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To Study the Behavior of Concrete By Partial Replacement of Recycled Coarse Aggregate With Recycled Plastic Granules

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Abstract - In this research 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 - low density poly ethylene (LDPE), coarse aggregate, compression and split tension strength

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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. 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.

Significance:

Concrete is the most widely used man made construction material in the world and its second only to water as the most utilized substance in the planet. Seeking aggregates for concrete and to dispose of the plastic waste is the present concern. Today sustainability has got top priority in construction industry. In the present study the recycled plastics were used to prepare the coarse aggregates thereby providing a sustainable option to deal with the plastic waste. There are many recycling plants across the world, but as plastics are recycled they lose their strength with the number of recycling. So these plastics will end up as earth fill. In this circumstance instead of recycling it repeatedly, if it is utilized to prepare aggregates for concrete, it will be a boon to the construction industry.

Most of the failures in concrete structures occur due to the failure of concrete by crushing of aggregates. Plastic Coarse Aggregates which have low crushing values will not be crushed as easily as the stone aggregates. These aggregates are also lighter in weight compared to stone aggregates. Since a complete substitution for Normal Coarse Aggregate

is not found feasible, a partial substitution with various percentage of Plastic Coarse Aggregate is done. Volumetric substitution was employed in this investigation.

LITERATURE REVIEW

The past researchers research in all aspects is covered in this literature review

Praveen Mathew, (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. The suitability of recycled plastics as coarse aggregate in concrete and its advantages are discussed here. The initial questions arising of the bond strength and the heat of hydration regarding plastic aggregate were solved. Tests were conducted to determine the properties of plastic aggregate such as density, specific gravity and aggregate crushing value. As 100% replacement of natural coarse aggregate (NCA) with plastic coarse aggregate (PCA) is not feasible, partial replacement at various percentage were examined. The percentage substitution that gave higher compressive strength was used for determining the other properties such as modulus of elasticity, split tensile strength and flexural strength. Higher compressive strength was found with 20% NCA replaced concrete. Heat resisting behaviour of the PCA concrete is also discussed in this study.

Eldho Varghese (2017) 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. If the production of waste cannot be prevented, then it is attractive to create an alternative use in another process instead of disposal. The benefits of plastic recycling can be economically advantageous, due to abundant availability lower cost for mixing with other variants like concrete, bitumen etc. The development of concrete with nonconventional aggregate, such as polystyrene foam wastes, HDPE, polyethylene terephthalate (PET), and other plastic materials has been investigated for use in concrete in order to improve the properties of the concrete and reduce cost.

Nagan.S, Thiagarajar (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. Electronic waste, abbreviated as e-waste, consists of discarded old computers, TVs, refrigerators, radios – basically any electrical or electronic appliance that has reached its end-of-life.

OBJECTIVES

1. To compare the compressive strength of Recycled Plastics used as Coarse Aggregate for Constructional Concrete with the Conventional concrete.

2. .To compare the physical characteristics of natural aggregate with Plastic recycled aggregate.

3. To study the behavior of fresh and hardened concrete reinforced with plastic waste coarse aggregate.

MATERIALS

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.

Low-density polyethylene **(**LDPE) is a thermoplastic made from the monomer ethylene. It was the first grade of polyethylene, produced in 1933 by Imperial Chemical Industries (ICI) using a high pressure process via free radical polymerization. Its manufacture employs the same method today. The EPA estimates 3.3.7% of LDPE (recycling number 4) is recycled. Despite competition from more modern polymers, LDPE continues to be an important plasticgrade. In 2013 the worldwide LDPE market reached a volume of about US$33 billion.

Figure 1: LDPE granules

A cement is a binder, a substance that sets and hardens and can bind other materials together. The word "cement" traces to the Romans, who used the term *opus caementicium* to describe masonry resembling modern concrete that was made from crushed rock with burnt lime as binder. The volcanic ash and pulverized brick supplements that were added to the burnt lime, to obtain a hydraulic binder, were later referred to as *cementum*, *cimentum*, *cäment*, and *cement*. Cements used in construction can be characterized as being either hydraulic or non-hydraulic, depending upon the ability of the cement to beused in the presence of water. Non-hydraulic cement will not set in wet conditions or underwater, rather it sets as it dries and reacts with carbon dioxide in the air. It can be attacked by some aggressive chemicals after setting.

Fine aggregate (Sand) is a naturally occurring granular material composed of finely divided rock and mineral particles. It is defined by size, being finer than gravel and coarserthan silt. Sand can also refer to a textural class of soil or soil type; i.e. a soil containing more than 85% sand-sized particles (by mass).

