UNITED KINGDOM QUALITY ASH ASSOCIATION

Technical Datasheet

Fly Ash in Highway Construction Specification for SFA

Foreword

Soil treated with fly ash (SFA) is an alternative to soil cement. It is constructed by mixing fly ash with either lime or cement to site arisings, generally using the mix-in-place method of stabilization. The use of fly ash reduces cement content, construction risk & costs. Design details are given in Technical Data Sheet 6.1.3.

The mixture SFA – constituents & mixture requirements - is standardized in BS EN 14227-14.

The construction of SFA is specified in the 800 series of the Specification for Highway Works (SHW) along with other hydraulically-bound mixtures (HBM) for use in base and sub-base.

This data sheet strips-out the other FABM and HBM from the series 800 to produce a 'stand-alone' specification for SFA that meets the design requirements for sub-base in data sheet 6.1.3 and the Highways Agency foundation design document, IAN73. The specification should also be suitable for SFA base application.

The specification is considered equivalent to the series 800 but requires no reference to it or to BS EN 14227-14.

1. **General**

   1.1. This specification describes the requirements for the constituents, composition and performance of soil treated with fly ash (hereafter designated SFA). During construction and prior to overlaying with at least 300mm of pavement, the temperature of SFA shall not fall below 5^0C. The specification shall be used in conjunction with Table 2, which is 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 parties.

2. **Standards:** The following standards are referred to:

   2.1. BS EN 459. Specification for building limes

   2.2. BS EN197-1. Cement. Composition, specifications and conformity criteria for common cements

   2.3. BS EN 14227-4. Fly ash for hydraulically bound mixtures.

   2.4. BS EN 14227-14. Soil treated with fly ash

   2.5. BS EN 13286 - 2. Unbound and hydraulically bound mixtures – Part 2: Test methods for the determination of the laboratory reference density and water content – Proctor compaction

   2.6. BS EN 13286 - 4. Unbound and hydraulically bound mixtures – Part 4: Test methods for laboratory reference density and water content – Vibrating hammer

   2.7. BS EN 13286 - 48. Unbound and hydraulically bound mixtures – Part 48: Test method for the determination of the degree of pulverisation

   2.8. BS EN 13286 - 51. Unbound and hydraulically bound mixtures – Part 51: Test method for the manufacture of test specimens of hydraulically bound mixtures using vibrating hammer compaction

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

   3.1. SFA - soil treated with fly ash in combination with either lime or cement meeting the requirements of this specification.

   3.2. Fly ash – fly ash resulting from the combustion of pulverized coal in energy-generating plants (also known as pulverized fuel ash [PFA] in the UK)

   3.3. OMC – optimum moisture content

   3.4. MCV – moisture condition value

4. **Constituents:** The following definitions apply:

   4.1. **Soil:** Soil 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.

Soil, particularly soil 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 BS EN 459 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} = 3mm, 80% < 0.2mm, 50% < 0.08mm

4.3. **Cement:** Cement shall be Portland cement CEM I complying with BS EN197-1.

4.4. **Fly ash:** Fly ash shall be dry or conditioned (wet) siliceous ash complying with BS EN 14227-4. Before use, conditioned fly ash 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. SFA shall be made from soil, fly ash and either lime or cement, all complying with 4, and shall satisfy the requirements of this section and the performance requirements of section 8.

5.2. Subject to a minimum total of 8% by dry mass and unless otherwise agreed by the engineer, the following minimum proportions by dry mass of constituents shall be as follows;

5.2.1. Lime or cement 2%

5.2.2. Dry fly ash 5%

5.2.3. Conditioned fly ash 7%.

5.3. Where lime is used to ameliorate (break down) cohesive soils prior to the addition of fly ash, 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 addition of fly ash. The moisture content at this stage shall be not less than the OMC (or more than the equivalent MCV) for the mixture determined in accordance with the 2.5kg Proctor method of BS EN 13286-2.

