ICS 91.100.10

DMS 29-1:2018
First revision
EN 197:2011
IDT

DRAFT MALAWI STANDARD
(COMESA AND SADC HARMINIZED)

Cement–Part 1: Composition, specifications and conformity criteria for common cements

NOTE: ***This is a Draft Proposal and should not be regarded or used as a Malawi Standard***

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Cement–Part 1: Composition, specifications and conformity criteria for common cements

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Price based on 30 pages

TABLE OF CONTENTS

Contents .... **Page**

FOREWORD

This Draft Malawi Standard is a revision of MS 29:2002. It is a Common Market for Eastern and Southern Africa (COMESA) and Southern African Development Community (SADC) Harmonized Text, covering requirement different types of cements.

The harmonization of standards and Technical Regulations in the COMESA is an obligation under the COMESA Treaty in order to promote the achievement of the aims and objectives of the Common Market as set out in Article 3 of COMESA Treaty.

In SADC, harmonization of standards and technical regulations is also an obligation under the SADC Trade Protocol which was established under the SADC Treaty to provide elimination of tariffs and non-tariff barriers to trade.

This draft Malawi Standard is identical to the following standards:

European Standard EN 197-1:2011 *Cement – Part 1: Composition, specifications and conformity criteria for common cements* which was adopted by COMESA.

SADCSTAN HT 5/SANS 50197-1: 2011 Ed 1 – *Cement Part 1: Composition, specifications and conformity criteria for common cements*

Acknowledgement is made for the use of the above standards.

TECHNICAL COMMITTEE

This Draft Malawi Standard was developed by the Technical Committee MBS/TC 9 Cement and lime products and the following companies and organisations were represented:

Geological Survey Department

Jogs Concrete Products

Kulimba Cement Limited

Lafarge Cement

Malawi Building Construction and Allied Trades Association

Malawi Bureau of Standards

National Construction Industry Council

University of Malawi – The Polytechnic

NOTICE

This Draft Malawi Standard shall be reviewed every five years, or earlier when it is necessary in order to keep abreast of progress. Comments are welcome and shall be considered when the draft Malawi Standard is being reviewed.

DRAFT MALAWI STANDARD

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

1 SCOPE

This Draft Malawi Standard defines and gives the specifications of 27 distinct common cements, 7 sulphate resisting common cements as well as 3 distinct low early strength blast furnace cements and 2 sulphate resisting low early strength blast furnace cements and their constituents. The definition of each cement includes the proportions in which the constituents are to be combined to produce these distinct products in a range of nine strength classes. The definition also includes requirements which the constituents have to meet. It also includes mechanical, physical, and chemical requirements. 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 can 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 can be agreed between the parties concerned.

NOTE 2 - The word “cement” in this Malawi Standard is used to refer only to common cements unless otherwise specified.

This Malawi Standard does not cover the following cements which have been covered in other standards:

– very low heat special cement;

– supersulphated cement;

– calcium aluminate cement;

– masonry cement.

2 NORMATIVE REFERENCES

The following standards contain provisions which, through reference in this text, constitute provisions of this standard. All standards are subject to revision and, since any reference to a standard is deemed to be a reference to the latest edition of that standard, parties to agreements based on this standard are encouraged to take steps to ensure the use of the most recent editions of the standards indicated below. Information on currently valid national and international standards can be obtained from the Malawi Bureau of Standards

MS 29-2:2000, Cement – Part 2: Conformity evaluation

MS 1062-1, *Methods of testing cement – Part 1: Determination of strength*

MS 1062-2, *Methods of testing cement — Part 2: Chemical analysis of cement*

MS 1062-3, *Methods of testing cement – Part 3: Determination of setting times and soundness*

MS 1062-5, *Methods of testing cement – Part 5: Pozzolanicity test for pozzolanic cement*

MS 1062-6, *Methods of testing cement – Part 6: Determination of fineness*

MS 1062-7, *Methods of testing cement – Part 7: Methods of taking and preparing samples of cement*

