# Overcoming Barriers to CCP Use

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ABSTRACT

The use of coal combustion products (CCP's) in the United States has steadily increased for a number of years however only a portion of the material produced is beneficially used. This paper examines the various barriers to CCP use in the construction industry and explores pathways to break down or through these barriers. The barriers that exist can be grouped into three distinct categories; administrative, economic and technical. They may be real or perceived but the end result is the same, the use of CCP's are often limited or even excluded from some projects.

With the recent increased awareness of sustainable development practices among state and government entities as well as in the private sector it is becoming increasingly important that materials such as CCP's, that are recycled products, be utilized beneficially as opposed to being landfilled.

In addition to examining the barriers to their use, methods to combat these barriers are discussed. The CCP industry has been actively educating the construction industry for many years however there still remains work to be done. A discussion of the future role for the CCP industry is provided in the quest for complete utilization.

## INTRODUCTION

According to the American Coal Ash Association (ACAA) the overall trend for the production of Coal Combustion Products (CCPs) in the United States has been steadily increasing since 1966.[1] The beneficial use of CCPs has also been on the rise but it has always been, and continues to be, a mere fraction of the total amount produced. For instance in 2003, 121.7 million tons of CCPs were produced however only approximately 46.4 million tons were utilized which represents just 38.1% of the amount available for use. With 61.9%, or 75.3 million tons, disposed of in landfills across the United States in one year, our nation is heading for a crisis. Landfills are filling up fast and it is getting harder to acquire support from the governments to build more. The general public has the "not in my backyard" mentality yet we clearly are dependent on landfills to store our waste. Anything that can be done should be done to divert material from the landfills. Using materials, such as CCPs, beneficially not only saves landfill space but also helps the built environment by supplying a valuable renewable resource. Landfilling CCPs is clearly wasteful and it has also become increasingly expensive. The tipping fees at landfills are on the rise as is the cost associated with fuel needed to transport the material to the landfill. With the impending landfill crisis on the horizon, it is imperative that the CCP industry do all that it can to assist the construction industry in utilizing CCPs in the highest proportion possible.

Over 30 years ago our society began to examine the affect that we had on the environment due in part to the industrial revolution and the population explosion. The news was not good, we were damaging the environment and steps needed to be taken to correct, or at least, slow down the destruction. The governments around the world attempted to tackle the environmental concerns individually but it was soon apparent that approach was not working. What was needed was a more holistic way of protecting the environment. The concept of "sustainable development" was embraced by World leaders, who challenged the industries and governments to incorporate sustainable approaches within the framework of their organizations. "Sustainable development" is often translated to mean "meeting the needs of today without compromising the ability of future generations to meet their needs".[2] The construction industry responded with total interest and has adopted the concept of "green building", which is defined by ASTM E2114 "Standard Terminology for Sustainability Relative to the Performance of Buildings"[3] as "a building that provides the specified building performance requirements while minimizing disturbance to and improving the functioning of local, regional, and global ecosystems both during and after its construction and specified service life."[4] Green buildings utilize "green" building materials but are also charged with "balancing the environmental responsibility, resource efficiency, occupant comfort and well-being, and community sensitivity".[2] In 1993, the U.S. Green building Council (USGBC) was formed and began to respond to the need for industry standardization for "green buildings". Five years later they delivered to the industry a rating system, known as LEED Version 1.0 Pilot Program. As refinements were made to the system, successive versions followed and interest was generated in the design and building communities. The current system is LEED-NC Version 2.1. As designers and builders become more comfortable with the system,

they are increasing their use of “green” building materials not only for LEED rated projects but also for other sustainable construction projects. The LEED Materials and Resources credit MR Credit 4.1 encourages the use of “building products that incorporate recycled content materials, therefore reducing impacts resulting from extraction and processing of new virgin materials”.[5] Coal fly ash is one of the materials that have caught the interest of architects, engineers and the concrete industry at-large, as it qualifies for this credit.

