USE OF PET BOTTLE AND BLAST FURNACE SLAG AS CONSTRUCTION MATERIAL

Siddhant Gupta[1], Vedant Pardhe[2], Aniket Ikhar[3], Aditya Aaglawe[4], Rashmi Manmode[5], Shilpa Bankar[6]

[1] *Siddhant Gupta Student, Department of Civil Engineering,Priyadarshini J. L. College of Engineering, Nagpur,Maharashtra, India*
[2] *Vedant Pardhe Student, Department of Civil Engineering,Priyadarshini J. L. College of Engineering, Nagpur,Maharashtra, India*
[3] *Aniket Ikhar Student, Department of Civil Engineering,Priyadarshini J. L. College of Engineering, Nagpur,Maharashtra, India*
[4] *Aditya Aaglawe Student, Department of Civil Engineering,Priyadarshini J. L. College of Engineering, Nagpur,Maharashtra, India*
[5] *Rashmi Manmode Student, Department of Civil Engineering,Priyadarshini J. L. College of Engineering, Nagpur,Maharashtra, India*
[6] *Shilpa Bankar Student, Department of Civil Engineering,Priyadarshini J. L. College of Engineering, Nagpur,Maharashtra, India*

ABSTRACT

Our project proposes the use of waste plastic PET bottles as construction entity to standardised bricks. As plastics are non biodegradable its disposal has always been a problem. Waste plastic bottles are major cause of solid waste disposal. Polyethylene tetra phthalate is commonly used for carbonated beverage and water bottles. This is an environmental issue as waste plastic bottles are difficult to biodegrade and involves processes either to recycle or reuse. Today the construction industry is in need of finding cost effective materials for increasing the strength of structures. This project deals with the possibility of using waste PET bottles as a partial replacement. So, to decrease the cost of building materials here is a plan to build a house with PET bottle and binding material blast furnace slag .Bottle wall construction also avoids emission of gases like CO, CO2, SO2, NO, HCN as happened in manufacturing of bricks.

In our project, we have constructed structure using bottle wall of quantity (1.26x0.9x1.5) is 1.7cub.m.Cost and strength comparison is done for traditional brick structure and PET bottle structure, it is found that cost is comparatively less and strength is comparatively more than traditional wall. Also study of Embodied energy is done.

Keyword: *Waste Bottles; Blast furnace slag; Embodied energy; cost comparison*

1. INTRODUCTUION

Utilization of waste material as secondary material is being developed world wide. One of these waste materials is plastic bottles which are being produced in large amount. In food industries, plastic bottle is mostly made by Polyethylene Tetra phthalate (PET), and PET become very popular during the last decade because it is known as safe, durable and good material for packaging.

Bottle construction is a plan to build a house with plastic bottle and the binding material. It is a type of sustainable development which maintain the environment as well as include binding material and also ensures the safety to life and property. This type of construction decreases the cost of binding material and help in making the bottle, a renewable material. Bottle construction is also beneficial for business in small area as people are attracted

towards the aesthetic view of the place. Recycling is only feasible in limited circumstances because only PET bottles can be recycled all other bottles are discarded and only 1 out of 5 bottles are sent to the recycle bin. So there is a need for environment friendly constructive use of waste plastic bottles.

Embodied energy is the sum of all the energy required to produce any goods or services, considered as if that energy was incorporated or 'embodied' in the product itself. The concept can be useful in determining the effectiveness of energy-producing or energy-saving devices, or the "real" replacement cost of a building, and, because energy-inputs usually entail greenhouse gas emissions, in deciding whether a product contributes to or mitigates global warming. One fundamental purpose for measuring this quantity is to compare the amount of energy produced or saved by the product in question to the amount of energy consumed in producing it. Embodied energy is an accounting method which aims to find the sum total of the energy necessary for an entire product life-cycle. Determining what constitutes this life-cycle includes assessing the relevance and extent of energy into raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition as well as human and secondary resources.

1.1 Design and Technology

The bottle walls can be constructed in many different ways, they are typically made on a foundation and rebar can be set to add stability to the structure. Some side support is needed for constructing the bottle wall as bottles are not firm but slippery while construction. Bottle walls range one bottle to two bottles thick. Primitive mixture, such as cement mortar, concrete or clay can be used as mortar to bind the bottles. It is thickly spread on the previous layer of bottles followed by the next layer which is pressed into it. Coping of mortar or PCC can be provided at some intervals for level load distribution. A chicken mesh can be provided on both or either dies of wall for holding the bottles along with mortar in transverse direction which will provide extra support to the bottle wall. Plastering can be or cannot be done on either side of wall for an aesthetical purpose. Two bottles can be cut and taped together to create a window-type effect. This taped bottles act as an opening allowing a light passageway. This also traps air and creates a small amount of insulation. Window frames and doorways can be accommodated in the construction, and windows and doors can be constructed in these spaces, just like in normal construction.

