COAL COMBUSTION FLY ASH--
OVERVIEW OF APPLICATIONS AND OPPORTUNITIES IN THE USA

Sam Tyson, P.E. and Tom Blackstock, P.E.
Executive Director and Director of Technical Services
American Coal Ash Association, 2760 Eisenhower Ave, Suite 304,
Alexandria, VA 22314

Keywords: fly ash, CCBs, ash utilization

ABSTRACT

The American Coal Ash Association, Inc. (ACAA) is an organization representing the coal combustion byproducts industry. Since 1968, the goal of ACAA has been to gain recognition and acceptance of coal fly ash as an engineering material on par with competing virgin, processed and manufactured materials by advancing uses that are technically sound, commercially competitive and environmentally safe.

An annual survey of coal-burning electric utilities is conducted by ACAA to determine the quantities of coal fly ash produced and used in the USA. In 1993 approximately 43.4 million metric tonnes(47.8 million short tons) of coal fly ash were produced. Approximately twenty-two percent or 9.5 million metric tonnes (10.5 million short tons) was used while the remaining portion was deposited in disposal areas. The major markets for coal fly ash include cement and concrete products, structural fills, road base stabilization, flowable fills, mineral filler in asphalt, grit for snow and ice control, grouting, coal mining applications, and waste solidification and stabilization.

INTRODUCTION

An annual survey of electric utilities is conducted by ACAA to determine the quantities of CCBs produced and used in the United States (Ref. 1; ACAA 1994). In 1993 approximately 80.3 million metric tons (88.5 million short tons) of CCBs were produced in the U.S. in the form of fly ash, bottom ash, boiler slag and flue gas desulfurization (FGD) material. Approximately twenty-two percent of the combined production of these byproducts was used, while the remaining portion was deposited in disposal areas. Production and use quantities for these byproducts are summarized in Table 1.

Table 1. Production and Use of Coal Ash.
[1993 Data; Million metric tons (million short tons)]

	Fly Ash	Bottom Ash	Boiler Slag	FGD Mat'l
Production	43.4 (47.8)	12.8 (14.2)	5.6 (6.2)	18.4 (20.3)
Use	9.5 (10.5)	3.8 (4.2)	3.1 (3.4)	1.0 (1.1)
% Use	22%	30%	55%	6%

It is clear from survey data gathered by ACAA over the years that the annual use of 18.2 million metric tons (20.3 million short tons) of CCBs represents a major continuing effort by a number of parties, including the electric utility producers of CCBs and their marketers. It is equally clear, however, that

significant quantities of CCBs are not used each year. Therefore it is essential for ACAA to promote the use of coal combustion byproducts in numerous applications that are technically sound, commercially effective and environmentally safe.

CCBs are engineering materials and are similar in use to competing virgin, processed and manufactured materials. CCBs are affected by local and regional factors, which include production rates, processing and handling costs, transportation costs, availability of competing materials, seasonal adjustments, and the experience of materials specifiers, design engineers, purchasing agents, contractors, and other construction professionals.

COAL FLY ASH APPLICATIONS

It is instructive to consider the total amounts of coal fly ash that are used in the leading markets based on ACAA's 1993 survey results, presented in Table 2.

Table 2. *Summary of Fly Ash Uses.*
[1993 Data; Million metric tons (million short tons)]

Fly Ash Uses	Million Tons	
	Used	Percent
Cement and concrete products	6.17(6.8)	65.0
Road base/subbase	0.91(1.0)	9.5
Structural fills, embankments	0.83(.91)	8.7
Flowable fill	0.34(.38)	3.6
Filler in asphalt mixes	0.10(.11)	1.0
Grouting	0.02(.02)	0.2
Waste stabilization	0.40(.44)	4.2
Other	0.76(.84)	17.8
Total Used	9.53(10.5)	100.0

CEMENT AND CONCRETE PRODUCTS

In 1993 approximately 6.17 million metric tons(6.8 million short tons) of coal fly ash was used in the *U.S.* in cement and concrete products (Ref. 1; ACAA 1994). The amount of coal fly ash in typical structural concrete applications ranges from 15 to 35 percent by weight, with amounts up to 70 percent for massive walls and girders, concrete road bases, and dams.

Various concrete mixtures are produced with coal fly ash including 2500 to 6000 psi normal weight and lightweight concretes, high strength (>6000 psi) concrete, early strength concrete for form removal requirements, low-slump paving concrete, controlled low strength material (*CLSM*), and architectural concrete.

With the principal exception of high strength concrete, all of these coal fly ash concrete mixtures are routinely air-entrained for added workability and for resistance to freezing and thawing. A state-of-the-art report on the use of coal fly ash in concrete has been prepared by the American Concrete Institute (ACI) (Ref. 2; ACI, 1987). Fly ash for use in concrete is covered in an ASTM specification (Ref. 3; ASTM, 1994).

Flowable Mixtures (CLSM)

ACI Committee 229 deals with certain flowable grout-like materials under a general designation, "Controlled Low Strength Materials" (CLSM). Such materials have compressive strengths of 1200 psi or less, as currently defined by ACI, and may also represent a wide range of fly ash contents. Applications of CLSM currently being reviewed by ACI 229 include but are not limited to: backfills, structural fills, insulating fills, road and slab base, trench bedding and so on.

While flowable mixtures can be produced without fly ash, it is very easy demonstrate that economical mixtures with the most desirable characteristics, including flowability, cohesiveness, minimal bleeding, and controlled density, can be produced only with fly ash in combination with relatively small amounts of portland cement. The percentage of fly ash used in grout mixtures may be in a wide range from 20 to 95 percent by weight.

