Utilization of LDPE Plastic Waste and Laterite Soil in Manufacturing of Stabilized Earth Brick

Sarath Chandra[1], Beulah M[2], Gayathri G[3], Dr.R.Subashchandra bose[4] Sahana M B[5] Monica.R[6]

[1]*Assistant Professor, Department of Civil Engineering, Christ (Deemed to be University), Bangalore, Karnataka, India , sarathchandra.k@christuniversity.in,*
[2]*Associate Professor, Department of Civil Engineering, CHRIST (Deemed to be university), Bangalore Karnataka, India , m.beulah@christuniversity.in*
[3]*Associate Professor , Department of Civil Engineering ,ACS college of engineering, Bangalore Karnataka, India, gayathri.jayaram30@gmail.com*
[4]*Associate Professor, Department of Civil Engineering, ACS College of Engineering, Bangalore, Karnataka, India ,scbose2018@gmail.com*
[5]*Assistant Professor, Department of Civil Engineering , ACSCE, Bangalore ,Karnataka, India sahanamb1995@gmail.com*
[6]*Assistant Professor Department of Civil Engineering, ACS college of Engineering Bangalore, Karnataka, India monicarraj@gmail.com*

Abstract: The innovative combination of LDPE plastic waste and laterite soil presents a compelling solution for sustainable construction. This approach not only aligns with circular economy principles but also minimizes the environmental impact of building activities. Research has shown that stabilized earth bricks incorporating 60% LDPE plastic exhibit superior compressive strength compared to traditional mud bricks and laterite stone. Moreover, the inclusion of LDPE plastic waste enhances the bricks' water absorption and thermal resistance properties, making them especially suitable for humid regions, Using LDPE plastic waste and laterite soil to manufacture stabilized earth bricks can reduce pollution, promote sustainability, and offer affordable housing solutions. The study emphasizes their potential as a viable alternative for construction and to develop a stabilized earth brick using plastic waste and laterite soil that can meet the standards of a conversional brick.

Keywords: Laterite Soil, Plastic Waste, Compressive strength, Water absorption, Stabilized Earth Brick

