
UTILIZATION OF WASTE PLASTIC IN MANUFACTURING OF BRICKS

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ABSTRACT

The plastic bricks are lightweight and present a waxy surface. The results of plastic bricks are compared with those of traditional local bricks. It is observed that plastic bricks have low water absorption, low apparent porosity and high compressive strength. Plastic waste which is increasing day by day becomes eyesore and in turn pollutes the environment, especially in high mountain villages where no garbage collection system exists. A large amount of plastic is being brought into the tourist trekking regions are discarded or burned which leads to the contamination of environment and air. Hence, these waste plastics are to be effectively utilized. High-density polyethylene (HDPE) and polyethylene (PE) bags are cleaned and added with sand, cement & fly ash at various percentages to obtain high strength bricks that possess water and sound insulation properties to control pollution and to reduce the overall cost of construction, this is one of the best ways to avoid the accumulation of plastic waste which is a non-degradable pollutant. This alternatively saves the quantity of sand/clay that has to be taken away from the precious river beds/mines. The plastic waste is naturally available in surplus quantity and hence the cost factor comes down. Also Coloring agents can be added to the mixture to attain desired shades. Hence in this thesis, an attempt is made to study regarding the properties of the brick which is manufactured using plastic wastes.

Keyword- Plastic bricks, Garbage collection system, High-density polyethylene (HDPE), Polyethylene (PE) bags, non-degradable pollutant, etc.

1. INTRODUCTION

Plastic is a very common material that is now widely used by everybody in the world. Plastic plays a predominant role in reusable in this era, as it is compact and light in weight. Common plastic items that are used are covers, bottles, and food packages. The great problem with plastic is its decomposition. Plastic is made of polymer chemicals and they are non-biodegradable. This means that plastic will not decompose when it is placed in earth. Though plastic is a very useful material that is flexible, robust and rigid they become waste after their use and they pollute the air and land. Recycling is processing use waste materials into new products to prevent waste of potentially useful materials. The increase in the popularity of using eco-friendly, low cost and lightweight construction materials in building industry has brought about the need to investigate how this can be achieved by benefiting to the environment as well as maintaining the material requirements and their standards. From the advantages of plastic recycling procedure is used. For the production of plastic bricks is an optimal method for controlling the problem by decomposition of plastic waste and also it costs economical for the production of building materials. In this study, plastic waste from factories will be used to incorporate with cement and sand to produce sand bricks. The bricks will then be tested to study the compressive strength, efflorescence and water absorption. In the recent past research, the replacement and addition have been done with the direct inclusion of polyethylene, polyethylene terephthalate (PET) bottles in shredded form, chemically treated polyethylene-fiber, PET in small particles form by replacing natural coarse aggregate. Most of replacements have been done by volume calculation, and showed the decreased in compressive strength as the increased plastic waste.

2. MOTIVATION

Plastic waste is increasing day by day throughout the world. Where proper garbage collection system is not available, waste plastics are strewn everywhere which becomes eyesore. It also pollutes the environment. A

large amount of waste plastic are discarded or burned which leads to the contamination of environment and air. The large volume of materials required for infrastructure construction is potentially a major area for the reuse of waste materials. Recycling the plastics has advantages since it is widely used worldwide and has a long service life, which means that the waste is being removed from the waste stream for a long period. Reuse of waste plastics has environmental benefits not only related to the safe disposal of bulk waste, but also to the reduction of environmental impacts that arises due to burning of plastics. The present research is performed to study the properties of bricks manufactured by mixing sand and waste plastics. This study is expected to provide some information regarding the suitability of such plastic bricks for use in construction industry.

