

FINAL TECHNICAL REPORT
November 1, 2000, through October 31, 2001

Project Title: **COMMERCIALIZATION OF HIGH-CARBON FLY ASH IN
CEMENT MANUFACTURE**

ICCI Project Number: 00-1/3.1A-1
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ABSTRACT

The goal of this project was to generate awareness and acceptance in an attempt to commercialize CTL's ICCI-sponsored and proven technology for utilizing high-carbon fly ash from Illinois coal in the manufacture of portland cement at Illinois cement plants. This work was an extension of our successful laboratory-, pilot-, and commercial-scale demonstration that showed that high-carbon fly ash provides many benefits to the manufacture of portland cement. Some of the tangible benefits include measurable improvements in the production and properties of portland cement, and a significant manufacturing energy savings due to the carbon content of the fly ash.

Since the successful commercialization of this technology is primarily based on the interest and participation of both the cement manufacturers and fly ash producers, this phase of the project was designed to generate a high level of interest with key personnel from cement manufacturers and fly ash producers. Key personnel were brought together through a series of group meetings at CTL's and participants' facilities. At these meetings, the needs, constraints, and expectations of the cement manufacturers and fly ash producers were discussed with the goals of addressing the problems of reliable fly ash availability, transportability, and logistics related to cement plants processing and operational parameters.

To facilitate the commercialization of this technology, CTL also provided both onsite and offsite technical support and expertise to both the cement manufacturers and fly ash producers. CTL's technical support was focused on solutions to key technical issues and to minimize the barriers that may otherwise prohibit the widespread use of high-carbon fly ash from Illinois coal in Illinois cement plants.

EXECUTIVE SUMMARY

Power plants using Illinois coal (fly ash producers) generate large volumes of high carbon fly ash. This fly ash is not acceptable for use in concrete, and is typically landfilled. This non-beneficial use of fly ash places an economic burden on the power generating plants.

Similarly, Illinois cement manufacturers have a need for cost-effective alternative raw materials and process improvements. High-carbon fly ashes from Illinois coal are rich in silica, alumina, iron oxide and carbon. These components make high carbon fly ash an attractive alternate raw material for cement manufacturers.

During our 1999 work for ICCI, we demonstrated the feasibility of utilizing high carbon fly ash in the manufacture of portland cement. This work focused on the laboratory and pilot scales. In 2000 with the support of ICCI, CTL demonstrated on commercial scale that high carbon fly ash from Illinois coal could successfully be utilized in the manufacture of portland cement. During this large-scale demonstration, the high carbon fly ash was used to replace shale/clay in the raw feed of a cement plant while providing added fuel savings from the residual high carbon. During the demonstration, measurable improvements in the cement production and quality, and a significant energy saving due to the carbon content of the fly ash were realized. Additionally, the cement produced during the demonstration met the applicable standards, and had superior characteristics, compared to that of their normal cement.

As an extension to our lab-, pilot- and a proven commercial-scale demonstration of the technology, the current efforts involved CTL working with the four Illinois cement manufacturers and numerous fly ash producers that burn Illinois coal with the objective of promoting the technology to utilize large volumes of high carbon fly ash in the manufacture of portland cement.

Group Meetings with Key Personnel

To achieve this objective, CTL organized a series of technical forums and focused group meetings by bringing together key personnel from Illinois cement manufacturers and fly ash producers that utilize Illinois coal. The goal was to foster and strengthen relationships, and to encourage the commercialization of technology. At these meetings, the needs, constraints, and expectations of the cement manufacturers and fly ash producers were discussed with the sole objective of promoting the technology. The underlying issues of reliable fly ash, compatibility with cement plant raw material, transportability, delivery, and other logistic constraints were also addressed.

Group meetings were held at CTL's facilities in Skokie, IL, Illinois Cement in LaSalle, IL, Ameren's Coffeen Power Station in Coffeen, IL, and at Cinergy's Gibson Power Station near Mount Carmel, IL. The meetings at the participant facilities enabled the participants (cement manufacturers and fly ash producers) to understand each other's operations, needs, and facilities. Additionally, during the second meeting at Illinois

Cement, a second commercial demonstration of the technology was performed. The demonstration was as successful as the 2000 commercial demonstration.

The meetings brought together key industry personnel within and outside Illinois. The meetings were open to all fly ash producers that utilize Illinois coal and cement manufacturers with plants in Illinois. One additional non-Illinois cement manufacturer was included because of their ongoing business relationship with a fly ash producer that utilizes large volumes of Illinois coal.

