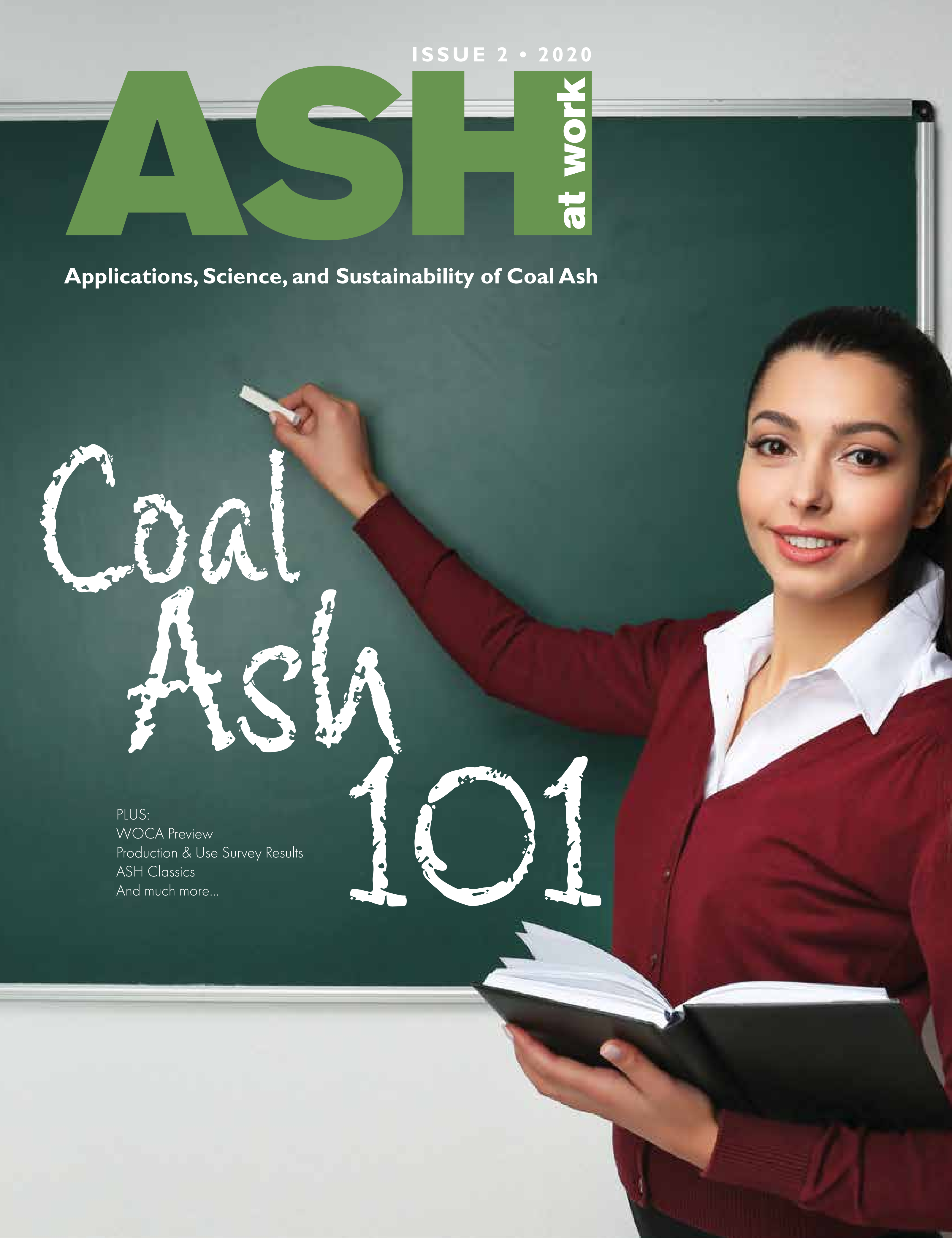
ISSUE 2 • 2020

ASH at work

Applications, Science, and Sustainability of Coal Ash



PLUS:
WOCA Preview
Production & Use Survey Results
ASH Classics
And much more...

ISSUE 2 • 2020

ASH at work

Applications, Science, and Sustainability of Coal Ash

Published for:

ACAA

American Coal Ash Association
38800 Country Club Drive
Farmington Hills, MI 48331
Phone: 1-720-870-7897
Fax: 1-720-870-7889
www.acaa-usa.org
www.FGDProducts.org
www.wwccpn.net

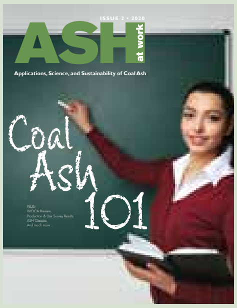
Table of Contents

Coal Ash 101

Also Featuring

On the Cover

Coal combustion products are beneficially used across numerous industries, from concrete and cement manufacturing to agriculture, wallboard fabrication, and road construction.



Mixed Emotions

By Kenny Tapp, ACAA Chair

As I write this final Message from the ACAA Chair, I am filled with mixed emotions. I have previously announced to the ACAA Board of Directors, and now I must let everyone else know, I am retiring from Louisville Gas & Electric and Kentucky Utility Services Company effective December 31, 2020. I have struggled with this decision, but I feel the timing is right for me to move on to the next chapter of my life. It is difficult to know for sure when the time is right, much like eating a bowl of Captain Crunch cereal. If you eat it too soon after pouring the milk in, it tears up the roof of your mouth—but if you wait too long, it then becomes soggy. I believe I have chosen a time that is just right. I do not want to be accused of becoming soggy!

I have enjoyed my time serving the ACAA in the roles you have had enough confidence to elect me to. I have met many individuals within the ACAA and the beneficial use industry that I count as friends, and I will miss each and every one of you. I have been blessed to have Tom Adams and Alyssa Barto on the ACAA team as our only full-time staff. They have both been instrumental in keeping the ACAA moving forward. We are fortunate to have both Tom and Alyssa on the ACAA team. The support that I and the ACAA have received from the management firm Advancing Organizational Excellence has also been invaluable. I am confident that Steve Benza will step into the role as Chair of the ACAA and lead it to a bright future, as he has been an invaluable asset serving as Vice Chair. Lisa Bradley has performed her role of Secretary/Treasurer in a most outstanding manner and has helped keep us on track with nominations and elections for open positions in the ACAA. She has also done a superb job keeping us in line by overseeing the budget. All the members of the Board of Directors have been vital in making strong, thoughtful decisions and have helped keep the ACAA moving forward. The ACAA could not run without these individuals who are willing to go above and beyond in their commitment to excellence.

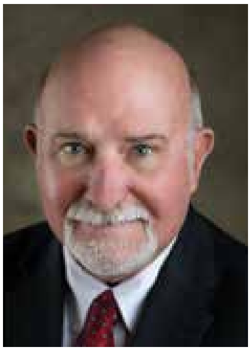
I would be remiss if I didn't mention those appointed by the Chair to the committee chair positions. John Ward has done a fantastic job in his role as Chair of the Government Relations Committee. As per our tax-exempt status, we cannot lobby on behalf of our positions in Washington, D.C.; however, we can educate those in Congress and those in regulatory rulemaking positions. John has developed a strong working relationship with individuals in key decision-making positions and continues to espouse the benefits of using coal combustion residuals in responsible ways, and to promote regulatory rulings favorable to the ACAA. Rafic Minkara is among the most knowledgeable individuals I know in the beneficial use industry, and he has performed his role as Chair of the Technical Committee in an outstanding manner. His work with ASTM International has helped promote standards that are fair and balanced and are in the best interest of the beneficial use industry. When I asked Travis Collins to serve as Chair of the Communications and Membership Committee, he immediately said yes. His thoughtful decision-making process has served him well in this position. Peggy Rennick serves as Chair of the Membership Recruitment and Retention Subcommittee under Travis's leadership, and her attention to detail has been invaluable to the subcommittee. All the aforementioned individuals could not perform their roles without the help of the many volunteers that serve as members on the various committees, and my heartfelt thanks goes out to you all.

This Association could not function without the support of the member companies. They have stepped up in providing funding for many of the projects we undertake, and their sponsorship and exhibit booth displays at our meetings bring in valuable financial support that allows us to keep our membership dues lower than most Associations our size.

In closing, let me say that I am looking forward to this next chapter in my life, and being able to spend valuable time with my wife, Deborah. She has supported me throughout my career and has acted as a levelheaded sounding board for many of the decisions I have made. This is where my mixed emotions enter. I am excited to be able to travel and spend time with Deborah, but I will also miss the time spent and the relationships built with you all.

Stay safe and God bless.


Fly Ash
You need it.
We get it.™
Fly ash has become a strategically important component of producing durable, sustainable concrete.
We get it.
You need fly ash supplies that are consistent and reliable.
We get them for you.
At Boral Resources, we have the resources to get fly ash where you need it, when you need it.
We are the fly ash industry's pioneers.
BORAL®
RESOURCES
We get it.
Find out how.
FLYASH.COM



Thinking About 2020....

By Thomas H. Adams, ACAA Executive Director

In the last issue of *ASH at Work,* I wrote about finding "the new normal" amid the impacts of the coronavirus pandemic. Several months later, we are still trying to find it. In the meantime, our nation and the world struggle to deal with protecting those who are most vulnerable to serious health impacts while allowing society to resume the functions that make our country work and prosper. The economy, education, entertainment, recreation, and religious activities are still in various stages of recovery depending on state and local mandates. To me, it is most troubling to see the energy wasted on the blame game. Political posturing has played a major role in the delivery or lack of delivery of needed materials and services. Hopefully, by the time you are reading this issue of *ASH at Work,* substantial progress on a vaccine will have been made and we will be on our way to a full recovery in our homes, schools, businesses, and churches.

Social unrest exploded in 2020. Incidents of the use of deadly force by police were the catalyst for major protest in which destruction of public and private property became acceptable in many cities. Attacks on all law enforcement became fashionable. Assaults against private citizens have been accepted as collateral damage. I witnessed some of this before, having lived in Detroit during the 1967 riots in that city. Not only did the civil unrest fail to draw the community together to work on solving real grievances, the city became a ghost town. Citizens able to move out of the city did so. Businesses that served Detroit's neighborhoods left their burnt-out buildings behind and started over in the suburbs. It has taken several decades for Detroit to begin its recovery. Violence and property destruction did not work for Detroit in 1967. It will not solve problems in the 21st century either.

As this issue of *ASH at Work* goes to press, recounts, runoffs, and litigation resulting from the November 3 election rage on. Many voters are convinced there was massive corruption. Others believe the election results were legitimate and reflect the will of the people. One thing that is certain is that we must do better in making the election process fair and transparent. Failing to do so erodes the very foundation of this great country.

Finally, I would like to thank Kenny Tapp, Chair of the ACAA Board of Directors, for his service to the ACAA and our industry. Kenny is retiring from LG&E and Kentucky Utilities on December 31. He is stepping down as the Chair of the ACAA Board of Directors as well at that time. Kenny has been a valuable asset to our industry for many years with thoughtful and practical guidance on how to meet the challenges we face in defending and promoting the beneficial use of coal combustion products. I have valued his counsel and his willingness to listen to my ideas over the years. I know our entire membership will miss his leadership. On behalf of the ACAA membership, I wish you and Deborah all the best for a long and happy retirement!

When Kenny announced his retirement plans, he was careful to let us know that he had discussed his intentions with Steve Benza, Vice Chair of the Board. Since the vice chair is generally elected to serve as the chair of the board of directors, we were anticipating that Steve would be officially taking that position after the election at the annual meeting. However, stepping into the role about one month sooner was not a major concern as Steve has been involved with ACAA about as long as any active member we currently have. When I was looking at historical documents for our 50th anniversary, I found an issue of *ASH at Work* from 1982 in which a young Steve Benza was featured as one of the future leaders of the beneficial use industry. It is comforting to have a person with Steve's experience in our industry and with our association take the reins. Welcome, Steve!

As for the year 2020, I think many of us share the same thought….go away!

BRINGING INNOVATION AND EXPERTISE TO ASH POND SOLUTIONS.

Whether it's a closure by removal (CBR) or a cap-in-place, no two ash ponds are exactly the same. That's why Charah® Solutions innovation and experience are essential to your next ash pond project. Utilities need the benefit of a customized approach that provides the exact solution to the challenges you face, including our turnkey Environmental Risk Transfer (ERT) services designed to meet the evolving and increasingly complex needs of utility partners while maximizing the value of the assets and improving the environment. With the Charah Solutions team, you get the proven experience and expertise to handle every regulatory, engineering and technical issue. Above all, you can count on service that is on time and on budget.

For more information, contact us at 877-314-7724 or visit charah.com.

Charah® Solutions

Service Above All®

Coal Combustion Products

By John Simpson

Coal combustion products (CCPs)—often referred to as "coal ash"—are solid materials produced when coal is burned to generate electricity. There are many good reasons to view CCPs—including fly ash, bottom ash, boiler slag, flue gas desulfurization (FGD) gypsum, fluidized bed combustion (FBC) ash, and cenospheres—as a resource rather than a waste. Using them conserves natural resources and saves energy. In many cases, products made with CCPs—from cement to concrete, asphalt, and wallboard, among others—perform better than products made without them. As coal produces approximately one-quarter of the electricity generated in the U.S., significant volumes of CCPs continue to be produced.

Since 1968, the American Coal Ash Association has tracked the production and use of all types of CCPs. These surveys are intended to show broad utilization patterns, and ACAA's data have been accepted by industry and numerous government agencies as the best available metrics of beneficial use practices. The most recent survey, for 2019, shows that 52% of all CCPs were recycled for beneficial use—the fifth year in a row that more than half of all CCPs produced in the U.S. were beneficially used rather than disposed. Even as coal-fueled electricity production declines amid competition from other fuel sources, CCPs harvested from storage in landfills and surface impoundments will help meet market demand well into the future.

Fly Ash

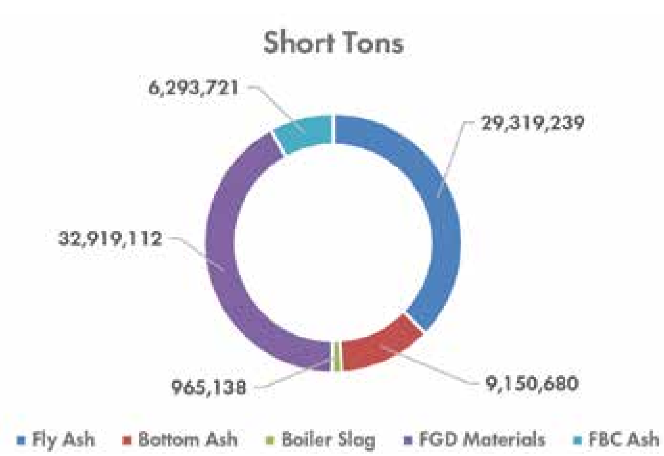
Fly ash is a powdery substance that is produced by the combustion of pulverized coal in the boilers of coal-fueled electric and steam generating plants. This material is captured by particulate emission control devices, such as electrostatic precipitators or filter fabric baghouses, before it can "fly" up the stack.

Depending on the type of coal that is combusted, fly ash is categorized as either Class F or Class C. Class F fly ash is produced from the combustion of bituminous or anthracite coal, while Class C fly ash is produced from the combustion of sub-bituminous or lignite coal.[1] Class F fly ash is highly pozzolanic, meaning that it reacts with excess lime generated in the hydration of portland cement. Class C fly ash is also pozzolanic and can be self-cementing. In ASTM C618, Class F fly ash may contain up to 18% calcium oxide (CaO). Class C fly ashes have CaO content in excess of 18%.[2]

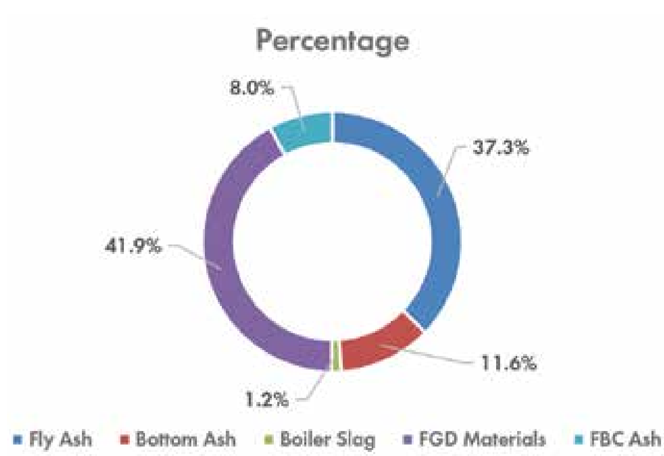
Owing both to its chemical and physical properties, fly ash is widely used in an array of construction activities to help improve project costs and environmental and product performance. By far, the largest beneficial use market for fly ash is in the manufacture of concrete—the world's most widely used material (after water).

As a pozzolan, fly ash can be partially substituted for ordinary portland cement in the manufacture of concrete—in amounts reaching 70% or more depending on the application. Doing so yields significant environmental benefits, as each ton of fly ash used to replace portland cement saves approximately one ton of carbon dioxide emissions. What's more, using fly ash produces additional benefits to the process and product alike—improving concrete's pumpability and workability; decreasing its shrinkage, cracking, and permeability; lowering the heat of hydration; mitigating against alkali-silica reaction and sulfate attack; and improving concrete's long-term strength gain.

2019 Production Of Coal Combustion Products, By Tonnage



2019 Production Of Coal Combustion Products, By Percentage



Finally, as a byproduct material that is available relatively inexpensively compared to many of the virgin materials it replaces across applications, fly ash can save money—both in up-front material costs and in long-term maintenance. An economic analysis by the American Road and Transportation Builders Association found that the use of fly ash saves $5.23 billion in the average annual cost of building roads, runways, and bridges in the United States. This includes a $2.5 billion savings in the annual price of materials; an additional $930 million each year in pavement repair work; and $1.8 billion in bridge work due to the longer pavement life of fly ash concrete.[3]

Beyond concrete, fly ash is used in numerous other applications, including:
- Component in concrete products and grout
- Feedstock in the production of cement
- Fill material for structural applications and embankments
- Ingredient in waste stabilization and/or solidification
- Ingredient in soil modification and/or stabilization
- Component of flowable fill
- Component in road bases, sub-bases, and pavement
- Mineral filler in asphalt[4]

Please see the relevant sections on each of these topics for details on the benefits of using fly ash in these applications.

Bottom Ash

The most commonly used coal-fueled furnace among U.S. electric utilities is the dry-bottom pulverized coal boiler. When pulverized coal is burned in this type of boiler, approximately 80% of the unburned material is suspended in the flue gases before being captured and recovered as fly ash. The remaining 20% is collected in a water-filled hopper at the base of the furnace as bottom ash.[5]

Physically, bottom ash is gray to black in color, angular, porous, and ranges in size from fine sand to fine gravel. Variations in these physical properties depend on the source and the type of coal from which it is derived, as well as the operating conditions in the plant in which the coal was combusted.[6]

Bottom ash's chemical makeup is similar to that of fly ash but it typically contains larger quantities of carbon. Because bottom ash particles are bigger and more fused than those in fly ash, it also tends to be more inert, less pozzolanic, and as such is less suited for use as a binding agent in cement or concrete products.[7]

Bottom ash is commonly used in bulk, unencapsulated applications, including the following:
- Filler material for structural applications, embankments, and backfill for retaining walls, abutments, and trenches
- Aggregate in road bases, sub-bases, and asphalt pavement
- Feedstock in the production of cement
- Snow and ice traction control material[8]

It is also utilized as aggregate in lightweight concrete products.

Please see the relevant sections on each of these topics for details on the benefits of using bottom ash in these applications.

All coal ash is derived from coal—whether anthracite, bituminous, sub-bituminous, or lignite.

Boiler Slag

Boiler slag is produced in wet-bottom boilers—either a slag-tap, which burns pulverized coal, or a cyclone, which burns crushed coal. When pulverized coal is burned in a slag-tap boiler, up to half of the ash produced is boiler slag. In a cyclone furnace, up to 85 percent of the ash generated is boiler slag.[9]

Chemically, boiler slag comprises predominantly silica, alumina, and iron—with smaller amounts of calcium, magnesium, and sulfates.[10] Physically, boiler slag is made up of hard, black, angular particles with a smooth, glassy appearance. Uniform in size, boiler slag particles are durable, resistant to wear, and in high demand across a range of end-use applications—particularly as blasting grit and roofing shingle granules. Owing to the ongoing removal from service of many of the plants that produce boiler slag, its supplies are decreasing.[11]

In addition to blasting and roofing applications, boiler slag is commonly used for:
- Mineral filler in asphalt
- Fill material for structural applications and embankments
- Raw material in concrete products
- Snow and ice traction control material[12]

Please see the relevant sections on each of these topics for details on the benefits of using boiler slag in these applications.

FGD Gypsum

Flue gas desulfurization (FGD) gypsum is a synthetic product that is generated by the removal of sulfur from the combustion gases of coal-fueled power plants via emissions control devices ("scrubbers"). Unlike the coal combustion products discussed above, it is not an "ash."

The two most common scrubber technologies used in the U.S. are "wet" and "dry" systems. Wet FGD systems, the more common of the scrubbing systems employed in the U.S., inject an alkaline sorbent spray comprising lime or limestone into the exhaust gas, with which it reacts to form calcium sulfite. When air is forced into the system, the calcium sulfite is converted into gypsum.[13]

Dry FGD systems use less water than wet systems and produce a dry byproduct. The most common dry FGD system sprays a slaked lime slurry into the flue gas, with the resulting product comprising calcium sulfite with minor amounts of calcium sulfate.[14]

FGD gypsum has the same chemical formulation—calcium sulfate dihydrate—as mined gypsum. However, FGD gypsum boasts a higher purity (typically above 90%) than natural gypsum.[15] Physically, FGD gypsum has more desirable spreading characteristics than mined gypsum,[16] which is helpful in a number of its end-use applications, such as its use as a soil amendment or structural fill.

The largest market for FGD gypsum is in the manufacture of gypsum panel products—also known as "wallboard" or "drywall"—which today is the predominant material used in the construction of the interior walls and ceilings of buildings throughout the United States. FGD gypsum is used in roughly half of the wallboard manufactured in the U.S.[17]

However, FGD gypsum is also used in a multitude of other applications, including:

- Fill material for structural applications and embankments
- Feedstock in the production of cement
- Ingredient in waste stabilization and/or solidification[18]

Please see the relevant sections on each of these topics for details on the benefits of using FGD gypsum in these applications.

FBC Ash

Fluidized bed combustion (FBC) ash is generated from a special type of boiler that uses anthracite and bituminous coal refuse as its primary fuel to generate electricity.[19] In an FBC boiler, the fuel particles are suspended in a hot, bubbling fluidized bed of ash and other particulate materials (sand, limestone, etc.) through which jets of air are blown to provide the oxygen required for combustion.[20]

Both fly ash and bottom ash are produced from this process. FBC fly ash, a fine material captured from the flue gas, contains high levels of alumina and silica. FBC bottom ash, a coarser

Beneficial Use Case Studies

The American Coal Ash Association maintains a database of case studies highlighting the beneficial use of coal combustion products in a wide range of construction projects, from foundations to buildings, bridges, and dams. This online directory includes more than 30 case studies from all over the world listing the type of CCP used in a given instance; project location, participants, description, and photographs; and how CCPs were used to help solve a construction design or engineering challenge. Drawn from the pages of *ASH at Work,* the case studies showcase the beneficial use of fly ash, bottom ash, FGD gypsum, and FBC ash.

FGD gypsum is generated by the removal of sulfur from the combustion gases of coal-fueled power plants via emission control devices.

material recovered from the combustion bed off-take, contains comparably higher levels of calcium sulfate and lime. The presence of lime, alumina, and calcium sulfate in FBC ash gives it cementitious properties when it is mixed with water.[21]

While the elevated alkalinity and sulfur content of FBC ashes generally make them unsuitable for use as a cement replacement in concrete, their elevated pH makes them highly effective in mitigating acid mine drainage. This has become an important beneficial use of FBC ash throughout much of the Appalachian coal region, where abandoned mines from two centuries of coal extraction continue to discharge acid runoff into waterways.[22]

The beneficial use of FBC ash in mine reclamation begins with the processing of coal refuse material at the mine site by screening to remove rock and other inert materials. The finer refuse materials are used as fuel for the FBC boiler, in which limestone is added to the furnace to capture sulfur dioxide emissions. The ash that results from the combustion process is then returned to the mine site and mixed with any unusable coal refuse to help neutralize on-site acidic materials. The materials can then be compacted in place for ground contour restoration.[23]

In addition to its use in the reclamation of abandoned surface mines and abatement of acid mine drainage, FBC ash is used in several other applications, including:

- Waste/sludge management
- Soil stabilization/modification[24]

Please see the relevant sections on each of these topics for details on the benefits of using FBC ash in these applications.

Cenospheres

Cenospheres are small, lightweight, inert, hollow spheres formed during the coal combustion process following the partial melting of ash particles and the simultaneous release of gases (O_2, N_2, CO_2, etc.).[25] Cenospheres are typically harvested from wet surface impoundments following the disposal of fly ash, bottom ash, and/or boiler slag. Because their specific gravity is less than that of water, they rise to the top of the pond whereupon they are captured, transported to a processing facility, dried, screened, sized, and packaged.[26]

Cenospheres are highly valued by industry because of their strength, low density, good thermal and electric capacity, and tolerance of chemical agents and high temperature.[27] Owing to these attributes, they are useful in fillers in a wide variety of materials, including concrete, paint, plastics, and metal composites.[28]

CCPs may vary in color, grain size, and other attributes depending on the type and source of the coal from which they are derived as well as the operating conditions in the plant in which the coal was combusted.

Endnotes

[1]Basham. Kim D., et al. "Adding Fly Ash to Concrete Mixes for Floor Construction." *Concrete Construction.* November 29, 2007.
[2]ASTM C618-19, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete."
[3]American Road & Transportation Builders Association. *The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction.* 2011. p 4.
[4]American Coal Ash Association. "Fly Ash." https://www.acaa-usa.org/aboutcoalash/whatareccps/flyash.aspx . Retrieved on October 23, 2020.
[5]U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction.* Material Description. Bottom Ash. https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cbabs1.cfm. Retrieved on October 23, 2020.
[6]University of Wisconsin. Recycled Materials Resource Center. "Coal Bottom Ash/Boiler Slag - Material Description." https://rmrc.wisc.edu/ug-mat-coal-bottom-ashboiler-slag. Retrieved on October 23, 2020.
[7]Robl, Tom, et al. *Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation.* "Chapter 2: CCPs and Electric Power Generation." p 20.
[8]American Coal Ash Association. "Bottom Ash." https://www.acaa-usa.org/aboutcoalash/whatareccps/bottomash.aspx. Retrieved on October 23, 2020.
[9]University of Wisconsin. Recycled Materials Resource Center. "Coal Bottom Ash/Boiler Slag - Material Description." https://rmrc.wisc.edu/ug-mat-coal-bottom-ashboiler-slag. Retrieved on October 23, 2020.
[10]U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction.* Material Description. Boiler Slag. Chemical Properties. https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cbabs1.cfm. Retrieved on October 23, 2020.
[11]University of Wisconsin. Recycled Materials Resource Center. "Coal Bottom Ash/Boiler Slag - Material Description." https://rmrc.wisc.edu/ug-mat-coal-bottom-ashboiler-slag. Retrieved on October 23, 2020.
[12]American Coal Ash Association. "Boiler Slag." https://www.acaa-usa.org/aboutcoalash/whatareccps/boilerslag.aspx. Retrieved on October 23, 2020.
[13]Panday, Dinesh, et al. "Flue Gas Desulfurization Gypsum as Soil Amendment." *Soil Amendments for Sustainability: Challenges and Perspectives*. January 2019. Abstract.
[14]University of Wisconsin. Recycled Materials Resource Center. FGD Scrubber Material - Material Description. https://rmrc.wisc.edu/fgd-scrubber-material. Retrieved on October 23, 2020.
[15]Panday, Dinesh, et al. "Flue Gas Desulfurization Gypsum as Soil Amendment." *Soil Amendments for Sustainability: Challenges and Perspectives*. January 2019. Abstract.
[16]Greenleaf Advisors LLC. Gypsum for Agricultural Use: The State of the Science. February 2015. p 1.
[17]Gypsum Association. "FGD Gypsum and Sustainable Materials Management." https://gypsum.org/press-roomfgd-gypsum-board. Retrieved on October 23, 2020.
[18]American Coal Ash Association. "FGD Gypsum." https://www.acaa-usa.org/aboutcoalash/whatareccps/fluegasdesulfurizationgypsum.aspx. Retrieved on October 23, 2020.
[19]ARIPPA. What Is ARIPPA? https://arippa.org/. Retrieved on October 23, 2020.
[20]American Coal Ash Association. *Coal Combustion Products Safety Data Sheet Guidance Document.* August 2018. p 11.
[21]Jewell, Robert, et al. *Center for Coal-Derived Low Energy Materials for Sustainable Construction Final Scientific/Technical Report*. July 2012. pp. 4-5.
[22]ARIPPA. "Coal Refuse." White Paper. October 2015. p 3.
[23]Brisini, Vincent. Testimony of ARIPPA before the House Committee on Energy and Commerce, Subcommittee on Energy and Power. February 3, 2016. pp 9-10.
[24]American Coal Ash Association. "Beneficial Use of Coal Combustion Products: An American Recycling Success Story." 2019. p 6.
[25]Karr, Clarence, Jr., ed. *Analytical Methods for Coal and Coal Products: Volume II.* p 639.
[26]Wendell, T. "Cenospheres: From Waste to Profits." *American Ceramic Society Bulletin.* June 1995. Abstract.
[27]Karr, Clarence, Jr., ed. *Analytical Methods for Coal and Coal Products: Volume II.* p 639.
[28]American Coal Ash Association. Beneficial Use of Coal Combustion Products: An American Recycling Success Story." 2019. p 6.

For More Information

- American Coal Ash Association. *ASH at Work*.
- American Coal Ash Association. "Beneficial Use of Coal Combustion Products: An American Recycling Success Story."
- American Coal Ash Association. "What Are Coal Combustion Products?"
- American Road & Transportation Builders Association. *The Economic Impacts of Prohibiting Coal Fly Ash Use in Transportation Infrastructure Construction.*
- Robl, Tom, et al. *Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation.*
- University of Wisconsin. Recycled Materials Resource Center.
- U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction.*
- We Energies. *Coal Combustion Products Utilization Handbook.*

John Simpson is editor of *ASH at Work*.

FBC ash has been used to reclaim abandoned mine lands, such as this area in southwestern Pennsylvania.










Concrete, Concrete Blocks, and Controlled Low-Strength Material

By John Simpson

Concrete is among the most widely manufactured products in the world today, used to build critical infrastructure ranging from bridges to tunnels, dams, pipelines, and other durable structures. Traditionally, one of the main ingredients in concrete has been portland cement, whose manufacture involves vast energy consumption and emissions production. Fly ash can be used as a partial substitute for cement in the manufacturing of concrete—saving much of these emissions while improving the strength and durability of concrete. Fly ash and, to a lesser degree, bottom ash are both used in the manufacture of concrete blocks (standardized light construction blocks) and controlled low-strength material (CLSM)—flowable cementitious filler that boasts many operational and performance advantages over compacted soil in a range of fill applications.

CCPs Used in Concrete

- Fly Ash

CCPs Used in Concrete Blocks

- Fly Ash
- Bottom Ash

CCPs Used in Controlled Low-Strength Material

- Fly Ash
- Bottom Ash

Concrete

Two millennia ago, Romans discovered that the ash from a volcano near the town of Pozzuoli, when mixed with water and lime, formed a cement that could be used to make a particularly durable type of concrete.[1] What they had discovered was that this siliceous volcanic ash was a natural pozzolan—a material that reacts chemically with calcium hydroxide to form cementitious compounds.[2] Concrete made from this ash would be used to build the Pantheon, the Colosseum, and many other Roman structures that survive at least partially intact to this day.

