Fabrication and Testing of Plastic Sand Bricks

S S Chauhan, Bhusan Kumar, Prem Shankar Singh, Abuzaid Khan, Hritik Goyal, Shivank Goyal
Department of Mechanical Engineering, G.L. Bajaj Institute of Technology & Management, Greater Noida, India
sschauhan3456@gmail.com

Abstract: In this study, the use of plastic bottles and plastic waste in the making of plastic sand bricks is examined. Plastic apart from being one of the highly generated waste is also one of the most easily recyclable materials. Using this property of recyclability, plastic waste in the form of PET bottles will be used to create masonry units that may be able to replace conventional bricks which are made up of clay and sand only. Sand will be mixed with plastic in different ratios and tests such as compressive strength test, water absorption test, efflorescence test and fire resistance test will be done. Results from this study are expected to help determine the appropriate mixing ratios of sand and plastic in order to obtain optimum strength and other properties.

1. Introduction

Plastics, being one of the most used materials by humans are also hazardous material. It is often used as a short term replacement for any other alternatives which are usually costlier than plastic. For example, polyethylene bags are used instead of its more organic counterparts like Jute bags. It is a non-biodegradable substance that stays as it is for centuries. Moreover, the amount of plastic waste generated per year is increasing every year. Approximately, every 10 years the rate of expansion is doubled. This can be attributed to the factors such as population growth, urbanization, industrialization, and change in trend and lifestyle. All these factors complemented with the population density of India, make the management of plastic waste a challenge which gets a bit harder every year to overcome. 40 million Tons of MSW has generated in India annually with an increasing rate of 1.5% to 2% [1]. Hence, the only solution that is left with us is the effective utilization of plastic waste generated across the country which will not only solve the crisis of plastic waste management, but also strengthen the economy. [2]

Plastic waste along with being non-biodegradable also causes land and water pollution. Among the various types of plastics used, Polyethylene (PE) is one of the most used. It is usually used in single use plastics such as carry bags, plastic bottles etc. One viable solution to using this plastic waste can be Plastic bricks [3]. These bricks will eventually be able to enhance our management of plastic along with promoting sustainable development. Traditional Bricks are made by clay, which puts stress on soil and also leads to soil erosion. The use of plastic sand bricks can be beneficial and would help to reduce waste. Thus the use of plastic bricks is a promotion to sustainable development and eco-conservation at the same time.
2. Methodology
The materials used for the fabrication of the plastic sand bricks are the PET bottles and river bed sand. For this plastic PET bottles are collected and sorted. Generally the cold drinks bottles are made of PET and those bottles are used for the purpose of fabricating the bricks. The PET bottles cannot be used as they are in usual shape and size, for our use the bottles need to be cut into smaller pieces of same size. First of all the bottles are cleaned and dried to remove moisture. Then these bottles are cut into smaller pieces, in this case we used a shredder for shredding the plastic into smaller pieces[4]. The plastic is melted in a drum and sand is mixed with it form the bricks. The processes can be explained as follows:

2.1 Collection of Material
The process is incredibly simple. Put the dustbin in the canteen for collection of waste bottles. Select the plastic bottles of cold drinks and water from canteens. Bring river sand for plastic brick. IS2386 (Part- I) The more you collect the more plastic you will divert from the landfill or clean up out of the environment.

2.2 Fixing the Proportion of Sand and Plastic
For the fabrication of plastic sand bricks, plastic and sand are mixed in different proportions and bricks containing different amount of plastic and sand are made. Plastic and river sand are mixed in different ratios 1:2, 1:3, 1:4. The reason behind taking different proportions of plastic and sand is to find the optimum proportion which gives the desired results. The bricks made of these ratios will further be investigated for various desired properties.

| Mixing Ratio | 1:2       | 1:3       | 1:4       |
|--------------|-----------|-----------|-----------|
| For 1 brick (in gram) | 1100:2200 | 850:2550  | 650:2600  |
| For 2 bricks (in grams) | 2200:4400 | 1700:5100 | 1300:5200 |

2.3 Preparation of Brick Mould
The moulds used are wooden moulds and are made in the carpentry shop. All the sides and surfaces of the mould should be even for the brick to have better surface finish. Both fixed and movable moulds can be used for the purpose. Wooden mould will be cost effective and serve the purpose whereas if better surface finish is needed then cast iron moulds can be used. Mould size would be (230*100*75) mm.
2.3.1 Procedure of Casting Plastic Sand Bricks

