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EXPERIMENTAL STUDY ON THE STRENGTH OF CONCRETE BY PARTIAL REPLACEMENT OF COARSE AGGREGATE BY USING PLASTICS

Sanjai Kumar K

Master of Engineering in Structural Engineering, Department of Civil Engineering, RVS Technical Campus, Coimbatore, Anna University, Chennai, Tamil Nadu, India

ABSTRACT

Many ways of reusing plastics for were implemented, yet those ways were not enough to manage the amount of plastic wastes being generated. So incorporating plastic wastes in concrete can be another way to reduce the disposal problem of plastic wastes. It can not only reduce the waste disposal problem but also reduce the excessive extraction of natural aggregates. Excessive extraction of natural aggregates can cause silting and sedimentation in rivers and can also change river courses, causes death of aquatic life and expose land to agents of degradation. Since waste is abundantly available, concrete with plastic aggregates can be cheaper compared to conventional concrete.

KEYWORDS: *Natural Aggregates, Reduce the Disposal Problem of Plastic Wastes*

Article History

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1. INTRODUCTION

1.1 General

The productive use of waste material represents a means of alleviating some of the problems of solid waste management (Davis and Cornwell, 1998). The reuse 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 environment and it also helps to save and recycle energy production processes. 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 (Hassani et al., 2005).

Concrete is the mostly used man made material used in construction industry and is the second after water as the most utilized thing on the Earth. In simple words it is defined as a mixture of four ingredients as coarse aggregates that form the largest proportion of the mix, fine aggregates such as sand that act as filler material in the voids, binding material such as lime or pcc that binds these material together and water that reacts with binding material. The mixing of these four materials gives us a paste that is called as matrix. At this stage it is called as fresh concrete or green concrete and get hardened like a stone, as the water reacts with binding material. This reaction is called as hydration of concrete. In fresh state concrete can be casted into any desired shape by placing it in forms. This property of concrete help in using the concrete in most efficient manner. Plastic needs no introduction as it is the widely used material now a days on our Earth. Due to its properties like strength, durability and easy processing it can be used for many purposes. Studies show that plastic is nearly inert that is it get very less affected by the chemicals and have higher durability. Disposal of plastic waste is a huge problem as due to absence of organic compounds, it is non-decomposable material and proves to be a threat to our environment as it has many health hazards. As decomposition of plastic is a serious problem as it takes very long time and adversely affection the environment in many ways. So we can use it in construction, where we need life of structure to be improved and use of waste plastic after small processing can help us to reduce the waste in the environment which is new motto of civil engineering.

1.2 OBJECTIVES

The main objective of this research is to explore the possibility of using waste plastics in concrete as concrete aggregate and reduce the problems associated to plastic wastes disposal as well as the extraction of natural aggregates from the environment. Other objectives of the research are as follows:

- To obtain optimum 50% percentage of aggregate replacement.
- To study the change in mechanical properties of concrete.
- To study the feasibility of its application based on the properties obtained.

1.3 SCOPE

We get most of the aggregates by quarrying the stones and then crushing. As quarrying of stones cause change in geological aspects of the area, crushing causes the entry of dust particles in the environment. So causing bad impact to the environment in dual manner. To minimize these researchers focused on the usage of waste materials that were also adversely affecting the environment. Some of these are already in use such as Iron slag, Crusher Dust, etc. and many others are under research. So usage of these waste materials helping in dual role by minimizing the usage of raw material of concrete and by using the waste materials that are affecting the environment. The other advantage of using these waste materials is that they are helping in improving the properties of concrete. The waste materials we have taken for our study is Plastic. Plastic has very bad impact on our environment but due to some of its properties it can be used in concrete.

2. LITERATURE REVIEW

2.1 General

The literature review of plastic waste as aggregate in concrete done by various scholars have been briefed in this chapter.

2.2 Literature Review

Elango A and Ashok Kumar A in 2018 performed study concrete with plastic fine aggregates. They used OPC 53 grade, River sand and crushed aggregates. They used plastic in place of fine aggregates in proportion of 10%, 20% and 30%. They test mechanical and durability properties on their concrete samples. They found the decrease in strength of concrete. But found that the concrete shows good results against acid attacks and increase in elasticity. So they concluded that the plastic aggregate concrete can be used in place where we need less compressive strength but more durability.

Lhakpa WangmoThingh Tamanget. al. in 2017 performed experiment on Plastics in Concrete as Coarse Aggregate. They performed the testing of mechanical properties of concrete containing Plastic aggregates They use plastic aggregates in proportion of 10%, 15%, and 20%. They found marginal reduction in strength and suggested the optimum result as 15% replacement.

B Jaivignesh and A Sofi in 2017 performed Study Properties of Concrete with Plastic Waste as Aggregate. They used the plastic place of fine aggregates as well as coarse aggregates in proportion of 10%, 15 % and 20%. They also added steel fibre to the concrete. Their research concludes to the reduction in strength but suggested its use in favor of reduction of waste material and eco friendly materials.

