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# Reuse of Plastic Bottles as a Construction Material

**Atul Chaurasia, Mr. Sumit Gangwar**

*Abstract*—**Disposal of non-bio-degradable substance has become an issue of major concern now days. Mounds of plastic garbage have been created on earth surface. Laterite quarry waste is abundantly available and disposal of waste plastics (PETE, PP, etc.) is the biggest challenge. Only one in six plastic bottles are properly recycled .On other hand high cost of primary requirement for constructing the houses in places on where people are under poverty line is forming one of most significant problems of people.**

**A suitable approach for this situation is using some part of urban rubbish or waste as required materials for building construction. Plastic bottle is considered as urban junk .but with sustainability characteristic it can be used as construction material instead of some conventional material such as brick in building construction. The work intends to investigate the application of plastic bottles which is one of the urban waste in building construction and that how it can lead to sustainable development .It also mentions some ways for self-standing and insulating them in thermal and sound point of view and some positive points which this material have versus others.**

***Index Terms*—Plastic Bottle, Sustainable Material, Construction material, Innovative wall**

## I. INTRODUCTION

Nowadays, human apply all of its potentiality to consume more. The result of this high consumption is nothing unless reducing the initial resources and increasing the landfill. In recent times, human from the one hand is always seeking broader sources with lower price and from the other hand is following the way to get the rid of the wastes. The waste today can be produced wherever humans footprints be existed, and remind him that they have not chosen the appropriate method for exploitation of the nature At the present time, the possibility of utilizing the renewable resources such as solar, wind, geothermal has been provided for us more than before, and development of this science is making progress. But those energies can be chosen as one of the renewable and alternative energies instead of fossil fuels which are cheap as possible and have fewer environmental impacts. Since no attention to economic issues lead to that the use of these energies be just for groups dedicated to specific segments of society.

Whilst many renewable energy projects are large-scale, renewable technologies are also suited to rural and remote areas, where energy is often crucial in human development. With population growth in today's world, the need to the building has increased and to respond to this demand, the countries tend to use the industrial building materials and decline the use of indigenous and traditional materials.

These factors in spite of increasing the energy consumption in the industry section; they can also raise the cost of house and are considered as the barrier for users to obtain the basic needs of the life. The problem of users is losing the power and ability of design and building their own homes by themselves. Two factors that prevent aboriginal people from building their homes are high cost building materials and labor and also maybe long transportation. One of the solutions for this problem can be Solve In following Manner.

- Use of affordable recycled materials in buildings
- Using the method of regenerating through proper education to people

In the past, the glass was common in packing some foods such as milk and etc. They could be returned to the factory for using again for the same purpose. But now by changing the human's disposal culture, glass bottles have been replaced by plastic bottles, as they have increasingly become one of the substances of destruction of the landfills because they decompose in a long time. Two alternative solutions against the plastic bottle disposal are recycling and reusing process. Recycling needs additional energy to treat the materials for producing something usable. Moreover, the recycling process produces wastewater and air pollutants. So the best solution is reusing for which no additional energy is required and does not contribute to pollution. Indeed, when we reuse junk, we are helping to save the obtained energy which would otherwise be wasted. It is focused on not only the financial aspect but also the environmental aspect.

Plastics are produced from the oil that is considered as nonrenewable 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. This work is 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.

Plastic have many good characteristics which include versatility, light-ness, hardness, and resistant to chemicals, water and impact. Plastic is one of the most disposable materials in the modern world. It makes up much of the street side litter in urban and rural areas. It is rapidly filling up landfills as choking water bodies. Plastic bottles make up approximately 11% of the content landfills, causing serious environmental consequences. Due to the consequences some of the plastic facts are as follow:

- More than 20,000 plastic bottles are needed to obtain one ton of plastic.
- It is estimated that 100 million tons of plastic are produced each year.

**Atul Chaurasia**, M.Tech Scholar, Department of Civil Engineering, Faculty of Engineering & Technology, Rama University, Kanpur, India.

**Sumit Gangwar**, Assistant Professor, Department of Civil Engineering, Faculty of Engineering & Technology, Rama University, Kanpur, India.

- The average European throws away 36 kg. of plastics each year.
- Some plastic waste sacks are made from 64% recycled plastic.
- Plastics packaging totals 42% of total consumption and every year little of this is recycled.

