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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by

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to

JAYPEE UNIVERSITY OF INFORMATION TECHNOLOGY

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HIMACHAL PRADESH, INDIA

June - 2020

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 liable for the contents of my project report.

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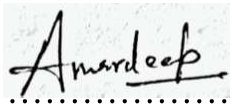
CERTIFICATE

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 the 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, 2019 to June, 2020 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: 10/06/2020



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ABSTRACT

Plastic waste is skyrocketing every day at an alarming rate as increase in the number of populations, industries and factories, consumers, urbanization and developmental activities. The quantity and disposal of plastic related waste in the present day has become the biggest challenge globally due to their non-biodegradability. According to Plastic Pollution-Our World in Data it is estimated that yearly worldwide produces around 380 million tons of plastic waste as of 2018. About 6.3 billion tons of plastic waste has been produced starting from the 1950s to 2018, of which 9 percent of the total waste is being recycled and 12 percent has been burnt. Few scientists predicted that by 2050, the plastic waste will surpass the number of fish in the ocean. Therefore, the main objective of proposed eco-friendly bricks which is made up of introducing plastic is to reduce the environmental problems such as land degradation, pollution hazards affected by waste plastic. The "Plastic sand bricks" is one such invention i.e. gaining momentum among several waste reduction strategies. The sand, bauxite, aluminum dust, fly ash are added along with different proportions of shredded plastic to make eco-friendly bricks. The compressive strength of brick is however analyzed 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 compared 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

GENERAL

The usage of plastic is daily increasing and it may be handy and convenient but is also a perilous material. At the hour of requirement, plastic is possessed to be very essential but after its use, it's simply disposed, generating toxics and hazards to the surrounding and environment. Plastic wastes are imperishable and has been a hazardous material for hundreds of years. The amount of plastic waste in Municipal Solid Waste (MSW) is growing speedily. According to the Central Pollution Control Board (CPCB) report, it is evaluated that the figure of plastic usage multiplies every decade. This is mainly because of the exponential growth of population, urban area, developmental activities and changes in lifestyle which guides to extensive littering on the surrounding. The waste is imperishable and also analyst have concluded that the plastic waste can endure on earth for 4500 years without decaying. In India approximately 40 million tons of municipal solid waste is produced yearly, which evaluates to 1.5 to 2% in the increase rate per annum.

Hence, these plastics are to be used fruitfully. These days, it unfeasible for any organization to work unaccompanied by usage of plastic beginning from agricultural purpose to industrial purposes. Therefore, we cannot restrict the use of plastic but reuse the plastic waste as building material, industries are examined to be the most practicable applications od such idea. The utilization of plastic waste for the manufacturing of bricks is the finest method to resolve the issue of storing waste materials and to revamp the cost for the production of building materials. In this project, plastic waste is introduced with sand, bauxite, aluminum dust and fly ash to manufacture sand bricks. The bricks will then be analyzed to investigate the compressive strength, water absorption and efflorescence. In the previous research, the substitution and incorporation have been done with the direct addition of polyethylene or plastic fiber, polyethylene terephthalate (PET) bottles in shredded form, chemically treated polyethylene fiber, PET in aggregate form by substituting natural coarse aggregate. Most of the replacements have been done by volume ratio and showed in the reduction of compressive strength with increase in the ratio of plastic waste. In this research, High-Density Polyethylene (HDPE) plastic waste has been utilized in crushed form. The substitution has been done by weight rather than by volume.

CHAPTER 2
LITERATURE REVIEW

2.1 GENERAL

Already, various research studies and investigations have been conducted on the utilization of waste plastic 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 plastic to stone dust ratio 3:7. The compressive strength was found 5.6 N/mm^2 at the compressive load of 96 KN and concluded that those bricks are most economical, shows excellent results compared to bricks made using fly ash and 3rd class clay bricks for construction purposes.