"Modern" concrete production dates back only two centuries and is traced to the invention of portland cement, a powder made by heating and grinding limestone, clay, and other materials[3] that, when subsequently mixed with water and aggregates, hardens into concrete through a chemical reaction called hydration.[4] For much of the past 200 years, concrete production has used essentially four ingredients: air, water, aggregates, and cement. With the large-scale adoption of coal-fueled electricity production in the 20th century, however, a new source of pozzolanic material for use in concrete became available: fly ash.

Fly ash is a fine, powdery substance that "flies up" from the coal combustion chamber (boiler) and is captured by emission control devices, such as an electrostatic precipitator or fabric filter "baghouse" and scrubbers.[5] This material is virtually identical in its composition to volcanic ash, with pozzolanic properties that make it ideal in manufacturing concrete. As such, it can be used to replace up to 50 percent or more of the cement in concrete mixes depending on the intended application.

Substituting fly ash for a portion of the cement used to manufacture concrete confers significant economic, environmental, and performance benefits, as it:

- Generally is less expensive than portland cement.
- Improves concrete's workability and allows for the use of less water.
- Helps concrete achieve a higher compressive strength than that which uses only portland cement.
- Mitigates against alkali-silica reaction and sulfate attack, which can degrade concrete's durability.
- Lowers concrete's heat of hydration, helping to prevent thermal cracking in mass concrete placements (such as dams and large foundations).
- Decreases concrete permeability, thereby improving its corrosion resistance.
- Lowers the greenhouse gas emissions associated with concrete manufacturing (each ton of fly ash used in replacement of portland cement saves approximately one ton of carbon dioxide emissions).
- Avoids landfilling of ash.

In 2018 alone, over 12.5 million tons of fly ash was beneficially used in the manufacture of concrete and related products in the United States.[6] Guidelines covering the use of fly ash in concrete in the U.S. are published in ASTM C-618 and AASHTO M295, "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete."[7,8]

Concrete Blocks

Bottom ash comprises the agglomerated ash particles formed in pulverized coal furnaces that are too large to be carried in the

flue gases and are collected in a hopper at the bottom of the furnace.[9] In the U.S. and elsewhere throughout the world, bottom ash is utilized in the manufacture of concrete masonry units—standardized cast blocks used widely in light construction work, such as retaining walls and low-rise construction projects. Bottom ash is used as an aggregate material in such applications.[10]

Fly ash is commonly specified for use in autoclaved aerated concrete (AAC) blocks. Made from fine aggregates, cement, and an expansion agent that causes the concrete to fill with air, these blocks combine insulation and structural capability for use in walls, roofs, and floors.[11] In the UK, fly ash provides the major silica source for AAC blocks[12] and can contribute up to 70 percent of the product by mass.[13] In the U.S., use of fly ash in AAC blocks can contribute to Leadership in Energy and Environmental Design (LEED) points for a building project.[14]

Controlled Low-Strength Material

The American Concrete Institute describes controlled low-strength material (CLSM) as a self-consolidating cementitious material used primarily as a backfill in lieu of compacted fill.[15] Sometimes referred to as flowable fill, flowable fly ash, or fly ash slurry, CLSM has a compressive strength of 1200 pounds per square inch (psi) or less[16]—considerably lower-strength than concrete but greater than soil backfill.

CLSM mixtures typically comprise fly ash, portland cement, fine aggregate, and water. However, other recycled industrial materials, including bottom ash, can be used provided the mix attains the desired performance characteristics pertaining to strength, density, flowability, and excavatability.[17] A host of ASTM standards apply to CLSM covering preparation and testing methods, sampling practices, flow consistency, and other aspects of CLSM mixes.

CLSM is typically batched and mixed at a plant and delivered via ready-mix concrete truck at a consistency that resembles a very workable concrete.[18] Fly ash is used to give the mix its flowability and allows CLSM to be placed on the job site via chute, bucket, pump, or conveyor.[19] Owing to its flowable consistency during placement, CLSM can more easily, safely, and completely fill an irregular or difficult-to-access void than soil backfill. Because it is self-leveling, it needs no spreading or compacting, helping to speed project timelines and reduce labor requirements. And while compacted soil backfill can settle even after compaction, CLSM does not settle after hardening.[20]

For More Information

- Adams, Thomas H. "How Well Do You Know CLSM?"
- American Coal Ash Association. "Beneficial Use of Coal Combustion Products: An American Recycling Success Story."
- Boral Resources. "Fly Ash for Structural Concrete."
- Boral Resources. "Fly Ash in Controlled Low Strength Material."
- Carroll, R.A., and Guest, J.E. "Coal Combustion Products for the Manufacture of Precast Masonry Units in the United Kingdom."
- Portland Cement Association. "Autoclaved Aerated Concrete."
- Portland Cement Association. "How Concrete Is Made."
- Ragan, Steve. *A Cost-Effective Alternative to Compacted Soil Backfill.*
- Smith, Anne. "Controlled Low Strength Material."
- U.S. Department of Transportation. *Fly Ash Facts for Highway Engineers.* "Chapter 3: Fly Ash in Portland Cement Concrete."
- U.S. Department of Transportation. *Fly Ash Facts for Highway Engineers.* "Chapter 5: Fly Ash in Flowable Fill."

Due to its ease of use, CLSM has many common construction applications, such as in bases and subbases for pavement; bedding material for electrical, telephone, and other conduits; and backfill for trenches, holes, or other narrow or difficult-to-access cavities. CLSM may also be used as a foundation support, helping to provide a level, uniform surface for foundation footings and slabs that would otherwise rest on weak soils or uneven/non-uniform subgrades. In such instances, CLSM's compressive strength potentially can be gauged so as to lower the required thickness or strength of the concrete slab.[21]

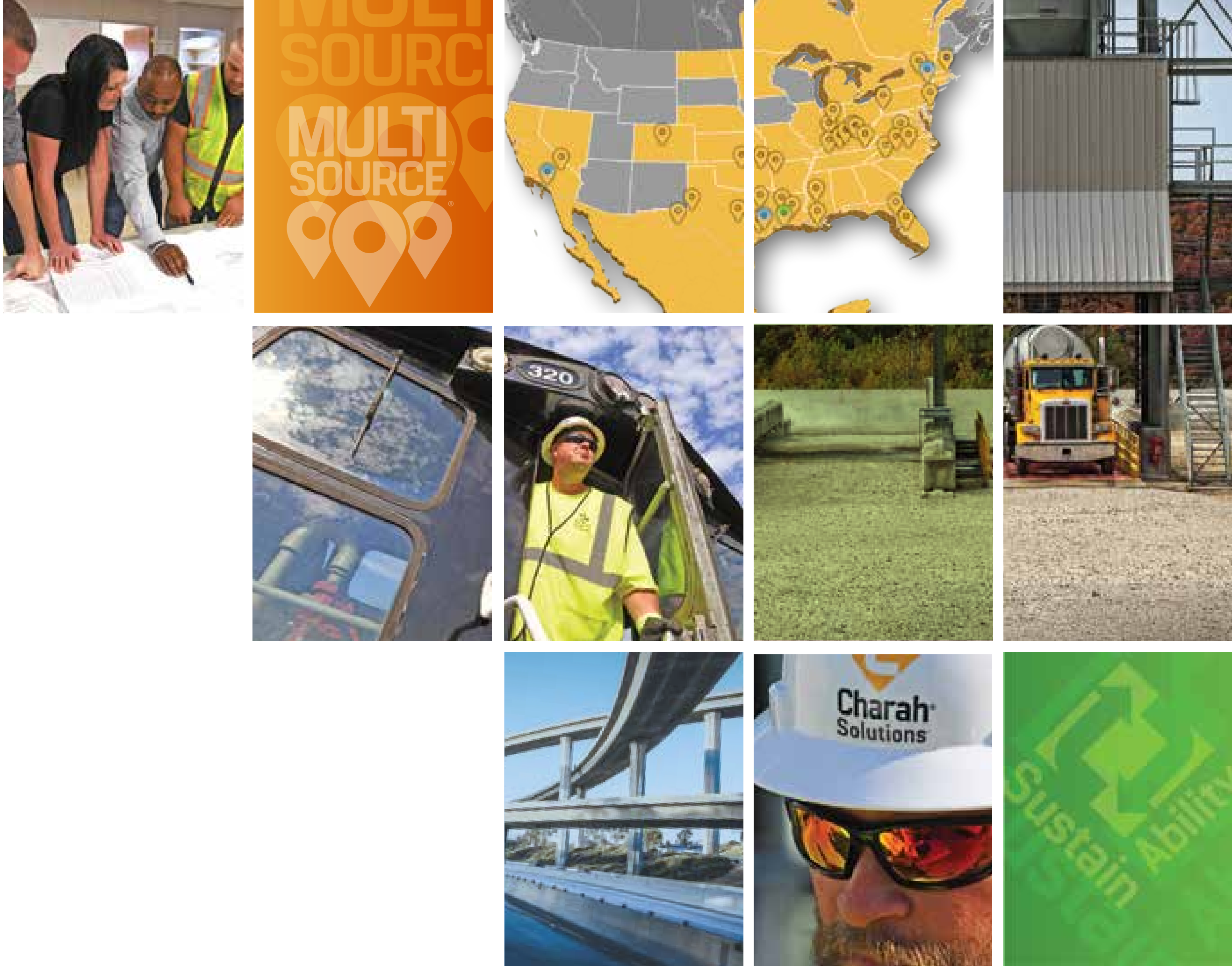
CLSM boasts a range of other operational and performance benefits, including:

- Fast placement.
- More durable and erosion resistant, and less permeable, than soil or aggregate fill.
- No need for heavy equipment, such as front-end loaders and rollers.
- Safe to use, as workers do not have to enter trenches or other confined spaces to place or spread material.
- Higher load-carrying capacity than compacted soil.
- Mix designs can be adjusted according to fill requirements.
- Easily excavated, provided the CLSM mix is 300 psi or lower.

Endnotes

[1]Faris, Daniel. "What Is Concrete: How Concrete Is Made and Why it's so Important." ZMEScience.com. April 20, 2017.
[2]American Concrete Institute. "Pozzolan." www.concrete.org/topicsinconcrete/topicdetail/pozzolan. Retrieved on September 22, 2020.
[3]Portland Cement Association. "How Cement Is Made." www.cement.org/cement-concrete-applications/how-cement-is-made. Retrieved on September 22, 2020.
[4]Portland Cement Association. "How Concrete Is Made." www.cement.org/cement-concrete-applications/how-concrete-is-made. Retrieved on September 22, 2020.
[5]American Coal Ash Association. "Fly Ash." www.acaa-usa.org/aboutcoalash/whatareccps/flyash. Retrieved on September 22, 2020.
[6]American Coal Ash Association. "ACAA 2018 CCP Survey Results." www.acaa-usa.org/Portals/9/Files/PDFs/2018-Survey-Results.pdf.
[7]ASTM International. "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete."
[8]American Association of State Highway and Transportation Officials. "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete."
[9]American Coal Ash Association. "Bottom Ash." https://www.acaa-usa.org/aboutcoalash/whatareccps/bottomash.aspx. Retrieved on September 22, 2020.
[10]Recycled Materials Resource Center. "Coal Bottom Ash/Boiler Slag - Material Description." https://rmrc.wisc.edu/ug-mat-coal-bottom-ashboiler-slag. Retrieved on September 22, 2020.
[11]Portland Cement Association. "Autoclaved Aerated Concrete." https://www.cement.org/cement-concrete-applications/paving/buildings-structures/concrete-homes/building-systems-for-every-need/autoclaved-aerated-concrete. Retrieved on September 22, 2020.
[12]Carroll, R.A., and Guest, J.E. "Coal Combustion Products for the Manufacture of Precast Masonry Units in the United Kingdom." 2006. Abstract. http://www.ukqaa.org.uk/wp-content/uploads/2014/02/AshTech-2006-Carroll-Guest.pdf.
[13]Ibid. Introduction.
[14]Portland Cement Association. "Autoclaved Aerated Concrete." https://www.cement.org/cement-concrete-applications/paving/buildings-structures/concrete-homes/building-systems-for-every-need/autoclaved-aerated-concrete. Retrieved on September 22, 2020.
[15]American Concrete Institute. ACI Committee 229. "Controlled Low Strength Materials." *Concrete International.* 1994. Abstract.
[16]Adams, Thomas H. "How Well Do You Know CLSM?" *ASH at Work.* Issue 2, 2019. p 24.
[17]Do, T.M., and Kim, Y. "Engineering Properties of Controlled Low Strength Material (CLSM) Incorporating Red Mud." *International Journal of Geo-Engineering.* No. 7. 2016. Introduction.
[18]U.S. Department of Transportation. *Fly Ash Facts for Highway Engineers.* "Chapter 5: Fly Ash in Flowable Fill." Updated June 27, 2017.
[19]Smith, Anne. "Controlled Low Strength Material." *Concrete Construction.* 1991. p 4.
[20]Ragan, Steve. *A Cost-Effective Alternative to Compacted Soil Backfill.* Technical Report. https://www.graniterock.com/technical_reports/a-cost-effective-alternative-to-compacte. Retrieved on September 22, 2020.
[21]Ibid.

John Simpson is editor of *ASH at Work*.



MULTISOURCE® MULTIPLIES YOUR FLY ASH SALES RESULTS.

Effective fly ash marketing is all about the strength of your network. Utilities and fly ash customers both know they can count on the Charah® Solutions MultiSource materials network and our dedicated sales team to deliver results. With nearly 40 strategic locations nationwide, and our proven MP618® fly ash beneficiation technology, we are ready with the network, the team, and the expertise to keep your fly ash moving. **For more information, contact us at 877-314-7724 or visit charah.com.**

Charah® Solutions

Service Above All®

Soil Stabilization, Road Base/ Sub-Base, and Structural Fill

By John Simpson

A range of coal combustion products are used in the stabilization of soils to improve their chemical and mechanical properties. Both Class C and Class F fly ashes are commonly specified to enhance soil's strength properties, stabilize embankments, control the shrink swell properties of expansive soils, and reduce soil moisture content to permit compaction. Coal combustion products can be particularly useful in stabilizing soil where structures such as roads and buildings are to be built upon it. Both Class C and Class F fly ashes are widely used to help provide stable road bases and sub-bases; bottom ash, boiler slag, and FGD gypsum are also used to varying degrees in base courses. Fly ash, bottom ash, and FGD materials are also used in structural fill to build stable embankments and strengthen and level uneven ground.

CCPs Used in Soil Stabilization

- Fly Ash

CCPs Used in Road Base/Sub-Base

- Fly Ash
- Bottom Ash
- Boiler Slag
- FGD Gypsum

CCPs Used in Structural Fill

- Fly Ash
- Bottom Ash
- FGD Gypsum

Soil Stabilization

Fly ash is commonly added to soil to improve its stability before erecting a structure of one sort or another atop it. Addition of fly ash can be useful in improving its density, plasticity, water content, and strength performance.[1] Class C fly ash, which originates from subbituminous and lignite coals, is often used as a stand-alone material because of its self-cementing properties.[2] Class F fly ash, which originates from anthracite and bituminous coals, can be used in soil stabilization applications with the addition of a cementitious agent (e.g., lime, lime kiln dust, cement, cement kiln dust).[3]

Fly ash is used in numerous geotechnical applications to:
- Enhance strength properties
- Stabilize embankments
- Control shrink swell properties of expansive soils
- Reduce soil moisture content to permit compaction[4]

Road Base/Sub-Base

Stabilization of road base and sub-base is essential to road building as these layers form the foundation beneath the pavement that helps maintain the road over time and usage. A high-quality base incorporating fly ash, aggregates, and potentially a cementing agent may even outlive the life of the pavement itself.

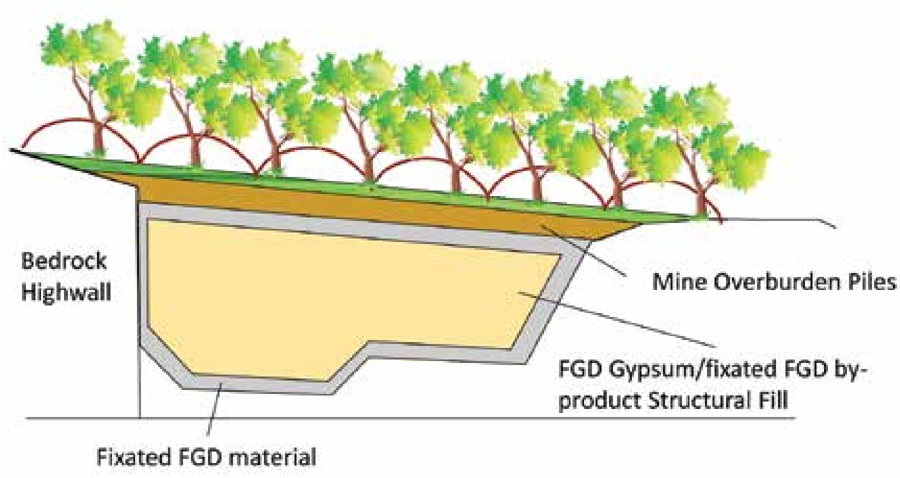
Stabilization of aggregate road bases with fly ash has a lengthy and successful track record in the United States. Starting in the 1950s, blends of fly ash, aggregate, and lime known as pozzolan-stabilized base ("PSB") have been used to underpin high-traffic roads. Bottom ash and boiler slag have also been added to such mixes for use in the base courses of residential streets and haul roads.[5] Base courses stabilized by coal combustion products are a proven, cost-effective alternative for the foundation of both flexible and rigid pavements where "conventional" base materials are cost-prohibitive or otherwise not readily available.

As noted above, both classes of fly ash (C and F) are regularly used in stabilized base and sub-base mixtures. Owing to its self-cementing properties, Class C fly ash does not require a chemical reagent or activator (i.e., lime, cement, or kiln dust). In most cases it is mixed, at amounts in the 5-15 percent range, with aggregate and water. In certain instances, however, it is used alone as the base material without any aggregate. Class F fly ash is added, together with a chemical reagent or activator, in amounts typically comprising 8-20 percent of the mix when combined with coarse-graded aggregates, and in the 15-30 percent range when combined with sandy aggregates.[6]

Fly ash-stabilized bases/sub-bases can:
- Add significantly to the strength and durability of base courses
- Allow for the use of lower-quality aggregates
- Reduce project costs[7]

Bottom ash, which can range from the consistency of fine- to coarse-grained sand, and boiler slag, which comprises hard, durable granular particles, are both occasionally used as unbound fine aggregates or granular base material in pavement construction. When used in stabilized base applications, they may need to be blended with natural aggregates to meet

specifications. And while both bottom ash and boiler slag have cementitious properties, lowering the requirement for the use of other cementitious materials in the mix, they may require grinding to achieve the desired particle size.[8]



SOURCE: OSU College of Engineering

Stabilized FGD material has also successfully been used in base construction in a number of state road projects throughout the United States, including in Florida, Ohio, Pennsylvania, and Texas. Typically, in such instances, FGD scrubber sludge is dewatered, after which a combination of pozzolanic or self-cementing fly ash, quicklime (or another activator), and portland cement are added to ensure the mix meets the required compressive strength.[9]

Structural Fill

Structural fill is material placed and compacted to create a strong, stable base for an intended use—whether for a building foundation, highway embankment, or as backfill for a retaining structure. Frequently, fill material comprises soil and natural aggregates. Alternatively, coal combustion products ranging from fly ash to bottom ash and flue gas desulfurization material can be used where they are more readily and/or inexpensively available and can provide the same or superior performance to conventional fill material. The specific attributes of each coal combustion product determine its use in a particular application.

The use of fly ash in structural fills was pioneered in Great Britain in the 1950s. Its use dates to at least 1971 in the United States, when Minnesota and West Virginia specified it as the fill material of choice in several state road projects.[10] In the half-century since, the use of fly ash to build embankments and strengthen and level uneven ground has expanded nationwide to projects ranging from shopping malls to housing developments, as well as diverse residential, commercial, and industrial developments.

When used as embankment or structural fill material, fly ash confers several advantages over soil and aggregate. For starters, it can be a cost-effective alternative where it is available in bulk quantity. A silt-like, lightweight material, it can be transported easily; generally does not require additional crushing or screening; and can be spread and leveled via bulldozer and grader, minimizing construction time and costs. Since fly ash is composed almost entirely of spherical-shaped particles, the material can be densely packed during compaction for low permeability to minimize seepage of water through an embankment. Finally, its high shear strength, compared to its weight, conveys good bearing support and minimizes settlement.[11]

Bottom ash has likewise proven itself as a structural fill material in highway embankments—as well as for use in the backfilling of abutments, trenches, and retaining walls. Generally lighter than natural granular fill materials, bottom ash drains easily, is not sensitive to moisture variation, and can be placed and compacted using the same equipment as fly ash. Nonetheless, as its particles are larger than fly ash, it may require grinding or screening prior to placement and compaction.[12]

Occasionally, flue gas desulfurization (FGD) materials are also used for structural fills and highway embankments. FGD materials boast several advantages over natural fill materials such as soil. As with fly ash and bottom ash, FGD materials possess a high shear strength-to-weight ratio relative to natural soils and can be readily spread over soft or low-bearing-strength soil to bolster its structural strength. FGD materials also typically provide higher slope stability compared to naturally occurring soils.[13] Additionally, FGD materials on occasion have been placed in underground mines as structural fill to ameliorate subsidence.[14]

Endnotes

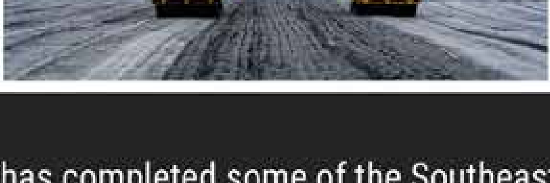
[1]American Coal Ash Association. *Fly Ash Facts for Highway Engineers*. p 12.
[2]Ibid. p 25.
[3]Ibid.
[4]Ibid. p 47.
[5]U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction*. "Introduction."
[6]Ibid.
[7]American Coal Ash Association. *Fly Ash Facts for Highway Engineers*. p 25.
[8]University of Wisconsin. Recycled Materials Resource Center. "Coal Bottom Ash/Boiler Slag - Material Description." https://rmrc.wisc.edu/ug-mat-coal-bottom-ashboiler-slag. Retrieved on October 11, 2020.
[9]U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction*. Material Description. "Highway Uses and Processing Requirements."
[10]U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction*. Table 5-4. "List of Fly Ash Embankment or Structural Backfill Projects Constructed in the United States."
[11]Ibid. "Performance Record."
[12]U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction*. Coal Bottom Ash/Boiler Slag. "Highway Uses and Processing Requirements - Granular Base."
[13]Robl, Tom, et al. *Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation*. "Chapter 6: The Utilization of Flue-Gas Desulfurization Materials." p 157.
[14]Ibid. p 161.

For More Information

- American Coal Ash Association. *Fly Ash Facts for Highway Engineers*.
- American Foundry Society. "Structural Fill and Embankment."
- ASTM International. *Standard Guide for Design and Construction of Coal Ash Structural Fills*.
- Charah Solutions. "What is a Fully Lined Structural Fill?"
- Ramme, Bruce W. Ph.D., P.E., and Tharaniyil, Mathew P., P.E. *Coal Combustion Products Utilization Handbook*.
- Robl, Tom, et al. *Coal Combustion Products (CCPs): Characteristics, Utilization and Beneficiation*.
- University of Wisconsin. Recycled Materials Resource Center. "Coal Bottom Ash/Boiler Slag - Embankment/ Structure Fill."
- U.S. Department of Transportation. Federal Highway Administration. *User Guidelines for Waste and Byproduct Materials in Pavement Construction*.

John Simpson is editor of *ASH at Work*.


THE RIGHT DIRECTION
FOR HEAVY CIVIL CONSTRUCTION &
POWER GENERATION PROJECTS



Cement Production

By John Simpson

While many are familiar with the use of coal ash in the production of concrete, it is also utilized as a raw feed material in the production of cement (itself a key ingredient in concrete). Adding coal ash to the materials that are fed into a cement kiln can help make the manufacturing process more efficient and improve the finished product. In the case of fly ash (as well as bottom ash and boiler slag), the carbon content can provide a fuel supplement to lower energy and emissions during kiln operations. FGD materials can replace the natural gypsum that is typically added to the final cement product to control its setting properties. Finished cements that incorporate coal combustion products (CCPs) can convey performance-enhancing traits, such as lower heat generation compared to portland cement, good workability, and reduced alkali-silica reactivity.

CCPs Used in Cement Manufacturing

- Fly Ash
- Bottom Ash
- Boiler Slag
- FGD Gypsum

Ordinary portland cement (OPC) is a key ingredient in the production of concrete, one of the world's most widely manufactured products. Cement is manufactured by crushing, combining, and heating a variety of quarried materials in a kiln until they form clinker, after which the material is cooled, ground into an ultrafine powder, and a small amount of gypsum is added to control the cement's setting properties. In the United States, cement is manufactured to technical standards published by ASTM International and the American Association of State Highway and Transportation Officials.

First developed almost two centuries ago, cement production is now one of the most energy-intensive and highest carbon dioxide-emitting industries, accounting for approximately 8 percent of man-made CO2 emissions globally.[1] Over half of the carbon dioxide released during cement production results from the calcination process—in which limestone is converted into lime and CO2—with most of the remainder resulting from the burning of fuel to generate the heat required for calcination to occur.[2] If coal ash is added to the raw feed, however, its carbon content can provide a valuable fuel supplement for this energy-intensive process.[3]

Chemical Makeup of Kiln Feed, Coal Ash

The primary chemical components in the typical cement kiln feed are alumina, iron oxide, lime, and silica.[4] Conveniently, fly ash and bottom ash are typically rich in these very same compounds, particularly alumina and silica, making them useful as a substitute for clay or shale, both of which are also commonly used in the kiln feed.[5] In addition to saving on the costs (both economic and environmental) associated with mining virgin resources such as clay and shale, use of coal ash in the raw feed avoids incurring potential ash-landfilling expenses.

Coal ash can be utilized in either dry or wet cement production. In the dry cement manufacturing process, ash is either premixed with the other raw materials in the kiln feed or added directly to the kiln. In the wet cement manufacturing process, coal ash is mixed into the slurry before the blend is heated in the kiln.[6] FGD materials can replace the natural gypsum that is commonly added to the final cement product[7] to control the hydration process when cement is mixed with water.

Sample oxide analyses of ash and portland cement (%)

Compounds	Fly Ash Class F	Fly Ash Class C	Portland Cement
SiO_2	55	40	23
Al_2O_3	26	17	4
Fe_2O_3	7	6	2
CaO (Lime)	9	24	64
MgO	2	5	2
SO_3	1	3	2

Source: U.S. Department of Transportation

While the chemical composition of coal ash varies depending on the type and origin of the coal from which it is derived, the key requirement of cement producers is that a given supply of ash be of a consistent chemical composition. This avoids having to constantly modify the raw feed mix to ensure the correct kiln feed composition is maintained.[8] X-ray fluorescence

spectroscopy can be used to test coal ash for its chemical composition, while gravimetric and loss-on-ignition testing can determine characteristics such as moisture and unburned carbon content.[9] Ultimately, cement manufacturers test and analyze finished cements for compliance with industry standards to ensure that their strength, durability, and other performance characteristics make them suitable for their intended construction uses.

Use of coal combustion products as part of the raw feed in cement production can convey significant benefits—to coal utilities, cement producers, and indeed the wider public. Coal utilities can avoid disposal expenses. Likewise, cement producers can reduce the manufacturing and environmental costs associated with their operations by substituting lower-cost byproduct materials in place of virgin mined materials—such as coal ash in place of clay or shale and FGD gypsum in place of natural gypsum. Cement manufacturers that use coal ash can also realize energy and emissions reductions from the enhanced efficiency of their kiln operations. Finally, cements that are made from coal ash acquire several important performance-enhancing characteristics, including lower heat generation compared to OPC, good workability, and reduced alkali-silica reactivity.[10]

For More Information

- 911 Metallurgist. "Fly Ash as a Portland Cement Raw Material."
- Alberici, Sacha, et al. "Fly Ash and Blast Furnace Slag for Cement Manufacturing."
- American Ceramic Society. "Fly Ash Binder Could Eventually Replace Portland Cement in Concrete."
- Argiz, Cristina, et al. "Coal Bottom Ash for Portland Cement Production."
- ASTM International. "Cement Standards and Concrete Standards."
- ASTM International. "Standard Specification for Portland Cement."
- Portland Cement Association. "How Cement Is Made."
- Portland Cement Association. "Sustainable Manufacturing Fact Sheet: Power Plant Byproducts."

Endnotes

[1]Lehne, Johanna and Felix Preston. *Making Concrete: Change Innovation in Low-Carbon Cement and Concrete*. Chatham House Report. Executive Summary. June 2018.
[2]WWF International. *A Blueprint for a Climate Friendly Cement Industry*. 2008. p 18.
[3]Bhatty, J. et al. "Utilization of Discarded Fly Ash as a Raw Material in the Production of Portland Cement." *Journal of ASTM International 3, no. 10*. 2006. Abstract.
[4]Barton, William. "Raw Materials for Manufacture of Cement." *Fly Ash Utilization: Edison Electric Institute, National Coal Association, Bureau of Mines Symposium Proceedings*. 1967. p 47.
[5]Bhatty, J. et al. "Utilization of Discarded Fly Ash as a Raw Material in the Production of Portland Cement." *Journal of ASTM International 3, no. 10*. 2006. Abstract.
[6]"Power Plant Ashes as Substitute Raw Materials." *Global Cement*. November 19, 2012.
[7]"About Cement." www.enhanceicd.com. Retrieved September 17, 2020.
[8]Barton, William. "Raw Materials for Manufacture of Cement." *Fly Ash Utilization: Edison Electric Institute, National Coal Association, Bureau of Mines Symposium Proceedings*. 1967. pp. 49-50.
[9]Bhatty, J. et al. *Use of High-Carbon Illinois Coal Fly Ash in Portland Cement Manufacturing.* Final Technical Report. 1999. p 3.
[10]"Power Plant Ashes as Substitute Raw Materials." *Global Cement*. November 19, 2012.

John Simpson is editor of *ASH at Work*.

Agriculture and Soil Modification

By John Simpson

Modifiers have been added to soil to improve plant growth and crop yield for thousands of years. For the past 50 years, flue gas desulfurization (FGD) gypsum—calcium sulfate dihydrate—produced by the removal of sulfur by coal plant emission control devices, has been added to soil to improve its nutrient profile. It is now widely used to boost the characteristics and yield of crops ranging from peanuts to tomatoes and cantaloupes. To a lesser degree, alkaline fly ashes have been tested and used to enhance soil conditions and crop growth by balancing the pH of acidic soils and improving their water-retention capacity.

CCPs Used in Agriculture and Soil Modification

- FGD Material
- Fly Ash

The use of fertilizers—soil additives intended to enhance plant growth—dates back thousands of years. The ancient Egyptians, for example, used pigeon manure to boost the growth of their vegetable and fruit gardens.[1] The 19th century English agricultural scientist Sir John Bennet Lawes is credited with inventing "artificial manure"—precursor to the modern chemical fertilizer industry—when he patented a soil additive formed by treating phosphates with sulfuric acid.[2] Today synthetic nitrogen fertilizers—typically produced using a highly energy-intensive procedure known as the Haber–Bosch process—underpin the productivity of much of modern agriculture.[3]

Of course, there are many other types of fertilizers in use today, including those derived from phosphorous, organic waste, industrial byproducts, and even municipal sludge. Use of one versus the other may depend on any number of factors, including cost, availability, local soil and climatic conditions, and the specific crop that is being grown. Gypsum's value as a soil additive has been known in the U.S. since the colonial times,[4] and agronomists continue to find new uses for it today.

