

Use of Recycled Plastic Waste as Partial Replacement for Fine Aggregate in Concrete

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ABSTRACT: Concrete is combination cement, aggregates and water. Due to enormous growth in concrete, aggregates are facing crisis. Apart from this growth of plastic has provoked the methods to solve environmental issue caused by plastic. We have made an experiment by partially replacing fine aggregate with plastic an investigation has been carried out. The strength properties of M30 grade concrete are studied with different plastic percentage proportions. The various plastic proportions are 5%,6%,8%,10%,15%,20% by volume. We studied strength properties of these mixes. There is decrease in compressive strength when the ratio of plastic to aggregate was increased. We have taken the mix for which compressive strength was least and to that mix we have partially replaced cement with silica fume of 5%,10%,15% by weight. The strength properties were again studied, It was noticed that when cement was partially replaced by 10%, 15% of silica fume was higher than reference mix.

KEYWORDS: PET plastic, Silica fume, Water absorption capacity, Compressive strength, Tensile strength, Flexural strength.

I.INTRODUCTION

As one of the greatest inventions in 20th century, plastic has brought huge benefit in human life. Numerous plastic products are being consumed with the development of society. However, large amounts of plastic waste give much pressure on the environment due to the very low biodegradability of plastic. It is necessary to develop a rational approach for the waste disposal indicating both the economy and environmental protection. The productive use of waste material represents a means of alleviating some of the problems of solid waste management. The recycle of wastes is important from different points of view. It helps to save and sustain natural resources that are not replenished, it decreases the pollution of the. Wastes and industrial by-products should be considered as potentially valuable resources merely awaiting appropriate treatment and application. Plastic wastes are among these wastes; their disposal has harmful effects on the environment due to their long biodegradation period, and therefore one of the logical methods for reduction of their negative effects is the application of these materials in other industries. Concrete plays an important role in the beneficial use of these materials in construction. Although some of these materials can be beneficially incorporated in concrete, both as part of the cementitious binder phase or as aggregates, it is important to realize that not all waste materials are suitable for such use. The strength properties and modulus of elasticity of concrete containing various types of plastic aggregate are always lower than those of a reference concrete containing normal density natural aggregate only, and they further decrease with increasing plastic aggregate content in concrete. Concrete containing plastic aggregate can stop or divert the propagation of micro cracks and improve concrete toughness, which is of great practical significance. The use of plastic waste as a natural aggregate substitute in concrete is a relatively recent concept. One of the first significant reviews on the use of waste plastic in concrete focused on the advantages and financial benefits of such use, besides their physical and mechanical properties. And more over use of plastic as aggregate gives a solution to the problems encountered with the quarrying of natural aggregate. The main objective of this investigation is to study strength properties after partially replacing fine aggregate with plastic. In this project we made M30 grade concrete with w/c of 0.40. Workability, dry density properties, compressive strength, tensile strength, flexural strength were studied.

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II. RELATED WORK

Simiha Akcozoglu (2009) had made investigation by using PET plastic, concluded that use of shredded PET granules due to its low unit weight reduces the unit weight of concrete which results in reduction in dead weight of building will help to reduce the seismic risk of building the earth quake forces linearly dependent on dead weight .

Mariaenrica Frigione (2010) had conducted an investigation on using recycled PET bottles as fine aggregate in concrete and concluded the workability, compressive strength, split tensile strength is slightly lower than reference concrete and moderately higher ductility.

Semiha Akcaozoglu (2011) had conducted an investigation on mortars by using PET as aggregate and studied the effect of Granulated Blast Furnace Slag , Fly ash on light weight mortars and concluded that the use of fly ash has decreased compressive strength ,flexural strength , tensile strength when compared to cement specimens .Both Granulated Blast Furnace Slag and fly ash increased carbonation depths of specimens .For this reason carbonation reducing measures must be taken when using these mineral admixtures .

R.V.Silva (2012) had conducted an investigation on concrete containing paste waste as aggregate and influence of curing conditions on the durability related performance of concrete. He concluded that workability decreases with increasing amount of coarser ,flakier and irregular shaped plastic aggregates. The gap between these values widened as all concrete specimens were cured in progressively drier environments with reductions varying between 11.1%,28.3% of coarser plastic aggregate specimens cured .

