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ICS 91.100.10

EAST AFRICAN STANDARD

Cement — Part 1: Composition, specification and conformity criteria for common cements

EAST AFRICAN COMMUNITY

Second Edition 2024

Foreword

Development of this Draft East African Standards has been necessitated by the need for harmonizing requirements governing quality of products and services in the East African Community. It is envisaged that through harmonized standardization, trade barriers that are encountered when goods and services are exchanged within the Community will be removed.

In order to achieve this objective, the Community established an East African Standards Committee mandated to develop and issue East African Standards.

The Committee is composed of representatives of the National Standards Bodies in Partner States, together with the representatives from the private sectors and consumer organizations. Draft East African Standards are circulated to stakeholders through the National Standards Bodies in the Partner States. The comments received are discussed and incorporated before finalization of standards, in accordance with the procedures of the Community.

East African Standards are subject to review, to keep pace with technological advances. Users of the East African Standards are therefore expected to ensure that they always have the latest versions of the standards they are implementing.

EAS 18-1 was prepared by Technical Committee EASC/TC/021, *Cement, building lime, clay and related products.*

In the preparation of this East African Standard, reference was made to the following standard:

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

The assistance derived from the above source is hereby acknowledged with thanks.

This second edition cancels and replaces the first edition (EAS 18-1), which has been technically revised.

EAS 18 consists of the following parts, under the general title *Cement* —:

— *Part 1: Composition, specification and conformity criteria for common cement*

— *Part 2: Conformity evaluation*

Cement — Part 1: Composition, specification and conformity criteria for common cements

1 Scope

This East African standard gives the specifications which include mechanical, physical and chemical requirements of 27 distinct common cements, seven sulphate resisting common cements as well as three distinct low early strength blast furnace cements and two sulphate resisting low early strength blast cements and their constituents.

The standard also gives the composition of each cement in terms of proportions and requirements of the constituents which are to be combined to produce these distinct products in a range of nine strength classes.

Furthermore, this standard states the conformity criteria and the related rules. Necessary durability requirements are also given.

NOTE 1 In addition to the specified requirements, an exchange of additional information between the cement manufacturer and user may be helpful. The procedures for such an exchange are not within the scope of this standard but should be dealt with in accordance with national standards or regulations or may be agreed between the parties concerned.

NOTE 2 The word "cement" in this standard is used to refer only to common cements unless otherwise specified.

2 Normative references

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

ASTM C311/C311M–13, *Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete*

ASTM C494/C494M–13, *Standard Specification for Chemical Admixtures for Concrete*

ASTMC 1777 Standard Test Method for Rapid Determination of the Methylene Blue Value for Fine Aggregate or Mineral Filler Using a Colorimeter

EAS 18-2, *Cement — Part 2: Conformity evaluation*

EAS 131-1, *Concrete — Part 1: Specification, performance, production and conformity*

EAS 148-1, *Cement — Test methods — Part 1: Determination of strength*

EAS 148-2, *Cement — Test methods — Part 2: Chemical analysis of cement*

EAS 148-3, *Cement — Test methods — Part 3: Determination of setting time and soundness*

EAS 148-5, *Cement — Test methods — Part 5: Pozzolanicity test for Pozzolanic cements*

EAS 148-6, *Cement — Test methods — Part 6: Determination of fineness*

EAS 148-7, *Cement — Test methods — Part 7: Methods of taking and preparing samples of cement*

EN 13639, *Determination of total organic carbon content in limestone*

ISO 9277, *Determination of the specific surface area of solids by gas adsorption using the BET method*

ISO 9286, *Abrasive grains and crude — Chemical analysis of silicon carbide*

ISO 29582-2, *Methods of testing cement —Determination of the heat of hydration —Part 2: Semi-adiabatic method*

3 Terms and definitions

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

3.1
reactive calcium oxide (CaO)
fraction of the calcium oxide which under normal hardening conditions can form calcium silicate hydrates or calcium aluminate hydrates

NOTE To evaluate this fraction the total calcium oxide content (see EAS 148-2) is reduced by the fraction corresponding to calcium carbonate ($CaCO_3$), based on the measured carbon dioxide (CO_2) content (EAS 148-2) and the fraction corresponding to calcium sulphate ($CaSO_4$), based on the measured sulphate (SO_3) content (see EAS 148-2) after substraction of the $S0_3$ taken up by alkalis.

3.2
reactive silicon dioxide (SiO_2)
fraction of the silicon dioxide that is soluble after treatment with hydrochloric acid (HCI) and with boiling potassium hydroxide (KOH) solution

NOTE The quantity of reactive silicon dioxide is determined by subtracting from the total silicon dioxide content (see EAS 148-2) that fraction contained in the residue insoluble in hydrochloric acid and potassium hydroxide (see EAS 148-2), both on a dry basis.

3.3
main constituent
specially selected inorganic material in a proportion exceeding 5 % by mass related to the sum of all main and minor additional constituents

3.4
minor additional constituent
specially selected inorganic material used in a proportion not exceeding a total of 5 % by mass related to the sum of all main and minor additional constituents

3.6
strength class of cement
class of compressive strength

3.7
autocontrol testing
continual testing by the manufacturer of cement spot samples taken at the point(s) of release from the factory/depot

3.8
control period
period of production and dispatch identified for the evaluation of the autocontrol test results

3.9
characteristic value
value of a required property outside of which lies a specified percentage, the percentile P_k, of all the values of the population

3.10
specified characteristic value
characteristic value of a mechanical, physical or chemical property which in the case of an upper limit is not to be exceeded or in the case of a lower limit is, as a minimum, to be reached

3.11
single result limit value
value of a mechanical, physical or chemical property which for any single test result in the case of an upper limit is not to be exceeded or in the case of a lower limit is, as a minimum, to be reached

3.12
allowable probability of acceptance CR
for a given sampling plan, the allowed probability of acceptance of cement with a characteristic value outside the specified characteristic value

3.13
sampling plan
specific plan which states the (statistical) sample size(s) to be used, the percentile P_k and the allowable probability of acceptance CR

3.14
spot sample
sample taken at the same time and from one and the same place, relating to the intended tests. It can be obtained by combining one or more immediately consecutive increments (see EAS 148-7)

3.15
heat of hydration
quantity of heat developed by the hydration of cement within a given period of time

3.16
low heat common cement
common cement with a limited heat of hydration

3.17
sulphate resisting common cement
common cement which fulfils the requirements for sulphate resisting properties

3.18
low heat low early strength blast furnace cement
low early strength blast furnace cement with a limited heat of hydration

3.19
sulphate resisting low early strength blast furnace cement
low early strength blast furnace cement which fulfils the requirements for sulphate resisting properties

4 Description of cement

Cement is a hydraulic binder, that is. a finely ground inorganic material which, when mixed with water, forms a paste which sets and hardens by means of hydration reactions and processes and which, after hardening, retains its strength and stability even under water.

