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Geogrid's Effect on Subsidence of Embankment Located on Cement and Lime Column Exist in Slope Soft Soil Layer

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ABSTRACT

The most important feature of soft soil is high and non-uniform subsidence because this type of soil has low shear strength. One way to prevent these subsidence is use of combining Geogrid with cement and lime columns. Geogrids due to their tensile strength and cement and lime column through bearing capacity and body friction, reduce subsidence of embankment. Recently wide researches has been done in the event of reducing and to uniform subsidence of embankment located on roads, but there are few studies for subsidence of embankment on slope soft soil layer. In this essay by using of Geogrid under embankment of road and above the cement and lime columns located in slope soft soil layers, try to reduce and uniform the subsidence of embankment. The realization of this issue cause reducing the subsidence and uniform the surface of embankment.

KEYWORDS: multilayer (oblique multilayer), Equalization, Geogrid, cement and lime column

1. INTRODUCTION

Soil reinforcement is one the effective and reliable ways to improve soil properties. Accession of polymer fibers such as: Geotextiles, Geogrid, Geomembrane, Geopipes and etc. made a big revolution in building of structure of reinforce soil. Geogrids are rigid or flexible sheet of plastic mesh which has numerous applications in civil engineering. Of Its use can show the reduction of subsidences of embankment located on soft soil. The most important problem of building the embankment of roads is high and non-uniform subsidences because of different layers of soil which exist under the embankment. Nowadays in order to solve these kinds of problems, there are different ways to improve the soil. One of these ways is combining Geogrid with some columns with different diameter, material and length which located in different distances under embankment. Geogrids with their tensile strength and columns by using of body friction cause reducing the subsidence of embankment. Resistance of long columns is more than short columns. For this reason, in high subsidence use long column and in low subsidence use short columns. These columns in addition to uniform the subsidence of embankment, bear the forces caused by loads of embankment and transportation through its bearing capacity and body friction and also cause integration of soil mass and increasing bearing capacity. Recently, many researches has been done on columns combining with embankment which are as follows: Chen [1] did many analyzes on severed columns with embankment. Liu et al. [2] and Chen et al. [3] did some experimentation on embankment combined with two types of columns. Zhuo et al. [4] did experiments on embankment combined with several materials. Zheng et al. [5] offered a way for lime-ashy column combined with embankment. Ian et al. [6] offered a systematic way for designing multiple combined column foundation. Hossain et al. [7] did numerical studies on improving soft soil by using of chemical candles under the embankment. Han et al. [8] did two-dimensional numerical modeling reinforced soil with Geogrid located above the deep columns. Liang et al. [9] did numerical and analyzes for foundation of combined buoyant columns with different types of candles. Asna-Ashari et al. [10] offered their studies on embankment combined with cement and lime column located on soft soil with slope layers. and also several three-dimensional limited and analyzes have been done on lime-ashy columns different diameters and lengths by Zheng et al. [11, 12]. Mousivand and Askari Ziarati [13] by using of cement and lime columns located under the embankment, reduce and uniform subsidence of embankment. Despite the numerous studies about embankment combined whit column, few studies has been done relating to combining Geogrid with cement and lime column combined with embankment on slope soft soil layers. In this essay by using of plaxis software, an embankment located on slope soil layer of part of Shahid Kalantari Urumieh-Tabriz Highway has been simulated. After analyzing, non-uniform subsidence observed. For reducing this subsidence formerly the writers of this essay by using of cement and lime column, reduce and uniform the subsidences of embankment. In this research tried to reduce and uniform subsidence of embankment by putting Geogrid under embankment and above cement and lime column.

2. MATERIALS AND METHODS

2-1. soil mass and boundary conditions

2-1-1. fig (2) shows soil profile and embankment relating to urumieh-Tabriz Shahid Kalantari highway(All dimensions are in meters).This highway is from urumieh to Tabriz and it crosses urumieh lake .part of the rood cross

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from western beach of lake on loose soil and lake sediments which usually consist of granules silty clay with low shear strength and high consolidation feature. Table (1) Features of soil and embankment, Table (2) Features of asphalt on the embankment, Table (3) shows features of Gegorid. On the left half asphalt entering 12 ($\frac{kn}{m^2}$) wide uniform load and on the right half 8 ($\frac{kn}{m^2}$). Also peculiarities of the points of the interests are shown in Table (4).

