ISSUE 1 • 2009

ASH at work

Applications, Science and Sustainability of Coal Ash

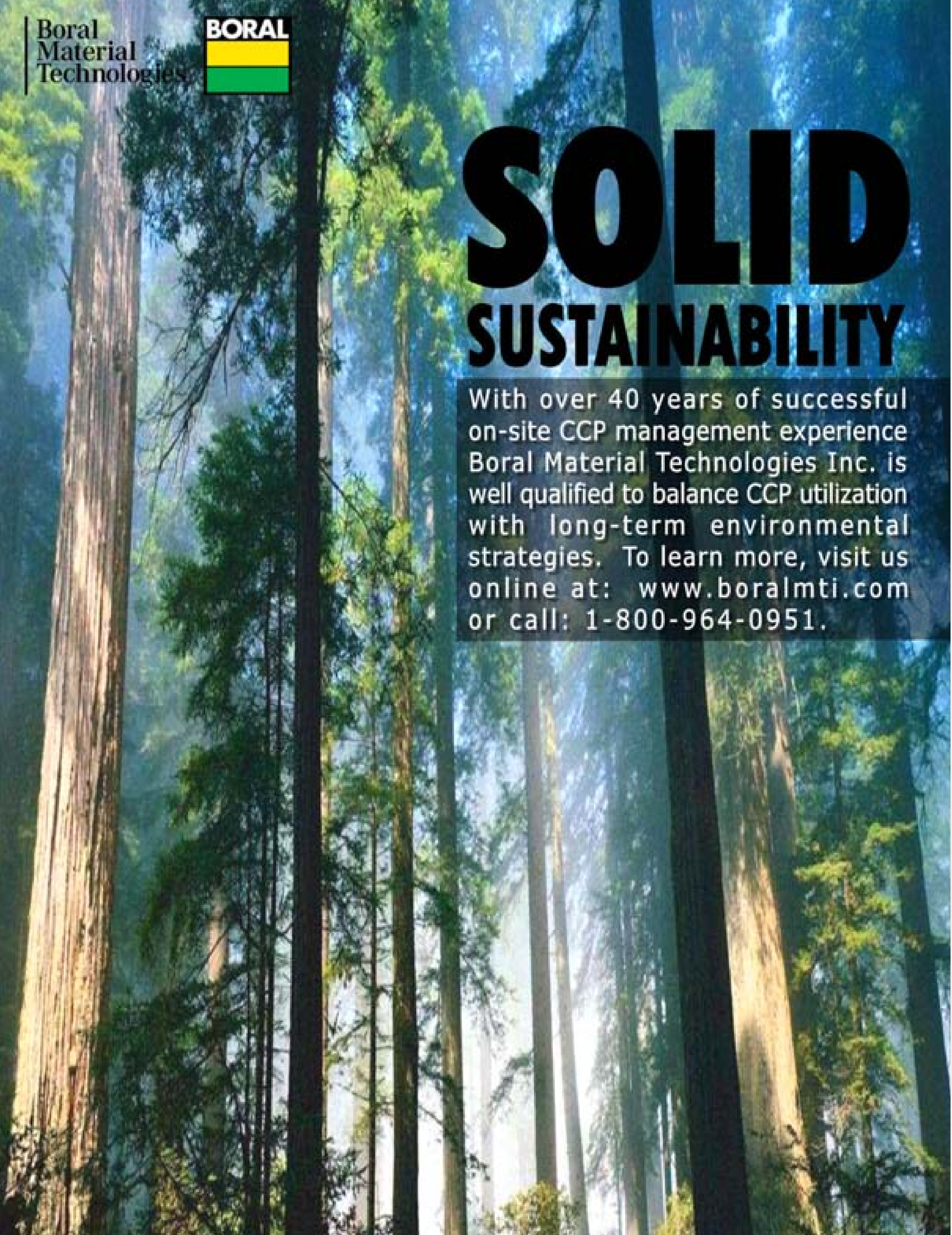
A GREEN GEM IN THE TREASURE STATE

PROJECT USES CONCRETE MIX WITH 100 PERCENT FLY ASH

GEOPOLYMER CONCRETES

A GREEN CONSTRUCTION TECHNOLOGY RISING FROM THE ASH

The Arthur Ravenel Jr. Bridge, Charleston, South Carolina, was constructed using high-volume fly ash concrete.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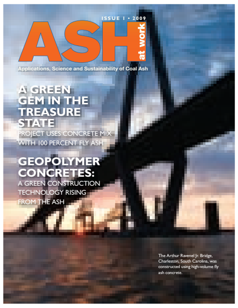
On the cover:
The Arthur Ravenel Jr. Bridge, Charleston, South Carolina, was constructed using high-volume fly ash concrete. This image of the bridge at sunrise is also symbolic as ACAA welcomes our new executive director, Mr. Thomas H. Adams, who will link diverse interests to advance CCP management and use.



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CHANGE IS OUR WAY OF LIFE

Mark Bryant, ACAA Incoming Chair, Ameren

2009 is in, 2008 is finally out, the year that started like a lamb and ended like a lion; a historic year that we will be talking about and studying for a long time. Politics, economic slowdown, elections, global issues, etc. Wow!

As an association we have made some history of our own, 40 years in the book, and we have a good year coming up. A new Executive Director, a retiring champion of our industry, yet another world class industry gathering in WOCA. It's sure to be interesting.

Having just returned from our well-attended meeting in Scottsdale and preparing for a changing of the guard, so to speak, CHANGE is our way of life it seems. Soon, we will all get the opportunity to meet our new Executive Director, Mr. Tom Adams. Tom comes to us from The American Concrete Institute and the American Shotcrete Association. Tom and his family will be relocating to Denver soon and he is looking forward to getting his feet wet with our association as soon as possible. This is no small task as we are a very diverse and dynamic association. Our members span several industries, our staff wears many hats and our friends and partners come from all corners of society; industry, government, academia, such that it may take more than a week or two to learn how it all works and meet everyone. Tom, you have many friends in our association and many resources to draw from, don't be afraid to call. Your success will be our success. We look forward to a bright future for you for many years to come.

While I'm on this topic, I would like to express my thanks to the Executive Director Search Committee without whom this process would've been MUCH more difficult. Our volunteer members' willingness to take precious time from busy schedules, travel on stretched budgets, and help to make difficult choices between several very qualified and capable candidates is appreciated. I owe you guys one and look forward to paying this debt off soon. Messrs. Christiansen, Gustin, Jansen, Frady, Price, Roof and Thomes; I thank you. A special note of proud thanks to the staff for their help with all the necessary arrangements and especially their honest and earnest input into this selection.

And now, we have an industry champion who has chosen to retire. In sports, as in life, it is always a desire to "go out on top." Dave, you have given us seven great years of steady leadership, remarkable energy, clear vision and you truly do go out on top. We are stronger in so many ways because of you. You have promised to be there if and when we need you and I can promise that we will be calling, we still have much to do.

I am excited for you and on behalf of all the association, proud to call you a friend. Thank You. What time is it again?

Finally, it is hard to believe that I started working on ash beneficial use, management and disposal issues in 1992, or about the same time that the last significant landfill regulations were being implemented. I realize that some things in this industry change very slowly, almost glacial. But even young dinosaurs are extinct, aren't they? However the structural failure at Kingston and the overflow at Widows Creek along with other recent events are sure to accelerate greatly the pace of the discussion and the possibility for new and protective and restrictive standards for ash management. ACAA and our friends and associates in the industry and affiliated industry will need to continue the excellent communications so that the true and factual "good" story of coal ash reuse and recycling can continue. Our positive impact on the economy is significant, and will be more so in the future. In the next weeks and months words like "hazardous" and "toxic" will be incorrectly applied in an attempt to persuade those who don't understand this issue as well as we do in the industry. If we listen to good science, these words will fall away and we will get to the right answers about whether changes are warranted. From challenges spring opportunities.

Thank goodness serious injury at Kingston was avoided. TVA should be commended for the quick response. I look forward to a thorough investigation and the opportunity to learn the lessons of this event as they are never as easy and straightforward as initially thought.

Taking a longer view, mercury control and activated carbon injection, structural fill standards, natural resource preservation, carbon dioxide, and economic impacts are issues that we will face in the future. As an industry we are going to have these and other issues and therefore some opportunities that we will need to address and that may take a special effort. For instance, I believe that state and federal regulators in all states would appreciate an industry standard of practice for beneficial use structural fills that could be adopted universally, appropriately including health and environmental considerations and that is prepared by the best resources available. To be proactive in this and other matters of importance to our industry is definitely in our best collective interest. This is the value of the ACAA.

No, I don't think the pace of change is going to slow for us for quite some time. So long for now, see you in Lexington, Ky. as we get ready for WOCA 2009. ❖

STEPPING AWAY BUT REMAINING INVOLVED

By Dave Goss, American Coal Ash Association

As we start year 41 of the American Coal Ash Association, it looks like it is going to be a year of change. President Obama has become the new Chief Executive and we have already seen that he is planning to change many things. The nation's economy is in the midst of turmoil. Our institutional financial system is undergoing dramatic upheaval as federal dollars are being injected into the economy in ways never before seen of this scale in the United States. The new president pledges an emphasis on rebuilding the nation's infrastructure, from roads and bridges, to water systems to public schools. And, there has been a national call for another look at coal ash, as a result of the unfortunate incident on December 22 in Kingston/Harriman, Tenn.

Like we did in the middle and late 1990s, ACAA will be working with the EPA, EEI (USWAG), government officials, state regulators, and other industry associations to respond to the misinformation being widely distributed by environmental advocacy groups as well as being reproduced in the media. We will be crafting messages that will support fact-based decision making. The spill at Kingston does not warrant regulating CCPs as a hazardous waste, nor were the releases of a "toxic" nature as was so carelessly reported by some (most?) of the media.

We always have maintained that when properly managed, CCPs do not have an adverse impact on public health and the environment. The breach of the containment pond resulted in a negative impact because its contents were no longer where they were intended. No injuries occurred and the public was isolated from the spill to minimize exposure and contact. The community was affected and changed in ways not expected. However, TVA should be commended for its aggressive and immediate response to the incident, which has been clearly documented in detail on its Web site at www.tva.org. We need to redouble our efforts to educate the public and their elected officials as to the benefits of using CCPs, thus reducing the need to dispose of them in wet or dry facilities. Furthermore, we cannot ignore the impacts of inefficient resource management on our environment and society. The use, reuse and recovery of industrial materials, including CCPs, play a vital role in sustainability.