5.4. At final compaction of the SFA layer, the moisture content for granular mixtures shall be not less than 0.9 OMC determined in accordance with the vibrating hammer method of BS EN 13286-4, 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 BS EN 13286-2.

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 of 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 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 constituent 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.

6.5 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 8.2.

8.1.1. **Pulverization:** This paragraph shall apply to cohesive mixtures only. At the amelioration stage, the degree of pulverization after lime addition of the full depth of treatment shall be in excess of 30% determined in accordance with BS EN 13286-48. 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%.

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 fly ash/cement treatment and for fly ash lime treatment, within 6 hours of the addition of lime or fly ash, whichever is mixed-in last, nor greater than 72 hours after the addition of the first.

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 and shall be the average of the results from tests carried out at at least 4 locations within a agreed area. Each test shall consist of at least 2 measurements at 180 degrees to each other using the same source rod hole and the result for each test shall be taken as the higher(est) of the measurements.

8.1.6. **Sealing:** Immediately on completion of final compaction, the surface of the layer shall be sealed with either bitumen emulsion applied at the rate of 0.5 litre/m^2 or other necessary quantity or other approved product or a single surface dressing (see 8.8) to achieve a continuous and uniform 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 BS EN 13286-51 or 1:1 cylindrical specimens made using MCV apparatus and MCV compaction, shall satisfy C XX/YY strength category (see note below). The age of testing shall be normally 28 days using 20C sealed curing for SFA using cement and 40C sealed curing for SFA using lime.

NOTE: As a minimum and depending on design requirements, the selected compressive strength category should be compatible with the requirements of 8.1.8 to 8.1.10 below and the 2000 to 3000 MPa element stiffness requirements of IAN73. As a rule, this will produce sub-base quality material or base for lightly-trafficked pavements.

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 compressive strength is > 1 MPa, and the layer is surface dressed.

8.1.9. **Frost resistance:** The compressive strength of SFA shall be not less than 2.5 MPa (or 0.25 MPa indirect tensile strength) at 28 days using 20C sealed curing for SFA using cement and 40C sealed curing for SFA using lime.

8.1.10. **Volume stability:** Volume stability testing of the mixture shall be carried out at mixture design stage on a group of 6 specimens and satisfy the requirements of Table 1 at not less than 28 days at 20 degrees C for SFA using cement and 40 degrees C for SFA using lime. (Curing for immersed specimens shall consist of 14 days sealed curing followed by 14 days full immersion in aerated water. Curing for sealed specimens shall consist of 28 days sealed curing.)

SFA type	Ratio of immersed to sealed strength (%)	% volumetric swelling
Coarse-grained	> 80	< 1
Fine-grained	> 70	< 2

Table 1 – Volume stability requirements

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

8.2. The frequency of tests, controls and checks shall be in accordance with Table 2 at locations agreed with the Engineer.

Test/control	Reference clause	Test frequency
On the constituents:		
Soil: m/c, plasticity, organics and total potential 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 & 6.3	3 per 1000m^2 but not less than 4 per day
On the SFA:		
Moisture content/MCV at all relevant stages	5.3 & 5.4	3 per 1000m^2 but not less than 4 per day
Pulverization after lime addition (cohesive mixtures only)	8.1.1	2 per 1000m^2 but not less than 4 per day
Pulverization at final compaction (cohesive mixtures only)	8.1.1	2 per 1000m^2 but not less than 4 per day
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. and then not less than 4 per day
In-situ density	8.1.5	Initially not less than 4 per 1000m^2, but can be relaxed to 2 per 1000m^2. and then not less than 4 per day
Compressive strength specimens	8.1.7	Initially not less than 2 per 1000m^2, but not leas than 4 per day.
Final level	-	To normal requirements depending on whether capping, sub-base or base
Immersed strength specimens (optional)	8.1.10	Not less than 2 per day & compared to results for sealed specimens

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 PFA / fly ash produced from the burning of predominantly coal in power stations.