

Hydraulically bound mixtures — Specifications —

Part 10: Soil treated by cement

The European Standard EN 14227-10:2006 has the status of a
British Standard

ICS 93.080.20

National foreword

This British Standard is the official English language version of EN 14227-10:2006.

The UK participation in its preparation was entrusted by Technical Committee B/510, Road materials, to Subcommittee B/510/4, Cementitious bound materials, unbound granular materials, waste materials and marginal materials, which has the responsibility to:

- aid enquirers to understand the text;
- present to the responsible international/European committee any enquiries on the interpretation, or proposals for change, and keep UK interests informed;
- monitor related international and European developments and promulgate them in the UK.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Catalogue under the section entitled “International Standards Correspondence Index”, or by using the “Search” facility of the BSI Electronic Catalogue or of British Standards Online.

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

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, the EN title page, pages 2 to 24, an inside back cover and a back cover.

The BSI copyright notice displayed in this document indicates when the document was last issued.

Amendments issued since publication

| Amd. No. | Date | Comments |
|----------|------|----------|
| | | |
| | | |
| | | |
| | | |
| | | |

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 June 2006

© BSI 2006

ISBN 0 580 48682 6

ICS 93.080.20

English Version

Hydraulically bound mixtures - Specifications - Part 10: Soil treated by cement

Mélanges traités aux liants hydrauliques - Spécifications -
Partie 10: Sol traité au ciment

Hydraulisch gebundene Gemische - Anforderungen - Teil
10: Bodenverbesserung mit Zement

This European Standard was approved by CEN on 3 February 2006.

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. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



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

Management Centre: rue de Stassart, 36 B-1050 Brussels

Contents

Page

| | |
|---|----|
| Foreword..... | 3 |
| 1 Scope | 4 |
| 2 Normative references..... | 4 |
| 3 Terms and definitions | 5 |
| 4 Symbols and abbreviations..... | 6 |
| 5 Constituents..... | 6 |
| 5.1 General..... | 6 |
| 5.2 Binder..... | 7 |
| 5.3 Soil | 7 |
| 5.4 Water..... | 7 |
| 5.5 Secondary constituents..... | 7 |
| 6 Mixture | 7 |
| 6.1 General..... | 7 |
| 6.2 Proportioning of the constituents, grading and dry density..... | 7 |
| 7 Requirements of the fresh mixture..... | 8 |
| 7.1 Water content..... | 8 |
| 7.2 Degree of pulverization..... | 8 |
| 7.3 Immediate bearing index..... | 8 |
| 7.4 Moisture condition value | 9 |
| 8 Laboratory mechanical performance classification..... | 9 |
| 8.1 General..... | 9 |
| 8.2 California bearing ratio of cement stabilized soil..... | 10 |
| 8.3 Classification of cement bound soil..... | 10 |
| 8.3.1 General..... | 10 |
| 8.3.2 Classification by compressive strength..... | 11 |
| 8.3.3 Classification by R_t , E | 11 |
| 9 Resistance to water..... | 14 |
| 9.1 General..... | 14 |
| 9.2 Strength after immersion in water | 14 |
| 9.3 Linear swelling after soaking in water..... | 14 |
| 9.4 Volumetric swelling after immersion in water | 15 |
| 10 Designation and description | 15 |
| 11 Labelling | 15 |
| Annex A (normative) Curing regimes for soil treated by cement test specimens..... | 16 |
| Annex B (informative) Production control for hydraulically treated mixtures..... | 18 |
| Bibliography..... | 24 |

Foreword

This European Standard (EN 14227-10:2006) 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 2006, and conflicting national standards shall be withdrawn at the latest by November 2006.

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

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

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

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

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

EN 14227-5, *Hydraulically bound mixtures — Specifications — Part 5: Hydraulic road binder bound mixtures.*

EN 14227-10, *Hydraulically bound mixtures — Specifications — Part 10: Soil treated by cement.*

EN 14227-11, *Hydraulically bound mixtures — Specifications — Part 11: Soil treated by lime.*

EN 14227-12, *Hydraulically bound mixtures — Specifications — Part 12: Soil treated by slag.*

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

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

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

1 Scope

This European Standard specifies soil treated by cement for the pavement layers of roads, airfields and other trafficked areas and specifies the requirements for its constituents, composition and laboratory performance classification. It provides for the use of aggregates with grading curves, which are not constrained by the limits defined in EN 14227-1 for cement bound granular mixtures.

