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Comparative Analysis of Tiles Made from Recyclable LDPE Plastic Waste

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***Abstract*—There is a need for use of materials made from recyclable plastics taking into considerations the adverse effects of plastic waste. There have been numerous procedures carried out for processing and recycling of plastic waste, but the use of LDPE plastic for making of internal partitions, tiles and plastic products with antimicrobial properties has not been well explored. Till date, largely research has been done using plastic as reinforcement but very less research has been done for exploring the use of plastic as a parent material with sawdust or fiber reinforcement. This research illustrates the manufacturing of tiles and bricks from LDPE, *Low-Density Polyethylene*, plastic waste. The LDPE was procured mainly from the Amazon delivery bags and other daily used plastic waste. Hot-ramming was carried out on the semi-solid plastic achieved by heating till Glass Point Temperature was achieved followed by tests included compression test, flammability test, friction test, etc. These test results were compared with that of traditional *Ceramic tiles*, in which, for the plastic tiles a weight reduction of 57.7322% was observed as compared to the conventional bathroom tile having the same dimension and flexural strength.**

Key Words—LDPE, recycling, floor tiles, plastic waste, compressive strength, burning rate, a glass transition temperature.

I. INTRODUCTION

Waste is defined as any material that is not useful and does not represent any economic value to its owner. Depending on the physical state of waste, wastes are categorized into solid, liquid and gaseous. Solid Wastes are categorized into municipal wastes, hazardous wastes, medical wastes, and radioactive wastes. Note that, gaseous waste that is held in a closed container falls into the category of solid waste for disposal purposes. However, this study will be focused on biodegradable and photodegradable materials to decompose the waste, along with sufficient moisture and nutrients to sustain microbial action. Thus, the deeper these plastics are buried in the landfill, the less likely they are to decompose. Therefore, it is reasonable to say that that the market for plastic recycling Managing solid waste generally involves planning, financing, construction and operation of facilities for the collection, transportation, recycling and final disposition of the waste.

Plastic is defined as synthetic or semi-synthetic materials which are polymeric and are composed of large molecules of organic substances known as monomers. The large molecules that are formed during a process known as polymerization are known as polymers [1]. Solid waste management (SWM) system includes the generation of waste, storage, collection, transportation,
processing and final disposal [2]. Plastic waste is carried to melt and mixed with a varying proportion of reinforcement. Reinforcement of 40% sawdust gives better results than micro-concrete tiles [3]. The utility of plastic bags pieces can be used for a possible increase in split tensile strength [4]. The experimental results show that the plastic aggregate have low crushing, low specific gravity, and density value as compare to natural aggregate, with use of suitable admixture, around 0.4% by weight of cement will improve the bonding between matrix and plastic aggregate [5].

The expanding population and increased preferences for plastic have a negative impact on the environment [6]. The major divisions of plastics are thermoplastic and the thermosetting polymers. Thermoplastics are the form of plastics that do not undergo chemical changes in their composition when subjected to heat and can be remolded into another shape even after solidification. Thermosetting, on the other hand, are non-recycled polymers which undergo an irreversible chemical change when subjected to heat, they melt and take a shape once after which they cannot be molded into another shape. The role of plastics in human lives cannot be overemphasized ranging from use as household appliances, packaging materials, potable water, and beverage containers, kitchen utensils, furniture, toys, automobile parts, polythene bags etc. [7]. Attributed the great attention given to their use as due to their generally light, cheap and durability nature and this account for their preference over other materials [8].In view of all the hazards that accompany the improper disposal of plastic wastes, the need then arises for an alternative means to manage the plastics waste. The only means of adequately take care of several tons of plastic wastes being disposed of is through the adoption of the recycling process. This recycling process will go a long way to contribute to a cleaner environment. Plastic recycling is the process of recovering plastic wastes and turning old or scrap plastic into useable products that can re-enter the manufacturing chains. This will, in turn, generate revenue, create more job opportunities and reduce the hazards associated with improper disposal of plastic wastes [9]. For recycling of this plastic firstly, the sorting exercise is carried out. After this, plastics are shredded into smaller, between 5 to 10 mm^2. The shredded plastics are melted and molded directly into a new product or melted and formed into pellets [10].

