Manufacturing Commercial Bricks with Illinois Coal Fly Ash

A Program Overview

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Outline

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Background Information

- Three million tons of Class F fly ash generated each year in Illinois
- Majority of this coal combustion by-product is ponded or landfilled
- No high-volume commercial uses in cement-related construction products

Chemical Composition Comparison

Chemical composition of Class F ash is similar to the raw materials of a conventional fired brick

wt%	**Clay**	**Shale**	**FA-1**	**FA-2**
SiO_2	57.10	63.30	53.47	48.96
Al_2O_3	25.04	16.65	21.10	22.47
Fe_2O_3	2.33	6.54	10.82	13.34
SiO_2+Al_2O_3+Fe_2O_3	**84.47**	**86.49**	**85.39**	**84.47**
CaO	0.46	0.39	3.28	1.35
MgO	0.53	1.79	1.09	0.83
Na_2O	0.02	0.92	1.58	1.50
K_2O	1.42	3.14	2.67	2.36
S	0.8	0.2	0.4	0.5
Loss On Ignition	**8.84**	**4.49**	**2.77**	**6.64**

FA-1 =Illinois Class F, Fly ash-1; FA-2 =Illinois Class F, Fly ash-2

Traditional Fired Brick Manufacturing

Brick Industry Association

Research and Development

ISGS/UIUC Research Project (1999-2001)

