BS EN 14227-3:2013

BSI Standards Publication

Hydraulically bound mixtures — Specifications

Part 3: Fly ash bound granular mixtures

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National foreword

This British Standard is the UK implementation of EN 14227-3:2013. It supersedes BS EN 14227-3:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/510/4, Cementitious bound materials, unbound granular materials, waste materials and marginal materials.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
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Foreword

This document (EN 14227-3:2013) has been prepared by Technical Committee CEN/TC 227 “Road materials”, the secretariat of which is held by DIN.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by November 2013, and conflicting national standards shall be withdrawn at the latest by November 2013.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 14227-3:2004.

Compared with EN 14227-3:2004, the following changes have been made:

— Changing of the title;

— Revision of Clause 5 "Constituents";

— Revision of Clause 6 "Fly ash bound granular mixture";

— Inclusion of Clause 6.4 "Other requirements for the fresh mixture";

— Revision of Annex B (informative) "Examples of fly ash bound granular mixtures using siliceous fly ash";

— Revision of Annex C (informative) "Examples of fly ash bound granular mixtures using calcareous fly ash".

This standard is one of a series of parts for EN 14227, *Hydraulically bound mixtures — Specifications*:

— *Part 1: Cement bound granular mixtures*

— *Part 2: Slag bound granular mixtures*

— *Part 3: Fly ash bound granular mixtures*

— *Part 4: Fly ash for hydraulically bound mixtures*

— *Part 5: Hydraulic road binder bound granular mixtures*

— *Part 10: Soil treated by cement*

— *Part 11: Soil treated by lime*

— *Part 12: Soil treated by slag*

— *Part 13: Soil treated by hydraulic road binder*

— *Part 14: Soil treated by fly ash*

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, Former Yugoslav Republic of Macedonia, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey and the United Kingdom.

1 Scope

This European Standard specifies fly ash bound granular mixtures for roads, airfields and other trafficked areas, and specifies the requirements for their constituents, composition and laboratory performance classification.

In this European Standard, fly ash refers to siliceous or calcareous fly ash complying with EN 14227-4. Where fly ash is part of cement conforming to EN 197-1 or hydraulic road binder conforming to EN 13282-1 and EN 13282-2, then reference should be made to EN 14227-1 or EN 14227-5 respectively.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 197-1, *Cement — Part 1: Composition, specifications and conformity criteria for common cements*

EN 459-1, *Building lime — Part 1: Definitions, specifications and conformity criteria*

EN 933-1, *Tests for geometrical properties of aggregates — Part 1: Determination of particle size distribution — Sieving method*

EN 1097-6:2000, *Tests for mechanical and physical properties of aggregates — Part 6: Determination of particle density and water absorption*

EN 1097-7, *Tests for mechanical and physical properties of aggregates — Part 7: Determination of the particle density of filler — Pyknometer method*

EN 13242, *Aggregates for unbound and hydraulically bound materials for use in civil engineering work and road construction*

EN 13286-1, *Unbound and hydraulically bound mixtures — Part 1: Test methods for laboratory reference density and water content — Introduction, general requirements and sampling*

EN 13286-2, *Unbound and hydraulically bound mixtures — Part 2: Test methods for laboratory reference density and water content — Proctor compaction*

EN 13286-3, *Unbound and hydraulically bound mixtures — Part 3: Test methods for laboratory reference density and water content — Vibrocompression with controlled parameters*

EN 13286-4, *Unbound and hydraulically bound mixtures — Part 4: Test methods for laboratory reference density and water content — Vibrating hammer*

EN 13286-5, *Unbound and hydraulically bound mixtures — Part 5: Test methods for laboratory reference density and water content — Vibrating table*

EN 13286-40, *Unbound and hydraulically bound mixtures — Part 40: Test method for the determination of the direct tensile strength of hydraulically bound mixtures*

EN 13286-41, *Unbound and hydraulically bound mixtures — Part 41: Test method for the determination of the compressive strength of hydraulically bound mixtures*

EN 13286-42, *Unbound and hydraulically bound mixtures — Part 42: Test method for the determination of the indirect tensile strength of hydraulically bound mixtures*

EN 13286-43, *Unbound and hydraulically bound mixtures — Part 43: Test method for the determination of the modulus of elasticity of hydraulically bound mixtures*

EN 13286-45, *Unbound and hydraulically bound mixtures — Part 45: Test method for the determination of the workability period of hydraulically bound mixtures*

EN 13286-47, *Unbound and hydraulically bound mixtures — Part 47: Test method for the determination of California bearing ratio, immediate bearing index and linear swelling*

EN 13286-50, *Unbound and hydraulically bound mixtures — Part 50: Method for the manufacture of test specimens of hydraulically bound mixtures using Proctor equipment or vibrating table compaction*

EN 13286-51, *Unbound and hydraulically bound mixtures — Part 51: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrating hammer compaction*

EN 13286-52, *Unbound and hydraulically bound mixtures — Part 52: Method for the manufacture of test specimens of hydraulically bound mixtures using vibrocompression*

EN 13286-53, *Unbound and hydraulically bound mixtures — Part 53: Methods for the manufacture of test specimens of hydraulically bound mixtures using axial compression*

EN 14227-2, *Hydraulically bound mixtures — Specifications — Part 2: Slag bound granular mixtures*

EN 14227-4, *Hydraulically bound mixtures — Specifications — Part 4: Fly ash for hydraulically bound mixtures*

3 Terms and definitions

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

3.1
hydraulically bound mixture
mixture which sets and hardens by hydraulic reaction

3.2
fly ash bound granular mixture
granular hydraulically bound mixture in which siliceous or calcareous fly ash is the essential constituent of the binder and the hydraulic reaction

Note 1 to entry: Hardening can be controlled by additional constituents.

3.3
slenderness ratio
height to diameter ratio of the specimen

3.4
compacity
ratio of the absolute volume of the solid to the apparent volume of the mixture (see Annex A)

4 Symbols and abbreviated terms

For the purpose of this document, the following symbols and abbreviated terms apply.

R_c is the compressive strength, expressed in megapascals (MPa);

R_i is the compressive strength after immersion, expressed in megapascals (MPa);

R_t is the direct tensile strength, expressed in megapascals (MPa);

R_{it} is the indirect tensile strength, expressed in megapascals (MPa);

E is the modulus of elasticity, expressed in megapascals (MPa);

E_c is the E determined by compression, expressed in megapascals (MPa);

E_t is the E determined in direct tension, expressed in megapascals (MPa);

E_{it} is the E determined in indirect tension, expressed in megapascals (MPa).

5 Constituents

5.1 Aggregates

Aggregates shall be selected from EN 13242.

The properties and the appropriate categories of the aggregates shall be specified depending on the position of the fly ash bound mixture in the pavement structure and the traffic to be carried.

Aggregates shall be volumetrically stable. When this is not the case, the use of the mixture shall be permitted provided there is a satisfactory performance record or a thorough laboratory evaluation of the mixture has been carried out in accordance with provisions valid at the place of use.

5.2 Fly ash

Siliceous or calcareous fly ash shall conform to EN 14227-4.

5.3 Lime

Quick lime (CaO) or hydrated lime [$Ca(OH)_2$] shall be type CL90 or CL80 in conformity with EN 459-1.

Quick lime shall comply with reactivity R4 or R5 and particle size distribution P1, P2, P3 or P4.

5.4 Cement

Cement shall conform to EN 197-1.

5.5 Gypsum

The percentage of $CaSO_4.2H_2O$ in gypsum shall exceed 90 %. The maximum size shall be less than 5 mm.

NOTE 1 Gypsum, natural or artificial, is a setting and hardening activator.

NOTE 2 Unless the constituents and the mixture are well known and proven, it will be necessary to check the expansion of mixtures containing gypsum.

