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# INVESTIGATING THE OPTIMAL LENGTH OF GEO-GRID REINFORCEMENT IN MECHANICALLY STABILIZED RETAINING WALLS

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**Abstract-** Reinforced soil is one of the most important initiatives of civil engineering in recent decades which achieved by the composition of the soil and a series of reinforcement components. In this way, buoyancy forces of the embankment are moved to reinforcement element by friction and moderated through tensile force created in the elements. This matter makes it possible to utilize from slopes with more angle by increased tensile strength. Reinforced soil structures are commonly used to increase stability, reduce risks and failures and applying more loads on the slope. The main problem in the design of reinforced soil is to control deformation and prevent from failures. For this purpose, various experimental methods have been proposed to control the deformation and failure of reinforced soil system. But the existence of simplifying assumptions in these relations and the uncertainty of them has made engineers to present conservative and non-economic designs. In present study, finite element method in the form of plane strain was used through Plaxis2D Software to precise investigation of reinforced soil system and its effect on under study system was evaluated by making changes in the length and vertical distances of geo-grids and finally the best design was extracted among obtained results.

**Keywords:** Reinforced Soil, Geo-Grid, Optimal Length, Plaxis2D, Finite Element Method.

## I. INTRODUCTION

Soils are among materials almost used in all different types of constructions. With the rapid development of construction projects on land and sea, it is time to study and investigate soil characteristics and ways to improve their properties.

In the past, changes were applied on the dimensions of foundation, geometric form of the embankment, the technical specifications of roads or the volume of their walls to achieve required harmony and balance between elements and increase lifetime, stability and resistance of under construction structures. But design philosophy and related calculation methods were turned into a major part of soil operation since construction of the first reinforced wall by Andrew Quinn [1] and then initiative design of Henri Vidal [2] called reinforced soil.

Nowadays, geo-synthetics are most commonly materials to reinforce the soil. Geo-synthetics dated less than other reinforcement materials. No.4439D of Standard ASTM defines geo-synthetics as follow:" a plate-form made by polymeric materials which alongside soil, rock and other geotechnical materials is used in human-made structures and projects". The most common types of geo-synthetics are geotextiles and geo-grids. Geotextiles form the greatest group of geo-synthetics. They are porous and permeable textiles made by polymeric fibers.

The advantages of using geo-grids are similar to geotextiles, but higher resistance of geo-grids is the main application of them to reinforce soil materials. Geo-grids have high tensile strength and considerable locking with soil. Among the most important usages of geo-grids, one can refer to construction of reinforced soil retaining wall to 90 degrees with high altitude, strengthen the asphalt layers, performing walls of vertical green space, stabilization and strengthen of steep slopes with green and diverse views, consolidation of railway and road beds and stability in order to prevent the movement of soil layers on steep slopes.

In the structural viewpoint, retaining wall is divided into two types of reinforced (armed) and non-reinforced (unarmed). In non-reinforced type, the wall is constructed using rock and concrete. In reinforced type, the retaining wall of soils materials is reinforced by tensile components such as geo-grids, geotextiles, bracing rods, steel bars and so on. The usage of reinforced soil retaining wall has had a growing trend since 1970 and has been widely used, particularly in rail and road transport networks as usual and acceptable type of retaining wall. The first geo-synthetics reinforced soil retaining wall was constructed in Poitiers city of France in 1970.

The first geotextile wall was constructed in France in 1971 and then in USA in 1974. Geo-grids were firstly used in constructing reinforced soil wall in 1978. In Iran, geo-grid was also firstly used in constructing reinforced soil wall of the area of Goftego Park in 1994 [3]. Therefore, the optimum usage of these reinforcing in construction of reinforced soil retaining wall which has been investigated in present study and optimum and effective length in the condition of lack of enough space to use them, as well as selecting the type of reinforcement and replacing them in different operational and economic conditions can be effective in construction of such technical building. Numerous studies have ever been conducted in this field, some of them mentioned in follow:

Klar and Sass investigated the mechanical behavior of reinforced soil wall using kinematic compatibility method [4]. They comprised the results of the method with results obtained from more precise continuous analysis methods such as finite element method and finite difference method. In addition, Ehrlich et al investigated the effect of soil compaction on the behavior of geo-synthetic reinforced soil retaining wall [5]. The conducted measurements showed that heavy density leads to increase in the maximum shear stress mobilized in the reinforcement, while light density has a less effect on the final displacement and tensile stress mobilized in the reinforcement.