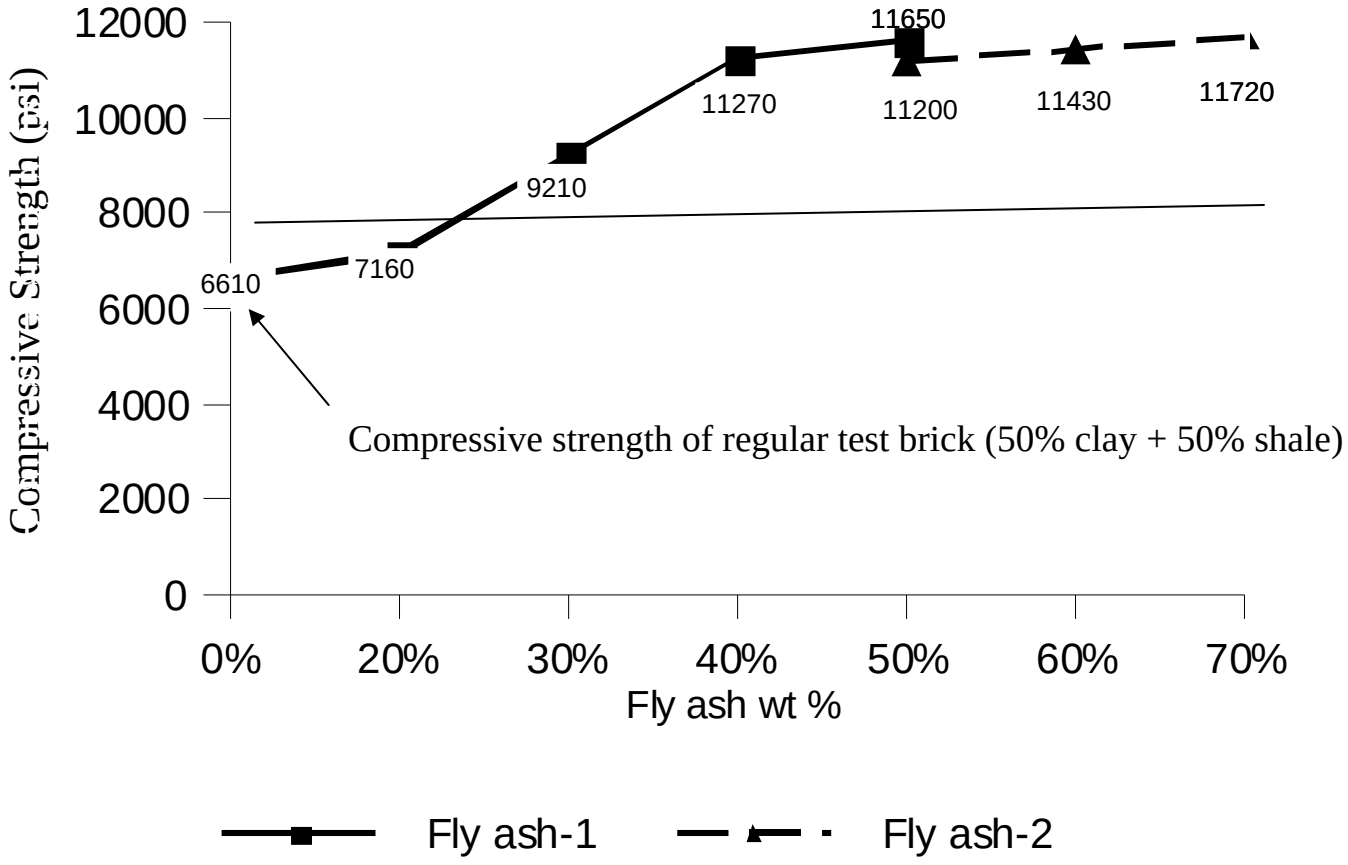
Laboratory-scale tests

- Conducted laboratory-scale tests
- Used various Illinois fly ashes
- Produced bricks with inputs of fly ash up to 70 wt%
- Performed characterization
- Performed market and preliminary economic analyses

