International Journal of Engineering, Management & Technology (IJEMT)
www.ijemt.com, Volume 2 Issue III, August 2023, PP 1-10, ISSN (Online): 2583 – 4517

An Investigation Into Using Plastic Waste in Place of Conventional Fine Aggregate

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ABSTRACT ***:*** *The manufacture of plastic is rising at a faster rate. The ecology is polluted by this plastic trash, making disposal more difficult. Burning plastic bottles emits toxic fumes and often takes hundreds of years for the plastic to degrade. By substituting this plastic waste for aggregates, the building industry may take action to address this problem. by replacing fine aggregate with waste plastic, a green solution. Waste plastic is increasing daily as time goes on since most of the plastic that humans use is not biodegradable. To examine the mechanical characteristics of concrete using waste plastic in place of conventional fine-sized aggregate, several laboratory investigations were carried out. Plastic waste was used to create concrete in varied ratios of 0, 2, 4, 6, 8, and 10%. This study ensures that employing recycled waste plastic in place of traditional fine-sized aggregate in concrete is a sound method to lower material costs and address some of the concerns with solid waste that plastics cause.*

KEYWORDS – *Compressive strength, Conventional aggregate, Flexural strength, Plastic waste, Split strength*

I. INTRODUCTION

After water as the most used resource on Earth, concrete is the most used man-made material in the construction sector. Simply put, it can be described as a mixture of coarse aggregates, which make up most of the mix, fine aggregates, like sand, which fill in the gaps, binding materials, like lime or Portland cement, which hold the ingredients together, and water, which reacts with the binding materials. We get a paste known as matrix when we combine these four ingredients. This step of the process is known as fresh concrete or green concrete, and as the water reacts with the binding substance, it hardens into stone. Concrete hydration is the name given to this reaction. Concrete can be cast into any desired shape while it is still in its fresh state by using forms.

Plastic doesn't need to be introduced because it is a material that is used so frequently today on Earth. It can be utilized for a variety of purposes because of qualities including strength, durability, and ease of processing. Studies demonstrate that plastic is practically inert, meaning that it is more resistant to chemical deterioration and has a longer lifespan. Plastic garbage is extremely difficult to dispose of since it lacks organic ingredients, making it a material that cannot decompose and endangering our ecosystem as well as posing several dangers to health. Plastic's long time to decompose and numerous negative effects on the environment make it a severe problem. Therefore, it can be used in construction when we need to extend the life of the structure, and using waste plastic that has undergone minimal processing can assist us in achieving the new civil engineering motto of reducing waste in the environment.

Conventional aggregates are produced by first quarrying and crushing the stones. Like how stone quarrying alters the local geology, crushing releases dust particles into the atmosphere. Consequently, this has two negative effects on the ecosystem. Researchers concentrated on the use of waste products that were also negatively influencing the environment to reduce this. Many of these are still being researched, but some of them are presently in use. Therefore, employing these waste materials serves a dual purpose by reducing the need for concrete's basic ingredients and using waste items that have an adverse impact on the environment. Utilizing these waste products also helps concrete characteristics by contributing to their improvement. Plastic garbage is what we use as research materials. Despite having a very negative influence on the environment, plastic can be utilized in concrete because of a few of its characteristics.

II. LITERATURE REVIEW

[1] investigated the performance concrete with fine aggregates of plastic. They utilized crushed aggregates, river sand, and OPC 53 grade. 10%, 20%, and 30% of the fine particles were replaced by plastic. On their concrete samples, they put mechanical and durability attributes to the test. They discovered that concrete's strength had decreased. However, it was discovered that concrete exhibits improved flexibility and good resistance to acid attacks. Thus, they came to the conclusion that flexible aggregate concrete can be employed when low compressive strength and higher durability is required.

