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Experimental Analysis Of Concrete Using Plastic Waste As A Substitute For Natural Aggregates

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Abstract—: Concrete is the most widely used construction material in today's world. It is very difficult to point out another material of construction as versatile as concrete. It is a material of choice where strength, durability, permanence, impermeability, fire resistance and abrasion resistance are required. It is so closely associated now with every human activity that it touches every human being in day todayliving. The basic materials required for producing concrete include cement, fine aggregate (sand), coarse aggregate (broken stone or boulders) and water. Sand and coarse aggregate required for making concrete are obtained from earth's crust, mainly from river basins. The extraction of aggregates from rivers has led to deterioration of river basins, large scale soil erosions, depletion of water table, decrease in sediment supply and has also led to increase in pollution and changes in pH level. Concrete being a crucial building material is utilized all over the world in billions of tonnes annually and the consumption is increasing at a faster rate with the every passing year. The requirement of aggregates is also increasing with increase in the production of concrete. This large scale extraction of aggregates will ultimately lead to irrepairable damages to the earth's natural resources.So, we need to search for new construction materials. A no. of innovative ideas have been put forward by many researchers suggesting the potential replacements of conventional concrete constituents, particularly coarse and fine aggregates. Plastic wastes in the form of powder as well as solid pieces have also been suggested as potential replacements of conventional sand and stone aggregate. Use of plastic wastes will not only help in reducing the adverse affects if plastic pollution but will also help in producing economical and light weight concrete.In my experimental work,

Keywords—Concrete Plastics, Light Weight Concrete, Durability, Impermeability

I. INTRODUCTION

Concrete is a composite construction material which is prepared by mixing an aggregate like sand or broken stone with dry Portland cement and water forming a plastic mass that can be easily moulded into any shape. The cement reacts chemically with water to form a hard matrix which binds all the materials together into durable stone like material called concrete**.** Certain materials are added to concrete to increase its properties like tensile strength, flexural strength, impact strength, this type of concrete is called reinforced concrete. The reinforcing materials used may be steel bars, fibres like asbestos, nylon, glass etc, polymers like polyster-styrene, methyl meta-crylate. Nowadays, experiments have been made for using plastics in concrete. Concrete is a crucial building material utilized all over the world. Concrete is best known for its long-lasting and dependable nature. However, additional ways that concrete contributes to social progress, economic growth, and environmental protection are often overlooked. Concrete structures are superior in energy performance. They provide flexibility in design as well as affordability, and are environmentally more responsible than steel or aluminum structures.

Plastic is a synthetic material made from a wide range of organic polymers such as polyethylene, PVC, nylon etc, that can be moulded into shape while soft and then set into a rigid or slightly elastic form. The plastic is one of the recent materials which has appeared in the markets all over the world. The use of plastics in various materials such as packing materials and the products such as bottles, polythene sheets, containers etc are increasing day by day. In addition to these uses, plastics are also used in the manufacture of automotive spare parts, medical delivery systems, artificial implants, other healthcare applications, land/soil conservation, water desalination, flood prevention, preservation and distribution of food, housing, communication materials, security systems, and other uses. Plastic materials are of two main types :

1. Thermosetting plastics.
2. Thermoplastics.

Thermosetting plastics are those plastics which cannot be remoulded in different shapes again and again upon heating. Examples of thermosetting plastics are epoxy resin and urea formaldehyde. Thermosetting plastics are generally stronger than thermoplastics due to their three dimentional network of bonds and are also better suited to high temperature applications. However, they are more brittle.

Thermoplastics are those plastics which can be remoulded in different shapes again and again upon heating. Examples of thermoplastics are nylon, polypropylene and polystyrene. Most thermoplastics have high molecular weight. The polymer chains associate through intermolecular forces which weaken rapidly with increased

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temperature yielding a viscous liquid. It is due to this property that thermoplastics can be remoulded into different shapes again and again.

Advantages of plastic materials :

Plastic with its exclusive qualities of being light yet strong and economical, has invaded every aspect of our day to-day life. It has many advantages; it is durable, light weight , has long life and low production cost, is easy to mold and can be adapted to different user requirements.

