

Technical Datasheet

Fly Ash in Highways Construction Specification for ESC

Introduction

Enhanced stabilised capping (ESC) is an enhancement of normal stabilized capping and is constructed by mixing powder additives to site arisings, generally using the mix-in-place method of stabilization. Full details are given in Technical Data sheet 6.9. The following is recommended specification for ESC:

1. General

- 1.1. This specification describes the requirements for the constituents, composition and performance of enhanced stabilized capping (hereafter designated ESC) made from soil treated with PFA in combination with lime or cement. During construction and prior to overlaying with at least 300mm of pavement, the temperature of the ESC shall not fall below 5°C. The specification shall be used in conjunction with Table ESC which forms part of this specification and a method statement, meeting the requirements of section 6 of this specification, produced by the contractor and agreed by all relevant parties.

2. Standards: The following standards are referred to:

- 2.1. BS 890 Specification for building limes
- 2.2. BS EN197-1 Cement. Composition, specifications and conformity criteria for common cements
- 2.3. BS EN450 Fly ash for concrete. Definitions, requirements and quality control
- 2.4. BS1924 - 1 Stabilized materials for civil engineering purposes. General requirements, sampling, sample preparation and tests on materials before stabilization
- 2.5. BS 1924-2 Stabilized materials for civil engineering purposes. Methods of test for cement-stabilized and lime-stabilized materials

3. Definitions, symbols and abbreviations: The following terms are used:

- 3.1. ESC - soil stabilized with PFA in combination with either lime or cement meeting the requirements of this specification.
- 3.2. PFA – pulverized fuel ash also known as (coal) fly ash
- 3.3. OMC – optimum moisture content
- 3.4. MCV – moisture condition value

4. Constituents: The following constituent materials definitions apply:

- 4.1. **Soil:** Soil for ESC shall be site-won material or other suitable natural, recycled or industrial material, cohesive or otherwise. The maximum size of particle shall be less than 100mm and also not more than 1/3 the thickness of the compacted layer/lift. Organic matter if present shall not adversely affect the performance of the mixture.

NOTE. Organic matter may delay the setting and hardening of the mixture.

- 4.1.1. Soil, particularly containing or suspected of containing sulfates or other potentially disruptive material, shall be deemed suitable for treatment provided the requirements of clauses 5.1 and 8.10 are satisfied.
- 4.2. **Lime:** Lime shall be quick lime to BS890 and the following specification:
 - 4.2.1. CaO + MgO content > 80%
 - 4.2.2. MgO content < 10%
 - 4.2.3. 'Reactivity with water' shall achieve a temperature of at least 60 degrees C within 5 minutes
 - 4.2.4. Particle size: $D_{max} = 3\text{mm}$, 80% < 0.2mm, 50% < 0.08mm
- 4.3. **Cement:** Cement shall be Portland cement CEM I complying with BS EN197-1.
- 4.4. **PFA:** PFA shall comply with EN450 or shall be dry or wet (conditioned) run-of-station ash in accordance with UKQAA Technical Data Sheet 6. Before use, conditioned PFA shall be stored for at least 3 days at a minimum moisture content of 10% and screened to remove lumps greater than 10mm.
- 4.5. **Water:** Water shall not contain components that affect the performance of the stabilized soil.

