

## Recycled Materials in Highway Construction for Sustainable Development

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**Abstract:** This study looks at various ways in which waste materials can be put into use in highway construction. It reviews the work of various researchers both locally and internationally on recycled materials such as plastics, glass, scrap tyres and sawdust. Also, it examines the conditions for the general acceptance of recycled materials in highway construction. It also highlights the environmental and economic impacts of recycling for construction works in general and highway in particular.

**Key words:** Wastes, recycling, impact, environmental, economic

### INTRODUCTION

Wastes can be defined as materials that are no longer needed and are thrown away (Hornby, 2000). Therefore, what one person considers as waste may be useful (not waste) to the other. The judgement of potential consumer defines what a waste is (Aribisala, 2004). As the world population grows, so do the amount of waste being generated (Schroeder, 2004). There is increase in waste generation as a result of population growth. The absence of adequate waste management techniques is causing environmental degradation. The problems associated with inefficient disposal of waste continue to grow. Existing landfills are beginning to fill up as we have in Lagos state. The situation therefore calls for methods such as recycling as alternative method of waste management. Some of the waste materials recyclable include glass, plastics, rubber, wood, etc. The use of waste materials rather than disposal will decrease the amount of waste in circulation, thus relieving some of the burdens associated with disposal. This process may also provide inexpensive and construction products with better properties. Recycling of waste materials also conserves natural raw materials, energy and water and reduces the production of pollutants.

The aims of this study are to review the research works on recycled materials and to highlight the environmental and economic impacts of recycling in highway construction.

### RECYCLABLE MATERIALS IN USE IN HIGHWAY CONSTRUCTION

Many waste materials are recycled in highway construction. Some are highlighted below:

**Plastics:** The wastes generated in urban cities comprise about 1 to 5% of plastics (Osewa, 1993). In the study conducted on the composition of waste in Ado-Ekiti, it was found that plastics and polythene comprised about 31.29% by weight of the waste generated. The use of virgin polyethelene as an additive to asphaltic concrete is not new; however two new processes also use recycled plastic as asphalt cement additive: NOVOPHALT and POLYPHALT (Ciesielski and Collins, 1993; FHWA, 1993). These two processes used recycled low-density polyethylene resin, which is generally obtained from plastic trash and sandwich bags. Recycled plastic is used in Portland cement concrete. In the study, recycled High-Density Polyethelene (HPDE) replaced 20 to 40% of fine aggregate by volume (7.5 to 15% by total volume) in a lightweight concrete mix. Compressive strengths remained fairly constant and the impact resistance of the concrete, which can be related to flexural toughness increased, making it suitable for use in concrete pavement. Many agencies have been experimenting with the use of recycled plastic for items such as guardrail posts and block-outs, fence posts etc (Engineering News Record, 1993).

**Glass:** Glass has been used effectively in highway construction. The wastes generated in urban cities comprised about 1 to 10% of glass by weight (Schroeder, 2004). Also, in the study conducted in Ado-Ekiti on waste composition, it comprised of 6.45% of glass by weight (Aribisala, 2004). The ability to use glass in highway construction depends on the types of collection, methods used, cost and public factors. Recycled glass finds use in the manufacture of glass beads for traffic control devices (Schroeder, 2004).

The Clean Washington Center of Seattle conducted tests on glass cullet for compaction, durability, gradation, permeability, shear strength, specific gravity, thermal conductivity and workability, as construction aggregate and developed recommendations for approximate percentages of glass to be used for different applications (Clean Washington Center, 1993)

**Scrap tyres:** Researchers have discovered that scrap tyres and other waste rubber products can be employed in various ways in highway construction. The effectiveness of using tyre chips as an insulating layer to limit frost penetration beneath gravel surfaced roads that experience severe deterioration during spring thawing was carried out. The results indicated that 152 mm (6 in) thick chip layer could reduce frost penetration by 40% (Dana and Robert, 1993).

The North Carolina Department of Transportation recently conducted a laboratory study on the use of scrap tyres in Portland cement concrete. In the study, the scrap tyres were processed to remove loose steel and fibers, they were processed to remove loose steel and fibers, they were finely ground. The ground rubber was then substituted for fine aggregate in the mix at increments of 10, 20 and 30% by volume of fine aggregate. Tests conducted showed that the compressive and flexural strength decreased with increasing rubber.

**Sawdust:** Vast quantities of sawdust are obtained in sawmills across the nation. Sawdust has been used extensively in England to make such products as precast units for portable housing, flooring, sub-flooring, precast building units and cement lumber (Washa, 1956). In the study conducted on sawdust concrete, the concrete from the nominal mixes 1:1:2, 1:1 1/2:3 or better mixes were found suitable for pavement surfacing, base and sub base of highway pavement (Ogundipe, 2006).

**Steel slag:** This is a by-product of steel making process. It contains fused mixtures of oxides and silicates primarily calcium, iron, unslaked lime and magnesium (Schroeder, 2004). Pennsylvania Department of Transportation found that bituminous mixtures containing steel slag exhibited high stability, high skid resistance and longer heat retention resulting in easier compaction of its high absorption rate (Ramirez, 1992).