Those of you who did not receive an invitation to the inauguration in Washington were introduced to another change in Phoenix at the ACAA annual meeting held on January 20 and 21. We included guest speakers and a specific topic at each of the three standing committee meetings. This allowed us to leverage our time and include in-depth presentations on timely topics, in addition to those presentations that are normally offered at our day-long technical session on Wednesday. Secondly, on Wednesday, as part of the State of the Association message, I had the privilege of introducing ACAA's new Executive Director. Mr. Tom Adams comes from the American Shotcrete Association and American Concrete Institute. Tom's experience in this allied industry will help his transition into ACAA. I know he will be pleased to get to know and work with you in the coming year.

As I step away from association activities, I plan to remain involved in the CCP industry. The variety of issues and the many friendships that I have makes leaving the day-to-day responsibilities of ACAA a somewhat regrettable parting. Yet, each of us reaches a point in our lives that we have worked for many years to achieve – retirement. I was just a college kid about ready to enter the Air Force when Paul McCartney wrote the song, "When I'm 64." Now that I am, those lyrics hit really close to home: "…When I get older losing my hair … Birthday greetings … bottle of wine … Doing the garden, digging the weeds, Who could ask for more … We shall scrimp and save … Grandchildren on your knee … Will you still need me … When I'm 64?"

And now that I have my Medicare card, I am really feeling the number. As I have achieved that "magic" number it is time to offer Tom the opportunity to take ACAA to the next level of achievement. We have a solid financial foundation with outstanding volunteer leadership and staff. As I move on, I do so thinking of Sgt. Pepper's words on board the Yellow Submarine, "As we live a life of ease, everyone of us has all we need." I sincerely appreciate your wonderful support and mentoring of me during my 14 years in the industry. You are all terrific. THANK YOU! ❖


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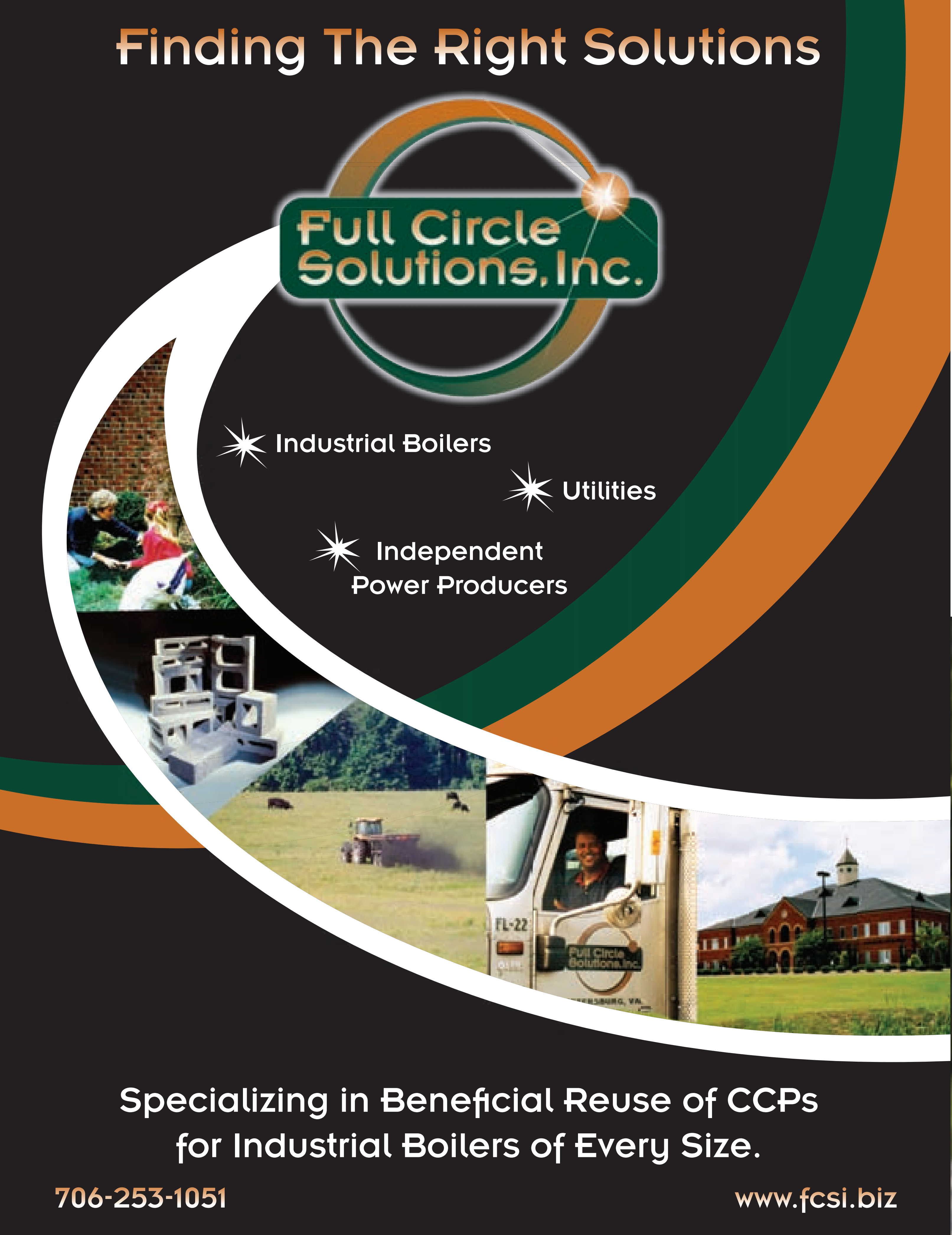
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FROM THE NEW KID ON THE BLOCK…

Thomas H. Adams, American Coal Ash Association

The noted twentieth century philosopher Yogi Berra once said, "It's tough to make predictions, especially about the future." And he was right. It is safe for me to say that 2009 will be a year of many changes for our country, the ACAA and for me personally. Some of these changes are predictable and some not. With the new administration in Washington we are faced with the very real probability of new regulations and restrictions affecting coal combustion products. In assuming the role of ACAA Executive Director, I will be challenged to learn the CCP industry while maintaining and building on the initiatives that have made the ACAA a successful entity. The association is blessed with strong leadership and staff to help me become familiar with the issues and interests of ACAA members.

I come to the ACAA from a career in the concrete industry working in marketing and technical services for three ready mixed concrete companies in Michigan. In addition, I have served as a staff member for the American Concrete Institute, American Shotcrete Association, and the Michigan Concrete Association. Having experience as both an elected volunteer leader and a staff member will be a valuable asset in serving the ACAA.

I would like to take this opportunity to thank Chairman Mark Bryant and the Search Committee for their thorough and timely responses to my questions and concerns regarding the expectations for the new Executive Director. Their professional approach to the process was most impressive and assured me that I can help lead the ACAA going forward.

Dave Goss has left the store in good shape. I have been assured that he will not wander too far, so I can rely on his guidance as I learn the CCP industry. I join all of the ACAA members in wishing Dave a long and happy retirement! ❖

Dave Goss has left the store in good shape. I have been assured that he will not wander too far, so I can rely on his guidance as I learn the CCP industry.

ISO-Veyor 'The workhorse for dry bulk'

InBulk Technologies Ltd, UK

Whether it's for cement, fly ash, limestone, dry mortars, screeds or ground blast furnace slag, when it comes to transporting and storing 'dry' construction materials, InBulk Technologies has developed a range of commercially and logistically viable alternatives to traditional storage silos, dedicated road, and rail wagons.

The ISO-Veyor is an intermodal tank container developed by InBulk Technologies, facilitating easy transition between road, rail and sea.

It consists of a cylindrical vessel constructed within the frame dimensions of a 20 ft or 30 ft ISO unit. It can be handled exactly as a standard ISO container, utilising currently available trailer chassis and rail car rolling stock and is compatible with container shipping as it shares the same ISO dimensions of standard shipping containers. The ISO-Veyor can be handled efficiently and easily by standard container infrastructure.

The ISO-Veyor can be filled at source and remain sealed until the point of delivery thus removing the need for intermediate handling or storage of the contents.

The clever part is that the ISO-Veyors fluidisation membrane is designed to follow the curvature of the tank barrel, avoiding the need for space consuming cones, thus allowing superior payloads and discharge performance in terms of both time and residue remaining. With the simple addition of an air supply (and without tipping, so reduced opportunity for accidents or need for a costly tipping chassis) the ISO-Veyor discharges its contents, 30 tons in 30 minutes and leaves very little material behind following every discharge.

The major advantage that the ISO-Veyor system offers is transportation flexibility.

Cement, coal ash and lime are being loaded at terminals by gravity through standard manholes, while mounted on a trailer or railcar, and then transported to a rail or barge shipping terminal for trans-shipment, without double handling of the material, to markets or destinations hundreds of miles away.

One area where InBulk has witnessed a surge of activity is for customers operating to projects located on Islands. Some scenarios include construction projects, where the ISO-Veyor provides an ideal system for intermodal deliveries without the requirement to make investments in silos or large volume storage facilities.

Previously, handling situations required Pressure Differential Tankers on ferries or RORO ships. Costs due to trailer damage, driver hours, longer distances and fuel surcharges are avoided. ISO-Veyors are more environmentally friendly as they allow owners to make choices between the most efficient methods for transport.

The ability for the material to be stored horizontally, up to four units high, also offers on-site storage options that in the past were hampered by economics or space limitations or lack of trailers or railcars.

The products which can be transported in ISO-Veyors have extended market access for powders like cement, fly ash, ground granulated blast furnace slag, white cement, aluminates and by-products. Future developments will see this range extended to chemicals and food grade versions, which would be fully cleanable in line with current systems for liquid ISO-Tanks.

Jim MacLean, Business Development Manager for the US & Canada explains:

"Through our parent group's global network, InBulk now has the ability to offer a managed dry bulk logistics service almost anywhere in the world.

New enquiries from areas such as mining, construction and industries seeking new supply sources have increased dramatically since our first start of operations, especially from island locations.

The enquiries have included ISO-Veyors travelling between locations in the Caribbean, Central and South America to North America. Asia, Indonesia and Malaysia are also interesting markets with a lot of scope for development."

The ISO-Veyor has made notable strides in key US markets. During 2006 Lafarge North America became the first American owners and operators of the ISO-Veyor.

The ISO-Veyors are proving to be a robust workhorse, withstanding the rigours of high utilisation and varying climate.

