5th SASTech Iran |Mashhad May 12 - 17 | 2011
5th Symposium on Advances in Science & Technology

Laboratory Study of Shear Strength Parameters of Sand Reinforced with Geotextile Layers

Mahmoud Ghazavi
Associate Professor, Civil Engineering Department, K. N. Toosi University of Technology, Tehran, Iran; Tel. +98 21 88779623; Fax. +98 21 88779476
Email: ghazavi_ma@kntu.ac.ir

Hamed Atabaki
Graduate Student, Civil Engineering Department, Islamic Azad University Tehran central branch, Tehran, Iran
Email: atabakihamed@yahoo.com

Name of the Presenter: Mahmoud Ghazavi

Abstract

In this research, shear strength parameters of sand reinforced with multi-layers of geotextiles have been determined using large direct shear test apparatus. For this purpose, 1, 2, and 3 layers of geotextile were used and placed at angles of 0, 30, 50, 55, 60 and 90^o with respect to the horizontal direction. Three normal stresses of 50, 100, and 200 kN/m^3 were used. The results show that the shear strength parameters of sand increases with increasing the number of geotextile layeres. In addition, the best angle between geotextile layer(s) with the horizontal direction is about 60^o, regardless the number of layers.

Key words: shear strength, geotextile, sand reinforced, direct shear test

1. Introduction

In recent years, geosynthetic reinforced soil has attracted significant attention in practice and comprehensive research work has also been performed on such reinforced soils. Gary and Ohashi (1982) carried out shear strength tests to investigate the shear characteristics of dry sand reinforced sand with fiber. The test results showed that the maximum increase in shear strength was acquired when the placement angle of fiber with respect to the intersection line of two shear surfaces is 60^o. Ghazavi and Ghafari (2008) used 30×30 direct shear test apparatus and determined shear strength characteristics of geotextile-sand interface. They obtained $\delta=0.87\phi$ and 0.94ϕ for the interface friction angles of dense and loose sand, respectively, where ϕ is the sand friction angle. Haeri et al. (2000) conducted triaxial tests on Babolsar sand reinforced with three types of geotextiles. Their results showed that geotextile caused an increase in both the sample resistance and axial strain at failure and a decrease in

the resistance after reaching the maximum resistance. The effects of these parameters increased as the number of geotextile layers increased (Haeri, et al., 2000).
In the current research in order to investigate the behavior of geotextile reinforced sand, large direct shear test apparatus with dimensions of 30 ×30 was used. Geotextile layers were placed at different angles in the soil. Various normal stresses were applied and the sample was then sheared.

2. Introducing the Material

The sand used in the test is SP based on the Unified Classification System and has specifications as outlined in table 1.

Soil classification	Quantity
Grain diameter of about 10 percent	0.202 mm
Grain diameter of about 30 percent	0.44 mm
Grain diameter of about 60 percent	1.44 mm
Grain diameter of about 100 percent	9.52 mm
Uniformity coefficient(CU)	7.13
Coefficient of gradation(Cc)	0.66
Minimum unit weight	16.3
Maximum unit weight	1.93 kN/m3
Internal friction of sand at 60% relative density and at 18 unit weight	37.75

Table 1. Sand specifications

In this research in order to create an all else equals situation we used the relative density of 60% using (Das, 1998):

$$D_r = \left[\frac{\gamma_d - \gamma_{d(min)}}{\gamma_{d(max)} - \gamma_{d(min)}}\right]\left[\frac{\gamma_{d(max)}}{\gamma_d}\right] \quad (1)$$

Using Eq. (1), the unit weight of the sand becomes 18 kN/m3.
The Geotextile used in this research was non-woven with width of 2.5 mm. Its mass per unit area is 400 gr/m3 and its ultimate tensile strength is 25 kN/m2.

3. Investigating the best geotextile placement angle for reinforcing sand

Figs. 1 to 3 illustrate the variation of shear stress versus geotextile placement angle for reinforced sand with one to three layers, respectively for three different normal stresses 50, 100 and 200 KN/m^2.

