Study on the Properties of Aerated Concrete Incorporating Fly Ash and PVC Granules

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Abstract

A considerable growth in the consumption of plastic is observed all over the world in recent years, which has led to huge quantities of plastic-related waste. Reprocessing of plastic waste to produce new materials like concrete or mortar appears as one of the best solution for disposing of plastic waste, due to its economic and environmental advantages. The use of plastic granules as fine aggregate seems to be a feasible option. This study deals with replacement of sand with plastic granules made by recycling plastic wastes sourced from scraped PVC pipes, PET bottles, plastic carry bags and then finding out an optimum ratio so as to have a target strength around 10 MPa.

Keywords: LWC, Aluminium powder, Fly ash, PVC granules

I. INTRODUCTION

Structural LWC has an in-place density (unit weight) on the order of 1440 to 1840 kg/m³ compared to normal weight concrete a density in the range of 2240 to 2400 kg/m³. For structural uses, the concrete strength should be greater than 17.0 MPa. Lightweight aggregate is an important material in reducing the unit weight of concrete to produce earthquake resistant structures the earthquake forces are linearly dependant on the mass of the structure. Lightweight aggregates are generally used to reduce the unit weight of concrete by replacing the conventional aggregates. One of the reasonable methods for disposal of PVC wastes, which causes environmental pollution, is using these wastes in the other industrial areas. Industry of construction engineering area seems to be appropriate with its high consumption capacity. This area can consume a large amount of PET wastes. Nowadays, there are many lightweight concrete applications made with natural or artificial lightweight aggregates. These are by using porous lightweight aggregate of low specific gravity, by introducing large voids in the concrete know as aerated, cellular or formed concrete, or by omitting fine aggregates.

II. ADVANTAGES

Rapid and relatively simple construction, Economical in terms of transportation as well as reduction in manpower, Significant reduction of overall weight results in saving structural frames, footing or piles, Most of lightweight concrete have better nailing and sawing properties than heavier and stronger conventional concrete. As the density decreases, thermal conductivity decreases thus providing more of an energy efficient space, which can isolate extreme climates. The use of LWC has sometimes made it possible to proceed with the design which otherwise would have been abandoned because of excessive weight.

III. DURABILITY

Durability is defined as the ability of a material to withstand the effect of its environment. In a building material, as chemical attack, physical stress, and mechanical assault. Chemical attack is as aggregate ground-water particularly sulphate, polluted air, and spillage of reactive liquids LWC has no special resistant to these agencies: indeed, it is generally more porous than the ordinary Portland cement. Physical stresses to which LWC is exposed are principally frost action and shrinkage and temperature stresses. Stressing may be due to the drying shrinkage of the concrete or to differential thermal movements between dissimilar materials or to other phenomena of a similar nature. Drying shrinkage commonly causes cracking of LWC if suitable precautions are not taken. Mechanical damage can result from abrasion or impact excessive loading of flexural members.

IV. LITERATURE REVIEW

A. Comparison of lightweight concrete with only PVC aggregates and with both PVC and sand aggregates

Semiha Akcaozoglu et al. (2009), Investigation was carried out on two groups of mortar samples, one made with only PET aggregates and, second made with PET and sand aggregates together. Additionally, blast-furnace slag was also used as the
replacement of cement on mass basis at the replacement ratio of 50% to reduce the amount of cement used and provide savings. The water–binder (w/b) ratio and PET–binder (PET/b) ratio used in the mixtures were 0.45 and 0.50, respectively. The size of shredded PET granules used in the preparation of mortar mixtures were between 0 and 4 mm. The results of the laboratory study and testing carried out showed that mortar containing only PET aggregate, mortar containing PET and sand aggregate, and mortars modified with slag as cement replacement can be drop into structural lightweight concrete category in terms of unit weight and strength properties. [1]

B. Strength behaviour concrete containing PVC Aggregate

Nabajyoti Saikia et al (2012), The compressive strength development of concrete containing all types of PVC-aggregate behaves like in conventional concrete, though the incorporation of any type of PVC-aggregate significantly lowers the compressive strength of the resulting concrete. The PVC-aggregate incorporation improves the toughness behaviour of the resulting concrete. This behaviour is dependent on PET-aggregate’s shape and is maximized for concrete containing coarse, flaky PVC-aggregate. The splitting tensile and flexural strength characteristics are proportional to the loss in compressive strength of concrete containing plastic aggregates. [2]

C. Study of surface microstructure of waste PVC lightweight aggregate

Yun-Wang Choi et al (2004), The WPLA was made from the waste PVC bottles and GBFS, and experimental tests were conducted on compressive strength, splitting tensile strength, modulus of elasticity, slump, and density of waste PET bottles lightweight aggregate concrete (WPLAC). The 28-day compressive strength of WPLAC with the replacement ratio of 75% reduces about 33% compared to the control concrete in the water–cement ratio of 45%. The density of WPLAC varies from 1940 to 2260 kg/m3 by the influence of WPLA. The structural efficiency of WPLAC decreases as the replacement ratio increases. The workability of concrete with 75% WPLA improves about 123% compared to that of the normal concrete in the water–cement ratio of 53%. The adhered GBFS is able to strengthen the surface of WPLA and to narrow the transition zone owing to the reaction with calcium hydroxide. [3]

