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

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ABSTRACT

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. In this work an attempt has been made to manufacture the bricks by using waste plastics in range of 60 to 75% by weight of laterite quarry waste and M-sand. The gypsum was added 5% for increasing the fire resistance capacity and 60/70 grade bitumen was added 2% by weight of soil in molten form and this bitumen- plastic resin was mixed with laterite quarry waste to manufacture the bricks. The bricks manufactured possess the properties such as neat and even finishing, with negligible water absorption and satisfactory compressive strength in comparison with red burnt brick to satisfy the increasing demand of conventional building materials.

Keywords: Plastic bricks**,** Poly ethylene terephthalate (PET), Laterite quarry waste, Bitumen, M-sand, Gypsum, Improvement of fire resistance capacity.

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1. INTRODUCTION

Today, the generation of plastics waste is a measure issue, as the plastics is not biodegradable, the waste today can be produced wherever human footprints be existed, and remind him that they have not chosen the appropriate method of exploitation of the nature at the present time. The concept of manufacturing the plastic bricks was we utilise the plastics waste, which is generated by people door to door, also the construction industry takes huge market in current scenario, utilization of waste in such construction industry may play major roll. Main important think while using the waste in plastic bricks was it can not made by recycling but just burn to plastic waste without adding any additives and it can also be used for at least 30-40 years in a construction industry.

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 age, 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

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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 M sand and quarry dust of sufficient bitumen & Gypsum to produce plastic bricks. The bricks will then be tested to study the compressive strength, efflorescence, water absorption and fire resistance test.

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-fibre, PET in small particles form by replacing sand and quarry dust. 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 wastes have been introduced in the form of small pieces, and this test increasing the fire resistance by using sufficient percent of gypsum. The replacement of plastic waste material has been done by weight.

1.1 PLASTIC BRICKS:

Plastic bricks are plastic drinking bottles packed with non-biological waste to make a reusable building block. A plastic brick is a plastic bottle stuffed solid with non-biological waste to create a reusable building block. These bricks are used to make modular furniture, garden spaces and full-scale buildings such as schools and houses. Plastic bricks are a collaboration powered technology that provides a zero-cost solid waste solution for individuals, households, schools and communities.

1.2 APPLICATIONS OF PLASTIC BRICKS:

- High-quality plastic bricks, which possess standard shape, sharp edges, smooth surfaces, high durability, and great strength, can be used for permanent structural construction such as buildings, roads, parking tiles, etc.
- Bricks can be used for construction of walls of any size (exposed brick walls, parapet walls, partion walls) floors, small arches, and cornices.
- Sun-dried or un-burnt bricks are used only for temporary structures and these bricks should be avoided where heavy dampness and frequent rain is predominant.
- Low-quality bricks or poorly mixed bricks are used as aggregate for foundation concrete and road metal works. This is because they can break easily and not suitable for construction purpose.

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- Bricks can be used for creating informal walkway or path to doors and walking path through flower garden.
- Holes in bricks can be used to create gorgeous planter/candleholders.

1.3 OBJECTIVES:

- To develop an efficient way to effectively utilize the waste plastics and that plastic wastes acts as a great threat for the sustainment of ecological balance.
- To reduce the consumption of earth-based material as clay for the manufacturing of brick that resulted in resource depletion, environmental degradation.
- To reduce the waste plastic quantities on the land and water to avoid land and water pollution.
- To reduce the dumping area of waste plastics.
- To produce the cost-effective materials.
- To prevent the people health from harmful diseases.

1.4 ADVANTAGE OF PLASTIC SAND BRICKS:

- Plastic brick possess more advantages which includes cost efficiency, resource efficiency, reduction in emission of greenhouse gases, etc.
- Reduce the intensity of plastic on earth. So, it can be used effectively in construction.
- Plastic brick is also known as “Eco-Bricks” made of plastic waste which is otherwise harmful to all living organisms can be used for construction purposes.
- It increases the compressive strength when compared to red burnt brick bricks.
- By use of plastic bricks, the water absorption of the brick is less and presence of alkalies was highly reduced.
- Owing to numerous advantages like weight, fire resistance etc., and further research would improve quality and durability of plastic bricks.