Introduction

Rapid growth usually leads to increased investment in new buildings and infrastructure projects. As these investments grow, more building materials will be needed to meet the demand for new construction. As a result, alternative building materials are a better option. Alternative building materials are not only eco-friendly, but they can also be more cost effective and energy efficient. There are many different types of alternative building materials, and each has its own unique benefits. Some of the most environmentally friendly options include reclaimed wood, plastic waste, stone wool, recycled glass, straw bale homes, and cardboard homes etc.Laterite soil is a reddish-brown, ferric oxide rich soil that forms in association with lateritic rocks. Laterite soil is a robust soil formation that has high mechanical strength and permeability properties, making it suitable for use as a building material. Laterite soils are one of the most underutilized materials in Dakshina Kannada and form a significant percentage of the land cover in the south region of Karnataka. However, given its favourable properties as a construction material, the use of it laterite soil could be immensely beneficial both economically and environmentally. Laterite, soil layer that is rich in iron oxide and derived from a wide variety of rocks weathering under strongly oxidizing and leaching conditions. It forms in tropical and subtropical regions where the climate is humid. Lateritic soils may contain clay minerals; but they tend to be silica-poor, for silica is leached out by waters passing through the soil. Typical laterite is porous and claylike. It contains the iron oxide minerals goethite, $HFeO_2$; lepidocrocite, FeO (OH); and hematite, Fe_2O_3. It also contains titanium oxides and hydrated oxides of aluminum, the most common and abundant of which is gibbsite, $Al_2O_3 \cdot 3H_2O$. The aluminum-rich representative of laterite is bauxite. A material that contains one or more polymers has a large molecular weight. It is solid in its finished state, or the same state will be manufacturing or processing into finished articles is known as Plastic. Waste management in respect to plastic can be done by recycling. Currently, about 56 lakh tonnes of plastic waste are dumped in India in a year. If they are not recycled, then they will become a big pollutant to the environment as they did not decompose easily and also do not allow the water to percolate to the soil and they are also poisonous. The feasibility of using polypropylene and polythene plastic waste in stabilized masonry block manufacturing using locally available lateritic soil. Soil samples from two nearby locations and depths were collected and analysed in this study. An initial study was conducted by manufacturing stabilized lateritic block specimens out of these samples with different mix proportions and tested. The optimized specimens based on strength were selected for further investigations using plastic waste. This study obtained prospective results [1],[6]. In both cases, the plastic wastes included demonstrated improved strength and durability. For polypropylene waste inclusion, the improvement can be dramatic. The improvement in strength over the reference blocks of each soil sample PP waste-added specimens showed much higher compressive strengths than PE waste. The improvement is more significant for the S4 soil sample with the PP waste. The characteristics of earth brick produced with 100% laterite as well as those produced by partially replacing laterite at 0%, 5%, 10%, 15%, and 20% separately with plastic, crushed ceramic tiles, and crushed glass materials for sustainable management of environmental waste. This was close to the compressive strength with 5% crushed glass replacement and ceramics having values of 1.86 N/mm2 and 1.75 N/mm2 respectively. It was also near to that with plastic replacement at 5%, which had a maximum value of 0.95 N/mm^2 after 28 days.[2],[3],[7].it was deduced that there was a reduction in the compressive strength of plastic, crushed glass, and ceramic as their percentage increased, but for plastic, as the number of days for air curing increased, the compressive strength reduced for all percentage replacement, unlike for crushed glass and ceramic, whereas the number of days for air curing increased from 7 days to 28 days, the compressive strength also increased. It can be recommended that bricks with up to 5% replacement of glass and ceramic have a compressive strength of approximately 2.0 N/mm^2 can be used for the earth brick industry with a view to reduce environmental waste[1],[6]. The non-recyclable waste thermoplastic granules constituting 0 to 20% by weight, with 4 kg of fly ash, cement, and sand making up the remainder. The bricks were cured under water for 28 days and baked at temperatures ranging from 90 °C to 110 °C for 2 hours. The key characteristics of these bricks are that they are lightweight, porous, have low thermal conductivity, and have appreciable mechanical strengths. The compressive strengths after the addition of waste plastic are the same as normal brick strengths. And, the water absorption capacity of brick is reduced compared with nominal brick. Efflorescence values were lower than normal bricks[3],[7]. Waste plastic, which is available everywhere, can be used to make bricks. Plastic bricks can help reduce environmental pollution, thereby making the environment clean and healthy. Plastic sand bricks reduce the use of clay in the making of bricks. Plastic sand bricks provide an alternative option to bricks at an affordable price. Water absorption by plastic sand bricks is zero percent. The compressive strength of plastic sand bricks is 5.6 N/mm2 at a compressive load of 96KN. They conclude that the plastic sand bricks are useful for the construction industry when we compare them with fly ash bricks and 3rd class clay bricks[3],[8],[10].The compressive strength increases by about 4, and the thermal conductivity is reduced by about 2. Clay bricks, whether unfired or fired, have poor flexural strength. The results obtained in this study demonstrate that clay soil bricks containing 30 % of laterite are the optimal mixture for both unfired and fired bricks[4],[8]. Manufacture an alternative building material by combining plastic, laterite quarry dust, and some bitumen as a binding material. Bricks are made of various percentages of plastic ranging from 20% to 70% plastic with 2% bitumen as binding material. This is to achieve the right plastic dosage for high compressive strength and low water absorption. It is a sustainable and effective way of managing laterite quarry dust and plastic waste to minimize environmental pollution [4],[8],[7]. The compressive strength of brick with 70% plastic and 5% bitumen is 9.10N/mm^2. But from economic considerations, bricks with 2% binder (bitumen) content are taken as having optimum binder content. The cost estimation for both laterite stone and fusion bricks was done, and it was found that fusion bricks are cheaper than laterite stone. Manufacturing bricks using laterite quarry dust and waste plastic provides an efficient usage of waste plastic. This contributes to the solution of the problem of safe disposal of plastics, while also avoiding its widespread littering[2,4,7,8]. Bricks or building blocks were manufactured from sand and waste plastics after being heated at 200^{o}C and tested for some physical and mechanical properties. It was concluded that these bricks could be used as an alternative to existing clay bricks. This is because of their low water absorption, bulk density, apparent porosity, and high compressive strength. This process of making bricks provides an effective way to dispose of waste plastic and thereby reduce environmental pollution, making the environment clean and healthy [5,9,7].