Any kind of spacing between the bottles can be obtained. Filling glass with liquid that will be subjected to freezing and thawing is not a good idea but is useful if the glass is protected from temperature. Another technique is the plastic bottles are filled and tightly packed with the sieved sand. Once filled, the bottle becomes a “brick” that can be used as a basis to build a solid structure. A wall made “bottle bricks” is up to 20-times stronger than a wall constructed of concrete blocks. Horizontal Bottle Wall Construction: Once the frame for the building is constructed, the bottles are laid horizontally by using mortar in between and for the finish. Curing is necessary for the wall if cement mortar is used. In case of natural soil used as a binding material between bottles, no need of curing but wall must be protected from natural impact of rain water.

2. PET BOTTLE WALL

Plastic is a product that was invented in early 20th century and now disposal of plastic is great significance. They have taken over from other materials as the material of choice in many sectors of industry and life. In contrast to other materials, the volume of plastics in Municipal Solid Waste (MSW) has increased phenomenally in recent years as more and more products are getting packed. It remains in earth for 4500 years without degradation. But the plastic has many good characteristics which include versatility, lightness and hardness also resistant to chemical, water and impact. It also has a hidden source of potential energy and alternative raw material, recycling of plastic waste net environmental and economic benefits. To have the balanced consideration for net environmental gain and economic sense must proceed for three types of consideration such as Reduce, Reuse and Recycle. Laterite soil is described from a Latin word “later” which means brick. It is originated from Southern part of India in 1807 and it was described by Francis Buchanan-Hamilton.

Plastics are produced from the oil that is considered as non-renewable resource. Because plastic has the insolubility. About 300 years in the nature, it is considered as a sustainable waste and environmental pollutant so reusing or recycling of it can be effectual in mitigation of environmental impacts relating to it. It has been proven that the use of plastic bottles as innovative materials for building can be a proper solution for replacement of conventional materials. The use of this material has been considered not only for exterior walls but also for the ceiling of the building. The objective to investigate the using of plastic bottles as municipal wastes in the buildings, the key and positive characteristics of this product and the benefits obtained by using it in building. It also intends to

compare the characteristics of some construction materials such as brick, ceramic and concrete block with bottle panel.

Bottle construction is a plan to build a house with plastic bottle and the binding material. It is a type of sustainable development which maintain the environment as well as include binding material and also ensures the safety to life and property. This type of construction decreases the cost of binding material and help in making the bottle, a renewable material. Bottle construction is also beneficial for business in small area as people are attracted towards the aesthetic view of the place.

There is a reciprocal relationship between climate and man in both indoor and outdoor areas. One of the significant objectives of designing buildings is to ensure the thermal comfort to occupants. This is because most people generally spend 85-90% of their time indoors and thus providing a comfortable and healthy environment is imperative.

Plastic bottles are used to store different substances for consumption and for other uses. Bottles used to package water takes over 1,000 years to bio-degrade and if incinerated, they produce toxic fumes. Recycling is only feasible in limited circumstances because only PET bottles can be recycled all other bottles are discarded and only 1 out of 5 bottles are sent to the recycle bin. So, there is a need for environment friendly constructive use of waste plastic bottles.