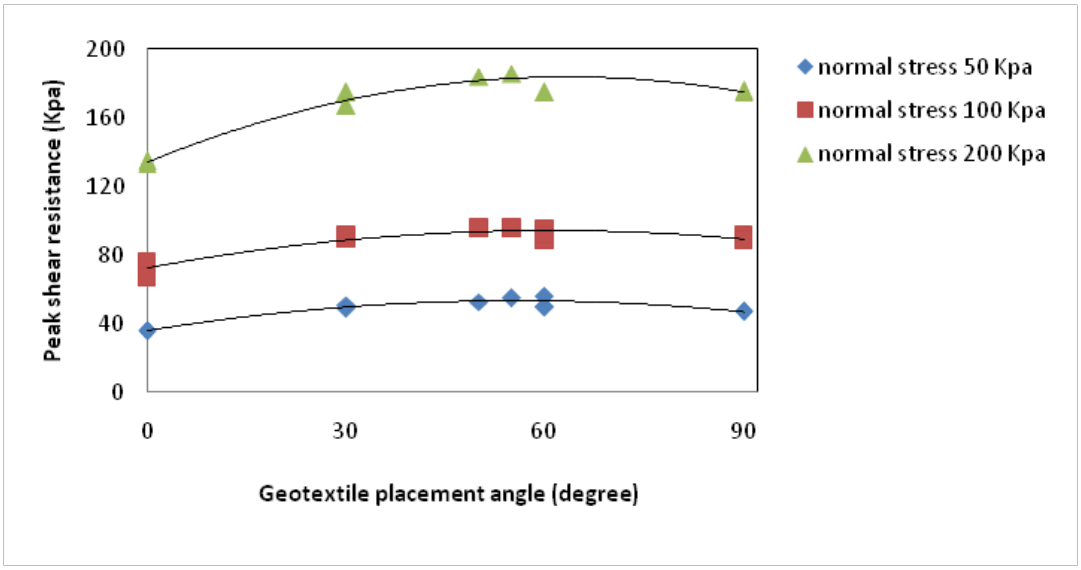

Fig 1: Variation of shear stress versus geotextile placement angle for reinforced sand with one layer

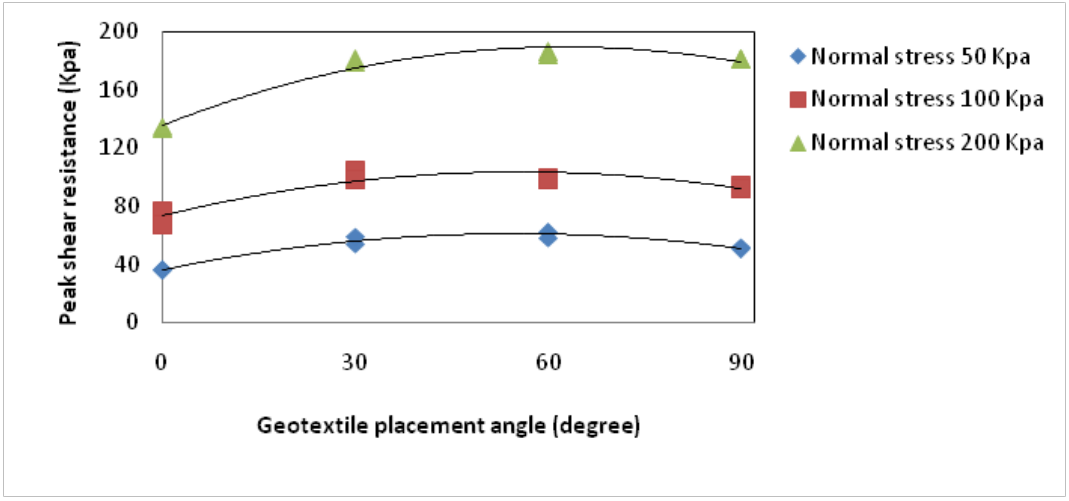

Fig 2: Variation of shear stress versus geotextile placement angle for reinforced sand with two layers

