Utilization of Waste Plastic in the Manufacturing of Bricks Along with Quarry Dust and M-Sand

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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 are 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.

Abstract

Introduction

1.1 Overview

Soil is a loose, unconsolidated material on the earth's crust and it is formed by the weathering of solid rocks. The laterite formation was named in southern India1807, and it was described by Francis Buchanan-Hamilton. He named it from the Latin word "later" which means brick. This rock can be easily cut into brick shaped blocks for building construction. The laterite stone is rich in iron and aluminium and it is formed in hot and wet tropical areas. A good reservoir of laterite stone is present in the coastal Karnataka and some Northen parts of Karnataka and also in the northern parts of Kerala, due to which lot of quarrying of laterite bricks takes place. In quarries while cutting out the laterite stones with the help of cutting machines which produces 15-20% of soil wastes which pose a problem of disposal. The quantity of plastic waste in Municipal Solid Waste (MSW) is expanding rapidly. It is estimated that the rate of expansion is double for every 10 years, this is due to rapid growth of population, urbanization, developmental activities and changes in life style which leading widespread littering on the landscape. Thus, disposal of waste plastic is a serious problem globally, since they are non-biodegradable and also researchers have found that the plastic materials can remain on earth for 4500 years without degradation. Plastic has many good characteristics which include versatility, lightness, hardness, and resistant to chemicals, water and impact There is considerable imbalance in the conventional building materials; there is a great demand in recent past years. In quarries while cutting out the lateritic stone with help of cutting machines which produces 15-20% of soil wastes which poses a problem of disposal & utilizing the quarry waste. The quantity of plastic waste in municipal solid waste collection is expanding rapidly ,the rate of expansion is double for every 10 years .since it is non-biodegradable which remain on earth for 4500 years without degradation & it is a great challenge in disposing of waste plastics ,it is also danger in repeat recycling of plastic waste it poses a danger of being transformed to a carcinogenic materials & only a small amount of pet bottles are recycled, it has a many good characteristics such as versatility , hardness, resist to chemical, water impacts. In recent years, the natural sand is replaced by the m-sand .m-sand is also used in mixture of plastic & soil, in this work an attempt has been made to manufacture of bricks by using the waste plastic in range of 60-80% by weight of lateritic quarry waste & m-sand mixture. The bricks manufactured possess the properties such as neat & even-finishing with negligible water absorption & which satisfies the compressive strength to a certain extent.

• MATERIAL USED-

1.1 WASTE PLASTIC-

The plastics can be made to different shapes when they are heated in closest environment it exists in the different forms such as cups, furniture's, basin, plastic bags, food drinking containers, and they are become a waste material. Accumulation or such wastes can result into hazardous effects to both human and plant life. Low density polyethylene (LDPE) as a binder. Density of LDPE range from 0.910 and 0.940 grams per cubic centimetre (g/cm^{3})

Fig 1.1 LDPE PLASTIC

1.2 QUARRY DUST-

Quarry dust is a fine substance which is obtained from crushing of rock. During this process 15-20% of soil wastes are generated and it is termed as quarry dust. These dusty particles scatter in the air and cause air pollution.

Fig 1.2 QUARRY DUST

1.3 M-SAND-

Manufactured sand (M-sand) is an alternative of natural sand. manufacture sand is produced by crushing hard granite stone. The size of M-sand is less than 4.75mm

Fig 1.3 M-SAND

1.4 Cement

53 Grade OPC (Ordinary Portland Cement) is a type of cement that is commonly used in construction. Which gives compressive strength 53 MPa (7735 psi) at 28 days. It has high strength and durability with low alkalinity. It gives good resistance to sulphate attack & Suitable for high-rise buildings, bridges, and other structural applications., etc. 53 Grade OPC Cement conforms to IS 12269:2013.

Fig 1.4 Cement

MIX DESIGN

Ratio 1:3 (Comparing with cement sand bricks)
Material used – Cement, Quarry dust, Water, M-sand, LDPE (Low Density Poly-ethylene)
The plastic is replaced with 1 part of cement for 3 part of sand, 70% M-sand & 30% Quarry dust.