Ferdousi and et al. have numerically investigated the stability of soil walls reinforced by geo-synthetic [6]. The results of their study showed that the amount of walls' horizontal deflection is decreased by increase in tensile stiffness of geo-synthetic. However, the effect of axial stiffness of geo-synthetic on reduction of walls' horizontal deflection is significant only up to a certain amount and after this certain amount, geo-synthetic axial stiffness increasing has no significant effect on these deflections and subsidence. In addition, the amount of walls' horizontal deflection is decreased by decrease in distance between reinforcing layers and increase in the length of geo-synthetic layer. But this reduction is considerable only up to certain numbers of layers and certain length and the changes are negligible after that.

Shabani and et al. have evaluated the function of reinforced soil retaining wall with a diagonal reinforcement, steep surface and reinforcement bracing [7]. The results obtained from empirical investigations of the study showed that side deformation of wall surface is reduced by slopping the surface toward embankment. In addition, the concluded that utilizing from diagonal reinforcement layers causes to more reduction in horizontal deflection. According to the obtained results, it was identified that implementing walls with surface of 80 ° to the horizontal and inclined toward the embankment and reinforced with a tilt of 10 ° to the horizontal significantly improves the wall's performance, so that the horizontal deflection of wall surface under the condition of allowable load is decreased up to 20%.

In addition, it was found that bracing the end of reinforcement at embankment has a useful but limited effect on wall's performance. Therefore, the present study was aimed to investigate the optimal length of geo-grid reinforcement in mechanically stabilized retaining walls. Hence, the purposes of present study are as follow:

1. By placing different lengths of geo-grid reinforcing in different layers, it was investigated how much the length of reinforcing can be reduced without causing to no interfere in stability and replacement of the wall.
2. Due to the lack of precise length of reinforcing used for retaining walls and relatively high difference in various scientific references and regulations of countries, the precise and detailed investigation of this matter can provide solutions to the problems of designing reinforced soil retaining wall in this new study.

## II. MATERIALS AND METHODOLOGY

According to the problems in methods based on failure, the stress-deformation analysis has been conducted in present study through numerical methods and utilizing from PLAXIS 2D Software which is specialized to soil mechanics. PLAXIS is among soft wares have been provided to market using finite element method in order to analyze 1) Stress deformation, 2) secretion, 3) strengthening and 4) stability of soil structures. The program has simple graphics capabilities to create geotechnical model and meshing. In PLAXIS Software, the geo-grid has a thin structure with axial rigidity and without bending rigidity. Geo-grids only tolerate tensile force and are not capability of tolerating compressive force. Geo-grids are made up of linear elements with two degrees of freedom at each node ($U_x$, $U_y$). In the case of utilizing from elements with 15 nodes, each element of geo-grid is determined by 5 nodes.

In present study, the underground water level is located at a depth of four meters and the water of trenches discharged by progress of drilling which applied in the construction steps of the model. In present study, the Mohr-Coulomb model has been used in modeling as behavior model. The boundary conditions must be defined to solve balance differential equation. In present study, the boundary conditions included certain amounts of displacement and force which called anchor condition and loading condition, respectively.

In solving problems through numerical method, the simulations must be performed properly and the components of the model must be determined in accordance with the conditions of problem. Some components of the model such as the number and dimensions of elements are effective in accuracy of calculations. With higher number of elements, the solutions become more precise but it is time-taking in model analysis. The matter is more observable in three-dimensional modeling.

In contrast, the solutions are less precise with lower number of elements and the results obtained from numerical modeling, would have no desirable accuracy. Although increasing the number of elements increases the accuracy of solutions (answers), but it cannot conclude that optimized gridding includes the highest number of elements. In the other words, increasing the number of elements or minimizing their size must be done only until achieving to modeling purpose with acceptable accuracy.

Therefore, in present study, the model has been calibrated properly. After creating numerical model and allocating parameters of characteristics of soil components and the structure, meshing and dividing of total space was carried out to perform finite element calculations. The work was done by Automatic Mesh command. During the mesh generation, the masses are divided into triangular elements which in PLAXIS 2D Software are done with one of the 6-nodes or 15-nodes elements. The 15 nodes elements have more accuracy in the calculations of stresses, load and failures (especially in symmetrical geometry). Moreover, meshes combined from 15-node elements are smaller and more flexible compare to the 6-node elements.