2-1-2. boundary condition for soil mass is the standard type. By applying these boundary conditions, the staddle of soil mass become articulated and the next staddles (left and right side) become a roller. By this action, soil can move vertically.

2-1-3. The surface of ground water is lower than bottom of the embankment; in other words the soil mass is unsaturated and the remaining soil is saturated.

2-1-4. The behavioural model of Moore column is complete elasto plastic behavioural model which has these 5 parameters : E,ν,ψ,ϕ,c . Also creep soft soil model in addition to ψ,ϕ,c parameters has also these three parameters M^*,λ^*,K^* which obtained through audiometer experiments.

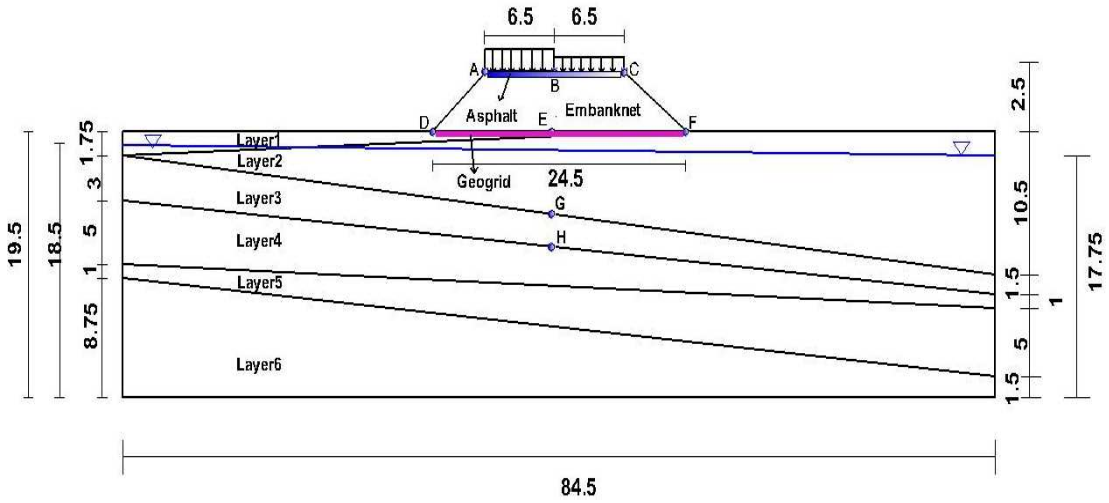

Fig. 1.Overview of soil and embankment

Table 1. Soil properties

Row	Parameter	Module	Embanknet	Layer1	Layer2	Layer3	Layer4	Liyer5	Liyer6
1	Soil name	-	-	CL	OL	CL	CL	OL	CL
2	Behavioural model	-	Mohr-coulomb	Creep soft soil	Creep soft soil	Creep soft soil	Creep soft soil	Creep soft soil	Creep soft soil
3	Conditions of draining	-	Drained	Undrained	Undrained	Undrained	Undrained	Undrained	Undrained
4	γ_{unsat}	$\frac{KN}{M^2}$	13	15.5	14.8	15.5	14.8	14.8	11.1
5	γ_{sat}	$\frac{KN}{M^2}$	11	17	17	16	16	17	15
6	K_x	$\frac{m}{day}$	1	3 E-5	3.5E-4	1E-4	1E-4	3.5E-4	3.09E-4
7	E	$\frac{KN}{M^2}$	5E4	-	-	-	-	-	-
8	ν	-	0.35	0.15	0.15	0.15	0.15	0.15	0.15
9	C	$\frac{KN}{M^2}$	1	20	5	20	20	5	20

10	$\emptyset$	Deg	34	35	30	30	30	30	35
11	ψ	Deg	0	0	0	0	0	0	0
12	λ^*	-	-	0.06	0.12	0.07	0.07	0.12	0.098
13	K^*	-	-	0.015	0.037	0.02	0.02	0.037	0.19
14	M^*	-	-	E2.5-3	3E-3	2.8E-3	2.8E-3	3E-3	3.3E-3

2-2. mesh

For meshing soil mass used 15 node element with two degrees of freedom and 5 node bar with three degrees of freedom considered for columns (2degrees translative and degree rotational). Also for meshing used medium mesh and for near the columns because of the importance of the issue, mesh is finer.

