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English version

Hydraulically bound mixtures –Specifications - Part 3: Fly ash bound mixtures

Mélanges traités aux liants hydrauliques - Spécifications -
Partie 3: Mélanges traités à la cendre volante

Hydraulisch gebundene Gemische - Anforderungen - Teil 3:
Flugaschegebundene Gemische

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 227.

If this draft becomes a European Standard, CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

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Foreword

This European Standard has been prepared by Technical Committee CEN/TC 227 "Road materials", the secretariat of which is held by DIN.

According to CEN/CENELEC internal regulations, the national standards organisations of the following countries are bound to implement this document: Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

This standard is one of a series of standards for hydraulically bound mixtures:

prEN 14227-1, *Hydraulically bound mixtures — Specifications — Part 1: Cement bound granular mixtures.*

prEN 14227-2, *Hydraulically bound mixtures — Specifications — Part 2: Slag bound mixtures .*

prEN 14227-3, *Hydraulically bound mixtures — Specifications — Part 3: Fly ash bound mixtures.*

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

prEN 14227-5, *Hydraulically bound mixtures — Specifications — Part 5: Granular materials bound with hydraulic road binders.*

prEN 14227-X, *Hydraulically bound mixtures — Specifications — Part X: Soil cement .*

prEN 14227-11, *Hydraulically bound mixtures — Specifications — Part 11: Lime treated mixtures .*

prEN 14227-12, *Hydraulically bound mixtures — Specifications — Part 12: Soil treated by granulated blast furnace slag .*

prEN 14227-13, *Hydraulically bound mixtures — Specifications — Part 13: Soil treated by hydraulic road binder.*

prEN 14227-14, *Hydraulically bound mixtures — Specifications — Part 14: Soil treated by fly ash .*

1 Scope

This European Standard defines " fly ash bound 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 prEN14227-4. Where fly ash is part of cement or hydraulic road binder conforming to EN197-1 or ENV 13282, then reference should be made to prEN14227-1 and prEN14227-5 respectively.

2 Normative references

This European Standard incorporates by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies.

EN933-1, *Tests for geometrical properties of aggregates — Part 1: Determination of particle size distribution — Seiving method*

EN 1097-6, *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 particle density of filler – Pycnometer method*

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

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

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

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

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

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

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

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

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

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

prEN 13286-47, *Unbound and hydraulically bound mixtures — Part 47: Test methods for the determination of California bearing ratio, immediate bearing index and one-dimensional swelling.*

prEN 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.*

prEN 13286-51, *Unbound and hydraulically bound mixtures – Part 51: Method for the manufacture of test specimens of hydraulically bound mixtures by vibrating hammer compaction.*

prEN 13286-52, *Unbound and hydraulically bound mixtures – Part 52: Method for the manufacture of test specimens of hydraulically bound mixtures by vibro- compression.*

prEN 13286-53, *Unbound and hydraulically bound mixtures – Part 53: Method for the manufacture of cylindrical test specimens of hydraulically bound mixtures by axial compression.*

prEN 14227-1, *Hydraulically bound mixtures — Specifications — Part 1: Cement bound granular mixtures.*

prEN 14227-2, *Hydraulically bound mixtures — Specifications — Part 2: Slag bound mixtures.*

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

prEN 14227-5, *Hydraulically bound mixtures — Specifications — Part 5: Granular materials bound with hydraulic road binders.*

3 Terms and definitions

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

3.1

hydraulically bound mixture

mixture which sets and hardens by hydraulic reaction

3.2

fly ash bound mixture

hydraulically bound mixture in which siliceous or calcareous fly ash is the essential constituent of the binder.

Note: Hardening can be controlled by additional constituents

3.3

slenderness ratio

height to diameter ratio of the specimen

3.4

compactness

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

4 Symbols and abbreviations

For the purpose of this European Standard, the following symbols and abbreviations apply:

R_c	compressive strength, expressed in megapascals (MPa);
R_t	direct tensile strength, expressed in megapascals (MPa);
R_{it}	indirect tensile strength, expressed in megapascals (MPa);
E	modulus of elasticity, expressed in megapascals (MPa);
E_c	E determined in compression, expressed in megapascals (MPa);
E_t	E determined in direct tension, expressed in megapascals (MPa);
E_{it}	E determined in indirect tension, expressed in megapascals (MPa);

5 Constituents

5.1 Fly Ash

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

5.2 Lime

Quick lime [CaO] or hydrated lime [Ca(OH)₂] shall conform to prEN 14227-Y

5.3 Cement

Cement shall conform to EN 197-1.

5.4 Aggregates

Aggregates shall be selected from prEN 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.

5.5 Gypsum

The percentage of $(\text{CaSO}_4 \cdot 2 \text{H}_2\text{O})$ shall be higher than 90 %. The maximum size shall be less than 5 mm.

Note 1: Gypsum, natural or artificial, is a 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 blast furnace slag shall conform to prEN 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 which adversely affect the hardening and the performance of fly ash bound mixtures.

6 Fly ash bound mixtures

6.1 General

6.1.1 Types

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

The mixture shall be selected from the 5 types described below and shall conform to the specified requirements for the selected mixture.

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6.1.2 Water content

The water content shall be selected to permit compaction on site by rolling and to optimize the mechanical performance of the mixture. The water content shall be determined by the Proctor test or other method in accordance with prEN 13286 Parts 1 to 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.

6.1.3 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.

6.1.4 Laboratory mechanical performance

The laboratory mechanical performance characterization and category shall be selected from clause 7.

6.2 Fly ash bound mixture 1

Fly ash bound mixture 1 shall be a 0/31,5 mm mixture with a grading, determined in accordance with EN 933-1, complying with Table 1.

