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Properties of Concrete by the Addition of Plastic Solid Waste

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Abstract: ***Concrete is a material which widely used in construction industry. The production of solid wastages is increasing day to day causing serious concerns to the environment. In this study, the recycled plastics are used in the concrete by partial replacement of coarse aggregate in concrete. The main purpose of this study is to investigate the properties of concrete such as workability, compressive as well as tensile strengths in the partial replacement of aggregate. And also thermal characteristics of the concrete are also studied. The results indicate that the use of plastic solid waste in the concrete results the formations of light weight concrete. The properties such as compressive as well as tensile strength are reduced with the addition of plastic in concrete. Further the thermal conductivity of concrete is also reduced, when it is mix with concrete.***

Keywords: Concrete, natural sand, solid plastic waste, environmental problems, compressive, Partial replacement and Workability.

1. Introduction

Due to rapid increase of population in world, the amount of waste products such as waste plastic also increases rapidly .These waste plastic will remain in the environment for hundreds of years. The combined of these waste plastic in concrete may reduces the environmental problems upto certain extent .It is possibility of disposal of these wastages in mass concrete such as in heavy mass concreting in PCC in pavements where the strength of concrete is not a major criteria under consideration *(Youcef Ghernouti, Bahia Rabehi,2011*).

The waste plastic is one component of Municipal Solid Waste (MSW). The disposal of the waste plastic which cause the big problems to the environment because the plastic is very low biodegradable material *(Ishwar Singh, 2007)* . As from many years the research concern that the use of by-products from industry may augment the properties of concrete. In the modern decades, the use of by-products such as silica fume, glass culvert, fly ash, ground granulated blast furnace slag (GGBS) etc., efforts have been made to use in civil construction. The application of the industrial by-products in concrete is as partial replacement of cement or partial replacement of aggregate *(Batayneh, 2007)*. The use of these waste plastic in concrete can control the environmental problems or constraints if safe disposal of these products. In the present study the recycled plastic used to prepare the coarse aggregate there by providing sustainable option to deal with plastic waste (Nabajyothi and Jeorge, 2012).

1.1 General

The word "plastic" means the substances which have plasticity and accordingly that it can be formed in soft state and used in solid state can be called plastic. The plastic can be separated into two types. The first type of plastic is thermosetting plastic and second is thermosetting. The thermo setting plastic cannot be melted by heating because the molecular chains are bonded firmly with meshed crosslink. These types of plastic are called polyurethane, silicone, epoxy resin, unsaturated polyester, melamine and phenolic. The second type is thermoplastic, which can be melted by heating and use for recycling in the plastic industry. These types of plastics are polypropylene, polyamide, polyethylene, polyoxymethylene, polyetetrafluorethylene and polyethyleneterephthalate. However at present these plastic wastages are disposed by either burning or burying, but the process is very costly. If the thermosetting plastics are reused , the cost of the process as well the pollution that is caused by the burning of plastic can be reduced. However to achieve this purpose , the thermosetting plastics are used in construction materials particularly concrete wall in construction (*Panyakapo, 2007*).

1.2 Plastic Waste Disposal

The quantity of Plastic waste is increases rapidly and it is estimated that the rate of expansion is double every 10 years. This is due to growth of population and industrial sector rapidly (*Phaiboon and Mallika, 2007*). The National Council on Public Works Improvement identified that the solid waste crisis as an area of infrastructure with great needs of improvements (*Rebeiz et al., 1993*).

Among the solid waste materials, plastic have a lot of attention it is not biodegradable. On the weight basis about 10 billion kg of plastic waste in the U.S. per year, which represents about 7% by weight of the total solid waste (*Thayer, 1989*)

1.3 Types of Recycled Plastics

- Polyethylene terephthalate (PET)
- High density polyethylene (HDPE)
- Unplasticised polyvinyl chloride (UPVC)
- Low density polyethylene (LDPE)
- Polypropylene (PP)
- Polystyrene (PS)

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1.4 Sources of Generation of Plastic Waste

- Household: Carry Bags, Bottles, containers and trash bags.
- Hotel and Catering: Mineral water bottles, Glasses, Packaging items, Plastic plates, Hand gloves
- Health and Medicare: Disposable syringes, surgical gloves, glucose bottles, blood, Intravenous tubes ,catheters *(Kiran Kumar & Prakash)*

2. Experimental Programme

The main objective of this experimental program is to compare the properties of concrete with the addition of plastic used as partial replacement if coarse aggregate and without any plastic. The basic tests which are carried out for plastic concrete are followed by a brief description about mix design and curing procedure.

