INVESTIGATING STRENGTH AND PROPERTIES OF ECOLADRILLO: ECO BRICKS

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ABSTRACT
Our population is increasing by leaps and bounds every year. Consequently the requirement of housing has also increased leading to a considerable imbalance between the available construction material and their increasing demand. Beside the fact that sustainable architectural principles are embraced into various buildings every day, still they are far-flung from a number of people due to the unawareness as well as lack of the knowledge. This paper propounds the utilization of the waste PET bottle as a substitute for conventional bricks. Plastic bottles usually take thousands of years to degrade it and produce toxic fumes if incinerated. As a matter of fact out of every 5 discarded bottles only 1 bottle is sent to the recycle bin. As a result giant mounds of PET bottles have been created on the earth’s surface. This paper tends to investigate various aspects of the bottle bricks such as water tightness, flexibility, and load bearing capacity as well as the cost analysis. The study also mentions the self insulating properties of the bottle bricks. Comparison of eco bricks versus other materials is also done. Finally the paper concludes that plastic bottle bricks can be more effective in terms of strength, insulating properties and heat resistance along with cost reduction when compared to conventional bricks. Bottle bricks also help in reducing CO₂ emissions that is released during manufacturing of conventional bricks thus leading to sustainable construction.

Key words: Poly Ethylene Terephthalene, Sustainable Material, Bagasse, Green Construction.

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INTRODUCTION
Plastic is a non-biodegradable material which takes hundreds of years to degrade itself. The global production of the plastic is 150 million tons every year. Earlier trend of recycling plastic bottles came into existence but it did not work efficiently. The recycling of the plastic can be done only 2-3 times after that the plastic tends to lose its strength. In fact 70% percent of the plastic is left as waste every year. This waste plastic leads to various problems such as landfill problem, and if disposed in water bodies it causes water pollution leading to the death of various aquatic lives. Hence there was a need to find any solution for this problem of disposal of plastic. Later on plastic bottle bricks came in existence. This trend acted as a boon in the construction industry. It solved various major issues such as disposal of plastic, preservation of environment and providing shelter at low cost. As we know India is a developing country. There are number of people who are below the poverty line. India is the second most populous country in the world after China hence majority of people are not able even to fulfill their basic necessity of food as well as shelter. Consequently these eco bricks have become a solution for all these problems all across the globe.

ECOLADRILLO OR ECO BRICKS
Theses bricks are made up of plastic bottles. Bottles are filled with different filler materials according to the availability of the material in that region. Filler material that can be used in making eco bricks are:
1. Waste plastics.
2. Soil
3. Fly ash
4. Bagasse.
These bricks are convenient to construct and are also economic.
As the matter of fact these bricks are supposed to be 20 times stronger than the clay bricks. These bricks are bullet proof and hence can be used in the areas which are prone to attacks such as Jammu & Kashmir.

Properties of Plastics
There are various physical properties of Polyethylene Terephthalate:
1. It is having high chemical resistance and good resistance to UV rays.
2. It is white cream in color.
3. Its density is 1.33220 gm/cm³
4. It is insoluble in water
5. It is resistant to acid, oils and fats.

Problem associated with the reuse of the plastic
If the bottle is not washed between various uses the bacteria from the hands and mouth of the user accumulates.
Repeating the hot water washing process of the bottles may lead to the breakdown of the plastics, as well as leaching of the toxic compounds into the beverages.
Consumers are not aware about the health risks associated with the high bacteria levels found in the plastic bottles due to the reuse of the plastic bottles time and time again.
Plastic facts
It requires more than 20,000 bottles to get one ton of plastics. As per estimation, near about 100 million tons of plastic is produced annually.\[^6\]

Plastics are made with oil which is a non renewable source. Plastic is having insolubility of about 300 years thus it is a sustainable waste and also environment unfriendly. Hence reuse of plastic bottles can help in reducing its environmental impact. The use of plastic bottles for construction is not only for exterior walls, but it can also be used in ceiling of the building.