Cement conforming to this standard termed CEM cement, shall, when appropriately batched and mixed with aggregate and water, be capable of producing concrete or mortar which retains its workability for a sufficient time and shall after defined periods attain specified strength levels and also possess long-term volume stability.

Hydraulic hardening of CEM cement is primarily due to the hydration of calcium silicates but other chemical compounds may also participate in the hardening process, for example, aluminates. The sum of the proportions of reactive calcium oxide (CaO) and reactive silicon dioxide (SiO_2) in CEM cement shall be at least 50 % by mass when the proportions are determined in accordance with EAS 148-2.

CEM cements consist of different materials and are statistically homogeneous in composition resulting from quality assured production and material handling processes. The link between these production and material handling processes and the conformity of cement to this standard is elaborated in EAS 18-2.

5 Constituents

5.1 General

The requirements for the constituents specified in 5.2 to 5.5 shall be determined in principle in accordance with the test methods described in EAS 148 unless otherwise specified.

5.2 Main constituents

5.2.1 Portland cement clinker (K)

Portland cement clinker is made by sintering a precisely specified mixture of raw materials (raw meal, paste or slurry) containing elements, usually expressed as oxides, CaO, SiO_2, Al_2O_3 Fe_2O_3 and small quantities of other materials. The raw meal, paste or slurry is finely divided, intimately mixed and therefore homogeneous.

Portland cement clinker is a hydraulic material which shall consist of at least two-thirds by mass of calcium silicates ($3CaO.SiO_2$ and $2CaO.SiO_2$) the remainder consisting of aluminium and iron containing clinker phases and other compounds. The ratio by mass (CaO)/(SiO_2) shall be not less than 2.0. The content of magnesium oxide (MgO) shall not exceed 5.0 % by mass.

Portland cement clinker incorporated in sulphate resisting Portland cement (CEM I) and sulphate resisting pozzolanic cements (CEM IV) shall fulfill additional requirements for tricalcium aluminate content (C_3A). The tricalcium aluminate content shall be calculated by Equation (1) as follows:

$$C_3A = 2.65A - 1.69F \qquad (1)$$

where

A is the percentage of aluminium oxide (Al_2O_3) by mass of the clinker as determined in accordance with EAS 148-2;

F is the percentage of iron (III) oxide (Fe_2O_3) by mass of the clinker as determined in accordance with EAS 148-2.Sulphate resisting Portland cements and sulphate resisting pozzolanic cements are clinker in which the C_3A content does not exceed:

a) for CEM I: 0 %, 3 % or 5 % as appropriate(see 6.2); and

b) for CEM IV/A and CEM IV/B: 9 %

5.2.2 Granulated blast furnace slag (S)

Granulated blast furnace slag is made by rapid cooling of a slag melt of suitable composition, as obtained by smelting iron ore in a blast furnace and contains at least two-thirds by mass of glassy slag and possesses hydraulic properties when suitably activated.

Granulated blast furnace slag shall consist of at least two-thirds by mass of the sum of calcium oxide (CaO), magnesium oxide (MgO) and silicon dioxide (SiO_2). The remainder contains aluminium oxide (Al_2O_3) together with small amounts of other compounds. The ratio by mass (CaO + MgO)/(SiO_2) shall exceed 1.0.

5.2.3 Pozzolanic materials (P, Q)

5.2.3.1 General

Pozzolanic materials are natural substances of siliceous or silico-aluminous composition or a combination thereof. Although fly ash and silica fume have Pozzolanic properties, they are specified in separate clauses (see 5.2.4 and 5.2.7).

Pozzolanic materials do not harden in themselves when mixed with water but, when finely ground and in the presence of water, they react at normal ambient temperature with dissolved calcium hydroxide ($Ca(OH)_2$) to form strength-developing calcium silicate and calcium aluminate compounds. These compounds are similar to those which are formed in the hardening of hydraulic materials. Pozzolanic materials consist essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other oxides. The proportion of reactive calcium oxide for hardening is negligible. The reactive silicon dioxide content shall be not less than 25.0 % by mass.

Pozzolanic materials shall be correctly prepared, that is, selected, homogenized, dried, or heat treated and comminuted, depending on their state of production or delivery.

5.2.3.2 Natural Pozzolana (P)

Natural Pozzolanas are usually materials of volcanic origin or sedimentary rocks with suitable chemical and mineralogical composition and shall conform to 5.2.3.1.

5.2.3.3 Natural calcined Pozzolana (Q)

Natural calcined Pozzolanas are materials of volcanic origin, clays, shales or sedimentary rocks, activated by thermal treatment and shall conform to 5.2.3.1.

5.2.4 Fly ashes (V, W)

5.2.4.1 General

Fly ash is obtained by electrostatic or mechanical precipitation of dust-like particles from the flue gases from furnaces fired with pulverized coal. Ash obtained by other methods shall not be used in cement that conforms to EAS 18-1.

Fly ash may be siliceous or calcareous in nature. The former has Pozzolanic properties; the latter may have, in addition, hydraulic properties. The loss on ignition of fly ash determined in accordance with EAS 148-2, but using an ignition time of 1 h, shall not exceed 5.0 % by mass.

Fly ash with loss on ignition of 5.0 % - 7.0 % by mass may also be accepted, provided that particular requirements for durability, especially frost resistance, and for compatibility with admixtures are met according to the appropriate standards and/or regulations for concrete or mortar in the place of use. In the case of fly ash with a loss on ignition between 5.0 % and 7.0 % by mass the maximum limit, 7.0 %, shall be stated on the packaging and/or the delivery note of the cement.

5.2.4.2 Siliceous fly ash (V)

Siliceous fly ash is a fine powder of mostly spherical particles having Pozzolanic properties. It consists essentially of reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds.