Construction aggregate (coarse aggregate), or simply "*aggregate*", is a broad category of coarse particulate material used in construction, including sand, gravel, crushed stone, slag, recycled concrete and geosynthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concreteand asphalt concrete; the aggregate serves as reinforcement to add strength to the overall composite material. Due to the relatively high hydraulic conductivity value as compared to most soils, aggregates are widely used in drainage applications such as foundation and French drains, septic drain fields, retaining wall drains, and road side edge drains.

Tests on Materials : The tests on materials which are used for concrete tested under the standard conditions and results are follows

Tests on Cement:

Table 1: Properties of Cement

S. No.	Properties	Values obtained	Standard values
1.	Specific gravity	3.15	3.15
2.	Normal consistency	30%	30%
3.	Initialand Final setting time	30 min and 580 min	Not less than 30 mins Not greater than 10 hrs

Tests on Fine Aggregates

Table 2: Properties of fine aggregates:

Properties	Values obtained
Specific gravity	2.65
Water absorption	1.01
Fineness Modulus	2.699

Tests on Coarse Aggregates

Table 3: Properties of coarse aggregates:

Properties	Values obtained
Specific gravity	2.68
Water absorption	0.8%

Test on Low Density Poly Ethylene (LDPE):

Table 4: Properties of Low Density Poly Ethylene (LDPE):

Properties	Values
Physical State	Solid
Appearance	Granules
Grain size	5-7 mm
Density	920 kg/m^3
Heat Resistance	80^o C

Mix Design:

Table 5: Calculation Of Plastic Granules Weight For The Mix

% replacement(by volume)	Weight of plastic granules used (kg)	Weight of coarseaggregate after replacement
10	2.71	79.2-2.37=76.83
20	5.43	79.2-5.43=73.76
30	8.13	79.2-8.13=71.07

Tests on Concrete:

Compressive strength test

Testing hardened concrete plays an important role in controlling and conforming the quality of cement concrete work. The main factor in favour of the use of concrete in structures is its compressive strength. One of the important properties of the hardened concrete is its strength which represents its ability to resist forces. The compressive strength of the concrete is considered to be the most important and is often taken as an index of the overall quality of

concrete. The compressive strength of concrete is defined as the load which causes the failure of specimen per unit cross section on compression under given rate of loading.

Table 6: Compressive Strength Test

% Granules added	Weight (kg)			Peak load (kN)			Compressive Strength (MPa)		
	7^{th} days	14^{th} days	28^{th} days	7^{th} days	14^{th} days	28^{th} days	7^{th} days	14^{th} days	28^{th} days
0 %	8.20	8.27	8.29	418.50	505.12	703.57	18.60	22.45	31.27
	8.10	8.17	8.22	402.75	501.07	723.37	17.90	22.27	32.15
10 %	7.96	7.99	8.00	371.5	391.90	562.20	16.50	20.40	27.90
	8.06	7.91	7.80	321.2	502.90	612.50	16.20	22.30	27.20
20 %	7.83	7.91	7.66	309	453.20	635.50	15.70	20.10	25.20
	7.60	7.76	7.75	334.6	438.00	621.50	14.80	19.40	26.60
30 %	7.83	7.75	7.80	373.9	416.30	739.80	15.40	18.50	22.80
	7.87	7.56	7.87	387.6	380.70	742.20	15.20	16.90	23.20

Results

Compressive strength of plastic replaced concrete is compared with conventional concrete. From graph it is found that a compressive strength up to 80% is achieved for a mix of waste plastic up to 30% (as a replacement for coarse aggregate) in concrete. The reduction in compressive strength of plastic replaced concrete is due to deficient bonding of plastic granules in the matrix.

Split tensile test

Concrete is not usually expected to resist the direct tension because of its low tensile strength and brittle nature. However the determination of tensile strength is necessary to determine the load at which the concrete members may crack. The cracking is a form of tensile failure.

Table 7: Split Tensile Test

Results:

Split tensile strength up to 70% is achieved for a mix of waste plastic up to 90% (as a replacement for coarse aggregate) in concrete.

The reduction in strength of plastic replaced concrete is due to deficient bonding of plastic granules in the matrix.

CONCLUSION:

The experimental results have shown the use of waste plastic material in making concrete/mortar can provide an alternative solution to minimize the environmental impactdue 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 with plain concrete and it is found that the compressive strength up to 80% is achieved for a mixof 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 notable differences 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.

Future Scope: The present research can be extended to

- The test can be carried out for different grades of concrete.
- The use of admixtures in the test can be performed to get improved strength.
- Experimental study has to be conducted for other varieties of plastics like HDPE, PP, PET etc.
- The durability of such a concrete has to be tested for beams and columns with varying proportions of waste plastic at different ages.

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