Stephane Caron, Distribution Operation Manager for Eastern Canada comments:

"We are delighted with the flexibility offered by the ISO-Veyor. Both costs and risks are minimised, whilst maximising supply chain efficiency. Empty containers are off-loaded, transported to our terminal for reloading and returned to the ship for the return leg same day. Lafarge also recognizes the ISO-Veyor technology supports our corporate goals for sustainability."

To arrange a trial of the ISO-Veyor contact Jim MacLean

James MacLean PEng

Business Development Manager

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RECYCLING THAT WORKS

In 1973, Phoenix Cement Company began recycling approximately ten thousand tons of raw fly ash per year from the Cholla Power Plant at Joseph City, Arizona for use in the production of ASTM C595 Type IP cement at its Clarkdale, Arizona Cement Plant. Prior to this, 100% of the fly ash and bottom ash produced at the Cholla plant was disposed of in settling ponds.

As demand grew for the benefits of a high quality, consistent fly ash, Phoenix Cement Company installed a fly ash beneficiation facility at Cholla in 1986. This would prove to be the beginning of a construction-based product recycling effort that has grown to include four power plants in New Mexico and Arizona, with multiple products being supplied to the concrete and concrete products industry throughout the Southwest.

Thirty Five years later, nearly ten million tons of Coal Combustion Products (CCP's) have been recovered and marketed by Salt River Materials Group, the commercial marketer of Phoenix Cement Company products, in its Pozzolans business unit. These CCP's are collected from the Cholla Power Plant at Joseph City, Arizona, the Four Corners and San Juan Power Plants near Farmington, New Mexico and the Escalante Generating Station at Prewitt, New Mexico.

Committed to adding value to its utility partners, Salt River Materials Group's quality control program also helps them burn more efficiently, reducing coal consumption and extending one of our country's greatest natural resources. All of this is done within the scope of a competitive business, providing valuable proof that, with vision and long term investment, market-based recycling is "Recycling That Works".

A GREEN GEM *in the* TREASURE STATE

Project Uses Concrete Mix with 100 Percent Fly Ash

By Doug Cross, Jerry Stephens and Mike Berry, Western Transportation Institute-Montana State University

PROJECT AND PARTICIPANTS

In 2007, MacArthur, Means and Wells (MMW) Architects of Missoula, Mont., contacted researchers at the Western Transportation Institute (WTI) at Montana State University (MSU) about using innovative concrete materials in an effort to achieve a Platinum (highest rating possible) LEED certification on a commercial building project they were working on for the Missoula Federal Credit Union (MFCU). Part of a project's rating is based on the characteristics of the materials from which it is constructed, with points being awarded for the use of recycled and locally available materials. MMW was interested in using a concrete that was produced with locally available fly ash for the binder and pulverized container glass for the aggregate. Ultimately, the footings and foundation walls, floor slabs, exterior precast architectural wall panels, and two interior load-bearing beams were constructed with this new, environmentally friendly material.

Prior to the MMW project, significant research had been conducted at Montana State University (MSU) on structural concretes in which 100 percent of the portland cement was replaced with fly ash.[1,2] In working with this new material, it was quickly discovered that it offered exceptional performance with respect to short-term strength gain, long-term ultimate strength, and workability relative to traditional portland cement concrete. Concrete mixtures with 100 percent fly ash routinely achieve two-day strengths in excess of 2,900 psi and 28-day strengths in excess of 4,800 psi (without extraordinary curing measures). Subsequent long-term strengths have reached as high as 8,000 psi at one year of age. These results have been achieved with very workable mixtures (6-inch slump) without the use of sophisticated admixtures common in the concrete industry.

In 2000, researchers at WTI/MSU began informally investigating the use of pulverized glass in 100 percent fly ash concrete for nonstructural applications, such as countertops and other architectural surfaces. The concrete mixes resulting from this work showed promise for structural applications with similar

ABOVE PHOTO:
Ground and polished floor slab before sealing

set times, workability, and strengths of traditional concrete. However, before moving ahead with this material in any such applications, it was recognized that significant testing would be required to investigate its fundamental engineering properties and long term durability, and the applicability of existing structural engineering design procedures in its use. This MMW project gave WTI/MSU the opportunity to formally begin researching these matters for 100 percent fly ash concrete made with glass aggregate.

Because of scheduling constraints, the research effort was focused only on the specific needs of this project, which consisted primarily of determining the specific mixture proportions required to produce a fly ash, glass aggregate concrete that met the performance requirements of the project, and subsequently confirming its durability and behavior in reinforced structural elements. Briefly described below are the steps that were taken to make this "green concrete" work for this project in Missoula.

MIX DESIGN AND MATERIALS

The fly ash used for this project is a Class C fly ash from the Corette Power Plant in Billings, Mont. Selected characteristics of this fly ash are presented in Table 1. Note the high calcium content, which is critical to the hydration reaction that occurs when water is added to the fly ash.

TABLE 1 Fly Ash Properties

Chemical						Physical		
Silicon Dioxide	Aluminum Oxide	Iron Oxide	Sulfur Trioxide	Calcium Oxide	Loss on Ignition	Fineness, Retained on #325 Sieve	Soundness, Autoclave Expansion	Density
(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)	
32.37	17.52	5.34	2.02	28.89	0.23	12.1	0.17	2.72

The recycled pulverized glass was of mixed color and was provided by the Montana Department of Environmental Quality. It was pulverized using an Andela crusher operated by Headwaters Recycling based in Helena, Mont. The glass particles were separated into two distinct size fractions, 1/8 inch minus and 3/8 inch to 1/8 inch. To ensure uniformity with respect to set time and strength gain, all the pulverized glass was thoroughly washed prior to use in the concrete mixtures.

One impediment to using 100 percent high calcium fly ash is the accelerated rate at which chemical reactions begin to occur when water is added, which leads to flash setting of the material. To avoid flash setting, 20 Mule Team Borax ($Na_2B_2O_3 \cdot 10H_2O$) was used as a set retarding admixture.

Two mix designs were developed for this project (Table 2). Both mixtures had a water-to-fly ash ratio (w/fa) of 0.20. The mixtures differed only in the aggregate size; one mix, referred to as mix (c), used equal amounts of fine (1/8 inch minus) and coarse (3/8 to 1/8 inch) glass, while a second mix, referred to as mix (f), only used the fine glass (1/8 inch minus).

TABLE 2 Mix Designs for 1 yd3

Batch	Water (lb)	Fly Ash (lb)	Fine Glass (lb)	Course Glass (lb)	Borax (lb)
c	346.68	1733.67	792.45	792.45	21.60
f	348.57	1742.58	1573.83	0	21.78

The criteria for developing the two mix designs were based on workability (slump of six to eight inches), set time (two to four hours), strength gain (greater than 4,000 psi at 28 days) and dimensional stability (nominal shrinkage). Once the mix designs were completed in the laboratory, full size trial mixtures were batched and mixed at the concrete producer's yard. Trial mixtures are paramount to successfully implementing this new material because they give key personnel an opportunity to observe firsthand its workability and setting behavior prior to actual application on the construction site. Once the trial pours were successfully completed, work began on the MFCU building, itself.

Chapman Concrete Construction Inc. employees hand-broadcasting green glass on surface of slab. (May 2008)

Chapman Concrete Construction Inc. employees placing interior slab sections. (May 2008)

DURABILITY

A major cause of deterioration of concrete is the generation of expansive forces within the material, which can result from delayed chemical reactions between alkali in the binder and silica in the aggregates (referred to as akali-silica reactivity or ASR), and/or physical expansion of water within the material during repeated freeze-thaw cycles.

The susceptibility of a particular concrete to ASR-related degradation is difficult to predict based simply on the properties of the binder and the aggregates themselves. Thus, this susceptibility is generally determined by testing. There are several accelerated test methods for determining ASR reactivity in concrete; ASTM C1260 was deemed to be the most appropriate test method for this project. In this test, mortar bars are submerged in a heated alkali solution, and their expansion is measured over time. The recommended limit of expansion to delineate potentially reactive aggregates is 0.2 percent (ASTM C1260) over 14 days, although some agencies adopt a more conservative limit of 0.10 percent. For this project, mix (f) had an average expansion at 14 days of 0.0312 percent and a 28-day expansion of 0.0597 percent; both of these values are well below the limits mentioned above. Mix (c) also performed well with 0.050 and 0.146 percent expansion at 14 and 29 days respectively.

Freeze-thaw resistance is being quantified following the procedures in ASTM C666 (Procedure A). This test method consists of subjecting concrete specimens to multiple freeze-thaw cycles while fully saturated. Weight loss and change in dynamic modulus are being monitored as a function of accumulated freeze-thaw cycles. As may be obvious, the degree of damage sustained by the concrete due to micro (as well as macro) cracking under freeze-thaw action is reflected by its attendant loss of weight and stiffness, where material stiffness can be non-destructively measured in terms of dynamic modulus. Once 300 cycles are completed, a durability factor will be calculated for the particular mix designs being investigated.

MMW's project for the MFCU has been an excellent next step and afforded WTI/MSU an excellent opportunity to continue its research and development of 100 percent fly ash concrete for building applications.

STRUCTURAL

In almost all structural applications, concrete must be reinforced to provide the strength and/or ductility required in contemporary designs. While the behavior of conventional concrete coupled with reinforcing steel is well understood, this behavior is complex, and it is important to confirm by laboratory test how reinforced elements behave that are made with new materials, such as fly ash as the binder and recycled glass as the aggregate. Past work at MSU has consistently confirmed that structural elements made with fly ash concrete with conventional aggregate behave similar to elements made with traditional portland cement concrete.[2]

The structural performance of 100 percent fly ash concrete with recycled pulverized glass aggregate was investigated through a series of 12 beam tests. The beams were tested in third-point bending until failure, and the force-deflection behavior was monitored. One of the 12 beams was a half-scale model of the actual beams used in the MFCU building.

Half scale beam test at failure. (November 2007) Kyle Applebury is inspecting the flexural cracks.

The results of these beam tests indicated that using existing design equations to determine the capacity and performance of reinforced elements made with this material appears promising. The predicted moment capacities of all the beams were within 12 percent of their actual capacities.

With respect to shear, the actual capacity exceeded the calculated capacity in all cases, although some of this apparent conservativism may be related to the test configuration used, rather than being an inherent property of the material (additional testing is necessary and is planned in this regard).