Table SEQ1 — Grading of fly ash bound mixture 1

	Grading envelopes	
Fly ash bound mixture	Mixture using siliceous fly ash	Mixture using calcareous fly ash
1 – 0/31,5	Figure 1	Figure 2

6.3 Fly ash bound mixture 2

6.3.1 Description

Fly ash bound mixture 2 shall be a granular mixture with compacity requirement where fly ash is part of the binder. There are 3 sub-types depending on the aggregate size.

6.3.2 Grading of the mixture

The grading of the mixture, determined in accordance with EN 933-1, shall comply with Table2. According to the use of the mixture, either category G1 or category G2 of the grading envelope in Figures 3 to 8 shall be specified.

SEQTable 2 — Gradings of fly ash bound mixture 2

Fly ash bound 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

6.3.3 Compacity

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

6.3.4 Immediate bearing index of the mixture

In the case of fly ash bound mixture 2 - 0/10, the immediate bearing index, determined in accordance with prEN 13286-47, shall not be less than 50.

6.4 Fly ash bound mixture 3

6.4.1 Description

Fly ash bound mixture 3 shall be a 'fine aggregate' mixture with immediate bearing index requirement where fly ash is part of the binder.

6.4.2 Grading of the mixture

The grading of the mixture , determined in accordance with EN 933-1, shall comply with Table3.

Table 3 – Grading of fly ash bound mixture 3

Sieve mm	12,5	6,3	0,063
Percentage passing by mass	100	≥ 85	≤ 35

6.4.3 Immediate bearing index of the mixture

In order to facilitate site compaction and depending on trafficking, the immediate bearing index of the mixture, determined in accordance with prEN13286-47, shall be selected from Table4.

Table 4 – Immediate bearing index categories for fly ash bound mixture 3

Immediate bearing index category	Immediate bearing index requirement
IPI_{40}	≥ 40
IPI_{25}	≥ 25
IPI_{NR}	No requirement

NOTE: Mixtures with an immediate bearing index less than 40 may not support immediate trafficking and should be used with care. The addition of another aggregate may be necessary to achieve the Immediate bearing index required for immediate use.

6.5 Fly ash bound mixture 4

Fly ash bound mixture 4 shall be a mixture where the grading, determined in accordance with EN 933-1, is declared by the supplier.

NOTE: If appropriate, other properties, such as immediate bearing index, may be declared.

6.6 Fly ash bound mixture 5

6.6.1 Description

Fly ash bound mixture 5 shall be a mixture where fly ash is the main constituent of the mixture and part of the binder.

6.6.2 Fly ash

The fly ash shall be siliceous fly ash conforming to prEN 14227-4.

6.6.3 Lime activated mixtures

In the case of lime activated mixtures containing gypsum, 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 6% by mass in the case of hydrated lime. Unless the constituents and the mixture are well known and proven, the mixture shall be checked for expansion in accordance with regulations at the place of use.

6.7 Examples of fly ash bound mixtures

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

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

7 Laboratory mechanical performance classification

7.1 General

Laboratory mechanical performance shall be characterized 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 nor should be assumed between the two methods.

7.2 Classification by R_c

Mixtures shall be classified by R_c determined in accordance with prEN 13286-41 carried out on specimens manufactured in accordance with prENs 13286-50 to 53.

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

NOTE: The permitted methods of specimen manufacture realize different specimen shapes and density, and thus for the same mixture, different strengths. Hence it is important, on the basis of experience and utilization, 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 characterization or mixture design testing in the laboratory, R_c 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_c taken as the average of the other values.

Table SEQ5 — R_c classification

R_c Class	Minimum R_c in MPa for cylinders of slenderness ratio 2 ^a	Minimum R_c in MPa for cylinders of slenderness ratio 1 ^a and cubes
C 0,4 / 0,5	0,4	0,5
C 0,8 / 1	0,8	1
C 1,5 / 2	1,5	2
C 3 / 4	3	4
C 6 / 8	6	8
C 9 / 12	9	12
C 12 / 16	12	16
C 15 / 20	15	20
C 18 / 24	18	24
C 21 / 28	21	28
C 24 / 32	24	32
C 27 / 36	27	36
C_{DV}	declared value	declared value

^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 characterization 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 prEN 13286-40.

E shall be determined in direct tension (E_t) in accordance with prEN 13286-43.

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

7.3.3 Method by indirect tensile testing

R_t shall be derived from R_{it} determined in accordance with prEN 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 prEN 13286-43 using the relationship $E = E_{it}$.

Specimens shall be manufactured using:

- either Proctor compaction for both in accordance with prEN 13286-50;
- or vibrating hammer for both in accordance with prEN 13286-51;
- or vibrocompression for both in accordance with prEN 13286-52;
- or axial compression for both in accordance with prEN 13286-53.

NOTE: The permitted methods of specimen manufacture realize different specimen shapes and density, and thus for the same mixture, different strengths. Hence it is important, on the basis of experience and utilization, 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 prEN 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 prEN 13286-43 using the relationship $E = E_c$.

Specimens shall be manufactured using:

- either Proctor compaction for both in accordance with prEN 13286-50;
- or vibrating hammer for both in accordance with prEN 13286-51;
- or vibrocompression for both in accordance with prEN 13286-52;
- or axial compression for both in accordance with prEN 13286-53.

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

8 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 Workability period

When required for the intended use, the workability period, determined in accordance with prEN13286-45, shall be declared.

10 Production control

See informative annex D.

