Study on Influence of Polyethylene Teraphthalate (PET) Bottles in Concrete Section

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Abstract-**Polyethylene Terephthalate (PET) inside concrete section is examined both experimentally under compression test, to be utilized as building units, partially replacing traditional concrete blocks. The purpose of this study was to examine the possibility of using PET bottles in Concrete block. The study required 200 ml plastic bottles placed inside concrete masonry units and analyzing of the compressive strength and other properties is done. The plastic bottles are used to create voids at equal distance between them in the masonry units. The testing for compressive strength and flexural strength test is determined according to the ASTM C140 standard. It is also proved from researches that Concrete blocks with plastic bottles have good results over traditional concrete blocks in many countries. A detailed study of concrete block with PET bottles as an advanced structural material for low cost buildings is done by comparative study. An experimental study on influence of PET bottles inside concrete block of size 400 mm x 200 mm x 150 mm for compression test is done. The results are compared for 1) Line aligned Air Filled Bottle (LAFB), 2) Zigzag aligned Air Filled Bottle (ZAFB), 3) Line aligned Fly ash Filled Bottle (LFFB), 4) Zigzag aligned Fly ash Filled Bottle (ZFFB). As per experimental result Line aligned Fly ash Filled Bottles (LFFB) has good strength. And PET bottle filled with sand, fly ash, etc. has good structural properties rather than empty PET bottles and it can be used as a construction material.**
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Keywords- **Polyethylene Terephthalate (PET) bottle, Urbanization, Eco friendly, plastic bottle, Sustainable, FEA, Ansys Workbench 16.**

1) INTRODUCTION

Despite of the scientific evolution of structural masonry technology in recent years, the design methods and structural safety analyses still need hard improvement. Now a day, most of designers of buildings prefer concrete blocks, rather than brick masonry. Concrete blocks are important and common member in building construction in India. Also, there is rapid increase in plastic bottles waste, which is harmful to environment. So, the utilization of used plastic bottles (PET) in concrete blocks will help to manage waste material. It is also proved from researches that Concrete blocks with plastic bottles have good results over traditional concrete blocks in many countries. Usage of plastic water bottles are increasing rapidly in India and other countries, are facing the challenge of overflowing of landfills and impacts of disposal of plastic water bottles.

This research intends to study the possibility of using recycled plastic water bottles within the local concrete blocks for the purpose of building construction with the focus of verifying the compressive strength. On other side of economy, they are less expensive, and consume less cement and less involvement of labors. In addition, they can be used, in different places.

The idea of using plastic bottles in concrete building construction was originated by Andreas Froses in Eco-Tec in 2001 where PET bottles are installed within the walls along with mortars to shape a structure (Froese, 2014). The Engineers without Borders at Kansas State University have worked on a method to use plastic bottles in wall construction of concrete walls. These plastic bottles were installed horizontally with concrete as mortar between them and also in the sides. Further tests were conducted to examine the compressive strength of concrete masonry units with plastic bottle cores. Results of the tests according to ASTM C140 showed that compressive strength is reasonable however further studies suggested confirming the validity in developing countries.

2) OBJECTIVES

1) To perform an experimental study on influence of PET bottles inside concrete block of size 400 mm x 200 mm x 150 mm for compression test.

2) To perform an experimental study on influence PET bottles inside concrete block of size 400mm x 200mm x 150 mm for flexural strength.

3) To compare results for ,
Line aligned Air filled Bottle (LAFB),
Zigzag aligned Air filled Bottle (ZAFB),
3) Line aligned Fly ash Filled Bottle (LFFB),
4) Zigzag aligned Fly ash Filled Bottle (ZFFB),

4) To study structural properties of PET bottles and its efficiency for construction.

