Regulatory and Legal Applications:  
Fly Ash Use in Cement and Cementitious Products

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FLY ASH: WHAT’S LAW GOT TO DO WITH IT?

Cement and concrete structures would seem to be a long way from the field of law and governmental regulations. This paper examines and suggests a connection and interaction between cement, the law, and coal fly ash. The continuously increasing production of fly ash necessitates a greater focus and attention to the development and utilization of beneficial fly ash use.

This paper will look briefly at regulatory issues, environmental law issues and at least in the United States (U.S.), product liability law issues regarding the use of fly ash. The Federal Government as well as many individual states endorse the beneficial re-use of fly ash for environmental purposes where appropriate. There are millions and millions of tons of coal fly ash generated annually. Without opportunities and methods for the re-use of these materials, landfills will be the primary answer for storage of these otherwise-potentially-useful materials.

From a U.S. perspective, various legal matters exist with regard to cement manufacture or the utilization of cement in construction. For example, contract law governs when dealing with the purchase and sale of materials and finished products. Likewise, labor and employment laws govern workplace safety or conduct at coal plant facilities and their accompanying partners in the coal ash industry. Environmental, property, and tort laws govern the use and operation of fly ash and the facilities that manage or create the fly ash, and the sufficiency of equipment utilized in the manufacture or transportation of fly ash. Here the focus will be more to laws which directly touch upon coal fly ash, the potential hazards and opportunities for beneficial re-use.
Coal contains many constituent elements including certain metals. The amount and concentration of the metals will always depend on where the coal was mined, the initial concentrations in the coal as well as how the coal is burned. The metals in coal of most frequent interest or concern include aluminum, arsenic, barium, chromium, iron, magnesium, lead, silicon, cadmium, and selenium just to name a few. As would be expected, once the coal is burned as fuel, the metals not burned off in that process exist in greater concentration in the coal ash.

There already exist testing methods to determine various aspects of concrete mixtures, fresh concrete or hardened concrete. Can these tests be mixed or matched to evaluate the fly ash content or the percent of mixture which can improve and enhance the more valuable characteristics of the concrete in all phases: volume of mixing water required, time of setting, bleeding, compressive strength, drying shrinkage, abrasion resistance, absorption, and weathering? Can these or similar test methods be developed to demonstrate to regulators the entrapment of the heavy metals of concern that are going to exist in fly ash but may no longer exist in a significantly leachable state after concrete cures?

SCIENCE IN THE DEVELOPMENT OF LAW AND REGULATION

Science can and does play a tremendous role in the development of law and regulation. The interplay of science and law exists at a number of levels, and science’s role in the law varies depending upon the context. Law may add incentives for scientific research, as in the area of patent law. In contrast, the law may place regulatory roadblocks in the way of scientific advancement.

Science also can be used to develop law – giving birth to new laws and new regulations. Additionally, science can be used to interpret the law from within and outside the courtroom. Thus raises the question of how scientific knowledge should influence legal obligations.

Higher ethical standards are created as realities come to light because of recent scientific studies, or with the acceptance of notions or theories within the scientific community, nationwide or worldwide. For example, science has revealed that when coal is burned, emissions such as carbon dioxide, sulfur dioxide, nitrogen oxides, and mercury compounds are released, and the release of these emissions can be harmful to the health of humans and the environment, whether directly or indirectly. These findings necessitate control devices to limit and reduce the amount of emissions, thus leaving the coal industry with massive quantities of resulting coal combustion residues contained by the control devices, including but not limited to fly ash and bottom ash. Science in turn plays a key role in the development of technologies and methods to control the amount and quantity of emissions. Furthermore, science has been implicit in determining myriad methods of re-using coal combustion residues, such as through the amending process of fly ash to be employed in the construction industry.
Because pollutants know no boundaries, neither state nor national, science’s role too must play an international and trans-boundary role. The pollutants of one state or one nation can, and often do, become the pollutants of another state or nation. This very notion of the transboundary nature of pollutants was brought to light by scientists in the post-World War II era, as they addressed concerns with the harm caused by nuclear tests that were releasing radioactive waste into the atmosphere.

