REUSE OF NON-DEGRADABLE WASTE PET BOTTLES AS A CONSTRUCTION MATERIAL

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Abstract:-**The 21st century is facing a serious situation in waste management, especially Plastic waste. Plastic has many advantages but with it comes with many problems too. Being non-degradable for years, it has become a global problem in recycling it. PET being one of the most common consumer plastics as it is used to build many basic and day to day life products like bottles, containers for food industry and beverage industry. PET waste has become major environmental issue due to its various properties like non-biodegradability and gases released on incineration. Therefore, PET waste has to be utilized and recycled efficiently.**

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.

This report consists of use of plastic waste bottle in construction as a brick which is filled with compacted sand or mud and other material, method and technique of use, its relative advantages over traditional bricks in this way plastic waste of bottle can be removed and reused safely for construction.

Index Terms:- Radovanic, Eco- brick, Terephthalate Ethylene, Assessment

Chapter 1
Introduction

The word plastic means any material which is made of synthetic or organic compound which has malleable properties. The major features which play a big role in the usage of plastic are malleable, durable, light weight, impervious to water and low cost. They have replaced traditional materials which were used in manufacturing like wood, metals, paper, stone etc. This makes plastic a perfect and effective raw material for production. Plastic has revolutionized each industry like automobile, Medical, Electronics, Toy, Manufacturing and many more. Thousands of polymers exist in nature and the most abundant one is cellulose. In 1861 Thomas Graham was the first one to observe that when organic compounds are dissolved in solutions they leave behind a sticky solution, he named them colloids which means glue in Greek. In 1870 John Hyatt used chemically modified Cellulose to produce celluloid. Around 1907 Leo Baekeland with two chemicals phenol and formaldehyde created the first synthetic man-made material. He named it Bakelite. This opened the gates for the further growth of synthetic materials. Plastic has many advantages but the problem which has risen is that after the usage of plastic it is thrown away. Being non degradable for years, Plastic recycling has become a global problem. Being non degradable it is causing harm to the nature in many ways. It is causing Land pollution where plastics are dumped. Harming marine ecosystem as plastic are just dumped into the oceans. It also Air pollution when incinerated. Burning of plastic release toxic gases like Dioxins,

Furans, Mercury and Polychlorinated Biphenyls. Burning of PVC liberates halogens hazardous to atmospheres which result into adverse effects on climate. Humans and Vegetation. The plastic production globally has gone from 2 Million tonne in 1950 to 380 Million tonne in 2015 with cumulative of 7800 Million tonne. Out of which 1/3 is in use and the rest is waste. Study shows only 9% of this is recycled and 12% have been incinerated.

Indian lone produces around 40 Million tonne of Urban Municipal Solid Waste (MSW) every year. Majority of this waste is sent to unsanitary landfill sites openly dumped due to weak infrastructure of recycling plastic. The major reason for failures is rapid urbanization which grew by a factor of 8.9 in Mumbai, 13.6 in Bangalore, 20.4 in Delhi from 1950 to 2015 and exponential population growth in India. Attempts to improve the present condition are being done by bringing the MSW Management and Handling Rules 2000 and Solid Waste Management (SWM) Rules 2016. India's MSW varies highly among urban and rural areas. Municipal Solid Waste typically includes degradable (paper, Textile, Food waste, straw and yard waste), partially degradable (wood, disposable napkins, sludge) and non-degradable materials (leather, plastics, rubbers, metals, ash from fuel, dust and electronic waste).

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 paper 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.

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 homes 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 of building materials and labor and also maybe long transportation.

One of the solutions for this problem can be using following factors:

- Use of affordable recycled materials in building
- 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.

1.1 Properties of plastic

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:

1. More than 20,000 plastic bottles are needed to obtain one ton of plastic.
2. It is estimated that 100 million tons of plastic are produced each year.
3. The average European throws away 36 kg. of plastics each year.
4. Some plastic waste sacks are made from 64% recycled plastic.
5. 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 low.

