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Behaviour of Concrete Using Waste Plastic as Partial Replacement of Fine Aggregate

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***Abstract*: In recent year, substantial grow thins consumption of plastic is observed all over the world, which has led to huge quantities of plastic-related waste. Recycling of plastic waste to produce new materials like concrete or mortar as one of the best solution for disposing of plastic waste, due to its economic and ecological advantages. Several works have been performed or are under way to evaluate the properties of cement-composites containing various types of plastic waste as aggregate, filler or fiber. This report presents are view on their cycling plastic waste as aggregate in cement mortar and concrete productions. For better presentation, there Portis divided into four different sections along within production and conclusion sections. In the first section, types of plastics and types of methods use are plastic aggregate as well as theme the so evaluation of various properties of aggregate and concrete were briefly discussed.. We are trying to reduce the plastic waste produced in environment by replacing it with aggregates to produce lightweight polymer concrete for multi-purpose use. It represents an environmental friendly and economical viable solution, for utilization of waste plastic. It is helpful in studying the effect of replacing natural aggregate with plastic aggregate on weight of concrete.**

Keywords: concrete, waste plastic, fine aggregate

I. Introduction

Plastic, one of the most significant innovations of 20th century, is a ubiquitous material. As substantial growth in the consumption of plastics observed all over the world in recent years, which also increases the production of plastic related waste. The plastic waste is now. Environmental there at to modern civilization. Plastic is composed of several toxic chemicals, and there for plastic pollutes soil, air and water. Since plastics a non-biodegradable material, land-filling using plastic would mean preserving the harmful material forever. They may block the drainage system of acuity. The blocked drains provide Excellent breeding grounds for disease Causing mosquitoes and water borne diseases besides causing flooding. Plastic garbage can reduce the rate of rain water percolating and deteriorate the soil fertility if it is mixed with soil. Plastic waste dumped in to rivers, Streams and seas contaminates the water and marine life. Aquatic animals can consume plastic waste, which can damage their health. Some marine life has been found with plastic fragments in the stomach and plastic molecules in their muscles.

In a new study published in science journal in the year 2015,about 275 million metric tons plastic waste generated by 192 countries and researches have quantified the amount of plastic entering oceans from coastlines of 192 countries. India is 12th in the list of top 20 countries. The UN Environment Programmed estimated in 2006 that every square mile of ocean contains 46,000 pieces of floating plastic. More than one million sea birds and approximately 100,000 sea mammals die each year after in gusting robe coming ending lading plastic debris. The threat of plastic waste seems to be ever increasing. Many countries have restricted the use of plastic bags and many are in the process of doing so.

Land filling of plastic is also dangerous due to its slow degradation rate and bulky nature. The waste mass may hinder the ground water flow and can also be the movement to foot. Plastic waste also contains various toxic elements especially cadmium and lead, which can mix with rain water and pollute soil and water.

Recycling plastics is a possible option. As plastic is an organic hydrocarbon based material, its high calorific value can be used for incineration or in other high temperature processes. But, burning of plastics releases a variety of poisonous chemicals into the air, including dioxins, one of the most toxic substances. Plastic waste can also be used to produce new plastic based products after processing. However it is not an economical process as there cycled plastic degrades in quality and necessitates new plastic to make the original product.

All though these alternatives are feasible except for land filling, recycling of plastic waste to produce new materials, such as cement composites, appears as one of the best solution for disposing of plastic waste, due to its economic and ecological advantages. Avast work has already been done on the use of plastic waste such as polyethylene terephthalate (PET) bottle, polyvinylchloride (PVC) pipe, high density polyethylene (HDPE), the setting plastics, shredded and recycled plastic waste, expanded polystyrene foam (EPS), glass rein forced plastic (GRP), polycarbonate, polyurethane foam, polypropylene fiber as an aggregate.