Science has the ability to act as a unifying force amidst international and national laws that vary, sometimes to astounding degrees. Thus, while nations and states may have different laws and methods of addressing the results of scientific research as these results pertain to human health and environment, the results remain the same, across the very geopolitical borders and boundaries that pollutants disregard.

Of primary interest to those in the legal profession is the role of science and scientists in the courtroom, where scientists utilize their knowledge to interpret the law. Scientists acting as expert witnesses in court cases play the vital role of instructing the lay person what numbers, charts, graphs and the like signify in laymen's terms, and more importantly, the significance of these readings to the case before the court. As mentioned above, results remain the same; however, the significance of testing results to a particular factual situation is open for interpretation, and varies depending on the side for which an expert witness advocates. The role of scientists in the courtroom, and as interpreters of the law is ever-growing, because of the certainty that science can bring to legal disputes, which by the very nature of the law, are matters subject to multiple interpretations.

REGULATORY AND LEGAL FRAMEWORKS

European Union:

The amount of coal combustion by-products (CCBs) and coal combustion products (CCPs) produced worldwide increases each year as the global need for energy continues to grow. The European Union (EU) is no exception to the increases in CCP; however, the EU has been the vanguard in passing regulations regarding the utilization of CCPs. Nearly 70% of the coal combustion products produced in the EU is fly ash, making fly ash the most common byproduct of coal burning power plants in the EU. While the EU has been progressive in passing legislation on the utilization of fly ash, additional legislation is to be expected regarding the storage and disposal of fly ash.

The effect of EU legislation on coal fly ash is being felt throughout Europe. The EU has sought to harmonize material standards. Prior to standardization some EU members utilized 100% of the coal combustion products produced in their country while others only utilized 10% due to differing regulations. The EU laws that have harmonized differing standards take precedence over national laws, and have benefitted the fly ash industry by requiring fly ash to be utilized more widely throughout the EU. Some of the common uses for coal fly ash are as an aggregate, cementitious material counting fully
or partially towards the cement content in concrete, use in road construction, and as fill material.  

Examples of the EU's harmonized standards are:  
- EN 450, "Fly Ash for Concrete," defines the EU's standard for the use of fly ash for concrete. Approximately 33% of fly ash created in Europe is used for this purpose. Calcareous fly ash cannot be utilized in this manner.  

- EN 197-1 defines the requirements for siliceous and calcareous fly ash for the use as a constituent of blended cements. This standard defines the requirements of the basic composition of the fly ash to be used in this manner, by setting sulphur and chlorine parameters, to prevent any damaging reactions in concrete constructions.  

Harmony within the EU is a product of regulations, directives, decisions, and recommendations, from the European Commission which instruct members of the Union as to the scope and requirements that national laws must meet in order to abide by the directives of the Union. "Directives form the main basis of the law affecting the Construction industry." Despite the fact that directives are binding as to the overall objectives of the legislation, they allow each country to interpret how the objective is to be achieved. While the harmonized standards have broadened the use of coal fly ash throughout the union, the directives often leave room for interpretation which causes conflict in how the directives are administered in each country. The issues created through different interpretations of the directives are decided in the European Court of Justice. Its rulings help to improve understanding and administration of the directives. Unfortunately, the EU legislative and judicial process for achieving standardized practices is not very time efficient.  

The fly ash industry in Europe has been reluctant to acknowledge any negative environmental side effects of fly ash and other coal combustion products. However, regulations have been passed at the national level in many European countries to protect human health and the environment from detrimental effects caused from the leaching of heavy metals found in fly ash. To this point, the national regulations have prevented negative impacts caused by the utilization of coal combustion products. The fact that many countries have already enacted their own environmental standards for utilization and storage of coal ash demonstrates that a push for harmonized environmental standards, similar to the harmonized coal ash utilization standards, is likely to be the next step taken by the EU.  

The European Union (EU) is known for having extensive regulations over fly ash and Furnace bottom ash. The EU has been attempting to encourage recycling, but some experts believe the excessive bureaucracy will actually discourage utilization.  