1.2 Disadvantages of plastic bottles:

a) Decomposition
b) Non-Renewable
c) Hard to Use
d) Difficult to Recycle

Decomposition:

The main disadvantages of plastic bottles are the shear amount of time they take to decompose he averages plastic bottle takes 500 years plastics decomposition can be agented by various factors, such as the types of plastic, the climate and acids in the landfill; plastic still lasts a long time, filling landfills for an indefinite period.

Non-renewable:

Plastic is manufactured using oil by products and natural gas material that could be used in numerous other applications or conserved was plastic usage lower. Natural gas for example, can be used to heat houses and cook food. Using plastic in the volume we currently do reduces the availability of these resources, which are gone forever when used up.

Hard to use:

The standard disposable plastic bottle is meant for one use, not many. Recycled plastic bottles are not refilled in mass they glass beer bottles are, and flimsy plastic bottles do not lead themselves well to at home re-usage. Water bottles, for example, are often reused in the home but become less and less sturdy over time and are ultimately thrown away.

Difficult to recycle:

Glass bottles can be meted and easily reused as can tin cans. Recycling plastic is not so simple. Much of the plastic placed in recycling boxes is not recycled at all, as most plastic cannot be recycled those bottles that are recycled are not used to make new bottles. Instead recycled plastic bottles are used to make non- recyclable products, such as t-shirts, lactic lumber or parking lot bummers. This means more raw materials need to be used to create new plastic bottles than is the case with easily recycled material, such as glass or tin.

Chapter 2
Literature Review

The first bottles house was built using 10000 glass beer bottles by William F. peck in 1902 in Tonopha, Nevada After that the newer innovative concept has been using plastic bottle instead of glass bottles in constructing the houses. This innovative idea took to account for some reasons such as providing a cost-efficient construction method for pauperized third-world countries, reusing the plastic bottles due to their not indecomposable characteristic, and etc. The first

plastic bottles house in Africa was constructed in the village of Yelwa in Nigeria by Andreas Forese.

Forese used the plastic bottles instead of bricks, bound the bottles together with string and at the end applied the plaster.

However nowadays, the concept has spread to countries all over the world. Various kinds of homes have been built from plastic bottles such as: ecological house constructed using 8000 bottles in Honduras; an Eco-Tec home in Bolivia constructed using the PET and wine bottle; a house of waste plastic bottles built in Serbia by Tomislav Radovanic; Taiwan's plastic bottle building; ecological bottle house built using 1200 PET plastic bottles for the walls near the lquazu Falls, Misiones, Argentina; and etc.

Nowadays, large amount of plastic bottles are wasted and disposed every day. People are thrown away them without considering that what those plastic bottles can have impact on the humans and/or environment. Andreas Froese, the founder of Eco-Tec Environmental Solution, in searching for finding an inventive solution to junk, established the innovation of building plastic bottle houses. The first bottles house was built using 10000 glass beer bottles by Wiliam F. peck in 1902 in Tonopha, Navada. After that the newer innovative concept has been using plastic bottle instead of glass bottles in constructing the houses. This innovative idea took to account for some reasons such as providing a cost-efficient construction method for pauperized third-world countries, reusing the plastic bottles due to their not indecomposable characteristic, and etc. The first plastic bottles house in Africa was constructed in the village of Yelwa in Nigeria by Andreas Forese. Forese used the plastic bottles instead of bricks, bound the bottles together with string and at the end applied the plaster.

Anyway, beside the Eco-Tec, various other institutions and groups have initiated the concept of reusing the plastic bottles for building construction. However nowadays, the concept has spread to countries all over the world. Various kinds of homes have been built from plastic bottles such as: ecological house constructed using 800 0 bottles in Honduras; an Eco-Tec home in Bolivia constructed using the PET and wine bottle; a house of waste plastic bottles built in Serbia by Tomislav Radovanic; Taiwan's plastic bottle building; ecological bottle house built using 1200 PET plastic bottles or the walls near the lquazu Falls, Misiones, Argentina; and etc. The purpose of this paper is to look into the using of plastic bottles as a municipal waste 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.

2.1 Mojtaba et al.

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 CO_2 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.

2.2 Shilpi et al.

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.

2.3 Puttaraj et al.

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.

2.4 Pratima et al.

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.

2.5 Arulmalar et al.

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.