3. loading and calculating

It is assumed that the columns have been built in a day and also Geogrid be done in one day. Also consider embankment in 5 level and for each level two days for stabilization of soil. The consolidation lasts 4 years. They pave the upper surface of embankment again and according to paragraph (2-1-1)and loading will done within a day. At this stage, they consolidate the soil for 6.5 years. This consolidation continues until the water pressure became less than 1(kpa) Reaching low water pressure is the criterion of ending the consolidation.

2-2. columns

Columns in use have fixed diameter and mode with cement and lime and with liner elastic behavior according to table (5). Also figure (2) shows the location of the short and long columns. The arrengment of the columns is fixed unitl the end of the research and just the material of the column changes. In the left half of embankment used short column and in the right half of the embankment used long columns. For side of the embankment which has much subsidence (right side) used long column and for the other side (left side) used short columns.

Table5. Column Features

Row	Parameters	Module	Lime column	Cement column
1	Behavioural model	-	Linear elastic	Linear elastic
2	EA	$\frac{KN}{M}$	2520.5	1.26E4
3	EI	$\frac{KN.M^2}{M}$	26.47	132.35
4	d	m	0.355	0.355
5	ν	-	0.3	0.3
6	Length of column	m	The length of short column is 8.5 meter and the length of long column is 19.5 meters	
7	Distance of columns	m	The distance between short columns is 1.5 meter and the distance betwwen long columns is 2 meters	

Table2. Asphalt Features

Row	Parameter	Behavioural model	Module	Amount
1	EA	Liner Elastic	$\frac{KN}{m}$	0.35
2	EI		$\frac{KN.m^2}{m}$	0.35
3	d		m	3.464

Table3. features of Gegorid

Row	parameter	Behavioural model	Module	Amount
1	EA	Liner Elastic	$\frac{KN}{m}$	2500

Table4. The coordinates of point in model

Row	Point	X(m)	Y(m)
1	A	34.8	21.9
2	B	41	21.9
3	D	30	19.5
4	E	41	19.34
5	G	41	13.2
6	H	41.25	11.3

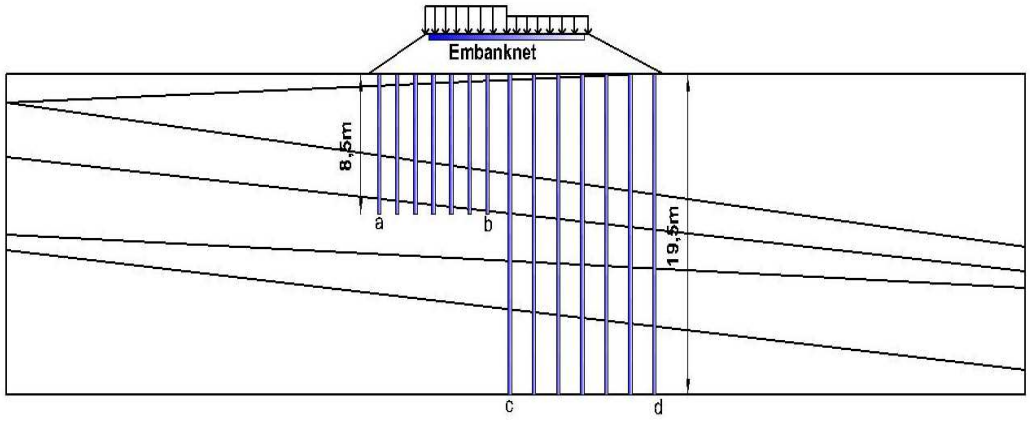

Fig. 2.Investing columns under embankment [13]

