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Fly ash used for cement and concrete

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Foreword

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(a) a member of International Organisation for Standardisation (ISO) and

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(c) the National Enquiry Point on TBT Agreement of the World Trade Organisation (WTO).

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Draft Uganda Standards adopted by the Technical Committee are widely circulated to stakeholders and the general public for comments. The committee reviews the comments before recommending the draft standards for approval and declaration as Uganda Standards by the National Standards Council.

The committee responsible for this document is Technical Committee UNBS/TC ###, *[name of committee]*, Subcommittee SC ##, *[name of subcommittee]*.

This second/third/… edition cancels and replaces the first/second/… edition (US nnn-n:yyyy), which has been technically revised.

US nnn consists of the following parts, under the general title *Introductory element — Main element*:

- *— Part n: Part title*
- *— Part [n+1]: Part title*
- *— Part [n+2]: Part title*

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Fly ash used for cement and concrete

1 Scope

The Standard specifies the terms and definition, classification, grade, technical requirements, test method, inspection rules, packaging, marking, transportation and storage of the fly ash used for cement and concrete.

The Standard is applicable to the fly ash used as admixture at time of mixing mortar and concrete, and fly ash used as active addition at time of cement production.

2 Normative references

The following referenced documents referred to in the text in such a way that some or all of their content constitutes requirements 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.

US 310-1: 2016, Portland cement - Ordinary Portland cement

US 100-2: 2016, Test methods - Part 2 - Chemical analysis

ASTM D6023 – 16, Standard Test Method for Density (Unit Weight), Yield, Cement Content, and Air Content (Gravimetric) of Controlled Low-Strength Material (CLSM)

US 100-6: 2016, Cement -Test -Methods - Determination of fineness

EAS 148-3: 2017, test methods - determination of setting times (2)

ASTM C1437 – 15, Standard Test Method for Flow of Hydraulic Cement Mortar

ASTM C471M - 17ae1, Standard Test Methods for Chemical Analysis of Gypsum and Gypsum Products (Metric)

DUS 2109: 2018, Radionuclide limitations

EAS 18-2: 2017, Part 2 Conformity evaluation

EAS 148-1: 2017, cement - test methods - part 1 determination of strength

DUS 2108: 2018, Sand for construction

ASTM C311 / C311M – 17, Standard Test Methods for Sampling and Testing Fly Ash or Natural Pozzolans for Use in Portland-Cement Concrete

3 Terms and definitions

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

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ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at http://www.iso.org/obp

3.1
fly ash
Powder collected in power plant pulverized coal furnace flue gas.

Note the fly ash does not include the followings:(1) When the coal is burnt with urban garbage or other wastes; (2) when the industrial or urban garbage is burnt in the incinerator; (3) the powder collected at time of combustion of the circulating fluidized bed boiler.

3.2
reference cement
The Portland cement or ordinary Portland cement conforming to provisions of EAS 100-1, or conforming to provisions of US 310-1 and satisfying the strength grade 42.5 required in relevant requirements in the Standard.

3.3
testing sample
The reference cement and fly ash to be inspected are mixed in the mass ratio 7:3.

3.4
reference mortar
The reference cement and normal sand with specified grading are mixed in the mass ratio 1:3.

3.5
testing mortar
The testing sample and normal sand with specified grading are mixed in the mass ratio1: 3.

3.6
strength activity index
The compressive strength ratio between the testing mortar and reference mortar in specified age is expressed in percentage.

4 Classification

4.1 According to the category of coal, the fly ash is divided into type F fly ash (fly ash collected from anthracite or bituminous coal burning) and type C fly ash (fly ash collected from lignite or sub-bituminous coal burning, with calcium oxide content generally more than or equal to 10%).

4.2 According to the purpose, the fly ash can be divided into the fly ash for mixing mortar and concrete and the fly ash as cement active addition.

5 Grade

The fly ash for mixing mortar and concrete is divided into three grades: grade I, II and III.

