# Use of Thermo Geoplastic (TGP) as Composite Material for Pavers and Filler for Bituminous Pavements

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***Abstract-The biggest challenge in the world is minimizing the impact of "global warming." The Earth's temperature has risen by 1°C in the past five decades, and scientists expect it to rise by 2 to 2.5°C further in the coming two decades. On the other hand, the use of plastic has been increasingly steadily in our everyday lives, as different types of plastic products meet a wide range of consumer needs. However, the disposal of plastic waste has become a major challenge worldwide among the waste produced. Addressing the problem of plastic waste disposal is attracting the several researchers as plastics pose significant hazards to human life.***

***Reducing plastic usage is a global effort, and awareness is being created among the public through education, media, and NGOs at school and college levels. Therefore, it is essential to employ the 3Rs—Reduce, Recycle, and Reuse method—to handle waste disposal management.***

***In the present paper, authors reported their study on use of plastic with different kinds of soils mixed at various temperatures to make it a composite material. Experiments at laboratory level indicate that the plastic mix with different soils produces a material which has improved compressive strength and it also makes the soil non absorbent of water. Hence this property of improvement in compressive strength and water non- absorption property can be utilized to manufacture plastic pavers known as "Thermo Geo-plastic Pavers (TGP)" and can also be used in flexible pavement construction as a wearing coat or for filling potholes.***

***Index Terms—Thermo geo-plastic, Global warming, Reduce Recycle Reuse,Solid waste, Wearing coat, Pavers.***

## I. INTRODUCTION

The world is focused on finding innovative, cost-effective, reusable, self- sustainable, and durable solutions for efficient waste disposal process. Waste is primarily classified into three groups: solid waste, liquid waste, and gaseous waste. Each of these groups can be further categorized as follows: a) Industrial waste, b) Domestic waste, c) Medical waste, and d) E-waste (electronic waste) in modern times.

While waste production is inevitable during the manufacturing of useful products and its use, the only way forward is to reduce, recycle, and reuse waste to minimize its impact on the environment.

Few of the hazards associated with plastic waste include:

i) Reduction of groundwater table due to the creation of an impervious layer on the earth reducing the infiltration rate of soil.

ii) Releases harmful fossil gases into atmosphere on burning of plastic waste contributing to global warming menace.

iii) Reduction in marine species due to consumption of plastic waste disposed.

The term "plastic" is a generic term used for polymeric materials that contain substances which when used with other materials can help to produce useful material. Among the kind of plastics such as thermoplastics and thermo-sets, thermoplastic materials consist of long molecules with side chains or groups that can be melted and solidified repeatedly through heating and cooling without undergoing a chemical change. This property minimizes their impact on the environment. The waste produced during the processing of thermoplastics can be efficiently reused in making the pellets. Whereas thermo-sets cannot be reused because they attain cross-linked structures while processing. However this type of plastic waste can be used for landfills.

## II. LITERATURE REVIEW

India generates 5.6 million metric tons of plastic waste annually. Plastics can be classified into two categories based on their physical properties: thermoplastics, which are remouldable, account for 80% of the total plastic waste generation, while thermosetting materials make up the remaining 20%. Some examples of thermoplastics that can be recycled and used for making plastic paver blocks [1] include Polyethylene Terephthalate (PETE or PET), High-Density Polyethylene (HDPE), Polyvinyl Chloride (PVC), Low-Density Polyvinyl Chloride (LDPE), Polypropylene (PP), and Polystyrene or Styrofoam (PS). Jeevan Ghuge et al., (2019) have mentioned that to manufacture around 1000 paver blocks, approximately 600kg of plastic is required. The strength of these plastic blocks is found to almost equal to that of ordinary paver blocks.

The production of pavers using waste plastic is considered the most productive method [2] for waste plastic disposal. It offers an eco-friendly, cost-effective, heat- resistant, and improved paving solution for non-traffic and light traffic roads, footpaths, garden walkways, parking areas, etc.

Plastic sand bricks have been proven to be cost-effective reducing the need for fertile land being used for dumping waste plastic [3]. They also contribute to the reduction of fossil gas emissions and address the growing demand for costly natural resources for the production of conventional concrete blocks.