According to ENSO Bottles, in the 1960's plastic bottle production has been negligible but over the years there was an alarming increase in bottles produced and sold but the rate of recycling is still very.

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 of this work is to investigate 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. One can use solar bomb (bottle filled with bleaching powder solution) will be fitted on the roof for light source.

## II. Literature Review

PETE bottles, plastic rope, soil, Portland cement, and water are the main material componentstoproducethePETEbottlesmasonry.Unfortunatel ythereisnoresearchthathas ever been undertaken to determine structural behavior of PETE bottles as masonry and that could have been an appropriate source of reference for a literature review in guiding thisresearch. Thefewattemptsthathavebeenperformedinbuildingstructurew ithPETE bottlesweremadebymeansof`trialanderroraccordingtoFroese( Personalcommunication, 2008).

Consequently,Ioptedforaliteraturereviewdealingwithearthma terialsnotablyrammed earth and stabilized compressed earth blocks to gather data on the materials used to pro- duce earthen masonries such as soil types and properties, cement, and mechanical properties of earthen masonries. Furthermore, the literature review armed the research with a shorthistoryonbottlespracticeinconstructiontounderstandther easonwhypeopleused it in building their homes.

**Figure 1:** William F. Peck's Bottle House. Source: Seltzer (2000)

**Figure2:**InteriorofonebuildingofGrandmaPrisbrey'sBottleV illage Source: Krepcio(2007)

Mojtaba et al. [1] Concluded that reusing the plastic bottles as the building materials can have substantial effects on saving the building embodied energy by using them instead of bricks in walls and reducing the CO2 emission in manufacturing the cement by reducing the percentage of cement used. It is counted as one of the foundation's green project and has caught the attention of the architecture and construction industry. Generally the bottle houses are bioclimatic in design, which means that when it is cold outside is warm inside and when it is warm it is cold inside. Constructing a house by plastic bottles used for the walls, joist ceiling and concrete column offers us 45% diminution in the final cost. Separation of various components of cost shows that the use of local manpower in making bottle panels can lead to cost reduction up to 75% compared to building the walls using the brick and concrete block.

Shilpi et al. [2] concluded that by utilizing PET bottles in construction recycled materials, thermal comfort can be achieved in very low cost housing, benefit in residents for those who cannot afford to buy and operate heating and cooling systems. Plastic is non-biodegradable, toxic, highly resistant to heat and electricity (best insulator) and not recyclable in true sense, plastic PET bottles use in bottle brick technique. This gives relief for the poor people of India to provide cheap and best houses for living [3-5].

Puttaraj et al. [6] examined that efficient usage of waste plastic in plastic-soil bricks has resulted in effective usage of plastic waste and thereby can solve the problem of safe disposal of plastics, also avoids its widespread littering and the utilization of quarry waste has reduced to some extent the problem of its disposal. 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 [4].

Pratima et al. [7] studied that plastic bottles wall have been less costly as compare to bricks and also they provide greater strength than bricks. The PET bottles that are not recycled end up in landfills or as litter, and they take approximately 1000 years to biodegrade. This has resulted in plastic pollution problems in landfills, water ways and on the roadside, and this problem continues to grow along with the plastic bottle industry.

Arulmalar et al. [8] studied that the initial perception on the use of PET bottles in construction is changing day by day. A paradigm which emerged as PET bottle bricks in the construction of load bearing walls with steel trusses and prefabricated metal sheet is at present witnessing flat roofs with nylon 6 replacing steel reinforcement and intuitive vault construction [6]. Even though research on the effective use PET in developing new material as an option, solutions exploring the application of PET bottles as structural members, foundation, retaining walls and secondary elements like street furniture, road dividers, pavements and other landscape elements is to be looked in to. The Governing bodies shall formulate policies to propagate this eco centric approach via appropriate practices, research investigations on the properties of the materials and construction techniques.

VikramPakrashi et al. [9] examined Eco-brick is a viable resource for construction purposes with a number of possible applications. The bricks are relatively easily manufactured with controlled weight and packing. Eco bricks have relatively good compressive strength, with values matching that of basic concrete cubes. The weight of Eco-brick was observed to hold a nearly relationship with load at failure and with specific strength. Eco-bricks have a relatively good specific strength. They are lightweight but strong for the weight they bear.