This European Standard does not specify requirements for strength prior to trafficking or frost resistance, which might be covered by requirements at the place of use.

Production control recommendations are included in the informative Annex B.

2 Normative references

The following referenced documents are indispensable for the application of this European Standard. 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 197-4, *Cement — Part 4: Composition, specifications and conformity criteria for low early strength blastfurnace cements*

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

EN 1008, *Mixing water for concrete — Specifications for sampling, testing and assessing the suitability of water, including water recovered from processes in the concrete industry, as mixing water for concrete*

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 the determination of the 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 methods for the determination of the modulus of elasticity of hydraulically bound mixtures*

EN 13286-46, *Unbound and hydraulically bound mixtures — Part 46: Test method for the determination of the moisture condition value*

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

EN 13286-48, *Unbound and hydraulically bound mixtures — Part 48: Test method for the determination of the degree of pulverisation*

EN 13286-49, *Unbound and hydraulically bound mixtures — Part 49: Accelerated swelling test for soil treated by lime and/or hydraulic binder*

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 by vibrating hammer compaction*

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

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

3 Terms and definitions

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

3.1

soil

natural, artificial or recycled material or any combination of these components

3.2

soil treated by cement

mixture resulting from the addition of cement and, where appropriate, secondary constituents to a soil

NOTE 1 Soils treated by cement are described in two groups for the purposes of this European Standard, defined as cement stabilized soil and cement bound soil. Soil improvement with cement, solely to allow construction to proceed without the necessity to improve the pavement structural capacity is defined as an earthworks process and outside of the scope of this European Standard.

NOTE 2 Soils treated by cement include for the use of fine-grained soils, which are pre-treated with lime to allow them to be re-treated with cement.

3.3

cement stabilized soil

mixture of soil or aggregate with cement as the binder and, where appropriate, secondary constituents, which is designed to attain stability measured by California bearing ratio capacity testing

3.4

cement bound soil

mixture of soil or aggregate with cement as the binder and, where appropriate, secondary constituents, which is designed to attain a structural integrity directly measured by unconfined compressive strength or tensile strength and elastic modulus testing

3.5

R_i/R ratio

ratio, at the same age and under the same temperature conditions, of the soaked strength of the mixture to the un-soaked strength of the mixture, either compressive or tensile, determined in accordance with EN 13286-40, EN 13286-41 or EN 13286-42

3.6

slenderness ratio

ratio of height to diameter of the specimen

4 Symbols and abbreviations

For the purposes of this European Standard, the following symbols and abbreviations apply.

CBR is the California bearing ratio, expressed in percent (%);

R is the compressive or tensile strength, expressed in megapascals (MPa);

R_c is the compressive strength, 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);

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

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

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

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

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

5 Constituents

5.1 General

The primary constituents shall be soil and binder. Other constituents shall be considered as secondary constituents.

NOTE Secondary constituents may include those necessary to deactivate or assist in the pulverization of the cohesive soil, to dilute or absorb sulfate, to improve grading, traffickability, mechanical performance etc.

5.2 Binder

Binder shall consist of one of the following:

- a) cement conforming to EN 197-1;
- b) cement conforming to EN 197-4.

NOTE Cement conforming to EN 197-1, grades CEM II to CEM V or EN 197-4 might have setting rates, which vary significantly from those for the CEM 1 grades of EN 197-1. This will need to be considered when selecting the fresh and mechanical performance criteria and testing regimes.

5.3 Soil

Not less than 95 % of the soil shall pass the 63 mm sieve when tested using the wet sieving method conforming to EN 933-1.

Where applicable, the soil shall conform to the requirements for classification and homogeneity valid in the place of use.

NOTE 1 Organic matter can delay or prevent the setting and hardening process. Laboratory mixture design work might determine whether soil containing organic matter can be accommodated. The amount of organic matter that can be accommodated depends on the type and particle size of the organic matter.

NOTE 2 Mixtures containing sulphates or other material that could result in expansion of the mixture should be tested for the resistance to water requirements of Clause 9.

5.4 Water

Any added mixing water shall conform to EN 1008.

5.5 Secondary constituents

Subject to satisfactory laboratory trials, secondary constituents may be added to improve the grading, the stability, the compatibility, the impermeability or the setting and hardening of the mixture.

6 Mixture

6.1 General

The mixture shall be made from the constituents specified in Clause 5.