The procedure of casting plastic sand bricks is a simple one. The first step is batching in which sand and plastic waste i.e. PET bottles are weighed. Then different proportions according to the weight are taken for casting the bricks. After that burning of the firewood is done and a drum is placed on the fire, the plastic pieces are added in the drum to melt. Then mixing of the melted plastic with sand is done by adding sand in the drum and stirring it continuously. Lastly the mixture obtained after continuous stirring is fed into the mould and compressed by tamping rod and left for cooling for 24 hours after which the brick is taken out from the mould.
2.3.1.1 Batching
Measurement of materials is known as batching. The waste bottles are rinsed with water and then dried after which the weights of bottles are measured. Sieving of sand is done by 600 micron sieve[1] and this sand will be used for making bricks. Various proportions of plastic bottles with sand is taken for bricks. The different ratios we used are 1:2, 1:3 and 1:4.

![Batching Process](image1)

**Fig 3:** Sand sieving process on the sand sieving machine on 600 micron gauge.

![Batching Process](image2)

**Fig 4:** The weighing of sand(left) and plastic(right) for the batching process

2.3.1.2 Burning
In this burning of plastic bottles is done. Plastic bottles are cut into pieces and then these pieces are put in drum for melting. In the first step stones, drum and firewood are arranged. The stones hold the drum and the firewood is ignited. Drum is heated to remove moisture from the drum. The plastic is then put into the drum and allowed to melt.
2.3.1.3 Mixing
Pieces of plastic are added into drum for melting until the proportion required by us is achieved. River sand is used for addition in plastic sand mixture. When the temperature of the melted plastic in the drum is around 180°C-200°C then the sand is added into the drum. The river sand and the melted plastic is stirred continuously so that both gets bonded perfectly. As the plastic pieces melts it start getting bonding with the sand particles and hence the mixture required for brick is created.

2.3.1.4 Moulding
In moulding process the prepared mixture is then filled into wooden mould and then compressed by tamping rod. The pressure is applied by the tampering rod so as the mixture gets filled properly in the mould. Then it is left for cooling in air but before filling the mould apply oil on the walls of mould so that at last brick can be removed easily. The application of oil on the inner surfaces of the mould is must as after solidification the brick will not come out easily and to remove the mould some pressure must be applied that would wear the edges of the brick. So proper oiling is needed before filling the mixture in the mould. The brick then can be removed from mould after 24 hours.

![Fig 5: Plastic Sand Brick after removing it from the mould](image)

2.4 TESTS ON BRICK

2.4.1 Compression Strength test (BS 5628: Part 1: 1992)
In this test, the cubical brick specimen is placed in the compression strength testing machine. After placing it we will apply the load on the brick without any shock. The load will be increased at a rate of 140kg/cm² min continuously till the specimen’s resistance to increasing load breaks down and it cannot withstand any greater load further [6]. Recording the maximum load applied to the brick specimen and the appearance and type of failure is also noted along with any unusual features.[7]

\[
\text{COMPRESSIVE STRENGTH} = \frac{\text{MAXIMUM LOAD APPLIED}}{\text{SPECIMEN AREA}} \quad (1)
\]

\[
= \frac{F}{A}
\]

Where,

- \( F \) - Maximum load applied (KN)
- \( A \) - Specimen Area (mm²)
**Table 2: Result of compressive strength test**

**Table 2.1: Compressive strength for 1:2 plastic to sand ratio, Plastic Sand Brick**

| Plastic Sand Brick (1:2 Ratio) | Maximum Load(KN) | Compressive Strength(kg/cm²) |
|-------------------------------|-------------------|-----------------------------|
| Specimen 1                    | 500               | 193.87                      |
| Specimen 2                    | 525               | 203.56                      |
| Specimen 3                    | 490               | 189.99                      |

![Bar chart showing compressive strength for 1:2 ratio](chart1.png)