Andreas Froese et al. [10] concluded that when the bottles are filled with soil or sand they work as bricks and form a framework for walls or pillars. Different types of walls varying in size and orientation of the bottles are built. The compression strength and fracture behavior of each wall are measured and compared. PET bottle walls can bear up to 4.3 N/mm² when the bottles are filled with sand which is the weakest filling material. The bottles bear one third of the load while the plaster bears two thirds. Plaster made of clay or a cement mixture fills the space between all bottles while a roof made of wood or corrugated metal completes the house. As only regional products are used the houses are cheap and can be afforded even by poor families. Additionally the method has so far proven to be earthquake resistant and allows short construction periods.

YahayaAhmade et al. [11] said that the structure has the added advantage of being fire proof, bullet proof and earthquake resistant, with the interior maintaining a constant temperature of 18 degrees C (64 degrees F) which is good for tropical climate.

Seltzer et al. [12] revealed that the first example of known structures built with bottles is the William F. Peck's Bottle House located in Nevada (USA). It was built around 1902, and it required 10,000 beer bottles to be built. These buildings were primarily made out of glass bottles used as masonry units and they were bound using mortar made out of adobe, sand, cement, clay and plaster.

Job Bwire&AritheaNakiwala et al. [13] suggested that, baked bricks, tiles, concrete and rocks, among other construction materials, have been essentials in construction. But did you know that a house constructed using plastic bottles can save you more and be just as strong as or even stronger than brick homes? Water bottle housing is an innovation aimed at providing low cost housing, while contributing to environment management [14-18].

## III. Problems in Recycling of Plastics

Plastics can be degraded very slowly. Photo degradation can breakdown plastic resin, but this process can take decades. Even longer, biodegradation of plastics takes centuries. The largest problem in recycling plastics is separating the plastics by type and number. In the current recycling system, the plastics must be separated by type. During the reprocessing of plastic containers, if the plastic is not of a uniform type, the raw plastic resin is unusable in the manufacturing industry.

Once the problem of sorting the resins has been overcome, the recycling loop is still not closed. Reprocessed plastic resin faces a weak market. Simply collecting plastic for recycling does not mean that there will be a manufacturer willing to pay for the raw material. Recycled plastic resin has limited value as a manufacturing resource because its quality degrades every time it is reheated during the recycling process. Consequently, most plastic is only reprocessed once before it goes to a landfill. "Down cycling" is a more accurate term than "recycling" when it comes to plastic. Unlike glass or paper, plastic recycling does not "close the loop" because most post-consumer bottles are not made into new plastic bottles. Instead, milk jugs, soda containers and other bottles are turned into lower-grade products such as jacket fill, fleece, carpet, toys or plastic lumber.

## IV. Advantages of using plastics in concrete

The growth in the use of plastic is due to its beneficial properties, which include:

- Extreme versatility and ability to be tailored to meet specific technical needs.
- Lighter weight than competing materials reducing fuel consumption during transportation.
- Durability and longevity.
- Resistance to chemicals, water and impact.
- Excellent thermal and electrical insulation properties.
- Comparatively lesser production cost.
- Unique ability to combine with other materials like aluminum foil, paper, adhesives.
- Far superior aesthetic appeal.
- Material of choice – human life style and plastic are inseparable.
- Intelligent features, smart materials and smart systems.
- Reduction of municipal solid wastes being land filled and
- An alternative to pressure-treated lumber that leaches toxic chemicals into water.

## V. Basic Construction Materials and Properties

This construction require some of the basic materials which ensures a stable, eco-friendly structure and also results in cheap construction as compared to brick wall. Materials uses for Bottle wall masonry construction are:

- Soil
- Plastic Bottle
- Cement
- Nylon rope
- Water

**(a) Soil**

Soil is the basic element in any construction project so before using it in our project we have to study the basic properties of the soil and go through different tests, so as to check whether the soil sample selected is suitable for the given project.

**Properties of soil**

- **Soil Texture:**

Soil texture can have a profound effect on many other properties and is considered among the most important physical properties. Texture is the proportion of three mineral particles, sand, silt and clay, in a soil. These particles are distinguished by size, and make up the fine mineral fraction.