2. MATERIALS USED& ITS PROPERTIES

The present investigation the following materials were used:

1) Waste plastics i.e., PET, PP etc.,
2) Quarry dust.
3) M-sand.
4) Bitumen.
5) Gypsum.
6) Water.

2.1 WASTE PLASTIC: -

By definition 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, basins, plastic bags, food and drinking containers, and they are become waste material. Accumulation of such wastes can result into hazardous effects to both human and plant life. Therefore, need for proper disposal, Waste management in respect to plastic can be done by recycling. If they are not recycled then they will become big pollutant to the environment as they not decompose easily and also not allow the water to percolate in to the soil and they are also poisonous. And, if possible, use of

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these wastes in their recycled forms, occurs. This can be done through process of plastic management.

ORIGIN OF PLASTIC

Waste plastic	Available As
Poly ethylene terephthalate (PET)	Drinking water bottles etc.
High Density Poly ethylene (HDPE)	Carry bags, bottle caps, house hold articles etc.
Low Density Poly ethylene (LDPE)	Milk pouches, sacks, carry bags, bin linings, cosmetics and detergent bottles.
Poly propylene (PP)	Bottle caps and closures, wrappers of detergents, biscuit etc.
Urea formaldehyde	Electrical fittings, handles and knobs
Polyester resin	Casting, bonding fibres (glass, Kevlar, carbon fibre)

Poly ethylene terephthalate (PET):

Bottles made of polyethylene terephthalate (PET, sometimes PETE) can be used to make lower grade products, such as carpets. To make a food grade plastic, the bottles need to be hydrolysed down to monomers, which are purified and then re-polymerised to make new PET. In many countries, PET plastics are coded with the resin identification code number "1" inside the universal recycling symbol, usually located on the bottom of the container. PET is used as a raw material for making packaging materials such as bottles and containers for packaging a wide range of food products and other consumer goods. Examples include soft drinks, alcoholic beverages, detergents, cosmetics, pharmaceutical products and edible oils. PET is one of the most common consumer plastics used.[1] Polyethylene terephthalate can also be used as the main material in making water-resistant paper. The physical properties of the cement are listed in Table – 1.

Table – 1: Physical Properties of PET

Coefficient of Thermal Expansion	7×10^{-3}/ºC
Long Term Service Temperature	115 - 170ºC
Melting point	260ºC
Specific Gravity	1.3 – 1.4

Water Absorption	0.07 – 0.10%

2.2 QUARRY DUST:

Quarry dust which a waste product from aggregate crushers could replace sand. Construction of pavements and building materials in expansive soils creates a lot of problems for civil engineers, stabilization with industrial waste like quarry dust gives results. AP state new capital is purely a black cotton soil area, which leads to the problems of swelling and shrinkage. It is found that the swelling of expansive soils is controlled and improvement in soil properties is observed by adding quarry dust. The particular properties are given are given in table-2.

Table – 2: Properties of quarry dust

Property	Quarry Dust
Specific Gravity	**2.54-2.60**
Bulk Relative Density (Kg/M3)	**1720-1810**
Absorption (%)	**1.20-1.50**
Moisture Content (%)	**Nil**
Fine Particles Less Than 0.075mm (%)	**12-15**
Sieve Analysis	**Zone-II**

2.3 M-SAND:

Manufactured Sand (M-Sand) is sand produced from hard granite stone by crushing. The crushed sand is of cubical shape with grounded edges. It is then washed and graded with consistency to be used as a substitute of river sand as a construction material. The table-3shows the properties of m-sand.