A recent journal article “Turning LEED™ into Leads: Coal combustion products in building material” attests to the increased interest. The article states that “CCPs have tremendous potential for use in a wide variety of building products.” It goes on to point out that “Coal combustion products are too valuable a commodity to continue to treat as waste destined for landfill.”[6]

The progression of the “green building” movement has provided the impetus for the CCP industry to increase their promotion efforts. The focus should correspond to the needs of the designers and builders, as they will be specifying and using the materials. With only a small portion of CCPs being utilized, our industry would be wise to concentrate on increasing the current usage and discovering innovative applications for the remaining products. Clearly, there is market potential and a captive audience, so the challenge to the industry is to respond by providing acceptable materials in areas where they are needed.

The focus of this paper will be on the use of fly ash in construction. Fly ash currently accounts for the largest share of CCPs usage. In 2003, 70.2 million tons of fly ash was produced in the United States accounting for 57% of the total CCP production. Fly ash is used extensively in concrete and to a lesser degree in concrete products and grout. The use of fly ash in structural fills embankments ranks #2 on the ACAA list of “CCP Use By Application”.[1] It is also used in a variety of other applications including as a raw feed in cement mills, for soil modification, as mineral filler in asphalt and for producing man-made aggregate. With the wide variety of uses, the total amount is still only 38.7% of that produced. Some of the reasons for this underutilization include quality, plant location, logistics in supplying the market, and market requirements. Obviously, there is quite a bit of room to grow the market before we surpass the amount produced. The U.S. Department of Energy (DOE) is looking for 50% of the annual production of fly ash used in some capacity by 2010.[7] In order to meet that goal, the CCP industry must step up the effort to find additional beneficial uses, modify or treat non-spec fly ash, help to create specifications for non-spec fly ash or increase the amount used in the present applications. There are certain barriers that must be overcome in our quest for increased utilization. Some of the barriers that have been encountered by the author are discussed in the sections below. Following the discussion on barriers are some ideas for overcoming those barriers.

## IDENTIFICATION OF BARRIERS

Humans are hesitant to change as it is often uncomfortable. A definition for change is "to undergo a loss or modification of".[8] Sometimes it's very hard emotionally for humans to undergo that loss, or modification, without knowing what will be put in its place. Acceptance of the unknown may be difficult for some people. Often moving into the unknown creates risks and some people may not be willing to take them. The higher the risk, the more difficult the decision to change becomes. Unfortunately, in the construction industry there is often resistance to change. This is seen at all levels from contractor, to ready-mix producer to engineer to architect. In some cases barriers are constructed to help resist change. In other cases they exist due to past events or circumstances. Real or imagined, these barriers are worthy of our attention. In order to break through these barriers, it's essential to understand them in their entirety as well as all the people involved and then work together to overcome them.

The knowledge that there is resistance to change will help when forming a strategy. If the person we are dealing with is resistant, it may be because they have something very valuable at stake, be it money, professional license, their job or even their reputation. The stakes may be very high on both a professional and personal basis. The strategy will involve minimizing risk as much as possible. That may be accomplished by providing laboratory data, testimonials, cost analyses or other information so the person is comfortable making the decision to move forward.

The barriers encountered can generally be grouped into three categories; administrative, economic and technical. The following sections provide some examples in each category. Once the barriers are identified the approach to take in overcoming them can be formulated.

### ADMINISTRATIVE

Administrative barriers can also be referred to as organizational barriers. These are barriers that are in existence due to situations within the specifying organization that may act to impede or prevent change.

*Example #1*: This situation involves various levels of approval within the organization. Any change in the specification must be approved by individuals on multiple tiers. In this situation there may be more than one barrier. The first may relate to the knowledge level of the individuals approving the change. If they are not aware of, or do not understand, the supporting reasons for the change it is unlikely that they will approve it. A second barrier involves the effort, or time, required to see the change through to completion. If the effort required is perceived to be more than the champion of the cause can tolerate, it may discourage them from initiating the process or from following-up on the progress. If the champion of the cause is uncomfortable with the timeline for whatever reason (other duties, upcoming retirement, planned vacation, etc.) they may not be willing to take on the added responsibility of promoter for the change.

