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DESIGN OF FLEXIBLE PAVEMENT USING PET (POLYETHYLENE TEREPHTHALATE) PLASTICS AS GEO-SYNTHETIC

Suryawanshi Krushna[1], Asst.Prof. Jayalakshmi Dheiveekan[2], Chaudhari Shubham[3], Zalte Rahul[4]

[1,3] Deparment of Civil Engineering, G.S.Moze C.O.E, Balewadi, Pune, Maharashtra, (India).

[2]Assistant Professor: Department of Civil Engineering, G.S.Moze C.O.E, Balewadi, Pune, Maharashtra, (India)

ABSTRACT

Good transportation is the important infrastructure for our nation development. Road is the greatest mode of transportation in India. And it is essential to achieve economy in the construction of roads. Along with the economy, quality is also an important factor to be considered. On the other hand the domestic wastage and industrial wastage disposal is a big problem. Especially the plastic which creates many environmental problems cannot be decomposable in nature. It is generally recycled and reused. The present investigation is to utilize the plastic waste in the form of reinforcement in road construction in order to increase its performance.

There are many ways to achieve economy and quality in roads. And geo-synthetic is one of the ways to improve the properties of pavement. It is used in flexible pavement for stabilization, to reduce the thickness of pavement and also to reduce the construction cost. There are many companies like Mirafi® which manufacture geo-textile from PET plastic.

Taking into account, the present study focuses to conduct a detailed investigation along with few testing on flexible pavement, geo-synthetic and PET plastic. We aim at studying different types of geo-synthetic material, their physical property, their characteristics, and their functioning. Our current work is to replace the geo-synthetic by processing PET plastic similar to geogrid which is readily available as domestic waste. Various tests are performed to find the compatibility between geo-synthetic and PET plastic. We are making our own geogrids in woven form by using plastic waste bottle instead of using PET geo textile which is already available in market considering the point of economy. We are comparing our specimen with the conventional geo-synthetic by modified direct shear test, stiffness test, trapezoidal tear test and wide strip tensile strength as per the IS and ASTM codal specification.

Keywords: Flexible pavement, Geo-synthetic, Modified direct shear, PET)

I INTRODUCTION

Roads are very important national investment and require maintenance to keep them in a satisfactory condition and ensure safe passage at an appropriate speed and with low road user cost. Road is a way of communication using a stabilized base other than rails or air strips open to public traffic, primarily the road is used for vehicles running on their own wheel loads. The road should be constructed for development and progress of our country. Road also constructed for connecting different capital of states, large industrial & tourist centers, different states & cities with each other for the purpose of transporting peoples, goods, tools, equipment, machinery etc. A road is well designed, well-constructed and well maintained is essential for agricultural, commercial, industrial and cultural progress i.e. for overall development of country. In the road foundation or pavement, various types of defects are occurs like un-stability, pot holes etc. due to improper proportion of materials, inadequate thickness of pavement & separation or settlement of any layer or any reason then this defects can be overcome by using various Geo-synthetic materials in road pavement to improves such defects this is our actually study as mentioned above.

Geo-synthetics can be defined as the manmade or natural fiber, which is used in construction. They are made up of natural fibers or synthetic fibers, which are weaved or bonded with partial melting, needle punching or the addition of chemical agents Generally, the Geo-synthetics are made of Polymer based - Polypropylene, PVC , Polyester, Polyethylene, Polyamide, PET High-Strength Woven Polyester Geo-textiles. Geo-synthetics are an established family of geo materials used in a wide variety of civil engineering applications. Many plastics common to everyday life are found in geo-synthetics. The most common geo-synthetics are polyolefin and polyester, rubber, fiberglass, and natural materials are used. The function of Geo-synthetics is used as a separator, filter, drainage, and reinforcement, protection, as a liquid and gas barrier. It can be also used in construction of road, retaining wall, railway embankment, earthen dam etc.

Polyethylene terephthalate is commonly known as PET or beverages plastic bottle. The PET the most common thermoplastic polymer resin of the polyester family is used in fibers for textile, containers, thermoforming for manufacturing, and in combination with glass fiber for engineering resins. The majority of the world's PET production is for synthetic fibers in excess of 60%, with bottle production accounting for about 30% of global demand. In the context of textile applications, PET is referred to by its common name, polyester, whereas the acronym PET is generally used in relation to packaging. Polyester makes up about 18% of world polymer production and is the fourth most. [5]

1.1 Properties of PET:

- Chemical formula : ($C_{10}H_8O_4$)
- Density : 1.38 g/cm^3 (20 °C)
- Melting point : > 250 °C
- Boiling point : > 350 °C
- Young's modulus : 2800–3100MPa
- Tensile strength : 55 TO 75MPa
- Elastic limit : 50 TO 150%

II OBJECTIVES OF THE PRESENT WORK:

The main objective of the present work is to develop cost effective material and to improve the performance by replacing geo-synthetic layer in flexible pavement.