Table-3: properties of m- sand

S.NO	PROPERTIES	M-SAND
1	TEXURAL COMPOSITION	
	COARSE SAND (4.75-2.00mm)	28.1
	Medium sand(2.00mm-0.425mm)	44.8
	Fine sand (0.425-0.075)	27.1
2	Specific gravity	2.63
3	Bulk density	15.1

2.4 BITUMEN: Bitumen is a common binder used in road construction. It is principally obtained as a residual product in petroleum refineries after higher fractions like gas, petrol, kerosene and diesel, etc., are removed. Indian Standard Institution defines Bitumen as a black or dark brown non-crystalline soil or viscous material having adhesive properties derived from petroleum crude either by natural or by refinery processes Indian Oil produces bitumen from its refineries and markets it in bulk as well as packed in steel drums. Indian Oil also markets modified Bitumen CRMB and Emulsion. The properties of bitumen as shown in table -4.

Table -4: properties of bitumen

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Experiments	Results
Penetration (mm)	67.5
Ductility (Cm)	59
Softening point (◦c)	58
Specific Gravity	1.01

2.5 GYPSUM: *Gypsum* is a soft sulphate mineral composed of calcium sulphate dihydrate, with the chemical. Selenite may also occur in a silky, fibrous form, in *which* case it is commonly called "satin spar". Finally, it may also be granular or quite compact.

Gypsum uses include: Manufacture of wallboard, cement, plaster of Paris, soil conditioning, a hardening retarder in Portland cement and bricks. Varieties of gypsum known as "satin spar" and "alabaster" are used for a variety of ornamental purposes; however, their low hardness limits their durability. Fire rated gypsum drywall is more fire resistant because it contains glass fibre reinforcement and other additives within its specially formulated gypsum core to help it hold up longer to a fire exposure.

- **Chemical formula of gypsum:** CaSO4-2(H2O), (Hydrated Calcium Sulphate).

2.6 WATER: The water used for experiments was potable water Fresh portable water free from organic matter and oil is used in mixing the preparation of plastic bricks. Water in required quantities were measured by graduated jar and added to the quarry dust and M-sand mix. The rest of the material for preparation of the mix was taken by weigh batching. The pH value should not be less than 7.

3. MIX DESIGN

The main objective of this research work is 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 and M-sand 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 laterite quarry waste was collected from puligilapadu village near to rapur. 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 19x9x9cm was prepared. Bricks of different mix proportions were prepared, for each brick 3kg of the laterite quarry dust and M-sand was added with varying bitumen content of 2% along with variation in percentage 0,60,65,70,75% of plastic waste and 5% of gypsum was added for increasing the fire resistance capacity. Bricks were prepared by compacting through vibration. 9kg of clean sieved laterite quarry waste is collected. 70% of plastic (PET) by weight of soil is cleaned and heated to a molten state. Then sieved soil is added at intervals with proper mixing.

At the final stage 2% of bitumen and 5% of gypsum by weight of soil is added and mixed for uniform distribution to prepare 3 bricks. The hot mix is poured into the moulds and

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then compacted by vibration.

The bricks are remoulded after 30 min and air dried for a period of 24hr for proper heat dissipation. Of each mix proportion bricks were prepared and tested for compressive strength in the compressive testing machine (CTM).

Table-5: Mix design of plastic brick

s.no	% of plastic replaced with quarry dust and m-sand	% of quarry dust&m-sand	% bitumen 60/70	% gypsum
1	0	100	2	5
2	60	40	2	5
3	65	35	2	5
4	70	30	2	5
5	75	25	2	5

3.1 Preparation of plastic brick:

1. First, we need to collect the plastic waste and separate it from other wastes and correctly weighing required plastic percentage.
2. Second, we should dry the plastic waste if it is wet and has a content of moisture. We have to use dry plastic waste.
3. The quarry dust and M-sand which we use in manufacturing of bricks/tiles is sieved for a size less than 4.75mm using sieve analysis.
4. After that correctly weighed percentage of quarry dust and M-sand.
5. Then, we add the quarry dust& M-sand along with gypsum into melt plastic.
6. Then, we can mix it properly and make a mix.
7. Finally add the bitumen to the mix.
8. Then, we poured the mix into moulds.

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9. Then keep it the mould for dry and remould it on a next 30 minutes.

