

Study of Plastic Bricks Made From Waste Plastic

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Abstract - Plastics are key resources in circular economy and recycling after the end of useful life with economic value creation and minimal damage to environment is the key to their sustainable management. Studies in a large stream of researches have explored impregnating waste plastics in concrete and reported encouraging results with multiple benefits. The present study makes a critical review of some of these findings and gleans some common useful trends in the properties reported in these studies. The study also presents results of experimental work on bricks made of non-recyclable waste thermoplastic granules constituting 0 to 20% by weight, 4kg of fly ash, cement and sand making up the remainder. The bricks were cured under water for 28 days and baked at temperature ranging from 90oC to 110oC for 2 hours. The key characteristics of these bricks are found to be lightweight, porous, of low thermal conductivity, and of appreciable mechanical strengths. Though such bricks hold promise, no similar study appears to have been reported so far. Unlike other processes of making porous bricks, which usually involve incineration to burn combustible materials in order to form pores with implication of high carbon emission, the proposed process is non-destructive in that the bricks are merely baked at low temperature, sufficient to melt the waste plastic that gets diffused within the body of the bricks. The compressive strengths after addition of waste plastic is same as normal brick strength. And also reduce the water absorption capacity of brick is reduced compare with nominal brick. Efflorescence values were low than the normal brick. The bricks are likely to add energy efficiency in buildings and help create economic value to manufacturers, thereby, encouraging the ecosystem of plastic waste management involving all actors in the value chain. A mathematical model is developed to predict compressive strength of bricks at varying plastic contents. The study introduces a new strand of research on sustainable thermoplastic waste management.

Key Words: Plastic waste, water absorption, compressive strength, efflorescence test, thermoplastic (LDPE).

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. In this study, recycled plastic waste have been introduced in the form of crushed. The replacement of plastic waste material has been done by weight.

2. PRESENT SCENARIO OF WASTE GENERATION IN INDIA:

Growth of population has increased our urbanization as a result rising standard of living due to technological innovations have contributed to an increase both in the quantity and variety of solid wastes generated by industrial, agricultural activities, mining and domestic. Globally the estimated quantity of wastes generation was 12 billion tones in the year 2002 of which 11 billion tones were industrial wastes and 1.6 billion tones were municipal solid wastes (MSW). About 19 billion tons of solid wastes are expected to be generated annually by the year 2020. Annually, Asia alone generates 4.4 billion tons of solid wastes and MSW comprise 795 million tons of which about 48 (6%) MT are generated in India. MSW generation in India, is expected to reach 300 Million tones and land requirement for disposal of this waste would be 169.6 km² as against which only 20.2 km² were occupied in 1997 for management of 48 Million tones. As it is studied that apart from municipal wastes, the organic wastes from agricultural sources alone contribute more than 350

million tons per year. However, it is reported that about 600 million tons of wastes have been generated in India from agricultural sources alone. The Quantity of wastes generated from agricultural sources are sugarcane baggage, paddy and wheat straw and husk, wastes of vegetables, food products, tea, oil production, wooden mill waste, coconut husk, jute fiber, groundnut shell, cotton stalk etc. In the industrial sector inorganic solid waste could be coal combustion residues, bauxite red mud, tailings from aluminum, iron, copper and zinc primary extraction processes. Generation of all these inorganic industrial wastes in India is estimated to be 290 million Tons per annum. In India, 4.5 million tons of hazardous wastes are being generated annually during different industrial process like electroplating, various metal extraction processes, galvanizing, refinery, petrochemical industries, pharmaceutical and pesticide industries.

3. MIX DESIGN OF PLASTIC BRICKS

In order to find the plastic bricks that they possess high compressive strength with various mix proportions are made and they are tested using compressive testing machine (CTM). The mix proportions were in the ratio of 1:2, 1:3 and 1:4. These are the ratio which represents the plastic, river sand respectively.

