Incorporation of Waste Plastic in Manufacturing of Bricks Along with Quarry Gravel and M-Sand

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Abstract— There is extensive lopsidedness in the regular struc-ture materials; there is an incredible interest in on-going past years. In quarries while removing the lateritic stone with assistance of cutting machines which produces 15-20% of soil squanders which represents an issue of removal and using the quarry squander? The amount of plastic waste in city strong waste assortment is extending quickly ,the pace of extension is twofold for like clockwork .since it is non-biodegradable which stay on earth for a very long time without debasement and it is an extraordinary test in discarding waste plastics ,it is likewise risk in recurrent reusing of plastic waste it represents a threat of being changed to a cancer-causing materials and just a limited quantity of pet jugs are reused, it has a numerous decent qualities like flexibility , hardness, oppose to synthetic ,water impacts. As of late, the regular sand is supplanted by the m-sand .M-sand is likewise utilized in com-bination of plastic and soil, in this work an en-deavor has been made to produce of blocks by utilizing the waste plastic in scope of 60-80% by weight of lateritic quarry squander and m-sand blend. The blocks fabricated have the properties like flawless and in any event, getting done with irrelevant water ingestion and which fulfills the compressive solidarity somewhat. The primary goal of this work is to build up a productive meth-od to successfully use the waste plastic which is incredible danger for the environmental equilibri-um. Plastic has various utilizations, plastics do pre-sent removal issues. The rationale being decrease of ecological related perils from plastic.

Keywords: Bricks, Plastic, M- Sand, Gravel, Flexibility

I. Introduction

A brick is a type of block used to build walls, pavements and other elements and components in masonry construction. Properly, when the term brick denotes a block composed of dried clay, but is now also used informally to denote other chemically cured construction blocks. Bricks can be joined together using mortar, adhesives or by interlocking them. Bricks are produced in numerous classes, types, materials, and sizes which vary with region and time period, and are produced in bulk quantities. Block is a similar term referring to a rectangular building unit composed of similar materials, but is usually larger than a brick. Lightweight bricks (also called lightweight blocks) are made from aggregate. Fired bricks are one of the longest-lasting and strongest building materials, sometimes referred to as artificial stone, and have been used since ancient times. Air-dried bricks, also known as mud bricks, have a history older than fired bricks, and have an additional ingredient of a mechanical binder such as straw. Bricks are laid in courses and numerous patterns known as bonds, collectively known as brick work, and may be laid in various kinds of mortar to hold the bricks together to make a durable structure. The typical image of a brick is shown in Figure 1.1.

Fig. 1.1: Typical image of a brick

A. *Types of bricks*

Bricks are classified into many types and each one is described in the following section.

1) *Sun-Dried or UN burnt Clay Bricks*

Sun-dried or un burnt bricks are less durable and these are used for temporary structures. Un burnt bricks preparation involved in 3 steps they are preparation of clay, molding and drying.

After molding, bricks are subjected to sunlight and dried using heat from sun. So, they are not that much strong and they also have less water resistance and less fire resistance. These bricks are not suitable for permanent structures.

Fig. 1.2: Sun-dried or un-burnt clay brick

2) *Burnt Clay Bricks*

Burnt bricks are good quality bricks but however they also consist some defected bricks. So, burnt bricks are classified into four types and they are

1) First class bricks
2) Second class bricks
3) Third class bricks
4) Fourth class bricks

B. *Fly Ash Bricks*

Fly ash bricks are manufactured using fly ash and water. These bricks have better properties than clay bricks and great resistant to freeze thaw cycles. These bricks contains high concentration of calcium oxide which is used in cement production, thus it is also called as self-cementing brick. Fly ash bricks are lightweight and thus it reduces self weight of structures.

The advantages of fly ash bricks over clay bricks are that they have high fire insulation, high strength, uniform sizes for better joints and plaster, lower water penetration, does not require soaking before use in masonry construction.

Fig. 1.3: Fly ash bricks

C. Concrete Bricks

Concrete bricks are manufacturing using concrete with ingredients as cement, sand, coarse aggregates and water. These bricks can be manufactured in sizes as required.

The advantages of using concrete bricks over clay bricks are that they can be manufactured at construction site, reduces quantity of mortar required, can be manufactured to provide different colors as pigmented during its production.

Concrete bricks are used for construction of masonry and framed buildings, facades, fences, and provide an excellent aesthetic presence.

Fig. 1.4: Concrete bricks

D. Engineering Bricks

Engineering bricks have high compressive strength and are used special applications where strength, frost resistance, acid resistance, low porosity is required. These bricks are commonly used for basements where chemical or water attacks are prevalent and for damp proof courses.

