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Utilizing Recycled Fiberglass for Affordable, Green Composite Technology

by

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Abstract: Faced with growing sustainability issues regarding increased hazardous landfill costs and over burdened waste fiber-reinforced-plastics (FRP) inventories, FRP manufacturers have found an economically viable remedy. Solid cast polymer technology utilizes recycled FRP and converts it into eco-friendly, commercially available structural products such as manholes, pipe, railroad ties, and segmental tunnels. Solid cast polymer composite technology is a bona fide economical Green composite solution.

Employment of light-weight FRP designs have improved the auto and aerospace industries' fuel efficiencies, while simultaneously giving rise to an entire alternative wind-energy market. Consequently, each industry has succeeded in reducing their carbon footprint.

Ironically, these same FRP materials, offering countless energy and environmental benefits, have looming issues regarding disposal and reclamation. FRP is not biodegradable and is not easily recycled. The FRP industry is facing growing sustainability problems regarding increased hazardous landfill costs and burdening waste-FRP inventories. Solid cast polymer offers the marketplace a viable cradle-to-cradle remedy.

According to a December 1, 2011 report, PR Newswire forecasts fiberglass global output will reach a total of 4.88 million tons by 2012 and will continue to increase at an annual rate of approximately 7.2%. Of that number, it is estimated that approximately 400k tons of FRP composite waste is being generated. This does not take into consideration existing FRP products reaching their life expectancy and design limitation and must be disposed of or reclaimed.

FRP is considered a hazardous waste as the fiberglass is not biodegradable and the thermosetting resins systems are typically bio-accumulative and/or toxic. Even the best available FRP manufacturing technology generates a significant quantity of waste. Fiberglass producers worldwide have serious concerns with their accumulation of FRP waste.

The greatest motivation for recycling FRP is overall cost. FRP recycling financially impacts fabricators in two ways: through opportunity costs and disposal costs. Opportunity costs are overlooked scrap cost of materials thrown away that might have been used to produce a saleable product. Disposal costs are what people are considering when the topic of waste cost is mentioned. Disposal costs include transportation and landfill fees. Hazardous landfills costs continue to climb due to increased government regulations, oversight and limited hazardous landfill storage.

The three common types of FRP recycling processes currently considered are mechanical shredding, incineration and reclamation. In recent years, these alternatives have not been as economically feasible as sending FRP scrap to a hazardous waste landfill. However, population, demographics, environmental awareness and increased landfill cost are forcing FRP fabricators to utilize alternative waste disposal methods that are economically feasible and include a beneficial public relations outcome. However, publicly-held corporations make it possible to address cradle-to-grave issues more cost-effectively, as going "Green" appeals to shareholders as well as consumers.

The incineration process which burns off resin binders leaving glass fibers is extremely expensive with exorbitant capital equipment costs. Incineration also triggers consequential air emission issues. Along with the high cost of ash disposal, incineration can degrade the physical properties of the remaining glass fibers as much as 50% leaving a residue that inhibits bonding of most thermosetting resins systems.

Conventional shredding produces inconsistent reclaimed fiber sizes resulting in fiber particles being too large or too small. The consumption of these recycled fillers is limited. Also, inconsistent fiber sizing will ultimately result in unpredictable physical properties and various resin-to-fiberglass loading, making it difficult to establish fixed raw material and manufacturing costs.

Reclamation harvesting is a more reliable and consistent method of recycling FRP waste. Developed by Wolfgang Unger over 20 years ago the Grinder/Muncher (Figure 1) acts similarly to a hammer-mill that is built to withstand abrasive fiberglass and maintains low temperature. The low temperature operation is important to eliminate spontaneous ignition and maintain the integrity of fibers for viable and effective reuse. The reclamation harvesting process lends itself to generating greater uniformity and consistency in fiberglass sizing (Figure 2). This process also allows for greater predictability of physical properties and resin-to-fiberglass ratios. More importantly, the harvested FRP preserves its original physical properties and provides for a more suitable reusable composite product.

Because of its lower overall manufacturing costs and more consistent reclaimed fiber sizes, reclamation harvesting is becoming a very practical alternative. Recycled FRP can be reused in various conventional FRP processes such as compression molding and pultrusion. However, the real question for all these methods of recycling is how much money can be made or saved from the recycling process and how much FRP waste can be disposed of. Most of the conventional methods for recycling have limitations regarding how much material can be consumed.

One solution is to exploit the FRP reclamation harvest method and incorporate the reclaimed fibers into solid cast polymer composite systems. Solid cast polymer utilizes recycled FRP by encapsulating it in environmentally responsible composite products such as pipe, manholes, railroad ties and other structural composite products. By means of extensive testing, solid cast polymer composites have a proven life expectancy in excess of 300 years.

