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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 pose 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 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 to satisfy the increasing demand of conventional building materials.

Keywords: Poly ethylene terephthalate (PET), Laterite quarry waste, Bitumen, plastic-soil bricks.

1 INTRODUCTION

Soil is a loose, unconsolidated material on the earth's crust and it is formed by the weathering of solid rocks. The laterite formation was named in southern India1807, and it was described by Francis Buchanan-Hamilton. He named it from the Latin word "later" which means brick. This rock can be easily cut into brick shaped blocks for building construction. The laterite stone is rich in iron and aluminium and it is formed in hot and wet tropical areas. A good reservoir of laterite stone is present in the coastal Karnataka and some norhten parts of Karnataka and also in the 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 [1]. Plastic have many good characteristics which include versatility, lightness, hardness, and resistant to chemicals, water and impact [9].

1.1 Chemical structure of a waste plastic (polyethylene terephthalate) [technical news letter][9]

The monomer for the production of Poly ethylene terephthalate (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

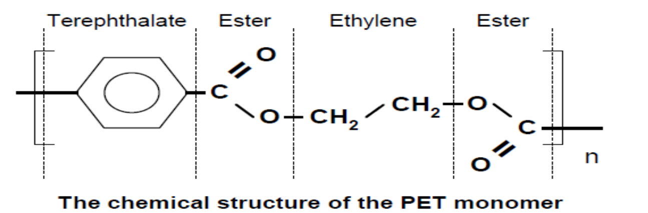

Fig.1. The chemical structure of PET monomer.

1.2 Properties of plastics [1]

Physical properties of PET were as given in Table 1

TABLE 1
PHYSICAL PROPERTIES OF POLY ETHYLENE TEREPHTHALATE

Coefficient of Thermal Expansion	7 x 10^{-3}/ºC
Long Term Service Temperature	115 - 170ºC
Melting point	260ºC
Specific Gravity	1.3 – 1.4
Water Absorption	0.07 – 0.10%

The test samples are collected from the laterite stone quarry nearer to village Aletti, which is located in the Dakshina kannada district, Sullia taluka, Karnataka, India.

Fig. 2. Laterite Quary.

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In this context work was under taken with following objectives To arrive at the optimum quantity of waste plastic (PET bottles) and also the bitumen that could result in a building material (brick) with good strength and less water absorption. To develop a scientific way of reusing the waste plastic (PET bottles) along with the utilization of laterite quarry waste that could result in an alternative building material with the satisfaction of all the requirements of good building material.

2 LITERATURE REVIEW

According to a Technical newsletter "Focus on PET", Poly ethylene terephthalate 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 [9]. In a paper "An review on waste plastic utilization in asphalting of roads" [1], 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 emphasises 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 2.

TABLE 2
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 fibers (glass, Kevlar, carbon fiber)

Research on "The Use of Recycled Materials in Highway construction" [6] and "Utilization of waste plastic in Bituminous Concrete mixes" [7] 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"[8], 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 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 [2]. This can be used as an alternative to the usual laterite stone. The laterite soil was procured from the laterite quarry near sullia. 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 [2]. As per the research work on "Use of Cement-Sand Admixture in Laterite Brick Production for Low Cost Housing" [4], 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.

3 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 quarry waste was collected from Aletti. 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

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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) 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 demoulded 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).

Fig.3. Weighing of PET Plastics & Hot molten mix

Fig.4. Mould used & Prepared Specimen

4 Material Properties

4.1 Preliminary test results

Sieve analysis test was conducted for the laterite quarry waste; The gradation curve obtained from the test is shown in Fig. 5

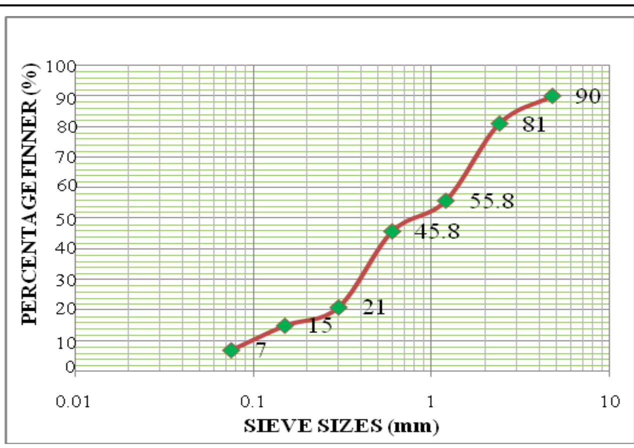

Fig. 5. Grain Size Analysis.

