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GEOTEXTILES APPLICATIONS TO IMPROVE WEAK SOIL FORMATIONS

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Abstract

The paper discusses the use of geotextiles for improving the performance of a railway track on weak formations. The findings of a laboratory experimental investigations are discussed.

In the maintenance of the permanent way, with respect to the ballast and soil interface several problems are encountered like disturbance of the top rail level, ballast puncture, choking of ballast and loss of drainage under repeated traffic load. To overcome these problems, a solution can be provided by providing a layer of geotextiles at the interface of formation and ballast over a cushion of coarse sand blanket. An experimental study as to how the introduction of geotextile arrests the puncturing of ballast in the soil formation, choking of ballast, foundation settlement and effect improvement of drainage was attempted by the authors in the laboratory by simulating railway track conditions. The experiments conducted reveal that application of geotextiles can be used to improve the fanctioning of a railway track over weak soil formation.

Introduction:

In a normal railway track, a layer of ballast varying in size from 100 to 250 mm is provided over the foundation of soil. The ballast support the sleeper which in turn bears the rails which finally, take the load of the locomotives/coaches and wagons. The 22 ton axle load is transferred to soil formation with reduced intensity of 5 to 7Kg/Cm.Sq. . For the maintenance of the permanent way particularly during the rainy season with respect to the ballast and soil interface, several problems are encountered as listed below :-

- The track settles down due to yielding of support and settlement of the weak formation under traffic load.
- The ballast punctures into the foundation and get lost for all practicable purposes.
- The soil particles along with water move up and fill up the voids of the ballast, thus choking it reduce the efficiency of the drainage.
- Consequent to poor drainage, foundation looses its bearing capacity by absorbing water.

1. Consequently the track geometry is distorted which results in slow down of vehicles along with an increase in hauling energy. To overcome these problems, a solution can be provided by providing a layer of geo-textile at the interface of formation and ballast, over a layer of 10 cm. thick course sand blanket as shown in fig.1(a). An experimental study as to how the introduction of geotextiles arrests, the puncturing of the ballast into the soil, choking of the ballast, the foundation settlement and effects the