MB Hossain et. al. in 2016 performed work on Use of waste plastic in concrete as constituent material. They replace coarse aggregates in proportion of 5%, 10% and 20 5. They found that the concrete was lighter in weight. But the compressive strength was lesser than that of conventional concrete. They also found that the concrete with 10% plastic aggregates shows strength nearly similar to the conventional concrete. So, the optimum result was 10% plastic aggregates.

METHODOLOGY

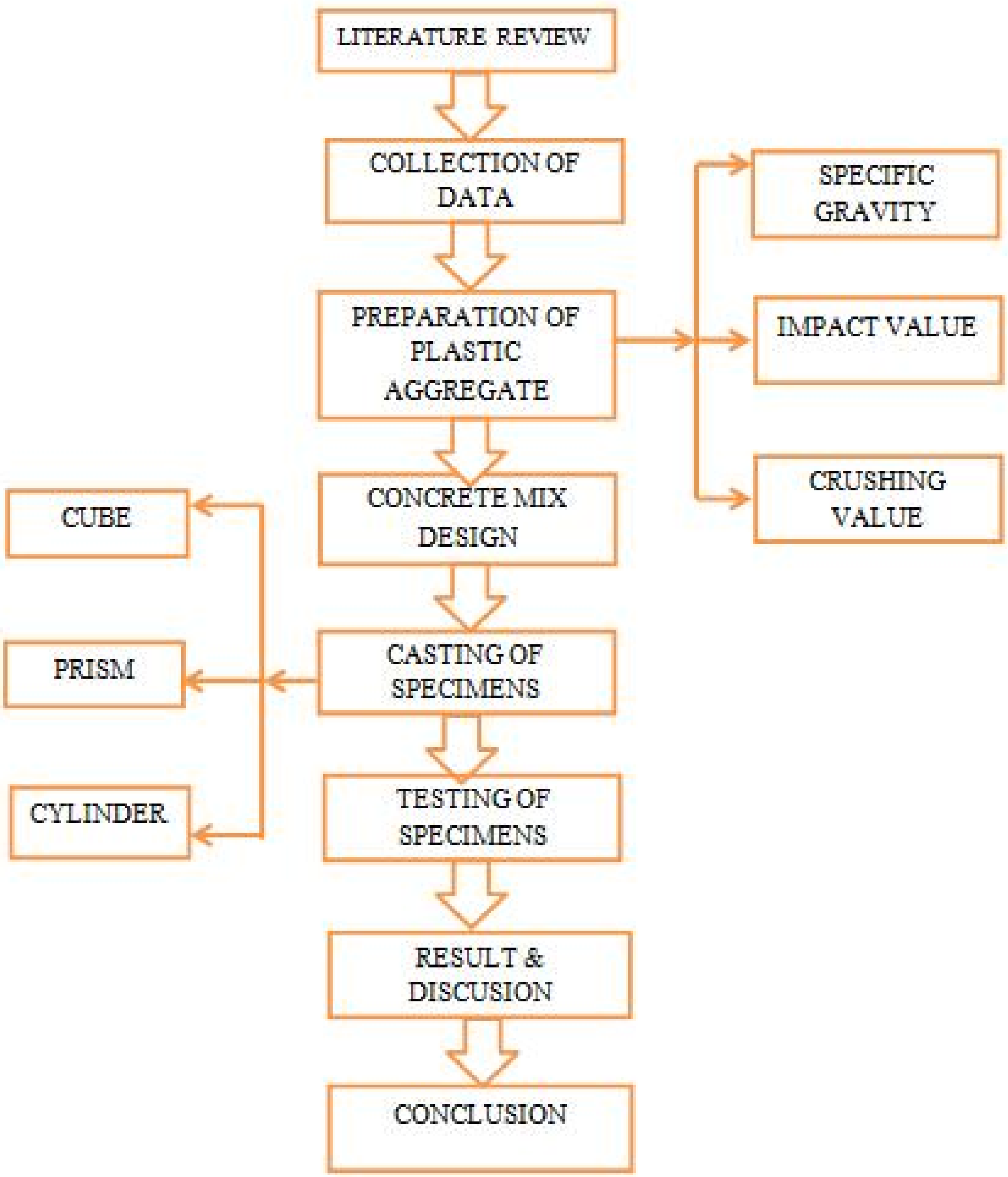

Fig 3.1 Methodology Plastic Aggregate.

4. TESTING OF SPECIMENS

4.1 CEMENT

4.1.1 FINENESSTESTONCEMENT

The Fineness Test of Cement is **done by sieving cement sample through standard IS sieve**. The weight of cement particle whose size is greater than 90 microns is determined and the percentages of retained cement particle are calculated. This is known as the Fineness of cement is given to table5.2, fig5.2

Table 5.2 Fineness Test on Cement

TYPES OF CEMENT	CEMENT SAMPLE	WIGHT OF SAMPLE	WIGHT OF REDUCE	PERCENTAGEEIGHT OF ACTUAL	AVERAGE %OF REDUCE
PPC	100	100	6	7	7%
PPC	100	8	8	8	8%
PPC	100	6	6	6	6%

Figure 5: 290 Micronsieve with Cement Sample.

