iJRASET
International Journal For Research in Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 8 **Issue:** II **Month of publication:** February 2020

DOI: http://doi.org/10.22214/ijraset.2020.2092

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International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.177
Volume 8 Issue II Feb 2020- Available at www.ijraset.com

Solid Blocks Embedded with Waste Plastic Bottles

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Abstract: ***Plastic is invariably used in a vast number of applications and its disposal after use has become a challenging task to the manufacturers, municipal corporations and related agencies. It has greatly influenced the environment and is increasingly becoming a potential threat to sustain a clean environment all over the world. However, Plastic has many advantages as it is compact and light in weight. Plastic is made of polymer chemicals which are not bio degradable. Though plastic is a very useful material that is flexible, robust and rigid, it becomes waste after use and pollute the atmosphere. The waste plastic may be put to use either by recycling or reusing. The recycling technique demands lot of energy consumption and hence difficult to implement. However, the reuse technique is much cheaper and is affordable. As such, the waste plastic bottles are being recycled and used in a variety of applications. In this study, these bottles were filled with brick powder collected from a building demolition site and embedded into solid blocks in variable numbers and positions to explore its influence on the strength properties of the block. The results are favorable and suggest that this method can be practically implemented.***

Keywords: Waste Plastic Bottles, Brick Powder, Solid Blocks, Patterns, Compressive Strength

I. INTRODUCTION

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 by 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 alarmingly increasing due to 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. Plastic bottles are increasingly becoming a danger to the environment due to the use of chemicals in the manufacture, use and disposal. For this, a sustainable way has to be found. Two alternative solutions against the plastic disposal are recycling and reusing process. Recycling needs additional energy, so the best solution is reusing for which no additional energy is required and does not contribute to pollution. Taking into account, a new concept of blocks made with plastic bottles has been introduced. When these bottles are filled with construction demolition waste like brick powder, 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 characteristics of this product and the benefits obtained by using it in building. It also intends to compare the characteristics of concrete block with plastic bottles filled with demolished waste in the form of brick powder and placed in different numbers and positions.

II. MATERIALS & METHODOLOGY

The following materials were used in the study.

Waste Plastic bottles, Cement, M-sand, Water, Brick Powder collected from a building demolition site. The materials were tested for their basic properties and the results are presented in Table 1 to 3.

Table 1
Properties Of Plastic

Color	White or light cream
Material Density of plastic	1.33220 gm/cm3
Melting point	255 to 265 ˚C
Solubility	Insoluble in water

Table 2. Properties of cement

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

Table 3. Properties Of Demolition Waste Brick Powder

Sl. No.	Test	Result
1	Sieve analysis	C_u=0.447 ,C_c =0.783 D_{10}=0.34,D_{60}=0.76,D_{30}=0.45
2	Specific gravity	2.54
3	Moisture content	9.51%

III. EXPERIMENTAL WORK

Waste PET bottles were collected from a nearby area. The volume of bottles used are 250 ml, 600 ml and 750 ml. The PET bottles were filled with brick powder collected from a building demolition site. The tests such as specific gravity, sieve analysis, moisture content etc. were conducted to determine the properties of brick powder. Cement, M- sand and aggregates (6mm) were also collected and tested. To prepare solid blocks, an assembly of three moulds with conventional dimension 16*8*8 inches each was used.

The waste PET bottles of different volumes such as 250 ml, 600 ml, and 750 ml were washed. The brick bats collected from building demolition site were crushed and sieved through 4.75 mm sieve and used as a filler material for the PET bottles. The brick powder was filled into these bottles in three layers; each layer compacted by tapping the bottle on a level platform. To determine the compressive strength of blocks, the PET bottles were arranged in different patterns in the blocks such as 250 ml bottles filled with brick powder in horizontal single layer, 600 ml & 250 ml bottles in horizontal single layer, 750 ml & 250 ml bottles in horizontal single layer, 250 ml bottles in horizontal double layer, 600 ml & 250 ml bottles in horizontal double layer, 750 ml & 250 ml bottles in horizontal double layer, 250 ml bottles in vertical layer and 250 ml bottles inclined at 45^0 in single layer.

A. Plastic Bottle Brick Filled Cylinders

The cement mortar of 1:3 proportion for the cylinders by weight with a water cement ratio of 0.6 was taken for cylinder mould 150 mm in diameter and 300 mm in length. The moulds were lubricated before the brick powder was filled in. The brick powder was filled in three layers each approximately 100 mm high. After the first layers a 750 ml brick powder 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 cured in water for 28 days and compression test was conducted. 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, brick powder. 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 presented in Tables 4 to 8.

