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Strength Characteristics of Solid Blocks Embedded with Waste Plastic Bottles filled with Soil

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ABSTRACT: Disposal of non bio-degradable substance such as waste plastics (PET, PP, etc.) has become a major problem. Plastic is a very common material widely used all over the world. Plastic has many advantages as it is compact and light in weight. The great problem with plastic is its disposal. Plastic is made of polymer chemicals and they are not bio degradable. This means that plastic will not decompose when it is buried. Though plastic is a very useful material that is flexible, robust and rigid, it becomes waste after use and pollute the atmosphere. Recycling technique is processing used materials (waste) into new products to prevent waste of potentially useful materials. The increase in popularity of using environmental friendly, low cost and lightweight construction materials in building industry has brought about the need to investigate how this can be achieved by benefiting to the environment as well as maintaining the material requirements affirmed in the standards. To protect the environment as well as to take advantage of plastic, recycling procedure is used. The use of waste plastic bottles for the production of bricks is an optimal method to solve the problem of storing waste materials and to optimize the cost for the production of building materials. In this study, plastic waste bottles were filled with soil and embedded in conventional solid blocks. The blocks were then tested to study the compressive strength and other properties. The laboratory results indicate positive trend and demonstrate that the above combination is useful.

KEYWORDS: PET bottles, Soil, Bottle Alignment, Strength

I. INTRODUCTION

Plastic bottles are increasingly becoming a danger to the environment due to the use of chemicals in the manufacture, use and disposal. It has resulted in pollution problems in waterways, landfills and continues to grow. We cannot reverse the damage that has been done but we need to control it and try to reduce it. For this, we must find a sustainable way and implement it. Two alternative solutions against the plastic disposal are recycling and reusing process. Recycling needs additional energy to treat the materials for producing something useable. So the best solution is reusing for which no additional energy is required and does not contribute to pollution. On the other hand, world human population is continuously increasing, it is difficult to make own houses for poor people using costly construction materials.

Taking into account the new concept of blocks made with plastic bottles has been introduced. When these bottles are filled with sand or soil, construction demolition waste like mortar and bricks, they have great insulating capability. These walls can absorb abrupt shock loads; being non-brittle they produce much less construction waste compared to conventional blocks. It is also reported that compared to brick and concrete block walls, concrete blocks with plastic bottle walls cost 75% less. Being lighter, plastic bottle walls can be better against earthquakes. Due to the compaction of filling material in the bottles, they are 20 times more load resistant than conventional blocks. The objective of this project is to investigate the key and positive characteristics of this product and the benefits obtained by using it in building. It also

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intends to compare the characteristics of concrete block with plastic bottles filled with soil and placed in different numbers and alignment. The use of plastic is increasing day by day. The consumption of plastic in India alone was 165 lakh tonnes in 2016. The consumption is expected to reach around 205 lakh tones in 2020. Plastic is one of the most disposed materials in the modern world. More than 100 million plastic bottles are used every day worldwide, and about 1500 bottles end up as waste in landfills or are thrown in ocean every second and its rate is increasing every second by its consumption. It has been proved that the use of plastic (PET) bottles as innovative materials for construction can be a proper solution for replacement of conventional materials rather than disposing or recycling.

II. MATERIALS & METHODOLOGY

The following materials were used in the study.

Soil, Waste Plastic bottles, Ordinary Portland Cement, M-sand and Water. The applicable tests on these materials were carried out in the laboratory and the results obtained are presented in Tables 1, 2 and 3.