Participating cement manufacturers involved in the meetings included:

- Lone Star Industries, Oglesby, IL
- Illinois Cement Company, LaSalle, IL
- Dixon-Marquette Cement Company, Dixon, IL
- Lafarge Corporation, Grand Chain, IL
- Holnam Corporation, Mason City, IA

Participating fly ash producers with plants in Illinois included:

- Dynegy Midwest Generation
- Ameren Energy Fuels & Services
- City Water, Light and Power (CWLP)

The non-Illinois fly ash producers included:

- Cinergy Corporation (Indiana)
- Dairyland Power (Wisconsin)
- TECO (Florida)
- Tennessee Valley Authority
- Seminole Electric (Florida)
- City Utilities of Springfield (Missouri)
- Northern Indiana Public Service

Technical Assistance to Promote the Technology

To encourage the commercialization of the technology, CTL offered onsite and offsite technical assistance to the program participants. Assistance was designed to aid in the implementation of the technology. Assistance was provided on an “as-requested” basis.

Offsite assistance was utilized more frequently than the onsite assistance. Onsite assistance was requested and provided twice. In both cases, the onsite assistance consisted of short visits and meetings at cement plants to discuss the technology and factors affecting its commercialization.

Offsite assistance was sought by the both cement manufacturers and fly ash producers. Requests were related to:

- Dryability of ponded fly ash
- Compositional characterization of fly ash and cement plant raw materials
- Compatibility of high carbon fly ash with a particular cement plant operation
- Thermal behavior and fuel value of high carbon fly ashes
- Potential emissions and organic species characterization of various fly ashes
- Applicability of the technology in non-preheater cement plants

All requests for offsite assistance were fulfilled.

OBJECTIVES

The objectives of this work were to build awareness and acceptance of the technology amongst fly ash producers and large-scale consumers (cement plants) so that the technology can be widely implemented.

Once implemented, the technology would impart the following economic, operational, product, and environmental benefits:

- This process will convert over 450,000 tons of fly ash per year to cement if all four Illinois cement manufacturers adopt this technology. This “waste to product” approach will generate additional economic incentives to utilize Illinois coal, while significantly reducing landfills in Illinois.
- As has been realized by the two commercial demonstrations, use of high carbon fly ash in cement manufacture reduces the amount of purchased fuel, conserves natural resources, and provides operational enhancements. This will impart significant economic advantages to the four Illinois cement manufacturers.
- Again, as shown in the commercial demonstrations, the cements produced from the high carbon fly ash raw material, will have lower alkali contents than the normally produced cements. Low alkali cements are in high demand for use in concrete due to their reduced alkali-silica reactivity with aggregates. This can also impart economic advantages to the four Illinois cement manufacturers.

INTRODUCTION AND BACKGROUND

Approximately 2.5 million tons of fly ash are generated per year from nearly 30 power plants in the state of Illinois. Of this, only one-third is used in commercial applications and the rest is either ponded or landfilled. The majority of the fly ash, which is not ponded or land filled, is from non-Illinois coal and is used in concrete. With the continued interest of the EPA in reducing NO_x emissions, the quantities of fly ash produced is likely to increase significantly. Additionally, the carbon content of the fly ash will also be substantially increased. Therefore, the future quantities of currently non-marketable high carbon fly ash are likely to increase.

Within the State of Illinois, there are four cement plants with a combined annual capacity of nearly three million tons of cement. Results from our ICCI-sponsored investigations have clearly demonstrated that large volumes of high-carbon fly ash from Illinois coal can conveniently and beneficially be used in the manufacture of portland cement.

This phase of the work involved promoting the technology to both fly ash producers and cement plants so that the technology would become widely commercialized.

RESULTS AND DISCUSSION

Task 1. Antitrust Considerations

To mitigate any antitrust concerns that may arise during group meetings with multiple members of an industry (i.e. competitors), CTL utilized the services of a general counsel (lawyer) that specializes in antitrust considerations. The general counsel reviewed the overall agenda of the first meeting and provided guidelines to avoid antitrust matters.

The guidelines involved making an antitrust statement at the beginning of meetings, providing a meeting agenda, recording meeting attendance, and avoiding group discussions of such topics as pricing and contracts.

The antitrust lawyer attended the first meeting to ensure that the attendees understood the antitrust considerations, and to direct them to adhere to the antitrust guidelines during future meetings.

Task 2. Group Meetings

CTL planned, organized, and participated in a series of group meetings of key personnel from all four of the Illinois cement manufacturers and a large number of fly ash producers that utilize Illinois coal. Originally, six meetings were planned; however, due to participant scheduling conflicts, only four meetings were possible.

During the group meetings CTL was able to promote and encourage the commercialization of the technology by:

1. Bringing together key personnel of the cement manufacturing and power generating industries that normally would not freely communicate and associate.
2. Generating a high level of interest and participation through continued activities.
3. Providing tours of plant facilities to allow the participants (cement manufacturers and fly ash producers) to understand each other's operations, needs, and facilities.
4. Providing a series of informal technical forums where the participants could learn about, and discuss the benefits and issues regarding the commercialization of the technology.
5. Assuring participants of CTL's offsite and onsite assistance with the commercialization of the technology.