*Example #2*: The specification is written by a department that is separate and distinct from the department implementing the specification. In this case, the specification writer(s) may be unaware of problems or chances for improvement discovered in the field and therefore find it unnecessary to make any changes.

*Example #3*: Generic "boiler-plate" specifications are used by the organization. These specifications are typically general enough to cover a variety of locations and situations. The use of "boiler-plate" specifications is not always problematic. However, it becomes an impediment if the specification is based on past experience and does not take into account current conditions, technology improvements or available materials. It can also be a hindrance when clauses, or lack thereof, are based on preconceived notions that are incorrect. In addition, another obstacle could be that the reasons for a particular clause, or lack thereof, are unknown or forgotten and the specification writer continues to support the clause, or lack thereof, because their belief is that there "must be a good reason behind it".

*Example #4*: An organization, or specification writer within the organization, believes that their current specification is just fine as it is. There have not been any problems reported so there is no motivation for change.

ECONOMIC

Economic barriers are quite simply related to the cost of making changes.

*Example #5*: The owner's cost is higher than anticipated due to additional costs incurred by a number of other parties, including but not limited to; fly ash marketer, ready-mix company, contractor, or testing laboratory. The owner is unwilling to accept the increase so he makes the decision to exclude fly ash from the project.

*Example #6*: The fly ash marketer's cost increases due to a variety of factors such as changes in operations at the plant, treatment or modification of the fly ash, transportation, or other issues. If this happens after the bid is accepted, the contractor may have to absorb the cost. He/she then decides to exclude fly ash.

*Example #7*: The economics of the project may be affected by an increase due to the use of fly ash. For example, the specification may require a replacement ratio of 1 part cement to 1.5 parts fly ash (1:1.5). This means that for every pound of cement that is replaced, 1-1/2 pounds of fly ash are needed. This extra material could potentially increase the total cost of the concrete mix.

*Example #8*: Economics may be affected due to added material costs, or additional costs incurred due to special equipment needs, such as a silo or guppy for fly ash storage. Expenditures may be required for additional testing, inspectors or quality control/quality assurance.

*Example #9*: The economics of including fly ash exceed the predicted cost.

*Example #10*: Economics may be perceived to be affected by additional troubleshooting or tending to failures on the project.

*Example #11*: When the relationship between the Utility Company and the fly ash marketer is strained, or onerous restrictions are imposed on the marketer, it could affect the economics of the fly ash supply. A Utility Company that is not very proactive with respect to fly ash production could also shift the economics of marketing the fly ash.

TECHNICAL

Technical barriers can be related to national organizations or specifications that hinder, limit, or disallow the use of fly ash. Technical issues that are either real or perceived may also encourage barriers.

*Example #12*: A great example is found in the American Concrete Institute's Building Code (ACI 318/318R). In Table 4.2.3-"Requirements for Concrete Exposed to Deicing Chemicals" for cementitious materials that are "Fly ash or other pozzolans conforming to ASTM C618" the "maximum percent of total cementitious materials by weight" equals 25%[9]. This maximum percentage is believed to be based on limited data obtained in the laboratory that is not duplicated by field trials. ACI, however, has been very slow in reevaluating this limit.

