ISSUE I • 2007

Application, Science and Sustainability of Coal Ash

ACAA RELEASES

ANNUAL COAL COMBUSTION PRODUCT PRODUCTION AND USE SURVEY

THE C²P² AWARDS

EPA RECOGNIZES INDUSTRY LEADERS

RECYCLING TO BUILD

SOUTH CAROLINA MAKES GOOD USE OF COMBUSTION PRODUCTS

FLY ASH

CHEMICAL CLASSIFICATION QUESTIONING VALUES

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COVER PHOTO:

American Coal Ash Association members AmerenUE, Charah, Inc. and Quikrete began a new venture beneficially using 60,000 tons of ash a year from the Labadie Power Plant west of St. Louis, Mo. Bottom ash and fly ash are incorporated into two million bags of high quality concrete dry mix sold at Home Depot stores. Labadie ash is used beneficially throughout Missouri, including as structural fill for the new packaging plant, depicted on the cover. This success story continues. See page 14



Photo courtesy Tim Fox.

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President Jeff Lester | (877) 953-2189

Sales Director Sean Davis | (888) 953-2190

Editor Bonnie Winter Fedak | (866) 953-2181

> Graphic Designers Doug Fedrau Candice Tonelete

Account Executives

Shannon Evans Louise Peterson Jennifer Shurvell

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ACAA LEADS AND UNIFIES INDUSTRY IN TIMES OF CHANGE

By Al Christianson, Great River Energy

s we begin a new year for the American Coal Ash Association, we are assured of one constant, and that is change.

Certainly, these are changing times in the utility industry. We're seeing more demand for coal and for new coal-based power plants as part of our nation's energy mix. That will result in an ever-increasing supply of coal combustion products. We're also seeing more stringent environmental regulations on both coal-based power plants and coal combustion products.

Our challenge as we face those changes, is to continue to maintain a good and growing supply of quality coal combustion products in the United States.

You can be assured that the leadership of the ACAA will continue to be proactive and serve as the unified industry voice as we advance the management and use of coal combustion products in ways that are technically sound, commercially competitive, and environmentally safe.



By AI Christianson ACAA Chairman

As you know, the ACAA was very successful in 2006. We grew our membership, implemented our strategic plan, and continued to be the premier voice for the CCP industry. These achievements can be attributed to the hard work of our members and our dedicated staff, led by David Goss, our executive director.

As we start a new year, the efforts of all our members will be required in order to grow our organization and to meet challenges facing the industry.





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LET IT SNOW, LET IT SNOW ... THE "WHITE STUFF" IS YEAR-ROUND

By David Goss, American Coal Ash Association

t's winter and in some parts of the country, folks are shoveling lots of white stuff from their driveways and sidewalks. The cold weather lends itself to producing a lot of snow. In other parts of the nation, however, power plants are producing mountains of some other white stuff, FGD gypsum. This product represents nearly 28 percent of the stucco used to manufacture wallboard. Additionally, more than a million tons are used in concrete and concrete products, cement production and agriculture. The uses of FGD gypsum in wallboard, cement and concrete are relatively familiar to many people. Agricultural uses, however, are not as well-known.

As you will read later in this magazine, the Coal Combustion Products Partnership (C^2P^2) has a new federal sponsor. In August 2006, the U.S. Department of Agriculture's Agricultural Research Services joined C^2P^2 . For many years USDA-ARS has been involved in research and testing FGD gypsum in agricultural and agronomic applications. In 1997, scientists and researchers from the Beltsville Agricultural Research Center hosted a multiday symposium on beneficial co-utilization of various byproducts, including FGD gypsum. That interest has grown greatly in the last decade.

Many ACAA members are deeply involved in non-traditional uses for FGD gypsum and the future suggests this is a valid strategy. With the planned addition of many new forced oxidation units, the quantity of FGD gypsum will increase significantly in the next ten years. The challenge will be to find beneficial uses for these materials and for those from other types of



By David Goss ACAA Executive Director

flue gas desulfurization systems. Recognizing the need to promote new uses for FGD materials, the USDA-ARS joined C^2P^2 to provide extensive expertise to our industry. Working with utilities, universities, marketing firms and the agri-business community, USDA and the industry will create new opportunities and share valuable knowledge to increase FGD utilization. The EPA is a willing partner with USDA to help provide mutually sound technical and environmental outreach and support.

Don't forget that when you speak of the American Coal Ash Association, that includes FGD materials, too. Maybe we really are the "ACA&FGDA." Expect to see more effort from the association and its members to spread the good word and knowledge about FGD gypsum and other materials, as we have for other CCPs for many years. We recognize that "white stuff" is a year-round business.

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AWARENESS AND BENEFITS DRIVE INCREASING CCP BENEFICIAL USE

2005 ACAA CCP PRODUCTION AND USE SURVEY RELEASED

The American Coal Ash Association recently released its annual Coal Combustion Product Production and Use Survey, reporting that 123.1 million tons of CCPs were produced in 2005. About 40 percent were used beneficially, or 49.6 million tons. This represents a slight 0.21 percent increase from 2004 when 49 million tons of CCPs were used, of 122.4 million tons produced. An increase of 0.53 percent was reported for 2004.

Though production and use have both increased steadily over the years, the pace of use is slowing. This underscores the challenge ahead in meeting a target of 50 percent use by 2011, a goal announced last fall by industry and the U.S. Environmental Protection Agency. The ACAA established its survey in 1966. Year 2005 data represents more than half of America's active coal-fired utility plants, which participated voluntarily. Data were also extrapolated from past surveys and reports from the Department of Energy's Energy Information Administration.

Coal combustion products include fly ash, bottom ash, boiler slag, flue gas desulfurization material (gypsum), and fluidized bed combustion materials. Their use, reported in 15 survey categories, creates a wide array of extraordinary environmental, economic and technical advantages that meet U.S. industry and government objectives.





Fly ash is the fine mineral produced from burning pulverized coal to generate steam for power.



Bottom ash is coarse-grained particles that fall to the bottom of a coal combustion furnace.

FLY ASH

Fly ash use accounts for 13 of 15 categories tracked by the survey. Of 71.1 million tons produced, 29 million was used in such applications as concrete products, structural fills and cement raw feed for clinker. Fly ash is the most produced and used CCP by volume, contributing to enhanced concrete strength and durability. One ton fly ash used instead of Portland cement, saves the atmosphere from one ton of CO_2 . Plus, fly ash is typically less expensive than Portland cement.



Flue gas desulfurization (FGD) gypsum is produced when sulfur dioxide is removed from boiler exhaust gas by scrubbing technologies using oxidizing and calcium-based sorbents.

FGD GYPSUM

Of 11.8 million tons produced, 77.4 percent or 9.2 million tons of FGD gypsum was used in 2005. FGD gypsum is tied to the amount of sulfur content in coal burned and the resulting SO_2 emissions "scrubbed." Synthetic gypsum is used for wallboard and agricultural soil amendment.

BOTTOM ASH

Bottom ash production amounted to 17.6 million tons in 2005 – a slight 2.3 percent rise – while utilization dropped 7 percent from 8 to 7.5 million tons. This represents 42.5 percent utilization in 2005. Primary applications are as varied as fly ash, including structural fills and road base construction.