D. Study on density of pulverized PVC in concrete

P. Suganthy et al. (2013), The density of the Pulverized plastic was found to be 460 kg/m³ & its specific gravity was 0.46. Sieve analyses were carried out & about 75% of the plastics were found to be in the range of 1 -1.7 mm. 45 nos. of 15cm x15cm x 15cm cement concrete Cubes of 1:1:2 (M 25) mix were cast for 0%, 25%, 50%, 75%, 100% sand being replaced with Pulverized plastic material. Volumetric proportioning was adopted instead of design mix since the density of plastic material was too low. Workability test, weight and compressive strength of the cubes were determined. The test results revealed that the yield as well as the ultimate strength of concrete at seventh day decreased by about 3 to 3.2 N/mm² for 25%replacement & 4 to 6.5 N/mm² for higher replacements of Plastic when compared to conventional concrete The ultimate as well as the yield strength of concrete at 14th day & 28th day decreased by about 0.2 to 1 N/mm²for 25%replacement & 9.1 to 14.6 N/mm² for higher replacements of Plastic when compared to conventional concrete The water Cement ratio was also found to increase with the proportion of Plastics for a slump of 10 mm & weight of the cube decreased with an increase in replacement of Sand by Plastic Material. Thus it is inferred that Replacement of sand by plastic up to 25% can be adopted so that disposal of used plastic can be done as well the deficiency of Natural aggregates can be managed effectively. [4]

E. Determine the efficiency of using waste plastic in concrete

Zainab Z. Ismail et al. (2007) Waste plastic was used as a partial replacement for sand by 0%, 10%, 15%, and 20%. All of the concrete mixtures were tested at room temperature. These tests include performing slump, fresh density, dry density, compressive strength, flexural strength, and toughness indices. Seventy cubes were moulded for compressive strength and dry density tests, and 54 prisms were cast for flexural strength and toughness indices tests. Curing ages of 3, 7, 14, and 28 days for the concrete mixtures were applied in this work. This study ensures that using waste plastic as a sand-substitution aggregate in concrete gives a good approach to reduce the cost of materials and solve some of the solid waste problems posed by plastics. [5]

F. Sand-substitution by PVC aggregates in cementitious concrete composites.

O. Yazoghi Marzouk et al. (2006) Various volume fractions of sand varying from 2% to 100% were substituted by the same volume of granulated plastic, and various sizes of PET aggregates were used. The bulk density and mechanical characteristics of the composites produced were evaluated. To study the relationship between mechanical properties and composite microstructure, scanning electron microscopy technique was employed. The results presented show that substituting sand at a level below 50% by volume with granulated PET, whose upper granular limit equals 5 mm, affects neither the compressive strength nor the flexural strength of composites. [6]

G. Effects of size and shape of PVC granules in concrete

Nabajyoti Saikia et al. (2013) The results indicate that the slump of fresh concrete increases slightly with the incorporation of pellet-shaped PVC-aggregate. Flakier plastic aggregate sharply decreases the slump of the fresh concrete and it further decreases

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if the content and size of this type of PET-aggregate increase. The compressive strength, tensile splitting strength, modulus of elasticity and flexural strength of concrete deteriorate due to the incorporation of PVC-aggregate and the deterioration of these properties intensifies with increasing content of this aggregate. Differences in size, shape and texture of PET-aggregates change the water to cement ratio as well as the slump of fresh concrete mixes, which ultimately change the mechanical behaviour. Flaky PVC-aggregates bridge the two separated concrete pieces and therefore prevent concrete from breaking apart after failure. The abrasion resistance of concrete mixes containing various types of PVC-aggregate is better than that of the reference concrete. The abrasion resistance of concrete with incorporation of various types and contents of PET-aggregates can be related to its compressive strength. [7]

II. Comparison of different strength of LWC containing PVC granules

Mohd Irwan Juki et al. (2013) the experimental investigation of relationship between splitting tensile strength and flexural strength with the compressive strength of concrete containing waste PET as fine aggregates replacement. Waste PET was reprocessed and used as the artificial fine aggregate at the replacement volume of 25%, 50% and 75%. Cylindrical and prism specimens were tested to obtain the compressive, splitting tensile and flexural strength at the age of 28 days. Based on the investigation, a relationship for the prediction of splitting tensile and flexural strength was derived from the compressive strength of concrete containing waste PET as fine aggregate replacement. [8]

I. High-performance aerated concrete

Keun-Hyeok et al. (2015) tested 16 concrete mixes to create a high-performance aerated concrete. The obtained high-performance aerated concrete was compared with the minimum requirements specified in ASTM C 1693. From the regression analyses of the test data, prediction models for dry density, compressive strength, stress–strain relationship, and thermal conductivity of aerated concrete were obtained. All concrete mixes tested showed enhanced workability and de foaming resistance, achieving self-compatibility performance. Mechanical properties prove that the developed high-performance aerated concrete can be used for practical application. [9]

V. CONCLUSIONS

From the literature review, it can be concluded that the direct inclusion of plastic in concrete does not effectively improve the strength of concrete. Workability of concrete containing waste plastic begins to decrease as the amount of waste plastic increases. Addition of plastics in concrete decreases the compressive strength. Addition of limited percentages of plastic in concrete has resulted in small improvements in the tensile strength of concrete. The increments of tensile strength improvement result from the bridging actions of the fibers in the concrete. The flexural strength of concrete improves with the addition of plastic fibers in concrete. The properties of concrete vary as the plastic fiber content in concrete varies. Thus, future research should focused on establishing a method for mixing plastic fiber in concrete, the shape of plastic fibers, the specified aspect ratios of plastic fibers, and the surface properties of plastic fibers so that the fibers adhered to the concrete mix.

ACKNOWLEDGEMENT

It is my privilege to express sincere thanks to my project guide, Dr. Elson John, Professor, Civil Department, MACE for his advice and assistance throughout the project. I would also like to express my sincere gratitude to all my friends and classmates for their help and support.

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