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Structure Made by Plastic Bottles, Geopolymer Cement & Cool Bricks

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Abstract - A Wall structure plays an important role in supporting the superstructures. In wall structures, cement and bricks are the important materials. However, cement and bricks manufacturing process will contribute to a high emission of Carbon Dioxide (CO2) which may lead to global warming and due to environmental materials. Therefore, by constructing these Bottle wall as a construction it will be able to reduce this environmental problem. We can solve the problem by replacing the use of bricks in building construction by plastic bottles filled with sand as we called it plastic bottle house. Plastic bottles are non- biodegradable so we can't use any where so we can use in construction purpose for small house and it will not harm to environment pollution, but it can also reduce the plastic pollution. The main aim of this project is the get more strength of bottle bricks. Therefore, there we calculate by one types of experiments were used to evaluate the properties of bricks and plastic bottle filled with sand which are compression test. So, we get more strength of plastic bottle filled with sand than the normal bricks. Cool bricks can also use in replacing by brick structure and it is more useful to season wise.

Key Words: Plastic bottles, Geopolymer Cement, Cool Bricks, Strength, and Temperature.

1. INTRODUCTION

All the waste is collected like bottle of various sizes, Geopolymer cement and cool bricks. These all material combine and we can make a building of G+0 or Bungalow.

Fig -1: Placing of Bottle Wall Structure

Compressive Strength can be defined as the maximum compressive stress that a material is able to resist at a limit.

Plastic is one of the most toxic materials in the modern world. Now a day, it is more difficult to make cement structure for poor people and it more costly so we use plastic bottle instead of bricks.. Can we use waste bottles for construction? Yes, it is difficult to think of a bottle csn be use as a brick. But a bottle filled with mud or sand is as strong as a brick and whatever you can do with a brick; you can do with a bottle, too. When the bottles are filled with soil or sand they work as bricks and form a framework for walls or pillars. As only regional products are used the houses are cheap and can be afforded even by poor families.

The cool brick masonry system mimics the effect of water-filled ceramic vessels. Each porous and lattice-like ceramic brick is 3D printed. Modular and interlocking, the bricks create a strong bond when set in mortar and they absorb water in their micro-pores with a sponge-like effect. As air passes through the brick's lattice structure, water held in the micro-pores evaporates, bringing cold air into the interior environment and lowering the temperature via the process of evaporative cooling. Furthermore, the printed brick shapes create shaded surfaces on the wall, helping to keep the surface cool and protected from the sun.

Fig -2: Cool bricks

2. LITERATURE REVIEW

Project Date:2008, The 3rd ACF International conference ACF/VCA Nguyen V. C., PhD., Bui Dang Trung, Geopolymer is a type of amorphous alumina-silicate cementitious material. Geopolymer can be synthesized by

polycondensation reaction of geopolymeric precursor, and alkali polyciliate. Comparing to Portland cement the production geopolymer has a relative high strength, excellent volume stability, better durability. Geopolymer concrete based on pozzolana is a new material that does not need the presence of portent cement as binder. This paper presents the result of studying material mixture composite, microstructure of geopolymer, and parameters affecting properties of geopolymer concrete.

Keywords: Geopolymer, mixture composite, microstructure, properties of concrete

Project date: 3 January 2017**,** Waste Plastic Bottle as Construction Material**,** Simanshu P. Pandey, Sakshi Gotmare, Prof. S.A.Wankhade**.** Disposal of non bio-degradable substance has become an issue of major concern now days. Mounds of plastic garbage have been created on earth surface. Laterite quarry waste is abundantly available and disposal of waste plastics (PET, PP, etc) is the biggest challenge. 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.

Keywords: Plastic Bottle, Sustainable Material, Construction material, Innovative wall.

Project name: Application Of Plastic Bottle as a Wall Structure for Green House, Mardiha Mokhtar, Suhaila Sahat, Baizura Hamid, Masiri Kaamin, M. Jahaya Kesot, Law Chia Wen, Loo Yong Xin, Ng Pei Ling, Vivian SimJia Lei. Wall structure plays important roles in supporting the superstructures, separates spaces in buildings into sections and delineates a space in open air. Most of the construction of house in Malaysia use bricks and mortar which consists of cement, aggregates and water as the materials to build the structure of wall. However, cement and bricks manufacturing process will contribute to a high emission of carbon dioxide (CO2) which may lead to global warming.

