Feasibility Study of Partial Replacement of Fine Aggregate with Waste Plastic to Enhancing the Properties Of Concrete.

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Abstract : Plastic waste which are frequently used in our daily life for various purposed accounts for a leading waste in today's Era. Indian agriculture is also based on plastic like pipes, pump and other agriculture equipments which contributes in total solid plastic waste. This waste plastic can be reduce, recycled and reused to avoid land pollution, water pollution and air pollution. Natural river bed sand resources are being consume from the various sources and Indian government has press control on the use of natural sand from the rivers. As an alternative to natural sand is artificial sand but again it is obtained from crush rocks. These rocks are also our natural assets. Hence, Using waste plastic as an alternative.Important reuse of plastic can be in form of fine aggregates. Waste plastic generated could be crushed and grinded and used partially replacement with the fine aggregates. The current study target to proper utilisation of waste polypropylene as partially replacement to fine aggregate in concrete mix beyond 20%. The present analysis looks at replacement of fine aggregate with plastic waste by 20%, 25% and 30%. Our aim to study the behaviour of concrete with recycled waste plastic as in cubes, cylinders and beams are cast. The properties of concrete using recycled plastic waste are thus established by experimental analysis.

Keywords: Reused Plastic Waste, Concrete ,Fine Aggregate, Plastic Solid waste, Compressive Strength,Polypropylene Waste, Splitting Tensile, Flexural Test.

1. Introduction

A lot of useless materials are generated from the various processes, like manufacturing, service industries, municipal corporation and agriculture solid wastes. The rise of fact about the environment has immensely contributed to the interest related with discarding of the spawn wastes. Plastic waste takes upto 100 years to degrade. Still, There are many attempts had done to research its use in concrete as a primary material. The evolution of new construction materials using recycled plastics is necessary to both the construction and the plastic recycling manufactory.

Plastics becomes an indivisible and essential part of our regular life. The volume of plastics used every year has been growing day by day. It's easy to handle, low density, strength, low cost and light weight, are the factors behind such exceptional growth.

Plastic is not easy to dispose and takes 100 years to disintegrate. India alone generates about 6.8 million tonnes of plastic waste. This plastic can be recycled and reused to avoid any ill effects caused from it. An alternative to natural sand is artificial sand but again it is derived from crush rocks, these rocks are also a part of natural resources. Hence, waste plastic could be used as an alternative. One of the important reuse of plastic in the form of fine aggregates in concrete. Waste plastic generated can be crushed and grinded and could be used partially or complete replacement for the fine aggregates.

1.1. Problem Statement

Feasibility Study of Partial Replacement of Fine Aggregate with Waste Plastic to Enhancing the Properties Of Concrete. Many studies have been completed on the properties of plastic wastes like Irrigation and Agriculture pipes/pump, Polyethylene Terephthalate (PET) bottles, etc. In this project, we have used Polypropylene (PP) waste as a replacement for fine aggregates.

1.2. Materials and methodology

1.2.1. Materials and properties

The considerable element of the plastic waste is low density polyethylene/linear low density polyethylene (LDPE) at about 23%, added 17.3% of high density polyethylene, 18.5% of polypropylene, 12.3% of polystyrene (PS/ extended PS), 10.7% poly-vinyl chloride, 8.5% polyethylene terephthalate and 9.7% of other types .The specific gravity of the plastic is 1.15. The plastic used in the composite was Polypropylene obtained from grinding the runner of waste drip irrigation pipes. This plastic was used to replace fine aggregates in the percentages of 20%, 25% and 30%. The research work carried in this regard demonstrated that a maximum up to 20% of fine aggregates could be replaced with plastic waste. Thus, this research intends further study the scope of using plastic waste beyond 20%. The grinded plastic waste is as shown in *Image 1*.