Table 1: Properties of Soil Sample

Sl. No.	Test	Result
1	Sieve analysis	$C_u=0.388, C_c=0.70$ $D_{10}=0.35, D_{60}=0.9, D_{30}=0.47$
2	Liquid limit W_L	40%
3	Plastic Limit W_P	54%
4	Specific gravity	2.35
5	Moisture content	10.64%

Table 2: Properties of Cement Used

Properties of Cement Properties	Results
Consistency	35%
Initial setting time	30 Minutes
Final setting time	600 Minutes
Fineness	8.16%
Specific Gravity	3.43

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Table 3: Properties of Plastic

Color	White or light cream
Material Density of plastic	1.33220 gm/cm ³
Melting point	255 to 265 °C
Solubility	Insoluble in water

III. EXPERIMENTAL WORK

Waste PET bottles of volume 250ml, 600ml and 750ml were collected from the surrounding area. The PET bottles were filled with soil, collected from a building demolition site. The tests such as specific gravity, sieve analysis, plastic limit, liquid limit, moisture content etc. were conducted to determine the properties of soil. Cement, M- sand and aggregates (6mm) were also collected and properties determined. To prepare solid blocks, an assembly of three moulds with conventional dimension 16*8*8 inches each was fabricated using mild steel sheet. The mould so prepared is shown in Fig. 1.



Fig 1: Mould for casting blocks(16*8*8)inches

Preparation of plastic bottle bricks

Waste PET bottles of different sizes 250ml, 600ml, and 750ml were collected and washed. The soil collected from a demolition site of building was crushed and passed through 4.75mm sieve and used as a filler material for the PET bottles. Fine soil was filled into these bottles in three layers; each layer compacted with by tapping the bottle on a level platform. The conventional solid blocks of standard size were prepared using cement and M sand and by embedding PET bottles filled with soil in different numbers and alignment, as listed below.

- i. 250ml bottles in horizontal single layer
- ii. 600ml & 250ml bottles in horizontal single layer
- iii. 750ml & 250ml bottles in horizontal single layer
- iv. 250ml bottles in horizontal double layer
- v. 750ml & 250ml bottles in horizontal double layer

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- vi. 250ml bottles in vertical single layer
- vii. 250ml bottles inclined at 45⁰ in single layer
- viii. 600ml bottles inclined at 45⁰ in single layer

Preparation of Plastic Bottle Brick Filled Cylinders

The cement mortar for the cylinders was taken in 1:3 (Ordinary Portland Cement: M sand) proportion by weight with a water cement ratio of 0.6. The size of the cylinder moulds was 150mm in diameter and 300mm in length. The moulds were oiled with medium viscosity oil before the mortar was poured in. The mortar was filled in three layers each approximately 100mm high. After the first layer a 750ml soil-filled plastic bottle brick was inserted into the middle of the moulds. Each layer was rammed 25 times with evenly distributed strokes. The cylinders were removed from the moulds after 24 hours and were immersed in water for curing.

IV. LABORATORY TESTING AND RESULTS

The test specimens consisting of solid blocks of size 16x8x8 inches were prepared. The waste PET bottles of different capacity and volume were filled with soil and embedded into the blocks in different numbers and patterns. The specimens were prepared as per the standard procedure and thereafter subjected to water curing for 28 days. The specimens were then taken out, dried and weighed. The blocks were subjected to compressive loading in a compression tester. Further, the test specimens consisting of cylinders of diameter 150 mm and length 300 mm were prepared as per standard procedure and embedded with one PET bottle filled with soil. Three specimens were prepared, cured for 28 days and tested for compressive strength in the compression testing machine. Similarly another three specimens were prepared and tested to determine indirect tensile strength. The results are tabulated in Tables 4 to 8.

Table 4: Compressive Strength of Solid Blocks Embedded with 250ml PET Soil Filled Bottles in Different Alignments

Sl. No.	Pattern	No. of bottles used	Vol. of each bottle (ml)	Wt. of block (kg)	Compressive Strength of block (N/mm ²)
1	One Layer Horizontal	4	250	34	20.92
2	Two Layers Horizontal	8	250	35	14.15
3	One Layer vertical	8	250	34	10.15
4	One Layer Inclined at 45 ⁰	6	250	34	9.53

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Table 5: Compressive Strength of Solid Block Embedded with 600ml & 250ml PET Soil Filled Bottles (Single Layer Horizontal)

Sl. No.	Pattern	No. of bottles	Vol. of bottle (ml)	Wt. of block (kg)	Compressive Strength of block (N/mm ²)
1	One Layer Horizontal	2	600	36	13.84
		1	250		
2	Two Layers Horizontal	4	600	35	18.84
		2	250		
3	One Layer Inclined at 45 ⁰	4	600	34	6.15