• Calculation for 2 % of LDPE
1:3 = 1+3 = 4
The size of brick is 190*90*90 i.e. in volume (0.001539 m^3

For cement = (0.001539*0.98*1/4) *1440 = 0.5430 kg
For 9 bricks = 0.5430*9 = 4.9 kg
Water ratio required = 4.9*0.5 = 2.6 lit
For plastic = (0.001539*0.02*1/4) *930(LDPE) = 0.0072 kg

For 9 bricks = 0.0072*9
= 0.064 kg
For M-sand (70%) = (0.00153*0.70*3/4) *1850
= 1.4948 kg
For 9 bricks = 1.4948*9
= 13.45 kg
For Quarry dust (30%) = (0.001539*0.30*3/4) *1.600 = 0.5540 kg
For 9 brick = 0.5540*9
= 4.9 kg

• Calculation for of 2.5 % LDPE
For cement = (0.001539*0.975*1/4) *1440 = 0.53742 kg
For 9 brick = 0.53742*9
= 4.8366 kg
For plastic = (0.001539*0.025*1/4) *950
= 0.00895 kg
For 9 bricks = (0.00895*9)
= 0.0805 kg

• Calculation for 3 % of LDPE
For cement = (0.001539*0.97*1/4)1440
= 0.53744 kg
For 9 brick = 0.53744*9
= 4.8346 kg
For plastic = (0.001539*0.03*1/4)
= 0.0107 kg
For 9 bricks = (0.0107*9)
= 0.096 kg

Note: -

Density of cement = 1440 kg/m^3
Density of LDPE = 930 kg/m^3
Density of M-sand = 1850 kg/m^3
Density of Quarry dust = 1600 kg/m^3

According to IS: 2691:1988 revision 2, Burnt clay facing bricks specification standard size of brick is 190mm*90mm*90mm.

Problem Statement

• High volumes of waste plastic in landfills and oceans.

• Depletion of natural sand resources.

• Limited availability of suitable quarry dust.

• High energy consumption and greenhouse gas emissions in traditional brick manufacturing.

• Inconsistent quality and properties of bricks.

• Limited affordability and accessibility of sustainable building materials.

• Due to excessive use of plastic in most of the product, there is a rise in the plastic waste which is non-biodegradable and has become a major problem in cities because of less availability of dumping ground.

Objectives

• 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.

• To make a new type of brick (size 190mmx90mmx90mm) from plastic waste, quarry dust, cement, water and M- sand.

• To study the structural behavior of the bricks manufactured using m-sand, quarry dust and recycled thermoplastic.

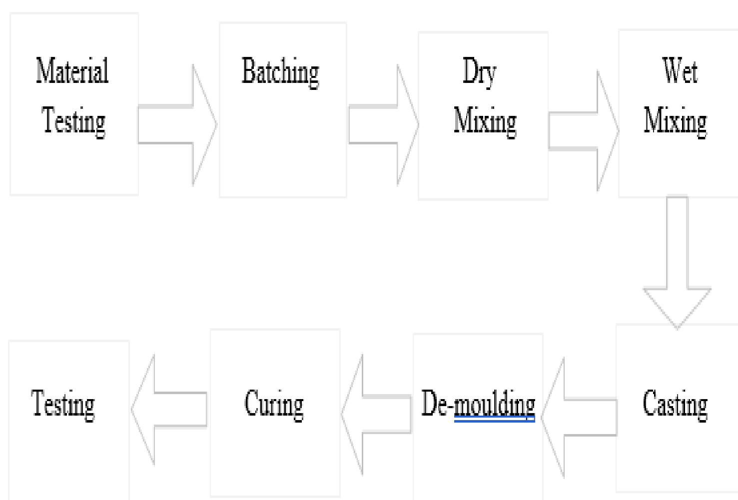
• To determine the suitability of waste polyethylene bags in the development of Plastic sand bricks for construction.

- To reduce the plastic waste.
- To use plastic waste material in construction methodology.
- To reduce the environmental and ecological challenge associated with plastic.