11 Designation and description

11.1 Designation

The product shall be designated by:

- a) Producer code of the mixture formulation
- a) Reference to this European standard
- b) Producer and place of production
- c) Type and characterisation of the fly ash bound mixture
(e.g.: Fly ash bound mixture 2 – Siliceous fly ash - 0/20 – G2 –C9/12)

11.2 Description

The product shall be described by:

- a) Description of the constituents
- b) Mixture proportion (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

12 Marking and labelling

The delivery ticket shall contain at least the following

- a) Designation
- b) Date of dispatch
- b) Quantity
- c) Serial number of the ticket

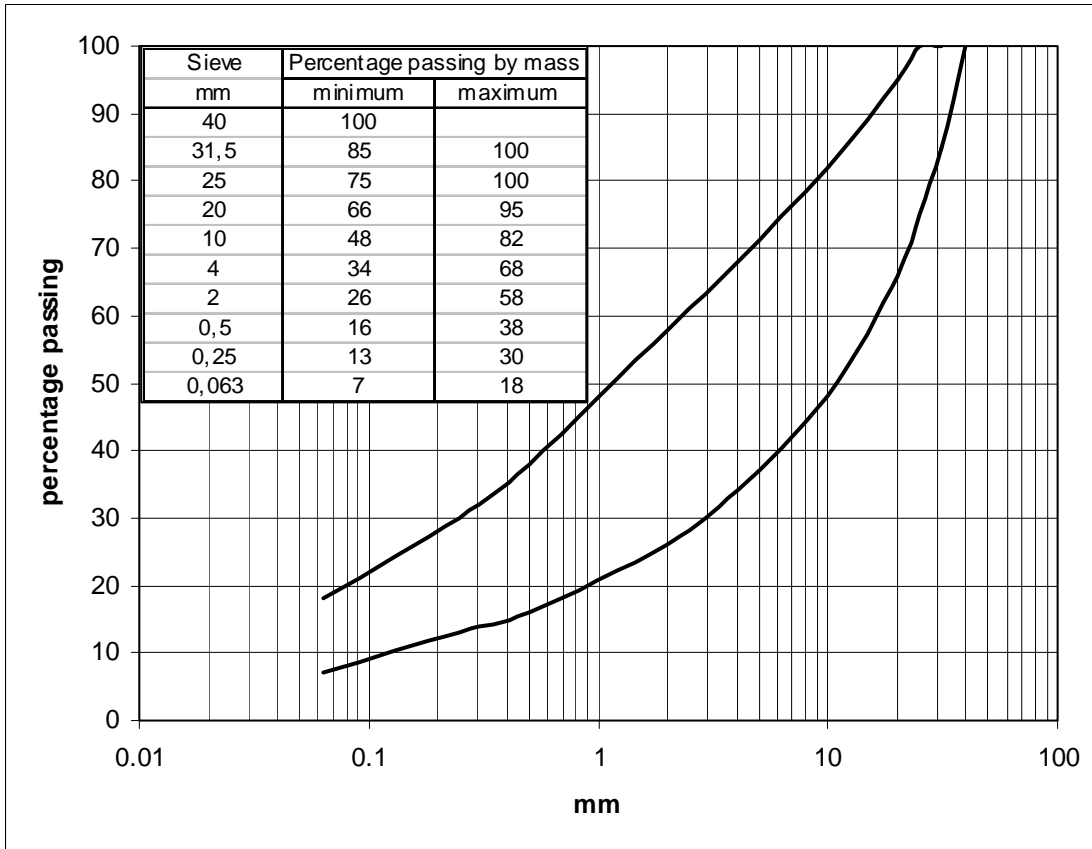


Figure 1 - Grading envelope for fly ash bound mixture 1 - 0/31,5 with siliceous fly ash

