Evaluation of Use of Plastic Waste in Construction

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Abstract— One of the environmental issues in most regions of Iran is the large number of bottles made from poly-ethylene terephthalate (PET) deposited in domestic wastes and landfills. Due to the high volume of these bottles, more than 1 million m3 landfill spaces are needed for disposal every year. The purpose of this experimental study was to investigate the possibility of using PET waste in asphalt concrete mixes as aggregate replacement (Plastiphalt) to reduce the environmental effects of PET disposal. 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 aggregate 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 Conventional Aggregate was not found feasible, a partial substitution with various percentage of plastic aggregate was done. Both volumetric and grade substitution was employed in this investigation.

Keywords: Plastic Waste, Construction

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 behavior is investigated.

II. LITERATURE REVIEW

M. A. Kamaruddin et al. (2000): "Potential use of Plastic Wastes Construction Materials: Recent Progress and Future Prospect" Plastic associates products based have been considered as the world most consumer packaging solution. However, substantial quantities of plastic consumption have led to exponential increase of plastic derived waste. Recycling of plastic waste as valued added product such as concrete appears as one of promising solution for alternative use of plastic waste. This paper summarized recent progress on the development of concrete mixture which incorporates plastic wastes as partial aggregate replacement during concrete manufacturing. A collection of data from previous studies that have been researched which employed plastic waste in concrete mixtures were evaluated and conclusions are drawn based on the laboratory results of all the mentioned research papers studied.

K.S. Rebeiz and A.P. Craft (2000): "Plastic waste management in construction: technological and institutional issues" The main objective of a solid waste management system is to effectively safeguard the public health, safety, and welfare. The various options involved in a waste management process are land filling, incineration, and recycling wastes into useful products. Plastics recycling, in particular, would not be successful unless the proper infrastructure to collect the waste is being set, the technology to economically reprocess the waste into new products is available, and the establishment of markets for the cost-effective use of recycled products are developed. The development of new construction materials using recycled plastics is important to both the construction and the plastics recycling industries. Extensive research investigated the use of resins based on recycled poly (ethylene terephthalate) (PET) plastic waste for the production of a high performance composite material, namely polyester concrete (PC). Resins using recycled PET offer the possibility of a lower source cost of materials for forming good quality PC. PC products also allow the long-term disposal of PET waste, an important advantage in recycling applications.

III. EXPERIMENTAL INVESTIGATIONS

A. Plastic

Plastic is a material consisting of any of a wide range of synthetic or semi-synthetic organics that are malleable and can be molded 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 moldable polymers that their name is an emphasis on this ability.

B. Cement

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 be used in the presence of water.

C. Fine Aggregates

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 coarser than 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).

The composition of sand varies, depending on the local rock sources and conditions, but the most common constituent of sand in inland continental settings and non-tropical coastal settings is silica (silicon dioxide, or SiO2), usually in the form of quartz. The second most common type of sand is calcium carbonate, for example aragonite, which has mostly been created, over the past half billion years, by various forms of life, like coral and shellfish. It is, for example, the primary form of sand apparent in areas where reefs have dominated the ecosystem for millions of years like the Caribbean.

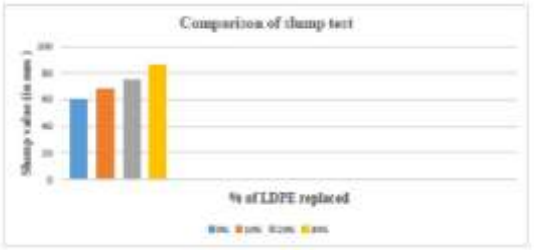
D. Coarse Aggregates

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 geo synthetic aggregates. Aggregates are the most mined materials in the world. Aggregates are a component of composite materials such as concrete and 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.

IV. EXPERIMENTAL RESULTS

A. Slump Test

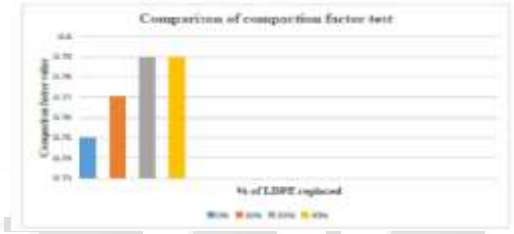
Workabilityisatermassociatedwithfreshlypreparedconcrete.Thiscanbedefinedastheease with which concrete can mixed, placed, compacted and finished. Slump test is the most commonly used method of measuring 'workability' of concrete in a laboratory or at site of work. It is used conveniently as a control test and gives an indication of uniformity of concrete from batch to batch. Vertical settlement of a standard cone of freshly prepared concrete is called 'slump'.