A major development in the United Kingdom has been the publishing of the Quality Protocol for Fly Ash and Furnace Bottom Ash in 2010. Before that document, useful products such as fly ash were classified as waste and required licensing to use. This
The document was created to define “end of waste.” The Quality Protocol was for England, Wales and Northern Ireland and was meant to define when ash ceased to be waste and it was supposed to remove the stigma of the word waste for fly ash utilization. However, fly ash is only considered a non-waste for the use in “bound applications,” like cement and concrete blocks.

The EU is continuing to work on harmonizing and simplifying the definition of “waste” and how coal combustion products will fit into that definition. The attempt has been going on since 2000 and has still yet to be decided. Several groups, such as ECOBA, the European Association for use of By-products of Coal-fired Power Stations, and Eurelectric have made a push to keep fly ash as a non-hazardous waste in the EU List of Wastes (LOW). If the EU added fly ash to the LOW, it would undermine the EU’s goal of reducing CO2 emissions and would increase the costs for disposal. So far, fly ash has not been added as a hazardous waste to the EU LOW.

U.S. REGULATION

In the wake of the fly ash slurry spill at the Tennessee Valley Authority's Kingston Plant on December 22, 2008, calls for more regulation on fly ash and CCPs became widespread in the U.S. Legislation has been introduced to open dialogue between utilities and the Environmental Protection Agency (EPA) regarding management of coal combustion byproducts. At this time there are no national regulations for the use or disposal of fly ash in effect. The coal industry takes the position that individual states can adequately regulate the use of coal combustion products and the ash disposal sites, but it is possible disasters like the Kingston spill will lead to national regulations.

The issue of coal ash utilization and disposal has arisen as a derivative effect of the Clean Air Act. In an attempt to decrease air pollution Congress passed the Act, which in part imposes restrictions to control the emissions from coal burning plants. As the demand for energy increases and scientists and engineers create increasingly refined emission filtering technology, the amount of coal fly ash trapped by filtering devices at coal-powered energy plants grows annually. In 2008, over 136 million tons of coal combustion waste was generated in the U.S. The EPA estimates that around 170 million tons of coal combustion waste will be generated annually by 2015.

A 1988 report by the EPA was presented to Congress illustrating that coal combustion wastes have the potential to contaminate groundwater. Since then, the EPA released two regulatory determinations in 1993 and 2000 on coal combustion wastes. To reach its findings in these two determinations the EPA evaluated the following factors: (1) the source and volume of coal combustion products generated per year; (2) current disposal practices; (3) potential danger, if any, to human health or the environment from the disposal of coal combustion products; (4) documented cases in which danger to human health or the environment has been proved; (5) alternatives to current disposal methods; (6) the cost of alternative disposal methods; (7) the impact of alternatives on the use of natural resources; and (8) the current and potential utilization of coal combustion products. In each of these two determinations, the EPA
concluded that there is no environmental harm from the beneficial use of CCPs.\textsuperscript{38} Furthermore, the 1993 and 2000 determinations found that CCPs need not be regulated as hazardous materials.\textsuperscript{39} The 1993 determination explicitly stated the "EPA believes that industry and the States should continue to review the appropriate management of these wastes."\textsuperscript{40} The figure below depicts a timeline of states that have enacted regulations on the uses of fly ash and other coal combustion products and when those regulations were enacted. This figure demonstrates that regulation on the use and storage of fly ash has been increasing and there are no signs of this trend slowing.