Literature Review

2.1 Review of Literature

According to a Technical newsletter "Focus on PET", Poly ethylene terephthalate belongs to the polyester family of polymers, one of the largest and most diverse of the polymer families. This family of polymers is linked by the common feature of having an ester (-COO-) link in the main chain, but the range of polyester materials is probably the largest of all the polymer families. And also, the chemical structure of the PET is having only atomic species that are carbon, hydrogen and oxygen. the properties of the PET it can be understood that it has got good chemical resistance and better resistance to UV rays . In a paper "A review on waste plastic utilization in asphalting of roads" the techniques to use plastic waste for construction purpose of roads and flexible pavements, which were developed by various researchers has been reviewed. And collectively emphasizes the concept of utilization of waste plastic in construction of flexible road pavement. In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength and life of road pavement. But its resistance towards water is poor. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with synthetic polymers like rubber and plastics. This bitumen mix show better binding property, stability, density and more resistant to water. Research on "The Use of Recycled Materials in Highway construction" and "Utilization of waste plastic in Bituminous Concrete mixes" to determine the suitability of plastic waste modifier in construction of bituminous mixes, where the heated. aggregates are transported on conveyor belts the shredded plastic is sprayed on it. So that plastic makes a coat on the aggregate this plastic-coated aggregate was later blended with hot molten bitumen to result in plastic modified bitumen. The research concluded that this waste plastic usage in bituminous concrete mixes resulted in improved resistivity to water absorption and better bonding with reduced susceptibility to stripping. "Useful products from oil and organic chemistry" classifies the plastic as Thermal softening plastics (Thermal plastics) and Thermal setting plastics (Thermal set plastics). Thermal setting plastics can be made plastic and malleable at high temperatures only once. Modern thermoplastic polymers soften anywhere between 65 ºC and 200+ ºC. In this state they can be molded in a number of ways they differ from thermal set plastics in that, they can be returned to this plastic state by reheating. They are then fully recyclable. LDPE used



in this project belongs to thermal plastics. Thermo-set plastics differ in that they are not re mouldable. Strong cross links are formed during the initial moulding process that gives the material a stable structure. They are more likely to be used in situations where thermal stability is required. They tend to lack tensile strength and can be brittle. Polyester resin, Urea formaldehyde etc. belongs to this type. An attempt to utilize the laterite wastes available abundantly in the laterite quarry for the manufacture of laterite soil bricks using cement as a stabilizing agent. This can be used as an alternative to the usual laterite stone. The laterite soil was procured from the laterite quarry near sullia. The study concluded that laterite soil stabilized with 7% cement for manufacturing of interlocking bricks with a good compressive strength of 4.72 N/mm2 . The concept of interlocking bricks of size 30x20x18cm was adopted which resulted in a cost-effective construction. As per the research work on “Use of Cement-Sand Admixture in Laterite Brick Production for Low-Cost Housing” in Makurdi (Nigeria) and other locations within Benue State, abundant lateritic soil deposits exist which can be harnessed for brick production. Results showed that laterite used in this study cannot be stabilized for brick production within the economic cement content of 5% specified for use in Nigeria. However, bricks made with laterite admixed with 45% sand and 5% cement attained a compressive strength of 1.80 N/mm2 which is greater than the specified minimum strength value of 1.65 N/mm2 .

3.1 Methodology

The main objectives of this research work are to develop an efficient way to effectively utilize the waste plastic which is a great threat for the sustainment of ecological balance, with the laterite quarry waste to manufacture an alternative building material by which both the questions of a scientific disposal of waste plastic as well as scarcity of traditional building materials can be answered. The quarry waste was collected from construction material site. When the laterite stone is cut from the quarry nearly 15-20% of laterite waste is obtained. This waste was crushed using rammers and sieved in a 2.36mm IS sieve. This sieved laterite soil was brought to laboratory for preparation of bricks. This soil was sun-dried to reduce the water content. A mould of size 190x90x90cm was prepared. Bricks of different mix proportions were prepared, for each brick 3kg of the laterite soil was added with varying m-sand content of 2, 2.5 and 3% along with variation in percentage of plastic. Bricks were prepared by compacting through tamping. 9kg of clean sieved quarry waste is collected. 2.5% of plastic (LDPE) by weight of soil is cleaned and cut. Then sieved dust is added at intervals with proper mixing. At the 15kg of m-sand is added and mixed for uniform distribution to prepare 9 bricks. The material mixing is poured into the moulds and then compacted by tamping. The bricks are demoulded after 24 hours. Of each mix proportion bricks were prepared and tested for compressive strength in the compressive testing machine (CTM).

LAB TEST ON PLASTIC BRICK

After preparing the plastic brick it should be kept for tests to know about its properties and shall be compared with the properties of other similar materials.

The tests which are done in this experiment of plastic bricks are

1. Compressive strength.
2. Penetration test.

Compressive Strength Test

Compressive strength or compression strength is the capacity of a material or structure to withstand loads tending to reduce **size, as** opposed to tensile strength, which withstands loads tending to elongate.

Procedure

i. Clean the bearing surface of the testing machine
ii. Place the specimen in the machine in such a manner that the load shall be applied to the opposite sides of the cube cast.
iii. Initialing the specimen centrally on the base plate of the machine.
iv Rotate the movable portion gently by hand so that it touches the top surface of the specimen.
v. Apply the load gradually without shock and continuously at the rate of 140 kg/cm^2/minute till the specimen fails.
vi. Record the maximum load and note any unusual features in the type of failure.