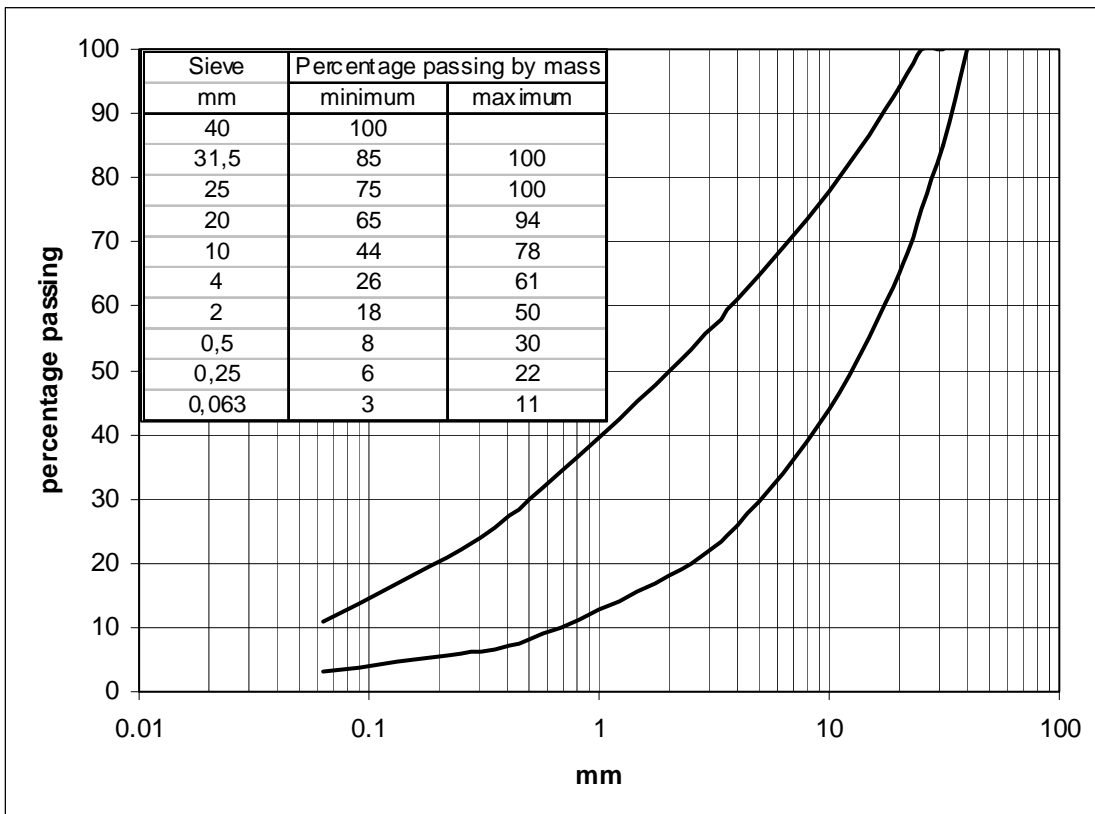


Figure 2 - Grading envelope for fly ash bound mixture 1 - 0/31,5 with calcareous fly ash

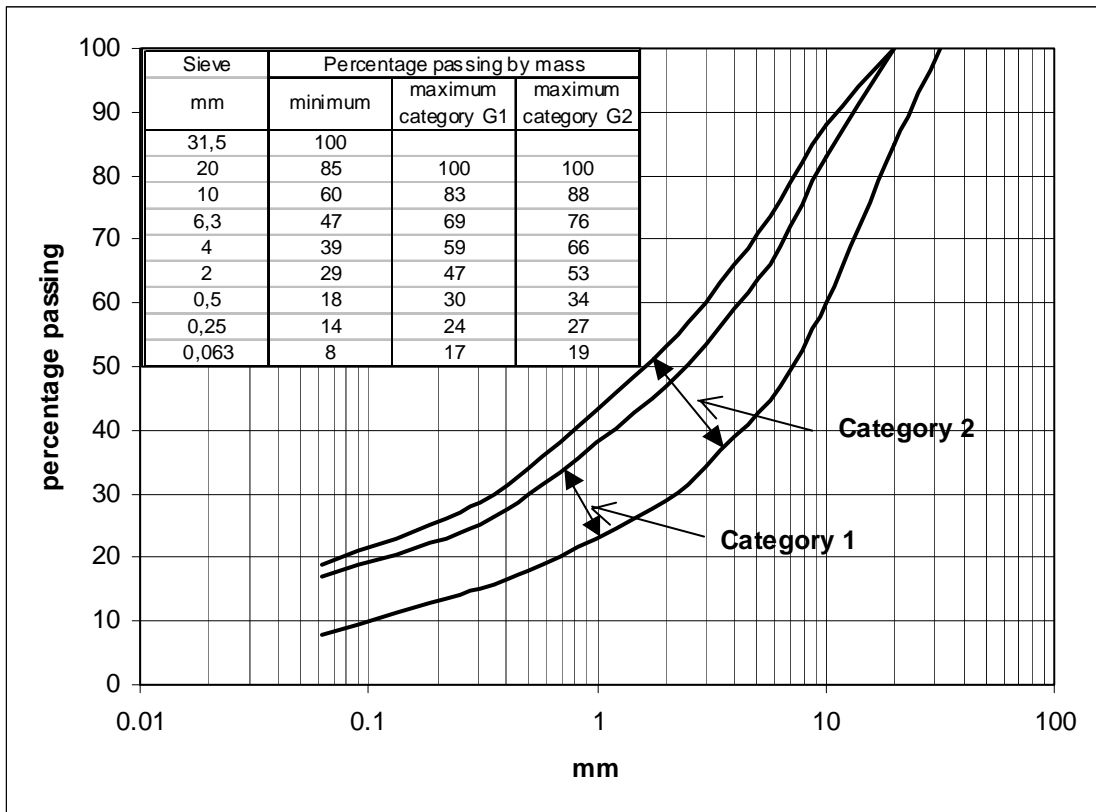


Figure 3 - Grading envelopes for fly ash bound mixture 2 - 0/20 with siliceous fly ash