Result

Average fineness of cement=7%

4.1.2 Specific Gravity of Cement

The specific gravity of cement is important because it is one of the factor which determines the density of the cement. As we know that, the cement may contain lots of moisture content if it is exposed to various conditions and humidity. We all know that water cement ratio is an important factor of cement paste is given to table5.5,fig 5.5.

Table 5.5: Specific Gravity of Cement

S.NO	DESCRIPITION	TRIAL1	TRIAL2	TRIAL3
1	EMPTYWEIGHTOF FLASK(W1)	122	122	122
2	FLASK+CEMENT (W2)	178	174	172
3	FLASK+CEMENT + KAROSENE(W3)	376	374	372
4	FLASK+KARASENE (W4)	330	330	330

Average=3.09

Figure 5.5: LE-Chatelier Flask

Result

Specific gravity of cement **= 3.09**

FINEAGGREGATE(M–SAND)

PHYSICALPROPERTIESOFFINEAGGREGATE

SIEVEANALYSIS OFM –SAND

Sieve Analysis Test of Sand is done to check the gradation of sand particles. Sand particle distribution in sand volume is important for good quality concrete and mortar. In this test, the sand sample is passed through a series of IS sieve sizes ordered from bigger to smaller sizes at the bottom

Fine aggregate used in M-sand confining to Zone – II as per **IS CODE 383- (1970)** is used in the study is given to table 5.8

Table 5.8: Sieve Analysis of M-sand

SI.NO	ISSIEVE	WEIGHT MATERIAL RETAINED (g)	%OF MATERIAL RETAINED	CUMULATION %OF MATERIAL RETAINED	% MATERIAL PASSING	ISCODELIMIT FOR SINGLE SIZEAGGREGATE			
						ZONE 1	ZONE 2	ZONE 3	ZONE 4
1	10mm	0	0.00	0.00	100.00	100	100	100	100
2	4.47mm	21	2.10	2.10	97.90	90-100	90-100	90-100	100
3	2.36mm	162	16.20	18.30	81.70	60-95	75-100	85-100	95-100
4	1.18mm	239	23.90	42.20	57.80	30-70	55-90	75-100	90-100
5	600micro	132	13.20	55.40	44.60	15-34	35-59	60-79	80-100
6	300micro	154	15.40	70.80	29.20	5-20	8-30	12-40	15-50
7	150micro	94	9.40	80.20	19.80	0-20	0-20	0-20	0-20
8	75micro	107	10.70	90.90	9.10				
9	Pan	91	9.10	100.00	0.00				
10	Total 1000			269.00	Fineness modules =269.00/100= 2.69				

Result

Fineness modules =269.00/100= 2.69

SPECIFIC GRAVITY OF FINE AGGREGATE

Specific gravity of fine aggregate(m-sand)is the ratio of the weight of given volume of aggregates to the weight of equal volume of water.

Weight of Pycnometer (W1) = 610g

Weight of Pycnometer + aggregate(W2) =1080g

Weight of Pycnometer +water+C.A(W4)= 152g

Specific gravity of aggregate=

$$\frac{W2-W1}{(W4-W2)-(W3-W2)}$$

Fig 5.6: Pycnometer with M-sand

Result

Specific gravity of aggregate=**2.23**

COARSE AGGREGATE

PHYSICAL PROPERTIES OF FINEAGGREGATE

Coarse aggregate 20mm of both natural aggregate and plastic aggregate is used in the Tests. The physical properties of coarse aggregate and plastic aggregate.

SPECIFIC GRAVITY OF COARSE AGGREGATE

Specific gravity of coarse aggregate IScodeis 2386-3(1963)methods of test for natural aggregates and plastic aggregate is given in table– 5.10, 5.11,figure5.7, 5.8

Table 5.10: SPECIFIC GRAVITY OF COARSE AGGREGATE-20mm

S.NO	DESCRIPITION	TRIALSI	TRIALSII
1	WEIGHTOFPYCNOMETER (W1)	610g	610g
2	WEIGHTOFPYCNOMETER+ AGGREGATE(W2)	990g	1010g
3	WEIGHTOFPYCNOMETER+ WATER+C.A (W3)	1700g	1730g
4	WEIGHTOFPYCNOMETER+ WATER (W4)	1460g	1460g

Figure 5.7: Specific gravity of Aggregate.

Result

Specific Gravity of Coarse Aggregate =**2.553**

Table 5.11: SPECIFIC GRAVITY TEST ON PLASTIC AGGREGATE

S.NO	DESCRIPITION	TRIALS I	TRIALII
1	WEIGHTOFPYCNOMETER(W1)	580g	590g
2	WEIGHTOFPYCNOMETER+ AGGREGATE(W2)	820g	860g
3	WEIGHTOFPYCNOMETER+ WATER+C.A (W3)	1510g	1540g
4	WEIGHTOFPYCNOMETER+ WATER (W4)	1460g	1480g

Specific gravity of aggregate= $\frac{W2 - W1}{(W4 - W1) - (W3 - W2)}$

Figure 5.8: Pyconometer with Plastic Aggregate

Result

Specific gravity of plastic aggregate**=1.27**

IMPACT TEST ON COARSE AGGREGATE

Aggregate impact value test determines the aggregate impact value(AIV) of aggregate which provides a relative measure of the resistance of an aggregate to sudden impact is termed toughness is given in table– 5.12, 5.13 figure5.9, 5.10.