5.6 Granulated blast furnace slag

Granulated, including partially ground and ground granulated blast furnace slag, shall conform to EN 14227-2.

5.7 Other constituents

Constituents, including calcium chloride and sodium carbonate, can be used to enhance the setting and hardening of fly ash bound mixtures.

5.8 Water

Water shall not contain components that adversely affect the hardening and performance of the fly ash bound mixture.

6 Fly ash bound granular mixtures

6.1 Types

Fly ash bound granular mixture shall be made from the constituents specified in Clause 5.

The mixture shall be selected from the six types described below and shall conform to the specified requirements for the selected mixture.

6.1.1 Fly ash bound granular mixture 1

The grading of the mixture shall be 0/31,5 mm, determined in accordance with EN 933-1 and shall comply with Figure 1 for mixture using siliceous fly ash and Figure 2 for mixture using calcareous fly ash.

6.1.2 Fly ash bound granular mixture 2

Granular mixture with a compacity requirement.

The grading of the mixture, determined in accordance with EN 933-1, shall comply with Table 1.

Either category G1 or category G2 of the grading envelope in Figures 3 to 8 shall be specified.

The minimum compacity of the mixture at the maximum modified Proctor dry density shall be 0,80 in accordance with Annex A.

The immediate bearing index category of the 0/10 mixture, determined in accordance with EN 13286-47 using modified Proctor compaction, shall be IPI_{50} in accordance with Table 4.

Table 1 — Grading of fly ash bound granular mixture 2

Fly ash bound granular mixture	Grading category	Grading envelopes	
		Mixture using siliceous fly ash	Mixture using calcareous fly ash
2-0/20	G1 or G2	Figure 3	Figure 4
2-0/14	G1 or G2	Figure 5	Figure 6
2-0/10	G1 or G2	Figure 7	Figure 8

6.1.3 Fly ash bound granular mixture 3

Fly ash bound granular mixture 3 shall be a granular mixture with a maximum nominal size of D equal or less than 6,3 mm with an immediate bearing index requirement.

The grading of the mixture, determined in accordance with EN 933-1, shall comply with Table 2.

The immediate bearing index class shall be selected from Table 4.

Table 2 — Grading of fly ash bound granular mixture 3

Sieve mm	2D	D	0,063
Percentage passing by mass	100	≥ 85	≤ 35

6.1.4 Fly ash bound granular mixture 4

Granular mixture with supplier declared grading, including declared upper and lower limits, and supplier declared immediate bearing index category.

The grading of the mixture shall be determined in accordance with EN 933-1.

The immediate bearing index category shall be selected from Table 4.

6.1.5 Fly ash bound granular mixture 5

The grading of the mixture when tested in accordance with EN 933-1 shall comply with the limits in Table 3.

The immediate bearing index category shall be selected from Table 4.

Table 3 — Grading of fly ash bound granular mixture 5

Sieve mm	45	31,5	20	10	4	2	0,5	0,25	0,063
Percentage passing by mass	100	85 to 100	66 to 100	48 to 100	34 to 100	26 to 100	16 to 75	13 to 60	7 to 35

6.1.6 Fly ash bound granular mixture 6

Fly ash bound mixture 6 shall be a mixture where fly ash is the main constituent of the mixture and part of the binder.

Unless the constituents and the mixture are well known and proven, the mixture shall be checked for volume stability in accordance with regulations at the place of use.

In the case of lime and gypsum activated siliceous fly ash, the proportion of gypsum shall not exceed 7 % by dry mass and the proportion of lime shall not exceed 5 % by mass, in the case of quick lime (CaO), or 7 % by mass in the case of hydrated lime ($Ca(OH)_2$).

6.1.7 Examples of fly ash bound granular mixtures

Annexes B and C give examples of fly ash bound granular mixtures.

NOTE The examples are not exhaustive, nor the proportions intended to be restrictive, but they illustrate the current use in Europe.

6.2 Water content of mixtures

The water content shall be selected to permit compaction on site by rolling and to optimise the mechanical performance of the mixture. The water content shall be determined by the Proctor test or other method in accordance with EN 13286-1, EN 13286-2, EN 13286-3, EN 13286-4 and EN 13286-5, and limits set to give a workable range of water content on site compatible with the compaction and the desired mechanical performance of the mixture.

6.3 Proportioning of the constituents, grading and dry density

The proportioning of the constituents, expressed as a percentage by dry mass of the total dry mass of the mixture, the grading, and the dry density of the mixture shall be declared. The declared proportions shall be based on the laboratory mixture design and/or practical experiences with mixtures produced with the same constituents and under the same conditions in a way that the mixture complies with the requirements of this European Standard.

Irrespective of the binder content necessary to fulfil the strength requirements of this standard, the binder content should not be less than any minimum value fixed by provisions valid in the place of use. This requirement may be necessary to ensure that there is adequate distribution of the binder throughout the mixture.

6.4 Other requirements for the fresh mixture

6.4.1 Compacity

The minimum compacity of Type 2 mixtures at the maximum modified Proctor dry density shall be 0,80 in accordance with Annex A.

6.4.2 Immediate bearing index of the mixture

The immediate bearing index shall be determined in accordance with EN 13286-47 using modified Proctor compaction.

The immediate bearing index category from Table 4 shall be IPI_{50} for mixture 2 – 0/10.

The immediate bearing index category shall be selected from Table 4 for mixtures 3, 4 and 5.

Table 4 — Immediate bearing index categories

Immediate bearing index requirement	Immediate bearing index category
Declared value	IPI_{DV}
≥ 50	IPI_{50}
≥ 40	IPI_{40}
≥ 25	IPI_{25}
No requirement	IPI_{NR}

Mixtures with an immediate bearing index less than 40 may not support immediate trafficking and should be used with care.

NOTE 1 Blends of aggregates can be used to achieve the required immediate bearing index.

NOTE 2 The addition of another aggregate can be necessary to achieve the immediate bearing index required for immediate use.

6.4.3 Workability period

When required for the intended use, the workability period, determined in accordance with EN 13286-45, shall be declared.

7 Laboratory mechanical performance classification

7.1 General

Laboratory mechanical performance shall be characterised and classified by one of the following methods:

— compressive strength R_c;

— the combination R_t, E of tensile strength R_t and modulus of elasticity E.

NOTE No correlation is intended or assumed between the two methods.

7.2 Classification by compressive strength

Mixtures shall be classified by compressive strength determined in accordance with EN 13286-41 carried out on specimens manufactured in accordance with EN 13286-50, EN 13286-51, EN 13286-52 and EN 13286-53.

The class of compressive strength shall be selected from Table 5 in combination with the selected method of specimen manufacture.

NOTE The permitted methods of specimen manufacture realise different specimen shapes and density, and thus for the same mixture, different strengths. Hence it is important, on the basis of experience and utilisation, not to separate strength from the method of specimen manufacture.

The age of classification and curing conditions shall be specified in accordance with practice at the place of use.

For characterisation or mixture design testing in the laboratory, compressive strength shall be the average result from at least three specimens. If one value varies by more than 20 % of the average, it shall be discarded and R_t and E taken as the average of the other values.