Reuse of these non-biodegradable plastic bottles not only can solve the environmental problem, but it can also reduce the pollution. The main concern of this project is the strength of bottle bricks. The compression test is prepared for 1.5L bottle brick, 250ml bottle brick and common clay brick. As results, the strength of 1.5L and 250ml bottle bricks is 3 and 4 times respectively stronger compare to common clay brick.

Keywords: Bottle bricks Strength Global warming Temperature Air humidity Wind velocity.

3. METHODOLOGY AND EXPERIMENT

3.1 Methodology

For Plastic Bottles.

- Filling the bottles with Sand, Gravels and Debris.
- Collection and cleaning of waste plastic bottles.
- Construction of column and wall done by using plastic bottles.
- Position of beams for stable roof and roofing with cemented /tin sheet.
- Leveling of the floor with bottles.
- Foundation will be done with bottle, bricks and concrete.
- Plastering and painting of wall.

For Geopolymer Cement

- Choose fly ash to red mud ratio.
- Choose silicate to aluminum ratio.
- Choose water content.
- Choose additional additives.
- Pre-weigh all components.
- Mix all components together and mix it thoroughly.
- Pour slurry into pre-made PVC pipes for designated time intervals.
- Compare samples qualitatively & through compression testing when applicable.

Fig -3: Methodology of Geopolymer Cement

Comparison for plastic bottle and brick work: For construction Time and speed of Execution for 5 persons team-one working day for plastic wall is 15% faster and for brick wall 120 m2. Material and equipment cost for plastic bottle wall is less as compared to brick wall. Transportation cost for plastic bottle wall construction is less than brick wall. Plastic bottle wall construction require less manpower as compare to brick wall and require high cost. Strength and load capacity for plastic

bottle wall construction is 20 times more than brick wall construction.

3.2 Cost Comparison between Brick Masonry Wall and Bottle Masonry Wall.

Here, we consider 10 sq. meter Masonry works for calculation of quantities.

- **Brick Masonry Wall.**

1. Number of Bricks

Actual size of brick = 19 * 9 * 9 cm.

Normal size of brick with mortar joint = 20 * 10 * 10 cm.

Volume of brick masonry = Area * Thickness of wall.

$= 10 * 0.23$

$= 2.3\ m^3$

$$\text{Number of bricks} = \frac{\text{Volume of brick masonry}}{\text{Volume of brick with mortar}}$$

$$= \frac{2.3}{0.2 * 0.1 * 0.1}$$

$= 1150$ no.

2. Mortar

Actual volume of brick in brick masonry

$=1150 * 0.19 * 0.09 * 0.09 * 0.09$

$= 1.76 m^3$

Volume of wet mortar = 2.3 - 1.76

$= 0.54\ m^3$

Take,

Increase the quantity by 15% for frog filling, cut bricks, wastage.

$$\text{Volume of Wet mortar} = 0.54 + \left(0.54 * \frac{15}{100}\right)$$

$= 0.621\ m^3.$

Volume of dry mortar reduces by 25% when water is added.

$$\text{Volume of dry mortar} = 0.621 + \left(\frac{25}{100} * 0.621\right)$$

$= 0.776\ m^3.$

3. Material for 1:3 Brick work.

Volume of brick masonry = $2.3\ m^3$

Number of bricks = 1150 numbers.

Proportion = 1:3.

Volume of dry mortar = $0.7763\ m^3$.

∴ C: S = 1:3 = 3 + 1 = 4

$$\text{Cement} = \frac{1}{4} * 0.776 = 0.194\ m^3$$

$$\text{Number of bag} = \frac{0.194}{0.035} = 5.54 \cong 6 \text{ bags.}$$

$$\text{Sand} = \frac{3}{4} * 0.776 = 0.582\ m^3$$

Table -1: Cost analysis of 10 m^2 brick masonry wall.

Sr.no.	Materials	Quantity	Rate	Per	Amount in Rs.
1	Bricks	1150	5	no.	5750
2	Cement	5.54	350	bag	1939
3	Sand	0.582	1700	m^3	990
				Total	8679

- **Plastic Bottle Masonry Wall**

1. Volume of bottle.

r_1= 1.4 cm

r_2 = 3.25 cm R = 3.25m, ∴ D = 6.5 cm = 0.065m

h1 = 13.5 cm

h2 = 7 cm H=13.5+3.25 = 20.5cm = 0.205m

Actual size of bottle = 20.5* 6.5 Ø cm

Normal size of bottle with mortar joint = 20.5 * 7.5 Ø cm.