Actual precast load bearing beams. (June 2008)

CONCLUDING REMARKS

MMW's project for the MFCU has been an excellent next step and afforded WTI/MSU an excellent opportunity to continue its research and development of 100 percent fly ash concrete for building applications. Building on previous projects which included casting ecological blocks, a building foundation, cast in place slabs, and many precast vault toilets for the Forest service, the results from this research program have proven that this is a viable building product and that in some respects it outperforms portland cement concrete.

While many people have contributed to the success of this project, the owners (MFCU), the architects (MMW) and the consulting engineers (Beaudette Consulting Engineers Inc.) of Missoula, Mont. need to be recognized for their ongoing commitment to push smart sustainable building to new heights. ❖

MacArthur, Means and Wells (MMW) Architects achieved a Platinum LEED certification for this commercial building project they were working on for the Missoula Federal Credit Union (MFCU).

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SYNMAT

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Synthetic Materials (synmat) specializes in the dewatering of synthetic gypsum slurries to produce gypsum cake. Synmat is involved in all aspects of synthetic gypsum production, marketing and transportation. By taking ownership of the gypsum in slurry form and providing the capital for the gypsum dewatering facility, Synmat eliminates gypsum production risk from the utility and meets the needs of our customers in gypsum board, cement and agriculture.

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ASH AT WORK MAGAZINE TO FEATURE SECTION WITH PEER-REVIEWED RESEARCH

The University of Kentucky's Center for Applied Energy Research with the ACAA is introducing a peer-reviewed journal entitled *Coal Combustion and Gasification Products*. Abstracts will be featured in an insert in *ASH at Work*, while the journal's full content, including papers, letters to the editor, book reviews, symposia proceedings, surveys, and other content will be available online, free-of-charge to both authors and readers.

While emphasis will be on products from coal combustion and gasification, products of the co-combustion of tires, petroleum coke, biomass, etc., with coal will also be considered. Above all, a contribution accepted for publication should be a novel, original, concise, and a well-written advancement in the science and/or engineering of coal combustion and gasification products.

Publishing with *ASH at Work* will provide immediate visibility for *Coal Combustion and Gasification Products* and enhance the impact of the online full-text papers. Other advantages to authors include the option to submit metadata for indexing; the opportunity for full-text indexing with top search engines; and the ability to provide supplementary materials for their papers, including color photos/graphics, audio and video, data sets, etc.

The journal's editorial board consists of experts from academia, industry and government. A list of the members is available via the journal's Web site.

For more information, please visit www.coalcgp-journal.org or contact the Editor-in-Chief, James Hower, PhD (hower@caer.uky.edu).

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GEOPOLYMER CONCRETES:

A GREEN CONSTRUCTION TECHNOLOGY RISING FROM THE ASH

By Erez Allouche,
Louisiana Tech University

The making of geopolymer concrete.

Introduced in the 1970s, inorganic polymer concrete (geopolymer) is an emerging class of cementitious materials that do not need the presence of portland cement as a binder. These inorganic alumino-silicate polymers are synthesized from materials of geological origin or byproducts such as fly ash, and are formed by the polycondensation of monomers (sialate) under highly alkaline conditions that yield polymeric chains, which are cross-linked with the aid of temperature, forming a gel-like structure with a short-range order. To form geopolymer concrete, a pozzolanic powder (e.g., fly ash, metakaolin) and an activator solution, e.g., a mixture of alkaline silicate and hydroxide, are blended together with fine and coarse aggregates using standard mechanical mixing devices. The resulting mixture can be handled and cast in the same manner as portland cement-based concrete. To achieve complete reaction, curing is commonly performed under elevated temperature (approximately 140° F), although curing at room temperature might be acceptable for non-structural applications. Growing public concern with the prospects of global warming, recognition of the need for a more sustainable economy, increased energy costs, and increased coal production to meet escalating global demand for electrical power, has earned geopolymers a growing attention worldwide as a potential commercially viable alternative to portland cement.

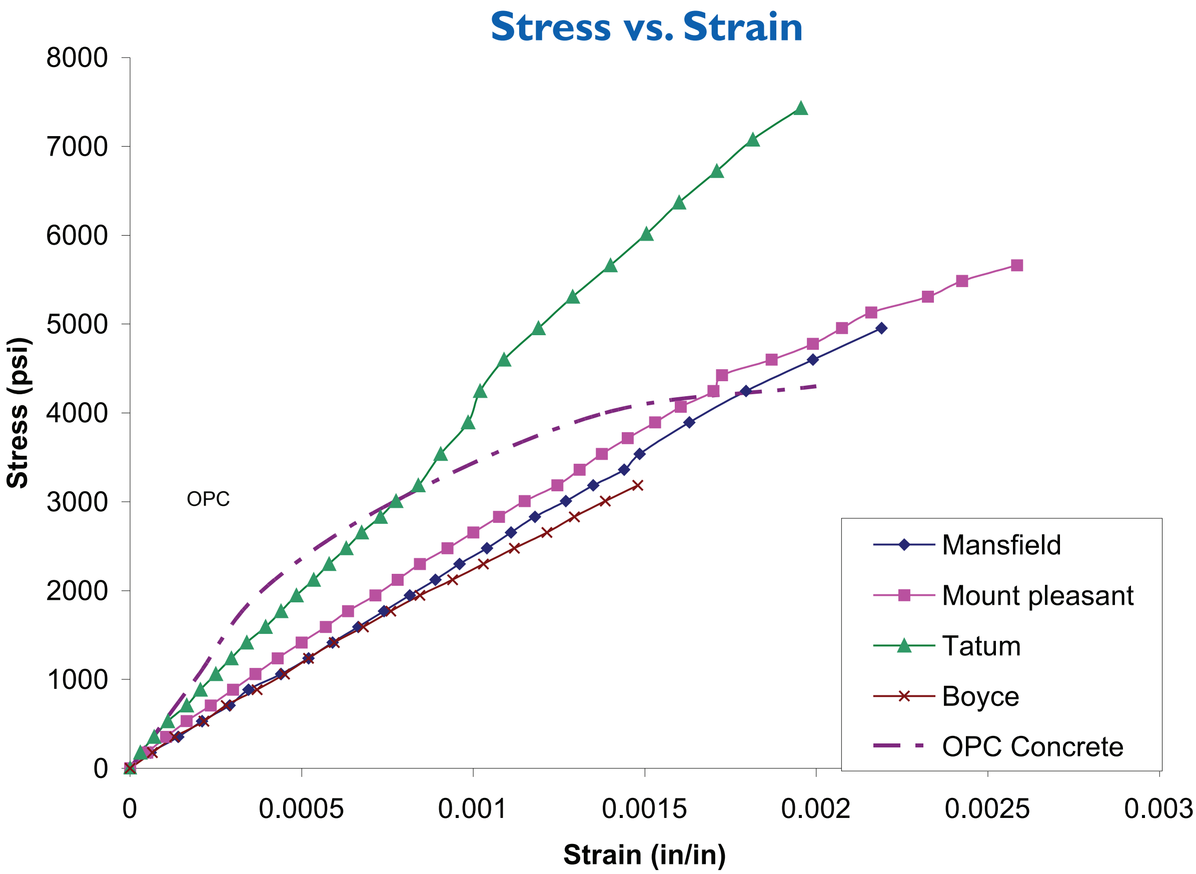
Researchers at LTU pouring a floor out of GPC

One of the main reasons for the growing interest in geopolymer concrete technology is its life-cycle greenhouse gas reduction potential. The production of portland cement, the most common construction material in the world, contributes about 7 percent of the total global man-made carbon dioxide emissions to the atmosphere, with 1 ton of carbon dioxide produced for each ton of portland cement manufactured. Unlike portland cement, which requires calcite (CaCO3) as its main raw material for the CaO necessary for clinkerization, geopolymer relies on fly ash, a coal combustion product (CCP). Thus, geopolymers are considered eco-friendly construction materials in two distinct ways: a) reducing the need for portland cement, and the associated carbon dioxide emissions; and, b) converting currently utilized CCPs into beneficial construction materials, thus reducing landfill and disposal facility requirements. Geopolymer concrete technology is particularly attractive as it's not limited to Class C fly ash (for which there's a high demand in the cement industry), but can also utilize Class F fly ash. Additionally, geopolymers can tolerate higher concentrations of ammonia and other impurities in the raw fly ash compared with current portland cement applications. This is of particular importance in view of recent air emission regulations faced by the coal-fired power stations. Measures taken to meet these new standards are expected to adversely affect some traditional utilization of coal fly ash because of increased levels of impurities.

By comparison to ordinary portland cement (OPC), geopolymer concrete (GPC) features higher resistance to acid and sulfate attacks, a substantially higher fire resistance (up to 2,500° F), high compressive and tensile strengths, a very rapid strength gain (a compressive strength of 16,000 psi can be achieved in as little as one day), and lower shrinkage. Alkali-aggregate reactions do not occur in geopolymer concrete and its nanoporous pore structure results in greatly reduced permeability and ionic diffusion. The United States produces 70 million tons of coal fly ash a year as a byproduct of energy production and other industrial activities. Annual production rates in India and China are estimated at 100 and 200 million tons, respectively, with global production exceeding 600 million tons. In recent years, coal consumption grew by nearly 5 percent per year to meet rising global demand for electrical power, and it's expected to keep growing at a high rate for the foreseeable future. The demand for portland cement around the globe is also on the rise, with current consumption level estimated at 1.56 billion tons per year. In the United States alone, demand is anticipated to increase 43 percent by 2030, to 183 million metric tons per year. China's current consumption of portland cement is nearly 600 million metric tons per year, and demand is not expected to diminish in the near future. Thus, it is of little surprise that researchers and entrepreneurs alike, around the globe, view geopolymers as ecologically friendly materials that could serve as substitute for portland cement in many applications.

To date, geopolymer concrete technology has focused on niche applications, with activities concentrated in Australia, New Zealand and France, among others. Specific applications investigated include precast applications (e.g., sewer pipes, railway sleepers, wall panels), pavements and pavement repair, void-sealing grouts, bricks for residential construction, and the encapsulation of mine waste. Other research work has focused on the adaptation of geopolymers for high-tech applications such as tooling for the aeronautic industry and the development of fire-resistant composite panels for the interior of aircraft. However, geopolymers have been little studied in North America in the context of large scale production. While offering many advantages, the characteristics of these materials and their drawbacks must be more fully understood to properly evaluate their potential and optimum application. In other words, the feasibility of converting various grades of fly ash to a feedstock for construction quality geopolymer concrete needs to be carefully examined. Specific areas requiring additional study include mix design formulations that are not source specific, design and construction guidelines and standards, and a new generation of admixtures. Additionally, full scale demonstration projects are needed to validate laboratory observations and provide increased confidence in this new generation of construction materials.