Pilot plant tests

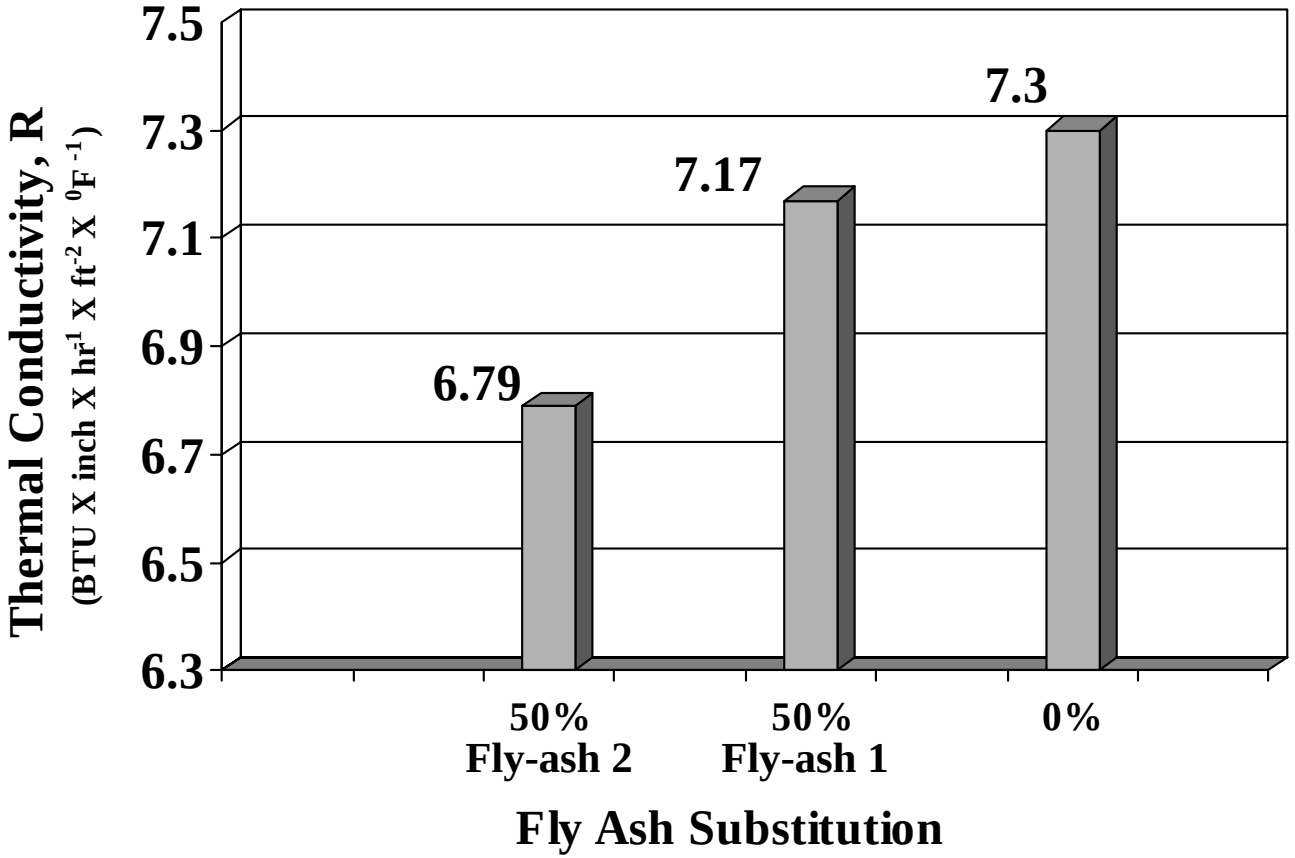
- Performed 300-brick pilot plant tests
- Established bench unit tests - resolved various issues
- Produced bricks from pilot plant test with 40 wt% fly ash