2. Methodology

1. Plastic Waste (LDPE):

Plastic waste from the surrounding area was collected and utilized to make bricks. It includes plastic carry bags, milk pouches, sacks, and so forth. The basic properties are provided in Table 2.

Table No 2: Basic properties of plastic

Sl.no	Particulars	Value
1.	Melting point	150^0 C
2.	Density	0.910-0.940 g/cm^3
3.	Tensile strength	0.20-0.40(N/mm^2)

2.Laterite waste:

Laterite wastes are crushed into fine powder (less than 4.75 mm) and is used in mix. The basic properties of laterite waste are given in Table 3:

Table No 3: Basic properties of laterite

Sl.no	Particulars	Value
1.	Specific gravity	2.69
2.	Max. dry density	1.31 g/cm^3
3.	Opt. moisture content	34%

Fig 2 Laterite waste

3.Collection of materials:

1. Collection of waste Low-Density Polyethylene (LDPE):

To manufacture bricks, essential materials include Laterite waste and waste plastic. In the waste plastic component, LDPE with a melting point of approximately 1500C, a density range of 0.910-0.940 g/cm3, and a tensile strength of 0.20-0.40 N/mm2 is collected. The LDPE is then shredded, washed, and dried for further use in the brick-making process.

Fig 3 Plastic

2. Collection of Laterite waste:

Laterite waste was crushed and used in this work. Crushed Aggregates passing through 4.75mm sieve were sieved and tested as per Indian standardspecification IS: 383-1970.

Fig 4 Laterite waste

3. Properties of materials:

Properties of each material used for the project are studied. It includes density, specific gravity, melting point, tensile strength, fineness modulus, water absorption, and chemical composition of materials.

4. Shredding of plastics:

Plastic shredders help recover waste during different industrial processes like moulding, trimming, and casting. Shredded waste is easier to handle or reuse. Shredding is also an efficient waste disposal method, and this greatly reduces the cost of recycling for several industries.

Shredding systems are used to reduce the size of a given material. While most online dictionaries define the shredder as “a device used for shredding documents as a security measure to prevent identity theft," shredders can be of many types based on the material being processed.

Fig 5 Shredding

Mix proportion:

It is the process of selecting suitable ingredients of concrete to achieve specified strength and durability. For this plastic brick, no moisture is added. For the casting of bricks, Rectangular -shaped moulds were prepared which have a volume of 0.001875m^3 each.

Preparation of Specimens:

1. Mould Design for Bricks

- For casting bricks, rectangular-shaped iron moulds are manufactured. They were designed in such a way that the specimen could be removed safely. All the measurements are developed in accordance with the Indian standard IS 15658:2006.
- The moulds are 150 x 125 x 100 mm and have a volume of 0.001875 m^3

Fig 6 Brick moulds

2. **Weighing:** The proportions of materials are taken by weight or by volume. The procedure we adopted in the current work is by weighing the material as it is more accurate than the volumetric method.
3. **Mixing and compacting:** After weighing all the ingredients that are to be used are taken for the mixing process. The mixing process can be done either by hand mixing or machine mixing. At first, ceramic waste and glass waste with quarry dust was mixed uniformly. Then plastic wastes are heated in a metal bucket at a temperature of above 150˚. As a result of heating, the plastic waste melts. The materials quarry dust, aggregate, and other materials as described above are added to it in right proportion at the molten state of plastic and well mixed. The metal mould is cleaned using a waste cloth. Now, this mixture is transferred to the mould. It will be in a hot condition and compact well to reduce internal porespresent in it.