Properties of PET plastics mentioned in Table-2.[4]

The application of various waste materials, such as plastic, steel slag, and crumb rubber, in the manufacturing of paver blocks has shown excellent results [5]. When waste steel aggregates are used in combination with elastic cushions, the compressive strength of paver blocks can increase by up to 50% compared to conventional paver blocks. Utilizing industrial waste materials as substitute materials by reducing the percentage of cement weight in the composition ratio, based on the comparative volume category of the paving block aggregate (0%, 5%, 10%, 15%, 20%, and 25%), has proven to be a viable approach.

Webert Silva et al. (2023)[6] have primarily focused on analyzing the mechanical behavior of pavements, including mix parameters, impact of by-products, design, sustainability aspects such as the heat island effect, management of contaminant concentrations in relation to permeability, and Life Cycle Assessment (LCA) for interlocking concrete blocks and have reported that interlocking pavements are approximately 33-44% cheaper, providing cooler temperature within the range of 22-150 C, exhibiting higher permeability (0.4cm/sec to 0.60cm/sec) compared to asphalt pavement[6].

The source of different types of waste plastic has been listed in the work reported by Jeevan Ghuge et al.[1] and are as shown in Table 1

Table1: Type of plastic waste and their source.

| Source | Waste Plastic type |
|---|---|
| Bottle caps, carry bags, house hold articles. | High density polyethylene (HDPE) |
| Carry bags, cosmetics, milk pouches and detergent bottles. | Low density polyethylene (LDPE) |
| Drinking water bottles. | Polyethylene Terephthalate (PET) |
| tergent bottles, biscuit kets and microwave trays. | Polypropylene (PP) |
| Bottle caps, food trays, egg boxes. | Polystyrene (PS) |

Drinking water bottles made from PET plastic possess specific properties that make them suitable for beverage packaging. These properties include transparency, lightweight, durability, rigidity, clearness, chemical resistance, difficulty properties, cost-effectiveness, and safety. Equally it is important that proper recycling and disposal practices to be followed to minimize environmental impact and promote sustainability. The present work carried by the author deals with the Polyethylene Terephthalate (PET) plastic which is obtained from drinking water bottles.

"Despite numerous research efforts worldwide to find efficient and productive solutions for waste plastic disposal,

there is still a need to develop cost-effective, eco-friendly, sustainable, and durable composite materials from these is still to be explored. The composite materials can be obtained using waste plastics with less expensive locally available soils.
The properties of the PET plastics (Waste drinking bottles) are shown in the Table 2.

Table-2. Properties of PET plastics
(Drinking water waste bottles) [4]

| Sl.No | Description | Value |
|---|---|---|
| 1 | Structure | Semi Crystalline |
| 2 | Chemical formula | (C10H804)n |
| 3 | Melting point | 260oC (482oF) |
| 4 | Boiling point | 350oC (662oF) |
| 5 | Young's Modulus "E" | 2800-3100MPa |
| 6 | Tensile strength | 55-75MPa |
| 7 | Density | 1.38g/cc |

## III. PROCEDURE ADOPTED

The 4.75 mm and downsize gravel, river sand, M-sand, B.C soil were used independently in different proportions with shredded PET waste plastics to make a composite material. Drinking water waste bottles (100µ) were shredded to approximately 4.75mm and down size.

## IV. METHODOLOGY

The methodology adopted to prepare composite material in different form and its use is depicted in Figure 1.

Natural soil | Shredding PET waste

Sieving | Melting PET

Sieved soil 4.75mm & down size | Melted plastic

Mixing and string under heat

Molding to prepare block | For wearing course of pavement | For filling potholes

Fig.1. Process of methodology..

Procedure adopted in the preparation of TGP composite material:
The TGP composite material is prepared by considering mix proportions of plastic to gravel as 1:1, 1:2, 1:3, and 1:4 by weight. The shredded PET waste plastic is heated in a container to melting temperature of 260°C. The melted plastic is then poured into the container of a graded soil. The mix is continuously stirred well under heat to form a homogeneous composite TGP mix. This is then poured into moulds of size200mm x 100mm x 50mm. On cooling blocks were tested for their compressive strength and water absorption.

