CONSTRUCTION OF ECO-FRIENDLY BRICKS USING PLASTIC WASTE

A

PROJECT REPORT

Submitted in partial fulfillment of the requirements for the award of the degree of

BACHELOR OF TECHNOLOGY

IN

CIVIL ENGINEERING

Under the supervision of

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NOVEMBER – 2019

DECLARATION

I hereby declare that the work presented in the Project report entitled **"CONSTRUCTION OF ECO-FRIENDLY BRICKS USING PLASTIC WASTE"** submitted for partial fulfillment of the requirements for the degree of Bachelor of Technology in Civil Engineering at **Jaypee University of Information Technology, Waknaghat** is an authentic record of my work carried out under the supervision of **Dr. Amardeep**. This work has not been submitted elsewhere for the reward of any other degree/diploma. I am fully responsible for the contents of my project report.

……..	…….
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CERTIFICATE

This is to certify that the work which is being presented in the project report titled **"CONSTRUCTION OF ECO-FRIENDLY BRICKS USING PLASTIC WASTE"** in partial fulfillment of the requirements for the award of the degree of Bachelor of Technology in Civil Engineering submitted to the Department of Civil Engineering, **Jaypee University of Information Technology, Waknaghat** is an authentic record of work carried out by **Cheku Dorji (Enrollment No.161632)** and **Leki Wangchuk (Enrollment No.161692)** during a period from August, 2018 to May, 2019 under the supervision of **Dr. Amardeep,** Department of Civil Engineering, Jaypee University of Information Technology, Waknaghat.

The above statement made is correct to the best of our knowledge.

Date: 26/11/2019

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AKNOWLEDGMENT

We want to express our heartfelt pleasure and gratitude to our esteemed mentor **Dr. Amardeep** for providing us invaluable guidance and suggestions, which inspired us to take part in this project. We are also indeed very grateful to sir for his keen professional observations and continued encouragement on the subject.

We also would like to record our sincere gratitude to Professor **Dr. Ashok Kumar Gupta** (*Head of The Department of Civil Engineering*) and faculty of Civil Engineering Department, Jaypee University of Information Technology for providing us platforms to do research work and project.

Moreover, we are equally indebted and thankful to **Learning Resource Center (LRC)** for providing us available resources, research publications and journals based on our project topics.

Last but not the least, we also would like to express our deep sense of appreciation to Sanju Computer's and Stationaries Shop owner, **Mr. Sanju Thakur** for the general dance on the cover design, printing, layout and remarkable patience.

ABSTRACT

Plastic waste is skyrocketing everyday at an alarming rate due to global population growth, industrialization, consumerism, urbanization and development activities. The quantity and disposal of plastic waste in Municipal Solid Waste (MSW) in present days has become a biggest challenge globally due to their non-biodegrability. According to Plastic Pollution-Our World in Data it is estimated that every year worldwide produce about 380 million tons of plastic as of 2018. About 6.3 billion tons of plastic has been produced globally from 1950's to 2018, of which 9% has been recycled and 12% has been incinerated. Some Researchers predicted that by the 2050, there will be more plastic than fish in the oceans by weight. Therefore, the main objective of proposed eco-friendly sand bricks which is made up of adding plastic is to reduce the environmental problems such as land degradation, pollution hazards affected by waste plastic. The "Plastic sand bricks" is one of the such invention i.e. gaining momentum among several waste reduction strategy. The sand, bauxite, aluminum dust, fly ash are added along with different proportions of shredded plastic to make eco-friendly sand bricks. The compressive strength of brick is however reviewed and improved by adding superplasticizers. The study shows that plastic bricks are found to be cost effective, eco-friendly, gives excellent water absorption, efflorescence, dampness result during experimentation compare to clay bricks.

KEYWORDS: Municipal Solid Waste, non-biodegrability, incinerated, bauxite, aluminum dust, superplasticizers, compressive strength, plastic bricks.

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ASTM	**American Society for Testing and Materials**
CC	**Chemical Composition**
CEB	**Compressed Earth Brick**
C&D	**Construction & Demolition Waste**
CLSM	**Controlled Low Strength Material**
CPCB	**Central Pollution Control Board**
CTM	**Compression Testing Machine**
FCC	**Face Centered Cube**
HDPE	**High Density Polyethylene**
JUIT	**Jaypee University of Information Technology**
IS	**Indian Standard**
ISC	**Indian Standard Code**
LDPE	**Low Density Polyethylene**
LRC	**Learning Resource Center**
MFI	**Melting Flow Index**
M-Sand	**Manufactured Sand**
MSW	**Municipal Solid Waste**
N-Sand	**Natural Sand**
pH	**Potential Hydrogen**
PET	**Polyethylene Terephthalate**
PP	**Polypropylene**

CHAPTER 1
INRODUCTION

1.1 GENERAL

The use of plastic is daily increasing and it is useful as well as a hazardous material. At the time of need, plastic is found to be very useful but after its use, it is simply thrown away, creating all kinds of hazards. Plastic is non-biodegradable that remains as a hazardous material for more than centuries. The quantity of plastic waste in Municipal Solid Waste (MSW) is increasing rapidly. According to Central Pollution Control Board (CPCB) report, it is estimated that the rate of plastic use is double for every 10 years. This is due to rapid growth of population, urbanization, developmental activities and changes in life style which leads widespread littering on the landscape. They are non-biodegradable and also researchers have found that the plastic materials can remain on earth for 4500 years without degradation In India approximately 40 million tons of the municipal solid waste is generated annually, with evaluated increasing at a rate of 1.5 to 2% every year.