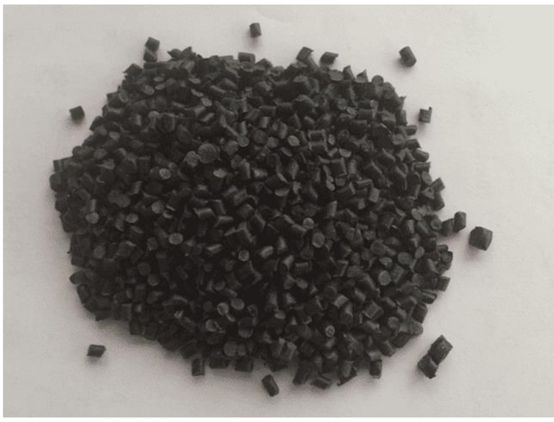


Image 1 - Grinded plastic waste aggregates

Along with Coarse aggregate of size 20mm was used having specific gravity 2.95. Crushed sand having specific gravity of 2.70 zone III was used. OPC cement Grade 53 was used. Specific gravity of OPC grade 53 cement was 3.15. Normal regular water was used for mixing and curing. All the materials were obtained on RMC site, except plastic aggregates, which were obtained from the waste irrigation pipe and crushed in local industry.

1.2.2. Methodology

All the materials were obtained on RMC site. The proportion of materials to be used was calculated as per the concrete mix design for M30 grade. Plastic replacement was done as per the percentage by weight of fine aggregates in respective proportions. The mixing was done in a mixer as shown in the *Image 3*. Water was added during the process of mixing. Admixture was added after the addition of water in small quantities. Mechanical mixing was done which was followed by filling the moulds with composite. Hand tamping was adopted as per specifications in the IS code for proper compaction. Three specimen of cubes, beams and cylinders of different batches were made for testing. Slump cone test was done on fresh concrete before placement of the concrete in the mould.

After 1 day, the moulds were opened and the composite was placed in the curing pond for 28 days. With proper curing of 28 days, the composite was taken off from the curing pond and taken for testing. The various test carried out on hardened concrete were compressive strength test for

Cubes, flexural strength test for beams and splitting tensile strength tests for cylinders.

Image 3 - Mechanical mixer

Before testing, weights of all composites were noted. Cube moulds were of size 150mm conforming to IS -10086-1982. Cubes were tested on a Digital Compression Testing machine. Gradual load was applied and readings were noted at failure. Beams were tested on Universal Testing Machine (UTM) and placed in as a single point load was applied to the topmost surface as cast in mould. Cylinders were tested on a Digital Compression Testing machine, bearing strips were placed between lower and upper bearing blocks of the testing machine before the application of load. The testing was done as shown in *Image 4(a), 4(b) & 4(c).*

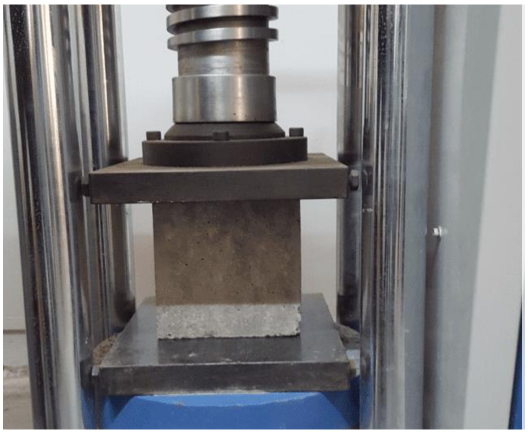


Image 4(a)- Fitting the cube in the compression test machine.

Image 4(b) - Arrangement for loading of flexure test specimen.

Image 4(C)- Fitting the cylinder in the compression machine

Table 1- Casting details

Sr. no	Concrete	Days	Percentage Replacement	Cubes	Cylinder	Beams
1	Conventional concrete	28 day	No plastic	3	3	3

			20%	3	3	3
2	**Concrete using Plastic Waste**	28 Day	25%	3	3	3
			30%	3	3	3

1.2.3. Concrete Mix Design

Concrete Mix design (Using to IS - 10262 - 2009)

Thus, For 1m^3 of concrete, mix proportions are obtained,

Cement = 340 kg

Water = 196 kg

Fine aggregate = 784 kg

Coarse aggregate = 1296 kg

Super plasticiser = 3.4 kg

2. Tables and figures

2.1. Tables

The compressive strength test, flexural strength test and the split tensile strength test results have been tabulated and shown as below.