Gypsum vs. Synthetic Gypsum

Traditionally, gypsum has been sourced from mines and quarries, and the United States today remains the largest producer of mined gypsum in the world. Since the passage of the Clean Air Act in 1970, however, a synthetic form known as flue gas desulfurization (FGD) gypsum has been available to the market. FGD gypsum is produced when emissions control systems at coal-fueled power plants remove sulfur and oxides from flue gas streams. The scrubbers spray liquid lime or limestone slurry into the flue gas path, where it reacts with sulfur in the gas to form calcium sulfite, which is then converted to gypsum through forced air oxidation. The material is then dewatered and processed, resulting in a powder that is typically finer, purer, and more uniform than mined gypsum, but which bears the identical chemical composition: CaSO4 2H2O (calcium sulfate dihydrate).[5]

As is obvious from its chemical formula, FGD gypsum is rich in both calcium and sulfur—two nutrients that are essential to virtually all crops. As such, FGD gypsum can be highly effective when applied to areas with calcium-poor soils and to crops with high calcium requirements. FGD gypsum is often applied to peanut fields, as well as to fruit crops such as cantaloupes and tomatoes that require calcium to strengthen their skin, reduce their blemishes, and improve their shelf life.[6] FGD gypsum's sulfur is an increasingly important soil additive as a result of the reduction of atmospheric sulfur deposition (largely as a result of its removal by emissions control devices) and the reduced level of sulfur found in much of today's nitrogen and phosphorous fertilizers.[7] Owing to its fine and uniform consistency, FGD gypsum is easily spread via conventional agricultural equipment. And, as it is only moderately soluble in soil,[8] FGD gypsum releases sulfur over the course of multiple years—minimizing the need for repeated applications.

As with any fertilizer or chemical additive, a range of considerations should be kept in mind when deciding whether and when to apply gypsum. FGD gypsum is not suitable for all soil types, soil conditions, or crops—and any use of FGD gypsum as a soil amendment requires a well-characterized study of the soil before application. Moreover, individual states may have regulations and standards that need to be observed regarding its use. It is typically recommended that the relevant state department of agriculture or state extension service be consulted before FGD gypsum is used as a soil amendment.[9] Appropriate application rates then can be determined to accomplish specific soil improvement goals.

That said, agricultural scientists continue to research and test new applications for FGD gypsum that could become increasingly important in the coming years. One promising avenue of research is in the use of FGD gypsum to reduce the incidence

and impact of "algal blooms"—caused by the runoff of phosphorous and nitrogen fertilizers into waterways—that are increasingly polluting U.S. water basins and threatening both human drinking supplies and wildlife. Spread over affected croplands, FGD gypsum has been shown to be effective in binding with phosphorus to make it less soluble and thus less able to run off into the water.[10]

Fly Ash in Soil Modification

To a lesser degree, fly ash has also been investigated and used to modify and improve soil properties for agricultural crops. (For information on fly ash's use in soil *stabilization* to improve the engineering performance of soils, such as for structural fills and subgrades in road construction, please see "Soil Stabilization, Road Base/Sub-Base, and Structural Fill" on page 16.)

Physically, fly ashes comprise silt-sized particles, which can be useful in helping transform the texture of sandy and sandy-clay soils to loamy, which is more favorable for agricultural cultivation.[11] In dry conditions, clayey soils can form dense, hard clods, leading to poor soil-seed contact and lower germination.[12] Fly ash has been shown to increase the water retention capacity in sandy soils and the ability of soil to transmit water in clayey soils.[13]

Chemically, fly ashes are comprised primarily of oxides of silicon, aluminum, iron, and calcium, with lesser amounts of magnesium, potassium, sodium, titanium, and sulfur. Many of these elements have been shown to increase the nutrient uptake and yield of certain crops. Fly ash has been demonstrated to improve the crop yields of alfalfa and barley, among other crops, under certain soil conditions.[14] Fly ashes' typically high alkalinity—most have a pH in the range of 8-12[15]—mean they can be used effectively as a liming agent to neutralize acidic soils and improve their nutrient status.

As with FGD gypsum, soil testing and characterization, as well as chemical analysis of the fly ash itself, should be undertaken before it is applied to agricultural soils.

For More Information

- DeMuro, Katie/Greenleaf Advisors LLC. "New Research Identifies Tool to Mitigate Phosphorus."
- Energy & Environmental Research Center. "A Comparison of Properties of FGD & Natural Gypsum Products."
- Environmental Protection Agency. *Agricultural Uses for Flue Gas Desulfurization (FGD) Gypsum*.
- FGDProducts.org. "Introduction to FGD Gypsum."
- Patil, Suhas V. Dr., et al. "Industrial Applications of Fly Ash: A Review."
- USDA Agricultural Research Service. "Fact Sheet: Gypsum."
- Watts, Dexter B., and Dick, Warren A. "Sustainable Uses of FGD Gypsum in Agricultural Systems: Introduction."
- We Energies. "Agricultural Gypsum."

Endnotes

[1]Food and Agriculture Organization of the United Nations. "Ancient Egyptian Agriculture." http://www.fao.org/country-showcase/item-detail/en/c/1287824. Retrieved on October 1, 2020.

[2]Encyclopedia Britannica. "Sir John Bennet Lawes, 1st Baronet." https://www.britannica.com/biography/Sir-John-Bennet-Lawes-1st-Baronet. Biography. Retrieved on October 1, 2020.

[3]Grow Journey. "5 Facts You Should Know About Synthetic Nitrogen Fertilizer." https://www.growjourney.com/5-facts-synthetic-nitrogen-fertilizer. Retrieved on October 1, 2020.

[4]We Energies. "Agricultural Gypsum." https://www.we-energies.com/environmental/gypsum.htm. Retrieved on October 1, 2020.

[5]Environmental Protection Agency. *Agricultural Uses for Flue Gas Desulfurization (FGD) Gypsum*. March 2008. p 2.

[6]Ibid. p 3.

[7]Ibid.

[8]Watts, Dexter B., and Dick, Warren A. "Sustainable Uses of FGD Gypsum in Agricultural Systems: Introduction." *Journal of Environmental Quality.* January 2014.

[9]Environmental Protection Agency. *Agricultural Uses for Flue Gas Desulfurization (FGD) Gypsum*. March 2008. p 2.

[10]DeMuro, Katie/Greenleaf Advisors LLC. "New Research Identifies Tool to Mitigate Phosphorus." Research Bulletin. Updated May 14, 2015.

[11]Reddy Katta J., et al. "Effects of a Carbon Dioxide Pressure Process on the Solubilities of Major and Trace Elements in Oil Shale Solid Wastes." *Environmental Science & Technology.* 25 (8). 1991 pp. 1466-1469.

[12]Salé, Loretta Y., et al. *Temporal Influence of Fly Ash on Soil Bulk Density and Aggregate Size Distribution.* Proceedings of the 20th Annual British Columbia Mine Reclamation Symposium in Kamloops, BC. 1996. p 185.

[13]Kersch, Christof. "Leachability of Metals from Fly Ash: Leaching Tests Before and After Extraction with Supercritical CO2 and Extractants." *Hydrometallurgy.* 71 (s 1–2). February 2004. pp. 119-127.

[14]Weinstein, L.H., et al. "Elemental Analysis of Grasses and Legumes Growing on Soil Covering Coal Fly Ash Landfill Sites." *Journal of Food Safety*. 9. pp. 291-300.

[15]Ukwattage, N.L., and Ranjith P.G. "Accelerated Carbonation of Coal Combustion Fly Ash for Atmospheric Carbon Dioxide Sequestration and Soil Amendment: An Overview." *Journal of Pollution Effects & Control.* 2018. 6:1. p 5.

John Simpson is editor of *ASH at Work*.

Gypsum Panel Products

By John Simpson

Gypsum panel products—gypsum sheet products including, but not limited to, drywall—have been used in a wide range of interior and exterior building applications in the United States for roughly three-quarters of a century. Traditionally gypsum panel product manufacturers sourced gypsum from mines. However, coal plants' adoption of sulfur dioxide "scrubbers," pursuant to the 1970 Clean Air Act and related regulations, has afforded such manufacturers a safe, synthetic, and environmentally benign source of this material: FGD gypsum. Typically purer than in its mined form, and less expensive, FGD gypsum today comprises almost half of all gypsum used in the manufacture of gypsum board in the United States.

CCPs Used in Gypsum Panel Products

• FGD Gypsum

Gypsum panels, also known as drywall or wallboard, are indispensable to the modern North American construction industry. According to the Gypsum Association, over 20 billion square feet of gypsum panels are manufactured annually in the U.S. and Canada.[1] Gypsum panel is favored for a wide range of construction applications—including, but not limited to wall, ceiling, and partition systems—because it is fire resistant and, relative to competing materials, lightweight and inexpensive.

Gypsum first gained popularity as a construction material in the U.S. in the mid-20th century as a result of its widespread availability in mined form. Today it continues to be mined in 19 U.S. states.[2] However, with the passage of the Clean Air Act of 1970—which put new restrictions on sulfur dioxide (SO2) emissions from industrial sources—coal-fueled power plants began generating flue gas desulfurization (FGD) gypsum as a byproduct of the scrubbing systems installed to remove SO2. In the ensuing decades, availability of this synthetic form of gypsum would greatly boost overall supplies of this mineral while markedly lowering its market price for gypsum panel manufacturers.[3]

Whether fabricated from mined or FGD gypsum, gypsum board ("drywall") is manufactured according to the ASTM C1396 Standard Specification for Gypsum Board—compliance with which is mandated by model building codes in the United States.[4] In the case of FGD gypsum, coal utilities follow a multistage manufacturing process to ensure their product meets the exacting requirements of the gypsum panel products and construction industries. The material that results from this process is typically called "washed FGD gypsum."[5]

The most commonly employed FGD scrubber technologies are wet and dry systems. Wet systems spray alkaline sorbent of lime or limestone (CaCO3) into the flue gas, which reacts with the sulfur dioxide to form calcium sulfite. The calcium sulfite is converted into gypsum via oxidation with water. Dry FGD systems use less water in the process and generate a dry byproduct.[6]

FGD gypsum produced from coal plant

scrubbers—calcium sulfate dihydrate—is virtually identical to that which is extracted from mines, but typically boasts a higher purity.[7] Unlike in the case of fly ash (or bottom ash), the chemical composition of FGD gypsum is not governed by the source of the coal or the boiler type—but rather by factors such as the type of reagent (typically lime or limestone), the water levels used to distribute the reagent throughout the flue gas, and a variety of other conditions within the scrubber unit.[8] Ultimately, FGD gypsum is tested by the power plant and again at the manufacturing facility to ensure it meets all required specifications for its intended use.

Because gypsum—both FGD and mined—is recyclable, it is considered a "green" building material. FGD gypsum, however, boasts additional environmental attributes. As a beneficially used industrial byproduct, it reduces the need to mine virgin gypsum (FGD gypsum is now used in almost half of all gypsum wallboard manufactured in the U.S.).[9] Moreover, beneficially using FGD gypsum avoids landfilling of this material. Finally, the proximity of many newer gypsum panel manufacturing plants to the coal power plants that supply them with FGD gypsum can save on transportation and energy costs, as well as the related emissions, potentially contributing to Leadership in Energy and Environmental Design (LEED) certification for projects that use these products.

The U.S. Environmental Protection Agency, in its 2014 report *Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard,* reaffirmed both the environmental benefits and safety of FGD gypsum use. The report concluded that "environmental releases of constituents of potential concern [from FGD gypsum wallboard] during use by the consumer are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors." The agency added, "EPA supports the beneficial use of [FGD gypsum in wallboard and] believes that these beneficial uses provide significant opportunities to advance Sustainable Materials Management (SMM)."[10]

For More Information

- Benson, Craig, and Bradshaw, Sabrina. *User Guideline for Flue Gas Desulfurization Material in Green Infrastructure Construction*.
- Duszynski, Dan. "Eco-Friendly FGD Gypsum Has a Role in Industries Across the Board."
- FGDProducts.org. "Introduction to FGD Gypsum."
- *Global Gypsum*. "Gypsum Wallboard in the USA."
- Gypsum Association. "FGD Gypsum and Sustainable Materials Management."
- Hamilton, Calvin and Rosanna. "Gypsum."
- Meima, Steve. "For Many Gypsum Association Member Companies, FlueGas Desulfurization Gypsum (FGD) Offers Alternative."
- Recycled Materials Resource Center. "FGD Scrubber Material - Material Description."
- U.S. Environmental Protection Agency. "Air Pollution Control Technology."
- U.S. Environmental Protection Agency. *Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard*.
- USG Corporation. "EPA Confirms Support for FGD Gypsum Wallboard."

Endnotes

[1]Gypsum Association. "Gypsum Industry Statement on COVID-19." April 6, 2020.
[2]Hamilton, Calvin and Rosanna. ScienceViews.com. "Gypsum."
[3]"Gypsum Wallboard in the USA." *Global Gypsum*. September 9, 2013.
[4]Gypsum Association. "FGD Gypsum and Sustainable Materials Management." Retrieved on September 17, 2020.
[5]Meima, Steve. "For Many Gypsum Association Member Companies, Flue Gas Desulfurization Gypsum (FGD) Offers Alternative." *ASH at Work*. Issue 1, 2016. p 42.
[6]Recycled Materials Resource Center. "FGD Scrubber Material – Material Description."
[7]USG Corporation. "EPA Confirms Support for FGD Gypsum Wallboard." Retrieved on September 17, 2020.
[8]Recycled Materials Resource Center. "FGD Scrubber Material – Material Description."
[9]Gypsum Association. "FGD Gypsum and Sustainable Materials Management." Retrieved on September 17, 2020.
[10]U.S. Environmental Protection Agency. *Coal Combustion Residual Beneficial Use Evaluation: Fly Ash Concrete and FGD Gypsum Wallboard*. February 2014. p 5-25.

John Simpson is editor of *ASH at Work*.

Mine Reclamation and Waste Stabilization

By John Simpson

Owing to their cementitious properties and generally high pH content, coal combustion products are often used—as backfill, solidifying material, pH-neutralizing agent, or soil conditioner—in the reclamation of abandoned mines, as well as to solidify or stabilize wastes and sludge. With respect to mine reclamation, fluidized bed combustion (FBC) boilers actually consume anthracite and bituminous coal refuse as their primary fuel to generate electricity, in the process producing ash that can be returned to the mine site both to neutralize acid runoff and to help return the surrounding environment to its original condition. Fly ash and FBC ash have both proven their use as additives to municipal and industrial sludge—variously to allow for landfill disposal and in the creation of beneficial use products, such as soil conditioner and aggregate.

CCPs Used in Mine Reclamation and Waste Stabilization

- Fly Ash
- Bottom Ash
- Boiler Slag
- FGD Material
- FBC Ash

Coal combustion products (CCPs) play an important role in the mitigation and management of industrial wastes—whether acid mine drainage or sludge. Depending on the application, CCPs are used as backfill, solidifying material, pH-neutralizing agent, or soil conditioner. Testing and analysis of both the CCP and the material to which it is being added are undertaken to ensure the environmental safety and efficacy of CCPs' use in a given application. ASTM E2278, "Standard Guide for Use of Coal Combustion Products (CCPs) for Surface Mine Reclamation: Revegetation and Mitigation of Acid Mine Drainage," sets guidelines for the use of CCPs in the restoration of abandoned mine lands.

Mine Reclamation

Prior to the enactment of the Surface Mining Control and Reclamation Act of 1977, any number of coal mines were abandoned without remediation efforts designed to return the land to its original condition. Many of these mines continue to discharge harmful mining residues into surrounding ecosystems to this day and/or pose a danger to humans and wildlife in instances where mine mouths remain unsealed.

Coal combustion products—fly ash, bottom ash, boiler slag, fluidized bed combustion (FBC) ash, FGD material, and combinations thereof—have been successfully used to help return abandoned mine lands to their original condition in many such instances.

- *Fly ash* can be used to backfill abandoned mines, enhancing their structural integrity and preventing subsidence by providing support to walls and pillars.[1] The alkaline nature of many fly ashes also helps neutralize acid runoff, thereby improving the quality of aquatic systems.
- *Bottom ash and boiler slag* can similarly be used as structural fill to stabilize mines and mitigate against the dangers of open mine entrances.
- *FGD material*—including fixated FGD and FGD gypsum—has been used as backfill to stabilize highwall/pit complexes.[2]
- *FBC ash,* owing to its elevated pH, is useful in mitigating acid mine drainage and improving soil quality to aid the establishment of sustained vegetative cover.[3]

FBC ash deserves a special callout in the context of its utility in mine reclamation. FBC boilers use anthracite and bituminous coal refuse as their primary fuel to generate electricity, in the process producing ash that can be returned to the mine site both to help neutralize acid runoff and as fill for ground contour restoration. To date, Pennsylvania's coal refuse-to-energy industry has removed and consumed as fuel over 225 million tons of refuse; improved or restored more than 1,200 miles of waterways; and reclaimed over 7,200 acres of abandoned mine lands through the beneficial use of FBC ash.[4]

Sludge Stabilization/Solidification

Owing to their cementitious properties and generally high pH levels, coal combustion products are also used in the treatment and solidification of various types of sludge. For example, FBC ash has been blended with sewage sludge to increase both its alkalinity and temperature so as to inactivate or destroy pathogenic organisms.[5] Research has further determined that combining these materials can create a useful soil conditioner, representing a viable beneficial use of both of these materials.[6] In other instances, FBC ash is added to solidify various types of industrial sludge and allow for its off-site disposal.[7]

SOURCE: Tami A. Heilemann

In a commercial venture between 1994 and 2000, Minergy Corporation combined fly ash from WE Energies' Oak Creek power plant with paper mill and municipal sludge to form a lightweight aggregate (LWA) product. The stone-like aggregate, which met ASTM C330 and C331 LWA standards, was suitable for use in a broad range of concrete products and geotechnical applications. The product was sold to concrete producers throughout the Midwest to reduce dead loads and improve the fire ratings of concrete in numerous construction projects.[8]

Endnotes

[1]Gitari, Wilson Mugera, et al. *Treatment of Acid Mine Drainage with Coal Fly Ash: Exploring the Solution Chemistry and Product Water Quality*. 2018. p 109.
[2]Butalia, Tarunjit Singh, PhD. et al. "Sustainable Use of FGD Materials in Mine Reclamation: Research to Commercialization." *ASH at Work*. Issue 2, 2019. pp. 7-8.
[3]Pennsylvania Department of Environmental Protection. *Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania*. 2004. p 314.

For More Information

- ARIPPA. "What Is Coal Refuse?"
- ASTM International. "Standard Guide for Use of Coal Combustion Products (CCPs) for Surface Mine Reclamation: Revegetation and Mitigation of Acid Mine Drainage."
- Beech, J.F. Ph.D., P.E., et al. "Case Study: Use of Circulating Fluidized Bed Boiler Byproduct to Solidify Oil Sludge."
- Butalia, Tarunjit Singh, PhD. et al. "Sustainable Use of FGD Materials in Mine Reclamation: Research to Commercialization."
- Gitari, Wilson Mugera, et al. *Treatment of Acid Mine Drainage with Coal Fly Ash: Exploring the Solution Chemistry and Product Water Quality*.
- Gray, Richard E., and Gray, Thomas A. "Coal Combustion Ash Haulback."
- Grillasca-Rodriguez, Cristina, et al. "Agricultural Use of Organic Wastes Stabilized with Fluidized Bed Combustion Solid Residues."
- Minergy Corporation. "Lightweight Aggregate (LWA)."
- Pennsylvania Department of Environmental Protection. *Coal Ash Beneficial Use in Mine Reclamation and Mine Drainage Remediation in Pennsylvania.*

[4]ARIPPA. https://arippa.org/projects-before-after. Retrieved on September 28, 2020.
[5]Grillasca-Rodriguez, Cristina, et al. "Agricultural Use of Organic Wastes Stabilized with Fluidized Bed Combustion Solid Residues." Conference Paper. Caribbean Food Crops Society. 33rd Annual Meeting. 1997. p ii.
[6]Ibid. p 65.
[7]Beech, J.F. Ph.D., P.E., et al. "Case Study: Use of Circulating Fluidized Bed Boiler Byproduct to Solidify Oil Sludge." World of Coal Ash. Conference Paper. 2009. pp. 5-9.
[8]Minergy Corporation. https://www.minergy.com/technology/lightweight-aggregate-lwa. Retrieved on September 28, 2020.

John Simpson is editor of *ASH at Work*.

Other End-Use Applications of CCPs

By John Simpson

Beyond their use in "high-profile" applications such as concrete and cement manufacturing, coal combustion products are utilized in a variety of other applications where their usage is specified principally for their physical characteristics. Fly ash is used as a mineral filler in asphalt pavement construction, where it displays good void-filling capacity and hydraulic conductivity. Boiler slag's hard, angular particles make it useful for blasting grit and roofing granules. Bottom ash, which is of a coarse, gritty consistency similar to sand, is utilized for traction control on snowy/icy roads, as well as for aggregate in construction projects.

CCPs Used in Asphalt Mineral Filler
- Fly Ash

CCPs Used in Blasting Grit/Roofing Granules
- Bottom Ash
- Boiler Slag

CCPs Used in Snow/Ice Control
- Bottom Ash
- Boiler Slag

CCPs Used in Aggregate
- Bottom Ash
- Boiler Slag

Mineral Filler

Use of mineral filler plays a key role in asphalt pavement construction by filling voids in, and improving the binding properties of, the asphalt mix. The most commonly specified filler is limestone powder; however, a range of alternatives can also be used, including fly ash.

Interest in the use of fly ash as a mineral filler dates to 1931, when the Detroit Edison Company assessed fly ash's physical properties against those of limestone dust. Their study revealed fly ash not only to have good void-filling traits, but also to have hydraulic conductivity that would reduce the potential for "stripping"—a condition in which the aggregate and binder at the bottom of the asphalt separate and cause deterioration in the upper pavement layer.[1]

The physical characteristics desired for the use of mineral filler in asphalt paving mixtures are stipulated in ASTM D242[2] and AASHTO M 17,[3] which specify standards pertaining to particle size, organic impurities, and plasticity. Surveys indicate that fly ash meeting these standards has successfully been used in asphalt mixes in at least 22 U.S. states to date.[4]

Beyond lowering the potential for asphalt stripping, usage of fly ash as an asphalt mineral filler conveys several additional potential benefits:
- Its low specific gravity (generally 2.0 to 2.6 vs. 2.6 to 2.8 for non-fly ash fillers) means that it will generally require less material, by weight, compared to other fillers to achieve the same level of performance.[5]
- Where it is locally available, it may be less expensive than competing mineral fillers.
- It avoids the potential landfilling of fly ash.

Blasting Grit/Roofing Granules

Boiler slag is produced from the bottom ash of a wet-bottom boiler—either a slag-tap or cyclone boiler. After the bottom ash is collected and quenched with water, it quickly cools and crystallizes into a dense, black, glassy mass that cracks into angular particles. These particles can then be crushed into a variety of sizes that are useful in a number of products that require hard, durable grit.[6]

By far, the largest beneficial uses of boiler slag are as blasting grit and roofing granules. In blasting applications, the variety of grit sizes in which boiler slag is available, as well as its hardness and sharp, angular edges, makes it a useful alternative to sand and other commonly used abrasives for everything from light blasting jobs, such as surface cleaning, to heavier jobs such as rust removal.[7] Likewise, boiler slag is commonly incorporated in roofing applications that require a durable, fire-resistant surface material. It is used as the granular surface covering asphalt shingles,[8] as well as in roofing membranes where, as a post-industrial recycled material, it can help projects qualify for Leadership in Energy and Environmental Design (LEED) credits.[9]

Snow, Ice Control

For the better part of a century, U.S. roads and highways have been treated by an assortment of materials and chemicals both to melt snow and ice and to provide better tire traction. A number of the more commonly applied materials, including salt and sand, are now understood to be environmentally detrimental when dispersed into the wider environment.

SOURCE: CC BY 3.0 - Dori

For several decades now, both bottom ash and boiler slag have been applied to roadways as useful alternatives to these materials. Their effectiveness as a winter road application derives from their physical characteristics—bottom ash is porous and dark-gray with a grain size similar to sand, while boiler slag is angular, coarse, and black in color. Specifically, they are:

- Angular in shape, providing a rough surface for tires to grip;
- Able to be applied to roads with conventional spreaders;
- Capable of being stored outside for long periods without degrading;
- Non-corrosive to roads, vehicles, and bridges;
- Useful as an anti-skid material regardless of temperature;

- Owing to their darker color, effective in snow/ice melting, helping to keep particles near the contact point with tires;
- Comparably inexpensive, as utilities have traditionally supplied them (particularly bottom ash) to municipalities free of charge.[10]

Aggregate

Aggregates—from sand to gravel, crushed stone, and other mined materials—are widely used in construction projects and products ranging from road-building to the manufacture of concrete. In such applications, aggregates serve as a reinforcing agent to add strength to the overall composite material. Here again, bottom ash and boiler slag are often substituted—both as unbound aggregate, such as when used as granular base material, or in combination with cementitious materials, such as in a stabilized base.

When used as granular base material, bottom ash and boiler slag are considered a fine aggregate. To meet the required specifications in this type of application, they may have to be mixed with other aggregates prior to use. Bottom ash may also require grinding or screening to reduce or remove large-sized particles.

In stabilized base and sub-base applications, bottom ash and boiler slag may be mixed with cementitous materials such as portland cement, cement kiln dust, or any of a number of pozzolans. Use of bottom ash or boiler slag as an aggregate in such an application may require moisture control, attention to sizing, and the removal of materials such as pyrites.[11]

Bottom ash has also been used as a coarse aggregate in the manufacture of concrete blocks.[12]

Endnotes

[1]U.S. Department of Transportation. Federal Highway Administration. "User Guidelines for Waste and Byproduct Materials in Pavement Construction." https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa52.cfm. Retrieved on October 15, 2020.

[2]ASTM International. "Standard Specification for Mineral Filler for Bituminous Paving Mixtures." 2014.

[3]American Coal Ash Association. *Fly Ash Facts for Highway Engineers*. Chapter 8 - Fly Ash in Asphalt Pavements. Table 1. "AASHTO M 17 Specification Requirements for Mineral Filler Use in Asphalt Paving Mixtures."

[4]U.S. Department of Transportation. Federal Highway Administration. "User Guidelines for Waste and Byproduct Materials in Pavement Construction." https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa52.cfm. Retrieved on October 15, 2020.

[5]American Coal Ash Association. *Fly Ash Facts for Highway Engineers*. Chapter 8 - Fly Ash in Asphalt Pavements. p 54.

[6]U.S. Department of Transportation. Federal Highway Administration. "User Guidelines for Waste and Byproduct Materials in Pavement Construction." https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa52.cfm. Retrieved on October 15, 2020.

[7]Reade International Corp. "Black Beauty® Abrasive (Boiler Slag, Coal Slag) Physical Properties." https://www.reade.com/products/black-beauty-abrasive-boiler-slag-coal-slag. Retrieved on October 15, 2020.

[8]Phillips, David. "Drying Processes for Coal Ash Reuse." *Process Heating*. February 8, 2016.

[9]Garland Canada. "Reformulated Garland StressPly® E High-Tensile Roofing Membrane Is Even More Eco-Friendly." News Release. December 5, 2011.

[10]Simpson, John. "CCPs Help Winter Drivers Get a Grip." *Ash at Work*. Issue 1, 2020. pp. 17-18.

[11]U.S. Department of Transportation. Federal Highway Administration. "User Guidelines for Waste and Byproduct Materials in Pavement Construction." https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa52.cfm. Retrieved on October 15, 2020.

[12]National Energy Technology Laboratory. *Clean Coal Technology*. Topical Report Number 24. August 2006. p 11.

For More Information

- AASHTO. "Specification Requirements for Mineral Filler Use in Asphalt Paving Mixtures."
- American Coal Ash Association. *Fly Ash Facts for Highway Engineers*.
- ASTM International. "Standard Specification for Mineral Filler for Bituminous Paving Mixtures."
- National Energy Technology Laboratory. *Clean Coal Technology*.
- U.S. Department of Transportation. Federal Highway Administration. "User Guidelines for Waste and Byproduct Materials in Pavement Construction."

John Simpson is editor of *ASH at Work*.


NMC
NATIONAL MINERALS CORPORATION

The Importance of Logistics in Ash Marketing

By Rob Reynolds

According to the American Coal Ash Association (ACAA), 58% of all coal combustion products (CCPs) produced during 2018 were recycled, marking the fourth consecutive year that more than half of the coal ash produced in the U.S. was beneficially used rather than disposed. Fully 59.4 million tons of the total 102.3 million tons of CCPs produced were beneficially used in 2018. With expectations for greater infrastructure spend and other market demands, this percentage is projected to increase. This means a higher demand for CCPs, especially for utilization of fly ash in the production of concrete.

The beneficial use of fly ash in cement and concrete production not only lowers costs and improves performance, but it also conserves natural resources by decreasing the need for ash landfill disposal, saving energy, and reducing producers' carbon footprint. Fly ash is currently marketed across the country for a variety of beneficial uses, including:

- Partial replacement of cement in ready-mix concrete and concrete products
- Cement production
- Structural fill projects for land reclamation
- Flowable fill projects such as filling old sewer pipes and underground tanks instead of excavating for replacement
- Bagged concrete products for use in the "do-it-yourself" market, including concrete repair, patching, and new surface applications
- Soil stabilization
- Solidification and drying of non-toxic wastes for delivery to approved landfills

While concrete producers aim to use as much quality fly ash as possible to enhance their products and manage costs, a lack of locally available ash, often caused by shifting supply dynamics associated with reduced coal-fueled power generation, can make that difficult. In some cases, the regions where utilities produce marketable fly ash are not located near where there is demand for high-quality fly ash. In other instances, the seasonal fly ash demands of the construction industry might not align with fly ash production, which tends to be year-round. The resulting challenges are all about logistics—ensuring the right product arrives when and where it is needed, while maintaining a competitive price, consistent quality, and continuous supply. This requires a very well planned and efficient logistics network to make it work.

To maximize utilization, utilities should consider alternative applications and expanded markets for their fly ash, then work to transport it efficiently. Through beneficial use, utilities can dramatically reduce the need and related expense to landfill high-quality fly ash and other sustainable materials while meeting the market demand for this material. Balancing the supply chain and ensuring that logistics remain economical are very important when developing a go-to market strategy to maximize fly ash utilization, something that benefits both the utility and the end user. It is a win-win scenario when the logistics challenge of transporting fly ash from areas of high supply to those of great demand is economical for both the suppler and the concrete producer.

Effective CCP marketing demands a strong, efficient, proven distribution network with strategically located terminals connecting high-demand regions with a variety of efficient transportation options. Gone are the days of a single source supplying a local concrete producer with a single product. Today's concrete producers are looking for reliable supply options that offer a complete CCP product lineup to give them a variety of product options and consistent sourcing, all at a competitive price.

The MultiSource® Network

Developed with concrete producers' needs in mind, Charah Solutions' MultiSource® materials network is a unique distribution system of nearly 40 nationwide locations serving the U.S., Mexico, and Canada with sourcing, transportation modes, and distribution options that ensure a steady and reliable supply of CCPs. The MultiSource® materials network provides CCPs to markets where they are needed, as well as sufficient storage to level out seasonal supply and demand fluctuations.

To ensure on-time delivery, logistics support must include an established network of transportation options, including truck, rail, and barge as well as sufficient storage and supply capabilities. As an example, to meet the growing demand for fly ash in the northeastern U.S., Charah Solutions broadened the MultiSource® materials network by investing in a transload terminal in Worcester, Mass. As a demonstration of its commitment to the Northeast region, in 2019 Charah Solutions anticipated the needs of regional concrete product manufacturers and expanded its supply and distribution capacity through the addition of the Hopedale, Mass., rail terminal. Hopedale was selected due to its centrally accessible location near the I-495 transportation corridor, allowing concrete product manufacturers in the greater New England area to access almost 30,000 tons of quality fly ash through the rail terminal. An additional 15,000 tons were railed directly to customers from the Dynegy Miami Fort Power Plant in Ohio. The installation of two supply silos provided fly ash storage and distribution flexibility to help serve customers in Massachusetts, Rhode Island, Connecticut, and New Hampshire.

With similar terminals and distribution hubs in place nationwide, concrete producers are now able to reliably purchase CCPs,

Charah Solutions' Hopedale, Mass., MultiSource® terminal provides concrete product manufacturers in greater New England with access to almost 30,000 tons of quality fly ash.