Definition of Plastic:

A material which contains one or more number of polymers having large molecular weight" Solid in its finished state or same state manufacturing or processing into finished articles is known as Plastic. Looking to the global issue of environmental pollution by post-consumer plastic waste, research efforts have been focused on consuming this waste on massive scale in efficient and environmental friendly manner. Researchers planned to use plastic waste in form of concrete ingredient as the concrete is second most sought material by human beings after water. The use of postconsumer plastic waste in concrete will not only be its safe disposal method but may also improve the concrete properties like tensile strength, chemical resistance, drying shrinkage and creep on short and long term basis.

Why the Plastics?

Polymers have a number of vital properties, which exploited alone or together, make a significant and expanding contribution to constructional needs.

- Durable and corrosion resistant.
- Good Insulation for cold, heat and sound saving energy.
- It is economical and has a longer life.
- Maintenance free (such as painting is minimized)
- Hygienic and clean
- Ease of processing / installation
- Light weight

Sources of generation of waste plastic:

Fig. 1. Waste from household materials like bottle, chairs, buckets, and tooth brush

II. Literature Review

1) Waste Polyethylene Terephthalate as an Aggregate in Concrete:

This paper reports the strength behavior of concrete containing three types of recycled polyethylene terephthalate (PET) aggregate. Results are also analyzed to determine the PET-aggregate's effect on the relationship between the flexural and splitting tensile strengths and compressive strength and to know whether the relationships between compressive strength and other strength characteristics given in European design codes are applicable to concrete made with PET-aggregates. The compressive strength development of concrete containing all types of PET-aggregate behaves like in conventional concrete, though the incorporation of any type of PET-aggregate significantly lowers the compressive strength of the resulting concrete. The PET-aggregate incorporation improves the toughness behavior of the resulting concrete. This behavior is dependent on PET-aggregate's shape and is maximized for concrete containing coarse, flaky PET-aggregate. The splitting tensile and flexural strength characteristics are proportional to the loss in compressive strength of concrete containing plastic aggregates.

The results of this investigation can be summarized as:

The development of compressive strength of concrete containing all types of PET-aggregates is similar to conventional concrete, though this incorporation significantly lowers the compressive strength of the resulting concrete.

The early compressive strength gain (0 to 7 days) relative to the strength determined after 91 days of curing for most of the concretes containing PET-aggregates is higher than that observed for conventional concrete.

The incorporation of PET-aggregate in concrete increases the toughness behaviour. For a given amount of PET addition, this order is: PC > PF > PP, which indicates that adding large-flake PET-aggregate can have more effect on the improvement of the toughness behaviour of resulting concrete than the two other fractions.

2) Utilization of Waste Plastics as a Partial Replacement of Fine Aggregate in Concrete Blocks:

The rapid industrialization and urbanization in the country leads lot of infrastructure development. This process leads to several problems like shortage of construction materials, increased productivity of wastes and other products. This paper deals with the reuse of waste plastics as partial replacement of fine aggregate in M20 concrete. Usually M20concrete is used for most constructional works. Waste Plastics were incrementally added in 0%, 2%, 4%, 6%, 8% and 10% to replace the same amount of Aggregate. Tests were conducted on coarse aggregates, fine aggregates, cement and waste plastics to determine their physical properties. Paver Blocks and Solid Blocks of size 200 mm X 150 mm X 60 mm and 200 mm X 100 mm X 65 mm were casted and tested for 7, 14 and 28 days strength. The result shows that the compressive strength of M20 concrete with waste plastics is 4% for Paver Blocks and 2% for Solid Blocks.

In the present investigation it is found that optimum up to 4% by replacing of waste plastics there is a slight deviation of compressive strength. From the test results it was observed that the compressive strength value of the concrete mix decreased with the addition of waste plastics more than 4% of waste plastics. So we can add waste plastics in concrete blocks so this will helps to reuse of plastics in concrete blocks.

