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STUDIES ON THE USE OF WASTE PLASTIC IN CEMENT-BASED COMPOSITE FOR LIGHT WEIGHT CONCRETE PRODUCTION

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Abstract

Plastic waste is now a serious environmental threat to the modern way of living. It is not feasible to use waste plastic for land filling, which require huge land space area and as well loses its fertility. It also causes serious problems such as clogging in drainage system, wastage of resources and environmental pollution. Utilization of industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes to reducing the consumption of natural resources In this study the waste plastic is replaced by 5%, 10%,15%,20% and 25% of sand to study the compressive strength, split tensile strength test and density of concrete. The workability of the concrete decreases as the replacement level of granulated plastic waste with fine aggregate increases. The effect is more noticeable between 0%to15% replacements.These reductions are attributed to the fact that some particles are angular and others have non uniform shapes resulting in less fluidity. compressive strength of curing for 28 days The results reveal that as the waste plastic content increases in mixes the tendency of the strength values decrease below that for the plain mix up to 53% at 28 days curing period for 30% replacement level .However, for 5% replacement of the fine aggregate with plastic waste at curing of 28 days,1% reduction in strength was recorded when compared to 0% replacement also curing at 28days.This reduction in compressive strength may be attributed to the decrease in adhesion or bond strength

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between the plastic aggregate and the cement paste. The decline in the splitting tensile strength is very less compared to the compressive strength. Results of the density tests reveal that the densities of waste-concrete specimen decreased with increase in amount of the plastic waste. This reduction on dry density is due to the lower density of plastics as compared to the density of fine aggregates.

Key words: Mix proportion, Fine aggregates, Casting, Slump test, Compressive test, Density test

Introduction

Plastic waste is now a serious environmental threat to the modern way of living. It is not feasible to use waste plastic for land filling, which require huge land space area and as well loses its fertility. It also causes serious problems such as clogging in drainage system, wastage of resources and environmental pollution. In this consequence, big attention is being focused worldwide on the environment and safeguarding the natural resources through recycling of waste plastic materials in the recent years. It may appear to be valuable property as construction material [1].

According to the surveys conducted,India produces approximately 56hundred thousand tons of plastic waste per year. Since it takes thousands of years for the biodegradation of plastics,disposing them through the processes of littering and landfilling creates severe environmental problems. Land-filling is dangerous because of its slow degradation rate.It blocks the ground water flow and also the movement of roots. Plastic waste comprises of several toxic elements like cadmium,lead,etc.,and dissolve in rain water and pollutes atmosphere.Incineration of plastics releases toxic chemicals like dioxins into the air. [2].

Concrete is the most widely used man-made construction material and it is obtained by mixing cement,water and aggregates(and sometimes admixtures)in required proportions.The mixture when placed in forms and allowed to cure becomes hard like stone.Thehardening is caused by chemical action between water and the cement for a given time to make it hardened.The strength,durability and other characteristics of concrete depend upon the properties of its ingredients, on the proportions of mix,the method of compaction and other controls during placing,compaction and curing.The advances in concrete technology have paved the way to make the best use of locally available materials by judicious mix proportioning, to produce concrete satisfying performance requirements. The main ingredients of concrete are cement, fine aggregate(sand) and coarse aggregate. Concrete is a widely used construction material for various types of structures due to its durability.For a long time it was considered to be very durable material requiring a little or no maintenance. Many environmental phenomena are known significantly the durability of reinforced concrete structures.We build concrete structures in highly polluted urban and industrial areas, aggressive marine environments and many other hostile conditions where other materials of construction are found to be nondurable.In the recent revisionof IS:4562000,one of the major points discussed is the durability aspects of concrete.So the use of concrete is unavoidable. At the same time the scarcity of aggregates are also greatly increased now a days.Utilization of

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industrial soil waste or secondary materials has been encouraged in construction field for the production of cement and concrete because it contributes to reducing the consumption of natural resources. For many years, waste plastics are considered as waste materials. They have been successfully used in the construction industry for partial or full replacement for fine and coarse aggregates. Some of the byproducts are also used as a Portland cement substitute.

