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STUDY ON USE OF PLASTIC BOTTLE IN WALL MASONRY

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Abstract:

In India, if we look towards urbanization a trend of use of non-renewable products like plastic bottles, have been increased, but increase of the such product, recycling or destroying is the main concern. Disposal of non bio-degradable substance has become an issue of major concern nowadays. Mounds of plastic garbage has been created on earth surface. 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. PET bottles have the different factors such as, load capacity, time of execution, cost, and flexibility. PET bottles have more compressive strength compared to some conventional building material such as brick. So, we can easily replace conventional brick by PET bottles. The paper 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.

Keywords: Plastic Bottle, Sustainable Material, Construction material

1. Introduction:

PET is short for polyethylene terephthalate, the chemical name for polyester. PET is a clear, durable, and low weight plastic that is extensively used for packaging beverages, especially convenience-sized soft drinks, juices and water. One of the essential disadvantages in constructing world house is high cost of the building. High cost of fundamental concern for constructing the houses in places on where people are under poverty line, is forming one of the most significant problems of people. Plastics are produced from the oil that is considered as nonrenewable resource. Because plastic has the inviolability about 300 years in the nature, it is assumed as a sustainable waste and environmental pollutant. 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. 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. Two factors that prevent aboriginal people from building their homes are high-cost building materials and labor and also maybe long transportation. 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. 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.

Plastic has many good characteristics which include versatility, lightness, hardness, and resistant to chemicals, water and impact. It also intends to compare the characteristics of some construction materials such as brick, ceramic and concrete block with bottle.

1.1 Literature Review:

The first bottles house was built using 10,000 glass beer bottles by William F. peck in 1902 in Tonopah, Nevada. After that the newer innovative concept has been using plastic bottle instead of glass bottles in constructing the houses.

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

The first plastic bottles house in Africa was constructed in the village of Yelwa in Nigeria by Andreas Foresee. Foresee 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 8000 bottles in Honduras; an Eco-Tec home in Bolivia constructed using the PET and wine bottle; 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.

1.2 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 in 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.

1.3 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.
- ✓ Reduction of municipal solid wastes being land filled.

2. Basic Construction Materials and Properties:

- ✓ This construction requires 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
  - ✓ Water

We can also use some alternate materials like Fly Ash, Foundry sand, Plastic Waste.

2.1 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.

2.1.1 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*:*

The term texture is used in reference to the size of individual soil particles but when the arrangement of the particles is considered the term structure is used. Structure refers to the aggregation of primary soil particles (sand, silt and clay) into compound particles or cluster of primary particles which are separated by the adjoining aggregates by surfaces of weakness. Structure modifies the effect of texture in regard to moisture and air relationships, availability of nutrients, action of microorganisms and root growth.

- ✓ Soil Permeability:

It is the ability of the soil to transmit water and air. An impermeable soil is good for aquaculture as the water loss through seepage or infiltration is low. As the soil layers or horizons vary in their characteristics, the permeability also differs from one layer to another. Pore size, texture, structure and the presence of impervious layers such as clay pan determines the permeability of a soil. Clayey soils with platy structures have very low permeability.

Permeability is measured in terms of permeability rate or coefficient of permeability (cm per hour, cm per day, cm per sec.)

2.2 CEMENT:

Cement is the important binding material. In this 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.

2.2.1 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.

2.3 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.

2.3.1 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:

- ✓ Wax like in appearance, translucent, odorless and one of the lightest plastics.

- ✓ Flexible over a wide temperature.
- ✓ Heat resistance.
- ✓ Chemically stable.
- ✓ Do not absorb moisture.
- ✓ Transparent.

2.4 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.