Compressive strength test was carried out on Digital Compression testing machine (FHCT- 2000D) according to the procedure given in IS Code. Flexural strength test was carried out on Universal Testing Machine (UTM) and splitting tension test was carried out on digital compression testing machine (FHCT – 2000D)

Table 2 - Average Compressive strengths of composites,

Trail No.	Percentage Replacement (%)	Average Weight (kg)	Average Compressive strength
1	0	9.20	40.30
2	20	8.08	28.94
3	25	7.97	27.84
4	30	7.86	25.36

Table 3 - Average Flexural strengths of composites,

Trail No.	Percentage Replacement (%)	Average Weight (kg)	Average Modulus of Rupture
1	0	42.91	3.51
2	20	38.11	2.39
3	25	36.67	2.21
4	30	35.42	1.74

Table 4 - Average Splitting Tensile strengths of composites,

Trail No.	Percentage Replacement (%)	Average Weight (kg)	Average Tensile strength
1	0	13.76	4.069
2	20	12.34	2.94
3	25	12.21	2.83
4	30	11.95	2.81

2.2. Figures

According to the results obtained, the respective compressive, flexural and split tensile strengths have been plotted as a comparative study for conventional concrete to the plastic aggregate composite.

The following figures represent a comparison of average strengths obtained by bar chart and comparison of strengths obtained of each specimen with strengths conventional concrete.

Figure 1a - Comparison of Average Weight & Compressive strengths.

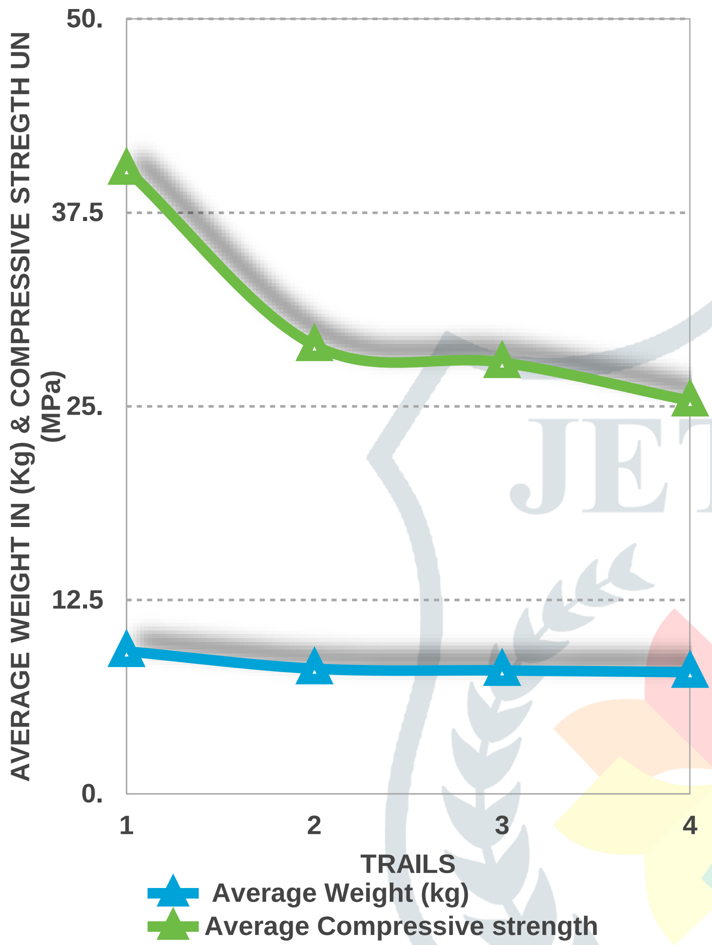


Figure 1b - Comparison of Average Compressive strengths & Percentage replacement(%).