Table 4
Compressive Strength Of Solid Block Embedded With 250 Ml Pet Bottles Filled With Brick Powder In Different Positions

Sl. No.	Pattern	No. of bottles	Vol. of bottle (ml)	Wt. of block (kg)	Compressive Strength of block (N/mm^2)
1	1 Layer Horizontal	4	250	33	16.92
2	2 Layer Horizontal	8	250	35	16.92
3	1 Layer vertical	8	250	32	12.30
4	Inclined at 45^0	6	250	32.5	13.85

Table 5
Compressive Strength Of Solid Block Embedded With 600 Ml & 250 Ml Pet Bottle Blocks Filled With Brick Powder

Sl. No.	Pattern	No. of bottles	Vol. of bottle (ml)	Wt. of block (kg)	Compressive Strength of block (N/mm^2)
1	1 Layer Horizontal	2 1	600 250	35.5	12.30
2	2 Layer Horizontal	4 2	600 250	36	11.07
3	Inclined 45^0	4	600	30	5.54

Table 6
Compressive Strength Of Solid Block Embedded With 750 Ml & 250 Ml Pet Bottle Blocks Filled With Brick Powder

Sl. No.	Pattern	No. of bottles	Vol. of bottle (ml)	Wt. of block (kg)	Compressive Strength of block (N/mm^2)
1	1 Layer Horizontal	2 1	750 250	31	12.30
2	2 Layer Horizontal	2 3	750 250	34.5	13.23

Table 7
Compressive Strength Of Cylinder Embedded With 750 Ml Pet Bottle Blocks Filled With Brick Powder

Sl. No.	Vol. of Bottle (ml)	Weight of Cylinder (Kg)	Compression Strength (N/mm^2)
1	750	11.3	0.79

Table 8
Tensile Strengths Of 750 Ml Pet Bottle Cylinder Filled With Brick Powder

Sl. No.	Vol. of Bottle(Ml)	Weight of Cylinder (Kg)	Tensile Strength (N/mm^2)
1	750	11.5	0.020

B. Comparison of Compressive Strength of Conventional Block and Block Embedded with Brick Powder filled Bottles

The compressive strength of solid blocks obtained embedded with different number of PET bottles filled with brick powder in different positions is presented in Fig. 1.