Volume of Bottle masonry = Area * Thickness of wall

$= 10 * 0.205 = 2.05\ m^3.$

$$\text{No. of Bottle} = \frac{\text{volume of bottle masonry}}{\text{volume of 1 bottle with mortar joint}}$$

$$= \frac{2.05}{0.205 * \left(\frac{\pi}{4} * 0.075^2\right)} = 2263.5 \cong 2265 \text{ no.}$$

2. Mortar

Actual volume of brick in brick masonry

$=1150 * 0.19 * 0.09 * 0.09 * 0.09$

$= 1.76 m^3$

Volume of wet mortar = 2.3 - 1.76

$= 0.54\ m^3$

Take,

Increase the quantity by 15% for frog filling, cut bricks, wastage.

$$\text{Volume of Wet mortar} = 0.54 + \left(0.54 * \frac{15}{100}\right)$$

$= 0.621\ m^3.$

Volume of dry mortar reduces by 25% when water is added.

$$\text{Volume of dry mortar} = 0.621 + \left(\frac{25}{100} * 0.621\right)$$

$= 0.776\ m^3.$

3. Material for 1:3 Brick work.

Volume of brick masonry = 2.3 m^3

Number of bricks = 1150 numbers.

Proportion = 1:3.

Volume of dry mortar = 0.7763 m^3.

For 1 bag of cement- Weight=50kg,

Volume=0.035m^3

∴ C: S = 1:3 = 3 + 1 = 4

Cement = $\frac{1}{4} * 0.776 = 0.194\ m^3$

Number of bag = $\frac{0.194}{0.035} = 5.54 \cong 6$ bags.

∴ Here, consider 500 ml of plastic bottle.

∴ 1 ml =1cm^3

Sand = $\frac{3}{4} * 0.776 = 0.582\ m^3$

Soil = 1990 * (1000*10^{-6}) = 1.99 m^3.

4. Number of labour.

One labour can made 450 bottles per day (filling soil in bottle).

Total no. of bottles = 2263.5 no.

Numbers of labour needed = $\frac{2265}{450} = 5.03 \cong 5$ no.

5. Calculate cost of per Plastic bottle

Rate of bottle in market = 10 rs/bottle with water filled.

25 bottles are packed in 1 carriage box = 120rs.

∴ = $\frac{120}{25} = 4.8$ rs/bottle with water filled.

∴ = $\frac{4.8}{10}$ =0.4 rs/bottle without water filled.

Table -2: Cost analysis of 10 m^2 plastic bottle masonry wall.

Sr.no.	Materials	Quantity	Rate	Per	Amount in Rs.
1	Plastic bottles	2265	0.4	bottle	906
2	Cement	5.54	350	bag	1939
3	Sand	0.582	1700	m^3	990
4	Soil	1.99	150	m^3	298.5
5	Labour work	5	300	person	1500
				Total	5633.5

3.3 Benefits of Plastic Bottle Masonry Wall and Cool Bricks.

The most important benefits of these alternative innovative materials compared to conventional materials such as brick can include:

A. Good construction ability: The walls built by these bottles are lighter than the walls built by brick and block, and that makes these buildings to show a good response against earthquake.

B. Low cost: 75 % cost will be reduces by constructing with plastic bottle as compare to brick structure.

C. Non-brittle characteristic: Using the non-brittle materials can reduce construction waste. Unlike brick, plastic bottle is non-brittle.

D. Absorbs abrupt shock loads: the plastic bottles are not fragile, they can be flexible and tolerates sudden loads without failure.

E. Green Construction: Plastic bottles can cause the green construction by saving energy and resources, recycling materials, minimizing the emission, having significant operational savings and increasing work place productivity.

3.4 Experiment Work

- **Analysis**

Table -3: Material Analysis

Size of the Cube	Mortar Proportion	W/C Ratio
150X150X150cm	1:3	0.3

Table -4: Proportional Ratio for Block

Size of the block	Mortar Proportion
150x150x150cm	1:3

- **Experimental Work Compressive Strength On Plastic Bottles.**

Table -5: Compressive Strength on Plastic Bottle.

No. of Reading Taken	Compressive Strength (Mpa)	Average Compressive Strength (Mpa)
1	7.9	
2	8	8
3	8.1	

- **Experimental Work of Geopolymer Cube Test and Normal Concrete Cube**

Density = $\frac{\text{Wt.of cube}}{\text{Size of cube}}$

= $\frac{3.35}{0.15*0.15*0.15}$ = 992.59 Kg/m^3

Compressive Strength = $\frac{\text{Load}}{\text{Area}}$

$= \frac{323*10^3}{150*150}$

$= 14.35\ \text{N/mm}^2$

Curing days- 7 Days.