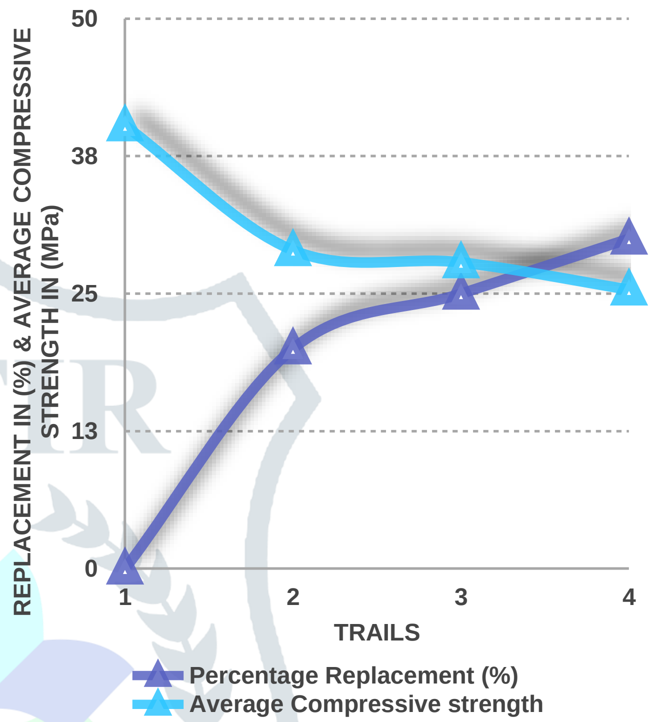


Figure 1c - Comparison of Average Weight (Kg) & Percentage Replacement (%).

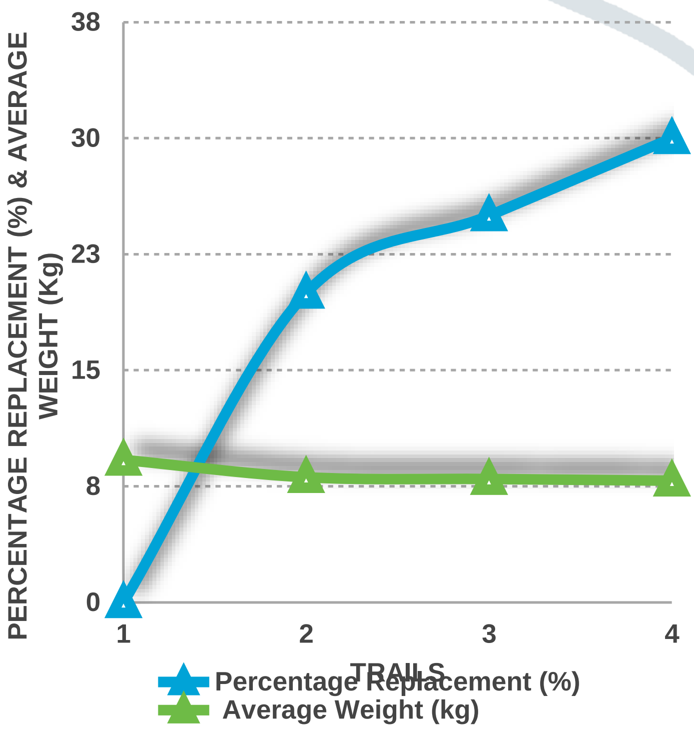


Figure 2a - Comparison of Average Weight & Modulus of Rupture.

