ISSN (Online) 2393-8021
ISSN (Print) 2394-1588

IARJSET

International Advanced Research Journal in Science, Engineering and Technology
National Conference on Emerging Trends in Engineering and Technology (NCETET'16)
Lourdes Matha College of Science & Technology, Thiruvananthapuram
Vol. 3, Special Issue 3, August 2016

Use of Sand-Tire Chip mixture as backfill for Geosynthetic reinforced walls

Radhika P Nair[1], **Anitha Nelson**[2]

PG Student, Civil Engineering Dept, St Thomas Institute for Science and Technology, Trivandrum, India [1]

Assistant Professor, Civil Engineering Dept, St Thomas Institute for Science and Technology, Trivandrum, India[2]

Abstract: In this work, an experimental investigation on the effectiveness of using soil-tire chip mixture as backfill for geosynthetic reinforced walls has been carried out. Earlier studies have established that sand-tire chip mixture has more shear strength than sand only backfill .In this study sand –tire chip mixtures containing 10%,20%and 30% tire chips were used as samples for Direct Shear test. Results revealed that adding tire chip increases the shear strength and maximum shear strength was obtained for 30% tire chip content. Higher shear strength and lower unit weight of sand-tire chip mixture make it effective for use as backfill material for various earth works. To study the effect of using this mixture in geosynthetic reinforced walls pull-out tests were carried out with a woven and non –woven PET geotextile. Test results shows that pull out force and Interaction coefficient increases with increasing tire chip content up to 30%.Further calculations were done to determine the number of geosynthetics and its embedded length required for retaining walls of different height. Both shows that walls using sand– 30%tire chip mixture backfill require less number and length of geosynthetic reinforcement than sand backfill. Lesser Rankine's lateral earth pressure force considerably increases the wall stability. These advantages make sand –tire chip mixture an efficient backfill material by considerably reducing the overall cost of retaining wall construction. This also opens an effective solution for disposal and reuse of scrap rubber tires which is accumulating in a huge quantity day by day.

Keywords: Shear strength, Geosynthtic reinforced walls, Direct Shear test , Geotextile, Pull-out force.

I. INTRODUCTION

Studies reveal that billions of scrap tires are disposed in huge piles around the world. Almost 30% of them are disposed in landfills, empty lots and illegal tire dumps. To minimize its effects new measures are investigated for the reuse of scrap rubber tires rather than dumping or burning. The contribution of civil engineers to solve this problem lies in innovative use of scrap rubber tires in reinforcing soft soils in road construction, for stabilizing slopes and for backfilling retaining walls.

In India, Scrap tires are being generated and accumulated in large volume creating serious environmental issues. To minimize its effects, environmental friendly disposal measures has to be identified. Reuse of rubber chips from waste tires has been included in many civil engineering applications which is widely accepted. Geotectinical applications of shredded tires include embankment fill, retaining wall and bridge abutment backfill, insulation layer to limit frost penetration, vibration damping layer and drainage layer.(Humprey 2003).

A number of research works have been carried out in the field of using shredded rubber tire as backfill material. Many investigations were done on the shear strength of soil-tire chip mixture and tire chip alone. Humphrey and Sandford (1993), Foose et aI. (1996), and Bernal et al. (1996) report that pure tire chip mixtures have a friction angle of 20-35° and cohesion of 3-11.5 kPa based on large-size direct shear tests. Triaxial tests conducted by Wu et aI. (1997) on small tire chips(«40 mm long) indicate that the friction angle can be in excess of 40° and that the cohesion intercept is negligible. Field evidence also exists that supports high friction angles for pure tire chips (Edil and Bosscher 1994). Ahmed (1993), Humphrey et al. (1993), Edil and Bosscher (1994), Foose et al. (1996), and Bernal et al. (1996) have re- ported that sand can be reinforced using tire chips. These stud ies have shown that adding tire chips increases the shear strength of sand, with friction angles as large as 650 being obtained for mixtures of dense sand containing 30% tire chips by volume. Foose (1993) shows, however, that the strength decreases when the tire chip content increases beyond 30% because the sand-tire chip mixture behaves less like reinforced soil and more like a tire chip mass with sand inclusion.

To use tire chips or tire chip-sand mixtures as backfill behind geosynthetic-reinforced walls and embankments, interaction properties between the backfill and geosynthetics are needed. Bernal et al. (1996, 1997) performed pull-out tests on geogrids using tire chips as backfill and obtained interaction coefficients lower than common interaction coefficients for geogrids with soils. They suggest that lower interaction coefficients may occur because the shearing areas above and below the geogrids are not fully developed, and thus the maximum shear stress is not mobilized along the geogrids.

The objective of the study described in this paper was to assess the shear strength and geosynthetic interaction of backfill consisting of tire chips or soil-tire chip mixtures that might be used for geosynthetic-reinforced retaining walls. Tests were conducted to characterize the interaction of soil-tire chip mixtures with geotextiles during pull-out, as well as the shear strength of soil-tire chip mixtures. The test results were then used to illustrate the potential advantages of constructing geosynthetic-reinforced walls and embankments with tire chips and soil-tire chip mixtures.

Interaction between geogrid reinforcement and tire-sand backfill is previously studied by T.Tanchaisawat in which conclusions were drawn on basis of interaction coefficient. Another study by Nilay Tatlisoz(1998) also analyze the interaction between reinforcing geosynthetisc and soil-tire backfill in which a geotextile and geogrid is used for the study.A no of works has been done using tire-chips as a stabilizing material for various soils. Such studies which included tests like UCC,CBR ,Direct shear concludes that there is a optimum value for tire-chip content to obtain maximum strength.

Only few studies have been done to study the use of sand-tire chips as backfill for reinforced earth walls because conducting large scale pull-out test is a tedious procedure. Pull-out capacity and Interaction coefficient are the factors deciding the suitability of replacing sand backfill with sand-tire chip mixture in geosynthetic reinforced walls. In this study a woven and non woven geotextile widely used in our country with sufficient reinforcement capacity is selected. This study also investigate to what extend this innovation is applicable in and around our locality.

II. EXPERIMENTAL PROGRAM

The experimental work was carried out to study the effectiveness of sand –tire chip mixture as backfill material. Direct shear test was carried out with samples containing sand alone and sand –tire chip mixture containing 10%,20%,30% tire chips. Test was conducted under normal stresses of 50,100,150,200 kpa. Further pull-out test were conducted on small size pull-out testing machine using a woven and non-woven PET geotextile. Backfill for the pull-out tests were sand alone ,sand -10% tire chip,sand-30% tire chip. Normal stresses were 50,100 and 200 kpa.

A. Materials

1) Sand:
Dense sand with no clay content was used for the study. Specific Gravity was obtained as 2.65 and unit weight 16.3kN/m$^{3.}$

2) Scrap Rubber Tire Chips:
Scrap rubber tire collected from garage was shredded to suitable size compatible for 6cmx6cm shear box. Size of tire chips were 15mmx2mmx1mm.. Specific Gravity of tire chips were 1.3.Figure 1 shows tire chips used for the study.

Fig. 1 Scrap Rubber Tire Chips

3) Geotextile:
A non woven PET geotextile needle felt-400 gsm and woven PET geotextile -800 gsm were used. The study demanded only the ultimate tensile strength of the geotextiles which were obtained as 60kN/m and 200 kN/m for non woven (GT1) and woven geotextile(GT2) respectively. Geotextile Specimen used for the pull out test was of size 6cmx18cm.Figure 2&3 shows needle felt nonwoven and single weave woven geotextile respectively

Fig. 2 Needle felt non woven geotextile

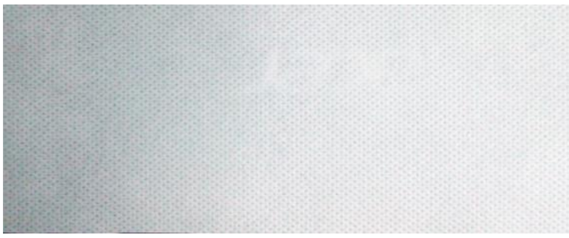

Fig. 3 Single weave woven geotextile

B. Experimental Setup

1) Direct Shear Test:
Direct shear test is conducted using sand and sand –tire chip mixtures. The shear box is square in plan of size 60x60x50mm.The soil specimen is placed in the box and compacted .While placing sand –tire chip mixture alternate layers of sand and chips are placed and compacted. Shear box is placed inside the container and mounted on loading frame. Strain rate of 1.25 mm/min is applied .Normal load is applied to give normal stress of 50,100,150,200 kN/m^2. Proving ring reading gives the

Shear force from which shear strength parameters are calculated. Test is repeated with sand-10%,20% and 30% tire chip content.

2) Pull-Out Test

The pull-out test was conducted on a small scale pull-out testing machine having similar dimensions of a direct shear machine. The container to place the shear box was one side opened to place the geotextile. Shear box size is 60x60x50mm.Backfill sample is first filled in the lower half and compacted. Then geotextile of size 60x180mm is placed over the sample with additional length extending beyond the box along the direction of shear. Upper box is placed and backfill is again filled and compacted. Grid plate and pressure pad are placed ad mounted on the container .Figure 4 shows the arrangement of soil sample and geotextile in the shear box.

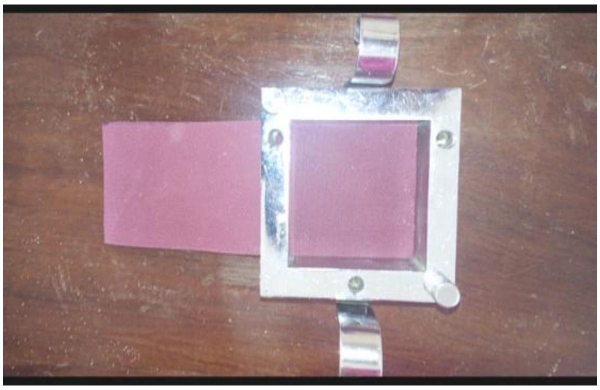

Fig. 4. Experimental setup

The projecting end of geotextile is held between the two saw toothed plates of clamp and screwed tightly .The geotextile should be of adequate length so that it does not stretch even after the clamp is tightened. Loading yoke is mounted on the pressure pad and the locking pins are not removed. The strain rate is maintained as 1.25 mm/min. Normal Load is applied to generate stress of 50,100,200 kN/m^{2}. Proving ring readings are noted to obtain the pull-out load and maximum reading on the proving rind indicated the pull out load. Displacement was also noted using a dial gauge with which load corresponding to 1-30mm displacement was recorded.

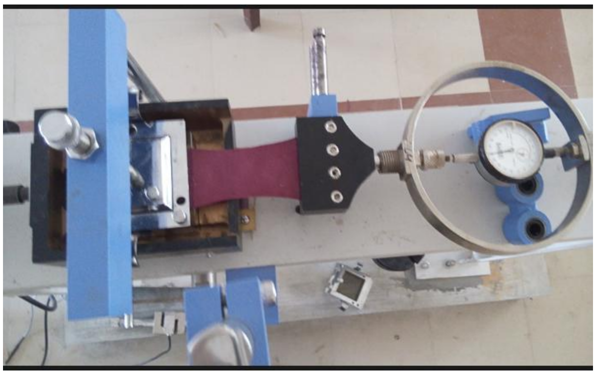

Fig. 5. Pull-Out test apparatus

The pull-out test was conducted with sample containing sand alone and sand-10% tire chip mixture and sand -30% tire chip mixture. The test was conducted to determine pull-out force for both geotextile

III.RESULTS AND DISCUSSION

Sand and sand –tire tire mixtures were subjected to Direct shear test and Pull-out test as described earlier are conducted and the shear strength, its parameters and pull-out force was determined. These values were further used for calculations like Interaction coefficient, Embedded length of geotextile, number of geotextile layer required for retaining walls of different height etc. The results of the study and its detailed discussions are given below.

A. Shear strength and Parameters

The shear strength and angle of internal friction are obtained from direct shear test. Shear stress obtained from proving ring reading corresponding to normal stress of 50,100,150,200 kN/m^2 were plotted graphically .Shear stress-Normal stress graph generates a failure plane the slope of which gives the angle of internal friction of the sample. Thus the shear strength of sand and sand with 10,20,30% tire chip content are determined. Table 1 shows the unit weight and c,φ values of sand, sand-tire chip. Figure 6 shows the variation of shear strength with 50,100,150,200 kpa normal stress.

Direct shear test results reveal that angle of shearing resistance increases with increase in tire chip content as a result shear strength also increases. Thus sand –tire chip mixture with higher shear strength and less unit weight is an effective backfill material. Thus addition of tire chips result in a light weight backfill material.

B. Pull-out capacity and Interaction Coefficient

Pull-out capacity is the peak force reached during the pull-out .Pull-out force which is pull-out load by width of specimen on using non-woven(GT1) and woven (GT2) geotextile is given in Table II .Graphs showing Pull out force capacity-Normal stress with sand, sand -10% tire chip and sand-30% tire chip for GT1 and GT2 is shown in Figure 7&8 respectively.

TABLEI Shear Strength Parameters

Material	Tire chip content (%)	Unit weight (kN/m3)	C (kpa)	Φ (degrees)
Sand	0	16.3	0	45
Sand –tire chips	10	15	0	48
Sand –tire chips	20	14.1	0	50
Sand –tire chips	30	13.2	0	53

IARJSET
ISSN (Online) 2393-8021
ISSN (Print) 2394-1588
International Advanced Research Journal in Science, Engineering and Technology
National Conference on Emerging Trends in Engineering and Technology (NCETET'16)
Lourdes Matha College of Science & Technology, Thiruvananthapuram
Vol. 3, Special Issue 3, August 2016

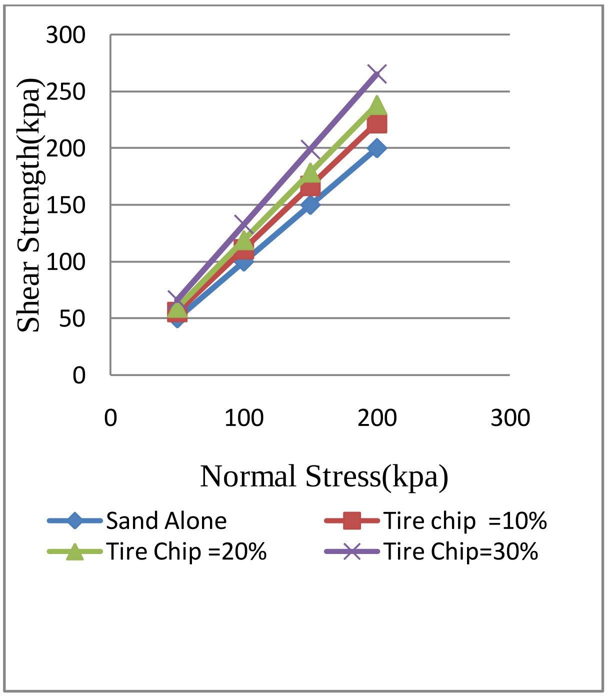

Fig. 6 Shear strength versusNormal stress curve

Pull-out test results shows that pull-out force increases with increase in normal stress. Pull-out force values obtained for sand –tire chip mixture is greater than sand only sample. Woven geotextile having higher strength has higher pull-out force values. In our test the force corresponding to 30mm displacement was recorded as the pull-out force.

Interaction coefficients (Ci) are a means to interpret the pull-out test results which compares the effective strength of the soil-geosynthetic interface to the shear strength of the soil. The interaction coefficient is defined for cohesionless backfill as (ORI Test Method OT6)

$$Ci = \frac{P}{2WL(\sigma_n \tan \varphi)}$$

P= Pull-out force W=Width of specimen
L=Embeded length σn=Normal stress

Values of Interaction coefficients are summarized in Table III.

The interaction coefficient for soil backfills typically decreases with increasing normal stress as a result of increasing progressive failure, caused by non-uniform displacements along the length of the geosynthetic layer . An interaction coefficient greater than unity (Ci > 1) indicates that there is an efficient bond between the soil and the geosynthetic and that the interface strength between the soil and reinforcement is greater than the shear strength of the soil. Interaction coefficients greater than one usually occur when resistance is provided by strike-through and restrained dilatancy. Strike through enhances pull-out capacity through rib bearing, whereas restrained dilatancy results in greater friction due to higher normal stressed .An interaction coefficient less than 0.5 normally indicates weak bonding between the soil and geosynthetic layer or breakage of the geosynthetic layer.

TABLE II PULL-OUT TEST SUMMARY

Backfill	Geo synthetic	Normal Stress (kPa)	Pull-out Force (kN/m)	Interaction Coefficient (Ci)
Sand	Geo textile 1	50	0.583	1.621
		100	0.661	0.9187
		200	0.895	0.622
Sand-10%Tire chips	Geo textile 1	50	0.7002	1.751
		100	0.8169	1.021
		200	1.128	0.7053
Sand – 30%Tire Chips	Geo textile 1	50	0.9336	1.954
		100	1.167	1.221
		200	1.4393	0.7532
Sand	Geo textile 2	50	0.6613	1.837
		100	0.778	1.081
		200	1.0503	0.7296
Sand-10%Tire chips	Geo textile 2	50	0.778	1.945
		100	0.9336	1.167
		200	1.3615	0.794
Sand-30%Tire Chips	Geo textile 2	50	0.9336	1.954
		100	1.2059	1.262
		200	1.5949	0.834

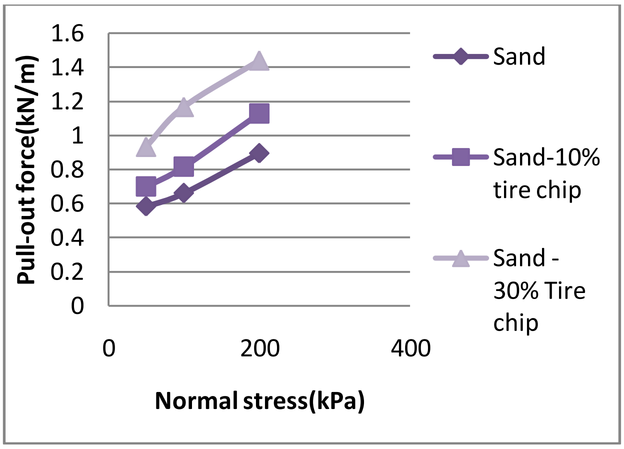

Fig. 7 Pull-out force versus Normal stress curve(GT 1)

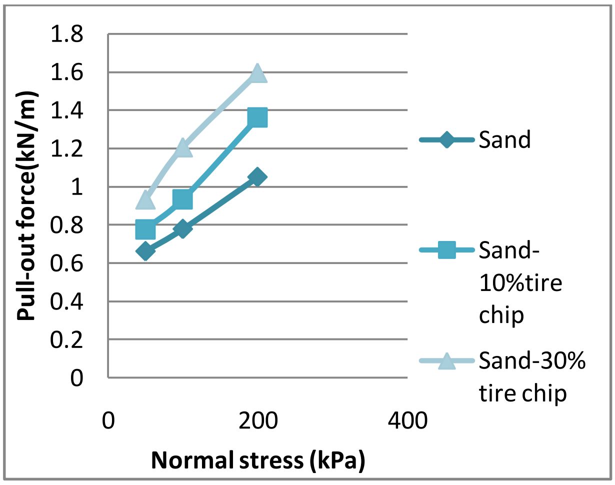

Fig. 8 Pull-out force versus Normal stress curve(GT 2)

Result shows that interaction coefficient increases with increase in tire chip content .This concludes that interaction between geotextile and backfill increases with increase in tire chip content. Thus strongly supports the idea of using soil-tire chip mixture as backfill for retaining walls.

Rankine's active earth pressure was calculated for retaining walls of height 7,10,15m with sand and sand-30%tire chip mixture. Graphs were plotted showing the same. Rankine's active earth pressure is calculated as follows:

$$Pa=1/2(ka\gamma H^2)$$

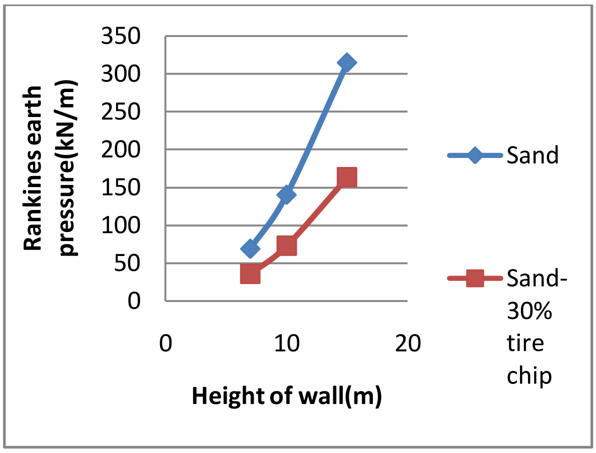

Fig. 9 Rankine's earth pressure versus Height of wall

Graph clearly shows that there is a huge reduction in the lateral earth pressure when sand-tire chip backfill is used. This is due to lower unit weight of sand-tire chip backfill. Thus a retaining wall with sand-tire chip backfill experience lesser earth pressure hence has more stability.
This also clearly depicts the advantage of using sand-tire chip mixture as backfill material.

Design calculation of geotextile reinforced walls were carried out to determine the number of geotextile layer required for sand alone and sand-tire chip backfill and graphs were plotted.Figure10 shows the number of geotextile layer required for retaining wall of height 7,10,15 m.

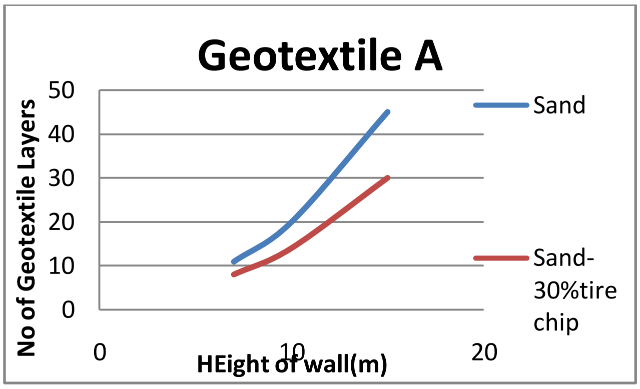

Fig. 10 No of geotextile versus Height of wall

Graph shows that addition of tire chips to sand backfill considerably reduces the number of geotextile layer required to reinforce the retaining wall.

IV.CONCLUSION

Based on Direct shear and Pull-out test results with sand – tire chip mixtures and two geotextile specimens following conclusions are drawn.

- The shear strength of sand backfill increases with addition of tire chip content up to 30%by volume of sand.
- The unit weight of sand-tire chip mixture is less than that of sand .Hence lateral earth pressure on retaining wall is les s for sand-tire chip backfill.
- Pull-out force increases with increase in tire chip content with maximum at optimum content of 30%.
- Interaction coefficient also increases with increase in tire chip content.

ACKNOWLEDGMENT

The authors greatly acknowledge Principal and all staff members of St Thomas Institute for Science and Technology for all their support throughout the project.

REFERENCES

[1]. Nilay Tatlisoz, funcer B. Edil,2 and Craig H. Benson,3 "Interaction Between Reinforcing Geosynthetics And Soil-Tire Chip Mixtures" Members, ASCE
[2] Alfaro, M., Hayahi, S., Miura, N., and Watanabe, K. (1995). "Pullout interaction mechanisms of geogrid strip reinforcement." Geosynthetics Int., 2(4), 679-698.
[3] ASTM. (1993). "Test method for laboratory compaction of soil using standard effort." Annual Book of Standards, Vol. 04.08, 0698, West Conshohoken, Pa., 165-172.
[4] Benson, C., Olson, M., and Bergstrom, W. (1996). "Temperatures of an insulated landfill liner." Transp. Res. Rec. 1534, Transportation Re- search Board, Washington, D.C., 24-31.

[5] Bergado, T., and Chai, J. (1994). "Pull-out force/displacement relation- ship of extensible grid reinforcements." Geotextiles and Geomem- branes, 13, 295-316.
[6] Bernal, A., Salgado, R., and Lovell, C. (1996). "Laboratory study on the use of tire shreds and rubber-sand in backfills and reinforced soil applications." Final Rep., Indiana Dept. ofTransp., Joint Hwy. Res. Proj. Rep. No. FHWAIlNIJHRP-96, Purdue Univ., West Lafayette, Ind.
[7] Bernal, A., Salgado, R., Swan, R., and Lovell, C. (1997). "Interaction between tire shreds, rubber-sand, and geosynthetics." Geosynthetics Int., 4(6), 623-643.
[8] Bosscher, P., Edil, T., and Kuraoka, S. (1997). "Design of highway em- bankments using tire chips." J. Geotech. and Geoenvir. Engrg., ASCE, 123(4), 295-304.
[9] Bosscher, P., Edil, T., and Eldin, N. (1993). "Construction and perfor- mance of shredded waste tire embankments." Transp. Res. Rec. 1345, Transportation Research Board, Washington, D.C., 44-52.
[10] Christopher, B., and Holtz, R. (1985). Geotextile engineering manual. Prepared for FHWA, Contract No. DTFH61-80-C-00094, National Highway Institute, Washington, D.C