Investigation of failure analysis of clay reinforced with sand encapsulated

Enquête sur l'analyse des défaillances d'argile renforcé avec du sable enrobe

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ABSTRACT: The paper includes discussions on the theory studies and numerical analysis as to stabilityof slopes reinforced with geotextile encapsulated with lenses of sand. In this study, given the laboratory research conducted on clay reinforced with geotextile encapsulated with lenses of sand, which showed in the high confining stresses due to the suitable interaction of clay and sand particles with geotextile, significant improvement is obtained in shear strength. Considering these results, based on the stability importance of slopesin the engineering projects and optimization, and increasing slopes stability, this technique is used as a reinforcement method in the clay slopes using various methods of reinforcement and the effect of various conditions such as the number of layers of reinforcement, confining pressures has been considered .In the study the numerical finite difference using software FLAC 2D has been applied. The results showed that the slopes with higher height the Sandwich technique to typical reinforcement with geotextile increases factor of stability safety under different studied scenarios because of improvement of intermediate behavior weakness by thin sand layers and the amount of factor of stability safety has been also enhanced, increasing the number of reinforcement layers.

RÉSUMÉ : Le document comprend des discussions sur les études théoriques et l'analyse numérique que les pentes stabilityof renforcés par des géotextiles encapsulés avec des lentilles de sable. Dans cette étude, compte tenu de la recherche en laboratoire menées sur de l'argile renforcée avec géotextile encapsulés avec des lentilles de sable, qui a montré dans les fortes contraintes de confinement en raison de l'interaction appropriée d'argile et de sable avec géotextile, une amélioration significative est obtenue dans la résistance au cisaillement. Compte tenu de ces résultats, basés sur l'importance de la stabilité des slopesin les projets d'ingénierie et d'optimisation, et d'augmenter la stabilité des pentes, cette technique est utilisée comme une méthode de renfort dans les pentes argileuses en utilisant diverses méthodes de renforcement et de l'effet de diverses conditions telles que le nombre de couches de renfort, des pressions de confinement a été pris en compte. Dans l'étude de la différence finie numérique à l'aide du logiciel FLAC 2D a été appliqué. Les résultats ont montré que les pentes à plus forte hauteur de la Technique du sandwich à renfort typique avec un facteur de sécurité augmente géotextile stabilité sous différents scénarios étudiés en raison de l'amélioration de la faiblesse comportement intermédiaire par des couches de sable fin et la quantité de facteur de sécurité de stabilité a été améliorée également, l'augmentation du nombre de couches de consolidation.

KEYWORDS: sandwich technique, reinforced soil, factor of safety, stability

1 INTRODUCTION

In non-reinforced backfills are constructed using natural materials the constraints from poor materials used, methods and non-favorable environmental andgeotechnical conditions on the project site created failures or adverse conditions in the backfill.

Intensity and scope of the failures may be increased to some extent that to impact the general and stability and complete servicing the intended project. In addition in some exceptional cases the project needs stimulate the engineers to consider construction of backfills with special dimensions inslope or height and stability against particularloadings such as earthquake. For example construction of road or rail backfills with more height or backfills with steep (in places due to limited land, the possibility of Transverse extension of backfill base missing) can be considered as specific items.Ineach of the above mentioned cases the Constructionof reinforcedbackfills with particular materials is felt,to be able to bear external factors effects as well as to have suitablestability in environmental and geotechnical conditions.

In the last three decades, Geosynthetics is widely used with high tension resistance to the soil reinforcement in geotechnical engineering. Makes using thereinforcesprovidesoil tension resistance in the soil and thus reduce lateral deformation of soil and increase overall stability of reinforced soil structures (Abiera,H.O.1991).

In past decades, mostly the reinforced soil technique has been applied using coarse materials as backfill (Backfill materials). Recently, due to economic considerations, the backfill material with low qualityand localaccess has been used successfully (Bergado et al. 2008). Although you need to determine the geotechnical properties for reinforcement elements and backfill materials to design reinforced soil system, but the mechanism of interaction of soil - reinforcementelement, plays an important role.

