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Study on Effect of Recycled Plastic Waste as Replacement to the Fine Aggregate

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Abstract: ***A substantial growth in the consumption of plastic is observed all over the world in recent years, which has led to huge quantities of plastic-related waste. Recycling of plastic waste to produce new materials like concrete or mortar appears as one of the best solution for disposing of plastic waste, due to it's economic and ecological advantages. Several works have been performed on plastic waste are under way to evaluate the properties of cement composites containing various types of plastic wastes as aggregate, filler or fiber. The rapid urbanization and industrialization all over the world has resulted in large deposition of plastic. This waste can be utilized under proper condition to replace aggregate content. M40 concrete is used for most of the constructional works, since it gives maximum strength. The strength of this concrete was compared with the concrete obtained by replacing fine aggregate with recycled plastic waste by 5% & 10%. Experimental investigation comprised of testing physical requirements of coarse aggregates, fine aggregates, cement and modifier (waste plastic). M40 concrete was prepared as per IS SP: 23-1982. By using the plastic waste as a modifier, we can reduce the quantity of sand by their weight hence decreasing the overall cost of construction. The modified cement concrete can be used in the construction works like rigid pavements.***

I. INTRODUCTION

Concrete is a very strong and versatile mouldable construction material. It consists of cement, sand and aggregate mixed with water. The initial hardening reaction usually occurs within few hours. It takes long time to reach the full hardness and strength. It can continue for several years. It is a well-known fact that plastic waste is an important issue for everyone and needs to be resolved on an urgent basis, as it's hazardous effects is deteriorating life of earth. Plastic is available in a variety of forms such as LDPE- Low Density Polyethylene, HDPE-High density Polyethylene, PET-Polyethylene terephthalate, Bakelite, etc. It is generally made from long chain of hydrocarbons along with additives and can easily moulded into desired finished products. Resources such as petroleum, kerosene etc which are limited are being utilized in plastic manufacturing. Plastic is available as polymer but to obtain it's various form monomers such as Vinyl, Propylene, Styrene, Benzene etc. Polypropylene (PP), also known as polypropene, is a thermoplastic polymer used in a wide variety of applications. It is produced via chain-growth polymerization from the monomer propylene. Polypropylene belongs to the group of polyolefins and is partially crystalline and non-polar. Its properties are similar to polyethylene, but it is slightly harder and more heat resistant. It is a white, mechanically rugged material and has a high chemical resistance. Polypropylene is the second-most widely produced commodity plastic (after polyethylene)

II. LITERATURE REVIEW

1) *Prakash Parasivamurthy:* This author in his work replaced fine aggregate by waste plastic to make concrete composite and tested the sample for 1, 3, 7, 14, and 28 days strength. Coarse aggregates of 20mm size, tap water, Portland cement and waste plastic are used as material for concrete. The experimental procedure included heating coarse aggregate and plastic to a temperature 75º C to 100º C. The waste plastics are shredded and added to the concrete mix at 2%, 4%, 6% and 8% by weight of aggregates. The mixing process is as like the conventional concrete mix. Standard cubes were casted. The cubes were tested for compressive strength and the results increased by 1.2%, when the plastic content was 5%. The result shows no clear evidence of deterioration of the composite durability.
2) *A. M. Alhozaimy and M. J. Shannag:* The main objective of this investigation is to explore the strength properties and shrinkage cracking control of concrete reinforced with recycled plastic fibres (RP Fiber). The test specimens are made of standard 150mm cubes for compressive strength test and prisms for flexural test. The concrete mixing was done by a drum mixer. The result indicate slight reduction compressive strength of recycled plastic fibre concrete mix, but the fibre samples did not undergo brittle failure. The flexural test results show that normal concrete specimens break into pieces when the peak load is reached while the recycled fiber specimens exhibiteds pseudo-ductile behavior. The results show increase in the flexural toughness due to RP fiber.