![Figure 1. States with laws, regulations, policies, or guidance authorizing CCP utilization.](image)

\textsuperscript{*Dates note when significant policies were finalized.\textsuperscript{41}}

In 2003, the EPA announced the Coal Combustion Products Partnership (known as C2P2). The goal of this program is to promote the beneficial use of CCPs throughout the U.S.\textsuperscript{42} and to reduce the adverse effects of CCPs by increasing utilization from 31\% in 2001 to 45\% in 2011.\textsuperscript{43}

Through beneficial utilization of coal combustion products the unsafe disposal of these products can be curtailed extensively. As a result of this initiative, the state of Texas has been the subject of substantial research on policies expanding the beneficial uses of CCPs that likely could be applied in states throughout the U.S. Texas is ideal for this study because it consumes more coal for the production of energy than any other state in the U.S., producing approximately 15 million tons of coal ash per year.\textsuperscript{44} One of the most important steps taken through this initiative has been the formation of the Texas Coal Ash Utilization Group, which aims to educate policy makers, state agencies, and
the public about the beneficial uses of CCPs. The formation of this group was crucial for the expansion of the re-use of fly ash. Ignorance and negative feelings towards the use of CCPs stemming from fears of environmental hazards has created an impediment to increased beneficial re-use of CCPs. Thus, educating the public, environmental groups and industry is essential.

Through its new regulations, Texas has reached a beneficial utilization rating of 60%-70% of coal ash, far exceeding its 15% utilization rate in 1992. Increased beneficial utilization of coal prevents the ash from being dumped in landfills and slurry ponds creating potentially large scale environmental risks. Fly ash and other coal combustion wastes must go somewhere; CCPs will be present and continue to grow whether or not beneficial use is made of it.

In 2007, the EPA released a report entitled "Human and Ecological Risk Assessment from Coal Combustion Wastes." This report illustrated health and environmental risks of placing coal combustion wastes in landfills or slurry impoundments. Some documented risks include increased risks of cancer and contaminated groundwater. Despite these findings, coal fly ash and other coal combustion wastes have still not been listed as hazardous materials and no national regulations have been passed on coal ash management.

The EPA issued a letter in March 2009, requesting information from all electric utilities regarding surface impoundments and landfills that hold coal combustion wastes under HR 493 "The Coal Ash Reclamation, Environment, and Safety Act of 2009." In this regard, the EPA has shown that it intends to conduct inspections of coal combustion impounds and mines, and develop legislation regarding the management of these materials. The modern trend is a push for federal regulations requiring dry storage of fly ash and other coal combustion wastes in mines.

The idea is to line the mines and seal them when filled. These changes should stop the heavy metals that contaminate ground waters from leaching out, and eliminate the danger of dams or dikes breaking, releasing a slurry pond of ash. In this manner spills like the incident in Kingston, Tennessee should and can be avoided.

Federal regulation may be expected to extend to the utilization of fly ash as well as its disposal. Because utilization also creates the threat of heavy metals leaching into ground water, the EPA is likely to regulate use as well as the disposal. Ultimately, beneficial utilization does prevent the stockpiling of fly ash in mines and landfills, which the Kingston accident has shown poses a massive environmental threat.

In the U.S., both private citizens and companies may initiate lawsuits against other individuals or corporations for one or more of many different legal theories. For example, consider a construction project where issues arise regarding the concrete used. The contractor might need an expert to help him show the work was performed correctly while the owner might need an expert to prove the poor work is the result of inadequate product mix or inadequate product composition. Or consider a claim that
concrete made with fly ash has leached metals into the ground water drinking supply. A microscopic examination of core samples of the concrete might provide visual evidence that the fly ash remains bound to the concrete, which requires looking elsewhere to determine the source of the metals.

In the United States, the Environmental protection agency announced a proposed regulation in 2010 that would lead to stronger governmental oversight of Coal Combustion residuals (CCRs). The EPA has advanced two possibilities for potential rules. The first rule would create a program under Subtitle C of the RCRA for the management of “special wastes.” The second would be enforced through citizen suits and would give the EPA the authority to set standards for the waste management facilities. Both rules would still allow CCRs to be used as components of products like concrete instead of placed in landfills.

Advocates for the utilization of fly ash, however, still feel threatened by the possible regulation because they maintain that the EPA proposed regulation would have negative results for fly ash utilization. According to one advocate, the classification of “special waste” creates a stigma that would hinder the public’s perception of the utilization of fly ash. More importantly, the label of hazardous waste would give the EPA the power to impose new handling procedures, which will make the utilization of coal ash more expensive. The EPA has not implemented the proposed regulation, even though it was announced in 2010.