6.2 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 experience with mixtures produced with the same constituents and under the same conditions as those to be applicable to the proposed mixture.

7 Requirements of the fresh mixture

7.1 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 optimum water content shall be determined by a selected test method in accordance with EN 13286-1 to EN 13286-5. In addition the range of water content shall be adhered to that is compatible with the compaction performance and the desired mechanical performance of the mixture.

The water content of the mixture shall conform to one of the categories in Table 1.

Table 1 — Minimum water content

| Minimum water content | Category |
|---|------------|
| No requirement | W_{NR} |
| Not less than 0,90 optimum water content of the mixture determined in accordance with the selected method of compaction from EN 13286-2 to EN 13286-5 | $W_{0,90}$ |
| Not less than 0,95 optimum water content of the mixture determined in accordance with the selected method of compaction from EN 13286-2 to EN 13286-5 | $W_{0,95}$ |
| Not less than the optimum water content of the mixture determined in accordance with the selected method of compaction from EN 13286-2 to EN 13286-5 | $W_{1,0}$ |
| Declared value | W_{DV} |

7.2 Degree of pulverization

The degree of pulverization of the mixture shall be determined in accordance with EN 13286-48 and shall conform to one of the categories selected from Table 2.

| Table 2 — Degree of pulverization | |
|--|----------|
| Degree of pulverization | Category |
| No requirement | P_{NR} |
| $\geq 30 \%$ | P_{30} |
| $\geq 40 \%$ | P_{40} |
| $\geq 60 \%$ | P_{60} |
| $\geq 80 \%$ | P_{80} |
| Declared value | P_{DV} |

7.3 Immediate bearing index

The immediate bearing index at the declared water content of the mixture shall be determined in accordance with EN 13286-47 and shall conform to one of the categories selected from Table 3. After mixing, the mixture shall be stored in bags in a sealed condition for 30 min to 60 min. The specimen(s) shall then be manufactured and the determination of the index carried out not later than 90 min after mixing.

Table 3 — Immediate bearing index

| Immediate bearing index | Category |
|-------------------------|------------|
| No requirement | IPI_{NR} |
| > 10 | IPI_{10} |
| > 15 | IPI_{15} |
| > 20 | IPI_{20} |
| > 25 | IPI_{25} |
| > 30 | IPI_{30} |
| > 40 | IPI_{40} |
| > 50 | IPI_{50} |
| Declared value | IPI_{DV} |

7.4 Moisture condition value

The moisture condition value of the mixture shall be determined in accordance with EN 13286-46 and shall conform to one of the categories selected from Table 4.

Table 4 — Moisture condition value

| Moisture condition value | Category |
|--------------------------|--------------|
| No requirement | MCV_{NR} |
| 6 minimum, 10 maximum | $MCV_{6/10}$ |
| 7 minimum, 11 maximum | $MCV_{7/11}$ |
| 8 minimum, 12 maximum | $MCV_{8/12}$ |
| 9 minimum, 13 maximum | $MCV_{9/13}$ |
| Declared values | MCV_{DV} |

8 Laboratory mechanical performance classification

8.1 General

The laboratory mechanical performance of the mixture shall be characterized and classified by one of the following methods:

for cement stabilized soils, by California bearing ratio (CBR);

for cement bound soils by compressive strength R_c ; or by 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 methods of characterization.

8.2 California bearing ratio of cement stabilized soil

The CBR class shall be selected from Table 5. The CBR value shall be measured in accordance with EN 13286-47, with the following modifications and additions:

- CBR specimens shall be stored at $(20 \pm 2) ^\circ\text{C}$;
- specimens shall initially be cured out of water, with any change in water content not exceeding 0,5 % and, when required, for a secondary period in a soaked condition;
- duration of the initial and secondary curing periods shall be selected from Table A.1.

Table 5 — California bearing ratio

| CBR requirements | Class |
|------------------|-------------------|
| No requirement | CBR _{NR} |
| ≥ 15 | CBR ₁₅ |
| ≥ 20 | CBR ₂₀ |
| ≥ 30 | CBR ₃₀ |
| ≥ 40 | CBR ₄₀ |
| ≥ 50 | CBR ₅₀ |
| ≥ 60 | CBR ₆₀ |
| ≥ 70 | CBR ₇₀ |
| ≥ 80 | CBR ₈₀ |
| Declared value | CBR _{DV} |

8.3 Classification of cement bound soil

8.3.1 General

The mechanical performance of cement bound soil shall be determined in accordance with EN 13286-40 to EN 13286-43, depending on whether the compressive strength R_c or a combination of tensile strength R_t and modulus of elasticity E is to be determined. Testing shall be carried out on moulded cubic or cylindrical test specimens conforming to EN 13286-50, EN 13286-51, EN 13286-52 or EN 13286-53.