2.6 Vikram Pakrashi et al.

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.

2.7 Andreas Froese et al.

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.

2.8 Yahaya Ahmade et al.

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.

2.9 Seltzer et al.

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.

2.10 Job Bwire & Arithea Nakiwala et al.

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

Chapter 3
Research Methodology

In this study, the first step taken was collection of waste PET bottles from stores, waste collectors and other possible resources. Once the bottles are collected, they have to be filled with local available soil so as to provide them the structural strength. In our experimental work we have taken 60,100 and PAN mesh size soil which is first screened by a sieve shaker properly so as to remove any unwanted foreign large size particles. Once all the collected bottles are filled with this prepared soil and tamping it in instalment, they are tightly capped and sealed. Now to check the structural strength various tests are performed and comparison is made against those for a brick. A comparative economic analysis is also done.

1) Collect of waste PET bottles and quarry dust.
2) Characterize quarry dust for index and engineering properties
3) To study the effectiveness of waste PET bottles in improving the bearing capacity using CBR tests.
4) California Bearing Ratio test was carried out on different configuration by arranging the bottles in different pattern such as triangle (3 bottles), diamond (4 bottles), circular (5 bottles) at different heights (taken cut bottles at 11.6cm, 9.3cm, 6.6cm) to achieve the desirable optimum aspect ratio i.e. height and diameter ratio. The bottles were placed at a depth of 5 mm below the plunger.
5) The different test configurations prepared within CBR mouldare

3.1 Pet plastic

Introduction of PET

PET is used for high impact resistant container for packaging of soda, edible oils and Peanut butter (Table 1). Used for cereal box liners, Microwave food trays. Used in medicine for plastic vessels and for Implantation. Plastic is heat resistant and chemically stable. PET is resistant to acid, base,

some solvents, oils, fats. PET is difficult to melt and transparent and other properties are Table 2.

Full Form	Polyethylene terephthalate
Molecular formula	$C_{10}H_8O_4$
Structure Composition	Polyester of Terephthalic acid and ethylene glycol

Table 1
Properties of plastic

Soil particle	Diameter(mm)
Gravel	>2.0
Sand	0.05-2.0
Silt	0.002-0.05
Clay	<0.002

Table 2
Properties of soil

3.2 Basic Construction Materials and Properties.

This construction requires some of the basic materials which ensures a stable, ecofriendly structure and also results in cheap construction as compared to brick wall. Materials uses for

Bottle wall masonry construction are:

- Soil
- Plastic
- Cement
- Nylon rope
- Water

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:

a) **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.

b) 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.

c) 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.

d) Soil porosity:

Many important soil processes take place in soil pores (air or water-filled spaces between particles). Soil texture and structure influence porosity by determining the size, number and interconnection of pores. Coarse textured soils have many large (macro) pores because of the loose arrangement of larger particles with one another. Fine-textured soils are more tightly arranged and have smaller (micro) pores. Macro pores in fine textured soils exist between aggregates. Because fine-textured soils have both macro- and micro pores, they generally have a greater total porosity, or sum of all pores, than coarse-textured soils.

PLASTIC BOTTLE

Polyethylene Terephthalate Ethylene (PETE) bottles are 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:

a) Wax like in appearance, translucent, odorless and one of the lightest plastics.
b) Flexible over a wide temperature.
c) Heat resistance.
d) Chemically stable.
e) Do not absorb moisture.
f) Transparent.

CEMENT

Cement is the important binding material. In these papers 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

a) Fineness:

Fineness or particle size of Portland cement affects Hydration rate and thus the rate of strength gain. The smaller particle size, and the 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.

b) 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.

c) 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) **Strength:**

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.

NYLON ROPE

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

a) Good abrasion resistance.
b) Tough and strong but flexible too.
c) High impact strength.
d) Absorb water which causes reduction in strength and impact properties
e) Resistant to most of the solvents and chemicals
f) High softening temperatures and thus molding becomes difficult.

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.