[2] conducted a study on the concrete's aggregate properties using plastic waste. They employed fine and coarse aggregates in proportions of 10%, 15%, and 20% in plastic instead of the natural materials. Additionally, steel fiber was added to the concrete. Although their research points to a drop in strength, it suggests using it to support the adoption of eco-friendly materials and less waste.

[3] conducted research on the utilization of waste plastic as a component ingredient in concrete. In the following proportions, they switch out coarse aggregates: 5, 10, and 20.5%. They found that the concrete was lighter. Nonetheless, it had a lower compressive strength than regular concrete. Additionally, they discovered that concrete containing 10% plastic particles exhibits strength almost identical to that of regular concrete. Therefore, 10% plastic aggregates produced the best results.

[4] conducted research on the use of plastic bags as fiber in concrete and evaluated its qualities. By weight of concrete, he adds fiber in proportions of 0.2%, 0.4%, 0.6%, 0.8%, and 1%. He discovered that while tensile strength increased with an optimal strength at 0.8% addition, compressive strength decreased as plastic content increased.

In a study conducted by [5], recycled plastics were employed as coarse aggregate for structural concrete. They experimented with different ratios of plastic particles in lieu of coarse aggregates in concrete and found that a substitution of 22% of coarse aggregates with plastic aggregates generated excellent findings. They went on to examine the other qualities of concrete that contained 22% plastic particles and discovered that it had lower fire resistance.

The use of discarded plastic in concrete blocks was the subject of research by [6]. The strength of the 200 mm X 150 mm X 60 mm and 200 mm X 100 mm X 65 mm solid and paver blocks was assessed after 7, 14, and 28 days of curing in M20 concrete. Plastic was substituted for aggregates in amounts of 2%, 4%, 6%, 8%, and 10%. They discovered that replacing 4% of the aggregates with plastic aggregates showed the favorable outcomes for paver blocks. Additionally, solid blocks include 2% plastic.

Waste Plastic in Concrete with Plasticizer was investigated by [7]. They tested the concrete with and without plasticizers after mixing M30 grade concrete with various proportions of plastic pallets. Pallets made of plastic are added in amounts of 5%, 10%, and 15% of the concrete's weight. They discovered that a drop in density could aid in the production of low density or lightweight concrete. They also discovered that the slump had decreased, which has an impact on the workability, but the problem is fixed by adding plasticizers. They discovered a very slight and allowable drop in compressive and flexural strengths.

[8] conducted research on the use of plastic aggregate in concrete. He substituted plastic for the coarse particles in concrete in the amounts of 25%, 50%, 75%, and 100%, respectively. He discovered that both the density and the strength of concrete had decreased. They claimed that concrete for structural use should not replace aggregates by more than 36%. They also advised using plastic to create lightweight concrete.

[9] tested the use of plastic trash as coarse particles in concrete. They prepared the concrete by replacing 5%, 10%, and 15% of the concrete's aggregates with plastic. They discovered that 10% plastic replacement of aggregates produced the best outcomes. Concrete loses strength when its plastic component rises further.

Research on the Strength and Behavior of Concrete Containing Waste Plastic was conducted by [10] Plastic bottles and plastic bags are substituted for fine aggregates in concrete in variable amounts, ranging from 0% to 5%. They concluded that since plastic weakens concrete in both situations, it should only be used for non-structural applications.

III. OBJECTIVE

The primary objective of this study was to replace the fine proportion of conventional aggregates with plastic waste and evaluate the mix performance by conducting Concrete's compressive, split-tensile, and flexural strengths tests. Other crucial concrete characteristics including workability, compaction, bleeding, and segregation will also be considered.

IV. MATERIALS AND METHODOLOGY

Materials:

Cement: OPC 43 grade cement was used in this study

Conventional aggregate: Conventional aggregates of coarse and fine sized procured locally and used in this study.

Waste plastic: Waste plastic is the leftover material from plastic containers that were gathered from the local market.

