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APPLICATION OF RECYCLED PLASTICS AND ITS COMPOSITES IN THE BUILT ENVIRONMENT

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ABSTRACT

Composite materials made from mixtures containing proportions of post-consumer polythene waste provided useful structural materials for many purposes, with physical properties sometimes superior to timber (Ofoegbu, Nwodo & Okonkwo, 2005). Durability, low maintenance and long-life make them economic alternatives (Waste and Resource Action Programme - WRAP, 2006). The text discusses the application of recycled waste plastic and its composite materials in the built environment: landscape, buildings and in alternative energy supply, in place of fossil fuel. It also compares the benefits of its use to that of new or 'virgin' materials. Consideration is also made of the benefit of recycling plastics and other waste materials to the environment, especially with respect to climate change. It recommends a regional effort to recycle plastics instead of banning their use. The paper concludes that recycled plastic materials and composites should replace new materials in the built environment.

KEYWORDS: Application, Composites, Environment, Plastics, Recycle

INTRODUCTION

Plastic is a relatively cheap, durable and versatile material and its products have brought benefits to society in terms of economic activity, jobs and quality of life. Plastics as waste, when not properly managed, imposes negative environmental externalities, European Commission (2011), because most of it is non-biodegradable and therefore can remain as waste in the environment for a very long time; imposing risks to human health as well as the environment. Because of its demand and use, plastic waste generation has continued grow.

Recycling of waste plastics, especially in Africa, has not kept pace with the rate of its waste-generation. That is why in some countries of sub-saharan Africa, legislations are put forward for total bans on the use of plastics. The East African Community, (EAC)'s move to control the use of polythene materials Afrique en Ligue (2012), is aimed at protecting the environment. The East African Legislative Assembly, for example, has recently passed a bill which currently awaits assent by heads of states of the five-nation bloc. In 2009, a similar bill was enacted in Uganda. In Nigeria, the National Orientation Agency (NOA), canvassed for bans on selected plastic packaging bags (Vanguard, 2011).

It is amazing that while the industrialized countries find numerous alternative uses for waste plastic materials many African countries are seeking legislations for limiting uses or total ban on plastics. It is the aim of this paper to highlight alternative uses of waste plastics, 'an environmental nuisance', which many African countries can utilize to reduce costs of construction materials, create jobs and sustainable environments in addition to supply of energy to built environments. South Africa, Young (2009), has a vibrant and viable plastics recycling industry employing many people and playing a vital role in the sustainability chain.

USES OF RECYCLED PLASTICS AND COMPOSITES IN THE BUILT ENVIRONMENT

The construction industry is not itself a major recycler of plastic but it has a key role to play in sustainability of the built environment by promoting plastics recycling (Plastics Federation of South Africa, 2007-2011). A large percentage of recycled plastics is made into extended-lifetime construction products, WRAP (2006), Young (2009), such as channels, insulation, fascias, damp proof membranes, water drainage, pipes and ducting, building blocks, roof tiles, decking, fencing and outdoor furniture. Other areas include roads and bridge construction, paving bricks and production of fuel for power generation. With use of the right additives and careful selection of feedstock, products made from recycled plastic are as good as those from virgin plastics.

In the United States of America and Europe, the building and construction industry ranks second in the use of plastics and its composites after the packaging industries, Gale Group (2008), being applied in floors, ceilings, insulation, panels, doors, windows, glazing, bathroom units, gratings and railings; structurally and in decorations.

Building Construction

Harvey Lacey, an American, has produced a hand-operated press that turns plastic trash into building blocks, best suited for less developed countries where modern materials and low cost housing are not affordable (Geiger, 2011). Harvey's focus is on simple, low-tech solutions. Virtually anyone with access to plastic trash, no matter how poor, can start generating an income and making blocks for their home with his machine adequate for building simple houses. His main goal is to provide villages with simple technology to make plastic blocks where it is not cost effective or practical to send low value plastic trash to big cities for processing, thereby creating a cottage industry process that's similar to the one used to produce compressed earth blocks in many countries. Film plastics like shopping bags that cannot be processed by many recycling processes are easily handled by Harvey's plastic block-making machine. Recycled plastic building blocks-making is an opportunity for changing the lives of those that build the shelters along with those that live in them, providing jobs and opportunities for entrepreneurships.

Geiger reports that plastic blocks are strong, waterproof, rot proof and insect resistant and could be used to create permanent housing, designed to fit the local culture and their immediate housing needs. All these are very important qualities for building in many African tropical climates where there is abundance of plastic trash, free for the taking. Plastic-harvesting would help clean up the environment and provide jobs.

Harvey is not the first person to venture into plastic block-making. Peter Lewis, the original inventor of recycled plastic blocks-making machine, is an architect and aerospace engineer in New Zealand. His machines clean, chop and press recycled plastic into numerous products, including building blocks, but Harvey's machine is simpler. Plastic fibre insulation is made mainly from recycled plastic milk bottles (polyethylene terephthalate or PET). The fibres, Do It Yourself (2011), are formed into insulation batts similar to high-density fiberglass and treated with a fire retardants. The material does not readily burn but can melt when exposed to flame. Recycled plastic is widely used in mainstream construction products, WRAP (2011), such as in damp proof membrane, drainage pipes, ducting, flooring. scaffolding boards and kerbstones, where its durability and weight has significant benefits.