2. **Aiswaria et al (2018)** used PET bottles and M-sand to make plastic sand bricks. For different mortar ratios, Prism test were conducted and analyzed and noticed that the compressive strength of masonry prism grows with an increase in mortar strength which is found to be greater than that of conventional burnt clay bricks.

3. **Priya, Nirmala and Dhanalakshmi (2018)** found the growth of load carrying capacity of the eco bricks up to 90 percent as compared to normal conventional bricks. Also, the composite bricks and eco bricks showed 12 percent growth in the strength than the conventional clay brick.

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 brick and by utilization of plastic, the water absorption and existence of alkalis were significantly decreased.

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)** substitute cement by plastic waste to make paver block and declared lesser cost analysis compared to that of conventional concrete paver blocks.

7. **Billygraham Singh et al (2017)** prepared the two brick mold samples; bricks were manufactured incorporating sand and waste compact discs (CD) and bricks made of sand and wastewater bottles. And then experiment results of those two brick specimens are compared to normal clay brick. It is noted that sand plastic bricks showed lower water absorption rate, lower apparent porosity and higher compressive strength.

8. **Agrawal and Goyal et al (2017)** conducted an experiment with 6 kg laterite soil and 70 percent of plastic waste by weight of soil. 2 percent by weight of bitumen was put in.

9. **Kumar and Gomathi (2017)** performed the test with sand, incorporating fly ash, lime, gypsum and plastic with different percentage (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 does not absorb less than 5% water, on top the introduction of sand and plastic gives superior test outcomes compared to sand and 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 brick, burnt clay brick and plastic sand brick. Mainly they focused on compressive strength and water absorption tests. And following compressive strength is obtained; fly ash brick (4.19 N/mm^2), burnt clay bricks (3.15 N/mm^2) and plastic sand bricks (5.12 N/mm^2) in which plastic brick possess high value. Water absorption of fly ash is (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 bricks utilizing plastic wastes, highlighted on merits and/or 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 a 2-liter PET bottle of M-sand resulted in good compressive strength of 180 KN compare to the other two specimens.

14. **Deepak Shiri et al (2015)** procured shredded Low-Density Polyethylene (LDPE) plastic using plastic extruder machine and prepared three brick samples. 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 showed the highest compressive strength and sustains a high compressive load.

15. **Dakwale and Ralegaonkar (2014)** used construction and demolition waste (C&D) as aggregate and cement, fly ash as a binder to prepare eco-bricks. The special experiment includes embodied energy tests and bricks made up of using construction

demolish waste had achieved least embodied energy (1.93 MJ/bricks) which is 16.8% lesser than fly ash bricks.

16. **Mallikarjun Hiremath et al (2014)** conducted compressive strength test for bricks incorporating 70 percent plastic content by weight of soil and 2 percent bitumen content by weight of soil that resulted in a compressive strength of 8.16 N/mm^2 which was higher than late-rite stone (3.18 N/mm^2). And also showed water absorption rate of 0.9536 percent which was very lower than laterite stone which showed absorption rate of 14.58 percent.

17. **Arshad and Pawade (2014)** carried out making two brick sample that is a 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 electronic waste which was produced by grinding, rubbing and mixing technique. Plastic waste was also incorporated in the concrete. M20 mixed design was done by referring the IS method. The cement used for the concrete preparation was Ordinary Portland cement of 43 grade. The fine aggregates were substituted by grinded E-waste and plastic waste by ratios of 0%, 2%, and 4%.

19. **Agilan (2012**) investigated the possible utilization of paper as a material for producing an efficient, cost-effective and lightweight composite brick. The bricks were produced by mixing with papercrete. Analyzed and reviewed the compressive strength, unit weight, and water absorption. Six different mix proportions were calculated by mixing the paper pulp and industrial by-products like ash, Rice husk ash. Due to the addition of paper pulp, the brick exhibited low thermal conductivity and also reduced the energy requirement for temperature control.