Brahim Safi (2013) had conducted an investigation by using plastic waste a fine aggregate in self compacting mortars. Concluded that this plastic waste type can be used successfully as fine aggregate in self compacting mortars (or concrete). Fluidity is significantly improved by the presence of these waste. Reduction in Compressive strength was between 15 % and 33% for mortar containing 20 % to 50% plastic waste.

III.MATERIALS AND THEIR PROPERTIES

The materials used in this investigation are

1. ZUARI OPC 53 grade cement confirming IS 12269:1987
2. Silica Fume confirming ASTM C1240 and IS 15388:2003
3. Natural river sand
4. Recycled PET Plastic
5. Coarse aggregate
6. Water
7. Master Glenium sky 8233 formely B-233 as admixture of BASF company

Cement

The fineness of cement is 3%, specific gravity of cement is 3.13, standard consistency of cement is 31%, Initial setting time is 60 minutes and final setting time is 250 minutes.

Silica Fume

Silica Fume is also called as micro silica. The colour of silica fume is white. The Specific gravity is 2.3 and size of silica fume is 10 µm

Natural river sand

Uncrushed natural river sand is used as fine aggregate in this investigation .As per IS 383:1970 fine aggregate properties were tested and concluded that the fine aggregate in this investigation falls in zone-II .The water absorption capacity is 1%, fineness modulus is 2.60,specific gravity is 2.65.

Plastic

Plastic used in this investigation is PET (polyethylene terephthalate) .The water absorption capacity is 0.12%, specific gravity is 1.32, size is below 4.75 mm

Coarse aggregate

As per IS 383:1970 the nominal size is 20 mm is used .The shape of coarse aggregate is angular, water absorption capacity is 0.5%, fineness modulus is 4.60, specific gravity is 2.73

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Water

Tap water is used in this investigation.

Admixture

Master Glenium SKY 8233 is used .It is a super plasticizer based on polycarboxylic ether .This free from chloride and low alkali .It is compatible with all types of cements .The aspect of admixture is light brown, relative density is 1.08±0.01 at 25.The PH is ≥6, specific gravity is 1.08.

IV. EXPERIMENTAL RESULTS

Mix proportion

The mix design was made confirming IS 10262:2009 .Ten mixes were made in this investigation including reference mix other than the reference mix ,the mixes were made by partially replacing plastic to fine aggregate of percentage 5%,6%,8%,10%,15%,20%. By taking the mix with least compressive strength was enhanced it with silica fume as partial cement replacer of percentage 5%,10%,15% .The w/c ratio is 0.40.The mix proportions are shown in table 1.

Table 1: Mix proportion of M30 grade with w/c of 0.40

Mix name	CEMENT (Kg/m ³)	SILICA FUME(Kg/m ³)	FINE AGGREGATE (Kg/m ³)	PLASTIC (Kg/m ³)	COARSE AGGREGATE (Kg/m ³)	WATER (Kg/m ³)	ADMIXTURE (Kg/m ³)
H1	394	0	662.027	0	1212.644	157.6	2.758
H2	394	0	628.97	16.610	1212.644	157.6	2.758
H3	394	0	622.35	19.93	1212.644	157.6	2.758
H4	394	0	609.10	26.57	1212.644	157.6	2.758
H5	394	0	595.86	33.22	1212.644	157.6	2.758
H6	394	0	562.76	49.83	1212.644	157.6	2.758
H7	394	0	529.66	66.44	1212.644	157.6	2.758
H8	374.3	19.7	529.66	66.44	1212.644	157.6	2.758
H9	354.6	39.4	529.66	66.44	1212.644	157.6	2.758
H10	334.9	59.1	529.66	66.44	1212.64	157.	2.758

Workability

In this investigation workability was measured in terms of slump. The slump results are shown in table 2.

Table 2: Slump values

Mix name	Slump in mm	Degree of workability
H1	120	High
H2	130	High
H3	135	High
H4	140	High
H5	142	High
H6	145	High
H7	150	High
H8	150	High
H9	150	High
H10	150	High

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Compressive strength

The results of the compressive strength for the waste plastic concrete mixes at 7 days 28 days are shown in table 3, table 4. By increasing the waste plastic to fine aggregate ratio the results shown a tendency to decrease on compressive strength . This is because there is poor adhesive strength between the surface of the waste plastic and the cement paste. The graphical representation is shown in fig 1, fig 2.

