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Fabrication of Sustainable Bricks:Integrating Plastic Waste, QuarryDust, and M-Sand

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ABSTRACT- The rising demand for traditional building materials has exposed a notable disparity between their supply and demand. Concurrently, the disposal challenge posed by waste plastics like PET and PP is intensifying, given that only a small fraction of PET bottles are recycled. Additionally, despite the ubiquity of laterite quarry waste, its potential remains largely untapped India, where each person produces an average of 0.5 grams of plastic waste daily, has been delving into the feasibility of creating sustainable bricks from plastic waste, quarry dust, and M-sand (manufactured sand). This innovative approach seeks to leverage the durability of plastics in a circular economy, promoting their reuse after their primary lifecycle, thereby ensuring minimal environmental impact while generating financial value. Results from the study indicate that incorporating plastic waste, quarry dust, and M-sand in brick manufacturing enhances the brick's strength and density while reducing water absorption. Bricks composed of 20% plastic waste, combined with 10% each of quarry dust and M-sand, demonstrated optimal characteristics. These bricks rival traditional red bricks in terms of neat finish, water absorption, and compressive strength. In high-altitude regions lacking efficient waste disposal systems, accumulating non-degradable plastic waste becomes not only an eyesore but also an environmental hazard. By converting this waste into high-strength bricks, which offer sound and thermal insulation benefits, we not only curb plastic pollution but also reduce the overall construction costs. This approach also alleviates the need for sand extraction from vital riverbeds. These waste-derived bricks present a promising alternative to conventional building materials. Still, more research is essential to assess the bricks' long-term resilience under different environmental conditions and to evaluate the feasibility of scaling up their production. In essence, integrating plastic waste in brick manufacturing offers a sustainable solution to meet the construction industry's demands and manage plastic waste effectively.

KEYWORDS- Include Ferric Oxide, Manufacturing Sand, Low Density Polyethylene, Quarry Dust, and Plastic Trash.

I. INTRODUCTION

Materials can account for up to 60% to 70% of a project's overall cost in the construction sector. Therefore, bricks are utilised extensively in the construction sector and come in a variety of forms, including clay, concrete, fly ash, and foam bricks. In order to boost the strength and economy of the bricks produced in this project and make them more affordable for the general public, we tried to create them using scrap plastic. Additionally, there will come a time when some practical challenges, such as a lack of material sources, expensive materials, jointing and cracking, and environmental impacts like high levels of hydration, will need to be overcome because of the high demand for traditional masonry work elements, including brick. In the meanwhile, sustainability can be achieved by replacing the sand in the brick mix design with quarry dust, a raw waste material. The need for sustainable solutions in the construction industry has grown as a result of the rising demand for building materials, the growing issue of plastic pollution, and the loss of natural resources. Utilising quarry dust, M-Sand, and plastic waste in the brick-making process is one potential option. Utilising these resources can potentially enhance the qualities and functionality of bricks while also addressing issues with plastic pollution and the depletion of natural resources. Plastic is a very useful material for our daily tasks, but because it is not biodegradable, it is quite difficult for us to discard it after we have used it. It becomes a dangerous material once used In many construction projects, plastic is used in the form of blocks, tiles, street asphalts, and other building materials. When plastic is used for these projects, the designs are more cost-effective and have sufficient strength and solidity. Plastic is one of the materials that is both useful and dangerous on a daily basis. When there is a shortage, plastic is seen as especially helpful but after use, it is simply thrown away, creating a variety of perilous situations. In India, plastic garbage is arranged in incinerators and burned at high temperatures. The gases that go through this eating mechanism contaminate the air and water. As a result, countless people are impacted and suffer the negative impacts of numerous deadly diseases. The annual production of strong urban garbage in India is estimated to be around 40 million tonnes, and it is growing at a steady rate of 1.5 to 2%. Landfills are becoming more and more cluttered with waste in all of its forms [3][10].