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3) *Nabajyoti Saikia, Jorge de Brito:* This paper is review on use of plastic as aggregates in cement mortar and concrete. This paper deals with the types of plastics and methods used to prepare plastic aggregate along with the various properties of the concrete prepared from plastic aggregate. It also discusses the practical implications and future research needs of the use of plastic waste in concrete.
4) *Faiz Uddin Ahmed sheikh, Sarvesh Mali:* This work focuses on the concrete properties made up of stabilized recycled plastic. The evaluation of various properties is done on ordinary Portland cement, Pozzolanic Portland cement and Ground granulated blast furnace slag cement (GGBS). Experimental procedure is comprised of three phases. The effects of increasing stabilizer dosages on flow time are evaluated in first phases and plastic and mechanical properties of stabilized concrete are tested in third phases. Increase in compressive strength is observed at 10% stabilized concrete. The fresh properties of all three concretes are in the range of tolerance.

III. MATERIALS

Fine Aggregate Sieve Analysis

SIEVE SIZE	ACCUMULATED PERCENTAGE PASSING	STANDARD LIMIT
10	100	100
5	97.39	89-100
2.36	93.15	60-100
0.18	79.09	30-90
0.6	37.09	15-54
0.3	5.72	5-40
0.15	1.31	0-15

1) *Fine Aggregate:* River sand passing through 4.75mm IS sieve and confirming to zone-1 of IS:383 (1987a) was used. The specific gravity was found to be 2.3.
2) *Coarse Aggregates:* It is crushed stones of maximum size 20mm and retained on 4.75mm IS sieves. The specific gravity was found to be 3.13.
3) *Water:* Potable water for conventional concrete.
4) *Recycled Polypropylene:* Polypropylene (PP) is broadly used as a reinforcing agent in concrete, because it provides three – dimensional support of the concrete. It's good chemical resistance, good fatigue resistance, better temperature resistance and lower density than higher density polyethylene.
5) *Types of Polypropylene:* Polypropylene Homopolymer is the most widely utilized general-purpose grade. It contains only propylene monomer in a semi-crystalline solid form. Main applications include packaging, textiles, healthcare, pipes, automotive and electrical applications.

Polypropylene Copolymer family is further divided into random copolymers and block copolymers produced by polymerizing of propene and ethane:

Polypropylene Random Copolymer is produced by polymerizing together ethene and propene. It features Ethene units, usually up to 6% by mass, incorporated randomly in the polypropylene chains. These polymers are flexible and optically clear making them suitable of applications requiring transparency and for products requiring an excellent appearance.

While in Polypropylene Block Copolymer, ethene content is larger (between 5 and 15%). It has co-monomer units arranged in regular pattern (or blocks). The regular pattern hence makes thermoplastic tougher and less brittle than the random co-polymer. These polymers are suitable for applications requiring high strength, such as industrial usages

Mix Proportions Of Concrete Mixtures

MIXTURES	W/C	CEMENT	WATER	GRAVEL	SAND	PLASTIC	PLASTIC %
M1	0.47	375	180	1145	700	0	0
M2	0.47	375	180	1145	665	55	5
M3	0.47	375	180	1145	630	70	10

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IV. METHODS

A. Specimen Prepration

Six cubes 100*100*100 mm per cast for compressive strength. Further more 3 beams 100*100*500 mm were prepared for flexural strength test and three cylinders 300mm height and 150mm diameter were cast for splitting test tensile strength for each mix.