- **Soil Colloids:**

Soil colloids refer to the finest clay in a soil. Colloids are an important soil fraction due to properties that make them the location of most physical and chemical activity in the soil. One such property is their large surface area. Smaller particles have more surface area for a given volume or mass of particles than larger particles. Thus, there is increased contact with other colloids and with the soil solution. This results in the formation of strong friction and cohesive bonds between colloid particles and soil water, and is why a clay soil holds together better than a sandy soil when wet.

- **Soil Structure:**

Soil structure is the arrangement and binding together of soil particles into larger clusters, called aggregates or pads. Aggregation is important for increasing stability against erosion, for maintaining porosity and soil water movement, and for improving fertility and carbon sequestration in the soil. Granular structure consists of loosely packed spherical pads that are glued together mostly by organic substances.

**(b) Plastic Bottle**

Plastic bottles are used as a fundamental element, so we have gone through every property of the PETE bottles so as to ensure a stable structure.

**Properties of PETE bottle:**

Polyethylene Terephthalate Ethylene (PETE) bottles is thermoplastic materials. This type of plastic are polymers and with or without cross linking and branching, and they soften on the application of heat, with or without pressure and require cooling to be set to a shape. Following are properties of plastic bottle:

1. Wax like in appearance, translucent, odorless and one of the lightest plastics.
2. Flexible over a wide temperature.
3. Heat resistance.
4. Chemically stable.
5. Do not absorb moisture.
6. Transparent.

**(c) Cement**

Cement is the important binding material. In these paper it is use to bind the plastic bottles to make the masonry wall more durable so that the quality of cement is check by following properties.

**Properties of cement:**

- **Fineness:**

Fineness or particle size of Portland cement affects Hydration rate and thus the rate of strength gain. The smaller particle size, greater the surface area-to volume ratio so that the more area available for water cement interaction per unit volume, the effects of greater fineness on strength are generally seen during the first seven days.

- **Soundness:**

Soundness is defined as the volume stability of the cement paste. Cement paste strength is typically defined in three ways: compressive, tensile and flexural. These strengths can be affected by a number of items including: water cement ratio, cement-fine aggregate ratio, type and grading of fine aggregate, curing conditions, size and shape of specimen, loading conditions and age.

- **Setting Time:**

The initial setting time is defined as the length of time between the penetration of the paste and the time when the needle penetrates 25mm into the cement paste.

**(d) Nylon Rope**

Nylon rope has a very high tensile strength so that it is use as the main binder for PETE bottles masonry.

**Properties of Nylon rope:**

Nylon rope is gotten from coal, Petroleum, air and water. It is a polyamide thermoplastic produced by series on condensation reaction between an amine and organic acids. the properties of nylon as follow:

1. Good abrasion resistance.
2. Tough and strong but flexible too.
3. High impact strength.
4. Absorb water which causes reduction in strength and impact properties.
5. Resistant to most of the solvents and chemicals
6. High softening temperatures and thus molding becomes difficult.

**(e) Water**

Water is in a similar way like cement, an active component in mortar. For cement-sand mortar, without water no hydration can be attained, hence no strength can be achieved. Water is responsible for the workability of a fresh mortar. 20% of the overall weight of the cement and soil was used to determine the quantity of water to be used in the mix. A slump test and a flow test were conducted to evaluate the consistency of the fresh mortar.

## VI. Work Study

We were decided to make a toilet and hanging garden by using plastic bottles.We have to be draft a plant with respect to cost, time, material, labors, execution of work etc. Whole work is divided in two main parts one is toilet construction and other is hanging garden.We decided time for whole work is about five days, two days, for material collection two day for masonry work and last one day is for finishing work.