Table 3 Compressive strength of concrete for 7 days and 28 days

Mix no	Average Compressive strength for 7 days in N/mm ²	Average compressive strength for 28 days in N/mm ²
H1	28.2	47
H2	27.66	46.1
H3	27.6	46
H4	27.24	45.4
H5	26.52	44.2
H6	25.26	42.1
H7	24	40

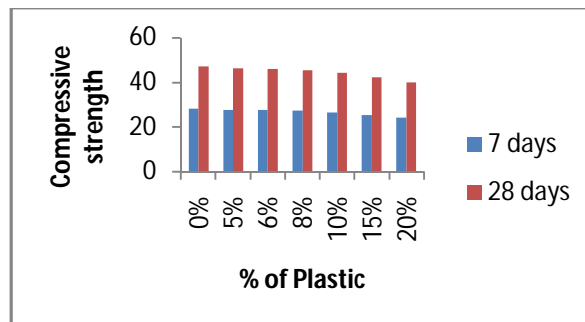


Fig 1 Compressive strength verses percentage of plastic for 7 days and 28 days

Table 4 Compressive strength of concrete with silica fume for 7 days and 28 days

Mix name	Average Compressive strength for 7 days in N/mm ²	Average compressive strength for 28 days in N/mm ²
H7	24	40
H8	27.108	45.18
H9	28.8	48
H10	29.4	49

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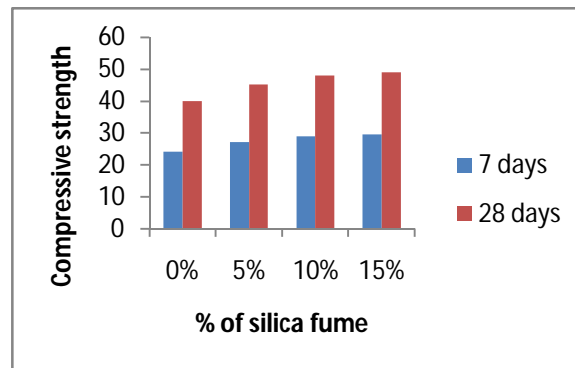


Fig 2 Compressive strength versus percentage of silica fume for 7 day and 28 days

Tensile strength To understand the influence of the replacement percentage of fine aggregate with plastic aggregate at 7 days and 28 days on tensile behavior of concrete, the concrete specimens were tested under split tensile test, the experimental results are presented in table 5 and table 6. The graphical representation is shown in Fig 3, Fig 4.

Table 5 Tensile strength of concrete for 7 days and 28 days

Mix name	Average Tensile strength for 7 days in N/mm ²	Average Tensile strength for 28 days in N/mm ²
H1	1.8	3
H2	1.833	3.055
H3	1.962	3.027
H4	1.782	2.97
H5	1.74	2.900
H6	1.71	2.85
H7	1.68	2.80

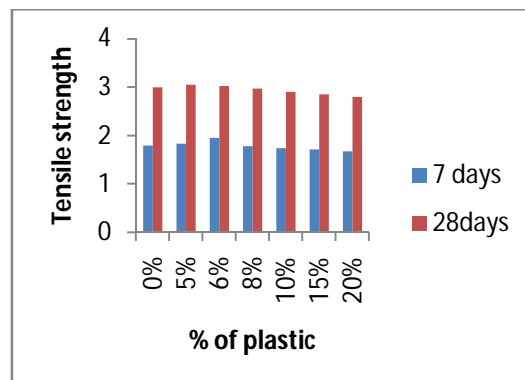


Fig 3 Tensile strength versus percentage of plastic for 7 days and 28 days

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Table 6 Tensile strength of concrete with silica fume for 7 days

Mix name	Average Tensile strength for 7 days in N/mm ²	Average Tensile strength for 28 days in N/mm ²
H7	1.68	2.80
H8	2.037	3.395
H9	2.052	3.42
H10	2.1852	3.642

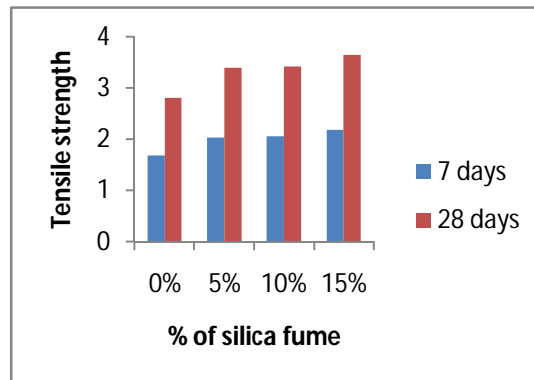


Fig 4 Tensile strength verses percentage of silica fume for 7 days and 28 days

Flexural strength

The results of the flexural strength tests for the plastic concrete mixtures are shown in table 7, table 8. The graphical representation is shown in Fig 5, Fig 6.

