# EXPERIMENTAL INVESTIGATION ON RECYCLING OF PLASTIC WASTES AND BROKEN GLASS IN TO CONSTRUCTION MATERIAL

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***Abstract :*** As natural aggregate sources are becoming depleted due to high demand in construction industry and the amount of disposed waste material keeps increasing, researchers are exploring the use of alternative materials which good preserve natural resources and save the environment. In this study, utilization of molten plastic waste as full substitution of cement and broken glasses as partial substitution of aggregate with fine river sand for the production of building construction input such as roof tile, floor tile and hollow plastic block is a partial solution to environmental and ecological problems. Quality control test of samples of prepared material are conducted and compared with the standard material specification. This study implies that for hallow plastic block, 33% molten plastic, 11.2% fine glass, 11.2% fine sand and 44.6% course glass gives an optimum compressive strength result and molten plastic waste with a ratio of 30% and 70% glass and sand gives better and quality roof tile, and using 32% molten plastic and 68% glass and sand is Preferable for light traffic zone (axle load less than 27Mpa) floor tile. Finally, conclude that using plastic tile in weather (wet) environment is preferable because it can resist cold and freeze weather due to low water absorption.

***Index Terms*** **- Sieve Analysis, compressive strength, Breaking Strength, water absorption & Temperature effect.**

## I. INTRODUCTION

In Ethiopia, most industrial and domestic activities are associated with significant amounts of non-biodegradable solid waste, which include a wide range of plastic and glass waste. The research studies to be undertaken intended to determine the efficiency of reusing waste plastic and broken glass in production of floor tile, roof tiles and hollow plastic block (HPB). Utilization of these waste materials is a partial solution to environmental and ecological Problems. Use of plastic and glass not only helps in getting them utilized in such types of material, it helps in reducing the cost of concrete making. Aggregates are used in a variety of building applications, and can be said to be the largest quantity of material used in any industry. Almost all aggregates are produced from natural resources such as gravel pits, river beds and rock quarries. In addition to depleting these natural resources, mining for aggregates also poses serious environmental risks like disturbance of natural habitats and creating open areas with no vegetation, therefore recycling of this material has also indirect benefits such as reduction landfill cost, saving energy, and protecting the environment from possible pollution effects. At a time when landfill space is becoming almost impossible due to increasing land value, then recycling and reuse of wastes as beneficial products should be strongly encouraged and examined. One potentially strong and viable market is to develop recyclable wastes into construction material, a common material used throughout the construction industry. The reuse of waste materials in building construction is a great idea, and the high demand for construction materials makes them a favorable medium in which to reuse recyclable materials. .

## II. RESEARCH METHODOLOGY

### 2.1. MATERIAL USED

#### 2.1.1. Waste Plastic

By definition the plastics can be made to different shapes when they are heated.in closest environment it exists in the different forms such as cups, furniture's, basins, plastic bags, food and drinking containers, and they are become waste material. Accumulation of such wastes can result into hazardous effects to both human and plant life. Therefore, need for proper disposal, and, if possible, use of these wastes in their recycled forms, occurs. This can be done through process of plastic management. Waste management in respect to plastic can be done by recycling. If they are not recycled then they will become big pollutant to the environment as they are not

decompose easily and also not allow the water to percolate in to the soil and they are also poisonous. As we have mentioned, there are many types of plastic among them we were only used Polyethylene Terephthalate (PET) and High Density Polyethylene (HDPE).

Figure 1 - Plastic waste in Addis Ababa (koshe)

Table 1-Properties of Collected waste plastic bottles

| Sl No | Experiment | Result |
|---|---|---|
| 1 | Specific Gravity | 0.985 |
| 2 | Density (Kg/m$^3$) | 386.7 |
| 3 | Color | Different colors |
| 4 | Absorption | Approximate to zero percentage |
| 5 | Thickness | 0.5 to 1 mm |

**2.1.2. Waste Glasses**

Basically waste glass material that cannot be reused due to the high cost of manufacturing. Therefore the manufacture will disposed in the waste landfill. Due to environmental problem, as we have mentioned, researcher tries to use the waste glass in to concrete, to create a new material to use in construction field. Researcher found that, the main material composition of glass is silica that also contain in cement production and other compound that also similarly contain in cement production. Glass recycling uses less energy than manufacturing glass from sand, lime and soda, generally this is our second material we were used in this research. The composition of uncolored glass containers is given as the following:

Table 2-composition of glass

| Material (Weight Basis) | Composition |
|---|---|
| $SiO_2$ | 71.5-73.5 % |
| $Na_2O$ | 12.5-15.5 % |
| CaO | 7.8-10.8 % |
| MgO | 0.1-3.6 % |
| $Al_2O_3$ | 0.4-2.2 % |
| $K_2O$ | 0.4-1.0 % |
| BaO | 0.0-0.5 % |
| $B_2O_3$ | 0.0-0.2 % |

However, as with other products, the composition of glass containers has changed over the years and is still changing. In the article "How Composition Affects Workability"

Figure 2-Collected broken window and door glass

**2.1.3. River Sand**

Basically we are going to use Fine aggregate (Natural Sand) resulting from the natural disintegration of rock and which has been deposited by streams or glacial agencies. The river sand was used as natural river sand. It is distinguished from gravel only by the size of grain or particle, but it is distinct from clays which contain organic minerals. Sands that have been sorted out and separated from the organic material by the action of currents of water or by winds across arid lands are generally quite uniform in size of grains. Usually commercial sand is obtained from river beds or from sand dunes originally formed by the action of winds. Much of the earth's surface is sandy, and the sand is usually quartz and other siliceous materials.

Table 3-physical properties of sand

| Properties | Limit |
|---|---|
| Type | River sand |
| Silt content | 9%(has been washed ) |
| Absorption (%) | 2.71 |
| Max size (mm) | 9.5mm |
| Density (kg/m3) | 1688 |
| Specific gravity | 2.62 |

*Figure 3-Stockpile river sand*

**2.2. Trial Mix Design**

**2.2.1. Trial Mix proportion**

The use of plastic block and tiles unit for construction has created a need with high compressive strength and other quality requirements. To achieve high strength levels, block and tiles producers generally define plastic mixtures by a trial and error process.

The most common procedure is to produce some trial mixtures possessing different plastic content using the equipment available in the mixer and extruder plant and test the quality of sample products relative to the standard specification.

**Table 4-Trial mix proportion of plastic block**

| Sample No | Plastic content (%) | Fine sand (%) | Fine glass (%) | Course glass (%) |
|---|---|---|---|---|
| 1 | 20 | 13.33 | 13.33 | 53.33 |
| 2 | 30 | 11.66 | 11.66 | 46.66 |
| 3 | 40 | 10 | 10 | 40 |
| 4 | 50 | 8.33 | 8.33 | 33.33 |

**Table 5-Trial mix proportion for plastic roof tile**

| Sample No | Plastic content (%) | Fine sand (%) | Fine glass (%) |
|---|---|---|---|
| 1 | 20 | 26.67 | 53.33 |
| 2 | 30 | 23.33 | 46.67 |
| 3 | 40 | 20 | 40 |
| 4 | 50 | 16.67 | 33.33 |

**Table 6-Trial mix proportion for plastic floor tile**

| Sample No | Plastic content (%) | Fine glass (%) | Fine sand (%) | Course glass (%) |
|---|---|---|---|---|
| 1 | 20 | 13.33 | 26.67 | 40 |
| 2 | 30 | 11.67 | 23.33 | 35 |
| 3 | 40 | 10 | 20 | 30 |
| 4 | 50 | 8.33 | 16.67 | 25 |

**(a) Sample product preparation**

**Step 1:** After batching the plastic bags were taken for burning in which the plastic bags are thrown one by one into the drum and allowed to melt. The drum is placed over the setup and it is heated to remove the moisture present in it. (Melting temperature is estimated of 150$^{o}$c).

**Figure 4-Plastic melting with wood fire**

**Step2:** The plastic changed in to fully liquid add the broken glass and sand simultaneously. Finally the mixture is gradually heated, while undergoing vigorous mixing. The mixture has very short setting bags are turned to molten state. The sand and glasses added is mixed time. Hence mixing process should not consume more time.

**Figure 5-mixig stage (sand, glass and molten waste plastic)**

**Step 3**: The mixture is then poured into the block and tiles mould. Before placing the mixture into the mould, the sides of the moulds are oiled to easy removal of the sample. After that Pours the mixture in to the mould by spade and compacted by using steel rod until the adequate compaction level reached, the surface is finished by using trowel.