The EPA has also ceased to promote CCRs through its Coal Combustion Products Partnership (C2P2) program, which promoted the beneficial use of fly ash. The move was a response to charges that the EPA promoted CCRs without fully analyzing the risks involved. All websites regarding C2P2 program have been removed from the EPA’s website until the EPA’s proposed regulation is settled. From the recent actions of the EPA, it seems that the organization is becoming more and more hesitant to support the utilization of coal ash.

Congress entered the fray in 2011 by introducing legislation to prevent the EPA from passing the regulation. The Bi-Partisan bill, introduced as an amendment to the Transportation Reauthorization Bill, passed the House by a vote of 267-144 but failed to garner the necessary support in the Senate. The legislation would leave the regulation of coal ash to the states, but would give the EPA the ability to step in if states refused to regulate coal ash or failed to follow certain EPA guidelines. The Obama administration opposes the legislation, believing that leaving regulation to the states would “undermine the Federal government’s ability to ensure that requirements for management and disposal of coal combustion residuals are protective of human health and the environment.”

Due to regulatory uncertainty, producers of coal ash have been more hesitant to recycle coal ash in the past four years. In fact, coal ash recycling has fallen below 2008 levels since 2009. In 20011, of 130.1 million tons of coal ash produced, only 43.5% was recycled, a decrease from the 44.54% recycled in 2008. These numbers
are also notable because only 130.1 million tons of ash were produced, but the EPA estimated that 170 million tons of coal combustion waste would be produced by 2015.

CHINA

The amount of coal combustion by-products produced in leading Asian nations has exploded recently amidst new construction and development of coal fired power plants. The annual emissions of CCWs in China are estimated to be over 300 million tons, around 130 million tons are produced in India, another 30 million tons come from Indonesia, and 10 million tons from Japan. These annual emissions are expected to continue rising for years to come. China, more so than other Asian countries, relies heavily on coal fired power plants for energy. Because there is a lack of high quality coal in China, the coal burning plants in China produce a large quantity of fly ash. In fact, the accumulative deposited amount of fly ash has exceeded 25 hundred million tons in China.

The disposal of fly ash in large quantity dumps throughout China poses a monumental potential threat to the environment. With little environmental regulation in China, and other parts of the Asian world, the need for proper disposal and utilization of CCPs cannot be overstated.

Regulation and reform of the Chinese coal industry is a slow and arduous process, much like reform in Eastern Europe and Russia, due largely to the mindset that the coal industry represents "the latest fortress of the old system." In China, "the most effective law on coal industry is the air pollution control law." The air pollution control law has been revised twice, once in 1995 and once again in 2000. The revisions in 1995 prohibited new coal power plants in large and medium cities unless they were IGCC plants powered by heat. The 1995 provisions also required new and rebuilt plants emitting sulphur contents above 1% to install desulphuration facilities. The revisions made in 2000 were more extensive. Under these provisions the government has the power to carry out total control of emissions. This entails checking and ratifying air pollutant emissions and granting emission permits. Furthermore, the government can levy fees for air pollutant emissions. In this manner, the Chinese government intends to strengthen clean energy by penalizing plants with high pollutant emissions rates. Additionally, the revisions encourage the development and promotion of clean coal technologies. As China takes steps against air pollution, the vast expanses of fly ash dumps remain unregulated and continue to grow. While safe disposal methods will help prevent an environmental disaster, the problem can only be corrected by safe and profitable utilization techniques.

Since 2010, China has, according to their own admissions, been encouraging the development of greentech solutions. Apparently, there is a strong future for some types of clean energy, but fly ash recycling has continued to lag.