5. Composition

- 5.1. ESC shall be made from soil, PFA and either lime or cement complying with 4 and shall satisfy the requirements of this section and the performance requirements of section 8.
- 5.2. Unless otherwise agreed by the engineer, the following minimum proportions by dry weight of constituents shall be as follows;
 - 5.2.1. Lime or cement 3%
 - 5.2.2. Dry PFA 6%
 - 5.2.3. Conditioned PFA 9%
- 5.3. Where lime is used to ameliorate (break down) cohesive soils prior to the addition of PFA, it shall be added and mixed with the soil not less than 24 hours (48 hours in the case of sulfate bearing cohesive soils) nor more than 72 hours before the PFA addition. The moisture content at this stage shall be not less than the OMC (or more than the equivalent MCV) for the lime modified mixture determined in accordance with the 2.5kg Proctor method of BS1924.
- 5.4. At final compaction, the moisture content for granular mixtures shall be not less than 0.9 OMC determined in accordance with the vibrating hammer method of BS1924, and for cohesive mixtures not less than the OMC (or more than the equivalent MCV) determined in accordance with the 2.5 kg Proctor method of BS1924.
- 5.5. The maximum moisture content at all stages shall be not more than the moisture content compatible with the ability of the material to support operations and to provide a rut and crack free layer of the requisite depth and finished level.

6. Method statement

- 6.1. Prior to undertaking the demonstration area described in 7, the contractor shall provide a full method statement indicating his operation, plant and estimated time durations and intervals between the main stages of the treatment; site preparation, lime amelioration stage (if applicable), treatment stage, curing and protection.
- 6.2. In particular, the statement should detail his procedures, controls and frequency of production control checks with respect to the following where relevant to the method of construction employed, either using central-plant mixing or the mix-in-place method; site preparation, powder spreading, pulverization (if applicable), water addition, batching and mixing records, MCV, depth of mixing, compaction, insitu density measurement, level control, finishing rolling, curing and protection.
- 6.3. The method statement shall include the intended mixture proportions, the supportive data to justify the proportions, the moisture content (or MCV) limits and spread rates for all stages of the work.
- 6.4. The method statement shall include a sample record sheet for completion for the lime amelioration stage (if applicable) and treatment stage detailing, construction times, sample and check locations, and check results.

It is imperative that these sheets should be completed as the main work progresses and handed to the main contractor on completion of each stage. Failure to do so will result in suspension of the work until the relevant sheet is made available. Any costs due to the resulting time delays and the need to re-stabilize will be borne by the stabilization contractor.

7. Demonstration area

- 7.1. Prior to the commencement of the main works, the contractor shall undertake a satisfactory demonstration area of at least 800m² conforming to his method statement. The demonstration area shall consist of at least 2 full-width bays so as to include a transverse end-of-bay joint
- 7.2. The demonstration area may be accepted into the permanent works with the agreement of the engineer.

8. Mixture performance and construction requirements

- 8.1. The frequency of tests, controls and checks shall be in accordance with 8.11.
 - 8.1.1. **Pulverization:** This paragraph shall apply to cohesive mixtures only. The degree of pulverization after lime addition of the full depth of treatment shall be in excess of 30% determined in accordance with BS1924. At the time of final compaction of the mixture after the final constituent addition, the pulverisation of the full depth of layer shall be in excess of 60% or other such value agreed by the engineer.

