Utilization of Waste Plastic in Manufacturing of Plastic-Soil Bricks

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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. Because of costly conventional recycling techniques, there has been an increased demand for more scientific and innovative technologies to effectively recycle these materials. One such effort is the efficient use of waste plastic and laterite quarry waste with a small quantity of bitumen, to develop an alternative building material such as bricks with negligible water absorption and satisfactory strength in comparison with Laterite stone to satisfy the increasing demand of conventional building materials.

***Keywords*— Poly ethylene teryphthalate (PET), Poly-Propylene (PP), Laterite quarry waste, Bitumen, plastic-soil bricks.**

I. INTRODUCTION

Soil is a loose, unconsolidated inorganic material on the earth's crust and it is formed by the mechanical and chemical weathering of solid rocks. The laterite formation was named in southern India in1807, and it was described by Francis Buchanan-Hamilton. He named it from the Latin word "later" which means brick. This rock can easily be cut into brick shaped blocks for building construction. In Asian countries laterite stone is a well known building material.

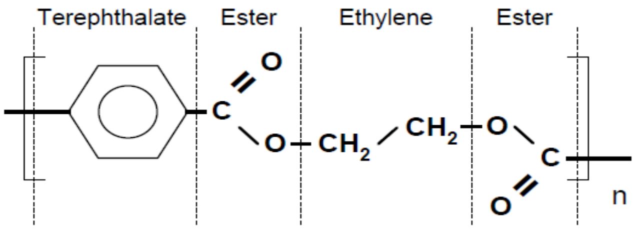
The laterite stone is rich in iron and aluminium and it is formed in hot and wet tropical areas. In coastal district of Karnataka, laterite covers a large area. In Karnataka state, the laterite formation has cap at elevations higher than 610m. The coastal laterite has a hard crest on the top, of varying thickness and the material is soft below the crest. A good reservoir of laterite stone is present in the regions of Dakshina Kannada and northern parts of Kerala, due to which lot of quarrying of laterite bricks takes place. In quarries while cutting out the laterite stones with the help of cutting machines which produces 15-20% of soil wastes which pose a problem of disposal.

The quantity of plastic waste in Municipal Solid Waste (MSW) is expanding rapidly. It is estimated that the rate of expansion is double for every 10 years; this is due to rapid growth of population, urbanization, developmental activities and changes in life style which leading widespread littering on the landscape. Thus disposal of waste plastic is a serious problem globally, since they are non biodegradable and also researchers have found that the plastic materials can remain on earth for 4500 years without degradation (Amit Gawande et.al, 2012). Looking forward the scenario of present life style a complete ban on the use of plastic cannot be put even though the waste plastic is taking the face of devil for the present and future generation.

But plastic is an effective raw material because of its large scale production witnessed after the industrial revolution. Today, it is impossible for any vital sector of the economy to work efficiently without usage of plastic starting from agriculture to packaging. Automobile, electronics, electrical, building construction, communication sectors has been virtually revolutionized by the applications of plastics. Thus we cannot ban the use of plastic but the reuse of plastic waste in building construction industry is considered to be the most feasible applications. Plastic have many good characteristics which include versatility, lightness, hardness, and resistant to chemicals, water and impact [Zeus Industrial Products].

A. Chemical Structure of Pet

The monomer for the production of PET is ethylene teryphthalate and this consists of the ethylene molecule ($-CH_2-CH_2-$), two ester molecules (-COO-), and the teryphthalate ring molecule. The only atomic species present in PET are therefore hydrogen, oxygen, and carbon. Burning PET generates only carbon dioxide (CO_2) and water (H_2O). So there is no potential danger of harmful gas emission even when PET is burnt but in the present work only melting of PET was required. The structure of the PET monomer is shown below



The chemical structure of the PET monomer

In this work an attempt has been made to manufacture bricks by using waste plastic in range of 60 to 80% by weight of laterite quarry waste in molten form, which acts as a binder, when this molten plastic was used, its binding capacity was not sufficient, to tackle this problem a little quantity of 60/70 grade bitumen was added in range of 2 to 5% by weight of soil and this bitumen-plastic resin was mixed with laterite quarry waste to manufacture bricks. The bricks manufactured possess the properties such as neat and even finishing, less water absorption and satisfactory compressive strength.

