WASTE TO WEALTH IN BUILDING MATERIALS DEVELOPMENT

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ABSTRACT

Human activities generate wastes in one form or the other. Most of these waste components are solid wastes which in most cases are non-biodegradable. Because of their nature the normally convenient method of disposal is in landfills. The cost of landfill sites is becoming high. There should be sustainable way of disposing these wastes on a more or less permanent basis. Putting solid wastes into use as construction materials is one means of achieving this purpose. As the wastes are collected and processed for use in construction, it generates income for those involved thereby converting waste to wealth. The aim of this paper is to highlight some solid waste materials that can be incorporated into construction and thereby generate income for those engaged in the process. It has been shown that waste plastics, waste glass, waste rubber tyres, construction and demolition wastes among others can be processed into useful construction materials. The paper concludes that most of this waste find suitable use as construction materials and gathering them for use as such is a means of generating income for the people involved. The paper recommends that designers should find ways of incorporating these processed wastes into their designs especially for lightly loaded structural elements. Government should also make deliberate policy for suitable wastes to be incorporated into construction. Also, the Standard Organisation of Nigeria should also find ways to develop standards for the use of the se waste material in construction.

Key words: Construction materials, municipal solid waste, solid waste disposal, waste processing, waste to wealth

INTRODUCTION

Human activities, both in production and utilisation of the resulting products, always generate wastes in one form or the other. The volume of these wastes has increased with the growth of population, increase in urbanization, rising standard of living resulting from technological innovations, etc, (Safiuddin et al (2010); Awoyera and Adesina, 2020). Most of these wastes are municipal solid waste (MSW). Babayemi and Dauda (2009) defined solid waste as non-liquid and non-gaseous product of human activities, regarded as useless. It could be in the form of refuse, garbage and sludge. Over 32 million of solid waste is generated annually in Nigeria (BioEnergy Consult, 2020a). Out of this amount only between 20 to 30% is collected. Municipal solid waste (MSW) therefore, are most times disposed carelessly and this has resulted into some adverse consequences which include blockage of sewers and drainage networks, as well as choking of water bodies. Also, very many of the MSW are non-biodegradable and there is low level of reuse and recycling of the waste. The major means of disposal is in landfills.

The increase in population and the resultant need to have land available for human habitation is making landfill sites difficult to acquire in terms of cost and availability. This further adds to the problem of environmental pollution. There should be sustainable ways of disposing of these solid wastes on a more or less permanent basis. According to Lee et al (2015) putting solid waste into use as construction materials offers one way of tackling the global issue of sustainability and climate change. The aim of this paper is to highlight some selected common municipal solid wastes and to identify the possible ways by which they can be incorporated into construction. The process of collection, sorting and processing of the waste can serve as a means of employment. the conversion of the wastes into construction materials and/or products can also be a means of income generation to those involved. The waste is hence turned into wealth and environmental is taken care of at the same time.

USE OF MUNICIPAL SOLID WASTE IN CONSTRUCTION

The use of solid wastes in construction should be one of the most viable options in disposal of solid wastes. The reason for this is the large quantity of materials required for construction and the relatively low-quality requirements of materials used in construction compared to so many other industries (Lashmi and Nagan,2011). Also, there is usually a large volume of construction works in progress at any given time. As a matter of fact, there is no time that construction work is completely at a standstill, unless of course when the circumstances warrant a complete stoppage as witnessed in the COVID-19 pandemic lockdown in 2020.

The use of solid waste in construction according to Dachowski and Kostvzewa (2016), is in either of two ways: reuse and recycling. Reuse is a situation whereby the material in its form as collected from the waste is incorporated into the construction. An example is when steel component removed from a previous construction is used as a component in a new structure. Recycling on the other hand entails having to process the waste into another form before being used in construction. Example includes having to burn rice husk into ash and then calcining it into pozzolana to be used in mortar or concrete. The choice as to which solid waste to use follows after sorting which is one of the preliminary processes involved in solid waste management. Sorting separates the waste into many categories: combustible and non-combustible, solid and semi solid, plastics, glass, stones, timber etc. Sorting is then followed by the choice as to which one in these categories to use for construction purposes.

MAJOR MUNICIPAL SOLID WASTES (MSW) COMPONENTS AND POSSIBLE USE IN CONSTRUCTION

The components and quantities of the various MSW are dependent on the standard of life in the particular community where the wastes are generated. Therefore, the components of the waste vary from one place to another. It is not all the component that may be useful in construction. The following are some of the major components of MSW and their possible usage in construction.

