The Effect of Mixing Randomly Shredded Plastics on The Technical Properties of M30 Concrete: A Research

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Abstract : This project aims to investigate the use of waste plastic materials as a means of enhancing the strength of concrete. Plastic waste is a major environmental issue, and finding ways to repurpose it is an important goal. In this study, various types of waste plastic, such as polyethylene terephthalate (PET) and high-density polyethylene (HDPE), will be used as additives to concrete mixes. The impact of different plastic percentages on the mechanical properties of the resulting concrete, such as compressive strength, tensile strength, and flexural strength, will be evaluated through laboratory testing. The study will also assess the effect of waste plastic content on the durability and permeability of concrete. The results of this research will provide valuable insight into the potential of using waste plastic in the construction industry as a sustainable and effective means of improving concrete strength, while also reducing plastic waste.

INTRODUCTION

Concrete is the most commonly used construction material in the world, and its production accounts for a significant portion of global carbon emissions. Additionally, plastic waste is becoming an increasingly severe environmental problem, with much of it ending up in landfills or the ocean. Thus, finding ways to recycle and repurpose plastic waste has become a crucial task for the construction industry.

In recent years, researchers have explored the potential of using waste plastic materials as additives in concrete. The addition of plastic waste to concrete can provide several benefits, including an increase in the material's compressive strength, tensile strength, and flexural strength. Moreover, the use of waste plastic can help to reduce the carbon footprint of concrete production, and at the same time, address the issue of plastic waste disposal.

Several types of waste plastic have been investigated as additives in concrete, such as polyethylene terephthalate (PET), high-density polyethylene (HDPE), and polystyrene. The properties of the plastic waste and the processing method can significantly influence the impact of plastic on concrete properties. Therefore, the selection of plastic type and proper processing technique is critical.

However, the use of waste plastic in concrete is still a relatively new area of research, and further investigation is required to optimize the material properties of plastic-enhanced concrete. This project will contribute to the body of knowledge in this field by conducting laboratory tests to investigate the effects of different waste plastic types and percentages on the mechanical and durability properties of concrete. By understanding the optimal conditions for using waste plastic in concrete, this project could provide new sustainable solution for the construction industry while also tackling the issue of plastic waste disposal.

Experimental Work

1) Cement

Ordinary Portland Cement (OPC) of grade-53 according to Indian Standard was employed in this study. Cement has undergone a number of tests, including those for Starting and Final Setting Times and Standard Consistency.

Fineness test of cement	IS: 4031
Consistency of a cement	IS: 4031
setting time of cement	IS: 4031
strength of cement	IS: 4031
soundness of cement	IS: 4031
Heat of Hydration	IS: 4031
Tensile strength	IS 5816
Chemical Composition Test	IS: 269-1998

2) Sand

In this value of effort, cement mixes have been made with characteristic sand from evaluation set zones 1, 2, and 3. Numerous tests were conducted in accordance with Indian Standards, such as silt content in sand and sieve analysis.

Sieve Analysis	IS 2386 Part -1
Specific Gravity	IS 2386 Part -3
Water Absorption	IS 2386 part - 3
Bulk Density and Voids	IS 2386 part - 3
Slit Content	IS 383
Bulking of Aggregates	IS 2386 part - 3

3) Coarse Aggregate or Gravel

In a concrete mixture, 0.2, 0.4, 0.6, 0.8, and 1% of the coarse aggregate mass are composed of shredded plastic.

Sieve analysis	IS 383
Specific gravity and porosity	IS 2386
Water absorption	IS 2386
Bulk Density of Aggregates	IS: 2386 (Part- III) - 1963.
Aggregate flakines	IS 2386 part 1-1963
Eongation index	IS 2386 part 1-1963
Silt content	IS 2386-2
Crushing value of aggregate	IS:2386-Part 4-1963
Aggregate Impact Value	IS: 2386 Part-4 (1963)
Aggregate Abration Value	IS:2386-Part 4-1963

4) Water

Potable water from the water supply system was used in the mixing and curing operations (tap water).

5) Polyethylene terephthalate (PET)

PET, also known as polyethylene terephthalate, is a versatile linear semicrystalline thermoplastic polymer. It is a member of the polymer family called polyester. These resins are renowned for having a fantastic combination of attributes. These characteristics include dimensional stability, mechanical, thermal, and chemical resistance. Its molecular structure is C10H8O4)n.