Characteristics of Bagasse:

1. It can resist heat up to 200 degrees.
2. It is a byproduct of sugar mill and is an essential fuel resource.
3. Bagasse products usually take 90 days to decompose.
4. It consists of hemi-cellulose sugars minerals and wax.
5. The value of bagasse mainly depends on its calorific value.
6. For every 100 tons of crushed sugar cane, nearly 30 tons of bagasse is produced in sugar factories.

Distilleries attached with sugarmills.

General Principles of ecobricks

Local transformation
Utilization of the locally available material that is otherwise considered as discarded should be used to make inert ecobricks. This material could be in any form whether plastics, polythene or soil.

Community collaboration
The focused collaboration of the community in order to attain sustainable development is the main motive of constructing ecobricks.

Benefits of bottle bricks
Waste management\[^5\]
Environmental protection
Cost effectiveness

Distilleries attached with sugarmills.
Investigating Strength and Properties of Ecoladrillo: Eco Bricks

Job opportunities
Shock resistant
Durability
Reduced carbon emission
Energy efficient

LITERATURE REVIEW

Shilpi et al. (2013) concluded that thermal comfort can be provided to the residents those who cannot afford heating and cooling appliances by constructing houses from eco bricks. This will help in providing shelter to the poor people in India. They also said that bottle bricks are nearly 20 times stronger than the baked bricks.

Mojtaba et al. (2013) said that plastic bottle bricks can help in preserving the environment as it will reduce the use of the cement and hence there will be a reduction in the CO\textsubscript{2} emissions due to decrease in the cement production. It is said that bottle houses are bioclimatic which means that they remain warm when it is cold outside and remains cool during hot summers. Consequently they help in the reduction of the use of coolers and blowers.

Rupali Goud et al. (2014) mentioned that the involvement of the local communities in the construction process will enhance their skills and knowledge of the work. When common people will be aware of this new technique they will be aware about the environment and the facilities they will attaining after adopting this sustainable construction. Number of the houses will be increased along with aesthetic look and environment will be preserved on the other hand.

Puttaraj et al. (2014) concluded that proper utilization of plastic soil bricks can help in the safe disposal of the plastics. If we use soil then we can also dispose of the excavated soil or the soil obtained after the quarrying process. Plastic is having an insolubility of around 300 years and hence can be utilized in construction industry which will help in reducing the land as well as water pollution caused due to the waste plastic. Hence the conventional material can be replaced by the plastic bricks.

Aditya Singh et al. (2014) mentioned that the construction cost of plastic bottle bricks is very cheap when compared to the construction with the baked bricks. They have shown a profit of Rs.5 in each brick. They also concluded that the weight of the bottle brick is very less than the baked brick.

Raut et al. (2015) mentioned that plastic bottles can be compared to various conventional building materials such as brick and concrete bocx in terms of load capacity, flexibility and, energy efficiency .they also explained the varieties of the plastic. They concluded that the bottle bricks have good construction ability and are cost efficient. They also mentioned its impact on the environment by reducing the CO\textsubscript{2} emissions by reducing the percentage of the cement used. They revealed their cost analysis which mentioned that the cost of 10 m\textsuperscript{2} brick masonry wall was Rs.7444.25 where as bottle wall was Rs.3879.25 Rs.

B Srinivasan et al. (2016) revealed that the plastic consumption is very high globally and recycling of the plastic is not helping in reducing the problem rather it is adding more pollution as the recycling process degrades the plastic and it requires further production thus leaving the recycled plastic as a waste. He also mentioned that about 70% of the plastic waste is lost over and thus causes disposal problem of the plastic waste.

Pratima et al. (2016) investigated that the plastic bottles are cheaper in comparison to bricks. Plastic bottles also provide greater strength than the bricks. Due to non biodegradable behavior of the plastic it takes thousands of years to biodegrade. This has lead to a drastic increase in the water and land pollution due the disposing problem of the plastic.
Nitin and Manisha et al. (2016) concluded that bottle brick houses are non brittle, bio climatic, re-useable, and easy to build and light in weight. They also mentioned that making of ecobricks will provide employment to the poor people without causing any harm to them.

