Manufacturing and Experimental Analysis of Bricks Made from Recycled Plastic and Asphalt

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ABSTRACT - Plastics are increasingly used in everyday life. Most of them cannot be recycled and the remaining plastics cannot be used or decomposed. This leads to an increase in plastic waste, which contributes to global warming by recycling heat. The main goal of this study was to use as much plastic waste as possible to produce bricks that match the properties of traditional bricks, without negatively impacting the environment and climate change. A balanced mix of high-density polyethylene (HDPE), silica sand, asphalt and other additives were used to produce these bricks. To check the quality of the bricks, various tests like compressive strength, water retention and efflorescence tests are carried out. The compressive strength of this brick was 37.5 MPa, which is very high as compared to normal bricks. Efflorescence and water absorption tests showed that the bricks contained virtually no soluble bases and retained very little moisture. The resulting bricks were lighter and cheaper as compared to conventional bricks.

KEYWORDS: HDPE, Quartz Sand, Bitumen, Compression testing, Water absorption test; Efflorescence test, Brick.

INTRODUCTION- Plastic, a synthetic material made from various high molecular weight organic compounds, was first introduced by Leo Baekeland in 1907. Since then, he has transformed many industries. The plastics industry experienced rapid growth during World War II, when manufacturers were able to use plastics to replace products that were previously made from natural resources. The best example was nylon, which replaced silk and was used in parachutes, helmets, and bulletproof vests. Another was plexus glass, used to replace glass in airplanes.

Over time, plastics have replaced traditional materials. They have become one of the most important materials in our daily lives. Their properties such as high strength, corrosion resistance, easy formability, water resistance and ductility make them suitable for a wide range of applications. They are used in almost all industries, including electrical and electronic applications, packaging, logistics and industrial machinery. More than 50% of plastics were produced after 2000. Most plastic is used in packaging.

all polymers are recyclable and can be used once or more to create an identical product. However, it must be carried out in controlled conditions and requires high-end machinery and technology. This is not a feasible solution, because it harms the environment and makes industries unprofitable. Therefore, it is best to sort waste plastic according to its categorization and qualities to extract recyclable plastic and use it to produce plastic products in the future. Because of the process-induced breakdown of the polymer chain, the properties of such recycled materials may differ from those of the original. These properties can be regained by adding the appropriate additives and strength-enhancing materials.

OBJECTIVE-

- To compare strength of plastic bricks with normal clay bricks.
- To vary the percentage of plastic in bricks to determine the strength performance.
- Cost comparison in between plastic bricks and normal clay bricks.

STATEMENT OF THE PROBLEM-

Plastics are one of the materials present in our everyday life; we used them for a variety of purposes due to their inexpensive, lightweight, and durable. But these materials have many chemical and hazardous substances which affect human health and it also serious-environment effects. So, it's important to find new materials with a lower environmental and human health impact, lower energy consumption, and minimum production period with affordable prices.

RESEARCH QUESTIONS-

What are the durability properties of brick that produced from PET waste plastic?
What is the major mechanical property of brick that produced from PET waste plastic?

LITERATURE REVIEW-

(i)Lucas Ernesto Peisino, María del Mar Barbero-Barrera (2024), Construction and demolition waste, along with discarded PET plastic bottles, have evolved into a widespread global resource. However, their current disposal in landfills poses a significant environmental pollution challenge. This research is centered on evaluating the performance of cement mortar composed by larger PET particles in conjunction with sand, construction and demolition waste, and lightweight expanded polystyrene aggregates.

(ii) **Kimendren Gounden, Festus Maina Mwangi, (2023),** High-density polyethylene (HDPE) polymer is one of the largest contributors to plastic wastes causing detrimental effects on various sectors of society, and is not biodegradable in nature. In the first stage, river sand and a recycled HDPE as a binder were used to manufacture eco-friendly plastic sand bricks with various sand(s):plastic(p) ratios: 60s:40p; 65s:35p; 70s:30p; 75s:25p; 80s:20p; 85s:15p. In the second stage, 1%, 5%, and 10% of Kaolin Clay was added to each ratio of sand:plastic, respectively.

(iii) **Joan Nyika Megersa Dinka (2022),** The production of plastic wastes is a growing environmental problem in the era of industrialization and economic growth due to the varied applications of polymeric materials. The wastes, which are mainly landfilled pollute land and waste resources due to the toxic and resistant to biodegradation nature of their components.

(iv) Pooja Lamba, Dilraj Preet Kaur (2020), The exponential rise in the production of plastic and the consequential surge in plastic waste have led the scientists and researchers look out for innovative and sustainable means to reuse/recycle the plastic waste in order to reduce its negative impact on environment. Construction material, converting waste plastic into fuel, household goods, fabric and clothing are some of the sectors where waste plastic is emerging as a viable option.