EN 196-8, *Methods of testing cement – Part 8: Heat of hydration — Solution method*

EN 196-9, *Methods of testing cement – Part 9: Heat of hydration — Semi-adiabatic method*

EN 451-1, *Method of testing fly ash – Part 1: Determination of free calcium oxide content*

EN 933-9, *Tests for geometrical properties of aggregates – Part 9: Assessment of fines - Methylene blue test*

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

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

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

3 TERMS AND DEFINITIONS

For the purposes of this document, the following terms and definitions 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 **MS 1062-2**) is reduced by the fraction corresponding to calcium carbonate ($CaCO_3$), based on the measured carbon dioxide (CO_2) content (see **MS 1062-2**), and the fraction corresponding to calcium sulphate ($CaSO_4$), based on the measured sulphate (SO_3) content (see **MS 1062-2**) after subtraction of the SO3 taken up by alkalis.

3.2
reactive silicon dioxide (SiO_2)
fraction of the silicon dioxide which is soluble after treatment with hydrochloric acid (HCl) 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 **MS 1062-2**) the fraction contained in the residue insoluble in hydrochloric acid and potassium hydroxide (see **MS 1062-2**), 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

3.5
type of common cement
one of the 27 products (see **Table 1**) in the family of common cements

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, 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 which is taken at the same time and from one and the same place, relating to the intended tests, and which can be obtained by combining one or more immediately consecutive increments

NOTE - See MS 1062-7.

3.15
heat of hydration
quantity of heat developed by the hydration of a 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 CEMENT

Cement is a hydraulic binder, i.e. 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, e.g. 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 **MS 1062-2**.

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 **MS 29-2**.

NOTE - There are also cements whose hardening is mainly due to other compounds, e.g. calcium aluminate in calcium aluminate cement.

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 **EN 196** 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, $Al2O_3$, $Fe2O_3$ 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 ($3CaO \cdot SiO_2$ and $2CaO \cdot SiO_2$), 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 fulfil additional requirements for tricalcium aluminate content (C_3A). The tricalcium aluminate content of the clinker shall be calculated by Equation (1) as follows:

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

where

A is the percentage of aluminium oxide (Al_2O_3) by mass of the clinker as determined in accordance with **MS 1062-2**

F is the percentage of iron (III) oxide (Fe_2O_3) by mass of the clinker as determined in accordance with **MS 1062-2**.

NOTE - It may happen that a negative C_3A value is obtained from the calculation. In this case, the value 0 % should be recorded. A test method to determine the C_3A content of clinker from the analysis of a spot sample of cement is currently under development by CEN/TC 51. Until this method is available, the C_3A content should be directly measured on the clinker. 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 minimum frequency of testing and the use of alternative methods for the direct or indirect evaluation of C_3A should be included in the factory production control (see **MS 29-2**). A typical frequency of testing is two per month in routine situations.

Sulphate resisting Portland cements and sulphate resisting pozzolanic cements are made with Portland cement clinker in which the C_3A content does not exceed:

– For CEM I: 0 %, 3 % or 5 % as appropriate (see **6.2**)

– 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 subclauses (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. Pozzolanas 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, i.e. selected, homogenised, 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 pulverised coal.

NOTE 1 - For definition of fly ash see **EN 450-1**.

Ash obtained by other methods shall not be used in cement that conforms to this standard.

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 **MS 1062-2**, but using an ignition time of 1 h, shall be within one of the following limits:

a) 0 % to 5.0 % by mass

b) 2.0 % to 7.0 % by mass

c) 4.0 % to 9.0 % by mass

The upper limit of loss on ignition of the fly ash used as a main constituent for the production of a cement shall be stated on its packaging and/or delivery note.