Hence, these waste plastics are to be effectively utilized. Today, it is impossible for any vital sector to work efficiently without usage of plastic starting from agriculture to industries. Thus, we cannot ban the use of plastic but the reuse of plastic waste in building constructions, industries are considered to be the most practicable applications. The use of waste plastic for the production of bricks is an optimal method to solve the problem of storing waste materials and to optimize the cost for the production of building materials. In this study, plastic waste will be used to incorporate with sand, bauxite, aluminum dust and fly ash to produce sand bricks. The bricks will then be tested to study the compressive strength, water absorption and efflorescence. In the recent past research, the replacement and addition has been done with the direct inclusion of polyethylene or plastic fibre, polyethylene terephthalate (PET) bottles in shredded form, chemically treated polyethylene fibre, PET in aggregate form by replacing natural coarse aggregate. Most of replacements have been done by volume calculation, and showed the decreased in compressive strength as the plastic waste ratio increased. In this study, High Density Polyethylene (HDPE) plastic waste has been introduced in crush form. The replacement has been done by weight calculation instead of volume calculation.

1.2 HISTORY OF THE PLASTIC BRICKS

The packing of plastic into bottles to sequester plastic and to make building blocks has arisen independently in locations around the world as a local solution to plastic pollution. Filling bottles with plastic waste builds upon the bottle building techniques of German architect Andreas Froese (using sand-filled PET bottles) in South America in 2000. Alvaro Molina began packing plastic into bottles on the island of Ometepe in 2003. Susana Heisse, in Guatemala began to encourage eco-bricking in 2003 as a building technique and for solving plastic pollution challenges faced in Lake Atitlan communities.

In 2010, in the Northern Philippines, Russell Maier and Irene Bakisan developed a curriculum guide of simplified and recommended practices to help local schools integrate eco-bricks into their curriculum. Applying the ancestral ecological principles of the Igorots for building rice terraces, they integrated cradle-to-cradle principles into ecobrick methodology: ensuring that ecobricks can be reused at the end of the construction they are used in. Through the Department of Education, the guide distributed to 1700 schools in 2014.

The open source development of ecobrick best practices and innovations that emerged from the Filipino movement became the genesis for the Global Ecobrick Alliance as founded by Russell Maier, Joseph Stodgel and Candice Mostert. The Global Ecobrick Alliance continues to develop and maintain the conceptual and technological infrastructure of the global ecobrick movement as an Earth Enterprise.

Movements in South Africa began in 2012, when Joseph Stodgel brought the concept to Greyton, throwing an annual Trash to Treasure festival at the local dumpsite with South African, Candice Mostert, who started local school projects under Greyton transition town building with the bricks made by the community. The movement has since grown in South Africa, with organizations like Waste-ED, founded by Candice Mostert, who works both in Zambia and Cape Town’s surrounds to educate people about plastic and its value, and the architect Ian Dommisse as the Ecobrick Exchange.

1.3 OBJECTIVE OF THE STUDY

- To construct the economical and environmental friendly bricks by utilizing different waste materials i.e. plastic, aluminum powder, red mud and gypsum.
- To minimize the use of fertile soil (which affects the crop production also) for the construction of bricks (by utilizing sand instead of clay and the other waste materials as stated above) as happened in case of clay bricks.
- To minimize and reuse the waste plastic to avoid land degradation and water pollution (pollution hazard).
- To construct more strength bricks by utilizing different wastes i.e. use of HDPE in form of aggregates (however, there is no provision of aggregate in the construction of brick).

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL

In the past, various research studies and investigation has been done on the use of plastic waste in making eco-friendly plastic sand bricks and other aspects. Below are some of the reports and journals presented by the authors within India and outside India.

2.1.1 STUDY CONDUCTED IN INDIA

1. **Singhal and Netula (2018)** did experiment with taking ratio of plastic to stone dust 3:7. The compressive strength was found 5.6 N/mm^2 at the compressive load of 96 KN and concluded that plastic sand bricks are most economical, shows excellent results compared to fly ash bricks and 3^{rd} class clay bricks for construction purposes.

2. **Aiswaria et al (2018)** used PET bottles and M-sand to make plastic sand bricks. Prism test was done for different mortar ratios for plastic soil bricks (1:4) and observed that the compressive strength of masonry prism increases with increase in mortar strength and is greater than that of burnt clay bricks.

3. **Priya, Nirmala and Dhanalakshmi (2018)** found 90% increase in load carrying capacity of eco-bricks was observed compared to conventional bricks whereas composite eco-bricks and eco-brick prism shows only 12 % increase in strength than the conventional one.

4. **Thirugnanasambantham et al (2017)** prepared sand bricks made up of cement, plastic, sand, fly ash and compared the all experiment results with respect to fly ash bricks. the results show excellent performance than fly ash bricks and by use of plastic, the presence of water absorption alkalis are significantly reduced.

5. **Pavan et al (2017)** determined the strength characteristics of Controlled Low Strength Material (CLSM) bricks of selected mix proportions. The CLSM bricks of all four types model satisfied the IS Standard Requirements and can be used for construction purposes.

6. **Shanmugavalli and Gowtham (2017)** replaced cement with plastic waste in making paver block and found lesser cost analysis compared to that of conventional concrete paver blocks.

