Utilization of Plastic Waste as a Partially Replacement of Course Aggregate in Concrete

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Abstract: ***Recycling plastic trash as a component of concrete will help cut down on waste disposal because India produces enormous amounts of plastic garbage each year. The creation of PP plastic garbage has also increased as a result of the Covid - 19 epidemic. Using plastic waste in concrete helps safeguard the environment and human health because medical plastic waste is bad for both. The environmental risk posed by medical plastic waste has prompted us to pause and explore secure alternatives for its sustainable reuse. The creation of concrete using plastic is one such method. Concrete can be a safe environment for using plastic because it has a longer lifespan than most materials. Different ratios of plastic trash are utilized as coarse aggregate it is tested for compatibility in concrete. In this study, the impacts of substituting plastic trash for coarse aggregate are investigated. This study looks into the plastic inclusion impact of concrete through a number of experimental tests. The current investigation used M30 grade concrete with varied percentages of medical grade PP plastic waste in place of The optimization of the replacement value for coarse aggregate (20%, 40%, 60%, 80%, and 100%) was conducted following an assessment of mechanical and physical characteristics. The best solution was found by carefully comparing the properties of hardened concrete and freshly mixed concrete, with PP plastic replacing natural coarse aggregate to a 40% extent. This required a thorough assessment and analysis of the properties of both the freshly poured and hardened concrete.***

Keywords: partially replacement of course aggregate

1. Introduction

Concrete stands as the second most widely employed resource on Earth, following only water, within the construction sector. It can be distilled down to a composite comprising four key constituents: water, which interacts with the binding elements; fine aggregates such as sand, which occupy the spaces left by the coarse aggregates; binding materials like lime or Portland cement, which serve to unite the components; and coarse aggregates, constituting the bulk of the mixture. These four ingredients are combined to create the matrix paste. Fresh concrete or green concrete is what is used in this stage of the process, and as water interacts with the binding material, it hardens into stone. This phenomenon is known as concrete hydration. Any desired shape can be made using concrete. This concrete quality aids in the most effective use of the material.

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 to 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. Due to its lack of organic ingredients, plastic trash is difficult to dispose of and poses a threat to the environment as well as numerous health risks.

Plastic's long time to decompose and numerous negative effects on the environment make it a severe problem. Therefore, When a structure has to have its useful life extended, we can utilize it in construction. Additionally, employing waste plastic that has had minimal processing can help us reduce environmental waste, which is the new slogan of civil engineering.

Currently, plastics play a significant role in our daily lives. Almost every production sector makes use of plastic. Even while the amount of waste keeps increasing, tons of plastic products are manufactured every day. Since most plastics are not biodegradable, a tremendous amount of plastic rubbish is continuing to amass worldwide, with developed nations being the primary producers of this waste. More specifically, the great majority of plastic rubbish is made up of packaging and containers. Around the world, worries about the amount of land required for landfills are growing.

Figure 1.1: Waste Plastic

An estimated 6.3 billion tons of plastic were generated globally between 1950 and 2018, of which 9% were recycled and the remaining 12% were burned. Only an estimated one - quarter of the more than 5 million tons of plastic that are consumed annually in India are recycled; the remainder ends up in landfills. Studies indicate that 90% of seabirds have plastic debris in their bodies, which indicates that this vast amount of plastic garbage will reach the environment.

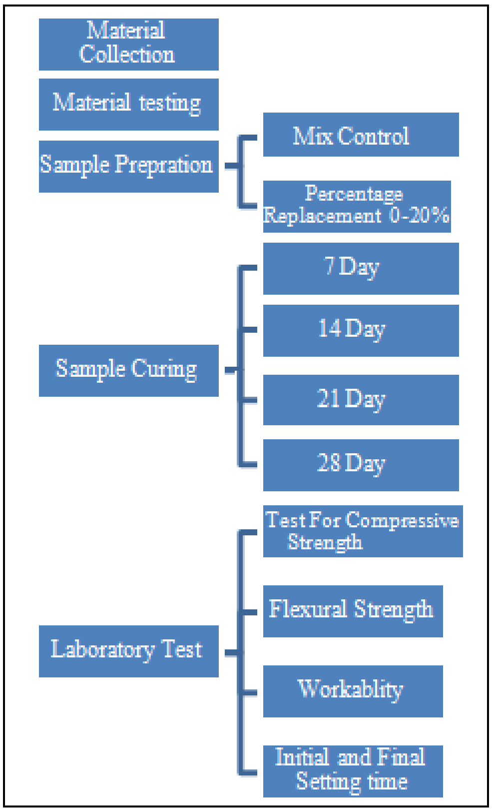
2. Literature Review

Das, Alam, and Chowdhury (2019) Declare that a significant portion of the waste produced worldwide is made of plastic. Currently, these waste streams are typically managed by incineration, recycling, or landfills (where the unsustainable process of landfilling is carried out).