- A company in Swansea, Affresol, has built three bedroom homes, Andrews (2010), each made from 18 tonnes of recycled plastic trash which would have wasted in landfills. The buildings are fire and waterproof, storm and wind proof and reportedly stronger than concrete. It insulates the house twice as well as concrete, thereby cutting down heating bills in half. Estimated lifespan of the houses is put at more than 60 years and after that they are recyclable.

Source: Andrews 2010

Plates 1 and 2: Three Bedroom Plastic Homes at Swansea, England

- I-plas, another United Kingdom (UK)-based company has already introduced a building material also called i-plas. The material made from recycled plastic is expected to replace concrete, steel, and timber, Schwartz (2008) and can be used for bridges, walls, fences and footpaths. It will neither splinter nor chip and requires no varnishing or coating, being moisture-resistant. Its production makes use of any type of plastic waste except polyvinyl chloride (PVC) and thermoset and saves more carbon dioxide (CO2) emission from landfills as much as would be generated by producing an equal amount of concrete. A major interesting aspect of plastic recycled products is their sustainability; the possibility of breaking them down to form new ones.

Source: Farmer, 2009.

Plate 3: Plastic Concrete: Building Bricks Made From Landfill Waste

Road Construction Landscaping

Waste plastics have been found to replace aggregates and surface covering materials in road construction and landscape. Discarded worn out tyres are ground and the resulting dust are non-laminated polymerically bound black rubber, which are commonly applied as an environmentally responsive, resilient flooring material (UN-Habitat, 2008). 'Virgin' rubber granules are added along with a urethane binder and the homogenized mixture, approximately 80% black rubber and 20% colored rubber, is applied in areas such as sports and recreation, veterinary housing (to provide comfortable surfaces that are easy to clean or maintain) and also in high traffic areas outdoors as vibration dampeners.

Recycled rubber floors are popular in fitness centres, dance studios and day care centres. As underlayment to many traditional floors, they act as acoustical barriers to reduce sound transmission and make floors more comfortable to walk on. Research has shown that recycled granulated tyres and rubber can be used in asphalt paving projects in driveways and sidewalks (Turner, 2010). They can take the place of gravel to serve as an aggregate base in concrete. Rubber-based concrete may be used to build walls, floors and foundations in buildings. They have also been recycled to form roof tiles. Landscaping could take up a lot of recycled rubber thereby diverting much tyres from landfills. Shredded rubber serves as an eco-friendly mulch in plant beds and as a popular replacement for mulch at playgrounds and other kid-friendly areas. According to the University of Massachusetts, recycled rubber serves as a light-fill material to control erosion and support roadways or other structures.

Walkways, jetties, pontoons, bridges, fences and signs are increasingly being made from recycled plastic composites (WRAP, 2011). Durability, low maintenance, resistance to vandalism and rot are all key reasons for plastic being used. Street furniture, signs and planters are frequently made from recycled plastic. They are equally cost competitive and resistant acid attacks.

- The recycled plastic bridge over River Tweed, Scotland, Kim (2011), is the first of its kind in Europe. It spans 27 metres and is strong enough to handle loads of up to 40 tonnes.

Source: Kim, 2011

Plates 4 and 5: Construction of Europe's First Recycled Plastic Bridge in Scotland

The construction used thermoplastic composite material from post consumer recycled high density polyethylene that would otherwise be sent to landfill sites. Like other plastic materials, it has the inherent properties of natural resistance environmental hazards. It also requires no finish, little maintenance and is totally recyclable. This overcomes the major problem of having to coat or replace aged steel bridges due to rust.

With an estimated life expectancy of above 50 years, the thermoplastic material results in a $3,300 per square metre lifecycle cost savings when compared to standard building materials like treated timber.

Power Generation

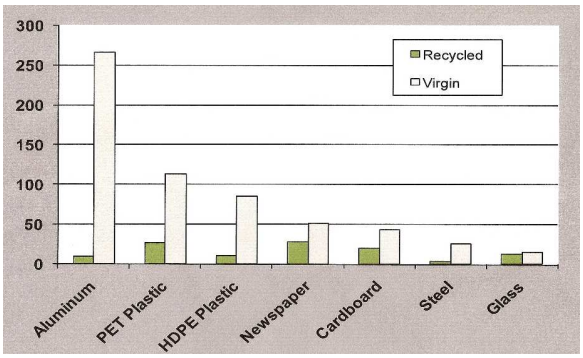
Apart from the use of old tyres and PET bottles in building and road construction, they have also wide applications in diesel and gas production; potential ingredients for power generation worldwide. The process involves the conversion and recovery of the energy value in the waste material through the application of high temperature and controlled combustion. The recovered thermal energy can then be converted to electrical energy in steam-driven turbine generators for use or it can be sold directly as steam or hot water for industrial processes and space heating. Waste-to-energy (WTE) system is a treatment which is advisable for waste plastic materials because they quickly release the energy required when burned. Although recycling is not best for some plastics (such as those that are soiled), the material can still serve a useful purpose if used in a waste-to-energy system (WTE).