Innovative Technology:

Solid cast polymer is a thermosetting polymer matrix blend comprised of inert, inorganic mineral fillers such as quartz, silica, and select reinforcing media (Figure 3). The fillers consist of 90% (by weight) of the total matrix composition. The resin binder materials in solid cast polymer are patented, environmentally “green” thermosetting resin systems comprising approximately 10% (by weight) of the total matrix composition. These components are combined and cured to produce a highly corrosion resistant, extremely strong concrete-like matrix. Characteristically, solid cast polymer is approximately 3-5 times stronger than Portland cement concrete (Figure 4, Figure 5). Solid cast polymer is typically produced by the static-cast vibration method. Similar to the mixing methods used in the production of precast Portland cement concrete products, blended solid cast polymer matrix is poured into a mold and vibrated to compaction. The density (wt./cu.ft.) of solid cast polymer ranges between 145-150 lbs./cu.ft., which again is similar to that of Portland cement concrete. Chemical resistance and physical property testing of solid cast polymer is performed in accordance with ASTM and ACI procedures.

Solid cast polymer has been in use in the construction of chemical containment structures for over 25 years.

Impermeable:

Solid cast polymer composite tight matrix system is non-porous preventing any permeability.

Solid Cast Polymer vs. Polymer Concrete

In general, solid cast polymer and conventional polymer concrete are similar in that they both are thermosetting resin-binder technology systems. This is where the similarity ends. Most conventional polymer concrete materials display excessive shrinkage, which can contribute to micro cracking and migration of chemicals throughout the matrix. Styrenated polyester resin systems can also display some long-term distortion, loss of strength and can leach toxic chemicals into the environment. In contrast, solid cast polymer’s enhanced “green” resin technology exhibits superior chemical resistance, impermeability, and physical characteristics. To date, third-party test (10,000 hour) results have demonstrated no long-term distortion or loss of strength. Furthermore, the non-shrink stability and 100% solids formula of solid cast polymers readily supports the incorporation of recycled FRP.

When compared to Portland cement concrete, the superior strength characteristics of a rigid, yet more ductile, solid cast polymer allows for thinner and lighter weight designs. The addition of recycled FRP fibers augment overall physical properties and facilitates thinner-walled structures. Solid cast polymer's natural tight matrix cell structure contributes to its impermeability. A lighter-weight part may result in the utilization of lighter-duty equipment, improved installation times, and increased jobsite productivity. The constructability and installation methodology of solid cast polymer is the same as concrete.

Corrosion resistance and strength notwithstanding, solid cast polymer has gained greater industry acceptance due to two key factors: raw material costs and manufacturing costs.

Raw Material Costs: Compared to the collective costs of coated or thermoplastic lined Portland cement concrete products, improvements in resin technology combined with a more competitive market and aided by the economies-of-scale have facilitated in the cost reduction of solid cast polymer raw materials. The synergy between FRP producers and solid cast polymer manufacturers is most advantageous. FRP fabricators lower their overall waste removal costs and solid cast polymer producers decrease their overall raw material costs while enhancing physical properties.

2. Manufacturing Costs: The process of manufacturing either large structures (manholes & tunnel segments) or structural components in large volume (railroad ties) allows for the significant consumption of recycled FRP. The development and improvement of large scale material handling and mixing equipment have greatly advanced the production of solid cast polymer products. Solid cast polymer manufacturing technology is now capable of producing over 360 yards or 720 tons of solid cast polymer matrix on a continuous and daily basis. Extremely fast cure times also allow manufactures to purchase fewer molds. Combined with the elimination of post-curing, the cost of manufacturing a solid cast polymer product compared with that of a precast concrete product is significantly lower. Recycled FRP fibers can be blended into the solid cast polymer matrix at a loading level of about 5-10% by weight without negatively affecting the manufacturing process or the physical integrity of the composite matrix.

There are varying opinions on the most efficient and constructive way to address the issue of FRP waste disposal. However, when addressing the basic issues of landfill space, cost and FRP waste volume, the blending of FRP reclamation harvested fibers with solid cast polymer composite offers a most cost-effective alternative for overall FRP disposal costs, landfill issues, and the consumption of large quantities of FRP waste. The merging of these two innovative technologies has created an improved solid cast polymer and a superior material-of-construction.