3. LITERATURE REVIEW

Youcef Ghernouti et al. (2017) The study present the partial replacement of fine aggregate in concrete by using plastic fine aggregate obtained from the crushing of waste plastic bags. Plastic bags waste was heated followed by cooling of liquid waste which was then cooled and crushed to obtained plastic sand having finesse modulus of 4.7. Fine aggregate in the mix proportion of concrete was replaced with plastic bag waste sand at 10%, 20%, 30% and 40% whereas other concrete materials remain same for all four mixes. In fresh properties of concrete it was observed from the results of slump test that with increase of waste content workability of concrete increases which is favorable for concrete because plastic cannot absorb water therefore excessive water is available. Bulk density decreases with increase of plastic bags waste. In harden state, flexural and compressive strength were tested at 28 days and reductions in both strengths with increasing percentage of plastic bag waste sand in concrete mix. Plastic waste increases the volume of voids in concrete which on other hand reduce the compactness of concrete simultaneously speed of sound in concrete is also decreased. Strength reduction in concrete mix was prime concern; however they recommend 10 to 20% replacement of fine aggregate with plastic aggregate. Use of admixtures to address the strength reduction property of concrete with addition of plastic aggregate is not emphasized. Khilesh Sarwe(2017)This study presents the results of addition of waste plastics along with steel fibers with an objective to seek maximum use of waste plastic in concrete. Two different categories of mix were casted in cubes (150mm x 150mm x 150mm), one with varying percentages of plastic wastes (0.2%, 0.4%, 0.6%, 0.8% and 1% weight of cement) and another mix of plastics waste/steel fibers (0.2/0.1, 0.4/0.2, 0.6/0.3, 0.8/0.4 and 1/0.5 % by weight of cement) to study the compressive strength at 7 and 28 days strength. The combine mix of plastic waste and steel fibers has shown more strength as compare to concrete mix prep only with plastic waste. He has reached to conclusion that a plastic waste of 0.6% weight of cement when used with steel fiber of 0.3 % (weight of cement) has shown the maximum compressive strength. This study has really focused on addressing the issue of reduced compressive strength with addition of plastic waste. Steel fibers when used along with plastic wastes will affect all the properties of concrete but the researcher only focused on compressive strength property which is insufficient to give clear picture of concrete behavior. R L Ramesh et al. (2015) they have used waste plastic of low density poly ethylene as replacement to coarse aggregate to determine its viable application in construction industry and to study the behavior of fresh and harden concrete properties. Different concrete mix were prepared with varying proportions (0%, 20%, 30% & 40%) of recycle plastic aggregate obtained by heat treatment of plastic waste in plastic granular recycling machine. A concrete mix design with 1: 1.5: 3 proportions was used having 0.5 water/cement ratio having varying proportion of plastic aggregate as replacement of crushed stone. Proper mixing was ensured and homogeneous mixture was prepared. A clear reduction in compressive strength was reported with increase in percentage of replacing plastic aggregate with crushed aggregate at 7, 14 and 28 days of casted cubes (80% strength achieved by replacing waste plastic up to 30%). The research highlights the potential application of

plastic aggregate in light weight aggregate. Their research was narrowed down to compressive strength of concrete with no emphasis given to flexural properties of concrete. They suggest future research scope on plastic aggregate with regard to its split tensile strength to ascertain its tensile behavior and its durability aspects for beams and columns. Praveen Mathew et al. (2014) they have investigated the suitability of recycled plastic as partial replacement to coarse aggregate in concrete mix to study effect on compressive strength, modulus of elasticity, split tensile strength and flexural strength properties of concrete. Coarse aggregate from plastic was obtained by heating the plastic pieces at required temperature and crushed to required size of aggregate after cooling. Their experimental results shown that plastic aggregate have low crushing (2.0 as compare to 28 for Natural aggregate), low specific gravity(0.9 as compare to 2.74 for Natural aggregate), and density value(0.81 as compare to 3.14 for Natural aggregate), as compare to Natural coarse aggregate. Their test results were based on 20% substitution of natural coarse aggregate with plastic aggregate. Increase in workability was reported when slump test for sample was carried out. Volumetric substitution of natural aggregate with plastic aggregate was selected best in comparison with grade substitution. At 400 centigrade temperature Plastic coarse aggregate shown considerable decrease in strength as compare to normal concrete. An increase of 28% was observed in compressive strength but decrease in split tensile strength and modulus of elasticity was observed. They recommended that with use of suitable admixture 0.4% by weight of cement will improve the bonding between matrix and plastic aggregate; however they demand more research to address the tensile behavior of concrete prepared with 20% plastic aggregate. Raghatate Atul M. et al. (2013) The paper is based on experimental results of concrete sample casted with use of plastic bags pieces to study the compressive and split tensile strength. He used concrete mix by using Ordinary Portland Cement, Natural River sand as fine aggregate and crushed granite stones as coarse aggregate, portable water free from impurities and containing varying percentage of waste plastic bags(0%, 0.2%, 0.4%, 0.6% 0.8% and 1.0%). Compressive strength of concrete specimen is affected by the addition of plastic bags and with increasing percentage of plastic bag pieces compressive strength goes on decreasing (20% decrease in compressive strength with 1% of addition of plastic bag pieces). On other hand increase in tensile strength of concrete was observed by adding up to 0.8% of plastic bag pieces in the concrete mix afterward it start decreasing when adding more than 0.8% of plastic bags pieces. Zainab Z. Ismail et al. (2013) they have conducted comprehensive study based on large number of experiments and tests in order to determine the feasibility of reusing plastic sand as partial replacement of fine aggregate in concrete. They conducted tests on concrete samples for dry/fresh density, slump, compressive and flexural strength and finally toughness indices on room temperature They have collected waste plastic from plastic manufacture plant consist of 80% polyethylene and 20% polystyrene which was crushed (varying length of 0.15-12mm and width of 0.15-4mm). Concrete mix were produce with ordinary Portland cement, fine aggregate (natural sand of 4.74mm maximum size), coarse aggregate (max size below 20mm) and addition of 10%, 15% and 20% of plastic waste as sand replacement. Their test results indicate sharp decrease in slump with increasing the percentage of plastic, this decrease was attributed to the presence of angular and non-uniform plastic particles. In spite of low slump however, the mixture was observed with good workability and declared suitable for application. Their tests also revealed the decrease in fresh and dry density with increasing the plastic waste ratio; however, increase was reported in dry density with time at all curing ages. Decrease in compressive and flexural strength was observed by increasing the waste plastic ratio which can be related to decrease in adhesive strength between plastic waste particles with cement. However, load-deflection curve of concrete containing plastic waste showed the arrest of propagation of micro cracks which shows its application in places where high toughness is required. The study has shown good workability in spite