Table 6: Compressive Strength of Solid Block Embedded with 750ml & 250ml Soil Filled PET Bottles (Single layer Horizontal)

Sl. No.	Pattern	No. of bottles	Vol. of bottle (ml)	Wt. of block (kg)	Compressive Strength of block (N/mm ²)
1	One Layer Horizontal	2	750	32.5	19.69
		1	250		
1	Two Layers Horizontal	2	750	34	13.53
		3	250		

Table 7: Compressive Strength of Cylinder Embedded with 750ml PET Bottle Blocks

Sl. No.	Vol. of Bottle (ml)	Weight of Cylinder (Kg)	Compression Strength (N/mm ²)
1	750	11.8	0.56

Table8: Indirect Tensile Strength of 750ml PET bottle cylinder

Sl. No.	Vol. of Bottle (ml)	Weight of Cylinder (Kg)	Tensile Strength (N/mm ²)
1	750	11.6	0.035

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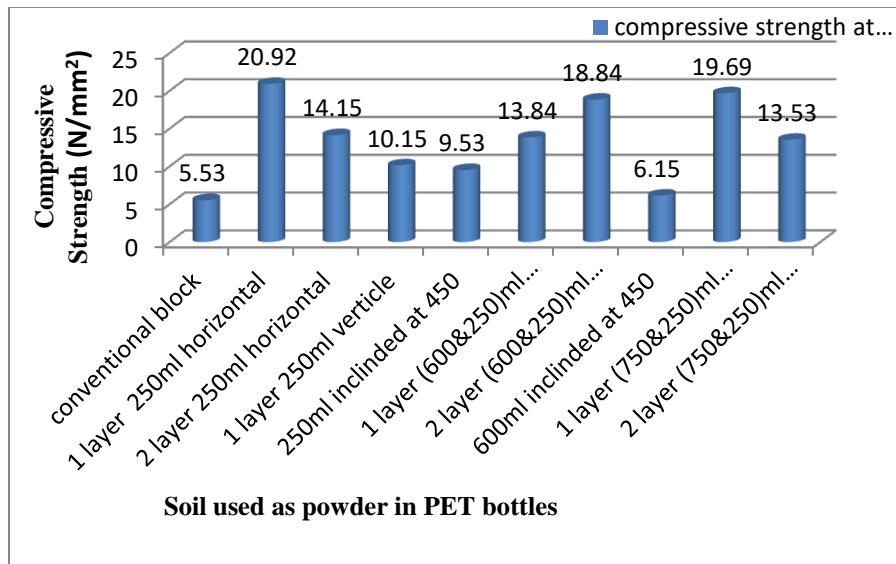


Fig 2: Comparison of Compression Strength of Conventional Block and Block Embedded with Soil Filled Bottles

Teston PET bottles filled with Soil

The PET bottles filled with soil were tested under Compression Testing Machine and the load carried by each is shown in Fig. 3.

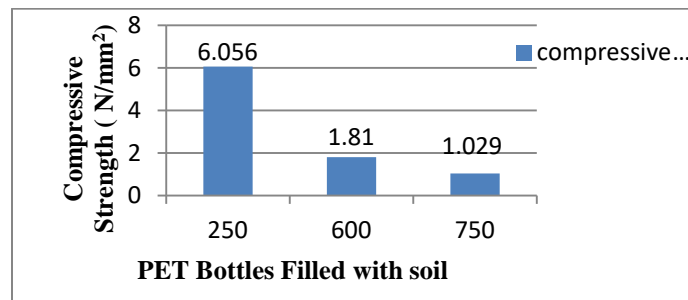


Fig. 3: Compressive strength of Soil filled PET bottles

V. COST ESTIMATION

Cost of making a single bottle brick is calculated and compared with the cost of a single brick.

