

# Green Sustainable Bricks Made of Fly Ash and Discarded Polyethylene Waste

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**ABSTRACT:** Green products which are made out of recycled, waste or discarded product can help the environment on a large scale. Construction industry can make use of large amount of green and sustainable products. By undertaken this experimental study a new green sustainable product has been created which makes use of discarded polyethylene waste which is extremely difficult to recycle and decompose along with the thermal energy by product i.e. fly ash to make composite bricks of cement fly ash and discarded polyethylene waste in shredded form. The results of these composite bricks have been compared against the red clay bricks and cement fly ash bricks available in the market. The purpose of comparison is to conclude whether the bricks have sufficient characteristic properties that it will be a viable replacement to the red clay bricks which pose a serious environmental threat.

**KEYWORDS:** Green Product, Fly ash, Composite bricks, Polyethylene waste, Sustainable.

## I. INTRODUCTION

The need for the construction industry to move towards Green and Sustainable products is the need of the hour since our dependency on non-renewable products is causing severe environmental damages, which in the longer run is harmful. Construction industry is infamous for the large amount of pollution which is caused by direct and indirect ways.

No matter how small a change or product that is used in the construction activity it will help to achieve the goal of sustainability in the longer run.

The use of conventional red clay bricks in our Indian construction industry is still rampant, the demand and use of red clay bricks is in several thousand crore and this is a major cause of concern Even the manufacturing of the clay bricks is a environmental concern as the brick kiln emit large amount of green house gases like carbon monoxide and oxides of sulphur, plus the trees are cut down which is used as fire wood to bake the bricks Our country's biggest source of electricity is obtained via thermal power plants, India has one of the largest coal reserves in the world but the coal mined here is high in ash content and low calorific value which is a major problem as well. Since close to 70% of the electricity is generated by burning of coal India has a huge problem of fly ash disposal which is a waste by product. Fly ash causes air, water and soil pollution when it is exposed to environment. Construction industry is one of the major sectors which can absorb large amount of fly ash and use it as a construction material Another rising environmental concern is the pollution due to discarded polyethylene waste, large scale dumping grounds which converts fertile land barren and is a serious threat to health. Polyethylene is an extremely stable product and the takes excessive duration of time to degrade on its own. Biodegrading of plastic is an extremely slow process and this is a rising concern in India as our plastic utilization has increased and we are only next to America and China in terms of plastic waste generation. Recycling polyethylene is also a difficult process because the melting point of the various types of polyethylene differs, plus segregating the plastic as per its type is a time consuming and costly process.

So the purpose of this experimental study is to find out whether a sustainable green product can be made by utilizing two waste products i.e. fly ash and discarded polyethylene waste in shredded form.

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## II. RELATED WORK

There have been several types of experimental work on Fly ash-Cement-Lime/Gypsum bricks by varying the percentage of each component and also by adding several other waste product which might help to enhance its characteristics like rice husk, PET, virgin plastic resin, steel slag and bottom ash among other things.

In some research work experimentation was done on fly ash bricks by mixing it with various other raw ingredients such as red clay, paper pulp. Substantial amount of work was found on use of polyethylene terephthalate (PET) but this ingredient was not used as suitable means to break down the PET product into smaller size ingredients were not available. The national thermal power corporation also some useful guidelines for the making of fly ash bricks with various other ingredients as well.

In the literature survey there was no satisfactory data found on the use of shredded polyethylene/waste polyethylene in brick making process. Work has been done on use of melted polyethylene for flexible pavement construction and melted plastic bricks, which are both energy intensive process but no where the use of shredded polyethylene waste was found.

## III. SCOPE OF RESEARCH

The scope of this experimental study is to make sustainable green composite bricks made up of fly ash, cement and discarded polyethylene waste which a growing problem is given the vast amount of polyethylene/plastic products we use today. An experimental study is to be conducted and the physical, mechanical properties of the brick made from these two waste materials will be compared with that of the conventional red clay bricks and fly ash bricks.

## IV. PROPOSED METHODOLOGY AND DISCUSSION

To start the experimental study first the method of manufacturing the fly ash bricks was studied by visiting the fly ash manufacturing plants. The two standard methods used to make cement fly ash bricks were by i-Vibro Press-machine plus manual operation, ii-Hydraulic Press- automated machine. For experimental and small scale brick making the Vibro press assembly was more suited and hence was used to cast the bricks. The waste polyethylene was collected from the garbage bins and local community houses which was later shredded into smaller particles by using a shredding device called the Agglomerator.