The optimum results were obtained for a proportion of plastic to Gravel, River s, M-sand and B.C. soils at 1:3, 1:3, 1:1, 1:3 mix proportions respectively. The results of the laboratory tests on compressive strength and water absorption of TGP blocks are provided in the Table 3.

Table-3. Results of lab tests on TGP.

| Composite material Plastic with | Optimum proportion | Density of paver Kg/m$^3$ | Compression Strength MPa | Water absorption % |
|---|---|---|---|---|
| M-Sand | 1:1 | 2105 | 9.90 | 0.23 |
| Gravel | 1:3 | 2145 | 15.94 | 1.39 |
| Sea Sand | 1:3 | 2765 | 10.80 | 0.29 |
| B.C.Soil | 1:3 | 1765 | 10.80 | 0.29 |

## V. FIELD APPLICATION

In view of the excellent results of the TGP composite material in terms of compressive strength and absorption of water, the potholes on a State Highway was filled with TGP composite material prepared from gravel and the plastic. The filled-up pothole showed an excellent functional performance even under heavy vehicular traffic.

The stage-wise process of pothole filling is illustrated in Fig 2 to 11.

Fig. 2 Collection of material

Fig. 3 Weighing of sample


Fig. 4 Shredded plastic   Fig. 5 Heating at site

Fig. 6 String while heating Fig. 7 Cleaning pothole.

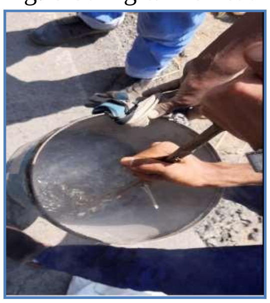
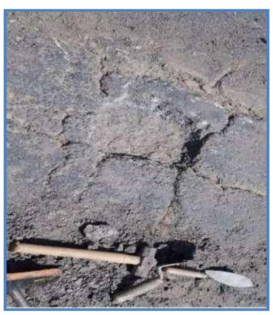
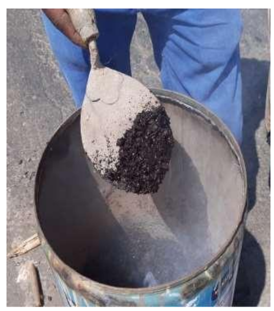



Fig. 8 Pothole ready Fig.   9 TGP ready to use.

for filling.

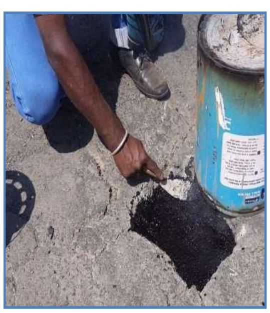



Fig. 10 Poring TGP and leveling   Fig. 11 TGP functioning after overlay with B.C

## VI. CONCLUSIONS

The challenges of disposal of waste plastic can be addressed by using waste plastic in the construction and service industry. The present work of the researchers demonstrates the use of waste plastic into useful composite material is an example in this direction. The experimental investigation shows that the optimum compressive strength were obtained for a mix proportion of plastic with Gravel, River sand, M. Sand, and B.C soil at 1:3, 1:3, 1:1, 1:3, respectively.

The maximum compressive strength of 15.94MPA has been able gained for a composite material made of Gravel and plastic waste with a proportion of 1:3 by weight. This is slightly better than the compressive strength of M15 conventional concrete. It is this property and water absorption property which has prompted us to use as material to fill the potholes in the state highway. It has sustained vehicular traffic and working efficiently.

The present work proves that TGP is probably the cost-effective solution for manufacturing paver blocks and filling up potholes, while disposal of waste plastic will also be addressed. It also helps us to keep the release of green house gasses lesser and marginally addresses the impact of global warming. The TGP can be an alternative to the bituminous material which is been used vastly for filling up potholes on roads.

These TGP blocks can be efficiently used for pavement construction of low volume traffic, parking pavements, walkways, footpaths.

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