Crumb rubber particles as an alternative aggregate

Food & Diet

EXPERIMENTAL STUDY OF CRUMB RUBBER PARTICLES AS AN ALTERNATIVE AGGREGATE IN ROLLER COMPACTED CONCRETE

Abstract

Several research works have been evaluated potential of the fresh concrete and hardened concrete properties of crumb rubber concrete (CRC). Technical characteristics (porosity, ductility, cracking resistance performance) can be improved by using rubber particles (Meddah et all., 2014). The aim of this present study is to elaborate the performance of different size crumb rubbers in roller compacted concrete (RCC). This study investigates experimentally the effect of using four particle size of crumb rubber (CR) (0. 5-1mm, dust crumb), (1-3mm), (3-5mm), and combination of all of them in RCC by replacing with 0%, 10% aggregates 7, 14 and 28 days. Tests conducted on the fresh and hardened concrete include unit weight, toughness, modulus of elasticity, porosity, compressive strength, tensile strength are investigated respect with crumb rubber in RCC mix.

Key words: Sustainability, Recycling, Concrete Technology, CR, CRC, RCC.

Background

Industrial and manufacturing wastes lead serious and ongoing threats in the environment. Sustainable development principles and environmental protection regulations help to conserve natural resources and reduce the amount of waste without jeopardizing the future. Therefore, recycling has been providing a significant environmental awareness related with construction. Sustainable structural engineering has become increasingly important subject for researchers. Recycling and application of waste materials in concrete has been increasing to improve material properties of the concrete when decreasing costs of concrete in the past three decades (Ataei, 2015). Relating to this principle, different environmental friendly solutions have been searched by improving material properties of the concrete. Reusing the demolished materials helps to prevent environmental pollution, keep the natural sources and use eco-friendly materials. Integrating environmental-friendly construction solutions is a highly focus field infrastructure or new construction projects by using polymer materials. Concrete additives producing from waste materials such as cellulose, wood lignin, bottom ash, fly ash and silica fume have been considered as viable or beneficial (Toutanji, 1996).

Rubber has attracted a great research attention because of the enormous quantities of waste rubber around the world and its potential in the construction. Many civil engineering applications have been carried out the utilization of rubber for the production materials in the construction industry. Rubber is one of the three main polymer material groups; the annual consumption of natural rubber is more than 15 million tons, and the output of rubber products is more than 31 million tons worldwide [1]. Accumulation of discarded waste tire has been a major concern because waste rubber is not easily biodegradable even after a long period of landfill treatment [2]. The storage of wastes in landfills represents environmental and public health hazards of increasingly relevant. The landfills with rubber waste are responsible for a grave risk in the ecology and the threat is always present. Even after long-period of landfill treatment, unmanaged waste tire poses environmental health risk through fire hazard and as a breading ground for disease carrying mosquitoes. Therefore, utilization of crumb rubber (CR) from this scrap tires for the production building materials in the construction industry would help to reserve natural resources and also maintain the ecological balance [3, 4].

Crumb rubber concrete (CRC) has been previously investigated to determine the fresh and hardened properties in several research works such as waterproofing, asphalt pavement, membrane lines. Previous works show that unit weight of CRC decreases as the percentage of the CR replacement increases due to the low specific gravity of CR particles. The strengths (compressive, flexural, splitting and modulus) of CRC decrease as the partial replacement of fine aggregate with CR aggregates. CRC exhibits high capacity for absorbing plastic energy under both compression and tension loading which also possesses higher toughness. Partial replacement of the fine aggregate by CR will improve workability of CRC [5, 6, 7, 8].

RCC is a dry (zero-slump) conventional concrete which has been made by vibrating rollers (Neville and Brooks, 1990). RCC has same ingredients with ordinary concrete (aggregates, cement, water and admixtures), lower cost and easier implementation (Meddah et all., 2014). So, RCC properties which is the subjected matter of this study is considered its advantages with CR.

Aim and Objectives

The main objective of this research is to improve performance of RCC by mixing with CR. Based on this research, five mixes are prepared RCC without CR, RCC with CR (maximum size of 1, 3, and 5) by using coarse and fine aggregate, cement, water and additive. There are 15% cement, 30%

aggregate, 55 % sand. Crumb rubber is used to replace with fine aggregate (sand) at 10%. In particular, technical objectives can be described as follow.

To define contents of RCC, cement and water contents are prepared related to ASTM D1557 standards (Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort) by using soil mechanics procedure (Marchand et al., 1997; Meddah et all, 2014).

To understand density and workability, according to ASTM C1170 (Standard Test Method for Determining Consistency and Density of Roller-Compacted Concrete Using a Vibrating Table), mechanical tests of fresh concrete (VeBe test and density of fresh concrete) can be measured for each sample.

To evaluate mechanical tests of hardened concrete (Compressive Strength Test, Splitting Tensile Strength Test and Bending Test are measured at 7, 14, 27 days related to ASTM C39, ASTM C78 and ASTM C496. Each test consists of 3 samples to each rubber contents. The arithmetic mean of three value is investigated for all experiments. Cylinder and cube specimens (150 x 300mm) and (100 x 100 x 100 mm) are prepared for compressive strength test, beam specimens (100 x 100 x 500 mm) are made for bending strength test and cylinder specimens (150 x 300 mm) are used for splitting tensile strength test.

To determine static modulus of elasticity and poisons’ ratio of concrete in compression, ASTM C469 is used at 28 days.

Number of Samples

Compressive Strength	Bending Strength	Splitting Tensile Strength		
Rubber Size	Cylindric (150×300 mm)	Cube(100x100x100mm)	Prismatic(100x100x500mm)	Cylindric (150 x300mm)
0	3	3	3	3
0. 5-1mm	3	3	3	3
1-3mm	3	3	3	3
3-5mm	3	3	3	3
0. 5-5mm	3	3	3	3

Total number of sample is 60.