The fly ash as cement active addition is not graded.

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6. Technical requirements

6.1 Physical and chemical property requirements

The fly ash for mixing mortar and concrete shall conform to the requirements of table1, and the fly ash as cement shall conform to the requirements of table 2.

Table 1 The physical and chemical property requirements of the fly ash for mixing mortar and concrete

Item		**Physical and Chemical Performance Requirement**		
		Grade I	**Level II**	**Level III**
Fineness (45μm square hole sieve screen residue)/%	Type F fly ash	≤12.0	≤30.0	≤45.0
	Type C fly ash			
Water Demand Ratio (%)	Type F fly ash	≤95	≤105	≤115
	Type C fly ash			
Ignition loss (Loss)/%	Type F fly ash	≤5.0	≤8.0	≤10.0
	Type C fly ash			
Water content/%	Type F fly ash	≤1.0		
	Type C fly ash			
Sulfur trioxide (SO_3) mass fraction/%	Type F fly ash	≤3.0		
	Type C fly ash			
Item		Physical and Chemical Performance Requirement		
		Grade I	Level II	Level III
Free calcium oxide (f-CaO) mass fraction/%	Type F fly ash	≤1.0		
	Type C fly ash	≤4.0		
Total mass fraction of silicon dioxide (SiO_2), aluminum oxide ($A1_2O_3$) and iron sesquioxide (Fe_2O_3)/%	Type F fly ash	≥70.0		
	Type C fly ash	≥50.0		
Density (g/cm^3)	Type F fly ash	≤2.6		
	Type C fly ash			
Stability (Le chatelier soundness test)/(mm)	Type C fly ash	≤5.0		
Strength activity index	Type F fly ash	≥70.0		
	Type C fly ash			

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Table 2 The Physical and chemical property requirements of the fly ash as cement active addition

Item		Physical and Chemical Performance Requirement
Ignition loss (Loss)/%	Type F fly ash	≤8.0
	Type C fly ash	
Water content/%	Type F fly ash	≤1.0
	Type C fly ash	
Sulfur trioxide (SO_3) mass fraction/%	Type F fly ash	≤3.5
	Type C fly ash	
Free calcium oxide (f-CaO) mass fraction/%	Type F fly ash	≤1.0
	Type C fly ash	≤4.0
Total mass fraction of silicon dioxide (SiO_2), aluminum oxide (Al_2O_3) and iron sesquioxide (Fe_2O_3)/%	Type F fly ash	≥70.0
	Type C fly ash	≥50.0
Density/(g/cm^3)	Type F fly ash	≤2.6
	Type C fly ash	
Stability (Le chatelier soundness test)/mm	Type C fly ash	≤5.0
Strength activity index	Type F fly ash	≥70.0
	Type C fly ash	

6.2 Radioactivity

Conform to the requirements of specified index of the main materials for building of the building in DUS 2109.

6.3 Alkali content

Expressed in $Na_2O+0.658K_2O$ calculation value. When there is alkali content requirement in the fly ash application, it shall be determined through negotiation between the supply and requisitioning parties.

6.4 Calcium Sulfate Hemihydrate content

For the fly ash discharged by the dry method or semi-dry desulphurization process, the calcium sulfate hemihydrate content is required to be tested ($CaSO_3•1/2H_2O$), which shall be not more than 3.0%.

6.5 Uniformity

Characterized by fineness, the fineness of single sample shall be not more than the maximum deviation of the average fineness value of previous 10 samples (average value of all aforementioned samples, if the sample size is less than 10), the maximum deviation scope shall be determined through negotiation between the buyer and seller.

7 Test methods

7.1 Fineness

Carry out as per the 45μm negative pressure screen analysis method in US 100-6, with the screen analysis time of 3 min.

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The screen shall be calibrated by the standard sample specified in ASTM C311/C311M - 17 or other standard sample of same grade, carry out screen calibration after screening for 100 samples, and the result treatment is same as that specified in US 100-6.

