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Use of Waste Plastic as a Construction Material

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Abstract— **In today's world, increasing problems related to plastics is a concern for every living species, so there is a need to find a solution to this problem. Hence, working on this issue, the main aim of this study is to tackle the plastic waste generated in abundance throughout the world. To gain success in this, a systematic method is employed which makes use of plastic extrude for reutilizing waste plastic into suitable construction materials. Using only plastic waste or adding some other ingredients such as powder, fly ash, etc plastic is converted into useful construction materials such as pavers, railway sleepers, building blocks, etc. A number of trials with different combinations were conducted to efficiently convert waste plastic into bricks. It was noted that maximum compressive load which the LDPE plastic beads brick could sustain was 13.69 N/mm2. This was followed by LDPE fly ash composite brick with a strength of 11.48 – 10.42 N/mm2, which is higher than the compressive strength of the conventional bricks available in the market made up of clay which had a compressive strength of 3-5 N/mm2.**

Index Terms— **LDPE, plastic beads, Fly ash, plastic extruder.INTRODUCTION**

I. INTRODUCTION

It is a well-known fact that plastic waste is an important issue for everyone and needs to be resolved on an urgent basis, as it's hazardous effects is deteriorating life on earth. Waste in form of plastic is increasing day by day, but a permanent solution to it is still not found. Landfills, which is used as a method to solve the problem of plastic disposal s indirectly harming the nature. Even landfills are glut with waste, hence demanding an urgency for the plastic disposal problem. Plastic to humans is available in a variety of forms such as LDPE, HDPE, PET, Bakelite, etc. It is generally made from long chains of hydrocarbons along with additives and can be easily moulded into desired finished products.

Resources such as petroleum, etc which are limited are being utilized in plastic manufacturing. Plastic is available as polymer but to obtain its various form, it is generally broken down in the presence of a catalyst to form monomers such as Vinyl, Propylene, Styrene, Benzene, etc. Further to get different categories of plastic, these monomers are chemically polymerized and 2 examples of the same are Thermoplastics and Thermoset plastics. However, there is a significant difference between these 2 categories of plastic. In thermoplastics, plastic is heated and can be moulded into any shape, however, it's advantage is that it can be reheated and plastic will be further softened. It includes various products such as PPS, LDPE, PVC, HDPE, PET, etc.

Thermoset plastics are totally different from thermoplastics. It can be melted into its liquid form but once after melting when its solidified it cannot be reheated and remains in the same shape. Products of this category are Nylon, Bakelite, etc. Owing to the number of side effects use of plastic have instead of decrease in the consumption, its utilization is increasing rapidly. This is proved by the estimated difference in plastic consumption in 1950's and its current consumption. Estimates have shown that plastic consumption increase from 5 million tones in 1950's to nearly 100 million tones at present. Every country around the world is trying to recycle the plastic waste at its best. India's rate of recycling plastic is highest with the rate of 60%. While another country has lower rates than this.

In relation to all this various problem, plastic extrusion plays a crucial role, as it efficiently converts waste plastic into sustainable construction materials. There is no waste generated when this method is used. It not only helps in making construction materials but also helps in plastic disposal problem. In this raw plastic is melted and form into a continuous profile allowing production for various construction material. This process causes no harm to any form of life or environment and helps in avoiding the use of other harmful methods such as landfills, burning in an incinerator, etc.

In India generally, methods which are employed for plastic disposal are harmful beyond one imagination in a long run. The methods include landfills, burning in incinerators or by littering them. Dumping in landfills is an ancient method used for plastic disposal and its harmful effects are seen in the area of deonar. Deonar is located in Mumbai and is India's largest and oldest dumping ground which was set up in the year 1927.

However, there were many problems created due to the impromptu outbreak of fire in the dumping ground. Cancer patient's rate has also substantially increased due to this; also infant mortality became another concern for residents living in nearby areas. Infant mortality rate increases drastically, the number stands at 60-80 per thousand live births which turn out to be double of the average for the entire city. Littering is done by people. Burning in incinerators also has some bad effects as it releases harmful gases. Hence, undoubtedly plastic exclusion helps in solving these problems.

Recently increasing awareness has led companies to manufacture products made from recycled plastics such as recycle rubber, road rail tile resins, P/C tiles etc. and also there is an immediate need to solve these problems, which extrusion helps for.

II. EQUIPMENT

Extruder's design is a complex type as it involves various types of equipment. The material used also plays a major role in the efficiency of a machine. Various operations such as drilling, boring, cutting, etc are done during the construction of machines. To clear up the confusions during the construction of the machine, different methods used were categorized under the heading, Cutting operation, Machine

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operation, Welding operation & assembly operation and finishing operation.