To consider soil interaction mechanisms – reinforcement element, studies have been done using direct shear and tension tests by various researchers (Zhenggui Wang and Werner Richwien 2002).

In the reinforced clay Soil, the contact resistance is low and consequently, failure in interfaceoccur prior to the reinforcertension strength to the final extent. Thus, a large percentage of the tension strength of reinforcernot mobilized at failure and cannot be used (Jewell.R.A and Wroth,C.P .1987).

Experimental results show that the shear stress around reinforcementis high and decreases rapidly with distance from its surface. Thus in the reinforced soil structures with low quality backfill material it is possible that a thin layer with granular material containing high resistance around the reinforcement will be used to control high shear stresses near the reinforce and in the interface (Ghiassian and Jahannia 2004). This method improves the stress transfer mechanism due to a

better interface properties which is called sandwich technique (sandwich technique), In fact, the basis of this method is to provide a thin layer of sand with high strength on both sides of Geotextile, in order to improve the shear strength and deformation behavior of the reinforced clay soil (Unikrishnan.N, Rajagopa.K and.Krishnaswamy,N.R. 2001).

1.1 *Studies on clay reinforced*

The Studies of Unikrishna et al. (2001) on the reinforced clay with lens of sand (sandwich technique) did show that adding sand improvesreinforced soil strength properties. Sand lens thickness, humidity and type of geotextile was paid attention.

Abdi et al. (2009) during large-scale direct shear tests, studied the resistance improvement due to providethe thin layers of sand on either side of the geogrid (sandwich technique) in the clay and reported the results of the study as follows.

- given the Figure (1) one can understand that providing a thin layer of sand with high strength on both sides of reinforceris very effective to improve plasticity and resistance of clay soils.

- using the buried geogrid system in the sand of fine granular soil (sandwich technique) increases the shear resistance impressively. The buried geogrid system in the sand is more effective on the internal friction of soil and less effective on the coefficient of cohesion.

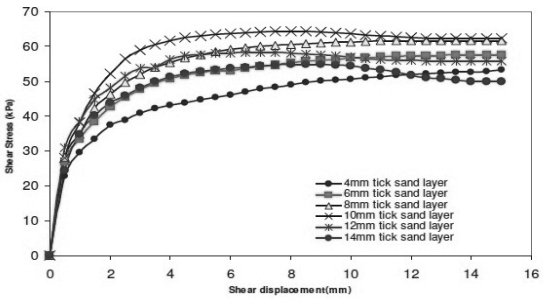

Figure 1. The relationship between shear stress - shear displacement under confining stress 75 kPa with different thicknesses of sand layers. (Abdi et al., 2009)

Abdi and Arjmand (2011) carried out various experiments on the pullout testonreinforced clay with geogrid encapsulated with thin layers of sand. The Samples have been prepared at the optimum moisture content and maximum dry density weight which have been obtainedfrom Standarddensity testing Proctor. One-way geogridis used with a sand layer, 6, 10 and 14 mm in thickness. Experimental results showed that the encapsulated geogridin thin sandy layers increases reinforced clay pullout resistance under the pullout conditions. The results showed that the maximum resistance to pullout increased with confining pressure and the optimal thickness of layer of sand is the same for all normal stresses.

Studies of Tabarsa and Radmehr (2011) on the reinforced clay with lens of sand (sandwich technique) yielded the following results.According to this research the increasing reinforcement layers caused to increase ultimate strenght . Also improved the recovery of samples increasing confining stress from 100 to 550 kPa and to confining stress300 kPathe improvement trend increases and then decreases. (Figure 2)