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Thus, the quantity of plastic waste generated is very high in amount. Very less work has been done on the tiles made from the waste plastic bags. Objectives of this research are:

- To recycle waste LDPE plastic bags.
- To create a prototype which tackles the threatening issue of disposal of plastic.
- To manufacture plastic tiles from the used plastic bags.
- To test various mechanical properties of the manufactured product like compressive strength, flammability, friction properties etc.

II.METHODOLOGY

A. Manufacturing

In this research, the component manufactured was made from the waste plastic bags. Following are the steps involved in its manufacturing:

- *Plastic collection:*
  The plastics wastes for recycling were collected by using Amazon packaging and other shop bags with LDPE label on them.

- *Manual sorting:*
  Each plastic waste type was separated from each other and unwanted materials were removed from the waste, all the other plastic bags which were not LDPE were removed.

- *Shredding:*
  The plastic bags were then cut into smaller pieces using scissors and cutters.

- *Washing:*
  The chips were then washed to remove glue, paper labels, dirt and any remnants of the product they once contained.

- *Making of the mold:*
  To give the molten plastic their final shape of the brick, a mold was made. This was manufactured by welding MS plates together. Along with it, a hammer was manufactured to apply vertical forces and compress the molten plastic to make it compact.

- *Melting:*
  This was done by gradually adding shredded plastic pieces in the mold. The source of heat was an electric heater in our Heat Transfer lab. As the plastic reached glass transition temperature, we would add more plastic. When there was some significant amount of plastic body formation, we started to add sawdust to the molten state plastic to play the role of a binder.

- *Shaping:*
  As the plastic became soft enough to undergo deformation, the vertical force was applied using the clamp/hammer to compress the plastic into a denser body and to make room for more plastic and sawdust.

The above procedure was repeated until we obtained a tile of a certain thickness.

B. Experimentation:

For checking the properties of LDPE made tiles following test were done on the component:

1. *Compression test:*
   Compression test was conducted as per the ASTM D 695-2015 Standard. For this, the standard specimen size is 12.7 x 12.7 x 25.4mm. The specimen is placed between compressive plates parallel to the surface. The specimen is then compressed at a uniform rate. The maximum load is recorded along with stress-strain data. An extensometer attached to the front of the fixture is used to determine modulus. Compressive strength and modulus are two useful calculations in this test. They are calculated using the following equations.

$$Compressive\ strength = \frac{maximum\ compressive\ load}{minimum\ cross-sectional\ area} \quad ...[1]$$

   Equipment used in this test are:
   - Instron universal tester
   - Extensometer

2. *Vertical flammability test*
   This test was done as per IS 15061:2002 Standard. For this test specimen size was 10x 13 x 95 mm. For passing this test the burning rate should not be more than 100 mm/min.

3. *Static friction test:*
   For this test, a block is placed on the component to be tested. The block is connected to a horizontal string which is passed over the pulley and made vertical. Another end of the string is connected to a weight box in which weights are added. The weight at which the block just started moving was noted. Static friction coefficient was calculated using the following formula:

$$\mu = \frac{Total\ weight\ of\ the\ weight\ box}{weight\ of\ block} \quad ...[2]$$

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III. RESULTS AND DISCUSSION

The density of the LDPE tile was observed to be 843 kg/mm³. For conventional tiles, it is near to 2400. So, the tiles can be used in various applications where we require weight reduction. In the LDPE made tile, the total weight reduction was observed to be 57.7322% as compared to the conventional bathroom tile having the same dimension.

The compressive strength of 17.26 MPa was observed. According to IS 15622:2006, a minimum of 1500 N breaking force is required to pass the test. The manufactured LDPE component showed 2175.6 N breaking force. So, these tiles can be used in places where there is no high weight bearing requirement.