Experimental Procedure

The methodology adopted for mix proportioning of various percentage replacement of sand by waste plastics and various tests are conducted.The cement used in this study was 43 grade ordinary Portland cement(OPC). Coarse aggregate of 20 mm down size were procured from Laxmeshwar. Fine Aggregates used for normal concrete were Natural River sand. Plastic Waste from GSM Industries, Dharwad ,Karnataka
Portable water was used in the present investigation for both casting and curing. MixDesign (IS 10262: 2009)GradeM25Minimumcementcontent:320Kg/m3Maximumcementcontent:450Kg/m3Maximumwatercementratio:0.45

Table 1: Mix proportions(Kg/m^3) and Mix ratio

Cement	Fine aggregate	Coarse aggregate	Water
424	822	991	191
1	1.93	2.33	0.45

Table 2: Concrete Mixtures with Different Proportions of waste plastic with sand

Sl.No	Fineaggregate-WastePlasticreplacement	Water Lit/m^3	Cement Kg/m^3	Fineaggregate Kg/m^3	Plastic waste Kg/m^3	Coarseaggregate Kg/m^3
1	95-5%	191	424	780.9	41.1	991
2	90-10%	191	424	739.8	82.2	991
3	85-15%	191	424	698.7	123.3	991
4	80-20%	191	424	657.6	164.4	991
5	75-25%	191	424	616.5	205.5	991

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Table3 : No of Specimens to be casted

Sl.No.	TestTobeConducted	7Days	28Days	TotalxNo.of Mixtures
1.	CompressiveStrengthTestonCube150x150x150mm	3	3	5x6=30
2.	SplittensilestrengthTestonCyclinder30x15cm	3	3	5x6=30

Casting of Test Specimens

Quantity of concrete and ingredients of mix was calculated. Required moulds (Cube and Cylinders) confirming to IS:516 were assembled and thinly coated with mould oil to prevent adhesion of the concrete.

Moulds were kept on vibrating table so that concrete can be poured immediately after mixing. The Cement, waste plastic, CA, FA, and water are brought to the room temperature and weighed.

The laboratory concrete mixer was cleaned and dried. The Mixer used in the experimental work is ribbon type mixer.The ingredients were poured in the following sequence–

½portion of 20mm CA→½portion of FA→Total Cement→Total waste plastic

→½portion of FA→½portion of→½portion of 20mm CA.

½portion of measured Plain water taken and sprinkled on top of materials poured.

The material was dry mixed for 4-5minutes.While keeping the mixer in running condition remaining portion of water was sprayed in the mixer. The care was taken that the liquid should not fall a lone place in mixer so that maximum surface area will be covered.The mixer was run until the concrete appears to be homogenous and has the desired consistency.The mixer door opened in running condition and concrete was collected in a tray.The concrete was filled into the mould in layers approximately 2"deep.In placing each scoop full of concrete, the scoop was moved around the top edge of the mould as the concrete slides from it, in order to ensure asymmetrical distribution of the concrete within the mould. Each layer was compacted by vibration. After the top layer has been compacted, the surface of the concrete was finished level with the top of the mould, using a trowel. Concrete was consolidated on vibrating table as per IS:7246.Moulds were transferred to leveled surface.After inspecting the setting of top

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surface of moulds, moulds were covered with wet gunny bags to avoid shrinkage of top surface by evaporation.After 24hrs of setting the specimens were demoulded without harming the edges. Each specimen was marked with Identification mark.The entire specimens were transferred to curing tank.

Concrete Slump Test

Mix the dry constituents thoroughly to get a uniform color and then add water. The internal surface of the mould is to be thoroughly cleaned and placed on a smooth, horizontal, rigid and non-absorbent surface.

Place the mixed concrete in the mould in the cleaned slump cone in 4 layers each approximately¼inheightofthemould.Tamp each layer 25times with tamping rod. Remove the cone immediately, rising it slowly and carefully in the vertical direction. As soon as the concrete settlement comes to a stop, measure the subsistence of the concrete in cms, which give the slump.

Test for Compressive Strength of Concrete Specimen as per IS: 516

The compressive strength test was carried on the Cube (150x150x150mm)

In the present work, Compressive strength test is carried for M25, with 0, 5,10,15,20 and 25% replacement of sand by waste plastic. The readings of the same are presented in Results and Discussion.

