Study on plastic pet bottles characteristics to develop eco-friendly plastic paver blocks

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Abstract: Production of plastic has been increased nowadays, nearly 16 tonnes are produced per day meanwhile the degradation of plastic is very difficult because of slow process degradation. This study focuses on an eco-friendly paving product. Here plastic waste has taken for the investigation to develop a product by replacing cement with plastic waste in paver blocks. The main objective of this investigation is to recycle plastic waste into pavers and to analyze its characteristics based on the recent developments in industrial needs. Nowadays plastic is more accustomed around the world. Hence this work paves the way to reduce plastic waste accumulation in the surrounding environment. The plastic wastes were collected from the nearest surrounding and it is mixed with M-sand of an optimum percentage to cast paver blocks. The plastic paver block reduces the plastic waste, controls the pollution, and reduces the overall cost of production. The application of pavement blocks is perfect on pathways and street ways as it is a simple way of finishing and laying, also cost-effective compared to conservative paving blocks. Here the strength properties of pavement blocks incorporating PET bottles are presented.

1.0. Introduction.

Pavement is used for surface coverings. Their construction materials include concrete and stones such as flagstone, Cobble stone etc., This pavement technology in India is being in practice for past decades for footpath and parking areas and now they have different uses. In this project properties such as compression test and oven test are carried out. The convention paver block consists of a raw material which includes cement, aggregates which are easily available but this paver block contains raw materials such as PET waste and quarry dust which are easily available and cost effective. From the observations of test results, PET can be reused with 50% of quarry dust and 25% of fly-ash in Plastic Paver block [1]. These paver blocks are used in places where there is no action of heavy loads since the compressive strength is low. Concrete paver block is a better option in road construction when compared to the conventional road which is made by bitumen and gravel [2]. One of the largest components of plastic waste is polyethylene terephthalate (PET). In order to reduce the plastic waste in environment paver blocks are made incorporating those PET waste and M sand and the strength properties are discussed in this project. Diversity of plastics applications is related with their specific properties, low density, easy processing, good mechanical properties, good chemical resistance, excellent thermal and electrical insulating properties and low cost (in comparison to other materials)[3].

A plastic as its behavior has impact on the environment at every extent of its stages from manufacture, usage and disposal. Recycling of plastics has lots of usage where it supplies energy economizing and...
1.1. PET:
Polyethylene terephthalate is considered to be a polyester material which is routinely used for making containers for food and beverages, pharmaceuticals and fibres. It is cited as PET or PETE and PET-P or PET-P in earlier. It is one of linear thermoplastic resin where its formation is based on condensation of terephthalic acid and ethylene glycol. Its application is worldwide because it is having high tensile strength, great resistance towards chemicals, transparency, fabricability and stoutness against fire. One such factor should be considered it is completely non-biodegradable that’s the reason its production rate is increased.

Figure 1: Polycondensation of BHET yields PET

Polyethylene terephthalate (PETE) is one of the polymerized forms of ethylene terephthalate (C10H8O4) monomer units. It possesses distinctive chemical and physical properties. It seems to be like amorphous glass like product. Additional heat treatment is given to the molten polymer or enhancing it by additive to amend its crystallinity and the rigidity. When PET is heated above 72$^\circ$C it leads to semi-crystalline state which tends to change into rubbery elastic form, easy to stretch or line up into desired shape. Between 255 and 265$^\circ$C PET tends to melt. As it a monomer Bis (2-
Hydroxyethyl terephthalate - BHET can be conglomerate by the esterification reaction between terephthalic acid and ethylene glycol with water as an end product. Another way of synthesis is transesterification reaction between ethylene glycol and dimethyl terephthalate with end product. Generally, Polymerization means large number of monomer molecules react together to form a polymer. Here it is through polycondensation reaction between the monomers (happen instantaneously after esterification or after transesterification) with end product of water.

