Experimental study on the use of waste plastics in concrete

J. Sheeba Ebenezer[1], Shahnawaz Ahmad[2], Kiran R. Govindappa[3], Khaled Alawi Mohammed[4], Mohammed Amin Bait Fareed[5], Ahmed Mohammed Kashoob[6]

[1,2,3]*Lecturer, Civil and Architectural Section, College of Engineering and Technology, University of Technology and Applied Sciences, PO Box 608, PC: 211, Salalah, Oman*

[4,5,6]*Student, Civil and Architectural Section, College of Engineering and Technology, University of Technology and Applied Sciences, PO Box 608, PC: 211, Salalah, Oman*

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Abstract - *In this project, the results of a pilot study were conducted to study the effects when the use of plastic waste in concrete as a replacement for fine aggregate. This study takes advantage of plastic waste to propose an environmentally friendly solution to address the plastic waste problem. In this experimental study, the replacement was done at 0% 1% 2% 3% and an optimum proportion of plastic was estimated based on compressive strength test results. Replacement results were comparable with the controlled mix results in terms of compressive strength test result, 2% replacement showed a considerable amount of increase in compressive strength, and further addition of plastic decreases the compressive strength.*

Key Words: **Plastic, Waste, Concrete, Compressive strength**.

1. INTRODUCTION

1.1 General

Polymers are the main component of the diverse class of synthetic or semi-synthetic materials known as plastics. Plastics can be moulded, extruded, or pressed into solid objects of many shapes because of their fluidity. It has gained popularity due to its versatility as well as several other attributes, such as being strong, lightweight, flexible, and reasonably priced to produce. Usually, plastics are produced using human industrial systems. [1]

Natural, organic materials like cellulose, coal, natural gas, salt, and, of course, crude oil are the raw materials used to make plastics. Before it can be used, crude oil must be processed because it is a complicated mixture of thousands of different compounds. Crude oil is first distilled in an oil refinery before plastics are made. By doing this, the heavy crude oil is separated into fractions, which are collections of lighter components. Each fraction is a blend of hydrocarbon chains, which are chemical compounds composed of hydrogen and carbon. The molecules in these chains vary in size and structure. Naphtha, one of these fractions, is an essential substance for making plastics.[2]

The world is facing a global plastics crisis. Out of the 8.3 billion tons of plastics produced since the 1950s, there is virtually no place on Earth which is left untouched by plastic pollution. Plastic waste is now so universal in the natural environment that scientists have even suggested it could serve as a geological indicator of the next era.[3]

1.2 Objectives

The aim of the experimental study is the use of plastic waste in concrete as a replacement of fine aggregate. This was done to reduce plastic waste, preserve the environment, and do something innovative and new in concrete. The results of the study gave the possibility of using plastic waste as building materials.

1.3. SCOPE

The main objective of this study is

1. to study the use of waste plastic materials in concrete mix and finding the strength and workability results of waste plastic reinforced concrete and conventional concrete.

2. The different percentages of waste plastic reinforced concrete used in the experimentation are 0%, 1%, 2%, and 3% with C25 mix concrete.

3. The results are compared with the plastic reinforced concrete produced and conventional concrete

2. LITERATURE REVIEW

P. Pooja (2019), According to this study, one of the main issues that arises in every nation is the disposal of plastic. According to government statistics, over 15,000 tons of plastic waste are produced daily in India, with 6,000 tons going uncollected and ending up in the streets. Reusing large waste is thought to be the most environmentally friendly way to address the disposal issue. Plastic is one such waste that has several potential uses.

