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Durability of Concrete by Partial Replacement of Coarse Aggregate with Recycled Plastic Granules

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Abstract: *This study investigates and reports on the usage of plastic granules in place of coarse aggregate while constructing concrete cubes and cylinders. Concrete cubes and cylinders made of plastic granules were hand cast, and test concrete's strength was then empirically assessed in terms of split tension and compression. It has been discovered that the compression and split tension strengths of plastic-replaced concrete can be on par with those of ordinary concrete. The current study focuses on concrete mixes that have plastic granules (0%, 5%, 10%, 15%,20%and 25%) partially replacing the coarse aggregate, which will help to reduce the structure's dead weight. This mix in the form of cubes and cylinders were subjected to compression and split tension to ascertain the strength parameter. Therefore, using plastic granules for creating concrete is not only advantageous but also useful for getting rid of plastic trash.*
Key words: Compressive Strength, Split Tensile Strength, Flexural Strength, Plastic Granules

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I. INTRODUCTION

One of the most significant environmental, economic, and social problems worldwide is how to dispose of and manage solid waste. To address the growing issues with garbage disposal, a comprehensive waste management system that incorporates source reduction, reuse, recycling, land-filling, and incineration must be put into place. Products created from recycled plastic are frequently not recyclable since a plastic is typically not recycled into the same type of plastic. Biodegradable polymers are being used more frequently. Because of the differences in characteristics and melt temperatures, reclaimed plastic cannot be recycled if any of it is combined with other polymers for recycling. The goal of this experiment is to determine whether it would be feasible to partially replace the coarse aggregate in concrete composites with granulated plastic waste materials.

The non-biodegradable nature of plastic garbage, which is causing several environmental issues, calls for specific attention among the various waste parts. India produces over 40 million tonnes of solid trash each year. This is rising between 1.5 and 2% annually. 12.3% of the waste created is made up of plastic, primarily from used water bottles. Because the plastic debris can start uncontrolled fires or contaminate the soil and flora, it cannot be dumped or burned.

On this subject, extensive research and studies have been conducted in certain nations, including the UK and the USA. On the other hand, there are hardly any investigations on plastics in concrete in India.In order to partially replace coarse aggregate, an attempt has been made to use waste plastic granules, and its mechanical behaviour is studied.

II. LITERATURE REVIEW

1. “**Behaviour of Concrete by Partial Replacement of Coarse Aggregate with Recycled Plastic Granules”Suryakanta Panigrahi , Nagarampalli Manoj Kumar(2021)**

It has been examined and reported that low density poly ethylene (LDPE) granules can be used in place of coarse aggregate to produce concrete cubes and cylinders.

Concrete cubes and cylinders made of LDPE were hand cast, and test concrete's strength was then empirically assessed in terms of split tension and compression.

2. "Use of plastic chips as partial replacement of coarse aggregate in cement concrete" Bijendra Patel, S. S. Kushwah, Aruna Rawat (2021)
Utilising waste products and by-products is a component of the answer to ecological and environmental issues. Utilising these materials not only encourages their use in cement, concrete, and other building supplies. In addition to lowering the cost of producing cement and concrete, it also has a wide range of indirect advantages, including lower energy costs and environmental protection from any pollution-related effects.

3. "E-waste as a partial substitute for coarse aggregate" y Arivalagan (2020)
With a water-cement ratio of 0.45, using e-waste as a partial substitute for coarse aggregate at 10%, 20%, and 30%, respectively. To improve the mechanical qualities of green concrete, recycled metallic components from e-waste were used. Comparing the compressive strength of the green concrete specimens to that of normal concrete, a 20% increase is seen.

4. "Strength Analysis of Concrete by Using Plastic Waste" Ahirwar, Shiv & Kansal, Rajeev. (2017)..
Large amounts of solid non-biodegradable trash are generated by industrial activity in India, with waste plastic playing the most significant role. Due to its extremely low biodegradability and widespread use, the disposal of plastic garbage in the environment is seen as a serious issue. Industrial wastes from various polymers have been calculated as another replacement for a part of the traditional aggregates in current times.

5. "Recycled plastic used in concrete paver block." Tapkire, Ganesh. (2014).
Concrete is mixed with recycled plastic aggregate in a variety of ratios, and their effectiveness is evaluated. Due to its extremely low biodegradability and prevalence in vast quantities, disposing of plastic garbage in the environment is regarded as a major challenge. Industrial wastes like plastic bottles, pallets, and carry bags, as well as polypropylene (PP) and polyethylene terepthalate (PET), have recently been explored as potential alternatives for some of the traditional aggregates used in concrete.