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

Table-1 The Physical Properties of Poly Ethylene Tetra phthalate

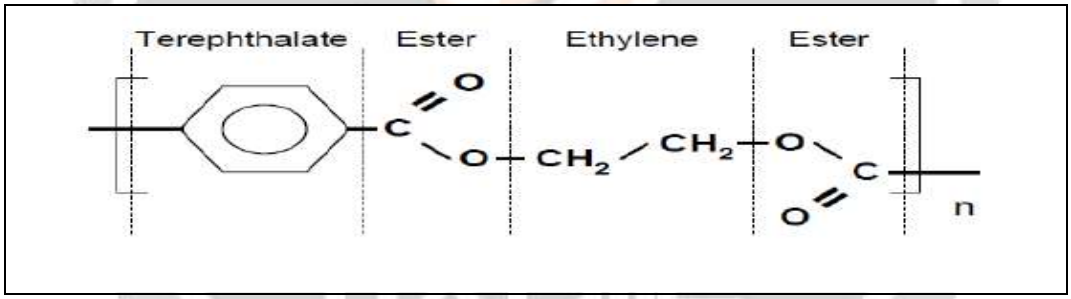

Table-2 Chemical Properties of PET Monomer

2.1 History of PET Bottle

The polymers were polystyrene (PS), first produced by BASF (Baden Aniline and Soda Factory) in the 1930s, and polyvinyl chloride (PVC), first created in 1872 but commercially produced in the late 1920s. In 1923, Durite Plastics Inc. was the first manufacturer of phenol-furfural resins. In 1933, polyethylene was discovered by Imperial Chemical Industries (ICI) researchers Reginald Gibson and Eric Fawcett. In 1954, polypropylene was discovered by Giulio Natta and began to be manufactured in 1957.In 1954, expanded polystyrene (used for building insulation, packaging, and cups) was invented by Dow Chemical. Polyethylene terephthalate (PET)'s discovery is credited to employees of the Calico Printers' Association in the UK in 1941; it was licensed to DuPont for the USA and ICI otherwise, and as one of the few plastics appropriate as a replacement for glass in many circumstances, resulting in widespread use for bottles in Europe.

They quickly became popular with both manufacturers and customers due to their lightweight nature and relatively low production and transportation costs compared with glass bottles. However, the biggest advantage plastic bottles have over glass is their superior resistance to breakage, in both production and transportation.

Andreas Foresewas the first to construct plastic bottle house in village of Yelwa of Nigeria. He used this bottle as brick and made the bonding with help of strings and plastered it. Mojtaba et al.concluded that there is huge effect on saving energy and reduce CO2 emission by using small percentage of cement.

2.2 Plastic Bottle Preparation

The used plastic empty bottles get collect in the garbage, the bottle size was same in 600ml or 1000ml. The sand is filled up in the bottle with compaction, the compaction can be done in three layers the tamping of sand in bottle done by the rod. With the proper compaction the rice husk ash can also be added in the bottle in the ratio of 3:1, (3 part of sand and 1 part of rice husk ash) rice husk ash decreases the voids in the sand. After compaction the bottles get close with bottle cap tightly.

3. Blast furnace slag

The main components of blast furnace slag are CaO (30-50%), SiO2 (28-38%), Al2O3 (8-24%), and MgO (1-18%). In general increasing the CaO content of the slag results in raised slag basicity and an increase in compressive strength. The MgO and Al2O3 content show the same trend up to respectively 10-12% and 14%, beyond which no further improvement can be obtained. Several compositional ratios or so-called hydraulic indices have been used to correlate slag composition with hydraulic activity; the latter being mostly expressed as the binder compressive strength.

3.1 Mixing of BFS in Cement Mortar

Blast furnace slag is mixed in mortar as a replacement of fine aggregate this replacement was up to 30%. In which we got comparatively more strength than that of 100% sand content. This mixing made our project economically strong as it was available for free. This also helped in waste management and saving mother earth.

4. Embodied Energy

Embodied energy is the sum of all the energy required to produce any goods or services, considered as if that energy was incorporated or 'embodied' in the product itself. The concept can be useful in determining the effectiveness of energy-producing or energy-saving devices, or the "real" replacement cost of a building, and, because energy-inputs usually entail greenhouse gas emissions, in deciding whether a product contributes to or mitigates global warming. One fundamental purpose for measuring this quantity is to compare the amount of energy produced or saved by the product in question to the amount of energy consumed in producing it.

Embodied energy is an accounting method which aims to find the sum total of the energy necessary for an entire product life-cycle. Determining what constitutes this life-cycle includes assessing the relevance and extent of energy into raw material extraction, transport, manufacture, assembly, installation, disassembly, deconstruction and/or decomposition as well as human and secondary resources.

5. Necessity of Waste Bottles in Wall Construction

Now a day plastic bottles waste increasing rapidly and, in our society, no any efficient techniques available to dispose it. So, if we make use of plastic bottles as a civil engineering construction material then we have solution to dispose plastic bottles and we can conserve natural resources.

- Resource conservation: To integrate environmental considerations into planning and development to respect the natural environment.
- Environmentalquality: To prevent or reduce processes which can lead to environment degradation and develop the culture of reusing and recycling process.