In this project, it was discussed about the behaviour of concrete with partial replacement of fine aggregate with plastic wastes ranging from 15-30% with small grain size incorporated and 20% replacement showed a considerable amount of increase in compressive strength, and further addition of plastic decreases the compressive strength. [4]

Dharmaraj (2016) researched the topic of Recycling plastic waste contributes to the nation's sustainable development and lessens waste disposal issues. The mechanical strength characteristics of concrete containing varying percentages (0–55%) of waste plastic aggregates were evaluated. Plastic aggregates, which are grains produced as the byproduct of the polymer recycling industry, are utilized in this work to replace fine aggregates in concrete. Compressive, split tensile, and flexural strengths are increased when plastic aggregate is added in place of fine aggregate, which aids in the creation of sustainable concrete. It is observed that, the optimum % of replacement of sand with waste plastic waste is 40% and it is also found that up to 55% of sand replacements with plastic wastes. Mechanical strength values are comparable with that of the normal concrete.[5]

Rakinul Islam (2020) found that, because of its benefits to the environment and the economy, reusing plastic waste to make concrete or mortar seems like an environmentally friendly way to get rid of it. The types of plastics, recycled plastics, and the recycling process are first illustrated in this paper. The influence on cementitious composites properties is then discussed in three sections: durability, mechanical properties, and physical properties. Large amounts of waste plastic are present, and their limited biodegradability has a detrimental impact on the environment. Every kind of plastic used in daily life eventually turns into waste and cannot be recycled completely right away. Tons of plastic waste require a lot of space to be stored. Reusing waste has several benefits, including recycling, lowering energy consumption and pollution levels, and maintaining and conserving irreplaceable natural resources.[6]

Dr. T. Srinivas (2020) investigated the use of recovered plastic trash to partially substitute fine aggregate in the creation of sustainable concrete. The use of two recycled plastic wastes, polyethylene terephthalate (PET) and polypropylene (PP), as fine aggregate in concrete has been examined in this study. In the percentages of 5, 10, 15, 20, and 25, recycled plastic trash has been used to partially replace the fine aggregate (River Sand) in M30 grade concrete. To determine the appropriate percentage of PET and PP incorporation in concrete, the workability and compressive strength results are examined. As the percentage of regenerated plastic waste increases, the workability decreases, according to the data. Ten percent is the ideal replacement percentage for PET. PP has shown a marginal reduction in compressive strength for 5% replacement.[7]

3. METHODOLOGY

The following methodology was used to study of strength behaviour of concrete using plastic waste in concrete as a replacement of fine aggregate. Here, the basic properties like specific gravity of fine aggregates and sieve analysis of coarse aggregates were done. C25 mix was designed and for the concrete samples, weight-based batching was used. Mixture mixing was used to mix aggregates, cement and water. Vibration compacting was used for compacting concrete samples. Curing of concrete specimen was done by keeping samples inside the water tank. Testing of compressive strength test was done using the Compressive strength testing Machine. Fine aggregate was partially replaced with 0%, 1%, 2%, and 3% by weight with the plastics. Compressive strength tests for C25 grade concrete with varied amounts of waste plastics were done after 7 and 28 days of curing. The strength results obtained were compared to those of standard concrete and the results for compressive strength were studied. The tests were done in the laboratory and the results are tabulated given.

Figure -1: Specific gravity test

Figure -2: Sieve Analysis

Table – 1: Properties of Aggregates

S. No	Tests done in Lab	Result
1	Specific gravity of fine aggregates	Specific gravity = 2.728
2	Sieve Analysis of coarse aggregates	Fineness Modulus = 4.95

Materials: In this research study, the 53 grade of ordinary Portland cement (OPC) was used. The coarse aggregate used in this study was angular shaped because angular aggregate provides more strength. C25 grade concrete design mix was done. The aggregate sizes used in the test were in the range between 10mm and 20mm. Fine aggregate was having a specific gravity of 2.728. Locally available transportable water was used.

Table – 2: Quantities of materials used

S. No.	Cement (kg)	Fine aggregate (kg)	Coarse aggregate (kg)	W/C
1.	14.25	14.25	28.5	0.55

In this study, plastics was used as a partial replacement of fine aggregate. The aggregates used in this study was replaced 0%, 1%, 2% and 3% by weight with plastics for making concrete and results compared with Normal concrete.