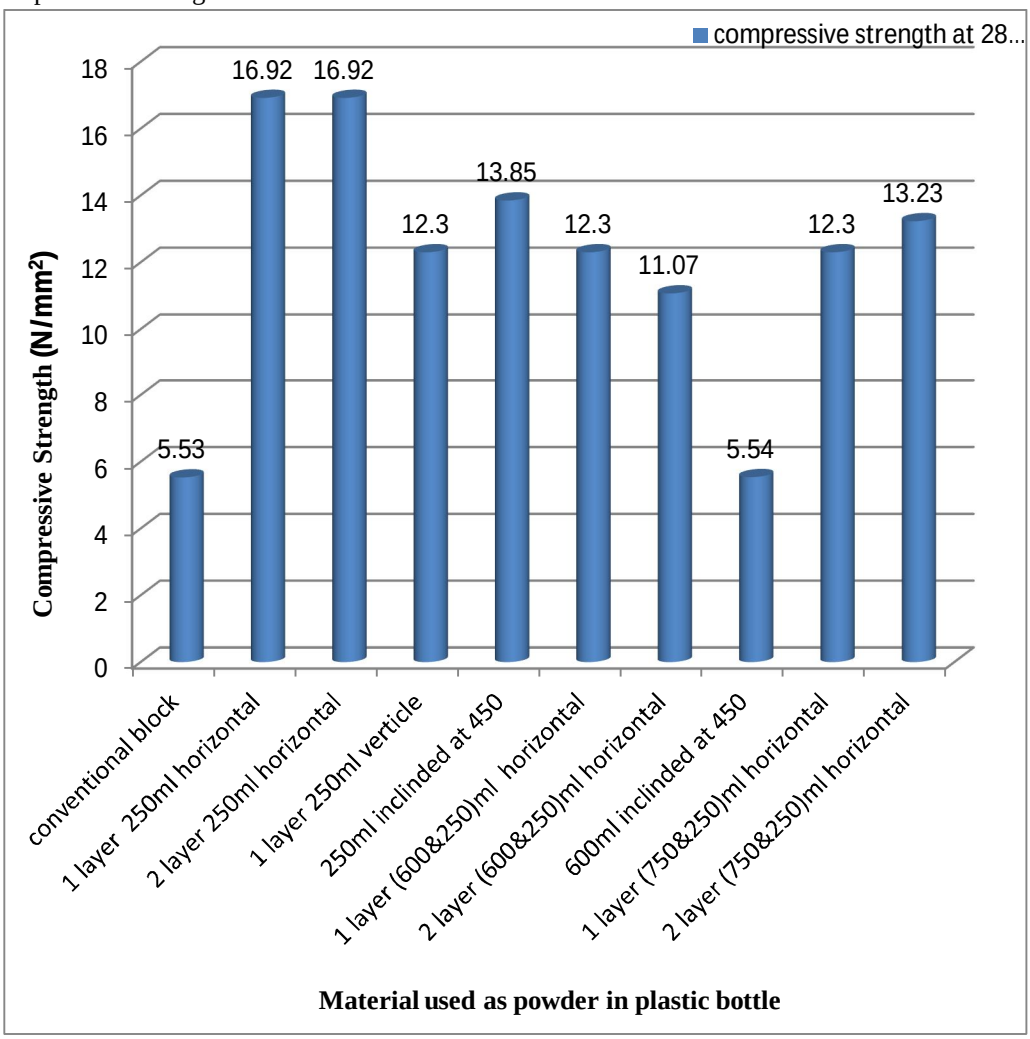

Fig. 1 Comparison of Compressive Strength of Conventional Block and Block Embedded with Brick Powder filled Bottles

IV. 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

1) 250 ml bottle

Wt. of a 250ml PET bottle = 11gms.

No. of bottles in 1 Kg. = (1000÷11) ~ 91

Cost of 1(250 ml) PET bottle = 12 ÷ 90 = Rs 0.13

2) 600 ml bottle

Wt. of a 600 ml PET bottle = 26 g

No. of bottles in 1 Kg. = (1000÷26) ~ 39

Cost of 1 (600 ml) PET bottle = 12 ÷ 39 = Rs 0.30

3) 750 ml bottle

Wt. of a 750 ml PET bottle = 34 g

No. of bottles in 1 Kg. = (1000÷34) ~ 30

Cost of 1 (750 ml) PET bottle = 12 ÷ 30 = Rs 0.40

A. Cost of Demolition Waste

2500kg = 200Rs for transport within 2-5 km distance

Cost of demolition waste per kg =Rs 0.08

1) Brick powder filled with 250 ml bottle

Cost of 250 ml bottle filled with brick powder

Wt. of brick powder filled bottle = 422 g

Empty wt. of bottle =11 g

Brick powder filled in bottle = 411g

Cost of brick powder filled in bottle =0.411X0.08 =Rs 0.033

Brick powder + bottle cost =0.033+0.13 = Rs 0.163

Total cost of 250 ml brick powder bottle = Rs 0.163

2) Brick powder filled with 600 ml bottle

Cost of 600ml bottle filled with brick powder

Wt. of brick powder filled bottle = 956 g

Empty wt. of bottle =26 g

Brick powder filled in bottle =930 g

Cost of brick powder filled in bottle =0.930X0.08 = Rs 0.075

Brick powder + bottle cost =0.075+0.30 = Rs 0.38

Total cost of 250 ml brick powder bottle = Rs 0.38

3) Brick powder filled with 750 ml bottle

Cost of 750 ml bottle filled with brick powder

Wt. of brick powder filled bottle = 1219 g

Empty wt. of bottle =34 g

Brick powder filled in bottle =1185 g

Cost of brick powder filled in bottle =1.185X0.08 = Rs 0.095

Brick powder + bottle cost =0.095+0.40 = Rs 0.50

Total cost of 250 ml brick powder bottle = Rs 0.50

4) Cost of one solid block

Aggregate 13kg	=	13 X 0.40	= Rs 5.2
M sand 13kg	=	13X0.40	= Rs5.2
Cement 2.5kg	=	2.5 X 7	= Rs17.5
Labor charge	=	Rs 4.0	= Rs4.0

Total Rs. 31.90

Table 9. Summary Of Cost Estimation Of 09 Blocks In Different Positions

Sl. No.	Volume of bottles (ml)	Position 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	1layer horizontal	4	0.163	0.68	31.9	32.60
2	250ml	2layer horizontal	8	0.163	1.31	31.9	33.21
3	250ml	vertical	8	0.163	1.31	31.9	33.21
4	250ml	inclined	6	0.163	0.98	31.9	32.88
5	600ml 250ml	1layer horizontal	2 1	0.38 0.163	0.76 0.163	31.9	32.83
6	600ml 250ml	2layer horizontal	4 2	0.38 0.163	1.52 0.326	31.9	33.75
7	600ml	inclined	4	0.38	1.52	31.9	33.42
8	750ml 250ml	1layer horizontal	2 1	0.50 0.163	1.00 0.163	31.9	33.07
9	750ml 250ml	2layer horizontal	2 3	0.50 0.163	1.00 0.489	31.9	33.39

V. CONCLUSIONS

A. The solid blocks embedded with waste PET bottles filled with brick powder and placed in different patterns resulted in different compressive strength. Each pattern has given compressive strength higher than that of a conventional solid block except the one with 600 ml bottles at 45^0 inclination.