The proportion of reactive calcium oxide shall be less than 10.0 % by mass; the content of free calcium oxide, as determined by the method described in ASTM C311/C311M–13 shall not exceed 1.0 % by mass. Fly ash having a free calcium oxide content higher than 1.0 % by, mass but less than 2.5 % by mass is also acceptable provided that the requirement on expansion (soundness) does not exceed 10 mm when tested in accordance with EAS 148-3 using a mixture of 30 % by mass of siliceous fly ash and 70 % by mass of a CEM I cement conforming to EAS 18-1 (see Clause 6). The reactive silicon dioxide content shall not be less than 25.0 % by mass.

5.2.4.3 Calcareous fly ash (W)

5.2.4.3.1 Calcareous fly ash is a fine powder, having hydraulic and/or Pozzolanic properties. It consists essentially of reactive calcium oxide (CaO), reactive silicon dioxide (SiO_2) and aluminium oxide (Al_2O_3). The remainder contains iron oxide (Fe_2O_3) and other compounds. The proportion of reactive calcium oxide shall not be less than 10.0 % by mass. Calcareous fly ash containing between 10.0 % and 15.0 % by mass of reactive calcium oxide shall contain not less than 25.0 % by mass of reactive silicon dioxide.

5.2.4.3.2 Adequately ground calcareous fly ash containing more than 15.0 % by mass of reactive calcium oxide, shall have a compressive strength of at least 10.0 MPa at 28 days when tested in accordance with EAS 148-1. Before testing, the fly ash shall be ground and the fineness, expressed as the proportion by mass of the ash retained when wet sieved on a 40-µm mesh sieve, shall be between 10 % and 30 % by mass. The test mortar shall be prepared with ground calcareous fly ash only instead of cement. The mortar specimens shall be demoulded 48 h after preparation and then cured in a moist atmosphere of relative humidity of at least 90 % until tested.

5.2.4.3.3 The expansion (soundness) of calcareous fly ash shall not exceed 10 mm when tested in accordance with EAS 148-3 using a mixture of 30 % by mass of calcareous fly ash ground as described above and 70 % by mass of CEM cement conforming to EAS 18-1.

NOTE If the sulphate (SO_3) content of the fly ash exceeds the permissible upper limit for the sulphate content of the cement then this has to be taken into account for the manufacture of the cement by appropriately reducing the calcium sulphate-containing constituents.

5.2.5 Burnt shale (T)

5.2.5.1 Burnt shale, specifically burnt oil shale, is produced in a special kiln at temperatures of approximately 800 °C. Owing to the composition of the natural material and the production process, burnt shale contains clinker phases, mainly dicalcium silicate and monocalcium aluminate. It also contains, besides small amounts of free calcium oxide and calcium sulphate, larger proportions of pozzolanically reacting oxides, especially silicon dioxide. Consequently, in a finely ground state burnt shale shows pronounced hydraulic properties like Portland cement and in addition Pozzolanic properties.

5.2.5.2 Adequately ground burnt shale shall have a compressive strength of at least 25.0 MPa at 28 days when tested in accordance with EAS 148-1. The test mortar shall be prepared with finely ground burnt shale only instead of cement. The mortar specimens shall be demoulded 48 h after preparation and cured in a moist atmosphere of relative humidity of at least 90 % until tested.

5.2.5.3 The expansion (soundness) of burnt shale shall not exceed 10 mm when tested in accordance with EAS 148-3 using a mixture of 30 % by mass of ground burnt shale and 70 % by mass of a CEM I cement conforming to EAS 18-1.

NOTE If the sulphate (SO_3) content of the burnt shale exceeds the permissible upper limit for the sulphate content of the cement then this has to be taken into account for the manufacture of the cement by appropriately reducing the calcium sulphate-containing constituents.

5.2.6 Limestone (L, LL)

Limestone shall meet the following requirements:

a) the calcium carbonate ($CaCO_3$) content calculated from the calcium oxide content shall be at least 75 % by mass;

b) the clay content, determined by the methylene blue test in accordance with ASTM C 1 777, shall not exceed 1.20 g/100 g. For this test the limestone shall be ground to a fineness of approximately 5 000 cm^2/g determined as specific surface in accordance with EAS 148-6;

c) the total organic carbon (TOC) content, when tested in accordance with EN 13639, shall conform to one of the following criteria:

(i) LL: shall not exceed 0.20 % by mass; and

(ii) L: shall not exceed 0.50 % by mass.

5.2.7 Silica fume (D)

5.2.7.1 Silica fume originates from the reduction of high purity quartz with coal in electric arc furnaces in the production of silicon and ferrosilicon alloys and consists of very fine spherical particles containing at least 85 % by mass of amorphous silicon dioxide. The content of elemental silicon (Si) determined according to ISO 9286 shall not be greater than 0.4% by mass.

5.2.7.2 Silica fume shall meet the following requirements:

a) the loss on ignition shall not exceed 4.0 % by mass determined in accordance with EAS 148-2 but using an ignition time of 1 h; and

b) the specific surface (BET) of the untreated silica fume shall be at least 15.0 m^2/g when tested in accordance with ISO 9277.

5.2.7.3 For intergrinding with clinker and calcium sulphate the silica fume may be in its original state or compacted or pelletized (with water).

5.3 Minor additional constituents

Minor additional constituents are specially selected, inorganic natural mineral materials, inorganic mineral materials derived from the clinker production process or constituents as specified in 5.2 unless they are included as main constituents in the cement.

Minor additional constituents, after appropriate preparation and on account of their particle size distribution, improve the physical properties of the cement (such as workability or water retention). They can be inert or have slightly hydraulic, latent hydraulic or Pozzolanic properties. However, no requirements are set for them in this respect.

Minor additional constituents shall be correctly prepared, that is, selected, homogenized, dried and comminuted depending on their state of production or delivery. They shall not increase the water demand of the cement appreciably, impair the resistance of the concrete or mortar to deterioration in any way or reduce the corrosion protection of the reinforcement.

NOTE Information on the minor additional constituents in the cement should be available from the manufacturer on request.

5.4 Calcium sulphate

Calcium sulphate is added to the other constituents of cement during its manufacture to control setting.