Boiler slag is a molten ash collected at the base of slag tap and cyclone furnaces that is quenched with water and shatters into black, angular particles having a smooth, glassy appearance.

BOILER SLAG

Boiler slag has the highest ratio of beneficial use at 96.6 percent. Of the 1.96 million tons produced, 1.89 million tons was used in 2005. Both tonnages are reductions from 2004; production is 1.11 percent lower, while usage dropped 4.18 percent. Blasting grit and roofing granules dominate boiler slag use, with lesser amounts in structural and asphalt mineral fills. Available slag is expected to decline as older cyclone and slag tap boilers units are retired.



A leader in coal combustion product usage.

For more than 50 years, AEP has been a leader in the research and use of coal combustion products. Today, CCPs from AEP's coal-fired generation plants are used in many ways, including land reclamation, road base, asphalt, concrete and roofing applications. In addition to reducing the need for landfill disposal, responsible use of CCPs helps the environment by replacing significant amounts of manufactured building materials. When it comes to researching new uses for CCPs, **AEP is there, always working for you.**



For more information about AEP's CCP programs, visit aep.com.

CCP USES AND BENEFITS

- Superior performance in lieu of, or combined with traditional applications in construction, manufacturing, remediation, and agriculture
- Markets are discovered, developed and grown every day worldwide
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- Preserves/extends natural resources or resources traditionally used by industry
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- Fills abandoned mines for aesthetics, safety, and to prevent groundwater contamination
- Lines landfills to limit or eliminate percolation of harmful liquid substances into underlying soils and groundwater
- Improves agricultural soils by increasing moisture holding capacity, positively modifying pH levels and adding nutrient content for crop production
- Composting with sewage sludge and other materials to produce fertilizers and soil conditioners
- Constructing non-toxic artificial reefs and shoreline erosion protection dikes
- Manufacturing home construction materials such as synthetic gypsum wallboard and flooring
- Creating improved concrete products that are stronger and longer lasting than non-ash concrete
- Replacing more expensive fillers in making plastics, ceramics, light weight metal tooled parts, paints, etc.
- In a May 2000 regulatory determination³, the EPA concluded that CCPs do not warrant regulation as a hazardous waste, and voiced support for their increased beneficial use in such applications as additions to cement and concrete products, waste stabilization, and use in construction products such as wallboard
- And, patent pending, the filtering of arsenic from drinking water affecting millions of people in the Third World and drastically reducing filtering costs in the U.S. (e.g., from average \$58 to \$327/ household to \$1/household) and at the same time meeting EPA drinking water standards⁵

LOOKING TO THE FUTURE

Greater increases in CCP utilization would seem inevitable over the next few years, based on historical trends and expanding, proactive government and industry awareness initiatives. The U.S. government has recognized and endorsed that the use of CCPs enhances the nation's sustainability and "green" objectives, while offering growth in technology, business and research initiatives.

Current and proposed initiatives will play a major role in reaching projected beneficial use growth over the next decade. Patents for new technology, as well as academia and industry research programs, continue providing additional impetus to CCP utilization. The environmental benefits of using CCPs in lieu of traditional natural materials are coming to the fore because of growing sustainability concerns of the public. Of particular note are new and expanding federal programs, such as the Green Highways Partnership, encouraging the use of CCPs for road construction, both at the federal and state levels. Similar awareness programs, within the public and private sectors, involving the amazingly broad and expanding range of CCP industrial applications, will also play a part in anticipated production-to-use increases.

- 1 DOE EIA U.S. Coal Supply and Demand (2005 Review)
- 2 American Coal Ash Association 2005 CCP Production and Use Survey, October 15, 2006
- 3 Environmental Protection Agency Regulatory Determination on Wastes from the Combustion of Fossil Fuels; Final Rule - Federal Register of May 22, 2000, Part III, EPA, 40 CFR Part 261, 32214-32228
- 4 DOE EIA-767 Report (2005), Steam-Electric Plant Operation and Design Report
- 5 Patent Application (WO/2005/092492) Treated bottom ash medium and method of arsenic removal from drinking water (http://www.wipo.int/pctdb/en/ia.jsp?IA=US2005005900&DISPLAY-DESC)



IMPORTANCE OF THE ACAA CCP SURVEY

We - and the Rest of the World - Will Miss You

During a busy workday, you receive an e-mail from ACAA asking you to fill out its annual voluntary CCP Production and Use Survey form. Your first thought might be a question such as "Is this really necessary?" or you may simply delete the request thinking your input won't be missed. Contrary to both responses, the CCP industry believes the survey is very necessary and ACAA wants you to be assured that your data will, in fact, be missed.

A Unique, Reliable and Credible Source

The survey, which requires as thorough an input as possible to realistically validate its findings, has a wide range of users. Financial investment analysts track and project CCP market trends. Federal, state and local regulatory agencies want to know how changes in production and utilization volumes will impact oversight processes. The news media watches and reports on the effect of CCPs on community, industrial, environmental and technological issues. CCP stakeholders, whose organizations are most concerned with the industry, want to know how their products or services are fairing when compared to the survey's consolidated information.

More specific examples of the survey's importance include the EPA's routine quotes in technical reports and assessments noting the impact of regulatory changes on the industry. For example, during a recent review of the use of CCPs in cement kilns, the EPA sought survey data to better understand how widespread this specific application had become. Projecting the impact of CAIR and CAMR, the agency used ACAA data as background to their understanding on how utilization might be affected in the future. Developing the background for the Report to Congress, mandated by the EPACT and SAFETEA-LU, the Office of Solid Waste is using ACAA data to provide background reference points against which future uses might be measured.

The EPA's Coal Combustion Products Partnership (C^2P^2) uses the ACAA survey data to determine if C^2P^2 is having a measurable impact on utilization. The DOE and FHWA and other agencies quote ACAA surveys in presentations, studies and report summaries that receive wide distribution. Similarly, articles about sustainability have included the statistics from this survey to frame broader understandings of reuse and recycling effort.

Participation More Important than Ever

ACAA has recently been made aware that the EIA 767 report, upon which the survey has depended for so long to extrapolate data otherwise not received from utility contributors, will no longer be available after the 2006 reporting period. The ACAA Survey will then become the only source of detailed CCP utilization information for both public and private purposes.

ACAA Appreciates Your Extra Efforts

We, at ACAA understand that none of the above reasons alone outweigh the added workload that you must manage, should you take the time to complete the survey. Because it is voluntary, we recognize your sacrifice in time and effort, and want you to remember your input is highly valued and appreciated. We hope you will continue to participate and if you have not in prior years, do so in the future. Your data will allow ACAA's survey to remain a respected and accurate source of information.



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- Glenn Outland, Plant Engineer, Roanoke Valley Energy Facility, 2004

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- Butch Houseknecht, Operations Manager, Separation Technologies, Inc. (STI) Baltimore, Maryland





AmerenUE, U.S. Environmental Protection Agency, Charah executives and the executives of Charah partners The Home Depot and Quikrete, gather to cut a giant ribbon before the 35,000-square-foot facility where concrete is being manufactured from the byproducts of burning coal to create electricity at the nearby AmerenUE Labadie Power Plant.