III. MATERIALS USED

1. Cement
Cement is a crucial component in the production of concrete. It can stick to any extra raw materials used to prepare concrete, especially when in contact with water, and as a result, it creates an effective paste. This uses cement of OPC grade 53.

2. Fine Aggregate
In order to determine the zone to which it belongs, fine aggregate is first graded. Sand from zone II is used in this project; its qualities are listed below. Usually, a 4.75 mm sieve is used to filter out fine material.

3. Coarse aggregate
Another essential raw element that offers strength, hardness, and increases the volume of the concrete is coarse aggregate. Here, 20 mm coarse aggregate with an angular crushed shape is selected.

4. Plastic
Plastic is a material made composed of a range of synthetic or semi-synthetic organic chemicals that are malleable and can be moulded into solid objects of numerous different shapes. Plastics are organic polymers with a large molecular mass, despite the fact that they frequently contain additional components. They are often created synthetically from petrochemicals, while many of them are also partially natural. Plasticity is the ability to deform irreversibly without breaking, however with this class of mouldable polymers, it occurs to such a degree that it is specifically mentioned in the name of the substance.

EXPERIMENTAL PROGRAM
The grade of concrete chosen is M25 Grade and the proportion of the mix is calculated as the thumb rule. The concrete selection criteria test performed are mentioned below.
Table 3.1 gives the properties of various materials such as cement, fine aggregates, coarse aggregates for M25 grade of concrete.

Table 3.1 Properties of materials

a)	Cement used	OPC 53 grade
b)	Specific gravity of cement	3.15
c)	Chemical admixtures	NIL
d) 1)	Specific gravity of Course aggregate	2.85
	2) Fine aggregate	2.54
e) 1)	Water absorption Coarse aggregate	0.3%
2)	Fine aggregate	2.62%
f)	Free surface moisture	

1)	Coarse aggregate	NIL
2)	Fine aggregate	NIL

Various Tests on Cement

TEST	Fineness	Std. consistency	Initial setting time	Final setting time
RESULT	3%	32%	34.5 min	51 min

Mix proportion of M25 grade of concrete without plastic chips.

Grade designation	M25
Type of cement	OPC 53 Grade
Maximum nominal size ofaggregate	20 mm
Minimum cement content	300 kg/m^3
Maximum water cement ratio	0.45
Workability	69.2 mm (slump)
Exposure condition	Moderate
Method of concrete placing	Non Pumped
Type of aggregate	Crushed aggregate
Maximum cement content	410 kg/m^3
Degree of supervision	Good

Mix calculations per unit volume for M25 grade concrete

Volume of concrete	1 m^3
Volume of cement	0.1314 m^3
Volume of water	0.192 m^3
Volume of all in aggregate	0.6766 m^3

MIX PROPORTION

Replacement of plastic granules	**Cement**	**Fine aggregate**	**Coarse aggregate**	**Plastic granules**	**Water**
CONV	413	859.3	964.2	0	197
5%	413	859.3	916	48	197
10%	413	859.3	868	96.5	197
15%	413	859.3	820	144.7	197
20%	413	859.3	772	193	197
25%	413	859.3	723	241	197

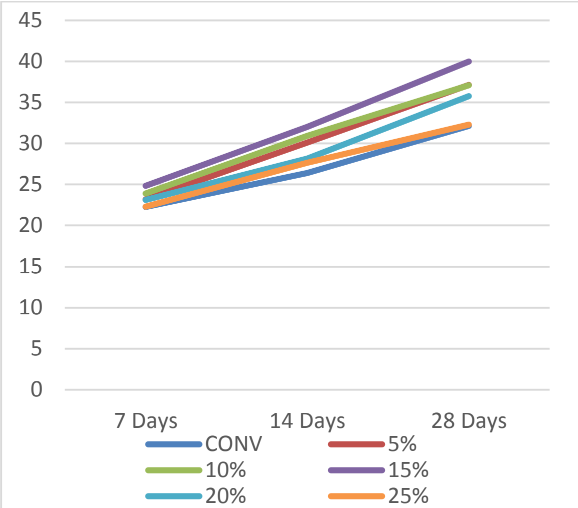
IV. RESULTS AND ANALYSIS

The experimental findings on various design mixtures are discussed in this section compressive strength tests, split tensile strength and flexural strength tests are all included in the results. In this investigation cubes ,beam and cylinders of each 18 specimens of each were cast and evaluated over the course of 7 days, 14 days, and 28 days. The comparison and findings are addressed in more detail in the following sections:

COMPRESSIVE STRENGTH TEST:

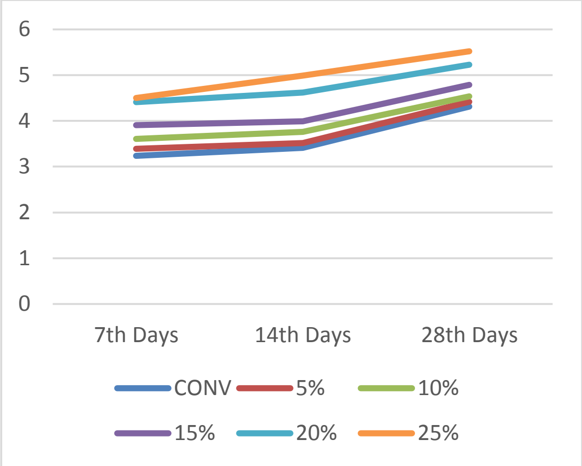
Replacement of plastic granules	No. of days	Average compressive strength in N/mm2
0%	7	22.25
	14	26.41
	28	32.14

5%	7	23.21
	14	30.11
	28	37.14
10%	7	23.91
	14	30.91
	28	37.09
15%	7	24.85
	14	32.01
	28	39.98
20%	7	23.10
	14	28.14
	28	35.77
25%	7	22.29
	14	27.64
	28	32.27



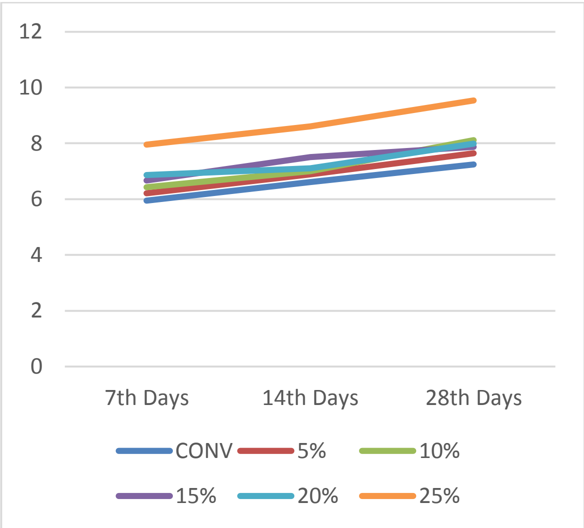
TENSILE STRENGTH TEST:

Replacement of plastic granules	No. of days	Average split tensile strength in N/mm2
0%	7	3.24
	14	3.41
	28	4.31
5%	7	3.39
	14	3.52
	28	4.42
10%	7	3.61
	14	3.76
	28	4.54
15%	7	3.91
	14	3.99
	28	4.79
20%	7	4.41
	14	4.62
	28	5.23
25%	7	4.5
	14	4.99
	28	5.52



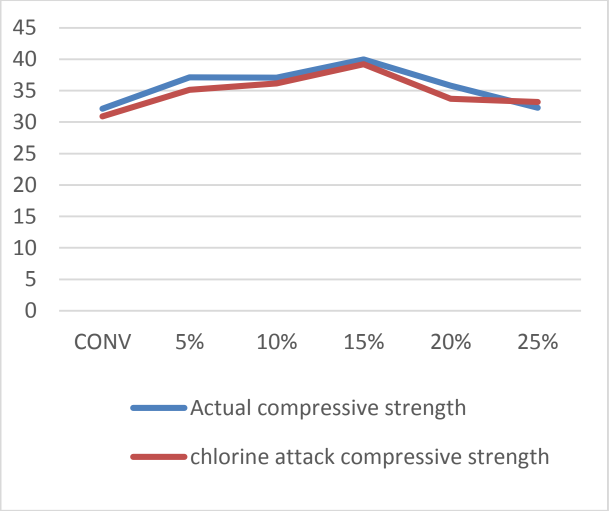
FLEXURAL STRENGTH TEST:

Replacement of plastic granules	No. of days	Average flexural strength in N/mm2
0%	7	5.95
	14	6.61
	28	7.24
5%	7	6.21
	14	6.89
	28	7.64
10%	7	6.43
	14	7.00
	28	8.11
15%	7	6.67
	14	7.51
	28	7.87
20%	7	6.86
	14	7.11
	28	7.99
25%	7	7.95
	14	8.61
	28	9.54



