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A STUDY OF THE EFFECTS OF RECYCLED PLASTIC MATERIALS AND QUARRY DUST ON COMPRESSIVE STRENGTH OF CONCRETE.

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Abstract- *Sustainability and material use is playing a leading role in the development of concrete industry in recent years. Concrete mix in construction serves as a crucial element in building up any type of constructions that require a wide range of mechanical and sustainable properties with a view to providing safe, reliable and durable structures. The variation of compressive strength and physical properties based on partial replacement of fresh Coarse and fine aggregates by recycled aggregates and combination of quarry dust with waste plastic materials has investigated in this study. Three type's proportions of cement, sand and aggregates respectively as 1:1.25:2.5; 1:1:2 & 1:0.75:1.5 is used in casting cylinder for getting concrete mix. In* characterizing *concrete mix, the water-cement ratio is kept 0.50. The percentage of recycled aggregates and combination of quarry dust with waste plastic materials used by volume basis are 15% and 25% as replacement of coarse and fine aggregates. With an aim to evaluate the character of aggregates and also to find out the physical properties of aggregates, gradation of both coarse and fine aggregates, unit weight of coarse aggregate in loose and dense conditions, water absorbing capacity of coarse aggregates and other related testes are experimentally performed. The present study through the aforementioned laboratory tests come up significant findings that 10 % aggregate replacement in fresh concrete in terms of recycled aggregates and combination of quarry dust with waste plastic materials (Combination 1) shows good result of compressive strength and required physical characteristic compare to fresh concrete. Similarly when the fresh aggregates are replaced with 25 % recycled aggregates and combination of quarry dust with waste plastic materials (Combination 2) gives a satisfactory result in comparison with fresh concrete for 7, 14 and 28 days.*

Keywords: Fresh aggregate, recycled aggregate, quarry dust, plastic materials, concrete, compressive strength and mix ratios.

1. INTRODUCTION

The scopes in using recycled materials obtained from construction and demolition waste are increasing over the world [1-3]. Environmental protection, conservation of natural resources, land shortages and increasing costs of demolition waste treatment are key factors for implementing the recycling concept. Concrete is the combination of fine aggregate, coarse aggregate, and biding materials, widely used for reinforced concrete construction industries. The strength of concrete is dependent on various factors: the strength of aggregates, deformation properties, durability and sustainability properties and the bonding between the paste and surface of aggregates influence the strength of concrete. In recent years, the use of recycled materials as coarse aggregates got increased remarkably due to cost efficiency and imparting sufficient strength [4-10]. Ahmed and Rahman [11, 12] demonstrated the effects of mix ratio, size, and texture of coarse & fine aggregates, method of compaction and curing period on the compressive strength of concrete by improving a mix design. Five different sizes of coarse aggregates were considered. The effects of coarse aggregate sizes were also inspected. Rahman [13] found that sufficient compressive strength can be obtained by replacing natural aggregates with recycled materials and waste plastic materials. A combination of recycled and waste plastics can be a prospective choice in the case of concrete mixed design according to this study. The essential criteria for using materials, water-cement ratio, the ratio of coarse aggregate (CA) to fine aggregate (FA), size of coarse aggregate and desired amount of admixtures in producing high strength concrete (HSC) are broadly studied by Manimaran et al., [14]. Rashid et al. [15] found that concrete with crushed bricks imparts more stiffness and strength than usual concrete. Kozul and Darwin [16] illustrated that the size of the aggregates small-scale effect on compressive strength for both normal and high strength concrete industry. They added that basalt or crushed limestone can be considered in concrete mixtures to obtain more strength. Rai et al. [17] discussed the use of waste plasticizer in the concrete mixture. They found that the reduction of strength gets flattened after increasing the plastic content 10%. The

context of using plastic materials in concrete in terms of environmental and waste management domain is broadly studied in Siddique et al. [18]. This research aims to perform experimental assessments of the concrete mixture using recycled materials in a different ratio. Three different categories are tested including fresh aggregates, 10% of recycled aggregates and 25% of recycled aggregates. The outcome of these studies demonstrated that concrete with recycled aggregates performs even better than M25 graded concrete. The conclusion of this study illustrates that recycled materials can be a decent choice for mix design in terms of gaining sufficient compressive strength.