7. **Billygraham Singh et al (2017)** prepared the two brick mold samples; bricks made from sand and waste compact discs (Spec. ID: CD) and bricks made of sand and waste water bottles (Spec ID: PB). And then experiment results of those two brick specimens are compared to normal clay bricks. It is observed that sand plastic bricks have low water absorption, low apparent porosity and high compressive strength**.**

8. **Agrawal and Goyal et al (2017)** conducted experiment with 6kg laterite quarry soil and 70% of plastic by weight of soil. At final stage 2% of bitumen by weight of soil is added to prepare two bricks.

9. **Kumar and Gomathi (2017)** performed the test with sand, fly ash (55%), lime (15%), gypsum (5%) and plastic with different proportions (0%, 5%, 10%, 15%, 20%). Accordingly, compressive strength is determined as per Is: 3495-Part 2-1992 and water absorption as per IS:3495-Part 2-1992.

10. **Kamble and Karad (2017)** found out that good quality of bricks doesn't absorbed less than 5% water, also the combination of sand and plastic gives better test results compare to sand & cement. However, they discussed good compressive strength of bricks is achieved by adding coal tar with plastic and sand.

11. **Sellakutty and Dinesh** (**2016)** compared the test result of three types of bricks, i.e. fly ash bricks, burnt clay bricks and plastic sand bricks. Mainly they focused on

compressive strength and water absorption test. And following compressive strength are obtained; fly ash brick (4.19N/mm^2), burnt clay bricks (3.15N/mm^2) and plastic sand bricks (5.12N/mm^2) in which plastic brick possess high value. Water absorption of fly ash are (8.012%), burnt clay bricks (9.086%) and plastic sand bricks (1.10%) which is less in plastic bricks.

12. **Goyal and Manisha (2016)** mainly researched on do's and don'ts in making of eco-bricks (bricks made of using plastic waste), highlighted on merits and demerits of eco-bricks over conventional bricks. Moreover, they underlined with various examples of case studies of plastic bricks wonder structures built across the world.

13. **Ravikumar (2016)** works mainly includes about replacement of Polyethylene terephthalate (PET) bottles with Manufactured Sand (M-sand), natural sand (N-sand) and clay soil. And they directly filled PET bottles with M-sand, PET bottles with N-sand, PET bottles with clay soil and constructed brick structure. The specimen filled with 2-liter PET bottle of M-sand resulted in good compressive strength of 180KN compare to other two specimen.

14. **Deepak Shiri et al (2015)** procured shredded Low-Density Polyethylene (LDPE) plastic using plastic extruder machine and prepared three brick sample. The sample I contains (100% reprocessed LDPE), sample II (70% industrial waste PP, 20% waste rubber powder, 10% $CaCO_3$) and Sample III (67% industrial waste LDPE, 25% waste rubber powder,8% $CaCO_3$). Sample II when waste plastics effectively mixed with rubber powder and calcium carbonate showed the highest compressive strength and sustains high compressive load.

15. **Dakwale and Ralegaonkar (2014)** used construction and demolition waste (C&D) as aggregate and cement, fly ash as binder to prepare eco-bricks. The special experiment includes embodied energy test and bricks made up of using construction demolish waste had achieved least embodied energy(1.93MJ/bricks) which is 16.8% lesser than fly ash bricks.

16. **Mallikarjun Hiremath et al (2014)** conducted 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 late-rite stone (3.18N/mm^2). And has a lesser water absorption (0.9536%) than laterite stone (14.58%).

17. **Arshad and Pawade (2014)** carried out making two brick sample that is brick made of clay, fly ash along with orange peels, paper mill waste and bricks made of clay, fly ash with coconut waste. The bricks sample prepared from coconut waste achieved excellent compressive strength for different coconut waste proportions.

18. **Arora and Dave (2013)** employed with the grinding, rubbing and mixing technique to use e-waste and plastic waste in concrete. A mix design was done for M20 grade of concrete by IS method. Ordinary Portland cement of 43 grade was selected. Grinded E-waste and plastic waste were replaced by 0%, 2%, and 4% of the fine aggregates.

19. **Agilan (2012)** presents a parametric experimental study which investigates the potential use of waste paper for producing an energy saving, low-cost and light weight composite brick as a building material. These alternative bricks were made with papercrete. An experimental investigation has been carried out to study the compressive strength, unit weight, and water absorption. In this study, six different mix proportions were computed by utilizing the Paper pulp and industrial by products like Fly ash, Rice husk ash. And also, due to the addition of paper pulp the bricks have low thermal conductivity, and it reduces the energy requirement for temperature control.

20. **Sorte (2008)** developed the paper pulp brick with fly ash, quarry dust, cement along with 10%, 20% and 30% paper pulp by weight. They reported that the best results of compressive strength of 10% paper pulp bricks after 3 days, 7 days and 28 days are 1.086N/mm^2, 3.057N/mm^2, 4.42N/mm^2 respectively.

2.1.2 STUDY CONDUCTED OUTSIDE INDIA

1. **Akinwumi et al (2019)** made compressed earth bricks (CEB) with a mixture of clayey soil and shredded plastic in varying percentage (0,1,3 and 7%). The highest compressive strength was obtained for the CEB containing 1% waste plastic of sizes <6.3 mm and also exhibited low erosion rate.

2. **Arhin et al (2017)** presents the development of Bauxite residue (red mud) based cement composite mortar blocks for applications in pavement construction. Composite mortar blocks of different batch formulations were produced and their physicochemical properties were investigated. The results show that the compressive strength of the as-prepared composite mortar blocks increased by 40% compared to the type M mortar strength of 2500 N/mm^2.