**Step 4**: Finally, the mould has removed carefully so that the plastic blocks and tiles are not damaged, because release is immediate and occurs with no problems, by carefully removing the mould.

**Fig. 6- Sample product of plastic block**

**Fig.-7 Sample products of plastic roof tile**

## III. EXPERIMENTAL RESULT AND DISCUSSION

The quality test is conduct to compare the results of the sample product to the standard material requirement (hollow concrete block and concrete roof and floor tile) according to ASTM.

### (3.1) Compressive strength test result

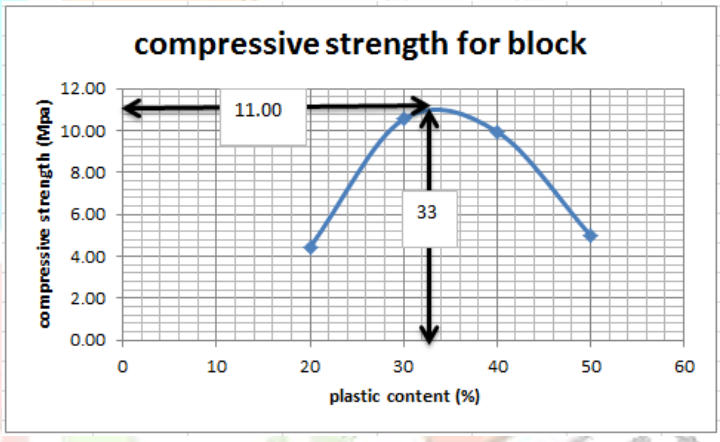


**Figure 8 -compressive strength result for different plastic proportion of HPB**

In this research the values of block compressive strength for different replacement of plastic contents (20%, 30%, 40% and 50%) is studied. From the Fig 8 graph above, there is abruptly increase in compressive strength from 20% – 33%.Between 33% - 40%compressive strength decrease gradually. Above 45% the compressive strength has the steepest slope with a decrease of 4.95 MPA from 40% to 50. According to ASTM C129, standard specification for non-load bearing wall masonry the minimum average compressive strength is 600 psi (4.14 MPA), but as we see in the above figure the result is 10595.42 psi (11 MPA).

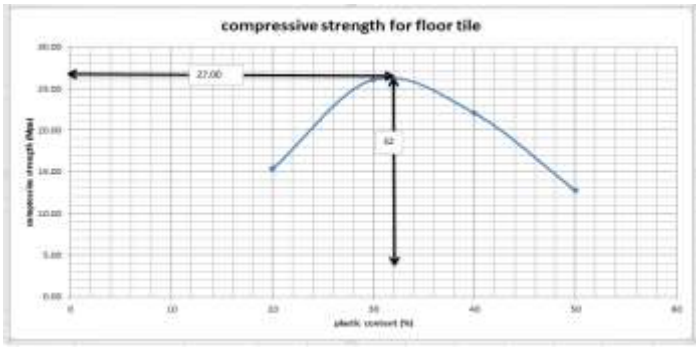


**Figure 9- compressive strength of different plastic proportion of floor tiles**

From the Fig 9 graph above, there is gradual increase in strength from 20% – 30% plastic replacement with an increasing rate of about 1.07Mpa.Between 30% - 50% plastic replacement the slope becomes less steep with a decrease rate of 0.67Mpa. According to

ASTM C-39 minimum recommended compressive strength 3500psi (25mpa). The optimum strength that we have obtained from the test is 3780psi (27mpa).