Calcium sulphate can be gypsum (calcium sulphate dihydrate, $CaSO_4.2H_2O$), hemihydrate ($CaSO_4 .1/2H_2O$), or anhydrite (anhydrous calcium sulphate, $CaSO_4$) or any mixture of them. Gypsum and anhydrite are found naturally. Calcium sulphate is also available as a by-product of certain industrial processes.

5.5 Additives

Additives for the purpose of EAS 18-1 are constituents not covered in 5.2 to 5.4 which are added to improve the manufacture or the properties of the cement.

The total quantity of additives shall not exceed 1.0 % by mass of the cement (except for pigments). The quantity of organic additives on a dry basis shall not exceed 0.5 % by mass of the cement.

These additives shall not promote corrosion of the reinforcement or impair the properties of the cement or of the concrete or mortar made from the cement.

When admixtures for concrete, mortar or grouts conforming to the ASTM C494/C494M–13 are used in cement, the standard notation of the admixture shall be declared on bags or delivery documents.

6 Composition and notation

6.1 Common cements

The 27 products in the family of common cements, covered by EAS 18-1 and their notation are given in Table 1. They are grouped into five main cement types as follows:

a) CEM I Portland cement;

b) CEM II Portland-composite cement;

c) CEM III Blast furnace cement;

d) CEM IV Pozzolanic cement; and

e) CEM V Composite cement.

The composition of each of the 27 products in the family of common cements shall be in accordance with Table 1.

NOTE For clarity in definition, the requirements for the composition refer to the sum of all main and minor additional constituents. The final cement is to be understood as the main and minor additional constituents plus the necessary calcium sulphate (see 5.4) and any additives (see 5.5).

Table 1 — The 27 products in the family of common cements

Main Types	Notation of the 27 products (types of common cement)		Composition [percentage by mass a]										Minor additional constituents
			Main constituents										
			Clinker	Blast-Furnace	Silica fume	Pozzolana		Fly ash		Burnt Shale	Lime stone		
						Natural	Natural calcined	Siliceous	Calcareous				
			K	S	D[b]	p	q	V	W	T	L	LL	
CEM I	Portland cement	CEM I	95-100	–	–	–	–	–	–	–	–	-	0 - 5
CEM II	Portland–slag cement	CEM II/A-S	80–94	6 - 20	–	–	–	–	–	–	–	–	0 - 5
		CEM II/B-S	65–79	21 - 35	-	–	–	–	–	–	–	–	0 - 5
	Portland-silica fume cement	CEM I/A-D	90 – 94	–	6 - 10	–	–	–	–	–	–	–	0 - 5
	Portland–Pozzolana cement	CEM II/A-P	80 – 94	–	–	6 - 20	–	–	–	–	–	–	0 - 5
		CEM II/B-P	65- 79	–	–	21 - 35	–	–	–	–	–	–	0 - 5
		CEM II/A-Q	80 - 94	–	–		6 - 20	–	–	–	–	–	0 - 5
		CEM II / B-Q	65 – 79	–	–	–	21 -35	–	–	–	–	–	0 - 5
	Portland – fly ash cement	CEM II / A-V	80–94	–	–	–	–	6 - 20	–	–	–	–	0 - 5
		CEMII / B-V	65 – 79	–	–	–	–	21 - 35	–	–	–	–	0 - 5
		CEM II/A-W	80–94	–	–	–	–	–	6 - 20	–	–	–	0 - 5
		CEMII/B-W	65 – 79	–	–	–	–	–	21 - 35	–	–	–	0 - 5
	Portland–burnt shale cement	CEM II/A-T	80–94	–	–	–	–	–	–	6 - 20	–	–	0 - 5
		CEM II/ B-T	65 – 79	–	–	–	–	–	–	21 - 35	–	–	0 - 5
	Portland–limestone cement	CEM II/ A-L	80 - 94	–	–	–	–	–	—	–	6 - 20	–	0 - 5
		CEM II/B-L	65- 79	–	–	–	–	–	–	–	21 - 35	–	0 - 5
		CEM II/A-LL	80 - 94	–	–	–	–	–	–	–	–	6 - 20	0- 5
		CEM II/ B-LL	65 - 79	–	–	–	–	–	–	–	–	21 - 35	0- 5
	Portland composite cement[c)]	CEM II/ A-M	80–88	<------ 12- 20 ------>									0 - 5
		CEM II/ B-M	65 -79	<------ 21 - 35 ------>									0- 5
CEM III	Blast–furnace cement	CEM III/A	35 - 64	36 -65	–	–	–	–	–	–	–	–	0 - 5
		CEM III/B	20 - 34	66 - 80	–	–	–	–	–	–	–	–	0 - 5
		CEM III/C	5 - 19	81 - 95	–	–	–	–	–	–	–	–	0 - 5
CEM IV	Pozzolanic cement [c)]	CEM IV/A	65 - 88	–	<---- 11 - 35 ---->					–	-	-	0 - 5
		CEM IV/B	45 - 64	–	<---- 36 - 55 ---->					–	-	-	0 - 5
CEN V	Composite cement [c)]	CEM V/ A	40 - 64	18 - 30	-	<-- 18 - 30 -->			–	–	-	-	0 - 5
		CEM V/B	20 - 38	31 - 50	-	<-- 31 - 49 -->			–	–	-	-	0 - 5

a) The values in the table refer to the sum of the main and minor additional constituents

b) The proportion of silica fume is limited to 10 %.

c) In Portland–composite cements CEM II/A–M and CEM II/B–M, in Pozzolanic cements CEM IV/A and CEM IV/B and in composite cements CEM V/A and CEM V/B the main constituents other than clinker shall be declared by designation of the cement (for example see Clause 8**)**.

6.2 Sulphate resisting common cements (SR-Cement)

6.2.1 The seven products in the family of the sulphate resisting common cements, covered by this standard are given in Table 2.