7.2 Water content ratio

Carry out as per Appendix A.

7.3 Ignition Loss, Sulfur Trioxide, Free Calcium Oxide, Silicon Dioxide, Aluminum Oxide, Ferric Oxide, Alkali Content

Carry out as per US 100-2, among them, aluminum oxide shall be measured by copper sulfate back titration method or x-ray fluorescence analysis method, in case of any dispute, the copper sulfate back titration method shall prevail.

7.4 Water content

Carry out as per Appendix B.

7.5 Calcium Sulfate Hemihydrate

It is determined according to relevant standards

7.6 Density

It is determined according to ASTM D6023 - 16.

7.7 Stability

The testing sample shall be prepared as per 3.3, and stability test shall be carried out as per US 100-3.

7.8 Strength activity index

Subject to Appendix C.

7.9 Radioactivity

Mix the fly ash with the Portland cement required in US 310-1 as per the mass ratio 1:1 well, and test as per DUS 2109.

8 Inspection rules

8.1 Numbering and sampling

The fly ash shall be numbered and sampled on basis of same category and grade before delivery. The bulk fly ash and bagged fly ash shall be numbered and sampled respectively. One number refers to the quantity less than 500 tonnes, and each number represents one sampling unit. When the capacity of the bulk fly ash is more than the number of tons of delivery number specified by the factory, it is allowed that the quantity of the number exceeds the number of tons specified for sampling. The fly ash mass shall be calculated as per the dry ash (water content less than 1%) mass.

Sampling method shall be as per US 310-2. Sampling shall be representative, sampling can be made continuously, or samples of equivalent amount can be taken from more than 10 different positions, with total amount less than 3kg.

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Note for the fly ash for mixing concrete and mortar, when necessary, the buyer can carry out random sampling and inspection.

8.2 Delivery inspection

8.2.1 For the fly ash for mixing concrete and mortar, the delivery inspection items are all items other than the ignition loss and strength activity index in table 1 in 6.1; for the fly ash discharged by dry method or semi-dry desulphurization process, the calcium sulfate hemihydrate content item in 6.4 is added ($CaSO_3 \cdot 1/2H_2O$).

8.2.2 For the fly ash as the cement active addition, the delivery inspection items are all items other than the strength activity index in table 2 in 6.1; for the fly ash discharged by dry method or semi-dry desulphurization process, the calcium sulfate hemihydrate content item in 6.4 is added ($CaSO_3 \cdot 1/2H_2O$).

8.3 Type inspection

8.3.1 The type inspection items of the fly ash for mixing concrete and mortar shall be as specified in table 1 in 6.1, 6.2 and 6.4.

8.3.2 The type inspection items of the fly ash as the cement active addition shall be as specified in table 2 in 6.1, 6.2 and 6.4.

8.3.3 In case of any of the following conditions, carry out type inspection:

a) When the raw materials and process have significant changes, which may affect product performance;

b) During normal production, inspect half a year (except the radioactivity);

c) When production resumes after long shutdown;

d) When the delivery inspection result is greatly different from last type inspection;

e) When the type inspection is required by national quality supervision and inspection agency.

8.4 Acceptance rules

8.4.1 Delivery inspection

8.4.1.1 When the delivery inspection items of the fly ash for mixing concrete and mortar conform to the technical requirements in table 1 in 6.1 and 6.4, it shall be judged as qualified in the inspection. If any one item does not conform to the requirements, it is allowed to carry out sampling again in the same number to carry out re-inspection of all items, to judge by the re-inspection result.

8.4.1.2 When the delivery inspection items of the fly ash as cement active addition conform to the technical requirements in table 2 in 6.1 and 6.4, it shall be judged as qualified in the inspection. If any one item does not conform to the requirements, it is allowed to carry out sampling again in the same number to carry out re-inspection of all items, to judge by the re-inspection result.