Researchers at Louisiana Tech University have embarked on a multi-year research initiative to develop practical applications for geopolymer concrete in the area of civil construction, and to bring some of these applications to market with the assistance of state agencies and private corporations. The following sections provide brief descriptions of some of these research projects, their objectives and accomplishments to date.



Stress-strain relationship of four different fly ash types vs. OPC

NOVEL GEOPOLYMER SPRAY-ON COATING FOR HARSH ENVIRONMENTS

Applying a protective coating is one of the most economic methods for prolonging the service life of concrete structures in harsh environments. The objective of this project is to produce a high-quality, durable and cost-effective spray-applied geopolymer coating product. The application selected was the protection of wastewater conveyance and treatment facilities. The challenge was to create a mix design that could satisfy both mechanical strength and corrosion requirements, with a suitable workability and pot life so it will be compatible with current application techniques. Corrosion resistance tests saw the specimens submerged in a 0.6 pH sulfuric acid solution for a period of eight weeks. Key observations from the study include:

- Geopolymer made using Class F ash exhibited a very high chemical resistance, with specimens retaining up to 95 percent of their original compressive strength following the acid immersion test; geopolymer specimens made of Class C fly ash and specimens made of a portland cement/silica fume blends retained 40 percent and 20 percent of their original strength, respectively.
- One-day compressive strengths achieved by the geopolymer using Class C and F ash were 16,000 psi and 8,000 psi, respectively. The portland cement mortar used had a seven-day compressive strength design of 7,000 psi.
- Curing time and temperature are critical factors in the geopolymerization process. While a temperature of 140° F and a curing time of 24 hours were found to be optimal, curing time as low as 12 hours yielded an acceptable mechanical performance. Additional work is underway to further reduce the needed curing time.

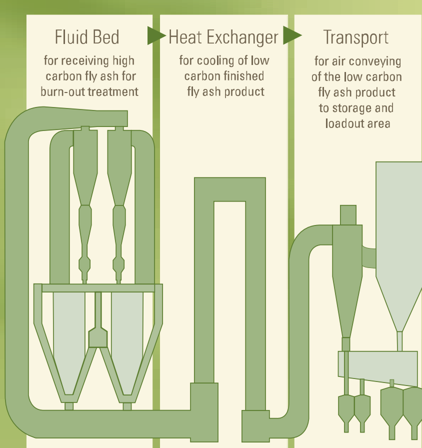
Conductivity Tests of Carbon Fiber entrained Geopolymer Concrete.

Structural Testing of a 7-foot-long, steel-reinforced GPC Beam

Corrosion Test Results – GPC (left) and OPC (right)

Our fly ash solution isn't just

IT'S GREENER.



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Our patented Carbon Burn-Out (CBO™) technology is the only zero-waste, ammonia-free, low-carbon process on the market, making it the most environmentally friendly solution available for utilities to recycle fly ash.

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Michael Van Sickel
General Manager, Branscome Concrete, Inc.

better than the competition's.

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PMI

Geopolymer coating applied to a concrete sewer pipe

CREATING A GEOPOLYMER ROAD MAP

A question asked by many producers of CCP is: "Is my fly ash suitable for geopolymer concrete?" Not all coals were created equal, thus fly ash stockpiles tend to vary significantly in terms of chemical composition and particle size distribution. Parameters include the precursor coal source, combustion temperature and duration, and post-combustion processes. Under the geopolymer road map project, fly ash stockpiles from across the country are being collected and subjected to rigorous analytical analysis and a mechanical testing program. The objective is to establish relationships among the fly ash's chemical composition and particle size distribution and the mechanical attributes (e.g., compressive, tensile and flexural strengths, elastic modulus and Poisson's ratio) and workability of the resulting geopolymer concrete. Analytical tests include particle size distribution, X-Ray diffraction and Raman chemical imaging. The researchers would like to request producers of CCPs provide samples of their coal fly ash so we can further expand our database and improve our prediction model.

"SMART" GEOPOLYMER STRUCTURES

The term "smart" structure refers to providing structural components with the ability to monitor their condition or the stress level to which they are subjected, and communicate this information to a remote-monitoring site in cases when the structure is experiencing structural distress. When entrained with a very low volume of carbon fibers, GPC are several times more conductive compared with OPC that contains the same fiber volume fraction. Additionally, the conductivity of GPC is less susceptible to variations in moisture content due to precipitation and humidity compared with OPC. The research team is working on the development of a "smart" geopolymer concrete whose response to a given electrical current can be closely correlated to the stress level to which the structure is subjected.

A commercially viable geopolymer concrete technology can help electric companies to manage their growing businesses …

SUMMARY

There is a growing consensus of the link between the emission of greenhouse gases and global climate change. However, significant cuts in carbon dioxide emission levels are feared to be associated with a high economic cost. The development of geopolymer concrete technology could contribute to reducing the level of carbon dioxide emissions around the globe with no economic sacrifice, while at the same time contributing to the conversion of CCPs to a high-performance and environmentally friendly construction material. Added benefits are conservation of valuable landfill space and conservation of non-renewable natural resources.

From a business perspective, greenhouse gas (GHG) emission policies in the United States are evolving rapidly, with several federal legislative proposals in the works and the emergence of regional climatic regulatory programs. Consequently, electric utilities may potentially face substantial GHG reduction liabilities and associated costs. A commercially viable geopolymer concrete technology can help electric companies to manage their growing businesses in a potentially carbon emission constrained environment by providing a cost effective GHG emission reduction avenue. The development of new technologies, such as GPC, will expand the supply sources of GHG emission credits, helping in the creation of a flexible, more liquid credit market, assisting the industry to avoid high compliance costs, and lessen the impact of those costs on their profitability. ❖

DÉJÀ VU ALL OVER AGAIN – HVFA

By David C. Goss,
American Coal Ash Association

The release in early 2008 of the third edition of "High Performance, High Volume Fly Ash Concrete" by Drs. Malhotra and Mehta comes six years after the first edition was published. It seems as if HVFA concrete is a relatively new phenomenon:

> …the concrete strengths were lower for a 50-percent replacement of portland cement by fly ash than for a 30-percent replacement … However, it is interesting to observe that, even with half of the portland cement replaced by fly ash, concrete strengths were obtained which at the age of 3 months were 5000 psi…[i]

It is commonly accepted today that larger percentages of fly ash are particularly helpful when used in mass-concrete structures. In 2002, a foundation slab for the BAPS Temple in Chicago was placed using as high as 65 percent fly ash replacement by mass of the total cementitious materials. The slab measured approximately 67 by 55 by 3 feet. At the time, this was the largest concrete slab cast as a monolith raft. Since then, many other large pours have used replacement percentages of 50 percent or greater.

> …under mass curing conditions, even at the relatively early age of 28 days, the strengths of the concrete containing fly ashes of low carbon content were considerably greater than those of the concretes containing corresponding portland cement without admixture, even for fly ash replacements as high as 50 percent. …the larger replacements of fly ash result in a substantial reduction in the heat of hydration as compared with that which would be obtained with the corresponding portland cement… the possibilities of the use of high-replacement fly ash cements for mass-concrete construction appear to be very attractive…[ii]

The seismic rehabilitation of the Utah State Capitol building, the CITRIS (Council for Information Technology Research in the Interest of Society) building at the University of California-Berkeley, and the De Young Museum in San Francisco have all demonstrated the value and benefits of using 50 percent fly ash or greater in concrete mixes. When properly designed, HVFA concrete can be used in almost any application.

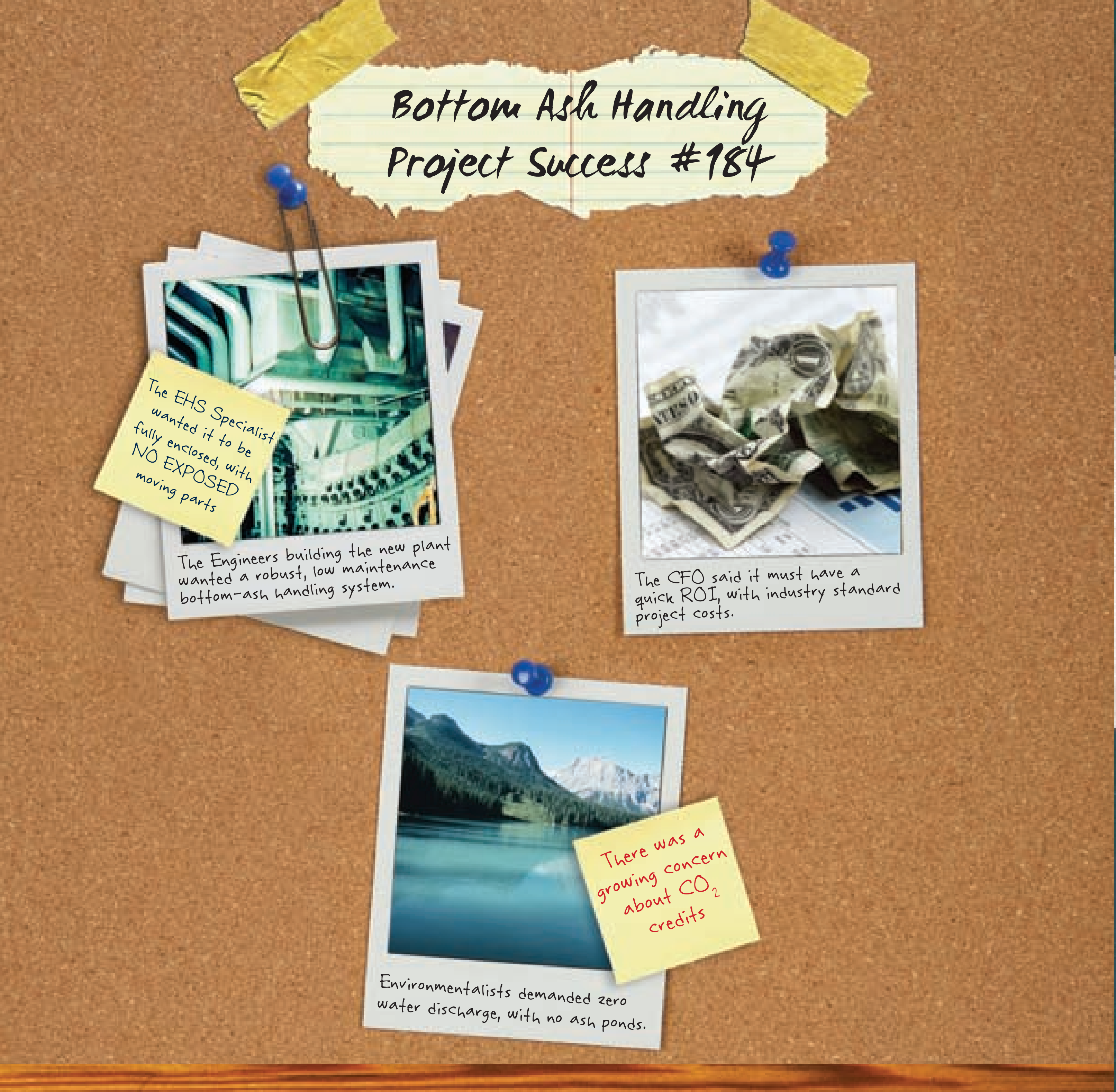
Why, therefore, is this article titled Déjà vu All Over Again? The two indented quotes above are not attributed to Yogi Berra, as the title is. Instead, they are taken from one of the first technical articles published by the American Concrete Institutes on the properties of cements and concretes containing fly ash, in 1937. ❖

PHOTO BY PATRICK SPENCE

[i] Raymond E. Davis, Roy W. Carlson, J.W. Kelly and Harmer E. Davis. "Properties of Cements and Concretes Containing Fly Ash. Journal of the American Concrete Institute. Vol. 33; pg. 598. May-June 1937.