2.5 PLASTIC WASTE:

Due to the ideal properties of the thermoplastic polymers such as corrosion resistance, low density, high strength, and user-friendly design, plastic usage has become much higher than the usage of aluminum or other metals. Plastics can be moulded into different shapes when they are heated in closest environment it exists in the different forms such as cups, furniture's, basins, plastic bags, food and drinking containers, and they are become waste material. Accumulation of such wastes can result into hazardous effects to human life. Therefore, need for proper disposal, and, if possible, use of these wastes in their recycled forms.
Plastic waste can be used in two ways:

- ✓ By compacting the collected plastic waste in plastic bottles.
- ✓ By shredding the plastic waste and melting the waste with sand to obtain the desired strength.

By using above any method, we can use plastic waste instead of natural sand.
We also get good compressive strength and durability by using plastic waste.

2.6 FLY ASH:

Fly ash produced from the burning of younger lignite or sub bituminous coal, in addition to having pozzolanic properties, has some self-cementing properties. Two classes of fly ash are defined by ASTM C618: Class F fly ash and Class C fly ash. The chief difference between these classes is the amount of calcium, silica, alumina, and iron content in the ash. The chemical properties of the fly ash are largely influenced by the chemical content of the coal burned (i.e., anthracite, bituminous, and lignite). Fly Ash is a cocktail of unhealthy and hazardous elements like silica, mercury, iron oxides, calcium, aluminum, magnesium, arsenic, and cadmium. It poses serious environment and health hazards for a large population who live in the nearby area of the plants. But the brick is better off, during the process of brick making the toxins associated with Fly Ash gets changed into a non-toxic product. The mixing of with lime at ordinary temperature leads to the hydration of calcium silicate and formation of a dense composite insert block. We can also use fly ash in making of mortar as it also has good fire resisting properties. High-Calcium fly ash geo polymer has good fire resistance up to 400^{o} C firing temperature.

2.7 WASTE FOUNDRY SAND:

Waste foundry sand (WFS) is a byproduct from the production of both ferrous and nonferrous metal castings. It is high quality
silica sand. Foundries use high quality size-specific silica sands for use in their molding and casting operations. Waste foundry sand can be used as a replacement for regular sand in making concrete or concrete related products. Strength properties of concrete mixtures increase with the increase in foundry sand contents and also with the age. Foundry
sand typically has a semi-cornered or circular shape. It has a uniform distribution of grain size; 85–95% of it has grain sizes of 0.6 to 0.15 mm, while 5–12% of it has grains smaller than 0.075 mm. As observed in the research papers, the workability of foundry sand increases. The compressive strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%. The split tensile strengths were increased with increase in the foundry sand in the concrete mix up to 60% and will decrease after 60% up to 100%. There is an enhancement in the strengths for respective replacement of aggregate with incorporation of foundry sand with natural sand.

3. METHODOLOGY:

3.1 MIX PROPORTION:

We have used following mix proportion based on our research and available materials:

A] Fly Ash and Cement:

i. Fly Ash- 50 to 60%
ii. River Sand or Stone Dust -30 to 40%
iii. Cement -8 to 12%

B] Fly Ash and Foundry Sand:

i. Fly Ash- 50%
ii. Foundry Sand- 40%
iii. Cement (53 grade)-10%

3.2 BRICKS PROPORTION:

Bricks were prepared for following different proportion’s

✓ *Brick A*

Sand = 60 %
PET Waste = 37 %
Bitumen = 0.3 %
Fly ash = 0 %

✓ *Brick B*

Sand = 4%
PET Waste = 37%
Bitumen = 0.3%
Fly ash = 20%

3.3 PROCESS:

i. Collect as many discarded plastic bottles as you can. They can be of various capacities.

ii. Sort the plastic bottles according to the size required for the block.

iii. Clean the bottles.

iv. Next process is to take the bottles, fill them with sand or plastic waste and compact the bottle and seal and then paste them with a mixture made of fly ash or foundry sand, adhesive and a little cement to provide additional strength and durability.

v. Compact the block to remove the air bubbles.

vi. Let the concrete set for 24 to 48 hours.

vii. After 2 days, unmould the block and keep it for curing for 7 days or 28 days.

viii. First, clean the bearing surface of the plate to remove any loose grit.