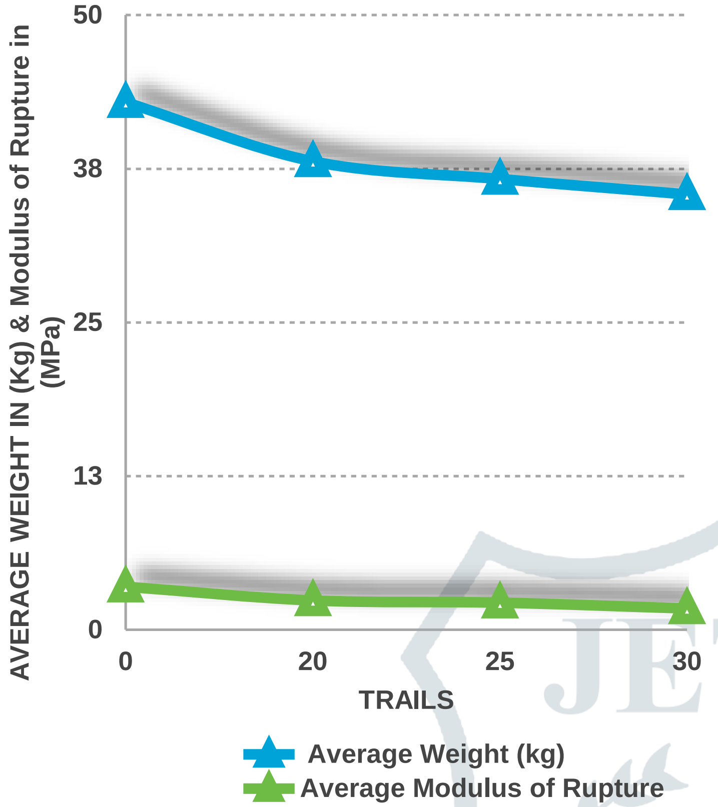


Figure 2b - Comparison of Average Modulus of Rupture & Percentage replacement(%).

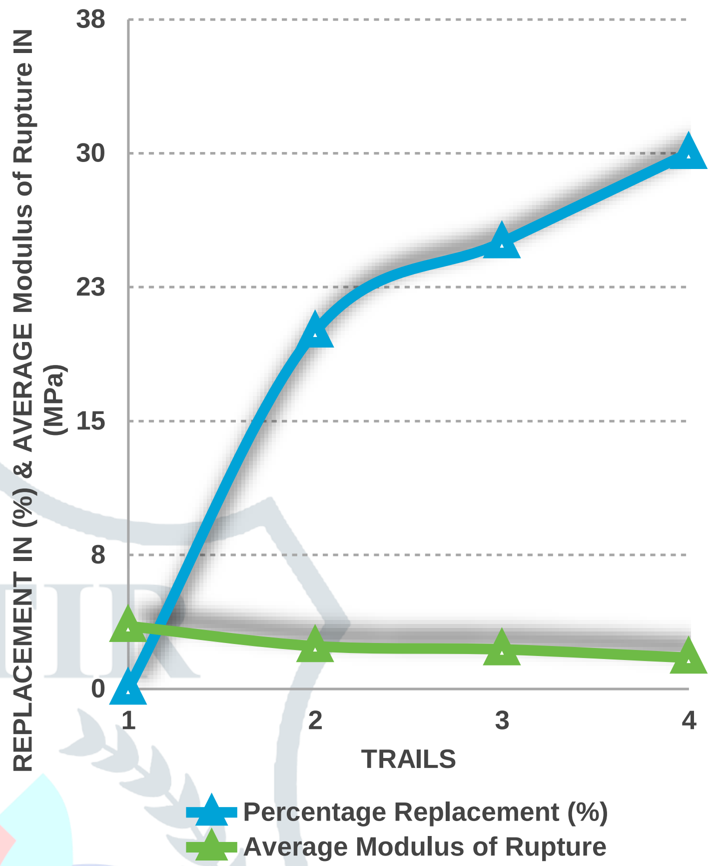
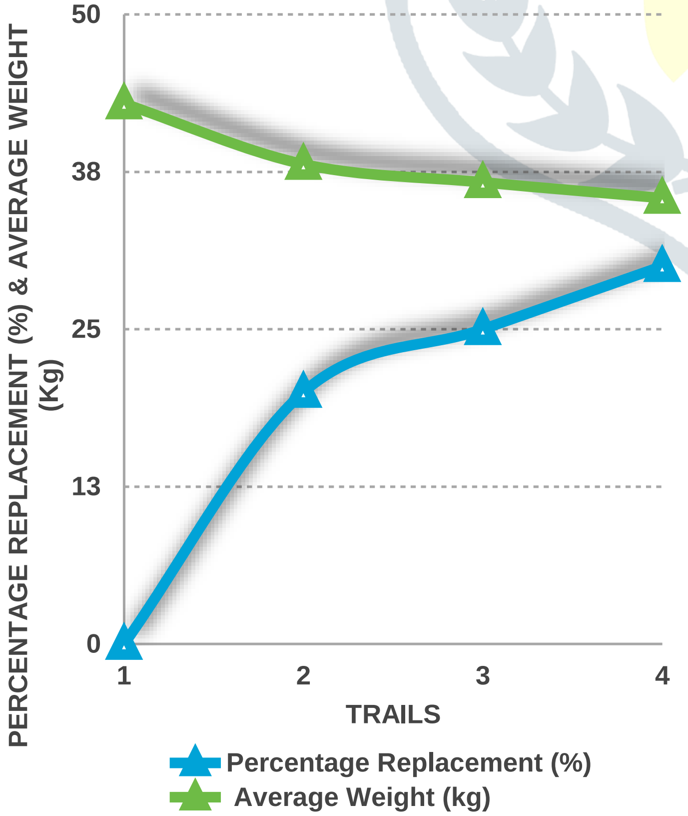