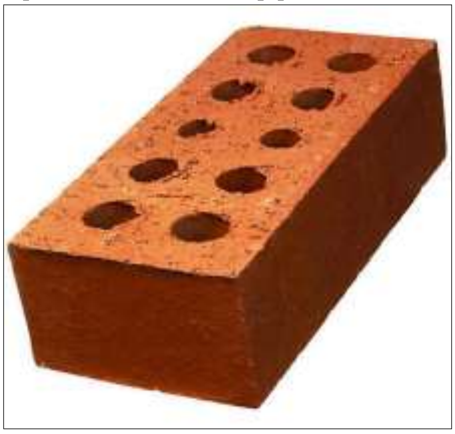


Fig. 1.5: Engineering bricks

E. Sand Lime or Calcium Silicate Bricks

Calcium silicate bricks are made of sand and lime and popularly known as sand lime bricks. These bricks are used for several purposes in construction industries such as ornamental works in buildings, masonry works etc.

Fig. 1.6: Sand Lime or Calcium Silicate Bricks

II. LITERATURE REVIEW

1) Mallikarjun et al. (2014) attempted to manufacture the bricks by using waste plastics in range of 60 to 80% by weight of laterite quarry waste and 60/70 grade bitumen was added in range of 2 to 5% 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 laterite stone
2) Kognole et al. (2019) tried to find efficient way to solve the environmental problem of plastic waste. Plastic wastes have been added into the bricks and create the bricks by using plastic wastes. It is most economical solution present in the construction industry and it is also economical and environment friendly solution of the plastic wastes.
3) Singhal and Netula(2018) manufactured bricks using Drinking Water Bottles (polyethylene terephthalate), Carry Bags, Bottles Caps, house hold Articles (High Density Polyethylene), Milk Pouches, Sacks, Carry Bags, Bin Linings, Cosmetics and Detergent Bottles (Low Density Polyethylene), Bottle Caps and Closures, Wrappers of Detergents, Biscuit (Poly Propylene), Electricals Fittings, Handles and Knobs
4) Bhushaiah et al. (2019) 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.
5) Billygraham(2017) performed to manufacture bricks or building blocks from sand and waste plastics. The bricks are produced by mixing waste plastic and sand after heating at 200ºC. Two specimens of bricks, one with sand and waste CDs; another with sand and waste water

bottles are produced and tested for some physical and mechanical properties.

III. MECHANICAL PROPERTIES OF BRICK

Under this heading of properties of bricks, compressive strength and flexure strength are included.

A. Compressive Strength

It is the most important property of bricks especially when they are used in load-bearing walls. The compressive strength of a brick depends on the composition of the clay and degree of burning. It may vary from 35 kg/cm^2 to more than 200 kg/cm^2 in India. It is specified under the I.S.S. codes that an ordinary type building brick must possess a minimum compressive strength of 35 kg/cm^2 .The first and 2nd class bricks shall have a compressive strength not less than 70 kg/cm^2 and 140 kg/cm^2 respectively.

B. Flexure Strength

Bricks are often used in situations where bending loads are possible in a building. As such, they should possess sufficient strength against transverse loads. It is specified that the flexural strength of a common building brick shall not be less than 10 kg/cm^2.Best grade bricks often possess flexural strength over 20 kg/cm^2.Similarly, it is required that a good building brick shall possess a shearing strength of 50-70 kg/cm^2.

C. Thermal Properties of Building Bricks

Besides being hard and strong, ideal bricks should also provide an adequate insulation against heat, cold and noise. The heat and sound conductivity of bricks vary greatly with their density and porosity. Very dense and heavy bricks conduct heat and sound at a greater rate. They have, therefore, poor thermal and acoustic (sound) insulation qualities. For this reason, bricks should be so designed that they are light and strong and give adequate insulation.

D. Durability

By durability of bricks, it is understood that the maximum time for which they remain unaltered and strong when used in construction. Experience has shown that properly manufactured bricks are among the most durable of man-made materials of construction. Their life can be counted in hundreds of years. The durability of bricks depends on some factors such as: absorption value, frost resistance, and efflorescence.

E. Absorption Value

This property is related to the porosity of the brick. True Porosity is defined as the ratio of the volume of pores to the gross volume of the sample of the substance. Apparent porosity, more often called Absorption value or simply absorption, is the quantity of water absorbed by the (brick) sample. This is expressed in percentage terms of the dry weight of the sample:

$$\text{Absorption}=W_2 - W_1 / W_1 \times 100$$

Where W2 is weight after 24 hours of immersion in water and W1 is the oven dry weight of the sample.