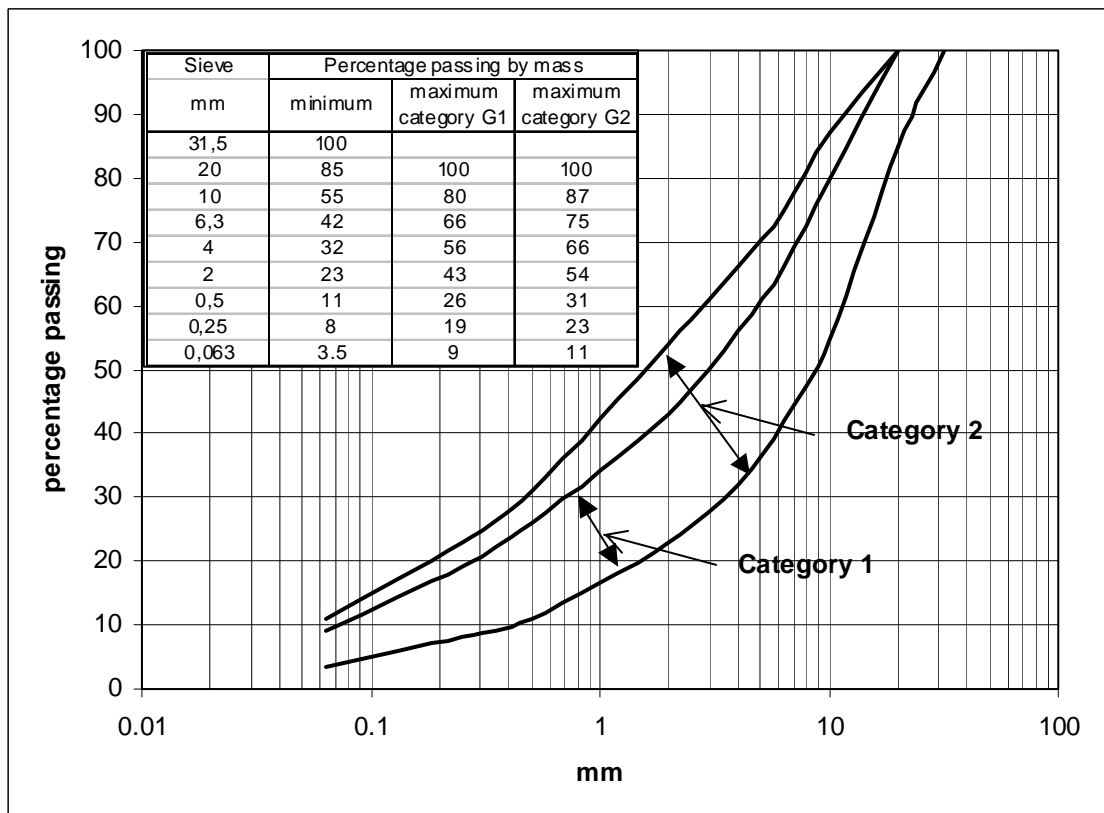


Figure 4 - Grading envelopes for fly ash bound mixture 2 - 0/20 with calcareous fly ash

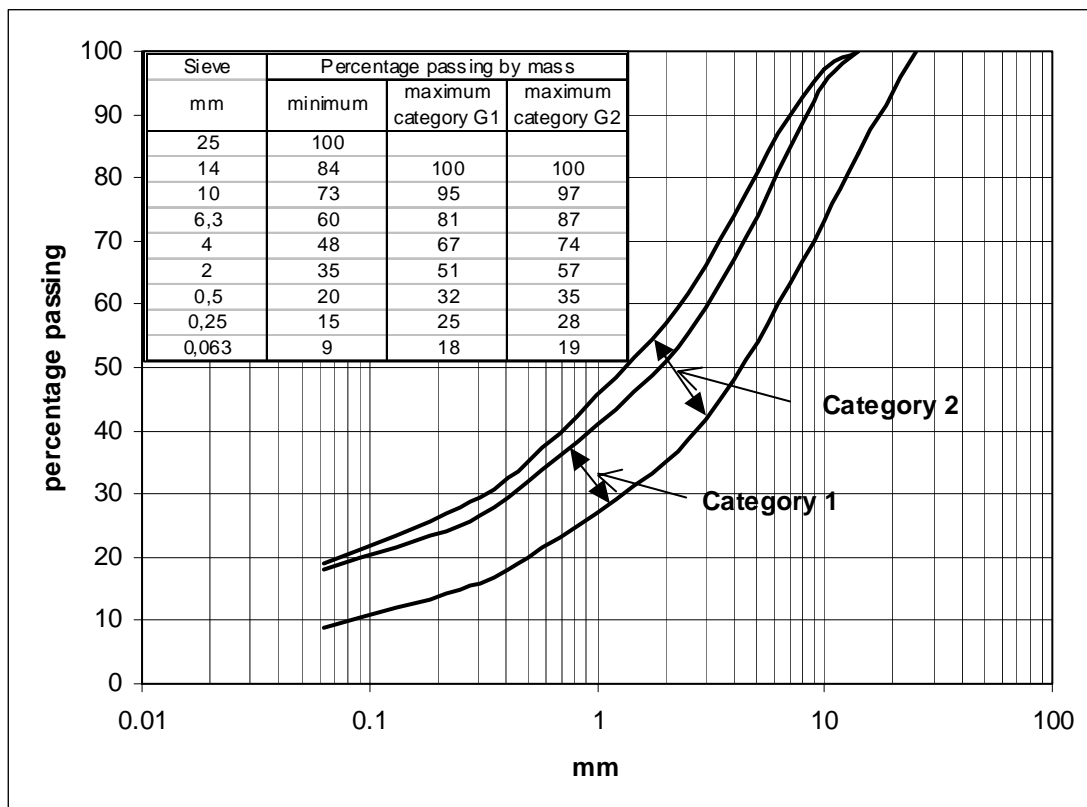


Figure 5 - Grading envelopes for fly ash bound mixture 2 - 0/14 with siliceous fly ash

