UNITED KINGDOM
QUALITY ASH
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Technical Datasheet

Fly ash in Pavement Construction

SFA - soil treated with fly ash

Introduction

Fly ash can be used in variety of ways within highway construction. The following describes one of the ways it can be used for technical, environmental and cost benefit for road & other pavements, with the aims;

- To make more extensive use of fly ash, a by-product from coal-fired power generation plants.
- To reduce the consumption of primary materials for pavement construction.
- To widen the range of pavement construction materials.
- To produce more cost effective and environmentally sustainable pavements.

Introduction

Soil treated with fly ash (SFA) is an alternative to soil cement for use as base, sub-base or capping. It is constructed by mixing fly ash with lime or cement to site arisings, generally, but not exclusively, using mix-in-place construction.

Following the availability of TRL Report 248, which illustrated their structural benefits over Type 1 granular sub-base, treated soils are being used increasingly in pavements, and in many instances, realising significant financial benefits.

To date, mainly combinations of lime, cement and ground granulated blast furnace slag have been used for this work but fly ash is also used and realising economies because of its favourable price compared to other powders.

Standards, design and specification

The mixture SFA is standardized in BSEN 14227-14.

With regard to sub-base thickness using treated soils, design for Highways Agency pavements is detailed in IAN73, and is based on achieving an element stiffness of 1750 to 2500 MPa depending on the class of foundation required.

The specification for the use of SFA sub-base in HA pavements is found in the 800 series of the Specification for Highway Works.

A specification for treated soils for sub-base must take account of the issues of durability and volume stability, particularly in the treatment of fine-grained materials like clays and chalks. In addition the specification needs to recognise that the treatment will normally be carried out by mix-in-place methods that are by definition more variable processes than central-plant mix.

In order to achieve durability and volume stability, it is recommended that SFA achieve;

- For frost resistance, an indirect tensile strength of not less than 0.25 MPa and
- For volumetric stability, an immersed compressive strength not less than 0.8 (possibly 0.7 for fine-grained soils) the sealed compressive strength.

Also for direct trafficking;

- a compressive strength class of at least C0.8/1 is recommended.

Experience indicates that SFA meeting these recommendations will produce a element stiffness in the range 2000 to 3000 MPa and thus satisfy IAN73 (Highways Agency) design requirements for sub-base and the requirements for bases for light traffic.

In addition, in order to ensure robust achievement of these recommendations,

- a minimum total powder addition of 8% by dry mass is advised.

It should be noted that for coarse-grained soils, it may be easier and simpler to use compressive strength instead of tensile strength and specify C3/4 compressive strength together with the 0.8 immersed strength requirement. This will achieve light-traffic base and IAN73 sub-base design requirements, frost durability and a directly traffickable layer.

A full specification for SFA is described in UKQAA Technical Data Sheet 6.4.3.

The role of Fly Ash for soil treatment

Fly Ash is particularly appropriate for the treatment of slightly plastic or silty site arisings, which is currently considered the domain of cement. However, because of its rapid set, cement has construction limitations for soil treatment.

In addition, the use of say 8% cement (usually necessary for a fine-grained soil) would require the spreading and mixing of $40kg/m^2$ of cement. To achieve this in a one spread-and-mix operation is unwieldy, and, as a consequence, such quantities are traditionally handled in two spread-and-mix operations. Since the first requires compaction to be carried out in order that the second can be accurately undertaken, the cement from the first stage has often commenced setting before the second stage has been completed.

It is acknowledged that the effect of this apparent shortcoming with cement is unknown. However it cannot be considered sound technical and construction practice.

A technically more robust solution than cement alone is to employ a slower setting addition for the first stage followed by cement in the second stage. Fly Ash would be ideal for this first stage.

Alternatively, fly ash, as it is a pozzolan, could be used with lime.

Mixture proportioning

As intimated previously, exact binder additions would be subject to advance laboratory testing depending on exact mechanical performance requirements. However since 8% minimum total powder contents are recommended, fly ash proportioning should be considered against this yardstick.