The absorption values of bricks vary greatly. It is, however, recommended that for first class bricks, they shall not be greater than 20 percent and for ordinary building bricks, not greater than 25 percent. The absorption characteristic of bricks affects their quality in many ways:

- Firstly: higher porosity means less solid materials; hence, strength is reduced.
- Secondly: higher absorption will lead to other water-related defects such as frost-action and efflorescence.
- Thirdly: higher absorption results in deeper penetration of water which becomes a source of dampness.

F. Frost Resistance

Water on freezing expands by about 10% in volume and exerts a pressure on the order of 140 kg/cm^2.When bricks are used in cold climates, their decay due to this phenomenon of “frost action” may be a common process. This is especially so because bricks are quite porous materials (apparent porosity = 20-25%). It is, therefore, essential that bricks in these areas should be properly protected from rain to minimize absorption.

G. Efflorescence

It is a common disfiguring and deteriorating process of bricks in hot and humid climates. Brick surface gets covered with white or gray colored patches of salts. These salts are present in the original brick clay. When rain water penetrates into the bricks, the salts get easily dissolved. After the rains, evaporation starts. The salts move out along with the water and form thin encrustations on the surface of the bricks. Salts which are commonly precipitated during efflorescence are: sulfates of calcium, magnesium, sodium and potassium. It is why; great emphasis should be laid while testing the chemical composition of the clay for brick manufacturing.

H. Materials used

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.

Trial	% plastic	% quarry gravel	% m-sand	%bitumen	%gyp sum
1	0	30	30	5	5
2	5	25	30	5	5
3	10	30	20	5	5
4	15	25	20	5	5
5	20	10	30	5	5
6	25	20	15	5	5
7	30	20	10	5	5
8	35	10	15	5	5
9	40	5	15	5	5
10	45	10	5	5	5

Table 1: Mix design of the plastic brick

IV. EXPERIMENTAL INVESTIGATIONS

Different types of tests were conducted to various samples of plastic induced bricks prepared with different percentage variation of plastic waste, quarry gravel and m-sand. The following section describes the methods used in conducting the suitability test for bricks to identify the mechanical properties of plastic waste induced bricks.

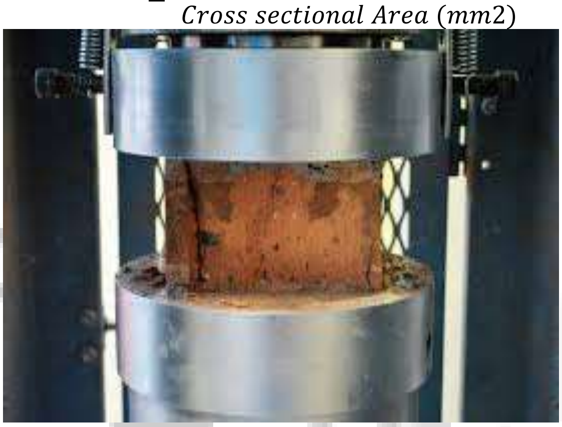
- Compressive strength
- Water absorption
- Efflorescence test
- Soundness test

A. Compressive strength

Compressive strength of bricks is the capacity of brick to resist or withstand under compression when tested on Compressive testing machine [CTM]. The Compressive strength of a material is determined by the ability of the material to resist failure in the form of cracks and fissure.

The tests on compressive strength of the specimen brick shall be calculated for 3 aspects after 7, 14 & 28 days of curing using the formula as follows

$$\mathit{Compressive\ strength} = \frac{\mathit{Applied\ Max\ load} \times 1000(N)}{\mathit{Cross\ sectional\ Area}\ (mm2)}$$



B. Water Absorption

Bricks should not absorb water more than 12% by its weight. The bricks to be tested should be dried in an oven at a temperature of 105ºc to 115ºc till attains constant weight cool the bricks to room temperature and weight (w1). Immerse completely dried and weighed (w1) brick in clean water for 24 hrs. At a temperature of 27±20ºc. The bricks are removed and any traces of water are wiped out and weigh immediately (w2).

$$\text{Water absorption in \% by wt.} = \frac{w_2 - w_1 \times 10}{w_1}$$

Fig. 4.2: Water absorption of bricks

C. Efflorescence test

A good quality brick should not contain any soluble salts in it. If soluble salts are there, then it will cause efflorescence on brick surfaces.For this test, brick has to be placed vertically in water with one end immersed. The depth of immersion in water being2.5 cm, then the whole arrangement should be kept in a warm-well-ventilated room temperature of 20-30oc until all evaporates. When the water in the dish is absorbed by the brick and surplus water evaporates. When the water is completely absorbed and evaporated place similar quantity of water in dish and allows it to absorb and evaporate as before. The determination of the brickwork after the experiment shall find out to be % of white spots to the surface area of brick. If any difference is observed because of presence of any salt deposit, then the rating is reported as ''effloresced". If no difference is noted, the rating is reported as not ''effloresced".