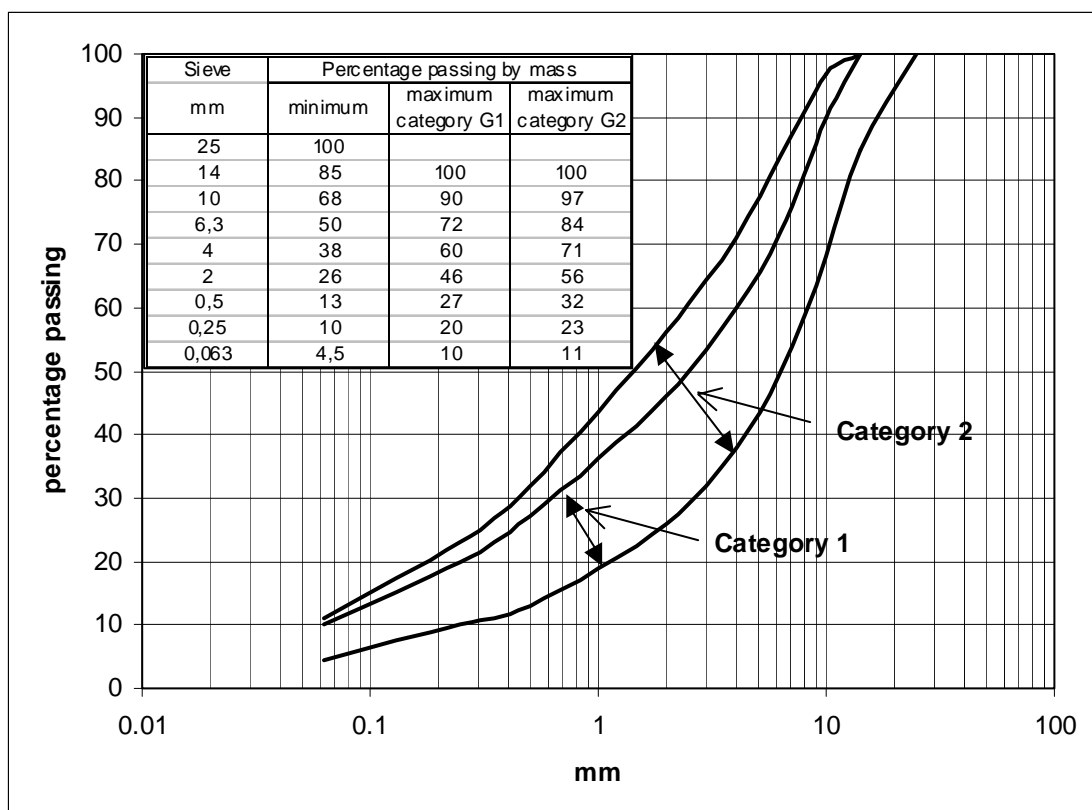


Figure 6 - Grading envelopes for fly ash bound mixture 2 - 0/14 with calcareous fly ash

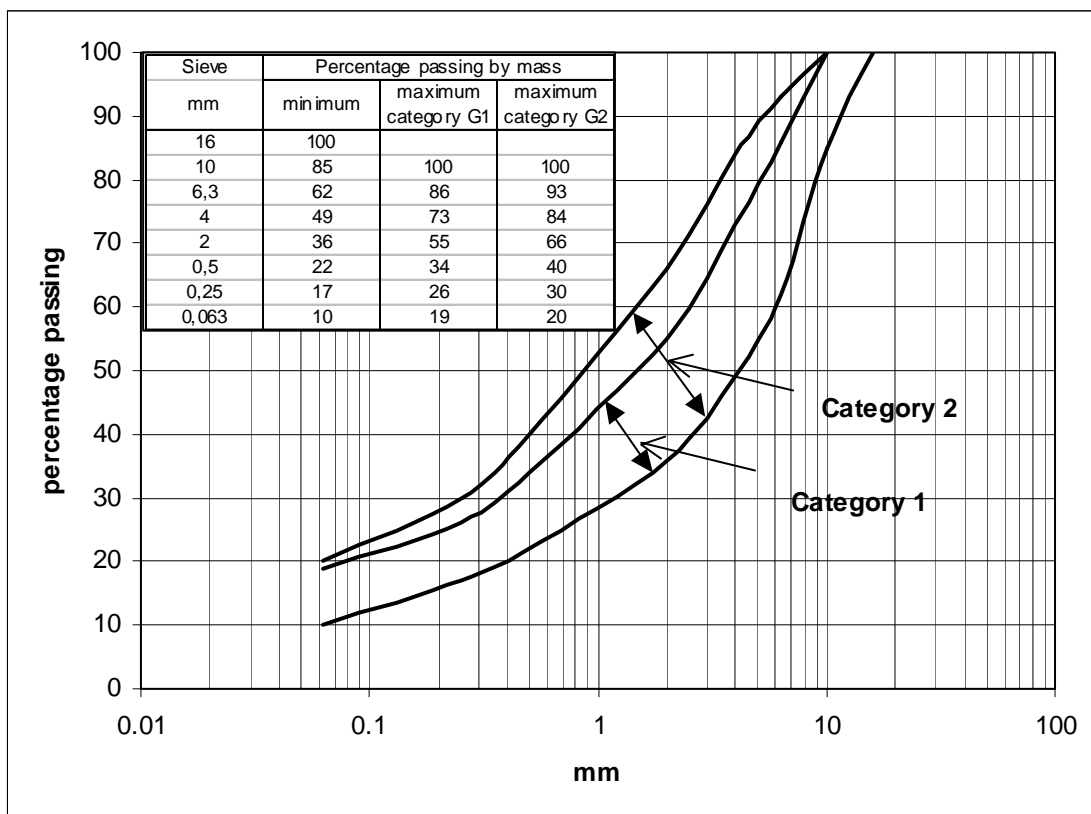


Figure 7 - Grading envelopes for fly ash bound mixture 2 - 0/10 with siliceous fly ash