**Table 1:** Design of toilet and hanging garden as follows

| Sr No. | Type of Structure | Particulars | Dimensions |
|---|---|---|---|
| 1. | Toilet | Shape<br>Inner diameter<br>Outer diameter<br>Height<br>Thickness of wall | Circular<br>1m<br>1.27m<br>1.45m<br>0.27m |
| 2. | Hanging Garden | Wall size<br>Number of walls | 4x4 sq.m<br>2 |

**Estimation and Delegation of Work**

- **Estimation**

Measurement of total quantities of items of works

**1. Bottle Calculation**

Toilet internal diameter = 1m
Outer diameter = 1.27m
Height of toilet = 1.45m
Volume= $\frac{\pi}{4}$ x ($D^2$- $d^2$ ) x (H)
= $\frac{\pi}{4}$ x ($1.27^2$- $1^2$ ) x (1.45)
= 0.6979 cum
Bottle volume with mortar thickness
Diameter of bottle = 0.07m
Length = 0.27m

Volume of bottle = $\frac{\pi}{4}$ x $D^2$ x L
= $\frac{\pi}{4}$ x ($0.07^2$ x 0.27
= 0.001093 cum
Deduction for Door
Volume = h x l x t
= 1.3 x 0.6 x 0.07
= 0.0546 cum
Deduction for Window
Volume = $h_1$ x $l_1$ x t
= 0.20 x 0.30 x 0.07
= 0.0042 cum
Total = 0.0588 cum
Final volume = 0.6979 – 0.0588
=0.6391 cum
**No of bottle= final volume / volume of bottle**
= 0.6391/0.001039
= 615 bottles
Bottles for panel of roof
Panel volume = 1 x 0.73 x 0.07
= 0.0511 cum
No. of bottles = 0.0511/0.001039
= 50 bottles for each panel
= 3 x3 50
= 150 bottles
For hanging garden approximately 50 bottles required
Total bottles required is
= 615+150+50
=815 bottles

**2. Soil Calculation**

Soil = volume of bottle x no. of bottles filled by soil
= 1 x 615
=615Kg

**3. No. of Steel Bars**

6mm ø – 4mm required of 1.5 m length

**4. Other Materials**

500m long metal rope
40 bricks for piers
40 card sheets
Crops seeds

- **Costing**

**1. Bottles**
= no. of bottles x rate per bottle
=815 x 0.50
= Rs. 407.50
**2. Rods**
=no. of rods x rate per rod
= 4 x 60
= Rs.240
**3. Bricks**
=no. of bricks x rate per brick
=40 x 6
= Rs. 240
**4. Other Materials**
Soil is taken from local hilly area without any cost. Card sheets taken from college waste paper submission, Seeds are purchase at Rs. 40.
**5. Transportation and T&P**
For collection of raw material Rs.200 required. For tools and plants Rs. 150 required
**6. Labors**
We have to work self physically, but minimum 4 labors required per day.
Total cost of construction = 407.50+240+240+40+200+150
= Rs. 1280

**Total Cost=Rs.1280**

## VII. Testing

This section evaluates the testing of the proposed method.

- **Compressive Test**

Compressive test of plastic bottle filled with soil is conducted on CTM machine. Compressive strength of plastic bottle is 45 $N/mm^2$

- **Water Absorption Test**

Water absorption test of plastic bottle is zero.

- **Weight Measuring Test**

Weight of plastic bottle when filled with soil is equal to 1.5 Kg.

- **Volume of Bottle**

Volume of plastic bottle is equal to 1 liter

## VIII. Necessities of Reuse of Plastic Waste Bottles

Now a day plastic bottles waste increase rapidly and in our society no any efficient techniques available to dispose it.

- So if we make use of plastic bottles as construction material then we have solution to dispose plastic bottles and we can conserve natural resources.
- Resource conservation: To conserve the nonrenewable resources such as fuel mineral and etc. to ensure sufficient supply for present and future generations.
- Built development: to integrate environmental considerations into planning and development to respect the natural environment.
- Environmental Quality: To prevent or reduce processes such as land filling which can lead to environment degradation and develop the culture of reusing and recycling process.
- Social Equity: To impede development that increases the gap between the rich and the poor and to encourage for reach to the social equality.

## IX. Conclusion

- Use of innovative materials with sustainable application such as plastic bottles can have considerable benefits including finding the best optimization in energy consumption of the region, reducing environmental degradation.
- Generally the bottle houses are bio-climatic in design, which means that when it is cold outside is

warm inside and vice versa.

- Re-using the plastic bottles as the building materials can have substantial effects on saving the building embodied energy by using them instead of bricks in walls and reducing the $CO_2$ emission in manufacturing the cement by reducing the percentage of cement used.
- Plastic bottles can cause the green construction by saving energy and resources, recycling materials minimizing the emission, having significant operational savings and increasing work place productivity.

