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Reuse of PET Waste Plastic in Paver Blocks

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Abstract - *The aim of this project is to reduce the plastic from surrounding and to study the compressive strength of the pavement block when compared to that of convention concrete paver blocks. The dreadful conditions speed of plastic waste is also a very time-consuming process. Hence the project is helpful in tumbling plastic waste in a constructive way. In this project we have used plastic waste in different proportions with fine aggregate. The paver blocks were prepared and tested and the results were discussed.*

Key Words: *Pavement block, tumbling plastic waste, ceramic waste, quarry dust, coarse aggregate* etc

1. INTRODUCTION

The problem of disposing and organization hard desecrate materials in all countries has become one of the main ecological, economical, and social issues. A total desecrates management system including source decrease, reuse, recycling, land-filling, and burning requirements to be implement to control the growing desecrate removal problems. Usually a plastic is not recycled into the same type of plastic products made from recycled plastics are often not recyclable. The use of eco-friendly plastics is growing. If some of these get mixed in the other plastics for recycling, the cultivated plastic is not recyclable because the variance in properties and melt temperatures. The purpose of this project is to evaluate the possibility of using granulated plastic waste materials to partially substitute for the coarse aggregate in concrete composites. As compare to other waste fractions, plastic waste deserves special attention on account non eco-friendly property which is creating a lot of problems in the environment. In India approximately 42 million tons of solid waste is produced annually. This is increasing at a rate of 1.4 to 2% every year. Plastics constitute 12.7% of total waste produced most of which is from discarded water bottles. The plastic waste cannot be disposed of by discarding or burning, as they produce unrestrained fire or contaminate the soil and vegetation.

2. METHODOLOGY

2.1 Physical property of material to be used

a. Waste plastics

A material which contains more polymers which have more molecular weight Solid are in finished state or same state while manufacturing or processing into finished articles is known as Plastic. Waste management with respect to plastic can be done by recycling. If they are not recycled then they will become big pollutants to the environment as they do not decompose easily and also not allow the water to percolate to the soil and they are also poisonous.

India generates 5.7 million metric tons of plastic waste annually. On the basis of physical properties, plastic can be classified as thermoplastic (remoulded) and thermosetting material which shares 80% and 20% respectively in total plastic waste generation. Polyethylene Terephthalate (PETE or PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low density polyvinyl chloride, (LDPE) Polypropylene (PP), Polystyrene or Styrofoam (PS) are some examples of thermoplastic which can be recycled and which are used for making plastic paver blocks. Plastic used for making plastic paver block is collected from various sources.

2.2 Polyethylene Plastic

HDPE is a type of polyethylene that is obtain by the natural gas ethane. When ethane is heated to 1500 degrees Fahrenheit, the molecules break apart. One of the new molecules formed is ethylene. Ethylene is a gas that becomes a resin during the process of polymerization. A polymer is a chain of molecules which forms as a product of chemical reactions involving catalysts and pressure. When ethylene molecules are polymerized, they produce polyethylene. Polyethylene and other plastic can be modified to enhance certain desired characteristics, such as flexibility, strength or imperviousness to a particular substance. Polyethylene can be manufacture into different types of plastics: Low-density polyethylene, or LDPE, and polyethylene terephthalate, also known as PET or PETE.

Table 2.1 Physical Properties of HDPE

Sr. No	Physical Properties	Values
1	Tensile Strength	0.2- 0.4 N/mm2
2	Max. Continued use temperature	65ºC (149ºF)
3	Thermal Coefficient of Expansion	(100-200) x10−6
4	Melting Point	126ºC (259ºF)
5	Density	0.941-0.965 g/cm3

Advantages

- Poly (ethene) is water resistant, durable and is of a low density.
- The polymer can be reused after initial use, as bin liners and shopping bags.
- Poly (ethene) can be burned to provide a source of energy as heating for buildings.
- Poly(ethane) bags can be recycled. An example would be milk bottle crates.

Disadvantages

- The polymer takes a long period of time to break down in landfill sites, which we are running out of space for.
- These landfill sites destroy greenspaces and habitats
- Poly(ethene) is made from crude oil, which is a now renewable fossil fuel. We will gradually run out of this material.
- The production and combustion of Poly(ethene) produce a by-product of Carbon Dioxide; this greenhouse gas contributes to global warming.
- Large amounts of energy are required to produce the polymer.

2.3 River sand

Sand is naturally occurring material which is composed of small particles and finely divided material. The composition of sand varies is depend upon the local rock conditions and sources, but the most constituent of sand in Inland continental settings and non-tropical coastal region is silica dioxide (Sio2) in the form of quartz.

The other commonly used sand is the calcium carbonate, for example aragonite, by various forms of life, like coral and shellfish. Sand are now one of the main materials for the construction process.

