AN EVALUATION OF USES FOR AFBC SOLID WASTES

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Combustion in an atmospheric pressure fluidized bed (AFBC) using limestone is being developed as a means to use high-sulphur coals in the Maritimes in an environmentally benign way.

The Department of Energy Mines and Resources (EMR) and the Department of National Defence, have jointly sponsored a demonstration of AFBC technology through the installation of two 18 metric tonne (steam)/hour boilers at CFB Summerside on Prince Edward Island. The installation has been designed to burn a variety of fuels including relatively high-sulphur (S = approx 5%) coals from Cape Breton, using New Brunswick limestone as a bed material (1). As a part of this project, the present study of potential uses for AFBC solid wastes has been made (2).

At atmospheric pressure, a limestone fluidized bed combustor produces solid residues comprising $CaSO_4$ (anhydrite), CaO (quicklime) and various silicates, aluminates and iron compounds derived from both the limestone and the coal ash. Unlike the residues from conventional thermal power generation they are not glassy alumino-silicates and they differ greatly in properties from pulverized fuel fly ash.

The installation at Summerside produces two waste products that are typical of limestone AFBC residues in general:

- bed-drain, comprising narrowly graded coarse sand-like particles of calcined and partly sulphated limestone;
- baghouse ash, a fine particulate (-200 mesh) consisting of lime, calcium sulphate and coal ash components.

These two residues are produced separately in the plant but are discharged as a mixed waste (termed silo ash) from the ash collection silo.

It is recognized that disposal of the residues may cause pollution of soil and water and that it is desirable that uses should be found for these materials.

Although the technology of fluidized-bed combustion was developed in Germany as long ago as the 1920's, only recently has attention been given to the nature, disposal and possible use of the solid residues from FBC boilers.

Data from previous studies of the nature and possible uses of material from

a number of FBC installations in the United States are available in the reports from four projects (3,4,5,6). Work has been reported by Bennett et al (7-10) on potential agricultural applications. The implications of previous work with regard to the possible use of AFBC in Canada has been the subject of two reports (11,12). The present investigation is the first to examine AFBC wastes from a Canadian source for the specific purpose of establishing their potential as usable resources.

The nature of AFBC solid wastes, suggests that three classes of properties may form a basis for their use:

1. Wastes derived from high-calcium limestone might be exploited as sources of CaO and $CaSO_4$;

2. The particulate characteristics may make AFBC wastes useful as fill or aggregate;

3. The ability of AFBC residues to react with water to form a cementitious mass may be exploited in a number of construction-related applications.

A broad range of potential uses based on these properties has been proposed by previous investigators. It was concluded from this study that the following were the most promising from a practical perspective:

- Use in agriculture;

- Use as a lime substitute in acidic waste neutralization and stabilization;

- Use in low strength backfill applications (with or without Portland cement)

- Use in soil stabilization and soil cementing;

- Use in asphaltic concrete.

The use of combustion residues in agriculture involves specific problems of environmental pollution and the transfer of potentially harmful substances to the food chain. For these reasons the present study was restricted to consideration of other, largely engineering, applications of the residues. It was noted however, that agricultural use of AFBC residues on P.E.I. could be economically attractive because of the large requirement for lime on the Island, all of which must be transported from mainland sources.

As materials for neutralization and stabilization of acidic wastes, AFBC residues have some advantages:

- The residues may be used to treat wastes that are acidic or that become acidic when subjected to biological or chemical decomposition after disposal.

- The reactivity of AFBC wastes with water and the cementitious nature of their hydrated products enables them to be used to dewater sludges and as components of a stabilized waste mass.

Typical applications in the pollution control field considered by other investigators include:

- Treatment of activated sewage sludge;
- Neutralization and treatment of acidic mine drainage;
- Treatment of heavy-metal finishing and lead smelting sludges;
- Stabilization of waste gypsum and FGD sludges.

The principal disadvantage to the use of AFBC residues for waste treatment is that the neutralization potential is much less (10 to 40%) than that of chemical lime. Where stabilization or dewatering is required in addition to neutralization of acidity, this may not present a significant disadvantage.

