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Analysis of Geogrid Reinforced Embankment on Soft Clay

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Abstract: As the population of people in this country increasing, the number of road user also increasing. The road network plays a major role in the development of the country. Often these roads are constructed on weak structure of soil such as soft soil. Hence, this research study the geogrid as reinforcement on the road embankment. Use of geogrid for soil renforcement is advantageous because they are more efficient, cost-effective and reliable. The effect of geogrid on soil reinforcement were studied in this study.This is due to the problem related with the previous study cause from the weak embankment. This research aims to determine settlement value with analysis on different location of geogrid and Compare settlement value with previous data. A finite element simulation of a road embankment with geogrid was carried out using Plaxis 2D software in this study. The model was loaded with an axle load 0 kN and 100 kN. The geometry model of road embankment is 3 m height, 16 m wide, and slope inclination for both sides is 1V:2H. The axial stiffness, EA = 950 kN/m has been used in the model, type of geogrid used are coated woven geogrid and the number of the geogrid layers was taken 3 position which is bottom, middle and top of embankment using previous research data. From this simulation, it has been compared tested by using different Axial stiffnes, EA 950 kN/m with previous study 13.5 kN/m. Each Axial stifness was tested by using 0 kN and 100 kN loading. The result settlement value from 950 kN/m shown that the location of geogrid at bottom was minimize compare to using 13.5 kN/m at bottom eventough the loading use are 0 kN and 100 kN. It can concluded that the bottom location for reinforced geogrid is the best. Therefore, geogrid could be used to industry as a reinforcement materials to overcome the problems on road embankment.

Keywords: Soft Clay, Road Embankment, Geogrid, PLAXIS 2D

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1. Introduction

Lately, the Malaysian Department of Public Works (PWD) has been involved in several soft-soil highway schemes. Soft soil is generally classified as low shear strength, highly compressible and low permeability soil [1]. Although soft clay is part of soft soil, any building constructed on unstable soft clay properties will lead in the construction to the major issue. Among the critical variables that could contribute to a high settlement are the high compressibility properties of soft clay. The properties of soft clay, especially in water, have very fine particles and high cohesiveness. The lowest permeability attribute of soft clay is where water is difficult to get into its tiny fragments and has a high moisture content [2].

Nowadays, various alternatives are available to increase the strength, stiffness, and improve soil behaviour under various loading and environmental conditions. Geotextiles are the soil reinforcement most widely used in various civil and environmental engineering projects. It is because geotextiles are cost-effective and environment-friendly in soil reinforcement [3]. Besides, various previous studies used geotextile as reinforcement in soft soil embankment. While the geotextile layers increase the embankment stability by virtue of two primary functions, tensile reinforcement and a drainage element reduce pore pressures [4].

1.1 Objective

This research aims to determine settlement value with analysis on different location of geogrid and Compare settlement value with previous data.

1.2 Scope of the Study

A finite element simulation of a road embankment with geogrid was carried out using Plaxis 2D software in this study. The model was loaded with an axle load 0 kN and 100 kN. The geometry model of road embankment is 3 m height, 16 m wide, and slope inclination for both sides is 1V:2H [5]. The axial stiffness, EA = 950 kN/m has been used in the model, type of geogrid used are coated woven geogrid and the number of the geogrid layers was taken 3 position which is bottom, middle and top of embankment using previous research data.

2. Literature Review

2.1 Soft Clay

Soft clays were a type of fine-grained soils which change volume when different from elastic deformation, consolidation and secondary compression[6]. Besides, soft clay also defined as soils with large fractions of fine particles such as silty and clayey soils, which have high moisture content, peat foundations and loose sand deposits, located near or under the water table [7].

2.2 Geogrid

Generally, geogrids are manufactured from polymers like polypropylene, polyethylene or polyester. The strength of geogrids primarily depends on the material from which they are manufactured. Most commonly, high-density polypropylene geogrids of desired shape and structure are used in the structural application. The grid formation is made by punching holes in the required pattern. Those holes are called as apertures. In the process of knitting or weaving, polyethylene or polyester materials are used to form flexible geogrids.

In this study, type of geogrid that was used are coated woven geogrid. In this category used 200 high tenacity polyester filament and contained them in very different compositions. They were fabricated in to grid structure by melt bonding the overlapping sheets together. Figure 1 shows the example of p coated woven geogrid that being used in this research.