But their calculation and analysis is more time-taking. In present study, 15-node elements with 12 tension points were used to more accurate two-dimensional modeling. The thickness of bed soil was considered equal to 15 m to increase the model's accuracy. The thickness is increased in other models with 1 m step and this increasing continued until it can be possible to neglect the effect of model's thickness on deformations. The obtained results have been presented in Table 1.

According to the results of Table 1, the thickness of bed soil layer is considered equal to 20 to remove the effect of boundary conditions on the results of thickness of bed soil layer of the model. The modeled environments of present study are generally in the form of the model has been presented in Figure 1. According to the Figure 1, the dimensions of the problem are considered with height of 30 m width of 40 m in modeling reinforced soil. In addition, the depth of trenches is considered equal to 6 m and the length of embankment considered equal to 8 m. according to the subject of present study, embankment geometry and geotechnical properties and soil resistance as well as reinforced soil cover profile (Gabion) remained without any changes in all of the created models. The profiles of bed soil, reinforced soil and Gabion have been provided in Table 2.

The study variables are dimension, kind of geo-grid material which have been shown in Table 3. The command window (generate mesh) and mesh size (fine) were used for meshing the problem to carry out finite element calculation which have been shown in Figure 2.

Table 1. The sensitivity analysis than thickness of the substrate soil

| Number of Analysis | thickness of the substrate layer | The maximum horizontal deformation | difference of deformations |
|---|---|---|---|
| 1 | 15 | 0.01927 | - |
| 2 | 16 | 0.01812 | 0.0115 |
| 3 | 17 | 0.01773 | 0.0038 |
| 4 | 18 | 0.01735 | 0.0038 |
| 5 | 19 | 0.01715 | 0.0020 |

Table 2. Material Characteristics of model

| Name | Behavioral model | Special Weight | Modulus of elasticity | Poisson's ratio | Cohesion | Angle of internal friction |
|---|---|---|---|---|---|---|
| Bed Soil | Mohr-Coulomb | 16 | 20000 | 0.33 | 8 | 29 |
| Reinforced Soil | Mohr-Coulomb | 19 | 30000 | 0.3 | 1 | 30 |
| Gabion | Mohr-Coulomb | 19 | 7000 | 0.3 | 20 | 45 |

Table 3. Research variables

| Name | Mark | Interval | Step | Unit |
|---|---|---|---|---|
| Length of geo-grid | $L$ | 4.5-6.5 | 0.5 | M |
| Geo-grid vertical distance | $S_v$ | 0.5-1 | 0.5 | M |
| Axial stiffness factor | EA | 1500-2000 | 500 | kN/m$^2$ |

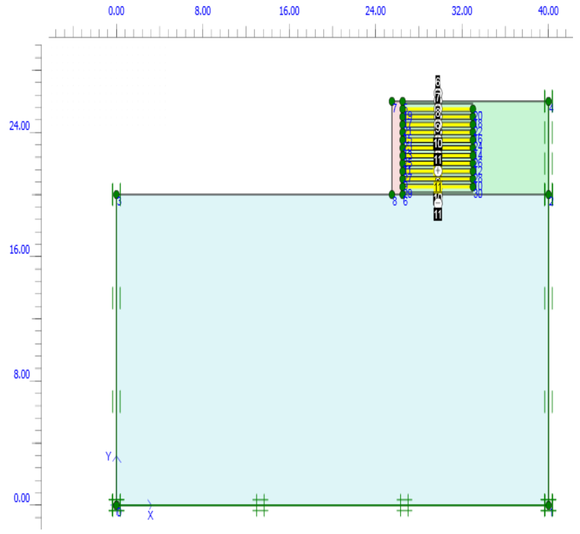
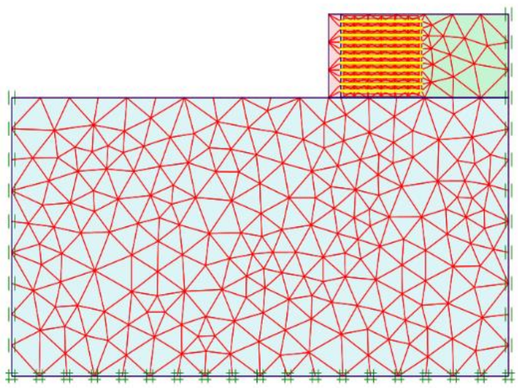



Figure 1. Sample analysis



Connectivities

Figure 2. Meshing of model

In addition, the results of modeling conducted by Ferdousi and et al. in 2015 were used to validate the software in present study. The profile of materials used in present study is in accordance with their model which has been shown in Table 2. The distance of reinforcing elements is between 0.25 to 1 m which the modeling environment has been presented in Figure 3.

