ASH UTILIZATION– PORCELAIN GRADE CERAMICS

Low-Quality Fly Ash Transformed Into High-Quality Floor Tiles

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High-quality porcelain grade ceramics from coal ash can now be produced using Ceramext technology. A wide variety of fly ash has been successfully used for production, including ash not suitable for concrete production.

Several thousand square feet of tile that have been successfully produced in pilot plants using Ceramext patented and patent pending technologies have been installed in commercial and residential buildings. The strength of this tile exceeds the strength of typical commercial Italian porcelain.

TYPES OF ASH USED

More than 40 types of power plant fly ash have been successfully tested including anthracite, bituminous, lignite and biomass ash, which can make high quality ceramics generally using 100 percent ash. No binders are required. All ashes can be mixed with other ashes or other fine particle wastes such as most mine tailings and quarry fines.

Class C fly ash can be used for producing Ceramext products as well as Class F. With Class C fly ash, the self-cementing properties are often helpful in producing a stable green product prior to firing. The higher alkali contents often contribute to the necessary glass part of the composition at relatively lower temperatures. Class C fly ash often has higher sulfate contents. Using a new patented technology held by Ceramext, LLC, sulfur in the waste materials typically oxidizes and combines with calcium oxide to form anhydrite. Anhydrite cannot react with water to become softer, unstable gypsum since the stable glassy matrix prevents water from reaching the anhydrite. Almost all potential waste materials tested to date have at least trace amounts of sulfur, with some materials having several percent sulfur that typically react to form anhydrite. The Ceramext® technology thus renders the sulfur in the waste materials inert by essentially locking the contaminant within a stable glassy matrix in the tile. The technology has been used to make strong ceramic products from coal fly ash containing in excess of 20 percent gypsum.

Fly ash that does not qualify for concrete production because of excessive LOI or particle size can be used with Ceramext technology. The unburned carbon in the fly ash is oxidized at about 750 to 800 C for a few minutes prior to hot forging at higher temperatures. If mercury is present with the unburned carbon, it will volatize at firing temperatures and may have to be collected in conventional retorts or carbon filters; however, the amount of total gaseous emissions and temperatures will be much less than the initial firing at the coal power plant. Particle size, critical for cement use, is not a problem for Ceramext® technology, even for larger ash particles of 200um. Ash color is not a problem and generally changes upon firing at production temperatures.

PRODUCTION OF CERAMICS FROM FLY ASH

Pilot plant production to date has primarily been with floor tile, roof tile and wall cladding. The green unfired tile is generally heated to about 750 to 800 C to oxidize unburned carbon. It is then raised to higher temperatures and hot forged in cold dies and then run through an annealing kiln. Then it can be polished, glazed, or left in its existing state, which is preferred by many architects for its visual qualities.

Tile made with this new technology have among the highest breaking strengths for commercial tiles and are essentially impermeable to water, even without glazing. Sulfur and many other contaminants can be rendered inert by locking them within a stable glassy matrix in the tile. The tile can also have the appearance of a variety of natural rock surfaces and can be polished or glazed if desired. Products made of this new composition can include floor, wall and roof tile; building cladding; brick and pavers; and other ceramic products.

The micro-fabric of this new composition provides for a high-strength tile while eliminating undesirable materials from the waste stream. The composition consists of some of the original partly melted fly ash or waste rock fragments (called clasts); glass melted from the clasts; and crystallites formed in the new glass. The strength of the material is increased by using pressure while the material is hot but below the melting point.

The unmelted clasts act much like the aggregate in concrete, with the newly formed glass as the cement binder holding the clasts together and the crystallites further reinforcing the glass itself. Since there is essentially a continuation from the clasts to the glass, there is no significant porosity to contribute to breakage, the release of contaminants from the composition, or the contamination of the composition by external liquids such as water. Initial studies indicate that the technology can enable certain potential

contaminants such as arsenic and lead to be locked up and rendered inert within a stable glassy matrix in the tile.

Actual production costs are still being evaluated; preliminary estimates are that energy costs will be significantly less than conventional ceramic production costs. With a worldwide emphasis to reduce energy consumption and rising energy costs, this should become an even more attractive aspect of the Ceramext technology. Obtaining high-quality clay material to process conventional ceramic tile is costly. A distinct advantage of the Ceramext technology is that it can be situated adjacent to an existing source of waste material that will have a very low or even a negative cost. A modern, fully automated ceramic factory using the Ceramext technology is expected to have capital costs less than a conventional ceramic tile factory.

PRODUCT QUALITY

Many natural rock-type appearances are possible, including rough, polished or honed. Glazing is optional, but can be useful with applications such as cool roof coatings. With a breaking strength of about 1,000 psi and a MOR of about 10,000 psi, the strength of the tile exceeds the strength of typical commercial Italian porcelain.

The tile is essentially impermeable (0.1 to 0.2 percent water absorption), and no sealants are required. The tile also features facial size control of ± 0.03 percent (without grinding) for normal commercial installations, thereby allowing narrow grout joints and precise layouts. In addition, it includes up to 100 percent recycled content and is eligible for LEED credits.

The technology is expected to produce quality ceramic products suitable for marketing at competitive prices. Porcelain-grade floor and wall tile has been produced with a range of earth tone colors. Tile of various colors including white, black, beige and subtle greens can be produced with no additives; the tile color depends on the specific type of fly ash being used. Mineral additives can produce many combinations of natural stone appearances and textures. Glazes in multiple colors can be applied, if desired, and relief designs can also be made.

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Pavers and landscape stones made using this technology are essentially impervious to water and thus well suited for outdoor use. They are very unlikely to absorb water that might cause them to freeze, crack or break. Roofing and siding tile produced with the technology are typically stronger and lighter than conventional cement and standard glazed ceramic roofing or siding tile. The tile also has desirable freeze-thaw qualities. ❖