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An Experimental Investigation To Produce A Cost Effective Concrete By Partial Replacement Of Coarse Aggregate With High Density Polyethylene (HDPE) Waste And Cement With Alccofine

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Abstract- *Waste plastic materials are generated in large amount and disposal of plastic waste is not eco-friendly as it is non-biodegradable. Usage of waste plastic aggregates in concrete helps in recycling and reuse of plastic and also as an alternative material for concreting. This experiment aims to produce a cost effective concrete and utilization of waste by partial replacement of coarse aggregate by plastic waste in 8%,16%,24% and 32% and cement by alccofine in 5%,10%,15%,20% and 25%. Experiments were conducted to determine strength and durability characteristics of concrete by destructive and non-destructive tests.*

Key Words : High Density Polyethylene (HDPE), Alccofine, Compressive strength.

1. INTRODUCTION

Research1concerningithe3use of waste-products to enhance the concrete properties has been conducting and occurring from several years. The potential applications of trade and industry waste materials in concrete square measure as an additive or substitute for aggregate and cement replacement, reckoning the chemical composition and grain size of the material. Utilizing these by-products or recycled materials in concrete comes from the environmental constraints for the safe disposal of these waste products. The application of plastic is growing rapidly. Quantities of plastic waste have been increasing day to day and recent studies have stated that it can remain unchanged for as long as 4500 years on earth.

Increment in construction activities has led to the inventions of new materials and methods and also utilizing the wastes as a substitute in concrete. Numerous experiments have been conducted using wastes such as rice husk, palm oil waste, plastic bottles and so on. In this paper a study is conducted using high density plastic and ultra fine particle alccofine.

Quantities of3 plastic3wastes have been increasing day to day. This case causes serious issues like wastage of natural resources and pollution of environment. Due to its chemical and physical properties, it is difficult to decompose or degrade and has a longer life span resulting pollution of environment. A partial resolution for environmental and ecological issues is the utilization of waste materials. Many experiments and investigations are conducted to use waste plastic in a effective way as aggregate for concrete. Use of these materials solely helps in getting them utilized in concrete as an alternative construction material.

In this paper, cable pipe (HDPE) wastes are used as coarse aggregate for production of concrete. Plastic aggregate and alccofine is used to produce durable polymer concrete.

2 LITERATURE REVIEW

Devinder Sharma, Sanja Sharma, Ajay Goyal (2016) carried out research by Utilizing Waste Foundry Slag and alccofine for Developing High Strength Concrete. Experimental study was conducted by replacing cement using alccofine and fine aggregates by foundry slag. By varying the percentage replacement level of foundry slag from 0 to 50%, water binder ratio as 0.239 and optimum dosage of alccofine, concrete specimens were casted and basic tests such as compressive strength, tensile strength (TS) and flexural strength (FS) were done and durability tests were carried out to find their properties. They suggested that high strength concrete can be produced by using foundry slag and alccofine as partial replacement for sand and cement. Result showed an increase in alkalinity and permeability properties of concrete by optimized replacement levels of Cement with Alccofine.

Sampada Chavan , Pooja Rao (2016) carried out research on Utilization of Waste Polyethylene Bottle (PET) Fibre in Concrete. Their experimental work was incorporation of plastics such as PET wastes in concretes as a light weight aggregate. The reduction of unit weight of concrete is one of the goals of production of earthquake resistant structures. PET fibre reinforced concrete has experimentally been proven to perform better. PET fibre or synthetic fibre has unique qualities. Compared to the ordinary fibre and this has been proved in this research work. This work has been concluded that 20% of PET aggregate can be used as a replacement for coarse aggregate without any detrimental effects and increased strength.

2. MATERIALS

Production of concrete using high density polyethylene waste aggregates and alccofine is a new combination adopted to enhance the strength properties of polymer concrete. The main intention of this project is to find the strength variation in polymer concrete by partial replacement of coarse aggregate by HDPE and cement by alccofine.

2.1 Cement*:* Ordinary Portland 43 grade Coromandel cement conforming to IS: 8112- 2013 is used as the binding material in this project

2.2 Fine aggregate*:* Locally available river sand conforming to grading zone II of IS: 383 –1970 is used as a substitute in concrete along with cement. Clean and dry fine aggregate passing through IS 4.75mm sieve and retained in 75 micron sieve is used for casting all specimens required for the experimental purpose.