NOTE 1 The systems of classification by compressive strength or by tensile strength with elastic modulus are mutually independent and no equivalence is intended between the strength classes of the two systems.

Cubic specimens shall have a nominal size of 100 mm or 150 mm. The nominal diameter of cylindrical specimens shall be 100 mm, 150 mm or 160 mm. Cylinder moulds with a nominal diameter of 100 mm or 100 mm cube moulds shall only be used for mixtures with an upper sieve size D not exceeding 22,4 mm. The slenderness ratio shall conform to the limits in Table 6.

NOTE 2 The permitted methods of specimen manufacture produce different specimen density and aggregate packing. Thus for the same mixture, different strengths are obtained when the specimen manufacturing method is varied. The curing regime used in storing specimens prior to test will also influence the strength and modulus test results. Hence it is important, not to separate strength, or strength and modulus of elasticity, requirements from the method of specimen manufacture and curing.

8.3.2 Classification by compressive strength

The class of compressive strength shall be selected from Table 6 in combination with the selected method of specimen manufacture in accordance with EN 13286-50, EN 13286-51, EN 13286-52 or EN 13286-53 and tested in accordance with EN 13286-41.

The curing period for the test specimens prior to compressive strength testing being carried out shall be selected from Table A.2.

For characterization or mixture design testing in the laboratory R_c shall be the average result from 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 two remaining values.

Table 6 — Compressive strength classification

| Minimum R_c in MPa for cylinders of slenderness ratio 2 | Minimum R_c in MPa for cylinders of slenderness ratio 1 ^a and cubes | R_c Class |
|---|--|---------------|
| No requirement | No requirement | C_{NR} |
| 0,4 | 0,5 | $C_{0,4/0,5}$ |
| 0,8 | 1 | $C_{0,8/1}$ |
| 1,5 | 2 | $C_{1,5/2}$ |
| 3 | 4 | $C_{3/4\ 5}$ |
| 6 | $C_{5/6}$ | |
| 8 | 10 | $C_{8/10}$ |
| 12 | 15 | $C_{12/15}$ |
| 16 | 20 | $C_{16/20}$ |
| Declared value | Declared value | C_{DV} |
| ^a Includes cylinder specimens with slenderness ratio of 0,8 to 1,2. Where specimens with slenderness ratio greater than 1,2 are to be used a correlation with cylinders with a slenderness ratio of 1 or 2 (whichever is the closer to the specimen slenderness ratio) shall be established. | | |

8.3.3 Classification by R_t , E

8.3.3.1 General

The class of R_t , E shall be selected from Figure 1.

The curing period for the test specimens prior to tensile strength testing and the determination of the modulus of elasticity shall be selected from Table A.2.

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 two remaining values.

R_t and E shall be established using one of the equivalent methods outlined in 8.3.3.2 to 8.3.3.4.

8.3.3.2 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 determinations, specimens shall be manufactured using vibrocompression in accordance with EN 13286-52.