Table – 3: % Replacement of plastics with fine aggregate

S. No.	% Replacement of plastics with fine aggregates	Plastics added (kg)	Fine aggregates(kg)
1	0	0	14.25
2	1	1.425	12.825
3	2	2.85	11.4
4	3	4.275	9.975

Testing:

The slump test was done, and the table below shows the value.

Table -4 - Slump test

% of Plastics Used	Slump in mm
0%	150
1%	120
2%	120
3%	130

Table- 5 – Standard Result of slump test

Degree of workability	Slump (mm)
Very low	0-25 mm
Low	25-50 mm
Medium	50-100 mm
High	100-175 mm
Very high	collapsed

Compressive strength: Cubes and specimens of 150 mm by 150 mm by 150 mm are used for compressive strength tests. The design of the concrete mix, concrete quality, cement strength, water-to-cement ratio, curing, and other variables all affect the concrete's compressive strength. Other factors including the mixing, placing, and curing of the concrete also have an impact. Concrete's compressive strength was determined by using a compressive testing machine.

Compressive Strength = P/A where, P = Compressive load in kN and A = Area of cube in mm^2.

Figure -5: Compressive strength test

The 7 days and 28 days average compressive strength of 6 specimens were taken and results are shown below in Table - 6.

Table -6: 7 days and 28 days Compressive strength test

% Replacement of plastics with fine aggregates	Strength in 7 days (N/mm^2)	Strength In 28 days (N/mm^2)
0	21.23	27
1	21.03	27.57
2	24.93	29.83
3	22.03	28.47

4. RESULT AND DISCUSSION

The density of the aggregate in relation to the density of water is its specific gravity. An aggregate's specific gravity value indicates how thick it is in relation to water. a material's mass per unit volume at a certain temperature divided by the mass of an equivalent volume of water at the same temperature. An aggregate's specific gravity serves as a gauge for the material's strength or quality. In general, low specific gravity aggregates are weaker than high specific gravity aggregates. This characteristic aids in the broad classification of aggregates.

The specific gravity of fine aggregate is between 2.4 to 2.9 and the result is 2.728

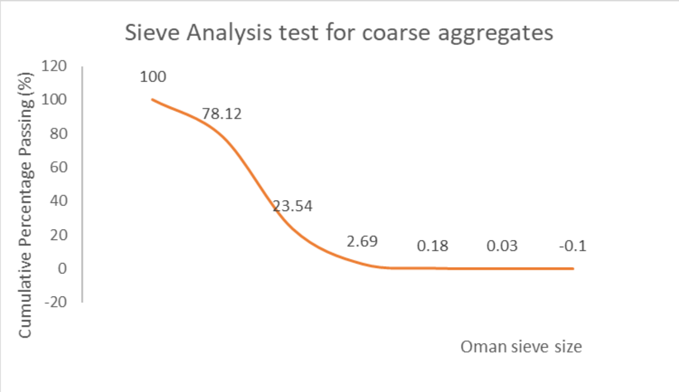

Figure -6: Sieve test curve

The distribution of aggregate particles by size inside a sample is ascertained using a gradation test, often known as a sieve analysis. It is employed to assess adherence to production and design specifications.

Gravel, or coarse aggregate: The aggregate that remains on a 4.75 mm sieve is referred to as coarse aggregate.

Well-graded: Aggregates that are well-graded have a uniform particle size distribution from the finest to the course. A well-graded aggregate concrete core slice reveals a dense field of particles with a wide range of sizes. It is distinguished by an S-shaped gradient curve.

Poor graded: Small size variations are a hallmark of poor-graded aggregate. Aggregate particles of nearly uniform size are present in it. This means that the particles pack together, leaving relatively large voids in the concrete. It is also called "uniform-graded". It is characterized by steep curve

The aggregate used is properly graded as it is clear from the above curve.