Sr no.	Parameters	Use of Bottle	Use traditional Bricks
1	Material & Equipment Cost	Saving in cement, Water	More Quantity depend on weight
2	Transportation Cost	Light and easy weight so less cost (No such manufacturing plant is	High Transportation Cost applied from manufacturing plant to site

		necessary)	
3	Strength	20 times more than bricks	Low strength Causing various factors
4	Wastage	No wastage (Filling Bottles destroys the waste)	High wastage and unusable

Table -2: Comparison between bottle and brick

6. Advantages of Bottle Wall

- Homes made construction from recycled plastic bottles are bullet-proof.
- PET bottle wall is commonly used as partition walls inside the small houses.
- Aesthetic view: Bottle houses are often more convenient to build in a circular fashion. The circular shape adds strength to the walls, while providing a very artistic and pleasing appearance.
- Waste Management: To build a small house one can use as many as 10,000 used bottles which are readily available. Waste that would otherwise be deposited in a landfill can now help solve other social problems of housing, schools and clinics. If the communities want to get rid of other plastic waste the bottles can be filled prior to construction.
- Provide Structures: Since in many parts of the world homeless people are considered outside normal society, it give structure and area for living to the needy one.
- Durability: The plastic bottles are known for their durability and can last as long as 300years.
- Cost effective: The use of recycle material make it more affordable than conventional building methods and will increase the accessibility to suitable housing. It is a well-insulated and cheaper solution. It also cut the cost of transportation of building material. For a region where money tends to be scarce, the houses are estimated to cost 1/3 of a house made of concrete and bricks.
- Employment: Bottles are collected and filled with sand. The unemployed and handicapped are trained in their construction methods.

7. Cost Comparison according to market survey.

Particular	Traditional brick	PET bottle Filled with Compacted soil
Cost	Up to 6 rupees	Up to 2.5 rupees (Practically observed)

- **For 1.701 cubic meter wall cost estimate was found to be-**

Sr. no	Type	Total amount	Remark
1	Traditional brick wall	Rs.7614/-	Generally, construction cost of traditional brick wall is comparatively more than PET bottle wall (with soil filling).
2	PET bottle wall (with sand filling)	Rs.6632/-	
3	PET bottle wall (with soil filling)	Rs.6524/-	

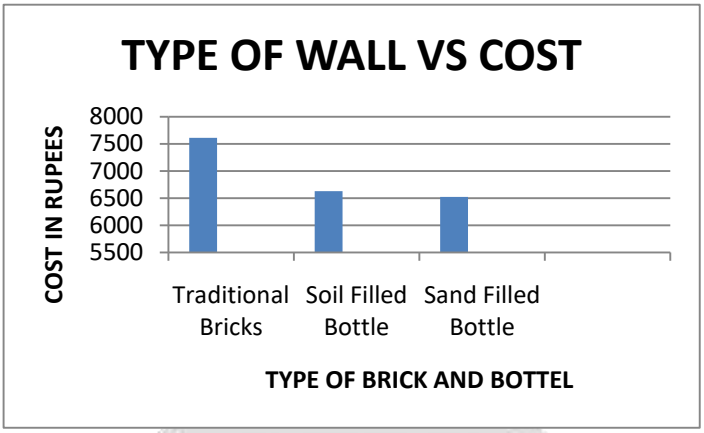

Chart -1:Type of wall Vs Cost (Practiced for 1.701 cubic meter volume)

8. CONCLUSIONS

1. It is concluded that, bottle wall using larger bottle wall (1 liter) are useful for stability of wall.
2. Construction cost of PET bottle wall (with soil filling) is found to be comparatively less than traditional brick wall. (Nearly by 15%)
3. Costing of Bottle wall proportionately reduces according with size of the wall.
4. Temp difference outside and inside of the pet bottle wall structure is found to be nearly 2 degree centigrade.
5. Such type of PET bottle wall (Single or Double wall) can be practically used as a partition wall.
6. Bottle wall construction also avoids emission of gases like CO, CO2, SO2, NO, HCN as happened in manufacturing of bricks.

9. REFERENCES

[1]. "PET Bottles as Sustainable Building Material: A Step Towards Green Building Construction", Aditya Singh Rawat, R. Kansal, August, 2014
[2]. "Experimental Investigation on Plastic-Soil Bricks", G.Miruthula1, L.Kokila, G.Bala Murugan, October, 2016
[3]. "Sustainable Construction of Bottle Wall and Binding Material", Saariya Fatima, April 2017
[4]. "Reuse of Plastic Bottles as a Construction Material", D.K.Khopade February, 2017
[5]. "Application of Plastic Bottle As A Wall Structure For Green House", Mardiha Mokhtar, Suhail Sahat, Law Chia Wen, March 2015.
[6]. "Investigating the Use of PET Bottles as a Sustainable Material in Construction", Suyog U. Dhote, April 2016
[7]. Reference book "Estimating and coasting in civil engineering by B. N. Dutta".
[8]. Reference book "Concrete Technology by M. S. Shetty ".
[9]. IS 2212 (1991) code of practice for Brick Work
[10]. IS 1542(1992) sand for plaster.