Polyethylene terephthalate

Key features :

- higher heat distortion temperature (HDT), stiffness, and strength than PBT
- very sturdy and lightweight, making transportation simple and effective.
- Excellent gas (oxygen, carbon dioxide) and moisture barrier qualities
- phenomenal electrical insulating qualities
- Wide temperature range, from -60 to 130°C

7) Concrete Mix Design

In the concrete mixture, 0.2%, 0.4%, 0.6%, 0.8%, 1% of the total mass of coarse aggregate is made of plastic which has been shred.

Cement Fine and Coarse Aggregate needed for M30 grade Concrete

MATERIALS	QUANTITY		RATIO
Cement	480	kg	1
Fine Aggregate	631.18	kg	1.31
Coarse Aggregate (20mm)	1160.215	kg	2.42
Water	186	Lit	0.39

Experimental Procedure

The investigation's goal is to use waste plastic to strengthen regular concrete. Shredded plastic makes up 0.2, 0.4,0.6,0.8, and 1% of the mass of the coarse aggregate in the concrete mixture. Compression test specimens were 150 x 150 x 150 mm cast iron cubes. The bending component was cast using a standard 700 X 150 X 150 mm-sized mould. The samples were then meticulously placed in curing tanks every day for 7 or 28 days, depending on the length of time. 9 cubes and 2 beams are produced by each percentage of shredded plastic.

Tests

Bulk Density

By dividing the object's total mass by its total volume, one can determine the density of any substance or object. Although it may be necessary to employ various techniques to determine the mass or volume of plastic, the density is found using the ASTM D792-98

ASTM D792-98

In accordance with ASTM D792 - 98, the specific gravity (relative density) and density of solid plastics in shapes like sheets, rods, tubes, or moulded products are determined. There are mostly two test methods:

Test method A : Testing the plastic in water.

Test method B : Testing the plastic in other liquids except water.

Slump Flow Test

One of the most crucial tests for self-compacting concrete is the slump flow test. This test is used to figure out how horizontally concrete flows. It is used to assess how well concrete will fill. An exterior inspection of this kind is possible.

Compressive Strength

Compressive strength testing, which is mechanical in nature, establishes the maximum compressive load that a material can sustain before failing. The test specimen, which frequently has the shape of a cube, prism, or cylinder, is compressed between the plates of a compression tester by a gradually applied load.


Flexural Strength

When a beam is put under a three-point stress, the bending test determines how much force is needed to bend it. When choosing materials for parts that do not bend under load, this information is frequently used. Concrete's tensile strength can be calculated using its flexural strength. evaluates the resistance to flexural failure of a slab or beam of unreinforced concrete. calculated by installing concrete beams measuring 6" x 6" (150 x 150 mm) with loads spanning at least three times their depth.

Splitting Tensile strength

The tensile strength of concrete is frequently assessed using a tensile split test. In this test, a biaxial stress field is produced by a compressive stress that is three times greater than the tensile stress.

Result

TEST DATA FOR MATERIALS		
Cement	OPC 53	
Specific Gravity of Cement	2.26	Test – IS: 2720
Specific Gravity of Coarse Aggregate	2.98	Test – IS 2386
Specific Gravity of Fine Aggregate	2.61	Test – IS 2386
Water Absorption of Coarse Aggregate	1.33%	Test – IS 2386
Water Absorption of Fine Aggregate	0.33%	Test – IS 2386

SIEVE ANALYSIS OF FINE AGGREGATE						
Sieve	Wt. Retained	Error Adjustment	Corrected Value	Cum. Retained	Cum Passing	% passing
4.75	97	1.01	98.01	98.01	901.99	90.2
2.36	128	1.33	129.33	227.34	772.66	77.27
1.18	399	4.15	403.15	630.49	369.51	36.95
0.6	166	1.73	167.73	798.22	201.78	20.18
0.3	179	1.86	180.86	979.08	20.92	2.09
0.15	19.3	0.2	19.5	998.59	1.41	0.14
Pan	1.4	0.01	1.41	1000	0	0
Total	989.7		1000			
Error	10.3					