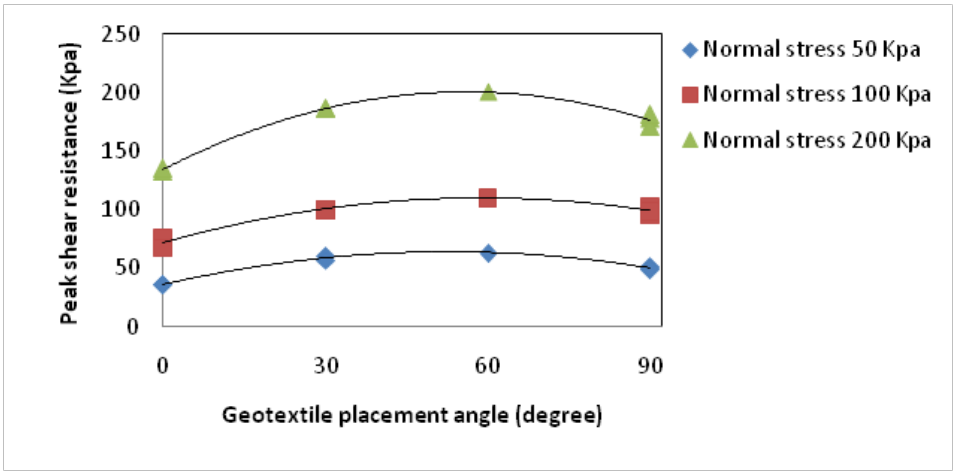

Fig 3: Variation of shear stress versus geotextile placement angle for reinforced sand with three layers

As seen in Figs. 1 to 3, shear strength becomes the lowest value when geotextile layers are placed horizontally. With increasing the angle to 30°, the shear strength increases. This increase continues until it reaches its peak and then the decreases until it reaches 90°. It is seen in Fig. 1 that for one geotextile layer reinforcement, the maximum shear strength varies in 56.6°-63o with an average of 63°. By calculating the mean of the three degrees mentioned above the placement angle of 60°. The average values of maximum shear strength for two and three layers are achieved for geotextile placement angles of 58° and 56°, respectively.

Figs. 4 to 6 show variation of $\frac{\tau_{Reinforced}}{\tau_{Sand}}$ with geotextile placement angle for sand reinforced with one, two, and three geotextile layers.