Disadvantages of plastic materials :

Disposal of plastic wastes is considered a huge environmental problem as plastic is a durable and non biodegradable material.The chemical bonds in plastic are and very strong which makes it resistant to the natural process of degradation. Plastics cause soil, water and land pollution. If incinerated, it causes air pollution. Plastics wastes have many adverse affects on the health of living beings including human beings. . In humans, it can be a cause of lot of deadly diseases like cancer. It has been seen that plastic wastes are a major cause of death of many animals due to suffocation encountered on eating them. A no of species of acuatic animals are facing threat of extinction due to pollution of water bodies by plastic wastes.

Problem Statement :

According to Central Pollution Control Board (CPCB) of India the annual production of plastic wastes in india is 56 lakh tonnes and the consumption is increasing by more than 10% per year. More than 40% of the plastic wastes produced annually are not recycled. Plastic pollution not only is responsible for large scale contamination of land and water resources but it also has a lot of adverse affects on the health of living organisms including humans. In humans, it can be a cause of lot of deadly diseases like cancer. Therefore one of the main environmental problem today is the disposal of these plastic wastes because plastics are normally stable and non-bio-degradable products. So their disposal.

poses problems because hundreds of years are required for the decomposition of plastic products. . Once hailed as a “wonder material”, plastic is now a serious environmental and health concern, here in our country and around the world, essentially due to its non-biodegradable nature.

Why Plastics :

The construction industry is expanding at a rapid rate and is facing problems due to insufficient and unavailability of construction materials. So, we need to search for new construction materials as well as methods to dispose plastic waste. A no. of innovative ideas have been put forward by many researchers suggesting the potential replacements of conventional concrete constituents, particularly coarse and fine aggregates. Plastics wastes in the form of powder as well as solid pieces have also been suggested as potential replacements of conventional sand and stone aggregate.Since seeking aggregates for concrete and to dispose off the plastic waste is the present concern and also in today’s world sustainability has got top priority in construction industry. In these circumstances, if plastic is utilized to prepare aggregates for concrete, it will be a boon to the construction industry. Also at a time when landfill space is becoming almost impossible due to increasing land value, then recycling and reuse of wastes particularly non biodegradable wastes as beneficial products should be strongly encouraged and examined.

Most of the failures in concrete structures occur due to the failure of concrete by crushing of aggregates. Plastic aggregate which have low crushing values will not be crushed as easily as the stone aggregates. These aggregates are also lighter in weight compared to stone aggregate.

Most concrete structures are produced using normal weight aggregates. However there are certain instances where light weight concrete is desirable, raising the need for partial replacement of the conventional aggregate with a lighter substitute. In addition to this, plastic wastes if used as aggregates can help in producing highly economical concrete. Since a complete substitution for Aggregate was is not feasible, a partial substitution with various percentage of plastic aggreate has to be done.

II. EXPERIMENTAL OBSERVATIONS

Tests results of cement:

1) Initial setting time = 50 minutes
2) Final setting time =180 minutes
3) Standard Consistency = 33%
4) Fineness = 6%
5) Specific gravity = 3.15

Test results of fine aggregate :

1. Fine aggregate : 2.56
2. Water Absorption : 1%
3. Sieve analysis for fine aggregate

(Conforming to grading zone II)

Test results of coarse aggregate :

1. Coarse aggregate =2.71
2. Water Absorption = 0.5%
3. Sieve analysis for coarse aggregate **(**Conforming to grading of IS: 383-1970)

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Test results on Polyethylene powder:

1) Specific gravity = 2.43
2) Water Absorption = 0%
3) Fineness Modulus = 2.5

MIX DESIGN FOR M 25 ACCORDANCE WITH IS: 10262-1982

Mix design is the process of selection of suitable ingredients of concrete and to determine their properties with object of producing concrete of certain maximum strength and durability, as economical as possible. The purpose of designing is to achieve the stipulated minimum strength, durability and to make the concrete in the most economical manner.

STIPULATIONS FOR PROPORTIONING :

a) Grade designation M25
b) Type of cement : OPC GRADE 43
c) Maximum nominal size of aggregate 20mm
d) Minimum cement content 240 kg/m3
e) Maximum water-cement ratio 0.45
f) Workability 50 mm
g) Exposure condition Moderate
h) Method of concrete placing Manual
j) Degree of supervise Good
k) Type of coarse aggregate Crushed Angular

m) Chemical admixture type : Nil
n)Maximum Cement Content 450 kg/m^3

TEST DATA FOR MATERIALS

a) Cement used OPC GRADE 43
b) Specific gravity of cement 3.15
c) Chemical admixture Nil
d) Specific gravity of :
I) Coarse aggregate 2.71
2) Fine aggregate 2.56
e) Water absorption:
I) Coarse aggregate 0.5%
2) Fine aggregate 1%

TARGET STRENGTH FOR MIX PROPORTIONING :

$$f'ck = fck + 1.65\ s$$

where

f'ck = target average compressive strength at 28 days,

fck = characteristic compressive strength at 28 days, and

s = standard deviation.