SIEVE ANALYSIS OF FINE AGGREGATE						
Sieve	Wt. Retained	Error Adjustment	Corrected Value	Cum. Retained	Cum Passing	% passing
4.75	97	1.01	98.01	98.01	901.99	90.2
2.36	128	1.33	129.33	227.34	772.66	77.27
1.18	399	4.15	403.15	630.49	369.51	36.95
0.6	166	1.73	167.73	798.22	201.78	20.18
0.3	179	1.86	180.86	979.08	20.92	2.09
0.15	19.3	0.2	19.5	998.59	1.41	0.14
Pan	1.4	0.01	1.41	1000	0	0
Total	989.7		1000			
Error	10.3					

SPECIFIC GRAVITY OF FINE AGGREGATE	
Calculations	Weight
Sand	
Empty Pycnometer w1	512.6
Pycnometer +Dry Sand w2	713.2
Pycnometer + Sand + Water w3	1381.1
Pycnometer + Water w4	1269.6
specific gravityof sand	2.25140292

SPECIFIC GRAVITY OF COARSE AGGREGATE	
Calculations	Weight
Sand	
Empty Pycnometer w1	512.6
Pycnometer +Dry Sand w2	713.6
Pycnometer + Sand + Water w3	1389.3
Pycnometer + Water w4	1269.6
specific gravityof sand	2.472325

SLUMP TEST (M30)	SLUMP (mm)
0.2 % Plastic By weight of Coarse Aggregate	157
0.4 % Plastic By weight of Coarse Aggregate	159
0.6 % Plastic By weight of Coarse Aggregate	162
0.8 % Plastic By weight of Coarse Aggregate	166
I % Plastic By weight of Coarse Aggregate	170

COMPRESSIVE STRENGTH TEST OF CUBE		
M30 FOR DIFFERENT PLASTIC%	**NO OF DAYS**	**COMPRESSIVE STRENGTH VALUE**
M30 (CUBE)	7 DAYS	20.37 N/mm^2
0.2% BY WEIGHT OF COARSE AGGREGATE	14 DAYS	25.35 N/mm^2
	28 DAYS	32.50 N/mm^2
M30 (CUBE)	7 DAYS	21.60 N/mm^2
0.4% BY WEIGHT OF COARSE AGGREGATE	14 DAYS	27 N/mm^2
	28 DAYS	33.30 N/mm^2
M30 (CUBE)	7 DAYS	22.20 N/mm^2
0.6% BY WEIGHT OF COARSE AGGREGATE	14 DAYS	28.55 N/mm^2
	28 DAYS	34.78 N/mm^2
M30 (CUBE)	7 DAYS	23 N/mm^2
0.8% BY WEIGHT OF COARSE AGGREGATE	14 DAYS	28.80 N/mm^2
	28 DAYS	35.69 N/mm^2
M30 (CUBE)	7 DAYS	25.49 N/mm^2
1% BY WEIGHT OF COARSE AGGREGATE	14 DAYS	36.38 N/mm^2

SPLIT CYLINDER TEST OF CYLINDER		
M30 (CYLINDER)	7 DAYS	1.12 N/mm^2
0.2% BY WEIGHT OF COARSE AGGREGATE	28 DAYS	1.59 N/mm^2
M30 (CYLINDER)	7 DAYS	2 N/mm^2
0.4% BY WEIGHT OF COARSE AGGREGATE	28 DAYS	2.34 N/mm^2
M30 (CYLINDER)	7 DAYS	3.50 N/mm^2
0.6% BY WEIGHT OF COARSE AGGREGATE	28 DAYS	3.89 N/mm^2
M30 (CYLINDER)	7 DAYS	4.1 N/mm^2
0.8% BY WEIGHT OF COARSE AGGREGATE	28 DAYS	4.67 N/mm^2
M30 (CYLINDER)	7 DAYS	4.9 N/mm^2
1% BY WEIGHT OF COARSE AGGREGATE	28 DAYS	5.00 N/mm^2

Conclusion

- Use of Shredded plastic has been beneficial in increasing the compressive and tensile strength of the concrete.
- The compressive strength of the concrete has drastically improved from 30 N/mm^2 to 36 N/mm^2.
- The strength of the concrete in tensile has also been improved.
- Because plastics are less dense than the small particles that lower concrete's specific gravity, they can be used to substitute some aggregates in concrete. For lightweight, no-load concrete applications like concrete panels, this material is beneficial.

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