The purpose of the slump test was to determine the consistency and workability of freshly mixed concrete, and consequently, the ease of flow. To guarantee immediate concrete quality in a construction project, this test is essential. Almost all building sites use it.

The slump test is quite straightforward and manageable. Additionally, it requires relatively less equipment and can be completed quickly. Under field conditions, the slump test is used to guarantee homogeneity for various concrete loads. Most preferred value range of slump is 5-17.5 cm.

The result is more than the range of slump value.

The 7 days and 28 days average compressive strength of 6 specimens were taken and results are shown below in figure 7 and figure 8.

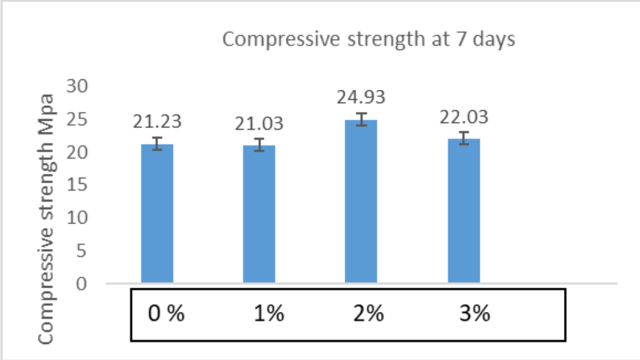

Figure -7: 7 days Compressive strength (MPa)

From the above Figure 7 the compressive strength of plastic replaced concrete at 7 days strength can be studied. According to the graph above, when plastic is added up to 2% by weight of fine aggregates, concrete has an optimum compressive strength of 24.93 MPa. When plastic content exceeds 2%, compressive strength gradually falls.

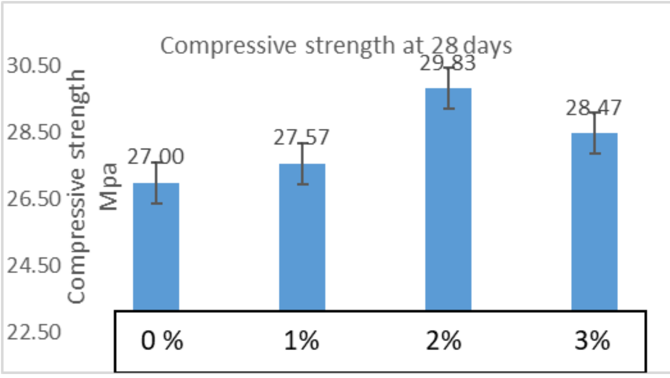

Figure -8: 28 days Compressive strength (MPa)

From the above Figure 8, the compressive strength of plastic replaced concrete at 28 days strength can be studied. According to the graph above, when plastic is added up to 2% by weight of fine aggregates, concrete has an optimum compressive strength of 29.83 MPa. When plastic content exceeds 2%, compressive strength gradually falls.

5. CONCLUSION

The ability of a material or structure to support loads on its surface without cracking or deflecting is known as compressive strength. The concrete cube test's compressive strength gives you a general sense of all the concrete's properties. One can determine whether concrete has been done correctly with this one test. In commercial and industrial buildings, concrete's compressive strength ranges from 15 MPa to 30 MPa and beyond general construction. Numerous factors, including the water-to-cement ratio, cement strength, concrete material quality, quality control throughout production, etc., affect concrete's compressive strength. The main purpose of compressive strength data is to ascertain whether the concrete mixture as supplied on site satisfies the task specification's stipulated strength, fc'.

The compressive strength of concrete is 29.83 MPa at 2% replacement of plastics with fine aggregate.

Results from replacement were similar to those from the controlled mix. 2% replacement demonstrated a significant gain in compressive strength, however additional plastic addition leads in a drop in compressive strength. 0% outcomes in terms of compressive strength test results.

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