3) Experimental Study on Plastic Waste as a Fine Aggregate for Structural Concrete

The use of plastic is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy. A healthy and sustainable reuse of plastics offers a host of advantages. The suitability of recycled plastics as fine aggregate in concrete and its advantages are discussed here. The initial questions arising of the bond strength and the heat of hydration regarding plastic aggregate were solved. Tests were conducted to determine the properties of plastic aggregate such as density, specific gravity. As 100%replacement of natural fine aggregate (NFA) with plastic fine aggregate (PFA) is not feasible, partial replacement at various percentage were examined. The percentage substitution that gave higher compressive strength was used for determining the other properties such as modulus of elasticity, split tensile strength and flexural strength. Higher compressive strength was found with 20% NFA replaced concrete.

This study intended to find the effective ways to reutilize the hard plastic waste particles as fine aggregate.

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Analysis of the strength characteristics of concrete containing recycled waste plastic have the following results:

1) It is identified that plastic waste can be disposed by using them as construction materials.
2) The compressive strength and split tensile strength of concrete containing plastic aggregate is retained more or less in comparison with controlled concrete specimens. However strength noticeably decreased when the plastic content was more than 20%.
3) Has been concluded 20% of plastic waste aggregate can be incorporated as fine aggregate replacement in concrete without any long term detrimental effects and with acceptable strength development properties.

III. Collection of Materials

A. *Description of plastic*

The majority of worlds PET (polyethylene Terephthalate) production is for synthetic fibers (in excess of 60%), with bottle production accounting for about 30% global demand. PET consists of polymerized unit of the monomer ethylene Terephthalate, with repeating ($C_{10}H_8O_4$) units. Depending on its processing and thermal history, polyethylene Terephthalate may exist both as an amorphous (transparent) and as a semi crystalline polymer.

Fig. 2. Waste from household materials like bottle, buckets, and tooth brush

Fig. 3. Plastics recycling overview

Objectives:

The primary objective of this study is to evaluate the possibility of using plastic aggregate as fine aggregate in concrete. Specific objectives of this work include:

1) To reduce the plastic waste produced in environment.
2) To prepare plastic aggregate of 4.75mm down size for plastic fine aggregate and above 4.75mm for plastic coarse aggregate.
3) To determine the properties of plastic aggregate.
4) To conduct a comparative study of plastic aggregate and natural aggregate.
5) To study the effect of replacing natural aggregate with plastic aggregate on compressive strength.

Materials:

- Cement.
- Fine aggregate (Sand)
- Coarse aggregate
- Water
- Shredded Plastic waste

IV. Experimental Methodology

Fig. 4. Cement (Normal Consistency)

Fig. 5. Vicat apparatus

IS: 5513-1976, Balance, Gauging Trowel, Stop Watch, mould, etc.

Procedure: The standard consistency of a cement paste is defined as that consistency which will permit the Vicat plunger to penetrate to a point 5 to 7 mm from the bottom of the Vicat mould.

1) Initially a cement sample of about 300 g is taken in a tray and is mixed with a known percentage of water by weight

of cement, say starting from 26% and then it is increased by every 2% until the normal consistency is achieved.

2) Prepare a paste of 300 g of Cement with a weighed quantity of potable or distilled water, taking care that the time of gauging is not less than 3 minutes, nor more than 5 min, and the gauging shall be completed before any sign of setting occurs. The gauging time shall be counted from the time of adding water to the dry cement until commencing to fill the mould.
3) Place the test block in the mould, together with the non-porous resting plate, under the rod bearing the plunger; lower the plunger gently to touch the surface of the test block, and quickly release, allowing it to sink into the paste. This operation shall be carried out immediately after filling the mould.
4) Prepare trial pastes with varying percentages of water and test as described above until. The amount of water necessary for making up the standard consistency as defined in Step 1 is found.