Table 2.2 Physical Properties of River sand

Sr. No	Properties	Result
1.	Natural Water Content (%)	10.7
2.	Specific Gravity	2.48
3.	Unit Weight (g/cc)	1.59
4.	Fineness modulus	2.89

Advantages of River Sand

i. **Wide availability:**
M-Sand gives the flexibility of manufacturing near the construction place, thus the transportation costs and promising assurance of supply to meet the demanded quantity.

ii. **Denser particle packing:**
M-Sand does not contain silt and clay particles and has denser particle packing then the river sand. This gives less impurities and good working properties.

iii. **High strength:**
M-Sand gives more compressive strength then river sand with it, higher flexural strength, better damage resistance, better water retention ability, higher unit weight and lower permeability.

iv. **Better workability:**
Due to its superior gradation, M-Sand provides good plasticity to the mortar, which gives better workability compared to river sand.

v. **Economical:**
M-Sand gives higher durability, better workability, higher strength, reduction in segregation and permeability, thus proving of its usage as highly economical and a perfect replacement of river sand

vi. **Eco-friendly:**
Usage of M-Sand reduces the use of river beds for river sand, thus preventing environmental by water scarcity, ground water depletion etc.

Disadvantages of River Sand

i. **Low moisture content:**
Naturally available river sand has moisture trapped between its particles which are required for good concreting.

ii. **Chances of adulteration:**
Due to its high demand, the example of M-Sand being changed with extraneous materials like quarry dust.
To ensure M-Sand is of the good quality, it's strongly advised to put it through a series of quality tests such as –

(a) Adulteration Test
(b) Workability Test
(c) Rebound Test
(d) Slump Cone Test

2.4 Mix design

Fig 3.6 Mix Design

Table 3.5 Mix design

Ratio	Fine aggregate (kg)	Plastic(kg)
1:4	4.1	0.88
1:5	4.3	0.74
1:6	4.4	0.68

3.3 Casting of pavement block Procedure:

- In first step we had collected the waste plastic bottles are sorted out and remaining is disposed safely.
- Next the collected waste bottles are cleaned with water and dried to remove the water present in it.
- The plastics were burned out by using stones, firewood and coal.
- The stones are arranged to hold the ghamela and the firewood is placed in the gap between the stones and it is ignited.
- The ghamela is placed over the above setup and it is heated to remove the moisture present in it.
- Then the plastic bottles are added to the ghamela one by one and the river sand is added to the plastic when it turns into hot liquid.
- The sand is added is mixed thoroughly using rod and trowel before it hardens.
- The mixture gets hard very fast hence mixing process should be done fast not taking much time put the mixture in mold and leave it for 24hrs.

Fig 3.1 Casting of pavement block

2.4 Observation done during our project

- Initial setting time of pavement was 2 min.
- Final setting time of pavement was 60 min.
- Total losses of PET plastic were 50% in gases form (20gm of bottle).
- Total time required for making of one pavement was 30min.
- Time required to melt the plastic was 20min.
- Required bottles for one pavement was 50 No's.
- Cost required for one pavement was 35 Rs.

3. CALCULATIONS

3. 1 Mix Design calculations: -

a. Ratio (1:4)

Size of pavement = 20 x 20 x 8 cm
= 0.20 x 0.20 x 0.08 m
Volume of pavement = 0.0032 m^3
Sum of proportion = 1+ 4 = 5
Amount of plastic = $\frac{0.0032}{5}$ x 1
= (6.4×10^{-4}) x1390…… (1390 PET density)
Amount of plastic = 0.88 kg of plastic.
Amount of sand = $\frac{0.0032}{5}$ x 4
= (2.56×10^{-4}) x 1620 …. (1620 Sand density)
Amount of sand =4.14 kg of sand.

b. Ratio (1:5)

Size of pavement = 20 x 20 x 8 cm
= 0.20 x 0.20 x 0.08 m
Volume of pavement = 0.0032 m^3
Sum of proportion= 1+5 = 6
Amount of plastic = $\frac{0.0032}{6}$ x 1
= (5.33×10^{-4}) x 1390… (1390 PET density)
Amount of plastic= 0.74 kg of plastic.
Amount of sand= $\frac{0.0032}{6}$ x 5
= (2.66×10^{-3}) x 1620…. (1620 Sand density)
Amount of sand = 4.32 kg of sand.

c. Ratio (1:6)

Size of pavement = 20 x 20 x 8 cm

= 0.20 x 0.20 x 0.08 m

Volume of pavement = 0.0032 m^3

Sum of proportion= 1+6 =7

Amount of plastic = $\frac{0.0032}{7}$ x 1

= $(4.57 \times 10^{-4}) \times 1390$ … (1390 PET density)

Amount of plastic=0.64kg of plastic.