Test for Split Tensile strength of Concrete Specimen as per IS:516

The Split Tensile Strength test was carried on the Cylinder (150x300mm).
The specimen from the mould after 24 hours was removed and immerse them in water for final

curing.The test is usually conducted at the age of 7–28days.Thetime age shall be calculated from the time of addition of water to the dry ingredients.Test at least three specimens for each age of test follows

Apply the load without shock and increase it continuously at the rate to produce a spilt tensile stress of approximately 1.4 to 2.1N/mm 2/Min, until no greater load can be sustained.Remove maximum load applied to specimen.Note the appearance of concrete and any unusual feature in the type of failure.Compute the split tensile strength of the specimen to the nearest 0.25N/mm2.SplitTensileStrength=2P/πxdxl

Test on Density of Concrete

After 28 days curing,one set(3cylinders) of concrete specimen were taken out from storage

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for density test according to ASTM C642,for testing at particular day.These specimens were turned to SSD(SaturatedSurfaceDry) condition by removing water from the surfaces.Then SSD weight of samples in air(C)was measured.Next the specimens were placed in oven at a temperature of 100 to 110°C for 24h.After that weight of the specimen was measured.This is oven dry weight of samples in air(A).After that,the specimens were placed under water in a bucket and weight under water

(D)was obtained.Temperature of water at test day(T)was also recorded and water density(ρ)was calculated for that temperature.Then from"Equation1",density of concrete was calculated.Density test results are shown in table no 4.From this test results,it can easily be said that density increases with days.But rate of density change is low.Concrete with SC shows more density values than concrete with BC.

RESULTS AND DISCUSSIONS

The present study is based on trial mixer sand achieving target strength. Mix proportions have been obtained for M25 grade Control concrete. Then waste plastic is replaced by 5%,10%,15%,20% and 25% of sand to study the compressive strength, split tensile strength test and density of concrete.

The Slump test was conducted on fresh concrete for various percentage of replacement of fine aggregate with waste plastic and their results are tabulated below.

Table 4: Replacement of waste plastic on sand.

Sl no	Percentage of fine aggregate	Percentage of waste plastic replacement	Slump values in mm
1	100	0	78
2	95	5	50
3	90	10	24
4	85	15	8
5	80	20	3
6	75	25	1

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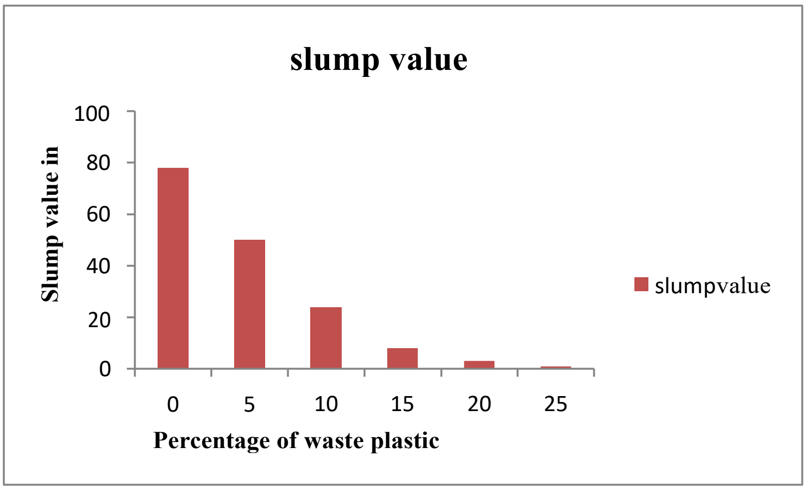

Fig: 1

The workability of the concrete decreases as the replacement level of granulated plastic waste with fine aggregate increases, as shown in Figure 1.It was found that slump decrease with increase in the waste plastic. The effect is more noticeable between 0%to15% replacements as shown in Figure 1.These reductions are attributed to the fact that some particles are angular and others have non uniform shapes resulting in less fluidity.