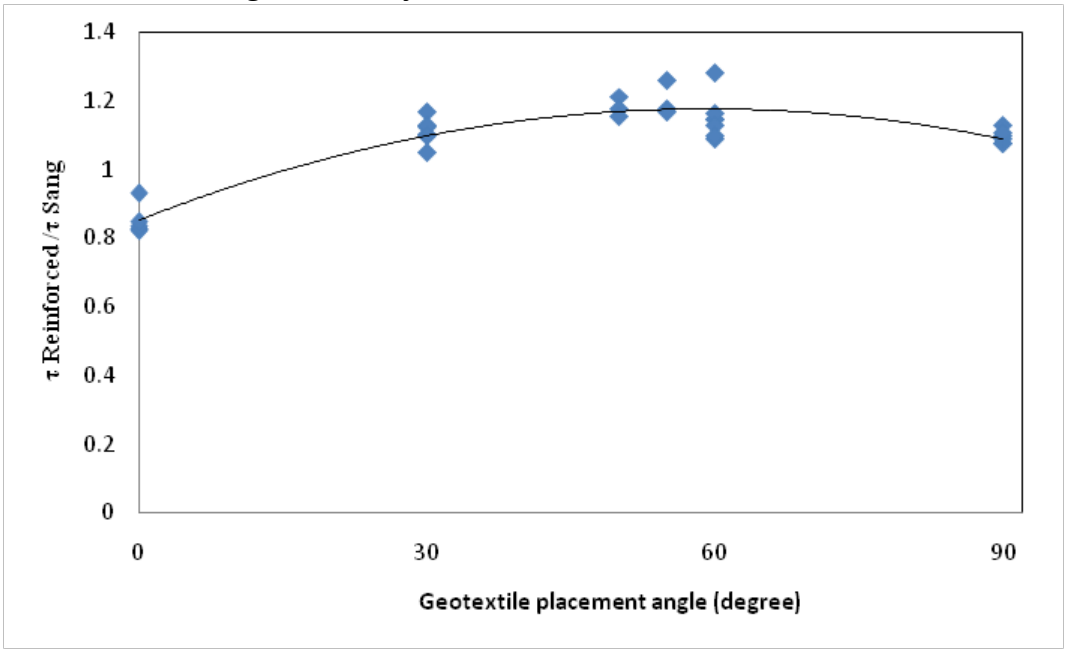

Fig 4: Variation $\frac{\tau_{Reinforced}}{\tau_{Sand}}$ with placement angle for sand reinforced with one geotextile layer

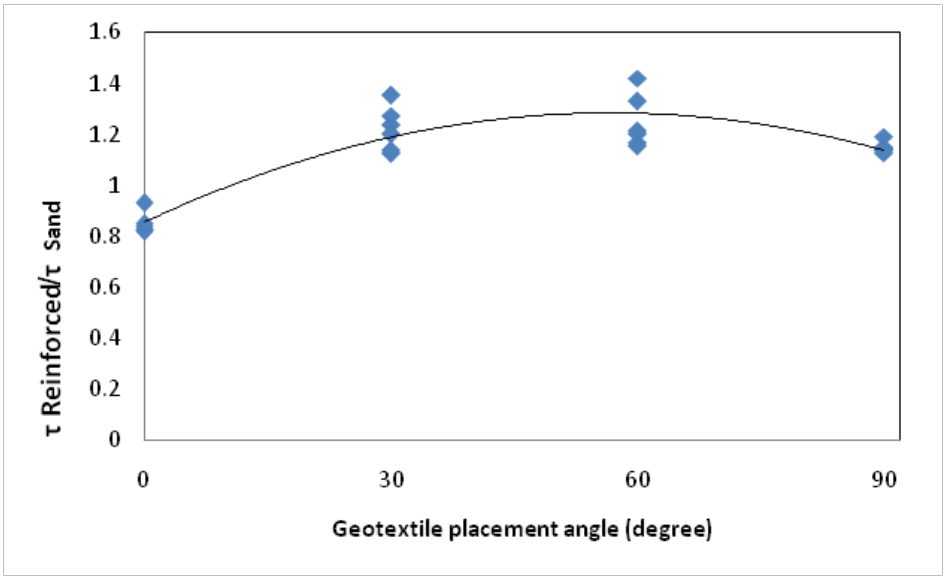

Fig 5: Variation $\frac{\tau_{Reinforced}}{\tau_{Sand}}$ with placement angle for sand reinforced with two geotextile layers