## References

**[1]** ENSO Bottles (2009). Plastic Bottles Environmental Impact. Available from http:// www.ensobottles.com/FAQ/FAQ-Environmental-Impact.html [Accessed 25 Februrary 2011]

**[2]** Felix,I, (1999). Compressive Strength and Modulus of Elasticity of Masonry Prisms. Thesis (Master). Carleton University. Available from: http://www.collection-scanada.gc.ca/obj/s4/f2/dsk1/tape8/PQDD_0019/MQ48451.pdf[Accessed 28 April 2011]

**[3]** Jaquin,P.A.,Augarde,C.E.,GALLIPOLI,D.andTOLL,D.G.(2009).Thestrengthof Unstabilised Earth materials. Geotechnique 59, No. 5, 487–490. Availablefrom:http:// dro.dur.ac.uk/5603/1/5603.pdf?DDD10+des0cea, [Accessed 22 May2011]

**[4]** Heath, A., Lawrence, M., Walker, P. and Fourie, C. (2009). The compressive strength of modern earth masonry. In: *11th International Conference on Non-conventional Ma- terials and Technologies, 6-9 September 2009*, BRE Centre for Innovative Construction Materials, Bath. Available from: http://opus.bath.ac.uk/16171/1/Paper_15.pdf, [Ac- cessed 20 March2011]

**[5]** Krepcio, T. (2007). Interior of one building of Grandma Prisbrey's Bottle Village. [Photograph]. Available from: http://www.krepcio.com/vitreosity/archives/roundhouse-babs-INT.jpg [Accessed 11 March 2011]

**[6]** Krepcio,T.(2007).TheBottleWall,revisited.Availablefrom:http://www.krepcio.com/vitreosity/archives/2007_03.html [Accessed 11 March2011].

**[7]** Plastics Industry (2011). The Environment Impact of Plastics - Environmental Impact of Plastic Products. [Online] Available from: http://www.plasticsindustry.com/plastics- environment.asp [Accessed 25 February 2011]

**[8]** Saman, A. A., (2006). Statistical Analysis Of Compressive Strength Of Clay Brick Masonry Prisms. Thesis (Master). The University Of Texas at Arlington. Available from: https://dspace.uta.edu/bitstream/handle/10106/496/umi-uta-1264.pdf?sequence=1 [Accessed 28 April 2011]

**[9]** Vianney, T. (2010). Plastic water Bottles for rural households. Available from: http:// arc.peacecorpsconnect.org/view/1463 [Accessed 04 June 2011]

**[10]** MojtabaValinejadShoubi., AzinShakibaBarough.; 'Investigating the Application of Plastic Bottle as a Sustainable Material in the Building Construction', International Journal of Science, Engineering and Technology Research (IJSETR) Volume 2, Issue 1, January 2013 ISSN: 2278 – 7798.

**[11]** ShilpiSaxena., Monika Singh.; 'Eco-Architecture: PET Bottle Houses', International Journal of Scientific Engineering and Technology Volume No.2, Issue No.12, pp: 1243-1246 1 Dec 2013, ISSN: 2277-1581.

**[12]** PuttarajMallikarjunHiremath., Shanmukhashetty.; 'Utilization Of Waste Plastic In Manufacturing Of Plastic-Soil Bricks', International journal of technology enhancements and emerging engineering research, volume 2, issue 4, ISSN 2347-4289.

**[13]** Pratima Patel., Akash Shah.; 'Sub stainable development using waste PET bottles as construction element' www.wastebottleconstruction.com.

**[14]** ArulmalarRamaraj, JothilakshmyNagammal (2014) 30TH International Plea Conference 16-18 December 2014, CEPT University, Ahmedabad, India.

**[15]** VikramPakrashi (2014) Experimental Characterization of Polyethylene Terephthalate 1 (PET) Bottle Eco-Bricks 60: 50-56.

**Atul Chaurasia**, M.Tech Scholar, Department of Civil Engineering, Faculty of Engineering & Technology, Rama University, Kanpur, India.

**Sumit Gangwar**, Assistant Professor, Department of Civil Engineering, Faculty of Engineering & Technology, Rama University, Kanpur, India.