Deciding the mix proportion of the composite bricks was the most crucial part; the literature survey showed that for optimum strength gain characteristics 40-45% fly ash was found to be ideal. After visiting several fly ash plants the cement content in the mix was found to be between 8% and 12%, water was added till proper flow ability was achieved. No prior data was found as to how the properties of fly ash bricks are affected when shredded polyethylene was added to the mix. The discarded polyethylene waste in shredded form was added as percentage of cement by weight in the mixture. A total of 6 varying polyethylene proportions were decided of which the initial 3 proportions have been casted and tested. The following figures show the discarded polyethylene waste in shredded form and the mixing of the shredded polyethylene into the mixture

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a) Shredded Polyethylene Waste in shredded form



b) The Shredded polyethylene being added to the mixture

The final mix proportions for a 100kg mixture was 45% by weight fly ash, 40% by weight crushed stone aggregate and 15% by weight OPC 53 grade cement. The table 1 enlist the weight of plastic added for different ratios taken into consideration. A 100 kg mixture of bricks would contain 15% OPC 53 grade cement i.e. 15kg cement. Shredded plastic will be added to the mixture as a percentage of the cement present in the mixture

Table 1: The quantity of Shredded Polyethylene added as per the Varying Proportions

| Sr.No | Shredded Polyethylene added as a Percentage of cement by weight | Weight of Shredded Polyethylene added in the Mixture(grams) |
|-------|-----------------------------------------------------------------|-------------------------------------------------------------|
| 1     | 0%                                                              | 0                                                           |
| 2     | 5%                                                              | 750                                                         |
| 3     | 10%                                                             | 1500                                                        |

The dimensions of the bricks are as per the IS 12894:2002, Clause 5.1.2 Dimensions and tolerance for non-modular bricks. A batch of 20 bricks for every varying proportion has been cast as per the IS 5454:1978.

The bricks were made following all the guidelines given by NTPC. After the casting the bricks were allowed to harden for a period of 24 hours after which they were moved to a curing tank. Once 28 days strength gain period was over the standard test were carried out by following the IS- 12894:2002 Pulverized fuel ash-lime brick specification and IS 3495 (Part 1 to 4):2002 Indian standard method of test for Burnt clay building bricks.

As per the above mentioned Indian Standard codes a series of test were carried out on the composite bricks to find out its properties like wet and dry compressive strength, water absorption, hardness and soundness test. The procedures implemented and formula used are also as per the IS code.

After the obtaining the results for the composite bricks they were compared with the results of the conventional red clay bricks and fly ash bricks which were available in the market.

## V. EXPERIMENTAL RESULTS

A) Soundness test-This sound is carried out to find out that a clear ringing sound is produced or not when the two bricks are struck with each other without breaking any of the two bricks. If the two bricks are not broken after striking with each other and a clear ringing sound is produced then it means that the bricks are sufficiently sound. The procedure of this test is self explanatory.

The conventional red clay bricks and fly ash bricks showed good results when struck together and the composite bricks gave a clear ringing sound when stuck against one another. The sound was much clearer and sharper when compared to conventional bricks.

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B) Hardness test-This test is carried out to see that the brick is sufficiently hard or not. We can judge hardness of the brick by making impression on the surface of the brick with the help of a finger nail. This test was carried out for all samples of fly ash bricks and clay bricks and composite bricks.

After carrying out the test there was no impression of scratching on the surface of the composite bricks.

C) Water Absorption Test- The water absorption test is carried out for only simple purpose i.e. to find out the amount of water absorbed by the brick when exposed to water for long duration of time. Lesser the water absorption the better it is.

The bricks were marked and dry weight (W1) of the bricks was taken before emersion in water, the wet weight after 24 hours was taken (W2). Water Absorption % =  $(W2-W1)/W1 \times 100$ . The following tables below show the water absorption values for the three initial ratios taken in to consideration. The more is the polyethylene percentage the lesser are the water absorption values.

Table 2: Water absorption for 0% Polyethylene composite bricks

| Sr.No | Dry Weight(grams) | Wet Weight(grams) | Percentage Water Absorbed |
|-------|-------------------|-------------------|---------------------------|
| 1     | 4247.0            | 4280.0            | 0.775                     |
| 2     | 3969.0            | 3990.0            | 0.755                     |
| 3     | 4296.0            | 4324.0            | 0.659                     |
| 4     | 4269.0            | 4309.5            | 0.936                     |
| 5     | 4343.5            | 4386.0            | 0.978                     |

Average Water Absorption = 0.8206%

Table 3: Water absorption for 5% Polyethylene composite bricks

| Sr.No | Dry Weight(grams) | Wet Weight(grams) | Percentage Water Absorbed |
|-------|-------------------|-------------------|---------------------------|
| 1     | 4308.0            | 4342.0            | 0.7892                    |
| 2     | 4904.0            | 4915.0            | 0.234                     |
| 3     | 4293.5            | 4907.5            | 0.326                     |
| 4     | 4391.0            | 4412.0            | 0.478                     |
| 5     | 4499.0            | 4513.5            | 0.290                     |

