

# “Use of Fly Ash to Make Bricks”

## Questions & Answers

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### 1. What is fly ash?

Fly ash is the ash removed from the exhaust gas of burning coal at power plants to generate electricity. The ash is removed from the exhaust by air pollution control equipment such as electrostatic precipitators before the exhaust is emitted through stacks or chimneys into the atmosphere. Thus, fly ash is a byproduct of burning coal for heating or generation of electricity.

### 2. Is fly ash utilized? If so, how much?

Over 70 million tons of fly ash is generated each year in the United States, of which only about 1/3 is used. The remaining 2/3 must be carefully disposed of in order to avoid any damage to the environment. Consequently, fly ash is regarded by the public as a solid waste material, though it is increasingly being used for various beneficial purposes.

### 3. What is fly ash used for usually?

Fly ash has been used in a number of applications. A major use is as an ingredient in making concrete, to substitute for a portion of the cement or aggregates used in the concrete. Another beneficial use is for strengthening road beds. Thirdly, fly ash serves as part of the raw materials for manufacturing cement. It has also been used in many other ways including soil stabilization (for improving the foundation of structures), soil improvement (for improving crop growth), etc.

### 4. Is fly ash a hazardous waste?

**No!** The guardian angel of the nation’s environment – the U.S. Environmental Protection Agency (EPA) – classifies fly ash as “*non-hazardous*.” Fly ash deserves such a classification for good reasons, one of which is that numerous scientific studies have found that fly ash does not cause water pollution. Because fly ash is usually basic rather than acidic, it does not leach out pollutants when immersed in water. Furthermore, fly ash has been used for more than a century in many countries; yet it has not generated any public health problem or even occupational health problem for those using and handling fly ash.

### 5. Should fly ash be handled carefully?

**Absolutely!** Before mixing with water, fly ash exists in powder form. All powder materials must be handled with care. Otherwise, they can easily be

suspended into air and cause air pollution in the form of particulates. All powders in air can cause eye irritation and breathing problems, especially if the powder concentration in air is high and/or there is prolonged exposure to the powder.

**6. Is fly ash powder worse than other kinds of powder that pollute air?**

**No!** Fly ash is less of a problem than most other powders including coal dust or road dust for a good reason. Most fly ash particles are tiny spheres rather than sharp-edged particles. When inhaled or in contact with eye, round particles can easily be expelled from lung and washed out from eye, causing less damage than sharp-edged particles do. Still, when handling or transporting fly ash powder, care must be exercised to minimize air pollution and human exposure to air containing fly ash.

**7. Can fly ash be used for making bricks and/or blocks? How?**

**Yes!** Fly ash can be utilized to make bricks and blocks in one of several ways:

- (a) To substitute for a portion of the cement and/or aggregates in making concrete bricks and blocks. This is a common use nowadays.
- (b) To substitute for a portion of the clay used in making clay bricks. This uses the same process for making clay bricks, requiring heating the adobes (green bricks) in kilns to more than 2,000 °F, which consumes much fossil fuel and generates air pollutants and carbon dioxides due to the combustion of the fossil fuel.
- (c) To substitute for all the clay used in making clay bricks, using the same process for making clay bricks which requires burning fossil fuel to heat adobes in kilns at over 2,000 °F . This uses the same process and has the same drawback of (b) except that 100% fly ash is used in making bricks.
- (d) *Use 100% fly ash to make bricks without heating adobes in kilns.* This room-temperature process to make fly ash bricks is the focus of the remaining questions and answers. **Henceforth, when mentioning “fly ash brick”, it means the 100% fly ash brick made at room temperature without binder.**

**8. How can fly ash be made into bricks at room temperature? Does it require the use of any binder?**

For fly ash that contains a large amount of calcium (e.g., Class C fly ash), the fly ash is *cementitious*<sup>1</sup> in nature, and no binder is required to make bricks or blocks at room temperature using such fly ash. However, for fly ash that is low in calcium (e.g., Class F fly ash), the fly ash is not cementitious. It consists of mostly inert materials that don't react chemically with water. In this case, it is necessary to add certain binder before bricks can be made at room temperature. Therefore, it is much easier and less costly to make fly ash brick using the room-temperature process if the fly ash is Class C rather than Class F.

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<sup>1</sup> “Cementitious” means that the fly ash reacts chemically with water in the same way that Portland cement does with water.