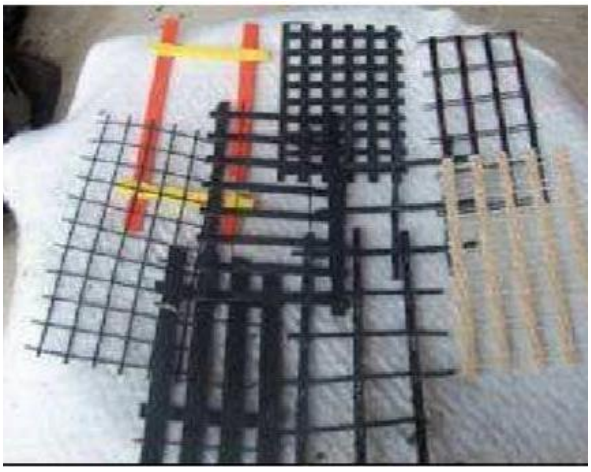

Figure 1: Coated woven of geogrids [7]

3. Methodology

In this research, Plaxis 2D are used to analyze the effects of settlement value with the presence of geogrid on road embankment with using previous data.

3.1 Geometry Model

Position of geogrid reinforcement have three different location. The first position at the bottom Y1= 0.0m from embankment, second position is at middle Y2= 1.500 m and third at the bottom Y3= 2.625 m. Aim for have three different location is about to identify value settlement based on different location. Each geogrid has same Axial stffness, EA value 950 kN/m in Figure 2.

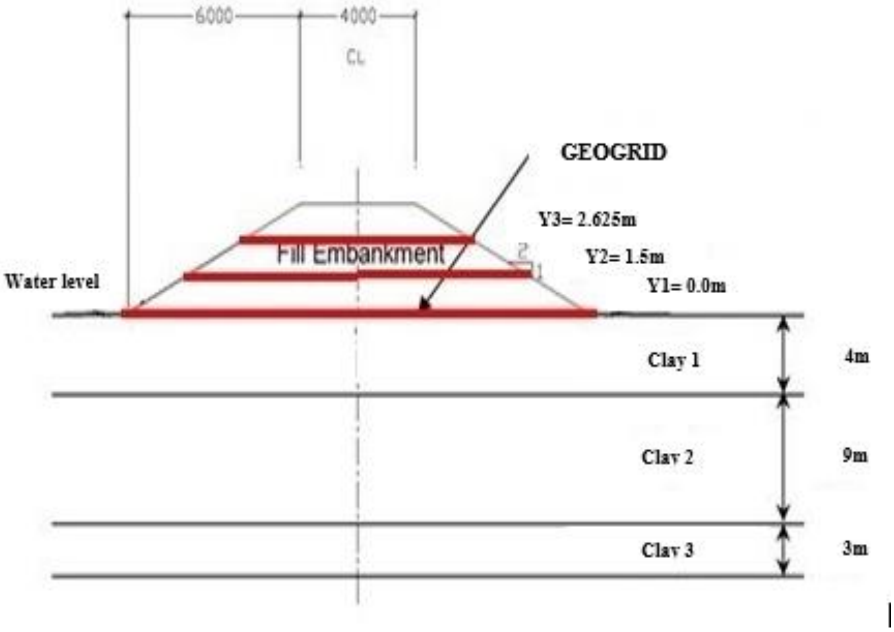

Figure 2: Geometry model

The material involved in this studied are fill embankment, clay 1, clay 2, clay 3, and woven geotextile. The fill embankment has been modelled using the Mohr-Coulomb model. The fill material is set for drained and for the foundation layer, it set by undrained behaviour. Other three layer of foundation; clay 1, clay 2, and clay 3 were modelled with the Soft Soil Creep model (SSC) provided by Plaxis 2D software as per shown in Table 1.