**Table 2.2: Compressive strength for 1:3 plastic to sand ratio, Plastic Sand Brick**

| Plastic Sand Brick (1:3 Ratio) | Maximum Load(KN) | Compressive Strength(kg/cm²) |
|-------------------------------|-------------------|-----------------------------|
| Specimen 1                    | 350               | 135.71                      |
| Specimen 2                    | 320               | 124.07                      |
| Specimen 3                    | 335               | 129.89                      |

![Bar chart showing compressive strength for 1:3 ratio](chart2.png)
Table 2.3: Compressive strength for 1:4 plastic to sand ratio, Plastic Sand Brick

| Plastic Sand Brick (1:4 Ratio) | Maximum Load(KN) | Compressive Strength(kg/cm²) |
|--------------------------------|------------------|-----------------------------|
| Specimen 1                     | 165              | 63.97                       |
| Specimen 2                     | 150              | 58.16                       |
| Specimen 3                     | 155              | 60.10                       |
2.4.2 Water Absorption test (ISS 1077-1970)

In this test at first the bricks are weighed in total dry conditions. Then they will be allowed to be dipped in fresh water for about 24 hours in a container. The bricks are taken out of the water after 24 hours and are wiped with a cloth. The wet brick is weighed using a weighing machine. For the calculation of water absorption, the difference between wet brick and dry brick is done. The difference is the amount of water absorbed by the brick. After that the percentage of water absorption is calculated using the data. [1]

Water absorption of bricks tells about the bonding of bricks with mortar. Although other factors such as grooves and design on bricks also improve the bonding. For sand bricks which have less water absorptivity leaner mortar layer is used for bonding bricks and mortar. [8]

Greater quality bricks absorb less amount of water. For a good quality brick the water absorption should be less than 20% of its own weight.

Water absorption = \{\text{Weight of wet brick–Weight of dry brick}/\text{Weight of dry brick}\}*100

(2)

Table 3: Results of Water Absorption test

| 1:2 Ratio Brick | W1(kg) | W2(kg) | Water Absorption (in %) |
|-----------------|--------|--------|-------------------------|
| Specimen 1      | 3.053  | 3.082  | 0.949                   |
| Specimen 2      | 2.958  | 2.997  | 1.318                   |
| Specimen 3      | 3.014  | 3.051  | 1.227                   |
Table 3.2: For 1:3 ratios plastic to sand bricks, the water absorption is given below.

| 1:3 Ratio Brick | W1(kg) | W2(kg) | Water Absorption (in %) |
|-----------------|--------|--------|-------------------------|
| Specimen 1      | 2.532  | 2.601  | 2.723                   |
| Specimen 2      | 2.498  | 2.564  | 2.642                   |
| Specimen 3      | 2.594  | 2.678  | 3.238                   |

Table 3.3: For 1:4 ratios plastic to sand bricks, the water absorption is given below.

| 1:4 Ratio Brick | W1(kg) | W2(kg) | Water Absorption (in %) |
|-----------------|--------|--------|-------------------------|
| Specimen 1      | 2.411  | 2.516  | 4.351                   |
| Specimen 2      | 2.397  | 2.492  | 3.963                   |
| Specimen 3      | 2.456  | 2.568  | 4.560                   |
2.4.3 Efflorescence test

The standard used for the test is ISS 1077-1970. It is done to detect the presence of alkalis in PET bricks which is harmful. The alkalis form a grey or white patch on the surface of the brick. A flat bottom container is used in which sufficient distilled water is poured. The depth of immersion is 25mm. The brick is immersed into the distilled water and left for 24 hours. The container is covered with a glass sheet to prevent excessive evaporation.[5] After that the brick is removed from the container and left to dry for the same amount of time wherein the same amount of water must have evaporated from the open container without the brick or the sheet.

Table 4: Alkali presence in the bricks as appeared on the surface

|                |              |
|----------------|--------------|
| Nil            | 0%           |
| Slight         | Up to 10%    |
| Moderate       | 10% to 50%   |
| Heavy          | More than 50% without powdered flakes |
| Serious        | More than 50% with powdered flakes |

The efflorescence in the brick can be categorised into the above categories on the basis of area covered by salt/alkalies.

2.4.4 Fire resistance test

The standard used for the test is BIS 3809 1979. The plastic alone is readily susceptible if not flammable to elevated temperatures and in case of fire, the sand and plastic mixture may withstand temperatures that plastics alone usually cannot.[9] It has been observed that the structural integrity of the bricks holds very well up to 180°C. In this test we will first heat and maintain the brick at the standard testing temperature in the furnace and then we will do the compressive strength test to check whether the properties change or not.