4.1 PLANNING AND DESIGNING

PLANNING

We were decided to make a toilet and hanging garden by using plastics bottles. We have to be draft a plan with respect to cost, time, material, laboures, execution of work etc. Whole work is divided in two main part one is toilet construction and other is hanging garden. Then assign work to group members to execute work with quality. We decided time for whole work is about five days, two day for material collection, two days for masonry work and last one days is for finishing work.

DESIGNING

Design of toilet and hanging garden as follows

4.2 ESTIMATION AND DELEGATION OF WORK

ESTIMATION

Measurement of total quantities of item of work

1. **Bottles calculation**

Toilet internal diameter = 1M

Outer diameter = 1.27M

Height of toilet = 1.45M

Volume = $\frac{\pi}{4} \times (D^2 - d^2) \times (H)$

$= \frac{\pi}{4} \times (1.27^2 - 1) \times (1.45)$

= 0.6979 cum

Bottle volume with mortar thickness
Diameter of bottle = 0.07M
Length = 0.27M

Volume of bottle = $\frac{\pi}{4} \times D^2 \times L$

$= \frac{\pi}{4} \times 0.07^2 \times 0.27$

$= \frac{\pi}{4} \times 0.07 \times 0.07 \times 0.27$

= 0.001039 cum

Deduction for door
Volume = h × l × t

= 1.3 × 0.6 × 0.07

= 0.0546 cum

Deduction for window

Volume = h1×L1×t
= 0.20 × 0.30 × 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 × 0.73 × 0.07

= 0.0511 cum

No of bottles = 0.0511 / 0.001039

= 50 bottles for each panel

= 3 × 50

= 150 bottles

For hanging garden approximately 50 bottles required
Total bottles required =

615+150+50

= 815 bottles

2. **Soil calculation**

Soil = volume of bottle × no of bottles filled by soil

= 1 × 615

= 615 kg

3. **No of steel bars**

6 mm Ø – 4 bars required of 1.5 m length

4. **Other materials**

500 m long metal rope

40 bricks for piers

40 card sheets

Crops seeds

Total cost = 1280 Rs

4.3 COSTING

1. **Bottles**

= no of bottles × rate per bottle

= 815 × 0.50

= 407.50 RS

2. **Rods**

= no of rod × rate per rod

= 4 × 60

= 240 RS

3. **Bricks**

= no of bricks × rate per brick

= 40 × 6

= 240 RS

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 40 RS.

5. **Transportation and T&P**

For collection of raw material 200 Rs required.

For tools & plants 150 RS required.

6. **Laboures**

We have to be work self physically, but minimum 4 laboure required per day.

Total cost of construction = 4 07.50 + 240 + 240 + 40 + 200 + 150

= 1280 Rs

4.4 EXECUTION OF WORK

TOILET CONSTRUCTION

1. **Layout**

As per design we mark a circle on ground with lime.

2. **Bottle filling with soil**

All bottles fill with red soil properly and to fill bottle steel rod use, it helps to avoid voids will chances of creation in bottle.

3. **Masonry work**
   All plastic bottles are arranged as an English bond with minimum mortar.

4. **Finishing work**
   Door, window, roofing work are done in this work

4.5 ADVANTAGES

- **Economical**
  Empty plastic bottles have low purchasing value as compared to bricks so therefore it can be reducing about 80% cost of construction.

- **Simple and easy construction**
  With the help of plastic bottles construction could be become easy there are no requirement of skilled laboure and mason.

- **Minimized waste from environment**
  If we make a reuse of waste plastic bottles in civil construction then percentage og waste in environment automatically decreases.

- **High durability**
  When plastic bottles filled with soil then it gives 45 N/MM ^ 2 compressive strength which 900% greater than standard brick. Plastic is non-degradable material remains as it is in the environment.

- **Curing does not require**
  Plastic bottles have 0% water absorption capacity and plastic is does not required water curing or any other curing method to increase strength.

- **Green construction**
  Plastic bottle is considered as a sustainable material which can help in achieving the SD. Using the plastic bottle can follow the objectives of SD. It can abstain from the resource depletion, assist in protecting the environment; prevent or reduce the environmental degradation process such as land filling through reusing process and it can assist to obtain a social equity by avoiding the gap between the rich and the poor people in the society.