Fig-1: preparation of plastic brick specimen

4.Results and Discussion

Compressive Strength:

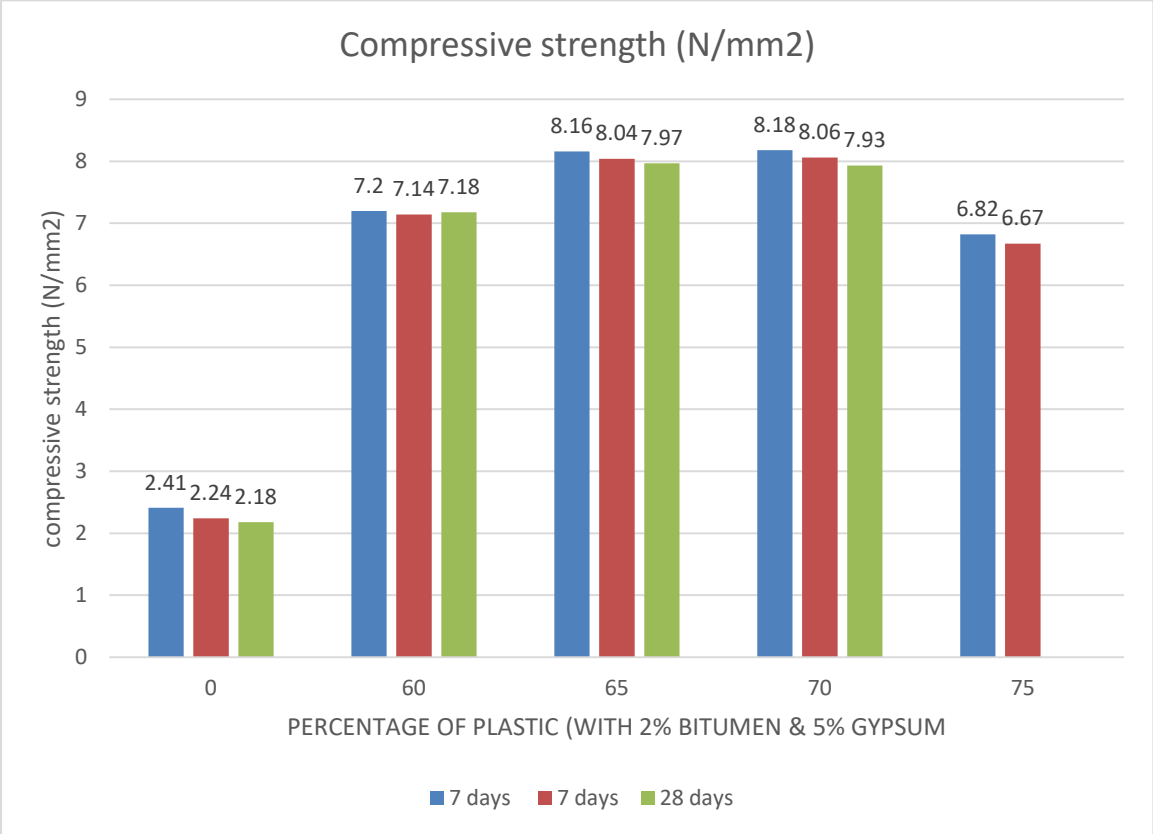

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Fig-2: variation of compressive strength of plastic brick

Water absorption:

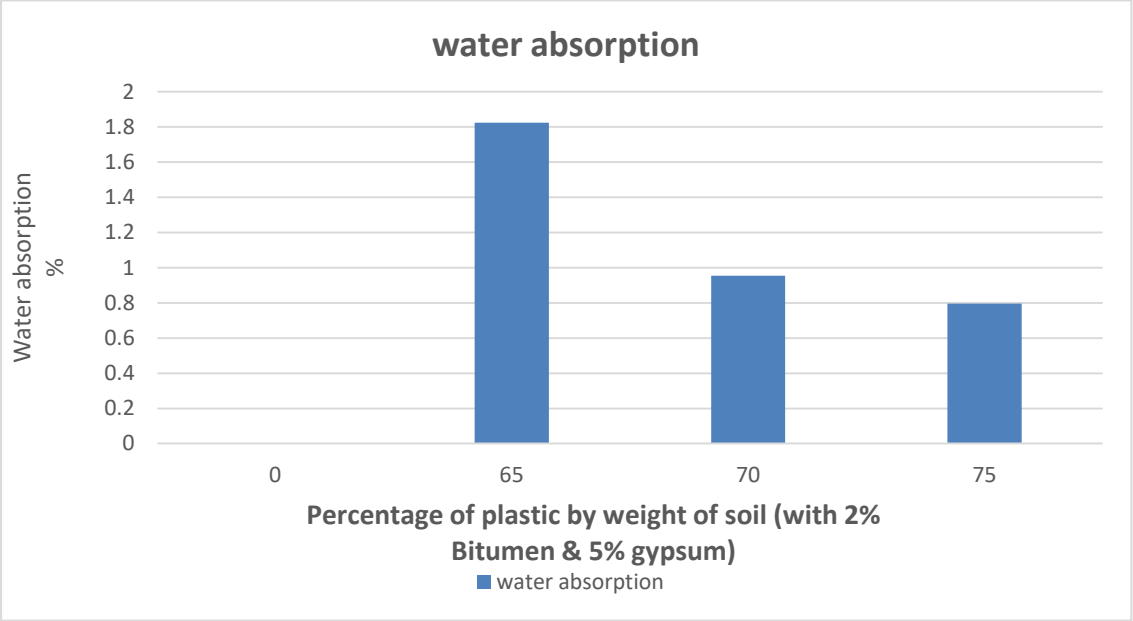

Fig-3: variation of water absorption of plastic brick

Water absorption of plastic brick vs conventional brick:

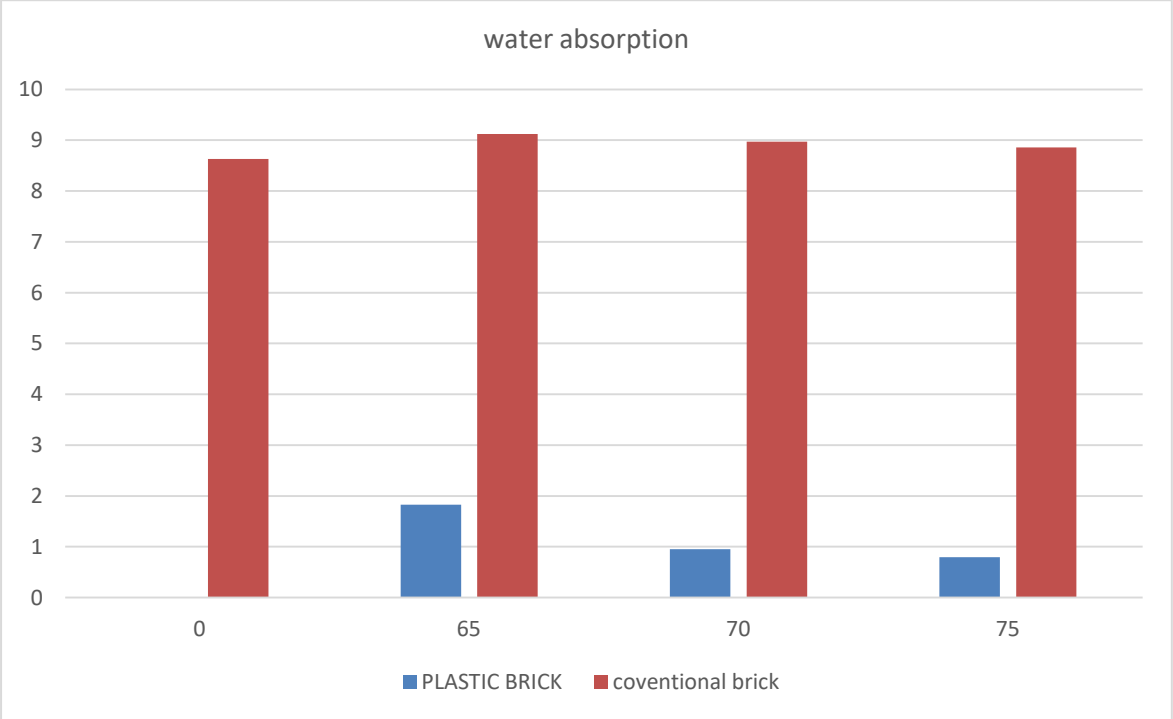

Fig-4: variation of water absorption of plastic brick vs conventional brick.

