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Production of Construction Materials Using Advanced Recycling Technologies

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EMERGING CONSTRUCTION TECHNOLOGIES

Other Technologies – Recycling

Production of Construction Materials Using Advanced Recycling Technologies

The Need

The need for recycling and recovering materials on the construction industry is more important than ever. Over the past few years, the construction industry faces recycling challenges on a large scale every day. Increasingly, contractors are finding innovative ways to work with environmental protection groups, local authorities and other businesses to recycle materials, rehabilitate contaminated areas, and preserve wetlands and other habitats for wildlife as well as people. With an estimated over 30 percent of landfill content originating from construction and demolition projects, vigorous construction activity has put an enormous burden on landfills. Municipalities facing diminishing landfill space are forced to raise tipping fees and promote alternative methods to handle waste removal-mainly to reduce, reuse and recycle. Thus, the construction industry is becoming a greater force in propagating recycling efforts on a national level.

The Technology

"Green" construction which includes economic, technical, and environmental issues related to recycling loop rest on four categories; waste reduction, material reuse, material recycling, and use of recycle-content products. Waste reduction, material reuse, and use of recycle-content products can be focused on the management system somewhat. In contrast, material recycling is the technical issue how to create new materials using wastes. Thus, three advanced recycling technologies; 1) Synthetic Lightweight Aggregate technology (SLA), 2) Clean Coal Technology (CCT), and 3) RP-1 Polymer Identification System are introduced.

Synthetic Lightweight Aggregate tech-nology (SLA)

SLA was manufactured from two materials, waste plastics, and fly ash, though disposal facilities. SLA was being developed and evaluated for use in construction applications such as geotechinical lightweight fill, concrete masonry blocks, and lightweight concrete structures. SLA was produced by melt compounding high concentrations of fly ash from coal with various thermoplastics. The compounding equipment used in this

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step, was a 30-mm Werner-Pfliederer inter-meshing; counter rotating twin-screw extruder (Figure 1) with a medium/high shear profile screw configuration.

FIGURE 1 TWIN-EXTRUDER (COURTESY OF GEI CONSULTANTS INC.)

The Thermoplastic binder material was starve-fed into the feed section of the twin screw using a single screw auger feeder. The relative feeder outputs were adjusted to control the filler concentration. The extrudate produced was a flat strip about 50-mm wide and 9.5-mm thick. The melting temperature was slightly higher than normal temperature used for melting High Density Polyethylene (HDPE). After compounding and cooling, the extrudate was granulated to produce the SLA (Figure 2) using a conventional thermoplastic granulator equipped with appropriate size screen.

FIGURE 2 EXTRUDATES BEFORE AND AFTER GRANULATION (COURTESY OF GEI CONSULTANTS INC.)

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Clean Coal Technology (CCT)

The goal of the U.S. Department of Energy's (DOE) Clean Coal Technology (CCT) Program is to furnish the U.S. energy marketplace with a number of advanced, more efficient coal-based technologies meeting strict environmental standards. These technologies will mitigate the economic and environmental impediments that limit the full utilization of coal as a continuing viable energy resource. In the DOE report identified in the references below, three projects completed under the CCT Program; 1) Advanced Flue Gas Desulfurization (AFGD), 2) Innovative Applications for the CT-121 FGD Process, and 3) Milliken Clean Coal Technology were introduced. These three projects achieved more than 90% SO_2 removal, with SO_2 removals as high as 98% being demonstrated. High particulate removal efficiencies were also achieved. In addition, these processes demonstrated the capability of producing wallboard-quality gypsum, a marketable by-product. As a result of these projects, significant experience has been gained by U.S. suppliers of FGD systems and system components. This expertise includes operating techniques, equipment designs, and selection of materials of construction.

The Benefits

SLA

- The SLA can be produced from compounding coal fly ash and recycled waste plastics.
- The strength characteristics of the SLA indicate that they have the potential to be used as an alternative to natural or lightweight aggregate for geotechnical applications.
- The SLA is suitable for used as geotechnical fill, as well as in pre-cast or cast-in-place concrete
- The carbon content in the fly ash does not affect the production process.
- The compressive strengths including tension of concrete made with SLA improved significantly as the fly ash content of SLA increased.
- The SLA provides a considerable ductility as compared with concretes made with expanded clay or normal weight aggregates.