20. **Sorte (2008)** developed the paper pulp brick with fly ash, quarry dust, cement along with 10 percent, 20 percent, and 30 percent paper pulp by weight. They reported that

the best results of compressive strength of 10 percent paper pulp bricks after 3rd day, 7th day and 28th day are 1.086 N/mm^2, 3.057 N/mm^2, 4.42 N/mm^2 respectively.

2.1.2 STUDY CONDUCTED OUTSIDE INDIA

1. **Akinwumi et al (2019)** manufactured Compressed Earth Brick (CEB) with a mixture of clayey soil mixed with shredded plastic in different percentage (0%1%,3% and 7%). The CEB containing 1% exhibited highest compressive strength and waste plastic size less than 6.3 mm also exhibited low erosion rate.

2. **Arhin et al (2017)** present the development of mortar blocks for pavement construction using Bauxite residue (red mud) with cement. Different batches were formulated and their physiochemical properties were analyzed respectively. The load bearing strength increased by 40 percent as compared to conventional mortar block.

3. **Bernardi et al (2017)** manufactured plastic brick with three fronts in mind; first, was to make a brick which is cost efficient and environmentally friendly for building house and closing the housing gap. Second was to produce by incorporating waste plastic as a solution to waste issues in the continent and its health and safety consequences in mind. Thirdly, as a solution to housing crisis due to rapid urbanization.

4. **Debieb, F et al (2016)** investigated the usage of PET and LDPE as a substitute for fibers and fine aggregates (powder) in sand concrete. Different ratios of sand to plastic aggregates were used by volume, and various amount of plastic fibers were used by volume in sand concrete mixes. The study showed in the reduction of the bulk density, reduction in the air content, causing an increase in load carrying capacity and flexural strength and especially for 10 percent and 20 percent of the replacement.

5. **Muyen, Z et al (2016)** analyzed the strength properties of different bricks made with addition of waste PET bottles filled with fine sand. Various bottles of varying capacity from 250 ml to 1500ml were used. The largest brick gave the highest compressive strength. These bricks showed twice the value of compressive strength as compared to normal concrete cylinder.

6. **Safinia et al (2016)** used plastic bottles in the concrete blocks. The voids were created by plastic bottles at an equal distance in the masonry units. examined the use of plastic bottles in concrete blocks. The concrete was poured around the bottles. 500ml bottles were used. American Society for Testing and materials C140 was used as a reference. The study showed 57 percent improvement in the load bearing capacity as compared to normal blocks.

7. **Wahid et al (2015)** used shredded PET bottles with sand and cement. Varying percentages (0, 5, 10 and 15%) of plastic were used and mixed. The blocks were tested for compressive strength, water absorption and efflorescence. The addition of PET bottles reduced the compressive strength. The reduction was minimal thus, the strength can be impowered by the addition of superplasticizer. On the other hand, the addition lead to lower water absorption rate and efflorescence.

8. **Shoubi et al (2013)** concluded that the employment of plastic bottles as a building material can be efficient and can reduce various elements such as time of execution, cost, load capacity, flexibility, reducing waste and energy efficiency.

9. **Zhang (2013)** researched the behaviors of brick produced by waste plastic under three different categories; firing, cementing and geopolymerization.

10. **Karaman et al (2006)** determined the effects of bricks due to firing time and temperature. The physical properties like compressive strength, water absorption, bending strength, weight loss, firing shrinkage and densities of clay bricks were determined with different firing times and temperatures. Higher temperatures exhibited higher compressive and bending strengths, higher density and lower

absorptions. On increasing firing time, only slightly altered the mechanical and physical properties of clay bricks. Therefore, firing temperature was the key factor to modulate the physical properties in clay bricks.

2.2 SUMMARY OF LITERATURE REVIEW

Although many researches and studies have been conducted about the utilization of plastic in the building materials, the production and manufacturing of such brick at a large scale or in an industrial level is very much limited. Further, more analysis, researches and development have to be done not only towards the technical, economical and environmental aspect but also imposition of standards and regulation of government policy and public education associated to waste generation, reuse, recycle and sustainable development.