*Example #13*: ASTM International's "Standard Specification for Architectural Cast Stone" (ASTM C1364)[10] excludes fly ash from surfaces intended to be exposed to view. This clause was added to the standard in 2001 because the subcommittee believed "Excessive color variation can be caused by the use of fly ash in architectural concrete finishes". Mr. Bryant Mather attempted to refute that with his negative vote on the Main Committee Ballot, "There is no justification for excluding fly ash from concrete exposed to view. All the concrete is exposed for view and variation in composition of cement/aggregate/slag can be just as much a source of color reaction from fly ash. If conformity of color is required say so as a property of the product and require a sample and let it be marbled as done in other specifications". The negative was found non-persuasive with the following rationale "The industry does not use fly ash in surfaces intended to be exposed to view due to unsatisfactory appearance (dirty looking) of the material".[11]

*Example #14*: ASTM International's "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use in Concrete" (ASTM C618-03) states in the scope that it "…covers coal fly ash…" while the definition of fly ash is as follows "3.1.2 *fly ash*- the finely divided residue that results from the combustion of ground or powdered coal and that is transported by flue gasses."[12] At this point there are no other standards to cover materials that are not solely derived from coal.

*Example #15*: The American Association for State Highway and Transportation Officials' "Standard Specification for Coal Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Concrete" (AASHTO M 295-00)[13] contains

the exact wording found in the ASTM C618 scope and definition sections pertaining to "coal fly ash". In addition, this standard contains a "Supplementary Optional Chemical Requirement" (Table 2) that invokes a test method that has been found to have poor repeatability and poor correlation with field experience[14]. With this requirement, good fly ashes may be erroneously rejected.

*Example #16*: United States Green Building Council LEED™ 2.1 Green Building Rating System[5] allows the inclusion of fly ash and awards up to 2 credits for its use. However there is no system in place to award credits for varying levels of usage. The exception to this is that in a past LEED™ certified project there was 1 "Innovation in Design" credit awarded for the use of 50% fly ash. The "Innovation in Design" credit is subject to interpretation and may not be awarded for the same issue on other projects. Only one "Innovation in Design" credit is given on a project.

*Example #17*: The perception in the industry is that the Portland Cement Association (PCA) has been slow to fully embrace the concept of fly ash in concrete. Historically fly ash was perceived to be a competitor to cement but viewed as"cheap filler". The CCP industry and the PCA are now two industries are now attempting to develop a working relationship with the mutual goal of concrete promotion. Progress has been made but there is still work to be done. In a recent article Dave Shepherd, the Director of Sustainable Development for PCA, discussed the benefits of including fly ash in the manufacturing process but provided a cautionary statement on the use of supplementary cementitious materials, of which fly ash is one, in concrete.[15] Furthermore, in the "Design and Control of Concrete Mixtures" the authors imply that fly ash is solely responsible for delay of set with the following statement, "the use of fly ash will generally retard the setting time of concrete"[16] but neglects to explain that the delay of set may be occurring due to the portion of cement that was removed due to the replacement of fly ash.

*Example #18*: Strength development has historically been a barrier for the tilt-up contractors. Their concern is that the 3-day strength of fly ash mixes is insufficient to allowing picking up the panels without failure.

*Example #19*: Past failures which occurred with the use of fly ash are very hard to overcome as the construction industry tends to have an excellent memory on this issue. In one case the failure happened over 20 years ago with a non-spec, substandard fly ash used in a deck. The deck failed and had to be removed and replaced. To this day, specifiers in the community are still hesitant to use fly ash because they don't want this to happen to their project.

*Example #20*: A specifier, contractor, engineer or owner may dislike fly ash but does not have a good technical reason. Regardless, this issue still needs to be addressed.

*Example #21*: The Environmental Protection Agency (EPA) has been working with the fly ash industry through various programs (C2P2, "Top 20" List) to promote the use of fly ash. However the "Mercury Issue" and the "Classification of fly ash as a waste" are two

major issues that need to be monitored by the industry. The mention of these issues tends to put fear and skepticism into the mind of the construction industry and the public at-large.