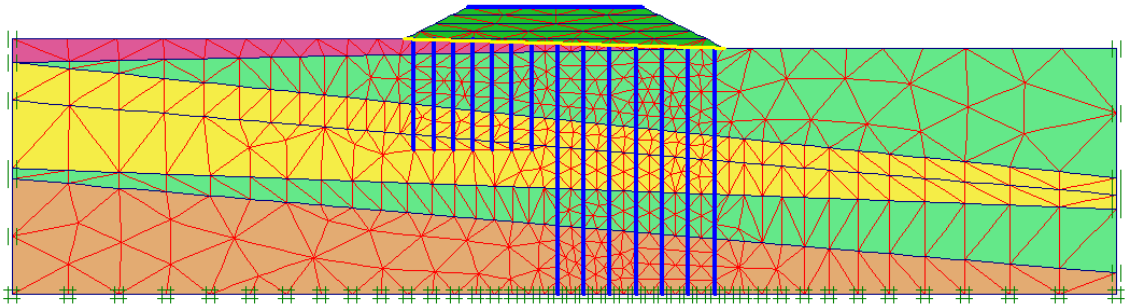

Fig. 3.Meshing the model

4. How to build model

In this research, modeling has been done by using of plaxis 8.2 finite element software. The mentioned software is two-dimensional and it is useful for projects which has plane strain condition. Because of the much length and consider the model as this research, can ignore the strain in long length and consider the model as a plane strain model. Table (6) shows the studies of this field. The considering abbreviations in order to ease of expression is in table (7).

Table 7. Abbreviations used in article

Row	Parameter	abbreviation
1	Cement column.	SC
2	Lime column.	LC
3	Result of embankment without column[13].	NC
4	The best result of using short and long cement columns[13].	Sc-pc
5	The best result of using short and long lime columns[13].	Sl-pl
6	The best result of combination of short and long cement and lime columns[13].	Sc-lc-pc
7	Combination Geogrid with embankment.	Nc-g
8	Combination of Geogrid with short and long cement columns.	Sc-pc-g
9	Combination of Geogrid with short and long lime columns.	Sl-pl-g
10	Combination of Geogrid with short and long cement and lime columns.	Sc-lc-pc-g
11	The distance betwwen short columns is 1.5(m) and the distance between long columns is 2(m).	L-d=1/5,R-d=2

Table 6.Specifications of studied models

Model number	1	2	3	4
Cases of investing columns	NC-g	Sc-pc-g	Sl-pl-g	Sc-lc-pc-g
Distance between columns	-	L-d=1/5,R-d=2	L-d=1/5,R-d=2	L-d=1/5,R-d=2

4. Analysis of results

Before offering any interpretation, suggests that the result of the analysis is relating to the consolidation (when water pressure become low).during this research which done by writers of this article ,putting columns under embankment with L-d=1.5,R-d=2(m)distance made of lime, cement and combination of cement and lime according to figure (2) is the best possibility to reduce the subsidence of embankment [13]. In this article, by putting Geogrid under embankment and above columns the result of the writers research will analyze.

5-1-Analisis of model (1):Analyzes of combination of Geogrid with embankment without column.

Figure (4) shows the amount of vertical subsidence cause reducing the subsidence in two cases of with Geogrid and without Geogrid. According to the figure using Geogrid cause reducing the subsidence.

5-2-Analysis model (2): Using the short and cement columns with Geogrid

We consider the distance between columns according to figure (2)as L-d=1.5,R-d=2(m).figure (5)shows the amount of vertical subsidence in two cases of Sc-pc and sc-pc-g. as in clear Gegorid with its tensile feature cause reducing the subsidence of embankment.

5-3-analysis model (3): Using the short and long lime columns with Geogrid

now we consider the distance between lime column according to the figure as L-d= 1.5 , R-d=2 (m).Figure (6) shows the amount of vertical subsidence in two cases of sl-pl and sl-pl-g.as is clear Geogrid reduces the subsidence of embankment

5-4-analysis of model (4):combination of Geogrid with cement and lime columns.