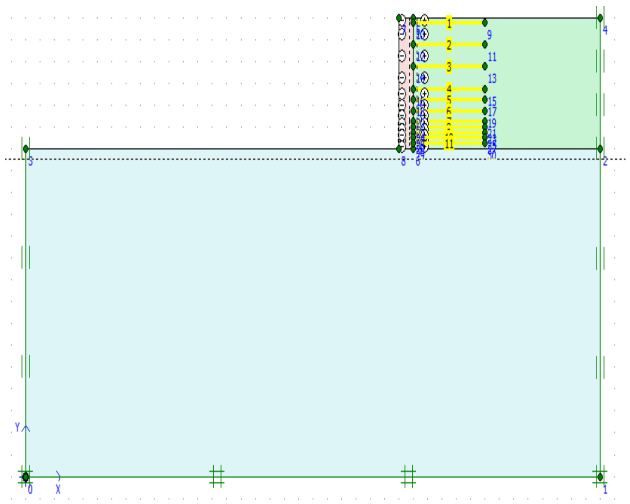


Figure 3. Created model in order to validation

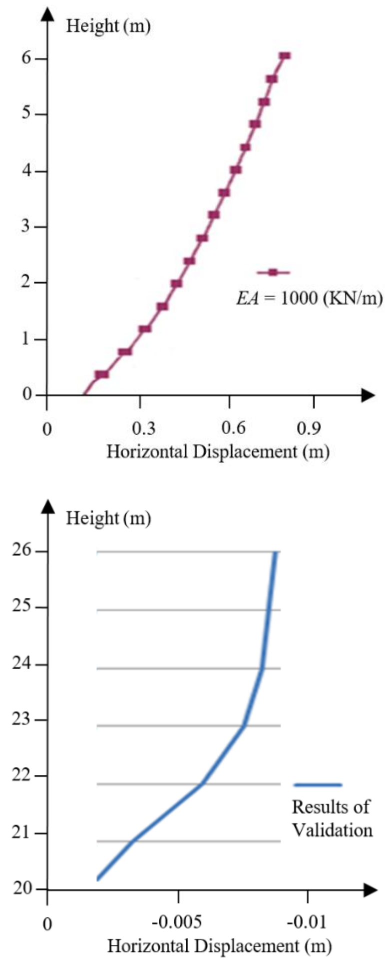



Figure 4. The diagram of validation

The results obtained from presents study with geo-grid profile provided in Table 4 are according to the diagram of Figure 4.

Table 4. Geo-grid specifications used in the model validation

| Geo-grid | $EA$ (KN/m) | $S_v$ (m) | $L$ (m) |
|---|---|---|---|
| | 1500 | 0.25-1 | 6.5 |

## III. RESULTS AND DISCUSSION

In present study, the effect of variables has been investigated in two outputs of horizontal deformation of the embankment behind Gabion and axial forces of geo-grids, which the diagrams of one of the models have been provided in Figures 5 and 6 as a sample, in continue.

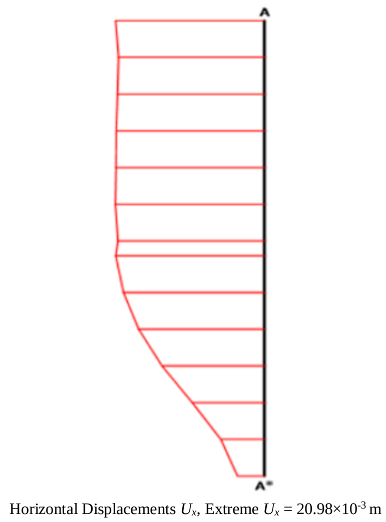



Figure 5. Horizontal deformation of the embankment in behind cover

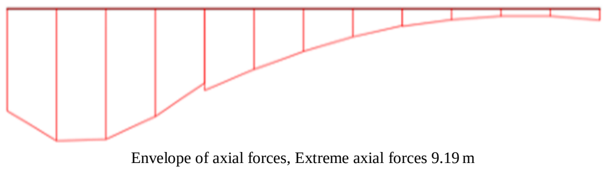



Figure 6. Geo-grid axial force.