Compressive strength of fired laboratory-size test bricks



Thermal conductivity (at 32^0F) of fired laboratory-size test bricks

with and without 50 wt% fly ash



Pilot Plant Tests

Issues

Extrusion

- Low plasticity
- High plasticity

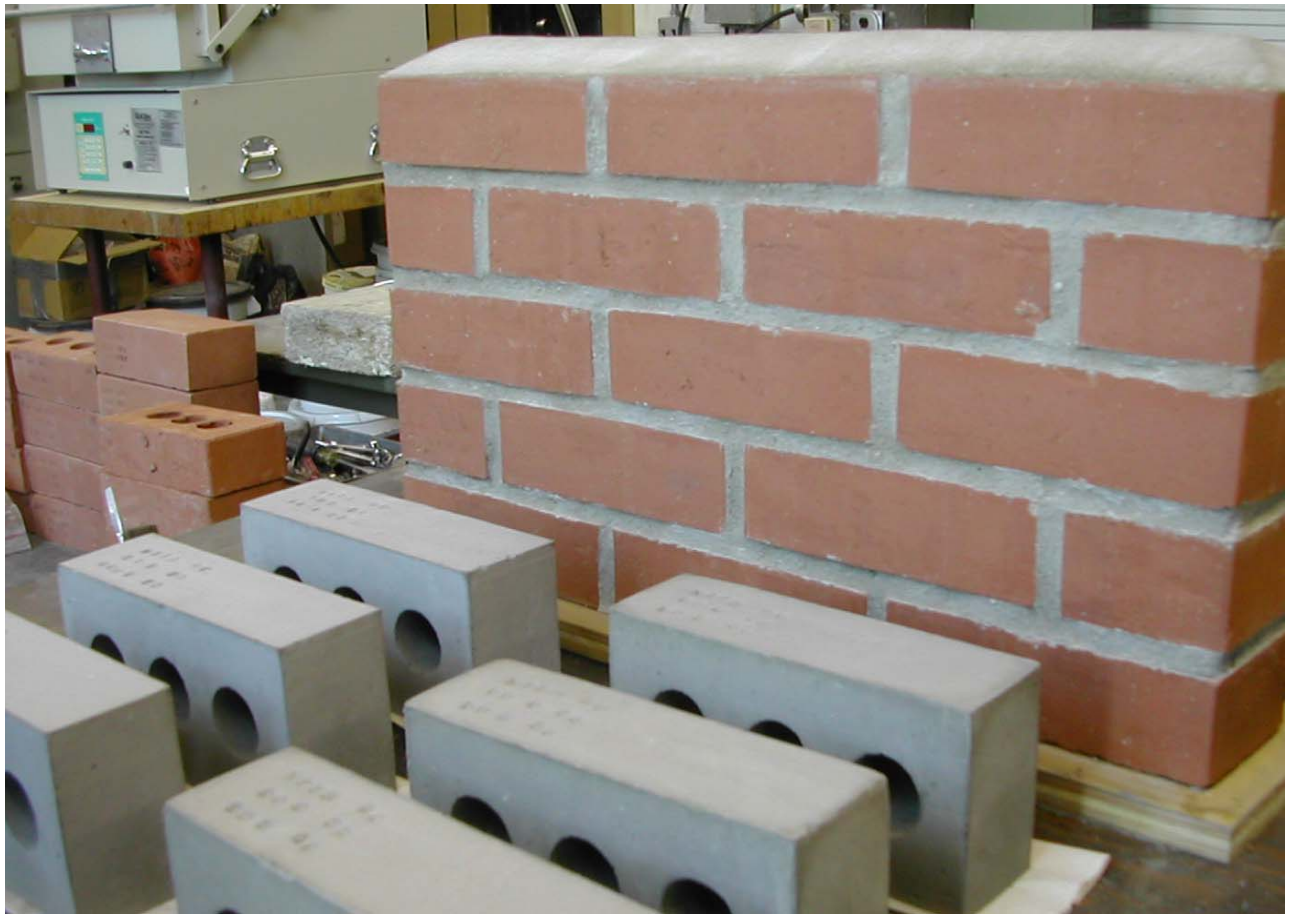
Firing

- Scumming
- Lime pops
- Black cores
- Bloating

Pilot Plant Tests

Successful firing of green bricks, containing 40 wt % fly ash, produced from a pilot plant test run

Pilot Plant Tests



Test wall built using fired bricks from pilot plant production

Commercial Production

ISGS/UIUC Commercial Production Project (2002-2003)

Using a beehive kiln

- Performed 5,000-brick production test
- Performed 10,000-brick production tests

Using a tunnel kiln

- Performed 2,800-brick production tests

Continued market and economic analyses

Commercial-Scale Tests

Commercial-scale extrusion test run producing three-hole green bricks

Commercial-Scale Tests

Regular commercial bricks with no fly ash

Three-hole building bricks with 40 vol% fly ash

- 5,000 bricks per batch fired in a beehive kiln

Commercial-Scale Tests

Ten-hole building bricks with 20 wt% fly ash

- 1,400 bricks per batch fired in a tunnel kiln

Commercial-Scale Tests

Compressive strength and water absorption properties of commercial-size test bricks made with ponded Illinois coal fly ash, Fly ash-2

			Pilot plant 3-hole-brick production test	Commercial-scale 3-hole-brick production test
Engineering properties		ASTM C 62 Standard Specification	Fly ash-2 : GCM mix 40 wt% : 60 wt%	Fly ash-2 : CBC shale : CBC clay 40 vol% : 40 vol% : 20 vol%
Max. water absorption	Cold water 24 hr (%)	# 8	6.20	6.50
	Boiling water 5 hr (%)	#17	8.50	9.10
	Saturation coefficient	#0.78	0.73	0.71
Fired compressive strength (psi)		3,000	12,930	15,770
ASTM grade		SW	SW	SW

GCM mix = Global Clay Marseilles' Mix at 60 wt% shale and 40 wt% clay; CBC = Colonial Brick Company; and SW= severe weather application

Potential Production Cost Saving Estimation: A Case Study

Based on the current mining and processing costs for the conventional raw materials, the cost of obtaining fly ash from a nearby available source, and the production cost of manufacturing fired bricks with 40 wt% fly ash:

- *Case I*, producing 12 million bricks per year and obtaining fly ash at $3.25/ton, could realize an annual production cost savings of $47,650

- *Case II*, producing 27million bricks per year and obtaining fly ash at $5/ton, could realize an annual production cost savings of $12,891

Summary

Process

- Uses conventional equipment
- Is potentially more energy efficient and less expensive

Product

- Produced with 20 wt% to 40 wt% fly ash from two Illinois sources
- Properties met or exceeded commercial specifications

Optimization

- Relies on the source and properties of the fly ash and the operation parameters of a specific brick plant

Recommendations and Further Work

- Since quality of the bricks produced with fly ash relies on the source and properties of the fly ash and the operation parameters of a specific brick plant, feasibility evaluation should be conducted on a case-by-case basis.
- ISGS/UIUC-developed fly ash brick process is nearly ready for commercialization at some brick plants. The ISGS/UIUC will continuously make its facility and expertise available to assist in advancing the fly ash brick-making process to commercial status.

An Illinois coal fly ash brick wall on display
at the Chicago Museum of Science and Industry

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