Fly ash utilization rates in China are indeterminable. China maintains that 60% or more of China’s coal ash is reused, but Greenpeace did an independent report and concluded China has less than 30% utilization rate. The Asian Coal Ash Association says Greenpeace’s statistics are skewed because most of China’s coal utilization takes place
in the east, but Greenpeace conducted its research mainly in central and western China.\textsuperscript{77} China has many issues in its efforts to utilize coal ash for four main reasons: 1) the imbalanced distribution of fly ash utilization in the east, 2) the quality of their fly ash is varied, 3) there are a limited number of uses for fly ash, and 4) the government isn’t really incentivized to use fly ash because it’s not very profitable.\textsuperscript{78}

So far, fly ash has been regulated specifically in China’s local authorities\textsuperscript{79} and in China’s Ministries.\textsuperscript{80} But on a higher level, the State Council and the National People’s Congress have yet to make any specific regulation regarding fly ash, and can only point to blanket legislation like the Law on Promotion of Cleaner Production. However, China still outwardly publicizes that it wishes to more quickly develop laws and incentives to improve the utilization of coal ash on a national level.\textsuperscript{81} So far, the only incentive for the utilization of coal ash is 30 yuan per ton, which is not much incentive at all.\textsuperscript{82}

Currently, fly ash is used in China mainly for building materials, but also for construction projects, road engineering, agribusiness, backfill, and other uses, such as the extraction of Aluminum.\textsuperscript{83} China needs to beef up their utilization of fly ash, however, because fly ash is China’s biggest source of solid industrial waste.\textsuperscript{84}

As of 2010, China produced 424 million meters of coal ash a year.\textsuperscript{85} From 2002 to 2010, china’s ash production more than doubled.\textsuperscript{86} Greenpeace found that wells near coal plants do not meet standards and cows on nearby farms have been producing less milk, as admitted by China’s climate and energy campaign head.\textsuperscript{87} In China, coal ash disposal sites are supposed to be at least 500 meters away from villages, but the ash is taking up too much room, and the sites are becoming increasing closer.\textsuperscript{88} The lack of law enforcement for the environmental regulations in China is one of the major hurdles that China faces in developing more fly ash regulations.\textsuperscript{89}

JAPAN

Japan has taken the lead among the Asian nations in developing technology to utilize the wastes from coal fired power plants. In Japan the Japan Coal Energy Center (JCOAL) is on the forefront of developing technology and techniques to utilize coal combustion products.\textsuperscript{90}

One of JCOAL's first steps has been to form a communication and information network with other Asian countries.\textsuperscript{91} This process has progressed slowly as regulations differ throughout each country. There is no governing body like the EU to standardize regulations amongst the Asian nations. To respond to this issue, JCOAL established the Committee for Advancing of Effective CCP Use, in September of 2007.\textsuperscript{92} This committee distributes results of research on coal ash domestically and abroad in order to build communication links throughout the Asian countries.

Japan's research on coal ash utilization has been highly productive. In 2007, Japan emitted 12 million tons of coal ash. Approximately 90% of Japan's fly ash is captured by electric duct collectors. Japan put 11.6 million tons of coal ash to effective use, and sent
only 400,000 tons to landfills. Japan was able to effectively use 97% of its total emission of coal ash. Japan has achieved the efficient use of fly ash through regulation, such as the revision of JIS A 6201, which expanded the scope of applications of fly ash. “The breakdown of Japanese fly ash use is 66% in the cement area, 14% in the civil engineering area, 4% in building, 1% in agriculture, and 15% in other uses.”

It is safe to say that coal ash production in Asia is growing rapidly. Therefore, utilization in this part of the world must continue to grow to prevent ash dumps from growing exponentially and creating a massive environmental threat.

Japan is still the leader in Asia regarding coal ash utilization. Japan’s regulation for fly ash, JIS A 6201, has been amended four times to keep up with changing times, most recently in 1999. One other method of recycling coal ash utilized in Japan is Ash Melting. For Ash Melting, plasma is used to melt the ash to form a non-leachable “glassy slag” that can be used for road aggregate.