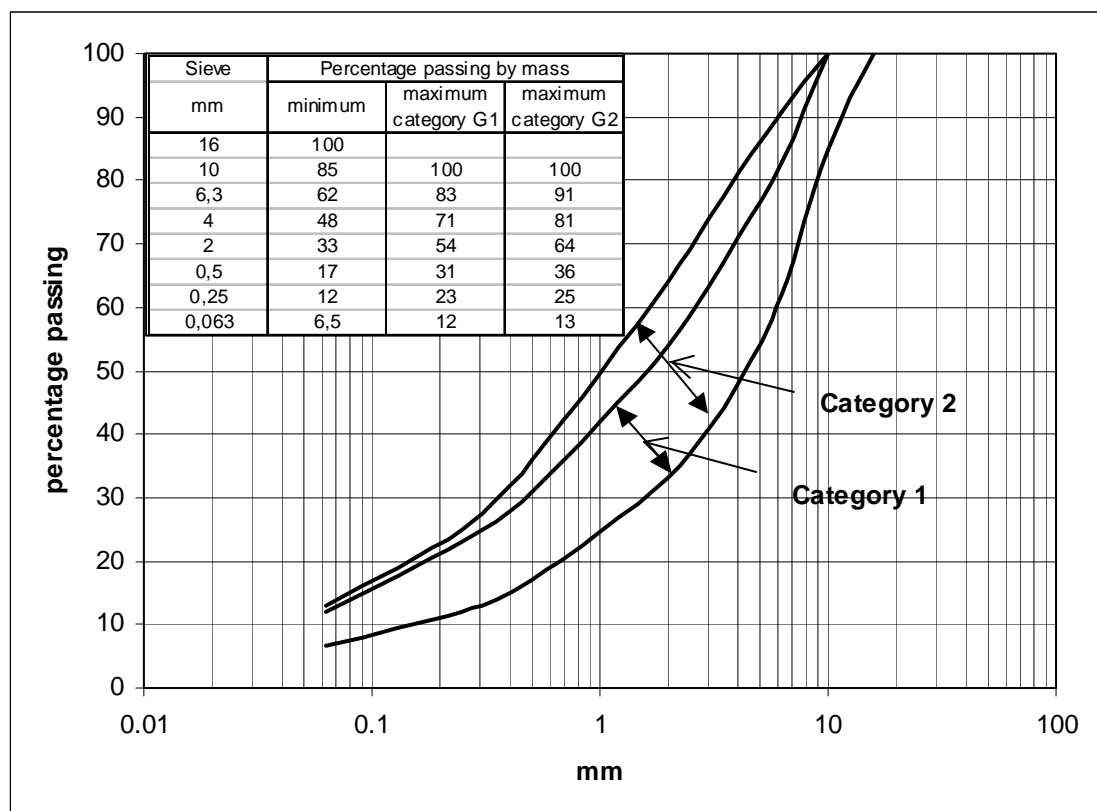
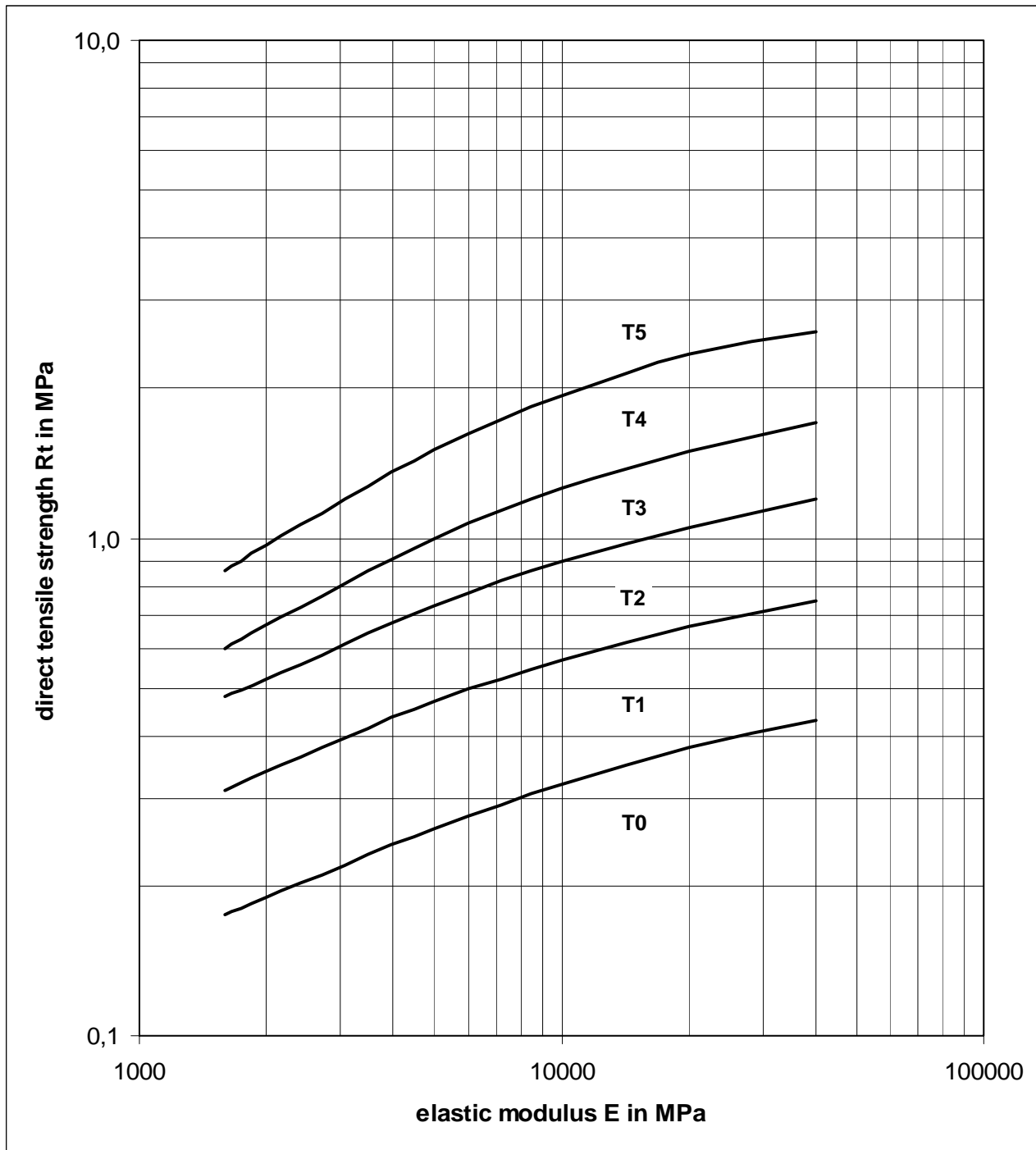