Z Muyen et al. (2016) concluded that the bottle bricks are cheaper than the bake bricks. These bricks are having higher strength and low construction cost. They made the cubes made of soil filled plastic bottles and compressive strength of cube made with 9 bottles was obtained as 35 MPa on 28th day.

Job Bwire and Arithea Nakiwala et al. mentioned that baked bricks, concrete and tiles are the essential materials of a construction. Use of ecobricks can reduce the overall cost of the structure along with greater strength and durability of the structure. Plastic bottle house is an innovation which is helping in providing low cost housing and contributing towards environment management simultaneously.

Seltzer et al. concluded exposed that that the first bottle house was prepared by William F.Peck’s in Nevada (USA).it was constructed in the year 1902. The house was made with 10,000 beer bottles. It was the first house of its kind later on a number of houses was constructed with the help of bottle bricks.

MATERIALS AND METHODS

Preparation of plastic bottle bricks
Bagasse which was brought from the Morinda sugar mill was dried in the air.

Empty capped bottles of uniform size (500ml) were collected from the cafeteria in the college campus.
The bottles were washed with water and then dried in the air.
Dry bagasse was filled into the bottles and was compacted with the help of a thin iron rod.
After compaction the Bagasse in the bottle tightly the cap of the bottle was then closed tightly.
Compaction test by standing on the bottle brick was done.
As the bottle did not deform it was ready for further testing.

Production of ecobricks
Compressive strength test on cube filled with bottle bricks

1. Wooden cube (25.5×25.5×25.5) cm was prepared.
2. The wooden cube was painted black to make the surface smooth and dried it in the air.
3. A layer of diesel was applied in the mould so that the cube can easily detach from the surface after drying.
4. The cement mortar ratio for the cube was kept as 1:3 (OPC).
5. A layer of 2cm was laid on surface of the mould and 25 blows were given with the help of the tampering rod.
6. Three 500 ml bottles were laid on the surface of the mould.
7. Another layer of the mortar was placed on the bottles covering them completely.
8. 15 blows of tampering rods were given this time.
9. Another layer of three bottles was placed on the mortar layer.
10. In the same manner nine bottles were inserted in the mould the final layer of the mortar was finished properly to attain smoother surface.
11. The mould was left in open air to dry for 48 hours.
12. On the third day the cube was taken out from the mould and wa was kept in curing tank for 28 days.
13. On the 28th day the cube was taken out from the curing tank.
14. It was then dried in open air.
15. Then the cube was placed in the digital compression testing machine between both the plates and the results were recorded.
16. The load at which the cube breaks out was the maximum loading bearing capacity of that cube.

Water absorption test

- At initial stage the weight of the bottle brick was observed.
- Bottle brick was then submerged into the water tank for 24 hours.
- After 24 hours bottle brick was taken out from the water tank and was cleaned with dry cloth from the outer surface.
Water absorption test of the bottle bricks

Heat resistance test
1. The bottle brick filled with bagasse was placed in oven at a temperature of 130 degree Celsius.
2. The bottle was kept in there for 24 hours.
3. Bagasse was also added in a tray and was placed at the same temperature for 24 hours.
4. Next day the bottle and the Bagasse tray were taken out and the change in the properties was then observed.

Cost comparison of bottle bricks with baked bricks;
- Calculation of the cost of plastic brick was calculated.
- Cost of brick was compared with eco bricks.