3) MATERIAL PROPERTIES AND MIX DESIGNS

Concrete Mix design

a) Concrete grade	= M20
b) OPC grade	= 53
c) Max size of aggregate	= 10 mm
d) Max cement content	= 450 kg
e) W/c ratio (IS 456 table 5)	= 0.5
f) Slump	= 75mm
g) Exposure condition	=Moderate
h) Method of concrete placing	= manual
i) Degree of supervision	= good

j) Type of aggregate = coarse Angular Aggregate
k) Chemical mixer Type = Plasticizer

4) PET BOTTLE PROPERTIES

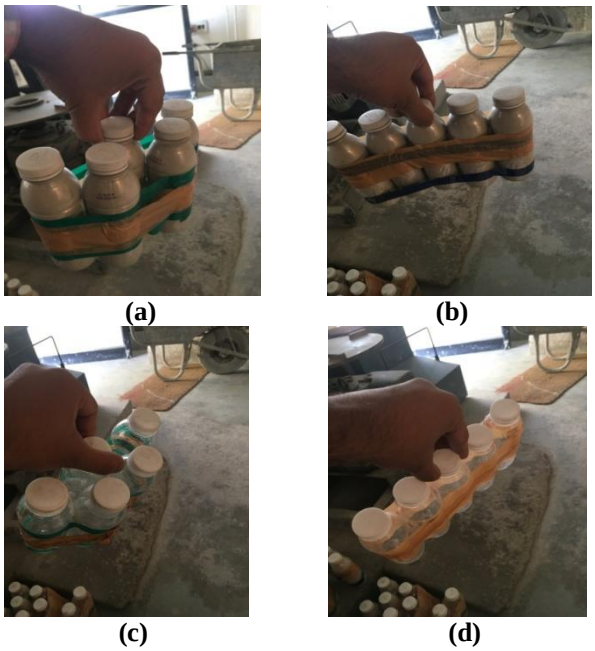
a) Wt of Single PET bottle = 10.5 gms
b) Wt of Single PET bottle Filled with fly ash = 258 gms
c) Area of bottle = 0.021 sq. m
d) Volume of Bottle = 200 ml
e) No of bottles = 250 No's

5) METHODOLOGY

The method of study designed for this research included tests for thirty six concrete blocks. In Each block five plastic bottles (200ml) was positioned. Main purpose is to control the concrete masonry to meet the ASTM C140 requirements. The compressive strength test was conducted for two times.

6) CONCRETE BRICK WITH PLASTIC BOTTLES

The size of concrete brick with plastic bottles used in this study is 200mm wide by 150mm high by 400mm long. The plastic bottles will create voids in the brick around five bottles (200 ml). This study has followed the ASTM C140 Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units as the procedure of the test. The compressive strength test of the 12 concrete blocks with plastic bottles was tested after one week; the second will be after 28 days. Each concrete blocks had five bottles and arranged as per required type i.e. 1) Line aligned Air Filled Bottle (LAFB), 2) Zigzag aligned Air Filled Bottle (ZAFB), 3) Line aligned Fly ash Filled Bottle (LFFB), 4) Zigzag aligned Fly ash Filled Bottle (ZFFB).



(a) **(b)** **(c)** **(d)**

Fig. 1: (a) Zigzag and (b) Line aligned arrangement of Fly ash Filled PET bottles
(c) Zigzag and (d) Line aligned arrangement of Air Filled PET bottles.

7) TEST PROCEDURES

In this paper the compression test procedure was based on the ASTM C140 Standard Test Methods for Sampling and Testing Concrete Masonry Units and elated Units procedure. Test was conducted on Universal Testing Machine (UTM). The three specimens of each type were taken under compression test. The loading was applied on the block in a manner of the bottles lying horizontally and subjected to a diametric compression mode, which simulates the way they are used in wall construction. The compressive strength of the blocks was determined as;

$$C=P/A$$

Where,
C= Compressive Strength in Megapascals (Mpa),

P= Compressive Load in Kilo Newton (KN),
A= Cross sectional area in meter square (sq. m).
In addition, the structural properties of single PET bottles as well as five combined PET bottles were studied. The results are noted down and are shown in tabular form as follows;

Flexural strength is one measure of the tensile strength of concrete. It is a measure of an unreinforced concrete beam or slab to resist failure in bending. The flexural strength is expressed as Modulus of Rupture (MR) in psi (MPa) and is determined by standard test methods ASTM C 78 (third-point loading) or ASTM C 293 (center-point loading). Flexural Strength of Concrete Flexural MR is about 10 to 20 percent of compressive strength depending on the type, size and volume of coarse aggregate used. However, the best correlation for specific materials is obtained by laboratory tests for given materials and mix design.
For a rectangular sample under a load in a three-point bending setup (**Fig 4-12**).

$$\delta = \frac{3FL}{2bd^2}$$

Where,
F is the load (force) at the fracture point (N),
L is the length of the support span,
b is width,
d is thickness.