**(3.2) Breaking strength**

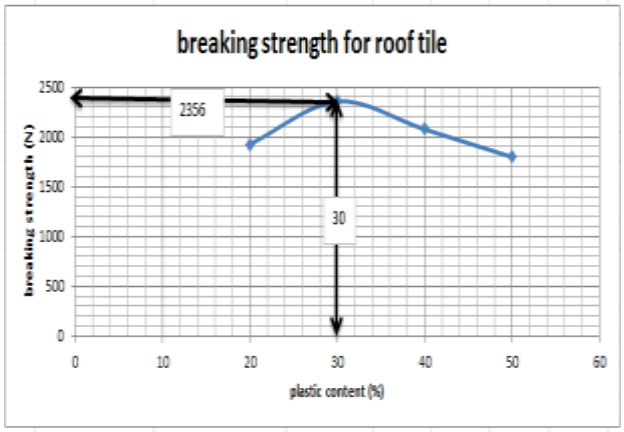


**Figure 10-Breaking strength for different plastic content of roof tile**

In this research the values of breaking strength for different replacement of plastic contents (20%, 30%, 40% and 50%). The graphs above represent varying strength of plastic roof in each of various percentages of cement replacement with molten plastic. As graph there is gradual increase in strength from 20% – 30% plastic replacement with an increasing rate of about 43N.Between 30% - 50% plastic replacement the slope becomes less steep with a decrease rate of 28N. Based on the above Testing application standard (TAS) no. 112-95 standard requirements for concrete roof tiles, for high profile the minimum average breaking strength is 1780 N. but roof tile product has breaking strength of 2356 N.

**(3.3) Absorption test**

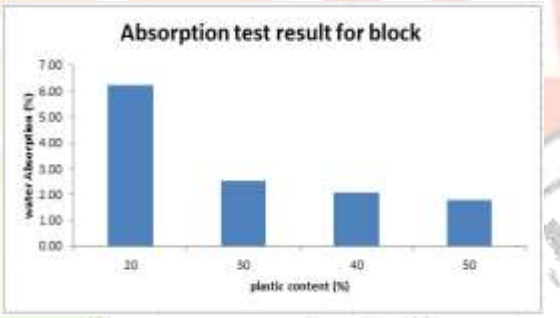


**Figure 11- water absorption result for different plastic proportion of HPB**

In the above figure 11 where the absorption satisfied the standard for all the proportion, the proportion of plastic to sand and broken glass equal to 30:70 only reached the absorption of 2.52 percent which was far below the standard of 5 %. The maximum water absorption recommended Based on ASTM C936 is 5 %, but our result is between 6.21% up to 1.79 % as shown in the above.

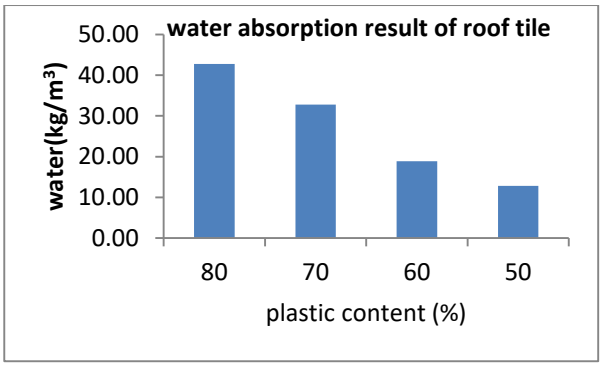


**Figure 12-water absorption test result for different plastic content of plastic roof tile**

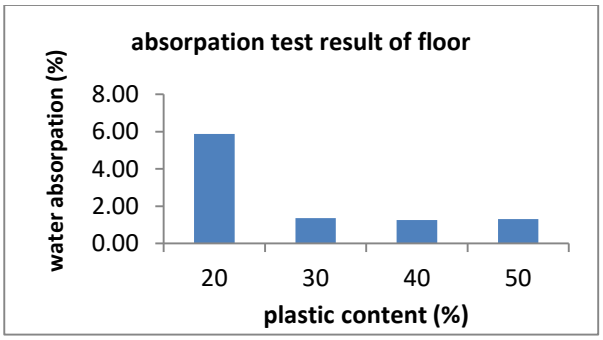


**Figure 13-water absorption result for different plastic content of plastic floor tile**

Based on ASTM C373 floor tiles are classified according to Water absorption percentage as follows

- ✓ Impervious tile : ≤ 0.5 %
- ✓ Vitreous tiles :0.5-3%
- ✓ Semi-Vitreous tiles :3-7%
- ✓ Non vitreous: ≥ 7%

**a.** From the above test result most part of the trial tiles are under Vitreous tiles which between 0.5-3% water absorption.

**b.**

**(3.4) Temperature effect test**

The Plastic is highly susceptible to temperature but in case of Plastic floor the presence of sand and glasses imparts insulation. Generally four specimens of floor tiles are taken to laboratory for testing and tested one by one. In this test a floor specimen is put on oven dry till it change on the surface of the floor breaks. The three specimens are no change in the structural properties of floor up to 165°C above which visible cracks and melting are seen and the floors deteriorate with increase in temperature.