A. Quarry Dust

When plastic is used for these projects, the designs are more cost-effective and have sufficient strength and solidity. Plastic is one of the materials that is both useful and dangerous on a daily basis. When there is a shortage, plastic is seen as especially helpful but after use, it is simply thrown away, creating a variety of perilous situations. In India, plastic garbage is arranged in incinerators and burned at high temperatures. The gases that go through this eating mechanism contaminate the air and water. As a result, countless people are impacted and suffer the negative impacts of numerous deadly diseases. The annual production of strong urban garbage in India is estimated to be around 40 million tonnes, and it is growing at a steady rate of 1.5 to 2%.

Table 1: Physical Properties of Quarry Dust

property	value
Specific gravity	2.54-2.60
Bulk density(kg/m3)	1720-1810
Absorption(%)	1.20-1.50
Moisture content(%)	nil
Fine particles less than 0.075mm(%)	12-15
Seive analysis	Zone II

B. M-Sand

M-sand, often known as manufactured sand, is a form of substitute building material that is made by crushing and moulding natural rock or stone. It is produced with the use of cutting-edge machinery and technology, ensuring that the grain size and quality are constant. The fundamental benefit of M-sand is that it is devoid of pollutants like clay, silt, and organic matter, which are frequently present in natural sand. Due to its various advantages, m-sand is gaining popularity as a building material.

Table 2: Properties of M-Sand

Property	Value
Surface texture	Smooth
Specific gravity	2.65
Fineness modulus	4.67
Water Absorption	6.02
Bulk Density(kN/m3)	15.2
Bulking	4

C. Plastic Waste

By definition, plastics are malleable and can be heated to take on a variety of shapes. They can be found in a variety of objects, including cups, furniture, basins, plastic bags, food and drink containers, and they can also be moulded to create other shapes, such as spheres.Such wastes may become accumulated, which could be dangerous for both people and plants.
The following steps are usually involved in the process of creating bricks from plastic waste: - Plastic garbage is collected from a variety of places, including landfills, recycling facilities, and other waste management facilities. After that, the plastic trash is sorted and divided into different piles based on its type and quality to make sure that only the best plastic is used to make bricks[7][11].

Table 3: Properties of Plastic

Property	Values
Density	386.7
Shape of particles	Fabriform with dimensions varying from 0.15-12mm
Colour	Different colours
Water absorption(%)	0.02

D. Waste Management – Solid

Amidst population growth and urbanization, India confronts a mounting waste management dilemma. Annual rubbish production startlingly stands at 62 million tonnes. The primary components of urban waste are organic materials (46%), paper (6%), glass (0.7%), and plastic (1%), with the rest being moisture. On average, residents of Indian cities generate 0.2kg to 0.6kg of waste daily. Of the yearly 43 million tonnes collected, only 11.9 million tonnes are processed, leaving 31 million tonnes land-dumped. Consequently, a mere 22-28% of city waste is treated, despite 75-80% being collected. Forecasts are grim, predicting waste generation to skyrocket to 165 million tonnes by 2030, highlighting an urgent need for sustainable interventions.

II. TESTING OF SPECIMEN

A. Compressive strength

The UTM was used to measure the compressive strength of specimen brick of dimension 190 x 90 x 90 mm. After performing a compressive strength test on five different brick specimens, the specimen's compressive strength was estimated. The specimen was then be placed flat-side down on the compressive testing machine's base. After that an axial stress was progressively applied to the specimen at different rates until the brick specimen begins to break.

B. Water Absorption Test

The water absorption test was carried out in accordance with IS 3495 (Part2) 1992. The brick specimen is first weighed on a digital scale (M1), dried at room temperature, and then submerged in distilled water for 24 hours at a temperature of 27+ 2 C. After the 24-hour soaking, the specimens were taken out and the water was wiped off with a dried cloth. Additionally, each specimen is weighed (M2); using the formula, determine it. The brick's positive attributes can only support 20% of its own weight. The formula yields the percentage of water absorption.[10][13]

$$W = [(M2 - M1) / M1] * 100$$

C. Efflorescence Test

Efflorescence is a term used to describe a whitish crystalline deposit or foggy salts on bricks made up of calcium sulphate, magnesium sulphate, sodium carbonate, and potassium carbonate. The building is harmed by the accumulation of alkalis in the bricks.The efflorescence test further demonstrated the plastic brick's superior performance. For the 65% and 70% of the bricks, no evidence of grey or white deposits could be seen