Cube Compressive Strength Results

Table: 5

Sl no	Proportion	w/c ratio	Percentage of waste plastic	Compressive strength 7days MPa	Compressive strength 28 days MPa
1	1:1.93:2.33	0.45	0	22.01	29.27
2	1:1.93:2.33	0.45	5	21.8	28.95
3	1:1.93:2.33	0.45	10	20.5	27.26
4	1:1.93:2.33	0.45	15	18.6	24.74
5	1:1.93:2.33	0.45	20	17.8	23.67
6	1:1.93:2.33	0.45	25	13.8	18.35

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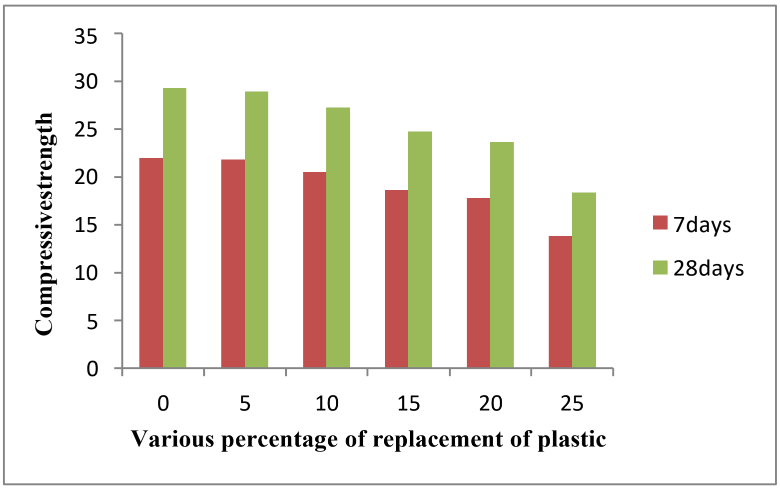

Fig: 2

The compressive strength tests outcome for the concrete mixes of the 0%(control),5%10%,15%,20% and 30% replacements are presented in Figure 2.while the compressive strength of curing for 28 days is shown in Figure. The results reveal that as the waste plastic content increases in mixes the tendency of the strength values decrease below that for the plain mix up to 53% at 28 days curing period for 30% replacement level as shown in Table. However, for 5% replacement of the fine aggregate with plastic waste (Table 5)at curing of 28 days,1% reduction in strength was recorded when compared to 0% replacement also curing at 28days.This reduction in compressive strength may be attributed to the decrease in adhesion or bond strength between the plastic aggregate and the cement paste.

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Split Tensile Strength Results:

Table 6: Percentage of waste plastic and its strength

Sl no	Proportion	w/c ratio	Percentage of waste plastic	Split Tensile Strength 7days MPa	Split Tensile strength 28 days MPa
1	1:1.93:2.33	0.45	0	1.48	4.5
2	1:1.93:2.33	0.45	5	1.39	4.2
3	1:1.93:2.33	0.45	10	1.29	3.9
4	1:1.93:2.33	0.45	15	1.06	3.2
5	1:1.93:2.33	0.45	20	0.95	2.88
6	1:1.93:2.33	0.45	25	0.83	2.5

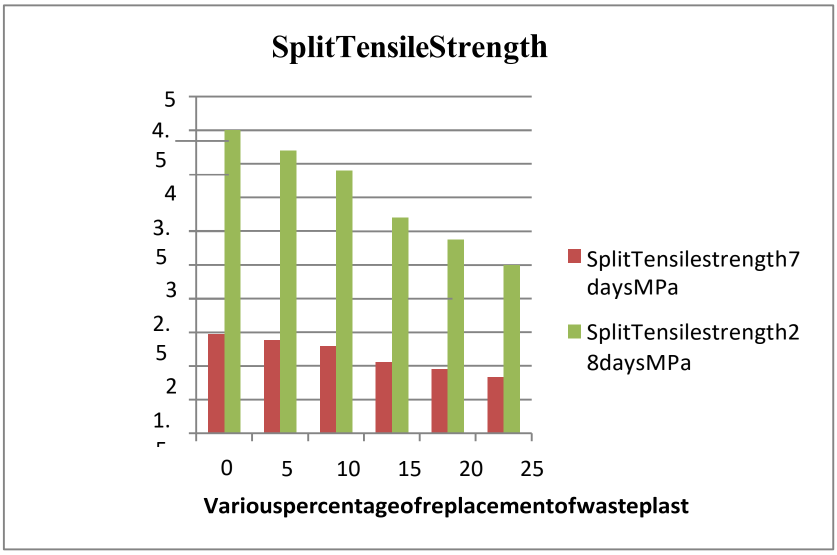

Fig 3:

The rate of splitting tensile strength reduction with the increasing percentage of HIPS aggregate was around 48% for 50% replacement almost similar to compressive strength at the age of 28days.Mortars containing 0%,5%,10%,15%,20% and 25% Plastic content showed a reduction in the splitting tensile strength of 0%,5%,10%,15%,20%and 25% respectively. But the decline in the splitting tensile strength is very less compared to the compressive strength.