CCT

- These three CCT projects achieved high SO_2 removal efficiency, produced valuable gypsum byproduct, were easily maintained and economical to operate, and thus offer industry new technology choices to enable continued use of coal in an economical and environmentally sound manner.
- The three CCT projects demonstrated technology that produces wall-board-quality gypsum eliminating the sludge disposal problem common to conventional wet Flue Gas Desulfurization (FGD) processes

The new FGD technologies demonstrated in the three CCT projects, because of high levels of particulate removal, were very effective at removing hazardous air pollutants form flue gas.

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Figure 3 Loading FGD By-product Gypsum for Transport to Wallboard Plantt (Courtesy of U.S. Department of Energy)

Status

Synthetic Lightweight Aggregate technology (SLA)

For geotechincal applications, the SLAs were tested for gradation, specific gravity, bulk density, absorption, 1-D compression (consolidation), and triaxial compression properties. The SLA exhibited a very high friction angle, high compressive strength, and a higher compressibility than normal fill. Concrete made with SLA exhibited a lower compressive strength as compared with the control material. As fly ash contents of the SLA increased, all properties of the SLA concrete were improved. SLA concrete can satisfy the minimum strength of 179 kPa (2500 psi) required for structural lightweight concrete and non load-bearing concrete masonry units. The SLA concrete samples tested for compressive strength exhibited a low elastic modulus and a unique post cracking ductile behavior. The concrete samples made with the SLA that contained the maximum amount of fly ash 80% showed an excellent freeze-thaw salt scaling resistance, surpassing concrete made with both natural and lightweight aggregate.

Clean Coal Technology (CCT)

Advanced Flue Gas Desulfurization (AFGD) was demonstrated at Northern Indiana Public Service Company's Bailly Station, near Gary, Indiana. The project was conducted by Pure Air on the Lake, L.P., a company formed by the process developer, Pure Air, which is a partnership between Air Products and Chemicals, Inc. and Mitsubishi Heavy Industries America, Inc. The scrubber was of unique design, incorporating cocurrent flow of gas and liquid. Coal sulfur content varied between 2.3% and 4.5%, typical of high-sulfur bituminous coals. A total of 210,000 tons of high-quality gypsum was produced during the demonstration and sold to a wallboard manufacturer.
Innovative Applications for theCT-121 FGD Process was demonstrated at Georgia Power's Plant Yates, Newnan, Georgia, using a novel scrubber known as a Jet Bubbling Reactor®. This single process vessel replaces the usual spray tower/reaction tank/thickener arrangement. The fiberglass-reinforced plastic

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used as the construction material proved highly corrosion resistant. Coal sulfur content ranged from 1.2% to 4.3%. In addition to SO_2 removal, the system also was highly efficient in removing hazardous air pollutants from the flue gas.

Milliken Clean Coal Technology was demonstrated at New York State Electric & Gas Corporation's (NYSEG) Milliken Station at Lansing, New York. On May 14, 1999, NGE Generation, an affiliate of NYSEG, completed the sale of its coal-fired power plants in New York State, including Milliken Station, to The AES Corporation. The FGD technology demonstrated at Milliken uses the Saarberg-Holter-Umwelttechnik (S-H-U) process, which incorporates a unique cocurrent/countercurrent flow path plus formic acid for enhanced absorption of SO_2. The Stebbins tile-lined, reinforced concrete absorber exhibited superior corrosion and abrasion resistance. FGD availability during the test period was 99.9%. Coal sulfur content averaged 3.2%.

Barriers

One of the primary obstacles in recycling is the lack of sufficient means to avoid cross contamination during collection.

SLA

- The specific way to enable row materials such as plastics, and fly ash to sort efficiently for recycling is required.
- Depending on the intended application of concrete, different properties are required and must be considered during the mix design.

CCT

- In the past, many utilities have chosen other options, including fuel switching and purchasing SO2 allowances, to meet increasingly stringent air quality regulations, but the significant benefits demonstrated by these new FDG processes should result in many more power producers opting for these clean coal technologies.

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Reviewers

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