8.4.2 Type inspection

8.4.2.1 When the type inspection items of the fly ash for mixing concrete and mortar conform to the technical requirements in table 1 in 6.1, 6.2 and 6.4, it shall be judged as qualified in the type inspection. If any one item does not conform to the requirements, it is allowed to carry out sampling from the reserved sample in the lot to carry out re-inspection of all items, to judge by the re-inspection result.

8.4.2.2 When the type inspection items of the fly ash as cement active addition conform to the technical requirements in table 2 in 6.1, 6.2 and 6.4, it shall be judged as qualified in the type inspection. If any one item

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does not conform to the requirements, it is allowed to carry out sampling from the reserved sample in the lot to carry out re-inspection of all items, to judge by the re-inspection result.

8.5 Inspection report

The inspection report shall include delivery number, delivery inspection item, classification and grade. When the user requires, the producer shall send the results of various inspections other than the strength activity index within 7days since the fly ash delivery, and report the strength activity index inspection result within 32days.

8.6 Arbitration

In case of dispute for the fly ash quality, relevant organization shall sign and seal the recognized sample and send to the quality supervision and inspection agency at or above provincial level recognized by the state for arbitration inspection.

9 Packing, marking, transport and storage

9.1 Package

The fly ash can be put in bulk or bag, and net content of each bag is 25 kg or 40 kg, and net content of each bag shall be not less than 99% of mark mass. Other package specifications shall be determined through negotiation between the buyer and seller.

9.2 Signs

Card shall be provided for bulk fly ash, including product name, classification, grade, net content, lot number, number of standard implemented, manufacturer name and address and date of production.

The bagged fly ash bags shall indicate the content same as those on the bulk fly ash card.

9.3 Transport and storage

During transportation and storage, the fly ash shall not be wetted and mixed with impurities, and environmental pollution shall be prevented.

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Annex A
(normative)

Fly ash water content ratio test method

A.1 Scope

The Appendix is applicable to the fly ash water content ratio measurement.

A.2 Principle

Measure the mortar fluidity of the testing mortar and reference mortar as per ASTM C1437 - 15, the water addition ratio when both meet the specified fluidity scope is the fly ash water content ratio.

A.3 Material

A.3.1 Reference cement: The Portland cement or ordinary Portland cement conforming to provisions of US 310-1, or conforming to the strength grade 42.5 specified in US 310-1, and the fluidity of the reference mortar prepared as per table A.1 is (L_0) within 145mm-155 mm.

A.3.2 Testing sample: the reference cement and fly ash to be inspected are mixed as per the mass ratio 7: 3.

A.3.3 Normal sand: the medium sand conforming to 0.5 mm-1.0 mm specified in US 100-2.

A.3.4 Water: clean fresh water.

A.4 Instrument and equipment

A.4.1 Balance

The range shall be not less than1000 g, and the division value shall be not more than 1 g.

A.4.2 Mixer

The mixer for mixing mortars as specified in US 100-2.

A.4.3 Fluidity jumping table

As specified in ASTM C1437 - 15.

A.5 Test procedures

A.5.1 mortar proportion shall be as per A.1.

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Table A.1 Fly ash water content ratio testing mortar proportion

Mortar category	Reference cement	Testing sample		Normal sand
		Reference cement	Fly ash	
Reference mortar	250	—	—	750
Testing mortar (gram)	-	175	75	750

A.5.2 The reference mortar and testing mortar are mixed as per provisions of US 100-2.

A.5.3 The fluidity of the reference mortar and testing mortar after mixed shall be tested as per ASTM C1437 - 15. When the testing mortar fluidity reaches ±2 mm of the reference mortar fluidity (L_0), record the water addition (m) at this time; when the testing mortar fluidity exceeds ±2 mm of the reference mortar fluidity (L_0), adjust the water addition again, until the testing mortar fluidity reaches ±2 mm of the reference mortar fluidity (L_0).