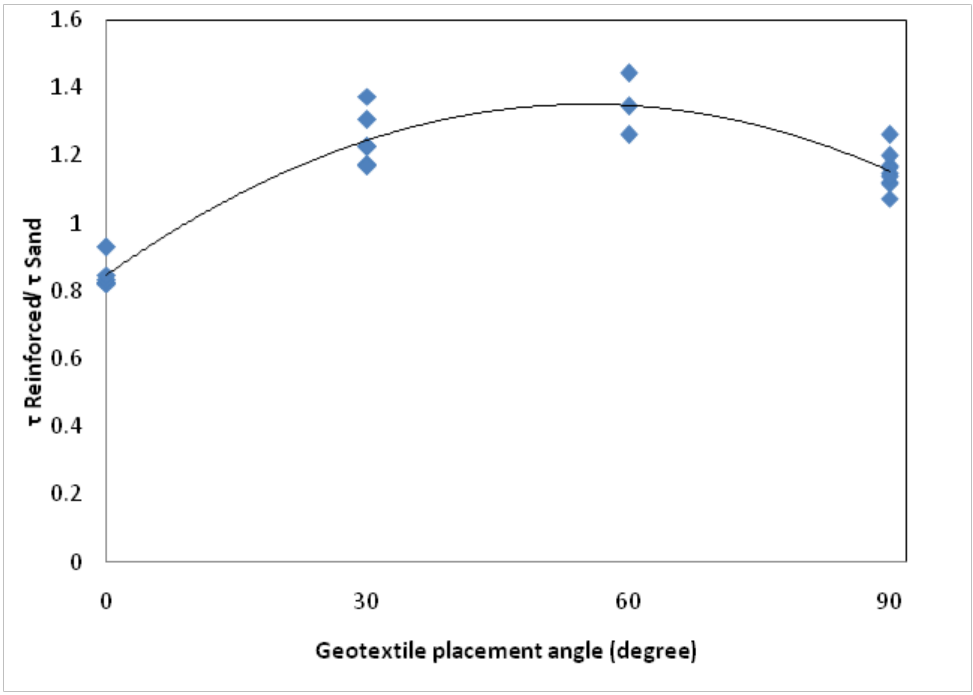

Fig 6: Variation $\frac{\tau_{Reinforced}}{\tau_{Sand}}$ with placement angle for sand reinforced with three geotextile layers

The values of $\frac{\tau_{Reinforced}}{\tau_{Sand}}$ related to the placement angles of 60°, 57°, and 55° with horizontal direction equal 1.18, 1.28, and 1.35 for sand reinforced with one, two, and three layers of geotextile, respectively. This implies for 18%, 28%, and 35% increase in shear strength when reinforcement layers are used in the best possible placement angles.
In general, it may be said the best angle range is within 55o-60o. This is in good agreement with findings of Gary and Ohashi (1983) for fiber reinforced sand and also with research done by Zomorodian and Moveydi (2009).

4. Effects of number of geotextile layers on sand shear strength

Figs. 7 to 9 show peak shear strength versus the number of geotextile layers for placement angles of 30°, 60°, and 90° under different normal stresses.

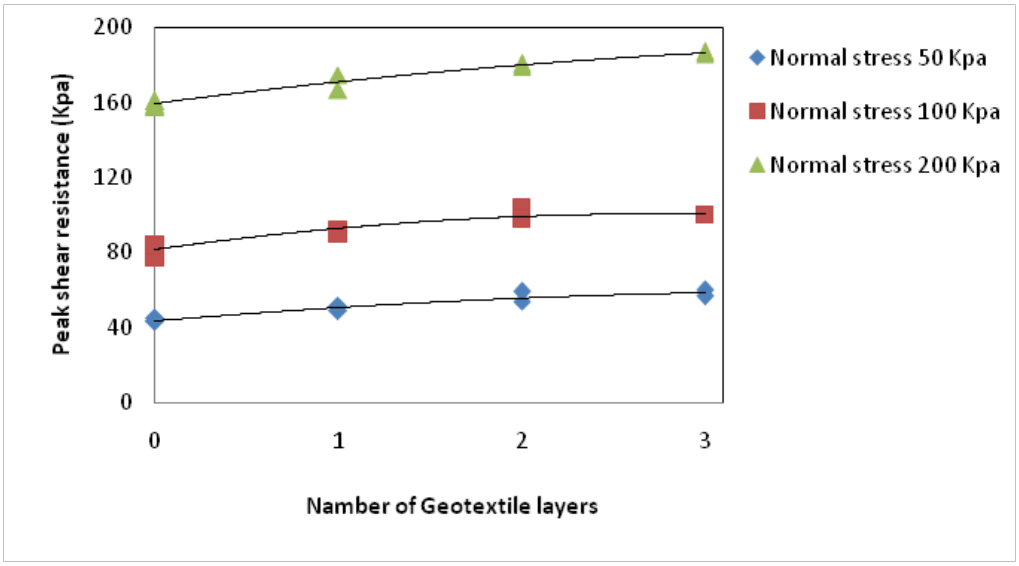

Fig 7: Variation of peak shear stress versus number of geotextile layers for geotextile placement angle of 30°