Methodology

A literature review of the information available on the usage of plastic in concrete was conducted. From the trash, plastic was collected. Any foreign objects, dust, etc. were removed from the plastic by cleaning. After a short period of sun drying, it melted in the container. The molten plastic was then poured onto a level surface and drawn into sheets before being allowed to cool and solidify. After the plastic sheets had cooled and hardened, they were pounded into smaller pieces. Tests were conducted to determine the characteristics of cement and aggregates. The amount of plastic fine aggregates in various blends was chosen based on the available research that was at hand. To determine the mechanical qualities of various mixes, tests were carried out and mix designs for various concrete ratios were chosen. The following plastic mixtures were chosen based on a review of the research and the ideal amount of plastic and are shown in Table 1.

Table 1: Mix specification for the concrete mixtures

Concrete Name	Conventional aggregate, %	Plastic aggregate, %
M1	100	0
M2	98	2
M3	96	4
M4	94	6
M5	92	8
M6	90	10

V. EXPERIMENTAL PROGRAM

Design of concrete mixtures

The process of choosing the different components used in concrete and figuring out their proportions while also taking into account the economy and various concrete characteristics including workability, slump value, and strength criteria is known as the creation of a concrete mix. The concrete mix was designed using the specifications from IS:10262-2009. A design mix for concrete of the M25 grade was produced in order to assess the mix design, alter the additive dosage, and establish the appropriate water cement ratio. In addition, test mixtures were made. Table 2 lists the factors that were employed in the mix design.

Table 2: Variables of mix design

Grade of concrete	M25
Type of cement	OPC 43 Grade
Admixture	RHEOPLAST SP-450
Fine aggregate	Zone III
Specific gravity (cement)	3.162
Specific gravity (fine aggregate)	2.617
Specific gravity (coarse aggregate)	2.667

Sample preparation

The mix proportions were followed for casting every sample. The necessary quantities were measured and blended to create these mixed proportions. Because concrete was mixed by hand, the weight of the cement was raised by 10%. The method of sample preparation for different tests are described subsequently. Specimens were tested for 7-, 14- and 28-days following casting. The method used to test specimens for qualities including compressive strength, split tensile strength, and flexure strength has been covered in this article.

compressive strength

Testing was done on specimens with cubical shapes of 150mmX150mmX150mm to determine the compressive strength of concrete mix. The necessary components were weighed in accordance with the mixed proportion. Cement and aggregate were first properly combined. Water was mixed with a substance. Then, water was added to the dry mixture. Three identical cubes per casting were used for testing during periods of seven, fourteen, and twenty-eight days. The cubes were taken out from the mold and placed in a curing tank after casting for 24 hours. Cube specimens were used to assess the compressive strength of concrete.

The testing was done in accordance with IS 516-1959. Then, specimens were placed in a curing tank for the allotted time. Specimens were then removed from the tank after 7, 14, and 28 days of curing and allowed to dry on the surface. They ought to be dried in the shade as opposed to an oven or in direct sunshine. The Compression Testing Machine (CTM) was then used to test the specimens. The rate of loading was then set at 5.2 KN per second, or 140 Kg/m3/minute. The peak load at which the specimen fails was determined after the load was applied. The following equation was used to calculate compressive strength of the produced mix.

Compressive Strength = P/A

where P is the load in kN and A is the cross-sectional area (mm^2).

Split tensile strength

Cylindrical specimens with dimensions of 150 mm in diameter and 300 mm in height were created to test the split tensile strength of the concrete mix. The necessary components were weighed in accordance with the mixed proportion. Cement and aggregate were first properly combined. Water was mixed with a substance. Nine comparable cylinders total were cast; each cylinder was tested for 7 days, 14 days, and 28 days. The cylinders were held for 24 hours before being demolded and put into a curing tank.