**Figure 14-Temperature effect test using oven**

**(a) Temperature effect test for Block**

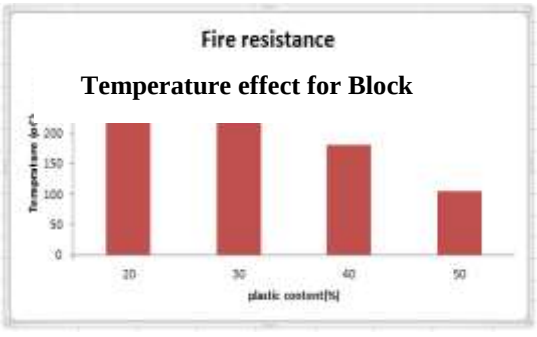


**Figure 15-Temperature effect test result for different plastic content of HPB**

**(b) Temperature effect test for roof tile**

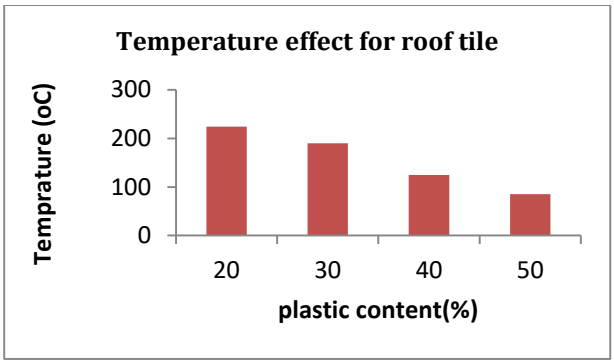


**Figure 16- Temperature effect test result for different plastic content of plastic roof tile**

**(c)Temperature effect test for floor tile**

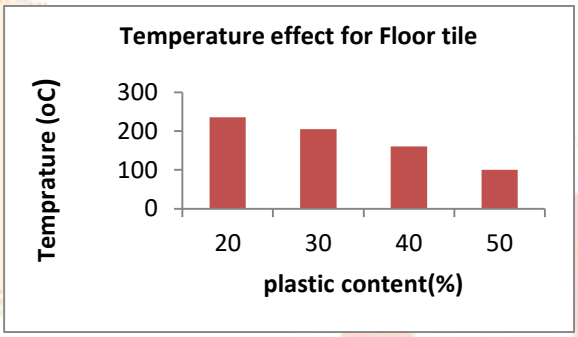


**Figure 17-Temperature effect result for different plastic content of plastic floor tile**

## IV. CONCLUSION

Compressive strength increases with increasing the plastic parentage from 20% to 33% replacement of glass and after 33% waste plastic added onwards the strength is decreases. Strength reduces because of low compressive strength of plastic. This implies that for hallow plastic block 33% plastic, 11.2% fine glass, 11.2% fine sand and 44.6% course glass gives an optimum compressive result, likewise it gives as good water penetration resistance.

In plastic roof, sand and cement can be replaced with glasses and plastic waste by 20% up to 30% of plastic and 53.33% up to 46.67% of waste glass to achieve more durable roof tile, the breaking strength of roof increase as the plastic content increase up to a limit 30% plastic binder. Using this optimum plastic content can fulfill the standard requirement of quality roof. Using plastic waste with a ratio of 30% plastic waste and 70% glass and sand gives better and quality roof.

The absorption rate for the standard sample contained 20% waste plastic was 6.0% and increased for 30% waste glass samples to below 2%, and continued to decrease generally. Tile with 30% plastic and above is impervious tile On ASTM C373 Vitreous tiles: 0.5-3%. In the standard sample contained 20% waste plastic, the rate of compressive strength increase up to 32% of plastic content which the optimum strength i.e. 27.00Mpa. As the plastic content increase beyond 32% the strength fails again because the capacity of plastic to resist compressive load is weak compared as concrete tile but the failures is ductile. Using 32% plastic and 68% glass and sand is preferable for light traffic zone (axle load less than 27Mpa).

The research was conducted with local equipment as replacement of extruder, shredder and hydraulic mould machine, those are fire drum, hammer and manual mould respectively, that leads the work tedious and has equipment limitation, due to this the overall result of the material quality may reduce, but if there is equipment modification the result will be improved compared to the traditional one. Because of material constrained the researchers have not conduct full research for the effect of glass fiber on block, floor and roof tile products and due to lack of material quality test laboratory the researchers couldn't conduct all necessary Quality tests that govern the material quality and specification.

**V. ACKNOWLEDGMENT**

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