2. OBJECTIVES OF THE STUDY

All over concrete industries and the academic world of thoughts of construction material, necessity of investigation into material use and its sustainability is now peaking up. As for safe and durable structures of today's concern, concrete mix-up is a much more focused and priority job for engineers, and it is worth a lot in terms of durability and meaningful cost management. When stress is applied, the response of concrete depends on the stress type and on influence that the combination of various factors performs on porosity of the different structural components of concrete. The investigation and experiment were conducted to attain primarily the following objectives:

(i) To investigate the effect of compressive strength of concrete due to partial replacement of fresh aggregates by recycled aggregates including waste plastic materials and quarry dust.

(ii) To find out the physical properties of aggregates while mixing at different proportions.

(iii) To use the recycled aggregates, waste plastic materials & quarry debris and reduce the environmental wastes.

3. METHODOLOGY

The materials such as fine aggregates (sand, quarry dust and waste plastic materials), coarse aggregates (fresh aggregates and recycled aggregates) and cement which have used to form concrete mixture was collected from Bahaddarhat, Chattogram and Mariali, Gazipur. To investigate the different physical properties of the materials epically for coarse and fine aggregates of that project work, different experimental tests are conducted in the laboratory as per standard testing methods. The physical properties of materials for this work included unit weight (dense & loose conditions), the aggregate cursing value, aggregate impact value, the water absorption value of coarse aggregates and fineness modulus of both coarse and fine aggregate are tested properly. Two types of sand like "Sylhet & Local sand" are used at (1:1) proportions in this experiment. To get exact variations in compressive strength, the concrete mix is prepared by taking the 3 proportions of cement, sand and aggregate i.e. mix ratio 1(1:1.25:2.5); mix ratio 2(1:1:2) and mix ratio 3(1:0.75:1.5) and the water-cement ratio is kept as 0.50. The specimen is prepared in cylindrical steel mould whose size is 6 inch in diameter and 12 inch in height using fresh aggregates and alternate aggregates. For combination 1, 15 % recycled aggregate is added as a partial replacement of fresh aggregates and 15 % quarry debris including waste plastic materials is used as the replacement of fresh fine aggregates. And again for combination 2, 25 % recycled aggregates and equal amount of quarry debris with waste plastic materials has mixed as a partial replacement of fresh coarse aggregates and fine aggregates. The proportion of quarry debris and waste plastic materials is kept 1:1. The coarse aggregates, fine aggregates and cement were mixed thoroughly. To attain a uniform workability for the mixture the addition of water is added. Then the casting has done properly as per rules with the help of mould. Oil was brushed to the mould properly prior to the casting of specimen. Completing proper oiling, the casting is done as shown in figure-1. When the casting is completed properly, it was given some time to be hardened and after that this cylinder is prepared for curing that is very essential part for gaining maximum strength. After 7, 14 and 28 days curing the cylinder is crushed with the help of universal testing machine as shown in figure-2 & figure-3.

Fig.1: Casting of concrete cylinder

Fig.2: Placing of the specimen in universal testing machine

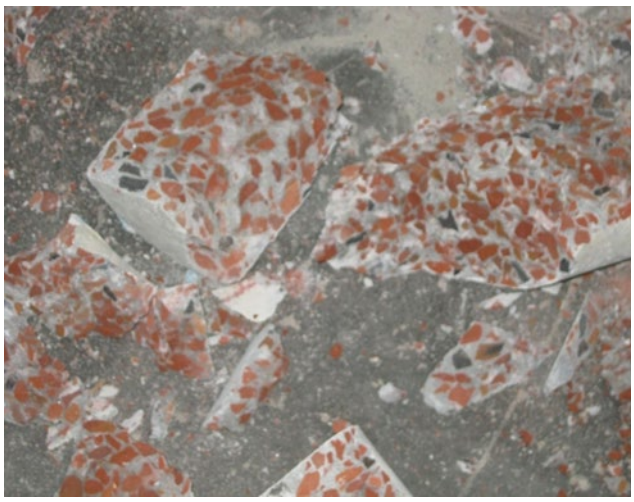

Fig.3: Crushing of the cylindrical specimen

3. RESULTS AND DISCUSSIONS

Different required experiments are conducted in the laboratory for investigating the physical characteristics of both coarse and fine aggregates.