Ling, and Mo (2000) cite the fact that because they are not biodegradable, plastics pose a significant environmental burden. They will therefore persist in the ecosystem forever, contaminating the land and water and causing ecological damage.

Mr. Suryakanta Panigrahi (2021) The use of low - density polyethylene (LDPE) granules as a substitute for coarse aggregate in the creation of concrete cubes and cylinders is examined and reported in this study. Manual casting of LDPE - based concrete cubes and cylinders allowed for experimental evaluation of the test concrete's strength under compression and under split stress.

3. Material and Methodology



3.1 Materials

3.1.1 Aggregates

Fine aggregate

Fine aggregate, also known as sand, is defined as material that passes through a 4.75mm sieve. It should typically have a lower limit particle size of 0.7mm. However, any material below 0.002mm in size is classified as silt, and in concrete, an excessive presence of silt should not exceed 6 percent of its volume. Beyond this threshold, it is further categorized as detrimental to the concrete mix.

Coarse aggregate

Coarse aggregates with a nominal size of 40mm, 20mm, 12.5mm, 10mm, and 8mm are acquired either through the sieving process or by crushing stones. The retained coarse aggregate particles are those that remain on the 4.75mm sieve.

Numerous aggregate qualities can affect how well concrete performs; therefore, several factors must be taken into account when choosing the substance. The specific gravity and other parameters of the aggregates utilized in this study were examined, and the findings have been tabulated.

3.1.2 Cement

In general, adhesives encompass a wide range of materials, but within the context of construction and civil engineering projects, a specific focus is placed on binders. These binders consist of finely powdered substances that, upon mixing with water, undergo a process of solidification, resulting in the formation of a durable mass. This solidification process is primarily driven by hydration, Cement compounds and water undergo a chemical reaction that creates tiny crystals or a gel - like substance with a sizable surface area. This, in turn, induces the setting and hardening of the material. These constructional binders, known for their ability to set and harden even when submerged in water, are often referred to as hydraulic cements due to their hydrating properties. Among these hydraulic cements, Portland cement stands out as the most pivotal and widely used.

3.1.3 Mixing and Curing

Concrete mixing and curing require water, which is defined as IS: 456 - 2000 (Cl.2.20). The IS: 456 - 2009 specifies the acceptable limits for solids in water. The maximum amount of chloride that may be present in water when performing Reinforced Concrete (RCC) work has been reduced from 1000 mg per liter as stated in IS: 456 - 1978 to 500 mg per litre in IS: 456 - 2000. Along with these criteria, it is also essential to consider the acidity and alkalinity of the water when assessing its suitability for use in concrete construction.

3.1.4 Plastics

Plastics that can no longer be broken down have been pulverized into tiny pieces. The primary component of these polymers is High - Density Polyethylene (HDPE).

Testing of concrete

Water	Cement	Sand	Coarse aggregate
0.5	1.0	1.0	2.0

Specimens were tested seven, fourteen - , and twenty - eight - days following casting. This article discusses the method used to test specimens for qualities like Strength of Concrete, split tensile strength, and flexure strength.

4.1. Strength of Concrete

The examination conducted through this test reveals the utmost importance of the concrete's properties, making it a pivotal assessment.

4.2 Workability

The characteristic known as "workability of concrete" largely determines how freshly mixed concrete behaves from mixing to compaction.

4.3 Flexural Strength Test

The standard beams were point - loaded until failure, and the test specimen was supported symmetrically over a 400 mm span. An equation derived from material strength theory was used to calculate the beam specimen's peak experimental flexural strength

4.4 Pull Out Test

Pull out test commonly in tests the force necessary to remove a specifically designed rod from the concrete with an expanded end that has been cast into the concrete.

4.5 Rebound Hammer Test

It is made up of a plunger with a tubular casing and a spring control hammer that glides on it. The mass springs back from the plunger when it is pressed on the concrete surface. In opposition to the spacing's force, it retracts. The rider is propelled along the guiding scale by the impact of the hammer on the concrete and the spring - controlled mass rebound. The rider may be kept still so that the reading can be captured by pressing a button.