D. Hardness Test

This test is carried out to ascertain the brick's hardness. A sharp object or fingernail is used in this test to scratch the brick's surface; if no impression is left, the brick has been sufficiently tested. Due to the plastic waste acting as a binder and the M-sand and quarry dust serving as fillers, none of the five different brick specimens in this test showed any signs of imprint. As a result, all of the brick samples were regarded as hard. [7]

III. TESTS AND RESULTS

A. Compressive Strength

The cubical brick specimen is inserted into the compression strength testing apparatus for this test. The load was applied on the brick without shock. The specimen's resistance to rising load was constantly raised at a rate of 140 kg per cm2 per minute until it was no longer able to endure additional increases in load. The maximum force applied to the brick specimen was reported, along with the appearance and type of failure and any unexpected characteristics.

A.1 Compressive Strength for 1:2 plastic to sand ratio (Plastic Sand Brick)

Table 4: Compressive Strength for 1:2 Plastic to Sand Ratio

Plastic Sand Brick	Maximum load (kN)	Compressive strength(kg/cm2)
Specimen 1	500	193.87
Specimen 2	525	203.56
Specimen 3	490	189.99

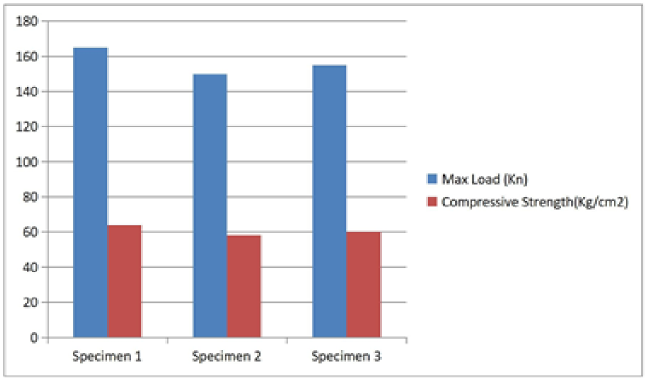

Figure 1: Graph Showing Compressive Strength for 1:2 Plastic to Sand Ratio

A.2 Compressive Strength for 1:3 Plastic to Sand Ratio (Plastic Sand Brick)

Table 5: Compressive Strength for 1:3 Plastic to Sand Ratio

Plastic Sand Brick	Maximum Load (kN)	Compressive Strength (kg/cm2)
Specimen 1	350	135.71
Specimen 2	320	124.07
Specimen 3	335	129.89

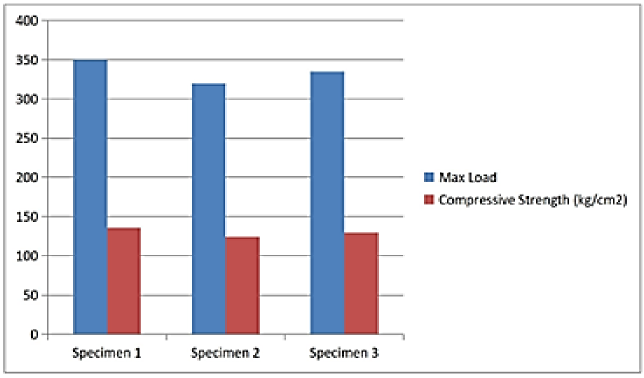

Figure 2: Graph Showing Compressive Strength for 1:3 Plastic to Sand Ratio

A.3 Compressive Strength for 1:4 Plastic to Sand Ratio (Plastic Sand Brick)

Table 6: Compressive Strength for 1:4 Plastic to Sand Ratio

Plastic Sand Brick	Maximum Load (kN)	Compressive Strength (kg/cm2)
Specimen 1	165	63.97
Specimen 2	150	58.16
Specimen 3	155	60.10