Table 5 — Compressive strength classification

Column	1	2	3
Line	**Minimum R_c for cylinders of slenderness ratio 2[a]** MPa	**Minimum R_c for cylinders of slenderness ratio 1[a] and cubes** MPa	**R_c Class**
1	0,4	0,5	$C_{0,4/0,5}$
2	0,8	1	$C_{0,8/1}$
3	1,5	2	$C_{1,5/2}$
4	2,3	3	$C_{2,3/3}$
5	3	4	$C_{3/4}$
6	4	5	$C_{4/5}$
7	5	6	$C_{5/6}$
8	6	8	$C_{6/8}$
9	8	10	$C_{8/10}$
10	9	12	$C_{9/12}$
11	12	16	$C_{12/16}$
12	15	20	$C_{15/20}$
13	18	24	$C_{18/24}$
14	21	28	$C_{21/28}$
15	24	32	$C_{24/32}$
16	27	36	$C_{27/36}$
17	30	40	$C_{30/40}$
18	33	44	$C_{33/44}$
19	36	48	$C_{36/48}$
20	Declared value	Declared value	C_{DV}

[a] If cylinders with slenderness ratios other than 1 or 2 are used, then the correlation with cylinders of either slenderness ratio 1 or 2 shall be established before use.

7.3 Classification by R_t, E

7.3.1 General

Mixtures shall be classified by the combination of tensile strength R_t and modulus of elasticity E, designated R_t, E.

The class of R_t, E shall be selected from Figure 9.

The age of classification and curing conditions shall be specified in accordance with practice at the place of use.

For characterisation or mixture design testing in the laboratory, R_t and E shall be the average result from at least three specimens. If one value varies by more than 20 % of the average, it shall be discarded and R_t and E taken as the average of the other values.

R_t and E shall be established using one of the equivalent methods outlined in 7.3.2 to 7.3.4.

7.3.2 Method by direct tensile testing

R_t shall be determined in accordance with EN 13286-40.

E shall be determined in direct tension E_t in accordance with EN 13286-43.

For both, specimens shall be manufactured using vibrocompression in accordance with EN 13286-52.

7.3.3 Method by indirect tensile testing

R_t shall be derived from R_{it} determined in accordance with EN 13286-42 using the relationship $R_t = 0{,}8\ R_{it}$.

E shall be derived from E_{it} (E measured in indirect tension) determined in accordance with EN 13286-43 using the relationship $E = E_{it}$.

Specimens shall be manufactured using:

— either Proctor compaction for both in accordance with EN 13286-50;

— or vibrating hammer for both in accordance with EN 13286-51;

— or vibrocompression for both in accordance with EN 13286-52;

— or axial compression for both in accordance with EN 13286-53.

NOTE The permitted methods of specimen manufacture realise different specimen shapes and density, and thus for the same mixture, different strengths. Hence it is important, on the basis of experience and utilisation, not to separate strength from the method of specimen manufacture.

7.3.4 Method by indirect tensile and compression testing

R_t shall be derived from R_{it} determined in accordance with EN 13286-42 using the relationship $R_t = 0{,}8\ R_{it}$.

E shall be derived from E_c (E measured in compression) determined in accordance with EN 13286-43 using the relationship $E = E_c$.

Specimens shall be manufactured using:

— either Proctor compaction for both in accordance with EN 13286-50;

— or vibrating hammer for both in accordance with EN 13286-51;

— or vibrocompression for both in accordance with EN 13286-52;

— or axial compression for both in accordance with EN 13286-53.

NOTE The permitted methods of specimen manufacture realise different specimen shapes and density, and thus for the same mixture, different strengths. Hence it is important, on the basis of experience and utilisation, not to separate strength from the method of specimen manufacture.

8 Other requirements for the mixture

8.1 Strength after immersion in water

The mixture shall satisfy the selected category for strength after immersion from Table 6.

In Table 6, R_i shall mean the average strength of not less than 3 specimens after Z days sealed curing, followed by W days full immersion curing in aerated water, and R shall mean the average strength of not less than 3 specimens after (Z + W) days sealed curing. All the specimens shall be manufactured from the same batch of mixture, using the same method of manufacture, and shall be cured at the same temperature. Z and W shall be specified in accordance with the practice and requirements at the place of use.

Table 6 — Strength after immersion categories for the mixture

R_i/R **ratio**	**Category**
No requirement	I_{NR}
> 0,6	$I_{0,6}$
≥ 0,7	$I_{0,7}$
> 0,8	$I_{0,8}$
Declared value	I_{DV}

8.2 Other characteristics

Where appropriate, other characteristics, such as frost resistance, shall be examined in accordance with the provisions valid in the place of use.

9 Production control

See informative Annex D.

10 Designation and description

10.1 Designation

The product shall be designated by:

a) manufacturer code of the mixture formulation;

b) reference to this European Standard;

c) manufacturer and place of production;

d) type and characterisation of the fly ash bound granular mixture (e.g. fly ash bound granular mixture 2 – Siliceous fly ash – 0/20 – G2 – C9/12).

10.2 Description

The product shall be described by:

a) description of the constituents;

b) mixture proportions (in % by mass);

c) method of manufacture, curing mode and period, and testing of specimens;

d) dry density of the specimens;

e) laboratory mechanical performance values;

f) other declared characteristics.

11 Marking and labelling

The delivery ticket shall contain at least the following:

a) name of manufacturer or supplier;

b) reference to this standard;

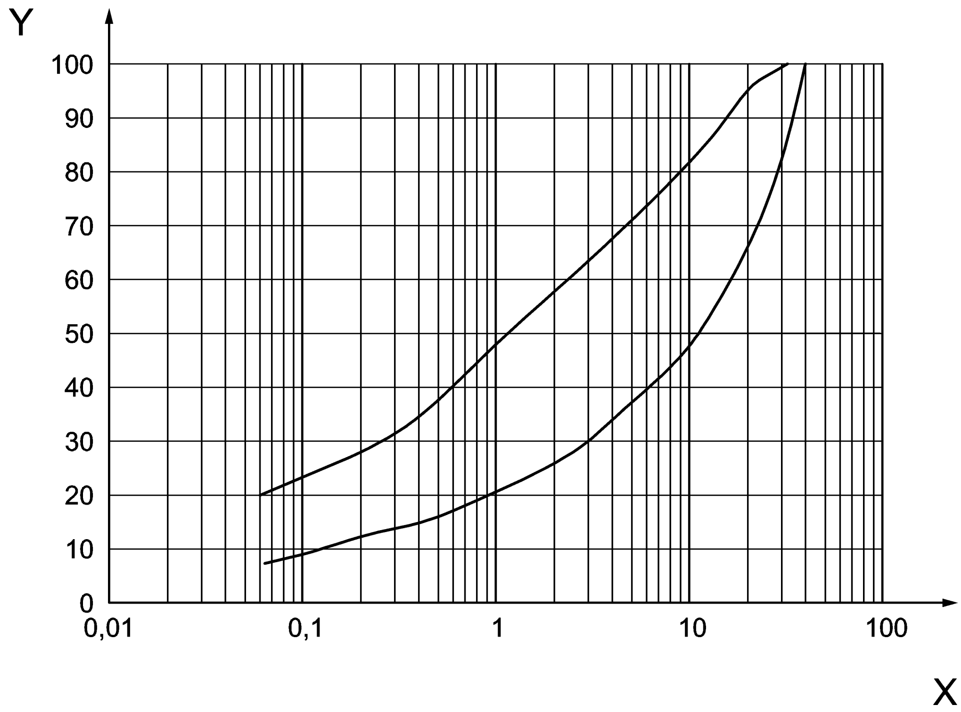
c) designation;

d) date of dispatch;

e) quantity;

f) serial number of the ticket.