The following participants actively participated in many of the meetings and communications that ensued. Participating cement manufacturers involved in the meetings included:

- Lone Star Industries, Oglesby, IL

- Illinois Cement Company, LaSalle, IL
- Dixon-Marquette Cement Company, Dixon, IL
- Lafarge Corporation, Grand Chain, IL
- Holnam Corporation, Mason City, IA

Participating fly ash producers with plants in Illinois included:

- Dynegy Midwest Generation
- Ameren Energy Fuels & Services
- City Water, Light and Power (CWLP)

The non-Illinois fly ash producers included:

- Cinergy Corporation (Indiana)
- Dairyland Power (Wisconsin)
- TECO (Florida)
- Tennessee Valley Authority
- Seminole Electric (Florida)
- City Utilities of Springfield (Missouri)
- Northern Indiana Public Service

The first meeting was held at the CTL corporate campus. Participation was excellent. Key personnel representing nine fly ash producers and all four cement manufacturers, including one national corporate manager participated. During the meeting, CTL personnel presented the technology and its benefits, and discussed the commercial demonstration. Sufficient background was presented to educate the participants on the basics of cement manufacture. The format of the meeting was kept open to encourage discussions and interaction.

The second meeting was held at the Illinois Cement Company plant in LaSalle, IL. During the meeting, a second commercial demonstration of the technology was performed. This provided an excellent opportunity for the participants to get a firsthand experience of the technology. For the demonstration, CTL arranged for 100,000 lbs of high carbon fly ash from Ameren's Coffeen Power Station to be utilized. Details of the demonstration are provided in a later section of this report. This meeting also allowed the fly ash providers to understand the operations, needs, and equipment of a cement plant. During this meeting, some salient features of the technology were also discussed.

The third meeting was held at Ameren's Coffeen Power Station in Coffeen, IL. During the meeting the group toured the entire power plant and fly ash handling facilities. The tour also allowed the cement manufacturers to understand the operations of a typical power plant. During the group discussion of this meeting, factors affecting fly ash suitability, availability, consistency, transportability, and processing were discussed.

The final meeting was held at Cinergy's Gibson Power Station near Mount Carmel, IL. During the meeting the group toured the fly ash and other byproducts handling facilities, including the material processing and treatment facilities, fly ash ponds, and landfill. During the meeting, CTL personnel again presented salient features of the technology,

discussed the initial commercial demonstration, and benefits of commercialization. During the ensuing group discussion, factors affecting fly ash suitability, availability, consistency, transportability, and logistics in handling and processing were discussed.

Task 3. Conference Calls

To further promote the technology, a series of group conference calls was planned. During the course of the project, however, it became apparent that conference calls were not required, so none were held.

During the first group meeting, the antitrust attorney encouraged the group to exchange contact information so that certain discussions could be held in a non-group setting. Contact information was collected and distributed to all participants. The group and individuals were communicated by email and telephone, as appropriate.

As planned, CTL disseminated project related information via email on regular basis. Additionally, CTL personnel promptly contacted participants that showed a lack of participation or faltering interest.

Task 4. Onsite Support

To aid in the commercialization of the technology, CTL planned to provide onsite assistance to any participating cement manufacturer or fly ash producer upon request. Three requests were made. The first request was to perform a second demonstration of the technology during the second meeting, as mentioned above. For other two requests, the onsite assistance consisted of visits and meetings at cement plants to discuss various aspects of the technology and factors affecting its commercialization.

Demonstration at Illinois Cement Plant

As part of the onsite assistance program, a second demonstration of the technology was performed at Illinois Cement using high carbon fly ash from the Coffeen Power Station. For this demonstration, CTL arranged for the transport of 100,000 lbs of the high carbon fly ash to Illinois Cement. The carbon content of the fly ash was approximately 17%.

Illinois Cement blended the fly ash with their raw kiln feed and was demonstrating the technology prior to and during the group meeting. Operational data received from Illinois Cement was minimal; however trends from the provided data were similar to those observed during the initial demonstration. The observed general trends included:

- Preheaters functioned normally without blockings/build ups
- Front end temperature increased
- Use of purchased fuel was reduced
- Production increased

Operational Data. Specific data regarding preheater exit gas and material temperatures were provided. Table 1 presents these temperatures. Again, these are similar to those of the initial demonstration, indicating repeatability of the technology.

