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

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***Abstract*— In this paper low density poly ethylene (LDPE) granules used as replacement for coarse aggregate for producing concrete cubes and cylinders has been investigated and reported. LDPE based concrete cubes and cylinders were cast manually and the strength of the test concrete in terms of compression and split tension were experimentally evaluated. It is found that the strength of plastic replaced concrete in terms of compression and split tension can be comparable with the conventional concrete. The present study is aimed at concrete mix with partial replacement of coarse aggregate by LDPE granules (0%, 10%, 20% and 30%) that will provide an advantage in reducing the dead weight of structure. This mix in the form of cubes and cylinders were subjected to compression and split tension to ascertain the strength parameter. Hence the use of plastic granules in concrete making is not only beneficial but alsohelpful in disposal of plastic wastes.**

Keywords*— *Compressive strength, split tensile strength, flexural strength, plastic granules

I. INTRODUCTION

The problem of disposing and managing solid waste materials in all countries has become one of the major environmental, economical, and social issues. A complete waste management system including source reduction, reuse, recycling, land-filling, and incineration needs to be implemented to control the increasing waste disposal problems. Typically a plastic is not recycled into the same type of plastic products made from recycled plastics are often not recyclable. The use of biodegradable plastics is increasing. If some of these get mixed in the other plastics for recycling, the reclaimed plastic is not recyclable because the variance in properties and melt temperatures.

The purpose of this project is to evaluate the possibility of using granulated plastic waste materials to partially substitute for the coarse aggregate in concrete composites.

Among different waste fractions, plastic waste deserves special attention on account non- biodegradable property which is creating a lot of problems in the environment. In India approximately 40 million tons of solid waste is produced annually. This is increasing at a rate of 1.5 to 2% every year. Plastics constitute 12.3% of total waste produced most of which is from discarded water bottles. The plastic waste cannot be disposed off by dumping or burning, as they produce uncontrolled fire or contaminate the soil and vegetation.

Considerable researches and studies were carried out in some countries like USA and UK on this topic. However, there have been very limited studies in India on plastics in concrete. Hence an attempt on the utilization of waste Low Density Polyethylene (LDPE) granules as partial replacement of coarse aggregate is done and its mechanical behaviour is investigated.

II. LITERATURE REVIEW

[1] "Recycled Plastics as Coarse Aggregate for Structural Concrete": Praveen Mathew, Shibi Varghese, Thomas Paul, Eldho Varghese (2013)

The use of plastic is increasing day by day, although steps were taken to reduce its consumption. This creates substantial garbage every day which is much unhealthy. A healthy and sustainable reuse of plastics offers a host of advantages.

[2] "Recycled plastics used as coarse aggregate for constructional concrete" SJB Institute of Technology, Bangalore

Landfill sites are becoming overcrowded and expensive for waste disposal, efforts are made to minimize the quantities of materials that are delivered to landfills. The threat due to leaching of non-biodegradable materials like waste plastics, scrap tyres. E-waste may contaminate the soil and ground water.

[3] "Studies on Concrete containing E plastic waste" Lakshmi.R, K.L.N.College of Information Technology, Sivagangai Nagan.S, Thiagarajar College of Engineering, Madurai (2010)

Utilization of waste materials and by-products is a partial solution to environmental and ecological problems. Use of these materials not only helps in getting them utilized in cement, concrete and other construction materials, it helps in reducing the cost of cement and concrete manufacturing, but also has numerous indirect benefits such as reduction in land•fill cost, saving in energy, and protecting the environment from possible pollution effects.

[4] "Utilization of e-waste and plastic bottle waste in concrete" Ankit Arora, UG student, Dr. Urmil V. Dave, Senior Professor, Institute of Technology, Nirma University,Ahmedabad (2013)

E-waste and plastic waste are the major problem in today scenario as these are non- biodegradable. Attempts were made in past to use them in concrete by grinding them. But it failed to give good strength because grinded particle has flattened shape. Grinded plastic and e waste mixed with concrete is a good way to dispose them with cheap concrete production.

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MATERIALS USED

1. Cement

Cement is one the major component in the manufacturing process of concrete. It has the property to stick to any other raw material added in the preparation process of concrete, especially when comes in contact with water and hence produces a good paste. Here, OPC 53 grade cement is used whose properties are shown below.

2. Fine Aggregate

Fine aggregate is first graded to decide the zone to which it belongs to. Generally, there are four categories of fine aggregate Zone-I, Zone-II, Zone-III & Zone-IV. In this work, sand of zone-II is chosen whose properties were given below. Generally, fine aggregate is passed through 4.75 mm sieve.