Result: The normal consistency of a given sample of cement is 35%

A. *Specific gravity of cement*

Aim: To determine the specific gravity of cement, kerosene which doesn't react with cement is used.
Apparatus used: Specific gravity bottle, funnel, kerosene, weighing balance, Le
Chatlier's flask is used for finding the specific gravity of cement. Mass of cement used.
Procedure:

- Weigh the dry and empty specific gravity bottle along with its lid (w_1).
- Weigh the specific gravity bottle with 1/3rd of cement (w_2).
- And fill the bottle with 1/3 rd of cement and add kerosene to it and care should be taken that no air bubbles are present in the bottle (w_3).
- And remove the water and again fill the bottle with full of kerosene and take the weight (w_4).
- Fill the bottle full with distilled water and take the weight (w_5).

Observations:

- W_1 = weight of empty flask = 60gms
- W_2 = weight of flask + cement = 91gms
- W_3 = weight of flask +1/3rd cement + kerosene(full) = 166gms
- W_4 = weight of flask + kerosene(full) = 142gms
- W_5 = weight of flask + water = 163gms

$$\text{Specific gravity of kerosene} = \frac{(W4 - W1)}{(W5 - W1)} = \frac{(142 - 60)}{(163 - 60)}$$

Specific gravity of kerosene = 0.8

$$\text{Specific gravity of cement} = \frac{(W2 - W1)}{[(W4 - W1) - (W3 - W2)]} \text{ x Specific gravity of kerosene}$$

$$= \frac{(91 - 60)}{[(142 - 60) - (166 - 91)]} \text{ x } 0.8$$

= 3.13

B. *Fineness test*

Objective: To determine the normal consistency of a given sample of cement.
Reference: IS: 4031 (Part-1) - 1988
Fineness of cement is tested in two ways:

a) By sieving
b) By determination of specific surface (total surface area of all the particles in one gram of cement) by air-permeability apparatus. Expressed as cm^2/gm or m^2/kg. Generally Blaine Air permeability apparatus is used.

Apparatus: Test 90 microns, Balance, Gauging Trowel, Brush, etc.
Procedure:

1) Fit the tray under the sieve, weigh approximately 10 g of cement to the nearest 0.01 g and place it on the sieve, being careful to avoid loss. Fit the lid over the sieve. Agitate the sieve by swirling, planetary and linear movement until no more fine material passes through it.
2) Remove and weigh the residue. Express its mass as a percentage, R1, of the quantity first placed in the sieve to the nearest 0.1 percent. Gently brush all the fine material off the base of the sieve into the tray.
3) Repeat the whole procedure using a fresh 10 g sample to obtain R2. Then calculate the residue of the cement R as the mean of R1, and R2, as a percentage, expressed to the nearest 0.1 percent.
4) When the results differ by more than 1 percent absolute, carry out a third sieving and calculate the mean of the three values.

Fig. 6. Fineness test

Conclusion/Result: The fineness of a given sample of cement is 9 %.

V. EXPERIMENTAL RESULTS

Mix Proportion: The mix design was made confirming IS 10262:2009. Cement Concrete for ratio of 1:1:2 (M25). The mixes are made by partially replacing plastic to fine aggregate

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of percentage 0%, 5%, 10% & 15%. The water cement ratio is 0.50.

TABLE I
WEIGHT DETAILS FOR CONCRETE

Mix Name	Weight in 'Grams'		
	7 Days	14 Days	28 Days
A (0%)	8235	8285	8350
B (5%)	7920	8010	8100
C (10%)	7705	7895	8050
D (15%)	7430	7670	7950

TABLE II
COMPRESSIVE STRENGTH DETAILS FOR CONCRETE

Compressive Strength in N/MM^2		
7 Days	14 Days	28 Days
20.49	29.49	31.37
18.43	27.35	30.83
16.84	25.68	28.64
16.08	25.36	28.38

TABLE III
MIX DETAILS

Mix Name	Volume of Cement in cm^3
A (0%)	491.98
B (5%)	491.98
C (10%)	491.98
D (15%)	491.98