By positioning the cylinder in the CTM so that the compressive force acts horizontally, the tensile strength is obtained. Due to the tension that has built up in the transverse direction, the failure occurs along the vertical axis. Additionally, it was put to the test for 7, 14, and 28 days. 2.1 kN of weight were loaded each second. The Split Tensile Strength can be derived by the following equation.

$$\sigma t = \frac{2P}{\pi DL}$$

Where P = load in kN, cylinder's diameter is D, L is the cylinder's length, and σ_t is the specimen's split tensile strength in N/mm^2.

Flexural strength

Beam specimens measuring 100mmX100mmX500mm were produced to test the flexure strength of the concrete mix. The necessary components were weighed in accordance with the mixed proportion. Cement and aggregate were first properly combined. Water was mixed with a substance. Then, water was added to the dry mixture. Nine comparable beams totaling three each for testing over seven, fourteen, and twenty-eight days were cast. The beams were cast for 24 hours, demolded, and then put into a curing tank.

The beams undergo a flexure strength test. The configuration for that is different, but the beams were arranged in CTM. In the CTM, more configurations were installed. It has a four-point load configuration with two on the lower side and two on the upper side. The loading speed was 0.1 kN/second. There are formulas that can be used to calculate the beam's flexure strength.

$\sigma c = \frac{3PL}{4bd^2}$ (Crack at middle portion of the beam)

$\sigma c = \frac{3Pa}{4bd^2}$ (Crack at outer third portion of the beam)

Where, P = load in kN, L= length of beam, b= width of beam, d= depth of beam, and a = distance between crack and the nearest support.

VI. RESULTS AND DISCUSSION

Slump test

To test the workability of concrete, a slump test was run on newly mixed concrete. Concrete's usability is described as how simple it is to operate with it without segregation. A key quality of freshly laid concrete is workability. Good workability should be present in concrete. The outcome of the slump test reveals that the slump first increased with the addition of plastic up to 5% before starting to decrease. Figure 1 presents the slump outcomes for various concrete mixes.