According to a Technical newsletter “Focus on PET”, Poly-ethylene teryphthalate belongs to the polyester family of polymers, one of the largest and most diverse of the polymer families. This family of polymers is linked by the common feature of having an ester (-COO-) link in the main chain, but the range of polyester materials is probably the largest of all the polymer families. And also the chemical structure of the PET is having only atomic species that are carbon, hydrogen and oxygen. Therefore melting of PET won’t result in release of noxious gases and also its properties reveal that a melting temperature of 260 ºC is required. Also from the properties of the PET it can be understood that it has got good chemical resistance and better resistance to UV rays. [Zeus Industrial Products]

In a paper “An review on waste plastic utilization in asphalting of roads” (Amit Gawande.et.al 2012), the techniques to use plastic waste for construction purpose of roads and flexible pavements, which were developed by various researchers has been reviewed. And collectively emphasizes the concept of utilization of waste plastic in construction of flexible road pavement.

In the construction of flexible pavements, bitumen plays the role of binding the aggregate together by coating over the aggregate. It also helps to improve the strength and life of road pavement. But its resistance towards water is poor. A common method to improve the quality of bitumen is by modifying the rheological properties of bitumen by blending with synthetic polymers like rubber and plastics. This bitumen mix show better binding property, stability, density and more resistant to water and also emphasized the availability of plastic in various forms as given in Table.1.

TABLE 1: ORIGIN OF PLASTIC

WASTE PLASTIC	AVAILABLE AS
Poly-ethylene teryphthalate (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 fibers (glass, Kevlar, carbon fiber)

Research on “The Use of Recycled Materials in Highway construction” (Schroceder L.R.et.al, 1994) and “Utilization of waste plastic in Bituminous Concrete mixes” (Sunil Bose.et.al, 2004) to determine the suitability of plastic waste modifier in construction of bituminous mixes, where the heated aggregates are transported on conveyor belts the shredded plastic is sprayed on it. So that plastic makes a coat on the aggregate this plastic coated aggregate was later blended with hot molten bitumen to result in plastic modified bitumen. The research concluded that this waste plastic usage in bituminous concrete mixes resulted in improved resistivity to water absorption and better bonding with reduced susceptibility to stripping.

“Useful products from oil and organic chemistry” [Zeus Industrial Products], classifies the plastic as Thermo softening plastics (Thermo plastics) and Thermo setting plastics (Thermo set plastics). Thermo setting plastics can be made plastic and malleable at high temperatures only once. Modern thermoplastic polymers soften anywhere between 65 ºC and 200+ ºC. In this state they can be moulded in a number of ways they differ from thermo set plastics in that, they can be returned to this plastic state by reheating. They are then fully recyclable. PET and PP used in this project belongs to thermo plastics.

Thermo-set plastics differ in that they are not re-mouldable. Strong cross links are formed during the initial moulding process that gives the material a stable structure. They are more likely to be used in situations where thermal stability is required. They tend to lack tensile strength and can be brittle. Polyester resin, Urea formaldehyde etc. belongs to this type.

An attempt to utilize the laterite wastes available abundantly in the laterite quarry for the manufacture of laterite soil bricks using cement as a stabilizing agent by (Bharath raj.et.al, 2012). This can be used as an alternative to the usual laterite stone. The laterite soil was procured from the laterite quarry near Sullia, Dakshina kannada district, Karnataka, India. The study concluded that laterite soil stabilized with 7% cement for manufacturing of interlocking bricks with a good compressive strength of 4.72 N/mm^2. The concept of interlocking bricks of size 30x20x18cm was adopted which resulted in a cost effective construction (Bharath raj.et.al, 2012).