NOTE 2 - The purpose of the requirement for the loss on ignition is to limit the residue of unburnt carbon in the fly ash. It is therefore sufficient to show, through direct measurement of unburnt carbon residue, that the content of unburnt carbon falls within the limits of the categories specified above. The content of unburnt carbon is determined in accordance with **ISO 10694**.

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 (CaO) shall be less than 10.0 % by mass, the content of free calcium oxide, as determined by the method described in **EN 451-1** 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 **MS 1062-3** using a mixture of 30 % by mass of siliceous fly ash and 70 % by mass of a CEM I cement conforming to this Malawi Standard.

The reactive silicon dioxide content shall not be less than 25.0 % by mass.

5.2.4.3 Calcareous fly ash (W)

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.

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 **MS 1062-1**. 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.

The expansion (soundness) of calcareous fly ash shall not exceed 10 mm when tested in accordance with **MS 1062-3** using a mixture of 30 % by mass of calcareous fly ash ground as described above and 70 % by mass of a CEM I cement conforming to this Malawi Standard.

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)

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.

Adequately ground burnt shale shall have a compressive strength of at least 25.0 MPa at 28 days when tested in accordance with MS 1062-1. 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.

The expansion (soundness) of burnt shale shall not exceed 10 mm when tested in accordance with MS 1062-3 using a mixture of 30 % by mass of ground burnt shale and 70 % by mass of a CEM I cement conforming to this Malawi Standard.

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 **EN 933-9**, 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 **MS 1062-6**.

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

   1) LL: shall not exceed 0.20 % by mass;

   2) L: shall not exceed 0.50 % by mass.

5.2.7 Silica fume (D)

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.

Silica fume shall meet the following requirements:

a) The loss on ignition shall not exceed 4.0 % by mass determined in accordance with **MS 1062-2** but using an ignition time of 1 h.

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**.

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

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, i.e. selected, homogenised, 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, $CaSO_4 \cdot 2H_2O$), hemihydrate($CaSO_4 \cdot ½H_2O$), 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 this Malawi Standard 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 0.2 % by mass of the cement. A higher quantity may be incorporated in cements provided that the maximum quantity, in %, is declared on the packaging and/or the delivery note.

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 **EN 934** series are used in cement the standard notation of the admixture shall be declared on bags or delivery documents.

6 COMPOSITION AND NOTATION

6.1 Composition and notation of common cements

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

- CEM I Portland cement,
- CEM II Portland-composite cement,
- CEM III Blast furnace cement,
- CEM IV Pozzolanic cement,
- CEM V Composite cement.

The composition of each of the 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

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Main types	Notation of the 27 products (types of common cement)		Composition (percentage by mass[a])										
			Main constituents										
						Pozzolana		Fly ash					
			clinker	Blast furnace slag	Silica fume	natural	Natural calcined	siliceous	Calc-receous	Burnt shale	Limestone		Minor additional constituents
			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 II/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
		CEM II/B-V	65-79	–	–	–	–	21-35	–	–	–	–	0.5
		CEM II/A-W	80-94	–	–	–	–	–	6-20	–	–	–	0.5
		CEM II/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	Pozzolana cement[c]	CEM III/	65-89	–	<---------- 11-35 ---------->					–	–	–	0.5
		CEM III/	45-64	–	<---------- 36-55 ---------->					–	–	–	0.5
CEM V	Composite cement[c]	CEM III/	40-64	18-30	–	<------ 18-30 ------>			–	–	–	–	0.5
		CEM III/	20-38	31-49	–	<------ 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 examples, see Clause 8).

