Utilization of plastic waste and polystyrene in making light weight red soil fly ash bricks

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Abstract. The plastic industry is the important sector in India which is more valuable and playing vital role in economy of our country. Even though it is an important industry, it produces few environmental brunt causing land and water impairment with some ill effects. The methods following for dumping, leads to ground water contamination and thereby cause other adverse effects. Many investigations have been organized in this area and found that the contamination level is greater in ground water and having problem mainly in dumping area premises. In the current study, an experiment had been made to reuse the plastic waste chips in manufacturing of building materials. The objective of this project is to identify the possibilities of using the waste plastic obtained from plastic product manufacturing industry as a brick material. The various test had been carried out such as compressive strength test, crushing strength test, water absorption test, efflorescence test, hardness test, soundness test and fire test for proving the modified bricks with conventional brick. The final outcome the test results shows that the lightest brick samples among the all tested four various samples produced the strength of 68.8% greater than the third class brick and its weight is around 33% of the conventional bricks. Light weight bricks are making by using lime, fly ash, red soil, polystyrene layer, decreased the self weight of the building which improved stability in earthquake situations.

Key Words: Light weight bricks, lime, fly ash, red soil, polystyrene layer (Thermocol)

1. Introduction
Bricks are a widely used construction material all over the world. Bricks are prepared from natural clay and weight about 3.5kg approximately. So we are introducing bricks which comprises of red soil, clay, plastic chips and polystyrene (thermocol), lime, fly ash, and cement to reduce the weight of conventional bricks. The main objective of the present study is to reduce the weight of brick and using plastic wastes. The plastics added chips and fibers form have been utilized to make construction bricks that serve a purpose of solid waste management. These wastes are used to reduce the quantity of clay as there is a greater shortage of clay in many construction places.

1.1 Literature Review
Tabin Rushads; Abhishek Kumar, Duggal SK; Mehta P K; “Experimental Studies on Lime-Soil-Fly Ash Bricks”, “International Journal Of Civil and Structural Engineering”. A lot of research has been carried out for effective utilization of fly ash in building industry. Use of fly ash in manufacturing brick is one such subject which is being studied by researchers. The aim of the present study is to investigate the
strength and water absorption characteristic of fly ash bricks made of lime (L), local soil (S) and fly ash (FA). The experiments were conducted both on Hand moulded and Pressure moulded fly ash bricks. It was observed that none of the L-S-FA bricks satisfy all the requirements of standard codes. [1]

Ravi kumar; Vandana Patyal; Balwinder lallotra Deebankar Kumar “Study Of Properties Of Light Weight Fly Ash Brick”, “International Journal of Engineering Research and Applications”[2]. In this paper, efforts has been made to study the behavior of fly ash bricks by taking different proportions of fly ash, cement, lime, gypsum and sand. Three types of fly ash bricks in the different percentage of cement such as 3%, 5% and without cement are designed and then various tests such as compressive strength test, water absorption test, efflorescence, weight test, structural test were performed in order to have comparison with conventional bricks. In the experimental study it is found that the compressive strength of fly ash brick containing 5% cement is 152.1 kg/cm² which is more than that of class I conventional bricks by 40% approximately. Effort has been made by making different proportions of ingredients having composition of fly ash, cement, lime, gypsum, and sand. [2]

Maneeth P D; Pramod K; Kishor Kumar; and Shanmukha Settee., “Utilization of Waste Plastic in Manufacturing of Plastic-Soil Bricks” International Journal of Engineering Research & Technology” 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 late rite quarry waste is abundantly available and the disposal of waste plastics (PET, PP) 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.[3]

2. Material proportion for making bricks:

Table 1. Materials Proportion

| Materials                | Type-I | Type-II | Type-III |
|--------------------------|--------|---------|----------|
| Red soil                 | 30%    | 30%     | 30%      |
| Fly ash                  | -      | 30%     | 30%      |
| Clay                     | 30%    | -       | -        |
| Plastic (chips & fiber)  | 15%    | 15%     | 15%      |
| Polystyrene layer        | 15%    | 10%     | 10%      |
| Cement                   | 10%    | 15%     | -        |
| Lime                     | -      | -       | 15%      |

Note:

- Red soil (available soil utilization)
- Clay (weather resistance)
- Plastic chip and fibers (waste utilization and light weight)
- Polystyrene layer (lightweight)
- Cement or lime (binder)
2.1 Cement (15%)
Cement is one of the binding materials in this research. Cement is the important binding material in today construction field. In this research we have selected the 53 Grade Ordinary Portland Cement (OPC) confirming to IS: 12269-2013 cement used.[6]

| Properties of cement | Results   | Requirement of IS : 8112-1989 |
|----------------------|-----------|-------------------------------|
| 1. Specific gravity  | 3.15      | 3.15                          |
| 2. Initial setting time | 70 minutes | Min 30 minutes               |
| 3. Final setting time | 310 minutes | Max 600 minutes            |
| 4. Fineness          | 402.92 m²/kg | Min 225 m²/kg             |

2.2 Fly ash (30%)
Fly ash is the byproducts from coal industry. It is very fine earth material contains primarily of silica, alumina and iron. While mixing the fly ash with water and lime form a cementitious composition which is almost similar to Portland cement.

