MECHANICAL PROPERTIES OF CONCRETE BY ADDING PLASTIC AS A PARTIAL SUBSTITUTE FOR COARSE AGGREGATE TO PROMOTE SUSTAINABILITY ON CONSTRUCTION INDUSTRY

Abstract

Concrete is without a doubt the most advantageous material in the building industry, but every coin has two sides. Raw materials used in the manufacturing of concrete, in one way or another, have a negative impact on the environment. For instance, as cement is produced, dust is released into the atmosphere during the production of aggregates. The area's geology is further impacted by the production of coarse aggregates. The use of waste materials in addition to or in place of cement is a step in this direction. Many of these substances, like silica fume and rice husk, are currently in use. In this investigation, synthetic coarse aggregates are employed in place of natural coarse aggregates. Plastic aggregates were only little treated from plastic waste. Plastic is currently the largest environmental problem, and it is becoming worse quickly. According to certain recent research, it can be used in the construction industry because of several of its traits, such inert behaviour and resistance to degradation. Utilising leftover plastic can help reduce the amount of plastic in the trash stream. Using plastic coarse particles, many tests were conducted to examine the mechanical properties of concrete. Concrete was made using plastic coarse aggregates with a variety of plastic compositions. Plastic coarse aggregates at varied concentrations of 0%, 2.5%, 5.0%, 7.5%, 10.0%, and 12.5% were used to make concrete.

Keywords: Super plasticizer-Polytancrete, Plastic-pellets, Workability, Compression strength, Split Tensile strength, Flexural strength.

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I. INTRODUCTION

Water, aggregate, and cement make up the majority of the ingredients in concrete. The desired physical properties of the finished materials can be achieved by adding reinforcements and additives to concrete mixtures. By mixing the ingredients in a certain ratio, it is possible to create monolithic structures that are easily shaped into the desired shape [1]. Over time, when the other components come together to form a solid matrix formed of cement, a single solid (rigid) robust substance with numerous applications, such as roads or structures, is created. The majority of the concrete technology developed by the ancient Romans was employed extensively across the Roman Empire. The Pantheon dome is the largest unreinforced masonry building in the world, whereas the Colosseum in Rome was primarily constructed of concrete. Concrete use declined with the fall of the Roman Empire in the middle of the eighteenth century, and the technique was re-pioneered [3]. The most often utilised man-made material in today's construction is concrete. The extraction and processing of raw materials has a significant environmental impact on the landscape, such as the loss of agricultural fields and the release of carbon dioxide. Plastic aggregates are utilised to lessen the environmental impact of coarse aggregate manufacturing. Finding the finest plastic required sorting through the plastics recovered from landfills. To remove any extraneous objects, these were thoroughly cleansed and finely pulverised. In order to achieve the proper brittleness, the material was then heated to a certain temperature. The molten plastic was extruded, then gathered in lumps around 100 mm in size. One method for making aggregate is by smashing plastic boulders [9].

II. OBJECTIVES

To evaluate the effects of partially substituting coarse aggregates with recycled plastic in concrete.

- The purpose of this study is to examine the impact of the use of plastic aggregates over natural coarse aggregate on the usability of concrete.
- To determine the impact of the use of plastic granules on the compressive strength of concrete compared to natural aggregates.
- The purpose of this analysis is to determine the density of the concrete after the plastic aggregates have been filled in place of the natural aggregates.
- Analysing and comparing the results.
- Based on the outcome, making recommendations.

III. LITERATURE REVIEW

1. **Kushwah (2021):** He made M20 grade concrete by replacing coarse aggregate with plastic coarse aggregates by 0%, 5%, 10%, 15% and 20%. The results of the 7, 14 and 28-day tests were evaluated. The 28-day findings demonstrated that concrete's compressive strength decreases with the percentage increase of plastic chips, with values at 30.26 N/mm2 and 27.55 N/mm2 respectively. The dry density of concrete decreased with the percentage increase in plastic fragments. The split tensile strength decreased with the volume increase of plastic chips. Concrete containing plastic chips was less workable with each addition. [5]