BRAZIL

Brazil uses an estimated 37 million tons of coal per year for its energy needs. Brazil's coal consumption results in the production of 17 million tons of ash (fly ash and bottom ash) per year, the majority of which is deposited in landfills for disposal. This ratio of coal to ash production is very high, and "the combustion of high ash content coals promotes a serious environmental problem in southern Brazil." Disposal of the ash in landfills and mines has deteriorated Brazil's environment and led to both surface and ground water contamination in at least two southern Brazilian provinces, Rio Grande do Sul and Santa Catarina. Much like the rest of the world, it is estimated that Brazil’s coal ash production will grow extensively with the need for more energy, and the threat for further contamination and environmental degradation will grow concurrently without utilization regulation.

In response to these problems Brazil has exhausted many resources in an effort to develop utilization techniques and procedures for coal ash in civil construction projects. As of 1999, Brazil utilized 30% of its coal ash in cement and construction industries, and much of the remaining coal ash was used to fill mine pits. However, new strategies to deal with the expanding amounts of coal ash production are being sought out but are yet to be developed. In order to protect the environment in Brazil new utilization techniques for CCPs will certainly be paired with new regulations to ensure their efficacy.

One major development in Brazil has been the use of coal ash to remove heavy metals, like manganese, from water. Water from the mining process of coal is contaminated, but scientists have found a way to release water back into the environment after contamination. First, they carry out the normal chemical treatment. Then, they incorporate the ash, the water is reduced to an acceptable level to be released back into the environment. This technology was only discovered late in 2012.
CONCLUSION

A common theme among countries in various regions around the world is a need for developing new regulations on CCP utilization, and the standardization of existing regulations on CCP utilization and disposal. Standardization of utilization regulations will create a broader marketplace within the U.S. for CCPs. Standardization has already been implemented between the countries in the EU. As of yet, no major environmental disasters have been reported in the EU due to their increased utilization of CCPs. However, the U.S. and Brazil have witnessed firsthand the dangers of storing fly ash in slurry ponds and disposing of ash in mines and landfills. Furthermore, China’s growing landfills of fly ash likely pose an environmental threat like the unlined landfills in the U.S. As the threats of storage have been evidenced in the U.S. and Brazil, and the positive effects of utilization are being evidenced in the EU, it is clear that more regulations are forthcoming.

As those regulations develop and the legal systems mature, a clear understanding of the smallest structures will impact the big policy issues.107

1 In this paper, the terms coal fly ash, coal ash, and fly ash will be used interchangeably, without detailing the differences. The intent of this paper generally is to address coal fly ash as an additive for cement/concrete applications.


3 According to the EPA, one landfill can range anywhere from 4 to 80 hectares (10 to 197 acres) and may be as deep as 9 meters (30 ft).

4 See ASTM C 192, Standard Practice For Making And Curing Concrete Test Specifications In A Laboratory, ASTM C 231, Test Method For Air Content Of FreshlyMixed Concrete By The Pressure Method, ASTM C 173, Test Method For Air Content Of FreshlyMixed Concrete By The Volumetric Method, and ASTM C 457, Standard Test Method For Microscopical Determination Of Parameters Of The Air-Void System And Hardened Concrete.


*Id.*


*Id.*

*Id.*

*Id.*


24 Id.


26 Id.


46 Id.


48 Id..
51 American Concrete Institute, *EPA Proposed Regulation of Coal Combustion Residuals (CCRs)*, [http://www.concrete.org/flyash/flyash.htm](http://www.concrete.org/flyash/flyash.htm).

52 American Concrete Institute, *EPA Proposed Regulation of Coal Combustion Residuals (CCRs)*, [http://www.concrete.org/flyash/flyash.htm](http://www.concrete.org/flyash/flyash.htm).

53 Id.

54 Id.


56 Id.


58 Id.


61 Id.

62 Id.


Like the Shanghai municipal government’s Management Regulation on Fly Ash Comprehensive

Like the Administrative Measures of Fly Ash Utilization.

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84 Meng Si, Coal Ash Cloud Looms Large Over China, Reuters (Oct. 3, 2010).

85 Id.
86 Id.
87 Id.
88 Id.


92 Id.
93 Id.
94 Id.
95 Id.


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Id.

Id.

Id.


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Design and Control of Concrete Mixtures (EB001.14) Chapter 3.