Charah Solutions' proprietary MP618® Multi-Process ash beneficiation technology converts fly ash that is otherwise unusable into a consistent high-quality fly ash that meets industry specifications.

including quality fly ash, through the MultiSource® network in the Midwest, Northeast, and Southern regions. In addition, Charah Solutions continues to strategically expand the network to meet growing customer demand.

While logistics expertise relies heavily on transportation and storage options, manpower and communication systems are also required to succeed. It is vital to maintain close, timely communications with utility partners in order to optimize distribution. Long-standing relationships with utilities around the country are necessary to provide the product availability to keep customers continuously supplied. Furthermore, the team must have the know-how and experience to comply with a diverse set of environmental regulations. Finally, it is important to recognize the growing role of international raw materials sales, with higher global demand expected in the use of these materials as well as CCPs in cement manufacturing.

Concurrently, beneficial use stakeholders are actively deploying technologies and strategies for harvesting previously disposed fly ash. For example, Charah Solutions' innovative new proprietary MP618® Multi-Process ash beneficiation technology converts fly ash that is otherwise unusable into a consistent high-quality fly ash that meets industry specifications—increasing both the percentage of utility fly ash that is marketable and the supply of ash in high-demand regions, while reducing the volume slated for disposal. By combining the strengths of MP618® technology, the proven MultiSource® network, and strategic investment in logistics infrastructure, Charah Solutions has the capabilities of meeting demand in regions not previously attainable while maintaining a competitive price and consistent quality and supply for concrete producers.

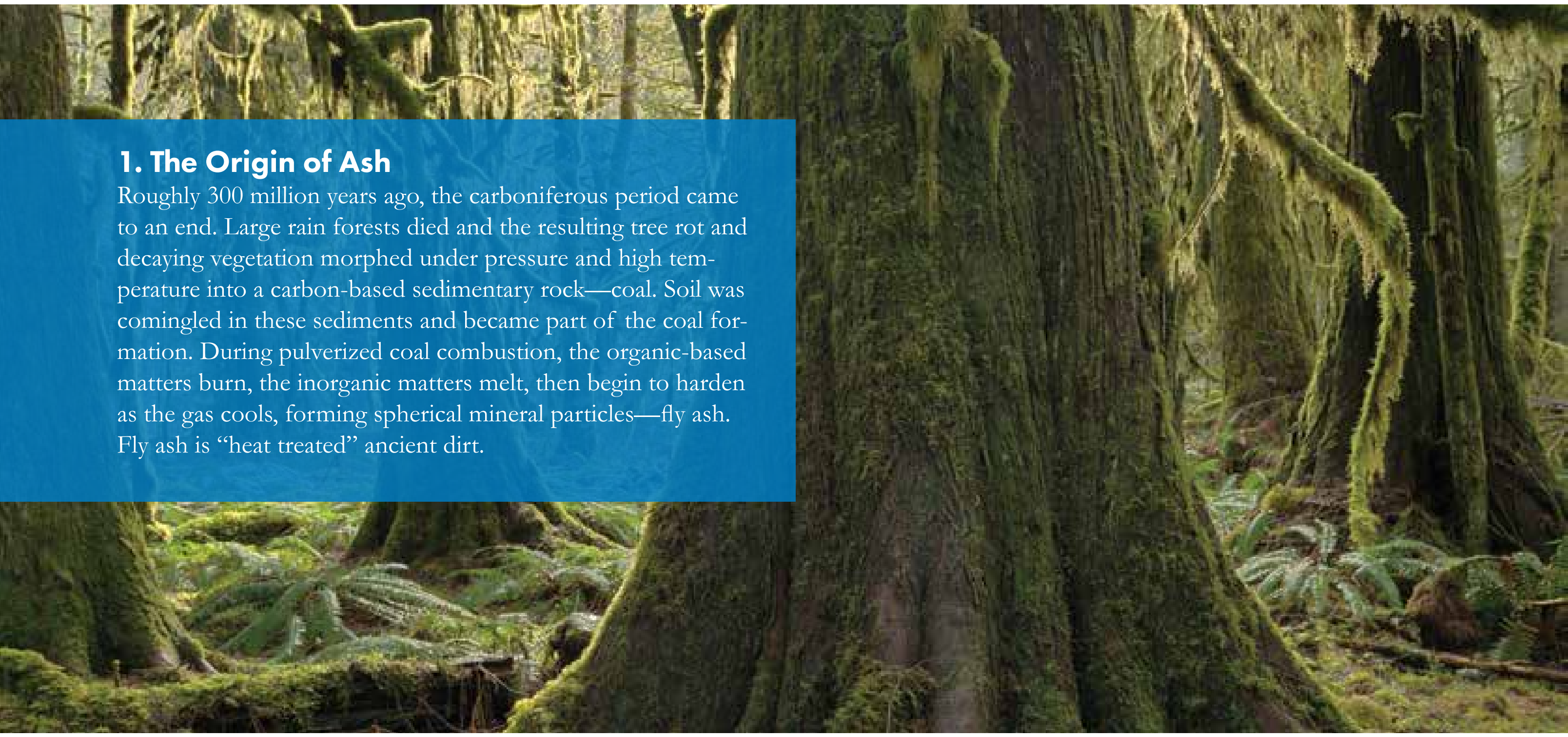
With expected increases in spending on infrastructure, as well as other markets, demand for CCPs, including fly ash, is likely to continue expanding. Logistics expertise is more important now than ever to ensure end users have a continuous and reliable supply of the CCPs they need, where and when they need them, while offering utilities cost-effective opportunities for beneficial use.

Rob Reynolds serves as Vice President of Byproduct and Material Sales at Charah Solutions Inc. He has been with Charah Solutions since 2012 and is responsible for beneficiation technology development and national byproduct and material sales efforts for existing and emerging markets. This includes Charah Solutions' MP618® technology deployment, terminal development, partnerships, and distribution channel management to concrete producer customers as well as all logistical elements associated with Charah Solutions' MultiSource® materials network.


CAT

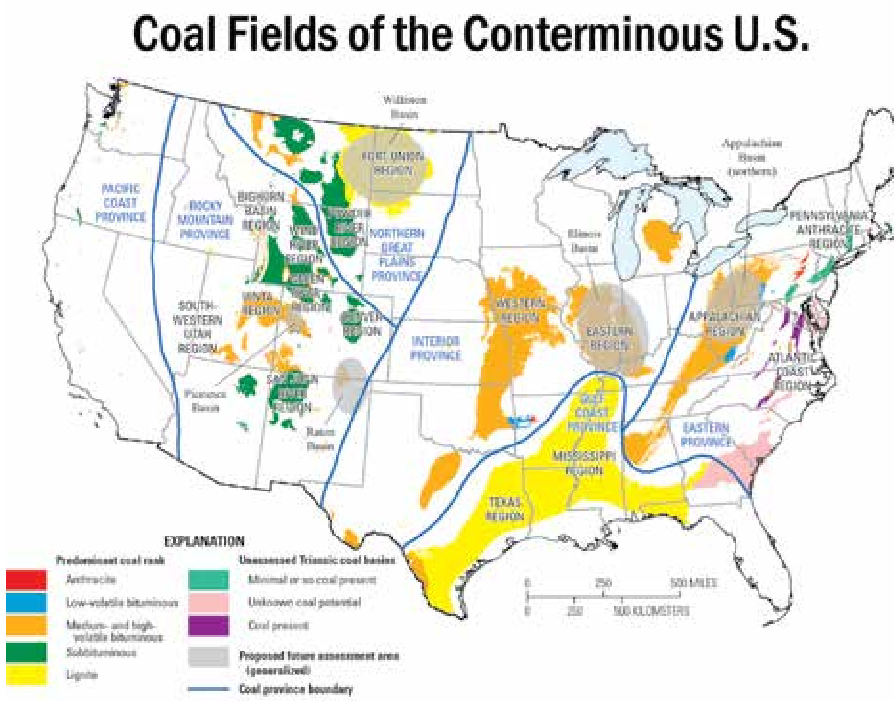
10 Things You Didn't Know About Fly Ash

By Rafic Minkara, Ph.D., P.E.



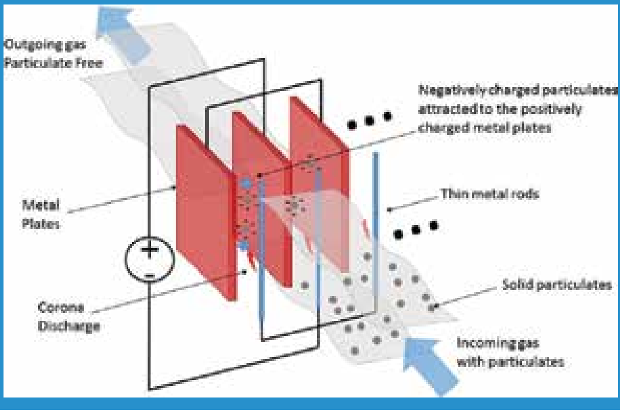
1. The Origin of Ash

Roughly 300 million years ago, the carboniferous period came to an end. Large rain forests died and the resulting tree rot and decaying vegetation morphed under pressure and high temperature into a carbon-based sedimentary rock—coal. Soil was comingled in these sediments and became part of the coal formation. During pulverized coal combustion, the organic-based matters burn, the inorganic matters melt, then begin to harden as the gas cools, forming spherical mineral particles—fly ash. Fly ash is "heat treated" ancient dirt.



2. The Types of Ash

Carbonaceous solid fuels and their ash products are not created equal. Bituminous coal is the most abundant rank. It produces low-calcium Class F fly ash—desired for concrete durability. Sub-bituminous is a low-rank coal mined primarily in the Powder River Basin in Wyoming. It produces high-calcium Class C fly ash, which is not desired in some DOT applications. Lignite mined in Texas and North Dakota has high ash content that makes a great quality fly ash for concrete and other applications. The other solid fuel, peat, is recently accumulated and partially carbonized plant debris. It is used for power generation in Ireland and Finland but is most notably known in Scotland for drying malted barley to produce the finest smoky Islay Scotch Whiskys.

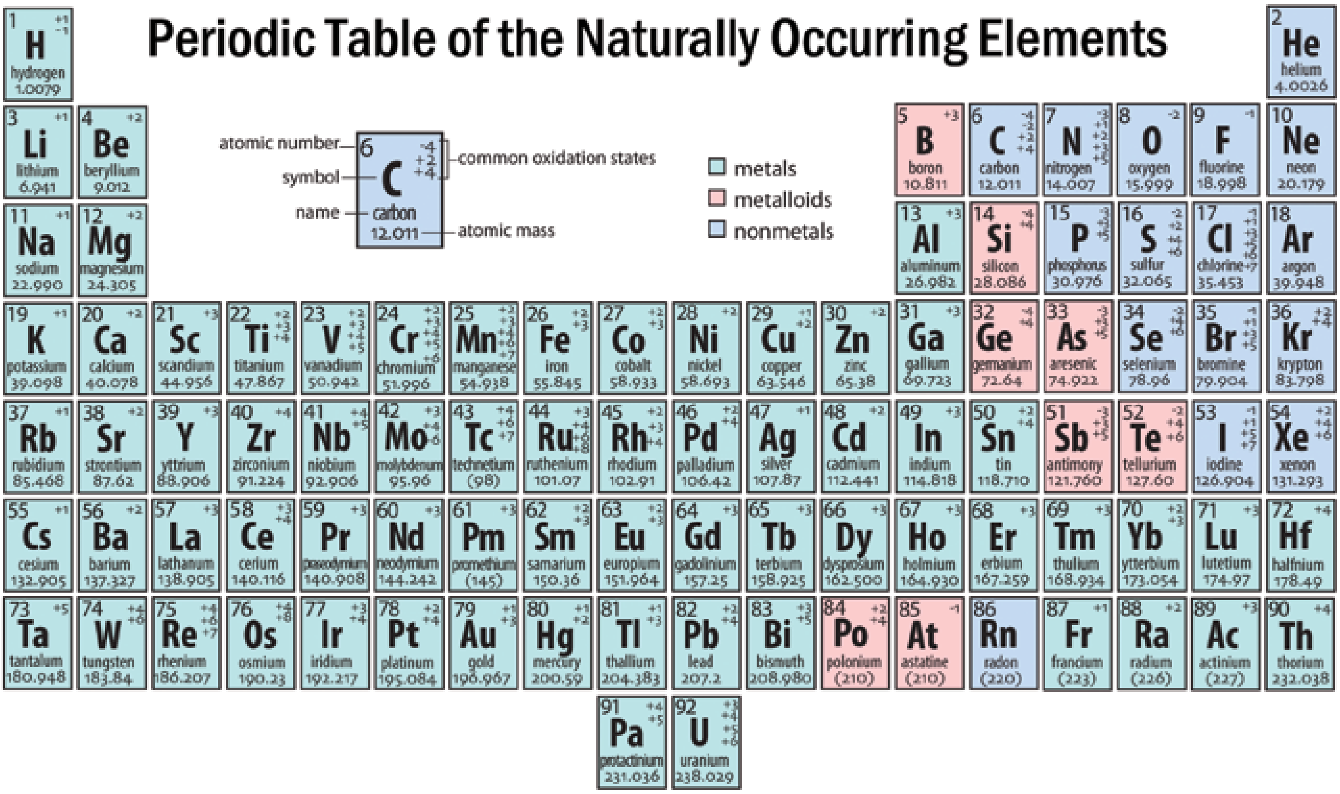


3. Ash Collection at Power Plants

The electrostatic precipitator (ESP) used to collect fly ash at power plants was invented by Frederick Cottrell, a professor of chemistry at the University of California, Berkeley, in 1907 to protect the wine industry in northern California by capturing lead oxide and acid fumes from smelters that were damaging the nearby vineyards.

4. First Successful Production of PCFA

Pulverized coal fly ash (PCFA), which is used in concrete for its pozzolanic benefits, was first produced 101 years ago after engineers for the first time successfully burned pulverized coal continuously and at high efficiency in steam boilers to produce electricity. The event took place at the Milwaukee Electric Railway & Light Company's Oneida Street Station, which has since been named to the National Register of Historic Places in recognition of this achievement.



5. The Nature of the Material

Ash is derived from coal, which is of natural organic origin. It contains most of the 92 naturally occurring elements. The bulk chemistry of ash is most similar to siliceous rocks, particularly shale, which consist of the oxides of silicon, aluminum, iron, and calcium.

SOURCE: CC BY 2.0 -gnuckx

6. Pozzolans

Pozzolans are inorganic minerals—naturally occurring ash—that consist of amorphous silicates and aluminates, which when combined with calcined lime and water react to form stable binding hydrates. The reaction was first described in 27-31 B.C. by Vitruvius, an engineer and architect for Julius Caesar. Pozzolan-based concrete was extensively used in the Roman era for notable buildings such as the Colosseum, built in 72-80 A.D., and the Pantheon, completed in 120 A.D. The term *pozzolan*, or "powdery ash," comes from from Puteoli, now modern Pozzuoli, Italy, which lies in the center of a volcanic caldera. It is also the city where Sofia Loren grew up.

SOURCE: Olivenhain Municipal Water District

7. Great Dam Projects

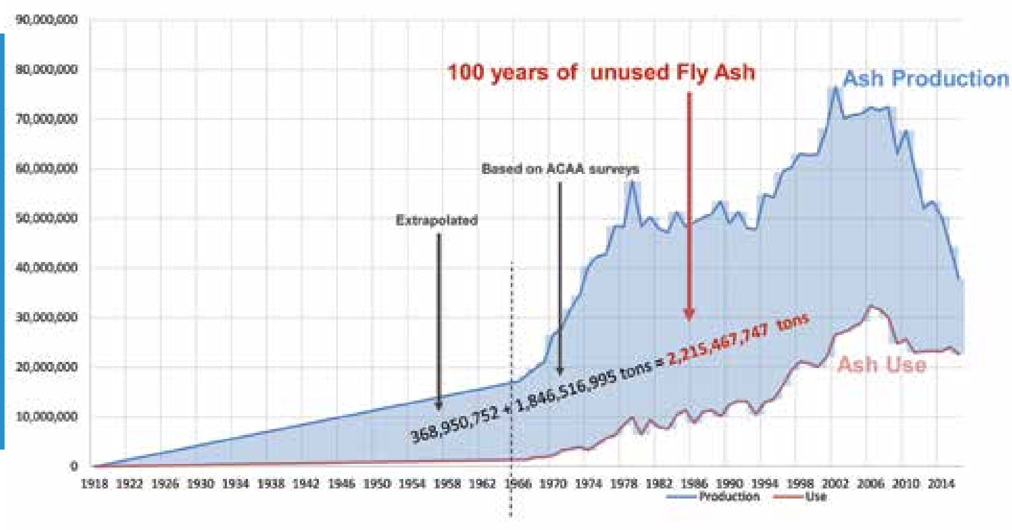
Dam projects were some of the first adopters of ash use in structural concrete. The great dam building era in the West, stretching from the 1940s through the 1970s, spawned the technical interest in the material science for ash use in concrete. Dams continue to be great beneficial use examples, such as the Olivenhain dam in California, which at 308 feet is considered the tallest roller compacted concrete dam in North America. It consumed 1.42 million cubic yards of concrete, which included over 150,000 tons of fly ash, representing about 65% replacement of portland cement.

8. Fly Ash Use Is Well Regulated by Standards Specifications

The first American standard specification for coal ash use in concrete (ASTM C618) was initially published in 1971. It continues to be the standard benchmark and is very similar to many international standards, such as EN450 (Europe), AS/NZ S3582 (Australia and New Zealand), IS3812 (India), and GB/T 1596 (China). There are numerous other specifications to address local construction needs and to ensure desired performance in concrete.

9. National Pozzolan Deposits

The historical gap between fly ash production and use as integrated and extrapolated from ACAA surveys is estimated to be about 2 billion tons over the last 100 years. Some of these deposits are technically and economically feasible to reclaim for beneficial use in concrete.




SOURCE: CC BY-SA 3.0 - Petr Šmerkl

10. All of the Above

Reclaiming legacy ash deposits is the cornerstone to meeting shortages in the U.S. caused by plant closures. Although some markets can still rely on the remaining operating plants, imports from nations with surplus quality material can fill in some supply gaps in coastal markets. The use of natural pozzolans, where available, can also help. In the long run, it's all of the above…

Rafic Minkara, Ph.D., P.E., is Vice President, Product & Business Development, at Boral CM Services. He has over 30 years of diverse professional experience including engineering design, construction management, and research and development in the environmental and utility industries. He received his BS, MS, and Ph.D. degrees in engineering and his MBA from the University of Toledo.

harvesting fly ash solutions

SRMG has partnered with Salt River Project at the Coronado Generating Station to expand an existing marketing agreement and allow for removal or “harvesting” of fly ash from the onsite landfill.

The harvesting project involves SRMG’s investment of additional capital dollars in beneficiation equipment to process the previously landfilled ash, resulting in a long-term supply of ASTM C618 Class F fly ash. This maximizes the utilization of fly ash and reduces the size of the current landfill.

SRMG’s Coronado Harvesting Project adds 300,000 tons per year to the SRMG fly ash supply network and helps close the gap on seasonal fly ash shortages in the marketplace.

With creativity and innovation, we continue to be your best source for fly ash.

SRMATERIALS.COM

SRMG
Salt River Materials Group
100% AMERICAN™

Coal Ash Regulation 101

By John Ward

Environmental regulation in the United States began in earnest in the 1970s with the enactment of a series of foundational federal laws. As those regulations evolved over the ensuing decades, they affected every aspect of coal ash production and use.

For instance, early provisions of the Clean Air Act required fly ash to be captured rather than allowed to disperse in power plant exhaust. Later Clean Air Act provisions aimed at reducing "acid rain" led to the widespread deployment of power plant "scrubbers" and the creation of an entirely new coal combustion product: flue gas desulfurization (FGD) gypsum.

The availability of these materials led to development of beneficial uses for them, such as fly ash in concrete and FGD gypsum in wallboard. While these beneficial uses were, and continue to be, exempt from federal regulation, regulations on the management and disposal of the materials had significant impacts on beneficial use markets. Those impacts were felt in both technology and public policy arenas.

As technologies were deployed at power plants to comply with requirements to reduce emissions of nitrogen oxides and mercury, the quality of coal combustion products changed. The coal ash beneficial use industry responded by developing and deploying a suite of "beneficiation" technologies to address the product quality changes and maintain marketability of the coal combustion products.

On the policy front, issues of regulatory certainty affected the beneficial use industry's ability to invest capital needed to build logistics systems and deploy beneficiation technologies. Following the U.S. Environmental Protection Agency's 2000 Final Regulatory Determination that coal ash would be managed as a non-hazardous waste, investments in beneficial use increased. EPA followed up in 2002 with creation of the Coal Combustion Products Partnership (C2P2), which was a cooperative effort between EPA, American Coal Ash Association, Utility Solid Waste Activities Group, U.S. Department of Energy, Federal Highway Administration, Electric Power Research Institute, and U.S. Department of Agriculture Agricultural Research Service to promote beneficial use of CCPs as an environmentally preferable alternative to disposal.

The C2P2 initiative included a challenge program, various barrier breaking activities, and development of coal combustion products utilization workshops. Results were impressive. In 2000, beneficial use volume was 32.1 million tons. Just eight years later,

Timeline of Key Regulatory Developments

January 1, 1970 - National Environmental Policy Act (NEPA) enacted.

December 2, 1970 - U.S. Environmental Protection Agency created to consolidate a variety of federal research, monitoring, standard-setting, and enforcement activities to ensure environmental protection.

1970 - Clean Air Act (originally enacted in 1963) rewritten, then further amended with major revisions in 1977 and 1990.

1972 - Federal Water Pollution Control Act (originally enacted in 1948) completely rewritten, then further amended through the addition of the Clean Water Act of 1977.

1974 - EPA promulgated the first Steam Electric Power Generating Effluent Guidelines and Standards covering wastewater discharges from power plants. Also known as Effluent Limitation Guidelines (ELG), they were amended in 1977, 1978, 1980, 1982, 2015, and 2020.

1976 - Resource Conservation and Recovery Act (RCRA) enacted, becoming the principal federal law governing the disposal of solid and hazardous waste.

1980 - "Bevill Amendment" to RCRA enacted, instructing EPA to "conduct a detailed and comprehensive study and submit a report" to Congress on the "adverse effects on human health and the environment, if any, of the disposal and utilization" of coal ash.

1988 and 1999 - EPA Reports to Congress recommended coal ash disposal regulation as non-hazardous waste.

1993 - EPA Regulatory Determination found coal ash regulation as a hazardous waste "unwarranted."

2000 - EPA Final Regulatory Determination concluded coal ash materials "do not warrant regulation [as hazardous waste]" and that "the regulatory infrastructure is generally in place at the state level to ensure adequate management of these wastes."

2002 - EPA Coal Combustion Products Partnership (C2P2) commences.

December 2008 - Kingston coal ash spill.

2009 - EPA initiates rulemaking for coal ash disposal regulations under RCRA, including a potential "hazardous waste" designation.

2010 - EPA C2P2 program terminated.

2015 - EPA issues coal ash Final Rule under "non-hazardous" section of RCRA, adopting the term "coal combustion residuals" (CCR), exempting beneficial use from regulation, and adopting "encapsulated" and "unencapsulated" as categories of beneficial use. ELGs related to coal ash management concurrently updated.

2016 - Congress enacts the Water Infrastructure Improvements for the Nation (WIIN) Act, which includes a provision shifting enforcement authority for EPA's disposal standards from citizen lawsuits to state environmental regulators.

2018 - U.S. Court of Appeals for the District of Columbia Circuit overturns several aspects of EPA's 2015 Final Rule and remands them to EPA for further rulemaking.

2019 and 2020 - EPA undertakes a series of rulemakings to revise its 2015 CCR Final Rule in response to matters requested for reconsideration, matters settled during litigation, matters remanded by the DC Court, and matters related to coal ash provisions in the 2016 WIIN Act.

Regulatory Exemption for CCP Beneficial Use

Beneficial use was a priority for federal policymakers from the very beginning. Even the name of the Resource Conservation and Recovery Act emphasizes "conservation and recovery." In its findings establishing RCRA, Congress stated: "The Congress finds with respect to materials, that (1) millions of tons of recoverable material which could be used are needlessly buried each year; (2) methods are available to separate usable materials from solid waste; and (3) the recovery and conservation of such materials can reduce the dependence of the United States on foreign resources and reduce the deficit in its balance of payments."

U.S. Environmental Protection Agency has at times actively encouraged coal ash beneficial use. (See discussion of the C2P2 program in the companion story.) Additionally, in 2014 EPA released an exhaustive study reaffirming the Agency's support for two major uses of coal ash—fly ash in concrete and FGD gypsum in wallboard. The study concluded "…environmental releases of constituents of potential concern (COPCs) from CCR fly ash concrete and FGD gypsum wallboard during use by the consumer are comparable to or lower than those from analogous non-CCR products, or are at or below relevant regulatory and health-based benchmarks for human and ecological receptors… EPA supports the beneficial use of coal fly ash in concrete and FGD gypsum in wallboard. The Agency believes that these beneficial uses provide significant opportunities to advance Sustainable Materials Management (SMM)."

EPA's 2015 Final Rule established a four-part definition of what constitutes beneficial use that is exempt from regulation:

- The CCR must provide a functional benefit;
- The CCR must substitute for the use of a virgin material, conserving natural resources that would otherwise need to be obtained through practices such as extraction;
- The use of CCR must meet relevant product specifications, regulatory standards, or design standards when available, and when such standards are not available, CCR are not used in excess quantities; and
- When **unencapsulated** use of CCR involves **placement on the land** of **12,400 tons or more** in **non-roadway applications** (emphasis added), the user must demonstrate and keep records, and provide such documentation upon request, that environmental releases to ground water, surface water, soil, and air are comparable to or lower than those from analogous products made without CCR, or that environmental releases to ground water, surface water, soil, and air will be at or below relevant regulatory and health-based benchmarks for human and ecological receptors during use.

Controversy over the fourth beneficial use criterion led to an August 2019 proposal by EPA to revise its approach, but the proposal was roundly lambasted by both industry and environmental activists. In the Agency's spring 2020 Regulatory Agenda, EPA announced it would take a step back on reconsidering the definition. (See "EPA Starting Over on Definition of Coal Ash Beneficial Use" in the News Roundup section of this issue of *ASH at Work*.) In December 2020, EPA published a Notice of Data Availability containing "new information and data" related to the beneficial use definition and teeing up additional rulemaking likely to begin in 2021.

beneficial use volume had nearly doubled to 60.6 million tons. Then EPA abruptly terminated this successful C2P2 program after it initiated a new CCR disposal rulemaking.

With regulatory certainty once again absent, the volume of CCP utilization drifted between 2009 and 2013. Even though beneficial use was exempt from the proposed disposal regulations, ash producers, specifiers, and users restricted coal ash use in light of the regulatory uncertainty and often negative publicity surrounding EPA's activities. In 2014, EPA began signaling that the "hazardous waste" designation proposal was off the table and in 2015 finalized CCR disposal regulations under the non-hazardous section of federal law. Ash utilization began to increase again once regulatory certainty was restored.

According to ACAA Production and Use Surveys, CCP utilization remained below 2008 levels for the five consecutive years of regulatory uncertainty concluding in 2013. If those five years had simply remained equal with 2008's utilization, 26.4 million tons less coal ash would have been disposed in landfills and impoundments.

Completion of the 2015 Final Rule did not completely restore regulatory certainty, however. Debate continues today over EPA's definition of beneficial use and how material destined for beneficial use is treated in regulations.

John Ward entered the coal ash marketing business in 1998 as Vice President, Marketing and Government Affairs, for ISG Resources (later Headwaters). For over a decade, he has served as president of John Ward Inc., a public affairs consultancy to the coal ash and energy industries. He is the longstanding chairman of ACAA's Government Relations Committee and was the first recipient of ACAA's Champion Award. He is the author of ACAA's weekly *Phoenix* newsletter and introduces himself the way his son did at a seventh-grade career day 15 or so years ago—as a used coal salesman.

Safe, Reliable and Cost-Effective CCR Management

Waste Connections is the solutions partner to meet the evolving demands placed on your coal-fired power generation facilities. Strategically aligned with Boral Resources, the largest CCR management company for beneficial use, Waste Connections has the expertise, capabilities and financial foundation to provide a viable solution, whether treating legacy impoundments or the current generation of coal ash.

With decades of landfill management experience, Waste Connections has the regulatory experience to navigate current and future compliance demands. Through our extensive network of disposal facilities, we are able to offer a variety of both on- and off-site options.

Our team is ready to manage your CCR disposal challenges and beneficial use programs. Contact us today.

WASTE CONNECTIONS, INC.
Connect with the Future®

JoeLa@WasteConnections.com
281.889.0084

Coal Ash Is Not Toxic

By Lisa JN Bradley, Ph.D., DABT

Coal ash is not toxic. How do we know this?

- When evaluating the material as a whole, there is a wealth of information on the toxicity testing of coal ash in mammalian and aquatic species that demonstrates that coal ash is not toxic.
- The constituents in coal, and coal ash, are naturally occurring in the world around us.
- When looking at the trace elements present in coal ash on an individual basis, comparison of concentrations to screening levels developed by the U.S. Environmental Protection Agency (EPA) for a child's and adult's daily exposure to soil in a residential setting demonstrates that all are below the screening levels, with the exception of the upper-bound concentrations of a few constituents.
- Adverse health effects can only be caused by the constituents in coal ash, or coal ash itself, if one is (a) exposed to the material, and (b) exposed at a level high enough to elicit a response.

A detailed discussion of these topics is provided in *ASH at Work* Issue 1, 2020 (see "Coal Ash Is Not Toxic," pp. 24-32). The points raised in that article are summarized hereafter.

Coal ash is registered for commerce under the European Chemical Agency's REACH program, which requires the performance of toxicity testing, including mammalian and aquatic toxicity studies.
Source: CC BY 2.0 - Daniel Soñé Photography LLC

Toxicity Testing of Coal Ash Under the EU REACH Program

The European Chemical Agency (ECHA)[1] of the European Union (EU) regulates a comprehensive program of toxicity testing of materials that are put into commerce. This program is referred to as REACH—the Registration, Evaluation, Authorisation, and Restriction of Chemicals[2]—and has been in place since 2006. Coal ash has been registered for commerce under REACH, and the dossier for "Ashes (residues), coal," registration number EC# 931-322-8, is available for review.[3] The REACH program requires that the performance of a battery of toxicity testing be conducted to support the registration dossier, including mammalian (human health) and aquatic toxicity studies. A dossier is issued a registration number and published on the REACH website only after it has been reviewed by ECHA.

Studies relevant to human health have been conducted to address 10 different toxicity endpoints. The 47 mammalian toxicity studies have been conducted on coal ash as a whole material, not separate individual components. The REACH system classifies materials by hazard category—if no hazards are identified, based on their classification system definitions, then the conclusion is that no classification is warranted due to "data conclusive but not sufficient for classification." The terminology is a bit cumbersome but means there is no hazard to classify.

A total of 39 studies have been conducted to address six types of aquatic toxicity, and in all cases the conclusion is that no classification is warranted due to "data conclusive but not sufficient for classification." Thus, the conclusion is no hazard.

By conducting the studies on ash as a whole material, they account for any cumulative, additive, synergistic, and/or antagonistic effects that single constituents may have in these complex mixtures. Taken together, this series of detailed and comprehensive toxicity testing and the conclusions of no hazard are good news—for the industry and for the community.

[1]https://echa.europa.eu/home – ECHA Home page.
[2]https://echa.europa.eu/regulations/reach/understanding-reach – ECHA – Understanding REACH.
[3]https://echa.europa.eu/registration-dossier/-/registered-dossier/15573/7/1 and https://echa.europa.eu/brief-profile/-/briefprofile/100.151.318 – ECHA – REACH – Ashes (residues), coal.