Amount of sand= $\frac{0.0032}{7}$ x 6

= $(2.74 \times 10^{-3}) \times 1620$ …. (1620 Sand density)

Amount of sand=4.44kg of sand.

3.2 Load calculation for compressive strength: -

a. Ratio (1:4)

Observed load (15 Day's) =205 KN

=205x 10^3 N

Area of pavement = $(200)^2$

=40000 mm^2

Compressive strength = $\frac{\text{force (N)}}{area(\text{mm}^2)}$

= $\frac{205\text{x}10^3}{40000}$

Compressive strength=5.12 N/ mm^2

b. Ratio (1:5)

Observed load (15 Day's) = 350 KN

=250 x 10^3 N

Area of pavement =$(200)^2$

=40000 mm^2

Compressive strength = $\frac{\text{force (N)}}{area(\text{mm}^2)}$

=$\frac{350\text{x}10^3}{40000}$

Compressive strength= 8.75 N/ mm^2

c. Ratio (1:6)

Observed load (15 Day's) = 250KN

= $250\text{x}10^3$N

Area of pavement = $(200)^2$

= $40000mm^2$

Compressive strength = $\frac{\text{force (N)}}{area(\text{mm}^2)}$

= $\frac{250\text{x}10^3}{40000}$

Compressive strength=6.25 N/mm^2

3.3 Water absorption test: -

a. Standard pavement observation: -

W1=6.1kg, W2= 6.4kg

% of water absorption= $\frac{(W2-W1)}{W1}$x100

=$\frac{(6.4-6.1)}{6.1}$x100

% of water absorption= 4.91

b. Plastic sand pavement: -

W1= 5.6kg, W2 = 5.7kg

% of water absorption = $\frac{(W2-W1)}{W1}$ x100

= $\frac{(5.7-5.6)}{5.6}$ x100

% of water absorption= 1.70

4. RESULT

4.1 Compressive strength:

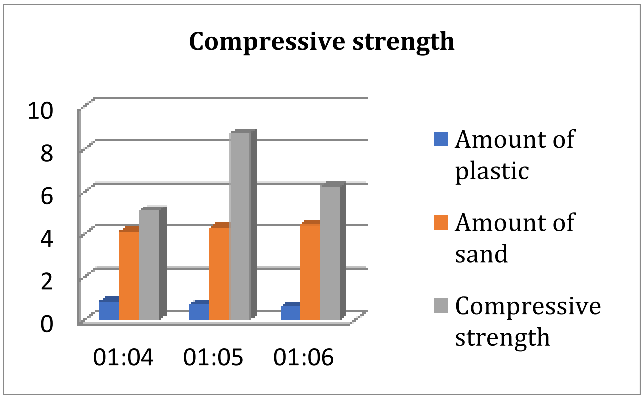

Fig -4.1: Compressive strength

From the above table 5.1 Compressive strength shows that the Mix design ratio between plastic and sand are 1:4,1:5 and 1:6 and the compressive strength are 5.12 N/ mm2, 8.75 N/ mm2 and 6.25 N/ mm2 respectively. After the compression test, it clearly shows that the Mix Design Ratio between the plastic and sand 1:5 gives more compressive strength 8.75 N/ mm2 rather than the other ratio.

4.2 Percentage of water Absorption:

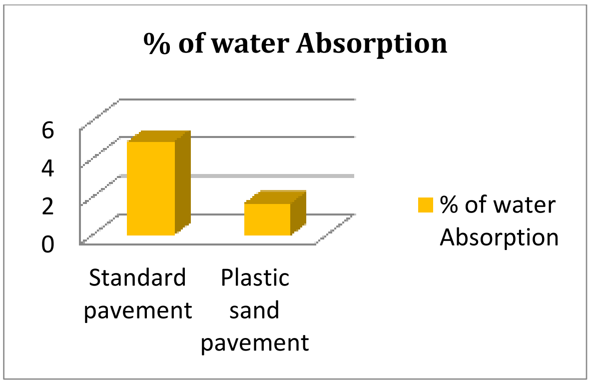

Fig -4.2: Compressive strength

From the above Table 5.2 Percentage of Water Absorption shows that the Standard pavement has 4.91% of Water Absorption whereas Plastic Sand Pavement has 1.70 % of Water Absorption. As per the test result, Plastic sand pavement is good in resisting water absorption as compared to standard pavement.

5. CONCLUSIONS

The Plastic sand pavements possess more advantages which include Cost efficiency. Reduction in the emission of greenhouse gases by the conversion of flue gases into synthetic oil etc., this method is suitable for the countries which have the difficult to dispose /recycle the plastic waste. The natural available resources used for the manufacturing of Plastic Paver blocks are very less when compared to its corresponding material. If we use fly ash/quarry dust or other waste products. There is chance of cost reduction in manufacturing.

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