ix. Put the cured plastic brick specimen in the testing machine relatively to its longitudinal axis, at the centre coinciding with the axis of the machine and then apply the load up to failure.

x. Consider the first crack that appears on the plastic brick specimen as the failure point.

xi. Stop the machine and record the cross-section area of the plastic brick in contact with the platen using a planimeter.

xii. Record the maximum loads at failure as well as the rate of loading (KN).

xiii. Firstly, lay out the bricks at both ends of your wall where the pillars will start.

xiv. Lay a 1-2cm mortar bed along the string line.

xv. At the point where you want your pillars to start, place a brick side-on to the end of the wall

xvi. Always build at least a course higher on the pillars than the rest of the wall.

xvii. Horizontal and vertical mortar joints should be 10mm thick.

xviii. To finish the beds, use the rounded edge of a brick jointer to scrape mortar into the joints.

xix. Lastly, give the finished wall a gentle brush over and clean up any mortar that has fallen onto the floor before it dries.

4. TESTING PROGRAM:

4.1 CASTING:

- ✓ All ratios of the concrete mix were by weight, and the volume of each block was a standard form of 15×15×15cm.

- ✓ All samples were cast three times. The cement, sand, and water were mixed well before adding the insoluble plastic flakes which aided the bonding of the cement and aggregates. The concrete was poured into the form and dried in the sun in a well-ventilated area.
- ✓ In the experiment, the mix was left to cure for about 28 days. At the scheduled date, the molds were taken off, and the blocks weighed to calculate density, before being tested for compressive strength.

Fig1: Casting of bricks

4.2 ARRANGEMENT OF BRICKS:

- ✓ After detailed research, we used following arrangement of plastic bottle in the bricks:
- ✓ As the selected arrangement of bottles gives good compressive strength it is most suitable arrangement for brick.

Fig 2: Layer of bottles placed in brick

4.3 TEST ON UTM:

- ✓ The universal testing machine is used in each test. Then the compressive strength values obtained from the test were compared.
- ✓ The sample blocks should bear the compressive strength of at least 2 MPa, based on the standard specification of lightweight concrete (TIS 1505-2541).
- ✓ After that the sample blocks were placed on a platform and compression increased until they disintegrate.

Fig 3: Test on UTM

5. COST COMPARISON:

- ✓ Labour Cost

1) Labour rate per day: 300Rs
2) Carrier rate per day: 150Rs

1 labour can make 300 bricks per day.

Therefore, cost of labour = (300+150)/300=1.5Rs

- ✓ Material cost

1) Plastic: Nil
2) Foundry Sand: Nil
3) Fly Ash: Nil
4) Bitumen:

a) Rate of Bitumen: 20 Rs/kg
b) Bitumen Required for 1 Brick: 0.084kg
c) Cost of Bitumen: 20*0.084 = 1.68 Rs/brick

- ✓ Transportation Cost

1) Foundry Sand: Density of foundry sand = 2590 kg/m3
2) Volume of truck = 14.5 m3

Rate for 1 trip of truck = 4000 Rs.

Cost of transport of foundry sand = 4000/37555 = 0.1 Rs/kg
= 0.1*1.68 = 0.16 Rs/brick

2) Plastic: Quantity of plastic filled in a truck = 3000 kg

Cost of transport of plastic = 4000/3000 = 1.3 Rs/kg
= 1.3*1.68 = 2.1 Rs/kg

3) Fly Ash: Density of fly ash = 600 kg/m3

Cost of transport of fly ash = 4000/8700 = 0.45 Rs/kg
= 0.84*0.45 = 0.37 Rs/brick

- ✓ Total Cost of Brick

Cost of brick = 1.5+1.68+0.16+2.1+0.37 = 5.90 Rs/brick i.e., approx. Rs. 6.00

Profit = 10% of 6.00 = 0.60 Rs/brick i.e., approx. 0.50 Rs

Total Manufacturing Cost of Brick
= 6.00+0.50
= 6.50Rs/brick.