The use waste plastic shows reduction in the field of compressive strength, it shows excellent result in water absorption and efflorescence. The load bearing capacity can be enhanced by the addition of superplasticizer. It is also efficient, cost-effective and ecofriendly to manufacture.

2.3 OBJECTIVE OF THE STUDY

- To construct the economical and environmentally 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 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 the form of aggregates (however, there is no provision of aggregate in the construction of brick).

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CHAPTER 3

METHODOLOGY

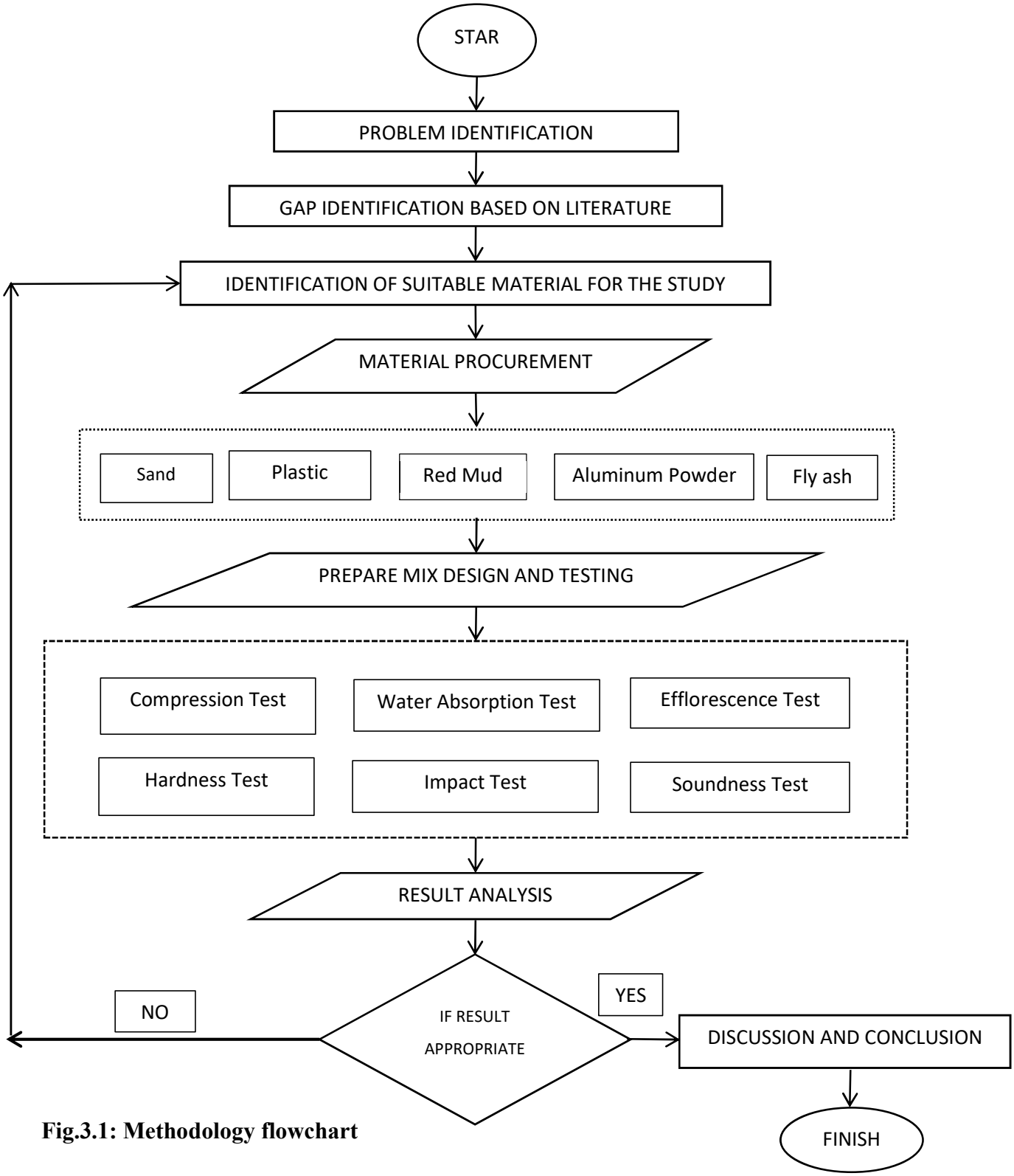

Fig.3.1: Methodology flowchart

In the chronological overall view of methodology, we have first 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 the manufacturing standard size (19cm x 9cm x 9cm) brick. 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 the various tests. The tests are performed on the laboratory as well as on the field and the following brick tests are conducted mentioned in the flowchart diagram below. After testing, collection of results and discussion are done followed by the overall conclusion.

3.1 Manufacturing Process of Plastic Sand Brick:

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

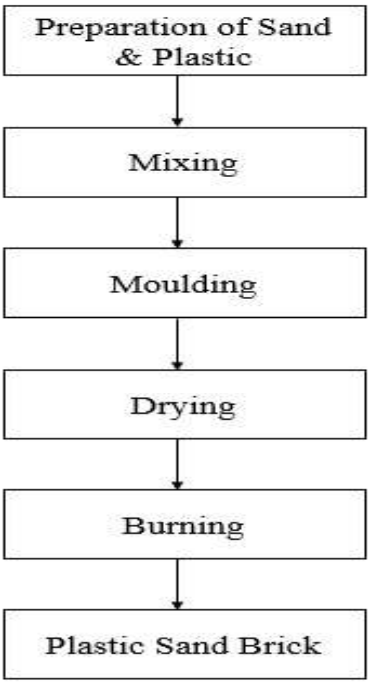

Fig.3.2: Operation involved in manufacturing of plastic brick

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. A