Figure (7) shows the combination of cement and lime columns with Geogrid. The distance between columns is L-d=1.5,R-d=2 (m).the gained results of sc-lc-pc and sc-lc-pc-g models are computed in figure (8).the results shows that Geogrid cause reducing the subsidence of embankment.

5-5-comparison of sc-pc-g,sl-pl-g and sc-lc-pc-g models

figure (9) compares sc-pc-g,sl-pl-g and sc-lc-pc-g . as is clear in figure the surface of embankment has less subsidence and much uniform subsidence in (sc-pc-g) the cement column with Geogrid model

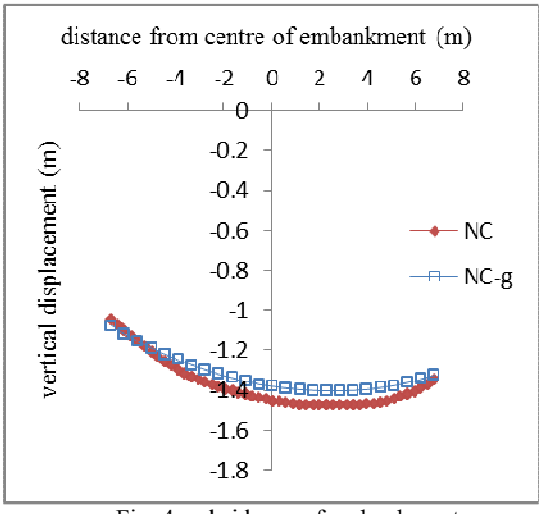

Fig. 4. subsidence of embankment

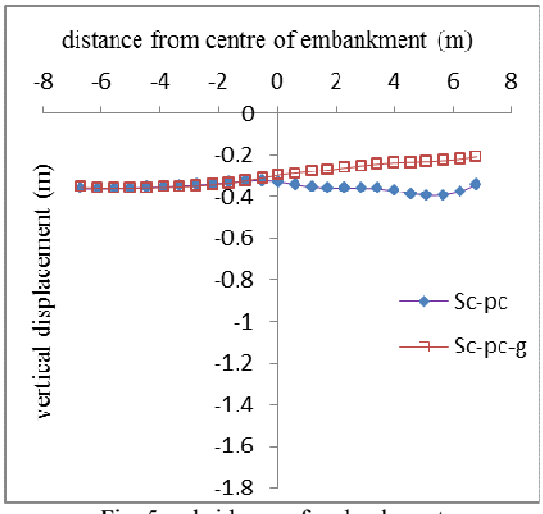

Fig. 5. subsidence of embankment

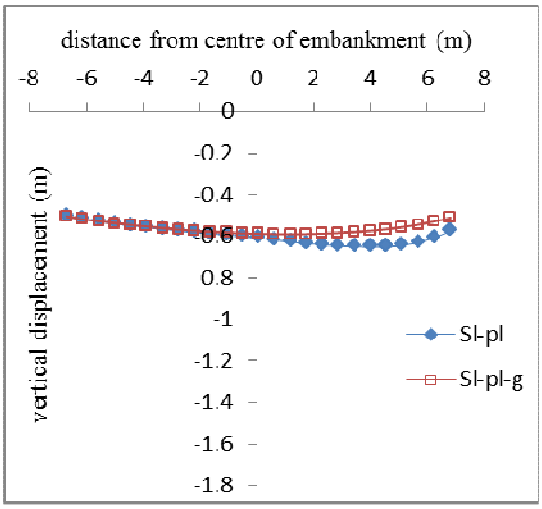