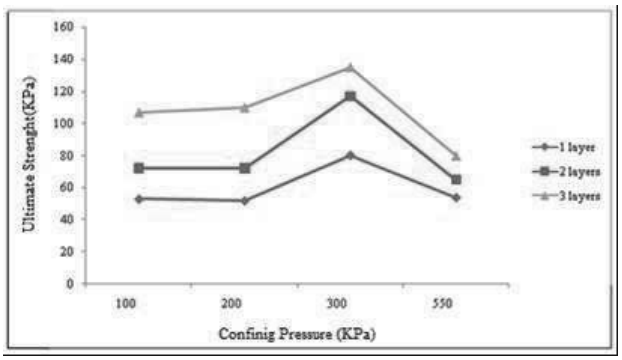

Figure 2. Effect of confining pressure on the reinforced sample, with geotextile and sand in 4 mm thick.(Tabarsa and Radmehr 2011)

Given the abovementioned forms it can be perceived that sample plasticity diminishes increasing the thickness of the layer of sand. Also, recovery percentage of resistance has increased slightly increasing the thickness of the sand in low confining stresses.And in highconfining stresses (550 kPa) the high resistance percentage has increased significantly and therefore it can be stated that the high confining stresses impact on the sand performance in the composite system desired result is achieved Because of the angle of high internal friction of the sand. The Results and research, suggest few studies on the subject of numerical simulation techniques for soil slopes stability analysis which the research has been done in this direction.

2 MODELING AND NUMERICAL ANALYSIS

FLAC software is based on the finite differential method. Finite differential methodis used in various engineering issues.Its application in the soil and rock mechanics is common because one can model the big displacements and stresses of soil and rock masses.in the research FLAC 2D software has been used.

3 CHARACTERISTICS OF THE STUDIED MATERIALS

In this study, to analysis the slope stability, the behavioral models Mohr - Coulomb is used. Also nonwoven geotextile have been used for modeling the slopes.

Table 1. details the parameters considered in this study

soil	Density,kg/m^3	Bulk module,kg/m^2	Shear module,kg/m^2	Dilation,degree	Cohesion,kg/m^2	Angle of internal friction,degree
clay	2000	2E6	3E6	0	20000	15
sand	2000	3E7	4E7	15	2000	39

4 GEOMETRIC PROPERTIES OF SLOPES

In the analysis, four types of slope with different heights of 6, 9, 12 and 15 m with the same slope of 56 degrees have been considered. The method of geotextiles arrangement is shown in Figure 3 in the sandwich technique for the slope 12 meters.

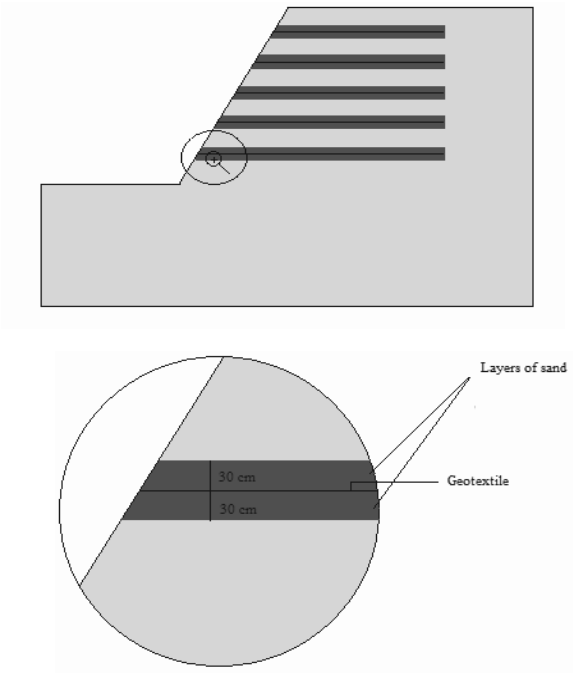

Figure 3.slopes12-meter, reinforced with sandwich technique

5 HOW TO MODEL

First defining the model geometry and thenrequired parameters are considered for different scenarios of various materials.

Given the importance of the boundary conditions on the both sidesthe slope is anchored inthe horizontal direction (x) and in downwardslope horizontal and vertical directions (x, y) are anchored. Then geotextiles with distances equal to 1.5 m with the same length have been modeled. And following given the characteristics of the geotextiles, the suitable interaction parameters are involved between soil and geotextile. Then thin layers of sand with equal 30 cm thickness are considered to simulate the effect of sandwich technique inreinforcement process on the border between the reinforcement element and the clay soil (geotextile),given the different distances between the layers.