- **Non-brittle characteristic**
  Using the non-brittle materials can reduce construction waste. Unlike brick, plastic bottle is non-brittle. So due to the frangibility property, the percentage of producing construction waste in brick is more than plastic bottles.

- **Absorbs abrupt shock loads**
  Flexibility is a characteristic which makes the building's performance higher against the unexpected load. Since the plastic bottles are not fragile, they can be flexible and tolerates sudden loads without failure. This characteristic can also increase the building's bearing capacity against the earthquake.

4.6 DISADVANTAGES

- **Material availability**
  In hilly or remote area which not well developed there are very less chances of a getting material for construction such as plastic bottles, soil etc.

- **Applicable only for load bearing structure**
  For multi-storeyed building it is not fully applicable but we can be use it in a patrician wall for construction.

4.7 Properties of plastic bottles

- Plastic bottles are remains as it is in environment for 300 years.
- Plastic bottles are bullets proof
- Plastic bottles are light in weight
- Non-absorptive material
- Chemical & insects' proof

Chapter 5
Results and Discussion

5.1 Introduction

Plastic bottles are certainly ubiquitous they bring us everything from house hold cleaners to soft dryings to things so readily available as water these bottles, while convenient, do have disadvantages when used on as wide a scale while most of these disadvantages are environmental in nature the consequences could have widespread economic consequences in the long-term.

5.2 Necessities of reuse of plastic waste bottles:

Now a day plastic bottles waste increases 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 non-renewable 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

5.3 Objective:

We are the part of the environment & we has responsibility towards society and environment. We should have to do such type of project which help to make our environment more sustainable.

- We have to minimize plastic bottles waste from environment and society.
- Plastic is non- degradable waste in environment therefore only reuse of plastic is the best way to dispose effectively.
- To make green structure to conserve natural resources for future need.

5.4 Mortar calculation

No. of labour calculation:

One labour can made 400 bottles per day (filling soil in bottles) (Table 3).

S. no	Material	Quantity	Rate	Per	Amount(Rs.)
1	Brick	1150 nos.	5	1 no.	5750
2	Cement	5.45	300	1 bag	1635
3	Sand	0.237	250	1 m3	59.25
Total	-	-	-	-	7444.25

Table 4 Cost estimation of brick wall masonry

Total no. of bottles = 1572

Numbers of labour needed = (1572/400) = 4 no's (Table 4).

S. no	**Material**	**Quantity**	**Rate**	**Per**	**Amount (Rs.)**
1	Plastic bottle	1572 nos.	0.5	1 no.	786
2	Cement	5.45	300	1 bag	1635
3	Sand	0.237	250	1m3	59.25
4	Soil	1.99	100	1m3	199
5	Labour work	4	300	1 person	1200
Total-		-	-	-	3879.25

Table 5 Cost estimation of plastic bottle wall

5.5 Comparison between the walls by plastic bottle wall and brick wall:

For construction Time and speed of Execution for 5 persons team-one working day for plastic wall is 15% faster and for brick wall 120m^2. Material and equipment cost for plastic bottle wall is less as compared to brick wall. Transportation cost for plastic bottle wall construction is less than brick wall. Plastic bottle wall construction require less manpower as compare to brick wall and require high cost. Strength and load capacity for plastic bottle wall construction is 20 times more than brick wall construction (Table 6).

S. No	Factors	Considerations	Plastic bottle wall	Brick wall
1	Time and speed of Execution	5 persons team one working day	15% faster	120 m2
2	Material and equipment costs	Implementation and installation of materials and equipment	Saving in cement, water, grinder and fitting	More weight, more materials
3	Transportation Costs	Displacement in the building	Lighter and higher volume, easy and cheap displacement	Greater weight and less volume, hard and costly displacement
4	Execution cost	Using calculations of panel	Less manpower and indigenous	More human resources- the higher cost
5	Strength and load Capacity	-	20 times more than brick	Greater wall thickness, lower strength High weight and loss of material
6	Resistance to Earthquake	Earthquake has a direct relationship with the weight of each structure	Low and Integrated weight without falling debris	-
7	Cleanness and beauty of work	-	Very clean execution, no construction waste	High volume of construction waste
8	Flexibility	-	Very clean execution, no construction waste	-

Table 6 Comparison between the wall by plastic bottle and brick

5.6 Benefits of plastic bottle masonry wall:

The most important benefits of these alternative innovative materials compared to conventional materials such as brick can include:

Good construction ability

The walls built by these bottles are lighter than the walls built by brick and block, and that makes these buildings to show a good response against earthquake. Due to the compaction of filling materials in each bottle, resistance of each bottle against the load is 20 times higher compared to brick. And these compressed filling materials, makes the plastic bottle to be prevented from passing the shot that makes the building as a bulletproof shelter.