6.2 Composition and notation of sulphate resisting common cements (SR-Cements)

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

They are grouped into three main cement types as follows:

Sulphate resisting Portland cement:

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

– CEM I-SR 3 Sulphate resisting Portland cement (C_3A content of the clinker ≤ 3 %),

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

Sulphate resisting blast furnace cement:

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

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

Sulphate resisting pozzolanic cement:

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

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

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 — The seven products in the family of sulphate resisting common cements

1	2	3	4	5	6	7	
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 natural** **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 cement	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/A-SR and 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 Composition and notation of 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 2** 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 a cement is the compressive strength determined in accordance with **MS 1062-1** 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 a cement is the compressive strength determined in accordance with **MS 1062-1** 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, a class with high early strength, indicated by R and a class with low early strength, indicated by L (see **Table 3**). Class L is only applicable for CEM III cements. These are the distinct low early strength blast furnace cements.

Table 3 — Mechanical and physical requirements given as characteristic values

1	2	3	4	5	6	7
Strength class	**Compressive strength MPa**				**Initial setting time**	**Soundness (expansion)**
	Early strength		**Standard strength**			
	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		≥ 45	
52.5 R	≥ 30.0	–				

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 **MS 1062-3**, shall conform to the requirements in **Table 3**.

7.2.2 Soundness

The expansion, determined in accordance with **MS 1062-3**, 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 either **EN 196-8** at 7 days or in accordance with **EN 196-9** 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 **EN 196-8** at 7 days and **EN 196-9** at 41 h. 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 of the cement type and strength class shown in columns 3 and 4 respectively of **Table 4** 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	MS 1062-2	CEM I CEM III	All	≤ 5.0 %
Insoluble residue	MS 1062-2 [b]	CEM I CEM III	All	≤ 5.0 %
Sulphate content (as SO_3)	MS 1062-2	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	MS 1062-2	all e	All	≤ 0.10 %[f]
Pozzolanicity	MS 1062-5	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 types 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 environmental conditions, the choice of cement has an influence on the durability of concrete, mortar and grouts, e.g. frost resistance, chemical resistance and protection of reinforcement. Alkalis from cement or other concrete constituents may react chemically with certain aggregates. Adequate requirements are given in **EN 206-1**.

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 application 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 fulfil 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)	MS 1062-2	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[c]	MS 1062-2[d]	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	MS 1062-5	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 a higher sulphate content. If so the numerical value of this requirement for higher sulphate content shall be declared on the delivery note.

c The test method for the determination of C_3A content of clinker from an analysis of the final cement is under development in CEN/TC51.

d 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**).

e Until the test method is finalised 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 (MS 29-2:2000, **4.2.1.2**).

8 STANDARD DESIGNATION

CEM cements shall be designated 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, R or L shall be added as appropriate (see **7.1**).

When in the same factory a manufacturer produces different cements complying with the same standard designation, these cements receive an additional identification in the form of a number or of two lower case letters, between brackets, in order to distinguish these cements from each other. For the numbering system, this number should be 1 for the second certified cement, 2 for the next, and so on. For the lettering system, the letters shall be chosen in such a way as to avoid confusion.

Sulphate resisting cement shall be designated additionally by the notation SR.

Cements not covered by this Malawi Standard for their sulphate resisting property but considered sulphate resisting according to National Standards listed in **Annex A** shall not be identified by the notation SR.

NOTE - The CE marking may be affixed for those products as common cements.

Low heat common cement shall be additionally designated by the notation LH.

EXAMPLE 1

Portland cement, conforming to MS 29, of strength class 42.5 with high early strength is designated by:

Portland cement MS 29-1 – CEM I 42.5 R

EXAMPLE 2

Portland-limestone cement, conforming to MS 29, containing between 6 % and 20 % by mass of limestone (L) with a TOC content not exceeding 0.50 % by mass of strength class 32.5 with an ordinary early strength is designated by:

Portland-limestone cement MS 29-1 – CEM II/A-L 32.5 N

EXAMPLE 3

Portland-composite cement, conforming to MS 29, containing in total a quantity of granulated blast furnace slag (S), siliceous fly ash (V) and limestone (L) of between 12 % and 20 % by mass and of strength class 32.5 with high early strength is designated by:

Portland-composite cement MS 29-1 – CEM II/A-M (S-V-L) 32.5 R

EXAMPLE 4

Composite cement, conforming to MS 29-1, 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 designated by:

Composite cement MS 29-1 – CEM V/A (S-V) 32.5 N

EXAMPLE 5

Blast furnace cement, conforming to THIS MALAWI 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 MS 29-1 – CEM III/B 32,5 N – LH/SR

EXAMPLE 6

Portland cement, conforming to MS 29-1, 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 THIS MALAWI STANDARD – CEM I 42.5 R – SR 3

EXAMPLE 7

Pozzolanic cement, conforming to MS 29-1, containing between 21 % and 35 % by mass of natural pozzolana (P), of strength class 32.5 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 MS 29-1 – CEM IV/A (P) 32.5 N – SR

EXAMPLE 8

Blast furnace cement, conforming to MS 29-1, containing between 81 % and 95 % by mass granulated blast furnace slag (S) of strength class 32.5 with low early strength and low heat of hydration and sulphate resisting is designated by:

Blast furnace cement MS 29-1 – CEM III/C 32.5 L – LH/SR

EXAMPLE 9

Portland cement, conforming to MS 29-1, 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 MS 29-1 – CEM I 42.5 R (1)

9 CONFORMITY CRITERIA

9.1 General requirements

Conformity of the 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 **MS 29-2**. Alternative test methods could be used provided that they have been validated in accordance with the appropriate provisions in the cited standards of the reference test methods. In the event of a dispute, only the reference methods are used.

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 MS 29-2.

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

– initial type testing,

– 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

1	2	3	4	5	6	7
Property	**Cements to be tested**	**Test method**[ab]	**Autocontrol testing**			
			Minimum testing frequency		**Statistical assessment procedure**	
					Inspection by	
			Routine situation	**Initial period for a new type of cement**	**Variables**[c]	**Attributes**
Early strength Standard strength	All	MS 1062-1	2/week	4/week	x	
Initial setting time	All	MS 1062-3	2/week	4/week		x [d]
Soundness (Expansion)	All	MS 1062-3	1/week	4/week		x
Loss on ignition	CEM I, CEM III	MS 1062-2	2/month [e]	1/week		x [d]
Insoluble residue	CEM I, CEM III	MS 1062-2	2/month e	1/week		x d
Sulphate content	All	MS 1062-2	2/week	4/week		x d
Chloride content	All	MS 1062-2	2/month e	1/week		x d
C_3A in clinker f	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5	MS 1062-2 g	2/month	1/week		x d
	CEM IV/A-SR CEM IV/B-SR	– h				
Pozzolanicity	CEM IV	MS 1062-5	2/month	1/week		x
Heat of hydration	Low heat common cements	EN 196-8 or EN 196-9	1/month	1/week		x d
Composition	All	– i	1/month	1/week		

a Where allowed in the relevant part of EN 196, other methods than those indicated may be used provided they give results correlated and equivalent to those obtained with the reference method.

b The methods used to take and prepare samples shall be in accordance with MS 1062-7.

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.

f The test method for the determination of C_3A content of clinker from an analysis of the final cement is under development in CEN/TC51.

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 finalised 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 (MS 29-2:2000, **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 of 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:

- the specified characteristic values for mechanical, physical and chemical properties as given in **7.1**, **7.2**, and **7.3**;
- the percentile P_k, on which the specified characteristic value is based, as given in **Table 7**;
- the allowable probability of acceptance CR, as given in **Table 7**.

