Available online at www.sciencedirect.com

ScienceDirect

Procedia Environmental Sciences 35 (2016) 681 – 691

Procedia Environmental Sciences

International Conference on Solid Waste Management, 5IconSWM 2015

An Overview on the Use of Waste Plastic Bottles and Fly Ash in Civil Engineering Applications

Sushovan Dutta*, M. B. Nadaf, J. N. Mandal

IIT Bombay, Powai, Mumbai, India

Abstract

With rapid growth in population, it becomes difficult to control the huge amount of residual materials generated from enormous industrial activities. The residuals that are not recycled, reclaimed or reused constitute the wastes only to get released to the environment. As some of the wastes cannot be assimilated by the environment, those can become hazardous for the environment quality and ensure pollution. This paper expresses the concern on two such industrial wastes, used plastic water bottles and fly ash. The present study emphasizes on the reuse of used waste plastic water bottles in the Civil Engineering applications and in this regard, it discusses the previous work by Dutta and Mandal (2013). Two different type plastic water bottles, having different diameter and tensile stiffness, were chosen to prepare perforated cells of different heights wrapped with jute geotextile from inner side so that fine infill materials cannot escape from the perforations. Laboratory strain controlled compression tests were carried out on the cells rested over a rigid base and filled with compacted fly ash or stone aggregates. Test results showed significant load carrying capacity of the composite cells with fly ash as infill material. Though fine fly ash appeared to be an effective infill material, use of coarse stone aggregates as infill material produced better load carrying capacity of the composite cells. It was also observed that with reduction in cell height over the rigid base, load carrying capacity of the composite cells got increased. The study confirmed that plastic bottles with suitable infill material can act as an ideal compression member.

Peer-review under responsibility of the organizing committee of 5IconSWM 2015

Keywords: Waste plastic bottle; Fly ash; Cell; Jute geotextile; Infill material; Stone aggregates; Load carrying capacity;

* Corresponding author.
E-mail address: sushovan@iitb.ac.in

Peer-review under responsibility of the organizing committee of 5IconSWM 2015
doi:10.1016/j.proenv.2016.07.067

1.0 Introduction

According to NIIR PROJECT CONSULTANCY SERVICES (NPCS), most single serve plastic bottles, including those for water, soft drink and juice are made of polyethylene terephthalate (PET or PETE), one of the most common types of plastics. Plastic consumption in India may reach 18.9 million tons by 2015, half of that in the form of packaging and bottles (Dolat Capital 2011). For the environmentally conscious citizens and organizations, disposing off the non-biodegradable used plastic bottles has become a major concern. Approximately 600 billion bottles are discarded every year all around the world and only 47% is collected (Perpetual Global Ltd.). The problem with what to do with used bottles is particularly acute in a country like India where the collection rate for used PET bottles (75%) is well above the global average (Tranié and Tandon 2012). A significant portion of these collected bottles end up in landfills or incinerators, and the remainder is mechanically recycled/ down cycled. Disposable plastics are the greatest source of plastic pollution. The amount of plastic pollution in the oceans and deserts is expanding at a catastrophic rate. Plastic recycling is not a sustainable solution to the crisis. Recycling of plastic is costly and does not stem the production of virgin plastic product. Instead of recycling, reuse of plastic is beneficial to overcome the disposal problems and also economical. As per available literatures, experimental investigations have been performed in the direction of using waste plastic bottles as cellular reinforcements with fly ash by Ram Rathan Lal and Mandal (2012, 2013, 2014a, b), as cells by Dutta and Mandal (2013) and as geocell mattress by Dutta and Mandal (2015).

Fly ash, generated as a byproduct due to the combustion of pulverized coals in the thermal power plants, possesses the properties that reflect minerals present in the coals. In India, generally same types of coals are used in different power plants. In the absence of a well-planned strategy in India for the disposal of fly ash, it is posing serious health and ecological hazards (Kanojia et al. 2001). The quantity of fly ash produced annually in India by the 88 coal/ lignite based thermal power stations of various power utilities reached 131.09 million tons during the year 2010-12, while total ash utilized was 73.13 million tons with percentage utilization of 55.79% [FLYASH Utilisation (FAU) 2013]. The utilization and disposal of fly ash in environment friendly manner is of foremost concern in countries where majority of electricity is produced through thermal power plants. Attempts were made to use fly ash as bulk fill material (Raymond 1958; Gray and Lin 1972; Joshi et al. 1975), for soil stabilization (Chu et al. 1955; Goecker et al. 1956; Viskochil et al. 1957; Vasquez and Alonso 1981; Tastan et al. 2011) and land reclamation (Kim and Chun 1994). Studies on the bearing capacity of shallow foundation on unreinforced fly ash were reported by DiGioia and Nuzzo (1972) and Kaushik and Ramasamy (1999). Bearing capacity of square footing on pond ash reinforced with jute-geotextile was reported by Ghosh et al. (2005). Model tests on fly ash, reinforced with single layer and double layers of geotextile, overlying soft soil were performed by Ghosh and Dey (2009).

The present study states the feasibility of reusing waste plastic water bottles as ideal compression member in various Geotechnical applications by illustrating the work by Dutta and Mandal (2013) which consisted of compression tests on plastic water bottles with infill materials as fly ash and stone aggregates.

2.0 Material Description

The materials used in the present study are post-consumer plastic water bottles, woven jute geotextile, stone aggregates and fly ash. Plastic bottles and jute geotextile were used to prepare the cells while the stone aggregates and fly ash were the infill materials. Description of the different materials is reported here.

2.1 Plastic Bottle Cells

The present investigation includes two different types of plastic water bottles collected from the waste disposal in Mumbai, India. One set of bottle cells were of 105 mm diameter (Type A), while the other was of 75 mm diameter (Type B). The maximum usable height of the bottles to acquire a perfectly vertical round shaped cell was 200 mm. First, the bottles were cut in to three different heights to attain cells of height 200 mm, 100 mm and 50 mm. Then those were perforated with a hot iron needle to make apertures of 10 mm diameter around the circumference and along the height of the cell maintaining an average 20 mm centre to centre spacing as shown in Figure 1. Before making perforations of 10 mm diameter with a 10 mm diameter hot iron needle, the locations of