B. Test Methods

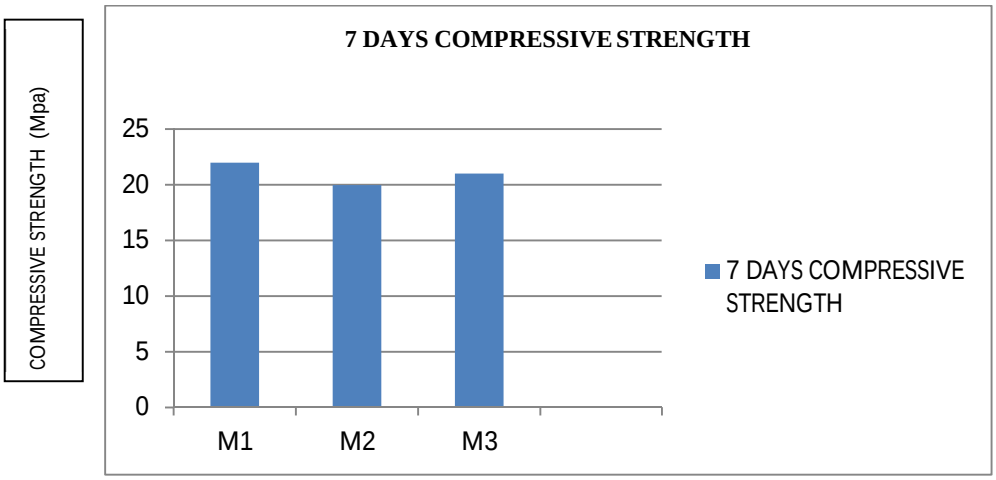
The compressive strength was determined at the ages of 7 and 28 days of curing with the compressing machine of maximum load of 2000 KN.

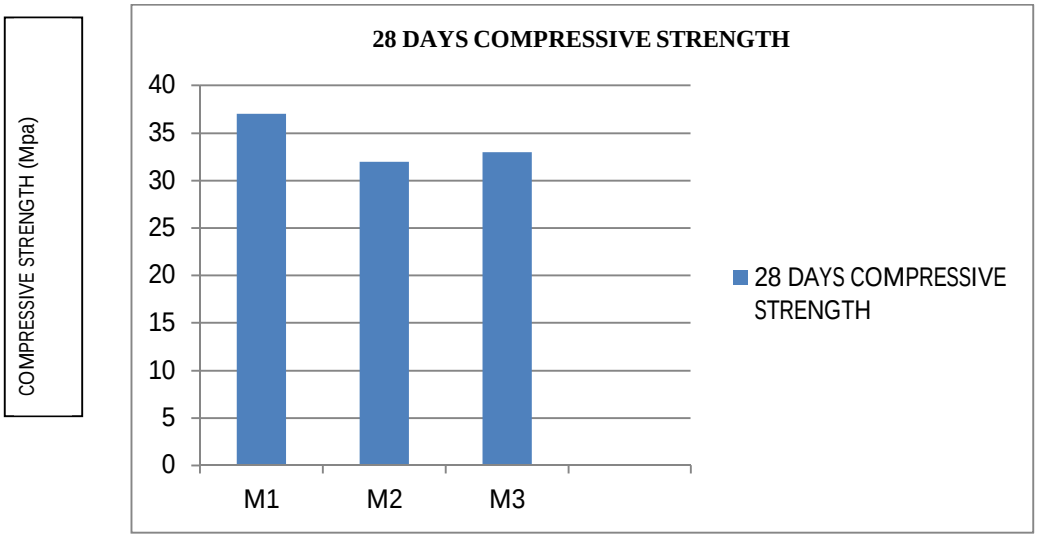
The splitting tensile strength was carried out after 28 days of curing the cylinder with compression device of maximum load of 3000 KN.

The flexural strength test was determined with the compression device with maximum capacity of 30 tons.

V. RESULTS AND DISCUSSION

Compressive Strength





From the test results its is found that there is decrease in compressive strength of M2 mix by 18.51 % and 15.08% for 7 and 28 days respectively when compared to the control mix M1.

For M3 mix 10% replacement decrease in strength with comparison to control mix is 9.42% and 12.72% for 28 days of curing.

The decrease strength is due to weak bonding between polypropylene pellets surface and cement paste.