Coal, Coal Ash, and Elements

Because coal is a natural geologic material, the inorganic elements and compounds in coal and in coal ash are also naturally occurring. The U.S. Geological Survey (USGS) has published detailed data on background levels of elements in U.S. soils.[4] Because plants grow in soil and take up minerals from the soil, these elements are also naturally present in the foods we eat.[5] We are also exposed to soils every day—at home, at school, in parks. Therefore, we are exposed to these elements every day from our diet and from our incidental/inadvertent ingestion of soil when we are outside.

Evaluating Coal Ash on a Constituent-Specific Basis

The bulk of rocks/shales *and* coal ash are made up of silicon, aluminum, iron, and calcium (90%), with sulfur, sodium, potassium, magnesium, and titanium making up the minor elements (8%) and "trace elements" that comprise less than 1% of the total content. The USGS conducted a survey of elements and inorganic compounds in coal ash.[6] The detailed compositional data for fly ashes and bottom ashes from the USGS can be compared to the EPA risk-based screening levels for residential soil.[7] A detailed report on this comparison is available from ACAA,[8] and a summary of the analysis was presented in *ASH at Work* Issue 1, 2012 (see "Coal Ash Material Safety," pp. 21-26).[9] Of the 20 trace elements evaluated in the full report, 15 are present in all ashes included in the evaluation at concentrations less than the EPA screening levels for residential soils. Concentrations of five constituents range to above the residential soil screening level in *some* but *not all* of the coal ashes: arsenic, chromium, cobalt, thallium, and vanadium. However, these concentrations are only slightly above the screening levels. This comparison demonstrates that there would be no basis for health risk for incidental contact with coal ash or fly ash on a daily or an infrequent basis.

Don't Be Confused by Misleading Graphics

Every element on the periodic table can elicit an adverse effect if administered at high doses. It has been common for groups to scare people about coal ash by listing all of the adverse effects that can occur for each element and showing where those occur in the body. But the same graphics would be just as true if the words "coal ash" were replaced with "soil." Such graphics are even more misleading where they suggest that *any* exposure to coal ash (and, really, soil) *will* result in these adverse health effects. This is just not true. The information provided here demonstrates that:

- Coal ash is not toxic—even at the high exposure levels used in animal tests;
- There are safe levels of exposure to each of the constituents in coal ash (and in soil), as defined by EPA; and
- Exposure must occur at a high enough level before an adverse effect can occur.

Humans routinely ingest soil particles in our homes, gardens, and parks, exposing us to many of the same elements and compounds found in coal and coal ash.

Let's Keep Our Discussions Scientific

It is easy to get press coverage when you say the sky is falling, or that coal ash is toxic. Bad news sells. Reasoned responses to such claims do not. We live in a complicated world, and the results of scientific research are hard to convey in easy language, let alone in sound bites. But we have to keep trying to get the scientific message out.

Those with political and money-raising objectives will make fun of what is said here. But there is an important distinction between making fun of what someone says and providing a science-based reply. Peer review and scientific discussions are always welcome—bullying is not. Let's stop bullying, and stop scaring people about coal ash, and start having a fact-based discussion about working to advance safe and technically sound disposal practices—as well as safe and environmentally sound beneficial uses of coal ash.

Lisa JN Bradley, Ph.D., DABT is a Principal Toxicologist with the environmental consulting firm Haley & Aldrich. She has a Ph.D. in toxicology from the Massachusetts Institute of Technology, 25 years of experience in risk assessment and toxicology, and is certified by the American Board of Toxicology. She is serving her third 2-year term as Secretary/Treasurer of the American Coal Ash Association. In May 2014, Dr. Bradley was appointed to the National Coal Council (NCC) by the U.S. Secretary of Energy to provide risk assessment and toxicology expertise to the NCC, and has been reappointed each year since then. She was named one of the 100 Global Inspirational Women in Mining in December 2015 by Women in Mining (UK).

[4] https://pubs.usgs.gov/sir/2017/5118/sir20175118_geo.php – Geochemical and Mineralogical Maps, with Interpretation, for Soils of the Conterminous United States.
[5] https://www.atsdr.cdc.gov/toxprofiledocs/index.html – ATSDR Toxicological Profiles.
[6] https://pubs.usgs.gov/ds/635/ - Geochemical Database of Feed Coal and Coal Combustion Products (CCPs) from Five Power Plants in the United States.
[7] https://www.epa.gov/risk/regional-screening-levels-rsls-generic-tables – EPA Regional Screening Levels (RSLs) - Generic Tables.
[8] https://www.acaa-usa.org/publications/freepublications.aspx – ACAA – Coal Ash Material Safety; under Technical Reports.
[9] https://www.acaa-usa.org/Portals/9/Files/PDFs/AshAtWork/ASH01-2012.pdf – ACAA – pp. 21-26.

Editor's Note: "I'm Glad You Asked" is a recurring feature that invites a different expert each issue to answer a commonly asked question about coal combustion products. If you would like to submit a question and/or volunteer to provide a written answer to one, please contact the editor at johnfsimpson@gmail.com.


Bill Petruzzi

This issue's guest columnist is William G. Petruzzi, P.G., Principal, Hull & Associates LLC. Bill is a leader in Hull's materials and waste management practice, supporting company-wide, waste-related strategic initiatives out of the company's Toledo, Ohio, office. His areas of expertise include strategic planning, materials and waste management, beneficial use, coal combustion products, industrial byproducts, dredged materials, shale oil/gas exploration materials and waste, environmental monitoring and compliance programs, and waste characterization and harvesting. Bill received his Bachelor of Science in Geology from Youngstown State University and is a registered Professional Geologist in Kentucky and Pennsylvania. He currently serves as Associate Member-at-Large on the American Coal Ash Association's Board of Directors.

Q. What happens to fly ash when it is cut, drilled, or demolished?

A. Interesting question. To focus my response, I would like to restate the question as, "What happens to construction materials like concrete that contain fly ash when they are modified or reach the end of their use (via cutting, drilling, or demolition)?" The reason for restating the question is that I want to emphasize that fly ash is not used in a construction application on its own, but it is rather an important product used largely as an ingredient in the concrete marketplace.

So the simple answer is that when fly ash is used in concrete, it ceases being fly ash, as it is consumed into the composition of the final product. This is much like flour and sugar when they are used as ingredients in a cake. The analogy between concrete and a cake may seem odd, but it can serve to illustrate how the crumbs of a cake do not represent the ingredients sugar and flour in their raw form. Similarly, the materials resulting from cutting or drilling concrete products do not represent the raw fly ash.

Here is some background. The combustion of coal in an electrical generating station creates coal ash. Coal ash is composed of two components, including the heavier fraction of bottom ash and the lighter fraction of fly ash. Other coal combustion products include boiler slag and treatment residuals such as flue gas desulfurization dust. Our discussion here focuses on fly ash.

Fly ash is a sustainable product that can be used to increase the performance of traditional concrete and is widely used in the construction industry. In 2018, 102.3 million tons of coal ash was produced, of which 58% was recycled. A portion of this coal ash from that year, 12.5 million tons of fly ash, met the performance criteria for reuse in concrete.[1] Fly ash is characterized prior to use to ensure compliance with industry performance standards set for two classes of fly ash typically used in concrete (Class C and Class F). Class C fly ash contains a high percentage of calcium oxide with a carbon content of less than 2 percent,

[1] https://www.prnewswire.com/news-releases/coal-ash-recycling-rate-declines-amid-shifting-production-and-use-patterns-300961238.html.

When fly ash is used in concrete, it ceases being fly ash, as it is consumed into the composition of the final product—much like flour and sugar when they are used as ingredients in a cake.
Source: Hull & Associates LLC

whereas Class F fly ash generally contains less calcium oxide. Class C provides strength in the early stages of construction, while Class F strengthens concrete over the long term.[2]

Whether Class C or Class F, fly ash serves as a binder; it contains silica and alumina, minerals that give fly ash the properties of a type of substance known as a pozzolan.[3] As a pozzolan, fly ash chemically reacts with lime (calcium hydroxide) and water in a pozzolanic reaction, forming a cementitious material analogous to portland cement (which typically contains gypsum and a natural pozzolan such as volcanic ash).[4] It is important to note that the products of the pozzolanic reaction (such as calcium silicate hydrate) have a chemical identity distinct from the reactants (such as silicic acid, lime, and water) with different physical and chemical properties. In the presence of water and fine and coarse aggregates, cementitious materials such as portland cement or pozzolanic-reacted fly ash form concrete, a durable and strong substance. Therefore, concrete may be made from portland cement, pozzolanic-reacted fly ash, or a combination of the two. The use of fly ash in concrete reduces the need for natural resources. Additionally, the use of fly ash in portland cement concrete imparts properties that are favorable for many applications, such as improved fluidity to the pourable concrete mixture and strength to the hardened, cured product.[5]

Therefore, fly ash not only adds benefits to concrete, but it is a sustainable product and reduces the use of raw material and resources in the production of cement and concrete. The life cycle of concrete starts with ingredients including water, portland cement, fly ash, and aggregate. At the traditional end of a life cycle, or when the integrity of the material may merit modification, concrete may be cut, drilled, and/or demolished, resulting in the production of excess materials. At this point, the excess materials can be profiled or characterized, and managed via reuse, recycling, or placement in a containment area following best management practices.

The materials at this point are non-hazardous per the federal Resource Conservation and Recovery Act (RCRA). In various states, they are not defined as a waste, but rather as a construction material. Some states have regulations that may apply to the demolition, cutting, or sawing of concrete and the management of the materials.

To conclude, the use of fly ash in concrete results in a new product whose characteristics differ from raw fly ash. Fly ash is a safe and sustainable product that, when characterized and managed properly, does not pose a concern for human health or the environment. When drilled or demolished, fly ash does not revert to the characteristics of the raw ingredient, but rather maintains the characteristics of the new product—again, just like the ingredients of a cake and the resulting crumbs when sliced and served.

The author would like to thank Edward Pfau, Risk Assessment Practice Leader, Hull & Associates LLC, and Abigail Calmes, Engineering Intern, Hull & Associates LLC, for their invaluable assistance in putting this article together.

[2] https://fclsubic.com/2019/08/24/class-c-vs-class-f-fly-ash-an-innovative-additive-in-construction/.
[3] https://www.fhwa.dot.gov/publications/research/infrastructure/structures/97148/cfa53.cfm.
[4] http://www.flyash.info/2011/032-Dunstan-2011.pdf.
[5] https://www.thebalancesmb.com/fly-ash-applications-844761

the Behind Scenes

WOCA

May 17-20, 2021
Covington, Kentucky

8 Things You Never Knew

We put the "world" in World of Coal Ash

With more than 1,000 attendees from 22 countries across 5 continents, WOCA is the most inclusive coal ash conference across the globe.

The Exhibit Hall, though

If a company is involved in coal combustion products and service, you can find them at WOCA. With more than 100 exhibitors and vendors, the WOCA Exhibit Hall is the best in show.

They say content is king

WOCA 2021 is at the head of the coal ash roundtable and will feature up to nine parallel sessions at one time – a new WOCA record and proof that we are committed to bringing the very best content to our attendees.

Top scientific journal

The Coal Combustion and Gasification Products Journal is a free, global publication that was born out of WOCA and its content.

Mixing Science with Social

At WOCA 2021, you can, easily, interact with presenters, industry leaders, and global research experts at both technical sessions and over food and beverages.

Student Engagement

Student engagement remains an important part of WOCA. If you want to find your next hire or learn about new techniques and emerging technologies, come and engage with the next generation of coal ash leaders.

A Poster Session Happy Hour?

Yep, we have that.

It's the people

WOCA attracts the best and brightest from industry, government, and higher education. And they all care about this industry and its future. Who wouldn't want to be part of that?

# of Attendees

2007	2009	2011	2013	2015	2017	2019
522	520	524	591	882	1018	1075

# of Exhibitors

2007	2009	2011	2013	2015	2017	2019
41	50	84	62	81	89	104

# of Sponsors

2007	2009	2011	2013	2015	2017	2019
25	29	25	23	22	27	36

Countries Represented

2007	2009	2011	2013	2015	2017	2019
26	23	22	18	19	19	16

http://worldofcoalash.org

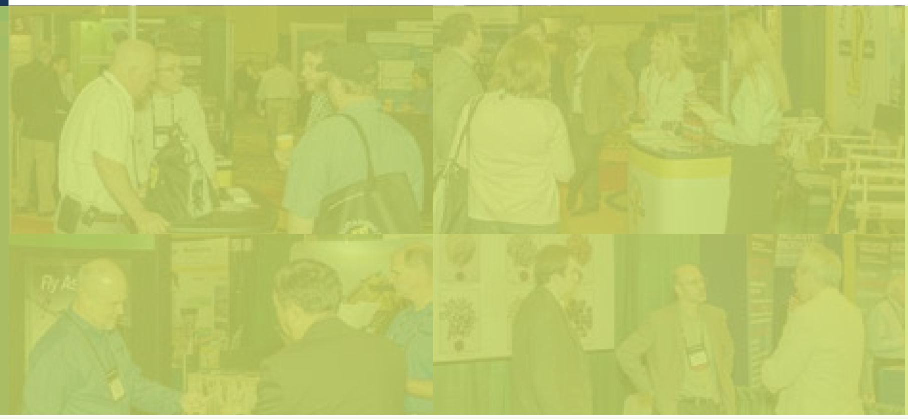
Keep on Growing

Cities Visited

Covington, KY; Denver, CO; Lexington, KY; Nashville, TN; St. Louis, MO



Come Visit Our Exhibitors



http://worldofcoalash.org

Booth	Company
1,2	Wood
3,4	Waste Management
5	Global Containment Solutions
6	Key Environmental
7,8	Chesepeake Containment Solutions
9	Marietta Silos
10	Atlantic Lining Co., Inc.
11	Geotechnics
12	United Conveyor Corporation
13	Axter Coletanche
14	Hanson Professional Services Inc.
15	Plastatech
16	Geocomp Corporation
17	Geosyntec Consultants
18	CSI
19	Emilcott
20	E-Tank
21	ASHCOR
22	EPI
23	Agru America
24	Tarmac International, Inc.
25	Sevenson Environmental Ser-vices, Inc.
26	Vecor
27	Geosyntec Consultants
28	Saiia
29	Ellicott Dredge Technologies

Booth	Company
30	DeWind One Pass Trenching LLC
31	ISCO Industries Inc.
32,33	Survey Equipment Services, Inc.
34	S&ME
35	Forgen
36	HIS Management Corporation
37	Watershed Geo
38	Ingios Geotechnics, Inc.
39	Thalle Construction
40	TenCate Geosynthetics
41,42	Stantec Consulting Services, Inc.
43	Mersino
44	Republic Services
45,46	The SEFA Group
47,68	Phillips and Jordan
48,49	Boral Resources
50	Golder
51	International Lining Technology
52	Charah Solutions, Inc.
53	Environmental Specialties Inter-national, Inc
54	CETCO
55	GAI Consultants
56	Hull & Associates
57	WL Port-land
58,59	Trans Ash
60	Mintek Resources
61	Solmax

Booth	Company
62	Titan Environmental
63	Arcadis
64	ATC Group Services
65	Barnard Construction
66,67	Xylem
69,70	R.B. Jergens
71	Atarfil
72	Hayward Baker
73	Moretrench
74	Tetra Tech
75	Geo-Solutions
76	TRC Solutions
77	Hallaton Environmental Linings
78	AECOM
79	CQA Solutions
80	Profile Products
81	SCS Engineers
82,83	Waste Connections
84	Cooper Barnette Page, Inc.
85	Griffin Contract Dewatering, LLC
86	RPM Solutions
87	Mustang Extreme
88	JF Brennan
89	Babcock Power
90	Infrastructure Alternatives, Inc.

Exhibitor Floor Plan can be found in the WOCA Program Book.

WOCA Sponsors *Make This Possible*

Platinum

SEFA

Platinum

CHESAPEAKE CONTAINMENT SYSTEMS, INC.

Silver

agru america

Environmental Specialties International, Inc.

Bronze

RYAN INC CENTRAL

Sevenson Environmental Services, Inc.

Awards

EPRI ELECTRIC POWER RESEARCH INSTITUTE

MIDWEST COAL ASH ASSOCIATION

Your registration includes:

1 x Welcome Reception in the Exhibit Hall

1 x Poster Session Reception in the Exhibit Hall

1 x Offsite Reception on the Cincinnati Belle

2 x Group Lunches

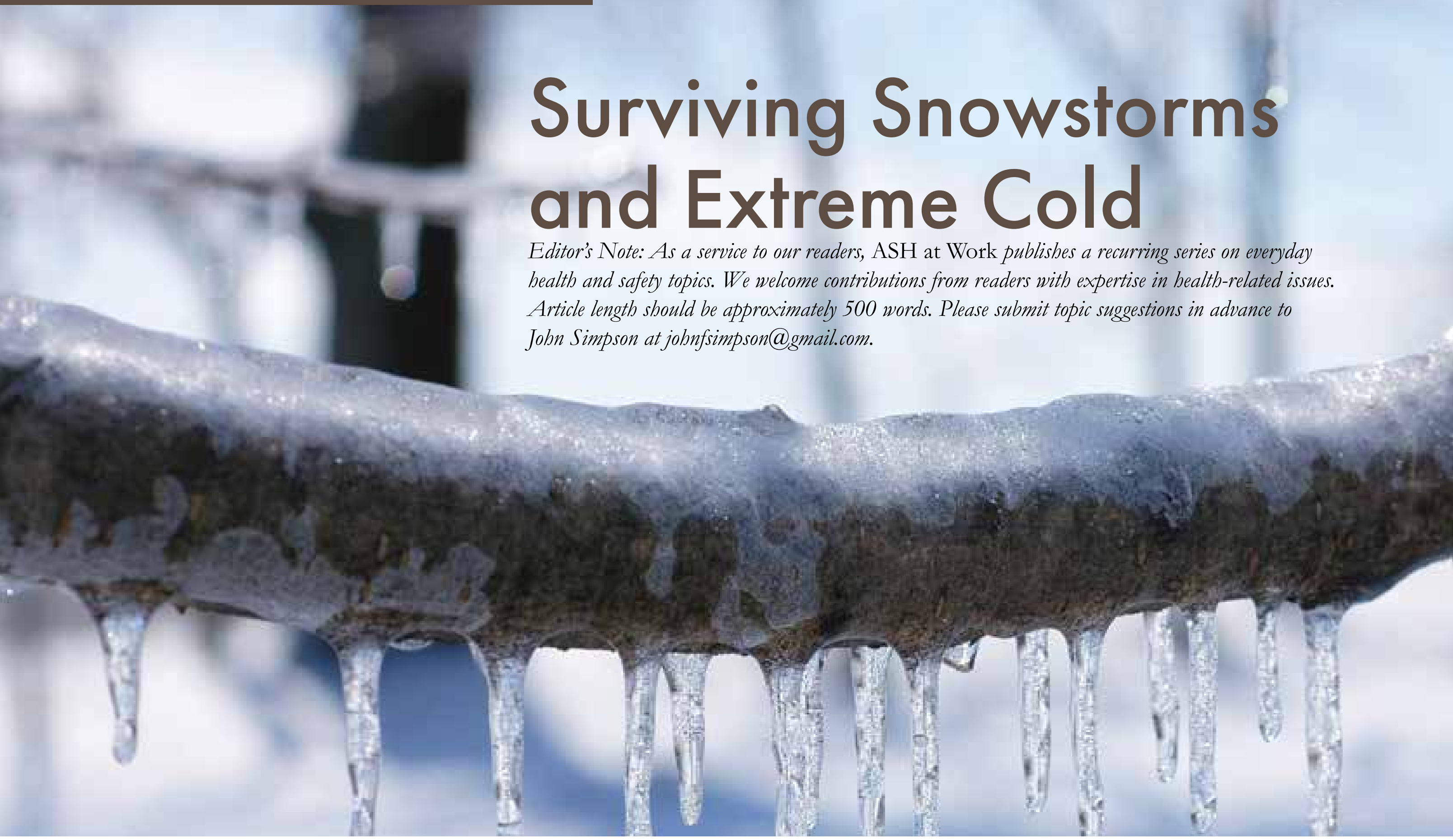
3 x Breakfasts

150+ Technical Presentations

Countless contacts in the industry!

Join us at WOCA 2021's offsite reception on the Cincinnati Belle riverboat! On Wednesday night we will have dinner, entertainment, and an evening river cruise aboard the Cincinnati Belle.

*We can't wait to see you at **WOCA 2021!***



Surviving Snowstorms and Extreme Cold

Editor's Note: As a service to our readers, ASH at Work *publishes a recurring series on everyday health and safety topics. We welcome contributions from readers with expertise in health-related issues. Article length should be approximately 500 words. Please submit topic suggestions in advance to John Simpson at johnfsimpson@gmail.com.*

Winter storms and blizzards can bring extreme cold, freezing rain, snow, ice, and high winds that knock out heat, power, and communication services. With that comes a higher risk of car accidents, hypothermia, frostbite, carbon monoxide poisoning, and heart attacks from overexertion. Seniors, young children, and the sick are at the greatest risk.

Prepare in Advance

- Know your area's risk for winter storms. Extreme winter weather can leave communities without utilities or other services for long periods.
- Prepare your home to keep out the cold with insulation, caulking, and weather stripping. Learn how to keep pipes from freezing. Install and test smoke alarms and carbon monoxide detectors with battery backups.
- Pay attention to weather reports and warnings of freezing weather and winter storms. Sign up for your community's warning system. The Emergency Alert System (EAS) and National Oceanic and Atmospheric Administration (NOAA) Weather Radio also provide emergency alerts.
- Gather supplies in case you need to stay home for several days without power. Keep in mind each person's specific needs, including medication. Do not forget pets' needs. Have extra batteries for radios and flashlights.
- Create an emergency supply kit for your car that includes jumper cables, sand, a flashlight, warm clothes, blankets, bottled water, and non-perishable snacks. Keep the gas tank full.
- Learn the signs of, and basic treatments for, frostbite and hypothermia.

Survive During a Storm

- Stay off roads if at all possible. If trapped in your car, stay inside.
- Limit your time outside. If you need to go outside, wear layers of warm clothing and watch for signs of frostbite and hypothermia.
- Avoid carbon monoxide poisoning. Only use generators and grills outdoors and away from windows. Never heat your home with a gas stovetop or oven.
- Reduce the risk of a heart attack. Avoid overexertion when shoveling snow.
- Watch for signs of frostbite and hypothermia and begin treatment right away.
- Check on neighbors.

Recognize and Respond to an Emergency

- Frostbite causes loss of feeling and color around the face, fingers, and toes.
    - Signs: Numbness, white or grayish-yellow skin, firm or waxy skin.
    - Actions: Go to a warm room. Soak in warm water. Use body heat to warm. Do not massage or use a heating pad.
- Hypothermia is an unusually low body temperature. A temperature below 95 degrees is an emergency.
    - Signs: Shivering, exhaustion, confusion, fumbling hands, memory loss, slurred speech, or drowsiness.
    - Actions: Go to a warm room. Warm the center of the body first—chest, neck, head, and groin. Keep dry and wrapped up in warm blankets, including the head and neck.

Materials adapted from ready.gov.

Fly Ash Use in Concrete Increases Slightly in 2019 as Overall Coal Ash Recycling Rate Declines

Fifty-two percent of the coal ash produced during 2019 was recycled—marking the fifth consecutive year that more than half of the coal ash produced in the United States was beneficially used rather than disposed. The volume of fly ash used in concrete increased 1 percent over the previous year, but most other uses saw significant declines, leading to an overall decrease in recycling activity of 31 percent.

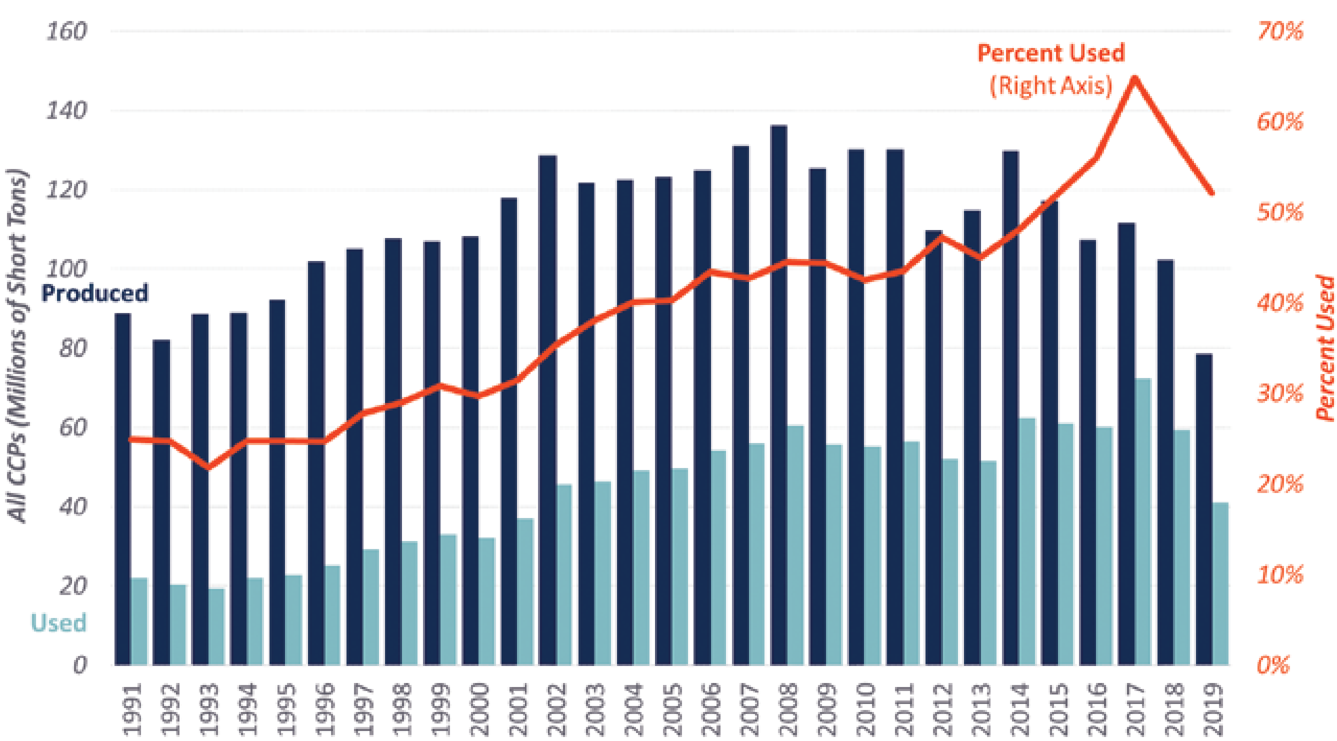
"As coal ash production declines, beneficial use markets are adopting new logistics and technology strategies to ensure these valuable resources remain available for safe and productive use in the highest value applications," said ACAA Executive Director Thomas H. Adams. "However, declining use in applications with lower economic value represents a lost opportunity to create significant environmental benefits. We must continue to support these practices that safely conserve natural resources while dramatically reducing the need for landfills."

According to ACAA's just-released "Production and Use Survey," 41 million tons of coal combustion products were beneficially used in 2019 out of 78.6 million tons that were produced. The rate of ash utilization decreased from 58.1 percent to 52.1 percent and the total volume of material utilized decreased by 18.4 million tons compared to the previous year. Coal ash production volume decreased 23 percent (or 23.6 million tons) from 2018 levels.

Highlights of CCP production and use in 2019 include:

- Use of coal fly ash in concrete increased 1 percent to 12.6 million tons. Concrete producers and consumers indicated a desire to use more fly ash, but several regional markets were affected by shifting supply dynamics associated with closures of coal-fueled power plants.
- Use of all coal combustion products in cement production declined 22 percent to 5 million tons.
- Use of synthetic gypsum in panel products (i.e., wallboard) declined 21 percent to 9.7 million tons.
- Synthetic gypsum use in agricultural applications—in which the gypsum improves soil conditions and prevents harmful runoff of fertilizers—declined 38 percent to 572,399 tons.
- Use of CCP in pond closure activities declined 26 percent to 2.4 million tons but remained well above 2016's total of only 435,000 tons. This activity is driven by utility compliance with coal ash regulations enacted in 2015 that effectively require an end to the practice of wet disposal. Fly ash, bottom ash, boiler slag, and synthetic gypsum were all used in construction of new permanent disposal facilities.
- Following a one-year volume increase in 2018, use of CCPs in structural fills resumed a multi-year decline in 2019, dropping 62 percent to 1.7 million tons.
- Production of boiler slag declined 37 percent as the number of cyclone boilers producing this material also continued to decline. Approximately 246,000 tons of boiler slag was utilized in the production of blasting grit and roofing granules. Approximately 362,000 tons of bottom ash was used in this application, a huge increase over 2018's utilization of only 27,000 tons and an indication that consumers have begun to shift away from the declining boiler slag resource.
- Approximately 944,000 pounds of cenospheres were sold in 2019, down 21 percent from the prior year but still well above 2017's volume of 148,000 tons. Increased cenosphere recovery was likely linked to increased pond closure activities.

"As America's electricity grid changes, the coal ash beneficial use industry is evolving as well," said Adams. "As we work diligently



to utilize the nearly half of coal combustion products that are still disposed annually, our industry is also taking significant strides in developing strategies for improving the quality and availability of these materials."

Adams explained that increasing beneficial use requires ash marketers to ensure that products are consistent and available when customers need them—requiring large investments in technology and logistics. Additionally, the coal ash beneficial use industry is actively deploying technologies and strategies for harvesting coal ash materials that were previously disposed.

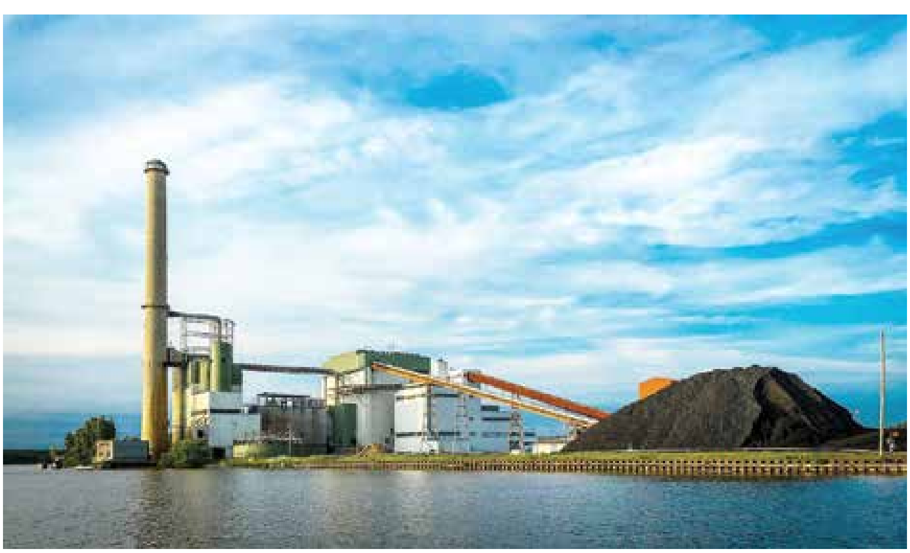
Ash Disposal Regulation Revisions Completed

The U.S. Environmental Protection Agency in 2020 finalized a suite of revisions to its coal ash disposal regulations, including the following:

- "A Holistic Approach to Closure Part A: Deadline to Initiate Closure and Enhancing Public Access to Information" was finalized on August 28, 2020. This final rule specifies that all unlined surface impoundments are required to retrofit or close—not just those that have detected groundwater contamination above regulatory levels. The rule also changes the classification of compacted-soil lined or "clay-lined" surface impoundments from "lined" to "unlined" and establishes a revised date, April 11, 2021, by which unlined surface impoundments and units that failed the aquifer location restriction must cease receiving waste and initiate closure or retrofit. The rule provides for cease-receipts deadline extensions at facilities where alternative capacity is technically infeasible or that have committed to permanent cessation of coal consumption by a date certain.
- "A Holistic Approach to Closure Part B: Alternate Demonstration for Unlined Surface Impoundments; Implementation of Closure" was finalized on November 12, 2020. This final rule creates a two-step process for utilities to make an alternative liner demonstration. Utilities interested in the option must file an application by November 30, 2020. Disposal units that pass initial EPA screening would then have until November 30, 2021, to prepare a "comprehensive final demonstration intended to ensure there will be no reasonable probability of adverse effects to human health or the environment resulting from groundwater contamination from the CCR surface impoundment" under the proposed alternative liner scenario. The Agency deferred action on other "Part B" proposals to allow utilization of coal combustion products during disposal unit closure operations and to require annual closure progress reports.
- "Effluent Limitations Guidelines and Standards for the Steam Electric Power Generating Point Source Category" revisions were finalized on October 13, 2020. This final rule under the Clean Water Act revises requirements for two waste streams from steam electric power plants: flue gas desulfurization (FGD) wastewater and bottom ash (BA) transport water. Key revisions to the 2015 rule include changing the technology basis for treatment of FGD wastewater and BA transport water; establishing new compliance dates; revising the voluntary incentives program for FGD wastewater; adding subcategories for high-flow units, low-utilization units, and those that will cease the combustion of coal by 2028; and finalizing requirements that are tailored to facilities in these subcategories.