From Table I, standard deviation, *s* =4 N/mm2•

Therefore, target strength =25 + 1.65 x 5

=31.6 N/mm2•

SELECTION OF WATER-CEMENT RATIO :

From Table 5 of IS 456,

Maximum water-cement ratio = 0.60 (for plain concrete)

Based on experience, adopt water-cement ratio as 0.45.

0.45 < 0.60 , hence O.K.

SELECTION OF WATER CONTENT :

From Table 2, maximum water content =186 litre (for 25 to 50 mm slump range) for 20 mm aggregate

Estimated water content for 50 mm slump = 186 litre

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CALCULATION OF CEMENT CONTENT :

Water-cement ratio = 0.45

Cement content =186 /0.45 = 413kg/m3

From Table 5 of IS 456, minimum cement content for 'moderate' exposure condition = 240 kg/m3

413 kg/m3 > 240 kg/m3, hence, O.K.

PROPORTION OF VOLUME OF COARSE AGGREGATE AND FINE AGGREGATE CONTENT :

From Table 3. volume of coarse aggregate corresponding to 20 mm size aggregate and fine aggregate (Zone II) for water-cement ratio of 0.50 =0.62.

In the present case water-cement ratio is 0.45. Therefore. volume of coarse aggregate is required to be increased to decrease the fine aggregate content. As the water-cement ratio is lower by 0.10. the proportion of volume of coarse aggregate is increased by 0.02 (at the rate of -/+ 0.01 for every ± 0.05 change in water-cement ratio).

Therefore. corrected proportion of volume of coarse aggregate for the water-cement ratio of 0.45 = 0.63

MIX CALCULATIONS :

The mix calculations per unit volume of concrete shall be as follows:

a) Volume of concrete 1 m3

b) Volume of cement -413/3.15 x 1/1000= 0.131m3

c) Volume of water =186/1 x 1/1000= 0.186m3

d) Volume of chemical admixture =0

e) Volume of all in aggregate : 0.683 m3

f) Mass of coarse aggregate :

0.683x0.63x2.71x1000

= 1166 kg

g) Mass of fine aggregate :

0.683x0.37x2.56x1000

= 647 kg

Mass of cement = 413 kg

Mass of water = 186 kg

MIX PROPORTIONS FOR 150 mm X 150mm X 150mm Cube :

Cement	:	1.39 kg
Water	:	0.62 kg
Fine aggregate	:	2.18 kg
Coarse aggregate	:	3.93 kg
Water-cement ratio	:	0.45

Ratio of constituents :

Cement : Sand : Course Aggregate = 1 :1.56 :2.43

III EXPERIMENTAL INVESTIGATION

Four trails were conducted in this investigation. Fine aggregate was replaced with 0 % polyethylene plastic powder in first trail, 3 % in second trail, 6 % in third trail and 9 % in fourth trail. The quantity of cement, fine aggregate, coarse aggregate and polypropylene powder used per 150 mm x150 mm x 150 mm cube in each trail is given in the table below

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TABLE 1

Percent Fine Aggregate Replacd	Cement Kg	Fine Aggregate Kg	Coarse Aggregate kg	LDPE Powder kg	Water kg
0 %	1.39	2.18	3.93	0.00	0.62
3 %	1.39	2.11	3.93	0.066	0.62
6 %	1.39	1.99	3.93	0.132	0.62
9 %	1.39	1.78	3.93	0.198	0.62

COMPRESSIVE STRENGTH TEST RESULTS OF HARDENED CONCRETE

For each of the four trails three cubes were casted. Each of the cubes was test for copresssive strength after 28 days of curing in compression testing machine. The observations of the compression test are given in the table below.

TABLE 2

S. No	Percent Fine Aggregate Replacement	Grade Of Concrete	Compressive Strength N/mm^2			Average Compressive Strength N/mm^2
			CUBE 1	CUBE 2	CUBE 3	
1.	0 %	M 25	30.31	29.53	28.52	29.45
2.	3 %	M 25	30.00	30.45	29.00	29.80
3.	6 %	M 25	29.82	30.43	30.25	30.20
4.	9 %	M 25	30.40	29.95	30.10	30.15

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WEIGHT ANALYSIS

The weight of the cubes in each trial was found out and the observations are given in the table below.