Figure 5 indicates the horizontal deformation of reinforced soil behind the wall. According to the figure, the deformations are less at the heels of embankment and gradually increased by increase in the height of embankment. It was expected that in continue and with changes in variables, only the magnitude of deformations is altered and their shape remain similar which the matter would be observable with providing the obtained results. Figure 6 shows the tensile axial force applied on geo-grid. According to the figure, the force increases with closing to the area behind the cover and decreases with closing to the free end of geo-grid which finally reaches to zero. The reason of this matter is due to the high amount of deformations at behind of the cover and as result, more tension of geo-grid at this part. Table 5 represents profile of used variables in different models of present study.

Table 5. Specifications of model variables of 1, 2, …, and 20

| Model | Length of geo-grid | Geo-grid vertical distance | Axial stiffness ($EA$) |
|---|---|---|---|
| 1 | 4.5 | 0.5 | 1500 |
| 2 | 4.5 | 1 | 1500 |
| 3 | 4.5 | 0.5 | 1000 |
| 4 | 4.5 | 1 | 1000 |
| 5 | 5 | 0.5 | 1500 |
| 6 | 5 | 1 | 1500 |
| 7 | 5 | 0.5 | 1000 |
| 8 | 5 | 1 | 1000 |

| | | | |
|---|---|---|---|
| 9 | 5.5 | 0.5 | 1500 |
| 10 | 5.5 | 1 | 1500 |
| 11 | 5.5 | 05 | 1000 |
| 12 | 5.5 | 1 | 1000 |
| 13 | 6 | 0.5 | 1500 |
| 14 | 6 | 1 | 1500 |
| 15 | 6 | 0.5 | 1000 |
| 16 | 6 | 1 | 1000 |
| 17 | 6.5 | 0.5 | 1500 |
| 18 | 6.5 | 1 | 1500 |
| 19 | 6.5 | 0.5 | 1000 |
| 20 | 6.5 | 1 | 1000 |

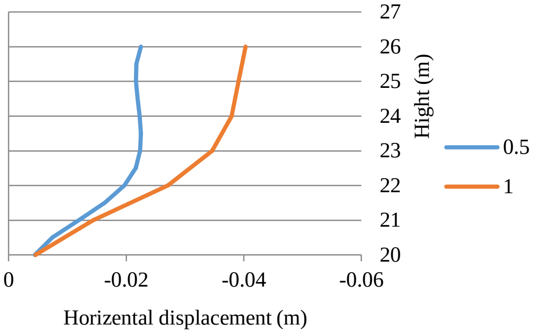



Figure 7. Horizontal deformation in the face of reinforced soil height with geo-grid length of 4.5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1500

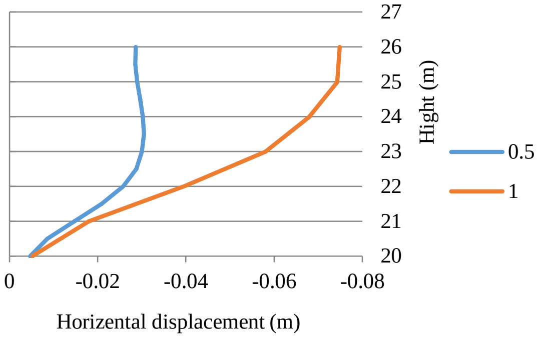



Figure 8. Horizontal deformation in the face of reinforced soil height with geo-grid length of 4.5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1000

Figure 7 represents a comparison between 0.5 m and 1 m distances of soil reinforcing and its effect on the horizontal deformations. According to the figure, increasing the distance has a significant effect on deformations caused by embanking, in a way that the deformations increased up to two times with doubling the distance between reinforcements. Significant changes are created in tensile forces caused by geo-grids with increasing the distance between reinforcements, in a way that the maximum tensile force of geo-grids increased by doubling the distance between reinforcements.

In continue, the results of changing axial rigidity from 1500 to 1000 were extracted and provided in Figure 8. As like Figures 6 and 7 represents the diagrams related to horizontal deformations for reinforcements with vertical distances of 0.5 m and 1 m, with the difference that the axial rigidity of geo-grids has been reduced to. The results show that significant changes have been again created in deformations with making changes in vertical distances of braces.

In this condition, making change in vertical distance of reinforcements has more effect on deformations with axial rigidity reduction. In addition, reduced axial rigidity of reinforcements has itself a significant effect on increasing deformations caused by embanking, which the matter is clearly observable by comprising Figures 6 and 7. Here, it is again observable that the effect of changing vertical distance between reinforcements on tensile forces applied on geo-grid has more alteration to the manner of *EA*=1500 by reduction in axial rigidity, in a way that the amount of tensile force for vertical distance of 1 m is two times higher than vertical distance of 0.5 m in *EA*=1500. But in *EA*=1000, the alteration is more than double. In continue and in Figure 9, the effect of increasing the length of reinforcements on deformations and tensile forces has been investigated.