8.3.3.3 Method by indirect tensile testing

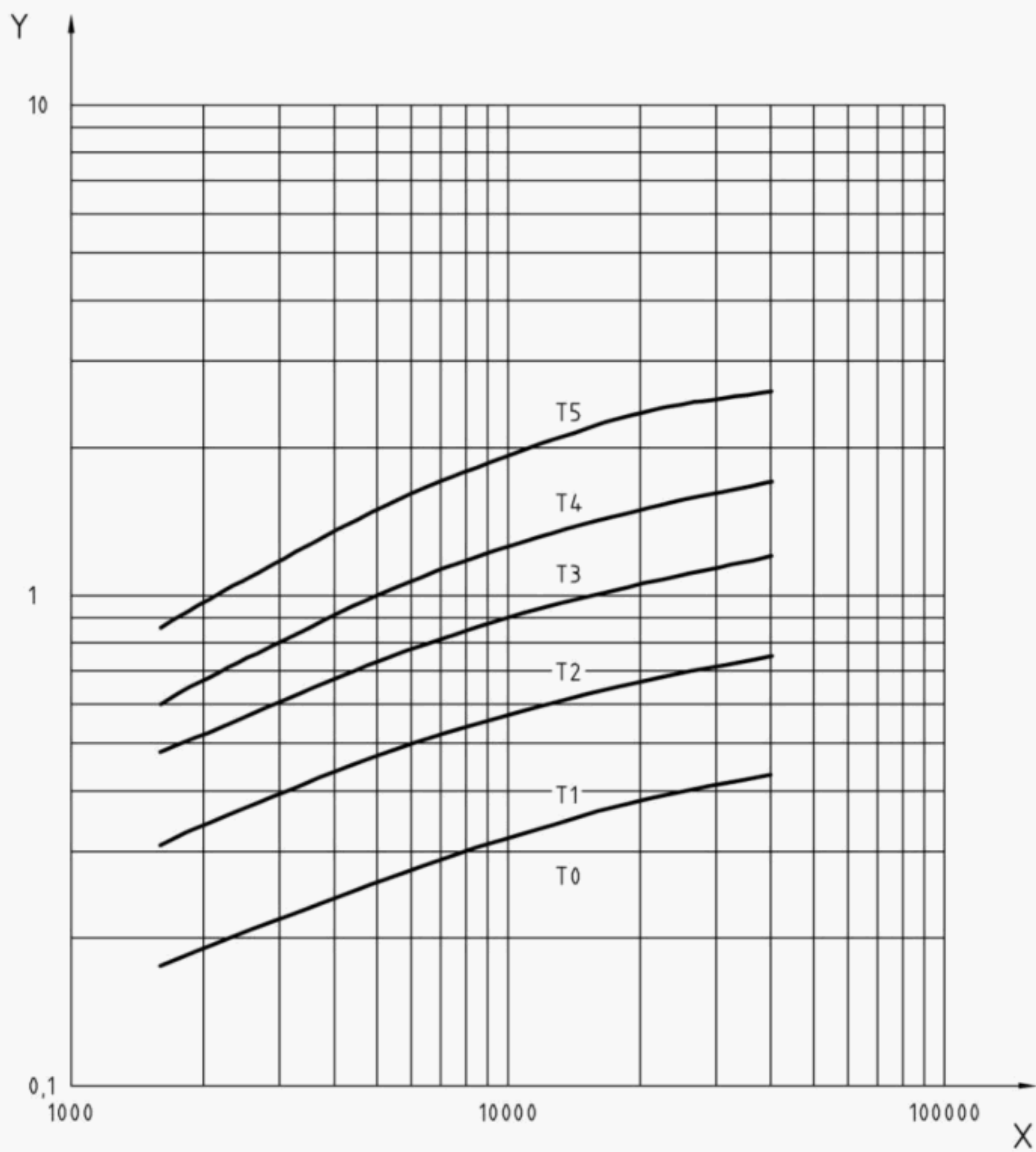
R_t shall be derived from R_{it} determined in accordance with EN 13286-42 using the relationship $R_t = 0,8 R_{it}$. Test specimens shall be made in accordance with EN 13286-50, EN 13286-51, EN 13286-52 or EN 13286-53 and tested in accordance with EN 13286-41.

E shall be derived from E_{it} (E measured in indirect tension) determined in accordance with EN 13286-43 using the relationship $E = E_{it}$. Test specimens shall be made using the same method as that used for the specimens to be tested for indirect tensile testing.

8.3.3.4 Method by indirect tensile and compression testing

R_t shall be derived from R_{it} determined in conformity to 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 conformity to EN 13286-43 using the relationship $E = E_c$.



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

| 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. | | | | | |

Figure 1 — Classification by R_t , E

9 Resistance to water

9.1 General

The resistance to water requirements shall be selected to conform to 9.2, 9.3 or 9.4.

9.2 Strength after immersion in water

The mixture shall satisfy the selected category for immersion from Table 7.

NOTE The selected category should reflect the nature of the main constituent, in particular materials containing sulphates or other potentially expansive material, the intended use of the mixture, the climate and weather conditions during construction.

In Table 7 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 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 A.3 gives the values from which Z and W shall be selected.