Table 1 – Measured Temperature in the Preheater

	Exit Gas Temperature, °F				Meal (Material) Temperature, °F			
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 1	Stage 2	Stage 3	Stage 4
Before	820	1060	1380	1480	780	1040	1060	1500
During	820	1080	1440	1520	780	1060	1280	1520
After	820	1060	1380	1450	780	1060	1100	1500

The degree of calcination of the kiln feed in the 4th (lowest) stage of the preheater was measured before and during the demonstration. Prior to the demonstration, the kiln feed was 51.2% calcined. During the demonstration, the kiln feed calcinations rose to 62.5%, an increase of 22%. This clearly shows that the use of high carbon fly ash is beneficial in increasing the efficiency of the preheater tower. As can be seen in Table 1, the high carbon fly ash increased the temperature of the lower stages of the preheater but did not increase the temperatures in the upper stages. In essence, the use of the high carbon fly ash transformed the preheater tower into a preheater/precalciner tower.

Clinker Characterization. The chemical composition of the clinker collected before and during the demonstration was characterized by the X-Ray Fluorescence (XRF) method. The composition and Bouge computations are shown in Table 2. As the composition suggests, the clinkers will produce Type I portland cement.

Table 2 – Chemical Composition of the Clinkers

Analyte	Composition, wt%	
	Before	During
SiO ₂	21.02	21.11
Al ₂ O ₃	6.01	6.15
Fe ₂ O ₃	2.63	2.76
CaO	63.14	63.11
MgO	2.47	2.88
SO ₃	1.90	1.34
Na ₂ O	0.32	0.30
K ₂ O	1.05	0.92
TiO ₂	0.33	0.34
C ₃ S	48	47
C ₂ S	28	25
C ₃ A	11	12
C ₄ AF	8	8

The major phases present in the demonstration clinker were also determined by X-ray diffraction (XRD) analyses. The XRD pattern, shown in Figure 1, confirms the presence of the typical alite (C_3S), belite (C_2S), aluminate C_3A , and aluminoferrite (C_4AF) phases in the clinker. Additionally, very little free lime was noted in the clinker.

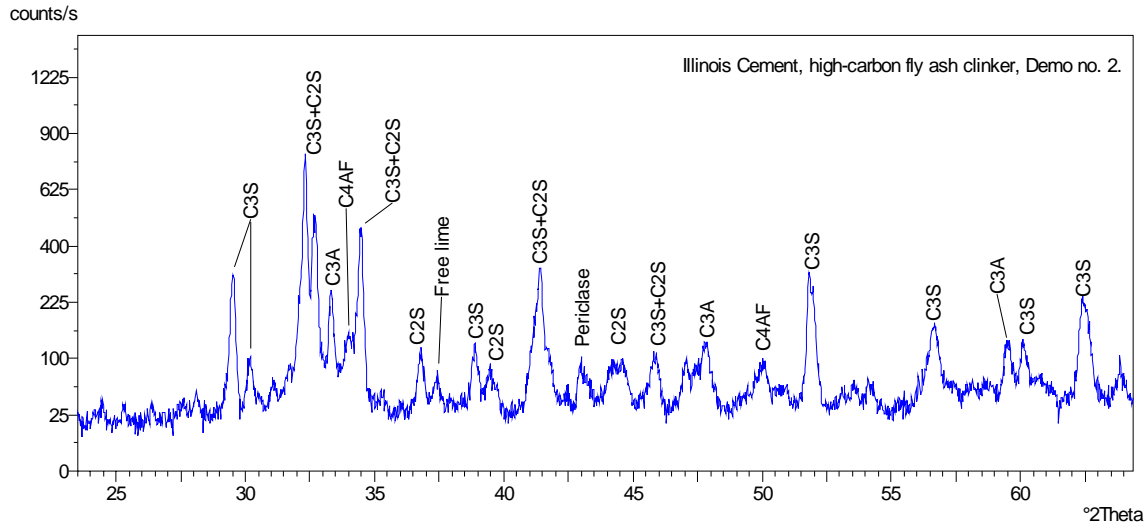


Figure 1 – Phase Composition of the Demonstration Clinker

Microscopical examination of the demonstration clinker was performed to determine the formation and distribution of the major phases. The micrograph of a polished section, shown in Figure 2, also confirmed a normal formation and distribution of the major phases of alite, belite, aluminate, and aluminoferrite phases.