Table 1: Fundamental properties of coarse aggregates

Properties	Obtained value		
Name of the test	Fresh aggregates	Combination	
		Fresh & 10% recycled aggregates	Fresh & 25% recycled aggregates
Unit weight, dense, (Kg/m^3)	1644.3	1645.0	1558.8
Unit weight, loose, (Kg/m^3)	1414.2	1368.2	1341.1
Absorption of water (%)	9.72	10.6	12.0
Fineness modulus (FM)	8.58	7.75	6.80
Aggregate Crushing value (%)	31.30	32.70	34.20
Aggregate Impact value (%)	12.60	13.60	14.20
Aggregate Abrasion value (%)	36.30	37.9	39.0
Soundness value (%)	5.30	4.90	4.05

Unit weight and water absorption of fresh coarse aggregates and Combination of fresh and recycled aggregates are determined by the procedure of AASHTO 19 and AASHTO T 85 accordingly. The abrasion value, impact value, crushing value, for aggregates are determined by the following test procedure AASHTO T 104 and BS 812 (part-3) respectively. The fineness modulus for both coarse and fine aggregates is determined in the laboratory. The soundness value of coarse aggregates is found out as per Sodium and Magnesium Sulphate (AASHTO T 104). The available value of all tests gotten from the laboratory is sufficient for using these ingredients in different constructions. The variation in these properties from the fresh aggregates to combined aggregates has got very slight. Test results of intrinsic properties of coarse aggregates are given in Table 1. The obtained compressive strength of concrete after 7, 14 & 28 days curing period through standard procedure is mentioned in the following tables based on fresh aggregates, Combination 1 (Fresh aggregate + 15 % recycled aggregate + 15 % quarry dust with waste plastic materials)and Combination 2 (Fresh aggregate + 25 % recycled aggregate + 25 % quarry dust with waste plastic materials) for mix ratio 1 (1:1.25:2.5), mix ratio 2 (1:1:2) and mix ratio 3 (1:0.75:1.5).

Table 2: Compressive strength of concrete based on fresh aggregates, combination 1 and combination 2 with w/c = 0.50

Mix ratio	Compressive strength of concrete (MPa) after 7 days curing		
	Fresh aggregate	Combination	
		Combination - 1	Combination - 2
1:1.25:2.5	25.55	22.21	21.55
1:1:2	26.87	23.73	22.30
1:0.75:1.5	28.48	24.16	24.27

Table 3: Compressive strength of concrete based on fresh aggregates, combination 1 and combination 2 with w/c = 0.50

Mix ratio	Compressive strength of concrete (MPa) after 14 days curing		
	Fresh aggregate	Combination	
		Combination - 1	Combination - 2
1:1.25:2.5	27.30	24.10	23.15
1:1:2	27.15	23.30	24.10
1:0.75:1.5	29.75	26.40	26.90

Table 4: Compressive strength of concrete based on fresh aggregates, combination 1 and combination 2 with w/c = 0.50

Mix ratio	Compressive strength of concrete (MPa) after 28 days curing		
	Fresh aggregate	Combination	
		Combination - 1	Combination - 2
1:1.25:2.5	32.15	27.80	26.97
1:1:2	35.35	30.10	27.95
1:0.75:1.5	36.24	31.55	31.20

4. CONCLUSIONS

The present study through the aforementioned experiments come up significant findings that the obtained compressive strength for combination 1(Fresh aggregate + 15 % recycled aggregate + 15 % quarry dust with waste plastic materials) is approximately 9.47 % less than the obtained value for fresh aggregates and for combination 2 its value is 15.73% less than the compressive strength of fresh aggregates after 7 days curing period for all using ratios. In case of 14 days curing period, the obtained compressive strength for combination 1 is approximately 10.62% less than the obtained value for fresh aggregates and for combination 2 the value is 15.06% less than the obtained value for fresh aggregates. Similarly, the compressive strength for fresh aggregate shows 9.82 % higher value than the combination 1 and 16.16 % higher value than the combination 2 for all mix ratios after 28 days curing period. Based on the results of experiments, it is observed that the difference in compressive strength between fresh aggregates and 15 % partially replaced aggregates with recycled aggregates and quarry debris including waste plastic materials is very slight and negligible. And at the same time for 25 % replacement of fresh aggregates by the combination of recycled aggregates and quarry debris with waste plastic materials shows satisfactory result. At mix ratio 1:0.75:1.5, the higher strength is obtained in comparison to other mix ratios with sufficient workability in all cases. Last but not least, this study believes that the use of recycled aggregates, quarry dust and waste plastic materials as replacement for coarse aggregate and fine aggregate in concrete will limit the environmental wastes as well, and thus the study is expected to add value to the existing body of research.

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