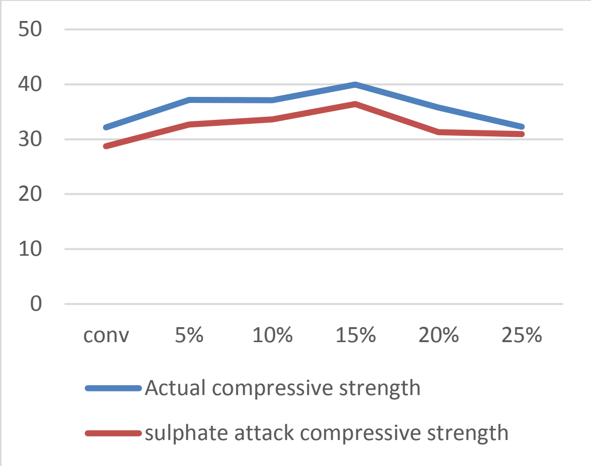
CHLORINE ATTACK

Replacement of plastic granules	Initial Weight (kg)	Final Weight (kg)	Weight reduction (%)	Compressive Strength (N/mm²)
Conv	8.43	7.96	5.60	30.91
5%	8.05	7.58	5.83	35.14
10%	8.09	7.63	5.66	36.14
15%	8.11	7.61	6.19	39.19
20%	7.92	7.47	5.70	33.69
25%	7.92	7.45	5.91	33.19



SULPHATE ATTACK

Replacement of plastic granules	Initial Weight (kg)	Final Weight (kg)	Weight reduction (%)	Compressie Strength (N/mm²)
Conv	8.43	7.49	11.19	28.73
5%	8.05	7.13	11.40	32.66
10%	8.09	7.18	11.25	33.59
15%	8.11	7.16	11.74	36.43
20%	7.92	7.02	11.29	31.31
25%	7.92	6.91	12.71	30.94



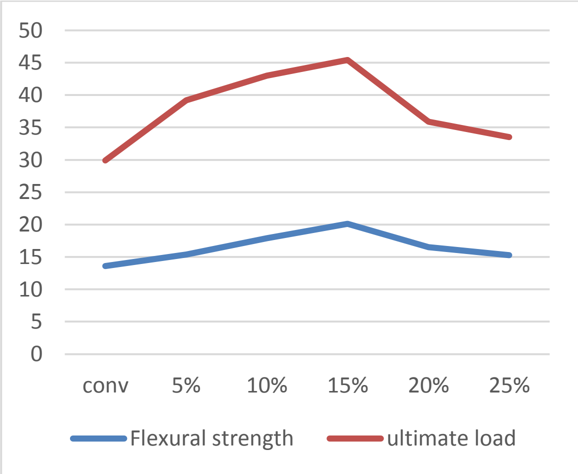
Details of RC beam design

The design of beam to find the flexural strength of concrete is done. A square shape beam of cross section 150mm x 150mm with 2000mm length is designed having 2nos of 10mm bars on tension side and 2nos of 8mm dia hanging bars with 8mm stripps at 100mm c/c spacing.

Experimental setup:

The load is applied to the beam with the help of hydraulic jack and the data is recorded from the data acquisition system, which is attached with the load cell. One LVDT (Linear Variable Deflection Transformer) is placed at the center of the specimen. The value of deflection is obtained from LVDT.

S. No	% of Recycled plastic granules	Flexural Strength (N/mm^2)	Ultimate Load KN
1.	Conv	13.6	29.9
2.	5%	15.4	39.2
3.	10%	17.9	43.0
4.	15%	20.1	45.4
5.	20%	16.5	35.9
6.	25%	15.3	33.5



CONCLUSION

- The results of Compressive Strength show that addition of 15% influencethe strength parameters. Also the replacement of Coarse aggregate up to 15% by weight of aggregate volume has increased the compressive strength.
- The results of Split Tensile Strength show that addition of 25% influencethe strength parameters. Also the replacement of Coarse aggregate up to 25% by weight of aggregate volume has increased the compressive strength.
- The results of Flexural Strength show that addition of 25% influence thestrength parameters. Also the replacement of Coarse aggregate up to 25% by weight of aggregate volume has increased the compressive strength.
- Sulphate attack, the compressive strength reduces the most, up to 8.9%, at15% replacement of plastic granules. Following 15%, the compressive strength continues to decrease and reaches a low of 12.5% at 20% replacement of plastic granules. As per the observations the weight of the specimen decreases the most, up to 11.25%, at 10% replacement of plastic granules after sulphate attack.
- Chloride attack indicate that the compressive strength decreases the most, up to 11.5%, at 1 5 % replacement of plastic granules after chloride attack. Subsequently, at 25% replacement of plastic granules, it decreases further to a maximum of 12%. Similarly, that after chloride attack, the weight of the specimen decreases the most, up to 6.19%, at 15% replacement of plastic granules. After 15% replacement of plastic granules, the weight continues to decrease, reaching a minimum of 5.83% at 5% replacement of plastic granules.

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