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.

3.2 MATERIALS

Brick could be an artifact to make walls, pavements and other elements in masonry construction. Within the past, bricks are made of mainly clay soil and nowadays it's widely to denote brick could be a masonry unit product of clay, concrete materials, lime, fly ash and sand. Our main aim of the project is to develop eco-friendly bricks during which folk can afford, reuse waste plastic in an efficient way. Therefore, following easily available materials are procured and used during our experiments;

3.2.1 Plastic waste (HDPE Granule)

Our main aim of the research study and project is to reduce plastic waste and utilize in an efficient way. Therefore, we used reprocessed High-Density Polyethylene (HDPE) plastic in granule form and mixed with other components in different ratios. We used HDPE instead

of LDPE to achieve greater compressive strength and has a property of high Melting Flow Index (MFI). The plastic granule is collected from R K Plastic & Company located at Baddi, Himachal Pradesh.

Fig.3.3: Reprocessed HDPE granule

3.2.2 Sand

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

Fig.3.4: Weighing machine & IS sieve apparatus

- **Bulking Value of Sand**

The bulking of sand is calculated by using the formula:

$$\text{Bulking of sand (\%)} = \frac{(200 - Y) \times 100}{Y} \quad \ldots\ldots \text{Equation 1}$$

Where Y – Height of sand in water.

