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UTILIZATION OF WASTE PET BOTTLES AND INDUSTRIAL BY-PRODUCTS AS A CONSTRUCTION MATERIAL

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Abstract – *Depletion of natural raw materials causes increase in the cost of construction. As resources become scarcer, alternate construction materials has to be used. Therefore, this paper focuses on reuse of waste materials such as Polyethylene Terephthalate (PET) bottles and Industrial by-products as a construction material to reduce the cost of construction and the problem of disposing the waste materials. The above wastes are reused as Bottle bricks for masonry wall construction.*

Key Words: **PET bottles, Industrial by-products, Bottle bricks, cost of construction**

1.INTRODUCTION

Increasing cost of construction materials is become a major problem for the societies. The construction industry is in need of finding cost effective materials. Reuse of waste materials may reduce the cost of construction. This paper investigates the reuse of PET bottles and industrial by-products as filling material for wall construction. PET bottles can not be used as such because it doesn't have enough compressive strength like brick. Hence it has to be filled with fine material.

1.1 PET Bottles

Plastic is everywhere in today's lifecycle. It's used for packaging, protecting, serving and eve disposing of all kinds of consumer goods. Through industrial revolution mass production of goods started and plastic seemed to be a cheaper and effective raw material. Today, every vital sector of the economy starting from agriculture to packaging, automobile, building construction, communication or Info Tech has been virtually revolutionized by the application of plastics.

Use of this non-biodegradable (according to recent studies, plastic can stay as long as 4500 years on earth) product is growing rapidly and the problem is what to do with plastic waste. Studies have linked the improper disposal of plastics to problems as distant as breast cancer, reproductive problems in humans and animals, genital abnormalities and even a decline in sperm count and quality.

Approximately 7 million tons of waste plastic bottles are produced yearly and this takes about 400 years to degrade in landfill. Only one of three bottles is sent to recycle bin. So there is a need for environment friendly constructive use of waste PET bottles.

1.2 Industrial by-products

The materials used to fill the PET bottles are fly ash, brick kiln dust and bagasse ash which are by-products from thermal power plant, brick manufacturing industry and sugar cane industry respectively.

1.2.1 Fly Ash

Fly ash is the finely divided residue, resulting from the combustion of ground or powdered coal and transported by the flue gases by the pulverized coal. It is available in large quantities as a waste product from thermal power and industrial plants. The fine particles of fly ash by virtue of their lightness become air borne and create health problems to all living things. Its indiscriminate disposal requires a large volume of land, water and energy.

Fig -1: Fly ash

1.2.2 Bagasse Ash

Sugarcane bagasse (SCB) which is a voluminous by-product in the sugar mills when juice is extracted from the cane. It is, however, generally used as a fuel to fire furnaces in the same sugar mill that yields about 8-10% ashes containing high amounts of un-burnt matter, silicon, aluminium, iron and

calcium oxides. But the ashes obtained directly from the mill are not reactive because of these are burnt under uncontrolled conditions and at very high temperatures. The ash, therefore, becomes an industrial waste and poses disposal problems.

Fig -2: Baggasse ash

1.2.3 Brick kiln dust

In India there are more than 10000 brick kiln operating and it's consuming about 35 million tons (MT) of coal in a year for baking the soil brick. While the cluster of brick kilns are mainly source of air pollution which affect local population agriculture and vegetation. The waste from the brick production facilities is also a cause of concern as the brick sector of India is unmanaged and has poor worker skill which causes high waste generation. These wastes are dumped in landfills making the land bootless. So it is obligatory to find a way to reuse these wastes.

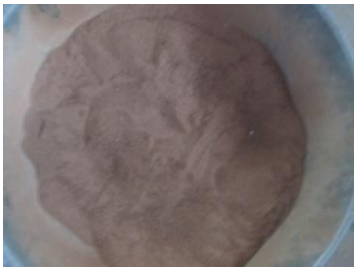

Fig -3: Brick Klin Dust

This paper provides the best way to reuse the waste PET bottles and industrial by-products as bottle bricks in an effective way in construction.

3.METHODOLOGY

- Collection of materials
- Preparation of PET bottles
- Filling of PET Bottles with Industrial by-products separately
- Determination of compressive strength
- Selection of filler material based on high compressive strength
- Casting and testing of Bottle brick (BB)masonry
- Construction of prototype BB house
- Cost analysis
- Conclusion

2. MATERIAL PROPERTIES

2.1. PET bottles

The molecular formula of Polyethylene Terephthalate (PET) is $C_{10}H_8O_4$. Structure Composition is Polyester of Terephthalic acid and ethylene glycol.

Table -1: Properties of PET

Color	White or light cream
Density of plastics	1.33220gm/cm^3
Melting point	225 to 265 C
Solubility	Insoluble in water

2.2. Industrial by-products

Table -2: Physical Properties of industrial by-products

Materials	Specific gravity	Fineness (%)
Fly ash	2.1	1
Bagasse ash	2.44	4.4
Brick kiln dust	2.35	3.3

3. PREPARATION OF BOTTLE BRICKS (BB)

- Waste PET bottles are washed and dried
- Then it is filled manually with industrial by – products such as brick kiln dust, bagasse ash and fly ash in separate bottles and tamped properly.
- The filled bottles are sealed tightly.

Fig -4: Bottle brick

4. TESTING OF BOTTLE BRICKS

Bottle bricks are subjected to compressive strength test. The average value is taken from the obtained results.

Fig - 5: Compressive Strength Test

Table – 3: Test Results

Material	Compressive strength(MPa)
Brick kiln dust	20.12
Bagasse ash	12.87
Fly ash	18.10

From the above results, bottles filled with brick kiln dust has high compressive strength compared to flyash and bagasse ash. Hence brick kiln dust has been considered for masonry test.