### 9. Where can Class C fly ash be found for making bricks?

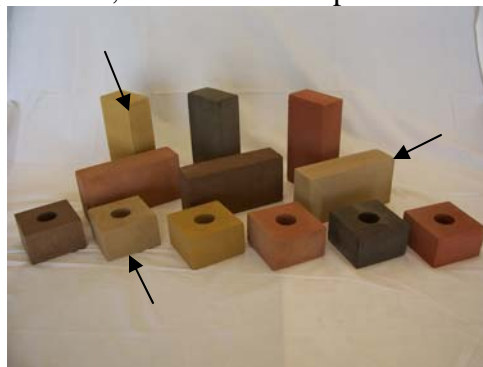
In the United States, approximated 50% of the fly ash is Class C. The Class C ash is generated by burning Western coals, usually subbituminous or lignite. For instance, the largest coal source and reserve in the United States – Powder River Basin Coals – produce Class C fly ash. For bituminous coals produced in Eastern states, they normally produce Class F fly ash. However, if such coals are burned with limestone in fluidized boilers in order to remove the sulfur in the coals, they produce fly ash of high calcium content. Therefore, there is plenty of high-calcium fly ash in the United States for making fly ash bricks, more so in the Western states than Eastern states.

### 10. What is the uniqueness of the fly ash brick made from the process (method) developed by the Freight Pipeline Company (FPC)?

Many individuals and organizations, including the University of Missouri-Columbia, have made and tested 100% fly ash bricks at room temperature. Though they succeeded in making bricks of good strength, the freeze-thaw resistance of the fly ash bricks made was unacceptable. The bricks made were unable to pass more than 10 cycles of the freeze-thaw test in laboratory, whereas the ASTM Standard C62 requires building bricks to pass a minimum of 50 cycles. Without passing the ASTM freeze-thaw test, the fly ash brick could not be used in most parts of the United States, where it freezes in winter. ***It was not until 2004 when a breakthrough occurred that solved the problem.*** The breakthrough was a result of extensive testing by FPC under an SBIR Phase II grant of the National Science Foundation (NSF). Upon trying 9 different methods to enhance the freeze-thaw resistance of fly ash bricks, an effective method was developed to make the fly ash brick freeze-thaw resistant. By using this method to produce fly ash bricks at room temperature and without binder, the brick can now pass the 50-cycle ASTM freeze-thaw test routinely, often being able to pass more than 100 cycles without damage.

### 11. Can the fly ash brick be made in colors and different shapes?

**Yes!** The natural color of fly ash bricks made of low-carbon fly ash is a pleasing buff color—see the arrows in the photo below pointing to such bricks. For fly ash bricks made of high carbon fly ash, the brick is gray or dark grey, which is also pleasing. Furthermore, by adding a small amount of color pigment, fly ash bricks of different colors can be produced, as shown in the photo below.



**Figure 1. Assorted fly ash bricks of different colors made at FPC.**

## 12. What advantages does the fly ash brick offer over conventional bricks?

The fly ash bricks have the following advantages:

- **Cost less to produce** – at least 10% less than concrete bricks and 20% less than clay bricks. Details on cost will be addressed later in this document.
- **Save construction cost** – Due to the uniform shape and size of the fly ash brick, it saves labor in laying bricks by about 15%. This translates into an estimated 7 cents reduction in labor cost in laying each brick, which is quite substantial.
- **Use less energy** – Much energy is consumed in heating clay bricks in kilns. By using fly ash bricks instead of clay bricks, much energy is saved in brick manufacturing. Details on energy saving will be addressed later in this document.
- **Reduce air pollution** – Much fossil fuel is used in heating clay bricks in kilns. Burning such fuel generates air pollution and greenhouse gas (CO<sub>2</sub>), contributing to global warming. By manufacturing fly ash bricks (at room temperature) instead of clay bricks (at over 2,000 °F), emission of air pollutants and greenhouse gas is avoided at brick plants, which helps to reduce air pollution and global warming. More on the environmental benefits will be addressed later in this document.
- **Cleans indoor air** – Recent research has shown that by using fly ash bricks indoors, the bricks adsorb mercury from the indoor air, causing the indoor air to be cleaner than the outdoor air.

Due to the foregoing, the fly ash brick is not only a low-cost, high-quality brick, it is also the “*Green brick*” of the future. Widespread use of the Green brick in the future would contribute not only to lower construction cost for housing but also to a cleaner and healthier environment.