2.3 Coarse aggregate*:* Crushed aggregate conforming to IS: 383-1987 is used. Graded coarse aggregate0of size 20mm and 12 mm has been utilized throughout the experimental work. 50% of 20mm and 50% of 12mm sized aggregates are used for concrete. Aggregate occupies nearly 75-80% of concrete volume.

2.4 Alccofine: Alccofine is a specially processed product based on slag of high glass content with high reactivity obtained through the process of controlled granulation. It is a low calcium silicate based mineral additive. It enhances the hydration process due to apparent hydraulic behaviour and pozzolanic reactivity. Addition of alccofine increases packing density of concrete and reduces the quantity of water and admixture.

2.5 Plastic*:* HDPE is adopted to be the replacement material. This is because of easy availability of this material, its density and its workability. Development of concrete with non-conventional aggregate such as polystyrene foam wastes, HDPE, PET and other plastic are used in concrete to improve the properties of the concrete and reduce cost. Use of plastic wastes in concrete will lead to sustain the concrete design and greener the environment

2.6 Water: Water assists within the chemical reaction with cement which is referred to as hydration of cement and strength depends on the coupling movement of hydrated cement gel. Water utilized for preparing concrete and curing was potable water, clean and free from injurious amounts of alkali, salts, and organic materials.

2.7 Admixture*:* The super plasticizer used is Conplast SP 430 G8 which complies with IS 9103 1999 and BS 5075 part 3, based on sulphonted naphthalene polymers and supplied as a brown liquid instantly disperable in water.

3. METHODOLOGY

In this experimental work concrete cubes were cast and tests were conducted to determine the characteristics of polymer concrete with alccofine. Coarse aggregate is replaced by natural coarse aggregate and cement by alccofine.

M30 grade concrete was adopted and the mix proportion is 1:2.38:3.12 with w/c 0.45.

First phase of experimental work is preparing a trial mix-M1 using conventional materials (cement, fine aggregate and coarse aggregate). During second phase various trials were done to determine the optimum dosage of super plasticizer to get the required slump. Then trial mix M2 was prepared to find optimum percentage of super plasticizer. During third phase trials were done to determine the optimum dosage of alccofine. Cement was replaced by alccofine by varying percentages such as 5%,10%,15%,20%,25% designated as (ALC1.ALC2,ALC3,ALC4,ALC5) During fourth phase of experiment, trials were done by replacing coarse aggregate by plastic aggregate by varying the percentage replacement of plastic aggregatesby8%,16%,24%,32% (HDPE1,HDPE2,HDPE3,HDPE4).
Slump test and compaction factor test was conducted on fresh concrete. Specimens were casted tests such as compressive strength, split tensile strength, flexural strength, acid attack, sulphate attack, water absorption, sorptivity, ultrasonic pulse velocity and rebound hammer were conducted and compared with the results of conventional concrete mix.

4. RESULTS AND DISCUSSIONS

4.1. Slump test

Table 1 Slump Test Results

Mix	Slump (mm)	Mix	Slump (mm)
M2	95		
ALC1	100	HDPE1	108
ALC2	102	HDPE2	110
ALC3	108	HDPE3	115
ALC4	110	HDPE4	118
ALC5	115		

4.2. Compaction factor (CF)

Table 2 Compaction Factor Test Results

Mix	CF	Mix	CF
M2	0.85		
ALC1	0.87	HDPE1	0.91
ALC2	0.89	HDPE2	0.92

ALC3	0.90	HDPE3	0.93
ALC4	0.91	HDPE4	0.93
ALC5	0.91		

Compaction factor lies in between 0.85 to 0.93 which is as per the required standards.

4.3 Density Test

Table 3 Density Test Results

Mix	Density (Kg/m³)	Mix	Density (Kg/m³)
M1	2429.62	M2	2438.51
ALC1	2444.44	HDPE1	2358.51
ALC2	2450.37	HDPE2	2352.59
ALC3	2453.33	HDPE3	2348.14
ALC4	2447.40	HDPE4	2311.11
ALC5	2441.48		

By the addition of plastic the density of concrete decreases and becomes light weight concrete.