2.1 Materials Used

2.1.1. Cement

Cement is a fine and grey powder form and it is mixed with water and materials such as sand, gravel and crushed stone to make the concrete uniform. Cement and water form paste together to bind the materials to harden the concrete. The composition of cement are shown in Table1

Table 1: Composition of Portland cement

Ingradient	*%content*
CaO (Lime)	60-67
SiO2 (Silica)	17-25
Al2O3 (Alumina)	3-8
Fe2O3	0.5-6
MgO(Magnesia)	0.1-4
Alkalies	0.4-1.3
Sulphur	1-3

The 53 grade of cement is used for the casting of cubes and cylinders for all concrete mixes. The colour of cement is uniform i.e. grey with a light greenish shade and was free from any hard lumps. The various properties of concrete that are come from laboratory are shown in Table 2 & 2.1

Table 2: Properties of cement

S.No	*Characteristics*	*Values Obtained*	*Standard values*
1	Normal Consistency	32%	-
2	Initial Setting Time	40min	Not less than 30minute
3	Final Setting Time	240min	Not greater than 600minutes
4	Fineness	5%	<10
5	Specific gravity	3.1	-

Table 2.1: Compressive Strength:-Cement: Sand (1:3)

S.No	No. of days	Values Obtain	Standard Values
1	3	24.5N/mm^2	27N/mm^2
2	7	35N/mm^2	41N/mm^2
3	28	53.5N/mm^2	53N/mm^2

2.1.2 Fine Aggregate

The fine aggregate that used in this experiment is locally available and should be sieved through Indian Standard Specifications IS: 383-1970. The sand first is sieved through 4.75mm sieve and the particles more than 4.75mm are removed and then washed to remove the dust. Therefore the properties of fine aggregate used for this experimental program are tabulated in Table3. The Sieve analysis of fine aggregate is presented in Table4**.**

Table 3: Properties of fine aggregate

S.NO.	Characteristics	Value
1	Type	Sand (natural)
2	Total Water absorption	1.03%
3	Specific Gravity	2.60
4	Fineness modulus	2.51

Table 4: Sieve analysis of fine aggregate

S.No.	*Sieve No.*	*Mass Retained (gm)*	*% Retained*	*% passing*	*Cumulative %age Retained*
1	4.75mm	95	9.5	90.5	9.5
2	2.36mm	42	4.2	86.3	13.7
3	1.18mm	111	11.1	75.2	24.8
4	600u	130	13.0	62.2	37.8
5	300u	308	30.8	31.4	68.6
6	150u	280	28.0	3.4	96.6
7	Pan	34	3.4	-	
				ΣF	251

Fineness Modulus of fine aggregate=ΣF/100
= 251/100
=2.51

2.1.3 Coarse Aggregate

The material which is retained by BIS test sieve no.480 is termed as coarse aggregate. The maximum size of locally available coarse aggregate was 20mm used in this work. The aggregate should be washed and remove the dust and aggregate were tested as per Indian Standard Specifications IS: 383-1970 .The various test conducted on coarse aggregate are tabulated in Table5 and Table6 shows the sieve analysis results of coarse aggregate.

Table 5: Properties of Coarse aggregate

S.NO.	Characteristics	Value
1	Type	Crushed
2	Maximum size	20mm
3	Specific gravity	2.82
4	Total water absorption (20mm)	3.65
5	Fineness Modulus	7.68

Table 6: Sieve analysis of 20mm aggregate

S.No.	Sieve No (mm)	Mass Retained (kg)	% Retained	% Passing	Cumulative % Retained
1	80	-	0.00	100	0.00
2	40	-	0.00	100	0.00
3	20	0	0.00	100	0.00
4	12.5	2.180	72.6	27.2	72.8
5	10	0.682	22.8	4.6	95.4
6	4.75	0.1380	4.6	0.00	100
7	Pan	0	0.00	-	-
				ΣC	268.2

Fineness Modulus of Coarse aggregate (20mm)=
ΣC+500/100=7.68

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2.1.4 .Plastic Material

The recycled plastic was used with partial replacement of coarse aggregate at 10% for making the concrete specimen. The plastic aggregate with different sizes as smaller, medium and bigger are used. All the plastic material is mix together so as to achieve the maximum packing density. The term packing density is defined as the ratio of volume of plastic aggregate to the volume of the equivalent aggregate. To find the volume of aggregate in a container, mass of plastic aggregate filled in the container is divided by the specific gravity of the aggregate.

2.2 Test Conducted

2.2.1. Workability

The workability of concrete is tested for controlled and plastic concrete with 0%, 10% & 20% of plastic is added. Workability is assessed by compaction factor by taking the weights of fully compacted and partially compacted concrete.

2.2.2. Dry Density

The dry density of controlled concrete and plastic concrete are tested. The percentages of plastics are 0%, 10% & 20%.

2.2.3. Compressive Strength

Cubical specimen of size 150mm was cast. The percentage of plastic was 0%, 10% & 20%. The compressive strength test was carried out as per IS: 516-1979. The test was carried at the end of 28 days, the average of three cubes are taken.

2.2.4. Split Tensile Strength

A cylindrical specimen of size 150mm dia and 300mm height were cast; the percentage of plastic was 0%, 10% & 20%. The test was carried at the end of 28 days.

2.2.5 Thermal Analysis

The basic purpose of this test was to find the effect of use of plastic on thermal conductivity of concrete with percentage of plastic as 0%, 10% & 20%. For doing this, copper-Constantine thermocouple was fabricated.