Table 1: Soil properties of road embankment

Parameter	Name	Backfill	Clay 1	Clay 2	Clay 3	Unit
General [5]						
Model	-	Mohr-Coulomb	Soft-Soil Creep	Soft-Soil Creep	Soft-Soil Creep	-
Drainage type	-	Drained	Undrained (B)	Undrained (B)	Undrained (B)	-
Dry unit weight	y_{unsat}	16.0	15.0	15.5	15.0	kN/m^3
Bulk unit weight	y_{sat}	18.5	17.5	17.5	18.0	kN/m^3
Parameters						
Modified compression index [5]	λ*	-	0.09	0.055	0.04	-
Modified swelling index [5]	k*	-	0.037	0.025	0.015	-
Friction angle [5]	φ’	25	20	18	30	°
Modified creep modulus [5]	μ*	-	2.14×10^{-4}	2.40×10^{-4}	1.00×10^{-3}	-
Cohesion [5]	c’	8	5	2	15	kN/m^2
Poisson ratio [5]	v’	0.38	-	-	-	-
Dilatancy cut-off [8]	-	No	No	No	No	-
Void ratio [8]	e_{init}	0.5	0.5	0.5	0.5	-
Young Modulus [5]	E	8500	-	-	-	kN/m^2
Undrained behaviour [8]	-	Standard	Standard	Standard	Standard	-

Table 2 shows the data for the parameter for reinforced material that being inserted in the Plaxis 2D.

Table 2: Parameter for reinforced materials

Material	Model Type	EA (kN/m)
Coated Woven Geogrid [7]	Geogrids [7]	950 [7]

3.2 Model Analysis

Based on the Table 3, there are many various that have been used in this research. Loading used for prediction test are 0 kN and 100 kN. The position of geogrid have three which is at the bottom Y1=0 m of embankment, middle Y2=1.500 m and top Y3=2.625 m of the embankment as per shown in Figure 2. This position was added from the journal field data because it used for bottom position only. This test was used to predict the best position of geogrid to put for reduce the settlement of embankment. Phase for this simulation are have eight phase. Interval height are 0.375 for each phase because average from the height 3 m. This average was used modified from the journal field data. The modelling was applied fine meshes, and the construction phase applied based on previous research data [5].

Table 3: Construction phase of the embankment [5]

Phase	Description	Thickness (m)	Duration (Days)
1	First layer	0.0 – 0.375	1
2	Second	0.375 – 0.750	6
3	Third	0.750 – 1.125	1
4	Fourth	1.125 – 1.5	1
5	Fifth	1.5 – 1.875	1
6	Sixth	1.875 – 2.25	3
7	Seventh	2.25 – 2.625	3
8	Eighth	2.625 – 3.00	1
9	Consolidation	-	401
10	Loading	-	1

4. Results and Discussion

4.1 Result settlement for loading 0 kN

Figure 3 shows the result of journal field which has been tested using Plaxis 2D [5]. The axial stiffness, EA from the journal are 13.5 kN/m and no load that applied, the first test started by no using geogrid which is unreinforced (UR) get the value of settlement are -0.579. Next, the result of settlement when geogrid was put at the bottom of embankment y= 0 mm are -1.099.