Burning rate was observed to be 52mm/min which was lesser than the standard 100mm/min required to pass the test.

The coefficient of friction was experimentally calculated to be 0.5 for test specimen which was equivalent to the commercially available bathroom tile of 0.512 which opens up new avenues for further research and improvement of the coefficient of friction to make antiskid tiles. This makes tiles we manufactured using LDPE usable for normal day to day applications avoiding any slippage.

Tables & Figures

Table I: Compression test result

Sr. No	Sample Identification	Compressive strength (MPa)	Peak Strength
1.	LDPE	17.26	2175.6

Table II: Vertical flammability test

Sr. No	specified	Observed	Remark
1.	The burning rate should not be more than 100mm/min	Burning rate 52mm/min	Pass

Table III

Material	μ			Average μ
	1	2	3	
LDPE Composite	0.5	0.5	0.5	0.5
Bathroom Tile	0.5185	0.5	0.5185	0.5123

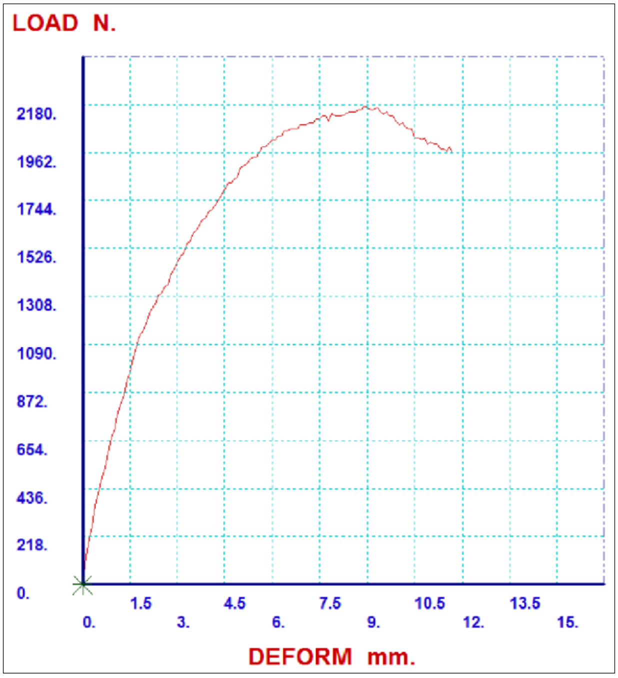

Figure 1:Graph for Load VS Deformation

Figure 2: Final LDPE Tile

Figure 3: Friction Test

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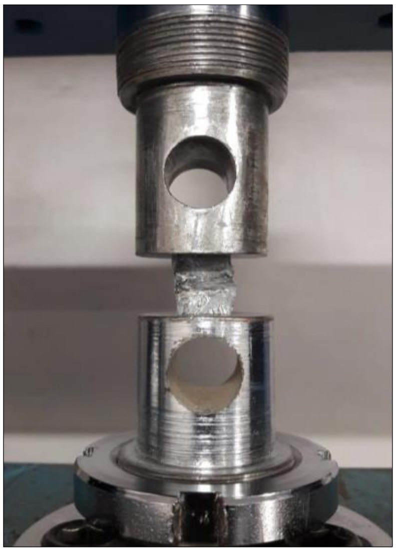

Figure 4: Compression test

Figure 5: Flammability test

IV. CONCLUSION

- A completely recycled product was manufactured at a very cheap price.
- The strength of the LDPE tile (2176 N) was found to be equally comparable to the strength of ceramic tile (2200 N).
- The material is unbreakable as against ceramic tile.
- The static friction factor is better than the available product making it suitable for anti-friction tile fittings.
- Manufactured tiles have good machinability in cutting and finishing.
- Manufactured tile floats on water, making it suitable for marine applications like rafts, floats.

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