of low slump but w/c content kept constant in all samples. They should have reduced the water content in order to improve the strength when workability was not an issue. P. Sugandh et al.[2012] This study investigate the application of pulverized fine crushed plastic (produce from melting and crushing of high density polyethylene) as replacement of fine aggregate in concrete with varying known percentages. Their main focus was on optimum replacement of natural sand by pulverized plastic sand. Five concrete mixes were produced from specified concrete materials having replacement of fine aggregate (sand) by 0, 25, 50, 75 and 100% respectively to study the test graph results of various concrete properties. The results showed increase in water/cement ratio with increase replacement of sand with plastic particles to achieve desired 90mm concrete slump. They have also observed from the results that gradual decrease in strength of concrete specimen for plastic replacement up to 25% but afterward the decrease in strength is rapid which shows suitable replacement up to 25% of sand with plastic pulverized sand. They have also concluded after testing of specimen (having different proportion of plastic replacement) for Ultimate and yield strength that both strength decreases with increase replacement of sand with pulverized plastic particles. Their study lacks detailed testing of properties of concrete because only compressive strength and w/c ratio tests will not be sufficient to study the matrix as a whole to be suitable for construction. No efforts were made to explore the use of admixtures in controlling of compressive strength reduction in a mix containing pulverized plastics. A Bhogayata et al. (2010) they have studied the environment friendly disposal of shredded plastic bags in concrete mix to be use in construction industry which have dire need for alternative material to be use in lieu of conventional materials. Different test results were analyzed after testing on 48 x concrete cubes (150mm x 150mm x150mm) prepared from varying percentage of polyethylene fibers (0.3, 0.6, and 0.9 to 1.2% of volume of concrete) with conventional concrete material to prepare mixes. Two type of plastic bag fibers were used, one cut manually (60mm x 3mm) and another shredded into a very fine random palette. Cubes were tested for 7&28 days compressive strength and compaction. They concluded that good workability was shown by the mix added with shredded fibers due to its uniform and higher aspect ratio evenly sprayed in the mix. Addition of plastics up to 0.6% is considered suitable after which reduction in compressive strength and compaction is seen affected. They observed that strength loss was less in concrete having shredded fibers of plastic as compare to hand cut macro fibers. Their research focus was only on comparative study of compressive strength but no work was carries out on other concrete properties like tensile strength, modulus of elasticity and density of concrete. M. Elzafraney et al. (2009) this study has incorporated use of recycled plastic aggregate in concrete material for a building to work out its performance with regards to thermal attributes and efficient energy performance in comparison with normal aggregate concrete. The plastic content concrete was prepared from refined high recycled plastics to meet various requirement of building construction like strength, workability and finish ability etc. Both buildings were subject to long and short term monitoring in order to determine their energy efficiencies and level of comfort. It was observed that recycled plastic concrete building having good insulation used 8% less energy in comparison of normal concrete; however saving in energy was more profound in cold climate in building with lower insulation. They recommended that efficiency of energy can further be increase if recycle plastic of high thermal capacity is used. They have suggested the use of recycle plastic aggregate concrete being economical and light weights are having high resistance to heat. The author should also incorporate the comparison of both buildings with regards to durability and strength.