Compares on of Slump Value

B. 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.

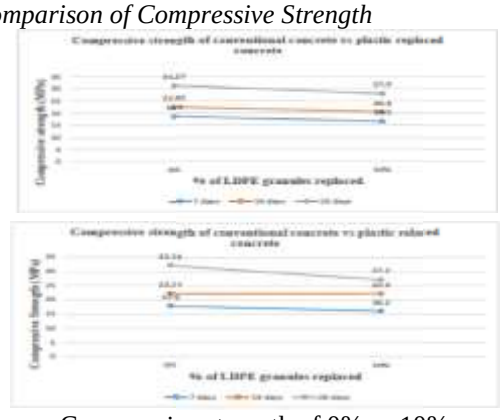


Comparison of Compaction Factor Test

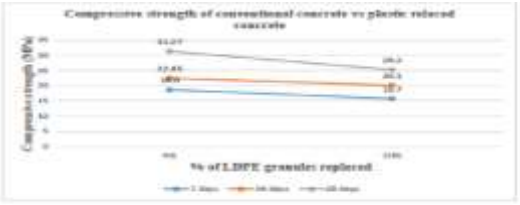
C. Compressive Strength Test

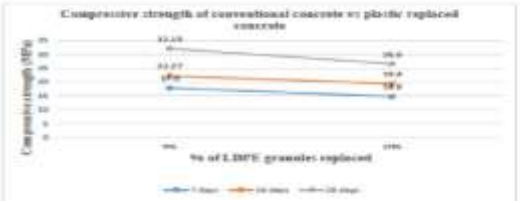
Testing hardened concrete plays an important role in controlling and conforming the equality of cement concrete work. The main factor in favor of the use of concrete in structures is its compressive strength. One of the important properties of the hardened concrete is its strength which represents its 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.

1) Comparison of Compressive Strength

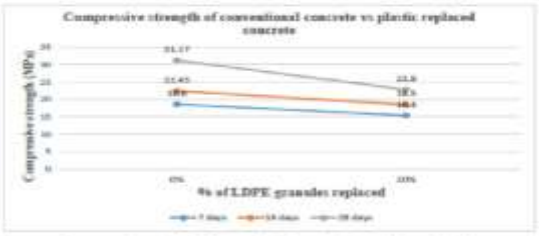


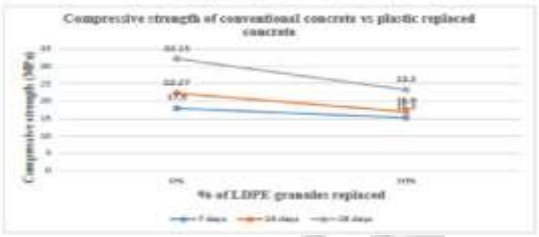
Compressive strength of 0% vs 10%



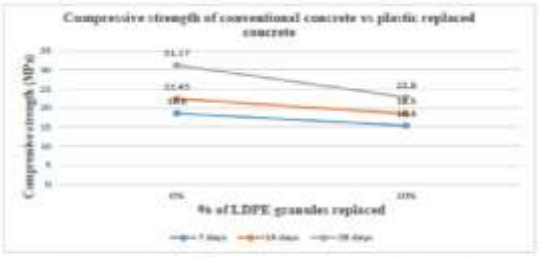


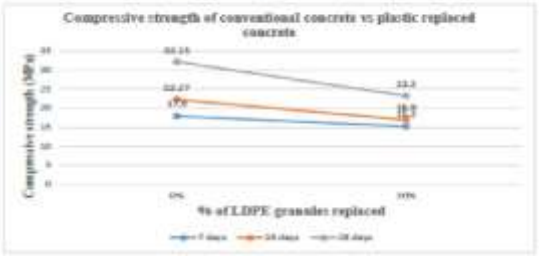
Compressive strength of 0% vs 20%





Compressive strength of 0% vs 30%





Compressive strength of 0%, 10% and 30%

2) Compressive Strength

Compressive strength of plastic replaced concrete is compared with conventional concrete.

Compressive Strength Test

3) 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.

Split Tensile Test

V. 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 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 be0.92.
- The compressive strength of test concrete is compared 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 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.

A. Advantages:

- A better workability is achieved for plastic reinforced concrete in comparison to the convention alone.
- Considerable reduction in the weight results in the formation of light weight concrete. Behavior of concrete by partial replacement of coarse aggregate with recycled plastic granules Dept. of Civil Engineering, TOCE, BANGALORE.
- Recycled plastic in the construction purpose can set a benchmark by utilizing the non-bio- degradable waste and eventually minimizing the environmental pollution.

B. Disadvantages:

- Strength achieved for the plastic replaced concrete is slightly less than the conventional concrete but can be improved by the use of admixtures.
- Cost of plastic is high in the place where we need to buy from the dealers and hence the cost of construction also increases.
- There is no proper bonding of plastic materials in the matrix unless admixtures are used.
- Plastics may be degraded under the action of direct sunlight which reduces their mechanical strength.
- Many plastics are flammable unless treated.
- High embodied energy content
- Low modulus of elasticity: makes them unsuitable for load-bearing applications.
- Thermoplastics are subject to creep and soften at moderate temperatures.
- Thermal expansion for most plastics is high: adequate thermal movement has to be allowed in detailing.
- Plastics are having low bonding properties so that the strength of concrete gets reduced such as compressive, tensile and flexural strength.
- Its melting point is low so that it cannot be used in furnaces because it gets melts its comes in contact with the heat at high temperature.

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