Experimental investigation on partial replacement of recycled plastic as coarse aggregate

[1]A.Faizuneesa, [2]S.Saranya, [3]S.P Kanniyappan
[1]Assistant Professor, [2] Assistant Professor, [3] Assistant Professor
[1]Civil Engineering,
[1]Rmk Engineering College, Chennai, India

Abstract: ***The use of plastic is increasing day by day. Some of the steps were taken to reduce its consumption. Recycled and reused plastic offers some advantages. The usage of recycled plastic as a coarse aggregate in concrete and its advantages are discussed further. Some of the properties in plastic aggregates are density, specific gravity and crushing value. The present study covers the use or recycled plastics as replacement of coarse aggregates in concrete. It is found that the use of plastic aggregates results in the formation of lightweight concrete. The compressive as well as tensile strength of concrete reduces with the introduction of plastics. Therefore, it can be said that recycled plastics can be used for thermal insulation of buildings. Research concerning the use of by-products to augment the properties of concrete has been going on for many years. In the recent decades, the efforts have been made to use industry by-products such as fly ash, silica fume etc., in civil constructions. The use of these materials in concrete comes from the environmental constraints in the safe disposal of these products. Recycled plastic can be used as coarse aggregate in concrete. Material test have been conducted using impact value test for both PCA and NCA. Compression test to be conducted for all the three percentages of PCA and NCA specimens for the curing periods of 7 and 28 days. As 100% replacement of natural coarse aggregate with plastic coarse aggregate is not feasible, so partial replacement will be carried out for the following percentages of 20, 25 and 30.***

Index Terms - Waste***, Plastic, Concrete, Partial Replacement, Coarse Aggregate, Strength.***

I. INTRODUCTION

Concrete is a composite material composed of coarse aggregate bonded together with a fluid cement that hardens over time. Most concretes used are lime-based concretes such as Portland cement concrete or concretes made with other hydraulic cements, such as cement found. When aggregate is mixed together with dry Portland cement and water, the mixture forms a fluid mass that is easily moulded into shape. The cement reacts chemically with the water and other ingredients to form a hard matrix that binds the materials together into a durable stone-like material that has many uses. Often, additives are included in the mixture to improve the physical properties of the wet mix or the finished material. Most concrete is poured with reinforcing materials (such as rebar) embedded to provide tensile strength, yielding reinforced concrete. Famous concrete structures include the Hoover Dam, the Panama Canal, and the Roman Pantheon. The earliest large-scale users of concrete technology were the ancient Romans, and concrete was widely used in the Roman Empire. The Colosseum in Rome was built largely of concrete, and the concrete dome of the Pantheon is the world's largest un reinforced concrete dome .Today large concrete structures are usually made with reinforced concrete. After the Roman Empire collapsed, use of concrete became rare until the technology was re-developed in the mid-18th century. Today concrete is most widely used man-made material Other cementitious materials such as fly ash and slag cement, are sometimes added as mineral admixtures - either pre-blended with the cement or directly as a concrete component - and become a part of the binder for the aggregate

II. DETAILS OF THE MATERIAL USED

Polypropylene (PP), also known as polypropene, is a thermo - Plastic Polymer used in a wide variety of applications including packaging and labeling, textiles (e.g., ropes, thermal underwear and carpets), stationery, plastic parts and reusable containers of various types, laboratory equipment, loudspeakers, automotive components, and polymer banknotes. An addition polymer made from the monomer propylene, it is rugged and unusually resistant to many chemical solvents, bases and acids. Polypropylene has a relatively slippery "low energy surface" that means that many common glues will not form adequate joints. Joining of polypropylene is often done using welding processes. In 2013, the global market for polypropylene was about 55 million tones. Polypropylene is the world's second-most widely produced synthetic plastic, after polyethylene.

Cement is a binder, a substance used in construction that sets and hardens and can bind other materials together. The most important types of cement are used as a component in the production of mortar in masonry, and of concrete, which is a combination of cement and an aggregate to form a strong building material. Coarse aggregates have a wide variety of construction applications because they resemble standard rock particles, as opposed to fine aggregate which more closely resembles sand. Fine aggregate is used in highway and airfield construction because of the high tensile strength that results from its fine grained structure. The absence of the coarse aggregate (crushed stone or gravel) substantially facilitates the preparation, transport and placing of the concrete particularly when concrete pumps are used.

III. OBJECTIVE OF THE STUDY

a) In our project the recycled plastic is used as a coarse aggregate as partial replacement.

b) The recycled plastic is partially replaced in three different percentages of 20%, 25% and 30%.

c) Impact value test, Compression test is conducted for both PCA specimens and NCA specimen.