A. SELECTION OF MATERIAL

The material used in the construction of machine depends on the properties of the material used. This includes, how easily can it be formed or with what ease can it be welded, its hardness, ability to resist abrasion, etc. Along with that, whether the material is economical or not and few other mechanical properties plays a major role in material selection. Materials used for the purpose of construction of machine are Barrel, Nozzle and Screw conveyor while the material used for the hopper is sheet metal.

B. MACHINERY PARTS

Screw conveyor and the barrel are constructed from 38 Cr MOAL/A featuring nitrogen treatment and the surface is treated with alloy as the possess high hardness. Thus, able to buck abrasion. Along with it, new screw design boasts uniform mixing & melting effects as it helps in achieving a high yield of low temperature. The spiral barrel with the longitudinal groove is able to improve the function of feeding, which guarantees high speed and greater yield of from extrusion. It also consists of various other equipment such as temperature control box, gearbox, ceramic band heaters etc.

Drilling and welding are carried out join different parts of machinery. Frame cutting is used for cutting metals into different shapes and sized as per the requirement which changes from machine to machine.

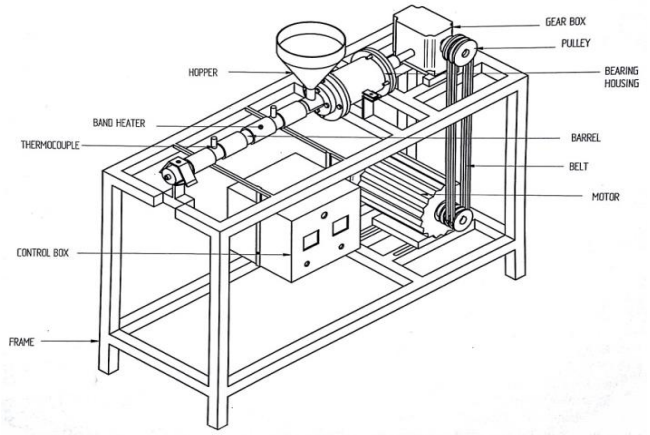

Figure 1. Final Setup of the Extruder for Recycling Waste Plastics

C. OPERATIONS

Working principle of the machine is given below:

1. The raw plastic material is fed into the hopper. It travels by gravity to the feed throat and drops on the rotating screw. This work is carried out after switching on the heater and setting the required temperature.
2. The rotation of screw conveys the plastic forward through the heated barrel.
3. As the plastic conveys forward along the screw, the channel depth keeps on decreasing which forces plastic through a smaller area.
4. This combination of compression and screw rotation causes friction which generates heat and is called as shear heating.
5. Shear heat along with barrel's heating system melts plastic. The final product is collected from the end of nozzle inside a mould. After the mould is filled it is properly cooled.
6. Brick is then removed from the mould and compressive strength is tested using the universal testing machine.

III. COMPOSITION AND CASTING OF THE PRODUCT

Plastic beads used in this process are generally made up of LDPE. Plastic beads are generated from plastics and are effectively converted into plastic blocks. Figure 2 shows the plastic beads used in the casting of bricks. Fly ash used was grade F. Figure 3 shows the fly ash which was used along with the different composition of plastic beads to get the maximum compressive strength.

Figure 2. Plastic beads

Figure 3. Flyash - Grade F

A number of trials with different combinations were conducted to efficiently convert waste plastic into bricks. The density of composite bricks varies from 500 kg/m^3-2000 kg/m^3

Table 1 Compositions of various samples

Sample No	Composition in Weight %
Sample No 1	100% LDPE plastic beads
Sample No 2	90% LDPE plastic beads + 10% fly ash
Sample No 3	80% LDPE plastic beads + 20% fly ash
Sample No 4	70% LDPE plastic beads + 30% fly ash

The photograph of the machine is shown in the Figure 4.

Figure 4. Final assembled photograph of the machine

Figure 5. 100% LDPE plastic beads bricks

Figure 6. 90% LDPE plastic beads + 10% fly ash bricks

Figure 7. 80% LDPE plastic beads + 20% fly ash bricks

Figure 8. 70% LDPE plastic beads + 30% fly ash bricks

Finally, 4 samples of various compositions of plastic beads and fly ash are selected. Table 1 shows the composition of the various samples of plastic beads and fly ash used.

IV. TESTING OF THE PRODUCT

The bricks produced were made from various trails and combinations using extrusion process. To check or to verify whether the bricks formed are stronger than conventional bricks or not, compression test was performed. In this test, a Universal Testing Machine (UTM) was used. Bricks were placed between 2 cushion type pads which applies load on the brick. The load is applied continuously till the brick fails. Figure 9 shows the failure of bricks at different loads. Testing of the brick in a controlled environment. The results of the 4 different samples and values for 3 trials are noted and presented in Table 2.