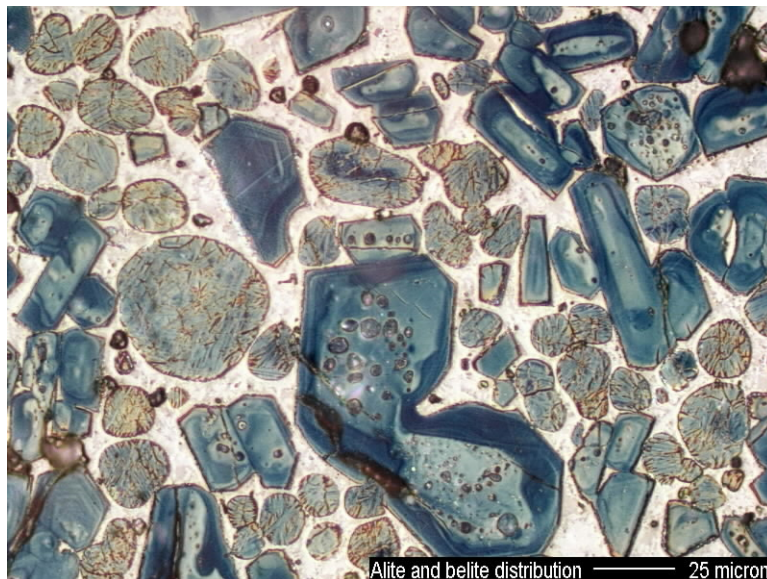


Figure 2 – Typical Phase Distribution of the Demonstration Clinker

* In cement notations: C=CaO, S=SiO₂, A=Al₂O₃, F=Fe₂O₃

In general, the results of this demonstration were as successful as, and similar to, those of the previous demonstration. Calcination of the kiln feed increased in the preheater tower, allowing the amount of purchased fuel to be reduced, while at the same time, increasing production. The clinker had the same chemical and phase distribution. The cement produced from the clinker is expected to have comparable or better performance than the normally produced cement.

Second Request for Onsite Assistance

The second request involved a visit and brief meeting at Dixon Marquette Cement plant in Dixon, IL. The plant is a dry process facility with three preheater kilns and one long dry kiln. During the meeting, emphasis was placed on the material and energy benefits of the technology. Additionally, logistics regarding reliable sourcing and transportability of high carbon fly ash were discussed.

Third Request for Onsite Assistance

The third request, received from Dairyland Power, was to assure Holnam's Mason City, IA. cement plant that the technology was fully compatible with their manufacturing process (long dry kiln). Currently, Dairyland, a power plant in Wisconsin using Illinois coal, provides fly ash to Holnam, but Holnam limits the carbon content of the fly ash to a maximum of 10%. To meet this requirement, Dairyland blends their high carbon fly ash with a no carbon fly ash (suitable for use in concrete).

We understand that even after Dairyland approached Holnam with the ICCI-sponsored technology, Holnam still had many concerns because they have a different manufacturing process than the facility where the technology had been demonstrated. Dairyland requested CTL's assistance to demonstrate to Holnam that the technology was equally applicable to their plant.

Prior to the visit and meeting at Holnam, CTL performed a series of laboratory analyses (described in the *Offsite Assistance* section of this report) to demonstrate that the Dairyland high carbon fly ash was compatible with the Holnam kiln operation. During the meeting, the technology was discussed in light of the data obtained from the tests. The Holnam personnel indicated their willingness to further study and potentially test the technology. Also during the meeting, Holnam indicated that they are building facilities to receive fly ash by rail. They also have facilities that can be used to dry ponded fly ash.

Task 5. CTL Technical Support

To further assist the commercialization of the technology, CTL provided offsite (laboratory) assistance to any participating cement manufacturer or fly ash producer upon request. This technical support was intended to minimize the barriers that may otherwise inhibit the commercialization of this technology.

Several requests from cement and power plants were received on the characterization and evaluation of fly ashes with respect to their use in cement manufacture. Selected high carbon ashes were characterized for the following parameters:

- Dryability of ponded fly ash
- Compositional characterization of fly ash and cement plant raw materials
- Compatibility of high carbon fly ash with a particular cement plant
- Thermal behavior and fuel value of high carbon fly ashes
- Potential emissions and organic species characterization of various fly ashes
- Applicability of the technology to non-preheater cement plants

Selected data from the characterizations and evaluations is presented below:

Chemical Composition of Fly Ash

Several fly ashes were tested for their composition and loss on ignition, which is an indication of the carbon content. Mostly the fly ashes were high in carbon and rich in SiO_2 , Al_2O_3 , and Fe_2O_3 . Chemical compositions are presented in Table 3.