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Density of Concrete Results:

Table 7: Percentage of waste plastic and it's strength:

Slno	Proportion	w/cratio	Percentage of waste plastic	Densityof Concrete7 daysMPa	Density of concrete 28 days MPa
1	1:1.93:2.33	0.45	0	24.53	24.67
2	1:1.93:2.33	0.45	5	24.80	24.53
3	1:1.93:2.33	0.45	10	24.00	22.16
4	1:1.93:2.33	0.45	15	21.99	22.84
5	1:1.93:2.33	0.45	20	22.01	22.43
6	1:1.93:2.33	0.45	25	20.21	20.77

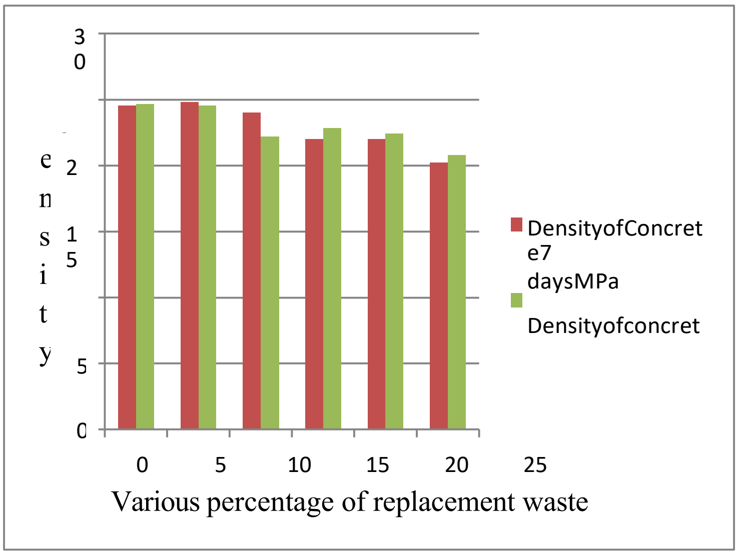

Fig 4:

Results of the density tests reveal that the densities of waste-concrete specimen decreased with increase in amount of the plastic waste as shown in Table 7.The decrease in the densities of the concrete is also presented graphically in Figure while Figure shows the effect of density for curing for 28 days at different replacement. After curing for 28days,a reduction of upto15% at 30% plastic replacement was recorded(Table 7).Similarly, after curing for 28days,a reduction of

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up to 0.24% at 5% plastic replacement was recorded when compared to control samples.This reduction on dry density is due to the lower density of plastics as compared to the density of fine aggregates.

Conclusions

The waste plastic is replaced by 5%,10%,15%,20% and 25% of sand to study the compressive strength, split tensile strength test and density of concrete. The workability of the concrete decreases as the replacement level of granulated plastic waste with fine aggregate increases. The effect is more noticeable between 0%to15% replacements as shown in Figure 1.These reductions are attributed to the fact that some particles are angular and others have non uniform shapes resulting in less fluidity. compressive strength of curing for 28 days The results reveal that as the waste plastic content increases in mixes the tendency of the strength values decrease below that for the plain mix up to 53% at 28 days curing period for 30% replacement level .However, for 5% replacement of the fine aggregate with plastic waste (Table 5)at curing of 28 days,1% reduction in strength was recorded when compared to 0% replacement also curing at 28days.This reduction in compressive strength may be attributed to the decrease in adhesion or bond strength between the plastic aggregate and the cement paste. The decline in the splitting tensile strength is very less compared to the compressive strength. Results of the density tests reveal that the densities of waste-concrete specimen decreased with increase in amount of the plastic waste. This reduction on dry density is due to the lower density of plastics as compared to the density of fine aggregates.

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