2. **Shanmuganathan and Dhaarani (2018):** For M40 grade concrete design, plastic coarse aggregates were used in the quantities of 0, 10, 20, and 30%. The concrete was evaluated after 7 days and again after 28 days. The 28-day test result showed the following values: 53.14 · 48.84 · 45.32 · 42.18 · On Day 28, the plastic concrete with a 10% replenishment reached a compressive strength almost equal to that of regular concrete. The testing for flexural strength showed a decrease in the strength of the plastic concrete when compared to the regular concrete. The test findings showed that plastic concrete has poor bonding capacity which has an effect on the concrete strength.[4]

3. **Bragadeeshwaran (2021):** He made concrete of M20 grade and tested at 3, 7 and 28 days after 0%, 10% and 20% replacement of coarse aggregate with plastic. The results of the 28th day tests are 24, 23, and 22 N/mm2 respectively. The compressive strength of concrete decreased as the amount of plastic increased in the mixture. At 7 days, the cube compressive strength decreased only marginally by 10% by replacing coarse aggregate [7].

4. **Lhakpa Wangmo Thing Tamang (2017):** He conducted experiments with the use of plastic as a coarse aggregate for concrete. The mechanical characteristics of concrete were evaluated using plastic particulates. He identified a slight decrease in strength and proposed that a replacement of 15% would be the optimal solution. There are three distinct levels of plastic aggregate: 10, 15, and 20%.[8]

IV. MATERIALS

The following materials were utilised in this study:

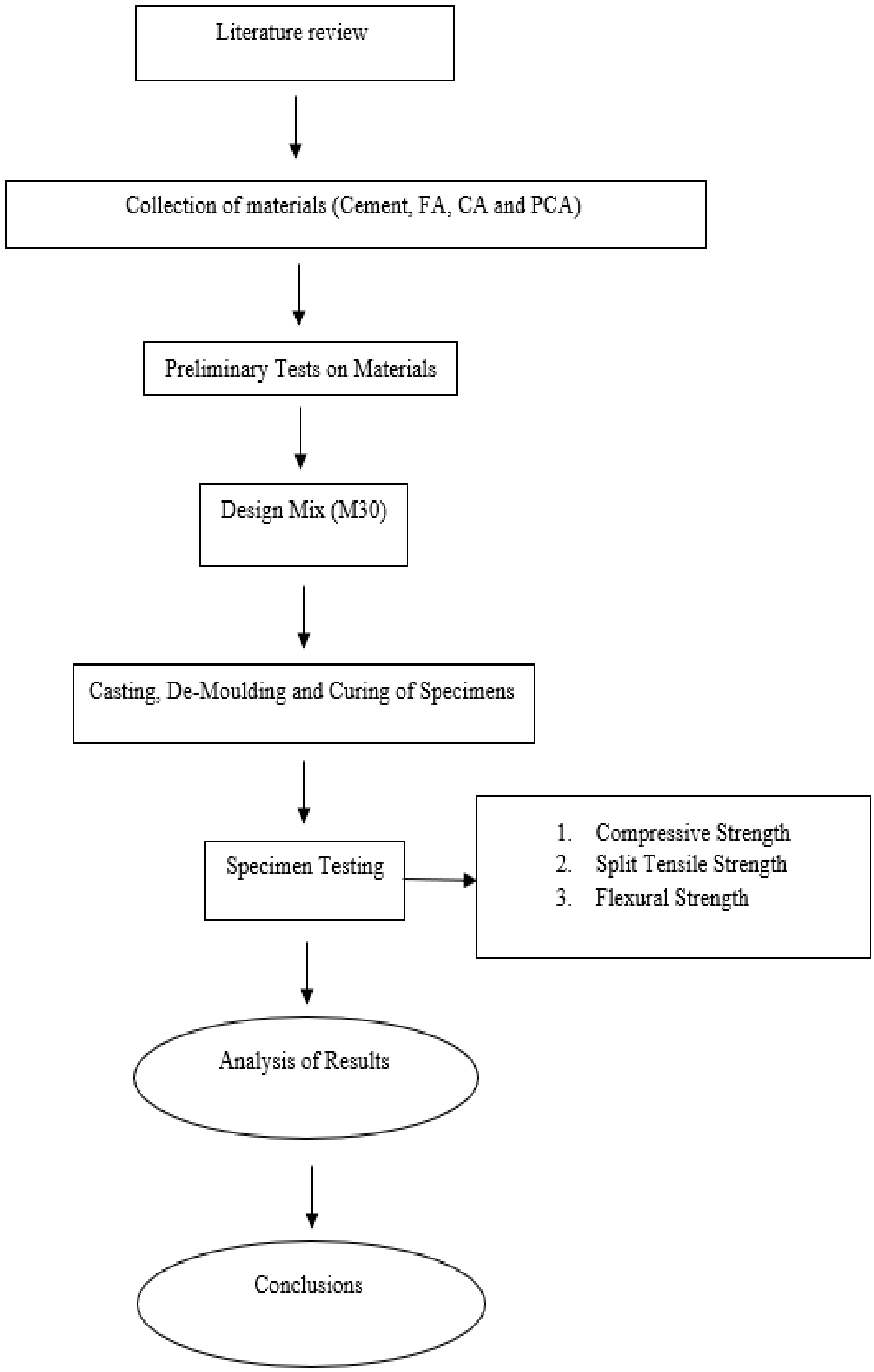
- Complying to IS: 1489-1 Portland Pozzolana Cement.
- According to IS: 2386-1, fine aggregate and coarse aggregate. Water.
- Plastic coarse aggregate.
- Super plasticizer – Polytancrete.