VENTURE RECYCLES 60,000 TONS OF ASH A YEAR

Home Depot sells new high quality concrete mix brand

By Melissa Burke, American Coal Ash Association

harah, Inc. with AmerenUE, Quikrete and The Home Depot launched a new product beneficially using 60,000 tons of coal ash a year. The ash from Ameren's Labadie Power Plant, located 35 miles west of St. Louis, Mo., will be incorporated into two million bags of high quality concrete dry mix a year. The mix is sold at 24 St. Louis area Home Depot stores under the Quikrete brand, creating revenue, while saving landfill space and disposal costs. What's more, each ton of ash used saves the environment about one ton of CO_2 created during Portland cement production.

"You don't come across win-win situations very often, but this is surely one of them – it's a win for Missouri, a win for the environment and a win for all the people gathered here today," said state Sen. John Griesheimer, during the grand opening ceremony held last fall. State Rep. Kevin Threlkeld also attended the event praising the venture.

The plant's electrostatic precipitators collect virtually all of the power plant's fly ash before it can go out its stacks. Ameren's goal is to ultimately recycle 100 percent of its ash at Labadie; the rate today is about half. Coal ash appears in a wide variety



of applications, from blasting grit and roofing shingles, to cement and concrete manufacturing, structural fill, snow and ice control, and a myriad of other uses featured on the American Coal Ash Association's Web site: www.acaa-usa.org.

Fly ash from Ameren plants was used to construct approaches to the Meramec River Bridge on Missouri Route 231 and on Tenbrook Road in Arnold, Mo. Also, the Illinois Department of Transportation approved using fly ash on a two-mile road near the company's plant in Meredosia, Ill. Labadie's bottom ash was used as structural fill for the Charah-Quikrete packaging plant (200,000 tons), as well as for a 1,200-foot rail berm project (450,000 tons) completed January 2007.

When the plant was built in the early 1970s, it burned mostly Illinois coal and rail access faced to the east of Union Pacific's mainline. With the 1990 Clean Air Act regulations on sulfur dioxide emissions, the plant converted to low-sulfur western coal. As a result, each 140-car train had to go past the east-facing entrance and back up into the plant, adding about four hours to the delivery time and slowing down other rail traffic.

The Charah-Quikrete packaging plant is the world's first and the only one that turns out consumer concrete mix on power plant

property. Charah President and CEO Charles Price achieved another first with his design for packaging the new product.

"When Charles came to Home Depot several years ago with this recycled concrete mix concept and its new packaging, my colleague, Jack Rheinhold called it 'the most exciting, powerful innovation in the bagged concrete industry in 70 years," says Giles Bowman, a Home Depot merchandising vice president. "The sealed plastic bag is sturdy, and the two handles make it very easy for our customers to lift and carry. At the same time, this packaging is less likely to break than traditional paper bags." The bags are also fully recyclable.

Charah annually processes 250,000 tons of bottom ash and markets it to concrete block and mix industries in North Carolina, South Carolina, Tennessee, Kentucky and Virginia. In April 2005, the EPA's Coal Combustion Products Partnership (C^2P^2) recognized Charah with its prestigious first place award for innovation for the patent-pending concrete mix and packaging, also sold at Home Depot stores in Virginia. (See story on C^2P^2 award-winners on page 16.)

"Charah continuously devotes a great amount of time and resources to finding beneficial uses for all of our customers' ash products," says Price. "As a charter member of C^2P^2 , we are dedicated to finding and developing as many markets for beneficial uses for CCPs as possible."

On a national level, EPA's Strategic Plan sets forth the goal of increasing the beneficial use of CCPs to 50 percent by 2011, up from 40 percent in 2004 and 32 percent in 2001. The EPA also established a goal of increasing the use of CCPs in cement from 12 million tons in 2001 to 18 million tons by 2011. Achieving these goals will lead to substantial benefits in lower greenhouse gas emissions, reduced landfilling and decreased use of virgin resources. By increasing the use of coal ash as a supplementary cementitious material from 12 to 18 million tons, the environment will benefit from a decrease in greenhouse gas emissions equal to taking approximately 3.5 million passenger cars off U.S. roads.□









Above: Matt Hale, (far left) and David Goss (far right) present the Special Recognition award for Innovation to the Center for Applied Energy Research. Accepting for CAER are (left to right) Dr.Tom Robl, Dr. Rodney Andrews and Dr. Jack Groppo.

Left: Dr. Ghassem Asrar, Deputy Administrator of the U.S. Department of Agriculture's Agricultural Research Center, the newest C²P² program sponsor, addresses award recipients.

EPA RECOGNIZES INDUSTRY LEADERS FOR BENEFICIAL USE

By David Goss, American Coal Ash Association

he EPA's Coal Combustion Products Partnership (C²P²) recognized industry leaders in beneficial use during the second annual C²P² awards ceremony held Oct. 23, 2007 in Atlanta, Ga. The C²P² program is led by the EPA with the ACAA, DOE, FHA, DOA - Agricultural Research Center (USDA-ARC), and Utilities Solid Waste Group (USWAG).

Awards were presented during the National Recycling Coalition's annual congress and exposition. Matt Hale, director of EPA's Office of Solid Waste presided, accompanied by Dr. Ghassem Asrar, deputy administrator of USDA-ARC and Robert Callan, Georgia Division administrator for FWHA. William Aljoe of DOE and David Goss of ACAA represented two C²P² sponsors unable to attend: USWAG and Southern Company.

Please visit http://www.epa.gov/c2p2 for more information on the partnership.

OVERALL ACHIEVEMENT

Great River Energy of Underwood, N.D. partnered with more than 10 public and private organizations to develop an extensive market for fly ash from Coal Creek Station, the world's largest lignitefired plant. Their marketing partnership with Headwaters Resources resulted in annual sales of more than 400,000 tons of high quality ash distributed to markets as distant as Denver, Colo., and the Pacific Northwest. Great River's industry leadership is well-respected within the CCP industry.

COMMUNICATIONS AND OUTREACH

First Place

Los Angeles Community College District was presented its C²P² award at the Byproducts Beneficial Use Summit in San Francisco, on Nov. 29, 2007. The LACCD's nine-campus renovation is one of the world's largest Green Building projects and serves as a model for architects and students. Construction practices include using high percentages of fly ash in concrete. A leader in sustainable development, the district's adoption of fly ash concrete has become an example to its more than 130,000 students, of the institution's commitment to reducing the construction impact on the environment.

Special Recognition

Stockton Cogeneration also received its award at the San Francisco Byproducts Beneficial Use Summit. The Air Products facility located in Stockton, Calif., produces approximately 50 megawatts of electric power to sell, as well as process steam from a fluidized bed boiler that blends bituminous coal with petroleum coke and tirederived fuel. New markets for the ash, high in limestone, were developed for dairy feedlot soil stabilization, stall-bedding material, composting agents and agricultural liming agents. Sharing of these projects with the surrounding community and others in California has been noteworthy and well-received.



David Goss visits with Mary Jo Roth (left) and Diane Stockdill after they accepted the Overall Achievement award for Great River Energy.



