First Commercial Installation Utilizing PMET Structural Product Technology

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BACKGROUND  
Pittsburgh Mineral & Environmental Technology (PMET) has developed technology to produce strong, environmentally safe, green structural products from a variety of waste materials. Key aspects of the technology are: economy of production, environmentally benign products and process, very high utilization of the by-product in the mix, adaptable to a wide variety of feed materials.

Typical mixes utilize ~90% of the target by-product material. Feed sources studied include, coal combustion fly and bottom ash, Municipal solid waste ash, copper mining wastes, rock quarry fines, red mud from alumina refining and many others.

The PMET process to produce structural products from these various waste streams is the subject of US Patents 6,068,803 and 8,361,374 and additional proprietary technology for which additional patent applications are planned.

PMET maintains a lab facility that is capable of evaluating various feed materials and mix designs for potential licensees of the technology.

THE PROCESS  
In the BRIXX manufacturing process, a mix containing one or more industrial waste materials, a calcium oxide or calcium hydroxide based mineral binder and water is blended, compacted to shape, and hydrothermally cured in an autoclave to produce attractive, strong, weather resistant building products.

The process:
  
  Is extremely energy efficient consuming only 10-30% of the energy consumed in the traditional manufacture of bricks and pavers.

  Involves a chemical reaction during the autoclaving process that produces a continuous crystalline matrix of hydrated calcium silicate (Tobermorite) which surrounds and encases each contained particle and prevents leaching of any contained heavy metals into the environment.

  Produces minimal sulfur oxides, carbon dioxide, carbon monoxide, nitrogen oxides, methane, ethane or volatile organic emissions in comparison with the manufacture of gas fired kiln clay bricks.
Does not generate any secondary solid, liquid, or gaseous waste streams.

Is capable of recycling 100% of any “off spec” products back into the production process.

All required equipment is commercially available.

Products can be shipped immediately-No costly time consuming curing.

Environmentally safe brixx products, including face brick, veneer brick, and pavers have been produced in a variety of colors and configurations using any one or a mixture of the aforementioned materials. An initial review by The Institute of Market Transformation to Sustainability has indicated that the Brixx Production Technology will at the very least qualify for the Gold Sustainable Materials Rating Technology (SMART) standard.
Indian Plant Feed Mineral Analysis

Mineral Analysis of Feed Ash
Quantitative XRD Analysis with Rietveld Refinement

<table>
<thead>
<tr>
<th></th>
<th>NBEIL 1</th>
<th>NBEIL 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Bottom Ash</td>
<td>Fly Ash</td>
</tr>
<tr>
<td>quartz</td>
<td>SiO2</td>
<td>35.1</td>
</tr>
<tr>
<td>muscovite</td>
<td>KAl2(Si3Al)O10(OH)2</td>
<td>2.1</td>
</tr>
<tr>
<td>mullite</td>
<td>Al6Si2O13</td>
<td>6.3</td>
</tr>
<tr>
<td>lime</td>
<td>CaO</td>
<td>0.5</td>
</tr>
<tr>
<td>anhydrite</td>
<td>CaSO4</td>
<td>0.8</td>
</tr>
<tr>
<td>dolomite</td>
<td>CaMg(CO3)2</td>
<td>0.5</td>
</tr>
<tr>
<td>hematite</td>
<td>Fe2O3</td>
<td>0.4</td>
</tr>
<tr>
<td>magnetite</td>
<td>Fe3O4</td>
<td>0.9</td>
</tr>
<tr>
<td>rutile</td>
<td>TiO2</td>
<td>1.3</td>
</tr>
<tr>
<td>carbon</td>
<td>C</td>
<td>1.7</td>
</tr>
<tr>
<td>amorphous</td>
<td></td>
<td>50.5</td>
</tr>
</tbody>
</table>

Key observations regarding this material are:

There is approximately 50% amorphous material in both materials,

There are no unreacted magnesium compounds that may present a swelling issue in curing,

There is a very low amount of unburned carbon present. Unburned carbon tends to detract from the strength of the final product,

There is a low amount of iron compounds that would otherwise discolor the product.