Sl. No	PLASTIC %	CEMENT (KG'S)	FLYASH (KG'S)	SAND (KG'S)	Plastic (KG'S)
1	5	0.992	4.04	3.078	0.162
2	10	0.992	4.04	2.916	0.324
3	15	0.992	4.04	2.754	0.486
4	20	0.992	4.04	2.59	0.648

4. METHODOLOGY

- Collection of Materials.
- Batching.
- Melting.
- Mixing.
- Moulding.
- curing.

4.1 COLLECTION OF PLASTIC MATERIALS

The plastic material 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

4.2 Batching of plastic

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 in sample collected ten proceed for burning.

4.3 Burning of waste plastic

After completion batching 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.

4.4 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. Hence mixing process should not consume more time.

4.5 Moulding

After completion of proper mixing we place mix into required mould. In these projects we use the normal brick sizes (19x9x9 cm). after 2 days remove the brick from the mould and then done curing.

4.6 Curing

The test specimens after moulding were allowed to dry for a period of 24 hours. The specimens were kept in curing tank and allowed to cure for a period of 28 days .

5. MATERIALS

- Plastic.
- Cement.
- Sand.
- Water.
- Fly ash.

5.1 PROPERTIES OF PLASTIC

When exposed to ambient solar radiation the plastic procedure two greenhouse gases, methane and ethylene. Due to its low-density properties (branching) it breaks down more easily over time, leading to higher surface areas. The supply of glasses shall be of diagonal gases from virgin LDPE increase with surface area or time, with rates at the end of a 212day incubation of 5.8 nmol g-1 d-1 of methane, 14.5 nmol g-1 d-1 of ethylene, 3.9 nmol g-1 d1 of ethane and 9.7 nmol g-1 d-1 of propylene. In case of air it was incubated, LDPE releases gases in air by ~2 times and ~76 times higher in comparison to water for methane and ethylene, respectively.

Sl. No.	Experiments	Values
1	Density @26°C	0.958
2	Elastic modulus	9
3	Tensile cube strength	8
4	Bending creep modulus	1
5	Tensile strength @23°C	2
6	Elongation at break (%)	>600
7	Thermal conductivity	0
8	Ignition Temperature	3

Table 3.3 Physical properties of cement.

5.2 SAND

The silica material was utilized as a fine aggregate in concrete and mortars. Natural river sand is the most preferred choice as a fine aggregate material. River silica sand is a product of natural weathering of rocks over a period of millions of years. It is mined from the river beds. River sand is becoming a scarce commodity now. River was the clean water of superior sand is far superior for construction purposes than any other sand used in construction. Quarrying of river sand is an important economic activity in India with river sand forming a crucial raw material to the construction industry.

Sl. No	Texture composition	(% by weight)
1	Coarse sand (4.75-2.0mm)	6.6
2	Medium coarse sand (2.00-0.425 mm)	73.6
3	Fine sand (0.425-0.075 mm)	19.8

Table 3.2 properties of sand.

5.3 CEMENT

The manufacturing of Cement was conducted by heating limestone (calcium carbonate) with small quantities of other materials (such as clay. 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.

Sl. No.	Tests	Standards
1	Initial setting time	30 minutes
2	Final setting time	600 minutes
3	Fineness	Not less than 90%
4	Specific gravity	3.10 to 3.15
5	Standard consistency	30% to 35%

Table 3.3 Physical properties of cement.

5.4 FLY ASH

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. The balance 20% of ash gets collected at the bottom of the boiler and is referred to as bottom ash. Fly ash got into a fine powder in the comparable to cement, however some particles have size less than 1 micron in equivalent diameter.

Sl. No	COMPONENTS	PERCENTAGE (%)
1	SiO ₂	35 to 39
2	Fe ₂ O ₃	0.5 to 2
3	Al ₂ O ₃	20 to 33
4	CaO	5 to 16
5	MgO	1 to 5.5
6	SO ₃	0.5 to 1.5

Table 3.4 Chemical composition of fly ash.