Mr. Michael Clark accepts Wal-Mart's First Place award for Environmental Achievement.

ENVIRONMENTAL ACHIEVEMENT

First Place

For many years, Wal-Mart has been demonstrating its leadership, not only in retailing and marketing, but also in its commitment to sustainability. Beginning in 1997, and every year thereafter, Wal-Mart has increased its use of fly ash in concrete. By specifying ash content of 20 percent to 25 percent, Wal-Mart uses more than 60,000 tons of fly ash annually, contributing to a total reduction of more than 350,000 tons of CO₂ emissions in the last decade. As it moves towards standardizing more environmentally sensitive stores, they anticipate increased uses for fly ash. A test facility in Colorado is evaluating many concrete mix designs using fly ash, including some with significant percentages of fly ash. This type of leadership could

prompt other retailers to adopt similar construction practices.

Special Recognition

Constellation Energy produces more than 800,000 tons of CCPs annually. In 2005, more than half that total was used in ready mixed concrete, as raw feed for cement kilns, in flowable fills, and in boiler slag applications. With the addition of beneficiation facilities at its Brandon Shores power plant, along with a new storage silo, the sale of fly ash from this station has increased dramatically. Constellation Energy continues to pursue new and broader uses for its CCPs, thus reducing its environmental impact upon the surrounding community. As a participant in the Green Highways Partnership, Constellation Energy is also supporting environmentally sensitive highway construction activities in Maryland.

INNOVATION

First Place

The California Department of Transportation (Caltrans) received its C²P² award at the Byproducts Beneficial Use Summit. Caltrans has long been a leader in the use of fly ash in concrete in the state. In constructing the new San Francisco Oakland Bay Bridge, the project called for over 30 different concrete mix designs. A mix of more than 50 percent ash is being used in footings and in high salt zones to address both seismic requirements and harsh operating conditions. In other settings, more than 60 percent fly ash was specified to obtain required thermal controls. Caltrans is also creating the first ever Structural Concrete Green House Gas Reduction Specification. This will encourage contractors and designers to build more bridges and structures with high amounts of fly ash.



Mr. John Jeffcoat accepts the Special Recognition award for Environmental Achievement on behalf of Constellation Energy.



Mr. Tommy Edens of Santee Cooper provides insight on the First Place award his company received for Enhanced Utilization.



Mr. Atle Lygren (center) addresses the audience after accepting the First Place Partnership award on behalf of Texas EMC and EMC Development AB.



Dr.Tarun Naik (center) of the University of Wisconsin-Milwaukee's Center for Byproduct Utilization accepts the First Place Research award on behalf of his organization.

Special Recognition

The University of Kentucky Center for Applied Energy Research (CAER) has, over the years, developed many new ideas and innovative processes pertaining to CCP utilization. This year's award was given to recognize a recently patented process known as $\mathsf{FastFloat}^{\mathsf{TM}}$, which incorporates beneficiation technologies normally applied to coal preparation and mineral processing in order to utilize CCPs. FastFloatTM makes use of selective density separation to recover carbon to produce high quality pozzolans. This type of innovation is representative of the research CAER and other institutions are conducting on behalf of the industry.

ENHANCED UTILIZATION

First Place

Santee Cooper, South Carolina's stateowned electric and water utility has continually sought opportunities to increase CCP utilization. In 2005, 92 percent of the CCPs Santee Cooper produced (698,000 tons) were used in concrete, concrete products, wallboard production and agricultural applications. The high profile, \$531 million Arthur Ravenel Jr. Bridge in Charleston utilized 30,000 tons of fly ash in its construction. Through the efforts of employees and its marketing partners, Santee Cooper has become an outstanding example of a utility's commitment to natural resourc-



es conservation through increased utilization and environmental stewardship.

PARTNERSHIP

First Place

EMC Cement and Texas EMC Products applied a unique process to inter-grind fly ash and Portland cement to create a highly activated pozzolan, "EMC - Dura-Pozz." Using Dura-Pozz allows designs to create concrete using between 50 percent and 70 percent fly ash to achieve comparable - if not superior - concrete mix designs. To gain acceptance in the marketplace, EMC Products developed partnerships with local contractors, highway and transportation officials, engineers and various end-users to show through demonstration projects, the success of this technology. The Texas Department of Transportation now accepts Dura-Pozz, opening the doors for markets to utilize the 300,000-ton annual capacity of the processing plant.

RESEARCH

First Place

The University of Wisconsin–Milwaukee Center for By-Products Utilization (CBU) has an international reputation for practical and innovative research in using CCPs and other industrial materials. During 2005, the CBU conducted five projects specifically related to fly use ash in conjunction with the Wisconsin Highway Research Program, We Energies and other university programs. In addition to conducting research, the Center offers courses, workshops and



Faculty members and students from the University of Puerto Rico accept the Special Recognition award for Research on behalf of the **Puerto Rico Construction Cluster.**

seminars to students, members of industry and academia, and others, to better understand the value these materials contribute to sustainability.

Special Recognition

The Puerto Rico Construction Cluster and the University of Puerto Rico at Mayaguez have worked together to identify potential uses for the fluidized bed combustion ash produced by the island's single coal-fueled utility. FBC ash characteristics can vary significantly around the world. In order to develop new markets in the Commonwealth of Puerto Rico, students guided by two professors conducted an extensive literature review of current and past practices. The resulting report has helped the plant's owners to identify and prioritize marketing efforts expected to become widely accepted.

INDIVIDUAL AWARDS

Individual Achievement

Thomas Jansen of We Energies in Milwaukee, Wis., has been a visionary leader, both within his company and in his service to the industry through participation in associations, engineering organizations, and public and private sector partnerships. Tom worked closely with others to develop the concept of the Green Highway Initiative, and has been instrumental in the state of Wisconsin in addressing construction and environmental issues resulting in widespread acceptance of CCPs in transportation and construction projects.

Lifetime Achievement

Dr. V. Mohan Malhotra received this special award at the Byproducts Beneficial Use Summit. Dr. Malhotra has worked in all aspects of concrete technology. His contribution on the sustainable nature of concrete and how using CCPs in concrete contributes to environmental stewardship, has marked him as an international spokesman and expert in the field.



Tom Jansen (right) and Dr. P. Kumar Mehta both received special recognition in Atlanta. Tom received an Individual Achievement award and Dr. Mehta a Lifetime Achievement award.

Lifetime Achievement

Dr. P. Kumar Mehta has been, for decades, one of the world's leading researchers and teachers on the use of fly ash in structural concrete. His cement and technology research and academic leadership has paved the way for significant advances in the use of coal combustion products within the United States and internationally. \Box

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WORLD OF COAL ASH

May 7-10, 2007 Covington, Kentucky, USA

The World of Coal Ash Conference is organized jointly by the American Coal Ash Association and the University of Kentucky's Center for Applied Energy Research. These groups first came together in 2005, combining previously separate international symposia into the definitive 'ash' conference.

The first gathering's outstanding success inspired ongoing commitment to the World of Coal Ash.

The agenda features an extraordinary variety of presentations on topics pertinent to the coal combustion products industry, including four parallel sessions over three days, plus an extensive poster session.