Table 3 – Chemical Composition of the Fly Ashes Provided

Analyte	#1	#2	#3	#4	#5	#6	#7
SiO_2	48.49	43.26	34.11	34.34	46.02	41.76	47.30
Al_2O_3	21.85	14.70	14.13	15.21	21.89	19.00	16.67
Fe_2O_3	7.55	4.89	7.43	8.20	15.46	8.60	7.34
CaO	3.24	11.80	5.97	13.27	4.64	8.20	4.28
MgO	1.39	2.23	1.38	2.38	0.80	2.05	1.06
SO_3	0.75	1.35	1.20	1.55	1.26	1.45	0.17
Na_2O	1.02	1.74	0.74	1.02	1.53	1.12	1.78
K_2O	2.44	0.55	0.86	1.50	2.03	1.36	2.50
TiO_2	1.09	0.79	0.82	1.38	1.08	0.97	1.02
P_2O_5	0.19	0.44	0.54	10.52	0.14	0.49	0.17
Mn_2O_3	0.04	0.02	0.02	0.61	0.08	0.03	0.04
SrO	0.06	0.18	0.13	0.07	0.04	0.15	0.05
LOI*	11.18	17.10	31.74	7.82	3.91	15.14	17.24
Total	99.29	99.06	99.08	97.88	98.86	100.32	99.62

*Loss on ignition at 950°C

Based on the SiO_2 , Al_2O_3 , and Fe_2O_3 contents, it can be inferred that these ashes can conveniently replace clay and/or shale in the raw feed being used in the Illinois cement plants. The addition of ash will be governed largely by the mix formulation and the type of cement intended in a given cement operation. As can be seen most of these fly ashes have high carbon contents. Therefore, the addition of the fly ashes in raw feed will also translate into fuel savings. Again, the actual fuel savings will depend upon the kiln

configuration and the amount of fly ash used in the raw mix. Requirements for a preheater-type plant may differ from those of the long dry plant. Thermal and emission characteristics of the ash can also affect fuel savings.

Thermal and Emission Properties of Fly Ash

Fuel value and potential emissions properties of several of the fly ashes listed above were quantified using Differential Scanning Calorimetry (DSC). The temperatures at which the combustion exotherms occur indicate that very low emissions are expected from these fly ashes. Furthermore, the heat values calculated from the areas of exotherms suggest significant fuel contributions from these ashes. Data on emission potentials and fuel values are provided in Table 4.

Table 4 - Thermal Characteristics of the Fly Ashes Provided

Fly Ash	Carbon Content, %	Emissions Potential	Fuel value, Btu/lb
#1	11.18	Extremely low	1019
#2	17.10	Extremely low	1432
#3	31.74	Extremely low	1823
#4	7.82	Extremely low	202
#6	15.14	Extremely low	1286

Dryability of Poned Ashes

Another request was made to explore the possibility of drying the high carbon fly ash stored in landfills or ponds. The ponded fly ashes are regarded as reliable source of compositionally uniform fly ash. In our previous work, it was determined that natural air-drying was an effective but impractical method of drying the ponded fly ash. This time, two addition methods - pressure drying and hot air drying - were explored.

Pressure-Drying. Several wet fly ash samples with a 30% moisture content were tested. Specimens were hydraulically compacted at various pressures, and the resulting moisture loss was determined. Results presented in Table 5, suggest that even at high pressures this method was ineffective at removing moisture.

Table 5 – Pressure Drying of Poned Fly Ashes

Applied Pressure, psi	Moisture Content, %			
	Fly Ash A	Fly Ash B	Fly Ash C	Fly Ash D
0	30.0	30.0	30.0	30.0
250	24.8	26.5	26.3	25.0
755	24.0	25.3	24.8	24.3
1260	23.2	24.5	22.8	23.4
2015	22.2	23.5	22.7	22.3
3020	21.6	22.7	21.6	21.5
4530	21.0	21.7	20.6	20.5

Hot Air Drying. A number of fly ashes, again with a 30% moisture content, were dried in a small forced hot air rotary drier. The air temperature was not sufficiently high as to ignite the carbon in the fly ash. Moisture contents were measured at regular intervals. This method of drying was extremely effective; however, material losses were excessive. Results are shown in Table 6.

Table 6 – Forced Air Drying of Pondered Fly Ashes

Drying Time, minutes	Moisture Content, %		
	Fly Ash D	Fly Ash E	Fly Ash F
0	30.0	30.0	30.0
20	20.4	18.1	20.9
30	11.8	11.7	13.8
35	4.3	3.9	6.7
40	1.2	1.9	2.4

Applicability of the Technology to Long Dry Kilns

Concerns were raised regarding the use of high carbon fly ash in a long dry kiln, primarily related to premature burning of the carbon in the back end of the kiln, causing overheating and emissions problems. This was addressed by testing a kiln feed from long dry cement plant by mixing with 10% fly ash, spiked with increasing levels of unburned carbon. Tests were performed in CTL's differential scanning calorimeter in which these mixtures were slowly heated in flue gas atmosphere from ambient temperatures to 750°C. Thermographs of two kiln feed/fly ash blends are shown in Figures 3 and 4.