FLYASH CLASS -C

The fly ash was the product from the burning of younger lignite in addition of younger lignite as in addition too pozzolanic properties. It is also have self-made cement properties. Generally, it contains more than 20% lime (CaO).

Sl. No	TESTS	STANDARDS
1	Specific gravity	2.62
2	Fineness	83%

Table 3.5 Physical properties of fly ash.

6. TESTS CONDUCTED ON PLASTIC BRICKS

- Compressive strength
- Water absorption
- Efflorescence test
- Soundness test
- Crushing test.

6.1 COMPRESSIVE STRENGTH

The tests on Compressive strength of the specimen brick shall be calculated for 3 aspects after 7, 14 & 28 days of curing using the formula as follows,

$$\text{Compressive strength} = \frac{\text{Applied Max load} \times 1000 \text{ (N)}}{\text{Cross sectional Area (mm}^2\text{)}}$$

The UTM was using the tests. The compressive strength of bricks. After the curing period gets over bricks are kept for testing. To test the specimens, the bricks are placed in the calibrated compression testing machine of capacity 3000 KN (Kilo Newton) and applied a load uniform at the rate of 2.9 kN/min. By obtaining the maximum load shall be taken as failure of load with specimen fails to produce any further increase in indicator reading on testing machine.

6.2 WATER ABSORPTION

Bricks should not absorb water more than 12% by its weight. The bricks to be tested should be dried in an oven at a temperature of 105°C to 115°C till attains constant weight cool the bricks to room temperature and weight (W1). Immerse completely dried and weighed (W1) brick in clean water for 24 hrs. at a temperature of 27±20°C. Remove the bricks and wipe out any traces of water and weigh immediately (W2).

$$\text{Water absorption in \% by wt.} = \frac{W_2 - W_1}{W_1} \times 100.$$

6.3 EFFLORESCENCE TEST

For this test, brick has to be placed vertically in water with one end immersed. The depth of immersion in water being 2.5 cm, then the whole arrangement should be kept in a warm-well-ventilated room temperature of 20-30°C until all evaporates. When the water in the dish is absorbed by the brick and surplus water evaporates. When the water is completely absorbed and evaporated place similar quantity of water in dish and allows it to absorb and evaporate as before. The determination of the brickwork after the experiment shall find out to be % of white spots to the

surface area of brick. If any difference is observed because of presence of any salt deposit, then the rating is reported as "effloresced". If no difference is noted, the rating is reported as not "effloresced".

6.4. SOUNDNESS TEST

This sound is carried out to find out that a clear ringing sound is produced or not when the two bricks are with each other without breaking any of the two bricks. If the two bricks are not broken after striking with each other and a clear ringing sound is produced, then it means that the bricks are sufficiently sound.

6.5. CRUSHING TEST

This is the main test conducted to test the suitability of the brick for construction work. This test is executed with the help of compression testing machine. A brick is placed in a compression testing machine. It is pressed till it breaks. Then the compression strength of the brick is recorded from meter of the compression testing machine. A brick after undergoing compression test, this test is carried out for both fly ash bricks and as well as burnt clay bricks.

7. TEST RESULTS

7.1 COMPRESSIVE STRENGTH TEST

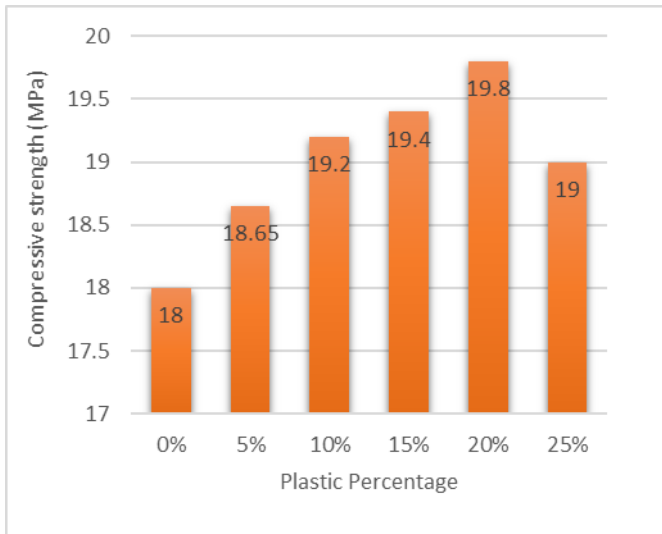
Sample No.	Plastic Percentage	Compressive strength
1	0	18
2	5	18.65
3	10	19.2
4	15	20
5	20	18.4