Figure 2c - Comparison of Average Weight (Kg) & Percentage Replacement (%).



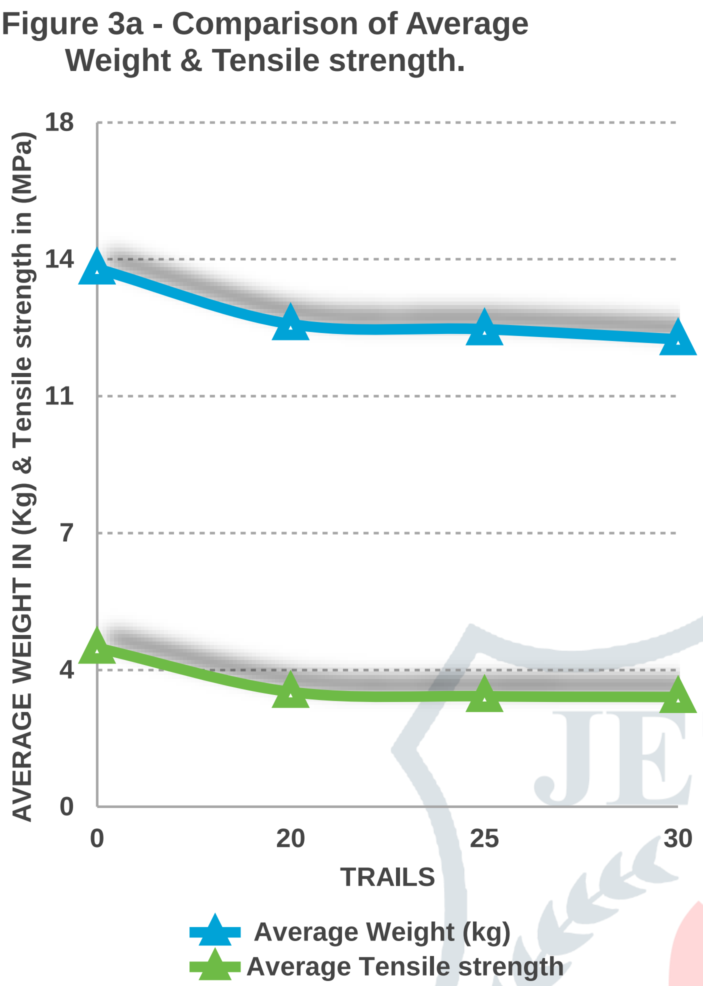


Figure 3a - Comparison of Average Weight & Tensile strength.
AVERAGE WEIGHT IN (Kg) & Tensile strength in (MPa)
18
14
11
7
4
0
0
20
25
30
TRAILS
Average Weight (kg)
Average Tensile strength