2.3 Clay (30%)
The clay is cohesive mineral which transmit plasticity to the soil when it is in wet state. The presence of captivated water in clay layer leads to plasticity therefore the clay minerals perform as a common binding material for cohesionless granular soil.

2.4 Lime (15%)
Lime tends to balance clayey soils through pozzolanic reaction. An addition of lime increasing the soil stability rather than cementing effect brought by pozzolanic effects.

2.5 Plastic chips & Carry bags (15%)
The manufacturer supplied the High Density Polyethylene (HDPE) in a immediate usage of pelletized form which has a thermoplastic property. The suitable grades available in market are PE 63, PE 80 and PE100. These pipes are converted into pressure pipes by the manufacturer. The HDPE grades manufacture pipe properties are furnished below.

| WASTE PLASTIC | AVAILABLE as                        |
|---------------|-------------------------------------|
| Poly – ethylene teryphthalate (PET) | Drinking water bottles            |
| High Density Poly – ethylene (HDPE)  | Carry bags, bottle caps, house hold articles |

| Coefficient of Thermal Expansion | 7×10⁻³ °C         |
|---------------------------------|-------------------|
| Long Term Service Temperature   | 115 -170°C        |
Melting Point 260°C
Specific Gravity 1.3 – 1.4
Water Absorption 0.07 – 0.10%

2.6 Polystyrene layer (Thermocol) (15%)
Polystyrene is a synthetic aromatic polymer available in solid or foamed form from the monomer styrene. Common properties of polystyrene are hard, clear. It is rather low barrier to oxygen and water vapor and has an approximate low melting point. It is transparent in nature and also can be make it in various colours by adding pigments.

Properties:
Chemical formula = (C8H8)n
Density = 0.96–1.04 g/cm3
Melting point = ~ 240 °C (464 °F; 513 K)[4] For Isotactic Polystyrene
Solubility in water = insoluble
Solubility = Non soluble in acetone
Thermal conductivity = 0.033 W/(m/k) (foam, ρ 0.05 g/cm3)
Refractive index (n D) = 1.6; dielectric constant, 2.6 (1 kHz – 1 GHz)

2.7 Water
Generally water is reacting with cement and causing the hydration process. Since the water is the major additive in this experiment potable water must be used for both immerse and blending of plastic material. The water having pH value around 6 to 7 can be used and it should not having any organic substance.

3. Experimental Procedure
The research clearly shows that there is no specific procedure and firm conditions for formal mix design of plastic material for manufacture the bricks. Hence in these experimental studies, few laboratory tests were conducted to achieve require mechanical properties of plastic material.

3.1 Mould Preparation
A mould was made of size 230mm×110mm×80mm and the joints were properly sealed without any hole to prevent the flow of brick ingredients through that hole.

3.2 Mixing
The mixing was done manually after batching all the required materials. A combination of cement, fly ash, plastic chips, plastic fibers (1:1.5:3) were used. The mixtures should be poured in the mould, rammed with wooden tamper and the smooth finish can be achieved by should be leveled by trowel within 30 minutes after started the mixing the ingredients.
3.3 Manufacturing of Bricks
After mixing, the ingredients are filled in the mould immediately by hand. The lumps of materials rammed in two layers and the surface finish can be done by trowel. Sometimes the vibrating table also can be used for compaction and then the moulded brick sets free for drying.

3.4 Mix Ratio

| S.NO | BRICKS | MIX RATIO (PERCENTAGE) |
|------|--------|------------------------|
|      |        | Clay | Red soil | Plastics | Polystyrene layer | Cement | Lime | Fly ash |
| 1    | B 1    | 30   | 30       | 15       | 15                | 10     | -    | -       |
| 2    | B 2    | 30   | 30       | 15       | -                 | 10     | -    | -       |
| 3    | B 3    | -    | 30       | 15       | 15                | -      | 10   | 30      |
| 4    | B 4    | -    | 30       | 15       | 15                | -      | 10   | 30      |

4. Material Characteristics

4.1 Bricks
The bricks are taken after drying burn the blocks at a specified temperature. Since the bricks are of equal shape and dimensions, they can be arranged easily. As well as the bricks are lighter in weight they do not need any special appliances for lifting. In our country, the manufacturing method of brick is same for long time rather than small deviations.
4.2 Crushing Strength
This test can be carried out with the help of compression testing machine. The load is applied gradually until it breaks, as per BIS: 1077 – 1957. As per code the minimum crushing strength of brick is 3.50 N/mm². The crushing strength for Class A brick is 7 -14 N/mm² and 14N/mm² for class AA brick.

4.3 Shape and Size
A brick is thoroughly investigated and ensure its standard size, shape with sharp edges. For testing 25 brick specimens were casted with the standard size of 190mm×90mm×90mm.