12 Figures



Key

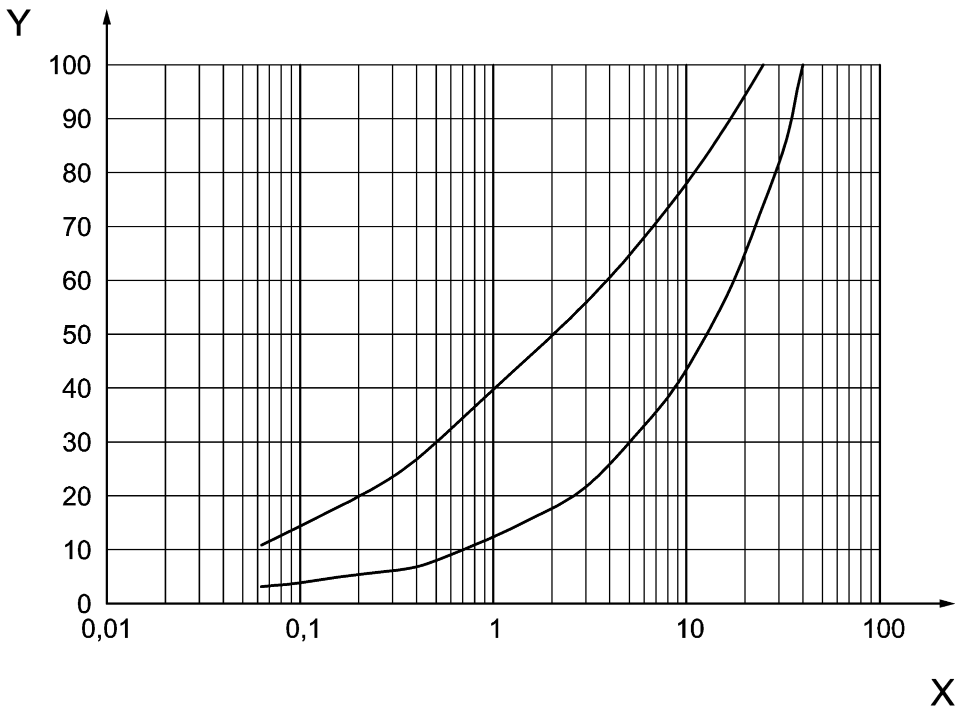
X sieve size, in mm
Y percentage of the mixture passing by mass

See Table 7.

Figure 1 — Grading envelope for fly ash bound granular mixture 1 – 0/31,5 with siliceous fly ash

Table 7

Sieve mm	**Percentage of the mixture passing by mass**	
	Minimum	**Maximum**
40	100	
31,5	85	100
20	66	95
10	48	82
4	34	68
2	26	58
0,5	16	38
0,25	13	30
0,063	7	20



Key

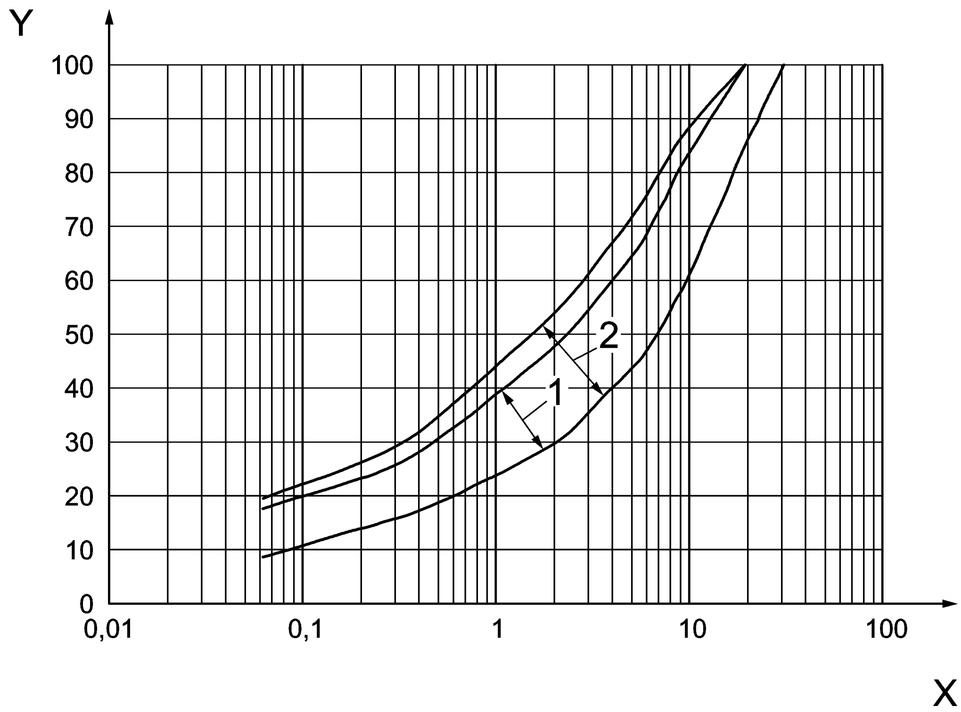
X sieve size, in mm
Y percentage of the mixture passing by mass

See Table 8.

Figure 2 — Grading envelope for fly ash bound granular mixture 1 – 0/31,5 with calcareous fly ash

Table 8

Sieve mm	**Percentage of the mixture passing by mass**	
	Minimum	**Maximum**
40	100	
31,5	85	100
25	75	100
20	65	94
10	44	78
4	26	61
2	18	50
0,5	8	30
0,25	6	22
0,063	3	11



Key

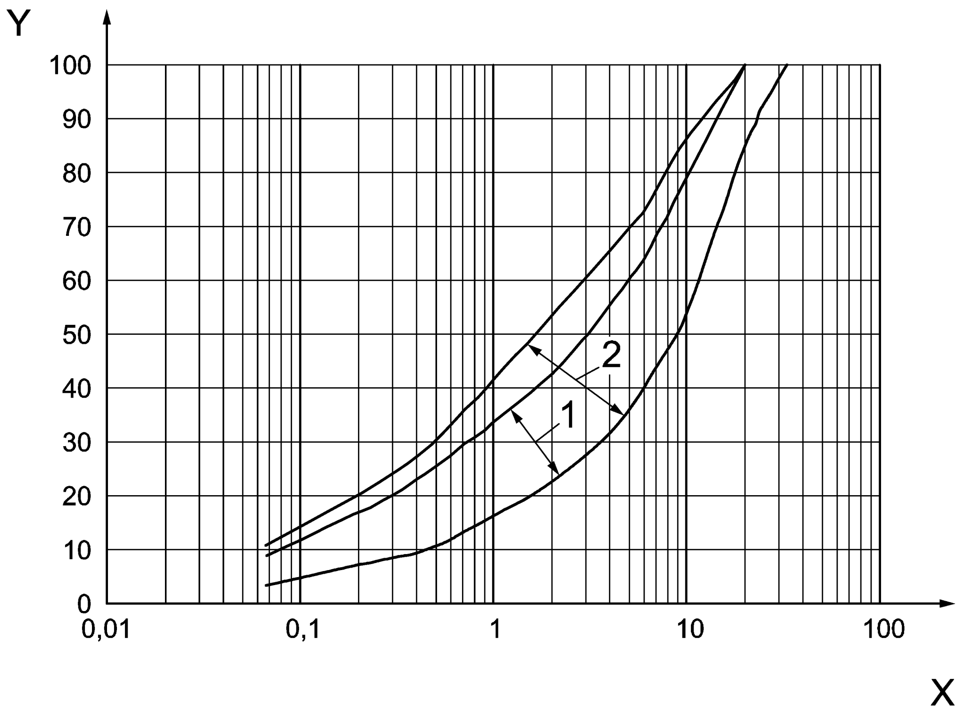
X sieve size, in mm
Y percentage of the mixture passing by mass
1 category G1
2 category G2

See Table 9.