Gravel = 10% Sand = 83% Silt & Clay = 7% 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 3.

TABLE 3

Index Properties Of Laterite Soil

Sl.No	Experiments	Results
1	Natural Water Content (%)	10.7
2	Specific Gravity	2.48
3	Unit Weight (g/cc)	1.59
4	Liquid Limit (%)	38.50
5	Plastic Limit (%)	27.48
6	Shrinkage Limit (%)	13.48
7	Optimum Moisture Content (%)	21.40
8	Optimum Dry Density (g/cc)	1.78

4.2 Properties of bitumen

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

TABLE 4

Index Properties Of Bitumen

Sl.No	Experiments	Results
1	Penetration (mm)	67.5
2	Ductility (cm)	59
3	Softening point (◦c)	58
4	Specific Gravity	1.01

5 Experimental Results

5.1 General

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

5.2 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.

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TABLE 5

COMPRESSIVE STRENGTH OF WATER COOLED PLASTIC-SOIL BRICKS

Sl.no.	Type of heat disssipat ion	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

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. Therefore only air cooling is adopted.

5.3 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 represented by bar diagram in Fig.6 and tabulated in the Table 6 respectively.

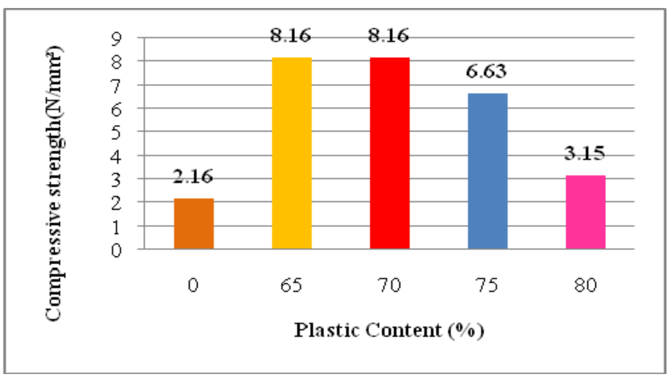

Fig. 6. Compressive Strength of Air Cooled Plastic-Soil Bricks.

Fig.7. Compression testing of spaceman & A Part of Failed Spaceman

From the test results it was found that as the percentage of plastic increased, the compressive strength of the brick also increased. So it shows that the strength of plastic-soil bricks is dependent on the percentage of plastic.

TABLE 6

COMPRESSIVE STRENGTH OF WATER 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

The compressive strength test results of plastic-soil bricks for 65 and 70% of plastic containt by weight of soil with constant binder content of 2% by weight of soil, gives same compressive strength(8.16 N/mm^2), but 70% plastic containt is considered as optimum in the view of workabality criteriaduring manufacture. From the test results it was observed that the water absorption also decreases with increase in percentage of plastic. The plastic-soil brick containing 70% plastic & 2% bitumen gives negligible water absorption of 0.9536%.

5.4 Effect of binder content variation on compressive strength of plastic-soil bricks

TABLE 7

EFFECT OF BINDER CONTENT VARIATION ON COMPRESSIVE STRENGTH

Bitumen content (%)	Optimum plastic content (%)	Compressive Strength (N/mm^2)
0	70	2.5
2	70	7.82
5	70	10
10	70	2.04

From the test results it is evident that for 5% bitumen by weight of soil gives maximum compressive strength of 10 N/mm^2 but from economical considerations 2% of bitumen content is taken as optimum binder content (refer table 9), which has a compressive strength of 8.16 N/mm^2 which would be satisfactory. 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. Also serves the purpose of transforming a thermoplastic into thermosetting plastic.