As per the research work carried out by (Olufemi Agbede.et.al 2008), in Makurdi (Nigeria) and other locations within Benue State, abundant lateritic soil deposits exist which can be harnessed for brick production. Results showed that laterite used in this study cannot be stabilized for brick production within the economic cement content of 5%

specified for use in Nigeria. However, bricks made with laterite admixed with 45% sand and 5% cement attained a compressive strength of 1.80 N/mm^2 which is greater than the specified minimum strength value of 1.65 N/mm^2. Cost comparison of available walling materials in Makurdi metropolis showed that the use of bricks made from 45% sand and 5% cement resulted in a saving of 30 - 47% when compared with the use of sand concrete blocks while the use of fired clay bricks resulted in a savings of 19% per square meter of wall. The study therefore recommends the use of laterite bricks in Makurdi and other locations because it is more economical and environmental friendly than fired clay bricks.

B. Objectives:

This work was under taken with following objectives

➢ The study was intended to evaluate the index properties of laterite quarry waste and general properties of Poly-ethylene teryphthalate (PET).

➢ To arrive at the optimum dosage of PET that could result in building material with good strength and less water absorption.

➢ To arrive at the optimum dosage of bitumen that could enhance the binding capacity of plastic in molten state, to achieve a mix with better binding quality there by leading to bricks with good strength & lesser water absorption.

➢ To develop an alternative building martial that could satisfy requirements of good building material. And also to arrive at a solution for the problem of imbalance between the availability and the demand of conventional building materials.

To develop a scientific way of reusing waste plastic (PET bottles) along with utilization of laterite quarry waste that could result in alternative building material.

C. Material Properties

a. Preliminary test results:

Sieve analysis test was conducted for the laterite quarry waste; the gradation curve obtained from the test is shown in Fig. 1.

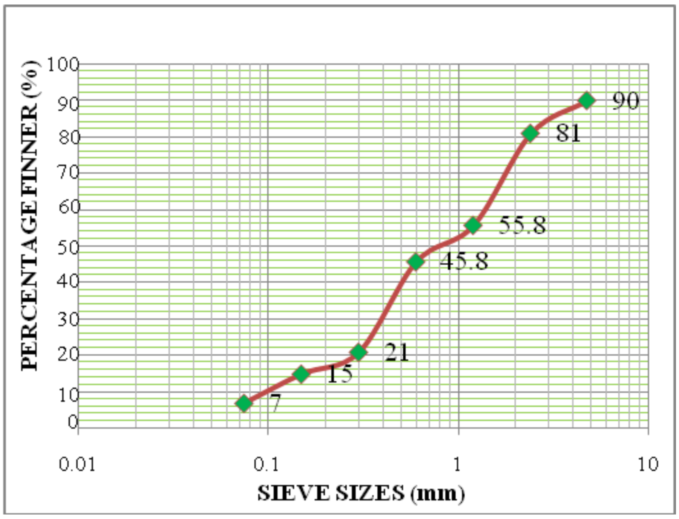


Fig.1: Grain Size Analysis

Gravel	= 10%
Sand	= 83%
Silt & Clay	= 07%
Uniformity co-efficient (Cu)	= 15.31
Co-efficient of curvature (Cc)	=1.03

The Cu > 15 & Cc is between 1 and 3 hence it is considered as well graded soil.

The various preliminary test results are given in TABLE 2

TABLE 2: INDEX PROPERTIES OF LATERITE SOIL

Experiments	**Results**
Natural Water Content (%)	10.7
Specific Gravity	2.48
Unit Weight (g/cc)	1.59
Liquid Limit (%)	38.50
Plastic Limit (%)	27.48
Shrinkage Limit (%)	13.48
Optimum Moisture Content (%)	21.40
Optimum Dry Density (g/cc)	1.78

D. Properties of Plastics

Physical properties of PET were as given in TABLE-3

TABLE 3: PHYSICAL PROPERTIES OF POLY-ETHYLENE TERYPHTHALATE (PET)

Coefficient of Thermal Expansion	7×10^{-5}/ºC
Long Term Service Temperature	115 - 170ºC
Melting point	260ºC
Specific Gravity	1.3 – 1.4
Water Absorption	0.07 – 0.10%

E. Chemical Resistance

PET has good resistance to most acids, alkalis, alcohols, greases, and oils. PET is very suitable for food contact and many of the major applications involve food contact. Extensive research into the use of PET for food contact has shown that PET is very suitable for contact with both liquids (mineral water or soda water) and with solid foods, such as bakery goods.