[ii] Ibid. pg. 600

The BAPS Temple in Chicago was built with a concrete mix of 65 percent fly ash.

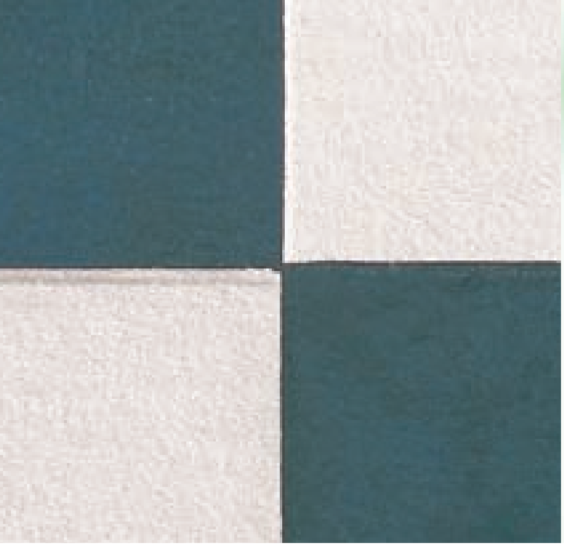

Bottom Ash Handling Project Success #184
The EHS Specialist wanted it to be fully enclosed, with NO EXPOSED moving parts
The Engineers building the new plant wanted a robust, low maintenance bottom-ash handling system.
The CFO said it must have a quick ROI, with industry standard project costs.
There was a growing concern about CO_2 credits
Environmentalists demanded zero water discharge, with no ash ponds.

WHAT STRATEGIC PLANNING CAN DO FOR YOU

By Cheri Miller

I'VE ALWAYS HATED BUYING A NEW CAR — IT'S A LOT OF WORK! You talk to your family to get consensus on what kind of car to buy and how much money you can spend. Then you have to do all your background research on gas mileage, safety ratings, accessories, dealer invoice, trade-in values, accessory packages, and lots more. It's always smart to go to the bank next and make sure that you can get pre-approved financing. Then — after gathering and studying all of that data, zeroing in on the model you want, and figuring out the financing, if you're married, you usually have to decide who's going to negotiate "The Deal" — and we all know that "The Deal" is the fun part. But without all the work and planning on the front end, you probably won't end up with "The Deal" that you and your family want.

Over the last 20 years or more we've seen coal ash and FGD gypsum transition from "wastes" to "byproducts." Now the industry refers to them as "products." But unlike other industries with products to market, it has been my experience that many utility ash managers seem to start by trying to negotiate "The Deal" and suddenly find that they are not empowered to close the deal — either because they don't have enough information or because they don't have the support of their "family" — upper management, plant, environmental, financial, and legal staffs. This is where strategic planning is critical to success.



Another important outcome of this process is that you will also have clearly identified those uses that are not options for your company

We've all been to training sessions on SWAT, PEST and RISK analysis — you probably came away from the training, put the notebooks on your bookshelf and never looked at them again. But strategic planning doesn't have to be complicated. If you've ever bought a car, then you know how to do strategic planning. The strategic plan should be a comprehensive document, and ideally should address all of the products at all your plants and any potential uses for which these materials may be suitable. But it should also be a fluid document so that when new opportunities arise the plan is easily amended.

To start, you'll need to address internal ("family") issues. By involving your internal stakeholders in the strategic planning process, ultimately you will find yourself empowered to close "The Deal." Some of these internal issues include:

Environmental issues — your environmental staff should be integrated into the process and should identify any environmental risks that need to be addressed including state and local permitting requirements.

Legal/Contractual Requirements — your legal team needs to be integrated into the process and should identify any legal risks that need to be addressed.

Availability of Plant Resources — with the help of plant staff, evaluate when and where materials are available and the cost to the plant for additional material handling requirements to support marketing and utilization. As part of the process, build in incentives for the plant to aid marketing. This usually means a budget to pay for marketing activities.

Infrastructure — evaluate the need for investments in material handling, processing or beneficiation required to meet certain marketing requirements.

Cost of current product handling method — allows you to accurately calculate the cost savings and revenue benefits of proposed markets and uses so that you can communicate the benefits of marketing to the plant manager and upper management.

Chemical and physical parameters — will enable you to effectively evaluate the suitability of your material for use in various products and processes by comparing to the potential customer's material specifications as well as environmental issues associated with the materials.

Internal Competition — If you operate more than one power plant, you won't benefit by expanding CCP markets at one plant at the expense of another. Your plants should complement and back up one another. It is important to employ strategies for market development that do not force your own plants to compete with one another.

Corporate Risk Tolerance/Aversion — with the involvement of plant, legal and environmental staffs, the strategic plan should provide enough information on the risks and benefits of CCP marketing and utilization for upper management buy-in, at least for common uses. Uses that are of such a unique or innovative nature that the strategic plan cannot cover them (e.g. require large capital investments or commitments of land on power plant reservations) may have to be addressed outside the strategic plan.

Next, examine external issues such as:

External Competition — careful evaluation of competing material sources will allow you to negotiate the best price for your materials. Competition can come from neighboring utilities or other natural or manufactured materials.

Transportation and Handling Equipment — Most of the cost of CCP sales and utilization is in the transportation and material handling and these costs must be minimized for your materials to be competitive. Fuel costs can make some marginal uses uneconomical.

Identify Potential Customers — includes brokers (e.g. "ash" marketing companies), end users such as cement kilns and wallboard plants, and opportunities for highway or land development projects.

Community Attitudes — it is important to gain the support of the local communities, particularly for projects where materials are used in construction projects like structural fills rather than manufactured products. State and local regulations and zoning ordinances also must be addressed.

Using all of this information and input, you can develop long-term and short-term plans for targeting marketing and utilization efforts to match each of your power plants' needs, available resources and opportunities. You will be able to clearly demonstrate the costs and benefits of each proposed material use. Environmental and legal risks will be clearly delineated.

The final strategic plan should reveal a systematic approach for marketing and utilization of your materials that everyone in the company can agree upon. The desired outcome will be a clear delegation of authority to the ash management team to pursue approved uses and make decisions and commitments required to "close the deal." Through the strategic planning process you will be able to zero in on how best to focus your effort and company resources, and prioritize materials and markets to pursue. Another important outcome of this process is that you will also have clearly identified those uses that are not options for your company, whether because of cost, material availability, or environmental and legal risks. Ultimately this will give you the freedom to just say "no" to uses that have no clear benefit to the company without expending valuable time and resources needed to examine each individual proposal. ❖

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CONGRATULATIONS & BEST WISHES TO DAVE GOSS

REMOVING MERCURY FROM COAL EMISSIONS:

OPTIONS FOR ASH-FRIENDLY TECHNOLOGIES

By John Sager, Office of Solid Waste, United States Environmental Protection Agency

Reducing emissions of mercury from coal-fired power plants is a vital concern in the United States and around the world. Mercury is a naturally occurring neurotoxin that can be released into the air when coal is burned to generate electricity. There are a variety of mercury emission control technologies in use today and our understanding and deployment of effective controls is evolving because of the social, political and economic importance of providing clean sources of energy.

The environmental considerations for controlling mercury emissions are paramount, but there are environmental considerations associated with the affect of the emission controls on coal fly ash, a byproduct of the combustion process. When emission controls do not compromise the physical and chemical characteristics of the fly ash for use as a cement feedstock or as a supplementary cementitious material (SCM), cement manufacturers can use the ash and avoid the generation of a corresponding amount of greenhouse gas emissions from the manufacture of traditional, portland cement. Where safe and practicable this use should be maximized because of the greenhouse gas reduction benefits.

In 2005, the U.S. Environmental Protection Agency (EPA) issued the Clean Air Mercury Rule (CAMR) to address the need to control mercury emissions. The emission targets specified in the rule will significantly reduce emissions of mercury, but some of the mercury control technologies change the characteristics of fly ash, rendering it incompatible with

the engineering requirements for use as an SCM. While CAMR was vacated by the D.C. Circuit Court in 2008, the EPA is reviewing the Court's decisions, and it is highly likely that mercury emissions will be regulated in the future. Amongst various regulatory scenarios under discussion at the state and federal level, target levels for mercury capture range from 70 percent to 90 percent.

In order to evaluate the kind of mercury emission control necessary to achieve a given standard, the degree of mercury capture already in place or planned at the facility because of the co-benefit of sulfur dioxide and nitrogen oxide emission controls must be considered first. These co-benefit control technologies can be deployed in different configurations and combinations that result in mercury capture ranging from 20 percent to 90 percent. The removal rate is affected by the halogen content of the coal and the level of unburned carbon, among other factors. Srivastava et al. (2006) presents a discussion of the effectiveness of mercury capture among different control systems and types of coal. These technologies generally do not affect the suitability of the fly ash as a cement feedstock or an SCM.