The tests have been conducted for all the three different percentages of recycled plastic as a coarse aggregate for the curing periods of 7 and 28 days

IV. MATERIAL TEST

To investigate the properties of material such as cement, fine aggregate, coarse aggregate and plastic coarse aggregate used for casting the specimen various laboratory tests were performed & the test results were obtained were compared with the Indian standard values the test results are tabulated below.

Table 1 Consistency of cement

Weight of the cement	Percentage of Water Added (in terms of Weight of Cement)	Volume of Water added(ml)	Reading on Gauge(mm)
400	25	100	35
400	28	112	17
400	29	116	16
400	31	124	11
400	32	128	7

Standard consistency (%) = (Volume of water added/ Weight of cement) x 100 =(100/400) x 100 =25%

Initial setting time of cement= t_2-t_1=100-0=100 min

Final setting time of cement= t_3-t_1=345-0=345 min

Table 2 Specific gravity of cement

S.No	Description(gm)	Trial1	Trial2	Trial3	Mean
1	Weight of empty Bottle(W_1)	14	14	14	
2	Weight of bottle + Cement(W_2)	114	115	114	
3	Weight of bottle + kerosene (W_3)	309	307	308	3.20
4	Weight of bottle +Kerosene(W_4)	240	238	239	

5	Specific gravity of cement	3.22	3.15	3.22	

Specific gravity of cement= $(W_2 – W_1)/((W_2- W_1)- (W_3- W_4))$

= (114-14)/((114-14)-(309-240)) =3.22

Table 3 Specific Gravity of Fine aggregate

S.No	Description	Trail 1	Trail 2	Trail 3	Mean
1	Weight of empty pycnometer(W1)	66.3	66.3	66.3	
2	Weight of pycnometer + fine aggregate(W2)	86.3	85.6	86.2	
3	Weight of pycnometer +fine aggregate + water (W3)	167.1	167	167.0	2.67
4	Weight of pycnometer + water (W4)	154.4	154.5	154.6	
5	Specific gravity of FA	2.7	2.66	2.65	

Specific gravity of cement= $(W_2–W_1)/((W_2- W_1)- (W_3-W_4))$

= (86.3-66.3)/((86.3-66.3)-(167.1-154.4))=2.7

Table 4 Water Absorption of Fine Aggregate

S.No	Description (gm)	Trial
1	Weight of saturated surface dry sample (W_1)	867.6
2	Weight of oven dry sample (W_2)	858.8
3	Water absorption	1.0%

= Water absorption = $(W_2-W_1)/W_1$ X 100

= (867.6-858.8)/867.6 X 100=1.0%

Table 5 Water Absorption for Coarse Aggregate

S.No	Description(gm)	For size 20mm Aggregate
1	Weight of oven dry sample (W_1)	1000
2	Weight of saturated sample(W_2)	1009
3	Water absorption	0.9%

Water absorption = $(W_2-W_1)/W_1$ X 100

= (1000-1009)/1000 X 100 = 0.9%

Table 6 Impact of Coarse Aggregate

S.No	Description	Coarse aggregate			
		Trial 1	Trial 2	Trial 3	Mean
1	W_1(gm)	425	425	425	7.29%
2	W_2(gm)	31	30	32	
3	Aggregate impact Value	7.3%	7.06%	7.5%	

Aggregate impact value = W_2/W_1 X 100

=31/425 X 100=7.3%

Table 7 Specific Gravity of Coarse Aggregate

S.No	Description	Trial1	Trial2	Trial3	Mean
1	Weight of empty Pycnometer(W_1)	66.5	66.5	66.5	2.71
2	Weight of pycnometer + coarse aggregate(W_2)	86.5	86.6	86.7	
3	Weight of pycnometer +coarse aggregate + water (W_3)	166.5	167.0	166.8	
4	Weight of pycnometer + water (W_4)	154.0	154.2	154.0	
5	Specific gravity of CA	2.67	2.75	2.72	

Specific gravity of cement= $(W_2–W_1)/((W_2- W_1)- (W_3-W_4))$

= (86.5-66.5)/((86.5-66.5)-(166.5-154.0)) =2.67

Table 8 Sieve Analysis of Coarse Aggregate

d)

S.No	IS Sieve Size (mm)	Weight of C.A Retained (gm)	Cumulative weight of C.A retained (gm)	Cumulative Percentage of C.A Retained (gm)	Cumulative Percentage of C.A passing
1	80	0	0	0	100
2	40	0	0	0	100
3	20	2.08	2.08	41.6	58.4
4	10	2.19	4.27	85.4	14.6
5	4.75	0.73	5	100	0