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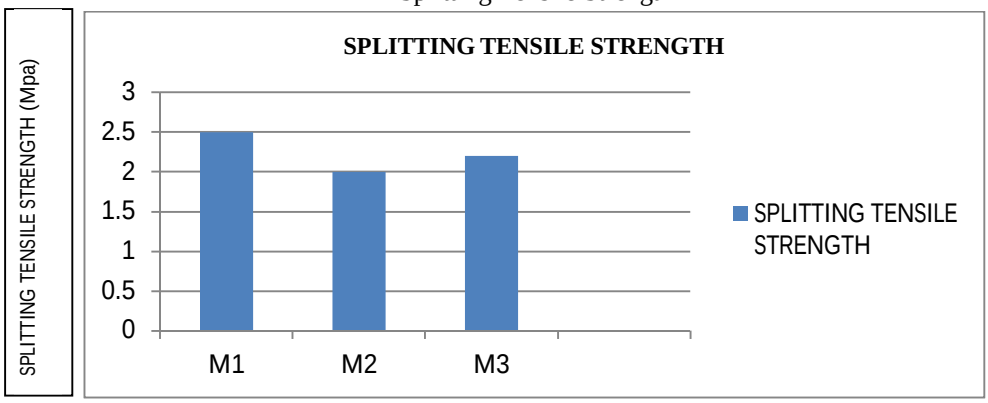
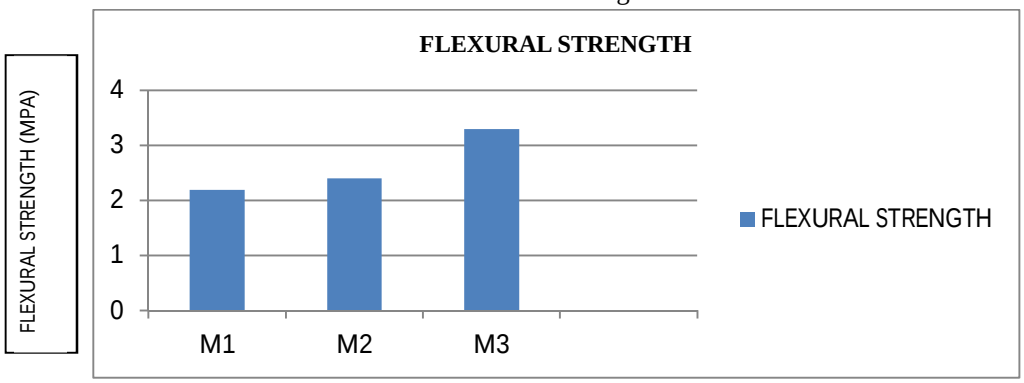
Splitting Tensile Strength



The test results confirm the decrease in the split tensile strength for M2 and M3 mixes.
M2 has decrease in strength by 18.15% compared to M1.
M3 has decrease in strength by 14.03% compared to M1.
But strength is increased in M3 by 4.78% from M2, this maybe due to uneven distribution of pellets in the M2 and M3 mixes.

Flexural Strength



The Flexural strength of M2 and M3 is going to be slightly increased than control mix M3.
The gain in flexural strength is due to High bending resistance of polypropylene pellets than the sand.

VI. CONCLUSION

The dry density for both 7 and 28 days of cured specimen rend to decrease compared to the control. The percentage difference between the sand and the plastic pellets density is 69.5% which explains the decrease in the weight of concrete mixex containing the 5% and 10% of PP pellets.
The compressive strength for 7 days cured specimen decrease by 18.51% and 9.42% for the 5% and 20% respectively. The 5% might have encountered some unnoticeable problem while mixing the PP pellets in the concrete mix. The 28 days compressive strength decreased by 15.08% and 12.72% for the 5% and 10% respectively.
The splitting tensile strength decreases for both the 5% and 10% mixtures than the control mixtures. This may be due to the weak bond between the cement paste and the PP surface.
The study shows that polypropylene pellets can be good alternative to the river sand which is used as fine aggregate.