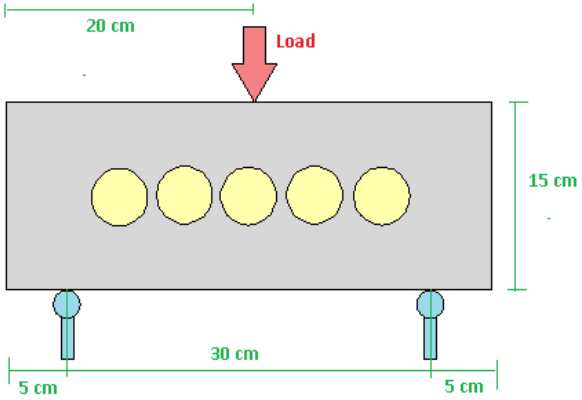


Fig 2: Setup for Flexural Test (Beam under Three Point Loading)

8) RESULT

The results for compression strength for 7 days and 28 days were determined. Table I represents the compressive load capacity for all types of concrete blocks. The first batch was tested after 7 days for 1) Line aligned Air Filled Bottle (LAFB), 2) Zigzag aligned Air Filled Bottle (ZAFB), 3) Line aligned Fly ash Filled Bottle (LFFB),4) Zigzag aligned Fly ash Filled Bottle (ZFFB). The maximum load is given with the accuracy of plus or minus 1%.The compressive strength of each of block is determined by taking the maximum load of the concrete block and dividing it by the area of the block. It is been observed that the concrete block specimens with Line aligned Fly ash Filled bottle has slightly greater strength values than other kind of concrete blocks varies near about 7.50 mpa to 7.60 mpa.

	Comp. Force (kN)	Area (m^2)	Strength (Mpa)	Weight (kg)
LAFB 1	369.93	0.08	4.62	29.91
LAFB 2	371.91	0.08	4.65	28.93
LAFB 3	370.18	0.08	4.63	30.01
ZAFB 1	358.12	0.08	4.48	28.79
ZAFB 2	360.28	0.08	4.50	28.81
ZAFB 3	363.45	0.08	4.54	29.09
LFFB 1	605.28	0.08	7.57	30.19
LFFB 2	607.43	0.08	7.59	29.89
LFFB 3	610.21	0.08	7.63	30.92
ZFFB 1	569.6	0.08	7.12	31.7
ZFFB 2	571.18	0.08	7.14	30.21
ZFFB 3	575.91	0.08	7.20	30.87

Table I: Compression test result after 7 days

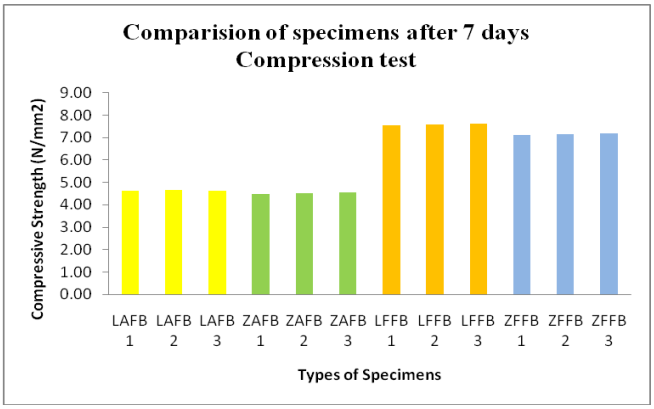


Fig. 4: Comparison between compressive strength and types of specimens after compression test (7 days).

Table II shows the strength values for concrete block specimens tested after 28 days under compression using universal testing machine as same as 7 days compression test. But, the strength values after 28 days test are greater than the 7 days test. 12 specimens were tested after 28 days for compression test. Fig.1 & Fig.2 shows the graph representing linear relationship and comparison of all types of concrete blocks after 7 days & 28 days test.

Flexural strength of all types of specimen is calculated and compared with each other in Table III and Fig 5 as shown below.