PET has good weathering resistance to sunlight, ozone and ultra-violet light. Plastic in a molten state acts as a good binding agent, so used as a major binding matrix in manufacturing of plastic-soil bricks. When PET burns, the only combustion products are hydrogen, oxygen, and carbon. PET can be safely burnt with no noxious gases being produced (Amit Gawande et.al, 2012).

F. Properties of Bitumen

The various tests are conducted on the bitumen. The results are obtained are tabulated in TABLE 4.

TABLE 4: INDEX PROPERTIES OF BITUMEN

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

G. Need of Bitumen in Plastic-Soil Bricks

Bitumen is primarily used to improve the binding property of molten plastic and also it serves the purpose of transforming a thermoplastic into thermosetting plastic.

H. Advantages of Using Bitumen

Usage of 2 to 5% of bitumen by weight of soil is found to improve the bondage in the molten soil plastic mix, resulting in good strength gain. The bitumen content used in the test serves to improve the thermal resistivity of bricks and better resistance to water.

II METHODOLOGY

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 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 soil waste was collected from Aletti (nearby Sullia). 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 20x10x10cm was prepared. Bricks of different mix proportions were prepared, for each brick 3kg of the laterite soil was added with varying bitumen content of 2, 5 and 10% along with variation in percentage of plastic. Bricks were prepared by compacting through vibration. 9kg of clean sieved laterite quarry waste is collected. 70% of plastic (PET, PP) 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 by weight of soil is added and mixed for uniform distribution to prepare 3 bricks. The hot mix is poured into the moulds and then compacted by vibration. The bricks are de-moulded 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).

A. Experimental Results

The results of experiments conducted for various percentages of plastic mixed with laterite soil with varying percentage of bitumen are discussed.

B. Effect of Water Cooling On Strength of Plastic-Soil Bricks

For manufacturing of plastic-soil bricks a minimum of 60% of plastic by weight of soil was required as determined by trial and error method, so 65% of plastic by weight of soil is considered as a starting proportion. Compression strength was conducted on bricks of size 20x10x10cm.The compression strength test results are given in Table 5 and graphical representation is shown in Fig.5.

There is no much effect on compressive strength of plastic-soil bricks on water cooling since for 3,7 and 28 days of water cooling the compressive strength is almost same, as given in Table 5. Therefore only air cooling method was adopted

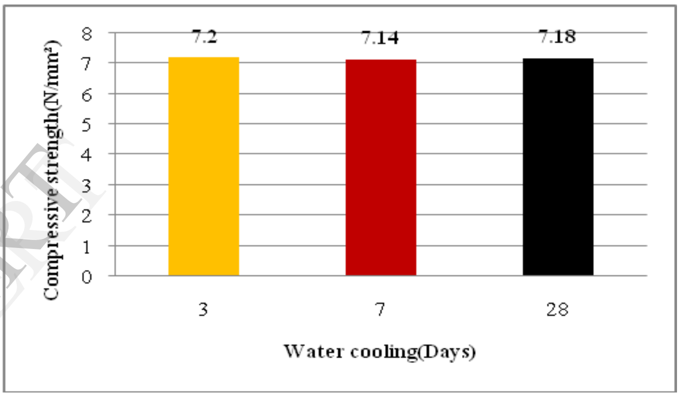


Fig. 2: Effect of Water Cooling On Strength

C. Effect of Variation in Plastic Content On Compressive Strength And Water Absorption Of Plastic-Soil Bricks

The effect of variation in percentage of plastic on compression strength of plastic soil bricks and the water absorption are tabulated in the Table 6 and Table 7 respectively. Also the same results were graphically represented in Fig.3

TABLE 5: COMPRESSIVE STRENGTH OF WATER COOLED PLASTIC-SOIL BRICKS

Sl.No.	Type of heat dissipation	Percentage of plastic (with 2% bitumen)	Days	Average compressive strength (N/mm^2)
1	Water cooled	65	3	7.20
2			7	7.14
3			28	7.18