6.2.2 They are grouped into three main cement types as follows:

6.2.2.1 Sulphate resisting Portland cement:

(i) CEM I-SR 0 Sulphate resisting Portland cement (C_3A content of the clinker = 0 %);

(ii) CEM I-SR 3 Sulphate resisting Portland cement (C_3A content of the clinker ≤ 3 %); and

(iii) CEM I-SR 5 Sulphate resisting Portland cement (C_3A content of the clinker ≤ 5 %);

6.2.2.2 Sulphate resisting blast furnace cement:

(i) CEM III/B-SR Sulphate resisting blast furnace cement (no requirement on C_3A content of the clinker); and

(ii) CEM III/C-SR Sulphate resisting blast furnace cement (no requirement on C_3A content of the clinker);

6.2.2.3 Sulphate resisting pozzolanic cement:

(i) CEM IV/A-SR Sulphate resisting pozzolanic cement (C_3A content of the clinker ≤ 9 %);

(ii) CEM IV/B-SR Sulphate resisting pozzolanic cement (C_3A content of the clinker ≤ 9 %);

6.2.3 The composition of each of the seven products in the family of the sulphate resisting common cements shall be in accordance with Table 2. The cement type notation shall be in accordance with the requirements of this standard with additional notation by SR 0, SR 3, SR 5 for CEM I cements and only “SR” for CEM III and IV cements.

Table 2 — Seven products in the family of sulphate resisting common cements

Main Types	Notation of the seven products(types of sulphate resisting common cement)		Composition (percentage by mass[a])				
			Main constituents				Minor additional constituents
			Clinker K	Blast furnace slag S	Pozzolana slag P	Siliceous fly ash V	
CEM I	Sulphate resisting Portland cement	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5	95 - 100	-	-	-	0 - 5
CEM III	Sulphate resisting blast furnace cement	CEM III/B-SR	20 - 34	66- 80	-	-	0 - 5
		CEM III/C-SR	5 - 19	81 - 95	-	-	0 - 5
CEM IV	Sulphate[b] resisting pozzolanic	CEM IV/A-SR	65-79	-	⇐---21- 35---⇒		0 - 5
		CEM IV/B-SR	45-64	-	⇐--- 36 - 55---⇒		0 - 5

a) The values in the table refer to the sum of the main and minor additional constituents

b) In sulphate resisting pozzolanic cements, types CEM IV/B-SR, the main constituents other than clinker shall be declared by designation of the cement (for examples, see Clause 8)

6.3 Low early strength common cements

Low early strength common cements are CEM III blast furnace cements as specified in Table 1. They differ from other common cements regarding the early strength requirements (see 7.1.2). Low early strength CEM III cements conforming to the requirements in Table 3 can also be declared as sulphate resisting common cements.

7 Mechanical, physical, chemical and durability requirements

7.1 Mechanical requirements

7.1.1 Standard strength

The standard strength of cement is the compressive strength determined in accordance with EAS 148–1 at 28 days and shall conform to the requirements in Table 3.

Three classes of standard strength are included: class 32.5 class 42.5 and class 52.5 (see Table 3).

7.1.2 Early strength

The early strength of cement is the compressive strength determined in accordance with EAS 148–1 at either 2 days or 7 days and shall conform to the requirements in Table 3.

Three classes of early strength are included for each class of standard strength, a class with ordinary early strength, indicated by N, and a class with high early strength, indicated by R and a class with low early strength, indicated by L. (see Table 3).

Table 3 — Mechanical and physical requirements given as characteristics values

Strength Class	Compressive strength MPa				Initial setting time	Soundness (expansion)
	2 days	7 days	28 days		min	mm
32.5 L[a]	-	≥ 12.0				
32.5 N	–	≥ 16.0	≥ 32.5	≤ 52.5	≥ 75	
32. 5 R	≥ 10.0	–				
42.5 L[a]	-	≥ 16.0				
42.5 N	≥ 10.0	–	≥ 42.5	≤ 62.5	≥ 60	≤ 10
42.5 R	≥ 20.0	–				
52.5 L[a]	≥ 10.0	-				
52.5 N	≥ 20.0	–				
52.5 R	≥ 30.0	–	≥ 52.5	–	≥ 45	
a) Strength class only defined for CEM III cements						

7.2 Physical requirements

7.2.1 Initial setting time

The initial setting time, determined in accordance with EAS 148–3, shall conform to the requirements in Table 3.

7.2.2 Soundness

The expansion, determined in accordance with EAS 148–3, shall conform to the requirement in Table 3.

7.2.3 Heat of hydration

The heat of hydration of low heat common cements shall not exceed the characteristic value of 270 J/g, determined in accordance with EAS 148-8 at 7 days or in accordance with ISO 29582-2 at 41 h.

Low heat common cements shall be identified by the notation “LH”

NOTE 1 Pre-normative research has demonstrated the equivalence of test results for EAS 148-8 at 7 days. Nevertheless, in case of dispute between laboratories, the method to be applied should be agreed.

NOTE 2 Cement with a higher hydration heat value is appropriate for some applications. It is necessary that this value should be agreed upon between manufacturer and user, and that this cement should not be identified as low heat cement (LH).

7.3 Chemical requirements

The properties of the cements type and strength class shown in columns 3 and 4 respectively of Table 3 shall conform to the requirements listed in column 5 of this table when tested in accordance with the standard referred to in column 2.

Table 4 — Chemical requirements given as characteristic values

1	2	3	4	5
Property	**Test reference**	**Cement type**	**Strength class**	**Requirements [a]**
Loss on ignition	EAS 148–2	CEM I CEM III	All	≤ 5.0 %
Insoluble residue	EAS 148–2 [b]	CEM I CEM III	All	≤ 5.0 %
Sulphate content (as SO_3)	EAS 148–2	CEM I CEM II [c] CEM IV CEM V	32.5 N 32.5 R 42.5 N	≤ 3.5 %
			42.5 R 52.5 N 52.5 R	≤ 4.0 %
		CEM III [d]	All	
Chloride content	EAS 148-2	all [e]	All	≤ 0.10 % [f]
Pozzolanicity	EAS 148–5	CEM IV	All	Satisfies the test

[a] Requirements are given as percentage by mass of the final cement.

[b] Determination of residue insoluble in hydrochloric acid and sodium carbonate.

[c] Cement type CEM II/B–T and CEM II/B-M with a T content > 20 may contain up to 4.5 % sulphate (as SO_3) for all strength classes.

[d] Cement type CEM III/C may contain up to 4.5 % sulphate.

[e] Cement type CEM III may contain more than 0.10 % chloride but in that case the maximum chloride content shall be stated on the packaging and/or the delivery note.