In general, the length, breadth, and area of different compositions of the sample prepared were similar because moulds of same sizes were used. However, there is a minute discrepancy in sizes of various samples due to human error. It is seen that the maximum compressive load sustained by LDPE plastic beads brick is 13.69 N/mm^2, this was followed by plastic fly ash composite brick having strength between 11.48–10.42 N/m^2. These strengths are much higher than the strength of normal clay brick which is around 3-5 N/mm^2. The strength of composite bricks varies in accordance with a change in fly ash content.

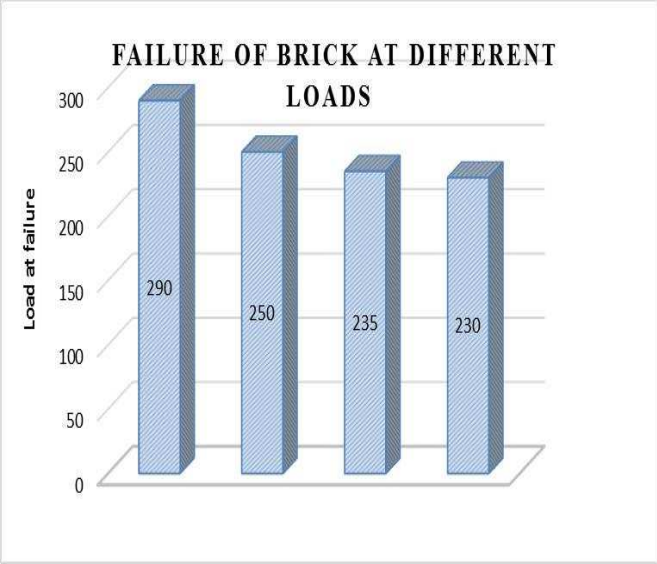

Figure 9. Failure of bricks at different loads

Table 2 Results of the compressive test on the brick samples

BRICK NUMBER	Sample No.1	Sample No.2	Sample No.3	Sample No.4
Length of Brick 'L' (mm)	144	149.5	148	149
Breadth of Brick 'B' (mm)	147	145.6	148.5	148
Area of Brick 'A' (mm^2)	21168	21767	21978	22052
Load at failure 'P' (N)	290000	250000	235000	230000
Compressive strength (N/mm^2)	13.69	11.48	10.69	10.42

As the fly ash content kept on increasing, strength kept on decreasing. Figure 10. Shows the compressive strength of different bricks.

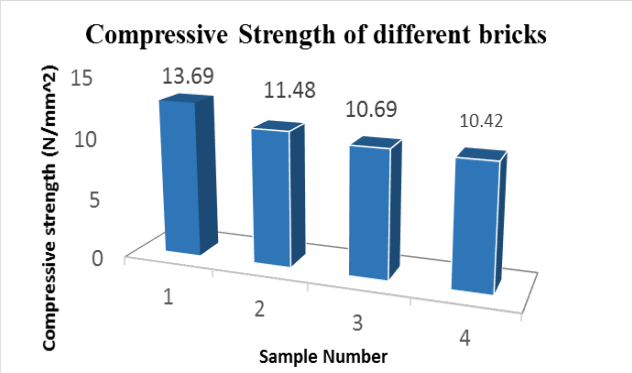

Figure 10.Compressive strength of different bricks

Bricks made up of plastic beads have the highest strength in resisting loads. Even though it is found that composite bricks sustain lower load than plastic beads brick, it still has compressive strength higher than conventional bricks and effectively converts waste plastic into a sustainable building material. It is quite evident from test results that this brick is higher in strength than normal bricks and has a lower weight in comparison to normal clay brick. For the bricks prepared it was also found that it has a water absorption capacity higher than conventional bricks, increasing its advantages. Water absorption (%) is 17-19 % for conventional bricks and is restricted at 20% by IS 1077(38), however, plastic beads brick and plastic fly ash composite brick had water absorption between 5-7%. Brick shall also resist insect attack and decay. Bricks were also tested for its workability with plaster and it was observed that plastering could also be done easily.

V. CONCLUSIONS

This work is able to achieve its main aim of reducing the plastic waste throughout the globe. It makes use of Extruder machine which is harmless to the environment and efficiently utilizes waste plastic to form a product i.e. brick, which is of higher strength, higher water absorption capacity, lower weight, etc than conventional bricks. It's of multiple uses as by increasing the size of the mould, the brick can be utilized as building blocks as well. It can be used for fencing instead of wire's which are traditionally used. It also finds its application in floor interlocks and as a building brick. It also stands out economical as it will prevent the cost of dumping into landfills and burning in an incinerator easily.

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