TABLE 6: COMPRESSIVE STRENGTH OF AIR COOLED PLASTIC-SOIL BRICKS

Sl.no.	Type of heat dissipation	Percentage of plastic by weight of soil (with 2% of bitumen)	Average compressive strength (n/mm²)
1	Air cooled	0 (0%plastic and 0%bitumen)	2.16
2		65	8.16
3		70	8.16
4		75	6.63
5		80	3.15

TABLE 7: WATER ABSORPTION OF AIR COOLED PLASTIC SOIL BRICKS

SL NO	Type of heat dissipation	Percentage of plastic By weight of soil (with 2% of bitumen)	Water absorption (%)
1	Air cooled	0 (0%plastic and 0%bitumen)	NA
2		65	1.8242
3		70	0.9536
4		75	0.7962
5		80	0.5954

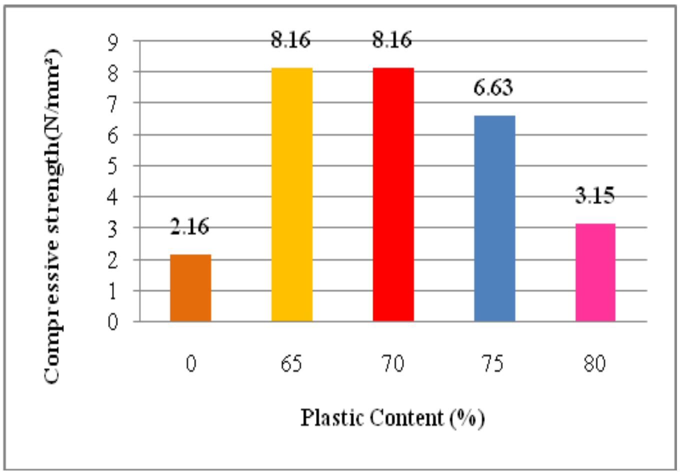


Fig .3: Optimum Percentage of Plastic Content

From the compressive strength results it is observed that both 65 and 70% of plastic by weight of soil with 2% of bitumen by weight of soil gives same compressive strength, even though 70% plastic is considered as optimum by considering workability criteria. Also from the test results it was observed that the water absorption also decreases with increase in percentage of plastic.

The results tabulated as in table 6 clearly indicate that the compressive strength of laterite soil brick with 0% plastic have very less strength. Hence, the percentage of plastic is increased to get higher strength and to avoid compromising with the strength criteria.

The study showed that the strength of bricks was dependent on percentage of plastic,. In this experiment it was found that as the percentage of plastic was increased, the compressive strength of the brick was also increased. From this investigation, we have selected an optimum proportion of plastic which gives considerably good compressive strength along with less water absorption.

The optimum mix so selected has the following proportion of the ingredients.

Laterite	58.14%
Plastic	40.70%
Bitumen	1.16%

The above proportion has a compressive strength of 8.16 N/mm² and water absorption of 0.9536 %.

By analyzing the failure criteria for the bricks it was observed that the increase in binder (bitumen) content may result in improving the compression strength.

D. Effect of Binder Content Variation on Compressive Strength of Plastic-Soil Bricks:

On increasing the percentage of binder (bitumen) the compressive strength of brick also increases up to 5%, but further increase in bitumen decreases the strength. From Table 8 and its graphical representation in Fig.4,it is evident that for 5% bitumen by weight of soil a maximum compressive strength of 10 N/mm² was obtained but from economical considerations 2% of bitumen content is taken as optimum binder content (Refer TABLE 11), which has a compressive strength of 8.16 N/mm² which would be satisfactory.