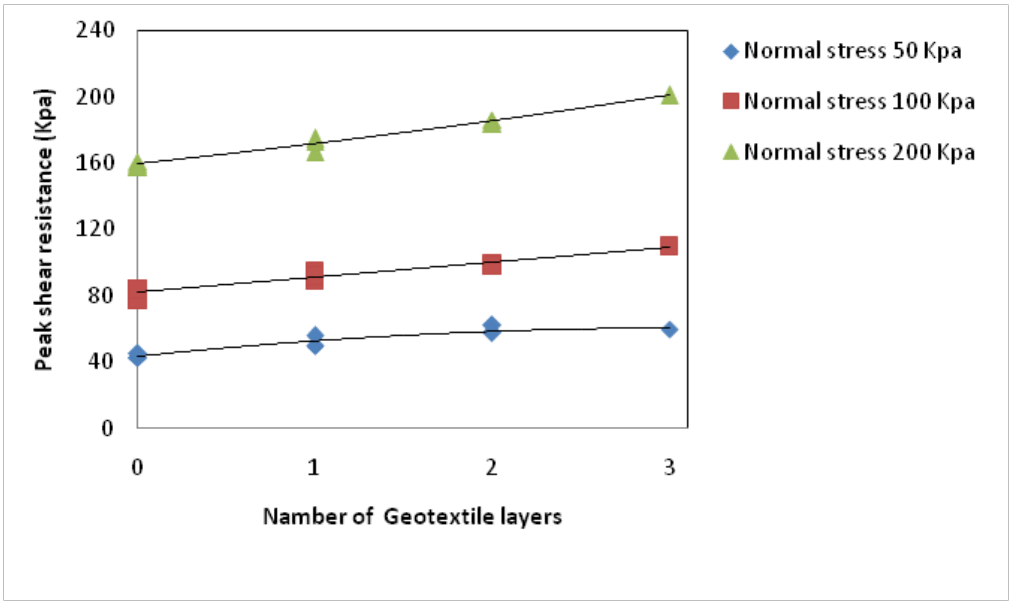

Fig 8: Variation of peak shear stress versus number of geotextile layers for geotextile placement angle of 60^{o}

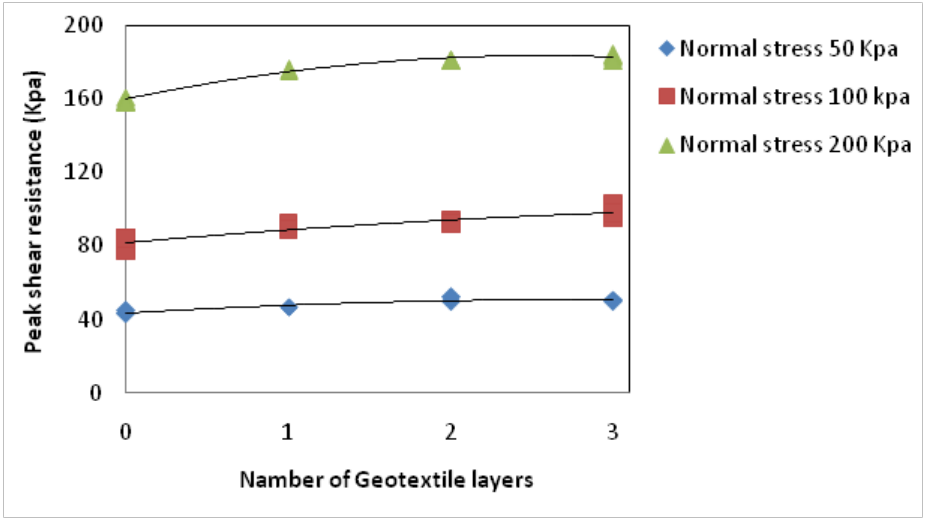

Fig 9: Variation of peak shear stress versus number of geotextile layers for geotextile placement angle of 90^{o}

According to Figs. 7 to 9, with increasing geotextile layers for sand reinforcement, the peak shear strength increases. This increase is faster for lower geotextile layers.