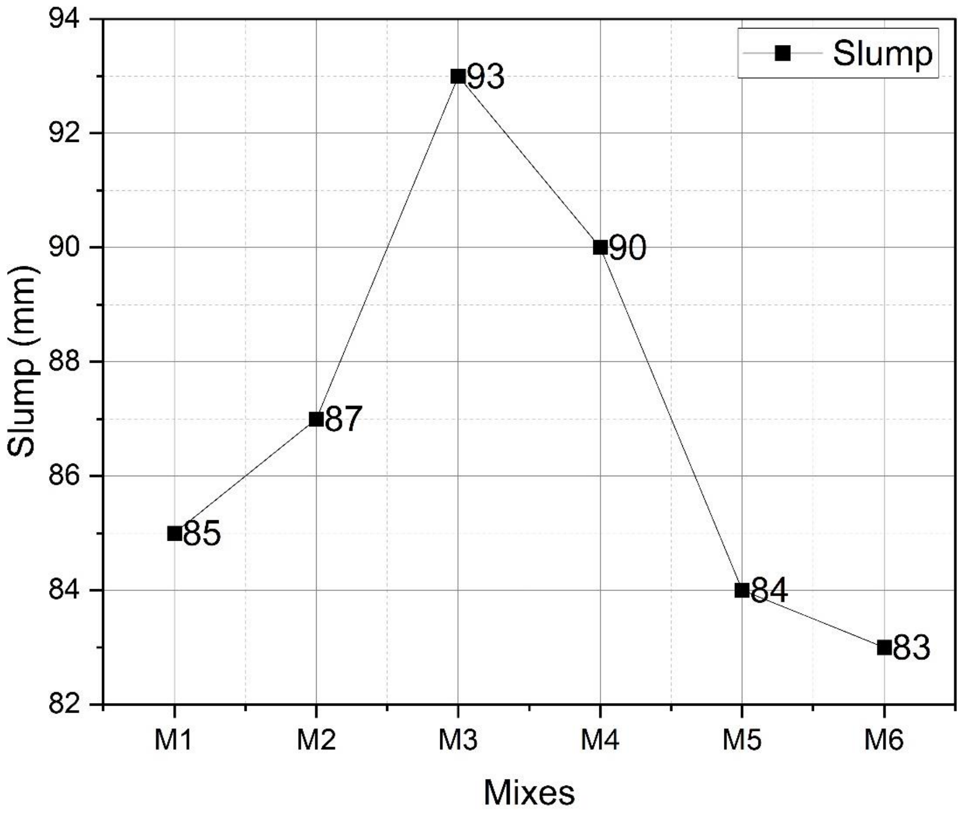

Fig. 1. Slump value for various concrete mixes

Compressive strength test

This test is carried out on hardened concrete to ascertain the strength of the material. The concrete specimens were squeezed uniaxially to a load per unit area of cross section and subjected to a predefined rate of loading. The compressive strength of concrete is expressed in N/mm2. For this test, conventional cubes 150mmX150mmX150mm were used. A concrete mixture was prepared and put into a cube mold in different ratios. The first setup was then given a 24-hour rest period. For testing over seven days, fourteen days, and 28 days, three samples each were created, for a total of nine samples. After the curing period was complete, the specimens were examined using a compression testing machine (CTM). The predetermined rate of loading was 140 kg per square meter per minute, or 5.2 KN. The maximum load (P) value that the specimen can withstand was noted and is shown in Table 4. The trends of the results for compressive strength are shown in Figure 2.

Table 4: Compressive strength of concrete

Mixes	7 days strength (N/mm2)	14 days strength (N/mm2)	28 days strength (N/mm2)
M1	20.24	28.66	33.54
M2	22.45	29.45	33.28
M3	23.22	30.58	34.47
M4	17.56	25.54	32.25
M5	16.54	24.57	29.74
M6	16.31	23.52	28.12