Table 5.12: Impact Test on Coarse Aggregate

SI.NO	DESCRIPTION	TRIAL
1	Weight of the empty cylindrical cup W1	950
2	Weight of cup + aggregates(W2)	1142
3	Weight of aggregates (W3)(W2–W1)	190
4	Weight of aggregates passing through 2.36 mm sieve(W4)	148

Figure 5.9: The Final Passing value of Impact Value

IMPACT VALUE=**77.9**

Table 5.13: Impact Test on Plastic Aggregate

SI.NO	DESCRIPTION	VALUE
1	Weight of the empty cylindrical cup W1	950
2	Weight of cup+Plastic aggregates(W2)	1080
3	Weight of plastic aggregates(W3)(W2–W1)	130
4	Weight of plastic aggregates passing through 2.36mm sieve(W4)	5

IMPACT VALUE=**3.84**

Figure 5.10: Impact Test on Plastic Aggregate

CRUSHING VALUE

The crushing value of aggregate provides the resistance of an aggregate sample tocrushing under gradually applied compressive load is given in table – 5.14, 5.15 figures5.11, 5.12

Table 5.14: Crushing Value Test Coarse Aggregate

S.NO	DESCRIPTION	TRIAL
1	Empty cylinder weight	970
2	Weightofcylinder +aggregate	2534
3	Weightoftheaggregatepassedthrough2.36mm sieve	682

Figure 5.11: Crushing Test Coarse Aggregate in CTM

Table 5.15: Crushing Value Test Course Plastic Aggregate

S.NO	DESCRIPTION	VALUE
1	Emptycylinder weight	970
2	Weightofcylinder+plasticaggregate	2080
3	Weightoftheplasticaggregatepassedthrough2.36mm sieve	60

Crushing test value=2.8

Figure 5.12: Crushing Test on Plastic Aggregate.

Table 5.16: Physical Properties of Course Aggregate

S.NO	DESCRIPTION	NATURALCOURSE AGGREGATE	PLASTICCOURSE AGGREGATE
1	SPECIFICGRAVITY	2.533	1.27
2	IMPACTVALUE	77.4	3.84
3	CRUSHINGVALUE	26.91	2.8

MECHANICAL PROPERTIES OF CONCRETE
COMPARISON IS CONVENCTIONAL CONCRETE AND PLASTIC AGGREGATE CONCRETE
SLUMPCONE TEST

Slump test was performed on freshly prepared concrete mixes to check the work ability of concrete. Work ability of concrete is defined as the ease to do work with it, without segregation. Work ability of concrete is an important property of fresh concrete. Concrete should have good workability.

The result of slump test shows that there was firstly increase in slump upto 5% addition of plastic and then it start decreasing is given in table 5.17, figure 5.13, 5.14.

Table 5.17: Slump Value

SI.NO	MIX	CONVENTIONAL CONCRETE	PLASTICAGGREGATE CONCRETE
1	Mix1	85	80
2	Mix2	87	88
3	Mix3	81	87

:

Figure 5.13: Conventional Slump Cone Test

COMPRESSIVE STRENGTH

This test is performed on hardened concrete, to check the strength of concrete. The concrete specimens were put under the load per unit area of cross section in uniaxial compression under a fixed rate of loading. The compressive strength of concrete is expressed in N/mm2. We performed this test on standard cubes of size 150mmX150mmX150mm.Concrete mix with different proportions was prepared and filled into cube mould. It was then left for 24 hours for initial setting. For every mix proportion 9 specimens were prepared, 3 specimens for each 7 days and 21 days testing. After completion of curing period the specimens were tested using Compression testing machine (CTM). Surface dried specimens were placed in CTM. is given in table 5.18, figure 5.15, 5.16, 5.17, 5.18

Compressive strength =P/A Here,

P=load on the cube

A=cross-sectional area of cube

Table 5.18: Comperssive Strength Convenctional Concrete and Plastic Aggregate Concrete

SI.NO	SPECIMEN	CONVENTIONAL CONCRETE		PLASTIC AGGREGATE CONCRETE	
		7 DAY	21 DAY	7 DAY	21 DAY
1	CUBE1	12	18.11	10.66	15.55
2	CUBE2	12.22	18.22	9.77	15.11
3	CUBE3	13.00	17.22	10.22	14.22