3. Coarse aggregate

Coarse aggregate is another fundamental raw material which gives strength, hardness and increases the volume of the concrete. Here, coarse aggregate of size 20 mm and angular crushed shape is chosen.

4. Plastic

Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organics that are malleable and can be moulded into solid objects of diverse shapes. Plastics are typically organic polymers of high molecular mass, but they often contain other substances. They are usually synthetic, most commonly derived from petrochemicals, but many are partially natural. Plasticity is the general property of all materials that are able to irreversibly deform without breaking, but this occurs to such a degree with this class of mouldable polymers that their name is an emphasis on this ability.

LDPE granules

7. Admixture

Superplasticizer “Conplast SP 430” is used for casting of concrete samples. It is made of Sulphonated Naphthalene polymer, specified as per IS: 9103-979 that achieves in reducing the water content by 20%.

8. Water

Normal tap water is utilized in the present work in the preparation of concrete specimens.

III. RESULTS & DISCUSSIONS

TESTS ON CONCRETE:

Slump Test:

Workability is a term associated with freshly prepared concrete. This can be defined as the ease with which concrete can mixed, placed, compacted and finished. Slump test is the most commonly used method of measuring ‘workability’ of concrete in a laboratory or at site of work. It is used conveniently as a control test and gives an indication of uniformity of concrete from batch to batch. Vertical settlement of a standard cone offreshly prepared concrete is called ‘slump’.

Slump Test

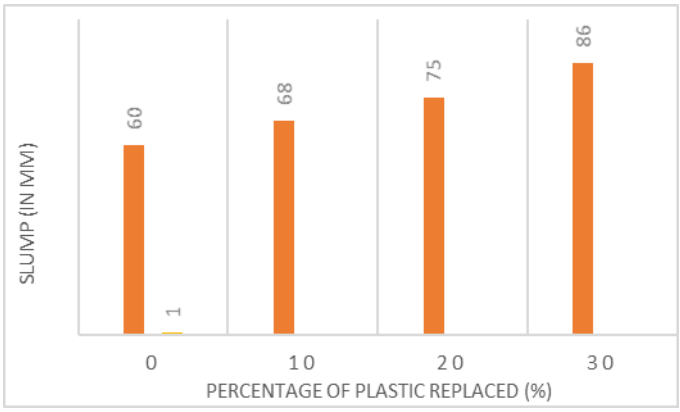

Fig 1: Slump values of concrete mixes replaced with various percentages of plastic granules

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Vol. 10 Issue 04, April-2021

Compaction factor test:

Compaction Factor is used to indicate workability of concrete where nominal size of aggregate does not exceed 40mm. It is a measure of density of concrete to which a fresh concrete mix can be compacted for a standard energy input relative to the theoretical maximum density corresponding to zero air content. This theoretical maximum density can be estimated in the laboratory as that obtained by full compaction under mechanical vibration. Compaction factor is calculated as below:

Compaction factor test

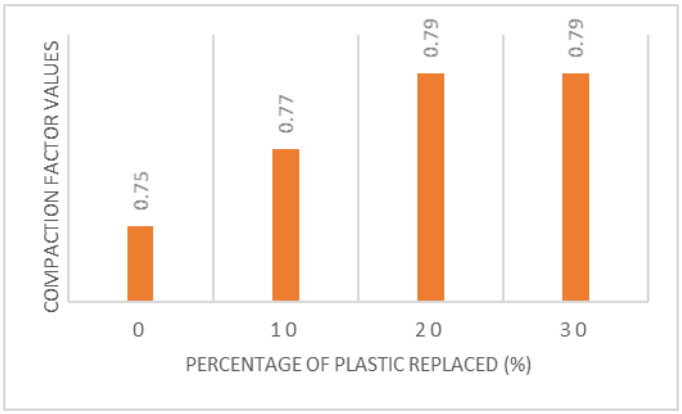

Fig 2: Compaction factor values of concrete mixes replaced with various percentages of plastic granules

Compressive strength test:

Compression Testing Machine

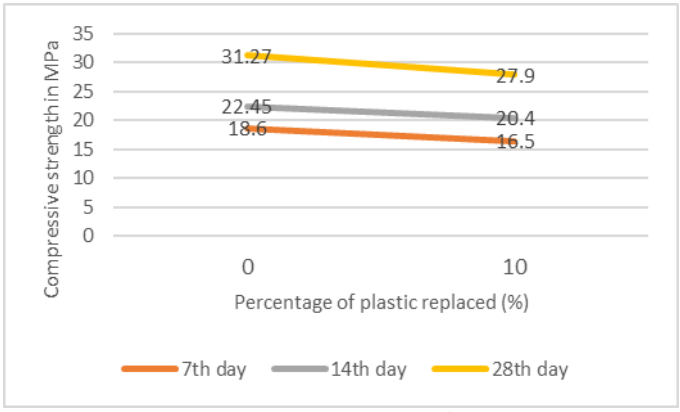

Fig 3: Compressive strength results comparison for 0% vs 10% plastic granules

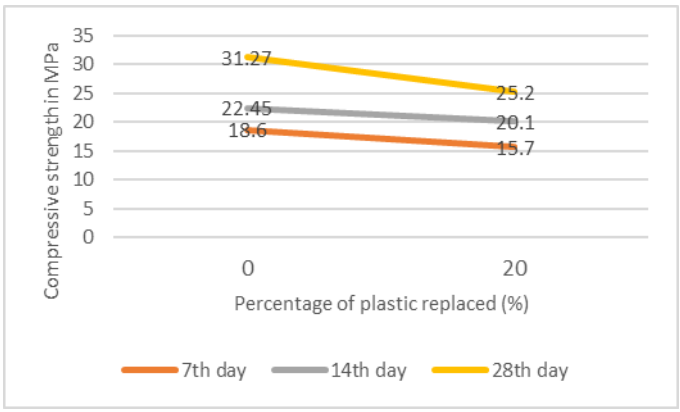

Fig 4: Compressive strength results comparison for 0% vs 20% plastic granules

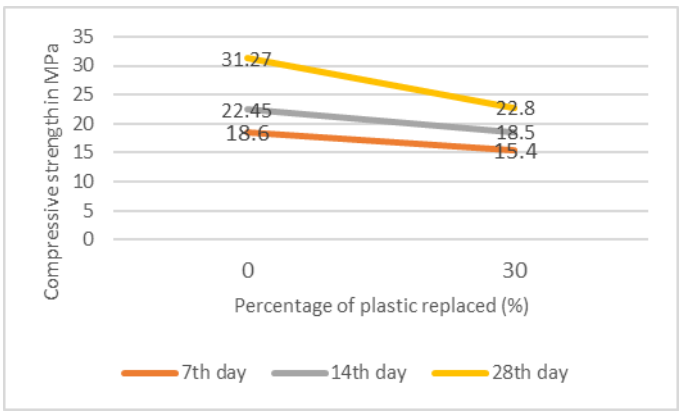

Fig 5: Compressive strength results comparison for 0% vs 30% plastic granules

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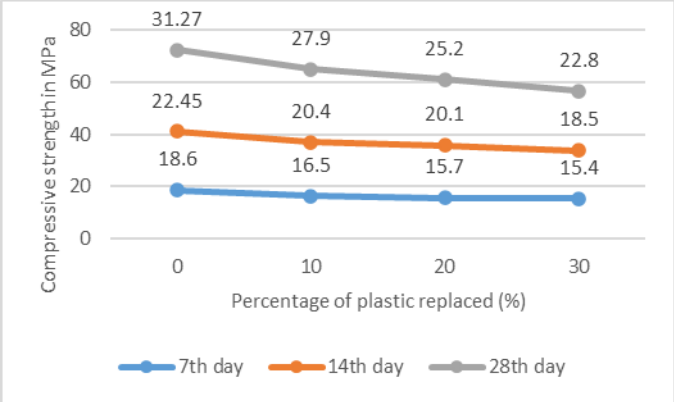
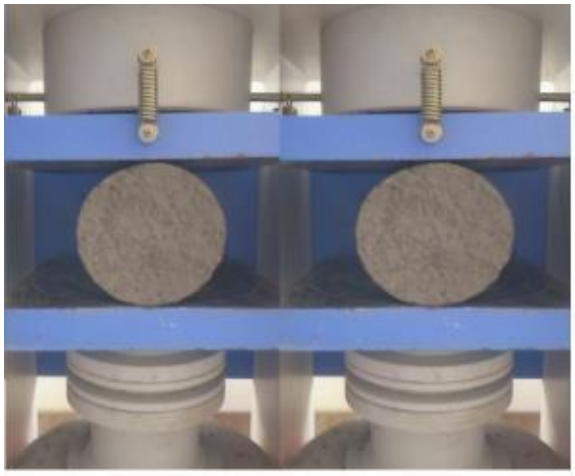


Fig 6: Compressive strength results for all substitutions of plastic granules

Split tensile strength test:



Split Tensile Test

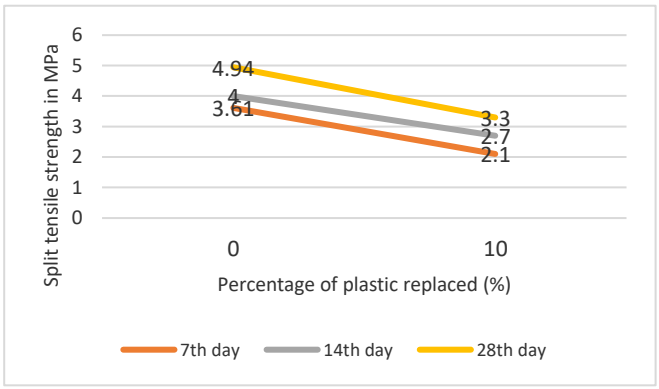


Fig 7: Split tensile strength results comparison for 0% vs 10% plastic granules

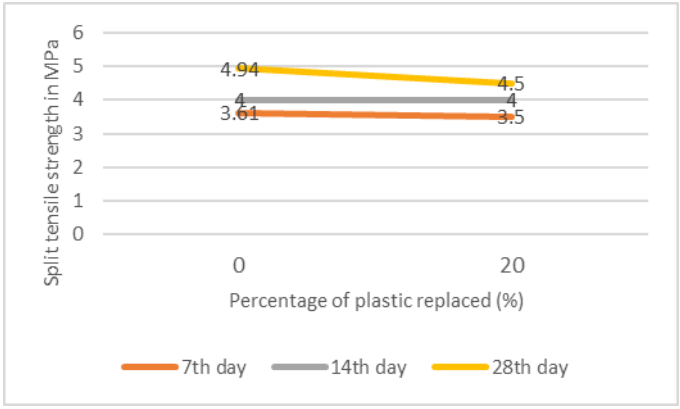


Fig 8: Split tensile strength results comparison for 0% vs 20% plastic granules

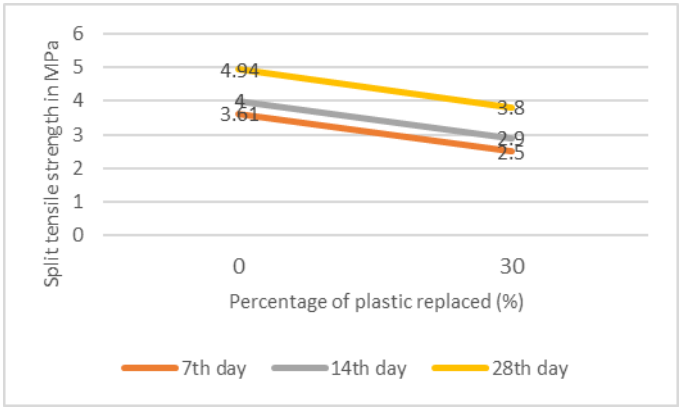


Fig 9: Split tensile strength results comparison for 0% vs 30% plastic granules

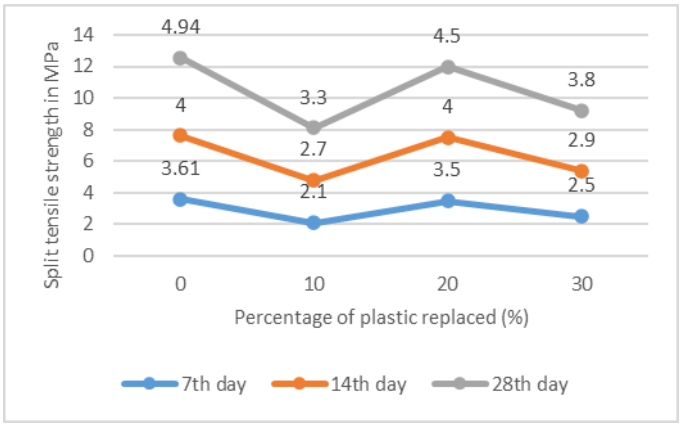


Fig 10: Split tensile strength results for all substitutions of plastic granules

IV. CONCLUSIONS

The experimental results have shown the use of waste plastic material in making concrete/mortar can provide an alternative solution to minimize the environmental impact due to unscientific disposal of waste plastic. The following conclusions were drawn:

- The properties of concrete containing various percentage of plastic (0%, 10%, 20%, and 30%) were tested for its physical properties and compressive strength.
- The waste plastic used for experiments is of LDPE (Low Density Poly Ethylene), 5-7mm size and specific gravity of waste plastic is found to be 0.92.
- The compressive strength of test concrete is compared

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with plain concrete (fig 1.1) and it is found that the compressive strength up to 80% is achieved for a mix of waste plastic up to 30% (as a replacement for coarse aggregate) in concrete. Hence it is recommended for light weight concrete structures.

- The mechanical properties of the test concrete did not display any notabledifferences depending on the color of the plastic waste.
- This research also has potential application for the production of lightweight concrete, for minimizing the amount of polymer wastes in landfills, and the creation of decorative, attractive landscaping products.

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