DESIGN OF PAVEMENT BLOCKS UTILIZING LOW DENSITY POLY ETHYLENE (LDPE) WASTE, AND IT'S EVALUATION

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ABSTRACT-India is suffering from huge problem of solid waste management in this age of rapid development and the major portion of this solid waste comprise of polyethylene, especially LDPE. Plastic waste has become one of the major environmental problems, so by utilizing plastic in a useful way we can reduce the burden on environment by a huge margin. In this study, an attempt has been made by replacing the cement used in the pavement blocks by low density plastic as the binding material. By using plastic as a binding material rather than cement, it can be proved beneficial to the environment in multiple ways. Hence, in this study LDPE waste is used for making pavement blocks using molten plastic (instead of cement) and sand. Different mixes of Plastic: Sand (P:S) ratio are prepared and then tested. The ratios being tested are 20:80 and 30:70 (Plastic :Sand) by weight. The results will then be compared with that of conventional pavement blocks (i.e. cement and sand blocks) on grounds of compressive strength, water absorption as well as on the basis of economy (approximate cost per pavement block).The results found are compatible and hence it can be suggested that plastic waste can be used for the making of pavement blocks.

Keywords-Pavement Blocks, Waste Material, LDPE

INTRODUCTION

Plastic waste has become one of the major environmental problems, so by utilizing plastic in a useful way we can reduce the burden on environment. By using plastic as a binding material rather than cement can be proved beneficial to the environment in multiple ways:

- Cement industry is the largest energy consuming industry in the world.
- By reducing use of cement we can reduce the carbon emission from cement industries.
- Plastic poses many environmental problems which can be avoided.
- It solves the increasing problem of dumping of polyethylene in dumping grounds.

In this study pavement blocks were made using molten plastic waste (LDPE) and sand mix. Different mixes of different Plastic: Sand ratio will be prepared and then tested. The results will then be compared with that of conventional pavement blocks.

Low density polyethylene (LDPE) is an important industrial material because it is durable, light-weight, easily processed and characteristically inert, but its everyday use is hazardous to the environment, plastics are a rapidly growing segment of the **Municipal Solid Waste (MSW)**stream.The dumping grounds in cities like Indore, Mumbai, Delhi etc. have become a major environmental threat and health hazard for the people living nearby. The Deonar dumping ground fire tragedy is well known for its huge adverse impact on environment and health of people of Mumbai. In a country like India where the population is going to cross 1.4 Billion in coming years the solid waste management is going to be a much more difficult task.

According to a new **Ellen MacArthur Foundation report** launched at the World Economic Forum,new plastics will consume 20% of all oil production within 35 years, up from an estimated 5% today. Plastics production has increased twentyfold since 1964, reaching 311m tonnes in 2014, the report says. It is expected to double again in the next 20 years and almost quadruple by 2050.

Despite the growing demand, just 5% of plastics are recycled effectively, while 40% end up in landfill and a third in fragile ecosystems such as the world's oceans.Under these circumstances the recycling of plastic waste has become very crucial.Plastic take millions of year to decompose and hence the only way left through which it can be re-utilized is by innovating new methods to recycle it.

PROPERTIES OF LPDE

PE is classified as a "**thermoplastic**" (as opposed to "thermoset"), and the name has to do with the way the plastic responds to heat. Thermoplastic materials become liquid at their melting point (110-130 degrees Celsius in the case of LDPE and HDPE respectively). A major useful attribute about thermoplastics is that they can be heated to their melting point, cooled, and reheated again without significant degradation. Instead of burning, thermoplastics like Polyethylene liquefy, which allows them to be easily [injection moulded] and then subsequently recycled.

By contrast, thermoset plastics can only be heated once (typically during the injection moulding process). The first heating causes thermoset materials to set (similar to a 2-part epoxy) resulting in a chemical change that cannot be reversed. If you tried to heat a thermoset plastic to a high temperature a second time it would simply burn. This characteristic makes thermoset materials poor candidates for recycling.

UniqueProperties of LDPE

- The melting point for average, commercial, low-density polyethylene is typically 105 to 115 °C (221 to 239 °F).

- Absorbs almost no water. Density range of 0.910–0.940 g/cm^3.
- Has good binding properties thus can bind sand particles effectively.
- It is non-reactive at room temperatures.Polyethylene is a homo-polymer in that it is composed of a single monomer constituent (in this case ethylene: CH_2=CH_2).

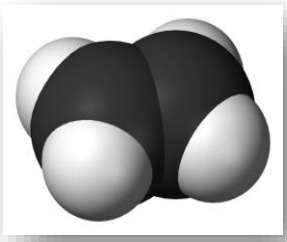


Fig 1: Ethylene (CH_2=CH_2)

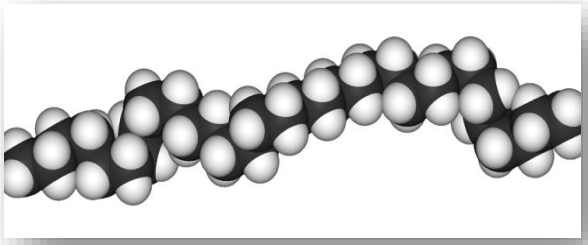


Fig 2: Spacefill model of polyethylene

Materials Used:

Mainly two materials have been used in making P-S blocks namely Sand and LDPE. The properties of sand and LDPE are given below in tables.