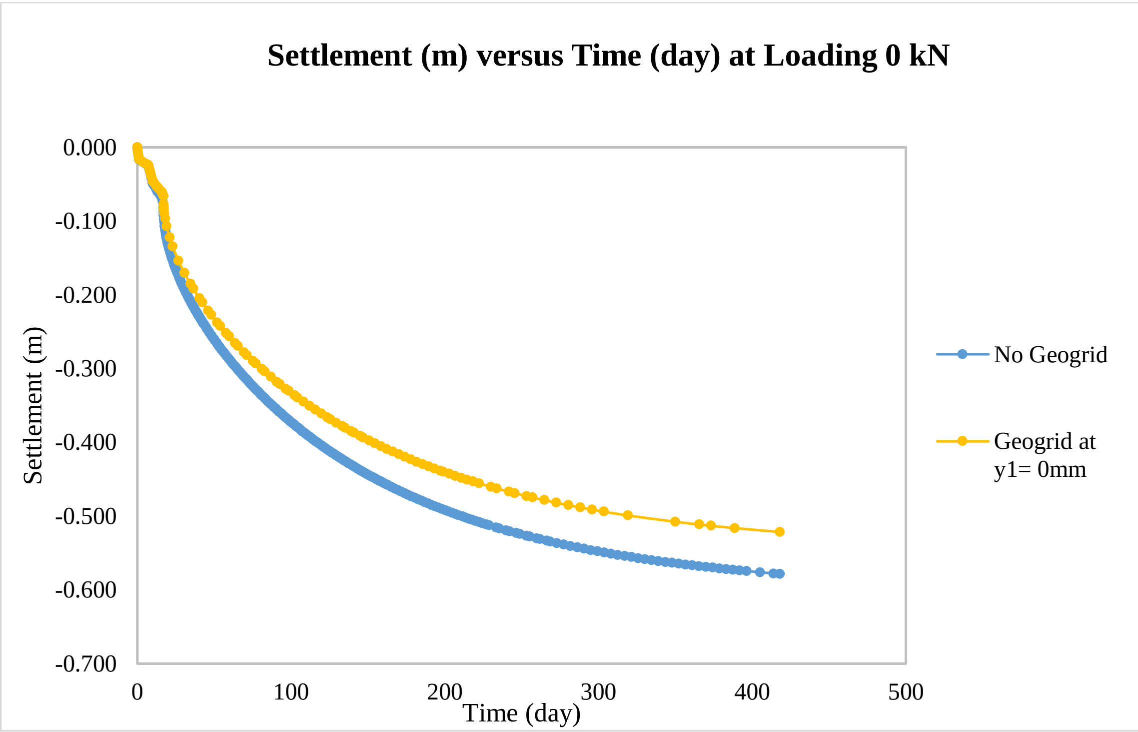

Figure 3: journal field data of loading 0 kN [5]

Figure 4 shows the result of prediction data which has been tested using Plaxis 2D. The axial stiffnes, EA that use are 950 kN/m and no load that applied, the first test started by no using geogrid which is unreinforced (UR) get the value of settlement are -0.581 m. Next, the result of settlement when geogrid was put at the bottom of embankment y= 0 m are -1.099. Position of geogrid was change to the middle y= 1.500 mm and get settlement value -0.578 m. Last, geogrid was put at the top y=2.625 m and get the settlement value -0.581m.