RESULTS AND DISCUSSION
Compression testing was done on near about 6 bottles and finally the average of 5 bottles was taken. The results are:

Table 1 Experimental testing data

<table>
<thead>
<tr>
<th>Load (Kn/mm²)</th>
<th>Area (mm²)</th>
<th>Compressive strength (MPa)</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td>365</td>
<td>14202</td>
<td>25.7006</td>
<td></td>
</tr>
<tr>
<td>330</td>
<td>14202</td>
<td>23.2361</td>
<td></td>
</tr>
<tr>
<td>342</td>
<td>14202</td>
<td>24.0811</td>
<td>24.3862</td>
</tr>
<tr>
<td>350</td>
<td>14202</td>
<td>24.6444</td>
<td></td>
</tr>
<tr>
<td>345</td>
<td>14202</td>
<td>24.2923</td>
<td></td>
</tr>
<tr>
<td>346</td>
<td>14202</td>
<td>24.3627</td>
<td></td>
</tr>
</tbody>
</table>

Sample calculation for first reading

**Load =**365 Kn/mm²  
**Area=**14202 mm²  
**Compressive strength =**Load/Area.  
365/14202  
=0.00257006×1000  
=25.7006 N/mm²  
Hence average of the 5 bottles is 24.3862 MPa.

Compressive strength for cube of 9 bottles

<table>
<thead>
<tr>
<th>Curing period</th>
<th>Number of bottles</th>
<th>Compressive strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>28 days</td>
<td>9</td>
<td>48</td>
</tr>
</tbody>
</table>
Water absorption test
After the submersion of bottle brick in water tank readings were:

- Initial reading: 130 grams
- Final reading: 130.10 grams.

130-130.1 grams = 0.1 gram moisture.

Hence there was minute presence of moisture in the brick even after its submersion in water for 24 hours which is almost negligible.

Water absorption capacity comparison

<table>
<thead>
<tr>
<th>Material</th>
<th>Water absorption %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Conventional brick</td>
<td>0.07-0.10</td>
</tr>
<tr>
<td>Plastic bottle brick</td>
<td>20-25</td>
</tr>
</tbody>
</table>

Heat resistance test
After keeping the bottle brick in oven at 130 degree Celsius for 24 hours the bottle bricks was then taken out. Slight deformation of the bottle was observed.

Cost comparison
The overall cost of making a plastic brick was compared with conventional brick’s cost:
Let us consider the cost of waste PET bottles be Rs.8/Kg.
Weight of 500 ml water = 26 grams.
Number of the bottles in 1 Kg = (1000/26) =38 Rs.
Cost of each 500 ml water = 8/38 =0.21

Cost of Bagasse
Cost of 3m$^3$ bagasse = 300 Rs.
Cost of 1m$^3$ bagasse = 100 Rs.
Bulk density of bagasse is 200 Kg/m$^3$
Cost of one Kg Bagasse = 100/200 =0.5 Rs.

Total cost of bottle brick:
Average wt. of bottle with bagasse = 130 grams
So, wt. of Bagasse in one bottle = (130-30) =100 grams.
Cost of Bagasse used in one bottle=0.100×0.5 =0.05 Rs.
Labor cost = Say Rs. 350 per day.
Total 160 bottles can be filled by one laborer in one day:
Therefore cost of filling one bottle = 350/160 =Rs 2.2
Total cost of bottle brick = cost of empty bottle + Cost of bagasse + Cost of labor

\[ = (0.21+ 0.05 +2.2) \]

=Rs 2.46

**Calculation of Profit**

Cost of brick = Say Rs. 8

Cost of bottle brick = Rs.2.46

Profit = \[ (8 - 2.46) \]

Rs 5.54.

Hence there was a profit of Rs. 5.54 in each brick.

**CONCLUSION**

PET bottles which are usually considered as waste can be used as bottle bricks. These bricks are light in weight, easy to make and provide greater durability as well as strength properties. As the bottles are water resistant hence problem of dampness will be avoided. Bottle bricks provide cost efficiency. These bricks are 5.54 Rs. Cheaper in comparison to the conventional bricks. Unit weight of the bottle bricks is also less than conventional bricks. On the other hand the bottle bricks emits CO\(_2\) during its production therefore use of bottle bricks can help in the preservation of the environment. Utilization of PET bottle bricks is Bio-Climatic and hence is a green construction.

**REFERENCES**