Figure 5.15: Prepration of Concrete

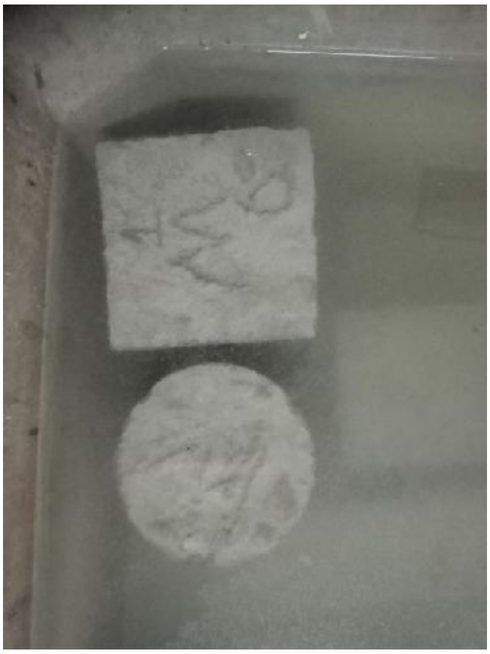

Figure 5.16 Curing Concrete

Figure 5.17: Concrete Cube Tested on CTM

Figure 5.18 Concrete Cube Before Test

4.4.3 FLEXURAL STRENGTH

The flexure strength test is obtained for the beams. The beams were placed in CTM, but the arrangement for that is different. Additional setups were installed in the CTM. It includes 4 point load setup, two at bottom side and two at upper side. The rate of loading was0.1KN/second. The flexure strength of the beam can be determined by using formulae, σc= 3PL/4bd2if crack occurs at the middle third span of the beam, or σc= 3Pa/4bd2} if the crack occurs at the outer third span of the beam is given table –5.19, figure5.19

Where,

P=load in KN,

L= length of the specimen b=width of specimen,

d=depth of specimen

a=distance between crack and the nearest support

Table 5.19: Flexural Strength Conventional Concrete and Plastic Aggregate Concrete

SI.NO	SPECIMEN	CONVENTIONAL CONCRETE		PLASTICAGGREGATE CONCRETE	
		7 DAY	21 DAY	7 DAY	21 DAY
1	CYCLINDER1	3.23	4.55	2.75	4.25
2	CYCLINDER2	3.85	4.19	2.48	3.97
3	CYCLINDER3	3.12	4.36	3.92	4.77

Figure 5.19: Teston Flexural Strength in CTM

SPLITTENSILE STRENGTH

This test is performed to evaluate the tensile strength of concrete. The tensile strength is obtained by placing the cylinderin the CTM, so that the compressive force acts horizontally. The failure occurs along the vertical axis due to the tension developed in transverse direction. It was also tested for7 days and 21 days is given in table –4.

The Split Tensile Strength can be calculated as $\sigma t=2P/\pi DL$

where,

P=load in KN

D=diameter of cylinder

L=Length of cylinder

Table 5.20: Split Tensile Strength Convenctional Concrete And Plastic Aggregate Concrete

SI.NO	SPECIMEN	CONVENTIONALCONCRETE		PLASTICAGGREGATECONCRETE	
		7 DAY	21 DAY	7 DAY	21 DAY
1	PRISM1	3.25	4.95	2.73	4.25
2	PRISM2	3.98	5.27	3.15	3.89
3	PRISM3	3.85	5.77	2.92	3.86

Figure 5.20: Splitting Tensile Strength Test On CTM

5. RESULT & DISCUSSION

The various different to comparised is conventional concrete and plastic aggregate concreter