Fig. 10 shows the variation of horizontal shear displacement versus geotextile placement angle for two geotextile layers. For brevity, only one figure is presented on horizontal displacement.

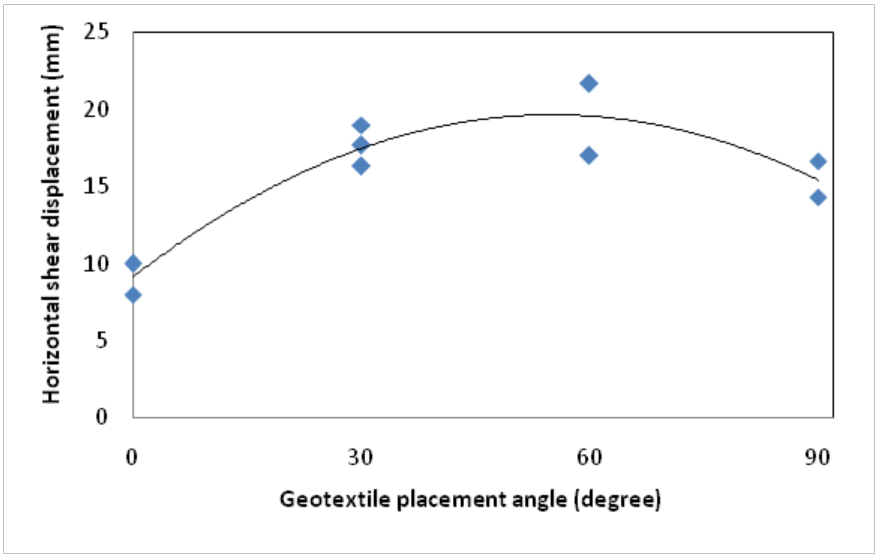

Fig 10: Variation of horizontal shear displacement versus geotextile placement angle for two geotextile layers

5. Conclusions

In the current research, sand was reinforced with 1 to 3 layers of geotextiles placed at various angles with respect to the horizontal directions. The general findins may be summarized as:

- The best geotextile placement angle for reinforced sand with one to three layers varies 56^{o}-60^{o}.
- The maximum horizontal displacement for failure stage of sand reinforced with two layers of geotextile occurs when the geotextile placement angle is 55^{o}.
- With increasing geotextile layers, the peak shear stress of reinforced sand increases. This increase is faster when less geotextile layers are used.
- Upon using geotextile layers at the best placement angle, the shear strength increase values of reinforced sand account for 18%, 28%, and 35%, for one, two, and three geotextile layers, respectively.

References

Das, B.M. (1998). *Principles of Geotechnical Engineering.*

Ghazavi, M., & Ghaffari, J., (2008). Experimental determination of sand-geosynthetic interface parameters using large direct shear tests. *Proceedings of the First Pan American Geosynthetics Conference & Exhibition*, Cancun, Mexico.

Gray, D.H., & Ohashi, H., (1983). Mechanics of fiber reinforcement in sand. *Journal of Geotechnical Engineering Division, ASCE*, 109(3), 335-353.

Haeri, S.M., Noorzad, R., & Oskoorouchi, A.M., (2000). Effect of geotextile reinforced on the mechanical behavior of sand. *Geotextiles and Geomembranes*, 18(3), 385-402.

Zomorodiyan, S.M.A., & Moayedi, H., (2008). Finding best junction of reinforced and failure wedge in direct shear test, *Fourth Civil Engineering National Congress*, Iran.