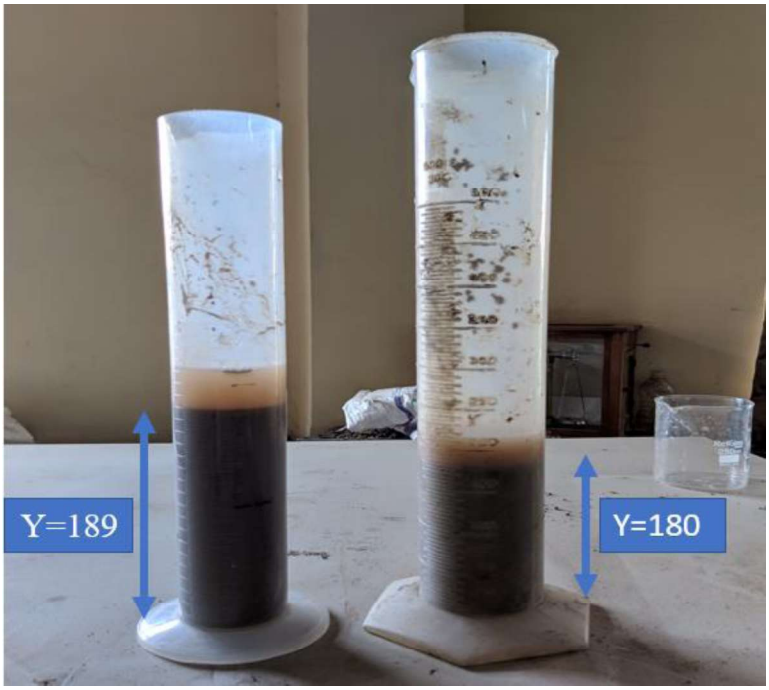

Fig.3.5: Measuring cylinder of silt content experiment

- **Silt content of sand**

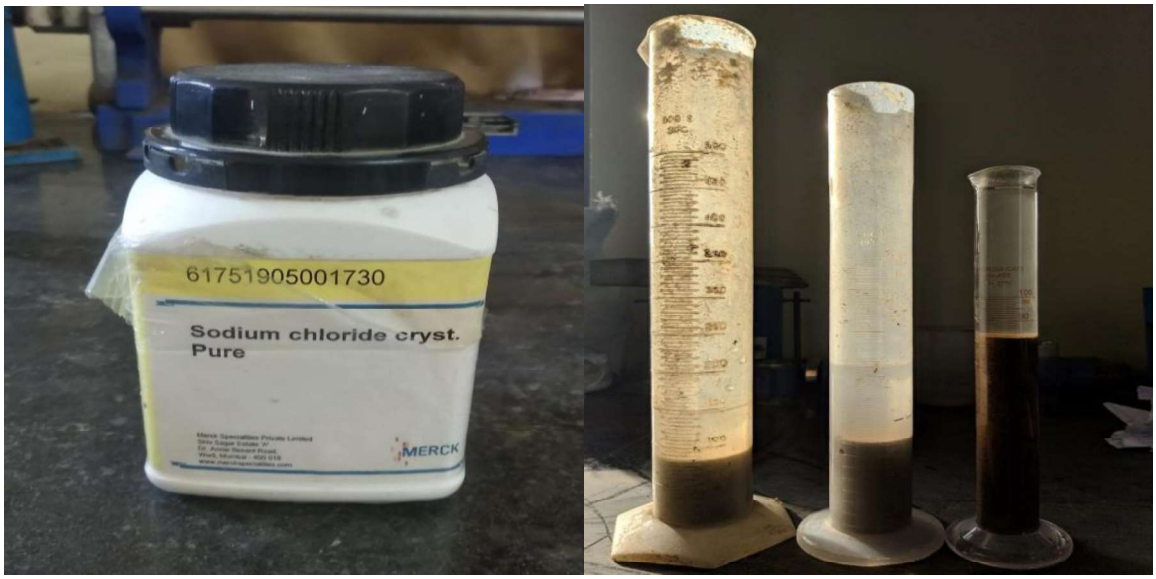

Fig.3.6: Sodium chloride & measuring cylinder

The silt content of the sand is calculated by the formula;

Silt content of sand= (V_2/V_1) x 100 ……Equation 2

where V_1 – volume of sample

V_2 – volume of silt

3.2.3 Red Mud

Red mud is a mixture of minerals which consists mainly of aluminum oxide bonded to one or more water molecules (hydrated aluminum oxide). They are diaspore, boehmite and gibbsite. With small amount of impurities such as SiO2, K_2O, Fe_2O_3, TiO_2, CaO, MgO and Na_2O.