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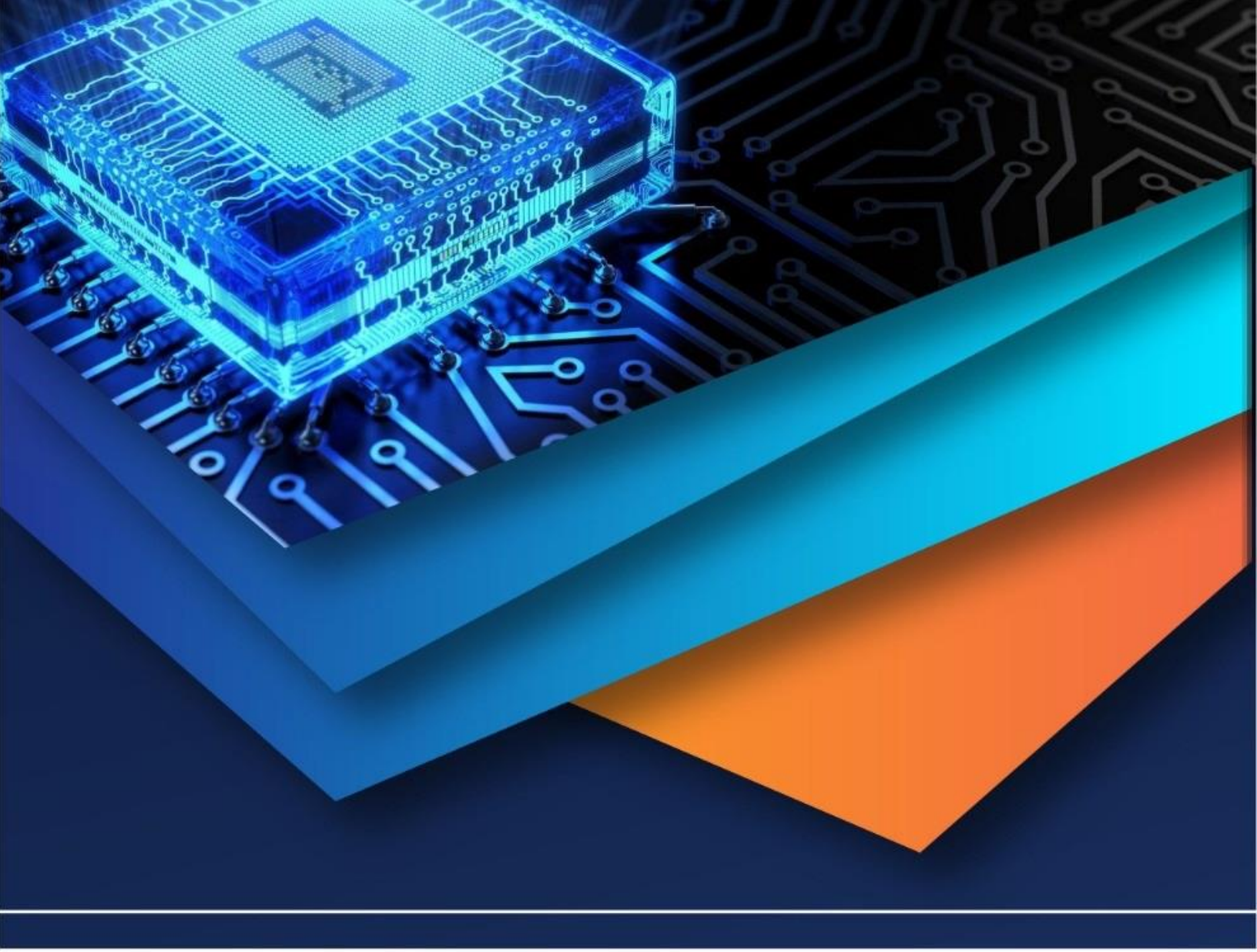

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