Low cost

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 walls can lead to cost reduction up to 75% compared to building the walls using the brick and concrete block. It must be noted that the sophisticated manpower can lead to reducing the construction time and the relative costs also become lower.

Non-britte characteristics

Using the non-brittle materials can reduce construction waste. Unlike brick, plastic bottle is non-brittle. So due to the frangibility property, the percentage of producing construction waste in brick is more than plastic bottles.

Absorbs abrupt shock loads

Flexibility is a characteristic which makes the buildings performance higher against the unexpected load. Since the plastic bottles are not fragile, they can be flexible and tolerates sudden loads without failure. This characteristic can also increase the buildings bearing capacity against the earthquake.

Green construction

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. These 13-plastic bottle vertical garden ideas will interest you if you are a creative person, DIY lover and love to grow plants. This way you can use plastic bottles to make something amazing out of them. Repurpose those old bottles, which you usually throw away to grow your favorite plants either indoor or outdoor and help to save our environment. If you love DIY ideas and you have a green thumb then starting a window farm is a smart idea. A window farm will let you do a lot with the little amount of space you have. The indoor window farms. Fallows the crops to take full advantage of the light and vertical space available at the windows. Here in this PDF, you will find all the instructions on how to build a Window Farm. Follow this amazing idea for growing small leafy vegetables, such as lettuce, fenugreek and spinach, herbs and medicinal plants. This plastic bottle vertical garden is made of by stringing the bottles horizontally in a grid along an interior wall, which then filled up by substrate and herbs. A remarkable kitchen garden with plastic bottles with minimal means and efforts. It can be set up easily and does not require regular watering. Here is the tutorial with more images of it (Figure 4). Do you want to create a low maintenance vertical soda bottle garden? Follow this idea. All that is required is bottles cut in half, cactus plants or succulents, and many colorful threads to get a really cool decorative effect (Figure 5). Use two-liter soda bottles, cut them in half and use the neck side. Turn them upside down. Adhere the bottles to a wooden frame and arrange them in such a way so that the open neck of the bottle will drain out the water into the bottle below it (Figure 6). Here's another idea to create a vertical garden using the plastic bottles. It is a great way to reuse old plastic bottles and to introduce some greenery to a small urban space (Figure 7). One more wonderful idea to make use of plastic bottles, more useful if you don't have much space on the ground (Figure 8). A hanging plastic bottle garden to make full use of vertical space. In this post, which we found on Source: Container Gardening (Figure 9). Plastic bottles are mounted on the wall for utilizing the vertical space. Bushy and trailing plants like lettuces and strawberries hide the structure, creating a nice 'green wall' effect (Figure 10). Another innovative and great looking plastic bottle vertical garden. Bottles are hanging horizontally, attached through the strings (Figures 11). Want to grow herbs but you don't have space? Well, even a wooden plank is enough. All you need is some plastic bottles, hooks, nails and hammer and you're all set to grow your own herbs. Be sure to check out our post on balcony herb garden ideas to find out more ideas like that (Figure 12).