7.2 WATER ABSORPTION TEST

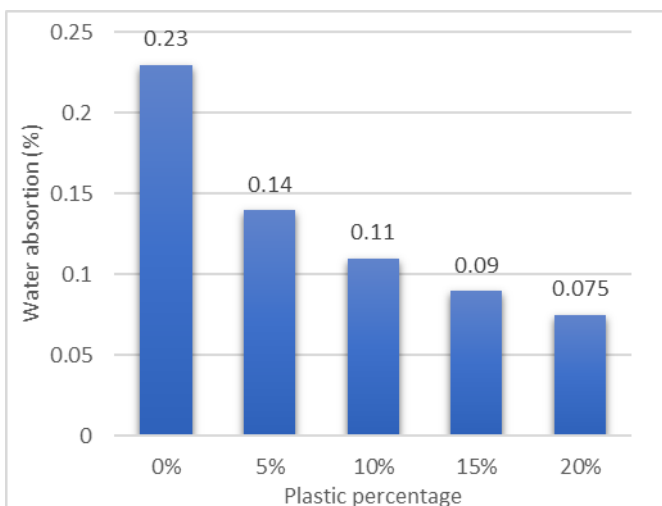
Sample No.	Plastic Percentage	Compressive strength
1	0	0.23
2	5	0.14
3	10	0.11
4	15	0.09
5	20	0.075

Table 7: water absorption

7.3 COMPRESSIVE STRENGTH TEST RESULTS



7.4 WATER ABSORPTION TEST RESULTS



ADVANTAGES

- Allow recycling of waste plastic.
- If made with hollow cells, they can be filled with compacted dirt, increasing their potential utility for projects lasting several years.
- They can be used for insulation
- They should be sufficiently economical, with potential for easy recycling. Under submerged conditions they should last much longer.
- Exotic shapes are possible for decorative purposes.
- Overall cost of brick will be reduced.

DISADVANTAGES

- Mortar would not stick, unless they are designed with specialized rough surface. Even then, mortar is not expected to stick reliably.

- Plastic may appear strong, but it would deform under pressure.
- As such they would have a limited lifespan due to degradation by UV. Extreme arctic weather would make them brittle. Or else, they would crack in several years due to thermal cycling. Skilled labors are required.
- When we are burning plastic for preparation plastic brick it emits toxic-gases into atmosphere.

FUTURE WORK

Plastic sand bricks give us hope and a way to work on innovative things related to the plastic and to try to invent some new civil engineering materials which shows some remarkable response in future industry and changes the thoughts of the researchers, users and industries. Such as, in going for

- Plastic sand wall in framed structures as a partition wall
- Plastic sand benches in the parks
- Plastic sand tracks for running and jogging in place of concrete or stone tracks.
- Research on Composition of plastic with fly ash, Quarry dust etc.

CONCLUSIONS

- Waste plastic, which is available everywhere, may be put to an effective use in brick.
- Plastic bricks can help reduce the environmental pollution, thereby making the environment clean and healthy.
- Plastic sand bricks reduce the usage of clay in making of bricks.
- Plastic sand bricks give an alternative option of bricks to the customers on affordable rates.
- Water absorption of plastic sand brick is zero percent.
- Compressive strength of plastic sand brick is 5.6 N/mm² at the compressive load of 96KN.
- We conclude that the plastic sand bricks are useful for the construction industry when we compare with Fly Ash bricks and 3rd class clay bricks.

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