Fig. 6. subsidence of embankment with lime columns

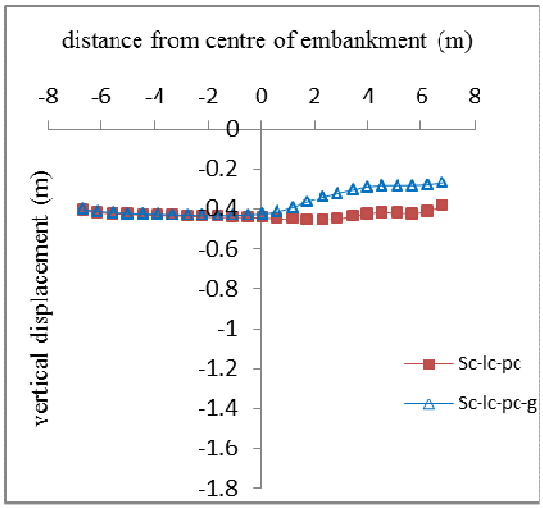

Fig. 8. subsidence of embankment with cement and lime columns

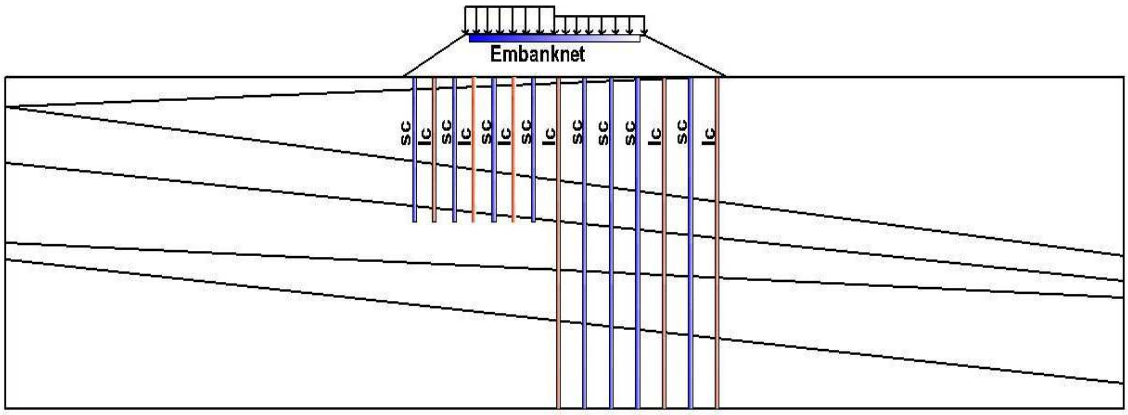

Fig. 7.Combination of cement and lime columns with L-d=1.5 , R-d=2 (m) distance

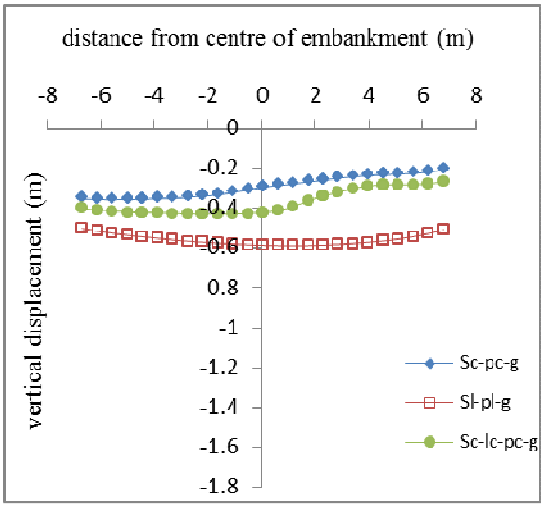

Fig. 9.Comparison of the best case of 3,2 and 4 models

5-6-changes of vertical subsidence against time.

For A,B,D,E,G,H points the vertical subsidence against tim chart for nc-g,sc-pc-g and SC-LC-PC-g according to figures (10,11,12,13,14,15) has been drawn. as is clear in the finger vertical shift in all mentioned points in nc-g model is more than other models. Lime columns has low bearing cement column is much.