Cost of waste PET bottle: Cost of waste PET bottle= Rs. 12/kg

- 250ml bottle
Wt. of a250ml PET bottle = 11g

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No. of bottles in 1 Kg = $(1000 \div 11) \sim 91$
Cost of 1(250 ml) PET bottle = $12 \div 91 = \text{Rs}0.13$

- 600ml bottle
Wt. of a 600ml PET bottle = 26g
No. of bottles in 1 Kg = $(1000 \div 26) \sim 38.50$
Cost of 1 (600 ml) PET bottle = $12 \div 38.50 = \text{Rs}0.31$
- 750ml bottle
Wt. of a 750ml PET bottle = 34g
No. of bottles in 1 Kg. = $(1000 \div 34) = 29.41$
Cost of 1 (750 ml) PET bottle = $12 \div 30 = \text{Rs}0.41$

Soil filled with 250ml bottle

Cost of 250ml bottle filled with soil
Wt. of soil filled bottle = 424g
Empty wt. of bottle = 11g
Soil filled in bottle = 413g
Cost of soil filled in bottle = $0.413 \times 0.08 = \text{Rs}0.034$
Soil + bottle cost = $0.034 + 0.13 = \text{Rs}0.17$
Total cost of 250ml soil filled bottle = $\text{Rs}0.17$
Similarly,
Total cost of 600ml soil filled bottle = $\text{Rs}0.40$
Total cost of 750ml soil filled bottle = $\text{Rs}0.51$

➤ Cost of one solid block

Aggregate 13kg = $13 \times 0.40 = \text{Rs}5.2$
M sand 13kg = $13 \times 0.40 = \text{Rs}5.2$
Cement 2.5kg = $2.5 \times 7 = \text{Rs}17.5$
Labor charge = $\text{Rs}4.0 = \text{Rs}4.0$

Total cost = $\text{Rs} 31.90$

Table: 9: Cost Estimation of 09 Blocks with Different Alignment

Sl. No.	Volume of bottles (ml)	Alignment of bottles	No. of bottles	Cost of bottles (Rs)	Total cost of bottles (Rs)	Cost of one solid block without bottles(Rs)	Total cost of block with bottles(Rs)
1	250ml	One layer horizontal	4	0.164	0.66	31.9	32.56
2	250ml	Two layers horizontal	8	0.164	1.31	31.9	33.21
3	250ml	One Layer Vertical	8	0.164	1.31	31.9	33.21
4	250ml	One Layer inclined at 45 ⁰	6	0.164	0.99	31.9	32.89

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5	600ml 250ml	One layer horizontal	2 1	0.40 0.164	0.80 0.164	31.9	32.87
6	600ml 250ml	Two layers Horizontal	4 2	0.40 0.164	1.60 0.328	31.9	33.83
7	600ml	One Layer inclined at 45 ⁰	4	0.40	1.60	31.9	33.50
8	750ml 250ml	One layer Horizontal	2 1	0.51 0.164	1.02 0.164	31.9	33.09
9	750ml 250ml	Two layers Horizontal	2 3	0.51 0.164	1.02 0.492	31.9	33.42

VI. CONCLUSIONS

1. The solid blocks embedded with waste PET bottles filled with soil and placed in different patterns results in different compressive strength. Each pattern has given compressive strength higher than that of a conventional solid block.
2. The single layer, 250 ml horizontal pattern resulted in highest compressive strength of 20.92 N/mm².
3. The single layer, 750 ml and 250 ml bottles combination resulted in compressive strength of 19.69 N/mm², which is the second highest value.
4. The two layers, 600 ml & 250 ml bottles combination resulted in compressive strength of 18.84 N/mm², which is the third highest value.
5. The least compressive strength was obtained for 600 ml bottles placed inclined, but even this value is higher than the compressive strength of conventional solid block.
6. The single layer 250 ml soiled filled bottle in vertical and inclined pattern resulted in compressive strength of 10.15 and 9.53 N/mm² respectively, which is almost twice the compressive strength of conventional solid blocks.
7. Selecting any of the above pattern will give a higher compressive strength than a conventional solid block. Hence the use of waste PET bottles filled with soil and embedded in solid blocks may be encouraged.

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