Fig 7 Mixing

4. **Drying:** The cast bricks are allowed for drying for 24 hours at a normal atmospheric temperature so that they will harden. After drying the brick is removed from the mould. The bricks are dried in a natural atmosphere.

Fig 8 Stabilized earth bricks

4.Results and discussion

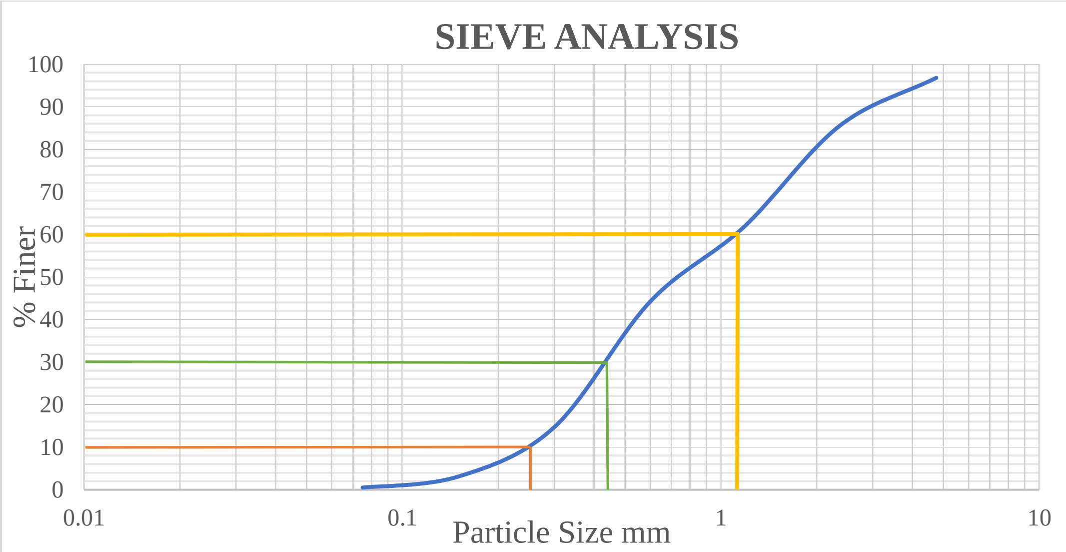

Fig 9 Particle size distribution curve

Uniformity Coefficient, $C_u = D_{60} / D_{10}$ $= 1.1 / 0.25 =$ **4.4**

As per Indian Standards, gravel with a uniformity coefficient between 4 and 6 is considered well graded.

Coefficient of Curvature, $C_c = D_{30}{}^2 / (D_{10} \times D_{60})$ $= (0.43)^2 / (0.25 \times 1.1) =$ **0.67**

As per Indian Standards, gravel with a coefficient of curvature Cc between 0 and 1 is considered well graded. Therefore, it can be used in brick production as an aggregate.