4. MATERIALS AND METHODS

4.1 Materials

- **Plastics** are commonly used substances which play an important role in almost every aspect of our lives. The widespread generation of plastics waste needs proper end of life management. The highest amount of plastics is found in containers and packaging's (i.e. bottles, packaging, cups etc.), but they also are found in durables (e.g. tires, building materials, furniture, etc.) and disposable goods (e.g. medical devices). Diversity of plastics applications is related with their specific properties, low density, easy processing, good mechanical properties, good chemical resistance, excellent thermal and electrical insulating properties and low cost to other Post-production and postconsumer plastics are utilized in a wide range of applications.
- **Cement** is made by heating limestone (calcium carbonate) with small quantities of other materials (such as clay). In this project Ordinary Portland cement of 53 grade conforming to IS456-2000 was used. Tests were carried out on various physical properties of cement and the results are shown in test data of materials. cement will act as a binding material. This ash is called as dry ash or chimney or hopper ash. The balance 20% of ash gets collected at the bottom of the boiler and is referred to as bottom ash. Fly ash is very fine comparable to cement, however some particles have size less than 1 micron in equivalent diameter.
- **Natural river sand** was used as a fine aggregate. The properties of sand were determined by conducting tests as per IS: 2386 (Part-1). The results are shown in test data of materials. The results obtained from sieve analysis are furnished. The results indicate that the sand conforms to zone.
- **Water** used for mixing and curing of concrete shall be clean and free from oils, acids, alkalies, salts and organic materials or other substances that may be deleterious to concrete or steel. Portable water shall be used for mixing of concrete. Suspended solid matter in the water shall not exceed more than 200mg/l. The pH value of the water shall not be less than 6.
- **Fly ash** is a residue resulting from combustion of pulverized coal or lignite in thermal power plants. About 80% of the total fly ash is in finely divided form which is carried away with flue gases and is collected by electrostatic precipitator or other suitable technology.

4.2 Methodology

- **Collection of Plastic Waste:** The plastic materials should be collected from the factories waste and hospital waste and industries waste and also food packages and plastic bottles this will come under the LDPE plastic type.
- **Batching:** Measurement of materials for making brick is called batching. After collection of materials we separate the types of plastic and remove any other waste presented in the collected material and check that any water content in sample collected then proceed for burning. The measurement of materials for making brick is termed as batching. Use of weigh system in batching facilitates accuracy, flexibility and simplicity. The collected waste bags are cleaned with water and dried to remove the water present inside the plastic and then weighted. The sand were sieved by using 600 micron sieve. The sand, fly ash, cement and the plastic bags were weighed in various proportions among which the plastic were taken for burning process.
- **Burning of Plastic Waste:** After batching the plastic bags were taken for burning in which the plastic bags are thrown one by one into the drum and allowed to melt. The first step of burning process includes the arrangement of stones, drum and therequired firewood. The stones are arranged to hold the drum and the firewood is placed in the gap between stones and it is ignited. The drum is placed over the setup and it is heated to remove the moisture present in it.

In other way the plastic waste were taken for burning in which the plastic bags are drop one by one into the container and allowed to melt. These would be done in closed vessel because to prevent the toxic gases released into atmosphere. These will be at the temperature of 90-110 degrees centigrade.

- **Mixing:** Mixing of materials is essential for the production of uniform and strength for brick. The mixing has to be ensure that the mass becomes homogeneous, uniform in color and consistency. Generally, there are two types of mixing, Hand mixing and mechanical mixing. In this project, we adopted hand mixing. until the entire plastic content required for making plastic brick of one mix proportion is added into it. then these plastic liquids thoroughly mixed by using trowel before it hardens. The mixture has very short setting bags are turned to molten state; the river sand is added to it. The sand added is mixed time. Then fly ash and cement added to it at their respective proportion at dry state. then water is added at given w/c ratio mixing process should not consume more time. Mixing of materials is essential for the production of uniform and strengthens brick. The mixing should ensure that the mass becomes homogeneous, uniform in color and consistency. Generally, there are two types of mixing, Hand mixing and machine mixing. In this project, we adopted hand mixing.
- **Moulding:** The plastic bags are added one by one into the drum, until the entire plastic content required for making bricks of one mix proportion is added into it. When these plastic thoroughly by using trowel before it hardens. The mixture has very short setting bags are turned to molten state, the river sand is added to it. The sand added is mixed time. Then fly ash and cement added to it at their respective proportion. Hence mixing process should not consume more time. The mixture is then poured into the brick mould and is compacted by using tamping rod or steel rod. The surface is finished by using trowel. Before placing the mixture into the mould, the sides of the mould are oiled to easy removal of bricks. Then removed the mould.
- **Curing:** The test specimens after compaction were allowed to dry for a period of 24 hours. The specimens were kept in ordinary curing tank and allowed to cure for a period of 7,14 and 21 days.