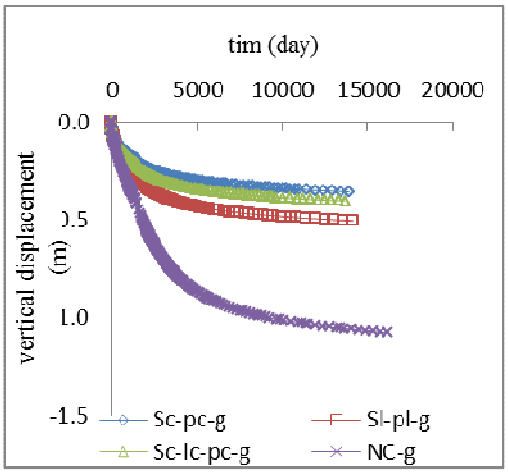

Fig. 10.Vertical displacement of point A

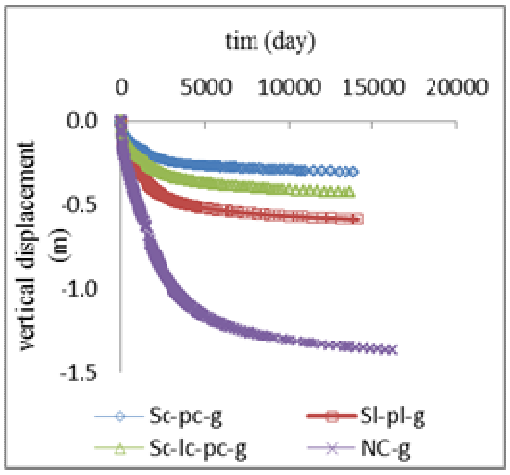

Fig. 11. Vertical displacement of point B

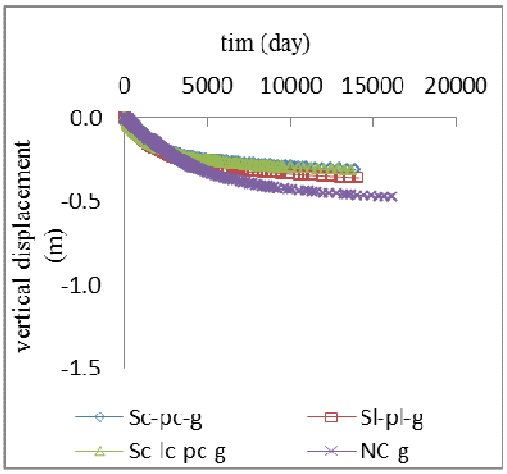

Fig. 12. Vertical displacement of point D

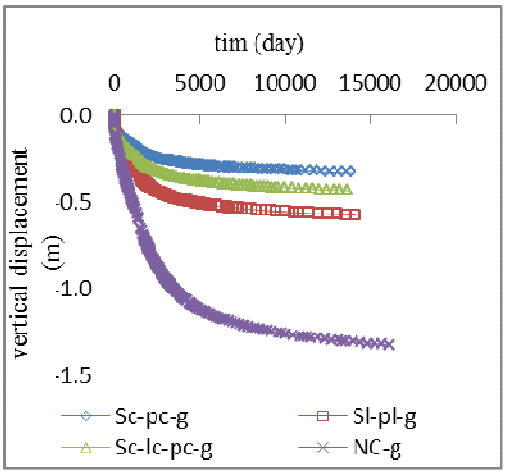

Fig. 13. Vertical displacement of point E

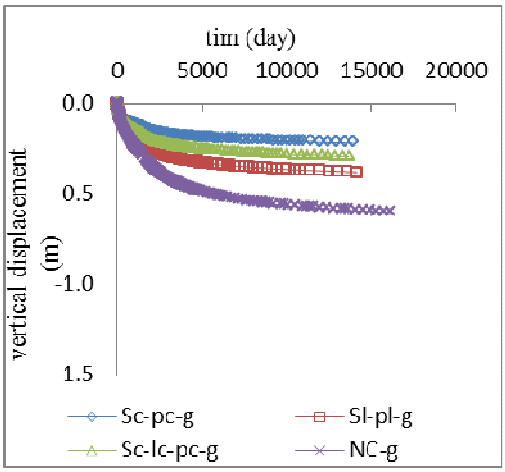

Fig. 14. Vertical displacement of point G

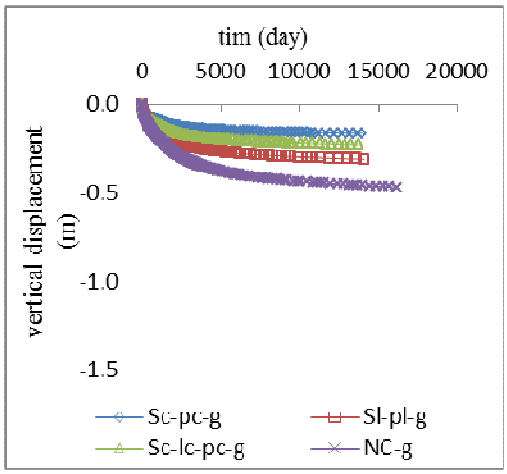

Fig. 15. Vertical displacement of point H

5-7-changes of hole water pressure against time

Figures (16,17) shows the changes of hole water pressure against time chart. As is clear hole water pressure in case of without column decrease later than other cases and in sc-pc-g case less time is necessary to reach the hole water pressure.

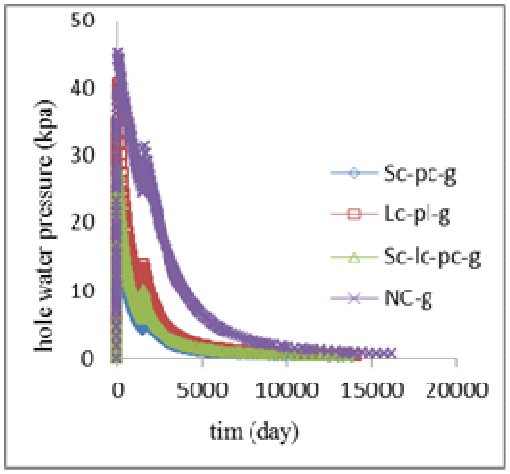

Fig. 16. The changes of hole water pressure in point G

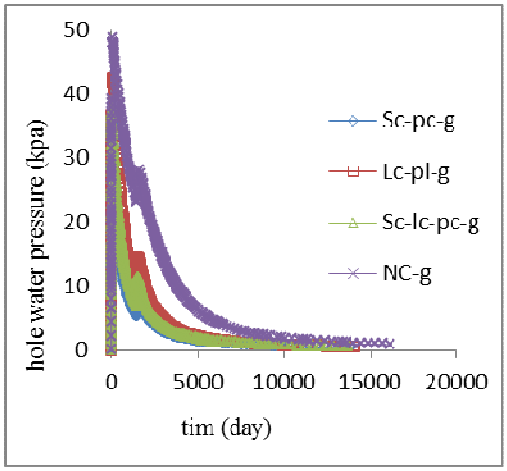

Fig. 17. The changes of hole water pressure in point H

6-CONCLUSION

Embankments crosses from the land which has many layers and ground water. the soil may be soft and has low bearing capacity and has high subsidence capability that should improve. One way of improving soil in this article is reinforcement of soil under embankment by combination of Geogrid with cement and lime columns. In fact, these columns

make structure in soil that cause reducing the subsidence and increasing bearing capacity and also Geogrid cause decrease in subsidence of embankment by its tensile feature. In this research, the effect of combination of Geogrid with cement and lime column in order to reduce and uniform subsidences of embankment located on slope soft soil layers relating to Shahid Kalantari Urumieh-Tabriz high way has been shown. Now summary of the results of this research described as follows:

A) Embankment without column but Geogrid (nc-g) has less subsidence embankment without column (nc), the most important reason is Feature of Geogrid.

B) In combination of georid with columns, the surface of embankment has less subsitence than case without Geogrid.

C) The surface subsidence of embankment in combination of Geogrid with cement columns is less than other models. Cement columns with their high bearing capacity and Geogrid with its tensile feature cause reducing and to uniform the subsidence

D) By analyzing the amount of subsidence different part of embankment which has column and Geogrid, against time can conclude that in the case without column ,the most time is necessary for consolidation and least time is relating to the case that just use cement column.

E) By comparing the hole water pressure in embankments which has Georid and column, can say that in case that embankment has not column the amount of hole water pressure decrease in much more time. Also in combination embankment which has cement and Geogrid, the least time is necessary to decrease the hole water pressure.

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