For a best quality bricks, the dimensions of brick should be the following allowable range:
- Length : 3670 mm to 3900mm
- Width : 1750 mm to 1850mm
- Height : 1750 mm to 1850mm

5. Result and Discussion
5.1 Weight
The ordinary bricks weight around 3 to 3.5kg but the light weight bricks around 1.5 to 2.20 kg. Sand based manufactured bricks are having weight around 65% to 70% of conventional brick weight as shown in figure 1. Hence these bricks are lighter in weight and also decrease the total estimated cost of building due to minimum self weight.

![Weight of bricks](image)

**Figure 3.** Comparison of light weight bricks with conventional bricks
5.2 Water Absorption Test
The bricks are soaked in water for 24 hours and then weighted with weighing balance. The test were carried out accordance with procedure given as per IS 3495 (Part – II) 1976 (36). [4]

5.3 Efflorescence Test
For conducting efflorescence test 5 bricks specimens were selected among the 20 specimens. Then all these bricks were immersed in distilled water at a depth of 2.5cm. Afterwards the samples are kept in the room temperature around 20°C to 30°C until the water in the dish evaporated. Again the container is refill with the same depth of distilled water and kept the specimen in same room temperature till the water has been evaporated. After two trials, the brick was tested for efflorescence.

5.4 Compression Test
The compression strength test had been conducted after 14th day from the date of casting. [5] The keen observation is needed while testing, because light weight brick never failed miserably, it is compressing like rubber. Hence the half compressive force was applied.
1. The light weight brick are elastic in nature and having less brittleness.
2. The uneven surface over the bricks was leveled at the earliest.
3. The brick was kept at centre of universal testing machine. Then the upper plate was lowered down till its reach the top surface of the brick and hold tightly without any movement.

| Table 6. Compressive strength of bricks specimen |
|-----------------------------------------------|
| Type of bricks | Weight in kg | Compressive strength in N/mm² |
|-----------------------------------------------|
| Conventional brick | 3.50 | 12 N/mm² |
| Clay+cement+redsoil+thermocol | 2.95 | 4.95 N/mm² |
| Clay+lime+redsoil+thermocol | 2.35 | 3.35 N/mm² |
| Flyash+cement+redsoil+thermocol | 2.43 | 7.50 N/mm² |
| Flyash+lime+redsoil+thermocol | 2.14 | 6.97 N/mm² |
5.5 Hardness test
A scratch test was conducted on all the three sides of brick. When the scratch has been made with finger nail on the bricks, create minor impression on its surface. Hence this minor impression results that bricks are sufficiently hard enough to withstand the abrasive force.

5.6 Soundness Test
For this test we need to choose two brick samples randomly and hit one with other on same proportion. The bricks are making ringing sound while hitting with another brick and also not broken easily. It shows that bricks are having good soundness property.

5.7 Fire Test
The fire test was carried out only for fibrous concrete bricks. The bricks will not burn when the interior and exterior plaster is provided on the fibrous concrete bricks.

6. Conclusion
1. These bricks are having good workability and easily compacted.
2. The sample B1 (4.950N/mm²) has possessed (45%) equivalent strength as conventional brick (C B = 12 N/mm²), which coming under 2nd class brick (7N/mm²) category. The other brick samples (B2, B3, and B4) strength is more than the third class brick.
3. Light weight brick sample B4 is the lightest brick sample weight is reduced to 68.8% and the strength is greater than the third class brick and the weight is around one-third of the conventional bricks.
4. Initially it was found that the Polystyrene layer lightweight bricks has a reliable strength for making the wall.
5. Light weight bricks using lime, fly ash, red soil, polystyrene layer, decrease the self weight of the building which produced better stability in seismic vulnerable zones.
6. From these experiment the conclusion has been made that the light weight bricks are suitable for non – load bearing walls only.
7. These bricks are suitable for inner partition walls construction and should not be used over water logging areas and external walls.
8. The usage of waste materials greatly reduced the landfills and land contamination.
9. The light weight brick construction cost is around 20% to 50% will be lesser than the ordinary brick wall construction.
10. Even though the compressive strength of the conventional brick is higher than the modified light weight brick, the cost of light weight brick is less when comparing with conventional brick since we were using the waste plastic material to sustaining the demand of natural raw materials.

7. References

[1] Tabin Rushads, Abhishek kumar, Duggal SK and Mehta P K 2011 *IJCSE* 1 pp 4
[2] Ravi kumar, Vandana Patyal, Balwinder lalotra and Deebankar Kumar 2014 *IJERA* pp 2248-9622
[3] Maneeth P D, Pramod K, Kishor Kumar and Shanmukha Settee 2019 *IJERT* 3 (8) pp 529-536
[4] Nit in Goyal; Manish. “Constructing structures using eco-bricks 2016 *IJRTER* 2 (4) pp 159-164
[5] Puttered M.H; Shanmukha S; Navaneeth Rai P.G; and Prathima.T.B 2014 *IJTEE* 2 (4) pp 102-107
[6] Anto J, Vigneshkannan S, Devananth R and Manju S 2019 *Mat proc* 21 pp 806-810