6. RESULTS:

6.1 Compression Test:

Sample	Weight(kg)	Density(kg/m3)	Max load at crushing (KN)	Compressive strength(N/mm2)
Brick A	3.76	1390	189.3	7.99
Brick B	3.25	1255	201.3	9.42

Table 1: Maximum load and compressive strength of different ratio of plastic waste

From the compression test result, it is clearly showing that the value of compressive strength decreases as the ratio of plastic waste increase. The brick sample B with 40% sand and 40% PET waste sand 20% fly ash shows the compressive strength of 9.42 N/mm2. Which is almost double than that of convention brick strength.

6.2 Water Absorption Test:

Sample	Weight before(kg)	Weight after(kg)	% water absorbed
Brick A	3.76	3.95	0.10
Brick B	3.25	3.50	0.11

Table 2: Maximum water absorption of different ratio of plastic waste

Water absorption test shows excellent performance of the plastic waste brick. Good quality of bricks does not absorb more than 20% of water. This concludes that the presence of plastic waste in the bricks helps on the performance of the bricks.

6.3 Efflorescence Test:

Efflorescence test also showed the excellence performance of the sand bricks. There is no absence of grey or a white deposit was shown on its sand bricks surfaces for all ratios. From this test, we can conclude that no alkalis were presence in this sand brick.

6.4 Hardness Test:

In this test, a scratch was made on brick surfaces. When the scratch is made with the help of finger nail on the bricks, very light impression was left on the sand brick surface. So, this test results that fibrous concrete bricks are sufficiently hard.

6.5 Soundness Test:

In this test two bricks of same proportion were taken and they were struck with each other. The bricks were not broken and a clear ringing sound was produced. So the bricks are good.

6.6 Structure Test:

In this test, the bricks were broken and the structures of that bricks were examined, whether they were free from any defects such as holes, lumps, etc. In this test, sand bricks can cut into equal parts. The sand brick piece structure was homogenous, compact, and free from defects and this brick pieces look like a cake piece

7. 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.
- ✓ Compressive strength of PET bottle filled with 50% fine and 50% coarse soil is larger than brick compressive strength.
- ✓ The foundry sand brick consists of waste materials and therefore cost is very low compared to conventional bricks.
- ✓ Since, the waste materials are used, it reduces landfills and pollution problems.
- ✓ The compressive strength of brick is more than that of conventional brick.
- ✓ The bricks were not broken after falling from height of 1 m. Using the foundry sand brick in a building, total cost will be reduced from 20% to 25%.
- ✓ In site lot of bricks are wasted while cutting only. The labors could not able to cut the bricks exactly what they need. But foundry sand bricks can be cut into exactly two pieces. By using conventional saw blades. So, we can get any shape and size of foundry sand brick.
- ✓ As we know that the cost of conventional brick is 9 Rs/brick. Manufacturing cost of sand brick is less than the cost of conventional brick of same size. So, this brick is economical than conventional brick.

8. REFRENCES:

- ✓ Simanshu P. Pandey, Sakshi Gotmare, Prof. S.A.Wankhade IARJSET,AGNIPANKH-16
- ✓ "Waste Plastic Bottle as Construction Material" Volume 4, Special Issue,3 Jan 2003
- ✓ Shubina, Abhishek Tiwari* and R.K. Sharma International Journal Of Current Engineering And Technology
  "Investigating the Compressive Strength of Pet Bottles as Masonry"Volume 8, No. 4, July-Aug 2018.
- ✓ Pranav Sonone , Rajanikant Devalkar
  International Journal of Innovative Research in Science, Engineering and Technology
  "Green Sustainable Bricks Made of Fly Ash and Discarded Polyethylene Waste" Vol. 6, Issue 4, April 2017
- ✓ Prof. A. S. Manjarekar, Ravi D. Gulpatil, Vivek P. Patil, Ranjit S. Nikam, Chetali M. Jeur.
  International Journal for Research in Applied Science & Engineering Technology
  "Utilization of Plastic Waste in Foundry Sand Bricks" Volume 5 Issue III, March 2017