Table 7 — Strength after immersion categories for the mixture

| R_i/R ratio | Category |
|----------------|-----------|
| No requirement | I_{NR} |
| $> 0,6$ | $I_{0,6}$ |
| $\geq 0,7$ | $I_{0,7}$ |
| $> 0,8$ | $I_{0,8}$ |
| Declared value | I_{DV} |

9.3 Linear swelling after soaking in water

The mixture shall satisfy the selected category for linear swelling from Table 8. The determination of swelling shall be in accordance with EN 13286-47 except that the water shall be continually aerated. Swelling shall be measured for at least 28 days or until swelling is less than 0,05 mm in 48 h, whichever is the longer time.

Table 8 — Linear swelling

| Average maximum swelling of a batch of 3 specimens mm | Maximum swelling of a single specimen mm | Category |
|--|---|-----------|
| No requirement | No requirement | LS_{NR} |
| 5,0 | 10 | LS_5 |
| 3,0 | 6,0 | LS_3 |
| 1,0 | 2,0 | LS_1 |
| Declared value | Declared value | LS_{DV} |

9.4 Volumetric swelling after immersion in water

The mixture shall satisfy the selected category for volumetric swelling in Table 9, when tested in accordance with EN 13286-49.

Table 9 — Volumetric expansion

| Volumetric expansion (after 7 days), $G_V 7d$ % | Category |
|--|----------|
| No requirement | G_{NR} |
| ≤ 5 | G_{V5} |
| ≤ 3 | G_{V3} |
| Declared value | G_{DV} |

10 Designation and description

10.1 The product shall be designated by:

- producer, place of production and producer code;
- reference to this European Standard, i.e. EN 14277-10;
- mixture type and mechanical performance characterization (e.g. Cement stabilized soil Class CBR₄₀, or Cement bound soil Class C_{3/4} or T₂ etc.);
- resistance to water category (e.g. I_{0,8}, LS₁ or G_{V3} etc.).

10.2 In addition, the product shall be described by:

- description of the constituents including, if applicable, the characteristics and homogeneity of the soil;
- mixture proportions including water content;
- selected fresh mixture categories (e.g. W_{0,95}, P₆₀, IPI_{NR}, MCV_{8/12}) including compaction method used to determine W and IPI, if applicable;
- laboratory mechanical performance values together with the method of manufacture, curing conditions, curing period, dry density and water content of the mechanical performance test specimens.

11 Labelling

When appropriate, the delivery ticket shall contain at least the following:

- designation;
- date of despatch;
- quantity;
- serial number.

Annex A

(normative)

Curing regimes for soil treated by cement test specimens

Table A.1 — Curing regimes for cement stabilized soil specimens prior to CBR testing

| Curing regime | Curing period (days) cured at 20 °C | |
|---------------|-------------------------------------|----------|
| | Without change in water content | In water |
| A | 7 | 0 |
| B | 7 | 21 |
| C | 7 | 28 |
| D | 14 | 14 |
| E | 3 | 4 |
| F | 3 | 25 |
| G | 3 | 88 |

Table A.2 — Curing regimes for cement bound soil specimens prior to compression, tension or elastic modulus testing

| Curing regime | Curing period (days) at (20 ± 2) °C | | | | |
|----------------|-------------------------------------|--|---|---------------------------------|----------------|
| | Cured in mould ^a | Cured in mould at 90 % to 100 % humidity | Cured in mould or within a watertight plastic bag | Cured at 90 % to 100 % humidity | Cured in water |
| A ₁ | 1 | | | 6 | |
| A ₂ | 1 | | | 27 | |
| A ₃ | 1 | | | 55 | |
| A ₄ | 1 | | | 90 | |
| B ₁ | 1 | | | | 27 |
| B ₂ | | | | | 55 |
| B ₃ | | | | | 90 |
| C | 1 | | | 24 | 3 |
| D | | > 90 | | | |
| E | | | > 90 | | |
| F ₁ | | | | 6 | 1 |
| F ₂ | | | | 27 | 1 |

^a Where specimens are too weak to be removed from their moulds at 24 h they may be retained in their moulds until they have gained sufficient strength for them to be removed.

Table A.3 — Curing/immersion regimes for cement bound soil specimens for testing to determine strength after immersion in water

| Water degradation resistance regime | Period of non-immersed curing, in days Z | Period of immersed curing, in days W |
|--|---|---|
| A | 7 | 21 |
| B | 7 | 49 |
| C | 7 | 84 |

Annex B

(informative)

Production control for hydraulically treated mixtures

B.1 General

This annex gives 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).