To achieve a high degree of mercury removal where co-benefit technology is insufficient, it may be necessary to deploy a mercury-specific control technology. To preserve the concrete-compatibility of the ash, utility managers and other stakeholders have a number of options. The following is a brief description of mercury control technologies and the resulting ash impacts. These technologies are either currently available or in development. Utility managers, working with their state regulators and other stakeholders, should make mercury control technology decisions based on the circumstances of the particular facility. Any references in this discussion to specific entities or products are not intended to imply any federal endorsement. The EPA does not endorse any particular product, service or enterprise.

INJECTED MERCURY SORBENTS

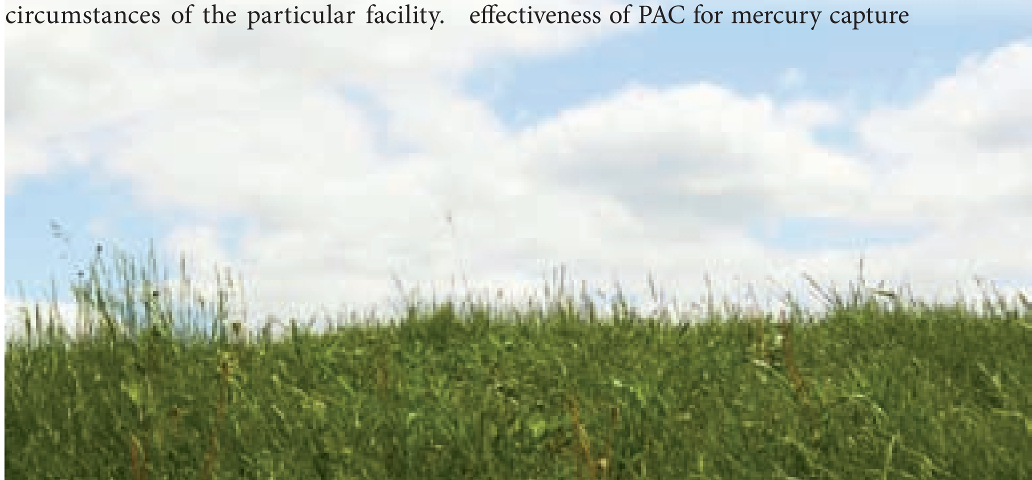
Powdered Activated Carbon

The Technology: Standard powdered activated carbon (PAC) is usually injected upstream of the fly ash collection system (electrostatic precipitator or baghouse), where mercury in the flue gas adsorbs onto the carbon particles. Therefore, standard PAC is most effective with low-sulfur, bituminous coals; lower rank coals tend to be too low in chlorine (Srivastava et al. 2006). The thief process, developed by the Department of Energy's National Energy Technology Laboratory (NETL) is similar, but the carbon sorbent used is less expensive.

Ash Impacts and Other Issues: Standard PAC injection often raises the levels of carbon in fly ash beyond acceptable levels for use as SCM in concrete, as does the thief process. If the use of fly ash as an SCM is not an important consideration, the use of PAC to capture mercury is an option. However, unless the PAC system can be deployed after particulate removal, which can pose engineering difficulties due to size and other considerations, the PAC remains in the fly ash, usually resulting in fly ash that cannot be used as an SCM. The PAC interferes with air-entraining agents—compounds added to the concrete mix to capture tiny air bubbles—which are necessarily employed in many concrete applications.

Chemically Treated PAC

The Technology: The use of a PAC with chlorine or other halogen added improves the effectiveness of PAC for mercury capture



from subbituminous coal and lignite (Srivastava et al. 2006). Four companies involved in developing these technologies are Alstom, Sorbent Technologies, Norit, and Calgon Carbon Corporation.

Ash Impacts and Other Issues: The addition of halogen to the PAC does not reduce the amount of carbon in the fly ash; therefore this technology is generally incompatible with the use of fly ash as SCM in concrete.

TOXECON™

The Technology: This system, developed by EPRI, employs PAC technology, but is designed to preserve the quality of the fly ash and is compatible with an installed electrostatic precipitator (ESP). A small baghouse is added downstream of the ESP, and the PAC is injected between the baghouse and the ESP. TOXECON™ can be effective at removing mercury across coal ranks (Srivastava et al. 2006). TOXECON II™ is a less-expensive adaptation of the TOXECON™ technology, where the sorbent is injected between the last set of ESP plates, and the ash is segregated, leaving the bulk of the ash without additional carbon contamination.

Ash Impacts and Other Issues: Since the fly ash is removed from the flue stream upstream of the injection of the PAC, nearly all the fly ash collected remains a suitable candidate for use as an SCM in concrete. The disadvantage is that the system is expensive to install, relative to the use of PAC alone, although TOXECON II™ has the potential to mitigate costs significantly.

Silica-Based Sorbents

The Technology: Silica-based sorbents are being introduced by Amended Silicates, LLC. The sorbents are injected into the flue gas in much the same manner as PAC, but contain no carbon. Tests of a silica-based sorbent at an operating power plant have shown mercury capture rates above 70 percent (IIT 2005).

Ash Impacts and Other Issues: Silica-based sorbents do not add carbon to fly ash, therefore, the suitability of fly ash as an SCM in concrete is unaffected by the use of silica sorbents.

OTHER SORBENT SYSTEMS

Metal Oxidation Catalysts

The Technology: Mercury oxidation catalysts using metals such as gold, palladium and iridium appear to be promising systems for mercury removal. Iridium and iridium alloys are particularly corrosion-resistant and have high temperature resistance. Investigations of these metal catalysts have been at the bench-scale to date, but have shown good results in mercury reduction (Granite 2004).

Ash Impacts and Other Issues: Metal catalysts have no affect on the suitability of fly ash for use as an SCM in concrete. However, this technology presumes the existence of a wet scrubber (FGD) downstream of the ESP and catalyst and is likely to be more expensive than PAC (exclusive of the loss of ash sales revenue and cost of disposal).

MerCAP™ and MercScreen™

The Technologies: MerCAP™ and MercScreen™ are new technologies that are being developed by EPRI. MerCAP™ is a static adsorption system that employs fixed plates coated with a noble metal (usually gold). EPRI recently conceived the MercScreen™ concept, a variant of MerCAP that uses a continuously moving, sorbent-coated band-like screen. This process is still in early development.

Ash Impacts and Other Issues: As either MerCAP™ or MercScreen™ would be located downstream of the particulate control, neither would have an impact on fly ash use viability. This is one of their primary benefits and reason for development.

Fuel Cleaning or Upgrading

The Technology: Fuel cleaning and upgrading are pre-combustion treatments of coal to remove mercury and other contaminants. A number of patented processes exist, including the Western Research Institute and K-Fuel processes for Powder River Basin and lignite coals. In addition, currently available deep cleaning processes are being investigated as a means of reducing the mercury content of eastern bituminous coals (in addition to providing other air pollution benefits).

Ash Impacts and Other Issues: This technology does not add carbon to the flue stream. However, limited research has been undertaken on the engineering properties of the resulting ash; therefore, the ready usability of this ash, while expected to be as good as current ash from those fuels, is not known with certainty.

EMERGING TECHNOLOGIES

The removal of mercury from coal power plant emissions is an area of intense ongoing research. Some technologies that show promise for mercury removal but are not yet commercially viable include:

Several sorbent variations using non-carbon materials, specially treated carbon-based sorbents that don't impact ash use, or highly effective carbon-based sorbents (thereby keeping the resulting carbon-in-ash content low enough to be acceptable for use as a partial replacement for portland cement in concrete).

Advanced filter technologies that enable the use of a compact second particulate control into which carbon could be injected without affecting the primary particulate capture system and, hence, the ash.

A number of integrated environmental controls, such as Airborne, ECO, possibly EnvirScrub™, all of which would follow the particulate control and not impact the fly ash.

Additives or electrochemical methods (e.g., Photochemical oxidation [PCO™] or PEESP) to enhance capture by SO_2 scrubbers (so that additional upstream capture using carbon sorbents is not needed). PCO was developed by DOE-NETL (Pavlish 2007) and licensed to Powerspan; PEESP is being developed by EPRI and Siemens.

Information about these and other technologies is available from:

Department of Energy's National Energy Technology Laboratory, www.netl.doe.gov/technologies/coalpower/ewr/mercury/

The Energy and Environmental Research Center at the University of North Dakota, www.undeerc.org

EPRI, http://my.epri.com/portal/server.pt?open=514&mode=2&objID=218874

ADA Environmental Solutions, www.adaes.com/mercury/overview/

In promoting further discussion and development of these technologies, EPA has posted a listing of mercury control technologies on the Coal Combustion Product Partnership (C^2P^2) Web site at www.epa.gov/c2p2

On a trial basis, we invite submissions of additional information to WasteWise@icf.com which we will post on the Web site as appropriate. This is in keeping with the practice of providing information concerning products that have been designated in the Comprehensive Procurement Guidelines for preferential purchase by the federal government. The Comprehensive Procurement Guideline for the purchase of concrete with cement made from coal fly ash was issued in 1983.

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COAL COMBUSTION PRODUCTS 2007 PRODUCTION AND USE REPORT

Every year the American Coal Ash Association releases a report detailing the amount of coal combustion products produced and used in the United States. This year's report of 2007 data came from more than 170 power plants, which volunteered the information.

The amount of CCPs used was 40.55 percent, an across-the-board decrease of 2.88 percent from the 2006 percentage of 43.43. Although this is the first statistical decrease in use since the year 2000, it's still the second highest reported in the 40 years since ACAA has conducted the survey. This decrease can be attributed to a slightly reduced reported fuel burn by utilities, and a decrease in demand in the building and construction sector, particularly related to declines in new home starts and new construction.[1]

Surveyed factors include the types of coal burned to generate electricity, i.e., bituminous, subbituminous and lignite, the method of coal burn, i.e., the boiler system used, and the resulting output of CCP materials: fly ash, bottom ash, boiler slag, flue-gas desulfurization (FGD) materials, fluidized-bed combustion (FBC) ash and cenospheres. Other factors recognized, but not measured for statistical consideration, are changing seasonal demands for coal-fired generated electricity and changing industry operating standards and imposed government regulations, and competing worldwide production and demand for CCPs.

The beneficial applications for CCPs are diverse. The report addresses 15 of the most common, e.g., agriculture, mine reclamation, wall panel products, cement production, concrete products, snow and ice control and waste stabilization. Cenospheres, a sub-set of fly ash, is a high-value material used for the manufacture of paints, plastics, metal alloys, and other applications.

Minor format modifications and additions were made to 2007's report. CCP production and utilization totals were placed in a dedicated column to improve the ease of reading and interpretation. A special addition to the report this year is data received from the Appalachian Region Independent Power Producers (ARIPPA), an organization representing 13 Independent Power Producers in Pennsylvania. Their data is displayed in two additional columns showing the potential impact of ARIPPA, had their numbers been used in the primary report.