3. **Bernardi et al (2017)** presents itself on three fronts: first, as a new, low-cost, and ecologically friendly way of building houses and closing the housing gap; second, as a solution to the mounting waste management crisis in South Africa and across the entire African continent, a pressing issue with dire health and safety consequences for the general public; and third, as a solution to the housing crisis that has resulted from rapid urbanization. Their ultimate goal of the project is to create a positive social, economic, and environmental impact in our locations, while also remaining profitable and viable as a business.

4. **Debieb, F et al (2016)** investigated the utilization of two type of waste plastic PET and LDPE as a fibers and fine aggregates (powder) in sand concrete. Various volume fractions of sand (10%,20%,30% and 40%) were substituted by the same volume of plastic aggregates, and various amount of plastic fibers (0.5%, 1%, 1.5%,2%) were introduced by volume in sand concrete mixes. The results showed that the use of plastic waste as partial replacement of sand contributes to reduce the bulk density, decrease the air content, causing an increase in compressive and flexural strength and especially for 10% and 20% of replacement.

5. **Muyen, Z et al (2016)** looked into the strength properties of waste PET bottles filled with fine sand. Five different sizes (250, 500, 1250, 1500 and 2000ml) of waste PET bottle bricks were tested for compressive strength and the largest bricks gave a compressive strength of 17.44MPa. The 1000ml bottle brick filled cubes with 9 and 12 bottles were prepared and tested. The 9 bottles brick filled cubes gave a compressive strength of 35MPa and the 12 bottle bricks filled cubes gave a compressive strength of 33.7MPa. These bottle brick filled cylinders exhibited double the compressive strength of conventional concrete cylinders.

6. **Safinia et al (2016)** examined the use of plastic bottles in concrete block. The plastic bottles were used to create voids at equal distance between them in the masonry units. Concrete was placed around each bottle to encase it in the masonry units. The study utilized 500-mL plastic bottles placed inside concrete masonry units and analyzed the compressive strength. The testing for compressive strength was determined according to the America Society for Testing and Materials (ASTM) C140 standard. The study showed 57% improvement of strength by using plastic bottles compared to local concrete blocks.

7. **Wahid et al (2015)** used shredded PET bottles with sand and cement. The properties of sand bricks which contain varying percentages (0, 5, 10 and 15%) of plastic were tested for compressive strength, water absorption and efflorescence. It was found that the reduction in compressive strength, due to replacement of sand by waste plastic bottle, is minimal and can be enhanced by addition of super plasticizer. The water absorption and efflorescence however showed excellent performance.

8. **Shoubi et al (2013)** concluded that in different factors such as time of execution, cost, load capacity, flexibility, reducing waste and energy efficiency, plastic bottles can be more effective compared to some conventional building materials such as brick, concrete and ceramic block**.**

9. **Zhang (2013)** research work are divided into three general categories based on the methods for producing bricks from waste materials: firing, cementing and geopolymerization. Although much research has been conducted, the commercial production of bricks from waste materials is still very limited. The possible reasons are related to the methods for producing bricks from waste materials, the potential contamination from the waste materials used, the absence of relevant standards, and the slow acceptance of waste materials-based bricks by industry and public. For wide production and application of bricks from waste materials, further research and development is needed, not only on the technical, economic and environmental aspects but also on standardization, government policy and public education related to waste recycling and sustainable development.

10. **Karaman et al (2006)** determined the effects of firing time and temperature on compressive strength, water absorption, bending strength, weight loss, firing shrinkage and densities of clay bricks. Higher compressive and bending strengths, higher density and lower absorptions are associated with higher temperatures. Increasing firing time only slightly altered the mechanical and physical properties of clay bricks. The result suggested that firing temperature was the key factor modulate the physical properties in clay bricks.

CHAPTER 3

MATERIAL & METHODOLOGY

3.1. GENERAL

A brick is a building material used to make walls, pavements and other elements in masonry construction. In past, bricks are made up of mainly clay soil and nowadays it is widely used to denote brick is a masonry unit made of clay, concrete materials, lime, fly ash, sand. Our main aim of project is to develop eco-friendly bricks which common person can afford, reuse waste plastic in efficient way. Therefore, following easily available materials are procured and used during our experiments:

3.1.1 Plastic waste (HDPE Granule)

Our main aim of research study and project is to reduce plastic waste and utilize in efficient way. Therefore, we used reprocessed High-Density Polyethylene (HDPE) plastic in granule form and mixed with other composition in different ratios. We used HDPE instead of LDPE to achieve greater compressive strength and has property of high Melting Flow Index (MFI). The plastic granule is collected from R K Plastic & Company located at Baddi, Himachal Pradhesh.

Fig.1.1: Reprocessed HDPE granule

3.1.2 Sand

The natural river sand is directly procured and following test are carried out for sand to be used in making plastic sand bricks:

- **Test for Grading Zone of sand**

The grading zone of sand were determined by sieve analysis method as per IS:383-1970 mentioned below and the results indicates that the sand is confirmed to Grading Zone II.