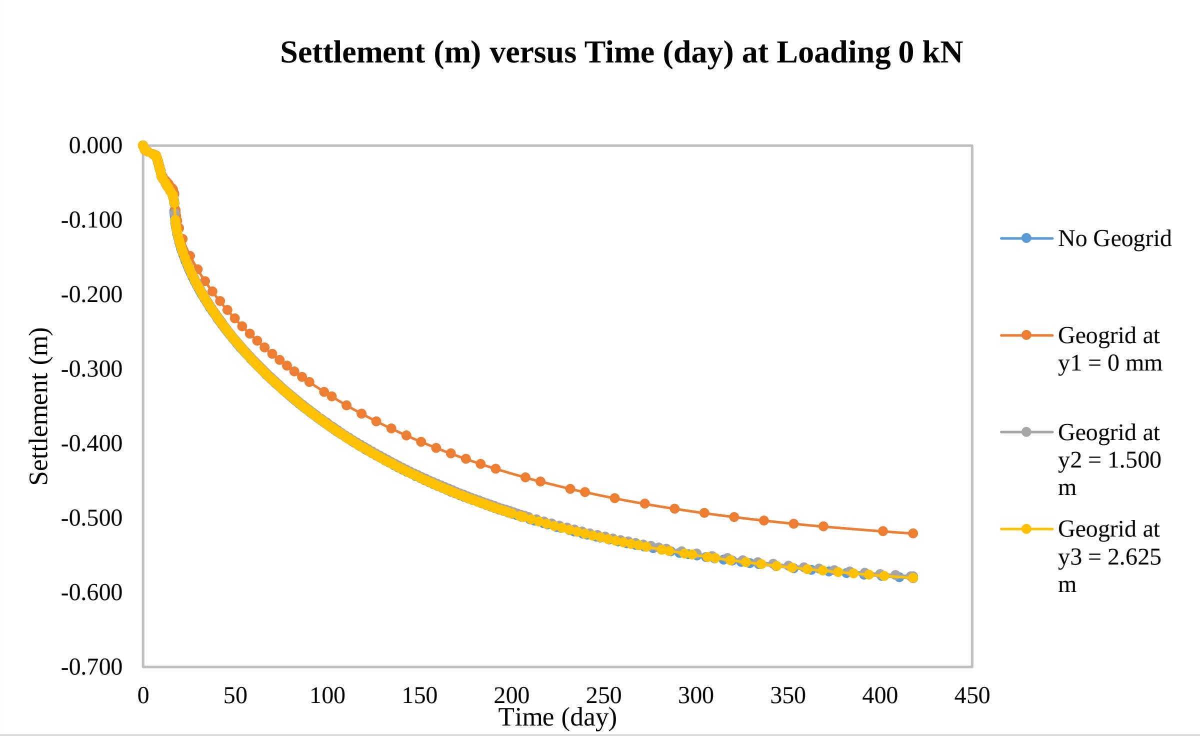

Figure 4: prediction result of loading 0 kN

4.2 Result settlement for loading 100 kN

Figure 5 shows the result of journal field which has been tested using Plaxis 2D [5]. The axial stiffnes, EA from the journal are 13.5 kN/m and 100kN load that applied, the first test started by no using geogrid which is unreinforced (UR) get the value of settlement are -1.099. Next, the result of settlement when geogrid was put at the bottom of embankment y= 0 mm are -1.097.

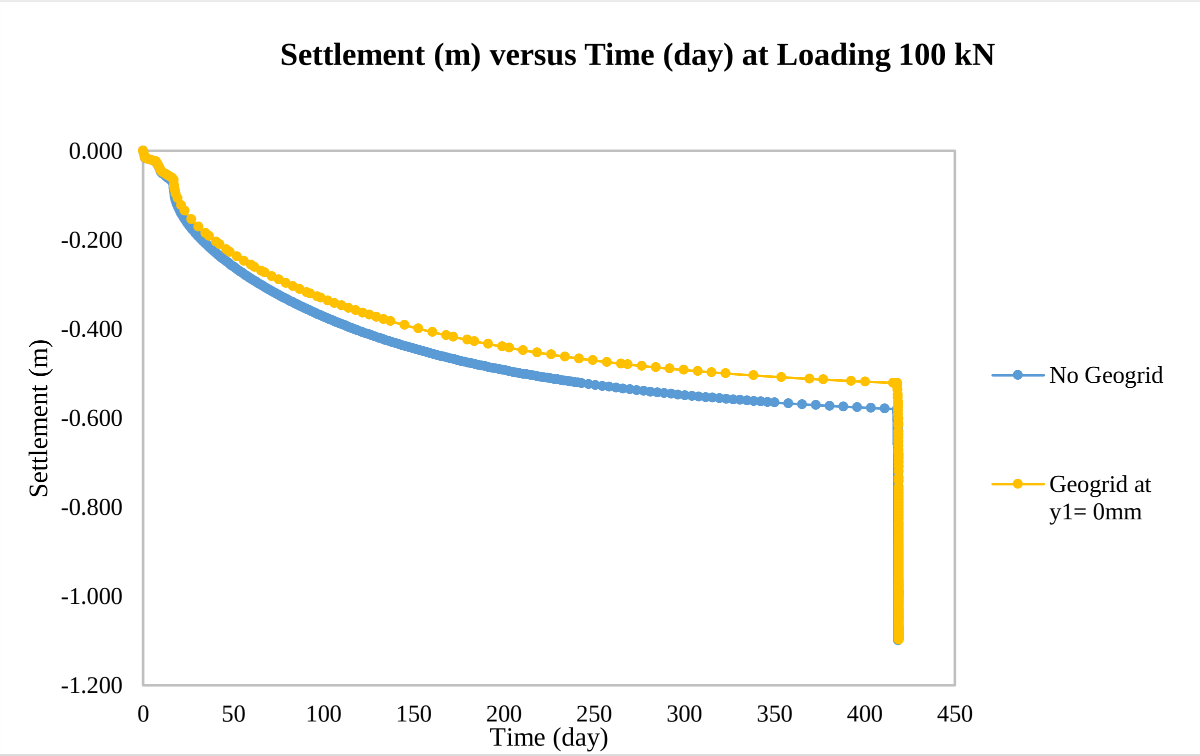

Figure 5: journal field data of loading 100 kN [5]

Figure 6 shows the result of prediction data which has been tested using Plaxis 2D. The axial stiffnes, EA that use are 950 kN/m and 100 kN load that applied, the first test started by no using geogrid which is unreinforced (UR) get the value of settlement are -1.132 m. Next, the result of settlement when geogrid was put at the bottom of embankment y1= 0.000 m are -1.096 m. Position of geogrid was change to the middle y2= 1.500 m and get settlement value -1.378m. Last, geogrid was put at the top y3=2.625 m and get the settlement value -1.581 m.