[f] For pre–stressing applications cements may be produced according to a lower requirement. If so, the value of 0.10 % shall be replaced by this lower value which shall be stated in the delivery note.

7.4 Durability requirements

7.4.1 General

In many applications, particularly in severe environment conditions, the choice of cement has an influence on the durability of concrete, mortar and grouts, for examplefrost resistance and protection of reinforcement. Alkalis from cement or other concrete constituents may react chemically with certain aggregates. Adequate requirement are given in EAS 131-1.

The choice of cement, from this standard, particularly as regards type and strength class for different applications and exposure classes shall follow the appropriate standards and/or regulations for concrete or mortar valid in the place of use.

Low early strength common cements will have lower early strength compared to other common cement of the same standard strength class and may require additional precautions in their use such as extension of formwork stripping times and protection during adverse weather. In all other respects, their performance and suitability of applications will be similar to the other common cements, conforming to this standard, of the same type and standard strength class.

7.4.2 Sulphate resistance

Sulphate resisting common cement shall fulfill the additional chemical requirements specified in table 5. Sulphate resisting common cements shall be identified by the notation SR.

Table 5 — Additional requirements for sulphate resisting common cements given as characteristic values

1	2	3	4	5
Property	**Test reference**	**Cement type**	**Strength class**	**Requirements[a)]**
Sulphate content (as SO_3)	EAS 148-2	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5[b)] CEM IV/A-SR CEM IV/B-SR	32.5 N 32.5 R 42.5 N	≤ 3.0 %
			42.5 R 52.5 N 52.5 R	≤ 3.5 %
C_3A in clinker	EAS 148 -2[c]	CEM I-SR 0	All	= 0 %
		CEM I- SR 3		≤ 3 %
		CEM I-SR 5		≤ 5 %
	-[e)]	CEM IV/A-SR CEM IV/B-SR		≤ 9 %
Pozzolanicity	EAS 148-5	CEM IV/A-SR CEM IV/B-SR	All	Satisfies the test at 8 days

[a)] Requirements are given as percentage by mass of the final cement or clinker as defined in the table.

[b)] For specific applications cements CEM I-SR 5 may be produced according to higher sulphate content. If so the numerical value of this requirement for higher sulphate content shall be declared on the delivery note.

[c)] In the specific case of CEM I, it is permissible to calculate the C_3A content of clinker from the chemical analysis of the cement. The C_3A content of clinker shall be calculated by the formula: C_3A = 2.65 A-1.69 F (see 5.2.1).

[d)] Until the test method is finalized the C_3A content of clinker (see 5.2.1) shall be determined on the basis of the analysis of clinker as part of the manufacturer's Factory Production Control (EAS 18-2, 4.2.1).

8 Standard designation

CEM cements shall be identified by at least the notation of the cement type as specified in Table 1 and the figures 32.5, 42.5 or 52.5 indicating the strength class (see 7.1). In order to indicate the early strength class the letter N or the letter R shall be added as appropriate (see 7.1).

EXAMPLE 1:

Portland cement conforming to this standard of strength class 42.5 with a high early strength is identified by:

Portland cement EAS 18–1– CEM I 42.5 R

EXAMPLE 2:

Portland–limestone cement containing between 6 % and 20 % by mass of limestone with a TOC content not exceeding 0.50 % by mass (L) of strength class 32.5 with an ordinary early strength is identified by:

Portland–limestone cement EAS 18–1 –CEM II/A–L 32.5 N

EXAMPLE 3:

Portland–composite cement containing in total a quantity of granulated blast furnace slag (S), siliceous fly ash (V) and limestone (L) of between 6 % and 20 % by mass and of strength class 32.5 with a high early strength is identified by:

Portland–composite cement EAS 18–1 –CEM II/A–M (S–V–L) 32.5 R

EXAMPLE 4:

Composite cement containing between 18 % and 30 % by mass of granulated blast furnace slag (S) and between 18 % and 30 % by mass of siliceous fly ash (V) of strength class 32.5 with an ordinary early strength is identified by:

Composite cement EAS 18–1 –CEM V/A (S–V) 32.5 N

EXAMPLE 5:

Blast furnace cement, conforming to this standard, containing between 66 % and 80 % by mass of granulated blast furnace slag (S), of strength class 32.5 with an ordinary early strength and a low heat of hydration and sulphate resisting is designated by:

Blast furnace cement FD EAS 18-1 – CEM III/B 32.5 N - -LH/SR

EXAMPLE 6:

Portland cement, conforming to this standard, of strength class 42.5 with high early strength and sulphate resisting with C_3A content of the clinker ≤ 3 % by mass is designated by:

Portland cement EAS- 18-1 – CEM I 42.5 R – SR3

EXAMPLE 7:

Pozzolanic cement, conforming to this standard, containing between 21 % and 35 % by mass of natural pozzolana (P), of strength class 6 with an ordinary early strength and sulphate resisting with C_3A content of the clinker ≤ 9 % by mass and meeting the requirement for pozzolanicity is designated by:

Pozzolanic cement EAS 18-1 – CEM IV/A (P) 32.5 N – SR

EXAMPLE 8:

Blast furnace cement, conforming to this standard containing between 81 % and 95 % by mass granulated blast furnace slag (S) of strength class 32.5, with low early strength and low hydration and sulphate resisting is designated By:

Blast furnace cement, EAS 18-1 – CEM III/C 32.5 L – LH/SR

EXAMPLE 9:

Portland cement, conforming to this standard of strength class 42.5 with high early strength and where the factory produces different cements complying with the same standard designation, is designated by:

Portland cement EAS 18-1 – CEM I 42.5 R (1)

9 Conformity criteria

9.1 General requirements

Conformity of the 27 products to this standard shall be continually evaluated on the basis of testing of spot samples. The properties, test methods and the minimum testing frequencies for the autocontrol testing by the manufacturer are specified in Table 6. Concerning testing frequencies for cement not being dispatched continuously and other details, see EAS 18–2. Alternative test methods could be used provided that they have been validated in accordance with the appropriate provision in the cited standards of the reference test methods. In the event of a dispute, only the reference methods are used.

For certification of conformity by an approved certification body, conformity of cement with this standard shall be evaluated in accordance with EAS 18–2.

NOTE 1 This standard does not deal with acceptance inspection at delivery.