Fig.1.2: Weighing machine & IS sieve apparatus

Table 1.1: Fine aggregate as per IS:383 – 1970

IS Sieve	Percentage Passing by Weight			
	Grading Zone I	Grading Zone II	Grading Zone III	Grading Zone IV
10 mm	100	100	100	100
4.75 mm	90-100	90-100	90-100	95-100
2.36 mm	60-95	75-100	85-100	95-100
1.18 mm	30-70	55-90	75-100	90-100
600µm	15-34	35-59	60-79	80-100
300 µm	05-20	08-30	12-40	15-50
150µm	0-10	0-10	0-10	0-15

Table 1.2: Observation data for grading zone of sand

IS Sieve Size	Weight of Aggregates Retained				% Retained	Cumulative % Retained	% Passing
	Determinations No. (Gram)						
	I	II	II	Average			
10 mm	0	0	0	0	0	0	**100**
4.75 mm	24.8	26.1	22.7	24.53333333	2.453333333	2.453333333	**97.54666667**
2.36 mm	37.6	41.6	43	40.73333333	4.073333333	6.526666667	**93.47333333**
1.18 mm	45	46.3	50.8	47.36666667	4.736666667	11.26333333	**88.73666667**
600 µm	438.1	501.9	490.1	476.7	47.67	58.93333333	**41.06666667**
300 µm	346.6	268.4	280.4	298.4666667	29.84666667	88.78	**11.22**
150 µm	49.6	52.6	55.5	52.56666667	5.256666667	94.03666667	**5.963333333**
75 µm	45.7	49.6	45.3	46.86666667	4.686666667	98.72333333	**1.276666667**
PAN	12.6	13.5	12.2	12.76666667	1.276666667	100	**0**
Total	**1000**	**1000**	**1000**	1000	100		

- **Bulking Value of Sand**

The increase in the volume of sand due to increase in moisture content is known as bulking of sand. A film of water is created around the sand particles which forces the particles to get a side from each other and thus the volume is increased. The increase in moisture of sand increase the volume of sand. Thus, bulking of sand depends on the moisture in the sand. The bulking of sand is nothing but the looseness of sand without compacting. The bulking value of sand experiment is carried out as per IS Code Reference:2386 (Part III) – 1963 and following results are obtained.

The bulking of sand is calculated by using formula:

$$\text{Bulking of sand (\%)} = \frac{(200 - Y) \times 100}{Y}$$

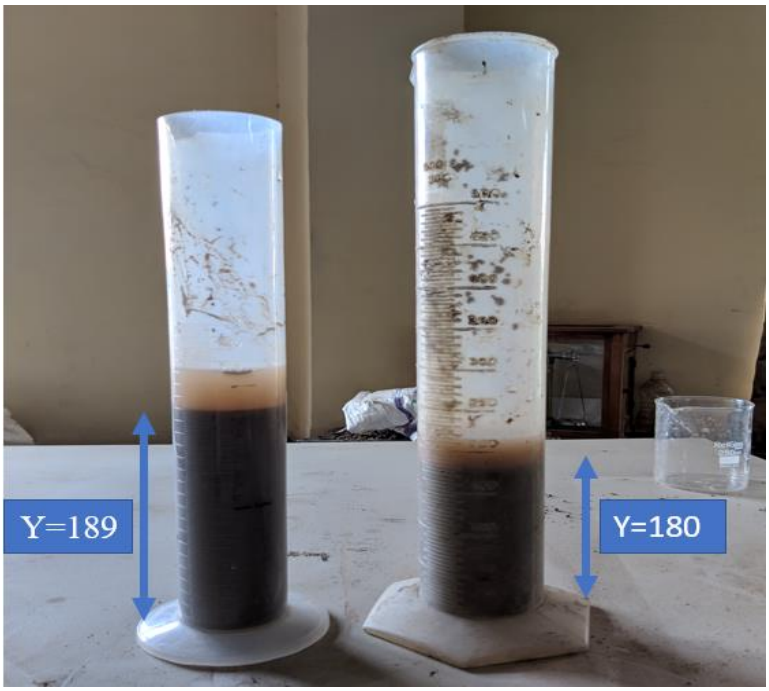

Fig.1.3: Measuring cylinder of silt content experiment

Table 1.3: Determination of bulking value (%) of sand

SI. No	Description	Sample No		
		Sample I	Sample II	Sample III
1	Volume of loose sand (ml)	200	200	200
2	Volume of saturated sand, Y (ml)	180	189	191
	Bulking of sand (%)	11.11	5.82	4.71

The sand bulkage value for above observation is = (11.11% + 5.82% + 4.17%) / 3

=7.21%

Therefore, the sand bulkage value comes about 7.21% which shows that sand contains negligible amount of moisture content. The sand is oven-dried before test commencement which interferes with low value of bulking percentage.

- **Silt content of Sand**

The silt is a very fine particle which is less than the size of 150 microns. Silt content is shrinking and expand due to the weather condition. So, it will affect the strength and crack shall occur in the brick structure. The excessive accumulation of silt leads to absorption of water which leads to shrinkage and expansion of bricks. It also affects bonding between cement and aggregates. Therefore, it is paramount significant to know the silt content of sand before making of sand bricks. The test of silt content is performed as per IS Code reference: 1386 (Part II) – 1963 and following results are achieved:

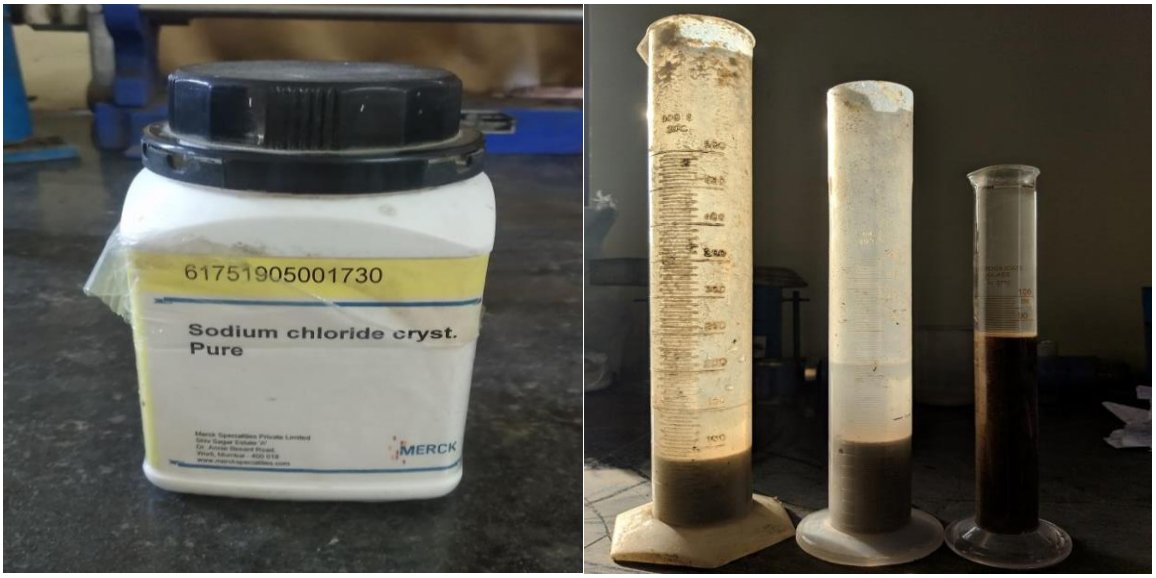

Fig.1.4: Sodium chloride & measuring cylinder

Silt content of sand= (V_2/V_1) x 100

Table 1.4: Determination of silt content (%) in sand

SI. No	Description	Sample No		
		Sample I	**Sample II**	**Sample III**
1	Volume of sample (V_1) ml	96	96	84
2	Volume of sample (V_2) ml	4	4	5
	Silt Content (%)	4.17	4.17	5.15

From the above observation table, silt percentage = (4.17 + 4.17 + 5.15)/3

= 4.5% < (6% or 7%)

The permissible silt content of sand is 6% or 7%. The silt content of sand comes around 4.5% which is in allowable limit range. Thus, it is concluded that river sand can be used for construction purposes.

3.1.3 Red Mud

Red mud is defined as a mixture of minerals which consists mainly of aluminum oxide bounded to one or more water molecules (hydrated aluminum oxide). They are diaspore, boehmite and gibbsite. With Small amount of impurities such as SiO_2, K_2O, Fe_2O_3, TiO_2, CaO, MgO and Na_2O. Red mud is the primary source for industrial aluminum and alumina production by Bayer process.

Red mud is also used to produced refractory bricks, During Firing of red mud below 1200°C, its structure is transformed into dense granules contains mainly Corandom ($\propto$-Al_2O_3). At temperatures within the range (1250–1350) °C the mullite phase is formed as a result of the reaction between silica and alumina. Gibbsite or hydrargillite listed its hydrate at (290–340) °C and transform to boehmite, and at less than (1200–1300) °C it is transformed to corundum

Table 1.5: Chemical analysis of red mud

Compound	Percentage (%)
Al_2O_3	53.00
Fe_2O_3	04.50
CaO	02.70
SiO_2	01.70
TiO_2	02.40
LOI	30.60

3.1.4 Aluminum Dust

In these studies, an attempt has been made to manufacture plastic sand bricks using aluminum powder in order to see the brick properties such as physical and mechanical properties. Accordingly, the above properties are reviewed by adding aluminum dust. And it bricks weight are reduced bricks and found to be light weight.

Alumina is the chief constituent of a good brick earth. A content of about 20% to 30% is necessary to form the brick earth of a good quality. It imparts plasticity to the earth so it helps in the moulding of the brick earth. If alumina is present in excess with inadequate quantity of sand then the raw bricks shrink and warp during drying, on burning they become too hard. So, it is important to have an optimum content of alumina.

Table 1.6: Properties of aluminum powder

SI. No	Parameters	Properties
1	Appearance	Fine Powder
2	Colour	Silver Gray
3	Chemical Composition (CC)	Aluminum (min 99.3%), copper (max. 0.1%), iron (max 0.4%) silica (max 0.2%)
4	Atomic Weight	26.98g
5	Density at 25^oC	2.7g/cm^3
6	Crystal structure	Face-Centered Cubic (FCC)
7	Purity	99%

3.1.5 Water

Water is one of the most important elements in construction and is required for the preparation of mortar, bricks, mixing of cement concrete and for curing work etc. The quality of water used has a direct impact on the strength of the motor and cement concrete in the construction work. The water used for curing and mixing must be free from high quantities of alkalis, acid, oils, salt, sugar, organic materials, vegetable growth, etc. that might be deleterious to bricks, concrete or iron.Portable water shall be used for mixing of concrete. Suspended solid matter in the water shall not exceed more than 200mg/l. The pH value of the water shall not be less than 6. The quantity and quality of water required are referred from the IS Code Recommendations: Water Quality for Building Construction (IS 456:2000).

3.1.6 Brick Mold

The brick mold was made of metal as well as wooden by man-made according to standard brick size, i.e. 190mm x 19mm x 19mm.

