Recycling of Polyethylene into Strong and Tough Earth-Based Composite Building Materials

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Abstract: Polyethylene (PE) waste often piles up in the environment for up to 30 to 50 years, without complete degradation. This paper describes how PE waste can be used as a reinforcement in laterite bricks for sustainable building materials. The bricks are produced with different volume percentages (0–30 vol. %) of PE. The flexural/compressive strengths and fracture toughness values of the composite blocks are compared with those of mortar (produced from river sand and cement). The composite containing 20 vol. % of PE is shown to have the best combination of flexural/compressive strength and fracture toughness. The flexural/compressive strengths and fracture toughness values increase with increasing volume percentage of PE up to 20 vol. %, before decreasing to minimum values for composites with 30 vol. % of PE. The trends in the measured strengths and fracture toughness values are explained using composite and crack bridging models. **DOI: 10.1061/(ASCE)MT.1943-5533.0001385.** *© 2015 American Society of Civil Engineers.*

Author keywords: Polyethylene-reinforcement; Laterite; Compressive strength; Flexural strength; Fracture toughness; Crack bridging models.

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Introduction

Plastics are synthetic organic hetero-atomic polymers that are often synthesized in large quantities from oil, coal, and natural gas (Seymour 1989). They are generally nonbiodegradable in the presence of enzymes or microbes (Mueller 2006). This has led to environmental concerns, since almost 30% of plastics produced worldwide are found in food packaging, detergents, and chemical substances, with this sector of the global economy growing at an annual rate of 12% (Orhan et al. 2000). The most commonly used plastics include polyethylene (PE), polypropylene (PP), polystyrene (PS), and polyethylene terephthalate (PET).

Approximately 140 million tons of manmade polymers, including PE, are produced annually across the world, with a utility rate of 12% (Albertsson 1980). This hinders the implementation of an efficient disposal system. Also, although PE can be degraded by chemical, thermal, photodegradation, and biodegradation techniques (Witt et al. 2001; Ghosh et al. 2013), there is a need to recycle it into other functional materials (Yang et al. 2007).

Before the colonization of Africa, most of the houses in Africa were constructed from clay and silt (Aguwa 2009). However, the shrinkage of clays and the effects of mechanical loads due to wind loading can induce cracking in such structures (Liu et al. 2010). Cracking can also be exacerbated by the effects of thermal cycling and the environment (Robinet et al. 1996; Sultan et al. 2002). Similar failure phenomena have been observed in cement-based structures that have been used more recently across the world (Hoskova et al. 2001). However, cement production is associated with 5% of global CO_2 emissions (Worrell et al. 2001). There is, therefore, a need to reduce the amount of cement that is used in building materials.

Alternatives to cement include laterite (Osula 1996; Aguwa 2009; Lemougna et al. 2011), recycled materials such as blast furnace slag (Savastano et al. 2001), and polyethylene (de Carvalho et al. 2014). Laterites are products of the chemical weathering of naturally occurring rocks (Lemougna et al. 2011). The weathering process may take several of years before the soil (with high clay content) is produced (Lemougna et al. 2011). The soil formed is usually rusty-red or reddish brown due to the presence of iron in the oxides. It is often found in tropical regions, especially in wet and hot areas (Lemougna et al. 2011).

Laterites have been recommended for the construction of roads and dams, as well as applications as fillers for soil reclamation (Gidigasu 1976). The uniform distribution and availability of well-graded particle sizes of laterites, as well as their compressibility, enable the molding of bricks with improved mechanical properties (Aguwa 2009). However, the use of laterites alone in bricks does not provide the required strengths for load-bearing structures. There is, therefore, a need to mix them with binders, especially cement or lime, to enhance their mechanical properties (Osula 1996). However, such binders (cements) are relatively expensive

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