2.4.5 Test to determine the Relative rise in temperature of Plastic Sand Brick and Clay Bricks:

The set up used simply demonstrated the rise in temperature in the bricks when fire or heat was presented on one side of the wall. Both type of bricks were used to form a wall partition and on one side of it
burning coal with an average temperature of 500° C was applied. The chamber that contained burning coal was insulated to remove heat losses. Gradually the temperature of the bricks increased. It was noticed that the clay brick’s temperature increased more rapidly than the temperature of plastic bricks. Although, this confirms that the conductivity of plastic brick is lower than the clay bricks, continuous exposure to higher temperatures above 350° C led to partial melting of the brick. This makes these plastic bricks unsuitable to be used where fire risks are present.

Table 5: Increase in Temperature of Plastic Bricks and Clay Bricks

|                  | 1:2 Plastic: Sand Brick | 1:3 Plastic: Sand Brick | Clay Brick |
|------------------|-------------------------|--------------------------|------------|
| Initial Temperature(° C) | 36.0                    | 35.8                     | 36.2       |
| Temperature After 30 minutes(° C) | 41.2                  | 41.7                     | 43.8       |
| Temperature After 45 minutes(° C) | 45.2                  | 46.4                     | 54.3       |

3. Conclusion
Plastic Sand Bricks made of plastic waste which otherwise would have created pollution, possess advantages of cost efficiency, resource efficiency, etc. It leads us towards our sustainable development goal. The bricks made have less porosity and light weight with more compressive strength. Further research might improve the quality and durability of Plastic Sand Bricks.

The results we have got shows us that the compressive strength of this brick is high when compared to the conventional clay bricks for the same size and also the weight of these bricks are less which in turn will decrease the dead weight of the structure. The water absorption of these bricks are very less 0.9 % - 4.5% and whereas in normal clay bricks it is around 15% - 20% of the weight of brick. Although, the fire resistance of plastic bricks is something that requires further research, in its current composition these bricks can serve excellently for water conservation purposes, Underground tanks or to form an underlining for sanitary landfills.
References
1. Aiswaria K, Khansa Abdulla, E B Akhil, Haritha Lakshmi V G, Jerin Jimmy “Manufacturing and Experimental Investigation of Bricks with Plastic And M-Sand” International Journal of Innovative Research in Science, Engineering and Technology Vol. 7, Issue 6, June 2018
2. Nitin Goyal, Manisha, “CONSTRUCTION STRUCTURESPUSING ECO-BRICKS” International Journal of Recent Trends in Engineering & Research, ISSN 2455-1457.P
3. Central Pollution Control Board, “An overview of Plastic Waste Management” Delhi, pp. 1-22, 2012.
4. A.S. Manjarekar , Ravi , D. Gulpatil, Vivek P. Patil, Ranjit S. Nikam, Chetali M. Jeur (2017). "Utilization of Plastic Waste in Foundry Sand Bricks", International Journal for Research in Applied Science & Engineering Technology (IJRASET).
5. Gopu Mohan. C, Jikku Mathew, JithinX Ninan Kurian, John Thomas Moolayil. “FABRICATION OF PLASTIC BRICK OMANUFACTURING MACHINE AND BRICK LANALYSIS” International Journal of Innovative Research in Science and Technology, ISSN (online) 2349-6010, Volume 2, Issue 11th April 2016
6. Loukham Gerion Singh, Pongsumbam Boss Singh, Suresh Thokchom(2017). "Manufacturing Bricks from Sand and Waste Plastics", National Conference on Innovations in Science and Technology (NCIST-17).
7. Sina Safinia, Amani Alkalbani. "Use of Recycled Plastic Water Bottles in Concrete Blocks" Middle East College ,KOM, Rusayl, Muscat PC 124,Oman 2016
8. IS 1905 , “Indian Standard code of practice for structural use of unreinforced masonry”, Bureau of Indian Standards, New Delhi, India, 1987
9. IS 3495 (Parts 1 to 4) , “Indian Standard methods of tests of burnt clay bricks”, Bureau of Indian Standards, New Delhi, India, 1992.