Red mud is also used to produced refractory bricks, During the Firing of red mud below 1200°C, its structure is transformed into dense granules contains mainly Corundum (∝-Al2O3). At temperatures within the range (1250–1350) °C the mullite phase is formed as a result of the reaction between silica and alumina.

3.2.4 Aluminum Dust

In these studies, an effort has been made to manufacture plastic sand bricks using the aluminum powder so as to determine the brick properties like physical and mechanical properties. Accordingly, the above properties are reviewed by adding aluminum dust. And its bricks weight is reduced bricks and established to be lightweight. Alumina is the main element to excellent brick earth. 20 to 30 percent of its content creates excellent quality brick.

3.2.5 Water

Water is an elixir of life and also plays paramount significant role as prime elements in construction and preparation of bricks, cement concrete mortar and for curing of cement, etc. The quality and quantity of water has direct implications on strength, workability, consistency of concrete in the preparation of bricks. The water used in preparation and construction of bricks should be free from high percentage contents of alkalis, acids, salt,

sugar, vegetables, oil, organic substances, etc, that is very harmful to bricks, cement concrete. The portable water with recommended pH range should be used for concrete work. The water should contain suspended solid matter not more than 200mg/l. The water used in concrete works should not be less than 6. The IS Code Recommendations: Water Quality for Building Construction (IS 456:2000) are referred to check the quantity and quality of water

The formula used to test for water absorption test;

1. Water Absorption= $\{[W_2 - W_1] / W_1\} \times 100$ …… Equation

Where, W_1 = Weight of dry brick (kg)

W_2 = Weight of wet brick (kg)

3.2.6 Brick Mold

The man-made brick mold was made of metal as well as wooden according to standard brick size, i.e. 190 mm x 90 mm x 90 mm.

Fig.3.7: Standard size brick mould

The compressive strength is calculated using the formula;

Compressive Strength= $\frac{\text{Maximum load (P)}}{\text{Area of specimen (A)}}$ ……. Equation 4

Where, P- Maximum load (KN) A- Area of specimen (mm^2)

CHAPTER 4

RESULTS AND DISCUSSIONS

4.1 GENERAL

To know the quality of plastic sand bricks, the following tests were carried out as per the Indian Standard Code (ISC) in the laboratory as well as infield. According to the results obtained from the various tests, the 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 Test for Grading Zone of sand

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

Table 4.1: 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 4.2: 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	24.53	2.45	2.45	**97.54**
2.36 mm	37.6	41.6	43	40.73	4.07	6.53	**93.47**
1.18 mm	45	46.3	50.8	47.37	4.74	11.26	**88.73**
600 µm	438.1	501.9	490.1	476.7	47.67	58.93	**41.07**
300 µm	346.6	268.4	280.4	298.47	29.85	88.78	**11.22**
150 µm	49.6	52.6	55.5	52.57	5.26	94.04	**5.96**
75 µm	45.7	49.6	45.3	46.87	4.68	98.72	**1.27**
PAN	12.6	13.5	12.2	12.77	1.27	100	**0**
Total	**1000**	**1000**	**1000**	1000	100		

4.1.2 BULKING VALUE OF SAND

The bulking value of the sand experiment is carried out as per IS Code Reference:2386 (Part III) – 1963 and therefore, the following results are obtained.

Table 4.3: 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%

Therefor4.1.3e, 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.

4.1.3 SILT CONTENT OF SAND

The test of silt content is performed as per IS Code reference: 1386 (Part II) – 1963 and the following results are achieved:

Table 4.4: 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 silt (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.