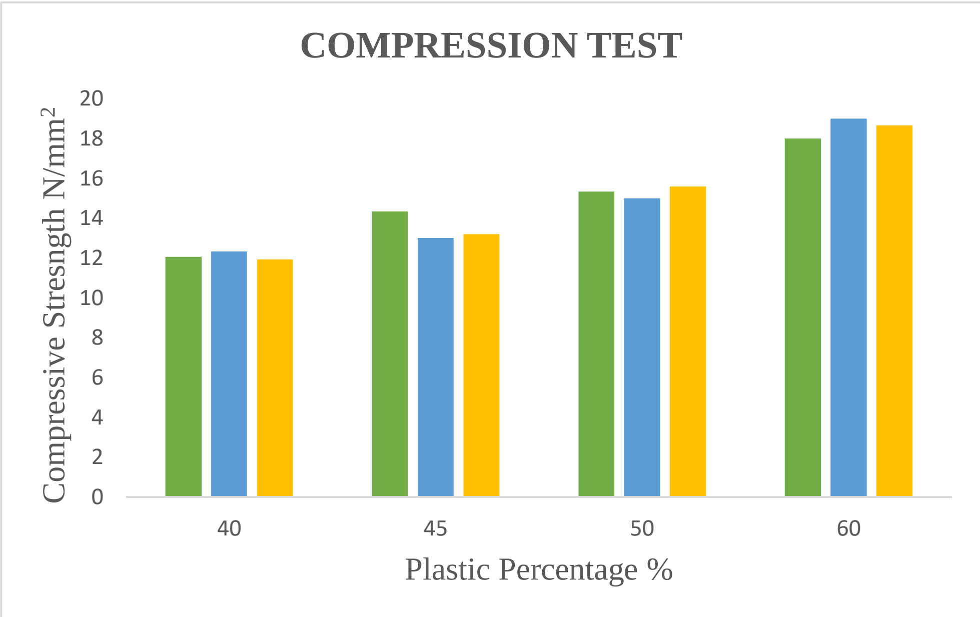

Fig 10. Compressive strength of stabilized earth bricks

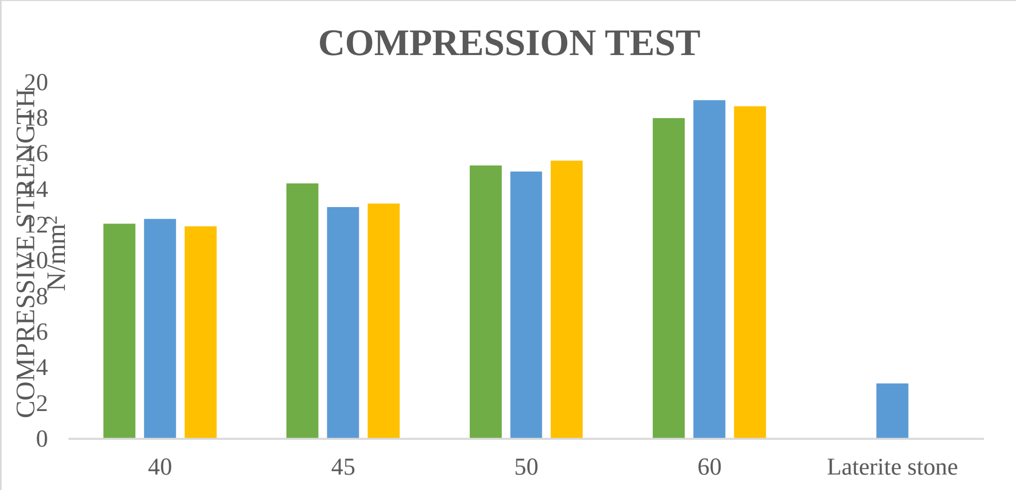

Fig 11. Comparison of the compressive strength of stabilized earth bricks and laterite stone