*Example #22*: Another issue that seems to resurface frequently is the claim that fly ash is radioactive. A publication was distributed a number of years ago by the President of the American Pozzolan Corporation (APC) that states "…EPA tests have shown the presence of toxic metals such as Tellurium, Selenium, and Arsenic, as well as radioactivity high enough to cause cancer within 10 years if people sat near office or home walls made with Fly Ash."[17] This was refuted in a letter to APC by Paul J. Tikalsky, Chairman ACI Committee 232 Fly Ash and Natural Pozzolans.[18]

## BREAKING THROUGH THE BARRIERS

One of the best ways to break through many of these barriers is through education. Selling is not educating. Educating is done to promote understanding of the product or system in a non-threatening atmosphere. It should be remembered that we are promoting change, which can be uncomfortable and often times involves risks. Education can be done at a variety of levels from students to teachers, architects to engineers, CEO's to laborers and everyone in between. Education can be accomplished over "brown-bag" lunch seminars, in classroom lectures, during formal presentations (American Institute of Architects/Continuing Education System, Continuing Education Units, etc.), within small group or one-on-one meetings, electronic seminars (webinars), or even by mentoring. It's a good idea to supply ample literature that they can take with them. The literature can be promotional brochures, journal articles, or excerpts from books, whatever information you can find that will help tell the story of your product. It's also a good idea to communicate that you are willing to take calls or emails with any questions that may come up.

Now let's take a look at the examples provided in the above categories and see what else is needed to break through the barriers.

## OVERCOMING ADMINISTRATIVE BARRIERS

In example #1, education at all the levels is the key. First it's necessary to identify your champion for the cause, someone inside the company that will escort this change through the organization. Next, determine the involved parties and supply them with adequate information so they can make an informed decision. Help them all to understand the benefits of the change you are proposing. Minimize the risks by providing pertinent information from high quality sources. Stay in touch with your champion and support them in the quest to get the change approved. Most important of all is to be patient and supportive.

The individuals in example #2 will also greatly benefit from education. In addition it is essential to maintain communication with the people in the field so you know their challenges and can help them find the solution. Encourage them to present it to the

other party. When necessary you may need to facilitate discussions between the different departments.

For help with overcoming the barriers associated with example #3, it is helpful to research the reasons behind the clauses in question. You may need to interview people within the company to find the answer or by you asking the question of the origin they may be prompted to investigate the reasons. Once you obtain that knowledge, education will assist in enlighten the involved parties. Keep in mind that they may not be willing to change the national specification but agree to change the local specification.

For the scenario in example #4, education about the material as well as the additional benefits that will be realized for their company will help them to consider the change. Also testimonials from people within their segment of the industry will be very helpful.

OVERCOMING ECONOMIC BARRIERS

For the first 6 examples, development of a cost analysis for the project would be invaluable. The analysis should compare the cost with and without fly ash in the concrete. If the fly ash concrete increases the cost, review the many benefits that they will receive by using fly ash. Education, once again, is necessary for everyone involved with the project (owner, CFO, architect, engineer, contractor, etc.). The goal is for them to be comfortable with the decision to use fly ash.

The scenario in example #11 is difficult to overcome but can be done with persistence and patience. Communication and education are great starting places. It may be necessary to help the Utility see the many benefits of developing a positive working relationship with the marketer. Get involved in the process by learning about their business and teach them about yours. Encourage working together to produce and market the highest quality fly ash possible.

OVERCOMING TECHNICAL BARRIERS

The best way to overcome barriers involving national organizations is to become actively involved. Attend meetings, volunteer to be on task groups, run for office, get to know the committee members, voice your opinion. These are all ways to begin the process of change. Get involved as much as possible because the old saying that “you get out of it exactly what you put in” seems to ring true with committees. Recently in California, the Green Book Committee adopted a change that took about 2 ½ years of hard work and dedication from the fly ash industry. They now allow 20% fly ash on all “alternate class mixes” and concrete pipe and have approved an extended age criteria in recognition of not loading for extended periods of time.[19] That change most likely would not have happened if the fly ash industry was unwilling to devote their time to the cause.