5.TESTING OF BOTTLE BRICK MASONRY

BB masonry is constructed using brick kiln dust and fly ash and tested for compressive strength. A steel mesh is placed between the layers of BB to improve strength and bond.

Fig -6: Bottle Brick Masonry

Table – 4: Test results of BB masonry

Material	Compressive strength(MPa)
Brick kiln dust	4.80
Flyash	2.94

From the above results, brick kiln dust bottle brick masonry has highest compressive strength compared to flyash bottle brick masonry. Therefore brick kiln dust bottle brick masonry has been chosen for prototype house construction.

6. CONSTRUCTION OF PROTOTYPE BB HOUSE

- Size of prototype BB house 1mx1mx1m
- The boundaries are marked on the ground and the soil is excavated up to 1/2' for foundation.
- The foundation is laid by using BB.
- At the corners the BB are arranged in such a way that three bottles are placed horizontally and two bottles are placed in perpendicular direction for connecting the walls.
- Steel meshes are placed in between each layers of BB inorder to improve their strength and bonding.
- Colour coated sheet is used for roofing.

Fig -10: Prototype BB house

7. COST ANALYSIS

7.1. Cost of one brick at construction site

Cost of one brick at manufacturing unit = Rs.6
Transportation cost for 2000 bricks= Rs.500
Cost for one brick = 500/2000= Rs.0.25
Loading charge for 1000 bricks = Rs.37.75
Unloading charge for 1000 bricks = Rs.37.75
Total loading and unloading charge for one brick = Rs.0.07

Total Cost of one brick at site = 6+0.25+0.7 = Rs.6.32

7.2. Cost of one BB at construction site

Cost of one PET Bottle:

Average weight of 500ml PET bottle = Rs.0.02Kg
Cost of PET bottles per Kg =Rs.20
No. of bottles per Kg = 1000/0.02 = 50 bottles
Cost of one bottle = 20/50 = Rs.0.40

Transportation Cost:

For PET bottles:
No. of bottles = 250 x 30 = 7500
Transportation cost = Rs.500
cost for one bottle = 500/7500 = Rs.0.06

For Brick kiln dust :
Weight of one bag = 30 Kg
Weight of 30 bags = 900Kg
Cost for transportation of 1 Kg = 500/900 = Rs.0.55
Amount of brick kiln dust in one BB = weight of one BB – weight of one empty bottle
= 0.99 – 0.02 = 0.97Kg
Transportation cost for 0.97Kg brick kiln = 0.55 x 0.97 =Rs.0.53

Loading and Unloading Cost:

Loading charge for 1 cub metre = Rs.26.30
1 cub metre = 2406.53 Kg
Loading cost for 0.97 Kg brick kiln dust
= (26.03 x .97)/2406.53 = Rs.0.01

Unloading cost for 0.97 Kg brick kiln dust = Rs.0.01
Total cost for loading and unloading =Rs.0.02

Labour cost:

Labour charge per day (8 hrs) = Rs.255
Time required for filling one bottle = 5 min
No. of bottles filled in 1hr = 12 bottles
Labour cost for 1 hr = 255/8 = Rs.31.87
Labour cost for 5 min = (31.87 x 5)/60= Rs.2.65

Total cost = 0.40 + 0.06 + 0.53 + 0.02 + 2.65 = Rs.3.65

Cost Saving = 6.32 - 3.65 = Rs.2.60

7.3. Total cost of conventional brick masonry (1mx1mx1m)

= cost of bricks+ cost of cement+ cost of sand+ labour cost

Cost of Bricks:
No. of bricks used = 300
Cost for 300 bricks = 300 x 6.32 = Rs.1896

Cost of cement:
Cement required = 20Kg
Cost for 1 bag (50 Kg) cement = Rs.400
Cost for 20 Kg cement = (400 x 20)/50 = Rs.160

Cost of Sand:
Sand required =100 Kg
Cost for 100 cub ft sand = Rs.4000
1 cub ft. = 68.15 Kg
Cost for 100Kg sand = (4000 x 100)/6815 = Rs.58.70

Labour Cost:
Labour cost for mason for brick Work-I Class/day = Rs.451
Labour cost for mazdoor category II per day = Rs.255
Total Labour cost = Rs.706

Total Cost = 1896 + 160 + 58.7 + 706 = Rs.2820

7.4. Total cost for BB masonry (1mx1mx1m)

Total cost = cost of BB + cost of cement + cost of sand + labour cost

Cost of BB:
No. of BB used = 400
Cost for BB = 400 x 3.65 = Rs.1460

Cost of Cement:
Amount of cement used = 45 Kg
Cost of cement used = (400 x 45)/50 = Rs.360

Cost of sand:
Amount of sand required = 225Kg
Cost for 100 cub ft. sand = Rs.4000
Cost of sand used = Rs.132

Labour Cost:
Labour cost for mazdoor category II per day = Rs.255

Total Cost = 1460 + 360+ 132 + 255 = Rs.2207

Cost saving = 2820 – 2207 = Rs.613

8. CONCLUSION

From the above study, the compressive strength of the BBs filled with brick kiln dust is greater than standard bricks. While comparing the cost, the BBs are 41% less than the standard bricks and BB masonry is 22% less than the conventional brick masonry. The strength of the BB masonry house can be improved by placing mesh between each layers of BB. It can also be used for other construction such as foundation, toiletry etc., Finally this paper concludes the brick kiln dust bottle brick masonry can be used for house construction and is economical than the conventional brick masonry. It also provides solution for the disposal of industrial by – products and PET bottles.

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