Average Water Absorption = 0.4234%

Table 4: Water absorption for 10% Polyethylene composite bricks

| Sr.No | Dry Weight(grams) | Wet Weight(grams) | Percentage Water Absorbed |
|-------|-------------------|-------------------|---------------------------|
| 1     | 3918.0            | 3931.0            | 0.3318                    |
| 2     | 3853.0            | 3870.0            | 0.4412                    |
| 3     | 3869.0            | 3882.0            | 0.3360                    |
| 4     | 4307.5            | 4329.0            | 0.4990                    |
| 5     | 4313.0            | 4330.0            | 0.3941                    |

Average Water Absorption = 0.40043%

D) Wet Compressive Strength-For finding out the wet compressive strength the frog of the bricks are filled with a cement and sand mortar and then the mix is left to dry for a couple of hours. After which it is covered by moist gunny

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bags for 24 hours. Followed by this the bricks with their frog filled are immersed in clean water for duration of 3 days after which they are removed and any excess surface moisture is wiped off.

The following figures show the Universal Testing Machine setup with composite brick specimen and the brick specimen after failure.



(d) Universal Testing Machine with brick Specimen



(e) The Brick Specimen after Failure.

The formula is as follows

Compressive strength in  $N/mm^2$

(Kgf,  $cm^2$ ) = Maximum load at failure in N (kgf)/Average area of the bed faces in  $mm^2$  ( $cm^2$ )

The average dimension of the bricks are L= 230mm, B= 105mm, H= 75mm

The tables below show the wet compressive strength of the samples tested and also the average compressive strength.

Table 5: Wet Compressive Strength of 0% Polyethylene composite bricks

| Sr.No | Dimensions (mm)<br>LBH | Load Taken(KN) | Compressive Strength<br>MPA ( $N/mm^2$ ) |
|-------|------------------------|----------------|------------------------------------------|
| 1     | 230x105x75             | 430.91         | 17.84                                    |
| 2     | 230x105x75             | 403.38         | 16.70                                    |
| 3     | 230x105x75             | 396.03         | 16.39                                    |
| 4     | 230x105x75             | 414.66         | 17.16                                    |
| 5     | 230x105x75             | 392.925        | 16.26                                    |

Average Compressive Strength =16.87 MPA

Table 6: Wet Compressive Strength of 5% Polyethylene composite bricks

| Sr.No | Dimensions (mm)<br>LBH | Load Taken(KN) | Compressive Strength<br>MPA ( $N/mm^2$ ) |
|-------|------------------------|----------------|------------------------------------------|
| 1     | 230x105x75             | 392.43         | 16.25                                    |
| 2     | 230x105x75             | 400.64         | 16.59                                    |
| 3     | 230x105x75             | 400.16         | 16.57                                    |
| 4     | 230x105x75             | 419.002        | 17.35                                    |
| 5     | 230x105x75             | 437.11         | 18.15                                    |

Average Compressive Strength = 16.982 MPA

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Table 7: Wet Compressive Strength of 10% Polyethylene composite bricks

| Sr.No | Dimensions (mm)<br>LBH | Load Taken(KN) | Compressive Strength<br>MPA (N/mm <sup>2</sup> ) |
|-------|------------------------|----------------|--------------------------------------------------|
| 1     | 230x105x75             | 493.38         | 20.43                                            |
| 2     | 230x105x75             | 463.48         | 19.18                                            |
| 3     | 230x105x75             | 512.94         | 21.24                                            |
| 4     | 230x105x75             | 499.66         | 20.69                                            |
| 5     | 230x105x75             | 487.83         | 20.21                                            |

Average Compressive Strength = 20.34 MPA

E) Dry Compressive Strength- For finding out the dry compressive strength the frog of the bricks are filled with a cement and sand mortar and then the mix is left to dry for a couple of hours. After which it is covered by moist gunny bags for 24 hours. Followed by this the bricks with their frog filled are allowed to dry so that any moisture absorbed from the gunny bag can evaporate and the bricks are completely dry before testing. The formula is same as that of wet compressive strength. The tables below show the dry compressive strength of the samples tested and also the average compressive strength.