1. To study conventional and available materials of geo-synthetic that are used in flexible pavement.
2. To develop cost effective material to be used as replacement of geo-synthetic that is PET plastic bottles.
3. To fabricate Geogrid manually using PET plastic bottles without changing its property.
4. To conduct various test and to compare the performance of various samples.
5. To design the pavement and cost analysis.

Fig.1.1 PET Plastic bottles

III METHODOLOGY

3.1 Sample Preparation

Fig. 3.1 Sample for Modified direct shear test Fig. 3.2 Sample for wide strip tensile strength test


Fig. 3.3 Sample for trapezoidal tear resistance test **Fig. 3.4 sample for stiffness test**

3.2 Test Procedure

3.2.1 Stiffness or flexural rigidity or flexural stiffness [3]. (ASTM D1388):

1) The geotextile specimen is a 25 mm wide strip. The geotextile is placed along the length of a horizontal plane and bends gravitationally under its own weight on inclined plane making an angle of 41.5 degree with the horizontal.

2) Stiffness of the geotextile = $(L/2)^3$ x W

Where, L = length of overhang geotextile and bending length = l/2 (cm), w = mass per unit area (mg/cm2)

3) The minimum stiffness of geotextile depends on the various degree of required workability.

3.2.2 Wide strip tensile test [1] (IS 13325: 1992):

. **3.2.2.1 Apparatus required**

1) Tensile Testing Machine

2) Jaws

3) Jig Plates

3.2.2.2 Procedure

1) Setting up of Tensile Testing machine

2) Insertion of Test Specimen in Jaws

3) Measurement of Tensile Strength

4) Start the tensile testing machine and the area measuring device

5) Measurement of Strain

6) Tensile strength of geotextile (T geo-textile) can be expressed as force per unit width.

Tgeotextile = Fb/ W (kN/m)

Fb = Observed breaking force (kN), and

W = Specimen width (meter)

3.3.3 Trapezoidal tear strength test [4] (IS 14293: 1995):

3.3.3.1 Apparatus required:

1) Tensile Testing Machine

2) Clamps

3) Trapezoidal Template.

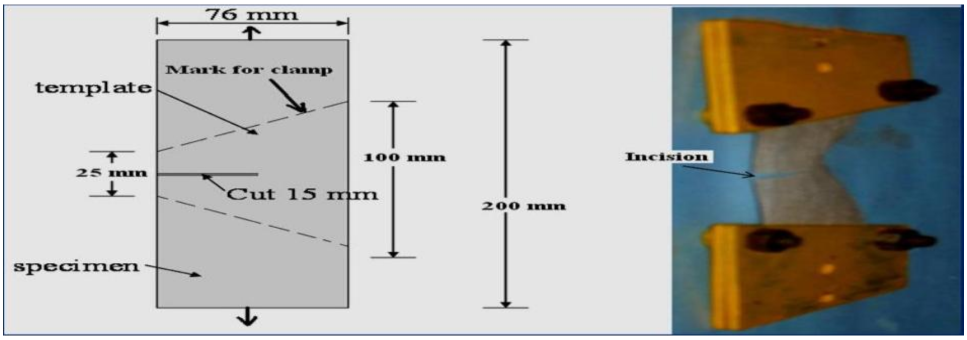


Fig. 3.5 Trapezoidal tear strength test

3.3.3.2 Procedure:

1) Test the thoroughly wet specimen in the normal machine setup within 2 minutes after removal from the water.

2) Set the distance between the clamps

3) Secure the test specimen in the machine

4) Start the machine and record the tearing force on the autographic recorder.

7) Calculate the average excluding outlier values.

3.3.4 Modified direct shear test [2] (IS 13326 (Part 1): 1992):

3.3.4.1 Apparatus

1) The bottom half of the box should have facility to be made into a solid block by placement of mild steel (chromium plated) spacer 300 x 300 x 75 mm..

2) Two mild steel strips 350 x 25 x 5 mm

3) Porous stone

4) Drainage plate

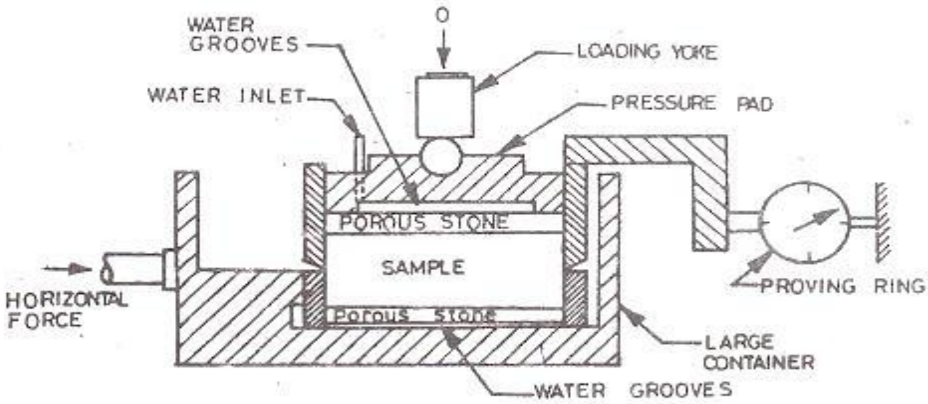


Fig. 3.6 Direct shear mould

Fig. 3.7 Sample after failure

3.3.4.2 Procedure

1) The spacer is fitted into the bottom half of the shear box. Then the geo-synthetic test specimen is fixed on its top so that the top face of the material is flush with the top edge of the lower half of the box. Geotextile needs to be fixed on two sides whereas geogrid is fixed only on one side opposite to the direction of shearing.
2) The top half of the shear box is then assembled and the soil is filled to the required density and the loading plate positioned.
3) The shear box is placed in the container carefully.
4) The required normal load is then applied. The test is usually conducted at normal stresses of 50, 100 and 200 KPa.
5) The upper half of the box is lifted up slightly to leave a gap of about 1 mm between the two parts of the box.
6) The shear strain should be applied using a deformation rate of 0.20 mm/min.
7) The shearing is continued until the shearing load becomes essentially constant or until a displacement of 60 mm is reached whichever is larger.
8) During the shearing, the shearing loads is measured at regular intervals of shear deformation.
9) After the completion of the test, the apparatus is dismantled, the geo-synthetic is removed and its condition is observed.
10) The test is repeated for all the three normal stress levels

3.3.4.3 Calculation

Shear strength can be found out by following formula:

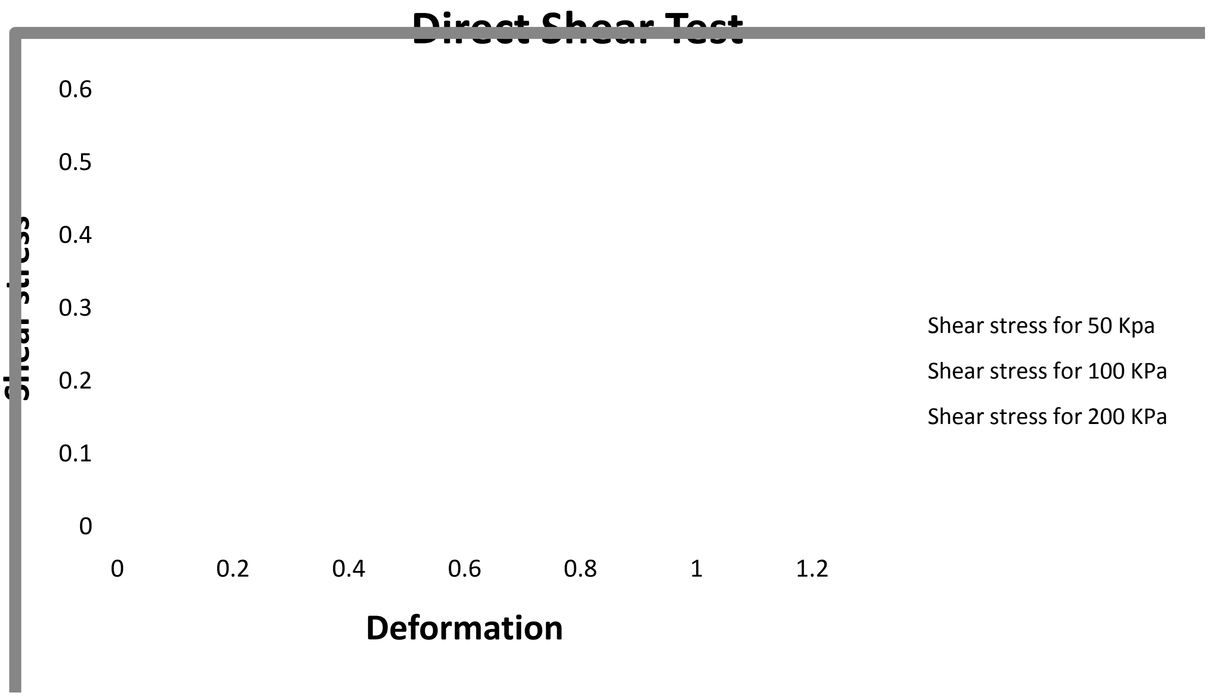
$\tau g = Ca + \sigma n. \tan\delta$

τg = shear strength of soil-to-geo-synthetic

Ca = adhesion between soil and geo-synthetic

δ = Angle of wall friction between soil and geo-synthetic

DEFORMATION	Normal stress 50kpa	Normal stress 100kpa	Normal stress 200kpa
0.1	0.081	0.14	0.15
0.2	0.096	0.205	0.216
0.3	0.125	0.338	0.375
0.4	0.143	0.416	0.442
0.5	0.155	0.487	0.527
0.6	0.155	0.479	0.479
0.7	0.205	0.456	
0.8	0.215		
0.9	0.209		
1	0.203		



Graph 1.Deformation Vs. Shear stress

3.3.4.4 Result

Test No.	Normal stress (Kg/cm²)	Shear stress at failure (Kg/cm²)	Shear displacement at failure (mm.)
1	0.5	0.215	0.8
2	1.0	0.487	0.5
3	2.0	0.527	0.5

Table no.1. Observation table for modified direct shear test

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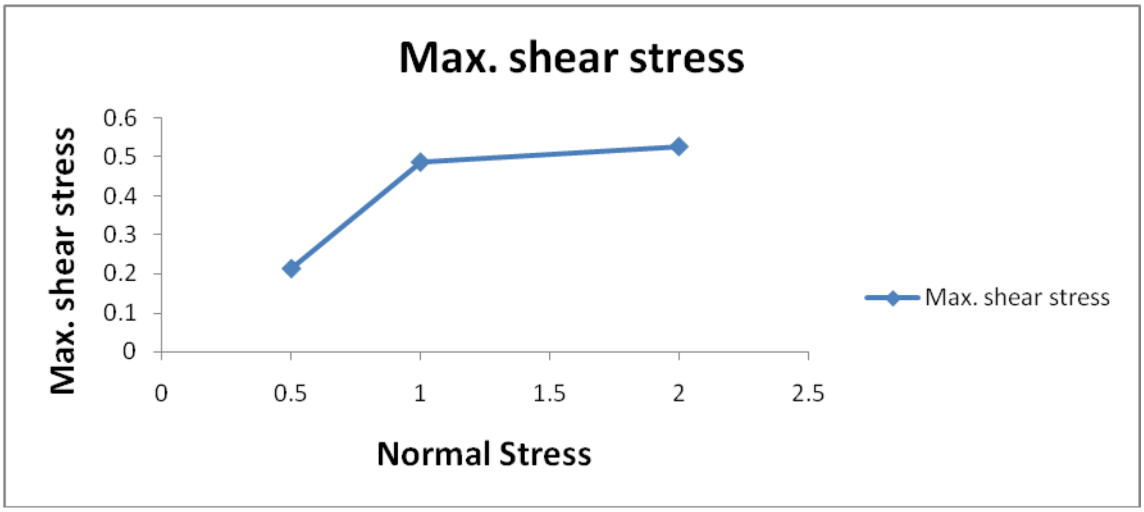

Graph 2 Normal stress Vs. Peak stress

IV CONCLUSION

1) From the results obtain it is observed that the specimen tested with PET plastic as reinforcement give better shear strength than conventional specimen
2) The fabricated grid structure of the present specimen improve interlocking and bonding between layers
3) The economy achieved by using PET plastic for the higher side in the whole of construction cost
4) From the present investigation eco-friendly environment promoted by reusing waste plastic bottles
5) The problem of domestic waste disposal is resolved and the utilization of waste as better resource for better performance
6) Further the investigation can be extended by performing various test for several property

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