TABLE 8: EFFECT OF BINDER CONTENT VARIATION ON COMPRESSIVE STRENGTH

Bitumen content (%)	Optimum plastic content (%)	Compressive strength (n/mm²)
0	70	2.5
2	70	7.82
5	70	10
10	70	2.04

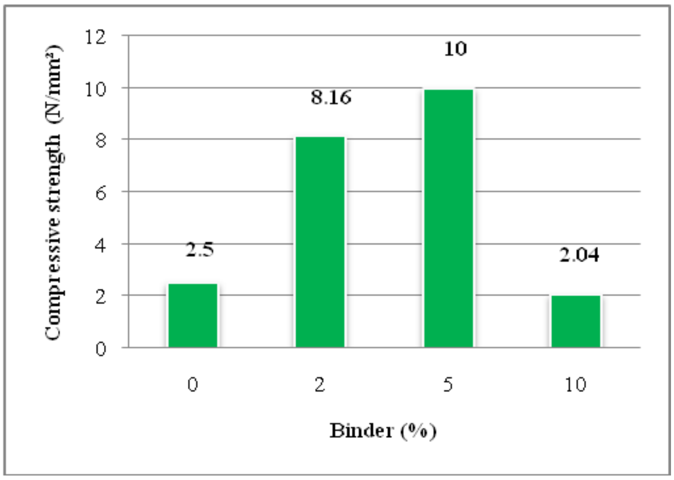


Fig .4: Effect of Binder Content Variation

E. Tests on Plastic-Soil Bricks with Varying Composition:

On varying the composition and its proportion for plastic-soil bricks following test results were obtained and the same is shown in Table 9. For the grain size of 4.75mm passing and retaining on 2.8mm the compressive strength is 6.63N/mm^2, which is less than 8.16N/mm^2 for grain size 2.36mm down size .Also this grain size between 4.75mm to 2.8mm posed a problem of segregation in hot molten mix.

Replacement of 50% soil with 6mm jelly resulted in a low compressive strength. Complete replacement of soil with 6mm jelly also resulted in a low strength. Since the efficiency of liquid plastic to bind large sized grain size is comparatively less.

Using LDPE (polythene bags etc…) as a coating on soil as done in case of road asphalting, has not resulted in any improvement of compressive strength since the melted PET cannot efficiently bind the coated soil also proper blending of LDPE with PET is not possible. Replacement of some proportion of PET with PP has also not resulted in improvement of strength because of improper blending between PET and PP since they have variable melting points and also differences in other properties. Complete replacement of PET by PP has resulted in a good strength gain of 9.9 N/mm^2, since PP is denser and has a good binding property in a molten state with thicker paste generation on melting. The bricks formed with PP showed much smoother surface finish.

TABLE 9: COMPRESSIVE STRENGTH OF PLASTIC-SOIL BRICKS FOR VARIOUS MODIFICATIONS

SL. NO.	Particulars	Percentage of plastic	Average Compressive Strength (N/mm^2)
1	Grain size variation for soil(passing 4.75mm and retaining on 2.8mm)	70%	6.63
2	50% soil & 50% 6mm jelly	65%	4.08
3	Plastic with 6mm jelly	65%	2.55
4	Plastic with 5% LDPE shredded plastic coated on soil	70%	2.55
5	45% PET and 20% PP plastic	65%	5.16
6	25% PET and 40% PP plastic	65%	4.59
7	2% bitumen with 70% PP plastic	70%	9.99

F. Compression strength test and water absorption on laterite stone:

The Compressive strength and water absorption test on laterite stone of size 30x20x15cm was conducted and the test result is as shown Table 10. The Compressive strength and water absorption test on laterite stone of size 30x20x15cm was conducted and the test result is as shown Table 10

From the result, plastic-soil Brick has good compressive strength (8.16 N/mm^2) and less water absorption (0.9536%) than laterite stone and it is considered as first class brick because water absorption is less than 20%. properties of plastic-soil bricks are uniform which is not the case in laterite stone whose properties vary widely depending on the quarry from which it was obtained.

G. Wall-Interlocking System:

To reduce the cost and increase the speed of construction, the wall interlocking system was adopted. Laterite soil with 2% of bitumen content, 70% of plastic are added and the hot molten mix is compacted by vibration. To form a 30x20x18cm interlocking brick with grooves of size 5x1.5cm and projections of 4.8x1.5cm on both horizontal and vertical faces respectively. The mixing and compaction is done same as the 20x10x10cm bricks.