Figure 8 - Grading envelopes for fly ash bound mixture 2 - 0/10 with calcareous fly ash



NOTE: The table gives the values of Rt and E used to draw the curves defining the lower limits of the classes T1, T2, T3, T4 and T5.	E (MPa)	2000	5000	10000	20000	40000
	Lower limit of class	Rt (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	

Figure 9 – Classification by Rt,E

Annex A (normative)

Compacity of a fly ash bound mixture 2

The compacity before setting of a fly ash bound 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:

$$C = (\gamma_m/100) \times (a/\gamma_A + b/\gamma_B + c/\gamma_C \dots)$$

where

- C is the compacity;
- γ_m is the maximum dry density of the mixture, in megagrams per cubic metre (Mg/m^3);
- γ_A is the particle density of the constituent A, in megagrams per cubic metre (Mg/m^3);
- γ_B is the particle density of the constituent B, in megagrams per cubic metre (Mg/m^3);
- γ_C 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 (γ_A , γ_B , γ_C ,...) shall be determined according to EN1097-6 Annex A, or EN1097-7, 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:

Constituent	%	Particle density (Mg/m^3)
Coarse aggregate 6,3/20	50	2,69
Coarse aggregate 0/6,3	36	2,65
Siliceous fly ash	12	2,20
Hydrated lime	2	2,25
Maximum modified Proctor dry density of the mixture (Mg/m^3)		2,11

$$C = (2,11/100) \times (50/2,69 + 36/2,65 + 12/2,20 + 2/2,25) = 0,81$$

Annex B (informative)

Examples of fly ash bound mixtures using siliceous fly ash

Ref	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		Fly Ash / Lime	93 to 97	3 to 7	—	—	—	—	15 to 25
2	5	Fly Ash / Lime / Gypsum	91	4	—	—	—	5 % gypsum	15 to 25
3		Fly Ash / Cement	90 to 95	—	5 to 10	—	—	—	15 to 25
4		Fly Ash / Lime / Granular Material	4 to 13	1 to 3	—	30 to 40	50 to 55	—	6 to 8
5	1 and 2	Fly Ash / Cement / Granular Material	3 to 6	—	1 to 3	40 to 45	50 to 55	—	6 to 8
6		Fly Ash / GBS ^b / Granular Material	5 to 7	0 to 2	—	30 to 40	50 to 55	5 to 7 % GBS ^b	6 to 8
7	3	Fly Ash / Lime / Fine Aggregate	9 to 12	2 to 4	—	84 to 89	—	—	~10
8		Fly Ash / Cement / Fine Aggregate	6 to 8	—	2 to 4	88 to 92	—	—	~10

^a Lime means CaO or Ca(OH)₂, and may be supplied preblended with dry fly ash.

^b Granulated blast furnace slag.

Annex C
(informative)

Examples of fly ash bound mixtures using calcareous fly ash

Ref	Type	Examples	Typical proportions as a percentage of dry mass %					Typical water content %
			Calcareous Fly Ash	Cement	Fine Aggregate	Coarse Aggregate	Other Material	
1	5	Fly Ash / Cement	80 to 95	5 to 20	—	—	—	15 to 30
2	1 and 2	Fly Ash / Granular Material	3 to 6	—	—	94 to 97	—	5 to 7
3		Fly Ash / Cement / Granular Material	3 to 16	1 to 4	—	80 to 96	—	5 to 7
4	3	Fly Ash / Fine Aggregate	4 to 8	—	92 to 96	—	—	~10
5		Fly Ash / GBS ^a / Fine Aggregate	2 to 4	—	92 to 96	—	2 to 4 % GBS ^a	5 to 7
6		Fly Ash / Cement / GBS ^a / Fine Aggregate	1 to 3	1 to 2	92 to 96	—	1 to 3 % GBS ^a	5 to 7

^a Granulated blast furnace slag.

Annex D (informative)

PRODUCTION CONTROL FOR HYDRAULICALLY TREATED MIXTURES

D.1 General

This annex describes the recommendations for a production control system for producers 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 producer should establish and maintain his policy and procedures for production control in a quality manual that should include:

- the producer's organizational 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 Organization

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 producer 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 producer 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 producer'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 producer 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 3 years or longer if legally required.

D.3.7 Training

The producer 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:
 - calibrating, maintaining and adjusting the process and testing equipment,
 - sampling the constituents and mixture,
 - data recording during processing,
 - adjusting the process according to weather conditions;
- d) 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 and the contract.

Where applicable, the composition of regularly produced mixtures will be included in a catalogue of mixtures compositions and considered as the mixture base line 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 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 producer should maintain records of relevant data of production, which can be referenced from information when appropriate on the delivery ticket.

If appropriate the producer's quality manual should describe the characteristics of any mixture storage system and define its mode of operation. The producer 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 producer 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 should 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 (C.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 computerized composition for every truck or every batch, one sample should be taken every 2000 tonnes or 1000 m³ or one per day for lesser quantities.
- In the case of other types of plants or production, one sample should be taken every 300 tonnes or 150 m³, with a minimum of 1 sample per day or 3 per contract.
- 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 producer should be responsible for the control, calibration and maintenance of his 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 must 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 tests standard
- Equipment to be used in accordance with documented procedures.
- Equipment to be uniquely identified and calibration records should be retained.

- Keeping of calibration records.

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.