V. METHODOLOGY

This shows the components utilised for strength testing, casting, and mix design. The results are contrasted with typical concrete. During the test study, the best use of plastic aggregates was also found.

- Material obtaining
- Analysing the material properties
- Design mix (according to IS 10262:2019)
- Casting of moulds
- Curing and Testing
- Analyse the results of the tests.

The process is shown in below flow chart.



VI. DETAILS OF EXPERIMENTAL INVESTIGATION:

Table 1: Physical Properties of Cement

Properties		Standard values as per IS code	Test Results
Fineness		<10%	8%
setting time	Initial	>30 min	52 min
	Final	<600 min	7 hrs 5 min
Specific gravity		-	2.99
Consistency		-	34.5%

Table 2: Properties of fine aggregate

Properties	IS code used	Test result
Fineness modulus	IS:2386 [Part 1]	2.94
Specific gravity	IS:2386 [Part 3]	2.62
Particle size	IS: 2386 [Part 1 and 2]	<4.75 mm
Water absorption	IS:2386 [Part 3]	0.8
Bulk density	IS:2386 [Part 3]	1545 kg/m^3

Table 3: Properties of coarse aggregate

Properties	IS code used	Test result
Fineness modulus	IS:2386 [Part 1]	6.61
Specific gravity	IS:2386 [Part 3]	2.74
Particle size	IS: 2386 [Part 1 and 2]	<20 mm
Water absorption	IS:2386 [Part 3]	0.83
Bulk density	IS:2386 [Part 3]	1788 kg/m^3

Table 4: Details of Mix design

Replament Percentages	Cement (Kg/m3)	Fine Aggregate (Kg/m3)	Coarse Aggregate (Kg/m3)	Plastic Coarse Aggregate (Kg/m3)	Water (Kg/m3)	Chemical Admixture in ml/m3
0%	410	642.97	1197.04	0	162.77	1640
2.5%	410	642.97	1179.99	10.67	162.77	1640
5%	410	642.97	1137.195	21.34	162.77	1640
7.5%	410	642.97	1107.268	32.10	162.77	1640
10%	410	642.97	1077.34	42.68	162.77	1640
12.5%	410	642.97	1047.41	53.36	162.77	1640

VII. CONCRETE DESIGN MIX

A volumetric proportionate mix of 1:1.56:3.291 was used to construct an M30 mix after the densities of natural and plastic aggregates were established. It is 0.39 for the water cement ratio. quantities needed for the mix per 1 m3 of concrete when coarse plastic aggregate is only partially replaced. On cast samples, compression, flexural, and split tensile tests were performed. The compression and tensile tests were carried out on a compression testing machine (CTM), and the flexural test was carried out on a flexure testing machine [2].

Concrete compressive, split tensile, and flexural strengths are calculated using an average of three samples tested at each curing age. The results of each test are displayed below in a bar/line graph. The X-axis represents mix proportions, while the Y-axis represents concrete strength in N/mm^2.