Table 7 – Required values P_k and CR

1	2	3	4
	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** and 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:

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

and

$$\bar{x} + k_A \cdot s \leq U \quad (3)$$

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**, 4 and 5 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

1	2	3
Number of test results n	**k_A [a]**	
	for P_k = 5 %	**for P_k = 10 %**
	Early and standard strength (lower limit)	**Other properties**
20 to 21	2.40	1.93
22 to 23	2.35	1.89
24 to 25	2.31	1.85
26 to 27	2.27	1.82
28 to 29	2.24	1.80
30 to 34	2.22	1.78
35 to 39	2.17	1.73
40 to 44	2.13	1.70
45 to 49	2.09	1.67
50 to 59	2.07	1.65
60 to 69	2.02	1.61
70 to 79	1.99	1.58
80 to 89	1.97	1.56
90 to 99	1.94	1.54
100 to 149	1.93	1.53
150 to 199	1.87	1.48
200 to 299	1.84	1.45
300 to 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 9**.

Conformity is verified when Equation (4) is satisfied:

$$c_D \leq c_A \tag{4}$$

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

1	2
Number of test results n[a]	**c_A for P_K = 10 %**
20 to 39	0
40 to 54	1
55 to 69	2
70 to 84	3
85 to 99	4
100 to 109	5
110 to 123	6
124 to 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 – 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**.

Table 10 — Limit values for single results

1	2	3	4	5	6	7	8	9	10	11
Property		**Limit valuesfor single results**								
		Strength class								
		32.5 L	32.5 N	32.5 R	42.5 L	42.5 N	42.5 R	52.5 L	52.5 N	52.5 R
Early strength (MPa), lower limit value	2 days	–	–	8.0	–	8.0	18.0	8.0	18.0	28.0
	7 days	10.0	14.0	–	14.0	–	–	–	–	–
Standard strength (MPa), lower limit value	28 days	30.0			40.0			50.0		
Initial setting time (min), lower limit value		60			50			40		
Soundness (expansion, mm), upper limit value		10								
Sulphate content (as % SO3), upper limit value	CEM I CEM II[a] CEM IV CEM V	–	4.0		–	4.0	4.5	–	4.5	
	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5[b] CEM IV/A-SR CEM IV/B-SR	–	3.5		–	3.5	4.0	–	4.0	
	CEM III/A CEM III/B	4.5								
	CEM III/C	5.0								
C`VHJKL;A (%), upper limit value	CEM I-SR 0 CEM I-SR 3 CEM I-SR 5 CEM IV/A-SR CEM IV/B-SR	1 4 6 10 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 5**). 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

The composition of the cement shall be checked by the manufacturer at least once per month 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** and **Table 2**. The limiting quantities of the main constituents specified in **Table 1** and **Table 2** 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 PACKAGING AND MARKING

10.1 Packaging

Cement shall be packed in containers that are strong enough to withstand normal handling and transportation and that will prevent leakage or contamination of the product in the containers.

Where cement is supplied in a bag for manual handling, the weight should be 50 kg or less within the permitted tolerances.

10.2 Marking

10.2.1 General

The exchange of additional information between the manufacturer and the user if so required, should be made in accordance with, but not limited to, this clause.

10.2.2 Conditions of supply

10.2.2.1 Identification

Cement should be identified on the bag or the delivery note, and on any test report, with the following particulars:

a) the name, trade mark or other means of identification of the manufacturer to facilitate traceability to the factory in which the cement was manufactured;

b) the *designationlname,* the notation/type and strength class of the cement; e.g.

   Portland cement CEM I 42.5N;

   Portland -fly ash cement CEM II/B-V 32.5R;

   Portland-limestone cement CEM II/A-LL 42.5N

   Blastfurnace cement CEM IIl/A 42.5 N;

c) the number of this Malawi Standard i.e. DMS 29:2018;

d) the standard notation of any admixture where applicable; and in the case of bagged supply only:

e) the weight of the bag packed with cement.

10.2.3 Test report

10.2.3.1 General

If a test report is requested from the manufacturer, it should include result of the following tests on samples of the cement, and the information, where indicated, relating to the materials delivered.

10.2.3.2 All CEM cement

a) compressive strength at either 2 days or 7 days, as appropriate, and also at 28 days (see 7.1);

b) initial setting time (see 7.2.1);

c) soundness (see 7.2.2);

d) chloride content (see 7.3).