Fig. 1.5: Standard size brick mould

3.2 METHODOLOGY

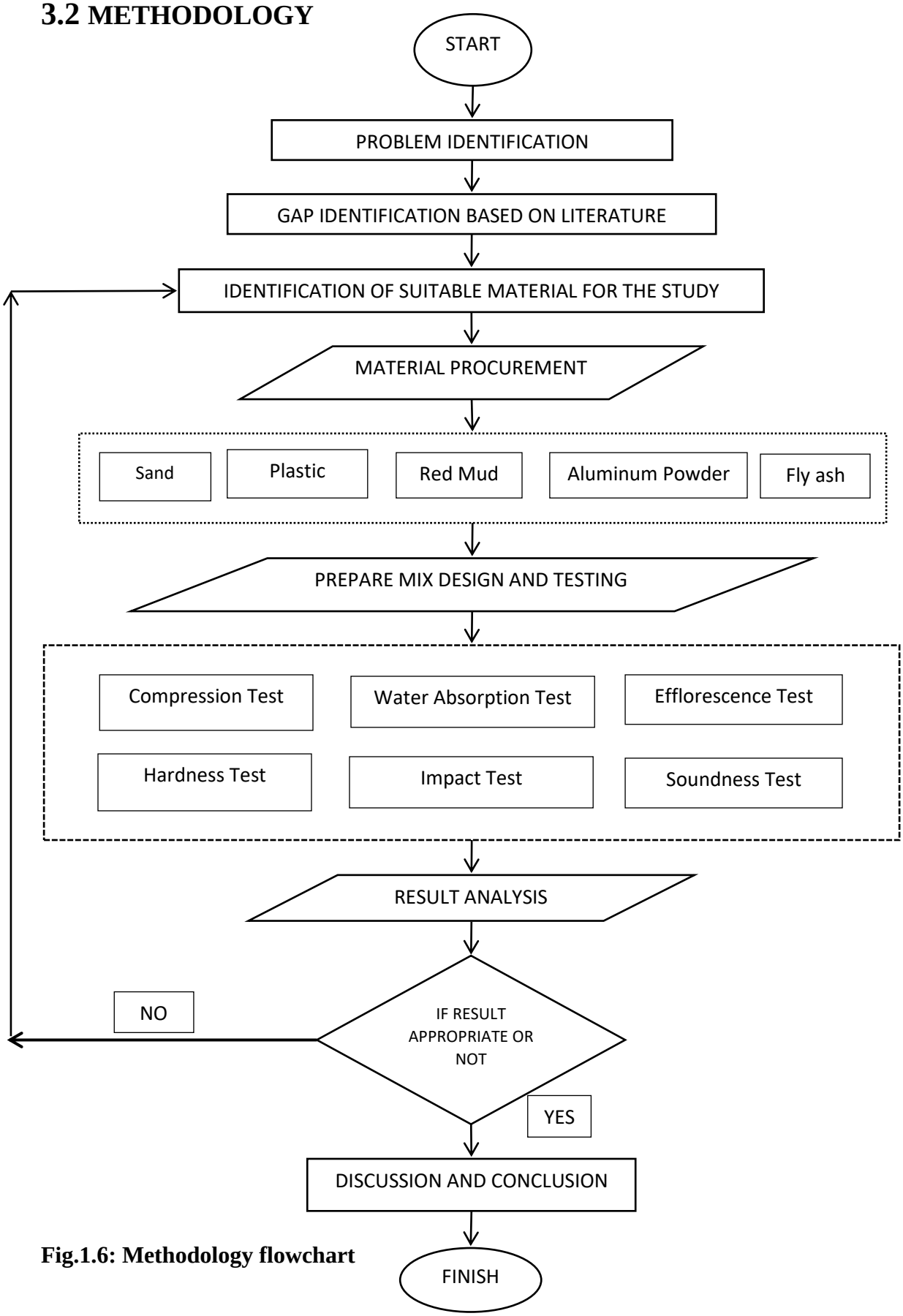

Fig.1.6: Methodology flowchart

3.2.1 GENERAL

In the chronological overall view of methodology, we have firstly studied research conducted in India and outside India. Then, accordingly we have procured and collected raw materials like HDPE plastic, sand, bauxite, aluminum dust and proceeded to manufacturing of standard size brick (19cm x 9cm x 9cm). During brick manufacturing, sand and plastic ratios are overviewed. After completion of brick making, the brick samples are thoroughly investigated and checked the quality of plastic sand bricks by performing various test. The tests are performed on laboratory as well as on the field and following brick test are conducted mentioned in the flowchart diagram below. After testing, collection of results and discussion are done followed by overall conclusion.

3.2.2 Manufacturing Process of Plastic Sand Bricks:

The operation involved in the manufacturing of plastic sand bricks are represented diagrammatically**.**

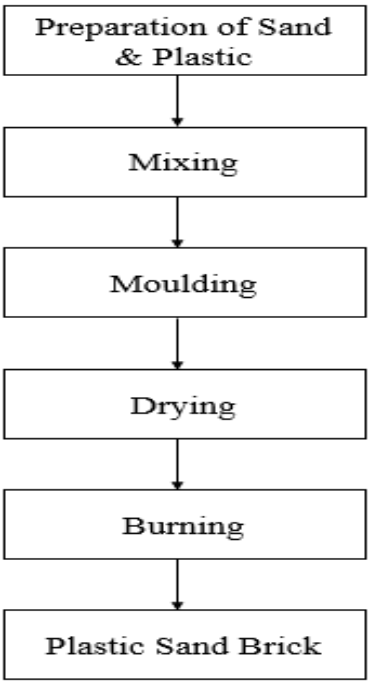

Fig.1.7: Operation involved in manufacturing of plastic bricks

1. Preparation of sand and plastic

In the first phase, sand is prepared with different testing and plastic waste are collected.