American Coal Ash Association 2007 CCP Production & Use Survey

CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash (not including ARIPPA FBC Ash data)	CCP Production/ Utilization Totals	FBC Ash combined with ARIPPA* FBC Ash production	CCP Production/ Utilization Totals (including ARIPPA FBC Ash data)
Total CCPs Produced by Category	71,700,000	18,100,000	2,072,695	12,300,000	16,600,000	1,812,511	2,449,731	1,273,061	126,307,998	6,092,756	131,127,693
Total CCPs Used by Category	31,626,037	7,303,538	1,663,980	9,228,271	810,080	150,365	113,298	323,741	51,219,310	5,143,436	56,039,005
1. Concrete/Concrete Products /Grout	13,704,744	665,756	0	118,406	0	21,266	0	5,518	14,515,690	5,518	14,515,690
2. Blended Cement/ Raw Feed for Clinker	3,635,881	608,533	6,888	656,885	0	0	81,801	0	4,989,988	0	4,989,988
3. Flowable Fill	112,244	0	0	0	0	12,427	2,735	0	127,406	0	127,406
4. Structural Fills/Embankments	7,724,741	2,570,163	158,767	0	97,610	555	0	46,282	10,598,118	46,282	10,598,118
5. Road Base/Sub-base	377,422	802,067	20	0	0	0	0	0	1,179,509	0	1,179,509
6. Soil Modification/Stabilization	856,673	314,362	169	0	0	154	429	199,441	1,371,228	199,441	1,371,228
7. Mineral Filler in Asphalt	17,223	21,771	63,729	0	0	0	0	0	102,723	0	102,723
8. Snow and Ice Control	0	736,979	44,367	0	0	0	0	0	781,346	0	781,346
9. Blasting Grit/Roofing Granules	0	71,903	1,377,658	0	0	0	0	0	1,449,561	0	1,449,561
10. Mining Applications	1,306,044	165,183	0	0	299,793	111,195	0	0	1,882,215	4,819,695	6,701,910
11. Gypsum Panel Products**	0	0	0	8,254,849	0	0	0	0	8,254,849	0	8,254,849
12. Waste Stabilization/Solidification	2,680,348	7,056	0	0	10,378	1,416	28,333	72,500	2,800,031	72,500	2,800,031
13. Agriculture	49,662	2,546	0	115,304	9,236	3,352	0	0	180,100	0	180,100
14. Aggregate	135,331	806,645	450	70,947	0	0	0	0	1,013,373	0	1,013,373
15. Miscellaneous/Other	1,025,724	530,574	11,932	11,880	393,063	0	0	0	1,973,173	0	1,973,173
Totals by CCP Type/Application	31,626,037	7,303,538	1,663,980	9,228,271	810,080	150,365	113,298	323,741	51,219,310	5,143,436	56,039,005
Category Use to Production Rate(%)	44.11%	40.35%	80.28%	75.03%	4.88%	8.30%	4.62%	25.43%	40.55%	84.42%	42.74%
F. Supplemental:											
Cenospheres Sold (Pounds)	12,659,597										

FINDINGS

With a slight drop of .06 percent in national utility coal burn numbers from 2006 to 2007, and an adjusted relative decrease in CCP production1, utilization of CCPs dropped in all reported categories with the exception of cenospheres sold.

Fly Ash beneficial use was the least impacted category despite the decrease of overall CCP production numbers. A drop of slightly more than half a percent represents a decrease from 32,423,569 tons used in 2006 to 31,626,037 tons in 2007. It continues to be the most diversely used CCP, with respondents reporting its use in 12 of the 15 survey application categories. Fly ash was consumed primarily in concrete products, structural fills and raw feed as clinker for cement production.

Flue Gas Desulfurization (FGD) Gypsum is second only to fly ash when beneficial use totals are compared. Seventy-five percent of the 12,300,000 tons produced, or 9,228,271 tons, were used for beneficial purposes. This is a 4 percent drop from 2006. The manufacture of gypsum wallboard panels used 8,254,849 tons of FGD gypsum. Because of increasing numbers of installed flue gas desulfurization emission control systems, production numbers should go up in the years to come, and depending on market demands, utilization will gradually follow.

Bottom Ash was third in CCP beneficial utilization at 7,303,538 tons, or 40.35 percent of the total produced, 18,100,000 tons. This is an approximate drop of 5 percent from 2006 figures. Bottom ash is primarily used in structural fills and embankments with lesser amounts in road base, pavement and as an aggregate.

FBC Ash, typically, has not been reported to ACAA in any large amounts. In 2006, only 29,341 tons were identified as being produced and primarily used for waste stabilization. As noted above, the 2007 survey includes, albeit separately, the CCP production and use data submitted by ARIPPA. They reported production of 6,092,756 tons FBC ash, with usage of 5,143,436 tons, or 84.42 percent. Of the total, 94 percent is used for mine reclamation applications.

Boiler Slag, although produced in relatively small numbers, 2,072,695 tons in 2007, its reported beneficial use percentage is highest among regularly reported categories. Over 80 percent of produced boiler slag is used as blasting grit and roofing granules. This latter figure is down from its highest level in 2005 of 96.6 percent. The availability of boiler slag will gradually be reduced with the continuing retirement of more and more cyclone and slag-tap boiler units.

SUMMARY

ACAA's 40 years of CCP reports have reflected steady growth in both production and beneficial use. Although periodic leveling out or decreases occur, as indicated by this year's survey results, the historical record tends to mark these changes as precursors to potential future increases.

ACAA in conjunction with its industry members and affiliates, as well as federal,

ACAA's forty years of CCP reports have reflected steady growth in both production and beneficial use.

state and local government offices, continually promote the positive impact of CCP utilization. Annual survey findings offer a tool for evaluating the effectiveness of these CCP promotional initiatives. For example, the highest visibility CCP program, nationwide, is the Coal Combustion Products Partnership (C^2P^2). C^2P^2, of which ACAA is an active sponsor, is a joint partnership between the U.S. Environmental Protection Agency and industry. Its single goal is promoting awareness and understanding of the benefits of using CCPs through conservation of natural resources, support of utilization of sustainable industrial processes and materials, the reduction of greenhouse gas emissions, and the elimination of the need for added landfill space. C^2P^2 details and case studies can be found at the EPA website http://epa.gov/epaoswer/osw/conserve/c2p2/

ACAA advances the management and use of CCPs that are environmentally responsible, technically sound, commercially competitive and more supportive of a sustainable global community. Its annual CCP report is only one means it uses to support this mission. For more information about ACAA, please visit www.acaa-usa.org

Also visit its two additional CCP information Web sites, www.fgdproducts.org and www.wwccpn.org ❖

Please address questions or comments concerning the CCP report to Mike MacDonald of ACAA at 720-870-7897 or e-mail to mlmacd@acaa-usa.org.

REFERENCE

[1] "FGD Other" material production was inadvertently not reported by a survey respondent in 2006. The same respondent did report applicable numbers in 2007, amounting to over 2 million tons of "FGD Other" materials. If the total 2006 production was adjusted to reflect a similar amount, 2006 overall beneficial use would have been 42.69 percent versus the reported 43.43 percent. Such realized adjustments will be footnoted, as here, and changes made if necessary for each year's findings. The adjustment noted here will not be applied, but are recorded for historical purposes.

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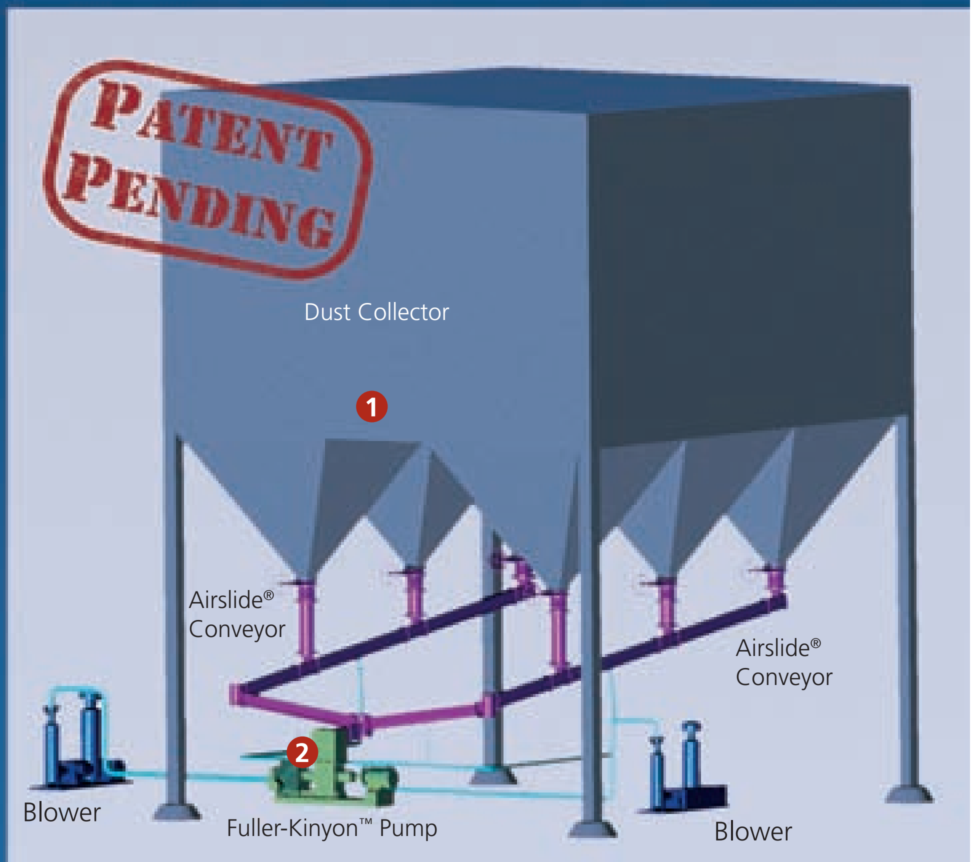

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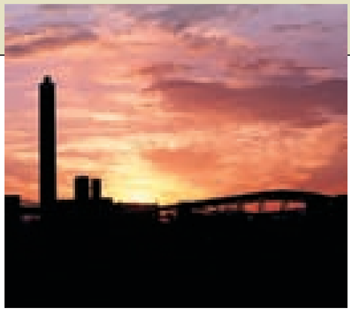

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