Plastics

A large proportion of plastics produced annually are for the purpose of producing single-use, disposable packaging items or products which will permanently be discarded within one year (Akoh, 2018). Huge quantities of plastic related waste have therefore, been generated in recent years all over the world. This is as a result of an observable substantial growth in the consumption and usage of plastics according to Saika and de Brito (2012). Nigeria generates 0.85million metric tonne of waste plastic annually (Jambeck, Andrady, Simion and Furh, 2015). However only a very negligible proportion of this amount is recycled or reused. The rest are disposed carelessly most of the times. This is the reason for the abundance of waste plastics all over the places in very many urban areas and even in some rural areas.

Waste plastics find beneficial usage in so many areas of construction. Gulati (2012) reported that waste plastics can be used for laying plastics-bitumen mix roads. The plastic blend is referred to as polymer modified bitumen according to Aslam (2009). According to Reddy (2013), plastics improve aggregate impact value and helps to improve the quality of flexible pavement as well. Another example of areas of application of waste plastics is a process where plastic blends are used to create moulded item, a process described by Ross (2014) as Powder Impression Moulding

(PIM). This process is used to produce hoarding panels that can be used on construction sites. Also, the recycled plastic can be used as a “former” which is then encapsulated by a thin layer of higher value plastic. The resulting product has the appearance and the performance characteristics of the higher value plastic. This process is called encapsulation (Ross 2014).

There are possibilities of recycling electronic plastics using various means such as coke oven processing, thermal recycling and mechanical recycling among other processes as reported by Kang and Schoenung (2005). According to these authors, the major challenge for plastic waste recycling are the requirements for continuous and stable supply of the materials to be recycled, and the recycling technologies available are not cost effective. However, from the common experiences in Nigeria, the continuous and stable supply of waste plastics for recycling will not be a challenge in the near future.

Nasvik (1991) reported that researchers found that waste plastic (Polybutylene terephthalate, PBT) has great potential as replacement for mineral aggregates. Its inclusion affects the strength of the resulting concrete positively, together with resistance to abrasion and impart. There are two types of aggregates used in concrete production: coarse and fine aggregates. The coarse aggregate serves the purpose of volumizing the concrete while the fine aggregate fills the voids between the coarse aggregate in concrete. One important characteristic of the aggregate in concrete is that it should be stable in the environmental conditions under which the concrete will be in service. Plastic has adequate resistance to the environmental condition under which most concrete structure function. According to studies carried out by Lakshimi and Nagan (2010) and Matthew, Vargese, Paul, and Varghese (2013) concrete made using waste plastic coarse aggregate will be lighter than with natural coarse aggregate, and also have a better workability than with natural coarse aggregate.

The compressive strength property of such concrete using waste plastic can also be improved with addition of about 10% replacement of the cementitious materials with an appropriate pozzolana.

Rhagagate (2012) investigated the use of pieces of polythene bags, commonly used for packaging and carrying goods, in making concrete. The plastic bag pieces were used as partial replacement for fine aggregate for partial replacement of up to 1%, the compressive strength was up to 20 N/mm^2 compared to 26 N/mm^2 attained by the control mix at 28 days. A split tensile strength of 5.12 N/mm^2 was attained at 1% replacement compared to 4.12N/mm2 attained by the control mix at 28days. This is an indication that the use of plastic pieces as partial replacement for fine aggregate increases the tensile strength of the concrete produced.

Paving blocks can also be produced from waste plastics. Dinesh, Dinesh and Kirubakaran (2016) identified polyethylene (commonly used to produce grocery bags) as one of the largest components of plastic wastes and followed by polypropylene. Polyethylene bags can be used to produce the paving blocks together with sharp sand. The paving blocks produced have the strength and dimensional stability up to 180ºC, and low alkaline content. It also has higher compressive strength compared to those made using cement and sharp sand (Dinesh, Dinesh and Kirubakaran 2016).

Waste plastic can also be used as the core material in flush doors. The waste plastic use in sachet water production can be collected, washed and dried and then packed compactly as infilling material in flush doors. This type of core has the potential of enhancing the insulation properties of the flush door.

Waste Glass

Glass is a highly transparent material. It is produced by melting a mixture of silica., soda, ash and calcium carbonate at a high temperature, and then by cooling the melted mixture for solidification without crystallization. It is used in the manufacture of such products as sheet glass, bottles, glass-ware etc., (Park, Lee and Jim, 2004). It is nonbiodegradable and its use in construction can be a beneficial solution to environmental issues caused by this type of solid waste.