Other regulation revisions that EPA advanced but did not finalize in 2020 included:

- Creation of a federal permitting program for coal ash disposal regulations, which was required by Congress in the 2016 Water Infrastructure Improvements for the Nation (WIIN) Act and which shifted enforcement authority for EPA's disposal standards from citizen lawsuits to state environmental regulators. The federal permit program is intended for use in states that do not seek EPA approval for their own programs and for use in Indian Country. The proposed federal program includes electronic permitting and sets requirements for permit applications, content and modification, as well as procedural requirements.
- An Advanced Notice of Proposed Rulemaking to kick off development of coal ash disposal regulations for inactive surface impoundments at inactive electric utilities, referred to as "legacy CCR surface impoundments" or "legacy units." This rulemaking was required by the August 21, 2018, opinion by the U.S. Court of Appeals for the District of Columbia Circuit that vacated and remanded a provision that exempted inactive impoundments at inactive facilities from EPA's 2015 CCR Final Rule. The Court required EPA to regulate these facilities but did not mandate how regulations should be written or set a deadline for EPA to act. EPA on October 14, 2020, sought input on a potential definition of a legacy CCR surface impoundment and specifically solicited information on the types of inactive surface impoundments at inactive facilities that might be considered legacy surface impoundments. The Agency is also taking comment on EPA's regulatory authority, the appropriate regulatory approach for these units, and the time frames to come into compliance with those regulations.



EPA is seeking comments and data on inactive surface impoundments at inactive electric utilities to assist in the development of future regulations for these CCR units.

EPA Starting Over on Definition of Coal Ash Beneficial Use

The U.S. Environmental Protection Agency's 2015 coal ash disposal regulation created controversy over its definition of beneficial use by requiring environmental evaluations of "unencapsulated" uses involving more than 12,400 tons in non-roadway applications that are in direct contact with the ground, as well as setting up inconsistent regulatory treatment of piles staged for beneficial use. These controversies were remanded to EPA for further rulemaking in a 2018 federal court decision. In August 2019, EPA proposed revisions that were roundly criticized by commenters on all sides, including the American Coal Ash Association.

In its Spring 2020 Regulatory Agenda, EPA decided to go back to the drawing board on the issue. "Based on the public comments received on the August 2019 proposal, the Agency does not intend to take final action at this time on the proposed revisions for the beneficial use definition and requirements for managing piles of CCR," EPA wrote. "The Agency will continue to reconsider these issues and plans to seek additional information. Pending the review and analysis of any additional information found, the Agency will determine the appropriate next steps. While these two issues are under the Agency's reconsideration, the provisions promulgated in the 2015 CCR rule remain in place for the beneficial use definition and piles of CCR."

EPA commenced a series of "stakeholder calls" to gather additional information on the issues. ACAA representatives participated in two stakeholder calls with EPA. Other organizations invited to give input included the National Ready Mixed Concrete Association and the Portland Cement Association. Other stakeholder calls have already been held with wallboard manufacturers (Gypsum Association), agricultural retailers, utilities (Utility Solid Waste Activities Group, American Public Power Association, and National Rural Electric Cooperative Association), environmental groups, and other federal agencies.

ACAA Encourages Expansion of Federal Coal Ash Products Procurement

The American Coal Ash Association on July 6, 2020, filed extensive comments on a U.S. Environmental Protection Agency Request for Comments on the agency's "Designations and Recommendations for Recycled-Content Products." The action is related to EPA's Comprehensive Procurement Guidelines (CPG) program, which is intended to encourage other federal agencies to use recovered and recycled materials.

"ACAA is proud to note that 'Cement and Concrete Containing Fly Ash' was the subject of the very first CPG published by EPA in 1983 and that EPA subsequently added guidance for purchasing flowable fill containing coal fly ash. ACAA strongly recommends that EPA maintain both of these CPGs and add new guidelines covering the purchase of wallboard containing FGD (synthetic) gypsum, soil and waste stabilization using CCP, asphalt containing fly ash, and structural fills containing CCP," ACAA wrote.

"Coal remains the fuel source for more than a quarter of electricity generation in the United States and produces large volumes of solid coal combustion products … almost 43 million tons of CCP were disposed in 2018, adding to an inventory of more than 1.5 billion tons of previously disposed material that contains large volumes of products suitable for harvesting for beneficial use. This immense resource base presents an ideal opportunity to advance principles of Sustainable Materials Management (SMM) and achieve EPA's statutory and policy objectives to encourage the beneficial use of recovered materials. The agency's CPG program can be a vital tool in advancing this important work."

ACAA sincerely thanks the team of volunteers who provided major contributions to the comment development process. Task team leaders included Stephen Hart and Brian Borowski of Geocycle/LafargeHolcim, Scott Palmer of Salt River Materials, Andrew Hicks of ASH Mineral Solutions, Mike Schantz of Lhoist, Ivan Diaz of Boral Resources, Danny Gray of Gray Energy Technologies, and Sheryl Smith of ATC Group Services. Additionally, more than a dozen other members provided assistance in the final review of the document.

ASH Allies:

National Rural Electric Cooperative Association

NRECA
America's Electric Cooperatives

The National Rural Electric Cooperative Association (NRECA) is the national trade association representing nearly 900 of America's electric cooperatives. From growing suburbs to remote farming communities, electric co-ops are engines of economic development for 42 million Americans across 56% of the nation's landscape.

NRECA and its members in 48 states stand for:

- *Safe, affordable, reliable power*—Access to safe, affordable, and reliable electricity is foundational to electric cooperatives' mission of advancing their local communities. Co-ops are owned by the consumers they serve and operate at cost, creating a unique drive to innovate and save consumers money. Our purpose is to power communities and empower members to improve the quality of their lives. Affordable and reliable electricity is fundamental for rural America and, as such, ensuring this essential mission is the primary filter through which NRECA and its members analyze policy proposals.
- *Connecting rural America and bridging the digital divide*—Broadband internet access is a necessity to thrive in our 21st century economy, yet more than 21 million Americans—many in electric co-op service areas—lack high-speed internet access. These rural families and businesses are fighting an uphill battle in the digital economy. More than 150 electric co-ops are working toward meaningful and diverse solutions to bridge the digital divide and jump-start local economies, and more are assessing the feasibility of providing broadband. As advocates for America's rural communities, NRECA is committed to ensuring that policymakers and other stakeholders continue to take meaningful steps to support continued federal funding of rural broadband expansion.
- *Ensuring rural communities thrive*—Electric cooperatives are led by and belong to the communities they serve. As local businesses built by their consumer-members, electric cooperatives have meaningful ties to their members and invest $12 billion annually in their communities. Co-ops are continuing to recruit top-tier talent from local communities as they work to meet tomorrow's energy needs. NRECA's members are deeply invested in the economic well-being of their communities and advocate for federal policies that support their growth and prosperity.
- *Diversity of energy portfolios*—America's electric co-ops are focused on responsibly delivering affordable, reliable electricity in communities across the nation. Diversity of electric generation, including baseload sources, is essential to meeting co-op members' expectations. Consistent with that approach, electric co-ops thoughtfully explore all ideas that promote these core principles as they work to meet the evolving energy needs of their local communities.
- *Responsible CCR reuse and management*—Electric co-ops that generate electricity at coal-based power plants send the coal combustion residuals (CCRs) for beneficial use in other products or applications whenever possible. This includes gypsum for use in wallboard, fly ash for use in concrete and pavers, and bottom ash used as structural fill and roadbeds. When there is no market for the CCRs, they are responsibly managed according to the Environmental Protection Agency's CCR regulations. NRECA supports environmentally protective regulations that allow for tailored management to reflect site-specific characteristics. This includes administration of the federal CCR program through state permits, as is done under other major environmental programs such as the Clean Air Act and Clean Water Act.

NRECA continues to work with policymakers to ensure that any federal legislative and regulatory proposals provide long-term certainty and flexibility to maintain energy diversity for electric co-ops, protect the reliability of the electric grid, and minimize undue economic impact for consumers—especially those in rural America and in communities with persistent poverty.

For more information on NRECA, please visit **www.electric.coop** or **twitter.com/NRECANews**.

ACAA

Beneficial Use Case Study

B.C. Cobb Generating Facility and J.C. Weadock Landfill

Coal Combustion Product Type
Fly Ash, Bottom Ash

Project Locations
Muskegon, Michigan; Essexville, Michigan

Project Participants
Charah Solutions Inc., through its subsidiary Muskegon Environmental Redevelopment Group LLC (MERG); Consumers Energy, former B.C. Cobb Generating Facility site in Muskegon, Michigan; Consumers Energy, licensed J.C. Weadock Landfill in Essexville, Michigan, located at the former J.C. Weadock Generating Station site.

Project Completion Date
Equipment mobilization and construction at the B.C. Cobb ponds started in April 2020. Onsite dewatering, excavation, and transportation began in Q3 2020 and will continue through the end of 2021. State approval of the final pond closure is targeted as soon as early 2022, in advance of the Federal CCR Rule compliance deadline, which requires pond closure by March 2023.

Project Summary
Charah Solutions, through its MERG subsidiary, took ownership of the ash ponds at Consumers Energy's former B.C. Cobb Generating Facility site in Muskegon, Michigan. The coal combustion residuals (CCR) materials will be excavated and beneficially used as necessary fill material in Consumers Energy's licensed J.C. Weadock Landfill in Essexville, Michigan, located at the former J.C. Weadock Generating Station site.

Former B.C. Cobb ash ponds to be harvested and sustainably repurposed for the benefit of the watershed.

Project Description
Since the late 1940s, the B.C. Cobb Generating Facility, in Muskegon, Michigan, situated near Muskegon Lake, was owned and operated by Consumers Energy (Consumers), Michigan's largest energy provider. Consumers' B.C. Cobb Generating Facility and J.C. Weadock Generating Station in Essexville, Michigan, along with the J.R. Whiting Plant in Luna Pier, Michigan, were retired in April 2016.

Harvesting the existing ash ponds at the B.C. Cobb Generating Facility was part of the post-closure regulation requirements and sustainability objectives for the site and community along the eastern shore of Lake Michigan. In 2018, Charah Solutions approached Consumers with an innovative and cost-effective proposal to provide harvesting of the ponds and sustainable repurposing of the site while also implementing beneficial use practices for another Consumers licensed landfill project. A comprehensive one-stop solution was offered to effectively manage


Ash being excavated from B.C. Cobb ash ponds in preparation for pond closure.

Ash from B.C. Cobb ponds being loaded into railcars and trucks for transport to J.C. Weadock Landfill.

the environmental and construction aspects of safely closing the ponds and enhancing the site for the benefit of the community, while lowering the cost for Consumers and its customers. Charah Solutions' turnkey environmental risk-transfer services involve property acquisition, site harvesting/redevelopment, responsibility for the environmental liabilities plus permitting, and compliance with state and federal regulations—all designed to meet the evolving and increasingly complex needs of utility partners.

In April 2020, Charah Solutions announced its plans to close the B.C. Cobb Generating Facility's ash ponds and help restore the watershed's native soils and wildlife habitat. As part of this agreement, Charah Solutions, through its subsidiary Muskegon Environmental Redevelopment Group LLC, took ownership of the ash ponds during the closure process.

In addition to harvesting and sustainable repurposing, Charah Solutions is implementing beneficial recycling practices for the existing ponded ash. Approximately 650,000 cubic yards of coal combustion residuals (CCR) materials will be excavated and beneficially used as necessary fill material in Consumers' licensed J.C. Weadock Landfill, located at the former J.C. Weadock Generating Station site, to help fill the landfill and design closure grades. Approximately 75% to 85% of the ash will be transported by a fleet of 150 covered, high-sided railcars, with the remainder transported by covered trucks.

Upon completion of the project, the B.C. Cobb ash ponds, totaling 62.8 acres, will be sustainably repurposed for the benefit of the watershed. By reusing the ash as necessary fill material, it will be recycled, conserving approximately 650,000 cubic yards of virgin materials that would otherwise be required.

Straddle carrier unloading recycled ash from the railcars at J.C. Weadock Landfill.

As a sustainability leader in utility services for over 30 years, Charah Solutions is dedicated to preserving natural resources in an environmentally conscious manner through projects like this with Consumers. Sustainability is a Charah Solutions core value, and the company focuses its business on developing innovative solutions to complex environmental issues for the betterment of the planet, the communities in which it operates, and its customers.

This project is also a great example of Consumers' ongoing focus on communities and the environment. Leveraging an innovative, turnkey approach to risk transfer and beneficially using the ash material and repurposing the ponds will result in cost savings and reduced environmental risk for Consumers and its customers while protecting and enhancing the environment for the Muskegon Lake community.

Beneficial Use Case Study
Backfilling of Basement in Converted Manufacturing Facility

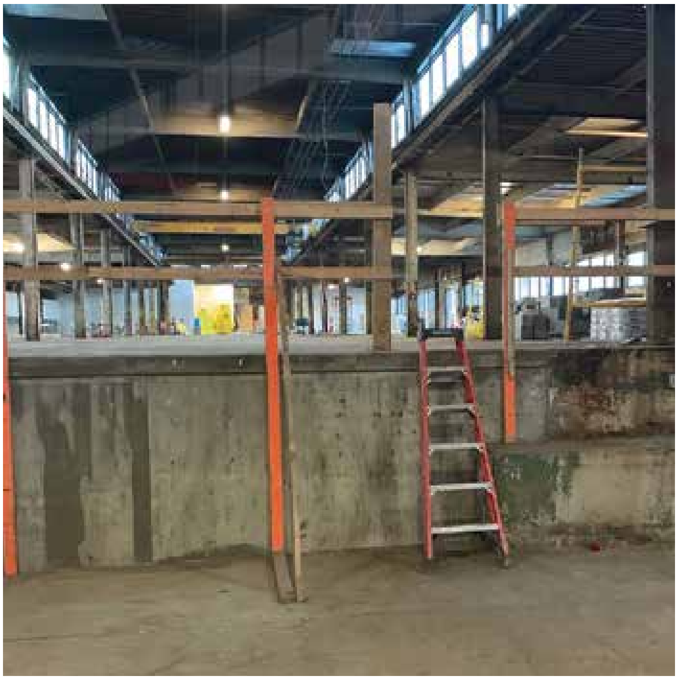
Coal Combustion Product Type
Controlled Low-Strength Material Using Class F Fly Ash

Project Location
Baltimore, Maryland

Project Participants
SEFA Group, KBK Builders LLC, Vulcan Materials

Project Completion Date
2020

Project Summary
A century-old building formerly used to manufacture airplane parts is being converted to office space with an industrial feel and decor. The building's basement, containing an old oil boiler, piping, and various obsolete pieces of equipment, was unused space and suffered from water intrusion—making it a good candidate for backfilling. Although ASTM No. 57 stone was initially considered for the job, controlled low-strength material (CLSM) using Class F fly ash was ultimately selected as the best way to completely and safely fill up the space.



SOURCE: SEFA GROUP

Project Description
The basement requiring backfilling measured approximately 11' x 20' x 40', or roughly 8800 cubic feet. A fill mixture with a ratio of 425 lbs. of fly ash, 75 lbs. of portland cement, and 60 gallons of water was selected for its flowability and to ensure that it could be easily excavated in the future if required. The flowable fill's Class F fly ash was sourced from SEFA's Keystone Generating Station, in Shelocta, Pennsylvania.

Placement was carried out in three phases, on three successive days, using the procedures outlined in ASTM D 6103, "Standard Test Method for Flow Consistency of CLSM." A 3" x 6" open cylinder was filled with slurry; the cylinder was lifted; and two diameter measurements were taken, at 90 degrees apart, to ensure their average diameter was between 8" to 12" so the mix would have the proper consistency. The contractor used the old boiler flue pipe to pour in the CLSM, thus ensuring the unit was completely filled with CLSM and helping the CLSM flow into tight spaces behind the boiler. The pump hose was then moved to the main hatchway once the contractor was satisfied the material was flowing properly.

The contractor installed several pipes through the floor for two purposes. First was to create safe observation ports to observe how the CLSM was flowing and filling the void. Second, the pipes could then be used as reservoirs for flowable fill when topping off the last few inches under the floor. Most flowable fills subside slightly as the water decants naturally upward. The reservoirs provided just enough head pressure to keep the CLSM in contact with the bottom of the slab above.

On the first day of placement, 197 cubic yards of CLSM were pumped into the basement. The following day 144 cubic yards were poured, filling the void to within 8" of the underside of the slab above. On the final day, 54 cubic yards of CLSM were poured, topping the void. It would have been possible to fill the basement in one continuous placement, but due to its overall depth, complexity, and unknown chambers, the contractor elected to use three consecutive placements.

With the CLSM at the proper consistency, no workers were needed to spread it into position, and the CLSM self-leveled. Keeping valuable employees out of dangerous confined spaces like this is a significant benefit of using CLSM, as is the reduced labor cost. The pump arrangement was simple and, as it operated at low pressure, the pump was able to operate at peak rate, offloading the mixer trucks rapidly. With two trucks at the hopper, the next truck was able to get the proper consistency and begin discharging while the previous truck was rinsing the chute directly into the pump hopper. The pump operator never had to stop the strokes unless the crew was moving the hose.

Beneficial Use Case Study

ACAA

Burj Khalifa

Coal Combustion Product Type
Class F Fly Ash

Project Location
Dubai, United Arab Emirates

Project Participants
Skidmore, Owings & Merrill, William Frazier Baker, Samsung C&T Corporation, Ash Resources, CTL Group, Emaar, Hyder Consulting, Turner International, Doka, Unimix

Project Completion Date
2010

Project Summary
Burj Khalifa, a 163-floor concrete multi-use tower in Dubai, UAE, stands as the world's tallest building, at 2717 feet. The 465,000-square-foot building houses a hotel, as well as commercial, office, residential, retail, and entertainment space. High-strength concrete, supplemented with fly ash, was chosen for the construction material partly in response to the harsh environment in the region, but nonetheless brought with it logistical and engineering challenges.

Project Description
According to the building's architects—Skidmore, Owings & Merrill—the intent from the outset was for Burj Khalifa not only to be the tallest building in the world, but also the tallest freestanding man-made structure. With that as a goal, proper site characterization, material selection, mix design and testing, building shape, and construction logistics all became paramount.

The groundwater in which Burj Khalifa's substructure sits is extremely corrosive, with chloride and sulfate concentrations of up to 4.5% and 0.6%, respectively—higher even than those found in sea water. As a result, design of the piles and raft foundation focused on durability. Each of the 194 piles used to support the raft utilized a concrete mix of 25% fly ash, 7% silica fume, and a water-to-cement (W/C) ratio of 0.32—and measured 1.5 meters in diameter and 43 meters long. Piles were designed to support 3000 tons apiece, although load tests showed they could bear more than twice that amount. In total, 5300 tons of DuraPozz fly ash, sourced from Ash Resources' Lethabo, South Africa, plant, was used in the pilings. Piles were protected by a special waterproofing membrane to inhibit corrosion.

The piles were then locked together by a 3.7 meter-thick concrete raft that spans the tower's footprint. The durability and performance criteria for the raft were exacting, and sample blocks were made to test for shrinkage, modulus of elasticity, and heat of hydration. Ultimately, the 12,500-cubic-meter raft incorporated a concrete mix containing 40% fly ash and a W/C ratio of 0.34. The completed raft used a further 2350 tons of DuraPozz fly ash, helping to limit peak temperatures and the potential for cracking during mass placements in the hot desert climate.

The high-performance concrete tower itself was designed as a "Y" shape around a hexagonal core for maximum lateral and torsional stiffness and to limit the effects of wind on the super-tall structure. Pumping concrete to heights of nearly 2000 feet proved to be an engineering challenge—but one that was overcome using four different mixes with incorporation of fly ash to help ensure workability. During construction, Dubai-based ready-mix concrete maker Unimix set a world record for the highest single-stage pumping of concrete—helping to prove the viability of high-performance concrete as a preferred material in super-tall building construction.

SOURCE: GNU FDL 1.2 - IMRE SOLT

Beneficial Use Case Study

ACAA

R. Paul Smith Power Station Ash Beneficiation

Coal Combustion Product Type
Class F Fly Ash, Bottom Ash

Project Location
Williamsport, Maryland

Project Participants
Paul Blum Company, FirstEnergy, Maryland Environmental Restoration Group, C. William Hetzer Inc.

Project Completion Date
2020

Project Summary
In 2012, FirstEnergy closed down its R. Paul Smith Power Station, in Williamsport, Maryland, in lieu of retrofitting the plant to comply with Environmental Protection Agency regulations scheduled to take effect three years later. The coal-fueled plant, used only sparingly in its later years, had been disposing coal ash in surface impoundments and a landfill for several decades. Owing to demand from local cement manufacturers, in 2009 the plant's owners, in partnership with the Maryland Environmental Restoration Group (MERG), began excavating the ash and selling it to cement producers as kiln feedstock.

Project Description
The R. Paul Smith Power Station generated electricity from bituminous coal for 85 years, ending in 2012 when its owner closed the plant. Since 1947, fly ash and bottom ash from the plant had been conveyed by sluice to settling ponds in West Virginia, after which they were transferred to an adjacent dry landfill. Up to 50,000 tons of coal ash were generated annually prior to the plant's shutdown.

As market supplies of coal ash began to tighten following the closure of coal-fueled power plants, the plant's owners in 2008 partnered with MERG, a coal ash marketing company, and local cement producers to investigate the potential for use of its landfilled ash. The market demand came primarily from cement manufacturers in the Washington, D.C., and Frederick, Maryland, metropolitan areas.

Sampling and testing of the coal ash were carried out to assess the material's suitability in cement manufacturing—with mineralogy testing to determine, among other characteristics, its levels of silica dioxide, lime, iron oxide, aluminum trioxide, magnesium oxide, sodium oxide, potassium oxide, water, total alkalis, and loss on ignition. After tests had determined the ash's suitability for cement production, and state environmental regulators had authorized its excavation, the contractor began removal of the ash and its delivery to cement manufacturers, who combined the material with limestone and other feedstock. Landfill excavators used onsite blending to ensure the coal ash and shale levels would meet cement manufacturers' chemistry requirements.

Starting out as several truckloads per week to meet the peak needs of regional cement plants, the project soon scaled up to 450,000 tons of coal ash excavated annually. Six years into the operation, approximately 1.5 million tons of comingled Class F fly ash and bottom ash had been removed from the 30-acre landfill. It is estimated that the total amount excavated and beneficially used for cement manufacturing over the decade-plus since operations began is in the vicinity of 3.6 million tons. The project's success has piqued cement manufacturers' interest in locating additional sources of legacy coal ash for use in their operations.

Beneficial Use Case Study

University of Minnesota Recreation Center Expansion

Coal Combustion Product Type
Class F Fly Ash

Project Location
Minneapolis, Minnesota

Project Participants
Studio Five Architects, Cannon Design, JE Dunn Construction, Meyer Borgman Johnson, LKPB Engineers

Project Completion Date
2013

Project Summary
The University of Minnesota's (UMN's) Twin Cities campus accommodates one of the largest student populations in the United States, with over 50,000 enrolled. As student demand began to outgrow the capacity of the original recreation center, the university undertook an expansion that would nearly double the facility's size, adding climbing and bouldering walls, expanded weight and fitness areas, an indoor running track, and a four-story atrium, among other features. High-volume fly ash (HVFA) concrete was used extensively to strengthen the structural elements of the remodeled facility as well as for its aesthetic appeal as an exposed material.

Project Description
The expansion of the recreation facility involved approximately 160,000 square feet of new construction on an asymmetrical site on UMN's East Bank Campus in Minneapolis. To accommodate the complex site geometry, several structural systems were employed, including a cast-in-place concrete wide-module pan-and-joist system.

Fly ash was used to replace 30% of the required cementitious material in the concrete mixes for every concrete structural element in the expansion, including footings/foundation walls, shear walls, columns/pan-and-joist slabs, and slab on grade/slab on metal deck. According to engineer Michael Ramerth, of Meyer Borgman Johnson, the reasons to use HVFA were many and included the lower CO_2 emissions associated with its use vis-à-vis portland cement, as well as its enhanced durability, placability, and workability; its greatly lower cost compared with portland cement; and the opportunity to reduce landfilled ash.


SOURCE: UNIVERSITY OF MINNESOTA RECREATION AND WELLNESS

"We've been over-cementing our mixes for decades," Ramerth told an audience at the American Concrete Institute's Spring Convention shortly after completion of the project. "We've had great results keeping many of our mixes down at 520 lbs. (of cementitious material per cubic yard)," he added. For UMN's recreation center, both the footings/foundation walls and the slab on grade/slab on metal deck used HVFA mixes with only 520 lbs. of total cementitious material to achieve compressive strengths of 6906 psi and 6460 psi, respectively.

Ramerth acknowledged that when using high-replacement mixes, lengthier set times can potentially boost labor costs, particularly in finishing the flatwork. However, on this project set times for slab on grade/slab on metal deck and columns/pan-and-joist slabs were, respectively, only 1 hour and 15 minutes and 1 hour and 25 minutes above those for straight cement.

"Not bad," Ramerth remarked. "Keep that mix temperature above 70 degrees by heating the water; it's very effective. Keep the aggregate somewhat protected in a temperate space where it doesn't get snowed on and left to the 20-below temperatures. And, of course, temporary heat on site during the day of the pour and the night before is critical," he added.

"These mixes do take a little extra care and a little extra effort, but they are wonderful mixes and they're green," Ramerth noted.


SOURCE: UNIVERSITY OF MINNESOTA RECREATION AND WELLNESS

ASH Classics

A Look Back at the Beginnings of the U.S. Coal Ash Industry

"ASH Classics" is a recurring feature of **ASH at Work** *that examines the early years of the American Coal Ash Association and its predecessor, the National Ash Association (NAA), focusing on issues and events that were part of the beneficial use industry's defining years.*

By the close of the 1970s, coal ash was being beneficially used across a range of concrete and non-concrete applications in the U.S. This ASH Classic, from 1979, chronicles the formation of the NAA and its role in promoting education, standards, testing, and legislation to broaden the public's knowledge and acceptance of coal ash's varied uses.

ASH AT WORK

PUBLISHED BY NATIONAL ASH ASSOCIATION, 1819 H STREET NW, WASHINGTON, D.C. 20006

Printed on recycled paper.

Vol. XI | 1979 | No. 1

It's Not Too Late!

Act now! March 16 is the deadline for responding to the hazardous waste legislation proposed under the Resource Conservation & Recovery Act (RCRA).

The ash industry feels it was the intent of Congress to regulate discarded and/or contaminated industrial wastes and not recyclable natural resources such as power plant ash. As now written the regs would classify ash as being "guilty by association."

Most coal ashes being used today in a variety of environmentally sound applications pose no threat to human health and yet, by definition, they may become "hazardous wastes."

Key provisions are the development of criteria to determine which wastes are "hazardous," institution of a transport tracking system, and establishment of a permit system for treatment, storage, and disposal facilities.

First, some ash technologists feel the Extraction Procedure (EP) and Structural Integrity Test (SIT) tests are unrealistic for determining "hazardous" status. A longer time frame for implementation could result in finding a more reliable method.

Disposal regs will eliminate many reuses because a producer will no longer be able to stockpile ash. This will preclude the use of ash in large tonnage construction applications where the

(See NOT TOO LATE, Page 4)

Symposium Registration Exceeds 300

ATLANTA, GA—More than 300 have pre-registered for the Fifth International Ash Utilization Symposium opening here on February 25, according to Co-Chairman John H. Faber. Overall attendance is expected to reach 400-500, he added.

The two-day program, covering a wide-range of topics on ash technology, is being held at the Atlanta Hilton.

Twenty-five percent of the 71 papers to be presented at the symposium will document ash applications in nine foreign countries. These nations include the United Kingdom, Australia, Canada, India, Belgium, Saskatchewan, Yugoslavia, Romania, and the U.S.S.R.

A special feature of the ash conference will be two luncheon programs whose speakers will address topics of extreme importance to attendees—liability and resource recovery.

The two speakers are George P. Graves of American Alloy Steel, Inc. and Ms. Penelope Hansen of the Environmental Protection Agency. Graves' will discuss "Ash Liability in Cement Replacement" and Ms. Hansen will review "Guidelines for Government Procurement of Waste By-Products."

Graves has been involved in the field of ash handling for 10 years in Georgia, Colorado, Iowa, Mississippi, North Carolina, and Kansas. The EPA official is actively engaged in developing an awareness program within the Federal


Ms. Hansen


Mr. Graves

government on the use potential of various industrial by-products including power plant ash.

Also, two papers touching on environmental considerations will be presented by Dennis L. Kinder of American Electric Power Service Corporation and Bruce Boggs of AMAX Resource Recovery Systems, Inc.

Kinder, who is a member of the Utility Solid Waste Activities Group (USWAG), will review the impact of proposed RCRA Regulations on the ash industry and Boggs will cover the environmental aspects of ash disposal.

The NAA director stated the proposed new regs represent the most challenging crisis that has ever faced the ash industry.

"We must prevent an overkill by the environmentalists," Faber asserted. "We need to continue our clean-up efforts, but let's do so from a position of reason and knowledge," he added.

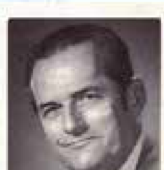
(See SYMPOSIUM, Page 4)

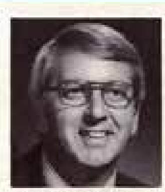
Session Chairmen


Allan W. Babcock, *Session A*


Ronald E. Morrison, *Session B*


Robert J. Collins, *Session C*


Robert J. Morrison, *Session D*


William E. Morton, *Session E*


John P. Capp, *Session F*

Faber, NAA Complete 10th Full Year of Service

WASHINGTON, DC—Early next month, on March 8 to be exact, the National Ash Association will conclude its 11th year of operation and 10th full year of service.

It is particularly relevant to note the anniversary on the eve of the Fifth International Ash Utilization Symposium in Atlanta as the trade association was the outgrowth of discussions at the first technical symposium held in Pittsburgh in March, 1967.

Additionally, no resume of NAA activities would be complete without incorporating the role of its only director—John H. Faber. Big John, as he is affectionately called by his associates, joined the association in May, 1968 and has been responsible for its day-to-day activities ever since. In fact, you might say he has devoted every waking moment to its activities.

The first steps toward the formation of the National Ash Association took place immediately following the Symposium. Early prime movers in this effort were Dr. Harry Perry of the U.S. Bureau of Mines, Leonard Bradley of the National Coal Association, Herbert Cohen of American Electric Power Co., James Williamson of Dayton Power & Light Co. (then serving as chairman of EEI's Prime Movers' Fuel and Ash Handling Sub Committee.) Ronald E. Morrison of American Electric Power Co., and Gerard C. Gambs of Consolidation Coal Company.

... has done a tremendous job ...

More than 50 representatives of coal companies, electric utilities, and railroads attended the organizational meeting in October 1967.

Gambs, now affiliated with Ford, Bacon & Davis in an executive capacity, recollected that "John came into the organization and got it started under most difficult circumstances and has just done a tremendous job of promoting ash utilization in this country."