5.5 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 8.

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TABLE 8

COMPRESSIVE STRENGTH AND WATER ABSORPTION OF LATERITE STONE (30X20X15 CM)

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

Properties of plastic-soil bricks are uniform but in the case laterite stone whose properties are varied widely depending on the quarry from which it was obtained.

6 CONCLUSIONS

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 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). 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.

APPENDIX

COST ANALYSIS

A. Estimation for Plastic-Soil Brick with Wall Interlocking System - size 30x20x18cm

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 (2012-2013) Mangalore circle is used. However, the cost of laterite quarry waste is not considered because, it is abundantly available in the quarry.

TABLE 9

ESTIMATION OF EACH INTERLOCKING PLASTIC-SOIL BRICK

Sl. no	Item	Quantity	Units	Unit rate Rs - ps	Amount Rs - ps
1	Plastic (collection & Transportation)	7.00	Kg	0.5	3.50
2	Bitumen	0.20	Kg	40.00	8.00
3	Soil (transportation)	10.00	Kg	0.15	1.50
4	Labour	lump-sum			3.50
TOTAL 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 $/m^3$

B. Abstract for Plastic-Soil Brick for Wall Construction:

TABLE 10

ABSTRACT FOR PLASTIC-SOIL BRICK WALL

Sl. no	Item	Quantity	Unit	Unit rate Rs	Amount Rs
1	Plastic soil brick	44.545	m^3	1699.5	75704.23
2	Pointing	230.26	m^2	20.9	4812.59
3	Wall painting (water proof)	496.26	m^2	49.7	24664.49
	TOTAL Rs				1,05,181.31

C. Abstract for Laterite Stone for Wall Construction:

TABLE 11

ABSTRACT FOR LATERITE STONE WALL

Sl. no	Item	Quantity	Unit	Unit rate Rs	Amount Rs
1	Laterite stone masonry	44.54	m^3	2593	115505.18
2	Plastering	496.26	m^2	126.5	62777.83
3	Pointing	230.26	m^2	20.9	4812.59
4	Wall painting	496.26	m^2	34.6	17170.85
	TOTAL Rs				2,00,266.47

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

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REFERENCES

[1] Amit Gawande, G. Zamare., V.C Renge., Saurabh Tayde, G. Bharsakale.. “an overview on waste plastic utilization in asphalting of roads”, Journal of Engineering Research And Studies (JERS) ,Vol. III, Issue II, April-June 2012,pp 01-05.

[2] Bharath Raj,Varshith A,Rashmitha Kotian, N.G. Ashwath. “Study on Laterite-Cement bricks” Project report, K.V.G College of Engineering, Sullia.DK. 2011-2012.

[3] Dr. B.C Punmia, “Soil Mechanics and Foundations”, Lakshmi Publications, sixteenth edition, New Delhi, 2010,pp 37-66 & 87-107.

[4] Isaac Olufemi Agbede and Manasseh Joel, “Use of Cement-Sand Admixture in Laterite Brick Production for Low Cost Housing” Department of Civil Engineering, University of Agriculture, Makurdi Benue State, Nigeria.,Issue 12,Jan –June 2008,pp 163-174.

[5] S.K Khanna. and C.E.G Justo. “Highway Engineering”, Nem chand and Bros. Publications, Ninth Edition, New Delhi.2001, pp 301-310.

[6] L.R Schroceder, “The Use of Recycled Materials in Highway construction”, Public Roads, Vol 58,Issue 2, 1994.

[7] Sunil Bose, Sridhar Raju,“Utilization of waste plastic in Bituminous Concrete mixes”, Roads and Pavements, vol 3 2004.

[8] “Useful products from oil and organic chemistry”, Topic 11/5 available at http://www.tep.org.uk/a2z_glossary/a2z/plastics.htm

[9] “Zeus Industrial Products”, Technical newsletter, Inc. 3737 Industrial Boulevard Orangeburg, SC 29118, pp 2-4 available at http://www.zeusinc.com/technicalservices/technicalbulletins/technicalnewsletters.asp

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