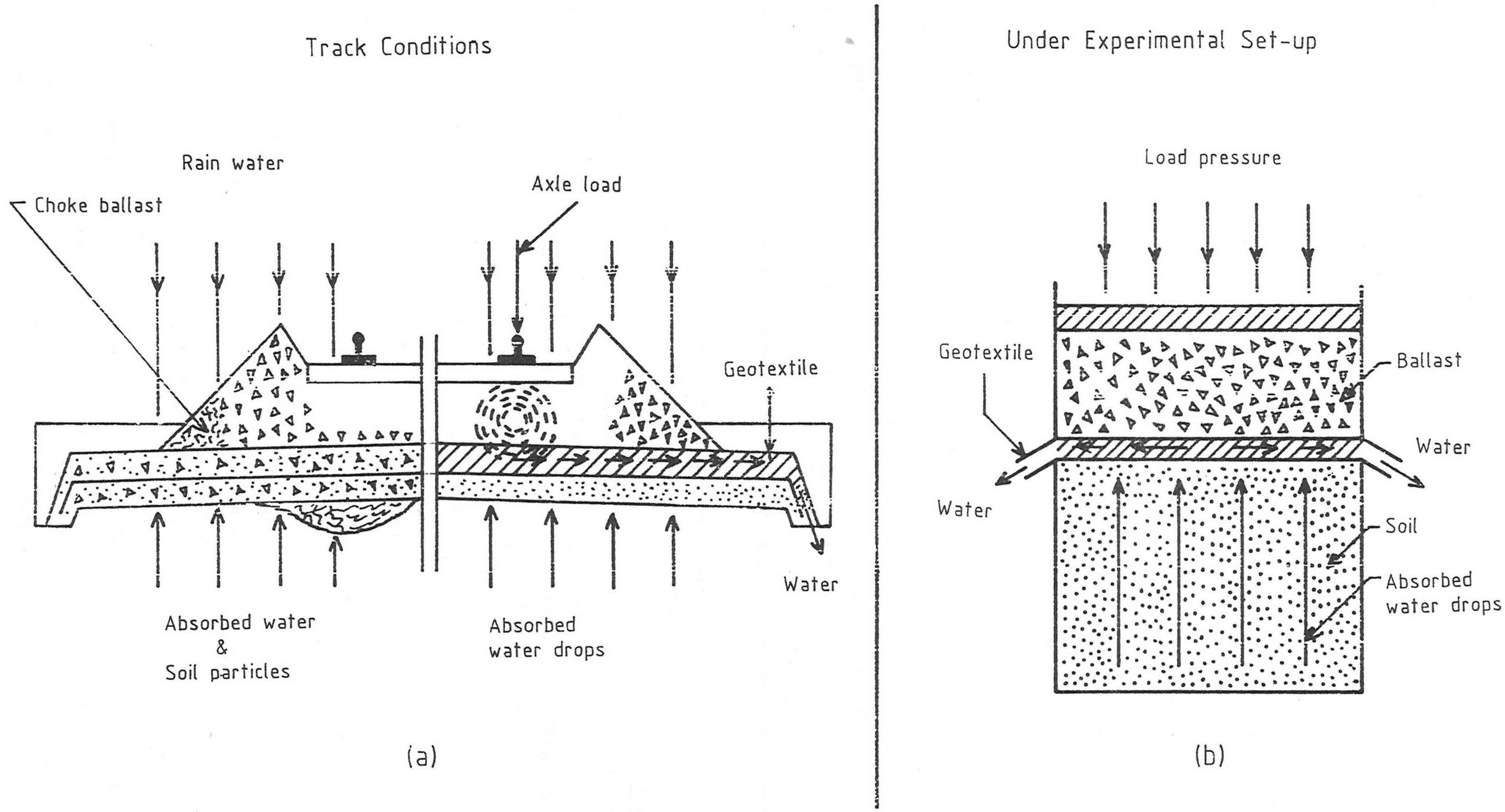

Figure 1: Behaviour of Water Particle Under Repetitive Loading.

improvement of drainage was carried out in the laboratory. The authors have attempted to verify quantitatively the effect of the geotextiles application under the ballast section simulating with the railway track and application of repeated loading to determine the following parameters:-

1) The effect of liquid limit of the soil on the sinking of the ballast under repetitive loading.
2) The effect of dry density of soil on the ballast under repetitive loading.
3) The effect of increased soaking with water on the sinking of ballast.

2. A study of the problem was undertaken to verify quantitatively the above effects of the introduction of geotextiles under the ballast section with the help of an experimental set up for which the details are given below:-fig.2

a) The experimental setup: It consists of the following components:-

1) Cylinder containing soil sample Height 145mm,Dia.102mm
2) Collar cap thickness 50mm and Dia.102mm
3) Pressure bearing plate 10mm thick Dia. 98mm
4) One perforated base plate dia. 110mm
5)One outer cylinder with provision of water supply from bottom, inside dia.150mm.
6) One 1.0 HP motor, alongwith cam arrangement to work the repeatitive load application.
7) A dial gauge along with fixing arrangement to measure settelment.
8) Geotextiles piece to cover the sample completely in between the soil and ballast section.

b) The properites of different soils, sand and geotextiles are as per tables-4&5

3) **Preparation of the test sample**:-

a) Two samples of soil about 3.0 kg each passing IS-sieve 2.38 mm are taken separately. Maximum dry density and optimum moisture content was determined by conducting Standard Procter Test.

b) The samples were soaked in water with perforated disc at the bottom,so that the water was just below top surface and kept for 96 hours similar to CBR testing.

c) After 96 hours soaking, the sample was taken out of water,the perforated disc was removed from the bottom and 6mm top layer of soil is removed and replaced with sand bed.

d)The collar cap is placed on the top of the cylinder after placing a geo-fabric on the sand layer. The 10mm size clean granite chips are fitted into the collar for 40mm depth. The aggregate was gently compacted to give a uniform thick layer and levelled surface. The pressure bearing MS plate was placed over the chips. The water was poured into the ballast till it appeared on the top surface

e) The soil samples were taken for moisture content test to calculate the dry density of the soil.