The World of Coal Ash 2007 is anticipated to draw at least 600 participants and 50 vendors, including CCP producers, marketers, architects, engineers, contractors, concrete producers, waste and disposal managers, researchers, members of academia, and government representatives. Mercury capture technology will be featured, along with its impact on CCP utilization, and the impacts of leaching and potential re-release of mercury. Dozens of papers will cover CCPs' impact on the environment, the management of ash in disposal settings, and how to take advantage of CCPs in construction of ash management facilities. With the implementation of air emission controls, uses for non-concrete quality ash become more important. WOCA will also address emerging technologies utilizing CCPs in non-traditional ways. Presentations on FGD gypsum in agriculture and agronomic settings are planned as are speakers on beneficiation technologies and research that mitigates the impact of high carbon fly ashes. WOCA will also contain many papers on fly ash and concrete chemistry, important elements for those who produce or have ASTM C 618 guality ash available. The use of various CCPs in mining applications and as aggregates will be discussed, as will the impact of blending different fuels and the resulting materials produced.

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COMBUSTION PRODUCTS: RECYCLING TO BUILD SOUTH CAROLINA... INCLUDING CHARLESTON'S NEW COOPER RIVER BRIDGE

By Willard Strong, PowerSource Magazine Photos by Jim Huff, Santee Cooper

a subscript and the line

Bridge Constructors, removes a sample of material from one of the tankers making a delivery to the Wando Concrete batch plant. The facility blended the material into the concrete delivered for pourings on the bridge project.

Mary Hill, a fly ash sampler with Palmetto

S antee Cooper has followed the old adage of "turning lemons into lemonade" by putting to good use its leftover ash — the combustion product left over after burning coal to generate electricity.

This ash can make useful products, such as cement, readymix concrete and concrete blocks. Santee Cooper provides fly ash and bottom ash for the manufacturing processes that supply materials to companies using it in constructing homes, schools and businesses in South Carolina and throughout the Southeast.

"Our annual recycling of combustion products was 47 percent in 2002 and 93 percent in 2005. We project that percentage to be 94 percent this year," says Tommy Edens, Santee Cooper's administrator of combustion products utilization. "I've set a personal goal of 100 percent."

CONVERTING ASHES INTO ASSETS

Nearly 30 years ago, Santee Cooper began viewing ash in a different light. In late 1974, Santee Cooper began supplying fly ash to the Santee Portland Cement Co. located in Holly Hill. This ash came from Units 1 and 2 at the Jefferies Generating Station near Moncks Corner.

"Instead of this fly ash going to the ash ponds at Jefferies, we were able to recycle it with the cement company," Edens says.

"It was a start."

Another turning point came in 1994 when a consultant suggested ways the state-owned utility could improve its ash utilization. At that time, only about 5 percent of its ash was recycled. Since that time, Santee Cooper has expanded its ash recycling activities at two generating facilities — Winyah Generating Station near Georgetown and Cross Generating Station at Pineville. Today, Santee Cooper sends more than 600,000 tons of fly ash annually to cement, ready-mix concrete and concrete block manufacturers.

Winyah, a carbon-recycling facility or "carbon burnout" facility, began operation in October 2002. Of all ash produced at Grainger Generating Station in Conway, approximately 60,000 tons, goes to Winyah for processing.

The CBO facility is owned by the SEFA Group, formerly Southeastern Fly Ash, a Moncks Corner-based firm. SEFA burns out the excess carbon from Winyah and Grainger's high-carbon ash, converting it into approximately 260,000 tons of low-carbon ash annually. The finished product is used in manufacturing ready-mix concrete. The heat recovered from the carbon-burnout process is returned to the boiler, thus providing a fuel savings.

This isn't just wishful thinking. The way things are going, Edens may just make that lofty goal a reality. To tell this recycling story,



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The coal pile at Santee Cooper's Winyah Generating Station near Georgetown, S.C., is the point from which more than seven million tons of coal annually is consumed in the station's four generating units. This consumption produces approximately 700,000 tons of fly ash suitable for use in making cement, concrete and other products.

one must go back to the "bread and butter" of Santee Cooper: generating electricity that is the direct and indirect source of power used by two million of the state's four million people.

The majority of Santee Cooper's generation mix, just more than 78 percent, comes from coal-fired generation. This electricity is produced at four large-scale generating stations in Berkeley, Georgetown and Horry counties.

These stations have a voracious appetite for coal, the fuel that makes them run. Last year, Santee Cooper burned 7.3 million tons of coal and is projected to burn an equal amount this year. Burning coal produces ash, and something must be done with that ash.



For electric utilities, that "something" has traditionally meant constructing ash ponds or landfills where the generating stations are located. The ash is filtered from the process and sluiced through large pipes to the ash holding ponds or stored dry in landfills. And for the longest time, that was it. The ash just sat there. And more ash was coming in all the time.

This facility is producing more than 30,000 tons of low-carbon ash that is a major ingredient in the more than 300,000 cubic yards of concrete being used in the construction of the new Cooper River Bridge in Charleston Harbor.

"All low-carbon quality ash meeting redi-mix standards goes to SEFA," Edens says. "The fly ash not meeting those standards goes to the cement companies in the Holly Hill area such as Holcim, Giant and Lafarge. The bottom line is, we are closing in on 100 percent combustion product utilization at Winyah and 80 percent at Grainger."

CREATING "SYNTHETIC" GYPSUM

There is another recycling success story at Cross Station. Several years ago, the sulfur dioxide (SO₂) scrubbing process was modified to allow for conversion of calcium sulfite to calcium sulfate, also known as synthetic gypsum. Gypsum is another key ingredient in making cement and a key ingredient used in the manufacturing of building materials commonly known as "sheetrock" or "wallboard." A "green" building component is used to make both. Previously, the calcium sulfite material was combined with ash and placed in an on-site landfill, making it a useless and costly waste material.

As part of the conversion process, a large "gyp storage dome" was constructed on site. The recycling numbers at Cross are dramatic. In 2000, more than 64,600 tons of gypsum were made available to the cement companies.

The following year that number was 68,210 tons, and last year it rose to 171,300 tons. This product doesn't travel far by truck, going to Holcim, Lafarge and Giant Cement in the nearby Holly Hill and Harleyville areas. Winyah Station also produces 50,000 tons of the heavier bottom ash.

"As a bottom-ash supplier to block manufacturers, we've managed to capture almost all of the lightweight concrete block business in Lower South Carolina," Edens says. More than 18 schools and colleges in the region are using the lightweight blocks in new construction projects.

"We do no trucking. That is handled by the companies we're doing business with. It's a good arrangement that benefits everyone. This whole process is tremendously good for the environment. We're conserving natural resources and saving landfill space by using coal ash in a useful way. This is a recyclable product these companies need, and we're supplying it from something we don't need."

Edens also says the gypsum produced at Cross Station saves the cement companies money because they previously had to import natural gypsum. The Cross gypsum quality is consistent, as well.

But it's good to know that what remains from this process is being used again. Just look at the new Berkeley High School or St. John's High School in Charleston County, or building projects in Loris and Myrtle Beach.