NOTE 2 For certification of conformity by a notified body, conformity of cement with this standard is evaluated in accordance with EAS 18-2.

The compliance of common cements with the requirements of this standard and with the stated values (including classes) shall be demonstrated by:

– Initial type testing; and

– Factory production control by the manufacturer, including product assessment.

Table 6 — Properties, test methods and minimum testing frequencies for the autocontrol testing by the manufacturer, and the statistical assessment procedure

			Autocontrol testing			
Property	Cements to be tested	Test method[a) b)]	Minimum testing frequency		Statistical assessment procedure	
					Inspection by	
			Routine situation	Initial period for a new type of cement	Variables [e)]	Attributes
1	2	3	4	5	6	7
Early strength Standard strength	All	EAS 148–1	2/week	4/week	X	–
Initial setting time	All	EAS 148–3	2/week	4/week	–	X[d)]
Soundness (Expansion)	All	EAS 148–3	1/week	4/week	–	X
Loss on ignition	CEM I, CEM III	EAS 148–2	2/month [e)]	1/week	–	X[d)]
Insoluble residue	CEM I, CEM III	EAS 148–2	2/month [e)]	1/week	–	X[d)]

Sulphate content	All	EAS 148–2	2/week	4/week	–	X[d)]
Chloride content	All	EAS 148–2	2/month [e)]	1/week	–	X[d)]
C_3A in clinker[)]	CEM I-SR 0 CEM I-SR 3 CEM – SR 5	EAS 148-2[g]	2/ month	1/week		x[d]
	CEM IV/A-SR CEM IV/B-SR	–[h]				
Pozzolanicity	CEM IV	EAS 148–5	2/month	1/week	–	X
Heat of hydration	Low heat common cements	EAS 148-8	1/month	1/week		x[d]
Composition	All	–[i)]	1/month	1/week	–	

[a)] Where allowed in the relevant part of EAS 148, other methods than those indicated may be used provided they give results correlated and equivalent to those obtained with reference method.

[b)] The methods used to take and prepare samples shall be in accordance with EAS 148–7.

[c)] If the data are not normally distributed then the method of assessment may be decided on a case-by-case-basis.

[d)] If the number of samples is at least one per week during the control period, the assessment may be made by variables.

[e)] When none of the test results within a period of 12 months exceeds 50 % of the characteristic value the frequency may be reduced to one per month.

[g)]In the specific case of CEM I, it is permissible to calculate the C_3A content of clinker from the chemical analysis of the cement. The C_3A content shall be calculated by the formula: C_3A= 2.65 A-1.69 F (see 5.2.1).

[h)] Until the test method is finalized the C_3A content clinker (see 5.2.1) shall be determined on the basis of the analysis of clinker as part of the manufacturer's Factory Production Control (EAS 18-2, 4.2.1.2)

[i)] Appropriate test method chosen by the manufacturer.

9.2 Conformity criteria for mechanical, physical and chemical properties and evaluation procedure

9.2.1 General

Conformity of cement with the requirements for mechanical, physical and chemical properties in this standard is assumed if the conformity criteria specified in 9.2.2 and 9.2.3 are met. Conformity shall be evaluated on the basis of continual sampling using spot samples taken at the point of release and on the basis of the test results obtained on all autocontrol samples taken during the control period.

9.2.2 Statistical conformity criteria

9.2.2.1 General

Conformity shall be formulated in terms of a statistical criterion based on:

a) the specified characteristic values for mechanical, physical and chemical properties as given in 7.1, 7.2 and 7.3 of this standard;

b) the percentile P_k, on which the specified characteristic value is based, as given in Table 7;

c) the allowable probability of acceptance CR, as given in Table 7.

Table 7 — Required values P_k and CR

	Mechanical requirements		Physical and chemical requirements
	Early and standard strength (lower limit)	Standard strength (upper limit)	
The percentile P_k on which the characteristic value is based	5 %	10 %	
Allowable probability of acceptance CR	5 %		

NOTE Conformity evaluation by a procedure based on a finite number of test results can only produce an approximate value for the proportion of results outside the specified characteristic value in a population. The larger the sample size (number of test results), the better the approximation. The selected probability of acceptance CR controls the degree of approximation by the sampling plan.

Conformity with the requirements of this standard shall be verified either by variables or by attributes, as described in 9.2.2.2 and 9.2.2.3 as specified in Table 6.

The control period shall be 12 months.

9.2.2.2 Inspection by variables

For this inspection the test results are assumed to be normally distributed. Conformity is verified when equation(s) (2) and (3), as relevant, are satisfied:

$$\bar{x} - k_A \times s \geq L \quad (2)$$

and;

$$\bar{x} - k_A \times s \leq U \quad (3)$$

where

$\bar{x}$ is the arithmetic mean of the totality of the autocontrol test results in the control period;

s is the standard deviation of the totality of the autocontrol test results in the control period;

k_A is the acceptability constant;

L is the specified lower limit given in Table 3 referred to in 7.1;

U is the specified upper limit given in Tables 3 and 4 referred to in clause 7.

The acceptability constant k_A depends on the percentile P_k on which the characteristic value is based, on the allowable probability of acceptance CR and on the number n of the test results. Values of k_A are listed in Table 8.

Table 8 — Acceptability constant k_A

Number of test results *n*	k_A [a)]	
	For P_k= 5 % (early and standard strength, lower limit)	For P_k =10 % (other properties)
20 - 21	2.40	1.93
22 - 23	2.35	1.89
24 - 25	2.31	1.85
26 - 27	2.27	1.82
28 -29	2.24	1.80
30 - 34	2.22	1.78
35 - 39	2.17	1.73
40 - 44	2.13	1.70
45 - 49	2.09	1.67
50 - 59	2.07	1.65
60 -69	2.02	1.61
70- 79	1.99	1.58
80 - 89	1.97	1.56
90 - 99	1.94	1.54
100 - 149	1.93	1.53
150 - 199	1.87	1.48
200 - 299	1.84	1.45
300 - 399	1.80	1.42
> 400	1.78	1.40

NOTE Values given in this table are valid for CR = 5 %.

[a] Values of k_A valid for intermediate values of *n* may also be used.

9.2.2.3 Inspection by attributes

The number c_D of test results outside the characteristic value shall be counted and compared with an acceptable number c_A, calculated from the number *n* of autocontrol test results and the percentile P_k as specified in Table 7.