"The very fact that most states have now adopted ash specification standards is one measure of the effectiveness of NAA's program," he added. Gambs related that back in 1968, Alabama was the only state that "permitted its use or had even given it serious consideration."

The spokesman further opined Faber's leadership in staging technical conferences throughout the world has given added stature to the organization.

The Association was incorporated here on March 8, 1968. The first meetings establishing the NAA followed in April.

Faber was named Executive Director and joined the team in May. His work in staging the aforementioned symposium was largely instrumental in his selection over the other candidates.

One of the primary objectives of the NAA was, and still is, to spread "the word" on how these coal by-products can be effectively blended with or substituted for conventional aggregates in many building components and construction applications.

"Although some may disagree, I think we have been moderately successful in promoting the expanded use and acceptance of coal ashes," Faber asserted.

The NAA executive, who refers to himself as a "plain old country boy," has steadfastly opposed the use of "gimmicks" in advertising and promotion. "We feel the benefits of our products are genuine and that we can back them up technologically; and if the use has not been proven, we will not promote it," Faber related.

In fact, the willingness of the National Ash Association to share its technology with others has probably contributed to the lack of financial support from potential dues paying members.

Many firms, who could well afford to become affiliated with the association have free loaded on the NAA by attending seminars and meetings and contacting individual members to solicit research data and hard won experience; many times, without so much as a thank you. Other unscrupulous individuals have garnered information the same way and sold if for a profit.

And, conversely, many non-members have shared their test results and expertise in ash utilization with the rest of the world through the National Ash Association.

John Tillinghast, Vice Chairman-Research for American Electric Power Company and the first president of the NAA, stated unhesitantly "We picked the right man in Faber to get the organization moving."

"The National Ash Association, under John's direction, has created a public awareness of ash that has materially increased its use and acceptance," Tillinghast added.

... we picked the right man ...

Always maintaining a low profile, Faber has quietly convinced researchers in the academic, private and governmental sector the physical and chemical properties of these coal by-products merited a closer examination. Today, ash has been accepted as a construction material by the U.S. Department of Transportation for highway and airport construction. Most state highway departments have also incorporated ash in their specification handbooks.

The NAA executive is a trusted and active member of many American Society for Testing and Materials (ASTM) and Transportation Research Board committees. He is often called upon to review technical proposals prior to their approval for Federal funding.

As a result the association has been established and recognized as the leading exponent of ash technology. Users and producers alike keep the NAA phone huming in their search for information.

If reason prevails in the final enactment of RCRA regulations by the Environmental Protection Agency it would appear that interest in the recycling of coal ash will continue to increase. And much of the credit for laying the foundation for this belief has to be given to Mr. Ash—John Henry Faber.

Resume of Major NAA Activities, 1968-1978

Listed below are some of the major activities of the NAA over the past decade:

1968

Opened office and headquarters.

Hired assistant director;

Initiated advertising program;

Sponsored field demonstration at fly ash brick pilot plant at West Virginia University.

Participated in UN sponsored meeting in Prague, Czechoslavakia on ash utilization;

1969

Paper on fly ash mineral wool research presented at AIME Annual meeting in Washington;

Published first edition of newsletter, ASH AT WORK; NAA President discussed "Role of National Ash Association in the Ash Utilization Industry" before American Power Conference;

1970

Co-sponsored Second General Conference on Ash Utilization in Pittsburgh;

In co-operation with CEGB sponsored a tour to United Kingdom and France to study ash utilization programs, projects, and utilization.

Conducted first regional seminar on ash utilization in St. Louis;

Staff members elected to ASTM committees at latter's annual meeting;

Underwriters' Laboratories, Inc approved results of fire endurance tests on concrete blocks with fly ash lighweight aggregate sponsored by the NAA.

Participated in UN meeting of ash experts in Ankara, Turkey. Faber chaired opening session.

Held First Annual Technical Meeting.

1971

Sponsored tour of gas concrete manufacturing facilities and construction projects in England, Germany, and Denmark;

Conducted tours of lightweight aggregate plants in Virginia and North Carolina;

Held regional seminar in Buffalo, NY;

Co-sponsored conference on lignite fly ash utilization with North Dakota Highway Department and ND's College of Engineering;

Addressed 24th Annual Short Course of the Midwest Ready Mixed Concrete Association on "Effective Uses of Fly Ash."

Conducted Second Annual Technical Meeting.

Initiated publication of a series of Technical Bulletins;

1972

Participated in demonstration project using fly ash-sulfate sludge basemix at a parking area at Dulles Airport for Transpo-'72.

Presented papers at roadbuilding seminars at Toledo, OH and Springfield, ILL.

Conducted Third Annual Technical Meeting.

Participated in demonstration sanitary landfill project at Morgantown, WV to evaluate effectiveness of fly ash in solid waste disposal;

1973

Co-sponsored Third International Ash Utilization Symposium at Pittsburgh, PA.;

Served as panelist at first progress review of the Federally Coordinated Program of Research & Development in Highway Transportation in San Francisco and at Electrical World's Management Conference on Waste Disposal in Chicago;

Cooperated with Iowa State University's Engineering Research Institute on a soil stabilization project in Linn County, Iowa;

Held Fourth Annual Technical Meeting at Toronto, Ontario, Canada;

Published a technical publication on "Lime-Fly Ash-Aggregate Mixtures in Pavement Construction."

1974

Federal Highway Administration and Federal Aviation Administration approved specifications for use of fly ash in Portland cement concrete and in base course construction culminating years of work by NAA in contacts and research with DOT staff members;

Assisted in preparation of legislation adopted by Maryland General Assembly classifying fly ash as a natural resource;

Joined with EEI in compilation of Ash Collection and Utilization Report for 1973.

Held Fifth Annual Technical Meeting in St. Louis, MO.;

Sponsored display booth and presented technical paper at first Coal and The Environment Conference in Louisville, KY.;

1975

Conducted tour of United Kingdom in cooperation with CEGB to view large tonnage applications of fly ash;

Received 100% response from State Highway departments on determine how extensively ash is being utilized in maintenance and construction programs.

Published 72-page Design Guide for use of fly ash basemixes in highway construction;

1976

Co-sponsored Fourth International Ash Utilization Symposium at St. Louis, MO.;

Participated in joint US/USSR Symposium and presented paper on ash utilization held in Russia;

Held Sixth Annual Technical Meeting at Washington, DC, FHWA released copies of bulletin titled "Fly Ash-A Highway Construction Material."

1977

Co-sponsored a short course on "Technology and Utilization of Power Plant Ash" at West Virginia University—a first for the industry.

Honored C. E. (Sam) Lovewell as the first recipient of the NAA's Award of Merit for his contributions to the ash industry.

Held Seventh Annual Technical Meeting in Kansas City, Mo. Session devoted to "Western Coal Ash: Past, Present & Future."

1978

Co-sponsored repeat session of an Ash Short Course at West Virginia University.

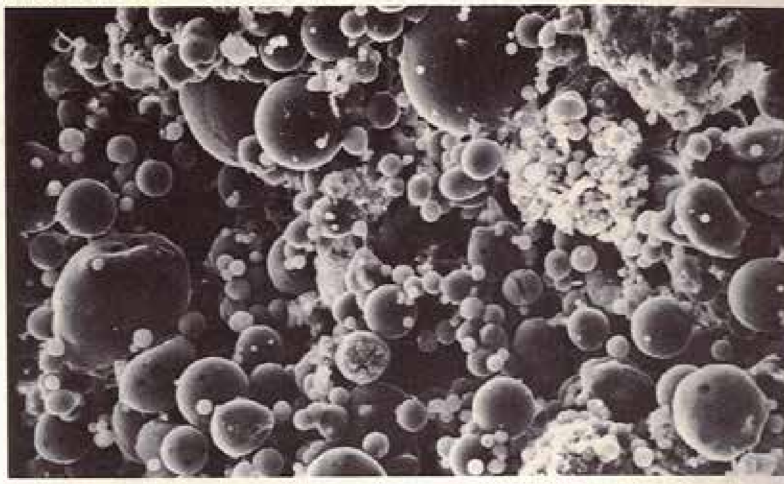
Co-sponsored an Ash Management Conference on the campus of Texas A. & M. University;

Co-sponsored an Ash Technology Exchange Congress at London, England;

Co-sponsored an Ash Short Course at Arizona State University in Tempe, Az.

How PFA Makes A Good Concrete Mix

By David Weeks



LONDON—Under the microscope pulverised fuel ash looks like a close-up of a bubble bath. And that's where the key to its successful use in concrete lies.

The Central Electricity Generating Board's experts have found that the spherical shape of the particles plays a big part in the quality of the concrete.

"It's a bit like throwing ball bearings on to a crowded dance floor," said Don Blackie—a civil engineer who has spent years analysing concrete and cement.

"The spherical particles give the mix mobility—something that is normally achieved by adding water."

When PFA is used the amount of water can be greatly reduced. This in turn reduces shrinkage and creep—two unwelcome deficiencies which occur in floors and granolithic surfaces when concrete sets.

The improvement in the size and shape of PFA molecules has come about recently through improved coal grinding mills and furnaces of higher thermal efficiency.

Better techniques have also been found for selecting ash for concrete from precipitators—the devices which catch the ash before it goes up the chimney.

The ash is as fine as household dust—the particles measure only 0.04 millimetres across.

It costs about 3 pound a ton and when added to concrete cuts down on the amount of cement needed in the mix by 30 per cent.

That's where the money saving starts—cement works out at about 25 pound a ton.

The first large-scale use of ash was made by the Generation Division in a PFA concrete mix at Littlebrook D—and it proved a big success.

"Littlebrook will always be an outstanding example because by using the ash to make a first-class concrete for the piles we saved 1.50 pound for every cubic yard. And the work was done in sulphate-bearing ground," said Don Blackie.

The success of the product has sent sales rocketing from about 500 tons a month in 1974 to 11,000 tons a month now.

"The qualities of PFA have been known since 1936 but it is only recently that we have come up with a quality assured product that is regularly available," said Don.

Concrete know-how

Twelve million tons of PFA are salvaged from coal-burning stations each year—but only a third of this meets the exacting standards which have been set up after years of research.

Blackie has been involved in concrete technology since Generation Division was formed and before that spent six years with the Cement and Concrete Research Association.

Now, along with ash marketing officers Bob Brown and Barry Cripwell from the North Eastern Region, Don is leading still deeper research into the behaviour of ash in concrete.

The Generation Division has already solved a major problem in the South Western Region when an alkali aggregate reaction was found in some concrete. This leads to the expansion and eventual break-up of even massive sections of concrete.

"The cement companies suggested we use a low alkali cement at a higher price but we have been able to show that a more effective way of dealing with the problem was to replace 30 per cent of the cement with PFA to stifle the reaction," explained Don.

Prices Secretary Roy Hattersley has urged the cement companies to get together with the CEGB to produce a blended product using PFA. This would save money and also a great deal of the energy used in making cement.

However, the Generation Division is convinced that the best economic benefit will be gained when the ash is blended on site.

About 60 per cent of all concrete used in Britain could readily contain PFA. And that could mean an income of 4,000,000 pound a year for what is basically a waste product.

(Courtesy Power News)

NOT TOO LATE

(Continued from Page 1)

material cannot be supplied on an as produced basis. Likewise, land farming interpretations would prevent the use of ash as a soil amendment.

Additionally, regulatory costs and administrative burdens imposed by the new RCRA regs will discourage producer interest in recycling these coal by-products. Also, individuals, private industry, and local governments will avoid any items carrying the "hazardous waste" label even if the application is termed environmentally safe.

Comments received prior to the promulgation of the regs will be considered. The last of five scheduled public hearings are set for March 7-9 in Denver, CO and March 12-14 in San Francisco, CA.

Contact the Office of Solid Waste, U.S. Environmental Protection Agency, Washington, D.C. 20460.

SYMPOSIUM

(Continued from Page 1)

The program has been split into six (6) different sessions including two concurrent meetings on Monday afternoon and three all-day panels on Tuesday.

This means an individual will have to pick and choose the sessions he wishes to attend, Faber noted. "However, all papers will be incorporated in the proceedings to be published by the Department of Energy," he stated.

William T. Wertman of the DOE's Morgantown Energy Research Center is serving as co-chairman for the symposium and will address the opening session.

Welcome, New ACAA Members!

BEUMER Corporation provides enclosed conveying systems to transport coal combustion products to landfills or to loadout facilities. The company has provided pipe conveyors to Louisville Gas & Electric to move coal combustion residuals constituents from the power plant to the landfill. They join as an Associate Member. Please visit **www.beumergroup.com** for more information.

CCR Strategies & Solutions, LLC

CCR Strategies & Solutions, LLC is a consulting business developed to assist companies in their efforts to manage and market coal combustion residuals materials. The company joins as an Associate Member. Please contact Dave Bristow at **brisdwb16@comcast.net** for more information.

Emilcott has been providing a wide range of environmental, health, and safety support to the utilities sector for over 30 years. The company has conducted multiple exposure assessments, audited existing industrial hygiene practices, and is working with industry partners to ensure that work being conducted on coal ash basins is done safely. Emilcott's expertise in industrial hygiene, air monitoring, and health & safety—and its experience in the utility, environmental, and construction industries—make it the ideal partner for health & safety support in the industry. They join as an Associate Member. Please visit **www.emilcott.com** for more information.

Ad Index

2020 ACAA Educational Foundation Scholarship Winners Selected

The American Coal Ash Association Educational Foundation (ACAAEF) awarded 13 scholarships to graduate and undergraduate students with interest in the management and beneficial use of coal combustion products. The cash awards ranged from $1,500 to $5,000 and went to applicants representing a wide variety of fields of study, including civil engineering, material science, environmental engineering, and public policy.

Students receiving scholarships included Amanda Basantis of the University of Virginia; Daniel Benkeser of the Georgia Institute of Technology; Mohammed Dardona of Wayne State University; Farzaneh Elyasigorji of the University of Wisconsin – Milwaukee; Eberechi Ichi of the University of North Dakota; Engy Khoshit of Drexel University; Zhipeng Li of Washington State University; Ifeanyi Mbah of Tufts University; Dimitrios Porter of Wayne State University; Sivakumar Ramanathan of the University of Miami; Pravin Saraswatula of Texas A&M University; Casey Sundberg of Michigan Technological University; and Ying Wang of the University of Miami.

A record number of scholarship applications were processed this year by ACAA Member Liaison Alyssa Barto and distributed to volunteer scholarship judges for evaluation. Each application was reviewed and rated by multiple judges to assess the course work, grades, recommendations, career goals, and essays of each applicant. ACAA thanks the following member volunteers for participating in the evaluation process: Travis Collins, National Minerals, Chair, Scholarship Evaluation Committee; Glen Amey, Charah Solutions; Mindy Dalton, Boral Resources; Tristana Duvallet, University of Kentucky; Gary Lee, Southern Company; Jennifer Rafferty, Titan America; Peggy Rennick, Charah Solutions; Mark Rokoff, AECOM; Michael Schantz, Lhoist North America; and John Trast, GEI Consultants.

ACAAEF was established by the American Coal Ash Association to promote understanding of the management and beneficial use of coal combustion products through scholarship awards, development and distribution of educational materials, supporting targeted research, and sponsorship of educational forums. The ACAAEF Board of Directors includes Kenny Tapp, LG&E and KU Energy, Chair; Thomas Adams, ACAA, President; Travis Collins, National Minerals, Secretary/Treasurer; and directors-at-large Ivan Diaz, Boral Resources; Dale Diulus, Salt River Materials; and Michael Schantz, Lhoist.

$5000 David C. Goss Scholarship Winners

Farzaneh Elyasigorji, University of Wisconsin – Milwaukee

Essay: "Use of Flue Fas Desulfurization (FGD) Gypsum for Production of Fire-Resistant Polymeric Materials"

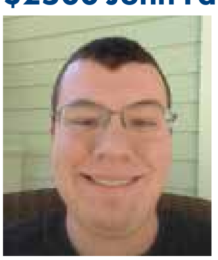
Abstract: Thermoset and thermoplastic polymeric materials are widely used in a number of applications, such as aircraft, automobiles, toys, appliances, clothing, packaging, medicine, engineering, etc. High-performance polymeric materials have many benefits in these applications, but they are at increased risk of fire because of their flammability and emission of toxic gases. Therefore, assessment of low-cost and effective fire-resistant additives for a variety of polymeric applications is highly demanded. This research aims to explore the potential utilization of flue gas desulfurization (FGD) gypsum as filler within polymeric materials for production of fire-resistant thermoset and thermoplastic materials.

Zhipeng Li, Washington State University

Essay: "Developing Novel Steel Tube Concrete Using Expansive Geopolymer Binder Based on Coal Fly Ash and Nanomaterial"

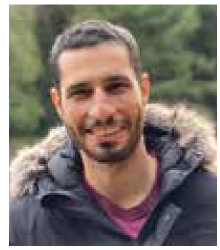
Abstract: A novel steel tube concrete will be developed by employing the nano-enhanced and expansive fly ash-based geopolymer as the sole binder. This upcycling application in structural concrete not only diverts coal fly ash from the waste stream, but also reduces the demand for portland cement, which has a large footprint (CO2 emission, energy consumption, etc.). A nanomaterial (graphene oxide) is introduced into the alkali-sulfate-activated fly ash to engineer an expansive geopolymer binder that bonds well with steel. Then a novel steel tube concrete with high bearing capacity will be developed using this fly ash-based binder, which generates strong self-stress under the surrounding constraint.

$2500 John Faber Scholarship Winners



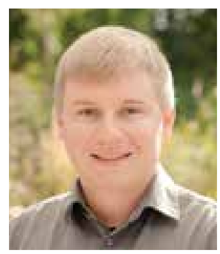
Daniel Benkeser, Georgia Institute of Technology

Abstract: With increasing reliance on natural gas and renewable energy, the U.S. supply of the coal combustion product (CCP) fly ash is dropping. For decades, fly ash has been a highly desired supplementary cementitious material (SCM) used in concrete to improve its workability, strength, and durability and contribute to its sustainability (via cement replacement and enhanced service life). At the same time, increasing regulation of CCPs stored in ash ponds or landfills prompts re-examination of the reuse options for these materials. In ongoing research at Georgia Tech, the reactivity of the stored ash (13 samples from southeast power plants) has been measured through standard and emerging test methods and benchmarked against ASTM standards for fly ash. Test methods confirm that the majority of these ashes meet standards for physical, chemical, and mechanical characteristics, suggesting that—despite spending decades in wet storage—they can be used successfully in concrete. The main issues encountered with these ashes include loss on ignition that exceeds the 6% limit, large particle size distribution, failure to meet Strength Activity Index, and variation in composition, primarily associated with comingling with bottom ash, clay, and gypsum. Our research has shown that often these can be compensated for with low-cost beneficiation (e.g., sieving, grinding) or selective reclamation. In a preliminary study, we have also demonstrated that chemo-mechanical activation of fly ash can increase amorphous content by 5% to 36%, providing a novel means for increasing reactivity of marginal ash sources. If these processes are used on these ash sources, then a large quantity of these ponded ashes can be marketed as SCMs, thus compensating for the decreasing domestic supply of fly ash.



Mohammed Dardona, Wayne State University

Abstract: Fly ash is the byproduct of coal combustion and it has been used in construction; however, more than 40% of it is being dumped in landfills. My research is focused on taking advantage of valuable elements existing in fly ash called rare earth elements (REEs). According to the Department of Energy, these elements play a critical role in U.S. national security due to the fact that the U.S. relies on foreign resources to provide REEs. This research aims to investigate, evaluate, and propose a process to extract these elements from fly ash, taking environmental and economic aspects into consideration.



Casey Sundberg, Michigan Technological University

Abstract: Coal combustion products (CCPs) have the potential to provide many benefits to the concrete production industry, even beyond those currently garnered. Portland cement concrete (PCC) is the most widely produced man-made material in the world and is the most commonly used building material, affecting all of society. Although PCC is a proven building material, there are some applications in which its properties have been shown to lead to catastrophic failure. This is particularly true in high-temperature applications, as demonstrated by disasters such as the Fukushima Daiichi nuclear disaster and the Atlanta I-85 bridge collapse. High-temperature failures in PCC are primarily due to portland cement dehydrating and decomposing when overexposed to high temperatures, since it requires hydration products to maintain a stable microstructure. This is one area where the use of CCP-based materials, including fly ash-based alkali-activated materials (AAMs), can provide a measured benefit by increasing performance and safety. Low-calcium AAMs, such as those based on Class F fly ash precursors, do not require hydration reactions and associated hydrated reaction products to maintain the bulk of their structural integrity, so they are not as susceptible to degradation at high temperatures as PCC. AAMs can be used as a replacement binder directly in place of portland cement-based binders in concrete and can provide additional benefits beyond high-temperature resistance, such as improved immobilization of contaminants and hazardous radioactive materials. Although fly ash-based AAMs provide a measured benefit over PCC in many high-temperature applications, there is still room for improvement. Methods can be developed to increase the plasticity and decrease the compressive strength losses in these AAMs when exposed to high temperatures, leading to an increase in safety and adaptation of this material.

Ying Wang, University of Miami

Essay: "An Improved Strength Activity Index Test for Fly Ash"

Abstract: ASTM C618 and AASHTO M295, both coal fly ash specifications in the United States, use the Strength Activity Index (SAI) to differentiate reactive and inert materials. The SAI is an indirect measure, a poor way to measure reactivity, and often shows false positives. If beneficiated fly ashes, and fly ashes coming from landfills and ponds, are to be used with confidence, then the SAI test must be improved. In this document, strategies for the improvement of the SAI test, including testing at high replacement levels, testing at higher temperature, and the use of bulk resistivity, are explored. It is anticipated that an improved SAI test can lead to a greater use of unconventional fly ashes.

$1500 ACAA Educational Foundation Scholarship Winners

Amanda Basantis, University of Virginia

Essay: "Promoting or Enhancing the Sustainable and Environmentally Responsible Utilization of CCPs"

Eberechi Ichi, University of North Dakota

Essay: "The Multi-Varied Economical, Sustainable, and Environmental Roles and Impacts of Coal Combustion Products (CCPs)"

Engy Khoshit, Drexel University

Essay [untitled] investigating the use of sodium hydroxide solvent with bottom ash and off-spec fly ash to create aggregates for use on a large scale, cutting costs for construction and reducing waste

Ifeanyi Mbah, Tufts University

Essay [untitled] proposing the use of coal ash as a component of a synthetic lightweight aggregate

Dimitrios Porter, Wayne State University

Essay: "Sequential Processing of CFA"

Sivakumar Ramanathan, University of Miami

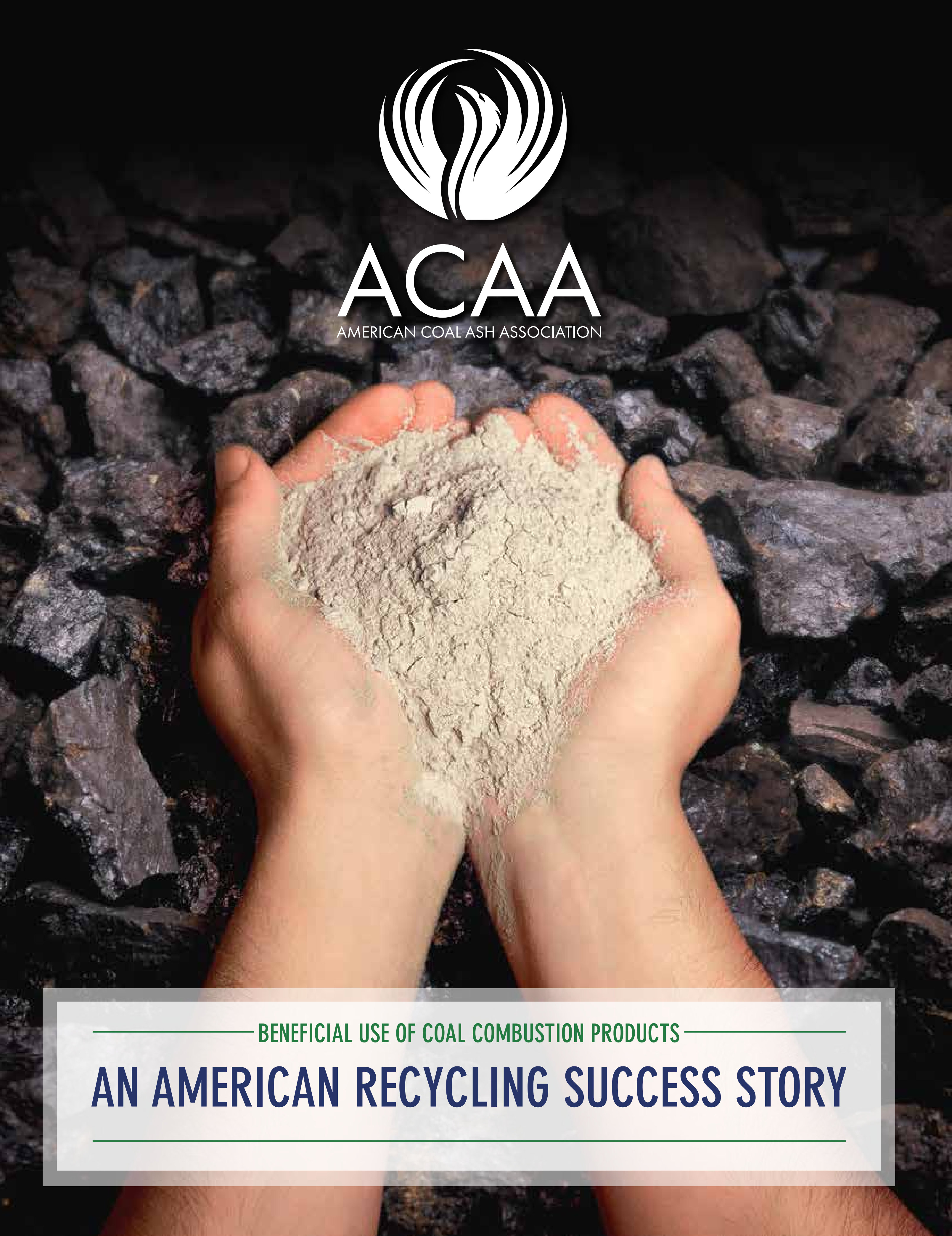
Essay: "Reactivity and Synergies in Blended Fly Ashes"

Pravin Saraswatula, Texas A&M University

Essay: "Linking Pore Solution Chemistry of Concrete with CCPs to ASR Potential Through Machine Learning as a Performance-Based Approach"

2021 Application Deadline Announced

The ACAAEF has announced the schedule for its 2021 scholarship program. The deadline for submittal of applications is **May 7, 2021**, with the announcement of awards scheduled for July 1. Information on the application process will be posted on the ACAA website, **www.acaa-usa.org**, by February 5.



ACAA

AMERICAN COAL ASH ASSOCIATION

BENEFICIAL USE OF COAL COMBUSTION PRODUCTS

AN AMERICAN RECYCLING SUCCESS STORY

ACAA

AMERICAN COAL ASH ASSOCIATION

The American Coal Ash Association *was established in 1968 as a trade organization devoted to recycling the materials created when we burn coal to generate electricity. Our members comprise the world's foremost experts on coal ash (fly ash and bottom ash), and boiler slag, flue gas desulfurization gypsum or "synthetic" gypsum, and other "FGD" materials captured by emissions controls. While other organizations focus on disposal issues, ACAA's mission is to advance the management and use of coal combustion products in ways that are: environmentally responsible; technically sound; commercially competitive; and supportive of a sustainable global community.*

AN AMERICAN RECYCLING SUCCESS STORY

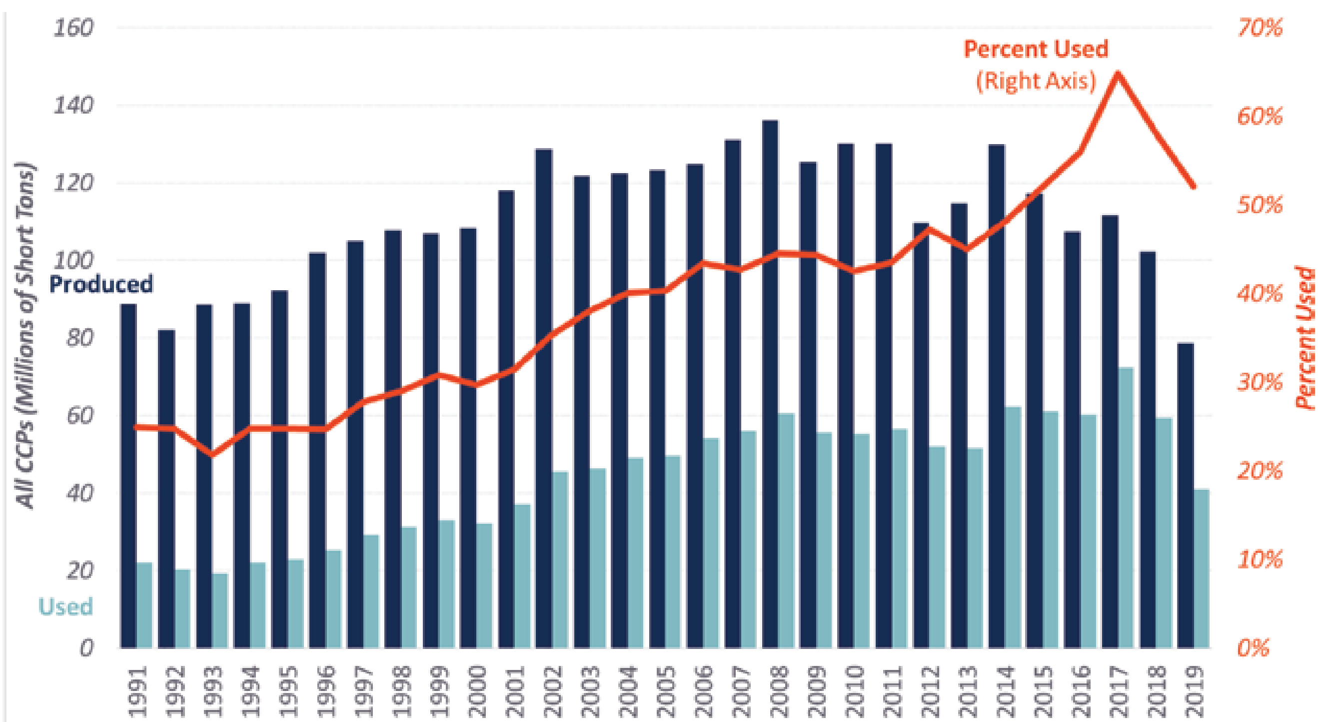
Coal combustion products – often referred to as "coal ash"– are solid materials produced when coal is burned to generate electricity. There are many good reasons to view coal ash as a resource, rather than a waste. Using it conserves natural resources and saves energy. In many cases, products made with coal ash perform better than products made without it.

As coal continues to produce approximately one-third of the electricity generation in the United States, significant volumes of coal ash are produced. Since 1968, the American Coal Ash Association has tracked the production and use of all types of coal ash. These surveys are intended to show broad utilization patterns and ACAA's data have been accepted by industry and numerous government agencies as the best available metrics of beneficial use practices.

Fifty-two percent of the coal ash produced during 2019 was recycled—marking the fifth consecutive year that more than half of the coal ash produced in the United States was beneficially used rather than disposed.

The volume of fly ash used in concrete increased 1 percent over the previous year, but most other uses saw significant declines, leading to an overall decrease in recycling activity of 31 percent. Concrete producers and consumers indicated a desire to use more fly ash, but several regional markets were affected by shifting supply dynamics associated with closures of coal-fueled power plants.

