Experimental Investigation on Repair and Maintenance of Flexible Pavement using Geo-synthetics

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Abstract. Flexible pavements are frequently damaged with excessive cracks, settlements, and potholes due to various reasons. There are many options to maintain and repair such defects depending upon serviceability standard, funds available and priorities for maintenance operations. Since last few decades' geo-synthetics material are introduced in market for wide range of geotechnical application such as reinforcement, separator, drainage, gabions etc. In this study, an attempt is made to study the effectiveness of non-woven geotextile for repair of potholes. For this, geotextile was used over a patch of the potholes to act as reinforcement and drainage overlaid by the aggregates. To check the effectiveness of the geotextile performance, cyclic plate load test was carried out in the laboratory model of 0.8 x 0.8 x 0.8 m tank to measure settlement. The same set of the test was also conducted by simulating potholes and repaired without geotextile layer, and then the comparison of the settlement was done to check the performance of the Geotextiles. It was found that pavement with geotextile produce 45% less settlement than pavement without geotextile.

Keywords: Potholes, Geotextile, Flexible Pavement, Cyclic Plate Load.

1 Introduction

Streets in India are fundamentally bitumen-based macadamized streets. The principle streets in India are under immense weight and in extraordinary need of modernization so as to deal with the expanded necessities of the Indian economy. Not withstanding support, the extension of the system and broadening of existing streets is winding up progressively imperative. This would then empower the streets to deal with expanded activity, and furthermore take into consideration a comparing increment in the normal development speed on India's streets. Advancement of potholes on Indian streets and avenues after the beginning of rainstorm is a typical wonder[1,3]. Consistently there is an open objection and daily papers are brimming with pictures demonstrating pot-holed street asphalts. Hot blend black-top plants are generally closed down amid storms and no hot bituminous blend is accessible for filling potholes. Thusly, numerous potholes are either not repaired or repaired with out of date procedures. Many researchers have attempted to repair it with refill and overlay with bitumen layer [1], using polymer products[2] or using cementitious materials[3]. However very few have attempted the Geo-synthetics to satisfy various capacities that contributes altogether to the great execution of roadways[4-6]. They incorporate the elements of partition, stiffening, reinforcement, drainage, separation, and protection. One or on the other hand a greater amount of these different capacities has been utilized as a part of no less than six imperative roadway applications. Further, none of them have an attempted to check its effectiveness to repair the potholes, because it is found that majority of the pothole failures are due to poor compaction of the subgrade. Therefore, the objective of this study is to evaluate the performance of the pothole repaired with geotextile layer embedded as reinforcement.

2 Materials

2.1 Geo-textile

The geotextile texture can be a woven, non-woven or weaved texture comprising of long-chain polymeric fibers or yarns, for example, polypropylene, polyethylene or polyester or any blend thereof, framed into a steady system to such an extent that the fibers or yarns hold their relative position to each other. There are a few application territories for geotextile requiring particular capacities specifically separation, filtration, drainage, reinforcement. In this study, non-woven geotextile HTSF W-3020A made of 100% polypropylene mad by multifilament yarn was procured from the local supplier. The property of the geotextile used is narrated in Table-1.

Fig. 1. Photograph of the geotextile material used

Table 1. Physical property of the Geotextiles used in this study.

Specific Gravity	Tensile strength at 20° C (MPa)	Modulus of Elasticity (GPa)	Strain at break (%)
0.97	560	1.6	32

2.2 Soil Sub-grade.

To simulate the actual flexible pavement condition in the tank, the soil selected was the local soil collected from the road-side where the potholes were created. The soil was tested for index and engineering properties and they are listed in Table-2. The soil was CI type and was compacted to OMC with 50% dry side of the MDD in the laboratory tank to simulate the poor compaction in the field.

Table 2.Index and engineering properties of the subgrade soil used in this study

Liquid limit%	Plastic limit	IS classification	Cohesion kN/m^2	Free-swell index%
42	30	CI	16	12

2.3 Aggregates.

The aggregate tests were performed on the various specified properties, and the resulting test results were compared with the allowable values in the MORTH specification, as shown in the table 3-5.

Table 3. Aggregate characteristics and results of 6mm Grit

Sr. No	Sieve Size	% Passing	Req.	Flakiness Index, %	Elongation Index, %	Method of Test
01	40.0 mm	100	100			IS:2386
02	20.0 mm	91.52	85-100	15.26	20.14	(Part-1):1963
03	10.0 mm	2.15	0.-20	Combined Shall be < 40%		Reaffirmed
04	4.75 mm	0.08	0-5	(As per MORTH)		2016

Table 4. Aggregate characteristics and results of 10mm Aggregates

Sr. No	Sieve Size	% Passing	Req.	Flakiness Index, %	Elongation Index, %	Method of Test
01	12.5 mm	100	100	17.05	22.21	IS:2386 (Part-1):1963 Reaf-firmed 2016
02	10.0 mm	88.50	85-100			
03	4.75 mm	5.95	0-20	Combined Shall be <40% (As per morth)		
04	2.36 mm	0.94	0-5			

Table 5. Aggregate characteristics and results of 20mm Aggregates

Sr. No	Sieve Size	% Passing	Req.	Flakiness Index, %	Elongation Index, %	Method of Test
01	40.0 mm	100	100	15.26	20.14	IS:2386 (Part-1):1963 Reaf-firmed 2016
02	20.0 mm	91.52	85-100			
03	10.0 mm	2.15	0-20	Combined Shall be < 40% (As per morth)		
04	4.75 mm	0.08	0-5			

2.4 Bitumen

Bitumen grade was used in this study is VG-30. Sample of bitumen were tested for penetration test, ductility test, viscosity test and softening point test. The test results of different bitumen tests results are shown in table-6

Table 6 Bitumen Test Results

Sr. No.	Tests	Results	Requirements as per IS: 73-2013
1	Penetration at 25° C,0.1mm, 100gm, 5s	52	Min 45
2	Softening Point, ° C	49.5	Min 47° C
3	Absolute Viscosity at 60° C, Poise	2932	2400-3600
4	Kinematic Viscosity at 135° C, cSt	429	Min 350
5	Ductility @ 25° C	95	Min 40 cm

3 Experimental Work

To evaluate the response of the pothole repaired with geotextile as reinforcement, and without geotextile layer, The Cyclic plate load test was performed to measure the settlement of the paved surface The experimental work was performed on mild steel tank as shown in figure-2 having following properties:

1) Size of Box: 0.8 x 0.8 x 0.8m.

2) Thickness of the plate: 1.20mm.

The entire flexible pavement was simulated in this tank as per the figure-3 and the actual aggregates and subgrade properties mentioned in the table1-7 the various layer were laid and compacted as shown in the figure-4 to8 .

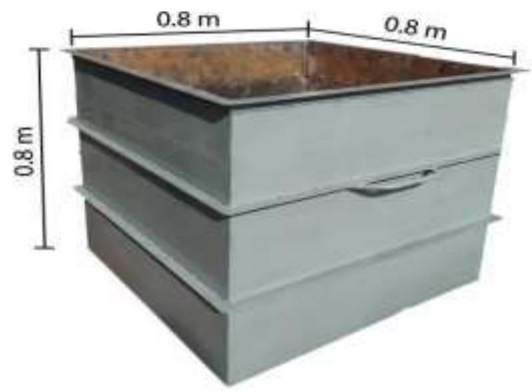

Fig 2. Mild Steel Tank used in this study

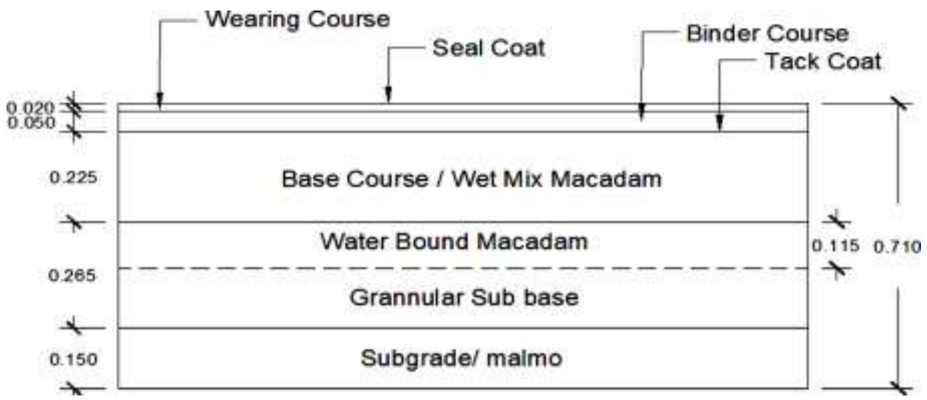

Fig 3. Pavement Layers for prepared sample (all dimension are in ‘m’)

Pavement Layer Criteria: for the 2 msa traffic with CBR 4%, (Source: IRC:37 (2001) Page No. 23, Pavement Design Catalogue)

a) Granular Sub base = 265 mm
b) Base Course = 225 mm
c) Binder Course = 50 mm
d) Wearing Course = 20 mm

Table 7. Layer Composition

Layer	Density (gm/cm^3) (As per Morth 5th Revision)	Volume (m^3)	Total Weight (kg)
Subgrade	1.785	0.096	171
Granular Sub base	1.803	0.096	173
Water Bound Macadam	1.803	0.0736	132
Base Course /Wet Mix Macadam	2.214	0.144	318
Binder Course	2.214	0.032	70
Wearing Course	2.214	0.0128	28

Fig 4. Preparation of bottom most layer filling and compacting subgrade and granular subbase

Fig 5. Preparation of base course layer

Fig 6. Preparation of Wearing course

3.1 Cyclic Plate Load Test for Normal Sample

1) Load Test calculations:
a) SBC = 40 t/m^2
b) Test load = 40 x 2.50 = 100 t/m^2, Pressure Gauge Least Count = 10 kg/cm^2
Ram Diameter = 9.62 cm^2, Plate Area = 0.075 x 0.075 = 0.005625 m^2

Total Apply Load = 100 x 0.005625 = 562.5 kg

Increment nos. = 562.5/5 = 112.5 kg but Actual apply load = 96.2, therefore increment = 6 with maximum load of 96.2 kg

Fig 7. Pot hole simulation with and without Geotextile Layer

Fig 8. Test Setup

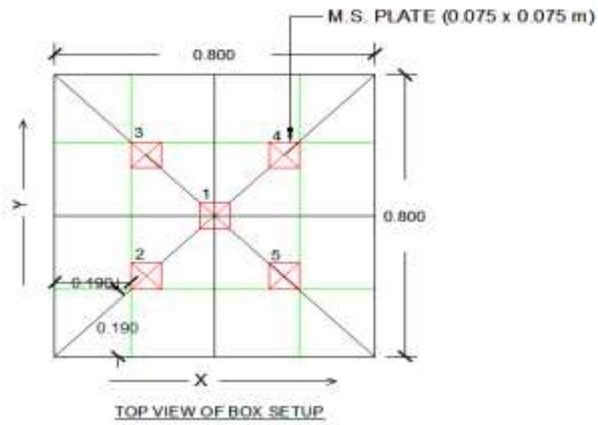

Fig 9. Graphical representation of Geo-textile based sample

4. Result & Discussion

As mentioned earlier, the cyclic plate load test was carried out with and without Geotextiles layer in the tank to measure the settlement of the repaired patch work. The settlement readings were taken at the five different points as shown in the figure9. The figure 10 & 11 shows the settlement v/s load graph of the various points as shown in figure-9 for the pavement without and with Geotextiles layer. It is evident that for maximum settlement in the case of without geotextile is reaching up to 10mm while the load is 450kg while in the case of with geotextile the settlement is around 4 mm the average load of 500 kg. Thus the geotextile layer is functioning and load is distributed through the membrane action of geotextile and therefore the settlement is reduced.

Further, in figure-12 the comparison of the readings of the settlement at all the five points as shown in figure-9 is shown. It is evident that, the settlement at all the point in the case of pothole repaired with geotextile is significantly reduced and this is around 30-50% , the reason behind this could be the geotextile is acting as reinforcing material and the stresses are dispersed through the geoteitle’s tensile strength. In the case of pothole repaired without geotextile it is observed that the plate was failed in shear and therefore at point no.2 maximum settlement of 8.2mm is observed.

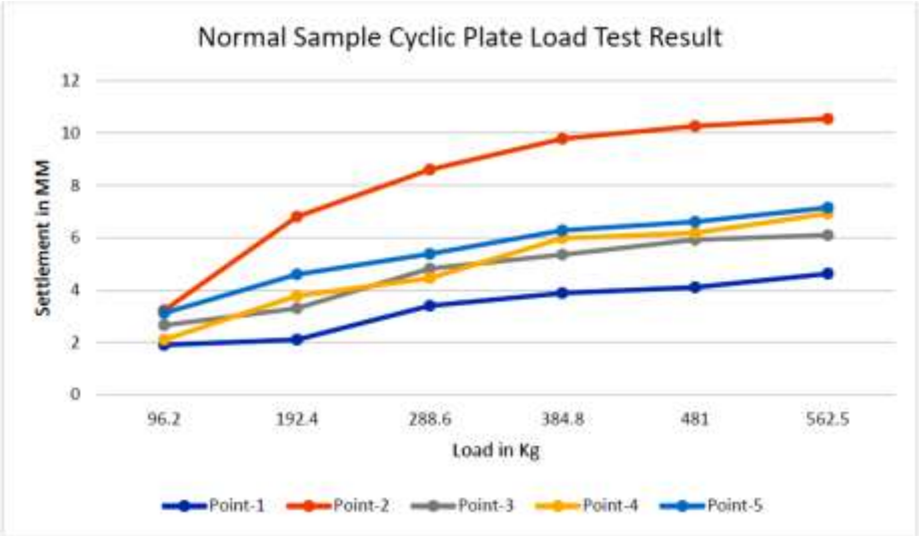

Fig 10. Graphical representation of Geo-textile based sample

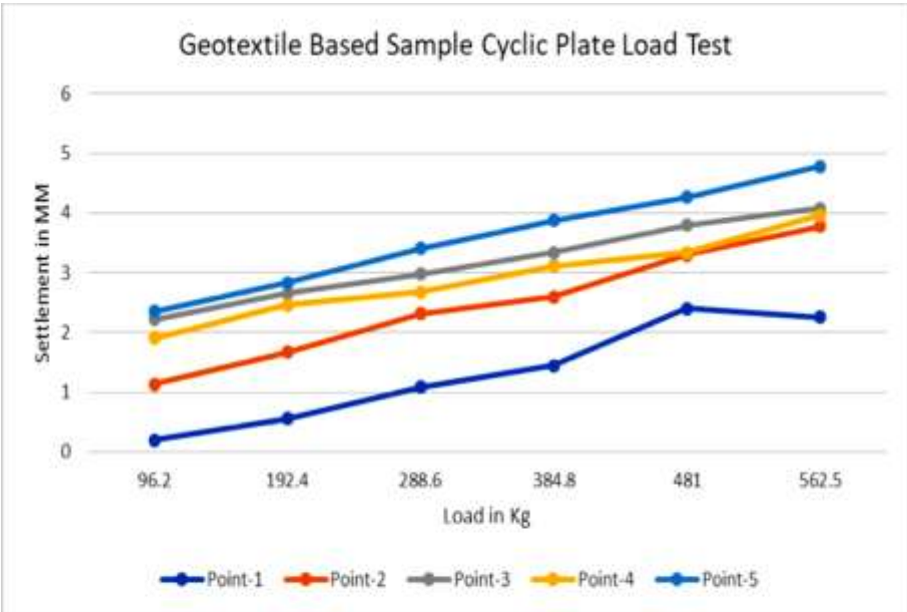

Fig 11. Graphical representation of Geo-textile based sample

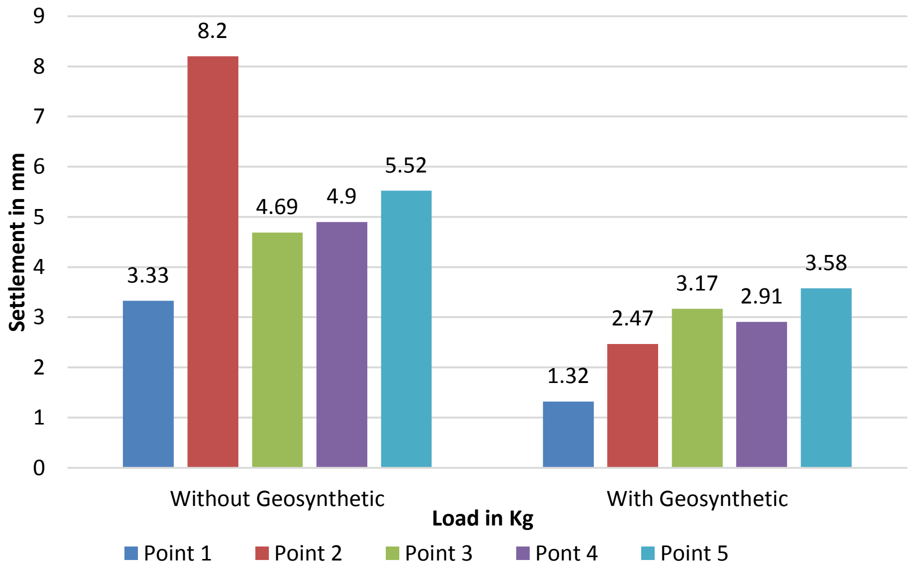

Fig 12. Graphical representation of Geo-textile based sample

5 Conclusion

Based on the laboratory experiments and analysis, the following conclusions are drawn:

- It is observed that, for geotextile-based sample results are decreased than normal sample. This indicates that the use of geotextile in repair of potholes can increase the load carrying capacity and gives better strength in repair.
- The average decrement in geotextile based sample is 47.12% compared to normal sample.

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