4.4 Compressive Strength Test Results

Table 4 Compressive Strength Test Results

Mix	Compressive strength (N/mm²)			
	3days	7days	14 days	28 days
M1	14.91	23.38	27.90	41.37
M2	15.64	23.71	30.50	42.14
ALC 1	13.92	20.61	29.35	43.58
ALC 2	14.02	20.93	30.68	45.33
ALC 3	17.98	25.42	36.51	49.81
ALC 4	16.35	22.63	33.98	46.86
ALC 5	15.11	22.39	32.61	45.60

Table 5 Compressive Strength Test Results

Mix	Compressive strength (N/mm²)				
	3days	7days	14 days	28 days	56 days
M 2	15.64	23.71	30.50	42.14	43.61
HDPE 1	19.15	22.50	26.30	40.23	45.32
HDPE 2	18.15	21.18	24.73	37.66	43.86
HDPE 3	14.31	16.66	22.91	35.54	42.28
HDPE 4	12.39	14.84	20.46	30.98	39.85

Compressive strength is maximum for 20%replacement of cement by alccofine and in polymer concrete, strength is high for 8% replacement of coarse aggregate by HDPE.

4.5 Split Tensile Strength Test

Table 6 Split Tensile Strength Test Results

Mix	Split tensile strength (N/mm²)			
	3days	7days	14 days	28 days
M1	1.74	2.79	3.28	3.14
M2	1.87	2.87	3.30	3.90
ALC 1	2.04	3.02	3.35	4.63
ALC 2	1.89	3.25	3.39	4.68
ALC 3	2.15	3.31	3.90	5.02
ALC 4	1.85	2.49	3.42	4.57
ALC 5	1.63	2.59	3.26	4.32
HDPE 1	2.06	2.64	3.56	4.00
HDPE 2	1.73	1.96	2.92	3.82
HDPE 3	1.62	1.74	2.88	3.76
HDPE 4	1.41	1.58	2.62	3.2

Plastic aggregates having crushing value less than 10 has the ability to resist tension applied. It is observed that the concrete with 8% plastic aggregates has higher split tensile strength

4.6 Flexural Strength Test Results

Table 7 Flexural Strength Test Results

Mix	Flexural strength(N/mm²)	
	3days	28 days
M1	3.38	4.34
M2	3.5	4.56
ALC 1	3.8	4.76
ALC 2	4.0	4.84
ALC 3	4.28	5.14
ALC 4	3.68	4.16
ALC 5	3.56	3.96
HDPE 1	3.96	4.28
HDPE 2	3.56	3.98
HDPE 3	3.40	3.73
HDPE 4	3.24	3.54

At 15 % replacement and 8 % plastic aggregate the flexural strength is high. This indicates that concrete with plastic material has the ability to withstand the highest stress experienced within the material. Plastic aggregates being a polymer material can resist high tensile forces. The

arrangement of molecules in polyethylene material is stringing in nature which give a closely packed structure and intermolecular bond resulting in high flexural strength.

4.7 Acid Attack Test

Table 8 Acid Attack results

Trial mix	Compressive strength after 28 days curing (N/mm²)	Compressive strength after immersion in HCl solution for 28 days (N/mm²)	% weight loss
M2	42.10	40.98	1.12
HDPE 1	39.86	37.85	1.68
HDPE 2	37.52	35.98	1.70
HDPE 3	35.32	34.15	1.73
HDPE 4	29.65	28.77	1.71

Plastic aggregate being a polymer material is not affected by chemical reaction and withstands the reaction within the concrete.

4.7 Sulphate Attack Test Results

Table 9 Sulphate Attack Test Results

Trial mix	Compressive strength after curing in water for 28 days (N/mm²)	Compressive strength after curing in Na_2SO_4solution for 28 days (N/mm²)	Percentage weight loss
M2	37.14	35.66	2.24
HDPE 1	34.55	34.83	2.20
HDPE 2	34.66	35.17	2.17
HDPE 4	29.54	30.12	2.13
HDPE 4	27.98	29.61	2.10

After immersion in sodium sulphate solution, negligible variation has been observed in compressive strength. Effect of chemicals on HDPE concrete is less when compared to control mix. HDPE being a polymer based material can resist the chemical attack. From the test it can be noticed that when plastic percentage level is increased weight loss is minimum. The chemical composition and the polymer compounds are responsible for resisting the chemical actions and corrosion.