And of course, the most visible and distinctive use of Santee Cooper's combustion product is the new Cooper River Bridge in Charleston.□



Above: A load of fly ash from Santee Cooper's Winyah Generating Station is pumped into a storage silo at Wando Concrete's batch plant. Each tanker carries about 25 tons of fly ash. For the bridge project, that was enough for blending into approximately 200 yards of concrete.

Inset: Tommy Edens holds one of the 23-pound lightweight concrete blocks made using Santee Cooper fly ash.

Dry Silo Fly Ash Facts at Santee Cooper:

- There are 140 pounds of fly ash in one yard of concrete;
- There are 50,000 pounds of fly ash per truck load;
- One truckload of fly ash equals 357 cubic yards of concrete;
- 2005 shipments equal five million cubic yards of concrete or 14,000 truckloads of fly ash.

Bottom Ash Facts at Santee Cooper:

- 5,500 tons of bottom ash equals one million concrete blocks;
- Shipments in 2005 produced 10 million concrete blocks;
- An average new public school used 250,000 concrete blocks;
- Lightweight blocks produced from Santee Cooper ash went to build 18 new public schools;
- Projected shipments for 2005: 48,000 tons.



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FLY ASH CHEMICAL CLASSIFICATION **BASED ON LIME**

TRADITIONAL SPECIFICATION

Fly ash specifications ASTM C 6181 and AASHTO M 2952 have long distinguished between Class F and Class C fly ashes based on the sum of the weight percent oxides of silicon (SiO₂), aluminum (Al₂O₃) and iron (Fe₂O₃), or S+A+F. Class F fly ashes contain at least 70 percent S+A+F and Class C fly ashes contain a minimum of 50 percent S+A+F. The value of the S+A+F chemical classification as a predictor of ash pozzolanic activity has been questioned. ³ Much of the iron in fly ash is present as inert crystalline oxides that are non-pozzolanic. Little correlation exists between fly ash iron content and concrete durability. ⁴

Class F fly ash is generally produced from high-rank coals (bituminous and anthracite), while Class C fly ash is produced from low-rank coals (sub-bituminous and lignite).⁵ The S+A+F chemical specification does not insure that all Class C fly ashes are cementitious and its failure to link lime content and cementitiousness is known.⁶ Because coal rank and geochemistry vary with depositional basin, some low-rank coal ashes contain more than 70 percent S+A+F and are marketed as Class F fly ash. For fly ash classification, iron may not be as useful as lime.

LIME SPECIFICATION

Typically, total lime content (CaO) of fly ash is shown in fly ash reports, but its significance is not addressed in U.S. specifications. The phase name for CaO is lime and is sometimes confused with hydrated lime (portlandite) (Ca $[OH]_2$) or ground limestone (CaCO₃). In Canada, fly ash is chemically classified into three types based on the weight percent CaO, or C, instead of weight percent S+A+F. Type F fly ash contains less than 8 percent CaO and is essentially equivalent to ASTM Class F fly ash. Type CI fly ash contains 8 percent to 20 percent CaO and corresponds to intermediate lime fly ashes sold as ASTM Class F, C, or F/C. Type CH fly ash contains more than 20 percent CaO and includes ASTM Class C fly ashes that are marketed for their cementitious and pozzolanic character.^{7,8}

COMPOSITION AND PHASE RELATIONSHIPS

Classification of fly ash based on lime corresponds with the crystalline phases observed by X-ray diffraction (XRD) after thermal relaxation of the glass. A ternary S-A-C phase diagram plot of fly ash compositions with ash fields typical of various coal sources, shows this relationship (Figure 1).



Figure I. The S-A-C ternary diagram shows the location of fly ash compositions by coal rank and source in North America. Field I is Wyoming Powder River Basin (PRB) subbituminous coal ashes. Field 2 is for Montana and North Dakota lignite ashes. Field 3 is Texas, Louisiana, and Saskatchewan lignite ashes. Field 4 is non-PRB subbituminous ashes. Field 5 is bituminous coal ashes. Phase boundaries shift with the introduction of magnesium and the diopside field becomes stable adjacent to anorthic. Lines of 8 and 20 percent CaO mark fly ash classification boundaries in the CSA specification.

High-rank coal fly ashes fall consistently in the mullite field. Depending on the geochemistry of the depositional basin, low-rank coals vary widely in their content of organically bound metals (esp. Ca, Mg, and Na), and their ashes span a wide range of compositions. Many low-rank coal ashes are intermediate in lime content and fall in the diopside-anorthite region of the ternary. Fly ashes from the sub-bituminous coals of the Powder River Basin falling in the melilite field, is the most important category of low-rank coals containing sufficient lime for their fly ashes to contain the cementitous phase tricalcium aluminate.

PRACTICAL CONSIDERATIONS

Natural variations in source coals and coal blending to meet emissions targets, lead to a wide range of possible fly ash compositions and applications. The current fly ash specification is limited and does not address the key parameter CaO. For certain applications, a low lime ash is preferred. When a Class C fly ash must be cementitious, lime content above 20 percent will be required. Fly ashes produced from sub-bituminous coal from the Powder River Basin usually contain sufficient lime to be cementitious, however, blending other coals with PRB coal may result in calcium being present in phases other than tricalcium aluminate. For quality control, total fly ash CaO may be quickly and easily determined by a rapid calorimetry procedure. Heat evolved by mixing 20 grams of fly ash and 75 mL of 15 percent HCl is related to total CaO using a simple linear correlation.⁹

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INCREASING CLASS C FLY ASH REDUCES ALKALI SILICA REACTIVITY

By James K. Hicks, P.E., Mineral Resource Technologies, Inc., A CEMEX Company

n the right proportions, Class C fly ash mitigates alkali silica reactivity in highly reactive, high alkali concrete mixes. Contrary to earlier studies, it has been shown that incremental additions of Class C do reduce ASR. Further, by adding metakaolin, silica fume or additional Class C, the reduction is even more pronounced. Also, tests show reduction in coulomb readings for the rapid chloride permeability test or ASTM C 1202. Some past studies indicated little benefit from the addition of Class C. Current findings demonstrate that correct proportions are critical. Recent testing demonstrates that Class C used at beneficial proportions of cementitious materials mitigates ASR in concrete mixes. This occurs although



Use of Class C Fly ash as an Additive to Mitigate ASR

available alkalis in the fly ash are at a level near the maximum AASHTO limit of 1.5 percent. A separate report demonstrates early performance remains uncompromised with properly proportioned aggregates.¹

In the study cited above, all mixes contained 611 pounds of cementitious material per cubic yard of concrete. The Portland cement used was high alkali cement from Maine with greater than 1 percent alkalis expressed as sodium equivalent in accordance with ASTM C 114.² The study incorporated aggregates from Massachusetts, known by the Massachusetts Department of Transportation to have ASR. The control mix, with cement as the only cementitious material, and aggregates tested at greater than 0.26 percent expansion, was determined using ASTM C 1260. Aggregates causing expansion over 0.2 percent by this standard are considered highly reactive. ^{3,4}

The Class C fly ash used for the test was from the Labadie Station plant in Missouri. Labadie fly ash, typically, has between 1.3 percent to 1.45 percent available alkalis by ASTM C 311.