CLSM mixtures can be proportioned to provide a desired flowability and unit weight, and to have a compressive strength which is equal to or greater than that of well-compacted soil. CLSM can also be designed for a maximum strength where future excavation may be necessary.

The use of CLSM flowable mixtures is open to numerous innovative engineering solutions for everyday problems that would otherwise be viewed as traditional soils backfilling and foundations problems.

ROAD BASE AND SUBBASE

The ACAA pavement manual (Ref. 4; ACAA, 1991) offers pavement design engineers, materials engineers, and construction managers guidance in the design and construction of low- to high-strength "pozzolanic stabilized mixture" ("PSM") base and subbase layers having coal fly ash in combination with activators, aggregates and water.

To capture the long-term service and cost-saving features of PSM design, the document details a mixture proportioning system, a thickness design procedure, and established mixing and construction techniques. The user can apply the contents of this manual with professional advice to produce satisfactory pavement structures of acceptable uniformity in accordance with current specifications and QC/QA requirements of individual state departments of transportation.

The ACAA pavement manual is supported by guidelines and guide specifications in four chapters that comprise a publication (Ref. 5; AASHTO, 1990) developed by a Joint Committee of the American Association of State Highway and Transportation Officials (AASHTO), the Associated General Contractors (AGC) and the American Road and Transportation Builders Association (ARTBA).

STRUCTURAL FILLS

Fly ash may be used as a borrow material in the construction of fills. When the fly ash is compacted in lifts, a structural fill is constructed which is capable of supporting buildings or other structures. An embankment is constructed when the fly ash is placed to support roads or to impound water. The size of structural fills/embankments that have previously been constructed with fly ash ranges from small fills, consisting of a few thousand cubic yards of material covering less than one acre, to fills covering several acres.

When used in structural fills and embankments, fly ash offers several advantages over soil and rock. These advantages include low unit weight and high shear strength. The compacted maximum dry density of fly ash is typically within the range of 70 to 105 pcf. Compared to fills of silty sand that have a compacted maximum dry density of about 115 pcf, placing fly ash over weak, compressible foundation soils results in lower total settlement. Hauling costs will also be reduced because there is less tonnage for a given volume of fill. Another significant characteristic of fly ash used as a fill material is its strength. Compacted fly ash is as strong or stronger than many compacted soils. Class C ash will self-harden, resulting in a fill that is stronger than most compacted soil.

REGULATORY AND LEGISLATIVE ISSUES

The U.S. Environmental Protection Agency (EPA) issued a final regulatory determination on the four large volume CCB streams from coal-burning electric utilities in August 1993 (Ref. 6; EPA, 1993). The EPA determined that "large volume wastes from coal-fired electric utilities pose minimal risks to human health and the environment. Therefore, it is unnecessary to manage these wastes as hazardous." This determination continues to provide for the management of CCBs under Subtitle D of the Resource Conservation and Recovery Act (RCRA).

The U.S. Department of Energy (DOE) issued a report on the barriers to the increased use of CCBs in July 1994 (Ref. 7; DOE, 1994). The report is expected to have a significant effect on the use and management of CCBs. This report was developed as the result of the Energy Policy Act of 1992 [Public Law No. 102-486, October 24, 1992] in which DOE was charged with the task of conducting a detailed and comprehensive study on the "institutional, legal and regulatory barriers to increased utilization of CCBs by potential governmental and commercial users".

The recommendations in the DOE report address a network of related barriers which can be overcome only through cooperative efforts among federal and state government and industry. ACAA has addressed many of these issues in its business plan and will expand these activities in the future.

SUMMARY

Throughout ACAA's history, its goal has been to gain recognition and acceptance of CCBs as engineering materials on par with competing virgin, processed and manufactured materials by advancing CCB uses that are technically sound, commercially competitive and environmentally safe. It is clear from survey data gathered by ACAA over the years that the annual use of some 18.2 million metric tons (20 million tons) of CCBs represents a

major continuing effort by a number of parties, including CCB producers, marketers and other organizations. It is equally clear, however, that significant quantities of CCBs are not used each year. Therefore it is essential for ACAA to promote the use of coal combustion byproducts in numerous applications.

REFERENCES

1. 1993 Coal Combustion Byproduct Production and Consumption, American Coal Ash Association, Inc., Washington, D.C., 1994, 1 page.

2. Use of Fly Ash in Concrete, American Concrete Institute, Committee 226 Report, ACI Materials Journal, Detroit, September-October 1987, pages 381-409.

3. Standard Specification for Fly Ash and Raw or Calcined Natural Pozzolan for Use As a Mineral Admixture in Portland Cement Concrete, ASTM C 618, American Society for Testing and Materials, Philadelphia,PA, 1994, 3 pages.

4. Flexible Pavement Manual, American Coal Ash Association, Inc., Washington, D.C., 1991, 64 pages plus Appendices.

5. Guidelines and Guide Specifications for Using Pozzolanic Stabilized Mixture (Base Course or Subbase) and Fly Ash for In-Place Subgrade Soil Modification, AASHTO/AGC/ARTBA Joint Committee, Task Force 28 Report, 1990, 40 pages plus Appendices.

6. Environmental Fact Sheet, Large-volume Wastes from Coal-fired Electric Utilities Exempt as Hazardous Waste, EPA530-F-93-014, United States Environmental Protection Agency, Washington, D.C., August 1993, 2 pages.

7. Barriers to the Increased Utilization of Coal Combustion/Desulfurization Byproducts by Governmental and Commercial Sectors, DOE Office of Fossil Energy, Morgantown Energy Technology Center, July 1994, 36 pages.