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EFFLORESCENCE TEST:

The efflorescence test also showed the excellence performance of the plastic bricks. There is absence of grey or white deposits were shown on its plastic bricks surface for the 65 and 70 percentages. It was showed alkali and soluble salts in the 75 percentage.

Hence from this test we can conclude that no alkalis were presence in the plastic brick. The variation as shown in table 6.

PROCEDURE:

1. A shallow flat bottom dish containing sufficient distilled water to completely saturate the specimens is used for the test. The ends of the bricks are placed in the dish, the depth of immersion in water being 25 mm.
2. The whole arrangement is placed in a warm (between 20^0C and 30^0C) well ventilated room until all the water in the dish is absorbed by the specimens and the surplus water evaporates.
3. The dish containing the brick is covered with a suitable glass cylinder so that excessive evaporation from the dish may not occur.
4. When the water has been absorbed and brick appears to be dry, a similar quantity of water is placed in the dish and it is allowed to evaporate as before. Examine the bricks for efflorescence after the second evaporation and the results are reported

Table -6: variation of efflorescence test

s.no	percentages (%)	nil	slight	moderate	heavy	serious
1	0			✓		
2	60	✓				
3	65	✓				
4	70	✓				
5	75		✓			

5. CONCLUSION

Compressive strength test results for plastic bricks with 70% plastic content by weight of soil with the binder (bitumen) content of 2% by weight of soil will give a compressive

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strength of 8.16N/mm^2 which is higher than the red burnt brick (7.18N/mm^2).It has a lesser water absorption (0.9536%) than conventional brick (12.58%). So, it can be a better alternative building material from the compressive strength test results of plastic bricks for 2% of binder (bitumen) content & 5% of gypsum by weight of soil with constant plastic content of 70% by weight of soil.The fire resistance capacity also similar to the clay brick. The efficient usage of waste plastic in plastic-soil bricks has resulted in effective usage of plastic waste and thereby can solve the problem of safe disposal of plastics, also avoids its wide spread littering. And also, the utilization of quarry waste has reduced to some extent the problem of its disposal.

On the basis of result obtained during the experimental investigation, following conclusion was drawn:

I. Making bricks from sand and waste plastics can be an alternative to the available traditional clay bricks.

II. Sand plastic bricks have lower water absorption, bulk density, and apparent porosity when compared with those of normal clay bricks.

III. Sand plastic bricks have higher compressive strength than normal clay bricks.

IV. Waste plastics which is available everywhere may be put to an efficient use in brick making.
V. Plastic bricks can help reduce the environmental pollution thereby making the environment clean and healthy.

COST ANALYSIS:

Sl. no	Item	Quantitty	Units	Unit rate (Rs –Ps)	Amount (Rs – ps)
1	Plastic (collection & Transportation)	1.96	Kg	0.7	1.37
2	Bitumen	0.056	Kg	23.00	1.28
3	Soil (transportation)	1.00	Kg	0.15	0.50
4	Gypsum	0.14	kg	1.7	0.2
5	Labour	lump- sum	-	-	1.3

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TOTAL Rs.	4.6

For all materials, it is required to know well in advance the approximate cost. Therefore, an attempt is made to work out the cost of a brick as in the table 9 which is giving considerably good strength. For this purpose, schedule of rates (2019- 2020) Nellore circles is used. However, the cost of laterite quarry waste is not considered because, it is abundantly avail- able in the quarry.

Therefore, for each plastic brick =4.60 Rs
Plastic bricks required for $1m^3$ =93 no's
Amount required for $1m^3$ = 93*4.6=429Rs
Labour =195.00Rs

Total = 429+195 = 624Rs /m^3

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