2. Mixing

Then, the mixing is done in different portions of water, sand, plastic, bauxite and aluminum powder.

3. Moulding

The third operations that is moulding are done in standard brick mould size (190mm x 90mm x 90mm) keeping sample on the vibrator machine for thorough mixing.

4. Drying

After sand bricks are well moulded, it is kept 24 hours for drying in the room temperature.

5. Burning

After keeping brick sample for 24 hours, then we have put every brick inside muffle furnace subjected to 700^{o}C for uniform burning and bonding between mixture.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 GENERAL

To know the quality of plastic sand bricks, following tests were carried out as per Indian Standard Code (ISC) in laboratory as well as in field. According to the results obtained from the various tests, quality of bricks is determined and discussed. All the test results of plastic sand bricks achieved is compared to normal clay bricks. The following brick test is conducted for the project:

4.1.1 Compressive Strength Test

Fig 1.8: Compression testing machine

The brick of size 19cm x 9cm x 9cm was placed in compression testing machine (CTM) shown in figure below. The test was done mainly to find the compressive strength value. Generally, many specimens of bricks are taken to laboratory for testing and tested one by one. In this test plastic sand bricks were put on compressive testing machine and pressure are applied till the sample breaks. The plastic sand bricks of different proportion of plastic sand ratio are tasted one by one and found out that one sample gives high compressive strength value. And that compressive strength value is compared to normal clay bricks.

$$\text{Compressive Strength} = \frac{\text{Maximum load (P)}}{\text{Area of specimen (A)}}$$

Where,

P- Maximum load (KN)

A- Area of specimen (mm^2)

4.1.2 Water Absorption Test

In this test, bricks are weighed in dry condition and let them immersed in fresh water for 24 hours. After 24 hours of immersion, those are taken out from water and wipe out with cloth. Then, brick is weighed in wet condition. The difference between weights is the water absorbed by brick. The percentage of water absorption is then calculated. The less water absorbed by brick the greater its quality. Good quality brick doesn't absorb more than 20% water of its own weight.

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

Where, W_1 = Weight of dry brick (kg)

W_2 = Weight of wet brick (kg)

Table 1.7: Determination of water absorption (%)

SI. No	Description	Sample No		
		Sample I	Sample II	Sample III
1	Weight of dry brick W_1, (Kg)	2.834	2.962	2.836
2	Weight of wet brick W_2, (Kg)	3.119	3.385	3.16
	Water Absorption (%)	10.05	14.28	11.42

Water absorption= (10.05 + 13.94 + 11.42) / 3

=11.92% < 20%

Therefore, the acceptable water absorption limit shall not be more than 20% in case of clay brick as per water absorption of clay brick, IS:3495 (2):1992. Hence, it is concluded that normal clay bricks absorb water at permissible limit and can be used for construction purposes.

Fig.1.9: Weighing of wet brick

4.1.3 Efflorescence Test

The presence of alkalis in bricks is harmful where it forms a gray or white layer on brick surface by absorbing moisture. To find out the presence of alkalis in bricks, this test is performed. In this test, a brick is immersed in fresh water for 24 hours. Then, it is taken out from water and allowed to dry in shade. If the whitish layer is not visible on surface, it proofs that absence of alkalis in brick. If the whitish layer visible about 10% of brick surface, then the presence of alkalis is in acceptable range. If that is about 50% of surface, then it is moderate. If the alkali's presence is over 50%, then the brick is severely affected by alkalis.

4.1.4 Hardness Test

In this test a scratch is made on brick surface with steel rod (any hard material can be used) which was difficult to imply the bricks or blocks were hard. This shows the brick possess high quality.

4.1.5 Impact Test

In this test, the bricks were made to drop from a height of 1m on one of its corners. The bricks were not broken or shattered and it indicates the brick are of good quality.

4.1.6 Soundness Test

The soundness test is also done in the field. After the manufacturing of the brick are allowed to dry in air for 2 days. Then the bricks are made to hit each other, the ringing sound produced during the process, which denotes the quality of the brick is good. Good quality bricks produce the clear ringing sound. In our project both, both normal clay bricks and plastic sand bricks produced clear ringing sound.

CHAPTER 5
CONCLUSIONS & REFERENCES

CONCLUSION

Plastic sand brick possesses more advantages which includes cost efficiency, resource efficiency, reduction in emission of greenhouse gases, etc. Plastic sand brick is also known as “Eco-Bricks” made of plastic waste which is otherwise harmful to all living organisms can be used for construction purposes. It increases the compressive strength when compared to normal clay bricks. By use of plastic sand bricks, the water absorption presence of alkalis was highly reduced. Owing to numerous advantages further research would improve quality and durability of plastic sand bricks.

On the basis of result obtained during the experimental investigation, following conclusion was drawn:

- Making bricks from sand and waste plastics can be an alternative to the available traditional clay bricks.
- Sand plastic bricks shows lower water absorption, no efflorescence, and no dampness problem when compared with those of normal clay bricks.
- Sand plastic bricks possess higher compressive strength than normal clay bricks.
- Waste plastics which is available everywhere may be put to an efficient use in brick making.
- Sand plastic bricks can help reduce the environmental pollution thereby making the environment clean and healthy.
- The concept of eco-bricks is energy efficient and commercially feasible.

Therefore, compare to normal clay bricks, plastic bricks also called eco-bricks possess numerous merits. We can conclude that; today’s world is the story of plastic and it is never going away. Planet or Plastic? Take the pledge to choose our planet by adopting plastic bricks for construction, pavement purpose.

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