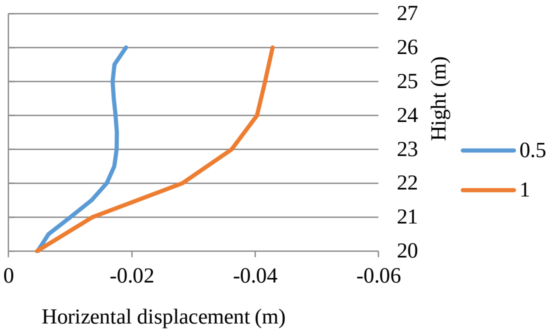



Figure 9. Horizontal deformation in the face of reinforced soil height with geo-grid length of 5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1500

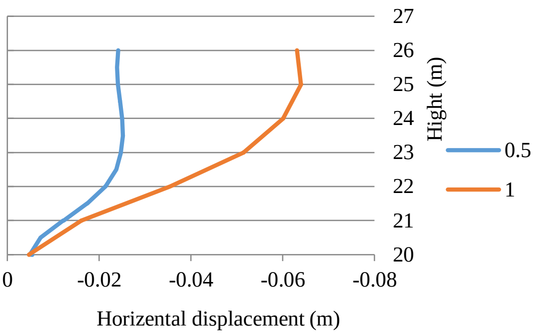



Figure 10. Horizontal deformation in the face of reinforced soil height with geo-grid length of 5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1000

Figure 9 provides a comparison between reinforcing the soil at distances of 0.5 m and 1 m and its effect on horizontal deformations. The figure indicates that in contrast with vertical distance of reinforcements, increase in the length of reinforcing elements has no significant effect on the deformations caused by embanking. With comprising Figures 8 and 9, it can be concluded that with reducing vertical distance between reinforcements or in the other words with increasing the number of reinforcements, increase in their length has also higher effect on deformations' reduction. In continue, the axial rigidity of geo-grids has been reduced from 1500 to 1000 KN/m which the procedure of changes has been provided in Figure 10.

A Comparison between Figures 10 and 6 indicates that increasing the length of geo-grids has no significant effect on the horizontal deformations caused by embanking. The procedure was also observable in previous diagrams. In continue, the increasing procedure of geo-grids length up to 6.5 m and with 0.5 steps has been continued and the effects' procedure continue as like previous figures which have been provided as follow:

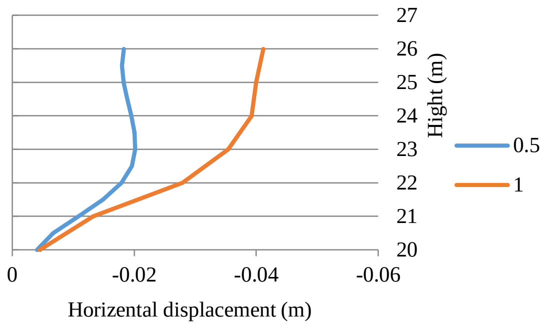



Figure 11. Horizontal deformation in the face of reinforced soil height with geo-grid length of 5.5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1500

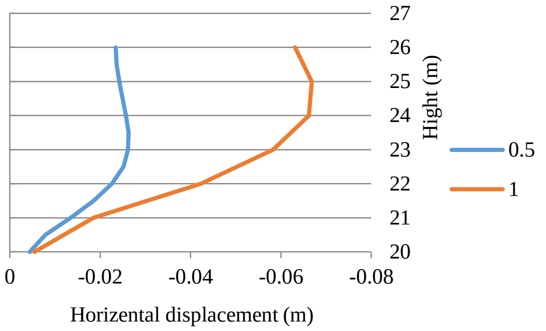



Figure 12. Horizontal deformation in the face of reinforced soil height with geo-grid length of 5.5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1000

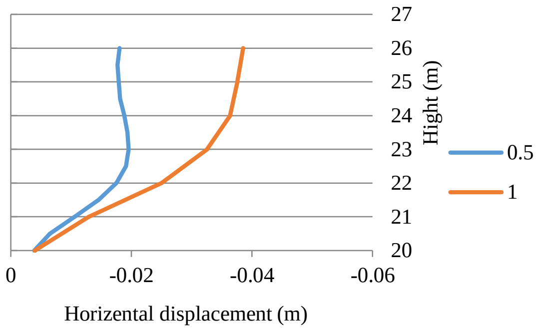



Figure 13. Horizontal deformation in the face of reinforced soil height with geo-grid length of 6 meter, vertical distance of 0.5 and 1, and axial stiffness is 1500