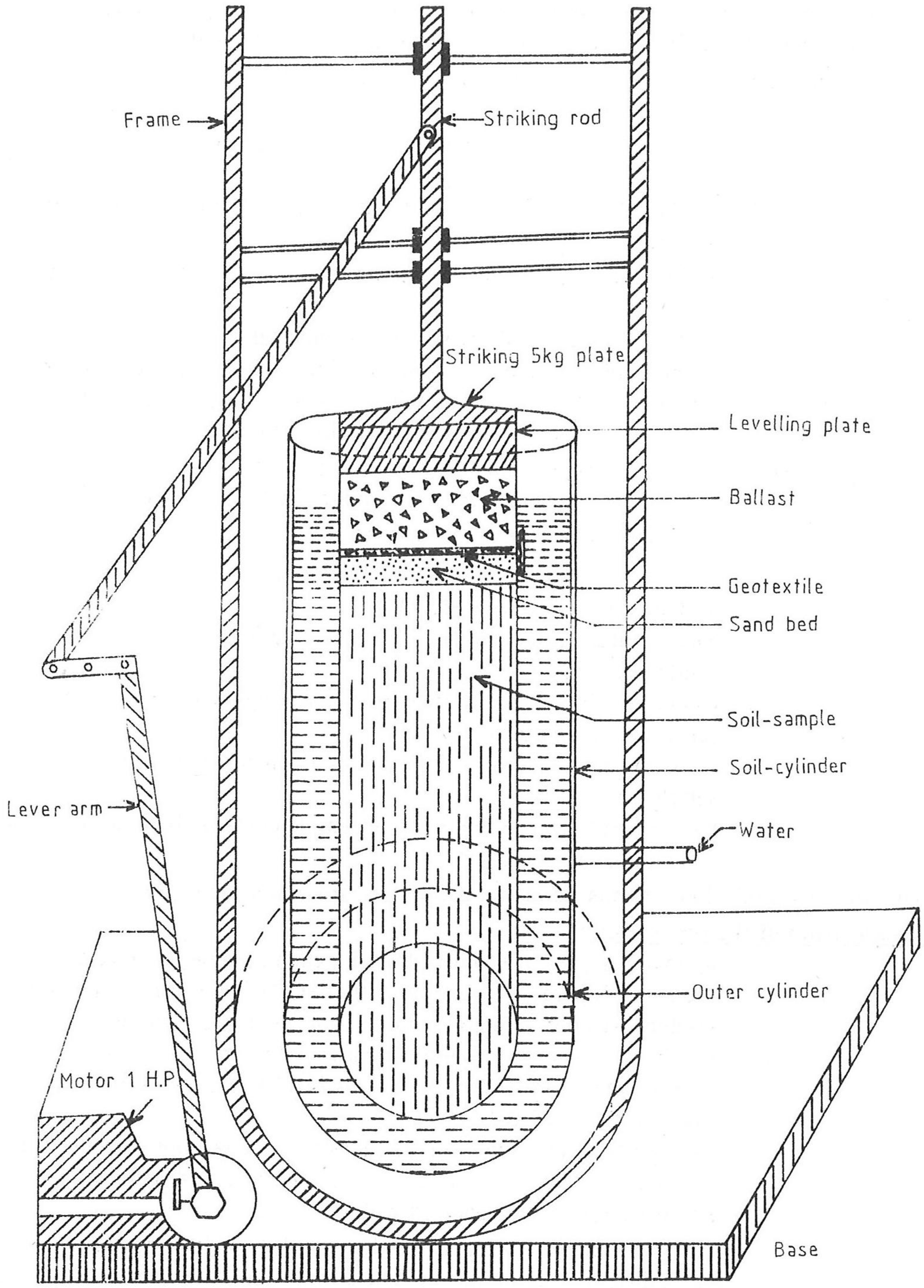

Figure 2: Experimental Set-Up

f) The soil sample prepared as above was placed in theouter cylinder and placed on the repetitive load application machine.

g) A dial gauge was fixed on the top plate to record the initial/final reading of the ballast sinking after designated load application.

h) A similar sample was prepared without geotextile and the test was repeated.