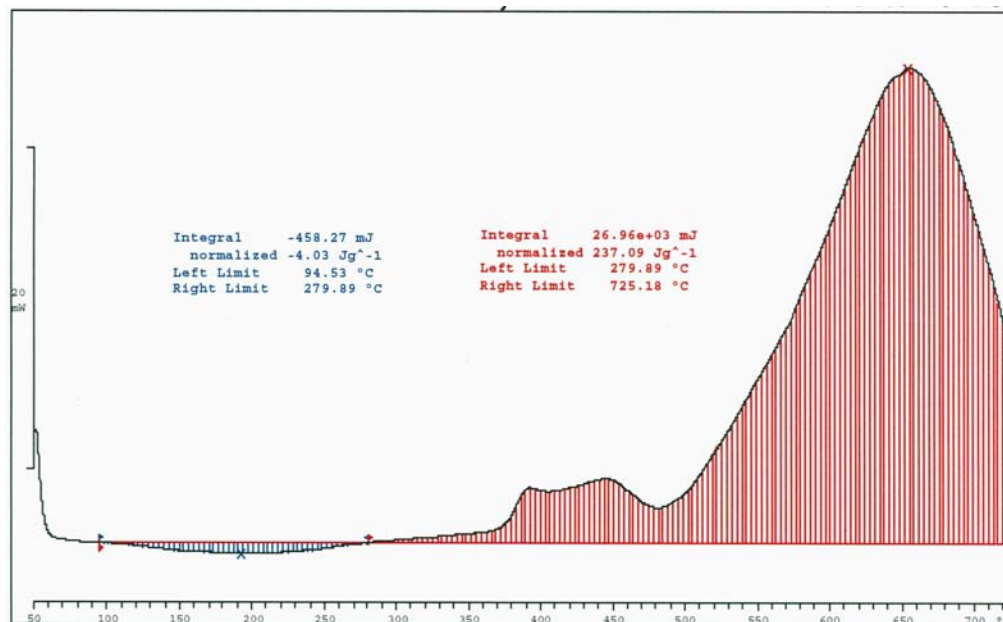


Figure 3 – Thermal Behavior of a Long Dry Kiln Feed with High Carbon Fly Ash #1

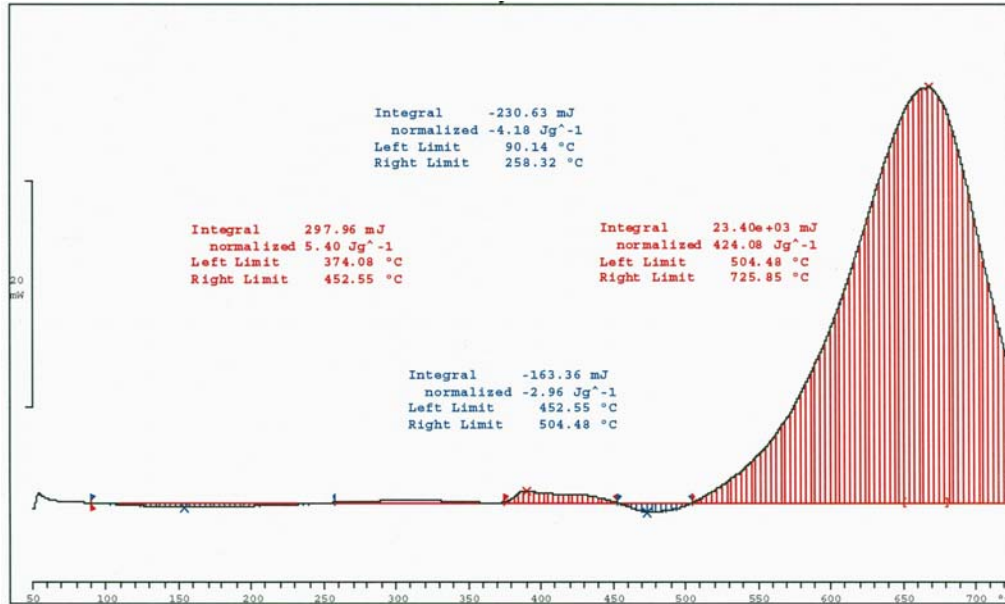


Figure 4 – Thermal Behavior of a Long Dry Kiln Feed with High Carbon Fly Ash #3

The very low release of heat at low temperatures and major exotherms at temperatures above 500°C suggest that the additions of high carbon ash will not contribute to any excessive heating of the back end of long dry kilns. Furthermore, extremely low exotherms at low temperatures suggest no emission problems. Thus, the technology appears fully transferable from preheater type cement plants to long dry type plants.

It might be pointed out that the high carbon fly ash from Coffeen power plant, used in the commercial demonstration phase of this project, had similar thermal characteristics, except that the endothermic peak below 550°C was more pronounced (see Figure 5).