A.3.3 Portland-slag (CEM II/A-5 and II/B-5) and blastfurnace cements (CEM Ill/A and CEMIll/B)

The proportion of blastfurnace slag, as a target mean, reported to the nearest 1 % by mass.

A.3.4 Portland-fly ash cements (CEMII/A-V and IIIB-V)

a) the proportion of siliceous fly ash, as a target mean, reported to the nearest 1 % by mass;
b) the loss on ignition of the siliceous fly ash;

NOTE - See 5.2.4.1 for the loss on ignition requirement.

A.3.5 Portland-limestone cements (CEM II/A-L and CEMII/A-LL)

The proportion of limestone, as a target mean, reported to the nearest 1 % by mass.

NOTE: The notation, CEM IIIA-LL, indicates that the total organic carbon (TOG) content of the limestone constituent does *not exceed 0,20* % *by* mass, *where* as *the notation, GEM IIIA-L, indicates that the TOG of limestone* does *not exceed 0.50 % by* mass (see 5.2.6).

A.4 ADDITIONALINFORMATIQN

A.4.1 General

The information in A.4.2 and in A.4.3, appropriate to the type of cement, should be made available, if requested at the time

A.4.2 All CEM cements

a) the type and quantity of any minor additional constituent;
b) the fineness;
c) the silicon dioxide, aluminium oxide, iron(lll) oxide, calcium oxide and magnesium oxide content of the clinker;
d) the sulphate content expressed as S03 (see 7.3);
e) an indication of the variability of the chloride content when its mean level exceeds 0,05 % by mass.

A.4.3 Alkali information for individual CEM cements

The alkali information, relevant to cement type, which should be made available is given in table A.1.

NOTE 1: *No proVIsIon is made in this Malawi Standard for standardizing low alkali GEM cements to* a *guaranteed alkali limit.* A *vailability and supply of such GEM cements should be agreed between purchaser and manufacturer.*

NOTE 2: A *limit of 0,60* % *by mass expressed* as *the sodium oxide equivalent, which the manufacturer guarantees will not be exceeded by any test result on any spot sample, has been defined (see as* 5328-1) as *the guaranteed alkali limit for cement. Low alkali sulfate-resisting Portland cement, conforming to as 4027, is* a *cement standardized to* a *guaranteed alkali limit.*

The terms used in table A.1 can be described as follows:

a) A 'CEM I type' component, of a cement which contains blastfurnace slag or siliceous fly ash as a second main constituent, is the cement excluding the proportion of the second main constituent.

b) A declared mean alkali content, is an alkali content expressed as the sodium oxide equivalent, which will not be exceeded without

Bibliography

[1] EN 206-1, Concrete — Part 1: Specification, performance, production and conformity

[2] EN 413-1, Masonry cement — Part 1: Composition, specifications and conformity criteria

[3] EN 450-1, Fly ash for concrete — Part 1: Definition, specifications and conformity criteria

[4] EN 934 (all parts), Admixtures for concrete, mortar and grout

[5] EN 14216, Cement — Composition, specifications and conformity criteria for very low heat special cements

[6] EN 14647, Calcium aluminate cement — Composition, specifications and conformity criteria

[7] EN 15743, Supersulphated cement — Composition, specifications and conformity criteria

[8] ISO 10694, Soil quality —Determination of organic and total carbon after dry combustion (elementary analysis)

[9] Regulation (EC) No. 1907/2006 of the European Parliament and of the Council of 18 December 2006 concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) establishing a European Chemicals Agency amending Directive 1999/45/EC and repealing Council Regulation (EEC) No. 793/93 and Commission Regulation (EC) No. 1488/94 as well as Council Directive 76/769/EEC and Commission Directives 91/155/EEC, 93/67/EEC, 93/105/EC and 2000/21/EC

ICS 91.100.10 **DMS 29-1:2018**
Second edition

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