(v)"**Bhusan Kumar, Prem Shankar Singh, Abuzaid Khan, Hrithik Goyal, Shivank Goyal" (2019)** This report outlines the utilization of municipal plastic waste (MPW) in construction industries. Plastic is a non-bio-degradable substance which takes thousands of years to decompose that creates land as well as water pollution to the environment.

(vi) **"Arvind Singhal, Dr. Om Prakash Netula" (2018).** They used the mixture of plastic and stone dust in the molten form in the ratio of 3:7 in standard brick mould for which stone dust was sieved through 4.75 mm using

sieve analysis and conducted test on water absorption to be found as 0%. Compressive strength of plastic sand bricks is 5.6 N/mm2 at the compressive load of 96 KN.

(vii)**"Ronak Shah, Himanshu Garg, Parth Gandhi, Rashmi Patil, Anand Daftardar."2017.** Utilizing MPW as construction materials especially in production of bricks is one of a promising step towards a sustainable resources and waste management. Plastic waste can substitute either partially or completely one or more of the materials in brick production.

(viii) "Gopu Mohan C, Jikku Mathew, JithinX Ninan Kurian, John Thomas Moolayil", April 2016. 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.

(xi) "Hiremath PM, Shetty S"(2014). There has been a considerable imbalance between the availability of conventional building materials and their demand in the recent past. On the other hand the laterite quarry waste is abundantly available and the disposal of waste plastics (PET, PPetc.) is a biggest challenge, as repeated recycling of PET bottles pose a potential danger of being transformed to a carcinogenic material and only a small proportion of PET bottles are being recycled.

(x)**Maneeth. P.D, Pramod. K, Kishore Kumar, Shanmukha Shetty, 2014**. There has been a considerable imbalance between the availability of conventional building materials and their demand in the recent past. On the other hand, the laterite quarry waste is abundantly available and the disposal of waste plastics (PET, PP, etc.) is a biggest challenge, as repeated recycling of PET bottles poses a potential danger of being transformed to a carcinogenic material and only a small proportion of PET bottles are being recycled.

TYPES OF PLASTIC & PROPERTIES

Plastic- Plastics are a wide range of synthetic or semi-synthetic materials, the main components of which are polymers. Due to its plasticity, plastics can be molded, extruded or pressed into solids of various shapes. There are many different characteristics, such as this adaptability. Widely used due to its light weight, durability, flexibility and low cost manufacturing. Plastics are usually produced by human industrial facilities. Most modern plastics are made from fossil fuel-based chemicals such as natural gas and oil. However, newer industrial methods use variants made from renewable raw materials such as corn and cotton.

Types of plastic- Two different types of plastics.

(a) Thermo plastics

(b) Thermo setting

Thermo plastics- Many types of Thermoplastic.

(i) Polyethylene Terephthalate (PET),

(ii) High-Density Polyethylene (HDPE)-

(iii) Polyvinyl Chloride (PVC)-

(iv) Low- density polyethylene(LDPE)-

(b)Thermosetting- Thermosetting materials are those, which once set cannot be remolded /softened by applying heat. It includes phenol, melamine and urea formaldehyde, unsaturated polyester, epoxy and polyurethanes. These materials are not recyclable.

MATERIALS - They following materials use

(i) High-density polyethylene (HDPE)

(ii) Sand

(iii) Bitumen

(i)HDPE –

High-density polyethylene (HDPE) is usually derived from petroleum. HDPE is a low- cost thermoplastic material that performs well for low- and medium-technical applications. High-density polyethylene (HDPE) or polyethylene high-density (PEHD) is a thermoplastic polymer produced from the monomer ethylene.

Figure no. 1HDPE

Properties of HDPE – the are Flexible, translucent/waxy, weatherproof, good low temperature toughness (to -60'C), easy to process by most methods, low cost, good chemical resistance.

Table no. 1 Properties of HDPE

S.No.	Property	Units	HDPE
1	Yield stress	MPa	18
2	Youngs modulus	MPa	960–1000
3	Density	Kg/m^3	941–967
4	Melting point	C	130–133
5	Coefficient of thermal elongation	%	20–100
6	Impact resistance	J/m	27–160

(ii) Sand - Sand is a granular material composed of finely divided mineral particles. Sand has various compositions but is defined by its grain size. Sand grains are smaller 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 percent 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.