Table 3

S. No.	Trial	Percentage of fine aggregate replacement	Weight kg			Average Weight kg
			Cube 1	Cube 2	Cube 3	
1.	Trail 1	0 %	7.50	7.45	7.40	7.45
2.	Trail 2	3 %	7.35	7.40	7.40	7.40
3.	Trail 3	6 %	7.25	7.20	7.30	7.25
4.	Trail 4	9 %	7.10	7.05	7.15	7.10

PHOTO GALLERY

COARSE AGGREGATE

FINE AGGREGATE

43 GRADE OPC

LOW DENSITY POLYPROPYLENE POWDER

LDPE POWDER BEING MIXED TO CONCRETE MIXTURE

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DRY MIX OF VORIOUS CONCRETE CONSTITIUENTS

CUBES BEING COMPACTED

IV RESULTS AND DISCUSSION :

The main purpose of this investigation was replace certain percentage of fine aggregate in concrete wth low density polyethylene powder and fine its effects on compressive strength, workability and weight of concrete. The effect polypropylene powder on compressive strength, workability and weight of M 25 grade concrete is discussed below :

1. COMPRESSIVE STRENGTH :

The replacement of fine aggregate with polyethylene plastic powder has shown an increasing trend in compressive strength at 3 % and 6 % dosage. The average compressive strength of normal concrete was recorded as 29.45 N/mm^2 which increased to 29.80 N/mm^2 at 3 % replacement of fine aggregate with polyethylene powder. The compressive strength further increased to 30.20 N/mm^2 at 6 % replacement. However the compressive strength showed a decreasing trend at 9 % replacement of fine aggregate. The compressive strength decreased to 30.15 N/mm^2 9 % dosage, but the compressive strength at 9 % dosage is still in the permissible limit which means even 9 % replacement is totally safe for producing good quality concrete.

2. WORKABILITY :

The slump test was conducted for every trail and it was observed that slump value showed a decreasing trend with increase in polyethylene powder content. The slump value for normal concrete was found out to be 50 mm which decreased to 46 mm at 3 % replacement of fine aggregate with polyethylene powder. At 6 % replacement the slump value decreased to 40mm and at 9 % replacement the slump value decreased to 36 mm. The decrease in workability is not a major issue because required workability of concrete can be maintained with the help of plasticizers. The decrease in workability also takes place when fibres like steel fibre, glass fibre etc are added to the concrete.

3. WEIGHT :

Weight is an important characteristic feature of concrete because self weight of concrete has a major impact on the design parameters. The weight of concrete due to the replacement of fine aggregate with polyethylene powder has shown a decreasing trend. The average weight of cubes for normal concrete was found out to be 7.45 kg. At 3 % replacement the average weight decreased to 7.40 kg and at 6 % and 9 % replacement the average weight decreased to 7.25 kg and 7.10 kg respectively. Therefore, it may be concluded that polyethylene plastic powder can prove to be an effective alternative in the production of light

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weight concrete, that too with little or no compromise in compressive strength.

V CONCLUSION

The following are the conclusive points obtained from the experimental investigation :

1. The replacement of fine aggregate with polyethylene powder upto 9 % has shown no significant negative impact on compressive strength of concrete. So, low density polyethylene powder can prove to be an effective alternative to natural sand in future with further research in this direction.
2. Slump value showed a decreasing trend with increase in polypropylene powder content. The decrease in workability is not a major issue because required workability of concrete can be maintained with the help of plasticizers. The decrease in workability also takes place when fibres like steel fibre, glass fibre etc are added to the concrete.
3. The weight of concrete due to the replacement of fine aggregate with polyethylene powder has shown a decreasing trend. Therefore, it may be concluded that polyethylene plastic powder can prove to be an effective alternative in the production of light weight concrete, that too with little or no compromise in compressive strength.
4. The cost per cubic meter of concrete seems to decrease by a small margin at these dosages but keeping in mind that billions and billions of cubic meters of concrete are produced every year throughout the world. Therefore even at these small dosages there is an enormous scope of saving money and resources.
5. The concept of of using plastic wastes in concrete could be very environmental friendly method of disposal of plastic wastes, this study has shown a potential towards this concept.

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