Strength characterization of novel concrete using plastic waste as additional material

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Abstract: An investigation is carried out to find the optimum usage of plastic waste in the cement motor of 1:3 mix and cement concrete of grade M30. PVC (Polyvinyl chloride) taken from switch plug. ABS (Acrylonitrile Butadiene Styrene) taken from electronic waste. PP (Polypropylene) taken from broken chairs are there different plastics used in this research. Plastic added as 2, 4, and 6% in both cement motor and cement concrete mix as an experiment. Specimen (70.7mmx70.7mmx70.7mm) used for cement motor. Compression strength Specimen (150×150×150mm) for compressive strength of concrete and Specimen size of 150×300mm for Split tensile strength are cast for testing hardened concrete. Curing is down for 28 days. The compression strength test and split tensile strength test us down to the concrete and compression strength of cement is down to the cement motor. Cement mortar strength was increased to 2% to 3.6% by the replacement of plastic waste when compared with normal cement mortar. The compressive strength of conventional concrete increased to 1% for PVC waste.

Keywords: Plastic waste, Polyvinyl chloride, Acrylonitrile Butadiene Styrene, Polypropylene.

1. INTRODUCTION

Presently mother earth is facing a lot of problems, that mainly population pollution and minimization of natural nonrenewable resources. These three leading to the satiability problem in the future, researches are going on these problems [8]. as a result, some solutions as finding like new methods or new techniques or innovations are made but it's not enough, it's our responsibility to do some word regarding their aspects. In 2019, the world produced 400 million tons of plastics, in which 10-20% of total produced plastic is only recycled. Remaining 80-90% is just used as landfilling or dumped without any treatment. The construction industry [1] is one of the huge users of natural nonrenewable resources like water, sand, gravel which causes a large impact on satiability, minimization the usage and uses plastic waste as alternate construction materials. In this research PVC (Polyvinyl chloride) taken from switch plug. ABS (Acrylonitrile Butadiene Styrene) taken from electronic waste. PP (Polypropylene) taken from broken chairs. Used in motor, concrete with 2%, 4%, and 6% of total weight, the grade of concrete used is M30 [5] (The mix design is adopted as per (IS: 10262-2009) and cement motor of 1:3. Specimen cast for cement mortar with and without plastic waste, Specimen size of 70.7mmx70.7mmx70.7mm used for cement motor compression strength. Specimen size of 150×150×150mm for compressive strength of concrete and Specimen size of 150×300mm for Split tensile strength are cast for testing hardened concrete [4] Curing is down for 28 days, Specimens are tested for 7 and 28 days. Cement mortar strength was increased to 2% to 3.6% by the replacement of plastic waste when compared with normal cement mortar. The compressive strength of conventional concrete increased to 1% for PVC waste. Split tensile strength of self-compacting concrete increased to 7% by replacing plastic waste.
2. MATERIALS AND METHODS

2.1. Materials

2.1.1. Cement. Ordinary Portland Cement OPC 53 Grade available in the local market was used as per IS: 269-2015. The specific gravity of cement found in laboratory is 3.06.

2.1.2. Fine aggregate. Fine aggregates passing through 4.75mm IS sieve conforming to grading zone 11 of IS383-2015 the specific gravity of fine aggregate 2.52.

2.1.3. Coarse aggregates. Coarse aggregate available from local sources with maximum size of 20mm and conforming to IS383-2015 the specific gravity of coarse aggregate 2.6

2.1.4. Plastic waste. PVC (Polyvinyl chloride) taken from switch plug. ABS (Acrylonitrile Butadiene Styrene) taken from electronic waste. PP (Polypropylene) taken from broken chairs. Plastic waste was collected from crushing plant which is located at wgl-hyd highway. Cost of the plastic is per kg 30Rs Specific gravity of plastic waste is having much differences when compare to aggregates.

2.1.5. Water. Potable water (As per IS 3025) was used in the experimental work for both mixing and curing.

2.2 Methods

2.2.1. Compressive strength test of cement mortar. The test is of under IS 4031(part6)1998. The average compressive strength of three specimen cubes (area of face 70.7 mm² with a ratio of 1:3 composed of one part of cement and three parts of standard sand by mass and(P/4 + 3) percentage of a combined mix of cement and sand. where  P is a consistency of cement as per IS 4031(part4)1988.

2.2.2. Compressive strength test of concrete. The test of determining the compressive strength of concrete has attained maximum importance in concrete technology the durability, bond strength, tensile strength were interlinked with compressive strength for testing the compressive strength of concrete 150mm cubes are generally used [2]. The procedure is followed under IS516-1959 collecting and mixing the materials based on the mix design than the material is filled into the cube and the compaction is done by hand with the standard rod uniformly over the cross-section of the cube. After 24hrs the specimen is removed from the mould and kept immediately in clear and freshwater, the specimens are usually tested at 7 and 28 days of curing. To determine the compressive strength,

\[
\text{Compressive strength} = \frac{\text{load}}{\text{area}}
\]