All CCPs Production and Use with Percent



ACAA
AMERICAN COAL ASH ASSOCIATION

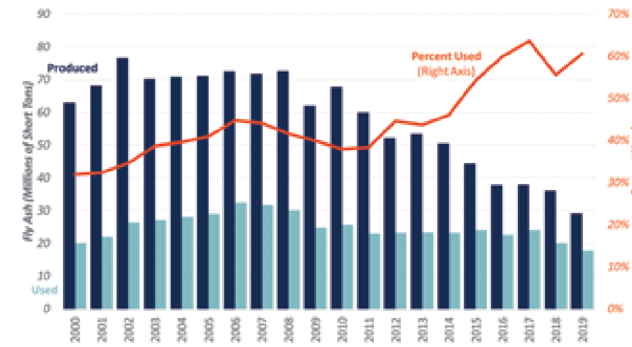
Fly Ash

Fly ash is a powdery material that is captured by emissions control equipment before it can "fly" up the stack. Mostly comprised of silicas, aluminas and calcium compounds, fly ash has mechanical and chemical properties that make it a valuable ingredient in a wide range of concrete products. Roads, bridges, buildings, concrete blocks and other concrete products commonly contain fly ash.

Concrete made with coal fly ash is stronger and more durable than concrete made with cement alone. By reducing the amount of manufactured cement needed to produce concrete, fly ash accounts for approximately 12 million tons of greenhouse gas emissions reductions each year.

Other major uses for fly ash include constructing structural fills and embankments, waste stabilization and solidification, mine reclamation, and use as raw feed in cement manufacturing.

Fly Ash Production & Use 2000 – 2019



Fly ash ranges in color from gray to buff depending on the type of coal.

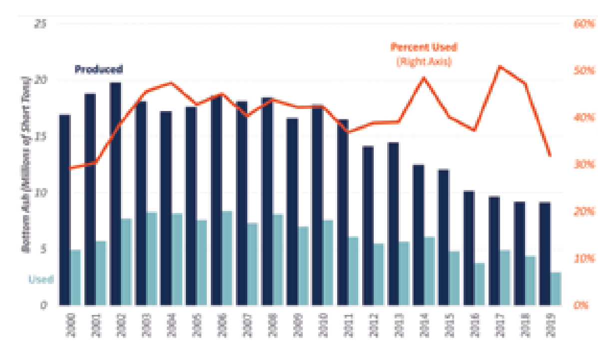
The American Road & Transportation Builders Association estimates coal fly ash use in roads and bridges saves $5.2 billion per year in U.S. construction costs.

Bottom Ash

Bottom ash is a heavier, granular material that is collected from the "bottom" of coal-fueled boilers. Bottom ash is often used as an aggregate, replacing sand and gravel. Bottom ash is often used as an ingredient in manufacturing concrete blocks.

Other major uses for bottom ash include constructing structural fills and embankments, mine reclamation, and use as raw feed in cement manufacturing.

Bottom Ash Production & Use 2000 – 2019



Bottom ash can be used in asphalt paving.

Bottom ash is a granular material suitable for replacing gravel and sand.

Synthetic Gypsum

Power plants equipped with flue gas desulphurization ("FGD") emissions controls, also known as "scrubbers," create byproducts that include synthetic gypsum. Although this material is not technically "ash" because it is not present in the coal, it is managed and regulated as a coal combustion product.

Scrubbers utilize high-calcium sorbents, such as lime or limestone, to absorb sulfur and other elements from flue gases. Depending on the scrubber configuration, the byproducts vary in consistency from wet sludge to dry powdered material.

Synthetic gypsum is used extensively in the manufacturing of wallboard. A rapidly growing use of synthetic gypsum is in agriculture, where it is used to improve soil conditions and prevent runoff of fertilizers and pesticides.

Other major uses for synthetic gypsum include waste stabilization, mine reclamation, and cement manufacturing.

Synthetic Gypsum Production & Use 2002 – 2019

Synthetic gypsum is often more pure than naturally mined gypsum.

More than half of the gypsum wallboard manufactured in the United States utilizes synthetic gypsum from coal-fueled power plants.

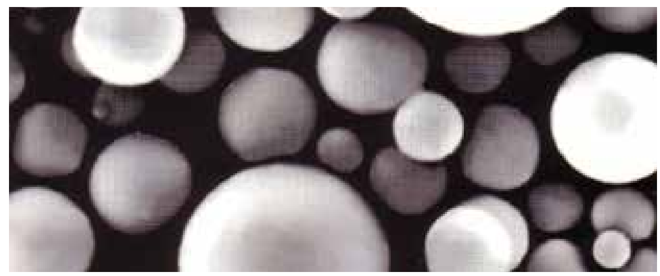
Synthetic gypsum applied to farm fields improves soil quality and performance.

Other Products and Uses

Boiler Slag – is a molten ash collected at the base of older generation boilers that is quenched with water and shatters into black, angular particles having a smooth, glassy appearance. Boiler slag is in high demand for beneficial use as blasting grit and roofing granules, but supplies are decreasing because of the retirement from service of older power plants that produce boiler slag.

Nearly 90 percent of all boiler slag is beneficially used.

Cenospheres – are harvested from fly ash and are comprised of microscopic hollow spheres. Cenospheres are strong and lightweight, making them useful as fillers in a wide variety of materials including concrete, paint, plastics and metal composites.



Because of their high value, cenospheres – seen here in a microscopic view – are measured by the pound rather than by the ton.

FBC Ash – is a category of ash from Fluidized Bed Combustion power plants. These plants reclaim waste coal for fuel and create an ash by-product that is most commonly used to reclaim abandoned surface mines and abate acid mine drainage. Ash from FBC power plants can also be used for waste and soil stabilization.

This regional park was constructed with FBC ash on the site of a former waste coal pile.

New Uses on Horizon

New beneficial uses for coal ash are continually under development. Researchers and ash marketers are currently focusing heavily on the potential for harvesting ash that has already been disposed for potential beneficial use. There is also renewed interest in the potential for extracting strategic rare earth minerals from ash for use in electronics manufacturing.

ACAA
AMERICAN COAL ASH ASSOCIATION

American Coal Ash Association
38800 Country Club Drive
Farmington Hills, MI 48331
Email: info@acaa-usa.org
Phone: 720-870-7897
Fax: 720-870-7889
Internet: www.ACAA-USA.org

2019 Coal Combustion Product (CCP) Production & Use Survey Report

Beneficial Utilization versus Production Totals (Short Tons)

2019 CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Production / Utilization Totals
Total CCPs Produced by Category	**29,319,239**	**9,150,680**	**965,138**	**22,975,581**	**6,217,129**	**3,707,974**	**18,428**	**6,293,721**	**78,647,890**
Total CCPs Used by Category	**17,768,235**	**2,923,586**	**697,001**	**13,285,876**	**359,529**	**90,346**	**0**	**5,882,468**	**41,007,041**
1. Concrete/Concrete Products /Grout	12,604,878	332,036	0	95,090	0	10,300	0	0	13,042,304
2. Blended Cement/ Feed for Clinker	2,556,358	910,914	65,758	1,464,262	0	0	0	3,442	5,000,734
3. Flowable Fill	102,196	0	0	0	0	0	0	0	102,196
4. Structural Fills/Embankments	501,668	532,676	67,104	617,122	0	0	0	0	1,718,570
5. Road Base/Sub-base	154,822	105,869	0	0	0	0	0	0	260,690
6. Soil Modification/Stabilization	76,239	126,719	0	3,911	0	0	0	0	206,869
7. Mineral Filler in Asphalt	4,598	4,711	3,831	0	0	94	0	0	13,234
8. Snow and Ice Control	0	73,720	10,114	0	0	0	0	0	83,834
9. Blasting Grit/Roofing Granules	0	362,281	245,601	0	0	0	0	0	607,883
10. Mining Applications	17,282	0	0	0	0	0	0	5,831,652	5,848,935
11. Gypsum Panel Products (formerly Wallboard)	0	0	0	9,688,345	82,703	0	0	0	9,771,048
12. Waste Stabilization/Solidification	604,222	57,689	0	16,503	0	11,858	0	47,374	737,646
13. Agriculture	0	2,449	0	572,399	0	59,966	0	0	634,814
14. Aggregate	63,609	137	0	0	0	0	0	0	63,745
15. Oil/Gas Field Services	152,053	436	0	0	0	8,128	0	0	160,617
16. CCR Pond Closure Activities	720,411	357,558	304,592	713,573	276,826	0	0	0	2,372,960
17. Miscellaneous/Other	209,898	56,391	0	114,671	0	0	0	0	380,960

Summary Utilization to Production Rate

CCP Categories	Fly Ash	Bottom Ash	Boiler Slag	FGD Gypsum	FGD Material Wet Scrubbers	FGD Material Dry Scrubbers	FGD Other	FBC Ash	CCP Utilization Total
Totals by CCP Type/Application	17,768,235	2,923,586	697,001	13,285,876	359,529	90,346	0	5,882,468	**41,007,041**
Category Use to Production Rate (%)	**60.60%**	**31.95%**	**72.22%**	**57.83%**	**5.78%**	**2.44%**	**0.00%**	**93.47%**	**52.14%**
2019 Cenospheres Sold (Pounds)	943,603	Data in this survey represents 152 GW of Name Plate rating of the total industry wide approximate 236 GW capacity based on EIA's July 2019 Electric Power Monthly.							

2020 American Coal Ash Association Membership Directory

These listings are organized into the following five membership categories:

Utility · Marketer · Specialty Marketer · Associate · Individual

Utility

Ameren Missouri
11149 Lindbergh Business Ct.
Saint Louis, MO 63123

Spencer Evans
Phone: (636) 459-6682
E-mail: sevans2@ameren.com

American Electric Power
1 Riverside Plaza
Columbus, OH 43215

Jason Echelbarger
Reagent Procurement & CCP Marketing
Phone: (614) 716-6286
E-mail: jechelbarger@aep.com

Aurora Energy, LLC
100 Cushman St, Ste 210
Fairbanks, AK 99701

Rob Brown
President

Colorado Springs Utilities
703 Conejos Street
Colorado Springs, CO 80903

Brian Leach
Phone: (719) 668-8965
E-mail: bleach@csu.org

Colstrip Energy Limited Partnership
1087 W River St, #200
Boise, ID 83702

R. Lee Roberts
General Partner
Phone: (208) 344-3570
E-mail: viellevigne@aol.com

Dairyland Power Cooperative
3251 East Avenue South
La Crosse, WI 54601

David Lesky
Lead Chemist
Phone: (608) 787-1351
Fax: (608) 787-1490
E-mail: dle@dairynet.com

DTE Energy
Department: Corporate Fuel Supply Procure & Plan
435 General Offices
Detroit, MI 48226

Ryan Pratt
E-mail: Ryan.Pratt@dteenergy.com

Duke Energy Corporation
400 S. Tryon Street, Mail Code: ST05A
Charlotte, NC 28202

Julie Olivier
Director CCP
Phone: (980) 373-4045
E-mail: Julie.Olivier@duke-energy.com

Evergy
818 S Kansas Ave, 800-1N
Topeka, KS 66612

Dan Hartzell
Senior Fuels Analyst
Phone: (785) 575-1893
E-mail: dan.hartzell@WestarEnergy.com

FirstEnergy Corp
800 Cabin Hill Drive
Greensburg, PA 15601

Jeff Kapolka
Senior Environmental Specialist
Phone: (724) 838-6824
E-mail: jkapol1@firstenergycorp.com

Great River Energy
1531 E Century Ave, Ste 200
Bismarck, ND 58503

Al Christianson
Director, Business Development & Governmental Affairs
Phone: (701) 250-2164
Fax: (701) 442-7864
E-mail: achristianson@grenergy.com

Indianapolis Power & Light Company
One Monument Circle, Rm 771
Indianapolis, IN 46204-2936

Jack Critser
Field Rep/Transportation Coordinator
Phone: (317) 464-7436
E-mail: jack.critser@aes.com

Kansas City Board of Public Utilities
300 North 65th Street
Kansas City, KS 66102

Ingrid Setzler
Director Environmental Services
Phone: (913) 573-9806
Fax: (913) 573-9838
E-mail: isetzler@bpu.com

LG&E and KU Services Company
220 West Main St, 7th Floor
Louisville, KY 40202

Kody Maikranz
By-Product & Industrial Coal Coordinator
Phone: (502) 627-3669
E-mail: Kody.Maikranz@lge-ku.com

Muscatine Power & Water
3205 Cedar Street
Muscatine, IA 52761-2204

Jean Brewster
Environmental Affairs
Phone: (563) 262-3259
Fax: (563) 262-3315
E-mail: jbrewster@mpw.org

Nebraska Public Power District
402 E State Farm Road North
North Platte, NE 69101

Thomas Schroeder
Fossil Fuels Manager
Phone: (308) 535-5327
Fax: (308) 535-5333
E-mail: tjschro@nppd.com

NRG Energy, Inc.
804 Carnegie Center
Princeton, NJ 08540

Amanda Udicious
Manager - Coal, Transportation & CCRs
Phone: (609) 955-0016
E-mail: Amanda.Udicious@nrg.com

Prairie State Generating Company
3872 County Highway 12
Marissa, IL 62257
Phone: (618) 824-7600

Southern Company
600 18th St, N, Bin 14N-8162, POB 2641
Birmingham, AL 35203

Hollis Walker
CCP Manager
Phone: (205) 257-5311
Fax: (205) 257-5765
E-mail: hwwalker@southernco.com

Talen Power
1005 Brandon Shores Rd, FSRC 1st floor
Baltimore, MD 21226

Ann Couwenhoven
Sr. Engineer Manager - Combustion Materials
Phone: (410) 787 5113
E-mail: ann.couwenhoven@talenenergy.com

Tennessee Valley Authority
1101 Market St, LP 5G
Chattanooga, TN 37402

Tara Masterson
Supervisor, Beneficial Reuse & By-Product Utilization
Phone: (423) 751-3845
E-mail: tvmasterson@tva.gov

Tri-State Generation & Transmission
PO Box 33695
Denver, CO 80233

Jeff Lorimer
Fuel and Water Resources Engineer
Phone: (303) 254-8189
E-mail: JLorimer@tristategt.org

WEC Energies Group
333 W Everett St, A231
Milwaukee, WI 53203

Bob Meidl
Senior Engineer - CCP Group
Phone: (414) 221-2249
E-mail: bob.meidl@we-energies.com

Marketer

ASHCOR USA Inc
7006 Regents Park Blvd
Toledo, OH 43617

Keith Bargaheiser
Phone: (567) 408-4307
E-mail: Keith.Bargaheiser@atco.com

Boral Resources
10701 River Front Pkwy
South Jordan, UT 84065

Steve Benza
Vice President, Business Development
Phone: (610) 349-8188
Fax: (610) 838-7066
E-mail: sbenza@boral.com

Charah, Inc.
12601 Plantside Drive
Louisville, KY 40299

Peggy Rennick
Regional Sales Manager
Phone: (610) 659-7318
E-mail: prennick@charah.com

Kansas City Fly Ash LLC
15100 E Courtney Atherton Road
Sugar Creek, MO 64058

Jarrod Huntley
President
Phone: (816) 808-4512
Fax: (816) 257-7479
E-mail: jhuntley@eaglematerials.com

LafargeHolcim (Geocycle)
USA Office

Dave Diedrick
Phone: (248) 761-8871
E-mail: dave.diedrick@lafargeholcim.com

National Minerals Corporation
12271 Margo Ave.
Hastings, MN 55033

Travis Collins
Vice President
Phone: (651) 686-1000
E-mail: travis@nmcflyash.com

Nebraska Ash Company
1815 Y St, PO Box 80268
Lincoln, NE 68508

Dale Kisling
President
Phone: (402) 434-1777
Fax: (402) 434-1799
E-mail: dalek@nebraskaash.com

Salt River Materials Group
8800 E Chaparral Rd, Ste 155
Scottsdale, AZ 85250-2606

Dale Diulus, P.E.
Senior Vice President, Pozzolan
Phone: (480) 850-5757
Fax: (480) 850-5758
E-mail: ddiulus@srmaterials.com

Separation Technologies, LLC
101 Hampton Ave
Needham, MA 02494

Tom Cerullo
Vice President, General Manager
Phone: (781) 972-2309
Fax: (781) 455-6518
E-mail: tcerullo@titanamerica.com

The SEFA Group
217 Cedar Road
Lexington, SC 29073

Walter LeMaire
Executive Director, Business Development
Phone: (803) 520-9000
Fax: (803) 520-9001
E-mail: wlemaire@sefagroup.com

Waste Management
1766 Highway 92 South
Fayetteville, GA 30215-5825

Dale Davis
Strategic Business Director
Phone: (404) 803-8479
E-mail: ddavis14@wm.com

ZAG International
1350 Buccaneer Lane
Vero Beach, FL 32963

Bill Stanley
VP, North America Region
Phone: (630) 247-1929
E-mail: william@zaginternational.com

Specialty Marketer

Beneficial Reuse Management, LLC/Gypsoil
372 W Ontario St, Ste 501
Chicago, IL 60654

Robert Spoerri
President
Phone: (312) 784-0303
Fax: (312) 784-0310
E-mail: rspoerri@beneficialreuse.com

Sphere One, Inc.
601 Cumberland, Building 32
Chattanooga, TN 37404

Ryan Brownhill
General Manager
Phone: (423) 629-7160
Fax: (423) 678-0614
E-mail: rbrownhill@sphereone.net

U.S. Minerals
18635 West Creek Drive, Ste 2
Tinley Park, IL 60477

Jason Vukas
Vice President
Phone: (219) 864-0909
Fax: (219) 864-4675
E-mail: jvukas@us-minerals.com

USC Technologies, LLC
1300 NW Briarcliff Pkwy, Ste 250
Kansas City, MO 64150

Richie Benninghoven
President
Phone: (816) 595-3013
Fax: (816) 595-3015
E-mail: rcb@usckc.com

Associate

AECOM
1300 E 9th Street, Ste 500
Cleveland, OH 44114

Mark Rokoff
Vice President, Power Business Line
Phone: (216) 622-2429
Fax: (216) 622-2428
E-mail: mark.rokoff@aecom.com

APTIM
200 Horizon Center Blvd
Trenton, NJ 08691

Sid Archinal
Senior Operations Manager
Phone: (609) 588-6305
Fax: (609) 588-6399
E-mail: sid.archinal@aptim.com

ASH Mineral Solutions
4501 Ludwig Road
Murrysville, PA 15668

Andrew Hicks, Ph.D.
Sole Proprietor
Phone: (423) 534-2802
E-mail: ash.mineral@gmail.com

Beneficiate: North America, LLC
10 South Chenango Street
Greene, NY 13778

Keith Day
President
Phone: (607) 372-4797
E-mail: keith@bnamerica.com

BEUMER Corporation
7300 W 110th St, Ste 530
Overland Park, KS 66210

Richard Munson
Phone: (913) 217-5699
E-mail: ri.mu@beumer.com

CALM Initiative
723 Woodlily Drive
Belmont, NC 28012

Christopher Hardin
Managing Director
Phone: (704) 687-0948
E-mail: chardin@energyenviro.org

CCR Strategies & Solutions, LLC
12123 Branch Overlook Drive
Manakin Sabot, VA 22103

David Bristow
Managing Director
Phone: (804) 316-7604
E-mail: brisdwb16@comcast.net

Cementitious Solutions LLC
125 H V Chandler Road
Chandler, GA 30628

Jeff Fair
Owner
Phone: (610) 751-7367
E-mail: jeff@cementitioussolutions.com

Certainteed Gypsum
12950 Worldgate Dr, Ste 700
Herndon, VA 20170

Scott Walton
Director EHS
Phone: (859) 512-6495
E-mail: scott.walton@saint-gobain.com

Civil & Environmental Consultants, Inc.
5899 Montclair Blvd
Cincinnati, OH 45150-3067

Anthony Amicon
Vice Principal
Phone: (800) 759-5614
E-mail: tamicon@cecinc.com

DustMaster Enviro Systems
190 Simmons Ave, POB 10
Pewaukee, WI 53072

Scott Adams
Product Manager
Phone: (262) 691-3100
Fax: (262) 691-3184
E-mail: scotta@dustmaster.com

Emilcott Associates, Inc.
301 McCullough Dr, Ste 400
Charlotte, NC 28262

Danaila Paspalanova
Senior Vice President
Phone: (917) 376-6271
E-mail: dpaspalanova@emilcott.com

EnCAP-IT
PO Box 4560
Glen Allen, VA 23058

John Swenson
Managing Partner
Phone: (804) 447-8498
Fax: (804) 804-5151
E-mail: john@mseberms.com

Environmental Specialties International, Inc.
7943 Pecue Ln, Ste A
Baton Rouge, LA 70809

Carolyn Johnson
Southeast Regional Business Development Manager
Phone: (225) 291-2700
E-mail: cjohnson@esiliners.com

FeX, LLC
200 Corporate Drive, Suite 330
Coraopolis, PA 15108

Doug Schaefer
Vice President and CFO
Phone: (412) 604-0403
E-mail: dschaefer@fexgroup.com

FirmoGraphs, LLC
4400 Keller Ave, Ste 140 #175
Oakland, CA 94605

David Cox
President
Phone: (510) 671-0373
E-mail: dave@firmographs.com

Frontier Group of Companies
500 Seneca St, Ste 504
Buffalo, NY 14204

Rob Zuchlewski
Chief Operating Officer
Phone: (716) 570-3607
E-mail: rzuchlewski@fic-services.com

GAI Consultants, Inc.
4200 Triangle Lane
Export, PA 15632-1358

Kent Cockley
Assistant Vice President
Phone: (412) 977-3512
Fax: (412) 476-2020
E-mail: k.cockley@gaiconsultants.com

GEI Consultants
3159 Voyager Drive, Ste A
Green Bay, WI 54311

John Trast
Vice President
Phone: (920) 455-8299
Fax: (920) 455-8225
E-mail: jtrast@geiconsultants.com

Georgia Pacific
2861 Miller Road
Decatur, GA 30035

Sam Turetsky
Product Stewardship Manager
E-mail: Sam.Turetsky@gapac.com

Global Containment Solutions
405 E Forest Street, Ste 110
Oconomowoc, WI 53066

Steve Daniels
President
Phone: (262) 354-0959
E-mail: s.daniels@globalcontainmentsolutions.com

Golder Associates Inc.
5100 West Lemon St, Ste 208
Tampa, FL 33609

Manitia Moultrie
US Power Sector Leader
Phone: (813) 287-1717
Fax: (813) 287-1716
E-mail: mmoultrie@golder.com

Gradient
20 University Road, Ste 500
Cambridge, MA 02138

Ari Lewis
Principal Toxicologist
Phone: (617) 395-5526
Fax: (617) 395-5001
E-mail: alewis@gradientcorp.com

Griffin Dewatering
5306 Clinton Drive
Houston, TX 77020

Chris Peschang
Vice President of Engineering & Business Development
Phone: (832) 272-5794
E-mail: chris.peschang@griffindewatering.com

Ground/Water Treatment & Technology, LLC
627 Mt. Hope Road
Wharton, NJ 07885

Robert Kunzel
President
Phone: (973) 983-0901
Fax: (973) 983-0903
E-mail: rkunzel@gwttllc.com

Haley & Aldrich, Inc.
201 N Westshore Drive #1807
Chicago, IL 60601

Lisa Bradley
Principal Toxicologist
Phone: (978) 846-3463
E-mail: lbradley@haleyaldrich.com

Hallaton Environmental Linings
1206 Sparks Road
Sparks, MD 21152

Bob Oler
Director of Corporate Development
Phone: (410) 583-7700
E-mail: roler@hallaton.com

Hanson Professional Services
1525 S Sixth St.
Springfield, IL 62703

Dan Whalen
Sr. Vice President
Phone: (217) 747-9315
E-mail: dwhalen@hanson-inc.com

HDR
249 Central Park Ave, Suite 201
Virginia Beach, VA 23462

Christine Harris
Power Generation Regulatory Practice Lead
Phone: (757) 222-1579
Fax: (757) 222-1515
E-mail: christine.harris@hdrinc.com

Hilltop Enterprises, Inc.
1585 McDaniel Drive
West Chester, PA 19380

Albert Silkroski
President
Phone: (610) 430-6920
Fax: (610) 430-6921
E-mail: al@hilltopes.com

Hull & Associates, Inc.
219 S Erie Street
Toledo, OH 43604-8607

William Petruzzi
Principal
Phone: (419) 385-2018
Fax: (419) 385-5487
E-mail: bpetruzzi@hullinc.com

Ish Inc.
317 Ibis Ln
Durham, NC 27703-8383

Ishwar Murarka
President & Executive Scientist
Phone: (919) 844-9890
Fax: (919) 844-0917
E-mail: ishwar@murarka.com

John Ward, Inc.
745 E 200 South
Salt Lake City, UT 84102

John Ward
President
Phone: (801) 560-9801
E-mail: wardo@wardo.com

Keller
100 Stickle Ave
Rockaway, NJ 07866

Paul Schmall
Vice President/Chief Engineer
Phone: (973) 627-2100
E-mail: PSchmall@moretrench.com

Lhoist North America
623 West Hickory Ct.
Louisville, CO 80027

Michael Schantz
Director, NBD
Phone: (720) 890-8022
E-mail: mike.schantz@lhoist.com

MRR Southern
5842 Faringdon Place, Suite 1
Raleigh, NC 29609-3930

Chris Roof
Operations Manager
Phone: (919) 436-3571
E-mail: croof@mrrsouthern.com

Nelson, Mullins, Riley & Scarborough
1320 Main St, 17th Floor
Columbia, SC 29201

Karen Crawford
Partner
Phone: (803) 255-9442
Fax: (803) 255-9145
E-mail: karen.crawford@nelsonmullins.com

Nu-Rock Technology USA LLC
4 Ramleh Street
Hunters Hill, NSW 2110 Australia

Martina Rahme
Phone: +6 140-988-3336
E-mail: martina.rahme@nu-rock.com

P. Cassels Law, PLLC
1421 E Broad Street, Ste #415
Fuquay Varina, NC 27526

Pam Cassels
Attorney
Phone: (919) 534-5735
E-mail: Pam@pcasselslaw.com

PENTA Engineering Corporation
10123 Corporate Square
Saint Louis, MO 63132

Manoj Mohan
Vice President Business Development
Phone: (314) 225-7646
E-mail: mmohan@penta.net

Philen Construction
PO Box 1499
Mt. Pleasant, NC 28124

Karen Kieffer
President
Phone: (704) 622-1233
E-mail: philenconstruction@gmail.com

Phillips and Jordan
10201 Parkside Drive, Ste 300
Knoxville, TN 37922

Max Morton
Senior Vice President
Phone: (865) 392-3000
Fax: (865) 688-9902
E-mail: mmorton@pandj.com

Quikrete Companies, LLC
10400 Pioneer Blvd, Unit #3
Santa Fe Springs, CA 90670

Charles Cornman
Phone: (714) 887-7242
E-mail: chuckc@cbpmail.net

Republic Services
18500 N Allied Way
Phoenix, AZ 85054

Bob Pickens
VP, Special Waste
Phone: (480) 627-2788
Fax: (480) 627-7084
E-mail: bpickens@republicservices.com

Resource Materials Testing
24 Fine Dr
Murphy, NC 28906-2308

Brain Trout
President
Phone: (828) 361-1114
E-mail: rmtiflyash@yahoo.com

Rich Kinch
Environmental Consultant
Phone: (703) 901-4200
E-mail: rjkinch@cox.net

RPM Solutions
3345 Overbrook Dr
Lexington, KY 40502

Michael Rafter
President
Phone: (513) 238-0531
E-mail: mrafter@rpmsolve.com

S&ME, Inc.
301 Zima Park Road
Spartanburg, SC 29301

Howard Perry
Sr. Vice President/ Sr. Engineer
Phone: (864) 574-2360
Fax: (864) 576-8730
E-mail: hperry@smeinc.com

Saiia Construction Company, LLC
4400 Lewisburg Rd
Birmingham, AL 35207

Ken Madison
Vice President Business Development
Phone: (205) 943-2209
Fax: (205) 943-2210
E-mail: kmadison@saiia.com

SCS Engineers
11260 Roger Bacon Dr., Suite 300
Reston, VA 20190

Michael McLaughlin
Senior Vice President
Phone: (703) 471-6150
E-mail: mmclaughlin@scsengineers.com

Sevenson Environmental Services
2749 Lockport Rd
Niagara Falls, NY 14305

Nick Tomkins
Business Development
Phone: (716) 284-0431
E-mail: NTomkins@sevenson.com

Silar Services
3213 Back Acres Road
Efland, NC 27243

Tim Silar
President
Phone: (215) 266-6299
E-mail: tsilar@silarservices.com

SMI-PS, Inc.
107 Walden View Ct
Lincoln, CA 95648

Laura Bailey
VP Marketing & Operations
Phone: (916) 345-0257
E-mail: laura@smiwater.com

Son-Haul, Inc.
P.O. Box 1449
Fort Morgan, CO 80701

Toria Neb
President
Phone: (970) 867-4401
Fax: (970) 867-2186
E-mail: tneb@son-haul.net

SonoAsh
1553 W. 75th Ave
Vancouver, BC V6N 3H9 Canada

Claudio Arato
CTO
Phone: (604) 307-5199
E-mail: claudio@sonoash.com

Stantec
10509 Timberwood Circle, Ste 100
Louisville, KY 40223-5301

Charles Allen
Sr. Environmental Engineer
Phone: (502) 212-5034
Fax: (502) 212-5055
E-mail: charles.allen@stantec.com

Superior Belt Filter
319 5th St N # 2876
Saint Petersburg, FL 33701-2811

John Glasscock
President
Phone: (727) 828-6533
E-mail: Jglasscock@superiorbeltfilter.com

Tarmac International Inc.
4121 NE Port Drive
Lees Summit, MO 64064

Randy Nuttall
Account and Project Manager
Phone: (816) 220-0700
E-mail: rnuttall@tarmacinc.com

Tetra Tech
6426 Horneker Road
Pacific, MO 63069

Don Grahlherr
Vice President, National CCR Practice
Phone: (314) 306-6097
E-mail: don.grahlherr@tetratech.com

Trans Ash, Inc.
617 Shepherd Dr, PO Box 15396
Cincinnati, OH 45215

Bruce Kazich
National Sales Manager
Phone: (513) 733-4770
Fax: (513) 554-6147
E-mail: bkazich@transash.com

TRC Environmental Corporation
79 Baybridge
Gulf Breeze, FL 32561

Mark Johnson
Sr. Client Service Manager
Phone: (850) 916-0506
Fax: (850) 916-0507
E-mail: mjohnson@trcsolutions.com

United States Gypsum Company
550 W Adams Street
Chicago, IL 60661-3676

John Gaynor
Director, Gypsum Supply
Phone: (312) 953-0138
E-mail: jgaynor@usg.com

University of Kentucky
2540 Research Park Dr.
Lexington, KY 40511-8410

Thomas Robl
Associate Director
Phone: (859) 257-0272
Fax: (859) 257-0220
E-mail: tom.robl@uky.edu

Waste Connections
3 Waterway Square Place
The Woodlands, TX 77380

Joseph Laubenstein
Director of CCR Management
Phone: (281) 889-0084
Fax: (281) 873-3299
E-mail: JoeLa@WasteConnections.com

WOOD
1070 W Main Street, Ste 5
Abingdon, VA 24210

Brian Owens
CCR Program Manager
Phone: (276) 676-5922
E-mail: brian.owens@woodplc.com

Indvidual

Tufts University
Dept. of Civil & Environmental Eng.
200 College Ave
Medford, MA 02155

Christopher Swan ScD
Dean Undergraduate Education
Phone: (617) 627-5257
Fax: (617) 627-3994
E-mail: chris.swan@tufts.edu

VA Tech Foundation
CSES Dept. MC 0404, VA Tech
Blacksburg, VA 24061-0404

W Lee Daniels
Professor
Phone: (540) 231-7175
Fax: (540) 231-7630
E-mail: wdaniels@vt.edu

Making A Positive Difference

STAR® Technology is a commercially-proven, sustainable solution to permanently remove coal ash from the environment.

RECLAIM

Coal ash from ponds, landfills, and production material is transformed into a consistent, high-quality product.

RECYCLE

STAR® Fly Ash can be used in more concrete mixes and at higher dosage rates for encapsulated beneficial use.

REUSE

Processing coal ash from ponds provides a continual supply of low LOI, Class F fly ash for the construction industry.

RENEW

The STAR® Process provides a permanent solution to remove coal ash from the environment and reduce long-term risk.

844-790-5551
www.sefagroup.com

SEFA