With regard to the Summerside residues, there are no significant sources of acidic waste sludges on the Island. Thus for this particular source, pollution control applications were not considered. However, elsewhere in the Atlantic Provinces, sources of acidic waste are available in a number of locations. If other AFBC installations are constructed in the region, pollution control applications may be valuable uses for the resulting residues.

In regard to potential construction applications, it has been suggested that AFBC residues may be used as aggregates, substitutes for lime in soil stabilization and cementing and as fillers for asphaltic concrete.

As aggregates, materials comprising largely unhydrated lime and calcium sulphate can be expected to be unstable either as fill or as components of concrete. The present work confirmed these expectations.

Reaction of all three types of residue from Summerside with water resulted in substantial expansion and decrepitation of the materials. It is apparent however, that in mass form (for example in a disposal pit) the material consolidates rapidly when exposed to moisture. As fill such a material would only be useable to support low-loads and could only be used where leaching of sulphate and other soluble components would not produce a hazard to the environment or to surrounding structures.

In conjunction with Portland cement, the residues (especially the bed-drain material) were found to expand excessively when used as aggregate. It is recommended that AFBC residues should not be considered for applications in Portland cement concretes, except under circumstances where expansion is either desired or unimportant (eg. for low-strength backfill).

It was found that acceptable asphaltic concretes could be prepared using the Summerside residues without the use of excessive quantities of asphalt. No evaluation was made of the quality of the asphalt concretes in this preliminary study. It is known that the use of lime as a filler in asphaltic concrete acts to improve durability. Further work to investigate this application is in progress.

A promising potential construction use for the Summerside residues was found to be as soil cement components. Highway construction in P.E.I. frequently requires the use of soil cement to stabilize sub-base soils that are non-plastic and silty. It has been generally found on the Island that though the use of soil cements is beneficial, reflection cracking of pavements occurs due to shrinkage of the stabilized soils.

Observations by previous investigators, confirmed by the laboratory tests conducted in this study , showed that AFBC soil mixes are subject to expansion in service. Under normal circumstances, such expansion would be destructive and materials causing it would be excluded from use in highway construction. However, if controlled or limited expansion resulted from combined use of AFBC residues with Portland cement, then it is possible that sub-base shrinkage and the consequent reflection cracking of pavements could be prevented.

A program of laboratory work to investigate preslaking and use of Silo ash from the AFBC boilers at CFB Summerside in soil cements was conducted. The following findings were reported:

(1) Pre-slaking of the residue is not practical. The amount of water required to control the rate of heat generation is in excess of that required for subsequent mixing and compaction.

(2) Compaction, strength and expansion tests showed that silo ash - Portland cement - soil mixes can be prepared to produce suitable materials for sub-base construction.

(3) Freeze-thaw durability of laboratory test specimens was not adequate to meet the normal standards applied to highway base and sub-base soil-cements.

Freeze-thaw durability is a major criterion of performance for such materials in Prince Edward Island. It is recommended that the Summerside residues not be used in soil-cements where exposure to cycles of freezing and thawing are anticipated unless tests are conducted on each specific soil/waste combination being considered.

It is considered possible that AFBC residues from other sources, in combination with other types of soils may well prove suitable as soil-cement systems. In particular, use of AFBC residue in soil cements in situations where the occurance of cycles of freezing and thawing is not a significant factor, should prove feasible.

It is recommended that EMR proceed as soon as possible to examine other potential uses. In particular it is recommended that investigations are conducted into the following potential applications:

- use as a supplement to agricultural lime;

- use as a filler in asphaltic concrete;

- use in pollution control.

Interest has been expressed by staff at the Provincial laboratories of Agriculture Canada in the potential use of AFBC residues. Some work has also been started on the design of asphaltic concretes using AFBC residue. Opportunities for applications in the field of pollution control are limited in PEI, however many acidic wastes and sludges are produced elsewhere in the Atlantic region. Further investigation of the possibilities of using the Summerside AFBC residues with these materials is recommended.

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