- 8.1.2. **Depth of mixing:** Applying to the mix-in-place method of construction only, the depth of mixing at all relevant stages of the process shall be checked using suitable reference stations to ensure that after final trim and compaction, the final thickness of the layer is to specification.
- 8.1.3. **Compaction:** Final compaction shall be completed within 2 hours of the mixing-in of cement for PFA/cement treatment and within 6 hours of the addition of lime or PFA, whichever is mixed-in last, for PFA/lime treatment.
- 8.1.4. **Surface finish:** On completion of compaction, the surface of the layer shall be well closed, free from movement under compaction plant, and free from ridges, cracks, loose material, segregated areas, pot holes, ruts and other defects.
- 8.1.5. **Density:** The full depth of the layer shall be compacted to an average wet density of not less than 95% of the average wet density of the strength specimens made in accordance with clause 8.7. The insitu wet density shall be measured using a calibrated nuclear density gauge in accordance with BS1924:1990 and shall be the average of groups of 4 tests. Each test shall consist of at least 2 measurements at 180 degrees to each other using the same source rod hole.
- 8.1.6. **Sealing:** Immediately on completion of compaction, the surface of the layer shall be sealed with either bitumen emulsion applied at the rate of 0.5 litre/m² or other necessary quantity or other approved product or a single surface dressing (see 8.8) to achieve a continuous and consistent seal across the whole area of the works.
- 8.1.7. **Compressive Strength:** Using samples of mixture representing the full depth of the layer after final mixing, the average compressive strength of groups of 4 cubical or 1:1 cylindrical specimens made to refusal in accordance with either BS1924 or using MCV apparatus or in rigid plastic (HDPE) moulds shall be not less than X MPa – see note below for appropriate values of X. The age of testing shall be not less than 14 days for ESC containing cement and not less than 28 days for ESC made from lime and PFA.
- NOTE: The selected value of compressive strength shall be the value, with an appropriate factor of safety (say 2 for central-plant mixing and 2.5 for mix-in-place mixing), equivalent to a NAT stiffness of 500 MPa. This equivalency shall be determined during laboratory mixture design.
- 8.1.8. **Traffickability:** Construction plant and other traffic shall not run on the layer other than to enable construction of the overlying layer. Where the contractor proposes to use the layer as a haul road, this shall be restricted until the laboratory compressive strength, at normal 20 degrees C curing, is greater than 1 MPa, and the layer is surface dressed.
- 8.1.9. **Frost resistance:** The compressive strength of ESC shall be not less than 2.5 MPa at the time of the first frost if the layer is to be left uncovered over the winter.
- 8.1.10. **Volume stability:** Volume stability testing of the mixture shall be carried out in accordance with the immersion test in BS1924 and satisfy the requirements of Table 1 at not less than 14 days (7 days sealed curing followed by 7 days immersion in aerated water at 20 degrees C) for ESC including cement or not less than 28 days (21 days sealed followed by 7 days immersion) for ESC made using lime and PFA.

ESC type	Ratio of soaked to unsoaked strength (%)	% volumetric swelling
Cohesive	> 65 (subject to mixture design)	< 2
Granular	> 65 (subject to mixture design)	< 1

Table 1 – Volume stability requirements

Note that the BS1924 test can be carried out on cylinders as well as cubes

- 8.1.11. **Testing frequency:** Compliance with the above requirements shall be determined in accordance with Table 2 at locations agreed with the Engineer.

Test/control	Reference clause	Test frequency not less than 4 per day
On the constituents:		
Soil: m/c, plasticity, organics and total sulfate	4.1	1 per 1,000m ²
Added constituents: Supplier certificate	4.2, 4.3, 4.4, 4.5	Weekly
Added constituents: Spread rates (mix-in-place only) or batching records (central plant only)	5.2 & 5.3	5 per 1000m ²
On the ESC:		
Moisture content/MCV at all relevant stages	5.4 & 5.5	3 per 1000m ²
Pulverization after lime addition (cohesive mixtures only)	8.1	2 per 1000m ²
Pulverization at final compaction (cohesive mixtures only)	8.1.1	2 per 1000m ²
Depth of mixing at all relevant stages (mix-in-place only)	8.1.2	Initially not less than 4 per 1000m ² , but can be relaxed to 2 per 1000m ² .
In-situ density	8.1.5	Initially not less than 4 per 1000m ² , but can be relaxed to 2 per 1000m ² .
Compressive strength	8.1.7	Initially not less than 4 per 1000m ² , but can be relaxed to 2 per 1000m ² .
Final level	8.1.2	± 20mm measured on a grid basis: 10m long, 2m transverse
Volume stability	8.1.10	1 per 1,000 m ²

Table 2 – Testing frequencies

In general usage the term 'fly ash' is used for pulverized coal ash but it can also cover ash from burning other materials. Such 'fly ash' may have significantly differing properties and might not offer the same advantages as ash from burning pulverized coal. UKQAA datasheets only refer to fly ash / fly ash produced from the burning of predominantly coal in power stations.

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