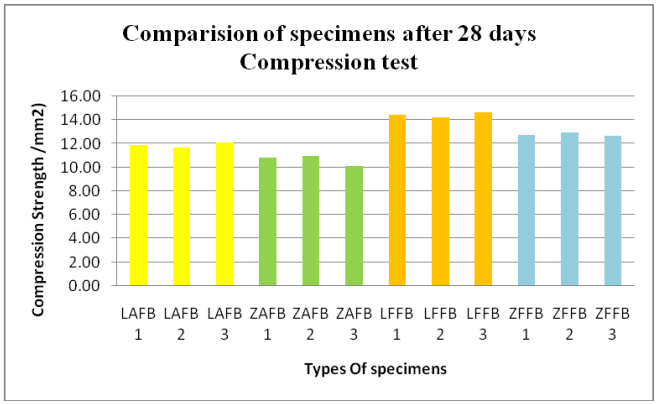


Fig. 4: Comparison between compressive strength and types of specimens after compression test (28 days).

	Comp.Force (kN)	Area (m^2)	Srength (Mpa)	Weight (kg)
LAFB 1	950.56	0.08	11.88	29.91
LAFB 2	935.34	0.08	11.69	29.2
LAFB 3	970.12	0.08	12.13	30.01
ZAFB 1	867.21	0.08	10.84	28.79
ZAFB 2	875.38	0.08	10.94	28.81
ZAFB 3	810.16	0.08	10.13	29.09
LFFB 1	1156.45	0.08	14.46	30.19
LFFB 2	1140.31	0.08	14.25	29.89
LFFB 3	1170.92	0.08	14.64	30.92
ZFFB 1	1021.13	0.08	12.76	31.7
ZFFB 2	1035.33	0.08	12.94	30.21
ZFFB 3	1015.54	0.08	12.69	30.87

Table II: Compression test result after 28 days

Column1	F (kN)	δ (Mpa)
LAFB 1	44.2	5.89
LAFB 2	43	5.73
LAFB 3	41.7	5.56
ZAFB 1	41.3	5.51
ZAFB 2	39.2	5.23
ZAFB 3	42.6	5.68
LFFB 1	62.1	8.28
LFFB 2	60.4	8.05
LFFB 3	63.5	8.47
ZFFB 1	58.7	7.83
ZFFB 2	56.2	7.49
ZFFB 3	59.1	7.88

Table III: Comparison of Flexural Strength

It can be observed that from Table III, LFFB has higher flexural strength than other kinds of specimens, i.e. average strength about 8.267 Mpa.

The comparison is done using equation, where F is the load or force at the fracture point.

The unit considered is Mpa or (N/mm^2).

Hence, depending upon above results we can easily concluded that, the deflection in LFFB is highest among other types of specimens i.e. LAFB, ZAFB, ZFFB, NB.

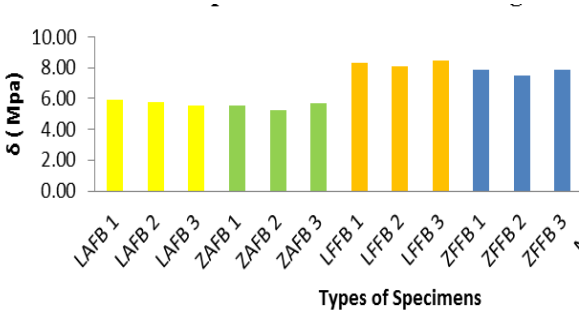


Fig. 5: Comparison of Flexural Strength

9) CONCLUSION

The following conclusions can be drawn;

The concrete block of Line aligned Fly ash Filled bottles showed slightly higher strength than the remaining else types of bottle filling, and. These blocks can be used for either as a construction or as a partition wall considering factor of safety as per IS standards. The use of concrete masonry units with plastic bottle cores could become possible in India.
Therefore using plastic bottles as an innovative material with sustainable applications may relieves the burden of their waste disposal achieving environmental awareness. Also using re-using plastic bottles in masonry reduces consumption of cement reducing the CO_2 emission. It can cause the green construction by saving energy and resources, recycling materials, minimizing the emission, having significant operational savings and increasing work place productivity. In future further researches can be conducted on other properties, economics and various environmental benefits using various placing, infill material, etc. for plastic bottles.

The study carried out and described in this entire project can be considered an approach for further investigations on the use of PET inside concrete block for structures. The results so obtained suggest that the use of PET bottles with Line Aligned Fly ash Filled Bottle (LFFB) can be effective and less expensive even for other types of structural elements. LFFB has 1.3 times i.e. 130 % greater flexural strength than NB (i.e. without PET bottle inside).

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