4.1.4 ANALYSIS OF RED MUD

Table 4.5: 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

4.1.5 ANALYSIS OF ALUMINUM POWDER.

Table 4.6: 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°C	2.7g/cm^3
6	Crystal structure	Face-Centered Cubic (FCC)
7	Purity	99%

4.1.6 COMPRESSIVE STRENGTH TEST

Table 4.7 observation for Compressive Strength test

Specimen	Maximum load (KN)	Compressive Strength (kg/cm^2)
Sample I	172	102.54
Sample II	168	100.15
Sample III	170	101.34

Compressive strength = (102.54 +100.15 + 101.34) / 3

= 101.34 kg/cm^2 < 105kg/cm^2

The minimum compressive strength of the bricks for First class brick is 105 kg/cm^2. Therefore, it is concluded that the plastic bricks can be used as building material and other masonry works.

4.1.7 WATER ABSORPTION TEST

Table 4.8: 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 the plastic bricks absorb water at permissible limit and can be used for construction purposes.

4.1.8 EFFLORESCENCE TEST

The presence of white layer or formation of gray layer on the surface was found to be less than 10% of the total surface area of brick on all the three samples. This proved that the presence of alkali is in the acceptable limit or range.

4.1.9 HARDNESS TEST

A hard material or the steel rod was used to scratch the surface of the brick samples. The rod felt difficult to imply scratch to the samples and much effort and energy was needed to make a scratch. Therefore, it was easier to conclude that the plastic brick possesses high quality.

4.1.10 IMPACT TEST

The plastic brick showed no sign of breakage when dropped from a height. Hence, it is concluded that the plastic brick is of acceptable quality.

4.1.11 SOUNDNESS TEST

The sample bricks were hit each other to make a sound. The ringing sound hence proved that the plastic brick is of good quality.

CHAPTER 5
CONCLUSIONS

5.1 General

Plastic brick gives rise to more advantages including cost efficiency, resource efficiency, reduction in the emission of greenhouse gases, etc. Plastic sand brick is additionally referred to as “Eco-Bricks” made from plastic waste which is otherwise harmful to any or all living organisms which will be used for construction purposes. It increases the compressive strength in comparison to normal clay bricks. By the employment of plastic sand bricks, the water absorption, presence of alkalis was highly reduced. Thanks to numerous advantages, further research would improve the standard and sturdiness of plastic sand bricks.

5.2 CONCLUSIONS

On the idea of the result obtained during the experimental investigation, the subsequent conclusion was drawn:

- Making bricks from sand and waste plastics may be another to the available traditional clay bricks.
- Sand plastic bricks show lower water absorption, no efflorescence, and no dampness problem in comparison with those of normal clay bricks.
- Sand plastic bricks possess higher compressive strength than normal clay bricks.
- Waste plastics that are available everywhere is also put to efficient use in brick making.
- Sand plastic bricks can help reduce 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 will conclude that; today’s world is that the story of plastic and it is never going away. Planet or Plastic? Take the pledge to decide on our planet by adopting plastic bricks for construction, pavement purpose.

5.3 SCOPE FOR FUTURE WORK.

India is a developed and larger country where there are millions of people who can't afford basic needs like:

- Food
- Shelter

With these, eco bricks can be blessing in disguise for people to start their own company and stay self-sufficient. As plastic sand bricks popularly known as 'eco bricks' are free from pollution, it can be also used as replacement of wood, timber, stone, concrete to make shelter for millions of people. The shelter or houses prepared from such bricks are very cost effective and environmentally friendly too.

Plastic sand bricks also give us rays of hopes in the research field and ways to work in innovative ideas and come up with inventions related to plastic based materials, broad scope in future plastic industry.

In future, plastic can be also used as replacement of aggregate, cement to construct plastic roads which are popular in few parts of the country. So, it can be also used to extend construction in macro-scale level which will soon gain momentum, as world gears to plastic free zone!

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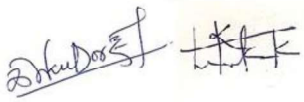

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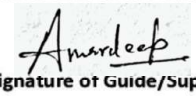

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