Finding ground powder of waste glass can be used as partial replacement for cement in concrete production. The glass powder having particle size less than 38 µm contains a high amount of amorphous silica which exhibits a pozzolanic behaviour, according to Shao, Lefort, Moras and Rodrigues (2000). Research works have shown that concrete containing pozzolanic material have good strength and durability properties. Also, using waste glass as fine aggregate improves the workability of concrete in the fresh state and the resulting concrete has a comparatively lesser unit weight (Topcu and Cambaz, 2004). The use of finely ground glass helps to reduce expansion resulting from alkali – silica reaction by up to 50% (Shao, Lefort, Moras and Rodrigues, 2000). Waste glass in ground from if added to fired bricks improves its compressive strength significantly (Demir 2009). The amorphous nature of waste glass particles enhances the sintering action and this leads to better compressive strength in the bricks. The content range for the desired increase in strength is between 15 to 30% by weight of clay (Larguenyang, Panyachai, Kaewsimork, and Siritai, 2009). The possibility of producing paving blocks having various levels of waste glass content instead of fine aggregate has also been reported by Turgat and Yahlizadee (2009). The content range is up to 10%. Dondi, Guarini, Raimondo and Zanelli (2009), however reported that the used of PC and TV glass in roof tiles and in clay bricks did not give any encouraging results.

Construction and demolition debris

Construction and demolition (C&D) debris, as the name implies are produced during construction and demolition operations. The growth in the construction industry will definitely result in more and more of the C&D debris and it constitutes a substantial proportion of solid wastes. The quantity and type of C&D debris depends on factors which include stage of construction, type of construction work as well as the nature of construction practice on site (Safiuddin, Jumaat and Roslan, 2010).

Construction and demolition debris generally comprise a larger portion of concrete rubble. Other constituents include bricks, tiles, sand, dust, timber, plastics, cardboard, paper and metal. After sorting from the other debris, the concrete rubble can be crushed and used as substitute for the natural coarse aggregates. This type of aggregate is referred to as recycled concrete aggregate according to Safiuddin, Jumaat and Roslan (2010). This type of aggregate can be utilized in producing concrete (Collins, 1994). It can also be used in road and airport pavement constructions (GTAA, 2007; Sherwood, 1995).

Waste rubber tyres

Rubber tyres are a ductile material, which like plastics are non-biodegradable. The increasing amount of waste rubber tyres has been recognized as constituting an environmental challenge (Li and Li, 1998). In many countries, including Nigeria, open burning as well as usage as a fuel are the most common ways to dispose of the waste rubber tyres. These methods constitute serious health hazards (Safiuddin, Jumaat and Roslan, 2010). Since it is almost practically non-biodegradable Segre and Jockes (2000) discovered that material and energy recoveries are viable alternatives to landfill disposal means of this particular solid waste.

Scrap tyre particle can be used in Portland cement concrete. The processed rubber tyres were used as partial replacements for both fine and coarse aggregates, depending on the fineness of the particles (Li, Li and Li, 1998). Concrete is recognized as the mostly widely used construction materials. Incorporating waste rubber tyre particles into concrete is a very good way to dispose the large quantities of waste rubber tyres.

The use of waste rubber tyre particles in concrete, in addition to being a profitable use of such a waste material, helps to improve some properties of the concrete. Such concrete has improved flexibility, ductility and energy absorbency compared to conventional concrete (Li, Li and Li ,1998; and Topcu, 1995). Bignozzki and Sandrolini (2006) further reported that it is preferable for use in self-compacting concrete as it effectively interacts with cement matrix to produce high flowability together withs good cohesiveness.

CONCLUSION

A lot of solid waste is generated in our communities that constitute environmental hazards. Many components of this solid wastes are no biodegradable which make their disposal a challenge as the usual means of disposal through landfills is becoming more difficult. They however can be incorporated into construction as a permanent and profitable means of disposal. Waste plastics which form a large proportion of the municipal solid waste find usage as partial replacement of aggregates in concrete. Among other uses, it can also be applied as a component of bitumen-based road surfacing material with very good properties. Waste glass two can be ground in fine powder and used as workable pozzolana. Depending on the size of the particles, waste glass two find usage as coarse aggregates in concrete. Other solid waste like construction and demolition debris can also be put to profitable use in construction. The collection and processing of these wastes is a means by which those involved can earn some income thereby turning the waste to wealth and help in ensuring profitable management of solid waste.

RECOMMENDATION

- Designers should make effort to take advantage of some of these findings to incorporate some of the products and materials that can be obtained from these solid wastes into their designs. Lightly loaded elements like lintels could be made using materials obtained from these solid wastes.
- As a deliberate policy of government on solid waste management, it should be made compulsory for some of these materials to be used for construction of building elements like the oversite concrete and other similar elements where the loading might not be very critical.
- Incentives could even be given to those who will be willing to set up waste recycling plants for the purpose of making them into useful materials.
- Standard Organisation of Nigeria should also initiate the process of issuing standards the will provide a guide in the use of these solid waste in construction.

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