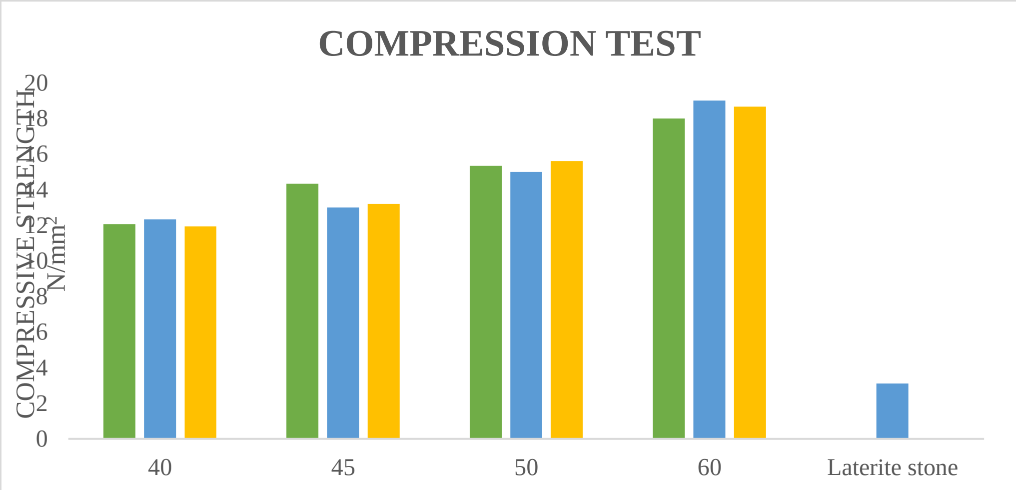

Fig 12. Comparison of the compressive strength of stabilized earth bricks and laterite stone