4) **Procedure of testing**:-

The soil sample as prepared above is placed in the outer cylinder, placed on the repetitive load application machine.The water is supplied through the inlet attached at bottom of the cylinder and the water level is maintained upto the ballast level so that the soil particles rising up alongwith absorbed water are eliminated without mixing with the ballast. The experiment involved the following steps:-

a) The machineis made to work so that weight falls from a height of 5cm at a rate of 10 strokes/minute. A total 500 strokes are applied for each sample.

b) The pressure bearing plate sinks down after repetitive load application and the level is noted through the dial gauge.

c) The second sample without geotextile is tested under similar condition and the sinking of ballast is recorded.The test is repeated with different samples of soils like local soils(Kanpur) ,and soils from Orai & Sandila etc.

d) The test is repeated with increased period of soil soaking and the sinking of ballast is noted to record its effect.

5) **Observations & Results**:-

The following observation are recorded during the test:-

a) In the soil samples when subjected to repetitive loading, the pore water pressure works upward alongwith soil particles,which fillup the interestices of the ballast and effects its drainage. In other words the mud-pumping is effected.

b) The repetitive loading effects the ballast movement down into the soil i.e. penetration of ballast takes place.

c) The soil, with lower value of dry density, showed the swelling and the penetration of ballast on higher side.

d) The soil, with higher values of liquid limits showed more sinking of ballast.

e) If the upward movement of soil particles is checked, the sinking of ballast is considerably controlled.

f) If the soaking period of soils is increased, the penetration of ballast is also increased but not in the same proportion as in the case of 96 hours soaking.

The observation for different soils are as given in tables 1,2 & 3.

Discussion of the results:- In this experimental study it was observed that under the repetitive loading the moisture in the form of small drops inside the soil moves upward carrying small particles of soil which fill up the interestices of the aggregates. The ballast gets choked up and effects voids under the sleeper at rail sections. The phenominon is known as mud-pumping and effect drainage of the ballast profile. The process results in more penetration of ballast, deeper inside the formation and creates ballast pockets as shown in fig.1(a) .The water gets accumulated in these ballast pockets which creates mud slurry under repetitive loading. Thus the load bearing capacity and the track geometry is effected. As already stated, the test was undertaken to examine the behaviour of the ballast sinking into the soil, with respect to

- liquid limit of the soil
- dry density of the soil
- effect of variable soaking period

Each of the above aspect is discussed as below:-

I. **Effect of the liquid limit:-**

The Kanpur soil indicated least value of sinking of ballast which has smaller value of liquid limit , where as Sandila soil with a higher value of liquid limit indicated maximum sinking of all the three soils. This indicate that soils with increased value of liquid limit are likely to be more troublesome, weak and more prone to absorption of water and settlement. The results are as shown in table 1.

II. **Effect of dry density of soil:-**

The dry densities of all the three soils were determined and it was seeen that soils with higher dry density values are more stable and effect in smaller values of ballast sinking. The Kanpur soil with dry density of 1.72 t/m3 could withstand the same loading with less values of ballast sinking as compared with Sandila soil having dry density values of 1.56t/m3 which showed that the soil with greater value of dry density were stable to withstand the same loading than the soils with less or dry density values. It indicates that denser soils are useful for track formation as compared with clayey or black cotton soils. The results are shown in table-2.