Conformity is verified when equation (4) is satisfied:

$$c_D \leq c_A \qquad (4)$$

The value of C_A depends on the percentile P_k on which the characteristic value is based, on the allowable probability of acceptance CR and on a number *n* of the test results. Values of C_A are listed in Table 9.

Table 9 — Values of C_A

Number of test results *n* [a)]	c_A for $P_K = 10\ \%$
20- 39	0
40 -54	1
55 - 69	2
70 - 84	3
85 - 99	4
100 - 109	5
110 - 123	6
124 - 136	7
NOTE Values given in this table are valid for CR = 5 %	
a) If the number of test results is n < 20 (for P_k = 10 %) a statistically based conformity criterion is not possible. Despite this, a criterion of $c_A = 0$ shall be used in cases where $n < 20$. If the number of test results is n > 136, C_A can be calculated as follows: $C_A = 0.075\ (n\text{-}30)$	

9.2.3 Single result conformity criteria

In addition to the statistical conformity criteria, conformity of test results to the requirements of this standard requires that it shall be verified that each test result remains within the single result limit values specified in Table 10.

Table10 — Limit values for single results

<table>
<tr><th colspan="2" rowspan="2">Property</th><th colspan="9">Strength class</th></tr>
<tr><th>32.5 L</th><th>32.5 N</th><th>32.5 R</th><th>42.5 L</th><th>42.5 N</th><th>42.5 R</th><th>52.5 L</th><th>52.5 N</th><th>52.5 R</th></tr>
<tr><td rowspan="2">Early strength (MPa) lower limit value</td><td>2 days</td><td>-</td><td>–</td><td>8.0</td><td></td><td>8.0</td><td>18.0</td><td>8.0</td><td>18.0</td><td>28.0</td></tr>
<tr><td>7 days</td><td>10.0</td><td>14.0</td><td>–</td><td></td><td>–</td><td>–</td><td>-</td><td>–</td><td>–</td></tr>
<tr><td>Standard strength (MPa) lower limit value</td><td>28 days</td><td colspan="3">30.0</td><td colspan="3">40.0</td><td colspan="3">50.0</td></tr>
<tr><td colspan="2">Initial setting time (min) lower limit value</td><td colspan="3">60</td><td colspan="3">50</td><td colspan="3">40</td></tr>
<tr><td colspan="2">Soundness (expansion, mm) upper limit value</td><td colspan="9">10</td></tr>
<tr><td rowspan="2">Sulphate content (as % SO_3) upper limit value</td><td>CEM I
CEM II [a)]
CEM IV
CEM V</td><td>-</td><td colspan="2">4.0</td><td>-</td><td>4.0</td><td>4.5</td><td>-</td><td colspan="2">4.5</td></tr>
<tr><td>CEM I-SR 0
CEM I-SR 3
CEM I-SR 5[b)]
CEM IV/A-SR</td><td>-</td><td colspan="2">3.5</td><td>-</td><td>3.5</td><td>4.0</td><td></td><td colspan="2">4.0</td></tr>
</table>

	CEM IV/B-SR						
	CEM III/A CEM III/B	4.5					
	CEM III/C	5.0					
C_3A(%). Upper limit value	CEM I-SR 0	1					
	CEM I-SR 3	4					
	CEM I-SR 5	6					
	CEM IV/A-SR	10					
	CEM IV/B-SR	10					
Chloride content (%) [c] upper limit value		0.10[d]					
Pozzolanicity		-	Satisfies the test at 15 days	-	Satisfies the test at 15 days	-	Satisfies the test at 15 days
Heat of hydration (J/g). Upper limit value	LH	300					

[a] Cement types CEM II/B – T and CEM II/B-M with a T content > 20% may contain up to 5.0 % SO_3 for all strength classes.

[b] For specific applications CEM I-SR 5 may be produced according to a higher maximum sulphate content (see Table 7). If so, the upper limit value is 0.5 % above the declared value

[C] Cement type CEM III may contain more than 0.10 % chloride but in that case the maximum chloride content shall be declared.

[d] For pre–stressing applications cements may be produced according to a lower requirement. If so, the value of 0.10 % shall be replaced by this lower value, which shall be stated in the delivery note.

9.3 Conformity criteria for cement composition

At least once per month the composition of the cement shall be checked by the manufacturer, using as a rule a spot sample taken at the point of release of the cement. The cement composition shall meet the requirements specified in Table 1. The limiting quantities of the main constituents specified in Table 1 are reference values to be met by the average composition calculated from the spot samples taken in the control period. For single results, maximum deviations of –2 at the lower and +2 at the higher reference value are allowed. Suitable procedures during production and appropriate verification methods to ensure conformity to this requirement shall be applied and documented.

9.4 Conformity criteria for properties of the cement constituents

The cement constituents shall meet the requirements specified in Clause 5. Suitable procedures during production to ensure conformity with this requirement shall be applied and documented.

10 Marking, labelling, packaging and storage

10.1 Marking and labelling

Each bag of cement shall be legibly and indelibly marked with the following information in English language:

a) the manufacturer’s name, address, (factory physical address)and/or trademark;

b) standard designation of cement;

c) net weight of cement in kilograms;

d) date of packing

e) batch number

10.2 Packaging and storage

10.2.1 The cement shall be packaged in a material that safeguards the quality, safety and integrity of the product.

10.2.2 The cement shall be stored in dry and cool place that allows easy access for inspection and identification, and in suitable waterproof building to maintain quality of the cement. It shall be stored on pallets not in contact with the walls / floors and roof.

Annex A
(normative)

List of common cements considered as sulphate resisting in EAC member states but not included in table 2

CEM Cement type
II/A-S,
II/B-S,
II/A-V,
II/B-V,
II/A-M,
II/A-D,
II/A,
V/A(S-V),
II/A-P,
II/A-M(S-V),
III/A,
V/A,
V/B,
II/A-R,
II/A-LL,
II/B-L,
II/B-LL,
II/A-W,
II/B-P,
II/B-W,
II/B-T,
IV/A,
IV/A,
IV/B,
II/B-M(D,V,S,T,LL),
IV/A(V)

Bibliography

[1] EN 197-1: 2011; *Cement – Part 1; Composition, specifications and conformity criteria for common cemen*