Figure 3 — Grading envelope for fly ash bound granular mixture 2 – 0/20 with siliceous fly ash

Table 9

Sieve mm	**Percentage of the mixture passing by mass**		
	Minimum	**Maximum Category G1**	**Maximum Category G2**
31,5	100		
20	85	100	100
10	60	83	88
6,3	47	69	76
4	39	59	66
2	29	47	53
0,5	18	30	34
0,25	14	24	27
0,063	8	17	19



Key

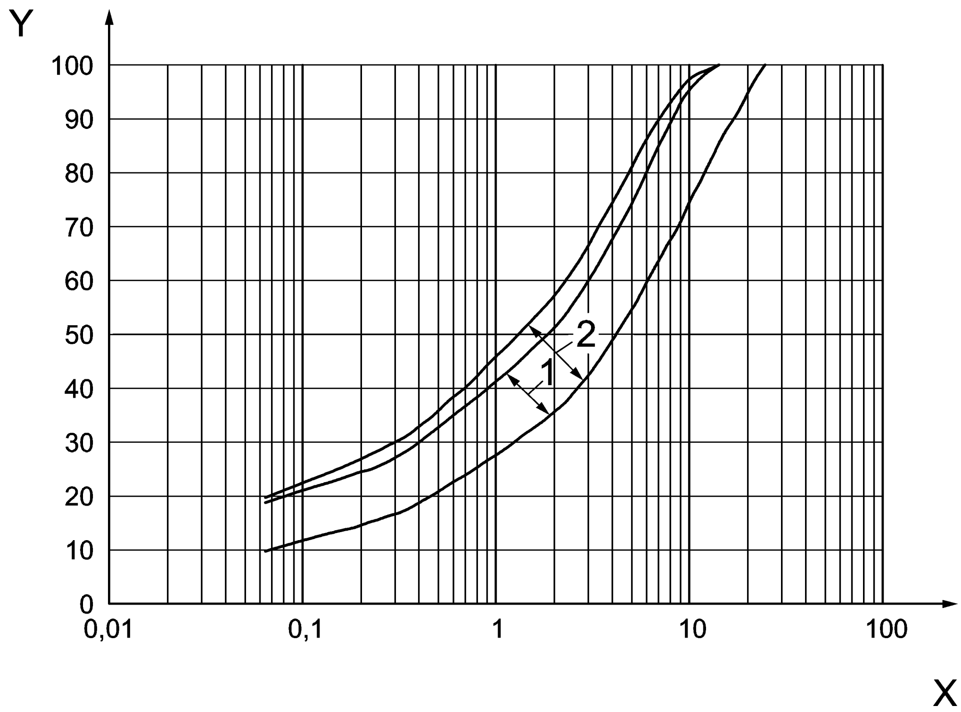
X sieve size, in mm
Y percentage of the mixture passing by mass
1 category G1
2 category G2

See Table 10.

Figure 4 — Grading envelope for fly ash bound granular mixture 2 – 0/20 with calcareous fly ash

Table 10

Sieve mm	**Percentage of the mixture passing by mass**		
	Minimum	**Maximum Category G1**	**Maximum Category G2**
31,5	100		
20	85	100	100
10	55	80	87
6,3	42	66	75
4	32	56	66
2	23	43	54
0,5	11	26	31
0,25	8	19	23
0,063	3,5	9	11



Key

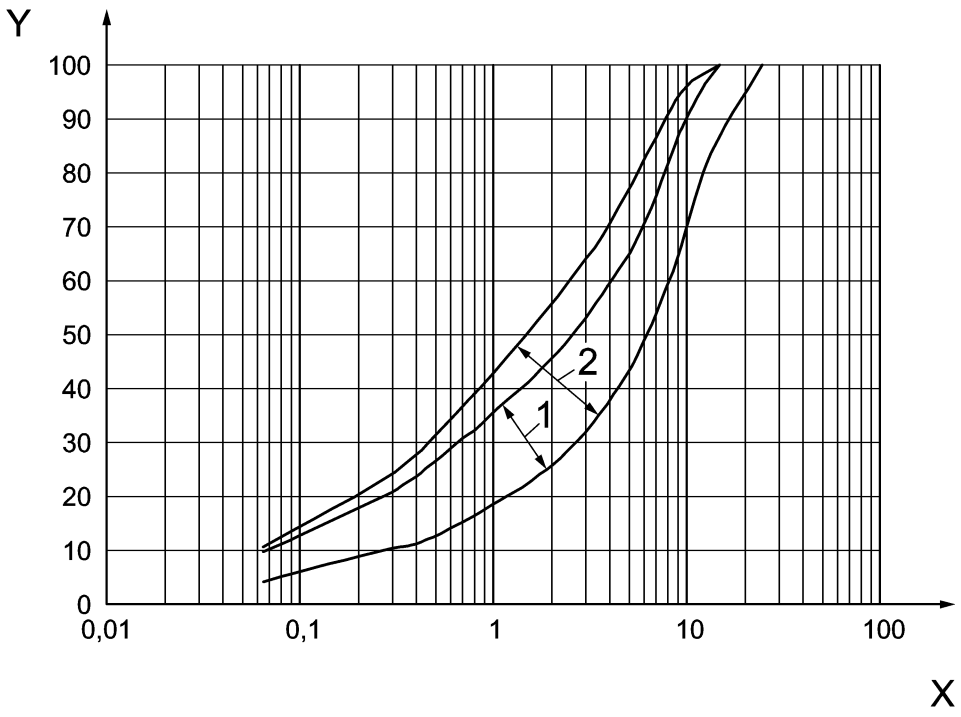
X sieve size, in mm
Y percentage of the mixture passing by mass
1 category G1
2 category G2

See Table 11.

Figure 5 — Grading envelope for fly ash bound granular mixture 2 – 0/14 with siliceous fly ash

Table 11

Sieve mm	**Percentage of the mixture passing by mass**		
	Minimum	**Maximum Category G1**	**Maximum Category G2**
25	100		
14	84	100	100
10	73	95	97
6,3	60	81	87
4	48	67	74
2	35	51	57
0,5	20	32	35
0,25	15	25	28
0,063	9	18	19



Key

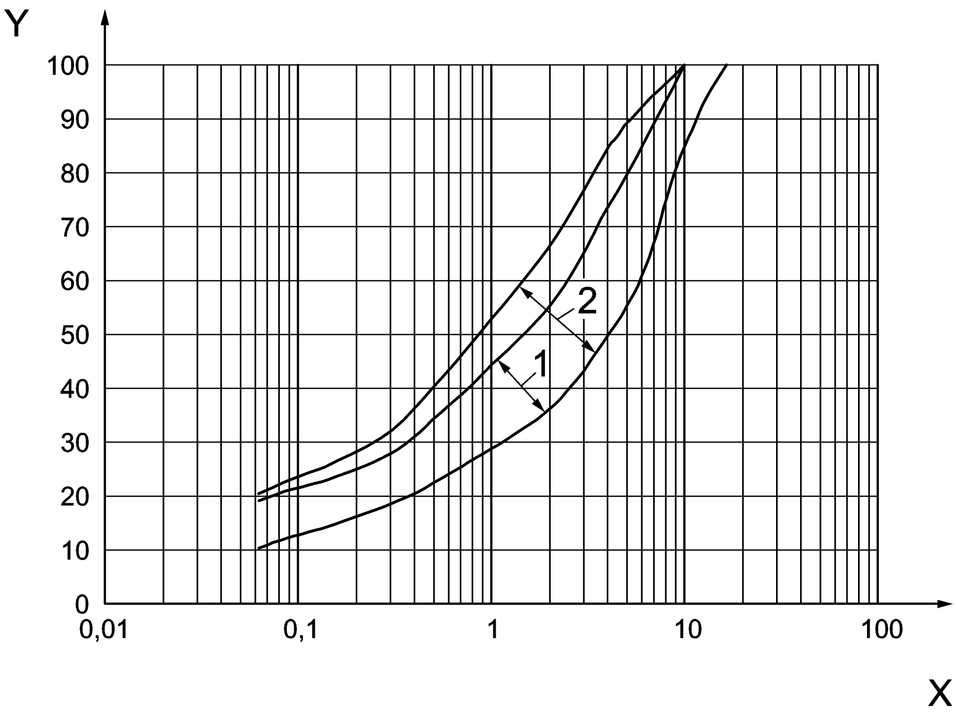
X sieve size, in mm
Y percentage of the mixture passing by mass
1 category G1
2 category G2

See Table 12.