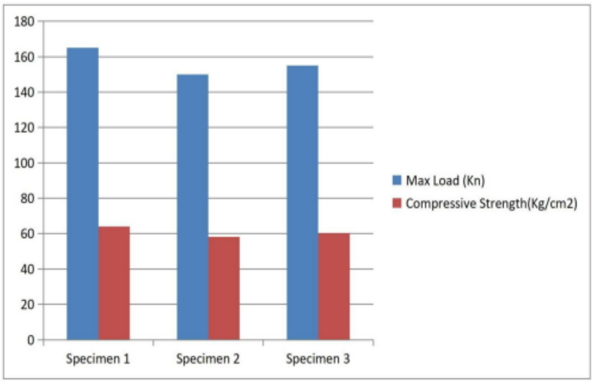

Figure 3: Graph Showing Compressive Strength for 1:4 Plastic to Sand Ratio

B. Water Absorption Test

The bricks are initially weighed in this test while being entirely dry. After that, they can spend about 24 hours in a container soaking in fresh water. The bricks are taken out of the water and wiped with a cloth after 24 hours. The wet brick is weighed using a weighing machine. The distinction between wet and dry brick is made in order to calculate water absorption. The amount of water that the brick absorbs makes a difference. Following that, using the data, the percentage of water absorption is computed. Bricks' ability to absorb water provides information about their relationship with mortar. Even so, other elements like brick grooves and designs also help the bonding. When bonding bricks with mortar, a thinner mortar layer is utilised with sand bricks since they absorb less water. Bricks of higher grade don't absorb as much water. A high-quality brick should not absorb more water than 20% of its own weight.[4][6]

Table 7: For 1:2 Ratios Plastic to Sand Bricks, the Water Absorption is Given Below

Plastic Sand Brick	W1 (kg)	W2(kg)	Water Absorption
Specimen 1	3.053	3.082	0.949
Specimen 2	2.958	2.997	1.318
Specimen 3	3.014	3.051	1.227

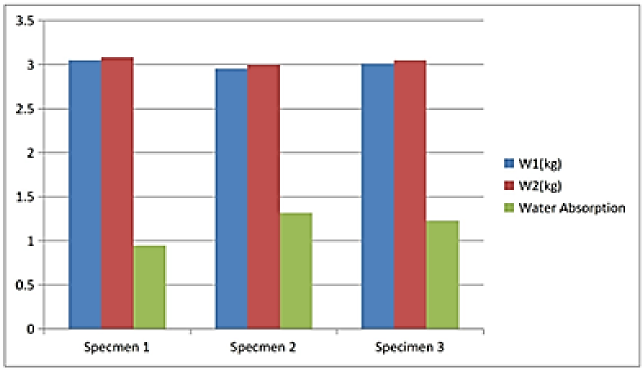

Figure 4: Graph Showing Water Absorption Test for 1:2 Ratios Plastic to Sand Bricks

- **1:3 Ratios Plastic to Sand Bricks, the Water Absorption is Given Below**

Table 8: For 1:3 Ratios Plastic to Sand Bricks, the Water Absorption

Plastic Sand Brick	W1 (kg)	W2(kg)	Water Absorption
Specimen 1	2.532	2.601	2.723
Specimen 2	2.498	2.564	2.642
Specimen 3	2.594	2.678	3.238

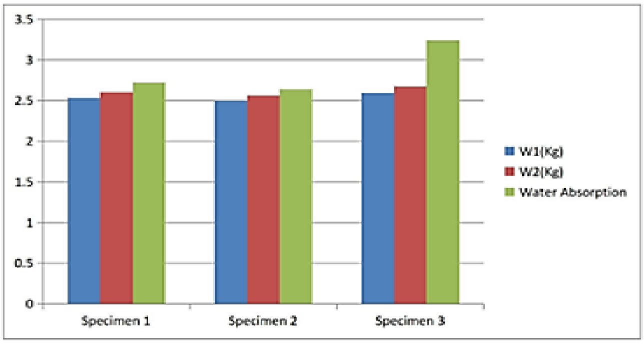

Figure 5: Graph Showing Water Absorption 1:3 Ratio Plastic to Sand Bricks

C. Hardness Test

In this test, a scratch was made oIn this test, a scratch was made on brick surfaces. When the scratch is made with the help of finger nail on the bricks, very light impression was left on the sand brick surface. So this test results that fibrous concrete bricks are sufficiently hard.n brick surfaces. When the scratch is made with the help of finger nail on the bricks, very light impression was left on the sand brick surface. So this test results that fibrous concrete bricks are sufficiently hard.