Table 5: Results of compressive strength

ID No.	Mix ID	7 days (N/mm^2)	14 days (N/mm^2)	28 days (N/mm^2)
1	P0	24.53	33.42	38.65
2	P2.5	25.44	33.98	39.12
3	P5	24.16	33.93	38.06
4	P7.5	23.88	31.66	37.17
5	P10	23.42	29.91	35.43
6	P12.5	20.89	28.02	33.75

Table 6: Results of split tensile strength

ID No.	Mix ID	28 Days (N/mm^2)
1	P0	3.52
2	P2.5	3.91
3	P5	4.29
4	P7.5	3.88
5	P10	3.32
6	P12.5	3.03

Table 7: Results of flexural strength

ID No.	Mix ID	28 Days (N/mm2)
1	**P0**	6.02
2	**P2.5**	6.28
3	**P5**	6.55
4	**P7.5**	6.31
5	**P10**	5.98
6	**P12.5**	5.46

VIII. RESULTS AND DISCUSSION

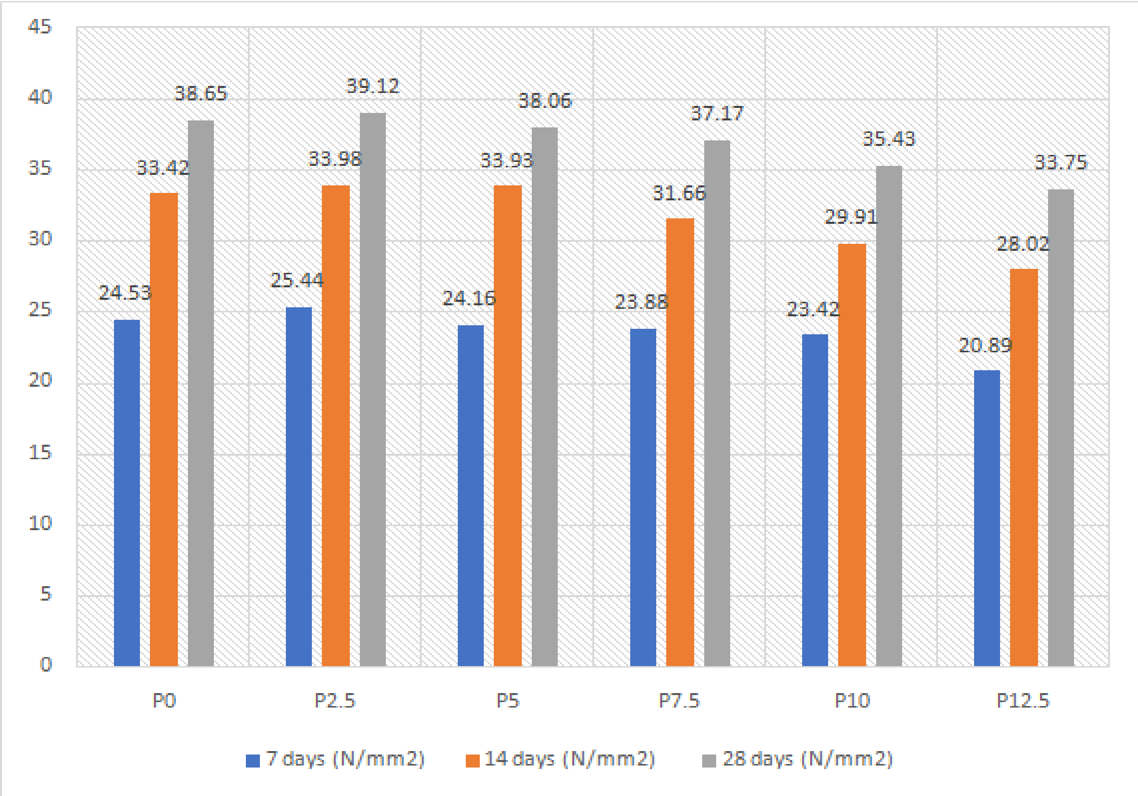


Figure 1: Average Compressive Strength Values at Various Ages

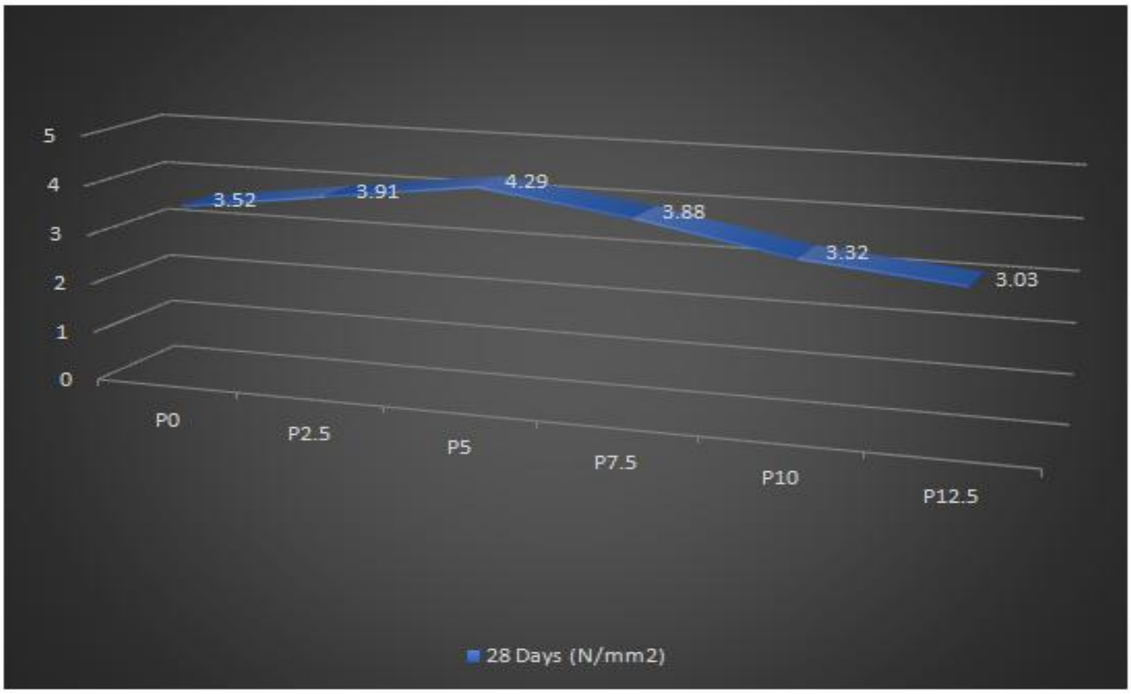


Figure 2: Average Split Tensile Strength Values at 28days

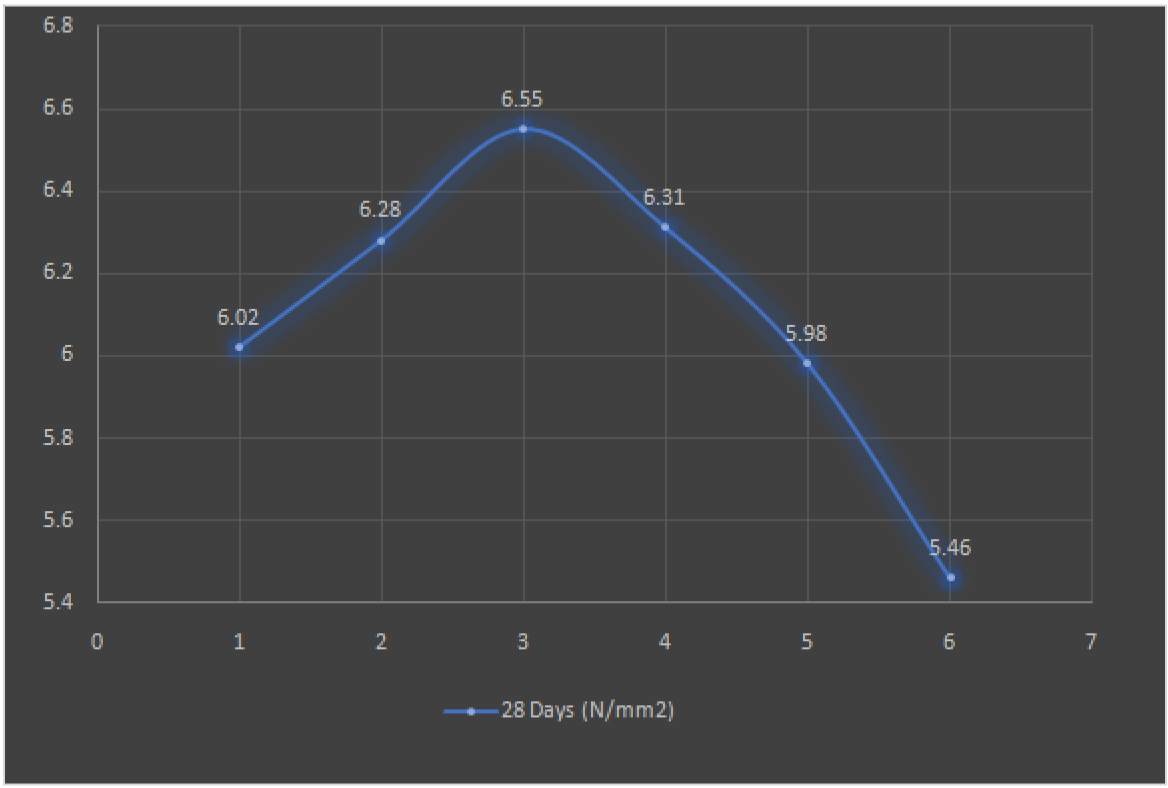


Figure 3: Average flexural strength values at 28days

1. **Compressive Strength:** Plastic waste was substituted for coarse aggregate in various proportions of 2.5%, 5%, 7.5%, 10%, and 12.5%. The mix design values in kg/m3 for using plastic waste in place of coarse aggregate are listed in Table 4. The findings for compressive strength at different PCA component percentages after 7, 14, and 28 days of curing are shown in Figure 1. After 10% replacement, the compressive strength dramatically decreased, while it had originally gained considerably. Strength rose by 1.21% when 2.5% replacements were performed, but fell by 