Figure no.4.2 sand

The particle size range of 0.1–0.3 mm was selected for the experiment. Quartz sand chemically resistant, and because it has a higher melting temperature than metals, it is used as a foundry sand and can be used for manufacturing bricks. Table no.4. 2 shows the properties of quartz sand. Quartz sand was purchased from **LOCAL MARKET GWALIOR.**

Table No 4.2. Properties of quartz sand

S.No.	Property	Units	Value
1	Specific gravity	-	2.45-269
2	Water absorption	%	1.9
3	Fineness modulus		2.2
4	Bulk Density		1690 $kg/m3$

(iii)Bitumen- Bitumen is mainly used for construction because of its higher binding characteristics; it is less costly compared to other binding materials. Bituminous materials have adhesive properties, are soluble in carbon disulphide, and are mostly made of high-molecular-weight hydrocarbons produced by distilling petroleum or asphalt.

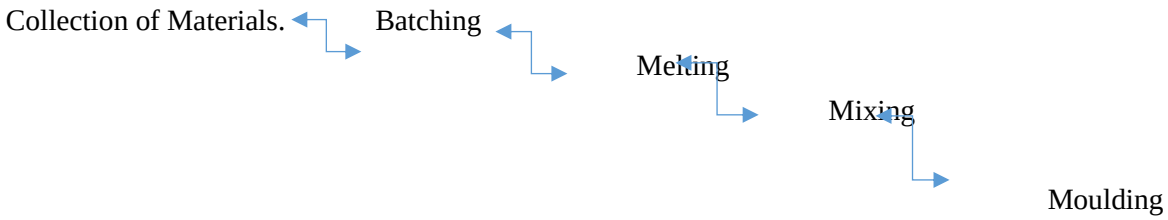
Figure no. 3 bitumen

Bitumen is also known for its binding properties. In this experiment, different percentages of bitumen (1%, 2%, and 3%) were considered. Table No. 4.3 shows the properties of bitumen. Bitumen was purchased from Local Market Gwalior (Madhya Pradesh).

Table no. 4. 3 Properties of bitumen

Property	Units	Value
Specific gravity	-	22.4
Softening point	^{0}C	35–70
Ductility	m	0.0264

METHOD-



Collection of Materials -Initially, used HDPE containers/bottles were collected and cleaned with warm water. Next, the HDPE waste was dried to enable further processing without any moisture content. These plastics were then broken down into smaller pieces using a shredding machine containing a series of rotating blades that cut the plastic containers/bottles into small pieces. The sizes of these pieces' ranges from 1 mm to 5 mm. To produce the desired brick, these plastics were then melted with sand.

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 melting.

Melting - Melting of waste plastic: After completion batching the plastic waste was taken for melting in which the plastic into the container and allowed to melt. Melting process is done in Closed Furnace which is closed from top and bottom also to prevent releasing of carbon toxic gases. Melting is carried out in Closed furnace. At the time of melting temperature is maintained up to 105^0 Centigrade.

Mixing - Quartz Sand and Bitumen A small quantity of bitumen was added as a binding agent to increase the strength of the brick, induce better bonding of granules and cover any voids. Different amounts of bitumen were added to the sample to determine the maximum strength (0%, 1%, 2%, and 3%). The mixing ratios of plastic and sand were varied (3:1, 3:2, 1:1, 2:3, and 1:3). The mixture was then heated using a kneader to firmly bond the plastic and sand.

EXPERIMENTAL DETAILS

Compression Tests-

The compression strength of the plastic bricks was tested using the ISO 604. Twenty bricks were tested in total. Because of their ductile nature, the bricks were cut into 10 mm × 10 mm × 10 mm pieces and tested on a compression machine. The load was applied until the brick broke or showed deformation. The test was performed on a Universal Testing Machine with a maximum force of 100 kN at a speed of 1 mm/min. The ultimate stress at which the brick deformed or broke was noted, and the compressive strength was calculated using the formula shown in Equation (1).

$$\text{Compression strength} = \frac{P}{A}$$

With

P as the maximum load [kN] and

A representing the area of the specimen [mm^2].

Water Absorption Tests-

The test was used to determine the amount of water absorbed by the brick. The quality of the brick was determined by its water absorption rate, with a lower water absorption rate considered the best. The bricks were heated to

remove any moisture content. The weight of the dry brick was noted as W_1. The brick was then fully immersed in water and undisturbed for 24 h. After 24 h, the brick was removed from the water and gently wiped with a cloth. The weight of the wet brick was noted as W_2. The percentage of water absorbed was calculated using the formula shown in Equation (2).

$$\text{Water absorption} = \frac{W - W_1}{W} * 100\% \quad \text{----------(2)}$$

with
W being the weight of the dry brick [kg]
W_1 being the weight of the wet brick [kg].