Table 7 Flexural strength of concrete for 7 days and 28 days

Mix name	Average Flexural strength in N/mm ² for 7 days	Average Flexural strength in N/mm ² for 28 days
H1	2.76	4.6
H2	2.64	4.4
H3	2.52	4.2
H4	2.4	4.0
H5	2.37	3.95
H6	2.31	3.85
H7	2.25	3.75

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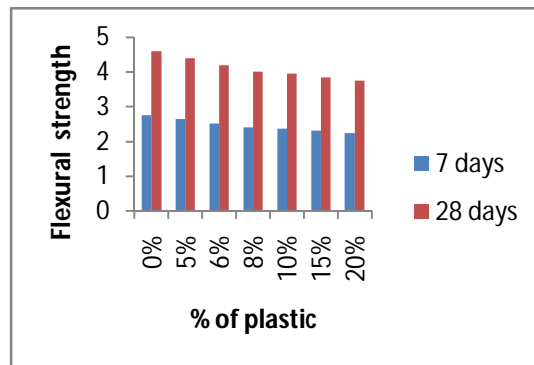


Figure 5: Flexural strength versus percentage of plastic for 7 days and 28 days

Table 8 Flexural strength of concrete with silica fume for 7 days and 28 days

Mix name	Average Flexural strength in N/mm ² for 7 days	Average Flexural strength in N/mm ² for 28 days
H7	2.25	3.75
H8	2.7	4.5
H9	2.76	4.6
H10	2.88	4.8

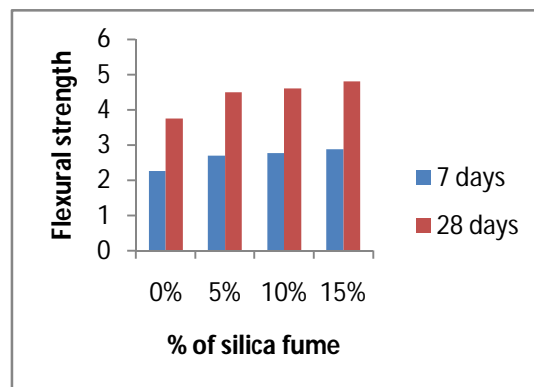


Fig 6 Flexural strength versus percentage of silica fume for 7 days and 28 days

V. CONCLUSIONS

1. As percentage of plastic increases workability also increases because the plastic which is used as aggregate is smooth .As well as water absorption capacity of plastic is also low.
2. By partially replacing fine aggregate with 20% of plastic in concrete the compressive strength has been decreased by 14.89% when compared to reference mix .By taking the mix which has least compressive strength(i.e where partial replacement of plastic is high) we have enhanced it by using a partial replacement to cement of silica fume by 5% ,10%,15%. The mix in which 15% of silica fume is used as binder the compressive strength increased by 22.5% when compared to the mix with no silica fume and plastic percentage of 20% .

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3. The tensile strength increases when fine aggregate is partially replaced by 6% of plastic however replacing plastic more than 6% to the fine aggregate will lead to decrement in tensile strength. Same as above observation tensile strength increased by 30.07% when silica fume is used.
4. The flexural strength at each curing age is prone to decrease with the increase of the waste plastic and aggregate ratio. This trend can be attributed to the decrease in adhesive strength between the surface of waste plastic particles and the cement paste .
5. The density of concrete decreased when plastic content increased.
6. Because plastic has more water tightness capacity when compared to natural aggregate this can help in arresting micro cracks.
7. By using recycled waste plastic in concrete can reduce the land fill and environmental issues .
8. This type of aggregate replacement is useful where aggregates are in crisis .By this we can conserve natural resources .

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