Graph showing Mitigation of ASR with Properly Proportioned Class C Fly Ash Concrete Mixture using the ASTM C 1567 procedures.



ASTM C 1567 Expansion, 35 and 40 percent Class C Fly Ash with Meta-Kaolin or Silica Fume Added in the Amount of 5percent.

Mitigation of High Alkali Silica Reactive Aggregate with Class C Fly Ash

with class C Fly Ash

DISCUSSION

Salient points gleaned from the tests performed show several positive aspects:

- Mitigation of ASR by the use of additional Class C fly ash was shown by utilizing additional amounts of Class C fly ash as an additive
- When Class C fly ash was used at 35 percent, ASR was reduced to approximately 0.09 percent expansion after 14 days curing (according to ASTM C 1260, the entire procedure takes 16 days)
- Metakaolin or silica fume as a 5 percent to 10 percent additive in the concrete mix, replacing aggregate, significantly reduced ASR
- When Class C fly ash is substituted 1-1 at 25 percent for high alkali Portland cement, and additional Class C fly ash is added at the rate of 10 percent (substituted for 10 percent of the fine aggregate) the ASR expansion was reduced to below 0.1 percent (innocuous per ASTM C1260)



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- Hypothetically, in addition to other reactions, the reduced permeability of fly ash mixes could be further reason for the improved ASR
- Over a 120-day period the rapid chloride permeability, as measured by ASTM C1202, in concrete mixes where Class C fly ash was more than 30 percent of the cementitious material, the measured coulombs equaled approximately 1,000 compared with 1,844 for mixes containing no fly ash
- An accelerated method of testing using elevated curing temperatures provided a similar differential with coulomb readings at 56 days below 1,000 for fly ash mixes, and 1,989 coulombs for mixes with no fly ash

CONCLUSIONS

- Class C fly ash mitigates ASR when the substitution for cement is greater than 30 percent
- ASR expansion can be further reduced by substituting 5 percent metakaolin or silica fume for the aggregate in concrete mixes with high (more than 30 percent) Class C fly ash substitution
- Substitution of Class C fly ash for aggregate did not reduce the ASR expansion as much as the same amount of fly ash substituted for cement
- Class C fly ash substitutions greater than 30 percent for cement reduced the concrete permeability
- The compressive strength of concrete with 30 percent Class C fly ash exceeded the strength of concrete with no fly ash at 28 days
- The improvement in conductivity is likely due to improved permeability in the concrete mix

FURTHER WORK

Additional testing needs to be performed utilizing the same cement and aggregates with:

• Higher and lower amounts of cementitious content in the concrete

- Varying the water to cementitious ratio for given cementitious contents
- Mixes using additions of Class C fly ash in higher amounts as an additive
- Also, further work with additional cements, fly ashes and aggregates should be performed
- The impact of these mixes on other parameters such as sulfate resistance, modulus of elasticity, flexural strength, freeze/thaw, rapid chloride conductivity and other parameters needs to be tested. □
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Percent Fly As	h	0%	30%	35%	40%	40%+ 6% Metakaolin	
PHYSICAL TEST RESULTS	Mix Pro- portions	611 Lb Port- land/yd ³	C + FA 611 lb/ yd ³				
Type II Portland Cement C 150		33.4	23.4	21.7	20.0	13.0	
Fly Ash Labadle C 618		0.0	10.0	11.7	13.4	7.0	
Concrete Sand C 33	Lbs.	65.6	60.0	59.8	58.9	35.9	
Stone C 33 1" Top Size		101.1	103.6	104.0	104.5	62.4	
Water AASHTO TP 26		15.0	15.0	15.0	15.0	8.0	
Metakaolin C 618	6% of C+ FA	0	0	0	0	1.2	
Water/Cementitious Ratio	0.45 Max.	0.45	0.45	0.45	0.45	0.40	
Total Including Added Water	-	215.10	212.00	212.20	211.80	126.30	
А.Е.А. ASTM C 260	oz/cwt to give 5-6%	0.50	0.76	0.90	0.91	0.91	
HR Water Reducer C 484	oz/cwt for 3-5″ Slump	6.1	0	0	0	0	
	P	hysical Test	Results				
Slump C 143	3 - 5 Inches	4	4.5	5	6.5	3	
Unit Weight ASTM C 138	Lb./cu ft	143.2	144.8	144	144.8	147.9	
Yield	Lb_/cu yard	3866.4	3909.6	3888	3909.6	3991	
Compressive Strength C 192 psi							
24 Hours		2590	2100	1680	1440	940	
3 Days		4050	3870	3780	2850	2740	
7 Days		5030	4,250	3850	3210	5340	
28 Days	4000 psl	5670	5890	5410	4930	6770	
56 Days		6400	6610	5820	5681	6800	

Mix design and test data for Class C fly ash substitution for cement at 35 and 40 percent and with metakaolin or Silica Fume substitution for aggregate at 5 percent



Fly Ash Content	0%	30%	35%	40%	50%	
Mix De	Mix Design (Lbs/Yd ³)					
High alkali Type I/II portland cement	611	428.6			305.5	
Fly Ash, Labadie Class C	0	183.2			305.5	
High ASR, MA Concrete Sand C 33	1,201	1,109			1,049	
High ASR MA C 33, ¾″ Coarse Aggregate	1,486	1,480			1,474	
High ASR C 33,	495	493	491	493	491	
3/8″ Coarse Aggregate	495	493	491	493	491	
Water, AASHTO TP 26	243	243	243	243	243	
Physical Test Results						
ASTM C 1567 ASR (14 Days)	0.278	0.119			0.042	

Mix Design Data for Class C Fly Ash Replacement of Portland Cement.

Fly Ash Content:	0%	25+10%	30+10%	30+15%
PHYSICAL TEST RESULTS	611 Lb Port- land/yd3	C + FA 611 Lb/ Yd3	C + FA 611 Lb/ Yd3	C + FA 611 Lb/ Yd3
High Alkali Type I/II Portland Cement, ASTM C 150 (Lbs/Yd3)	611	458.3	428.6	428.6
Fly Ash, Labadie Class C	0	152.7	183.2	183.2
High ASR Concrete Sand, ASTM C 33	1,201	1,109	1,109	1,109
High ASR ASTM C 33 Coarse Aggregate	1486	1480	1,480	1,480
High ASR ASTM C 33 3/8" Coarse Aggregate	495	493	493	493
Water, AASHTO TP 26	243	243	243	243
Additional Fly Ash as additive C + FA	0	61.2	61.2	91.8

ASTM C 1567 Expansion with 25 and 30 percent 1:1 substitution of fly ash for Portland cement with additional Class C fly ash to mitigate ASR.