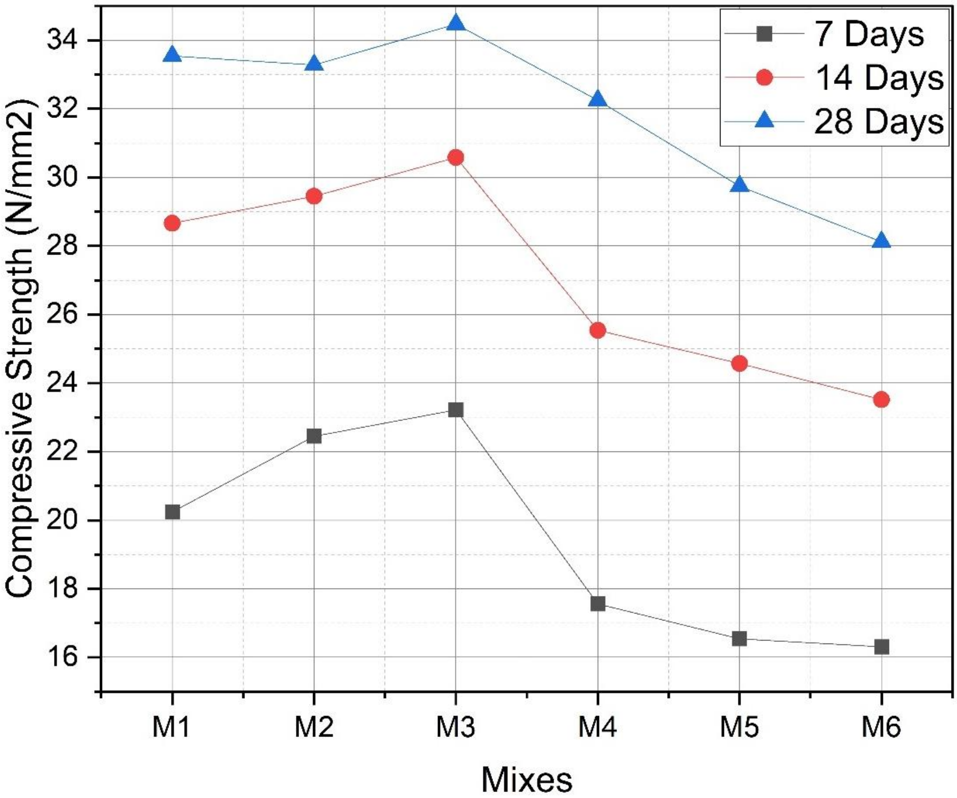

Fig. 2. Compressive strength of concrete mixes

Split tensile strength

This test's objective is to evaluate the tensile strength of concrete. The cylinder is positioned in the CTM to have the compressive force act horizontally, which yields the tensile strength. The failure happens along the vertical axis as a result of the transverse direction's accumulated tension. Additionally, it was put to the test for 7, 14, and 28 days. 2.1 kN of weight were loaded each second. Table 5 contains the test results for the Split Tensile Strength test. which is shown in Figure 3.

Table 5: Split tensile strength of concrete mixes

Mixes	7 days strength (N/mm2)	14 days strength (N/mm2)	28 days strength (N/mm2)
M1	2.21	3.01	3.57
M2	2.57	3.21	3.64
M3	2.78	3.45	3.85
M4	2.68	2.31	3.42
M5	2.57	2.15	3.25
M6	2.41	2.01	3.11

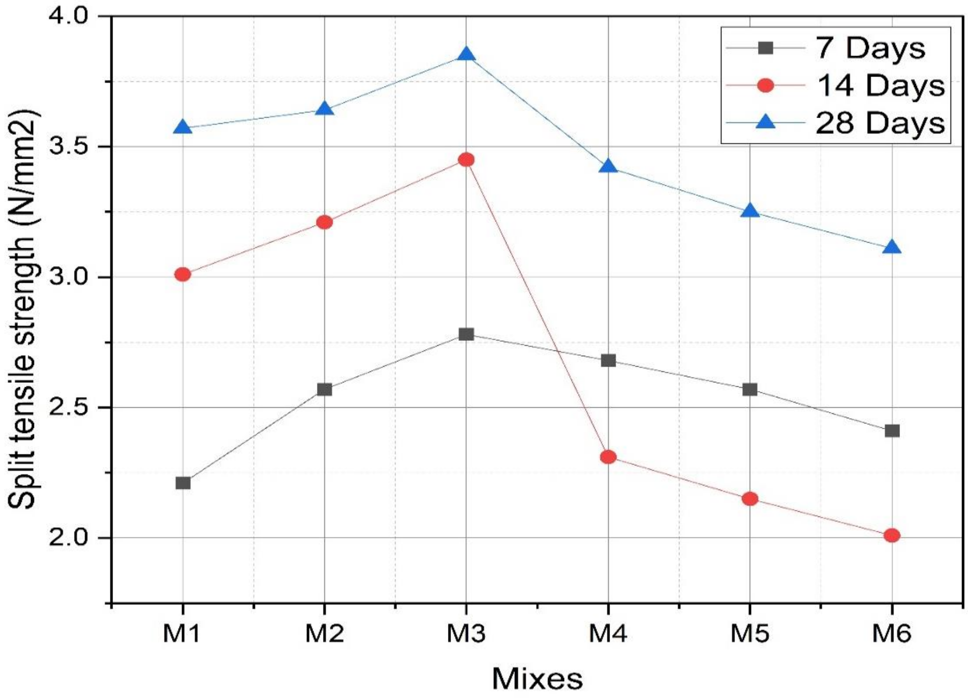

Fig. 3. Split tensile strength of concrete mixes

Flexural Strength

The beams undergo a flexure strength test. The configuration for that is different, but the beams were arranged in CTM. In the CTM, more configurations were installed. With two on the lower side and two on the top side, it has a four-point load structure. There was a 0.1 KN/second loading speed. The outcome of flexural test is tabulate in Table 6 and Figure 4 illustrates the results for flexural strength of different concrete mixes.