TABLE IV
VOLUME DETAILS

Volume of aggregates in cm^3			
Volume of fine aggregates	Volume of Plastic	Volume of coarse aggregates	Total
1062.68	--------	1820.34	2883.02
1062.68	91.01	1729.33	2883.02
1062.68	182.00	1638.34	2883.02
1062.68	273.05	1547.29	2883.02

TABLE V
PROPERTIES

Description	Properties
Length	2.0 – 4.5 mm
Diameter	1.5 - 4.0mm
Color	Black
Chemical formula	$C_8H_{10}O_4$
Density (g/cu.cm)	0.95

Plastic waste as fine aggregate:

Plastic used in this investigation is PET (Polyethylene Terephthalate). The specific gravity is 1.32, size is below 4.75mm.

TABLE V
PROPERTIES OF PLASTIC FINE AGGREGATES SIZE LESSER THAN 4.75MM

Description	Properties
Length	2.0 – 4.5 mm
Diameter	1.5 - 4.0mm
Color	Black
Chemical formula	$C_8H_{10}O_4$
Specific gravity	0.85
Density (g/cu.cm)	0.95

TABLE VI
PROPERTIES OF PLASTIC COARSE AGGREGATES SIZE LARGER THAN 4.75MM

Description	**Properties**
Color	Black
Chemical formula	$C_8H_{10}O_4$
Specific gravity	0.93
Density (g/cu.cm)	0.74

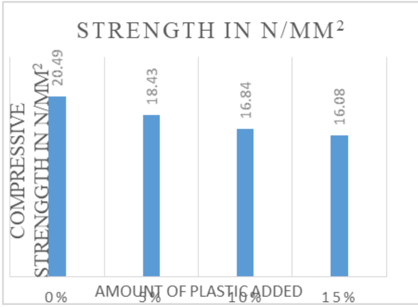

Fig. 7. Compressions strength at 7 days

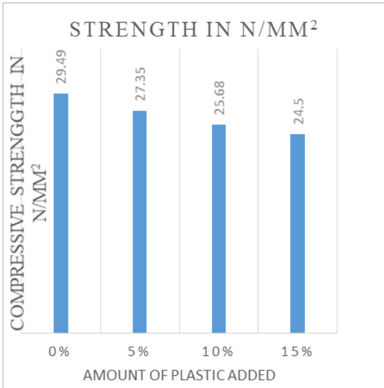

Fig. 8. Compressions strength at 14 days

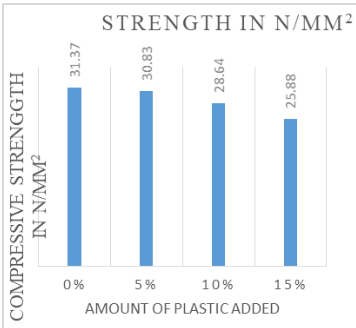

Fig. 9. Compressive strength at 28 days of curing

Fig. 10. Experimental setup

Advantages:

1) Helps in reducing environment pollution problems.
2) Reducing plastic waste disposal problems.
3) These types of aggregate replacement is useful when there is crisis in getting natural.
4) By this we can conserve natural resources.

Disadvantages:

1) This may be attributed to the decrease in the adhesive strength between surface of plastic aggregates and cement paste.
2) Increase in percentage of plastic reduces the compressive strength of concrete.
3) Plastic doesn't take part in hydration process

VI. Conclusion

The findings from these studies indicated that plastic waste can be used as a partial replacement of natural aggregate. From there result obtained from these studies the following conclusions can be drawn:

1. The density of concrete decreases when plastic content increases
2. Plastic has more water tightness when compared to natural aggregate this can help in arresting micro cracks
3. Optimum 10% of Waste Plastic is to be allowed
4. Higher percentage (upto 15%) of waste plastic can be used in Concrete for temporary Structures.
5. Overall construction and maintenance cost is reduced.
6. Using waste plastic in concrete we can minimized the use of natural aggregates.

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