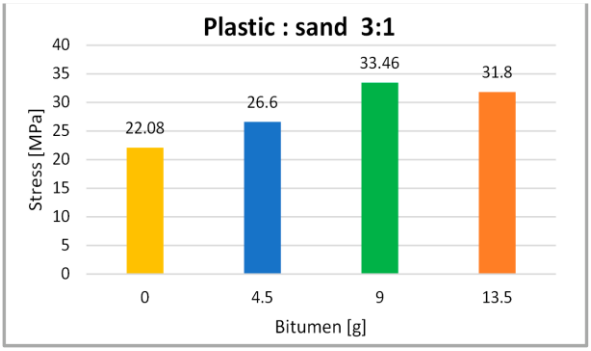
RESULTS –

Compression Test-

The test was carried out at a speed of 1 mm/min using a Universal Testing Machine (UTM). A total of five brick samples were taken, consisting of 20 bricks in total. The following results were obtained. The stress values were recorded when the strain value was 0.2, which is acceptable in most applications.

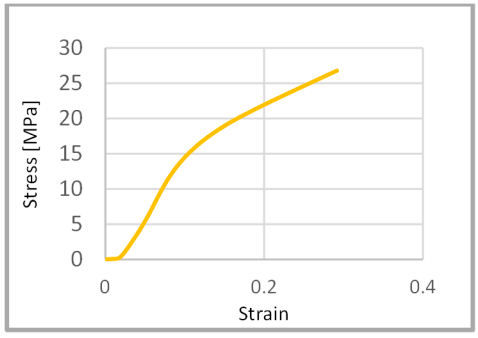
Brick Sample 1 (Plastic: Sand-3:1)

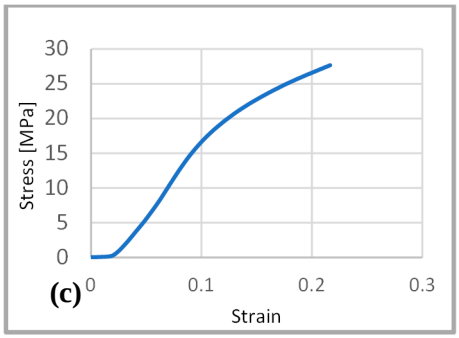
Figure no. 4 a shows that the bricks with more plastic (i.e., a plastic-to-sand ratio of 3:1) had higher compression strengths. When 0% bitumen was added, the strength of the brick was 22.08 MPa; when bitumen was added, the values varied between 26.6 MPa and 33.46 MPa, with 2% (9 g bitumen) being the optimal amount; and as bitumen was removed, the value fell to 31.8 MPa. The highest strength was attained at an optimal bitumen percentage of 2% (i.e., 9 g bitumen).



(a)

(b)





(c)

(d)

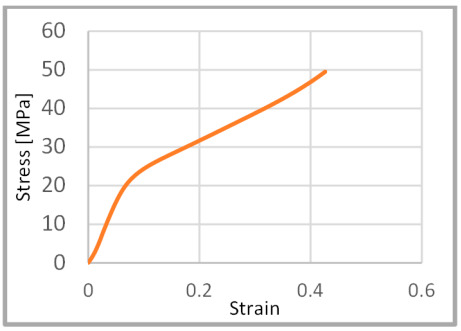


Figure no.4 Results of brick sample 1 (a) Compression strength values of brick plastic to sand 3:1 (b) Stress-strain curve with 0 g bitumen. (c) Stress-strain curve with 4.5 g bitumen. (d) Stress-strain curve with 13.5 g bitumen.

CONCLUSIONS –

(i) Re using plastic will reduce environmental pollution.

(ii) Plastic bricks can a very good alternative of traditional earthen bricks.

(iii) In this study, HDPE, silica sand, and asphalt were used to make the bricks. found to increase the strength of the bricks while reducing their weight. Moreover, the cost of these bricks was almost 50% less than traditional bricks.

(iv) The cost of one conventional brick is around 6.20 to 7.0 Rs/- However, the cost of one plastic sand brick is around 3.50RS/-, including the raw materials cost (i.e., for 1 kg of plastics, it costs 10.Rs/- for 1 kg of quartz sand, it costs 8.50 Rs/- and for 2% bitumen by weight (9g), it costs.0043Rs). HDPE and bitumen made the bricks more water-resistant by reducing their permeability, and quartz sand improved the binding between the plastics due to its strong binding properties.

(v) This research indicates that adding bitumen to bricks can significantly enhance their tensile strength, with a maximum value of 37.5 MPa observed.

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