B. The single layer, 250 ml horizontal and 250 ml double layer horizontal pattern resulted in highest compressive strength of 16.92 N/mm^2.

C. The single layer, 250 ml bottles inclined at 45^0 and double layer, 750 ml and 250 ml combined horizontal has resulted in the next highest and identical compressive strength.

D. The rest of the combinations resulted in an average compressive strength of about 12.00 N/mm^2

E. Selecting any of the above patterns will give a higher compressive strength than a conventional solid block. Hence the use of waste PET bottles filled with brick powder and embedded in solid blocks may be encouraged.

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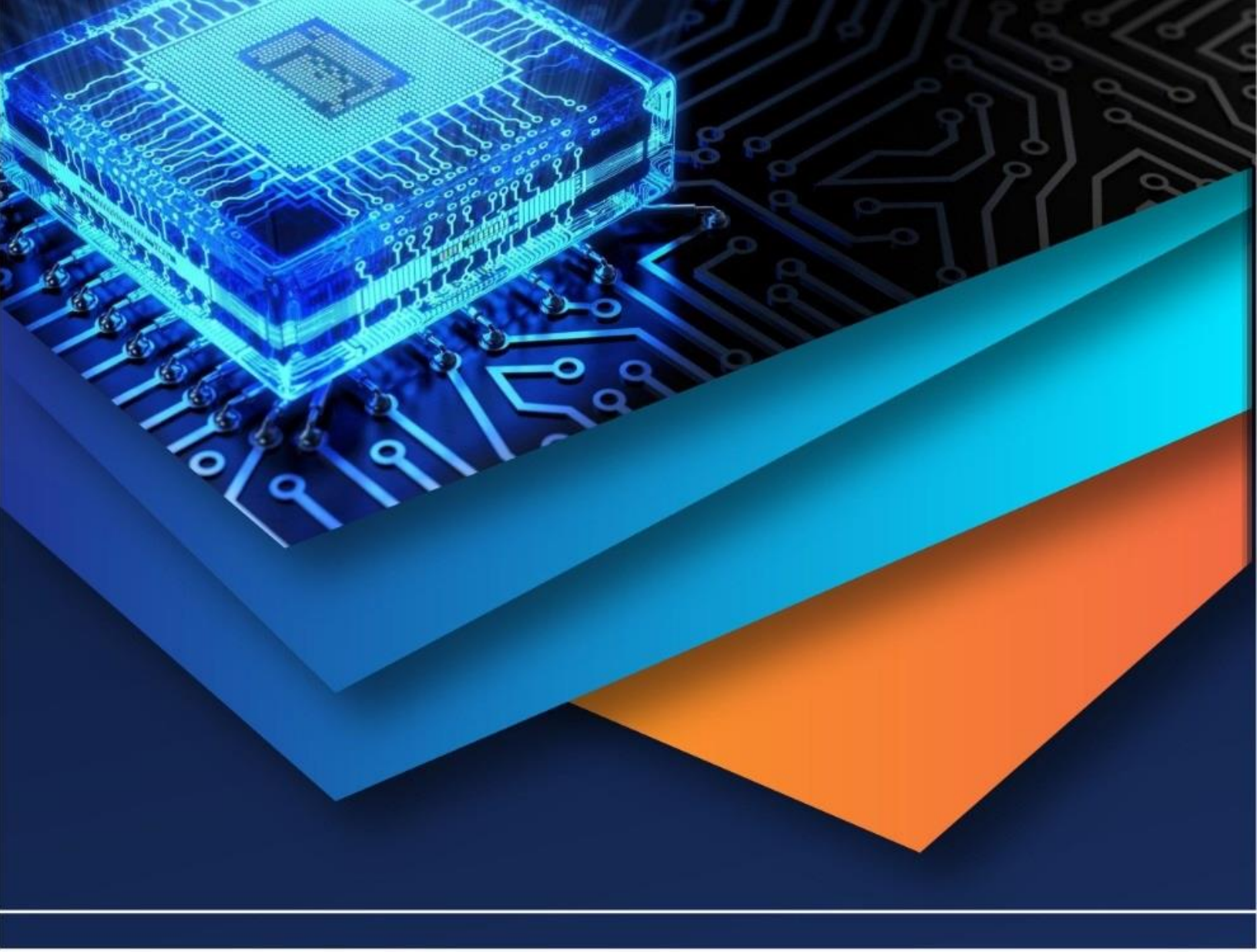

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