulfate value ( <i>MS</i> ) Percentage loss of mass	Sodium sulfate value ( <i>SS</i> ) Percentage loss of mass	Category <i>MS</i> or <i>SS</i>
≤10	≤5	<i>MS</i> <sub>10</sub> or <i>SS</i> <sub>5</sub>
≤15	≤10	<i>MS</i> <sub>15</sub> or <i>SS</i> <sub>10</sub>
≤20	≤15	<i>MS</i> <sub>20</sub> or <i>SS</i> <sub>15</sub>
≤30	≤20	<i>MS</i> <sub>30</sub> or <i>SS</i> <sub>20</sub>
>30	>20	<i>MS</i> <sub>Declared</sub> or <i>SS</i> <sub>Declared</sub>
No requirement	No requirement	<i>MS</i> <sub>NR</sub> or <i>SS</i> <sub>NR</sub>

Calculate the sulfate value (*MS* or *SS*) in percentage by mass for each of the two test specimens in accordance with [Formula \(1\)](#), recording each value to the first decimal place.

$$MS/SS = 100(M1 - M2) / M1 \quad (1)$$

where

*M1* is the initial mass of the test specimen, to the nearest ±0,1 g;

*M2* is the final mass of aggregate retained on the 10 mm sieve, to the nearest ±0,1 g.

Calculate and record the mean of the two results obtained to the nearest whole number.

### 8.3 Freeze-thaw resistance

#### 8.3.1 Water absorption as a screening test for freeze-thaw resistance

When required, the water absorption value as a screening test shall be determined in accordance and the result declared.

If the water absorption determined is not greater than the value selected as one of the categories specified in [Table 10](#), the aggregate shall be assumed to be freeze-thaw resistant.

**NOTE** With some aggregate sources containing a proportion of microporous flint aggregates, the differentiation between satisfactory and unsatisfactory freeze-thaw durability can be better assessed by density measurements rather than water absorption.

**Table 10 — Categories for maximum values of water absorption after 24 hours**

Water absorption Percentage by mass	Category <i>WA</i>
≤1	<i>WA</i> <sub>1</sub>
≤2	<i>WA</i> <sub>2</sub>
>2	<i>WA</i> <sub>Declared</sub>
NOTE The water absorption test is not applicable to blast furnace slag and unaltered porous basalt.	

**8.3.2 Resistance to freezing and thawing**

When required, the resistance to freezing and thawing shall be determined in accordance with EN 1376-1 and the results declared in accordance with the relevant category specified in [Table 11](#).

**Table 11 — Categories for maximum freeze-thaw resistance values**

Freeze-thaw Percentage loss of mass	Category <i>F</i>
≤1	<i>F</i> <sub>1</sub>
≤2	<i>F</i> <sub>2</sub>
≤4	<i>F</i> <sub>4</sub>
>4	<i>F</i> <sub>Declared</sub>
No requirement	<i>F</i> <sub>NR</sub>

Calculate the undersize by combining the residues from the three specimens, weigh and express the mass obtained as a percentage of the mass of the combined test specimens.

Calculate the freeze-thaw test (*F*) in percentage in accordance with [Formula \(2\)](#):

$$F = 100(M1 - M2) / M1 \tag{2}$$

where

*M1* is the initial dry total mass of the three test specimens, in g;

*M2* is the final dry total mass of the three test specimens, that is retained on the specified sieve, in g.

**8.3.3 Resistance to freezing and thawing in the presence of salt (extreme conditions)**

When required (see NOTE 1), the resistance to freezing and thawing shall be determined and the results shall be declared in accordance with the relevant category specified in [Table 12](#). In this case, the resistance to freezing and thawing ([8.3.2](#)) shall not be determined.

NOTE 1 The results of this test provide a means for assessing an aggregate’s resistance to frost weathering in areas where frequent freeze-thaw cycling occurs with seawater sprays or abundant de-icing conditions and where result values of normal test methods do not describe correctly aggregate performance in extreme conditions.

NOTE 2 This test has been found to be appropriate for certain petrographic types of aggregate (e.g. basalts) under severe conditions of use and might not be universally applicable to all rock types.

**Table 12 — Categories for maximum freeze-thaw resistance in the presence of salt**

Freeze-thaw Percentage loss of mass	Category $F_{EC}$
≤2	$F_{EC,2}$
≤4	$F_{EC,4}$
≤5	$F_{EC,5}$
≤6	$F_{EC,6}$
≤8	$F_{EC,8}$
≤14	$F_{EC,14}$
≤25	$F_{EC,25}$
≤50	$F_{EC,50}$
>50	$F_{EC,Declared}$
No requirement	$F_{EC,NR}$
NOTE When tested using de-icing solutions other than NaCl, the limits of <a href="#">Table 12</a> would not apply.	

Calculate the undersize by combining the residues from the three specimens, weigh and express the mass obtained as a percentage of the mass of the combined test specimens.

Calculate the freeze-thaw test ( $F_{EC}$ ) in percentage in accordance with [Formula \(3\)](#):

$$F_{EC} = 100(M1 - M2) / M1 \quad (3)$$

where

$M1$  is the initial dry total mass of the three test specimens, in g;

$M2$  is the final dry total mass of the three test specimens, that is retained on the specified sieve, in g.

#### 8.4 Volume stability — Drying shrinkage

Where disruptive shrinkage cracking of concrete might occur due to the properties of the aggregates, the drying shrinkage associated with aggregates to be used in structural concrete shall, when required, not exceed 0,075 % when tested in accordance with EN 1367-4 and the results declared.

NOTE This requirement does not apply to positions where drying out never occurs, mass concrete surfaced with air entrained concrete, or to structural elements symmetrically and heavily reinforced and not exposed to the weather.

#### 8.5 Alkali-silica reactivity

When required, the alkali-silica reactivity of aggregates shall be assessed in accordance with the provisions valid in the place of use.

NOTE Guidance on the effects of alkali-silica reactivity is given in [Annex B](#).

### 9 Evaluation of conformity

Requirements for evaluation of conformity may be given on a national level or established in agreement with an independent body certifying the production and the product. The requirement shall be available from the producer on request.

## 10 Designation

### 10.1 Designation and description

Aggregates shall be identified in the following terms:

- a) source and producer (if the material has been re-handled in a depot, both source and depot shall be given);
- b) type of aggregate;
- c) aggregate size.

### 10.2 Additional information for the description of an aggregate

The necessity for other information depends on the situation and end use, for example:

- a) a code to relate the designation to the description;
- b) any other additional information needed to identify the particular aggregate.

The purchaser should inform the producer at the time of order of any special requirements associated with a particular end use and of requirements for extra information.

## 11 Marking and labelling

The delivery ticket shall contain at least the following information:

- a) source and producer;
- b) designation;
- c) date of dispatch;
- d) serial number of the ticket;
- e) reference to this document, e.g. ISO 19595.