2.2.3 Split tensile strength test of concrete. It is the method of determining the tensile strength of concrete using a cylinder which splits across the vertical diameter. Which is carried out under code of IS 516-1959. The length of the specimens shall not be less than the diameter and not more than twice the diameter [3]. For routine testing and comparison of results, unless otherwise specified the specimens shall be cylinder 150mm in diameter and 300mm long. The procedure of making and curing tension test specimen in respect of sampling of materials, preparation of materials, proportioning, weighing, mixing, workability, moulds, compacting and curing shall completely in all respects with the requirements.

\[
T = \frac{2P}{\pi LD}
\]

Where: T= splitting tensile strength, N/mm², P= maximum applied load in Newton, L= length of specimen 300 mm, D = diameter of specimen 150 mm
3. METHODOLOGY

The different materials are PVC (Polyvinyl chloride), ABS (Acrylonitrile Butadiene Styrene), PP (Polypropylene) were used, first the cement mortar of 1:3 ratio is adopted with and without plastic waste, the specimens were casted in different percentages of 2%, 4%, 6%, of plastic materials like PVC, ABS, PP the materials are casted in 70.7mmX70.7mmX70.7mm cube for determining compressive strength of cement mortar is widely conducted to know which percentage is giving an rate of strength. Where as per this test results as shown in table 1 the 4% of plastic waste used materials give a high strength were it helps in using as it is in the conventional concrete. The Mix design is prepared as per IS 10262-2019 for M30 concrete [9]. The conventional concrete is prepared with and without plastic waste the specimens for compressive strength test and split tensile strength test was casted in 150mmX150mmX150mm cube and 150mm diameter 300mm height cylinder

4. RESULTS AND DISCUSSION

| SL | Mortar type | Mortar proportion & Plastic waste | 7 days(N/mm²) | 28 days(N/mm²) |
|----|-------------|----------------------------------|---------------|---------------|
| 1  | CM          | (1:3) 0%                          | 37.80         | 50.20         |
| 2  | CM+PVC      | (1:3) 2%                          | 40.20         | 51.53         |
| 3  | CM+PVC      | (1:3) 4%                          | 36.93         | 52.10         |
| 4  | CM+PVC      | (1:3) 6%                          | 38.44         | 51.42         |

From the above results (Table 1) understanding that CM+PVC cement motor (1:3) with 2% plastic waste getting the highest value in both 7 and 28 days strength.

![Graphical representation of compressive strength of cement motor (CM+PVC)](image)

From the above results (Table 2) & Figure 2 understanding that CM+ABS cement motor (1:3) with 4% plastic waste getting the highest value for 28 days strength.

| SL | Mortar type | Mortar proportion & Plastic waste | 7 days(N/mm²) | 28 days(N/mm²) |
|----|-------------|----------------------------------|---------------|---------------|
| 1  | CM          | (1:3) 0%                          | 37.80         | 50.20         |
| 2  | CM+ABS      | (1:3) 2%                          | 34.32         | 51.12         |
| 3  | CM+ABS      | (1:3) 4%                          | 35.20         | 51.20         |
| 4  | CM+ABS      | (1:3) 6%                          | 35.92         | 50.32         |
Figure 2. Graphical representation of compressive strength of cement motor (CM+ABS)

Table 3. Compressive strength of cement motor (CM+PP)

| Sl. | Mortar type | Mortar proportion & Plastic waste | 7 days (N/mm²) | 28 days (N/mm²) |
|-----|-------------|-----------------------------------|----------------|-----------------|
| 1   | CM          | (1:3) 0%                          | 37.80          | 50.20           |
| 2   | CM+PP       | (1:3) 2%                          | 38.80          | 50.32           |
| 3   | CM+PP       | (1:3) 4%                          | 34.52          | 51.20           |
| 4   | CM+PP       | (1:3) 6%                          | 34.42          | 50.42           |

From the above results (Table 3) & Figure 3 understanding that CM+PP cement motor (1:3) with 4% plastic waste getting the highest value for 28 days strength.

Figure 3. Graphical representation of compressive strength of cement motor (CM+PP)

Table 4. Compressive strength of concrete

| Sl. No. | Concrete type | Plastic waste | 7 days(N/mm²) | 28 days(N/mm²) |
|---------|---------------|---------------|---------------|----------------|
| 1       | CC            | 0%            | 24.16         | 36.48          |
| 2       | CC+PVC        | 4%            | 24.62         | 36.87          |
| 3       | CC+ABS        | 4%            | 24.02         | 36.12          |
| 4       | CC+PP         | 4%            | 24.82         | 36.84          |

From the above results (Table 4) & Figure 4 understanding that CC+PVC with 4% plastic waste getting the highest value for 28 days strength.
5. CONCLUSION

1. From the above results, it is clear that cement motor (1:3) with all three different 4% plastic wastes (PVC, ABS, PP) getting the highest value for 28 days Compressive strength of cement motor.

2. By adding 4% PVC plastic waste, the highest value of compressive strength of 36.87 N/mm² is optioned as compared with other plastic waste.

3. By adding 4% PP plastic waste, the highest value of split tensile strength 4.02 N/mm² is optioned as compared with other plastic waste.
ACKNOWLEDGMENTS

Authors wishing to acknowledge Dr. R. Gobinath, HOD, department of civil engineering and faculty for helping to complete this research successfully

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