PHYSICAL PROPERTIES OF COARSE AGGREGATE

Table 6.2: Slump Value

SI.NO	MIX	CONVENTIONAL CONCRETE	PLASTICAGGREGATE CONCRETE
1	Mix1	85	80
2	Mix2	87	88
3	Mix3	81	87

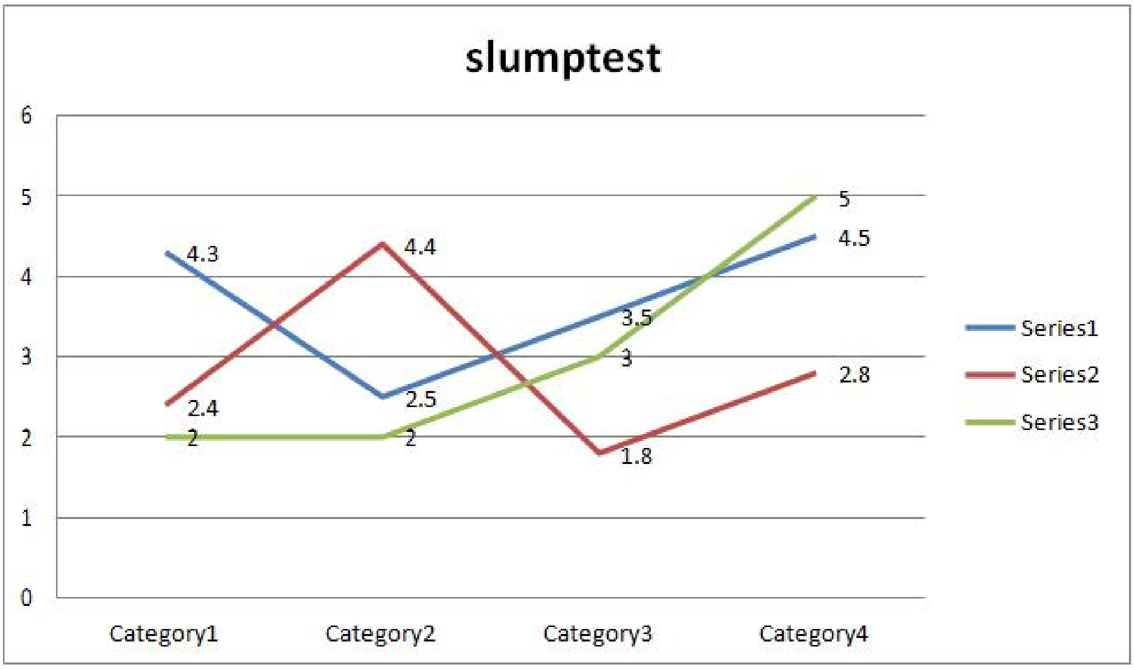

Figure 6: Slump Test Variations.

Table 6.3: Comprsssive Strength of Coarse Aggregate in Concrete

SI.NO	SPECIMEN	CONVENTIONAL CONCRETE		PLASTICAGGREGATE CONCRETE	
		7 DAY	21 DAY	7 DAY	21 DAY
1	CUBE1	12	18.11	10.66	15.55
2	CUBE2	12.22	18.22	9.77	15.11
3	CUBE3	13.00	17.22	10.22	14.22

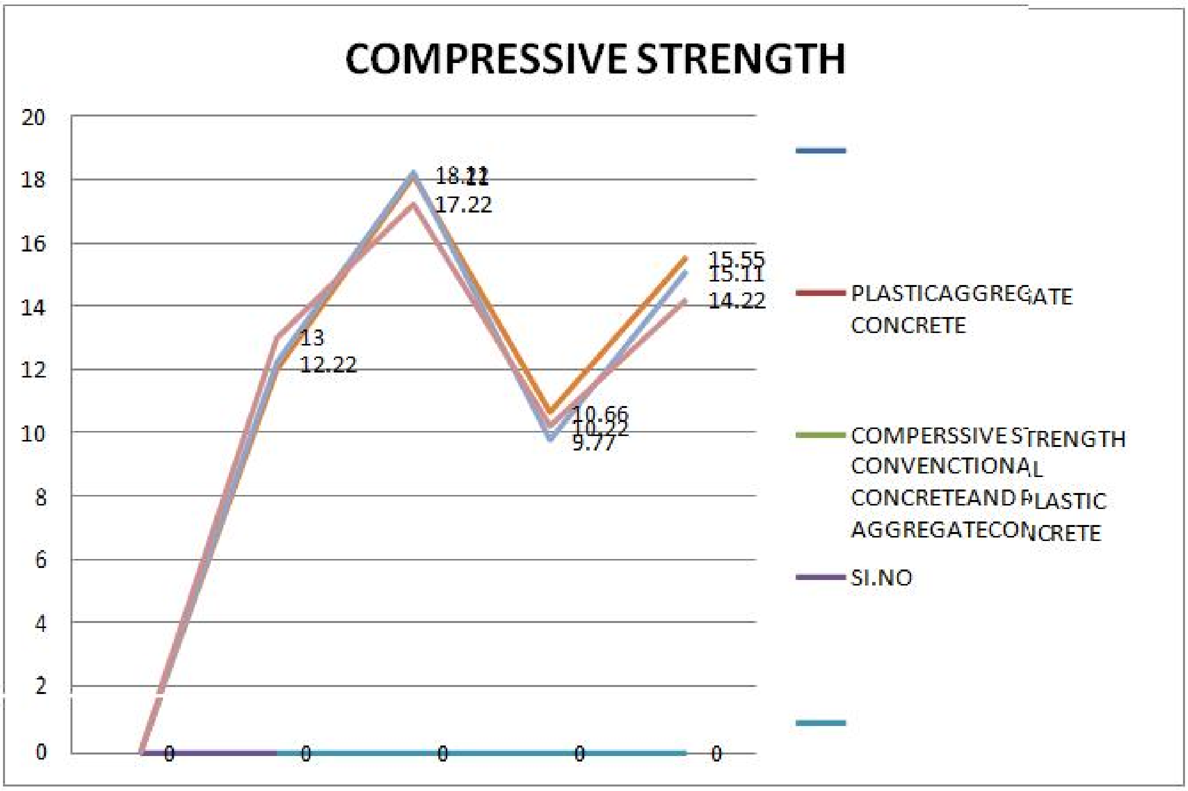

Fig 6.3: Comperssive Strength

Table 6.4: Flexural Strength of Coarse Aggregate in Concrete

SI.NO	SPECIMEN	CONVENTIONAL CONCRETE		PLASTICAGGREGATE CONCRETE	
		7 DAY	21 DAY	7 DAY	21 DAY
1	CYCLINDER1	3.23	4.55	2.75	4.25
2	CYCLINDER2	3.85	4.19	2.48	3.97
3	CYCLINDER3	3.12	4.36	3.92	4.77

