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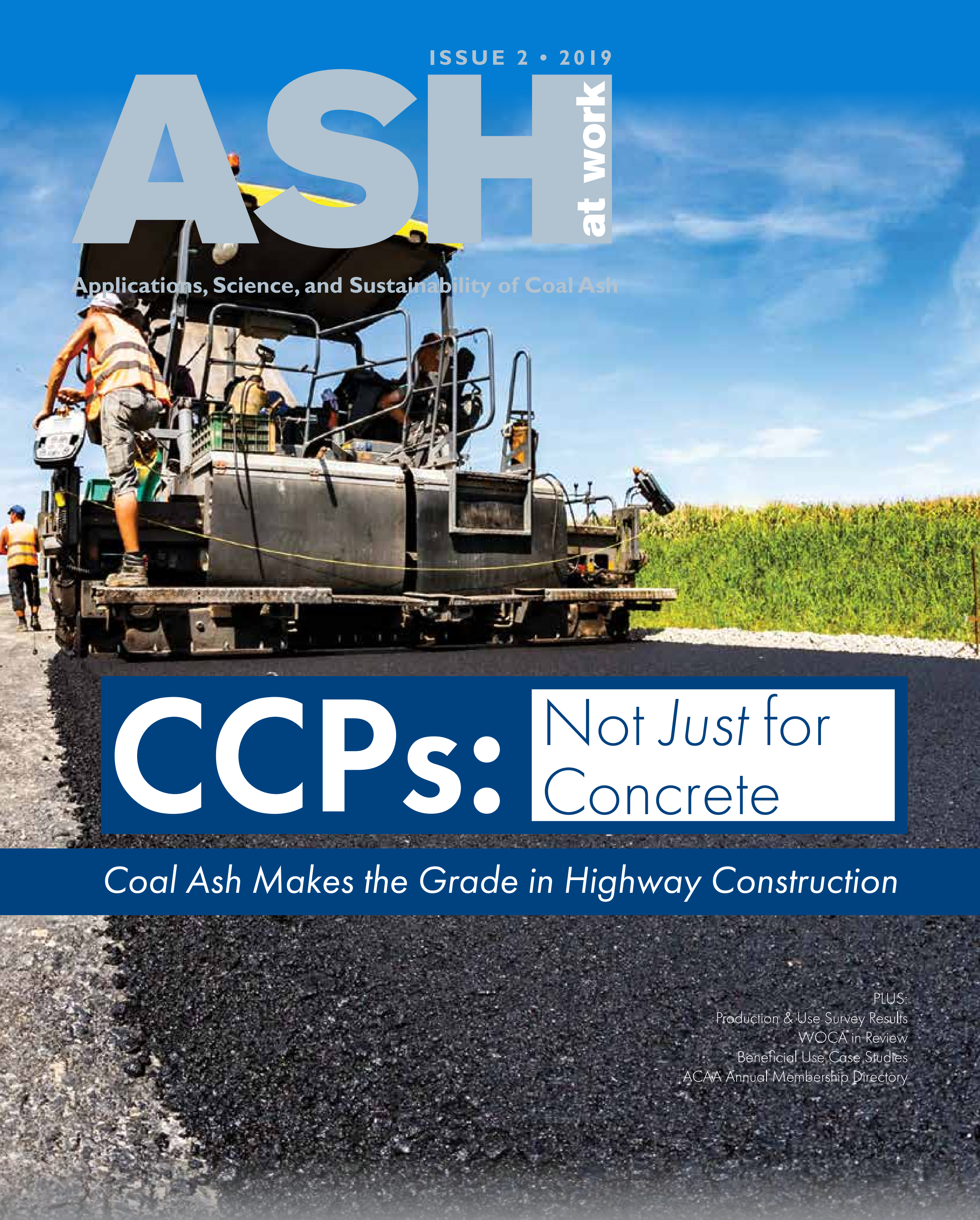
ASH at work

Applications, Science, and Sustainability of Coal Ash



CCPs: Not *Just* for Concrete

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Structural Fill: Conserving Natural Resources Through Projects Featuring Rigorous Engineering Standards

By John Ward

The numbers speak for themselves. According to ACAA production and use survey data, 188.7 million tons of coal combustion products have been placed in structural fill applications since 1980. The application represents one of the largest-volume opportunities to safely utilize CCPs in ways that reap environmental benefits while keeping material out of disposal impoundments and landfills.

Like many things related to coal ash, structural fill activities are frequently mischaracterized by anti-coal activists. The real story of structural fill is a long history of careful engineering and study by a wide variety of interested parties.