Normally the Compressive strength of bricks is determined by compression testing machine. Hence the prepared bricks are placed in the compressive testing machine. After placing this brick in compression testing machine, the load is applied on it until brick breaks. Note down the value which obtained at the breaking point and find out the compressive strength value of brick. Minimum compressive strength of brick is 3.50N/mm2. If it is less than 3.50 N/mm^2, then this type of bricks is not useful for construction purpose. The obtained results were shown in chart.

FIELD TEST ON PLASTIC BRICKS

Hardness Test

This type of test was conducted to check the hardness property of the prepared plastic brick. Hence this test was carried out either in laboratory or in construction site. In this test the sharp tool was used to scratch the surface of the bricks and the identifying the hardness by the depth of the scratch which was done by the sharp tool. If the brick has less impression, then the brick is a hard brick. The following figure shows the before and after scratch results.

Soundness Test

From this test, the observed result was that the sound of normal brunt clay brick was less when compared with the plastic sand bricks of different ratios. The plastic bricks do not get any crack or damages during the process of checking the soundness, but the brunt clay bricks get abraded at their surface.

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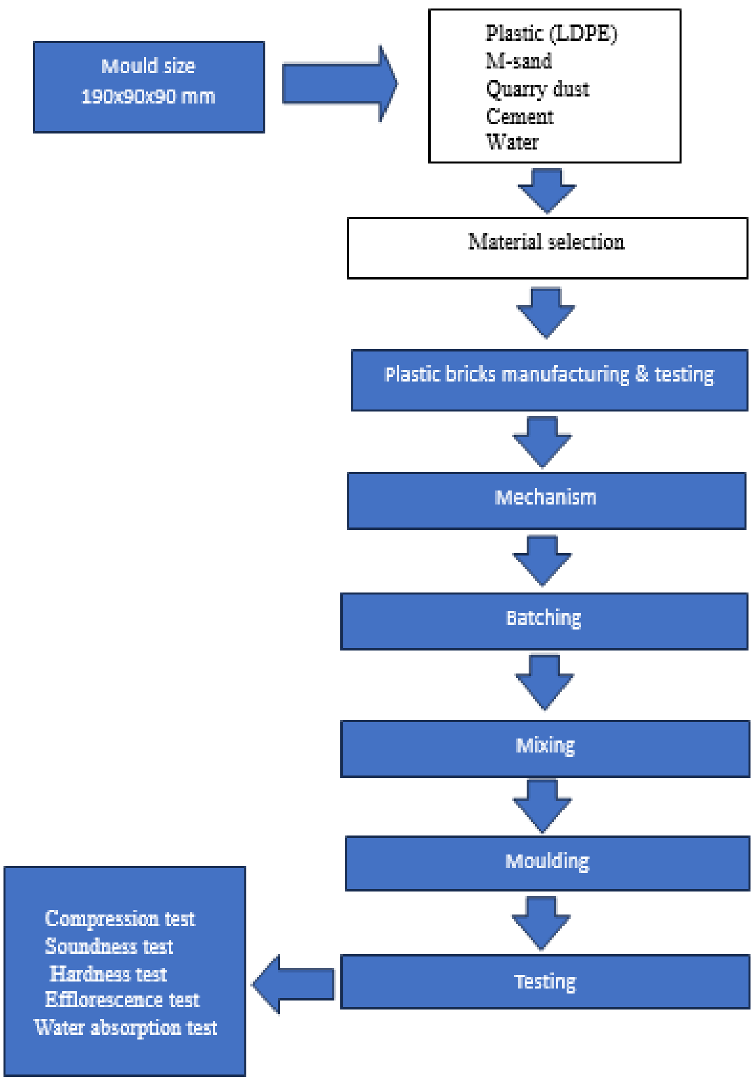
Efflorescence Test

From the testing of efflorescence for the bricks, it was observed that the plastic sand bricks do not show any efflorescence. Since the plastic contains a smaller number of soluble salts in it. Hence ,it is proved that the efflorescence of the plastic brick was very less

3.2 Flow Chart of Project Process



3.3. Block Diagram


Quarry Dust
M-Sand
Cement
Plastic
Water
Proposed Brick

Discussion

4.1 Discussion

The development and utilization of plastic bricks have shown promising results, offering a sustainable solution for managing plastic waste and reducing environmental impacts. Key findings include:

• Positive Outcomes:

1. Reduced plastic waste: Utilizes non-biodegradable plastic waste.
2. Conservation of natural resources: Decreases sand and aggregate extraction.
3. Improved durability: Resistant to pests, rot, and weathering.
4. Cost-effective: 10-30% cheaper than traditional bricks.
5. Job creation: Employs people in plastic waste collection, sorting, and brick manufacturing.