Education is applicable for technical barriers but it may also require field history evaluations or laboratory testing. Although research can often times be costly, it is absolutely essential. There are many areas left to be studied, and so many combinations of materials to evaluate. Armed with all the information available, the chances of accomplishing the change in specification or construction method are increased. Highlighting success stories and sharing testimonials always prove to be valuable. Aim for small steps in the process of change.

A good example of how this works is the progress that the Masonry Industry in Southern California has made. Historically the Masonry Industry has ignored fly ash as a viable construction material.[20] However with the "green building" movement gaining momentum, they were looking for ways to participate. With the help of their fly ash marketer they developed "Masonry System 90" which is a performance-based specification adherence designed to evaluate the entire concrete building system. Fly ash is incorporated into each individual component at specific amounts to provide the maximum benefit. The individual components include concrete footings, concrete block, concrete grout and concrete mortars. Initially small steps were all they could tolerate but in time the small steps all added to a large shift in their paradigm.

## FUTURE ROLE FOR THE CCP INDUSTRY

Over the last 20 years our industry has made great progress through education, research, and field experience. There still remains much work to do. Research must continue so changes can be implemented that are based on facts. Some of the existing information on fly ash is based on research conducted 10, 20 or 50 years ago. The historical research is sometimes viewed as antiquated and therefore dismissed. Some of this research may need to be duplicated using present technology and current coal sources. The construction industry and academia have become very interested in assessing interactions between different material combinations. This seems to be an area where the CCP industry lags behind. There is quite a bit of information about fly ash but more is needed on the other CCPs.

Education efforts could be expanded to include High School students. With the new requirement that all High School Seniors prepare a Senior Project, there is an excellent opportunity to provide mentoring related to our industry. Our outreach programs should include civil engineering students both undergrad and graduate levels. We need to determine the needs of the designers and builders and then supply the information they require. There are still many architectural firms across the nation that would benefit from outreach and education. Being able to provide credit (AIA/CES) to the architects for the seminars will encourage participation. Engineering firms would profit from any information gleaned from research. Providing credit (CEUs) for engineers will provide incentive for them to attend seminars. The creation of more informational brochures, technical papers, research reports and case studies would all be valuable in our effort to educate. Continued partnership with the construction industry will help to increase the use of CCPs in current applications.

There is much work to do with regards to standard specifications. We, as the industry, should be pushing for performance specifications. The prescriptive specifications that we currently have supply information on the material properties but do not provide meaningful information on the performance in the final product. Performance specifications are designed to supply the information that is needed by the construction industry. Until we move to performance specifications, we need to develop specifications on the alternate fly ashes that are currently being produced. These include the fly ashes produced from coal + petroleum coke, blended fly ashes, ammoniated fly ashes, coal + switch grass, and many other combinations. Specifications need to be developed on other CCPs. The development of specifications may be assisted by the industry but it takes a commitment from individuals to prepare the documents and usher them through the approval process. Individual companies are encouraged to participate in standard organizations as well as other national organizations.

Liaisons with other trade associations are proving to be valuable. It would also be a good idea to develop liaisons with all the national organizations in an effort to educate as well as promote CCPs. It is essential to continue working with the government agencies, such as the EPA, DOE, Army Corps of Engineers and Federal Highway Administration. True progress has been made in that area but it will require sustained support and active participation. It may also be necessary to seek out other government agencies and encourage partnership. Relationships should be formed with state, county and city agencies to encourage the use of CCPs.

In the past few years, the American Coal Ash Association has been instrumental in bringing our industry together, partnering with other organizations and providing resources to assist in our promotion efforts. Our trade association can only do so much, so it is up to the individual companies to get out and do the work to promote CCPs. It is crucial that we work together to actively seek solutions to overcoming barriers. Be it through education, communication or any other means possible. This will allow us to accomplish our goal for more complete utilization of all these valuable resources.

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