Figure 6 — Grading envelope for fly ash bound granular mixture 2 – 0/14 with calcareous fly ash

Table 12

Sieve mm	**Percentage of the mixture passing by mass**		
	Minimum	**Maximum Category G1**	**Maximum Category G2**
25	100		
14	85	100	100
10	68	90	97
6,3	50	72	84
4	38	60	71
2	26	46	56
0,5	13	27	32
0,25	10	20	23
0,063	4,5	10	11



Key

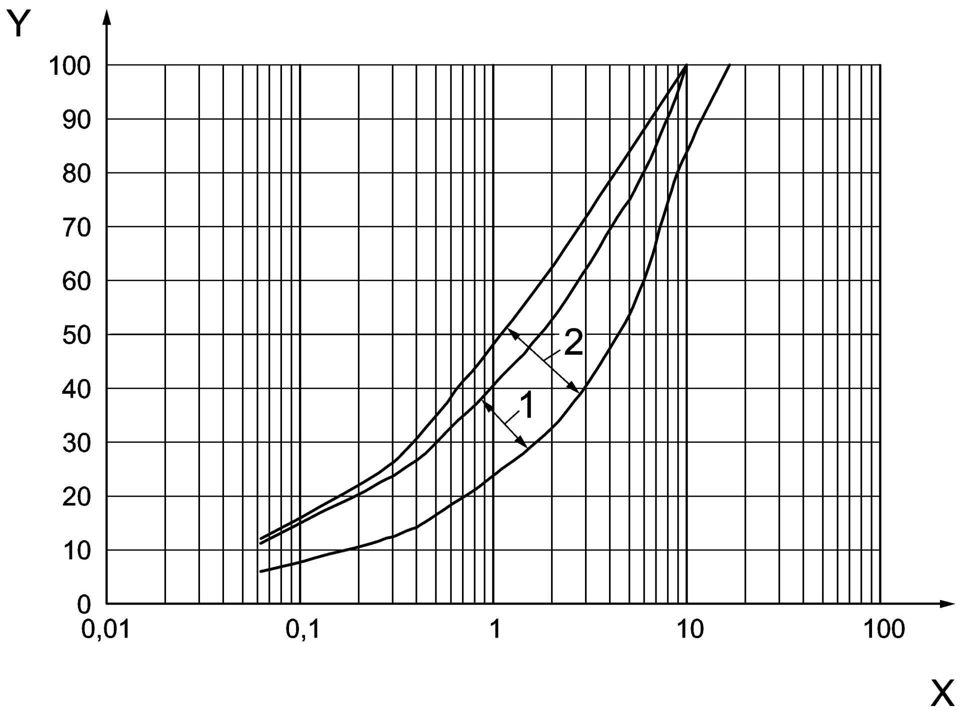
X sieve size, in mm
Y percentage of the mixture passing by mass
1 category G1
2 category G2

See Table 13.

Figure 7 — Grading envelope for fly ash bound granular mixture 2 – 0/10 with siliceous fly ash

Table 13

Sieve mm	**Percentage of the mixture passing by mass**		
	Minimum	**Maximum Category G1**	**Maximum Category G2**
16	100		
10	85	100	100
6,3	62	86	93
4	49	73	84
2	36	55	66
0,5	22	34	40
0,25	17	26	30
0,063	10	19	20



Key

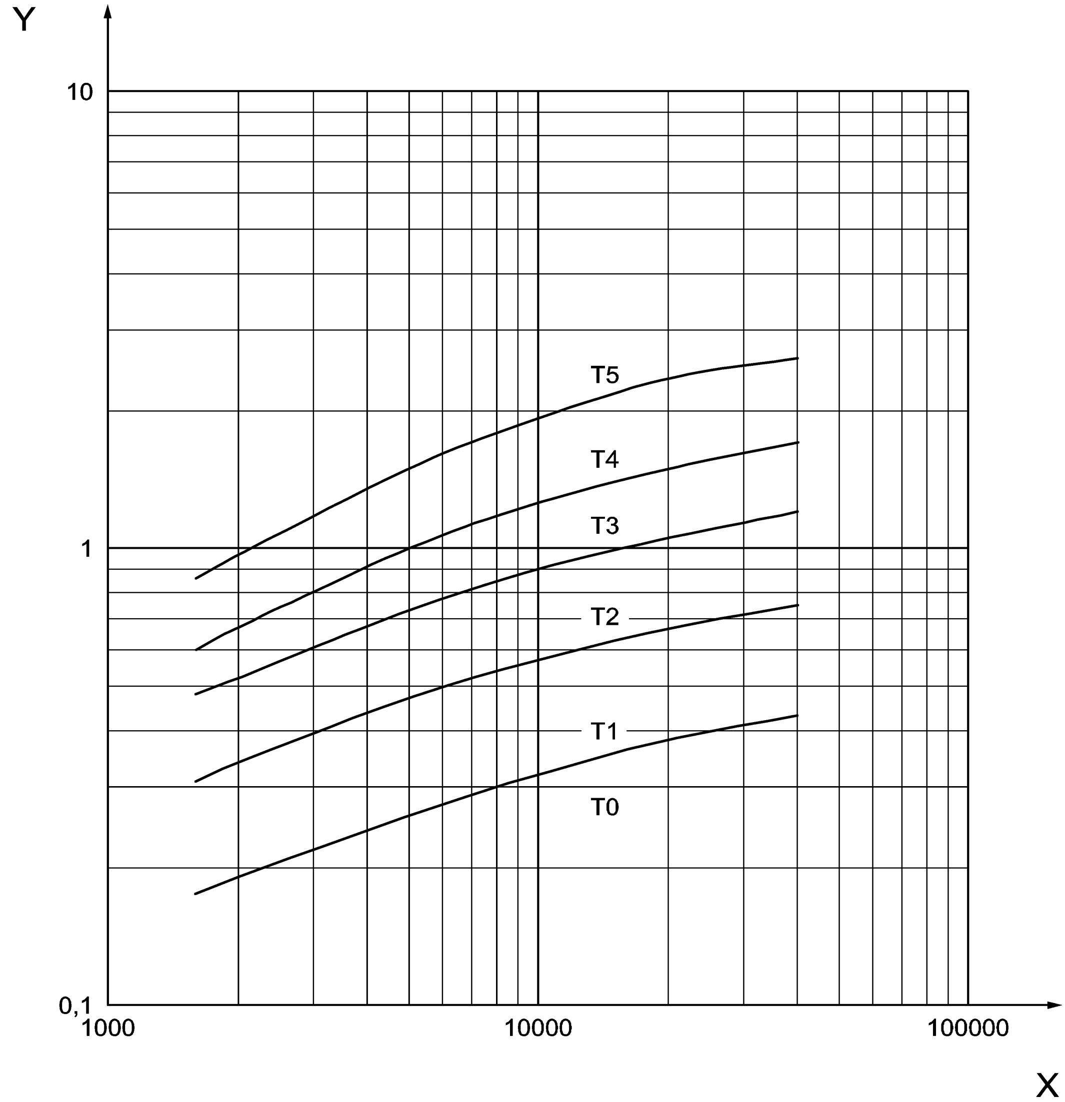
X sieve size, in mm
Y percentage of the mixture passing by mass
1 category G1
2 category G2

See Table 14.