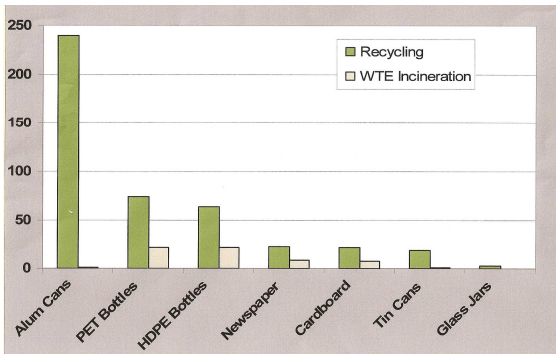
- A California based company, Green Enviro Tech Holdings Corporation, has planned to establish two tyre recycling plants in the United States using the latest technology from East Asia (Waste Management World, 2011). The technology, which is currently in operation in nine locations in East Asia, confirms the viability of the system which converts discarded used tyres to oil. Oil sample test results confirmed that converted oil was well within required levels and that emission levels were well within the limits imposed in the United States.

- In Ohio, another waste to oil firm, Vadxx Energy LLC has engaged Rockwell Automation Global Solutions to provide process engineering services to utilize the same proprietary processes to transform discarded petroleum-based wastes, including plastics and other polymer-based wastes, into synthetic crude oil and gas.

Tyre disposal is a major problem worldwide with landfills being the major disposal route. This relatively new technology is currently being practiced in many countries of Europe, including Britain and Germany, by many companies that recycle and sell fuel for cars, power generation, industrial and other domestic uses.

ENERGY BENEFIT ANALYSIS IN RECYCLING OF MATERIALS





Source: Morris, 2008 Source: Morris, 2008

Chart 1: Energy Use: Recycled & Virgin Content Chart 2: Energy Savings: Recycling Versus Waste. Products (MJ/kg) To Energy (WTE) Incineration (MJ/kg)

Charts 1 and 2 above show relative energy uses and savings when recycling of wastes are applied. Despite this, 45 billion aluminum beer and soft drink cans were wasted in the U.S. in 1998. Likewise, extracting and processing petroleum into common plastic containers (Polyethlene terephthalate 'PET' and High Density Polyethylene 'HDPE') takes four to eight times more energy than making plastics from recycled plastics. The recycling rate for these plastic containers was only 20.2% in 1998. Energy conservation is just one of the environmental benefits attained by eliminating waste, increasing material efficiency and manufacturing products from recycled rather than virgin materials.

Soft drink containers, Sheehan (2000), may be only 2 per cent of the waste stream and aluminum cans may only comprise 1.4 percent of the entire waste stream by weight, but they contribute ten times as much (14 percent) of the emissions embodied in a tonne of divertible waste sent to landfill. Plastic containers take large amounts of energy to manufacture.

RECOMMENDATIONS AND CONCLUSIONS

Recommendations

By examining the contents of the text of this paper, it is possible to replicate all the technologies involved in the processes of plastic waste-recycling, especially in the West African sub-region and much of sub-Saharan Africa in general by:

- Encourage Recovery of Waste Plastic

Recovery of waste plastic materials, especially polyethylene, should be encouraged by recycling industries and governments, by payment of collection fees, so as to make it worthwhile scavenging for them.

- Setting common targets

There should be an attempt to organize all member States by setting common targets for waste recycling, in general, at ministerial levels of Economic Community of West African States (ECOWAS) Summit. This will be aimed at cleaning the environment and at the same time provide job opportunities and affordable accommodation within the sub-region(s). It should be considered the best environmental alternative for solving the problem of waste disposal. The fraction

of plastic wastes in household wastes is large and increases with time, especially in urban centres. In each country the waste composition is different, since it is affected by socioeconomic characteristics, consumption patterns and waste management programs, but generally the level of plastics in landfill waste composition is high. In many countries of West Africa, plastic still remains the waste component not properly handled because of lack of technological know–how for its recycling. The large volume of materials required for construction offers a potentially major area and attraction for reuse in other sectors outside construction.

- Financial and Moral Assistance from Governments

Governments should assist cooperative groups with the knowledge and finance to engage in plastic waste recycling as a means of livelihood and self-employment.

- Encourage Research In Recycling

Universities should encourage research in plastic waste recycling, establish workshops and materials-testing laboratories. Inter university exchanges, especially with advanced and recognized universities should be encouraged.

CONCLUSIONS

Recycling plastics help to save energy and landfill space. Recycled plastics are used in new building and construction applications every day and can be blended with virgin plastic (plastic that has not been processed before) to reduce cost without sacrificing performance. Such recycled plastics are used to make polymeric timbers for use in everything from picnic tables to fences, thus helping to save trees. Trees serve as 'carbon sinks' to the environment, while they release oxygen in exchange. This element is useful to human existence, serving to maintain life and supporting the depleting ozone layer; the subject-matter of climate change and its adverse consequences currently being experienced in many parts of the world.

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