5. TEST AND RESULTS

Compressive strength test was conducted over the specimen and following results were drawn as mentioned below.

Table-1: Compressive Strength Test

Sr. no.	Description	Ratio (plastic sand ratio)	Compressive strength(MPa)		
			7 days	14 days	21 days
1	Normal	Cement 20%, Fly Ash 50%,Sand 30%	2.0	3.1	4.1
			1.8	3	3.9
2	Plastic	Cement 20%, Fly Ash 50%, Plastic/Sand 30% (1:3)	2.3	3.5	4.0
			2.6	2.9	5.55
3	Plastic	Cement 20%, Fly Ash 50%, Plastic/Sand 30% (1:4)	2.1	3.5	5.61
			1.81	3.15	4.5
4	Plastic	Cement 20%,	2.35	3.91	5.9

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		Fly Ash 50%, Plastic/Sand 30% (1:5)	2.5	4	6.1
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1) **Fig-1:** Plastic Brick Removing it from Mould



Fig-2: Brick after the compressive strength test, failure due to compressive load

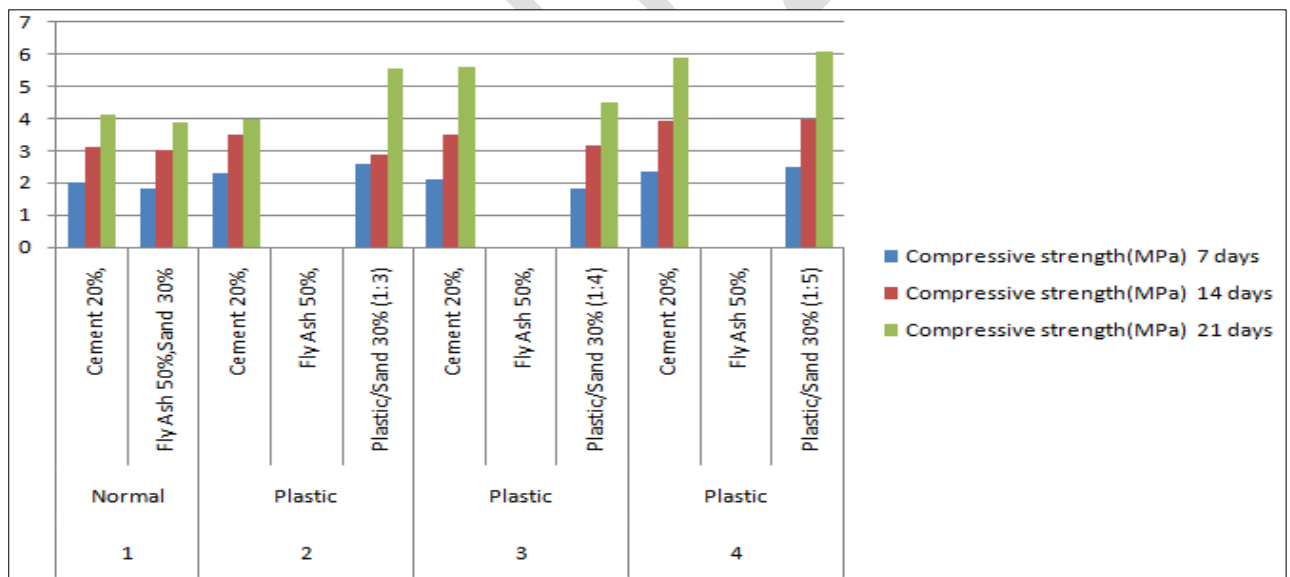


Chart-1: Compressive Strength Test

Water Absorption test was conducted over the specimen and following results were drawn as mentioned below.

Table-2: Water Absorption Test

Sr. no.	Description	Wet weight(gm)	Dry Weight(gm)	Water Absorbed (%)	Average Water Absorbed (%)
1	Normal	3126	2915	7.28	7.34
		3116	2901	7.41	

2	Plastic	2830	2750	2.9	2.88
		2835	2756	2.86	
3	Plastic	2926	2816	3.9	4.01
		2918	2803	4.2	
4	Plastic	2995	2854	4.94	5.10
		3012	2862	5.24	

CONCLUSIONS

Based on research following conclusion were drawn as follows:-

1. Use of Innovative Materials with sustainable application, plastics waste can have considerable benefits reducing environmental degradation.
2. Light weight and Compressive strength which lead to help in construction industry.
3. Re-Using the plastics bottles as the building material can have substantial effect on saving the building embodied energy by using them instead of bricks in wall reducing the CO₂ emission in reducing the % of sand.
4. Cost effective as cost of cement is high compare to plastics waste.

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