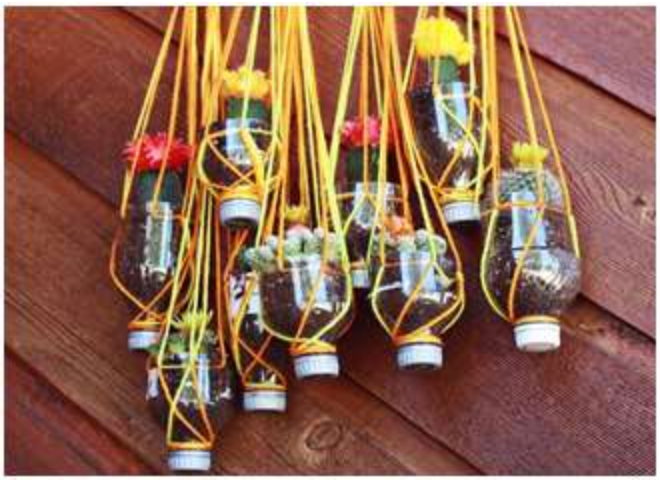


Figure 4 Growing cactus in hanging plastic bottles.

Figure 6 Here's another idea to create a vertical garden using the plastic bottles.

Figure 5 Half plastic bottle vertical garden on wooden frame.

Figure 7 Another vertical garden.

Figure 8 Bottles hanging on string.

Figure 10 Inspiring plastic bottle garden.

Figure 9 Plastic bottles hanging on net.

Figure 11 Hanging soda bottle garden.

Figure 12 Pyramid plastic bottle garden.

5.7 Testing

COMPRESSIVE TEST

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

WATER ABSORPTION TEST

Water absorption of plastic bottle is equal to zero.

WEIGHT MEASURING TEST

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

VOLUME OF BOTTLE

Volume of bottle is equal to 1 liter.

Chapter 6
Conclusions and Recommendations

a) Plastic waste and its recycling has become a problem in not only in India but globally. Plastic is need of the hour and its usage cannot be stopped in manufacturing sector. The Waste to energy segment in India has huge potential which has not yet been fully utilized. But with Efficient usage of Plastic waste in different products, Plastic waste can be utilized efficiently. It can be concluded that Plastic pavement with varying percentage plastic is better than the traditional flexible pavements in India. Its performance and life cycles are more and required low maintenance. The plastic bricks which are made from Plastic bottles has compressive strength of a 2nd level brick and can be used effectively everywhere in construction. The usage of plastic bottles as a construction material provides compressive strength lows compared to concrete blocks but has enough strength that it can be used to build partition walls and roof slabs from it. With higher thermal resistance they can also be used as insulators. Plastic bottles walls also shows better shock absorbing capacity towards abrupt shock loads which performs better in situation like earthquakes. Thus, these all methods can be adopted to use plastic waste in different sectors and products which can lead to efficient and effective use of plastic waste.

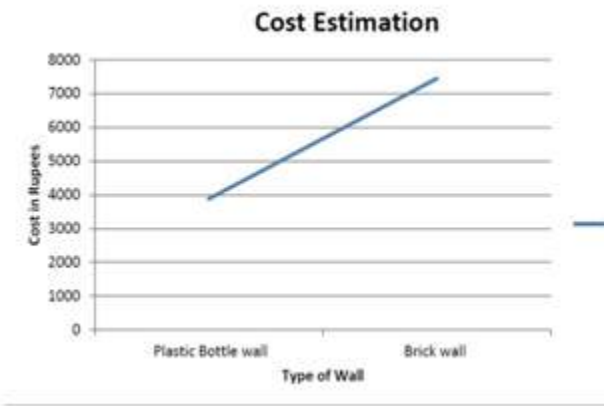
b) Use of innovative materials with sustainable application such as plastic bottles can have considerable benefits including finding the best optimization in energy consumption of the region, reducing environmental degradation.

c) Generally, the bottle houses are bio-climatic in design, which means that when it is cold outside is warm inside and vice versa.

d) From the above experimental observations, we can infer that no curing time is required if waste PET bottles are used as building

material as compared to bricks which require 28 days curing time.

e) Also, while baking of bricks there is a major issue of carbon emission which is negligible in using PET bottles.
f) PET bottles generally have a durability of over 300 years which is more as compared to standard bricks.
g) Weight of a unit bottle brick was found to be less than that of a standard brick.
h) 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.
i) 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.
j) Cost compression between bottles wall is roughly half than conventional brick masonry. i.e., Total cost of10 m2 Brick masonry wall is Rs. 7444.25 and total cost of 10 m2 Bottle masonry wall is Rs. 3879.2
k) 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.
l) 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.



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