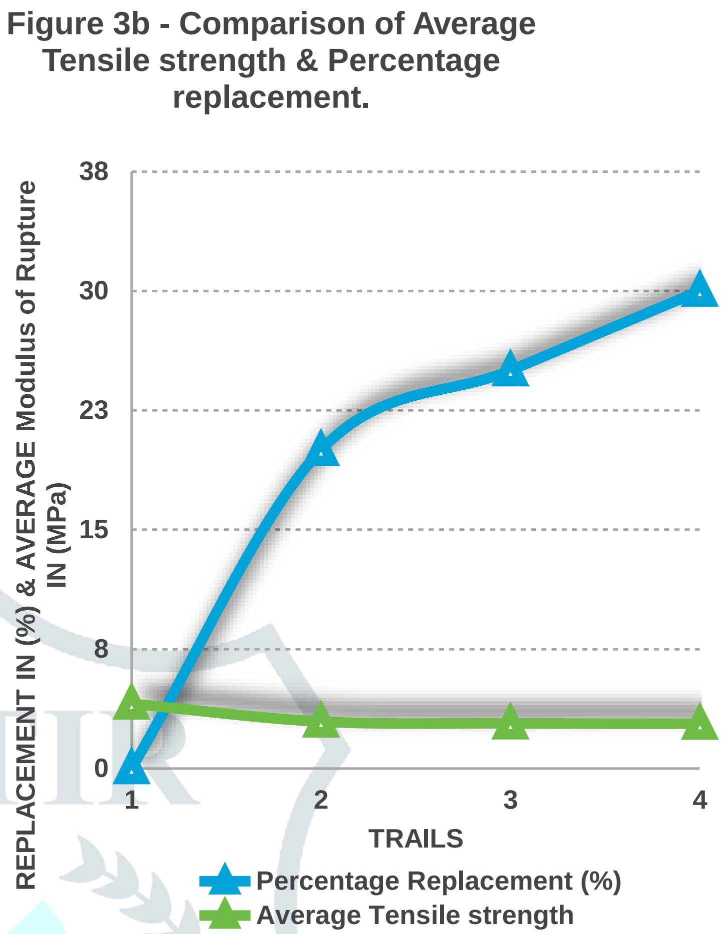


Figure 3b - Comparison of Average Tensile strength & Percentage replacement.
REPLACEMENT IN (%) & AVERAGE Modulus of Rupture IN (MPa)
38
30
23
15
8
0
1
2
3
4
TRAILS
Percentage Replacement (%)
Average Tensile strength