12.67% when 12.5% replacements were performed. Strength loses value with 5% replacement of plastic waste. This is a result of the waste plastic's poor binding capacity. Table 5 displays the experimental compressive strength values for different compositions at varying curing ages. A visual representation of compressive strength values for various mixtures is shown in Figure 1 [9].

2. **Split Tensile Strength of Concrete:** When PCA is used in place of coarse aggregate, its split tensile strength is higher. Because of the investigation's use of plastic trash, which has significant tensile properties, concrete cylinders' split tensile strength showed an increased trend. When the percentage of coarse aggregate replacement with PCA was kept below 12.5%, split tensile strength was found to be equivalent to that of conventional concrete. There was a drop in tensile strength with increasing the replacement component percentage. A PCA replacement rate of 5% of the coarse aggregate resulted in a tensile strength enhancement of up to 21.87%. The split tensile strength values for a 28-day curing time are shown in Table 6 together with the Mix

Designation. A visual representation of split tensile strength values for various compositions is shown in Figure 2 [9,10].

3. **Flexural Strength of Concrete:** To ascertain the rupture modulus of the concrete, a 150×150 ×700 mm beam with a 28-day curing period was cast and tested for flexural strength. The test was performed using flexural testing tools that were on hand in the facility. The best flexural strength was attained for all mixes P0, P2.5, P5, P7.5, P10, P12.5, over a 28-day period at 5% replacement of coarse aggregate with PCA, as shown in Table 7 and Figure 3 [8,10].

IX. CONCLUSION

The following claims are supported by the test results:

- Compared to natural coarse aggregates, plastic has a lower specific gravity.
- During the experiment, it was shown that adding 2.5% PCA initially boosts concrete's compressive strength, but adding additional PCA causes the strength to drop.
- Ideal compressive strength is reached at 2.5% PCA.
- The cylinder's tensile strength produces greater outcomes when compared to other strengths.
- The split tensile strength and flexural strength comparison shows comparable findings, with replacement increasing up to 5% and decreasing with more plastic.
- The dry density of concrete decreases as the percentage of plastic chips increases.
- The substitution of plastic, according to the test findings, imparts less bonding capacity, which has impacted the strength of concrete.
- Plastic may be used in concrete without harming the environment.
- The use of plastic in building will greatly slow the buildup of solid trash.
- 10. It may be determined that the replacement of plastic aggregates up to 10% will have no effect on the Design Characteristic strength of M30 Concrete.

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