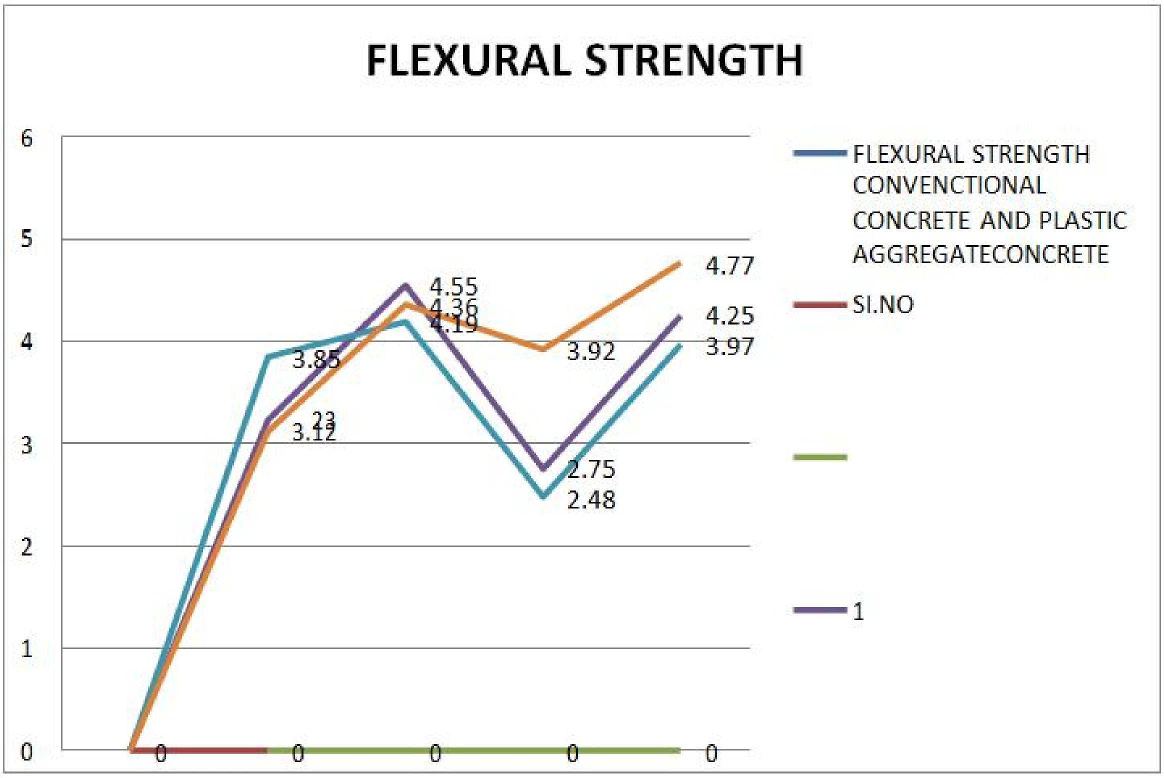

Figure 6.4: Flexural Strength.

Table 6.5: Split Tensile Strength of Coarse Aggregate in Concrete

SI.NO	SPECIMEN	CONVENTIONAL CONCRETE		PLASTIC AGGREGATE CONCRETE	
		7 DAY	21 DAY	7 DAY	21 DAY
1	PRISM1	3.25	4.95	2.73	4.25
2	PRISM2	3.98	5.27	3.15	3.89
3	PRISM3	3.85	5.77	2.92	3.86