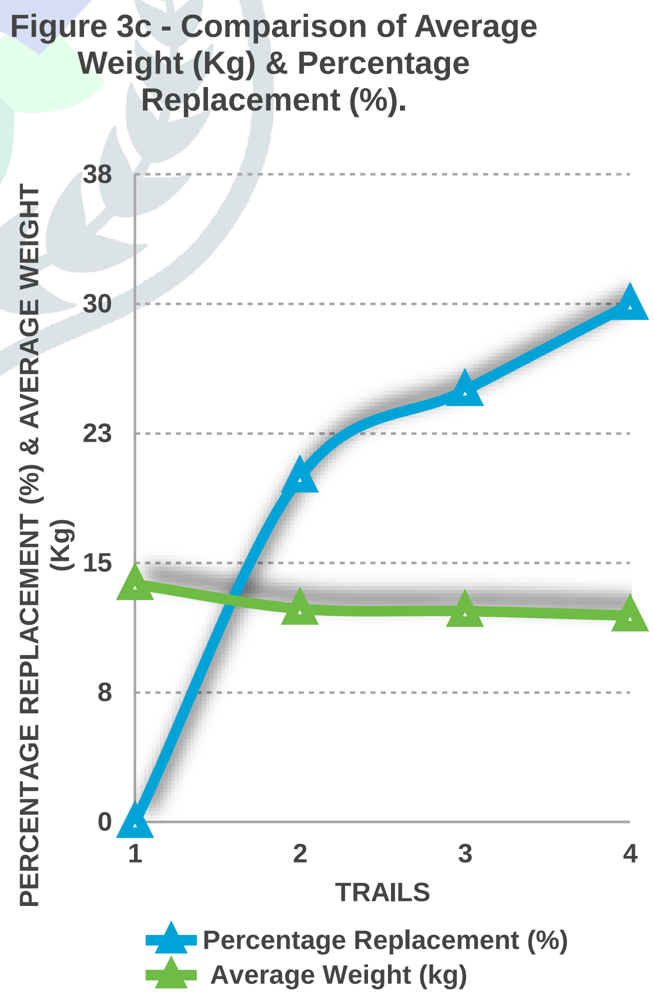


Figure 3c - Comparison of Average Weight (Kg) & Percentage Replacement (%).
PERCENTAGE REPLACEMENT (%) & AVERAGE WEIGHT (Kg)
38
30
23
15
8
0
1
2
3
4
TRAILS
Percentage Replacement (%)
Average Weight (kg)

2.3. Equations

The equations used for the computation of the results are,

Compressive strength,

$$\frac{Load}{C/S - area} \qquad \ldots(1)$$

Flexural strength,

$$f_b \quad \frac{P \times l}{a \times d^2} \qquad \ldots(2)$$

Split tensile strength test,

$$T \quad \frac{2P}{\pi L d} \qquad \ldots(3)$$

3. Observations and Conclusions

3.1. Observations

1. The average weight of the cubes of 20%, 25% and 30% plastic waste aggregate replacement composite was found to decrease as 8.08 kg, 7.97 kg and 7.86 kg respectively.
2. The average weight of the beams of 20%, 25% and 30% plastic waste aggregate replacement composite was observed to decrease as 38.11 kg, 36.67 kg and 35.42 kg respectively.
3. The average weight of the cylinders of 20%, 25% and 30% plastic waste aggregate replacement composite was observed to decrease as 12.34 kg, 12.21 kg and 11.95 kg respectively.
4. The average compressive strength for 20%, 25% and 30% plastic aggregate replacement was 28.94 MPa , 27.84 MPa and 25.36 MPa respectively.
5. The average flexural strength for 20%, 25% and 30% plastic aggregate replacement was 2.39 MPa, 2.21 and 1.74 MPa respectively.
6. The splitting tensile strength for 20%, 25% and 30% plastic aggregate replacement was 2.94 MPa, 2.83 MPa and 2.81 MPa respectively.
7. It was observed that due to the addition of super plasticiser and due to negligible absorption of plastic aggregates, water was saved.
8. It was observed that due to addition of waste plastic as a fine aggregates which have negligible weight in mixture, which fine aggregates saved.

3.2. Conclusion

1. It was found that there was drop in the weights of the composite with increase in percentage of plastic replacement when checked with conventional concrete. There was a decrease of 12%, 13% and 14% in cubes of 20%, 25% and 30% replacement of plastic waste aggregate respectively.
2. The decrease in the weights of the beams when checked with conventional concrete was 11%, 14% and 17% of 20%, 25% and 30% replacement of plastic aggregates respectively.
3. Similarly for cylinders, when compared to conventional concrete there was a decrease of 10%, 11% and 13% in 20%, 25% and 30% of plastic waste replacement respectively.
4. There was a drop in the strength of composite cubes when checked with to conventional concrete cubes. The percentage decrease in the strength of cubes of 20%, 25% and 30% composites was 21.5%, 24.5% and 29.6% respectively.
5. Similarly, there was a decrease in the flexural strength of composite when checked with conventional concrete beams as 25.6%, 31.3% and 45.8% of composites of 20%, 25% and 30% respectively.
6. However, the splitting tensile strength of the cylinders was constant with negligible variation, but it was still less than that of conventional concrete cylinders.
7. As the amount of plastic aggregates increased, the weight of each specimen decrease, which make structure lighter.
8. Due to its light weight properties we can used it for high rise building for non structural member.
9. As the amount of plastic aggregates increased, the amount of water saved also increased.

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