A.6 Result calculation

A.6.1 The water content ratio shall be calculated as per formula (A.1), and the result is reserved to 1%.

$$X = \frac{m}{125} x100 \qquad \text{.....} (A.1)$$

Where;

X Water content ratio, %

m The water addition when the testing mortar fluidity reaches ±2 mm of the reference mortar fluidity (L_0), the unit is gram (g);

125 reference mortar water addition, in gram (g).

A.6.2 When the test result is in conflict or requires arbitration, the reference cement shall preferably be the cement standard sample for strength inspection in US 310-2.

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Annex B
(Normative)

Fly ash water content test method

B.1 Scope

This Appendix is applicable to determination of fly ash water content.

B.2 Principle

Put the fly ash into the drying box with specified temperature for drying to constant weight, to determine the fly ash water content by the mass difference before and after drying and mass ratio before drying.

B.3 Instrument and equipment

B.3.1 Drying box

The controllable temperature is 105°C-110°C, and minimum division value shall be not more than 2°C.

B.3.2 Balance

The range shall be not less than 50g, and minimum division value shall be not more than 0.01 g.

B.4 Test steps

B.4.1 Weigh the fly ash sample for about 50g, to the accuracy of 0.01 g, and put into the evaporating dish dried to constant weight for weighing (m_1), to the accuracy of 0.01 g.

B.4.2 Put the fly ash sample into 105°C-110°C drying box for drying to constant weight, and take it out and place it in the dryer and cool to room temperature, and then weigh (m_0), to the accuracy of 0.01 g.

B.5 Result calculation

Water content is calculated as per formula (B.1), and the result is reserved to 0.1%.

$$w = \frac{m_1 - m_0}{m_1} x100 \qquad \text{.....} (B.1)$$

Where;

W water content, %;

m_1 mass of the sample before drying, in gram (g);

m_0 mass of the sample after drying, in gram (g).

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Annex C
(Normative)

Fly ash strength activity index test method

C.1 Scope

This Appendix is applicable to determination of the fly ash strength activity index.

C.2 Principles

Measure the 28d compressive strength of the testing mortar and reference mortar as per US 100-2, and determine the strength activity index of the fly ash by the ratio of the two.

C.3 Material

C.3.1 Reference cement: the Portland cement or ordinary Portland cement conforming to provisions of US 310-1, or conforming to the strength grade 42.5 specified in US 310-1.

C.3.2 Testing sample: reference cement and fly ash to be inspected are mixed as per the mass ratio 7: 3.

C.3.3 Normal sand: as specified in DUS 2108.

C.3.4 Water: clean fresh water.

C.4 Instrument and equipment

Balance, mixer, jolting table or vibrating table, compressive strength tester and other shall be as specified in US 100-2.

C.5 Test procedures

C.5.1 Mortar proportion shall be as specified in C.1.

Table C.1 Strength activity index testing mortar proportion

Mortar category	Reference cement	Testing sample		Normal sand	Water
		Reference cement	Fly Ash		
Reference mortar (gram)	450	—	—	1 350	225
Testing mortar (gram)	—	315	135	1 350	225

C.5.2 Carry out mixing, test piece formation and curing of the reference mortar and testing mortar as per US 100-1 respectively.

C.5.3 Cure the specimen for 28 days, and measure the compressive strength of the reference mortar and testing mortar as per US 100-1 respectively.

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C.6 Result calculation

C.6.1 The strength activity index shall be calculated as per formula (C.1), and the result is reserved to 1%.

$$H_{28} = \frac{R}{R_0} x100 \qquad \text{.....(C.1)}$$

Where;

H_{28} strength activity index, %

R Testing mortar's 28days compressive strength, in Mega Pascal (MPa);

R_0 Reference mortar's 28days compressive strength, in Mega Pascal (MPa).

C.6.2 When the test result is in conflict or requires arbitration, the reference cement shall preferably be the cement standard sample for strength inspection in US 310-2

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Bibliography

[1] GB/T 1596: 2017, Fly ash used for cement and concrete

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