Fig. 4.3: Efflorescence observed in bricks

D. Soundness test

Soundness test of bricks shows the nature of bricks against sudden impact. In this test, 2 bricks are chosen randomly and struck with one another. Then sound produced should be clear bell ringing sound and brick should not break. Then it is said to be good brick. The soundness test is carried out to find out that a clear ringing sound is produced or not when the two bricks are with each other without breaking any of the two bricks. If the two bricks are not broken after striking with each other and a clear ringing sound is produced, then it means that the bricks are sufficiently sound.

Fig. 4.4: Soundness test of bricks

V. EXPERIMENTAL RESULTS

A. Compressive Strength

Different samples of bricks were prepared with different percentages of plastic waste, quarry gravel and m-sand. The prepared bricks were tested for their compressive strength using Universal Testing Machine (UTM). The compressive strength of bricks obtained after 28 days of curing is presented in Table 5.1.

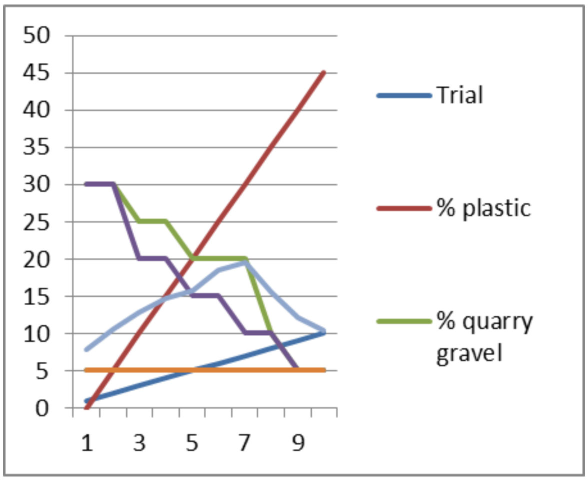


Fig. 5.1: Compressive strength of different brick samples

B. Water absorption

Different samples of bricks were prepared with different percentages of plastic waste, quarry gravel and m-sand. The prepared bricks were immersed in water and water absorption test was conducted. The results of water absorption of bricks obtained are presented in Table 5.2 and Figure 5.2.

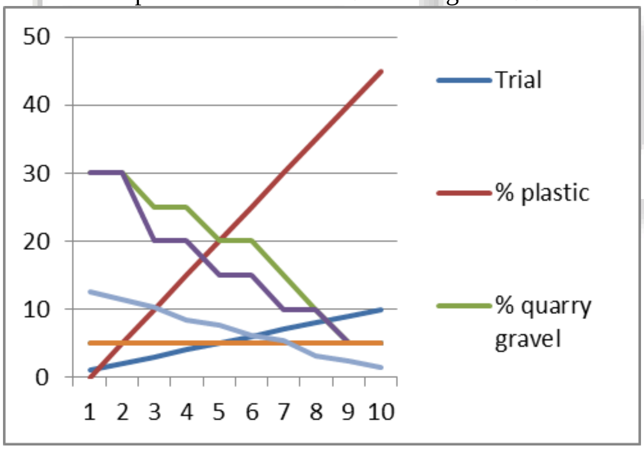


Fig. 5.2:Water absorption of different brick samples

C. 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 5.3.

1) Procedure

- 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 25mm.
- 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.
- The dish containing the brick is covered with a suitable glass cylinder so that excessive evaporation from the dish may not noccur.
- 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.

VI. Conclusions

- The maximum compressive strength obtained from the above trails is 19.56 N/mm^2. The optimal mix of the brick observed in Trail 7 with a combination of 30% plastic waste, 20% quarry gravel, 10% m-sand, 5% bitumen and 5% gypsum..
- The minimum water absorption percentage obtained is 1.4% in Trail 10 with a mix of 45% plastic waste, 10% quarry gravel, 5% m-sand, 5% bitumen and 5% gypsum.
- The compressive strength results indicated that the bricks prepared with plastic waste and other materials have higher compressive strength (19.56 N/mm^2) than the conventional clay brick (5.46 N/mm^2).
- The water absorption test results indicated that the bricks prepared with plastic waste and other materials have lower percentage of water absorption (1.4%) than the conventional clay brick (15.54%).
- So, the materials like plastic waste, quarry gravel, m-sand, bitumen and gypsum can be used as the alternative materials in manufacture of bricks other than clay.
- The fire resistance capacity is 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 to solve the problem of safe disposal of plastics, also avoids its wide spread littering.

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