Area of cubes- 150 * 150 mm^2

Table -6: 7 days Compressive Reading on Normal Concrete Cube

Sr. No.	Wt Of Cubes (Kg)	Density Of Cubes (Kg/M^3)	Failure Load (KN)	Comp. Strength (N/Mm^2)	Avg. Comp Strength (N/Mm^2)
1	3.35	992.59	323	14.35	
2	3.54	1048.88	286	12.71	13.07
3	3.6	1066.67	274	12.17	

Curing days- 7 Days.

Area of cubes- 150 * 150 mm^2

Table -7: 7 days Compressive Reading on Geopolymer Cement Cube

Sr. No.	Wt. Of Cube (Kg)	Density Of Cubes (Kg/M^3)	Failure Load (KN)	Comp. Strength (N/Mm^2)	Avg. Comp. Strength (N/Mm^2)
1	8.4	2488.89	310	13.77	
2	8.5	2518.52	315	14	13.96
3	8.6	2548.51	318	14.13	

3.5 Manufacture of Cool Bricks.

Manufacturing of cool bricks includes following process:

Preparation of Clay: Preparation of clay is done manually or by mechanically operated machines (excavators). Preparation of clay consists of following methods:

- **Un-soiling**: Un-soiling is the process of removal of top layer soil which consists of vegetation, Kankar or other impurities.
- **Digging**: Digging is the process of excavation of clay. It is done manually by tools or by machines such as excavators.
- **Cleaning**: Cleaning is the removal of impurities such as stones, Kankar and garbage materials. It is done by hand-picking method or by sieves.
- **Weathering**: Weathering is done to get the adequate amount of moisture in clay. In this method clay is spread in the form of layers (600to1200mm) and exposed to atmosphere for natural drying for at least 30 days.
- **Blending**: Blending is the process of mixing other constituent materials such as chalk, sand, limestone etc. to clay. This provides desired characteristics to clay.
- **Tempering**: Tempering is to knead the clay into a homogeneous mass with uniform consistency. Kneading can be done manually or by machines.
- **Moulding**: Molding is the process of giving desired shape to the tempered clay. Moulding is done manually or by machines. Mold is made up of wood or steel.
- **Drying**: Drying is to evaporate all superfluous moisture contained at the time of moulding without damaging the bricks and to make brick hard enough so it can handle operations in burning.

3.6 The Principle behind Cool Bricks

Cool Bricks masonry walls use this principle to passively cool the interiors of our homes. Made up of 3 dimensional printed porous ceramic bricks set in mortar, each brick absorbs water like a sponge. These bricks can be filled with water just like a sponge.

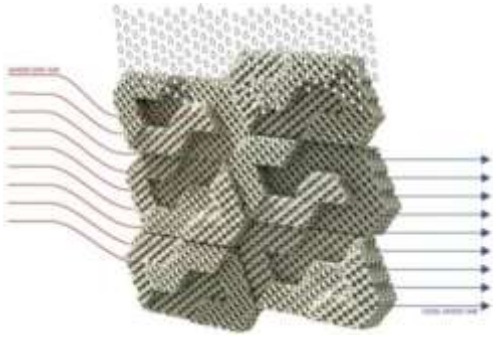

Fig -4: Photo of Cool Bricks

When the hot and dry air passes through the bricks, the air absorbs the water through evaporation and becomes cooler. This cooler air enters our rooms, lowering the interior temperature. Cool Bricks are modular and interlocking. They can be stacked together to create large screens. The 3-dimensional lattice creates a strong bond when set in mortar. The shape of the brick also creates a shaded surface on the wall to keep a large percentage of the wall's surface cool and protected

4. RESULTS

Compression strength of Geopolymer cement is more than normal concrete.
Cost of construction of plastic bottle is less than brick wall construction.

5. CONCLUSIONS

Red mud and fly ash based Geopolymer can act as a green alternative to cement. Much less energy consumption.
Almost no CO_2 emissions.
The compressive strength of Geopolymer cement is 1.5 times more than that of ordinary Portland cement.
Green house gas reduction potential as much as 90% when compared With OPC.
These plastic bottles are cheap so we can construct by bottle for poor people as a shelter.
Plastic bottles generally have a more durability of over 300 years which is more compared to standard bricks.
Cost of brick bottle construction is more economical than standard bricks.
Weight of a unit bottle brick was less than that of a standard brick. Compressive strength of the bottle brick is equal to standard brick.

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