![Chemical reaction between ethylene glycol and terephthalic acid yields BHET](image)

**Figure 1.1: Chemical reaction between ethylene glycol and terephthalic acid yields BHET**

### 2.0. Material properties.

#### 2.1. Waste plastic bottle (PET):

Plastic waste used in making paver block was collected from nearby places. The type of plastic waste collected is polyethylene terephthalate (PET) and its properties are given in Table 1. It includes bottles used for soft drinks. The plastic used has thermoplastic properties, which means it can be molded and remolded recursively when heated.

| S.NO | PARTICULARS      | VALUE    |
|------|-----------------|----------|
| 1    | Melting point   | >150 C   |
| 2    | Density         | 1.38 g/cm³ |
| 3    | Tensile strength| 55 Mpa   |
| 4    | Boiling point   | >230 C   |

#### 2.2. Quarry dust:

Crushed sand from quarry of size less than 4.75 mm were used. The advantages of quarry dust are cost effective, easily available and are used as a effective replacement of river sand. The properties for quarry dust are acquainted in Table 2.

| S.NO | PARTICULARS      | VALUE    |
|------|-----------------|----------|
| 1    | Specific gravity| 2.6      |
| 2    | Water absorption| 2.2      |
| 3    | Density         | 15.1 KN/m³ |
2.3. Preparation of test specimens:
The full plastic bottle is shredded into small plastic straps shown in (Img.3). The shredded plastic straps are heated in pan (img2) at a temperature >150 C, the plastic straps melts and become molten, once it becomes molten the quarry dust is added to it as per the design mix and are mixed together in the molten state. The cubes of size 70 X 70 X 70mm were cleaned and fixed and the mix were poured into the cubes in the molten state and let it to dry for 24 hours so that they become a hard mass. After drying they are demolded and tested for compression test.

2.4. Mix Ratio:
Block 1: plastic waste = 0.4, Quarry dust = 0.6;
Block 2: plastic waste = 0.5, Quarry dust = 0.5;
Block 3: plastic waste = 0.6, Quarry dust = 0.4.
2.5. Testing of specimen.

Compressive test:
The compressive strength of the specimen is found using UTM machine. The cube size of 70 X 70 X 70mm were casted and the test was carried out to determine the compressive strength. The specimens were tested one by one and average value is taken as the compressive strength of specimen. UTM used in shown in fig 4.

![Figure 4: Universal Testing Machine – compressive test.](image)

Oven test:
As paver blocks were made from melting of plastic waste, it is necessary to know the melting point so oven test is performed.

3.0. Result and discussion.

3.1. Compressive test result:
Table 3 shows the compressive strength of mix 2 with equal plastic waste and quarry dust is effective compared to other mixes.

| Paver block | PET waste | Quarry dust | Compressive strength |
|-------------|-----------|-------------|----------------------|
| Paver block 1 | 0.4       | 0.6         | 1.42 N/mm²          |
| Paver block 2 | 0.5       | 0.5         | 6.32 N/mm²          |
| Paver block 2 | 0.6       | 0.4         | 2.04 N/mm²          |
3.2. **Oven test result:**
The heat resistance is an essential parameter to be known as the paver blocks have been casted using waste plastics. Table 4 states behavior of each specimen in different temperature maintained in a controlled system (oven).

| Specimen | Temperature in °C | Remarks |
|----------|-------------------|---------|
| Specimen 1 | 50 | No change |
| | 100 | No change |
| | >140 | Melts |
| Specimen 2 | 50 | No change |
| | 100 | No change |
| | >140 | Melts |
| Specimen 3 | 50 | No change |
| | 100 | No change |
| | >140 | Melts |

3.3. **Discussion:**
Comparatively normal and plastic paver blocks have similar properties and durability characteristics that can give a good performance in paved areas, though not showing more improved parameters than normal paver blocks it appears to be a way to reuse plastic wastes (PET bottles). Mix 2 shows optimum strength and higher heat bearing ability among other two mixes making it perfect combination for making blocks.

4.0. **Conclusion.**
The results obtained from the tests clearly indicate that the block having equal ratio of plastic waste and quarry dust possess high compressive strength than that of other mixtures and all the test blocks melts again at a temperature greater than 140°C. Since these blocks have low compressive strength, they can be used in walking pavements where there is no action of heavy loads. The plastic paver blocks are economical than conventional paver blocks. This method of using recycled plastic waste in paver block serves the best way to reduce the impact of non-biodegradable plastic in the environment.

5.0. **References:**
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