Table 8: Dry Compressive Strength of 0% Polyethylene composite bricks

| Sr.No | Dimensions (mm)<br>LBH | Load Taken(KN) | Compressive Strength<br>MPA (N/mm <sup>2</sup> ) |
|-------|------------------------|----------------|--------------------------------------------------|
| 1     | 230x105x75             | 391.23         | 16.2                                             |
| 2     | 230x105x75             | 402.33         | 16.66                                            |
| 3     | 230x105x75             | 420.45         | 17.41                                            |
| 4     | 230x105x75             | 421.65         | 17.46                                            |
| 5     | 230x105x75             | 386.15         | 15.99                                            |

Average Compressive Strength =16.744 MPA

Table 9: Dry Compressive Strength of 5% Polyethylene composite bricks

| Sr.No | Dimensions (mm)<br>LBH | Load Taken(KN) | Compressive Strength<br>MPA (N/mm <sup>2</sup> ) |
|-------|------------------------|----------------|--------------------------------------------------|
| 1     | 230x105x75             | 579.78         | 24.07                                            |
| 2     | 230x105x75             | 517.68         | 21.43                                            |
| 3     | 230x105x75             | 525.71         | 21.76                                            |
| 4     | 230x105x75             | 474.67         | 19.65                                            |
| 5     | 230x105x75             | 428.19         | 17.73                                            |

Average Compressive Strength = 20.91 MPA

Table 10: Dry Compressive Strength of 10% Polyethylene composite bricks

| Sr.No | Dimensions (mm)<br>LBH | Load Taken(KN) | Compressive Strength<br>MPA (N/mm <sup>2</sup> ) |
|-------|------------------------|----------------|--------------------------------------------------|
| 1     | 230x105x75             | 522            | 21.60                                            |
| 2     | 230x105x75             | 468.75         | 19.40                                            |
| 3     | 230x105x75             | 530.21         | 21.95                                            |
| 4     | 230x105x75             | 531.66         | 22.00                                            |
| 5     | 230x105x75             | 486.07         | 20.12                                            |

Average Compressive Strength = 21.017 MPA

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The data collected for the standard test results of red clay bricks and cement fly ash bricks is as follows: (the average of the result is reported). The values from these tables below are used for the comparison between the composite bricks and the conventional red clay bricks and fly ash bricks available in the market.

Table 11: Standard Results of Red clay bricks available in the market

| Sr.No | Dimensions(mm)<br>LBH | Water Absorption % | Wet Compressive<br>Strength (N/mm <sup>2</sup> ) | Dry<br>Compressive<br>Strength<br>(N/mm <sup>2</sup> ) |
|-------|-----------------------|--------------------|--------------------------------------------------|--------------------------------------------------------|
| 1     | 232x101x75            | 18.23              | N.A                                              | 5.24                                                   |
| 2     | 220x100x75            | 14.80              | N.A                                              | 6.09                                                   |
| 3     | 222x100x76            | 17.91              | 5.93                                             | 7.05                                                   |
| 4     | 220x100x75            | 14.34              | N.A                                              | 6.36                                                   |
| 5     | 230x110x75            | 13.58              | N.A                                              | 8.05                                                   |
| 6     | 220x100x75            | 18.31              | 5.00                                             | 6.04                                                   |
| 7     | 220x100x75            | 13.88              | N.A                                              | 4.97                                                   |

Table 12: Standard Results of Fly ash bricks available in the market

| Sr.No | Dimensions(mm)<br>LBH | Water Absorption % | Wet Compressive<br>Strength (N/mm <sup>2</sup> ) | Dry<br>Compressive<br>Strength<br>(N/mm <sup>2</sup> ) |
|-------|-----------------------|--------------------|--------------------------------------------------|--------------------------------------------------------|
| 1     | 228x102x78            | 14.97              | 5.39                                             | 6.80                                                   |
| 2     | 239x112x88            | 11.19              | 6.16                                             | 7.02                                                   |
| 3     | 231x104x80            | 8.16               | N.A                                              | 6.87                                                   |
| 4     | 230x105x78            | 8.10               | 8.13                                             | 9.72                                                   |
| 5     | 230x105x78            | 8.58               | 8.42                                             | 9.81                                                   |
| 6     | 230x105x78            | 7.19               | 7.81                                             | 9.54                                                   |
| 7     | 230x110x77            | 8.53               | 6.71                                             | 8.21                                                   |

## VI. CONCLUSION

After comparing the results of composite fly ash brick (made from the use of discarded polyethylene waste) and the conventional red clay bricks and fly ash bricks it can be seen that the composite bricks have higher strength and very low water absorption values. Addition of polyethylene to the mixture shows higher strength at 10% by weight of cement proportion and even the water absorption figures very much below the permitted 20% by the IS codes. Waste Polyethylene in shredded form can be added to the fly ash bricks to create a sustainable green product and further increment in polyethylene percentage can be done so that more amount of waste can be utilized.

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