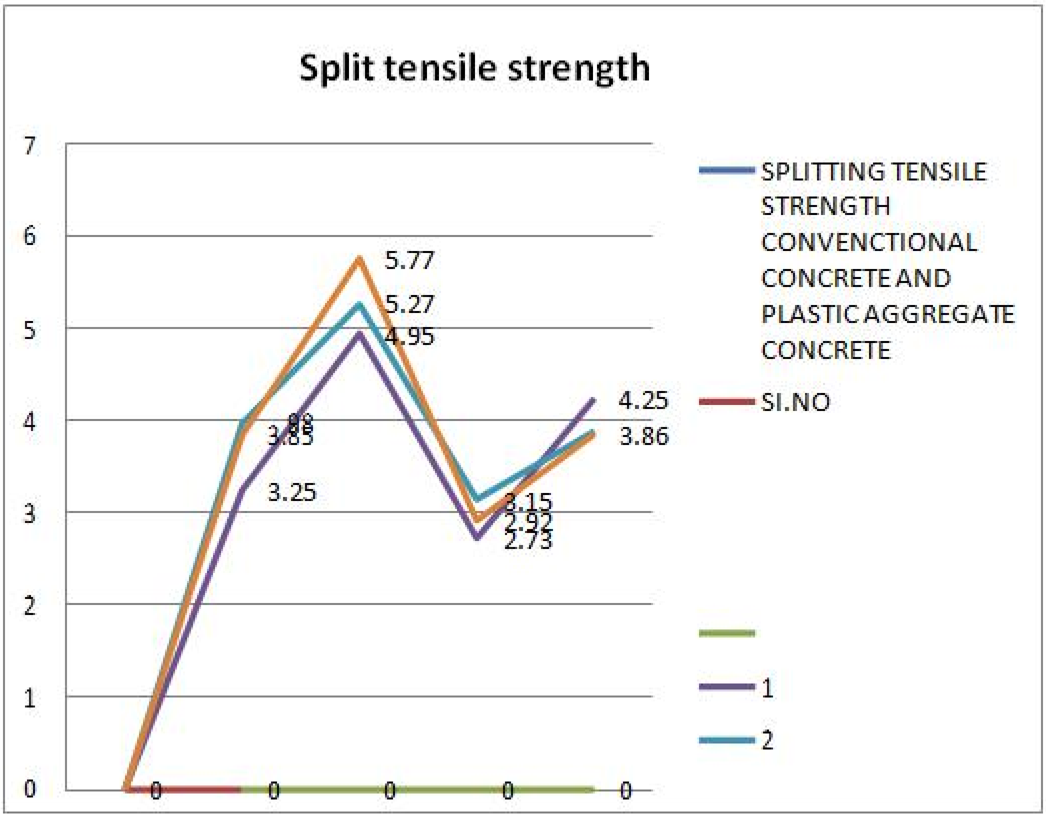

Figure 6.5: Splitt Tensile Strength

CONCLUSIONS

In the emerging civil structures fields. Materials rate will be increased on day by day. So, made by recycling plastics will be manufactured this type of plastic aggregate is very essential. It"s definitely suitable for construction work. Its highly economical compare with natural coarse aggregates.

It main disadvantage was it is not a fire resistance product, So this is not suitable For commercial buildings, Industrial building, factory, institutions buildings.

Using this product saves natural resources.

Some Properties of Plastic Aggregate given below.

i. The material used in the experiments is good and workable.

ii. The impact on the strength of concrete is good.

iii. The specific gravity of plastic was lesser than that of aggregates.

iv. While testing the flexural strength of the beam, it is seen that beam failed in between the loading span between its two supports and hence formula that we usedis3PL/4bd2.

v. The tensile strength of cylinder shows better strength compared to other strengths.

vi. PlasticAggregatesCompressiveStrengthIsLiterallyLowCompareWithNaturalCoarseAggregate

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MIXDEIGN FOR PLASTIC AGGREGATE IN CONCRETE

DATAcGIVEN

Type: pccGrade:M20

Exposure: moderate

Max Size Aggregate: 20mm

Workability:80 -130mm

Minimum Cement Content = 240 kg/m^3

Maximum Water Cement Ratio= 0.60

Target Strength =fck+(KS)

=fck+x

Target Strength =fck+(ks

=20 +(1.65 x9)

=26.6N/mm^2

Target strength = fck +x

=20 +5.5

=25.5N/mm^2

26.6>25.5

Target Strength=28.25N/mm^2

Free water / cement ratio:

Water/cement ratio= 0.54

Water content =200

Cement Content = $\frac{\text{Freewater}}{\text{Water cement ratio}}$

$=\frac{200}{0.54}$

=370.37 kg~ 371 kg

Air content for 20mmMSA $=\frac{0.8 \times 371}{100}$

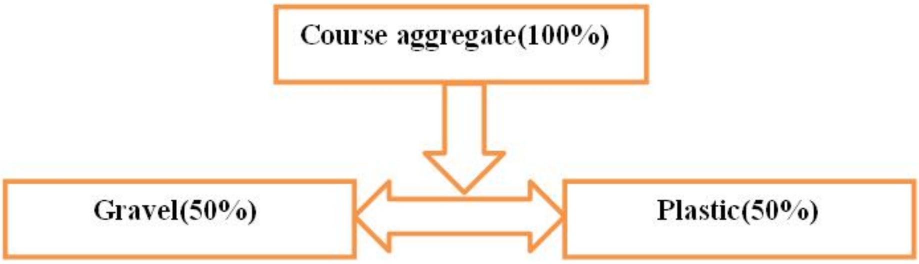
=2.97 kg

%of fie aggregate is refer by is 456 percentage is45(zone II)

% of course aggregate

100 –45 =55 %

All in Aggregate:



Fine– 45%

Gravel–27.5%

Plastic– 27.5%

Absolute volume= $\frac{\text{weight of material}}{\text{Specific gravity x 1000}}$

PPC $= \frac{371}{3.15 \times 1000}$

=0.117

Free Water $= \frac{200}{1.00 \times 1000}$

=0.20

Air 1% =0.01

Total =0.327

Volume of =1 –0.327

Aggregates =0.673

Volume of gravel $= \frac{27.5 \times 0.673}{100}$

=0.185

Volume of plastic $= \frac{27.5 \times 0.673}{100}$

=0.185

Volume of m sand $= \frac{45 \times 0.673}{100}$

Weight of Aggregates

Gravel =0.185 x 2.720 + 1000 =503.20 kg

Plastics =0.185x 1.277 +1000 =236.24 kg

M sand = 0.302 x 2.640 +1000 =792.28 kg

Water or Absorption

Gravel $= \frac{504 \times 0.30}{100}$

=1.152kg

M sand $= \frac{793 \times 1.05}{100}$

=8.326 kg

Total =9.838 kg