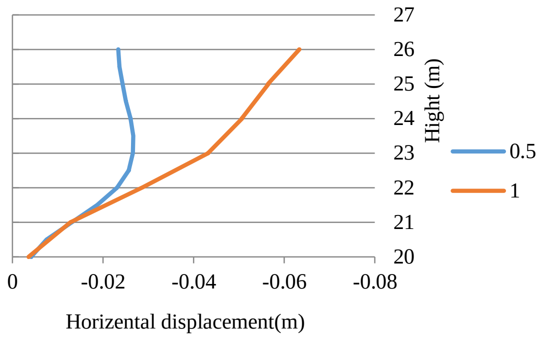



Figure 14. Horizontal deformation in the face of reinforced soil height with geo-grid length of 6 meter, vertical distance of 0.5 and 1, and axial stiffness is 1000

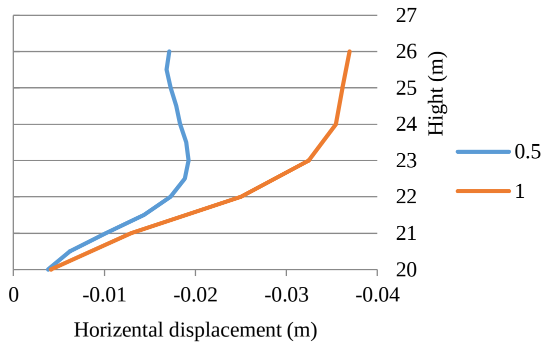



Figure 15. Horizontal deformation in the face of reinforced soil height with geo-grid length of 6.5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1500

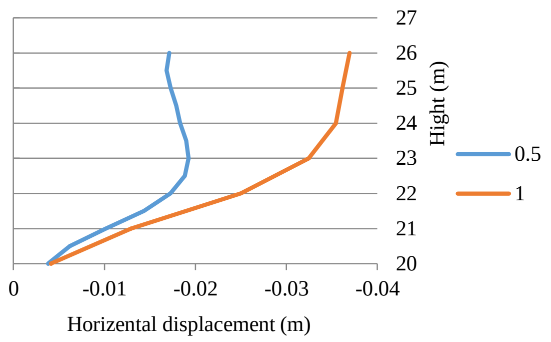



Figure 16. Horizontal deformation in the face of reinforced soil height with geo-grid length of 6.5 meter, vertical distance of 0.5 and 1, and axial stiffness is 1000

Following tables investigate the effect of increasing geo-grids length on horizontal deformations. As it can be seen from Table 6, increasing geo-grids length leads to a decrease in the horizontal deformations caused by reinforced embankment.

A comparison between Tables 6 and 7 indicates that the effect of increasing geo-grids length is higher in vertical distance of 0.5 m compare to the vertical distance of 1 m. The similar results in Tables 8 and 9 have been provided for *EA*=1000.

Table 6. The effects of geo-grids length on horizontal deformation

| Length of geo-grid | Axial stiffness (*EA*) | Geo-grid vertical distance | Horizontal deformation |
|---|---|---|---|
| 4.5 | 1500 | 0.5 | 0.022 |
| 5 | 1500 | 0.5 | 0.019 |
| 5.5 | 1500 | 0.5 | 0.0183 |
| 6 | 1500 | 0.5 | 0.018 |
| 6.5 | 1500 | 0.5 | 0.017 |

Table 7. The effects of geo-grids length on horizontal deformation

| Length of geo-grid | Axial stiffness (*EA*) | Geo-grid vertical distance | Horizontal deformation |
|---|---|---|---|
| 4.5 | 1500 | 1 | 0.040 |
| 5 | 1500 | 1 | 0.040 |
| 5.5 | 1500 | 1 | 0.0392 |
| 6 | 1500 | 1 | 0.038 |
| 6.5 | 1500 | 1 | 0.037 |

Table 8. The effects of geo-grids length on horizontal deformation

| Length of geo-grid | Axial stiffness (*EA*) | Geo-grid vertical distance | Horizontal deformation |
|---|---|---|---|
| 4.5 | 1000 | 0.5 | 0.030 |
| 5 | 1000 | 0.5 | 0.024 |
| 5.5 | 1000 | 0.5 | 0.023 |
| 6 | 1000 | 0.5 | 0.023 |
| 6.5 | 1000 | 0.5 | 0.022 |