• Challenges and Limitations:

1. Standardization: Lack of unified production processes.
2. Scalability: Limited production capacity.
3. Public acceptance: Overcoming perceptions of using plastic waste in construction.
4. Regulatory framework: Need for supportive policies and regulations.
5. Mechanical properties: Variability in compressive strength and density.

• Future Scope:

1. Large-scale adoption: Encourage widespread use in construction.
2. Improved manufacturing: Develop efficient, automated production processes.
3. Enhanced properties: Research additives to improve mechanical properties.
4. Specialized applications: Explore fire-resistant, thermal insulation, and acoustic insulation bricks.
5. Integration with other materials: Combine plastic bricks with natural materials.

• Potential Applications:

1. Affordable housing
2. Infrastructure development (roads, bridges)
3. Disaster-resistant construction
4. Coastal protection (sea walls, breakwaters)
5. Eco-friendly buildings

• Research Directions:

1. Life cycle assessment (LCA) studies
2. Performance evaluation under various environmental conditions
3. Development of recycled plastic aggregates
4. Investigating alternative plastic waste sources (ocean plastic)
5. Standardization and certification

• Policy and Regulatory Support:

1. Tax incentives for plastic brick manufacturers
2. Subsidies for plastic waste collection and sorting
3. Building codes and standards for plastic bricks
4. Public awareness campaigns
5. Collaboration with construction industry stakeholders

• Collaborative Efforts:

1. Industry-academia partnerships
2. Government initiatives
3. Non-profit organization involvement
4. Community engagement
5. International cooperation

By addressing challenges, exploring new applications, and fostering collaborative efforts, plastic bricks can become a game-changer in sustainable construction, waste management, and environmental conservation.

Conclusion

5.1 Conclusion

Plastics play an important role in modern society and are used daily in diverse applications due to their low cost, ease of manufacturing and attractive qualities. About 300 million tons of plastic are produced globally each year of which only about 25% is recycled and the rest is landfilled or find their way into rivers and oceans. An estimated 7 million tons of waste plastic end up as trach in the sea each year which cause significant environmental and health problems for fish and sea animals. Consequently, plastic waste brings serious environmental challenge to modern society because it is made of several toxic chemicals that can pollute soil, water and air if not managed properly. Recycling waste plastic is sustainable and can conserve natural resources. The percentage of recycled plastic can be increased by transforming waste plastic into mortar and concrete products suitable for housing and construction. In this study, melted plastic bags were used as a replacement for cement in the production of construction building bricks and concrete blocks. Using waste plastic in making bricks and blocks is advantageous due to its extreme versatility and ability to be tailored to meet specific technical needs and its light weight compared to other competing material which reduces fuel consumption during transportation. Also replacing cement with waste plastic will reduce environmental problems associated with the disposal of waste plastic as well as those associated with the cement industry.
The utilization of waste plastic in production of plastic bricks has productive way of disposal plastic waste. .

In this project, the plastic is used as the binder material so it restricts the absorption of water and also provides the good plasticity to the brick. So hence this type of bricks also resist the earthquake loads. This type of plastic bricks have high compressive or crushing strength at the ratio (1:3). And also has less absorption value when compared to normal conventional burnt clay bricks. So hence the plastic sand brick ratio 1:3 is preferable for the usage for the constructions. By use of plastic sand bricks, the water absorption was highly reduced. This plastic sand bricks are used as foundation bricks below the plinth level in order to avoid the seepage of ground water. Also, the study presented above helps in reducing the plastic waste disposal problem and converts that useless waste material into a useful construction material. The main drawback of this type of waste plastic sand bricks are easily get fire at normal fire. So, this type of bricks can be used at underwater construction, underground construction and also used for underground septic tank construction. Because this type of bricks can withstand high load than the normal brick. Hence the main aim of this project was to reduce waste plastic in our environment by utilizing as a material for the building construction. Since by using in the underground construction the plastic also gets degraded naturally. 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.

• Plastic bricks made using plastic waste, M-sand shows better result. It has good heat resistance.

• As a civil engineer and a citizen of our country we have the responsibility of educating people about the recycling and reusing of our resources because of the scarcity of resources and their effects.

• This attempt of recycling of plastic waste into a plastic brick has been made so as to reduce to the degradation of plastic waste into an "Eco Friendly "plastic brick.

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