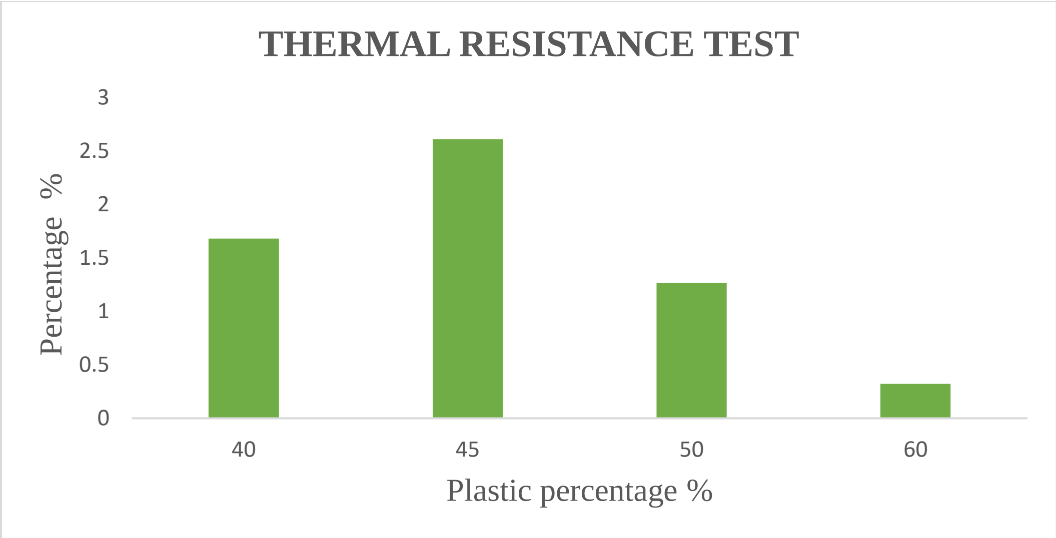

Fig 13. Thermal resistance test of stabilized earth brick

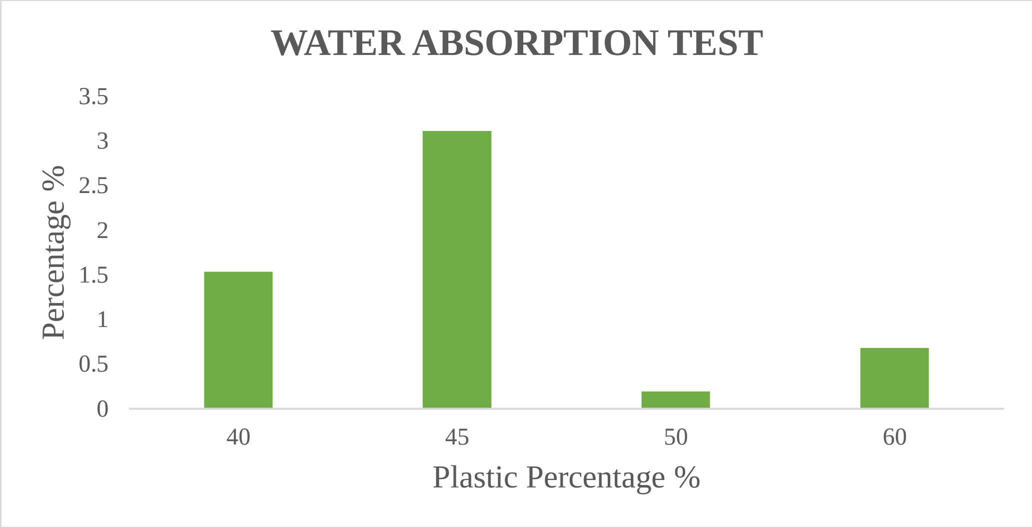

Fig 14. Water Absorption Test on stabilized earth brick

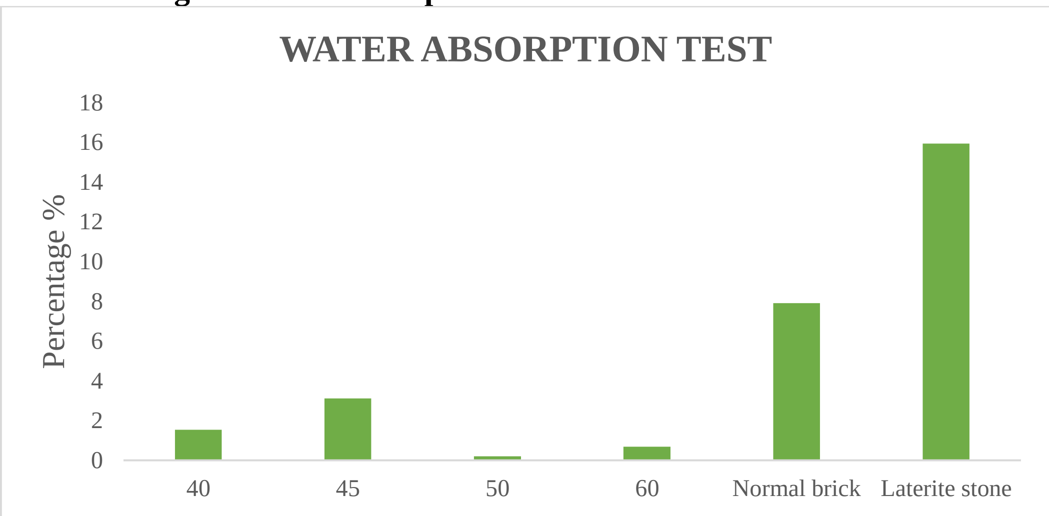

Fig 12 Comparison of water absorption between stabilized earth brick, normal brick, and laterite stone

6. Conclusion

Stabilized earth bricks offer a sustainable solution to plastic waste and affordable housing needs in developing countries. Adding LDPE plastic waste to laterite soil improves mechanical properties and durability, making them suitable for construction

The major conclusions drawn from the studies after tests are as follows:

- The compressive strength of stabilized earth bricks increases by an average of 23% when LDPE plastic content is increased from 40% to 60% by weight with laterite soil, but beyond 60% plastic content, ductile behavior is observed and may not be able to maintain proper dimensions
- Stabilized earth bricks have higher compressive strength than normal mud bricks and can be used as an effective alternative building material
- Addition of LDPE plastic waste improves water absorption and thermal resistance properties of stabilized earth bricks, making them suitable for use in humid regions
- Using LDPE plastic waste and laterite soil to manufacture stabilized earth bricks can reduce pollution, promote sustainability, and offer affordable housing solutions. The study emphasizes their potential as a viable alternative.

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