Percent Fly ash		0%	30%	35%	40%	40%+ 6%
			Metakaolin			
PHYSICAL TEST RESULTS	Mix Propor- tions	611 Lb Portland/ yd ³	1 Lb C + FA land/ 611 Lb/ Yd ³ d ³			
Rapid Chioride Permeability AASHTO T 277, ASTM C 1202	Maximum	Center 2", 2 Cylinders				
28 Days		3128	5461	4795	6460	1817
56 Days		2074	2122	1676	1968	1029
90 Days		2004	1441	1231	1410	757
120 Days	1000 Coulombs	1844	1185	989	1078	Completed
Rapid Chioride P HTO T 277, AST Accelerated	erm. AAS- // C 1202,	Center 2" average from 2 Cylinders				
28 Days	1000 Coulombs	2527	2122	1619	1501	757
56 Days		1989	989	576	885	Completed
90 Days		1772	Completed	Completed	562	
120 Days		1535			Completed	

Rapid Chloride Permeability of 611 lb/yard3 cementitious concrete mixes. Measurements discounted when coulombs were at or below 1000 or 120 days elapsed.

TEST METHODS

ASTM C 1202: Standard Test Method for Electrical Indication of Concrete's Ability to Resist Chloride Ion Penetration (Rapid Chloride Permeability)

ASTM C 1260: Standard Test Method for Determining the Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)

ASTM C 1567: Standard Test Method for Determining the Potential Alkali Reactivity Combinations of Cementitious Materials and Aggregate (Mortar-Bar Method) Compressive strengths, air content, slump, and yield were performed on all the mixtures in the MRT Technology Center in The Woodlands, Texas, following procedures for the appropriate ASTM Test Methods. ASTM C 1202, C 1260 and C 1567 testing was performed in the TEC Services Laboratory in Lawrenceville, Ga. TEC Labs approved for the tests performed by the American Association of Highway and Transportation Officials. TEC Labs also participates in the Cement and Concrete Reference Laboratory inspections and ASTM Interlaboratory Sample program.

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TEST PLAN

1:1 Substitutions of Class C Fly Ash for Portland cement at 0, 30, 35, 40 and 50 percent.

1:1 Substitutions of Class C Fly Ash at 35 percent and 40 percent for Portland cement, and substitutions of silica fume or metakaolin at 5 percent for the fine and coarse aggregate.

1:1 Substitutions of Class C Fly Ash for Portland cement at 25 percent, and further addition of 10 percent and 15 percent Class C fly ash as replacement for fine aggregate (FA).

PHYSICAL TEST RESULTS, 611 Lbs Cementitious per cubic yard concrete (Lbs/Yd ³)				
High Alkali Type I/II Portland Cement, ASTM C 150	397.4	397.4	366.3	366.3
Fly Ash Content	35%	35%	40%	40%
Fly Ash, Labadie Class C	214.3	214.3	245.4	245.4
High ASR Concrete Sand, ASTM C 33	1,094	1,094	1,079	1,079
High ASR ASTM C 33 3/4″ Coarse Aggregate	1,475	1,475	1,480	1,480
High ASR ASTM C 33 3/8″ Coarse Aggregate	491	491	493	493
Water, AASHTO TP 26	243	243	243	243
Metakaolin C 618 5 % of C + FA	30.6	0	30.6	0
Silica Fume C 618 5% of C + FA		30.6	0	30.6
ASTM C 1567 ASR 14 Days	0.045	0.031	0.036	0.026

Mix design and test data for Class C fly ash substitution for cement at 35 and 40 percent and with metakaolin or Silica Fume substitution for aggregate at 5 percent.

Particle Size Analysis Report





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General ACAA membership meetings offer industry intelligence, networking, and updates on new CCP production and use applications and technologies. Meetings are held three times a year. Every other year the association hosts the World of Coal Ash, with the Center for Advanced Energy Research of the University of Kentucky.

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World of Coal Ash Northern Kentucky Convention Center One West Rivercenter Blvd. Covington, KY 41011

SEPTEMBER 10-12, 2007

Fall Meeting Crowne Plaza Denver Hotel 1450 Glenarm Place Denver, CO 80202

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THINKING OUTSIDE THE BOX

By James McLean, InBulk Technologies

n early 2004, the European Coal Combustion Products Association distributed a report to the world ash community detailing the first application of a new conveyor system (ISO-Veyor) that was used to transport bulk fly ash to the construction of Heathrow's new Terminal 5 in London. The project involved delivering fly ash by rail to a concrete mixing operation near the construction site. Two moves a week were made using inter-modal dry bulk tank containers on rail flat cars.

The container is designed to be unloaded in a horizontal position with an air supply, rather than standing the container vertically. Containers are manufactured in 20-, 30- and 40-foot dimensions – standard lengths for rail movements in the United States, Canada and much of Europe. The containers can also be loaded onto truck trailers for easy transfer between power plant loading silos and rail delivery marshalling yards or waterborne vessel terminals.

The expansion of fly ash delivery systems into standardized containers is a new concept in North America – one that offers a great deal of flexibility. The ISO-Veyor container can be loaded and unloaded using standard port and terminal equipment and hauled by tractor-trailer trucks by rail or by water



transport. The container is loaded at a power plant by gravity – from an ash silo through a dustless unloader – into manhole hatches on top of the unit.

A typical 30-foot container unloads 35 tons of ash in 25 minutes. A unique air system design using patented Dense Phase technology from InBulk, allows for a slug of material to be moved with less air flow at pressures from 15 up to 30 PSI. More material is offloaded than with commonly used Lean Phase systems.

In North America, Dominion Ash of Canada, the agent for InBulk Technology, has pioneered the introduction of containerized loading systems for bulk powders. Working with Headwaters Resources, Cemex and Lafarge, InBulk and Dominion Ash have demonstrated the feasibility of this system by supplying material by railcar from plants in the United States to terminals in Mexico, Quebec and the Maritime Provinces.

Cost factors linked to distance, poor rail or truck service, and storage and infrastructure restraints often limits the ability of fly ash to be transported over long distances economically. The robust design of the containers have demonstrated that even after more than 2000 cycles, the units are not showing adverse downtime or lost availability due to damage or malfunction.

One needs only to stand by a busy rail line in North America to witness the booming growth of inter-modal freight transport. Entire trains of 80 to 110 cars of shipping containers routinely ply the rails from east to west and from the Great Lakes to the Gulf. The Association of American Railroads announced that 2006 would see the highest volume in inter-modal railroad-ing history. More than 12 million inter-modal shipments were made in 2006, up fourfold since the late 1970s.





One advantage that containers such as the ISO-Veyor system offer is transportation flexibility. Ash can be loaded at a plant in a truck mounted unit, and then transported to a rail or barge terminal for trans-shipment, without double handling of the material, to markets or destinations hundreds of miles away.

Logistical studies and demonstrations have shown that savings of up to 40 percent can be seen using these systems as compared to conventional pressure differential trailers. They open the door to many economic scenarios that were not possible in the past with more common rail cars or pneumatic trailers. The ability for the ash to be stored horizontally, up to four units high, also offers storage options that in the past were hampered by space limitations or lack of trailers or rail cars.

The cost of these containers is low enough to allow a marketer or distributor to purchase multiple units rather than construct an expensive storage building, dome or silos. One ISO-Veyor and a flatbed trailer is less than the cost of an Aluminum PD Trailer. These inter-modal containerized systems offer new opportunities for power plants with direct rail access and those facilities with lack of rail service, to reach markets previously considered impractical.

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