Figure 8 — Grading envelope for fly ash bound granular mixture 2 – 0/10 with calcareous fly ash

Table 14

Sieve mm	**Percentage of the mixture passing by mass**		
	Minimum	**Maximum Category G1**	**Maximum Category G2**
16	100		
10	85	100	100
6,3	62	83	91
4	48	71	81
2	33	54	64
0,5	17	31	36
0,25	12	23	25
0,063	6,5	12	13



Key

Y direct tensile strength R_t, in MPa
X elastic modulus E, in MPa

See Table 15.

Figure 9 — Classification by R_t, E

Table 15

E MPa	**2 000**	**5 000**	**10 000**	**20 000**	**40 000**
Low limit of category	R_t MPa				
T5	0,97	1,50	1,93	2,35	2,60
T4	0,67	1,00	1,26	1,49	1,70
T3	0,52	0,73	0,90	1,05	1,20
T2	0,34	0,47	0,57	0,67	0,75
T1	0,19	0,26	0,32	0,38	0,43
NOTE The table gives the values of R_t and E used to draw the curves limiting the categories T5, T4, T3, T2 and T1.					

Annex A
(normative)

Compacity of a fly ash bound granular mixture 2

The compacity before setting of a fly ash bound granular mixture 2 shall be defined as the value of the ratio:

— absolute volume of solid/apparent volume of the mixture.

This shall be calculated by the following formula:

$$C = (\gamma m/100) \times (a/\gamma A + b/\gamma B + c/\gamma C \ldots) \quad \text{(A.1)}$$

where

C is the compacity;

γm is the maximum dry density of the mixture, in megagrams per cubic metre (Mg/m^3);

γA is the particle density of the constituent A, in megagrams per cubic metre (Mg/m^3);

γB is the particle density of the constituent B, in megagrams per cubic metre (Mg/m^3);

γC is the particle density of the constituent C, in megagrams per cubic metre (Mg/m^3);

a is the constituent A content in mass related to the mixture, in percent (%);

b is the constituent B content in mass related to the mixture, in percent (%);

c is the constituent C content in mass related to the mixture, in percent (%).

The particle density of the constituents (γA, γB, γC, ...) shall be determined according to EN 1097-6:2000, Annex A (pre-dried particle density), or EN 1097-7, depending on their particle size.

For example, the compacity at the maximum modified Proctor dry density of the mixture described below shall be calculated as follows:

Table A.1

Column	1	2	3
Line	**Constituent**	%	**Particle density** Mg/m^3
1	Coarse aggregate 6,3/20	50	2,69
2	Coarse aggregate 0/6,3	36	2,65
3	Siliceous fly ash	12	2,20
4	Hydrated lime	2	2,24
5	Maximum modifed Proctor dry density of the mixture, Mg/m^3		2,11
$C = (2,11/100) \times (50/2,69 + 36/2,65 + 12/2,20 + 2/2,24) = 0,81$			

Annex B
(informative)

Examples of fly ash bound granular mixtures using siliceous fly ash

Column	1	2	3	4	5	6	7	8	9
Line	**Type**	**Examples**	**Typical proportions as a percentage of dry mass** %						**Typical water content** %
			Siliceous Fly Ash	**Lime**[a]	**Cement**	**Fine Aggregate**	**Coarse Aggregate**	**Other Material**	
1	1 and 2	Fly Ash / Lime / Granular Material	4 to 13	1 to 3	—	30 to 40	50 to 55	—	6 to 8
2		Fly Ash / Cement / Granular Material	3 to 6	—	1 to 3	40 to 45	50 to 55	—	6 to 8
3		Fly Ash / slag[b] / Granular Material	5 to 7	0 to 2	—	30 to 40	50 to 55	5 % to 7 % slag[b]	6 to 8
4	3	Fly Ash / Lime / Fine Aggregate	9 to 12	2 to 4	—	84 to 89	—	—	~10
5		Fly Ash / Cement / Fine Aggregate	6 to 8	—	2 to 4	88 to 92	—	—	~10
6	4 and 5	Fly ash / lime / all — in aggregate	16 to 20	3 to 5	—	—	—	All — in aggregate	~ 15
7	6	Fly Ash / Lime	93 to 97	3 to 7	—	—	—	—	15 to 25
8		Fly Ash / Lime / Gypsum	91	4	—	—	—	5 % gypsum	15 to 25
9		Fly Ash / Cement	90 to 95	—	5 to 10	—	—	—	15 to 25

[a] Lime may be supplied pre-blended with dry fly ash.

[b] Granulated blast furnace slag.

Annex C
(informative)

Examples of fly ash bound granular mixtures using calcareous fly ash

Column	1	2	3	4	5	6	7	8
Line	**Type**	**Examples**	**Typical proportions as a percentage of dry mass** %					**Typical water content** %
			Calcareous Fly Ash	**Cement**	**Fine Aggregate**	**Coarse Aggregate**	**Other Material**	
1	1 and 2	Fly Ash / Granular Material	3 to 6	—	—	94 to 97	—	5 to 7
2		Fly Ash / Cement / Granular Material	3 to 16	1 to 4	—	80 to 96	—	5 to 7
3	3	Fly Ash / Fine Aggregate	4 to 8	—	92 to 96	—	—	~ 10
4		Fly Ash / slag[a] / Fine Aggregate	2 to 4	—	92 to 96	—	2 % to 4 % slag[a]	5 to 7
5		Fly Ash / Cement / slag[a] / Fine Aggregate	1 to 3	1 to 2	92 to 96	—	1 % to 3 % slag[a]	5 to 7
6	4 and 5	Fly ash / all — in aggregate	6 to 10	—	—	—	All — in aggregate	~ 10
7	6	Fly Ash / Cement	80 to 95	5 to 20	—	—	—	15 to 30

[a] Granulated blast furnace slag.

Annex D
(informative)

Production control for fly ash bound granular mixtures

D.1 General

This annex describes the recommendations for a production control system for manufacturers of hydraulically treated mixtures (e.g. aggregates and soils treated by lime, hydraulic binders or hydraulic combinations).

The objective of production control is to give assurance that the mixture conforms to the specification.

D.2 Quality manual

The manufacturer should establish and maintain his policy and procedures for production control in a quality manual that should include:

- the manufacturer's organisational structure relating to quality;
- control of constituents and mixtures;
- process control, calibration and maintenance;
- requirements for the handling and storage of the mixture when appropriate;
- inspection, calibration and control of the measuring equipment in the process, and laboratory testing equipment for the mixture;
- procedures for handling non-conforming mixture.

D.3 Organisation

D.3.1 Responsibility and authority

The responsibility, authority and inter-relation of all personnel who manage, perform and verify work affecting quality should be defined in the quality manual, particularly personnel who have authority to identify, record and rectify any mixture quality problems.

D.3.2 Management representative

The manufacturer should appoint a person with appropriate authority, knowledge and experience of production control and to ensure that the requirements of the quality manual are implemented and maintained.

D.3.3 Internal audits

The manufacturer should carry out internal quality audits to verify compliance with the planned arrangements and the effectiveness of the quality system. Audits should be scheduled on the basis of the status and importance of the activity. The audits and follow up action should be carried out in accordance with documented procedures. The results of the audits should be documented and brought to the attention of the personnel having responsibility in the area audited. The management personnel responsible for the area should take timely corrective action on the deficiencies found by the audit and should keep a record of the action taken.

D.3.4 Management review

The production control system should be reviewed at appropriate intervals by management to ensure its continuing suitability and effectiveness. Records of such reviews should be maintained.

D.3.5 Sub-contract services

Where any services are supplied from outside the manufacturer's resources, means of control should be established.

D.3.6 Records

The production control system should contain adequately documented procedures and instructions.

The intended frequencies of tests and inspections by the manufacturer should be documented and the results of tests and inspections recorded.