Since it is also possible to use run-of-station fly ash for this work and that this is probably available delivered at less than 10% of the price of cement, lime or ground granulated blast furnace slag, it is possible to use quite high fly ash additions and still show significant overall cost savings.

Thus considering silty materials, fly ash could be added in advance of a reduced cement addition. For illustrative purposes, say 8% fly ash could be spread and mixed in a first stage (as 2 bites if necessary) followed by 4% cement in the second stage. As well as the cement reaction, the lime released by the cement during hydration would act hydraulically with the fly ash to provide further strengthening to give, subject to laboratory testing, a total enhancement equivalent to 8% cement alone.

In the case of slightly cohesive soils, where typically lime might be used in advance of cement or ggbs, fly ash could replace the cement. For illustrative purposes, 3% lime followed by 8% or more fly ash might be appropriate.

For coarse-grained soils and as a starter, 5% fly ash followed by 3% cement may be appropriate.

Fly Ash

Run-of-station fly ash, either dry or conditioned with water at the power station, can be used for SFA.

The specification for fly ash for SFA is found in BS EN 14227-4.

Construction

Construction of SFA using fly ash in combination with lime or cement, follows similar procedures to those employed for lime and or cement treated soils and is specified in the series 800 of the Highways Agency's Specification for Highway Works, except that fly ash would be added as a first stage when used with cement and as either a first or second stage with lime depending on the plasticity of the material to be treated.

Note that the fly ash could be either spread dry using purpose-made spreaders (as normal for lime and cement addition) or spread in a conditioned (wet) form by blade.

Example of design and benefit of using fly ash

Consider a road designed to carry in excess of 80msa on a sub grade CBR of 3%. Using conventional and SFA foundations, options might be as follows:

Conventional class 2 foundations		SFA class 2 foundation (or class 3 or 4 depending on SFA strength)
150mm Type 1 on 350mm capping or	300mm Type 1 granular sub-base without capping	300mm SFA using mix-in-plant method or 350mm SFA using mix-in-place method

Table 1: Illustrative design for SFA

Subject to site demonstration, 350mm of SFA should be constructible in one lift.

Benefits of using SFA will be a function of the price of Type 1 granular sub-base and capping material and the earthworks balance on the job bearing in mind the SFA will be constructed from site arisings, including material that without treatment might otherwise have been considered unsuitable for earthworks use.

In addition, there will be programme benefits since experience indicates that SFA operations will proceed quicker than Type 1 operations.

Experience also indicates that properly sealed, cured & dressed, SFA will be robust with respect to trafficking and other site operations such as drainage and edge details although programme and design modifications to some of these site operations may enhance even more the advantages of SFA.

References

TRL Report 248. Stabilized sub-bases in road foundations: structural assessment and benefits. Transport Research Laboratory, Crowthorne, Berkshire, 1997.

BS EN 14227-3. Hydraulically bound mixtures – Specifications – Part 3: Fly ash bound mixtures. BSI, London, UK.

BS EN 14227-4. Hydraulically bound mixtures – Specifications – Part 4: Fly ash for hydraulically bound mixtures. BSI, London, UK.

BS EN 14227-14. Hydraulically bound mixtures – Specifications – Part 14: Soil treated by fly ash. BSI, London, UK.

UKQAA data sheets;

6.0 Fly ash in pavement construction – Overview of FABM & SFA

- 6.1.1 Fly ash in pavement construction – FABM 1 (fly ash bound granular material)
- 6.1.2 Fly ash in pavement construction – FABM 5 (treated fly ash)
- 6.1.3 Fly ash in pavement construction – SFA (soil treated with fly ash)

6.2 Fly ash in pavement construction – Laboratory mixture design for FABM & SFA

6.3 Fly ash in pavement construction – Thickness design using FABM 1 & FABM 5

- 6.4.1 Fly ash in pavement construction – Specification for FABM 1
- 6.4.2 Fly ash in pavement construction – Specification for FABM 5
- 6.4.3 Fly ash in pavement construction – Specification for SFA

6.5 Fly ash in pavement construction – Fly ash & lime stabilised clays – preventing sulfate heave

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.