## 13. Has the fly ash brick technology received recognitions for its merit?

**Yes!** The fly ash brick technology was first presented in 2005 at the World of Coal Ash Conference, which is the largest and most prestigious international conference on coal ash. The paper won the Barton A. Thomas Memorial Award at the Conference. Then, in 2006, the fly ash brick technology was selected as one of 25 Semifinalists (out of more than 4,000 inventions considered) in an Invention Contest sponsored by the History Channel and Inventors Hall of Fame. As a result of the selection, in 2006 samples of the fly ash brick were exhibited free-of-charge in five major museums in the U.S., and in the International Exhibition Center in Shanghai, China. Stories about the fly ash brick invention was also covered in an Associated Press article, published in many newspapers, and in professional publications such as the ASCE News. In 2007, the POPULAR SCIENCE MAGAZINE selected the “*Green Brick*,” as one of 10 Award Winning inventions featured in the June 2007 Issue of the Magazine. Also, in May 2007 the National Science Foundation issued a news release entitled “*Follow the Green Brick Road*,” announcing the important discovery by FPC that the fly ash brick adsorbs mercury from air, instead of emitting mercury into air, a discovery that has strong implications not only to fly ash bricks but also to other fly-ash-made products. It is welcoming news for those who deal with coal ash products,

though no test has been done to date to prove that what works for fly ash bricks also works for other fly ash or coal ash products.

**14. When will the fly ash brick technology be ready for commercial use?**

The fly ash brick technology is ***now*** ready for commercial use, though R & D is continuing at FPC to further perfect the technology. For most technologies, R&D continues after the technologies are already in use. For instance, cars have been tested and used for over a century, yet R&D continues today by industry to improve and come out with better cars. The same holds for durable fly ash bricks. Research will continue even after the technology is used commercially.

**15. Does FPC plan to manufacture the fly ash brick?**

**No!** FPC being a small business does not have the resources to manufacture bricks for commercial use. The Company plans to license the technology to current clay brick manufacturers and concrete brick & block manufacturers for their use. They can easily build new plants or convert old clay-brick or concrete brick facilities to manufacture fly ash bricks. Two licensing policies have been developed by FPC, one for domestic (U.S.) licensees for use in the U.S., and the other for oversea (international) licensees for use in other nations. Companies interested in acquiring a license to manufacture the fly ash brick should contact Dr. Henry Liu, President, FPC, 2601 Maguire Blvd, Columbia, MO 65201, Phone: 573-442-0080; E-mail: fpc\_liuh@yahoo.com.

**16. Is there a patent to protect the IP rights of FPC on the fly ash brick technology?**

**Yes!** FPC has applied for a U.S. patent, a PCT (Patent Cooperation Treaty) patent, and a Chinese Patent. More patents of other nations will be filed in the near future. The existing pending patents are listed in Table 1 below.

**Table 1. Patents on durable fly ash bricks filed by FPC as of 20 June, 2007.**

Patent Type	Title	Appl.ic. No.	Applic. Date	Status
U.S. Non-Provisional	Method to Produce Durable Non-Vitrified Fly Ash Bricks and Blocks	11/307023	1/19/06	Pending
PCT (Patent Cooperation Treaty)	Same as above	PCT/US2006/006314	2/22/06	Pending
Chinese	Same as above	200680000117.3	9/22/06	Pending

***Note: While FPC welcomes users of this fly ash brick technology to obtain a license from FPC for use of this technology, the Company will aggressively protect its IP rights and bring legal actions against any party who infringes on these pending patents and proprietary information. Licensees will be given proprietary information needed for successful use of the technology to produce fly ash bricks.***

**17. Are the aforementioned patent applications limited to making bricks only?**

**No!** All those patent applications are for a common process or method that can make bricks and similar products, including but not limited to bricks, blocks, architectural stones, tiles, and similar products that can be made by the same products. The patents broadly define “bricks” as being any of such products.

**18. Does FPC have anything other than patents to protect its IP rights?**

**Yes,** as it is with all private companies dealing with R&D, FPC has a large body of proprietary information (unpublished technical information, test data, and trade secrets that do not exist in the aforementioned pending patents, and that have been kept confidential to protect FPC’s rightful interests in this technology.

**19. Has FPC applied for a U.S. trademark for the durable fly ash bricks produced by the process described in the patent applications listed in Table 1? If so, what is it?**

**Yes,** FPC has applied for a U.S. trademark, “*Greenest Brick*”, for this new product. The term “*Greenest Brick*” is derived from the fact that there are other fly ash bricks that are made of fly ash and are *Green* (environmentally friendly). However, since these other fly ash bricks either require the use of cement or lime in addition to fly ash, or require burning fossil fuel in kilns, they are not as *Green* as the bricks developed by FPC, which use 100% fly ash (no cement or lime), and which does not require burning fossil fuel in kilns which generates pollutants and greenhouse gas. Therefore, this is the *Greenest* type of fly ash brick, deserving the trademark name “*Greenest Bricks*”.