Sampling location, date and time, as well as details of the mixture or constituents tested, should be recorded together with any other relevant information.

Where the constituent or mixture examined does not satisfy the requirements of the appropriate specification and this standard, records should be kept of corrective actions taken to ensure the quality of the mixture is maintained.

Records should be kept in such a way that they are retrievable and be retained for the period stated in the quality manual, usually a minimum of three years or longer if legally required.

D.3.7 Training

The manufacturer should establish and maintain procedures for the training of all personnel involved in activities affecting quality. Personnel performing specific assigned tasks should be suitably qualified on the basis of appropriate education, training or experience, as required. Training records should be kept.

D.4 Control procedures

D.4.1 Production management

The production control system should contain the following:

a) the composition of the mixture to be produced;

b) procedures to adjust mixture composition;

c) procedures to ensure that constituents comply with requirements;

d) procedures to ensure that production equipment, including mixture storage facilities, maintain the composition, homogeneity, and consistency of the mixture;

e) procedures for:

   1) calibrating, maintaining and adjusting the process and testing equipment;

   2) sampling the constituents and mixture;

   3) data recording during processing;

   4) adjusting the process according to weather conditions;

f) instructions so that the mixture is identifiable up to the point of delivery as regards source and type.

D.4.2 Composition of the mixture

The composition of the mixtures should be established from a laboratory mixture design procedure intended to ensure the mixture should have properties conforming to the relevant standard.

Where applicable, the composition of regularly produced mixtures will be included in a catalogue of mixtures compositions and considered as the mixture baseline or target composition.

The compositions should be re-established in case of significant change in constituents and should be reviewed periodically to ensure the mixture conforms to requirements taking account any change in properties of constituents.

D.4.3 Constituents

Documentation should detail the source and type of each constituent of the mixture for use at the production location.

Adequate supplies of constituent should be available to ensure that the planned rates of production and delivery can be maintained.

The specifications for incoming constituents should be established and communicated to suppliers by means of written orders.

The control procedures should check that constituents are capable of providing the required quality.

Constituents should be transported and stored in such a manner as to avoid intermingling, contamination or deterioration that may affect the quality of the product.

D.4.4 Process control

The quality manual should include:

— a description of equipment and installation;

— a description of the flow of constituents and the processes carried out on them. If appropriate, this should incorporate a flow diagram;

— a schedule for monitoring the performance of the process (manual or automatic systems), including a record of equipment performance against the stated tolerances.

D.4.5 Inspection, calibration and control of process equipment

The quality manual should identify items of measuring devices that require calibration and the frequency of such calibration.

Calibration procedures should be provided, including the permitted tolerances for the devices to remain in service. The quality manual should state the required accuracy of all calibrations.

The equipment should be adequately maintained to ensure that it continues to be capable of producing a mixture to the required specifications and tolerances.

D.4.6 Handling and delivery

The quality manual should contain procedures to ensure that the mixture is handled and (where appropriate) delivered with the minimum of segregation or degradation and within the permitted water content range and time limit.

At the point of delivery, the mixture should be identifiable and traceable with regard to its production data. The manufacturer should maintain records of relevant data of production, which can be referenced from information when appropriate on the delivery ticket.

If appropriate, the manufacturer's quality manual should describe the characteristics of any mixture storage system and define its mode of operation. The manufacturer should ensure through checks, inspections and records that such systems are used correctly and that mixtures maintain their suitability for use.

D.5 Inspection and testing of constituents and mixtures during production

D.5.1 General

At the start of the production process, the homogeneity of the mixture should be considered with regard to the specification, the type and quality of the production plant and the quality and homogeneity of the constituents. This can be appreciated either from past production experience or by undertaking specific tests.

The quality manual should specify the frequency and nature of regular tests/checks/inspections that should be carried out during production. The manufacturer should prepare a schedule of frequencies considering:

- test frequencies in relation to periods of actual production of each mixture;
- test frequency where automated surveillance and monitoring of the production process exists;
- statistical approach for testing.

Reasons for changing the test frequencies and analysis should be stated in the quality manual.

NOTE If appropriate, long-term experience of the consistency of a particular property as well as mixtures with an established record for conformity can be taken into account.

D.5.2 Characteristics that require control during production

These may include:

- properties of the constituents including water content (before production);
- proportioning of the constituents including added water;
- grading of the fresh mixture;
- water content of the fresh mixture.

The above characteristics should comply with the requirements of the target composition of the mixture (see D.4.2).

D.5.3 Frequency of sampling the mixture

During the regular production of the mixture, the sample frequency may be as follows:

- In the case of plants with a validated and accepted automated surveillance and data collection system giving computerised composition for every truck or every batch, one sample should be taken every 2 000 t or 1 000 m^3 or one per day for lesser quantities.

— In the case of other types of plants or production, one sample should be taken every 300 t or 150 m^3, with a minimum of 1 sample per day.

— Alternatively and independent of the type of mixing plant, the frequency of sampling can be on a time related rather than a quantity related basis, such as a minimum of 1 sample per week or 1 sample per day depending on the characteristic being measured.

In the case of occasional production of a standard mixture, the production should be assessed cumulatively with previous production with the same or similar criteria. The frequency of sampling can be adjusted on a contract-by-contract basis according to the overall quantity of production required.

D.6 Inspection and testing equipment

D.6.1 General

All necessary facilities, equipment and personnel should be available to carry out the required inspections and tests.

Normally the testing should be performed according to the specified test methods given in the relevant standard.

Other test methods may be used, if correlations or safe relationships between the results of these test methods and the reference methods have been established.

D.6.2 Measuring and testing equipment

The manufacturer should be responsible for the control, calibration and maintenance of the inspection, measuring and testing equipment.

D.6.3 Measuring and testing equipment in the process

The points in the process where measuring equipment needs to be deployed should be stated in the quality manual.

The quality manual should indicate when control is carried out automatically or manually. There should be a description of how equipment is maintained and calibrated.

D.6.4 Measuring and testing equipment in laboratory

The testing equipment should be in a known state of calibration and accuracy, consistent with the required measurement capability.

The following points should be addressed:

— accuracy and frequency of calibration, which should be in accordance with the relevant test standards;

— equipment to be used in accordance with documented procedures;

— equipment to be uniquely identified and calibration records should be retained.

D.7 Non-conformity

D.7.1 General

Non-conformity can arise at the following stages:

- constituent delivery;
- constituent in storage;
- mixture production;
- handling, storage and delivery of the mixture if appropriate.

In the event that a non-conforming constituent, process or mixture is identified, investigations should be initiated to determine the reasons for non-conformity and effective corrective action should be implemented to prevent recurrence in accordance with procedures documented in the quality manual.

D.7.2 Non-conformity of constituents

In the case of non-conforming constituents, corrective action may involve:

- reclassifying the constituent;
- reprocessing;
- adjusting process control to allow for constituent non-conformity;
- rejection and disposal of the non-conforming constituent.

D.7.3 Non-conformity of the mixture

Non-conforming mixture should be evaluated and procedures for taking action should be followed.

The quality manual should identify the action to be taken when a non-conforming product is identified and should state the circumstances under which the customer will be notified of non-conforming results.

Such action may involve:

- corrective action (for example modification of the mixture and or adjustment of equipment);
- acceptance of the mixture following the agreement of the customer to accept a non-conforming mixture;
- if the mixture produced is incorrect it can be redirect to an alternative customer if appropriate;
- rejection of the mixture.

Bibliography

[1] EN 14227-1, *Hydraulically bound mixtures — Specifications — Part 1: Cement bound granular mixtures*

[2] EN 14227-5, *Hydraulically bound mixtures — Specifications — Part 5: Hydraulic road binder bound granular mixtures*

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