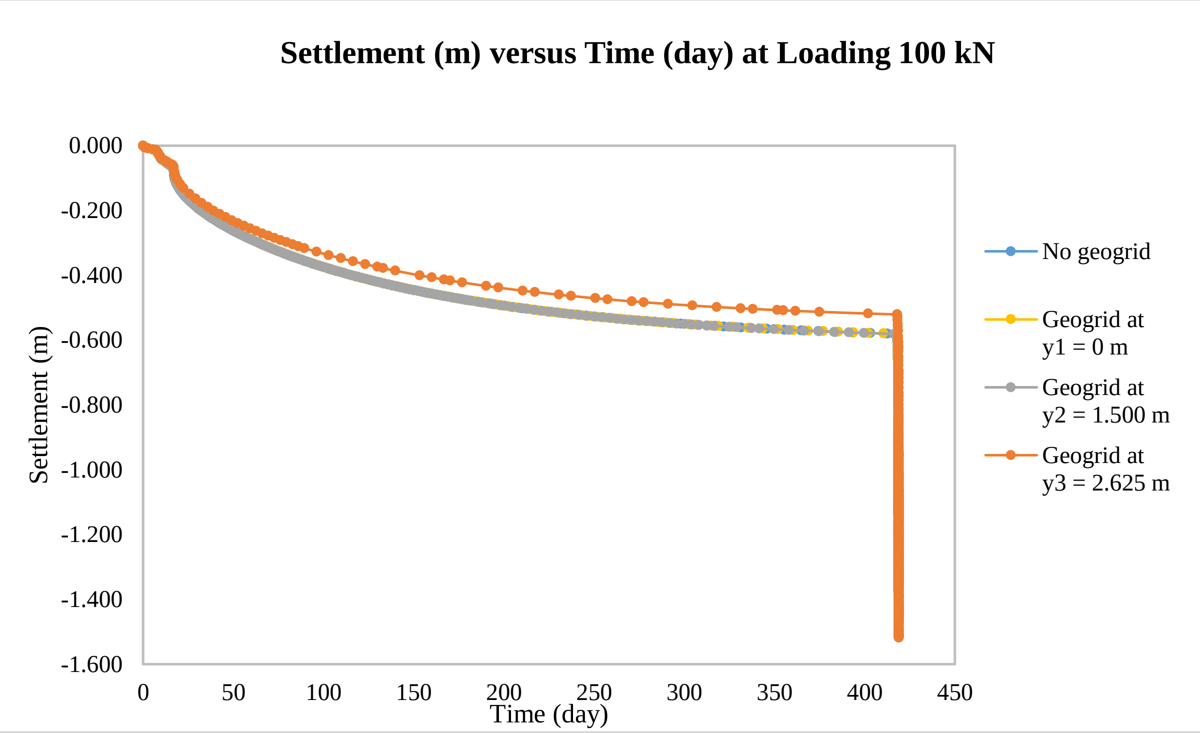

Figure 6 shows the prediction data of loading 100 kN

Table 4: Summary of the settlement embankment based on different loading

Loading (kN)	Prediction (EA = 950 kN/m)				Journal Paper [5] (EA = 13.5 kN/m)	
	No Geogrid	Geogrid at y1 = 0 mm	Geogrid at y2 = 1.500 m	Geogrid at y3 = 2.625 m	No Geogrid	Geogrid at y1 = 0 mm
0	-0.581	-0.521	-0.578	-0.581	-0.579	-0.521
100	-1.132	-1.096	-1.378	-1.581	-1.099	-1.097

The test was conduct by the different location of geogrid. This result was compred from the previous paper [5]. The maximum settlement value for 0 kN loading are at the y3= 2.625 m from bottom of embankment for prediction data which is -0.581 m. The maximum settlement value for 100 kN loading are at the y3= 2.625 m from the bottom of embankment are -1.581 kN loading. From the maximum value, it shows that is the worst position of location geogrid are top y3=2.625 m. The minimum settlement value 0kN loading are at the y1=0 m are -0.521 m. The minimum settlement value for 100 kN loading are at the y1=0 m are -1.096. From the minimum value, it shows the best location of geogrid are at bottom y1=0 m.

5. Conclusion

From this simulation, it has been compared tested by using different Axial stiffnes, EA 950 kN/m with previous study 13.5 kN/m. