International Journal of Innovative Technology and Exploring Engineering (IJITEE)
ISSN: 2278-3075 (Online), Volume-8 Issue-10, August 2019

Estimating Optimal Geotextile Type for Controlling Soil Erosion

Lava Kumar Reddy Palle, Arti Sudam, Madhav Madhira

Abstract— One of the major functions of geotextiles is to control soil erosion. Apparent opening size and permeability of non-woven geotextiles are properties that control erosion. In this manuscript, soil taken from an eroded pond is considered for the study. Filtration and clogging behavior of the several geotextiles are studied under laminar flow conditions and at three different hydraulic gradients. Results facilitate selecting the appropriate geotextile based on permeability, filtration and clogging for use as erosion control.

Keywords: Clogging, Erosion control, Filtration, Geotextile and Permeability.

1. INTRODUCTION

Geotextiles function as filters and prevent erosion of soils in contact with the filter. They are more permeable and thinner compared with granular filters (Giroud, 2010; Sabiri et al., 2017). Geotextiles enable water to pass through while retaining the soil structure stable by preventing migration of soil particles. However, particles larger in size than the AOS (Apparent Opening Size) of the geotextile may clog the openings in them. The performance of a geotextile evolves over time and depends on its own properties and those of the soil being retained. Clogging can be caused by biological, physical or chemical processes (Rollin and Gerard, 1988; Veylon et al., 2016).

The objective of this research is to evaluate the behavior of varieties of geotextiles for their clogging and filtration characteristics when used with respect to a silty soil obtained from a pond that is getting eroded. Eight different non-woven geotextiles have been chosen. Filtration tests on the soil-geotextile systems are carried out in the laboratory for assessing the performance with respect to clogging and filtration.

II.REVIEW OF LITERATURE

Gabr and Akram (1996), Aydilekand Edil (2003) and Liu and Chu (2006) present studies with respect to filtration of woven and non-woven geotextiles. Mechanical and physical properties of non-woven geotextiles produced from polypropylene and jute fibers in definite proportions have been analyzed and compared (Datta, 2007, Mitchell et al., 2003 and Rawal and Sayeed, 2013). Knowledge of pore-size distribution is a prerequisite for evaluating the performance of geotextiles for various functions including drainage, filtration and separation (Rawal and Harshvardhan, 2011). The theory and explanation regarding the Maheshwari and Deepak, 2008 is to conclude the behavior of the geotextile filter for the locally (Roorkee, India) available soils using three different geotextiles. The work of Ayuba and Olorunnaiye (2014) demonstrates that geotextiles control of soil erosion and the performance of these products can be evaluated rapidly using natural and synthetic materials. Sabiri et al. (2017) deal with the problem of evaluating and discriminating the performances of the geotextiles used here in terms of filtration and drainage functions**.** Puttitorn and Claude (2014) present study of the behavior of two geotextile liners with different openings installed in the pond bottom to control soil erosion.

The objective of this research is to estimate the clogging and filtration characteristics of eight non-woven geotextiles.

III. METHODOLOGY & RESULTS

Soil:

Soil used in the study was collected from a pond located in Khajipuram village, Chippagiri mandal, Kurnool district. The soil along the slopes of the pond is getting eroded and hence chosen for this study.

Geotextiles:

Eight geotextiles available in the market are chosen for their filtration and clogging potential. Table 1 lists their relevant properties, i.e., mass per unit area, thickness, flow rate and Apparent Opening Size (AOS) as furnished by the manufacturers.

Table 1 Characteristic of Geotextiles (as reported by the Manufactures)

PROPERTIES	UNIT	1 PE-120	2 PE-150	3 PE-160	4 PE-250	5 PE-300	6 PE-350	7 PE-500	8 Polyfelt TS-50
Mass per unit area	g/m^2	120	150	160	250	300	350	500	200
Thickness	mm	0.9	1.0	1.2	2.0	2.3	2.4	2.9	1.9
Flow rate	l/m^2/sec	70	70	60	50	40	40	20	85
AOS	microns	100	100	80	<80	<80	<80	70	100

Testing for Clogging, Filtration and Permeability:

Manuscript published on 30 August 2019.
***Correspondence Author(s)**
Lava Kumar Reddy Palle, PG Student, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana-500090, India.(e-mail: lavaridhireddy@gmail.com)
Arti Sudam, Assistant Professor, Department of Civil Engineering, VNR Vignana Jyothi Institute of Engineering and Technology, Hyderabad, Telangana-500090, India.(e-mail: artisudam_p@vnrvjiet.in)
Madhav Madhira, AICTE-INAE Dist. Visiting Professor, Hyderabad, Telangana-500090, India.(e-mail: madhavmr@gmail.com)

Geotextile is placed at the bottom of the standard permeability mould. The weight of the soil compacted at OMC in the permeability mould is 1.06 kg. Laminar flow is maintained for one hour in each test at three different hydraulic gradients and the amount of soil clogged and the quantity of fines passing through opening of geotextile are measured. The amount of soil clogging is determined as the difference in weight of oven dried geotextile after the test and the initial weight before the test.

Amount of fines (finer than the AOS) released along with water through the geotextile is determined from the water collected from the permeability and finding the residue after evaporating the water. The percentage of fines (f_g) released through the geotextile is

$$f_g = \frac{weight of fines released through the geotextile}{weight of soil in\ the\ mould} * 100 \quad - (1)$$

Permeability of the soil without and with the geotextiles is estimated

$$k = \frac{qL}{Ah} \qquad (2)$$

where k = coefficient of permeability in cm/sec, q= quantity of water collected per unit time, L= length of specimen in cm (8cm), A=cross sectional area of specimen in cm^2(78.53 cm^2) and h = head difference.

2. Experimental study

Soil brought from the site is tested for its properties, viz., specific gravity, liquid limit, plasticity index and compaction characteristics (OMC and maximum dry unit weight). Table 2 lists the same.

Table 2 Properties of Soil

Property	Values
Specific Gravity	2.61
Liquid limit	48%
Plasticity index	11%
Optimum moisture content (OMC)	22%
Maximum dry density (MDD)	1.69 g/cc

The soil is classified as MI (silty soil) based on liquid limit and plasticity index. The grain size distribution curve is portrayed in Figure1

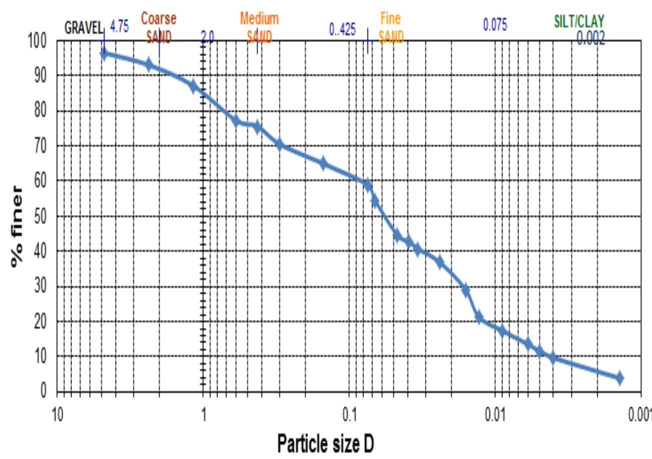

Figure 1 Grain size Distribution Curve

The percentages of gravel, sand, silt and clay are respectively 3.5, 36.5, 54.6, and 5.4. The permeability mould without or with geotextile placed at the base is utilized for determining clogging and filtration characteristics of all the geotextiles at three different hydraulic gradients over a time period of 1 hour.

Permeability and amount of fines released through the soil alone (with no geotextile) at three different (0.18, 0.25 and 0.31) hydraulic gradients over a period of one hour are given in Table 3.

Table 3 Permeability and Fines released through Soil (without geotextile)

Hydraulic gradients (i)	Permeability k 10^{-6} (cm/sec)	Fines released through opening (gms)
0.18	6.8	2.92
0.25	6.1	3.68
0.31	5.7	4.22

Permeability of the soil decreases and the amount of soil released increases with increasing gradient of flow possibly because some finer size particles get eroded and the migration of particles coarser than the pore sizes at the exit end of the sample clogs the soil sample. The results clearly establish the erodibility of the soil being tested.

Tests were repeated in the permeability mould but geotextile placed at the bottom beneath the compacted sample for all the three gradients. Tables 4, 5 and 6 list the results for hydraulic gradients of 0.18, 0.25 and 0.31 respectively.

Table 4 Results with Geotextiles at 0.18 Hydraulic Gradient

Geotextile type	AOS (microns)	Permeability k 10^{-6} (cm/sec)	Reduction in Permeability with Geotextile and with respect to Soil alone (%)	Weight of Soil Clogging the Geotextile (gm)	Weight of Fines released through Geotextile (gm)	Percentage of Fines released through Geotextile f_g (%)
Polyester(PE)-120	100	2.82	58.5	5.63	0.20	0.018
PE-150	100	2.92	57.0	5.94	0.21	0.019
PE-160	80	2.64	61.1	6.06	0.18	0.016
PE-250	<80	2.26	66.7	6.27	0.15	0.014
PE-300	<80	2.07	69.5	6.36	0.14	0.013
PE-350	<80	2.07	69.5	6.82	0.14	0.013
PE-500	70	1.50	77.9	7.73	0.12	0.011
Polyfelt ts-50	100	3.20	52.9	7.15	0.28	0.026

Permeability of the geotextile – soil system is 53 to 78%, 58 to 79% and 62 to 80% of the original soil at gradients of 0.18, 0.25 and 0.31 respectively (Table 4, 5 and 6).

Retrieval Number: J10120881019/19©BEIESP
DOI: 10.35940/ijitee.J1012.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

It appears the non-wovens used are either less pervious and/or exhibit lower permeability due to clogging. PE-500 with AOS of 70 microns has the maximum reduction in permeability, most clogging and least amount of fines are released through.

Table 5 Results with Geotextiles at 0.25 Hydraulic Gradient

Geotextile type	AOS (microns)	Permeability k 10^{-6} (cm/sec)	Reduction in Permeability with Geotextile and with respect to Soil alone (%)	Weight of Soil Clogging the Geotextile (gm)	Weight of Fines released through Geotextile (gm)	Percentage of Fines released through Geotextile f_g (%)
Polyester(PE)-120	100	2.26	62.9	6.12	0.26	0.024
PE-150	100	2.40	60.6	6.51	0.26	0.024
PE-160	80	2.12	65.2	6.89	0.24	0.022
PE-250	<80	1.83	70.0	7.01	0.20	0.018
PE-300	<80	1.69	72.2	7.08	0.19	0.017
PE-350	<80	1.69	72.2	7.36	0.20	0.018
PE-500	70	1.27	79.1	8.15	0.16	0.015
Polyfelt ts-50	100	2.54	58.3	7.18	0.30	0.028

Table 6 Results with Geotextiles at 0.31 Hydraulic Gradient

Geotextile type	AOS (microns)	Permeability k 10^{-6} (cm/sec)	Reduction in Permeability with Geotextile and with respect to Soil alone (%)	Weight of Soil Clogging the Geotextile (gm)	Weight of Fines released through Geotextile (gm)	Percentage of Fines released through Geotextile f_g (%)
Polyester(PE) - 120	100	2.15	62.2	6.67	0.31	0.029
PE-150	100	1.98	65.2	6.92	0.32	0.030
PE-160	80	1.81	68.2	7.07	0.28	0.026
PE-250	<80	1.58	72.2	7.23	0.23	0.021
PE-300	<80	1.47	74.2	7.29	0.22	0.020
PE-350	<80	1.47	74.2	7.57	0.22	0.020
PE-500	70	1.13	80.1	8.40	0.19	0.017
Polyfelt ts-50	100	2.03	64.3	7.20	0.33	0.031

Table 7 compares the effect of hydraulic gradient on weights of fines, clogging and passing through the geotextile PE-500 and on the reduction in permeability. All these parameters increase with increasing hydraulic gradient possibly due to increasing seepage force which is proportional to the gradient

Table 7 Results for PE-500 –Effect of Hydraulic Gradient

Hydraulic gradients (i)	Fines released through opening without placing geotextile (gm)	Weight of Fines released through Geotextile (gm)	Weight of Soil Clogging the Geotextile (gm)	Permeability k 10^{-6} (cm/sec)	Reduction in Permeability with Geotextile and with respect to Soil alone (%)
0.18	2.92	0.12	7.73	1.50	77.9
0.25	3.68	0.16	8.15	1.27	79.1
0.31	4.22	0.19	8.40	1.13	80.1

Geotextile material can reduce the finer passage (or) removal of fines when compared with traditional (or) without geotextile. At 0.18 Hydraulic gradients, for PE-500 geotextile the reduction in fines is 95.8%.At 0.25 Hydraulic gradient, for PE-500 geotextile, the reduction in fines is 95.6%.At 0.31 Hydraulic gradient, for PE-500 geotextile, the reduction in fines is 95.4%.

IV. CONCLUSION

Clogging potential and possible use of geotextile as an erosion control measure is studied using eight non-woven geotextiles available in the market. Tests using standard permeability set-up are carried out with and without geotextiles at three hydraulic gradients. Changes in (i) the permeability of the soil, (ii) the amount of clogging and (iii) the amount of soil passing through geotextile are measured. Among all geotextiles the PE-500 geotextile is best among all the geotextiles for controlling the soil erosion over the specified pond. As the Hydraulic Gradient increases, Permeability of the soil decreases and the amount of soil released increases possibly because some finer size particles get eroded and the migration of particles coarser than the pore sizes at the exit end of the sample clogs the soil sample. The amount of soil clogged in the geotextile increases with increase in hydraulic gradients and the permeability value of the soil decreased due to the accumulation of the soil particles in the pore spaces of the geotextile obstructing the path for flow of water. The percentage release of fines increased with increase in hydraulic gradient due to the influence of head of water which increases the pore pressure. Therefore, based on permeability, clogging and filtration properties the PE-500 geotextile is best among all the geotextiles for controlling the soil erosion.

REFERENCES

1. Aydilek, A.H. and Edil, T.B.(2003). Long-term Filtration Performance of Nonwoven Geotextile-Sludge Systems. Geosynthetics International, 10(4), 110-123.
2. Ayuba, K. and Olorunnaiye, E.S. (2014). Application of Geotextile materials in Soil Erosion Control. Jorind, 12 (2), 264-271.
3. Datta, U. (2007). Application of Jute Geotextiles. Journal of Natural Fibers, 4(3), 67-82.
4. Gabr, M.A. and Akram, M.H. (1996). Clogging and Piping criteria for Geotextile Filters for Fly-ash. Proceedings of the 3rd International Symposium on Environmental Technology. 22, 12-27.
5. Giroud, J.P. (2010). Development of criteria for Geotextiles and Granular Filters. *Proc9thInternational Conference on Geosynthetics*, 1, 45-64.
6. Liu, L.F. and Chu, C.Y. (2006). Modeling the Slurry Filtration performance of Nonwoven Geotextiles. Geotextiles and Geomembranes, 24(5), 325-330.
7. Maheshwari, B.K.E. and Deepak A.G. (2008). Filtration and Clogging Behavior of Geotextiles with Roorkee Soils. Geotechnical and Geological Engrg.,26,101–107.
8. Mitchell, D.J., Barton, A.P., Fullen, M.,Hocking, T.J. andZheng, Y.(2003). Field Studies of the effects of Jute Geotextiles on Runoff and Erosion in Shropshire, UK. Soil use and Management, 19(2),182-184.
9. Puttitorn, S. and Claude, E.B.(2014). Evaluation of Porous Geotextile Liners for Erosion Control. North American Journal of Aquaculture,76, 369–374.

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)

10. Rawal, A. and Sayeed, M.M.A.(2013). Mechanical Properties and Damage Analysis ofJute/Polypropylene Hybrid Nonwoven Geotextiles. Geotextiles and Geomembranes, 37, 54-60.
11. Rawal, A. and Harshvardhan, S. (2011). Pore size distribution of Hybrid Nonwoven Geotextiles. Geotextiles and Geomembranes, 29(3), 363-367.
12. Rollin, A. and Gérard, L. (1988). Mechanisms affecting long-term Filtration behavior of Geotextiles. Geotextiles and Geomembranes, 7(1), 119-145.
13. Sabiri, N.E.,Caylet, A., Montillet, A., and Laurence, L.C.(2017). Performance of Nonwoven Geotextiles on Soil Drainage and Filtration. European Journal of Environmental and Civil Engineering, 21, 1-19.
14. Theisen, M.S. (2013). The Role of Geosynthetics in Erosion and Sediment control. Geosynthetics in Filtration. Drainage and Erosion Control, 11, 535-550.
15. Veylon, G., Stoltz, G., Mériaux, P., Faure, Y.H. and Foltz, N.T. (2016). Performance of Geotextile Filters after 18 years' service in Drainage Trenches. Geotextiles and Geomembranes, 44(4), 515-533.

Retrieval Number: J10120881019/19©BEIESP
DOI: 10.35940/ijitee.J1012.0881019
Journal Website: www.ijitee.org

Published By:
Blue Eyes Intelligence Engineering
and Sciences Publication (BEIESP)