Fineness modules= total cumulative % weight retained/100

= 727/100

= 7.27

Table 9 Quantity of Material used

Material	Quantity(kg)
Cement	26
Fine aggregate	26
Coarse aggregate	39
Plastic coarse aggregate	13

Table 10 Mix Ratio

Sample	Percentage of ratio (%)		Fine aggregate(Kg)	Cement(Kg)
	PCA	NCA		

Cube	20	80	26	26
Cube	25	75	26	26
Cube	30	70	26	26

V.CASTING OF SPECIMEN

Cube mould of size 150x150x150mm to be used is cleaned properly with dry cloth and oil was applied before casting. The amount of cement, fine aggregate, coarse aggregate and plastic coarse aggregate were measured based on their weight and then they were mixed on water tight platform under standard condition. Water was added gradually till all the materials has been adequately mixed together to form a uniform mix. Concrete was then filled in mould and compacted using standard tamping rod. The casting is done for the partial replacement of plastic course aggregate of three different percentages 20, 25 and 30.

Fig 1 Mixing of concrete

Fig 2 Casting of concrete

VI. TESTING PROCEDURE OF SPECIMEN

For each mixture, cubes of 150 x 150 x 150mm were prepared .Totally 12 specimen was finished and allowed for curing. The compressive strength for cube is tested on compression testing machine having an capacity of 1000N/mm^2.The specimen is tested for 7 days and 28 days.

Fig 3 Curing of concrete

6.1 Compression Test

6.1.1 TESTED AFTER 7 DAYS OF CURING

Table 11 TESTED AFTER 7 DAYS OF CURING

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	450	150 x 150	20	18.8
2	400	150 x 150	17.7	

Table 12 20% usage of PCA on 7 days

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	350	150 x 150	15.55	14.44
2	300	150 x 150	13.33	

Table 13 25% usage of PCA on 7 days

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	300	150 x 150	13.33	13.55
2	310	150 x 150	13.77	

Table 14 30% Usage of PCA on 7 Days

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	360	150 x 150	16	16.11
2	590	150 x 150	26.22	

6.1.2 TESTED AFTER 28 DAYS OF CURING

Table 15 28th day Test for Compressive Strength of Conventional Concrete

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	550	150 x 150	24.4	24.7
2	525	150 x 150	23.3	

Table 16 20% usage of PCA on 28 days

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	530	150 x 150	23.56	21.98
2	460	150 x 150	20.4	

Table 17 25% usage of PCA on 28 days

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	450	150 x 150	20	19.335
2	420	150 x 150	18.67	

Table 18 30% usage of PCA on 28 days

TRIAL	LOAD(KN)	AREA(mm)	COMPRESSIVE STRENGTH(N/mm^2)	AVERAGE (N/mm^2)
1	420	150 x 150	18.67	19.89
2	475	150 x 150	21.11	

6.2 COMPARATIVE STUDY

6.2.1 COMPARATIVE RESULT ON CUBE AFTER 7 DAYS OF CURING

Table 19 Comparative study of cube on 7th day

Specimen	Compressive strength(N/mm^2)

Conventional concrete	18.8
Proportion 1(80% NCA & 20%PCA)	14.44
Proportion 2(75% NCA & 25%PCA)	13.55
Proportion 3(70% NCA & 30% PCA)	16.11

Table 20 Comparative study of cube on 28th day

Specimen	**Compressive strength(N/mm^2)**
Conventional concrete	24.7
Proportion 1(80% NCA & 20%PCA)	21.98
Proportion 2(75% NCA & 25%PCA)	19.34
Proportion 3(70% NCA & 30% PCA)	19.89

VII.CONCLUSION

Introduction of plastic in concrete tends to make concrete ductile, hence increasing the ability of concrete to significantly deform before failure . In our project the polypropylene is used as a coarse aggregate which is semi rigid and good heat resistance can be used in construction. The materials which can bear more number of blows on impact value test and high compressive strength when it is used in concrete. Plastics can be used to replace some of the aggregates in a concrete mixture. This contributes to reducing the unit weight of the concrete. This study shows that replacing a recycled plastic as a coarse aggregate for M25 grade of concrete is deviates the compressive strength of the concrete. Thus it is insufficient for M25 grade of concrete. It might be sufficient while introducing super plasticizers in to the concrete.

VII.REFERENCES

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