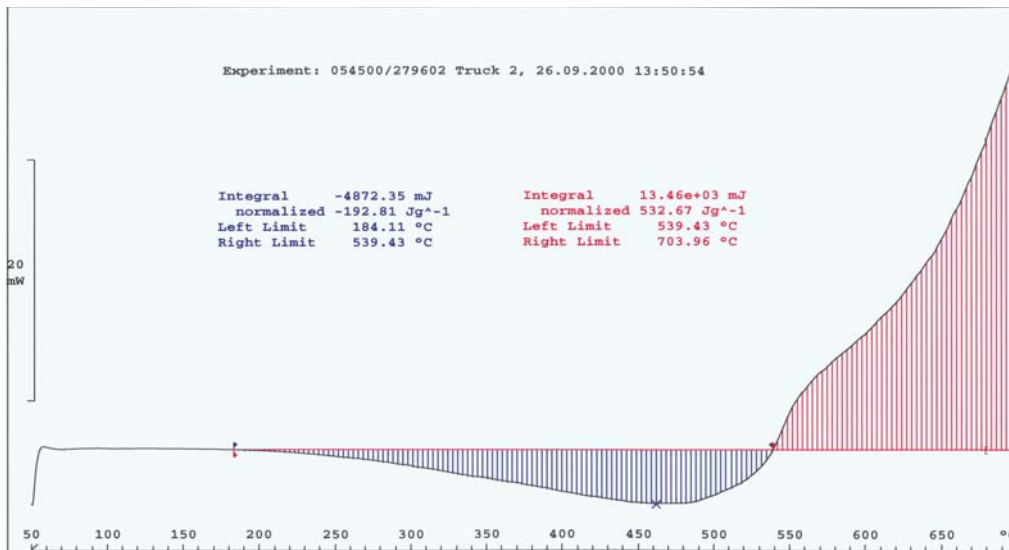


Figure 5. Thermal Behavior of High Carbon Fly Ash from Coffeen Power Plant

The lack of any exothermic peaks at temperatures below 550°C clearly suggests an absence of organic emissions at lower temperatures. Thus, very little release of volatile matters was anticipated in the upper preheater stages of the cement plant during the demonstration. The large endotherm also acted as a heat sink for the raw feed that resulted into reduced build-ups as indicated by the lower exit pressures at the upper preheater stages during the demonstration.

An increase in exit pressure implies the possibility of blockage due to build-ups, whereas a decrease suggests a clearing up of the pathways for smoother flow of material. During the demonstration, a general decrease in the upper stages of the preheater was noted. This was most likely due, in part, to the reduced temperature because of the large endothermic peak of the fly ash, and the higher temperatures in the lower portion of the preheater because of the large exothermic peak due to the presence of high carbon in the fly ash.

CONCLUSIONS AND RECOMMENDATIONS

The efforts to promote to commercialize the technology of using high carbon fly ash in cement manufacture were highly successful in many regards. Several key personnel from Illinois cement manufacturers (potential consumers of the fly ash) and power plants using Illinois coal (producers of fly ash), who normally do not interact, were brought together on a single platform. They developed understanding, fostered relationships, and gained an understanding of each other's operations and needs.

In our promotion efforts, we realized that two critical factors needed to be addressed to move forward:

- To achieve the commercialization of this technology, the interest of the cement manufacturers is the key; without their interest and support, the fly ash producers will continue to generate and dispose of large quantities of fly ash.
- Many the cement plants and fly ash providers need a great deal of encouragement to work together. Fly ash producers are primarily concerned with the generation of electricity, not the consistency of fly ash. Cement manufacturers are interested in a low cost or no-cost supply of consistent raw materials. With encouragement, and communications, these minor issues can be resolved.

We believe that through our interactive focused group meetings and site visits we were able to generate high level of interest amongst the cement manufactures and the fly ash producers with regard to the understanding of the technology and its eventual commercialization.

Our onsite and offsite assistance addressed various technical issues to help overcome apprehensions and potential barriers between the participants that would have prevented the commercialization of this technology. Although the technology was not

commercialized during this past fiscal year, we believe that by virtue of our efforts we are a step closer to commercialization.

DISCLAIMER STATEMENT

This report was prepared by Javed I. Bhatti, Ph.D., Construction Technology Laboratories, Inc. (CTL) with support, in part by grants made possible by the Illinois Department of Commerce and Community Affairs through the Office of Coal Development and Marketing and the Illinois Clean Coal Institute. Neither Dr. Bhatti, Construction Technology Laboratories, Inc. (CTL) nor any of its subcontractors nor the Illinois Department of Commerce and Community Affairs, Office of Coal Development and Marketing, Illinois Clean Coal Institute, nor any person acting on behalf of either:

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