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IEA CLEAN COAL CENTRE

Profiles

Land uses of coal fly ash – benefits and barriers

'There is potential for high volume and cost effective deployment'

'with less rigorous requirements than in the cement and concrete industries'

'best engineering practices ensure there is no environmental risk'

This report focuses on three sectors of fly ash utilisation: soil stabilisation, mine backfill and agriculture. The benefits of using fly ash include improvements over use of cement or lime alone at lower cost, more effective land reclamation using less primary materials, and enhanced fertility of soils. Barriers occur in marketing, transport, and through the potential for leachates containing trace elements from fly ash. These are being overcome by various means in the utilisation sectors.

Stabilisation with fly ash bound material

Stabilisation of soils, aggregates or waste materials is achieved successfully with fly ash using a binder or stabiliser or with self-cementing, class C fly ashes. Binders include cement, lime or gypsum. Cement bound fly ash may use for example 5-7% cement binder for road base or greater proportions of cement when stabilising some types of aggregate. Lime is used as an activator to produce cementitious, pozzolanic fly ash/aggregate base mixes. The mixes can be comparable to those using cement but usually cost less. The economics are further improved by the fly ash mixes reducing the material required in other road layers. Wet and cold soil conditions can be tolerated and lime/fly ash mixes are beneficial for treating high clay soils. High silt soils also benefit from the fly ash contributing the silica and alumina which tends to be lacking in a low clay soil. Limits on fly ash quality are less strict than for concrete but the effect of high carbon-in-ash is unknown. Self-cementing fly ashes are more similar to Portland cement than to lime mixes but they set significantly faster. They may also be used to dry soils and to stabilise clay soils with faster and better results than with lime stabilisation. Self-cementing fly ash is generally more economic than use of cement or lime. However, the sulphate content should not exceed 10% and freeze/thaw durability of some soil-fly ash mixes do not meet requirements.

Barriers to use of fly ash in soil stabilisation include distance of the source from the place of use and lack of supply at the time of demand. Leaching of trace elements such as chromium is a concern and additives may be deployed to depress its release. Self-cementing fly ash with soil reduced leachable contaminants in the ash and in the soil. These fly ashes are effective for treating wastes but suffer from by-product status compared to cement as a manufactured product.

Unbound fill applications

Fly ash is used with no binder as a fill which is stronger than materials such as soil or aggregate. It may also be added to gravels, for example 5-10 wt% fly ash, or to weak soil (30 wt%) to improve their mechanical properties. Mine mortars used in German underground mines are generally 60-70 wt% fly ash in dry mixes. When compacted, fly ash settles <1% during the construction period and not afterwards, its low density makes it suitable for high embankments, it makes farm roads stiffer and less sensitive to frost heave. This application is cost effective since it saves primary aggregates as well as offering a high volume use for conditioned, stockpiled and lagoon fly ash.

Various sources of information, for example in the UK and the USA, indicate that fly ash does not represent any significant environmental risk, when used unbound as a fill material. However, the fills must be designed following best engineering practices to protect ground water. Some fly ashes do not comply with Japanese standards on trace elements and long term leaching tests are in progress to use blast furnace slag, aluminium sulphate or zeolite to control leaching of trace elements from mixes of fly ash and soil.

Use of fly ash in mine backfill must be a genuine use rather than disposal and many abandoned and polluting underground and surface mines could benefit from reclamation using alkaline fly ash. It helps to prevent acid mine drainage, acts as an agricultural supplement to enhance artificial soils, seals and stabilises abandoned mines to prevent subsidence, serves as a good base for dams, pits and within the spoil area. This minimises disturbance of land in the mining area and the reclaimed land can be put to various economic uses. Other advantages are that fly ash can dry a wet soil, increase mine output by stabilising pillar strength, and prevent spontaneous combustion through air entering the mine through vertical cracks.

Fly ash is not always highly alkaline and may not prevent release of trace elements in some sites or under acidic conditions occurring later on. The effects of ammonia in fly ash on release

Improved crop yields through applications of pond ash in India						
Crop yield, Q/ha	Maize		Paddy crop		Sunflower	
	Grain	Straw	Grain	Straw	Seeds	Total dry matter
Control, + farmyard manure, chemical fertiliser	47.4	73.9	36.7	52.6	16.2	39.9
Control, + chemical fertiliser	38.0	60.9	37.7	57.0	15.5	36.5
10% pond ash, + farmyard manure, chemical fertiliser	52.0	92.1	43.4	60.7	17.8	42.7
10% pond ash, + chemical fertiliser	52.0	75.0	38.6	58.3	17.2	41.6
20% pond ash, + farmyard manure, chemical fertiliser	59.8	96.0	44.0	66.7	19.9	46.9
20% pond ash, + chemical fertiliser	54.3	86.8	40.9	62.0	18.3	42.0

of trace elements and of mercury controls similarly need confirmation at specific sites. Issues occurring through transport of fly ash can be avoided by using pipelines or forming fly ash aggregates at the power station.

Agriculture

Fly ash has similar physical and chemical properties to those of soil. It can be used directly as a soil amendment, or in land reclamation, with organic matter, lime or gypsum, in composts, or made into granulated materials or potassium silicate fertilisers. Fly ash improves the physical properties of the soil, increasing moisture retention in poor soils and aeration. It provides the micronutrients for plant growth, but lacks potassium and only supplies a limited amount of nitrogen.

Fly ash has been applied successfully in specific agricultural projects in many countries, such as Australia, Germany, India, Japan, South Africa, the UK and the USA. Improved crop yields have been demonstrated (see for example in the Table). Less fertiliser, gypsum and irrigation are required. This reduces costs as long as the ash does not need to be transported for long distances. For example, a fly ash treatment of 100 t/ha on sandy soils in Australia reduced water consumption by around 75%. Improved water retention also reduced the rate of leaching of any fertilisers used. Synergistic effects have been shown between coal ash and organic substances that improve the soil and promote plant growth. Various biosolids, including treated sewage sludge, have been shown to complement fly ash in composts. Fly ash composted with earthworms improved yield so that expensive chemical fertiliser applications could be reduced. However, the source and quality of fly ash needs to be matched with the soil or spoil being treated, the crop being grown as well as the local climate. Another agricultural use of fly ash is as pesticide due to the fine powder form.

Arsenic, boron and aluminium may cause toxicity although they are usually within regulated limit values. Boron may be limited by using partly weathered ash. Research is in progress to examine long term effects of trace element loadings through field tests in Australia, India, Japan, and the USA.

Each issue of *Profiles* is based on a detailed study undertaken by IEA Clean Coal Centre, the full report of which is available separately. This particular issue of *Profiles* is based on the report:

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