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Plastic waste as strength modifiers in asphalt for a sustainable environment

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This research took the form of an investigation into the applicability of polyethylene terephthalate (PET) as strength modifiers in asphalt road construction. Samples of thoroughly washed, naturally dried and shredded PET wastes were collected. The optimum binder content (OBC) of the unmodified asphalt mix was determined. The bitumen used for the control mix was replaced with PET waste in 1, 3 and 5% proportions. Another sample was prepared with the addition of 1, 3 and 5% of PET waste while the OBC was fixed. The samples were subjected to Marshall Stability (MS) and Marshall Flow (MF) tests. Bulk density (BD), void in total mix (VTM), and void filled with bitumen (VFB) were determined. The results were compared with standards. The PET content obtained that conforms to the specification in AASHTO, ASTM and Nigeria Federal Ministry of Works standards was found to be 1% addition to OBC by weight of aggregate. This percentage PET content was 15% by weight of bitumen with BD, VTM, VFB, MF and MS being 2.38 kg/m^3, 3.33%, 82.20%, 4.00 mm and 17.01 kN, respectively. The 1% PET modified asphalt was found to be useful for pavement construction and reduces the quantity of plastic waste in our environment.

Keywords: optimum binder content, pavement, polyethylene terephthalate, pure water sachet

Introduction

Plastic is a very adaptable material, and virtually every sector of Nigeria's economy – from agriculture to packaging, communication, automobiles and construction – has been transformed by the use of plastic. The estimated global consumption of plastic according to Amit et al. (2012, as quoted in ICPE, 8(1) 2007) is 24 to 28 kg per capita per year with only a quarter being recycled. The demand for plastic across the globe is increasing every day; Sinan and Emine (2004 as quoted in Mousa et al. 2016, 184) opined that if this trend continues for the next few decades the earth will be buried under a pile of disposable plastic material. Plastic waste also constitutes a major part of municipal solid waste in Southwest Nigeria. Further, it contributes to the degradation of groundwater quality by collecting pollutants (Badejo et al. 2013, 593).

This problem has been exacerbated by the growing bottled water industry which has sprung up due to diminishing water supplies in the face of growing populations. Increases in population have exerted enormous pressure on the provision of safe drinking water, especially in developing countries like Nigeria. Before independence in 1960, the government in Nigeria supplied water to the public free of charge. Today, however, Nigeria has moved from a mixed economy to a capitalist economy; consequently water now attracts rates and fees in cities and towns water, according to Sangodoyin (1990 as quoted in Edema, Atayese, and Bankole 2011, 4595). With the government unable to supply sufficient water, the private sector stepped in and began packaging portable drinking water, referred to as 'bottled water', which is now a common phenomenon in Nigeria. Drinking water is thus now commercially packed in easy-to-open bottles, and is referred to as bottled water (Edema, Atayese, and Bankole 2011, 4595).

The bottles used for bottling the water are made of polyethylene terephthalate (PET) materials. They are cheap and strong, and therefore attract patronage from the low to middle class of the populace. Once emptied, the bottles are generally dumped indiscriminately and therefore constitute a huge environmental nuisance. The disposal and environmental challenges posed by these bottles are overwhelming not only due to their non-biodegradable nature, but also by their large volume per unit mass. While plastics in municipal waste streams make up only between 7–9% of the weight of the total waste stream, they represent 20–30% by volume (Scott et al. 1990, 407).

What is alarming about this situation is that most countries in the world, including Nigeria, do not have efficient means of managing this volume of plastic waste. Government at all levels in Nigeria – local, state and federal – is faced with this huge task of nylon and plastic waste management. Discarded bottled water bottle are a common eye-sore on our streets; they also block drains, impeding the free flow of water channels and canals. The economic and environmental impacts of this plastic waste is increasing significantly, as they clog domestic sewage systems, choke water drains, threaten aquatic life in receiving water systems, often causing soil degradation and reducing biodiversity and the aesthetic quality of city parks and beaches (Adewumi 2006).

The enormous environmental challenge posed by the indiscriminate dumping of empty bottled water bottles has resulted in extensive research to find a lasting solution to the menace. For example, Plasma Pyrolysis Technology has conducted studies on plastics waste