B.2 Quality Manual

The producer should establish and maintain his policy and procedures for production control in a Quality Manual that should include:

- producer's organizational structure relating to quality;
- control of constituents and mixtures;
- process control, calibration and maintenance;
- requirements for 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.

B.3 Organization

B.3.1 Responsibility and authority

The responsibility, authority and interrelation 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.

B.3.2 Management representative

The producer should appoint a management representative with appropriate authority, knowledge and experience of production control to ensure that the requirements of the Quality Manual are implemented and maintained.

B.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.

B.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.

B.3.5 Sub-contract services

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

B.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 European 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.

B.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.

B.4 Control procedures

B.4.1 Production management

The production control system should contain the following:

- a) 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;

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

B.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 will have properties conforming to the relevant standard.

Where applicable, the composition of regularly produced mixtures should 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.

B.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 might affect the quality of the product.

B.4.4 Process control

The Quality Manual should include:

description of equipment and installation;

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

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

B.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.

B.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.

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

B.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.

B.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 B.4.2).

B.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 2 000 t or 1 000 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 t or 150 m³, 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.

B.6 Inspection and testing equipment

B.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.

B.6.2 Measuring and testing equipment

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

B.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.

B.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 standard(s) for the relevant test(s);

- equipment to be used in accordance with documented procedures;

- equipment to be uniquely identified and calibration records should be retained;

keeping of calibration records.

B.7 Non-conformity

B.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.

B.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.

B.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 redirected to an alternative customer if appropriate;

rejection of the mixture.

Bibliography

- [1] EN 14216, *Cement — Composition, specifications and conformity criteria for very low heat special cements*
- [2] EN 14227-1, *Hydraulically bound mixtures — Specifications — Part 1: Cement bound granular mixtures*

BSI — British Standards Institution

BSI is the independent national body responsible for preparing British Standards. It presents the UK view on standards in Europe and at the international level. It is incorporated by Royal Charter.

Revisions

British Standards are updated by amendment or revision. Users of British Standards should make sure that they possess the latest amendments or editions.

It is the constant aim of BSI to improve the quality of our products and services. We would be grateful if anyone finding an inaccuracy or ambiguity while using this British Standard would inform the Secretary of the technical committee responsible, the identity of which can be found on the inside front cover. Tel: +44 (0)20 8996 9000. Fax: +44 (0)20 8996 7400.

BSI offers members an individual updating service called PLUS which ensures that subscribers automatically receive the latest editions of standards.

Buying standards

Orders for all BSI, international and foreign standards publications should be addressed to Customer Services. Tel: +44 (0)20 8996 9001. Fax: +44 (0)20 8996 7001. Email: orders@bsi-global.com. Standards are also available from the BSI website at <http://www.bsi-global.com>.

In response to orders for international standards, it is BSI policy to supply the BSI implementation of those that have been published as British Standards, unless otherwise requested.

Information on standards

BSI provides a wide range of information on national, European and international standards through its Library and its Technical Help to Exporters Service. Various BSI electronic information services are also available which give details on all its products and services. Contact the Information Centre. Tel: +44 (0)20 8996 7111. Fax: +44 (0)20 8996 7048. Email: info@bsi-global.com.

Subscribing members of BSI are kept up to date with standards developments and receive substantial discounts on the purchase price of standards. For details of these and other benefits contact Membership Administration. Tel: +44 (0)20 8996 7002. Fax: +44 (0)20 8996 7001. Email: membership@bsi-global.com.

Information regarding online access to British Standards via British Standards Online can be found at <http://www.bsi-global.com/bsonline>.

Further information about BSI is available on the BSI website at <http://www.bsi-global.com>.

Copyright

Copyright subsists in all BSI publications. BSI also holds the copyright, in the UK, of the publications of the international standardization bodies. Except as permitted under the Copyright, Designs and Patents Act 1988 no extract may be reproduced, stored in a retrieval system or transmitted in any form or by any means – electronic, photocopying, recording or otherwise – without prior written permission from BSI.

This does not preclude the free use, in the course of implementing the standard, of necessary details such as symbols, and size, type or grade designations. If these details are to be used for any other purpose than implementation then the prior written permission of BSI must be obtained.

Details and advice can be obtained from the Copyright & Licensing Manager. Tel: +44 (0)20 8996 7070. Fax: +44 (0)20 8996 7553. Email: copyright@bsi-global.com.