What Is Structural Fill?

Coal combustion products have been widely used to convert sites with unsuitable topography into valuable, productive property. These materials can be placed, spread, and compacted using the same equipment as conventional fill materials. Placement to a controlled density and configuration can produce stable fills for site developments, roadways, parking areas, and building construction.

Several coal combustion products—including fly ash, bottom ash, and synthetic gypsum—routinely make their way into structural fill settings. The unique properties of each of these materials determine where they can add value in a construction setting. For instance, the qualities that make bottom ash a preferred material for construction bedding also make it desirable as a backfill material for small areas. Bottom ash is uniform, well graded, drains readily, is not sensitive to moisture variations, and is relatively lightweight compared to many natural materials. Bottom ash can be handled, placed, and compacted using the same techniques as other natural granular materials.

In the United States, the use of CCPs in structural fills dates back to at least 1971. The materials have been widely used in transportation (highway, rail, and airport) settings for constructing embankments and leveling uneven topography. They have also been used in housing developments, shopping malls, industrial parks, and other types of commercial, residential, and industrial developments.

Engineered structural fills are typically constructed in layers of uniform thickness or homogeneity and, where appropriate, compacted to a desired unit of density in a manner that will control the compressibility, strength, and/or hydraulic conductivity of the placed material as required in order to meet engineering specifications.

Structural Fills: Not Born Yesterday

The use of CCPs for structural fill applications is widespread throughout the United States. Some of the earliest uses for CCPs in structural fills began in the 1970s as reported extensively by the National Ash Association in Technical Bulletins and through workshops hosted by NAA at West Virginia University. The NAA (later the American Coal Ash Association) held biannual symposia on beneficial uses for CCPs beginning in 1968, and at each symposium case studies of geotechnical applications, including structural fills, were included.

Coal Ash Used in Structural Fill Applications, 2000 - 2017

In 1979, the Electric Power Research Institute (EPRI) issued a "Fly Ash Structural Fill Handbook" (Report EA-1281). This document contained detailed information on materials characteristics, test and analytical methods, and types of embankments and structural backfills. Subsequently, in 1988, EPRI published "High Volume Fly Ash Utilization Projects in the United States and Canada" (Report CS-4446, Second Edition). This lengthy document identified more than 170 projects, of which approximately half described the use of CCPs in embankments related to highway construction. At the same time, EPRI was conducting a number of demonstration projects in Maryland, Kansas, Michigan, and Georgia that used CCPs in geotechnical applications such as pavement base course and structural fills. In October 1988, EPRI issued "Fly Ash Construction Manual for Road and Site Applications" (CS-5981, Volumes 1 and 2). The technical discussions about using CCPs in the geotechnical projects covered in these two volumes further documented design considerations and construction techniques.

The historical documentation prepared by EPRI clearly demonstrates that the industry did not consider structural fills to be some form of disposal, but rather an accepted engineering practice that would achieve specific technical performance and allow incorporation of CCPs into civil engineering projects.

As a result of these many projects, the geotechnical community recognized a need for standardized guidance that would address the technical, construction, and environmental issues pertaining to the use of CCPs in geotechnical projects. First issued in 1995 by ASTM as a provisional standard, "Provisional Standard Guide for the Use of Coal Combustion Fly Ash in Structural Fills" (PS23-95) was provided to the engineering community to give specific technical and design guidance on the use of CCPs in structural fills that reflected the field experience seen in the previous two decades. Drawing from additional field experience, PS23-95 was extensively revised and re-issued in May 1997 as ASTM E1861-97 "Standard Guide for Use of Coal Combustion By-Products in Structural Fills."

ASTM E1861 was superseded in 2003 with the publication of ASTM E2277-03. The revision was again based on increased field experience and development of best management practices for CCPs in geotechnical projects. All technical documents published by ASTM required specific engineering practices for the use of CCPs in engineered structural fills and do not condone "indiscriminate" placement of CCPs into "projects similar to disposal." Since 2003, ASTM E2277 has been continually updated through a consensus process in order to address better methods of engineering and placement of materials, including CCPs in engineered structural fills.

Today, sectors utilizing CCPs for structural fill applications include state departments of transportation, county and city road districts, and private commercial construction. By adhering to standard construction guidelines such as the ASTM and other documents cited above, achieving high-strength structural fills with CCPs is a safe and beneficial use.

But "Unencapsulated" Uses Must Be Bad, Right?

