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Procedia Engineering 195 (2017) 127 – 133

Procedia Engineering

www.elsevier.com/locate/procedia

18th International Conference on Rehabilitation and Reconstruction of Buildings 2016, CRRB 2016

Investigation of Influence of Recycled Plastics from Cable, Ethylene Vinyl Acetate and Polystyrene Waste on Lightweight Concrete Properties

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Abstract

In this paper, the lightweight concrete made from cable, polystyrene and ethylene vinyl acetate (EVA) waste was studied. EVA waste from footwear industry, waste from electrical cable and waste polystyrene were used as an aggregate in the lightweight concrete. This idea was prompted by lack of polystyrene in the market and also large amounts of waste of foamed plastics, for which the application is looking for opportunities. Further aspect was that production of polystyrene pearls, used as a filler of lightweight concrete, it is very costly.

The plastic waste was used as the only aggregate or as a combination EVA-cable and EVA-polystyrene in a ratio of 1:3, 1:1 and 3:1. The water-cement ratio of 0.50 and the dose of cement – 175 kg/m3 were used for all mixtures. For lightweight concrete were verified particularly density, strength characteristics and heat-technical characteristics.

Peer-review under responsibility of the organizing committee of the 18th International Conference on Rehabilitation and Reconstruction of Buildings 2016

Keywords: lightweight concrete; waste; plastic; polystyrene; cable; ethylene vinyl acetate (EVA)

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Peer-review under responsibility of the organizing committee of the 18th International Conference on Rehabilitation and Reconstruction of Buildings 2016
doi:10.1016/j.proeng.2017.04.534

1. Introduction

In light of increasing waste production of various types with negative consequences for the economy and the environment is an effort to incorporate these secondary raw materials into production of building materials. In civil engineering, secondary raw materials are mainly used in the production of composite materials such as concrete and mortar, as fillers (fly ash and ash from power plants and heating plants [7, 8, 14], ash and slag from the incineration of municipal waste, blast furnace and steel slag, waste molding sand from foundries, wastes wood processing, waste from the production of artificial stone and aggregates, waste from the extraction and treatment of mineral resources and coal waste from the recycling of building materials and building structures [4, 6], waste paper, pulp, plastics etc.) or as adhesives and additives (ground blast furnace slag, gypsum from flue gas desulphurization and waste from chemical production, dust from cement and lime works, microsilica etc.) [15, 17].

Secondary raw materials also so called agro-wastes as e.g. ash from sugar cane, wheat straw and rice and so on are used. Recently, considerable attention is paid to the use of recycled waste plastics [3, 9, 10, 11, 12]: e.g. recycled polystyrene and polyurethane, plastic waste from electrical and electronic equipment, polyethylene terephthalate (PET) bottles, polyvinylchloride (PVC) pipes, etc..

One way to using recycled plastics is their incorporation into lightweight concrete (LWC). When selecting suitable combinations of filler and binder thus formed building material can be used not only in new construction, but also in reconstruction and renewal of existing buildings.

LWCs have quite wide application in construction practice. STN EN 206 [16] defines them as concrete by density less than 2000 $kg.m^{-3}$. Depending on the method of production they can be classified into the following groups: (a) LWC containing lightweight aggregate, (b) LWC with induced bubble voids and (c) LWC with no fine aggregate [2] LWCs have been developed for various construction applications such as high rise buildings, floors and walls, long span bridges, roof decks. Compared with the normal weight concrete, LWC is characterized by good heat-insulating and acoustic -insulating properties. Filler for indirect lightened heat-insulating lightweight concrete is the most common crushed or granulated polystyrene, expanded volcanic glass, for example perlite, expanding vermiculite etc. [5].

Polystyrene concrete as a special type of LWC is suitable for all horizontal structures as filling, heat-insulating lightweight material with bulk density less than 900 $kg.m^{-3}$, compressive strength ranging from 0.3 to 1.8 MPa, excellent heat-insulating properties (from about 0.057 to 0.235 $W.m^{-1}.K^{-1}$). It is fire resistance (from 700 $kg.m^{-3}$, nonflammable), ecological and hygienically safe [2, 15].

Waste polystyrene from packaging industry (electronics, electrical and white goods) is mostly used for the production of polystyrene concrete. The main reasons to using recycled polystyrene are relatively high price of polystyrene granules and its limited availability [18].

Nowadays, it is looking for an alternative to polystyrene filler in the form of other useful plastic waste, with a view to achieving the same or better properties, which characterize the polystyrene concrete.

2. Materials and Methods

2.1. Materials

Aggregates. Ethylene vinyl acetate (EVA) waste from footwear industry, waste polystyrene and waste PVC cables were used as an aggregate in the LWC. EVA is the copolymer of ethylene and vinyl acetate. It's an extremely elastic material that can be sintered to form a porous material similar to rubber, yet with excellent toughness.

Waste cables are crushed packing insulations of cable core, which are mainly made of polyvinyl chloride (PVC). EVA (Fig. 1a) and polystyrene (Fig. 1b) were crushed and selected on fraction 4/8 mm, PVC cables (Fig. 1c) on fraction 0/4 mm. Waste materials are characterized by bulk density EVA: 104.41 $kg.m^{-3}$, polystyrene: 11.44 $kg.m^{-3}$ and PVC cables: 433,30 $kg.m^{-3}$.

LWCs are made with using the only aggregate or as a combination of both materials in a ratio of 1:3, 1:1 and 3:1.