Table 9. The effects of geo-grids length on horizontal deformation

| Length of geo-grid | Axial stiffness (*EA*) | Geo-grid vertical distance | Horizontal deformation |
|---|---|---|---|
| 4.5 | 1000 | 1 | 0.069 |
| 5 | 1000 | 1 | 0.068 |
| 5.5 | 1000 | 1 | 0.066 |
| 6 | 1000 | 1 | 0.063 |
| 6.5 | 1000 | 1 | 0.063 |

## IV. CONCLUSION

According to the results of modeling, the best state to use the minimum amount of geo-grid in proposed project conditions is equal to geo-grids with the length of 6.5 m, vertical distance of 1 m and axial rigidity equal to 1500 KN/m because according to the designing rules, the allowable deformation is equal to 0.5% to 0.7% of embankment height which can meet the needs of soil to be reinforced based on the output results and occurrence of no failure in the Software.

1. The horizontal deformation caused by embankment is significantly affected with increase in vertical distances between geo-grids.
2. Increase in the length of geo-grids also leads to decrease in the horizontal deformation caused by embankment, but it is not as effective as changes in vertical distances between geo-grids.
3. The maximum shear stress occurs in the heel of the embankment and around geo-grids.
4. The maximum deformation occurs in the crown of embankments but with increasing the number of geo-grids row, the maximum deformation occurs in the middle of embankment.
5. Increasing axial rigidity (*EA*) of geo-grids can effect on the reduction of horizontal deformations.
6. Increasing axial rigidity (*EA*) of geo-grids leads to increase in the axial forces applied on the geo-grids. The reason of this matter is that most of the rigidity of embankment system turned into geo-grids and as result, most of the loads caused by embanking are tolerated by geo-grids.
7. Increasing the length of geo-grids reduces the effect of geo-grids rigidity on horizontal deformations.

## REFERENCES

[1] A. Sanaeirad, M. Jalalvandi, "The Use of Genetic Algorithms in the Design of Reinforcement Length of Reinforce Soil Gables", Science and Research Journal of Amir Kabir, Tehran, Iran, Vol. 47, No. 3, pp. 53-60, 2015.

[2] Q. Andrew, "Experience on a Retaining Structure by Nailing", VIII Conference of I.C.S.M.F.E., Stockholm, Sweden, 1940.

[3] M. Ehrlich, S.H. Mirmoradi, R.P. Saramago, "Evaluation of the Effect of Compaction on the Behavior of Geosynthetic-Reinforced Soil Walls", Geotextiles and Geomembranes, Vol. 34, pp. 108-115, 2012.

[4] SH. Ferdousi, F. Moghadasnejad, E. Aflaki, "Numerical Investigation of the Stability of Reinforced Earthen Walls with Geosynthetic", Civil Engineering Journal of Ferdowsi University, Mashhad, Iran, Vol. 27, No. 1, pp. 171-188, 2014.

[5] V. Hanry, "On Stability on Loose Earth", Philosophic Transactions of Royal Society, London, Part I, pp. 2-27, 1963.

[6] A. Klar, T. Sas, "The KC Method: Numerical Investigation of a New Analysis Method for Reinforced Soil Walls", Journal of Computers and Geotechnics, Vol. 37, Issue 3, pp. 351-358, 2010.

[7] M.J. Shabani Ramnati, M.A. Roshan Zamir, A. Eslami Haghighat, "Evaluation of the Performance of Reinforced Soil Retaining Wall", Journal of Ferdowsi University, Mashhad, Iran, Vol. 16, No. 1, pp. 55-68, 2016.

**BIOGRAPHIES**

**Sadegh Choupani** was born in Miyaneh, Iran in 1980. He received B.Sc. degree in Civil Engineering from University of Urmia, Urmia, Iran in 2002 and M.Sc. degree in Geotechnical Engineering from University of Tabriz, Tabriz, Iran in 2006. Since 2009, he is working as a lecturer at Civil Engineering Department at Bostanabad Branch, Islamic Azad University, Bostanabad, Iran. He has more than 6 papers published in the main international conferences of the Civil Engineering area; Currently, He is on an experimental research entitled "Cement composites reinforced with recycled and industrial steel fibers: Compressive and flexural behavior" which is funded by Islamic Azad university of Bostanabad. His research activities are focused in Geotechnical Engineering, with main interest in experimental methods.

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