These grooves locks one brick with another and does not allow them to move away from each other. The construction of wall is done same as laterite wall. The continuous vertical joints are eliminated. In corners like L-junctions, T-junctions the queen post and king post are prepared by chiseling the interlocking bricks.

The cost of each interlocking plastic-soil brick is Rs. 16.50 and cost of construction per m^3 is Rs. 1534.50 as given in appendix.

H. Estimation for plastic-soil brick with wall interlocking system - size 30x20x18cm

Using laterite stone is one way of cutting down construction cost. 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 table 11 which is giving considerably good strength. For this purpose, schedule of rates (2012-2013) Mangalore circle is used. However, the cost of laterite waste is not considered assuming that it is abundantly available in the quarry. The cost of waste plastic is also not considered assuming that it is abundantly available.

TABLE 10: COMPRESSIVE STRENGTH AND WATER ABSORPTION OF LATERITE STONE (30X20X15CM)

Material	Average (kN)	Compressive Strength (N/mm^2)	Water absorption (%)
Laterite stone	191	3.18	14.58

TABLE 11: *ESTIMATION OF EACH INTERLOCKING PLASTIC-SOIL BRICK*

SL.NO	ITEM	QUANTITY	UNITS	UNIT RATE Rs - Ps	AMOUNT Rs - Ps
	Plastic (collection & Transportation)	7.00	Kg		3.50
	Bitumen	0.20	Kg	40.00	8.00
	Soil(transportation)	10.00	Kg		1.50
	Labour	lump-sum			3.50
TOTAL in Rs					16.50

Therefore for each plastic-soil brick =16.50 Rs

Plastic soil bricks required for $1m^3$	=93 no's
Amount required for $1m^3$	= 93 x 16.50 =1534.50 Rs
Labour	=165.00 Rs
Total	=1699.50 Rs $/m^3$

The cost for walls of the building was estimated for both laterite stone and plastic-soil bricks. From the results, it was found that plastic-soil bricks are approximately 48% cheaper than laterite stone. Therefore, a plastic- soil brick proves to be more economical compared to ordinary laterite stone.

III CONCLUSIONS:

1. The gradation test conducted on laterite quarry waste showed that $Cu > 15$ and $1 < Cc < 3$ which indicates, the laterite quarry waste is well graded this shows its suitability to be compacted into a denser state while manufacturing of plastic-soil bricks.
2. From the compressive strength test results of plastic-soil bricks for various percentages of plastic content by weight of soil with constant binder content of 2% by weight of soil, it is observed that both 65 and 70% of plastic containt by weight of soil gives same compressive strength(8.16 N/mm^2), but 70% plastic is considered as optimum in view of workabality criteria.
3. From the compressive strength test results of plastic-soil bricks for various percentages of binder(bitumen) content by weight of soil with constant plastic content of 70% by weight of soil, it is observed that on increasing the percentage of binder(bitumen) the compressive strength of brick also increases upto 5% (10 N/mm^2), but further increase in bitumen decreases the strength(2.04N/mm^2). But from economical considerations 2% of bitumen content is taken as optimum binder content which results in compressive strength 8.16 N/mm^2 that is greater than laterite stone (3.18 N/mm^2).
4. From the water absorption test results of plastic-soil bricks it is observed that the water absorption also decreases with increase in percentage of plastic content.
5. The compressive strength test results for plastic-soil bricks with 70% plastic content by weight of soil with the binder(bitumen) content of 2% by weight of soil will gives a compressive strength of 8.16N/mm^2 which is higher than laterite stone (3.18N/mm^2).And has a lesser water absorption(0.9536%) than laterite stone (14.58%). So it can be a better alternative building material.
6. The compressive strength test results for 70% plastic content by weight of soil with the binder(bitumen) content of 2% by weight of soil, it is observed that in place of Poly-ethylene teryphthalate (PET), if Poly propylene (PP) is used will result in high strength(10 N/mm^2). But the availability of PP waste is comparatively less.
7. 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 the utilization of quarry waste has reduced to some extent the problem of its disposal.

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