6 THE RESULTS OF NUMERICAL MODELING

After modeling and static analysis using software it evaluates and compares the factor of stability safety in slopes for different heights and different modes of reinforcement as follows.

6.1 *Results of static analysis on slopes with different heights*

According to the analysis results, finite differences of reinforced clay slopes are shown as 6, 9, 12, 15 m, factors of safety in different states of reinforcement as computed (figures 4 and 5) and includes three modes 1- clay Model (C), 2 - clay with geotextile (CG), 3 - Sandwich Technique (CGS)

According to the output of numerical modeling analysis and the results shown in the above graphs, adding layers of sand on both sides of geotextiles(sandwich technique) increases significantly factors of safety at different height (6,9,12,15 m).
In Figure 6 this technique has a greater impact on stability of clay slopes in above heights and further increases the factor of stability safety.

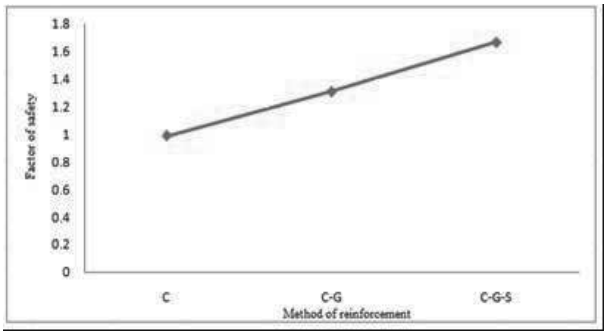

Figure 4. Comparison of factors of safety in 9 m slope

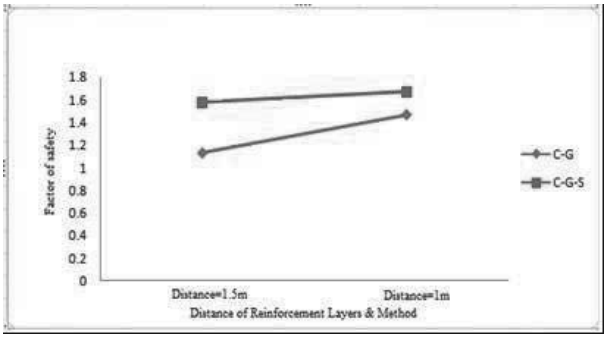

Figure 5. Comparison of factors of safety in 12m slope for geotextiledistances intervals in both 1 and 1.5 meter

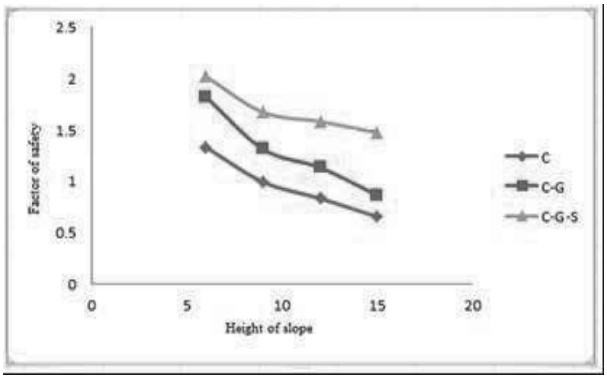

Figure 6. Comparison factors of safety of slop different heights in various states of reinforcement

7 CONCLUSION

- Analyses showed that the sandwich technique is an effective method of stabilizing clay slopes for engineers and results of the numerical analysis carried out in vitro studies are consistent with the sandwich technique.
- Sandwich techniqueis used in clay soils where have the poor and weak interaction with the geotextiles.
- given the acceptable development of a factor of safety using the sandwich technique we can make or design slopes with more height and slope in the engineering projects.
- sandwich technique in the more heights has more impact in the factor of safety increase , because of confining pressure increase and consequently getting better interaction condition between sand and geotextile .
- The factor of stability safety will be increased, increasing noumber of reinforced layers in the sandwich technique.

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