**20. Who sponsored the research on durable fly ash bricks or “Greenest Bricks”?**

We appreciate the sponsorship of the R&D by the **National Science Foundation (NSF)**<sup>2</sup>, which has made it possible for the development of this innovative new fly ash brick technology.

**21. How can I obtain a license from FPC to manufacture the fly ash bricks?**

Any company or individual wanting to apply for a license from FPC for manufacturing *Greenest Bricks* should indicate so in an e-mail to:

Dr. Henry Liu, President  
 Freight Pipeline Company  
 Email : fpc\_liuh@yahoo.com.  
 Phone: 573-442-0080

Upon receiving the e-mail request, FPC will send the inquirer two documents:  
 (a) “FPC Policy on Licensing Fly Ash Brick Technology to U.S. Users.”  
 (b) “Application for a License to Manufacture Fly Ash Bricks in U.S.A.”.

**22. Is there evidence on the cost-effectiveness of manufacturing fly ash bricks?**

**You bet!** In August 2007, FPC conducted a detailed and rigorous cost analysis of a fly ash brick factory designed for construction in Missouri in 2008. The factory is to

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<sup>2</sup> NSF-SBIR Phase II project entitled “Compacting Fly Ash to Make Bricks,” NSF Grant No. 0548719.

be located at a major coal-fired power plant that uses Powder River Basin Coal from Wyoming, and that generates approximately 100,000 (one hundred thousand) tons of high-grade Class C fly ash each year. The fly ash is sufficient to make 45 million bricks a year. Based on a life cycle cost analysis that includes all capital costs items and all operation/maintenance (O/M) cost items, taxes, insurance, depreciation (over 20 years), and return-on-investment (ROI) of 15%, it was found that the total capital cost for the factory is \$6.4 million for fly ash bricks made in their natural color, and \$6.7 million for fly ash brick with artificial color. The total annual O/M cost is \$4.4 million and \$5.7 million, respectively for natural-color and artificial-color fly ash bricks containing 1% color (based on the dry weight of fly ash). The unit cost (i.e., the cost for producing each thousand of fly ash bricks) is \$130 per thousand fly ash bricks of natural color, and \$160 per thousand fly ash bricks containing 1% artificial color. In contrast, the wholesale price of clay bricks of the same size and same quality as that of the fly ash bricks is approximately \$400 per thousand bricks. What this means is that even if we were able to sell the fly ash bricks at only half of the price of clay bricks of the same size and quality, we should be able to earn a 15% annual profit (ROI) in manufacturing the fly ash bricks. This shows the highly competitive nature of the fly ash brick over clay bricks in terms of cost.

**23. Any evidence on the energy efficiency of manufacturing fly ash bricks?**

Yes sir! (or Yes madam!). From a study conducted in July 2007, entitled “Energy in Making Bricks: A comparison between Clay Bricks and Flyash Bricks,” it was found that great saving of energy can be accomplished by manufacturing fly ash bricks instead clay bricks, due mainly to the elimination of the kiln firing process needed for manufacturing clay bricks, which is very energy intensive. This study found that steam curing of fly ash bricks uses only about 5% of the energy used in kiln firing of clay bricks. Consequently, while the energy cost of flyash bricks is only about \$5 per thousand bricks, the energy cost of clay bricks is more than \$60 per thousand bricks. This means the saving that can be achieved from energy conservation by making fly ash bricks instead of clay bricks is about \$60 per thousand bricks, or 6 cents per brick.

**24. Any evidence on the environmental benefits of fly ash bricks?**

Certainly! From a study conducted in July 2007, entitled “Environmental Benefits of Greenest Bricks,” manufacturing each ton of fly ash bricks instead of clay bricks will reduce emission of carbon dioxide – the major greenhouse gas -- by 0.0434 ton. If in the future fly ash bricks can replace 50% clay bricks in the U.S., there will be a reduction of clay bricks use in the U.S. by 10 million tons each year, which will reduce the emission of greenhouse gas (carbon dioxide) by 435,000 tons each year, equivalent to removing 400,000 cars from road. Furthermore, it will reduce total air pollutants (CO, NOx, SOx, particulate matters, and volatile organic compounds) by an amount equivalent to 920 million vehicle miles of truck use.

**25. How can I get further information on Greenest Bricks?**

Contact Henry Liu at the e-mail address or phone number listed on page 1.