Product Strengths
Mixes containing 12 wt% hydrated lime with ash mixes varying from equal amounts of fly and bottom ash to 25% bottom ash and 75% fly ash yielded compressive strengths ranging from 5500 psi to 7000 psi.
Mineral Analysis of Cured Brixx
Quantitative XRD Analysis with Rietveld Refinement

<table>
<thead>
<tr>
<th>Mineral</th>
<th>Formula</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>quartz</td>
<td>SiO2</td>
<td>34.2</td>
</tr>
<tr>
<td>mullite</td>
<td>Al6Si2O13</td>
<td>5.2</td>
</tr>
<tr>
<td>katoite</td>
<td>Ca3Al2(OH)12</td>
<td>4.8</td>
</tr>
<tr>
<td>tobermorite</td>
<td>Ca2.25(Si3O7.5(OH)1.5(H2O)</td>
<td>4.6</td>
</tr>
<tr>
<td>larnite</td>
<td>Ca2(SiO4)</td>
<td>2.4</td>
</tr>
<tr>
<td>muscovite</td>
<td>KAl3Si3O10(OH)2</td>
<td>2.4</td>
</tr>
<tr>
<td>calcite</td>
<td>CaCO3</td>
<td>2.0</td>
</tr>
<tr>
<td>anhydrite</td>
<td>CaSO4</td>
<td>1.8</td>
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<tr>
<td>hematite</td>
<td>Fe2O3</td>
<td>1.0</td>
</tr>
<tr>
<td>magnesioferrite</td>
<td>MgFe2O4</td>
<td>0.7</td>
</tr>
<tr>
<td>brucite</td>
<td>Mg(OH)2</td>
<td>0.6</td>
</tr>
<tr>
<td>rutile</td>
<td>TiO2</td>
<td>0.4</td>
</tr>
<tr>
<td>amorphous</td>
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<td>40.0</td>
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</table>

During curing (autoclaving) a portion of the fine silica minerals dissolve and reacts with the lime to form tobermorite. This is a hydrated calcium silicate compound that forms crystals that coat each particle as well as bond the individual particles together in a crystalline matrix. A second calcium aluminum hydroxide sometimes also forms if sufficient aluminum is present and this also contributes to the bonding/strengthening reaction during curing.

These reactions are obvious by comparing the mineralogy of the feed material against the product mineralogy.

Curing Conditions

Curing is carried out in an autoclave using saturated steam at 190-200 C. The green products must be held a temperature for a 6 hour period.

FIRST COMMERCIAL PLANT

Our first licensee is Nava Bharat Ventures Limited, with main offices in Hyderabad, India. They designed, sourced and/or built substantially all of the required plant. The actual plant is located adjacent to a modern circulating fluid bed electric utility they own in Paloncha, India. Ash is pneumatically conveyed from the plant to the Ash Product Plant.
The plant was constructed in 2017, with start up in late 2017 and commercial operations in 2018.

The plant has a design capacity of approximately 400 tonnes per day and is highly automated. There is no direct human interaction required from delivery of the feed materials to the mixing, pressing, and stacking operations.

Green products are automatically stacked on cars that can be shuttled to one of four autoclaves. On completion of curing, the cars exit the autoclaves on the opposite end to be stacked in an adjacent storage yard for delivery to customers.

The images that follow walk the reader thru the plant from feed silos to product storage.
INSIDE VIEW

SWITCH GEAR, OFFICE & LABORATORY
RAW MATERIAL STOCKING SILOS

OVERVIEW OF MIX MATERIAL CONVEYING SYSTEM
PRESS AND STACKER

STACKER HOLDING GREEN BRICKS
STACKING OF PAVERS ON CURING CARS

GREEN PRODUCTS INTO AUTOCLAVE
PULLING OF FINISHED PRODUCT CARS FROM AUTOCLAVE

FINISHED PRODUCT YARD
SHIFTING OF BRICKS WITH FORK LIFT

PLACING OF BRICKS INTO THE TRUCK
PRODUCT USE APPLICATIONS
The products have found usage in traditional applications, such as face brick for the construction of apartment complexes, pavers, and in retaining walls. Some examples follow.

APP BRICKS – SECURITY ROOM AT ASH PRODUCT PLANT

APP BRICKS – FOR WORK SHOPS
APP BRICKS – INDOOR SHUTTLE COURT & RECREATION CLUB

APP BRICKS – RETAINING WALLS CONSTRUCTION
APP BRICKS – CONSTRUCTION OF RESIDENTIAL BUILDINGS
APP BRICKS – DIVIDER ON HIGHWAYS
APP PAVERS – PAVING FOR DRIVEWAYS

APP PAVERS – PAVING FOR ROADS
APP PAVERS – FOR SIDE SLOPES
CONCLUSION

In summary, after years of development, the PMET BRIXX technology is finally in commercial use at a modern plant in Paloncha, Terlangana, India. The plant specific mix development work performed at PMET scaled up to production performance.

The PMET technology is available for licensing at other locations and can be adapted to other feed materials as the market situation demands. PMET is actively seeking licensees worldwide.

ACKNOWLEDGEMENT:

All photos provided by Nava Bharat Ventures Limited, Hyderabad, India