## **ENGINEERING ASPECTS OF RECYCLED MATERIALS**

Recycled materials that have suitable engineering, environmental and economic properties can be used in

highway construction (Holtz and Eighmy, 2000). For general acceptance, it is required that the engineering performance of recycled materials be the same or better than the performance using natural materials. It is therefore necessary that proper studies be carried out on recycled materials. The investigation to be done should include the following: the availability (origin of the materials and quantities available) current management options, market sources, engineering properties and applications.

**Availability of recycled materials:** This is an important aspect of accepting any recyclable materials for use in highway construction. There must be a balance between demand and supply of the materials i.e. they must be available in quantities large enough to meet the need for commercial purposes. Also, the origin of the materials must be ascertained, as it will give more insight into how best they can be used in highway construction. Studies have shown that recyclable materials are available in large quantities (Aribisala, 2004; Schroeder, 2004).

**Current management options:** Also important is the way the recycled materials are being managed. This refers to the ways the materials are collected from the point of generation: the two forms available are source separation and commingled recycling (Mark, 2005). Source separation means separating different recyclable materials at the point of generation while commingled recycling means placing all the recyclable materials into a single container which is transported to a processing facility, where different materials are separated by hands or by automated machines.

**Market source:** Market is the most critical aspect of recycling in construction works. Without markets, recyclable materials are trash. There are ready markets for recyclable materials, although government has a lot to do in enhancing market growth. Increase in the number and variety of markets and the number of haulers willing to handle recyclable materials will go a long way in promoting the business.

**Engineering properties:** The principal factor that determines the suitability of recyclable materials for use in highway construction is their engineering properties. For long-term performance, a number of tests are usually carried out on the products. These tests include the compressive strength test, flexural strength test, pH-dependent leaching and alkali-silica reactivity and so on. Studies have shown that most of the materials tested have suitable engineering properties (Schroeder, 2004).

**Applications:** There are many possible uses for recycled materials as highlighted in the review of some literatures. Recycled materials have been used in pavements, appurtenances, guardrails and lampposts, paints and signs and landscaping, although most of these employed small quantities of the materials (Holtz and Eighmy, 2000). The 6 pavement construction applications that require a large volume of recycled materials include: Asphalt concrete, Portland cement concrete, stabilized base, granular base, flowable base, flowable fill and embankments/backfills (Marcia *et al.*, 2000).

### ENVIRONMENTAL AND ECONOMIC IMPACTS OF RECYCLED MATERIALS

Many wastes products are generated in our day-to-day activities. Poor management of these wastes has negative impact on the environment. Recycling/reuse of recyclable materials provides safe and economic disposal of waste materials, in addition to providing better and more cost effective construction materials. Some of the impacts that recycling of wastes have on the environment are highlighted below, maybe, this will spur many investors to commit chunk of their investment into recycling.

**Improved aesthetic value:** Hills of waste are common sights in Nigeria (Aribisala, 2006). This disfigures and makes our cities unfriendly. Recycling of waste materials will reduce the amount of waste requiring disposal, subsequently the uncleared waste sites will vanish gradually.

**Surface and ground waters:** The study carried out to estimate the impacts of recycled materials on surface and ground water showed that only a few waste or by-products produced a toxic impact on nearby surface or ground water when they are placed into a pavement mixture as part aggregate. The leachates were generally non-toxic when passed through soils next to their placement in the highway materials, provided there was at least a nominal thickness (several centimeters) of a typical soil (Mark, 2005).

**Job creation:** Recycling of waste products will help in reducing the number of youths that are unemployed. Many will be employed at various stages of processing the recyclable materials i.e. collection, sorting, hauling and marketing. This will help in improving the socio-economic status of the nation as well as sustaining development.

**Wealth creation:** Successful utilization of waste materials for highway construction works is capable of generating

wealth for individuals and nations-a case of waste to wealth. This is achieved because the recyclable materials always cost less compared with the natural/virgin ones (Mark, 2005). Market competition between recyclable and virgin materials leads to reduction in prices, hence reducing the cost of production drastically.

**Conservation of natural raw materials:** Recycling reduces the consumption of non-renewable materials. This secures the future of the nation's generations to come, which is the basis for sustainable development. It reduces over dependence of the nation on foreign products, therefore ensuring stability of the economy.

**Reduction of pollution:** The current disposal method for most wastes is open burning. This process generates some hazardous gases that impact on human health negatively. Recycling of waste products will reduce the generation of pollutants to the environment. This will increase the life expectancy of the people, one of the indices for measuring how healthy a nation is.

### CONCLUSION

This study reviews the use of some recycled materials in highway construction. It highlights the environmental and economic impacts of recycling operations to include wealth creation, conservation of natural raw materials etc. For sustainable development, it is important that government promotes the use of recyclable materials.

In Nigeria, little or nothing is recycled, perhaps because government policies do not encourage it like we have in nations like United States, Netherlands, Sweden, Germany, etc. The regulation and management of recycling of waste materials in highway construction should be the responsibilities of both transportation and environmental agencies in our nation. The government at the federal, state and local levels should make legislations that encourage the use of recycled materials in construction, such as hefty landfills disposal taxes on materials that can be recycled. It is therefore recommended that appropriate authorities start taking steps in the right direction because the millennium development goals will best be achieved, if we can look inward and reduce our dependence on foreign products.

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