Type of plastic used : **Low Density Polyethylene (LDPE)**

Table 1: Properties of LDPE

Chemical formula	$(C_2H_4)_n$
Density	0.91-0.94 g/cm^3
Melting point	115–135 °C (239–275 °F)

Type of sand used : **Narmada Sand**

Table 2: Properties of Sand

Density	1.55 g/cm^3
Specific gravity	1.55

PROCEDURE

Making pavement blocks with Plastic: Sand ratio

i. 20:80
ii. 30:70

The waste plastic is collected from Dump area and then weighed depending on the number of blocks to be made out of it. For example: 1 block of 30:70 PS ratio needs 1.25 Kilograms of LDPE and 2.9 Kilograms of sand.

Fig 3: Plastic being melted in container

Fig 4: Molten plastic slurry

Fig 5: Plastic and sand being mixed.

Fig 6: Placing P-S mix in the mould

Fig 7: The P-S blocks after removal of mould.

Testing:

The blocks are ready to be tested after 24 hrs of casting, in 24 hours the blocks gradually get cool down and thus the plastic gets hardened. Compression test and Water Absorption test are performed for analysis.

CALCULATIONS

Compression Test Results

Average compressive strength of 20:80 block = **24.09** N/mm^2

Average compressive strength of 30:70 block = **24.74** N/mm^2

Water Absorption Test

1. **30:70 Block:**

Water absorption of 30:70 P-S block = **0.06%**

2. **2.20:80Block:**

Water absorption of 20:80 P-S block = **0.082%**

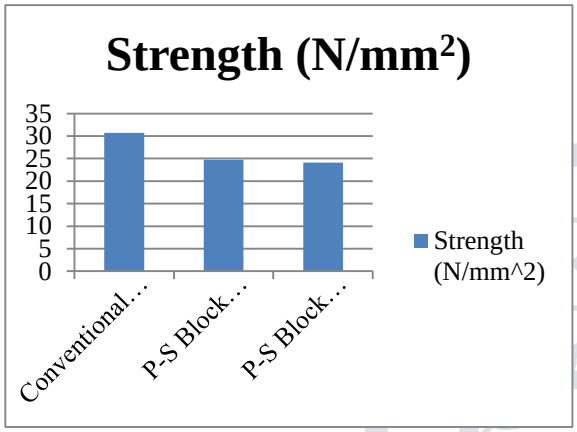
RESULTS

Table 3: Comparison of Conventional and P-S Blocks for various parameters

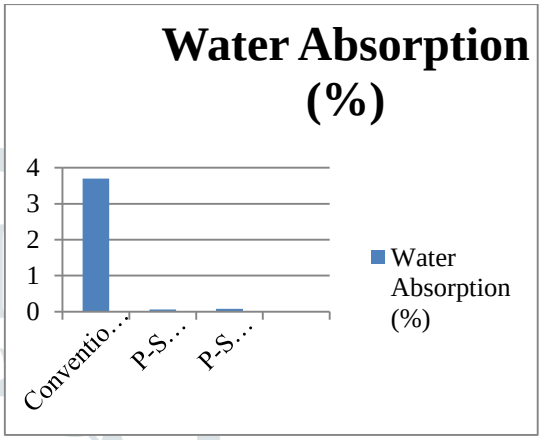
Block type	Proportion	Block no.	Weight of Block (Kg)	Average wt. of the block (Kg)	Strength N/mm^2	Average Strength N/mm^2
		1	5.32		30.017	
Conventional	1:3	2	5.30	5.3	30.171	30.75
		3	5.30		32.075	
		1	3.89		23.92	
P-S Block	2:8	2	3.76	3.82	24.05	24.09
		3	3.83		24.32	
		1	3.63		24.75	
P-S Block	3:7	2	3.60	3.63	24.85	24.74
		3	3.67		24.64	

Table 4: Water Absorption Table

Type of Block	Water Absorption
Conventional	3.7%
P-S Block (30:70)	0.060%
P-S Block (20:80)	0.082%



Graph 1: Compressive Strength of Blocks



Graph 2: Water Absorption(%) of Blocks

COST ANALYSIS

Type of Block	Cost (INR)
Conventional cement sand	10-15
Conventional low water absorbent	30-35
Collected plastic	
20:80 P-S Block	6
30:70 P-S Block	7
Purchased plastic	
20:80 P-S Block	18
30:70 P-S Block	22.5

CONCLUSIONS

- From the strength table it is clear that the strength of P-S blocks of both proportions is less than the strength of conventional pavement block. But as far as other properties are concerned namely water absorption and brittleness, the P-S block is proved to be better than conventional blocks.
- The water absorption of P-S block is drastically lower than that of conventional blocks, which implies that the material can also be used as water resistant covering on roof top. The weight of both P-S block is less than that of conventional blocks as the density of LDPE is less than that of Cement.
- Though the strength P-S block is less than that of conventional pavement block, the one quality that was observed was that the P-S block is less brittle than conventional block the reason being that the plastic is used instead of cement which has a tendency to get deformed under application of load.
- P-S blocks have very low water absorption as compared to conventional blocks reason being that the plastic does not absorbs water. This gives the block a unique property of water resistance which is absent in conventional pavement block.
- P-S blocks can be used in all weather conditions.No curing is required in making of P-S blocks as plastic doesn't require water to gain strength; it naturally gains strength when gets cool down.

- Cost to Benefit ratio of P-S block is more than that of conventional pavement blocks.

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