4.8 Sorptivity Test Results

Table 10 Sorptivity Test Results

Trial mix	Sorptivity value 10^{-4} mm/min$^{0.5}$
M2	4.01
HDPE 1	3.83
HDPE 2	3.28
HDPE 3	2.73
HDPE 4	2.19

The capillary rise of water is more in normal concrete it has porous structure it causes the capillary rise of water. The concrete cubes with alccofine and HDPE are packed densely, gaps formed between the aggregates are occupied by the fine particles and decreased the rise in capillary water. Conclusion drawn from this test is HDPE concrete is free from porous structure. Fineness of alccofine and compatibility of plastic aggregates along with the conventional concrete material has resulted in lesser sorptivity values

4.9 Rebound Hammer Test Results

Table 11 Rebound Hammer Test Results

Trial mixes	Rebound values at 56 days	Compressive strength from rebound hammer test (N/mm²)	Compressive strength by destructive test (N/mm²)
M2	40	42.16	43.61
HDPE 1	42	44.26	45.32
HDPE 2	41	43.21	43.86
HDPE 3	39	41.10	42.28
HDPE 4	36	37.94	39.85

Strength results obtained by correlating rebound number values are similar to the destructive test results. By the results we can conclude that quality of the concrete is good and it is a closed structured concrete.

4.10 Ultrasonic Pulse velocity Test

Table 12 Ultrasonic Pulse Velocity Test Results

Trial mixes	Method of probing	Travel path (mm)	Time (µs)	Pulse Velocity by cross probing (Km/sec)
M 2	Direct	150	35.71	4.20
	Indirect	105.0	21.00	5.00
HDPE 1	Direct	148	33.94	4.36
	Indirect	105.0	18.88	5.56
HDPE 2	Direct	149	32.04	4.65
	Indirect	105.0	22.20	4.73
HDPE 3	Direct	149	34.8	4.28
	Indirect	105.0	18.2	5.76
HDPE 4	Direct	150	36.7	4.09
	Indirect	105.0	26.9	3.90

The quality of concrete in terms of uniformity, incidence or absence of internal flaws, cracks and segregation, and level of workmanship is found to be good. The velocity criteria for concrete quality grading lies in between 3.5 to 4.5, which indicates the behaviour and homogeneity of concrete which is good as per the guidelines of IS specifications

4.11 Water Absorption Test Results

Table 13 Percentage Of Water Absorption

Trial mix	Dry weight in grams	Wet weight in grams	% water absorption
M2	7944	8236	4.4
HDPE 1	7647	7786	4.37
HDPE 2	7623	7931	4.26
HDPE 3	7606	7946	4.23
HDPE 4	7460	7963	4.13

Water absorption of plastic aggregate is nil, because of this nature water absorption in concrete is less when percentage replacement of plastic aggregates is increased. Water is absorbed only by the conventional concreting material. By this analysis it can be concluded that utilization of plastic aggregates reduces the water absorption.

Material	Rate / metric tonne (MT)	Conventional concrete		Concrete with alccofine and Plastic aggregate	
		Quantity (Kg)	Cost (Rs)	Quantity (Kg)	Cost (Rs)
Cement	7000	351	2457	298.35	2088.45
River sand	830	835.68	693.61	835.68	693.61
Coarse aggregate	830	1098.42	911.68	1054.49	875.16
Plastic aggregate	-	1		43.93	-
Alccofine	6500	--	--	52.65	342.22
Superplasticiser Conplast 430	42	3.5	147	3.5	147
Total cost			4209.30		4146

4.12 Cost analysis for 1 m^3 of concrete

The cost of HDPE utilized concrete is lesser than the conventional concrete. Plastic aggregates have reduced the consumption of natural aggregate by decreasing the overall cost. Plastic wastes are generated in large quantities, which are easily available and can be incurred with low cost

5. CONCLUSION

- Compressive strength of concrete specimens with alccofine as a replacement has been gradually increased and after 15% replacement strength has been reduced. Concrete with alccofine and HDPE has given a good strength for 8% replacement of plastic aggregate and 15% of alccofine
- Flexural strength test and split tensile strength test results of concrete specimen has shown a higher value, which can be concluded that plastic aggregate and alccofine utilised concrete can resist tension and rupture than the natural coarse aggregate
- Density of the HDPE incorporated concrete specimens has been decreased when the percentage of replacement level is increased.

- By this experimental analysis result obtained is, 8% plastic aggregates can be used as a replacement for natural coarse aggregate and 15% of alccofine for replacement of cement.
- By introducing plastic aggregates the capillary rise and water absorption has been reduced.
- The durability aspects are considerable when compared with normal concrete.
- The nondestructive test results indicate the structure and homogeneity of concrete are good as per the guidelines.

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