Table 6: Outcomes for flexural strength

Mixes	**7 days strength (N/mm2)**	**14 days strength (N/mm2)**	**28 days strength (N/mm2)**
M1	4.24	6.12	7.52
M2	5.47	6.54	7.54
M3	6.22	6.78	6.75
M4	4.76	6.13	6.52
M5	3.54	6.01	6.13
M6	3.24	5.74	5.45

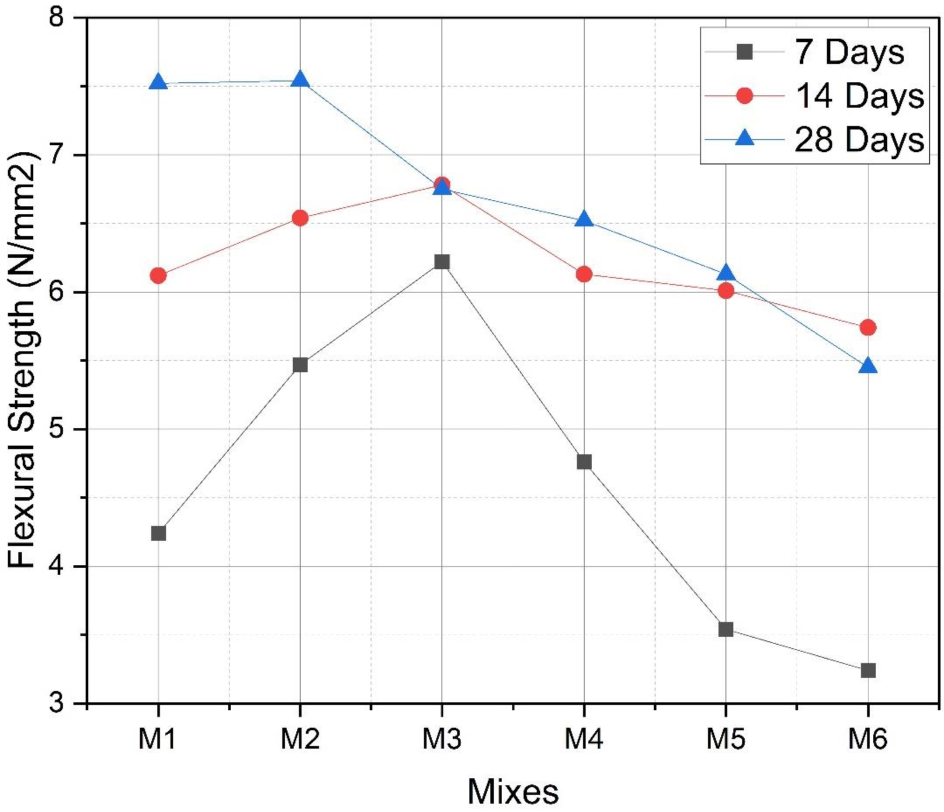

Fig. 4. Flexural strength of concrete mixes

VII. CONCLUSIONS

In concrete, plastic was substituted for fine particles in the following ratios: 0, 2, 4, 6, 8 and 10%. Based on the findings of the current investigation, the following Observations were made.

(i) The slump value was found to be increased up to mix M3 and then it starts decreasing. It rises by 9.41% from M1 to M3 and then it is reduced by 2.35 % for M6 as compared to M1.
(ii) The compressive strength outcomes of the waste plastic included mix were found to be comparable with the control mix which is M1. Mix M3 outperformed all the mix.
(iii) The outcomes for the split tensile strength were revealed that it rises to mixed M3 and then stares decreasing.
(iv) The outcomes for the flexural strength test were in line with the results of compressive strength and split tensile strength of concrete mixes.
(v) Therefore, based on the result of this study it can be concluded that fine sized plastic waste up to 6 % can be effetely used in making concrete mixes. Although the result reduces for further addition, it remains within the permissible criteria.

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