Wrong! Although the U.S. Environmental Protection Agency studied all forms of CCP beneficial use extensively beginning in 1980, issuing multiple reports and regulatory determinations supporting the practices, the agency's 2010 proposal for disposal regulations marked the first time it attempted to make a distinction between "encapsulated" and "unencapsulated" beneficial uses. ACAA and its members commented at the time that they were concerned about the distinction because EPA failed to adequately define the difference between the classifications, and EPA's proposed language indicated that the agency might take an overly restrictive view of what constitutes an encapsulated use.

ACAA's concerns have turned out to be well founded. In EPA's 2015 Final Rule for Disposal of Coal Combustion Residuals, beneficial use was once again exempted from regulation, but EPA advanced a definition of beneficial use that required enhanced evaluation of non-roadway structural fill activities larger than 12,400 tons—what EPA thought was the size of the smallest landfill in its rulemaking database. When EPA was shown that the 12,400-ton threshold was a mathematical error (in actuality, the smallest landfill in its database was more than 70,000 tons), the agency failed to correct it and recently proposed an entirely new approach to requiring enhanced

Photo: John Barker

evaluations. ACAA is pushing back against this unwarranted and potentially harmful regulatory mission creep. (See "ACAA Objects to Proposed Revisions to EPA's Definition of Beneficial Use" in the News Roundup section of this edition of *ASH at Work*.)

Rigorous Engineering Standards Are Already in Place

EPA's regulatory concern in advancing an evaluation requirement for large, non-roadway beneficial uses was the potential for "indiscriminate placement" of large volumes of CCPs. The agency did not present scientific analysis or relevant damage cases to justify its concern, but adopted an approach that could be described as "if it looks like a landfill, then it might be a landfill, so demonstrate its impacts."

As shown above, most structural fill projects conducted over the past four or five decades are anything but "indiscriminate."

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The enormous volume of historic structural fill projects in the United States has not resulted in damage cases precisely for the reasons EPA itself noted in its 2015 Final Rule. States already regulate these types of beneficial uses and consensus-based engineering standards are in place to establish best practices.

The use of CCPs as structural fill has been widely demonstrated to be a safe and beneficial use throughout the United States. The technical data contained in field reports and the sampling of groundwater near various projects have shown that when both the site and the CCPs are appropriately characterized for the conditions and intended use of the land, there is no adverse environmental impact. EPA, the Federal Highway Administration, state departments of transportation, public and private universities, and various other state and federal agencies have studied and evaluated the uses of CCPs and concluded that the material has favorable geotechnical properties for structural fill. In addition to the previously mentioned ASTM standard, additional standards and technical guidance have been developed by organizations such as the Portland Cement Association, the Federal Highway Administration, the Recycled Materials Resource Center, the American Concrete Institute, the American Association of State Transportation and Highway Officials, and many individual states.

ASTM E 2277-14 "Standard Guide for Design and Construction of Coal Ash Structural Fills" addresses important criteria that should be followed whenever constructing structural fill projects using CCPs. These criteria include materials characterization, site location restrictions, environmental protection procedures, testing procedures, and construction best practices.

A Beneficial Use Worth Protecting

Use of CCPs as a replacement for the soils or alternative fill material that would require excavation and import from a borrow site creates numerous environmental benefits, including:

- Conserving natural resources
- Minimizing land disturbance and associated runoff from extracting native materials
- Reducing energy use and carbon emissions from mining or excavation of native materials
- Reducing the volume of CCPs that would otherwise be landfilled

Conformance with the engineering standards developed over decades of testing and actual use ensures that these benefits are achieved with protection of human health and the environment as the primary concern.

Acknowledgement: Large portions of this article are drawn from the American Coal Ash Association's November 2010 written comments on the U.S. Environmental Protection Agency's then-proposed coal ash disposal regulation. Those comments were the product of approximately 100 volunteer ACAA members who expended more than 14,000 hours reviewing and drafting responses to EPA's proposals.

John Ward entered the coal ash marketing business in 1998 as Vice President, Marketing and Government Affairs, for ISG Resources (later Headwaters). For the past 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 12 or so years ago—as a used coal salesman.

How Well Do You Know CLSM?

By Thomas H. Adams

Controlled low strength materials (CLSM) provide a solution for many, many engineering challenges. CLSM, also known as flowable fill, is most commonly used as backfill for geotechnical applications. However, there are numerous other applications in which CLSM is used successfully. Controlling corrosion, lightweight and insulating fill, mitigating permeability, and managing electrical conductivity are examples of applications less familiar to the casual observer.