III. **Effect of increased soaking**:-

The Orai soil was tested for differented periods of soaking. The results indicated that increased period of soaking resulted in more sinking of ballast but soak period beyond 96 hours did not effect linear sinking. This indicates that the water should be separated from the soil as early as possible so that absorption of water is least. This could be achieved through effective slopes of formation on tops and side as well as cross water drains. The water logged areas also needs protection against its effect. The results are shown in table-3.

IV. **The use of geotextiles:-**

The use of geotextiles between the soil and balladt coniderably check the mud pumping and improper drainage of formation top.

7. **Role of geotextiles:-**

The application of geotextiles betwen the ballast bed and formation top help as under:-

- It filters the soil particles moving upward alongwith water.
- It effects smooth drainage of water on sides.
- It provides tensile strength to the soil and shear strength is improved.

- It checks the penetration of ballast into the formation.

8 **Conclusions:-**

Based upon the above discussion , it is concluded that the geo-fabrics are very useful for the treatement of weak soil as mentioned below:-

- Horizontal filtration of soil to improve the drainage of the formation and maintain its stability under adverse rainy seasons.
- The penetration of ballast is proportional to the dry density of the soil.
- The soils with higher values of liquid limit result in more ballast penetration.
- After the initial soaking of soil for 96 hours, further soaking does not effect much penetration of ballast.

9. **Recomendations:-**

With this limited experiments conducted it appears that the geotextiles can be used to improve the weak formations,to cättar to increased loading.

10.**Scope for further Study:-**

The use of geotextile can be made in the embankments of highways and railways. However before arriving at any firm conclusion full scale test and model studies are essential.

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TABLE-1 SINKING OF BALLAST VS LIQUID LIMIT OF SOILS

S.No.	Date of test	Sample Height (mm)	Ballast Thickness (mm)	Liquid Limit %	Penetration of ballast(mm) Without Geotextile	With Geotextile	Remarks
1.	12.05.90	138	40	37	22.7	6.0	Sample soaked for 96 hours
2.	06.08.90	,,	,,	58	32.5	14.2	,,
3.	14.06.90	,,	,,	42	30.5	10	,,

TABLE-2 SINKING OF BALLAST VS DRY DENSITY OF SOILS

S.No.	Date of test	Sample Height (mm)	Ballast Thickness (mm)	Dry Density Values t/m3	Penetration of Ballast Without Geotextiles	Penetration of Ballast With Geotextiles	Remark
1.	12.05.90	138	40	1.735	22.7	6.0	sample soaked for 96 hrs.
2.	06.06.90	138	40	1.53	32.5	14.2	"
3.	14.06.90	138	40	1.65	30.5	10.0	"

TABLE - 3 FFECT OF SOAKING PERIOD ON BALLAST SINKING:

S.No.	Date of Test	Sample Height (mm)	Ballast Thick. (mm)	Liquid Limit %	Dry density Value t/m3	Penetration(mm) Without Geotext.	Penetration(mm) With Geotext.	Soaking Period (Hrs.)	Remarks
1.	10.05.90	138	40	37	1.735	21.3	3.0	48	
2.	12.05.90	138	40	37	1.735	22.7	6.0	96	
3.	30.06.90	138	40	37	1.735	25.5	8.0	192	

TABLE-4 SPECIFICATION OF GEOFABRIC USED IN THE LABORATORY STUDIES:

1. Composition	Polypropylene
2. Mode of manufacture	Non-woven, needle punch
3. Thickness of fabric	3 mm and above
4. Weight	400 gm/m2 and above
5. Elongation at break	40-70%
6. Tensile strength	60-80Kg, for 20x50 cm strip
7. Pore size	120 microns
8. Thermal stability	0-100 degree celcius
9. Roll-width	4.50 m

TABLE 5: PROPERTIES OF SOILS:

Particulars	Liquid Limit %	Dry density t/m3	Colour
Local (Kanpur)	37	1.73	Light brown
Orai	42	1.65	Light blackish
Sandila	58	1.53	Blackish

PROPERTIES OF SAND:

Colour	Brown
F.M.	2.3