Reference Material:

(1) Fiberglass Reinforced Plastic Recycling – Kyle Bartholomew, Minnesota Technical Assistance Program

(2) Recycling Thermoset Composites in the United States - J.P. Simmons

(3) Fiberglass Production – Washington State Air Toxic Sources and Emissions Estimation Methods

(4) 2008 North American Tunneling Association -Solid Cast Polymer Tunneling Segments- Richard A. Cubeta

(5) 1999 Case Study - North Carolina Dept. of Environmental and Natural Resources

(6) September 2012 Fibre Composite Recycling/an Academic and Historic Summary – Professor Mikeal Skrifvars, School of Engineering, University of Boras

(7) Recycling Composite Boats – Taco Rison, Structural Composites Europe

Figure 1: Eco-Wolf Grinder/Muncher

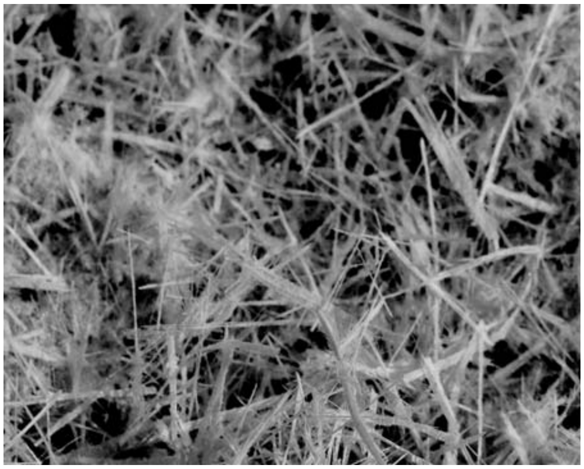

Figure 2: Reclamation Harvesting – Uniform Recycled Fibers

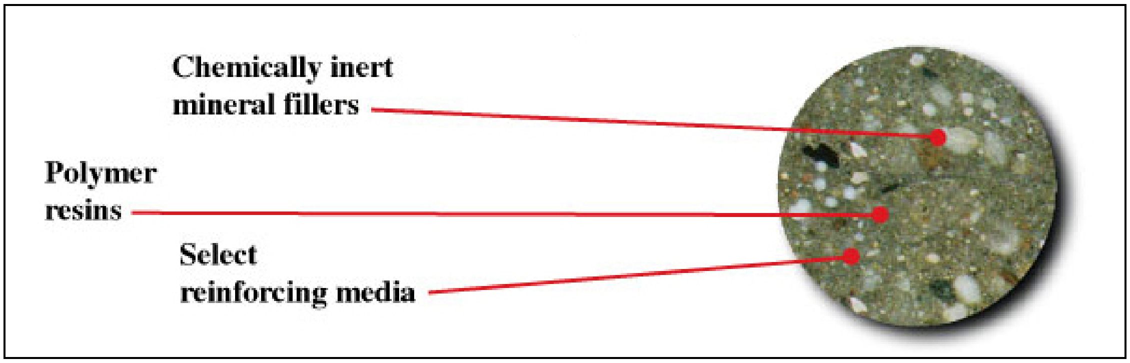

Figure 3: Solid Cast Polymer Matrix

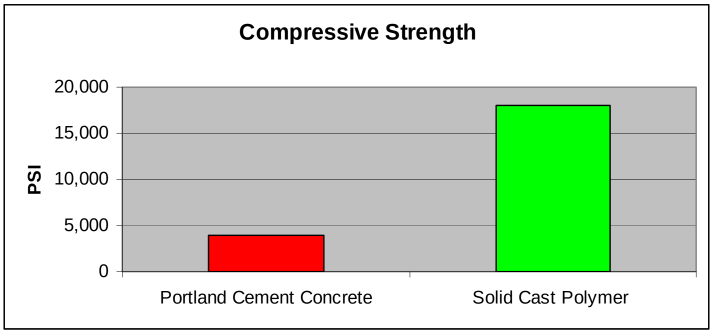

Figure 4: Solid Cast Polymer Compressive Strength

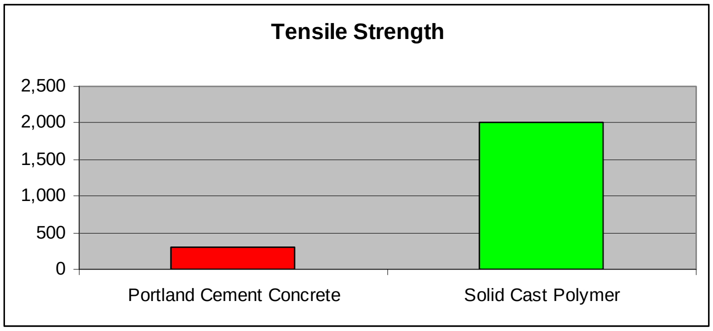

Figure 5: Solid Cast Polymer Tensile Strength