CLSM, by definition, is a low-strength material with a compressive strength of less than 1200 PSI and unconfined compressive strength of less than 300 PSI. If future excavation is a consideration, compressive strength should be less than 100 PSI. The material is not intended to be freeze/thaw resistant or resistant to abrasion or aggressive chemicals.

Among the many advantages of CLSM are the following:

- Readily available—a very wide spectrum of materials can be utilized. Locally available materials, both meeting specifications and non-specification materials, may be used depending on the application.
- Versatile—mixes can be tailored to meet the application and placement needs.
- Uses existing equipment—no special mixing or delivery equipment is required.
- Easily placed—placement is directly from the chute or through a pump, conveyor, or bucket. Since most mixtures are self-leveling, little or no labor is required for placement. Weather is not a factor for most CLSM placements.
- Fast and consistent—filling excavations with CLSM generally goes much faster than filling with aggregates, reducing closure to traffic for pavement repairs. Aggregate fill must be placed in layers with each layer tested for compaction. CLSM is generally prequalified, eliminating testing during placement.
- Smaller, safer trenches—when backfilling trenches, the trench can be narrower due to the fluidity of the CLSM mixture. The site is safer, since no workers are needed in the trench, eliminating the hazard of embankment collapse.

While a cubic yard of CLSM often costs more than a cubic yard of aggregate fill, CLSM often is much lower cost in place due to reduced labor costs and speed of placement.

Many state departments of transportation have their own CLSM specifications. Requirements vary from state to state, but generally cement factors are in the range of 50 lbs. to 80 lbs. per cubic yard. Mixes may or may not contain fly ash or other supplementary cementitious materials. When fly ash is used, the quantity can be as much as 2000 lbs. per cubic yard. No coarse aggregates are commonly used. Air entraining agents and foaming agents are used to control strength development and reduce density.

CLSM has been used for filling voids, backfilling utility cuts, encasing and protecting conduits, emergency response to fill sinkholes and slope stabilization, erosion control, lightweight and cellular structural fills, and many, many more applications. Some of the more creative examples of CLSM use are found below.

- In some local communities, CLSM advocates have convinced specifiers to require the use of colored CLSM in backfill for some infrastructure. When backfilling lines for natural gas transmission, electrical cables, telephone cables, fiber optic lines, and water and sewer lines, not only is the fill more consistent in support and encasement, it can be placed much faster with less labor. However, the biggest benefit is in safety. CLSM colored with pigments provides a warning to excavators that a utility line is nearby. This is especially important when dealing with explosive materials like natural gas or critical data transmission lines.
- In a large Midwestern city, the convention center started to exhibit some odd behavior in its basement. Doors would not close properly; cracks started to appear in the joints of the masonry; and floor slabs started to settle. Upon examination by a structural engineer, it was determined that the foundation was settling. The scope and location of the settling was established quickly with the use of sounding technologies. It was determined that a drainage line under the floor was not sealed properly prior to backfilling. The granular backfill around this line was washed away as stormwater flowed through the pipe. Approximately 2000 cubic yards of CLSM were pumped under the slab to fill the void and seal the pipe, resulting in significant savings to the owner without disruption to the use of the convention center.
- In Kansas City, an underground limestone mine was backfilled with CLSM. After mining operations were completed in a part of the mine, CLSM with Class C fly ash was pumped into the void to support the walls and create structural stability. Class C fly ash is not typically used in CLSM, since it hardens very rapidly without the use of set controlling materials. In this case, rapid set was a primary objective. The use of CLSM in this mine made the property above the mine suitable for commercial development. Today this property is populated with multi-story commercial development valued at several million dollars.

These are just a few examples of the creative and versatile use of CLSM.

The American Coal Ash Association (ACAA) has funded a risk evaluation of the use of CLSM utilizing the methodology developed by the U.S. Environmental Protection Agency (EPA). The EPA created this methodology to demonstrate the safety of beneficial uses in comparison to other conventional materials. It applied the process to the use of fly ash in concrete and FGD gypsum in wallboard. It did not examine other CCP beneficial uses. The ACAA has funded this work to demonstrate the safety of the use of CLSM containing CCPs. The risk evaluation report is expected by the end of 2019.

CLSM has been, and will continue to be, a valuable tool for solving engineering challenges. With some imagination and an understanding of the work and available materials, the choice of CLSM has proven to be a cost-effective answer to some serious challenges. The American Concrete Institute has a detailed report on CLSM from Committee 229. To obtain this report, visit www.concrete.org/publications.

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