3. Results and Discussions

3.1. Workability

The workability of concrete is assessed by the compaction factor. The compaction factor for controlled mix and plastic (0%, 10% & 20%) added concrete. The compaction factor values of controlled mix and plastic added concrete are tabulated as shown in Table 7 and Table 8.

Table 7: Compaction factor for Controlled mix

S. No.	W/C ratio	Compaction factor
1	0.40	0.870
2	0.45	0.893
3	0.50	0.899

Table 8: Compaction factor for various percentage of plastic

S.No	W/C ratio	Compaction factor (10% of plastic)	Compaction factor (20% of plastic)
1	0.40	0.813	0.792
2	0.45	0.862	0.840
3	0.50	0.893	0.871

3.2 Dry Density

The dry density of concrete is determined just before the compressive strength test. The dry density of controlled mix concrete and plastic added concrete with various percentage of plastic are obtained as shown in fig1.

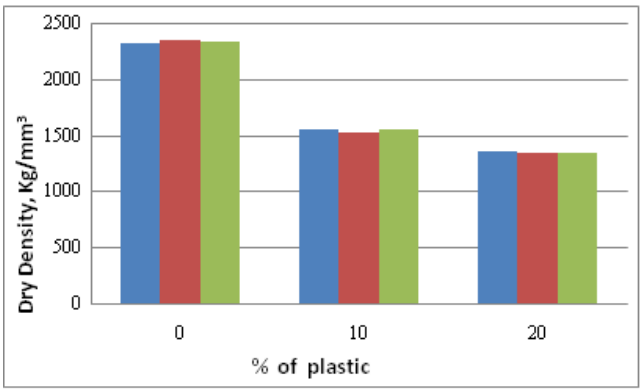


Figure 1: Graph between % of plastic and dry density of control concrete and plastic Concrete

3.3. Compressive Strength

The compressive strength of concrete is determined at different water cement ratios as 0.4, 0.45 and 0.50. Three cubes are prepared with controlled concrete and plastic concrete and average results should be taken. The compressive strength for control and plastic concrete for various percentage of plastic are as shown in fig 2.

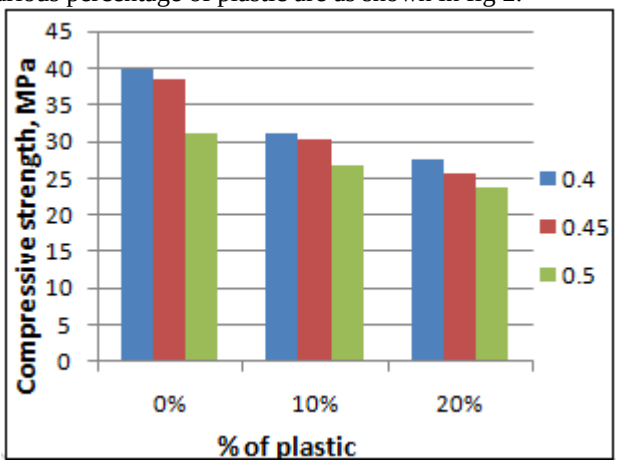


Figure 2: Graph between % of plastic and Compressive strength of control and Plastic concrete for 28days

3.4. Split Tensile Strength

The tensile strength for various percentage of plastic for control and plastic concrete are obtained by testing the concrete specimen at 28 days. The tensile strength of

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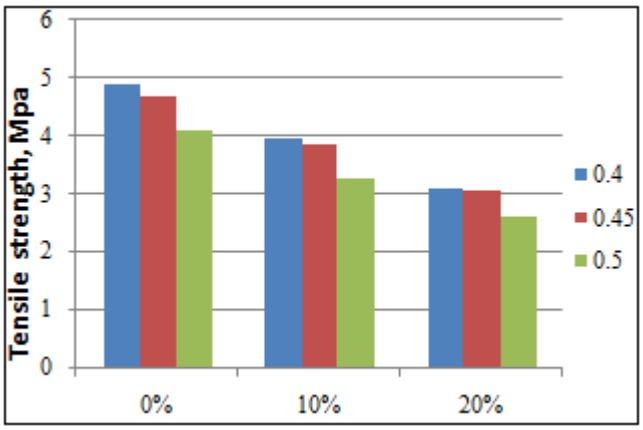


Figure 3: Graph between % of plastic and Tensile strength of control and plastic Concrete for 28days

3.5 Thermal Analysis

The thermal analysis was carried out on both the control concrete and concrete made by replacing 20% coarse aggregate with plastic aggregates. The percentage of water cement ratio was taken as 0.4, 0.45 & 0.50. From the experiment it was found that the temperature of the interior of concrete is lower than the control concrete. It indicates that the thermal conductivity of plastic concrete is lower than the control concrete. Not only the ultimate temperature reached is lower, the plastic concrete requires more time to reach a standard temperature.

4. Conclusion

Following are the conclusions can be made by the researches

1) The use of Plastic in concrete mix for a given w/c ratio, reduces the tensile and compressive strength and also lower the density.
2) When plastic used in concrete pavements it can be with stand at high temperature and also reduction in thickness achieved.
3) The effect of water cement ratio on strength development is not predominant in case of plastic concrete.

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