4. Result

Table 5.1: Ratio of each component's weight (in kg) in concrete for setting up the mixer

Weight of Materials (Kg)				
% Replacement	Cement	Sand	Aggregate	Plastic Waste
0	5	4	9	0
5	5	3.9	9	.25
10	5	3.7	9	.50
15	5	3.5	9	.75
20	5	3.3	9	.10

Table 5.2 replacement of sand in mix components with plastic waste

Compressive Strength Test

Table 5.7: Result For compression test 7, 14, 21, 28 Days

S. No.	% Replacement	7 Day		14 Day		21 Day		28 Day	
		Compressive strength n/mm^2	Average n/m m^2	Compressive Strength, n/mm^2	Average n/mm^2	Compressive strength, N/mm^2	Average N/mm^2	Compressive strength N/mm^2	Average N/mm^2
1	0 %	25.20	24.66	25.65	25.60	28.80	28.10	31.70	31.75
2		24.60		25.12		28.10		31.80	
3		24.20		25.62		28.15		31.75	
4	5 %	25.85	25.08	25.30	25.35	27.95	27.95	31.65	31.50
5		24.50		25.19		27.80		31.50	
6		24.90		25.20		27.90		31.69	
7	10 %	25.55	24.86	25.36	25.40	27.50	27.65	31.23	31.15
8		24.50		25.49		27.50		31.15	
9		24.55		25.63		27.63		31.35	
10	15 %	24.60	24.55	25.65	25.50	27.50	27.38	30.65	30.45
11		24.90		25.56		27.50		30.30	
12		24.15		25.50		27.30		30.90	
13	20%	23.90	23.68	24.85	24.80	26.75	26.70	30.10	30.10
14		23.25		25.65		26.86		30.25	
15		23.90		25.12		26.78		30.10	

Flexural Strength

Table 5.8: Results for Flexural strength

S. No.	% Replacement	Flexural Strength (MPa)		
		7 Days	14 Days	28 Days
1.	Control mix	3.25	3.59	4.41
2.	5 %	3.16	3.31	4.10
3.	10 %	3.10	3.65	4.29
4.	15 %	2.60	2.83	3.39
5.	20 %	2.21	2.52	2.99

Bond Strength

For 5, 10, 15, and 20% replacement, it was found that the bond strength decreased by 15, 6, 33, 43, and 61%, respectively. It was evident from the observation that plastic might be replaced to the extent of up to 40%. The strength steadily decreased with an increase in percentage replacement, as seen below in

Table 5.9: Various Concrete Mix Bond strength

S. No.	Percentage Replacements	Bond Strength (MPa)
1.	Control Mix	8.95
2.	5 %	7.55
3.	10 %	8.33
4.	15 %	6.56
5.	20 %	5.39

Relationship between Rebound Number and Compressive Strength

The correlation between compressive strength and rebound number was established based on the trial results outlined in

Tables 4 and 7. Rebound numbers were calculated in both horizontal and vertical directions, as illustrated in Figure 11. The horizontal relationship between rebound number and compressive strength is shown by the red line, and the vertical relationship is indicated by the blue line. At 28 days of age, the cubes' compressive strength and rebound number were evaluated, taking into account both factors when determining the cube's compressive strength.

Table 5.10: Rebound Value of Different Mix

S. No.	Replacement Percentage	Average Rebound Number (Horizontal)	Average Rebound Number (Vertical)
1.	Control Mix	26	34
2.	5 %	29	33
3.	10 %	26	33
4.	15 %	25	30
5.	20 %	25	28

5. Conclusion

The findings of the current work are listed below.

1) It has been noted that compressive strength declines as the percent replacement rises.
2) The percentage of plastic trash is found to be growing while the slump value is decreasing.
3) The slump value for replacing up to 20% of the sand with plastic trash shows a decline of roughly 11%.
4) At the age of 28 days after replacing 5%, 10%, 15%, and 20% of the sand with plastic waste, the reduction in compressive strength is only 1%, 2%, 3%, and 5%, respectively.
5) As a result of the results above, it is advised to substitute plastic waste for up to 20% of the sand for good compressive strength and optimal workability.
6) Concrete replaced with plastic waste underwent a test to determine the qualities of this concrete are satisfactory.

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