D. Efflorescence Test

The test was conducted in accordance with ISS 1077-1970. This test was used to find potentially dangerous alkalis in PET bricks. On the brick's surface, the alkalis create a grey or white spot. Enough distilled water was poured into a container with a flat bottom. An immersion depth of 25mm was used.A 24 hour period was given for the brick to soak in the distilled water. To avoid excessive evaporation, the container was covered with a glass sheet .The brick was then taken from the container and allowed to dry for the same period of time that water must have evaporated from the open container without the brick or the sheet.[19]

E. Alkali Presence in the Bricks as Appeared on the Surface

Test was carried out to measure the efflorescence, and it was discovered that the plastic sand bricks exhibited no efflorescence at all. because the plastic has fewer soluble ions than other materials. Thus, it was ultimately demonstrated that the plastic brick's efflorescence was extremely low.

Table 9: Alkali Presence in the Bricks as Appeared on the Surface

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

F. Test to determine the Relative Rise in Temperature of Plastic Sand Brick and Clay Bricks

The configuration used merely illustrated how brick temperatures would rise when heat or fire were applied to one side of the wall. A partition wall was formed by using both type of bricks and burning coal on one side of it with an average temperature of 500o C was applied. To remove heat losses a chamber containing burning coal was insulated. Temperature of the brick increased gradually. Clay brick's temperature increased more rapidly than the temperature of plastic bricks was noticed. Although, this confirms that the conductivity of plastic brick has lower than the clay bricks, continuous exposure to higher temperatures above 350o C led to partial melting of the brick. Thus it was noticed that plastic bricks are unsuitable for the places where fire risks are high.[17][19]

Table 10: Increase in Temperature of Plastic Bricks and Clay Bricks

	1:2 Plastic :Sand Brick	1:3 Plastic: Sand Brick	Clay Brick
Initial Temperature(℃)	36.0	35.8	36.2
Temperature afer 30 Minutes (℃)	41.2	41.7	43.8
Temperature After 45 minutes (℃)	45.2	46.4	54.3

G. Split Tensile Strength

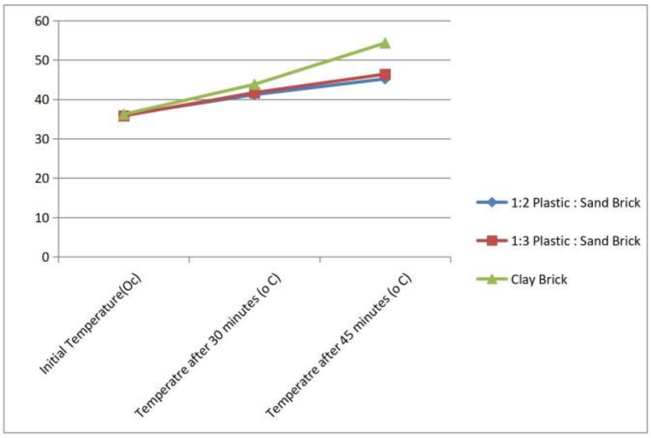

Figure 6: Graphical representation of Increase in Temperature of Plastic Bricks and Clay Bricks

IV. 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. The proposed project presented above intends to resolve in reducing the plastic waste disposal problem as it utilizes the waste even in its finest form and converts that useless material into a useful construction material. Extruder machine plays a prominent role in the conversion of waste plastic into its melted form. Also, extruder does not possess any threats to the environment and hence can be used without any restriction. It also helps in reducing the usage of natural resources which are utilized during the manufacturing of burnt bricks, also it reduces the pollution which is generated from kiln during brick manufacturing. The final end product can be used as brick, which is having a higher strength than conventional brick. Also, the water absorption capacity is higher in comparison to conventional brick with a lower weight. Its uses are not restricted as only brick; it can even be utilized as a building block by increasing the dimension of the mould. Also, it reduces the use of wire used for fencing. Floor tiles, sleepers, etc. can also be produced from it. This brick also turns out to be economical than conventional brick, by reducing the cost of incinerators for burning purpose and landfills.

CONFLICTS OF INTEREST

The authors declare that they have no conflicts of interest.

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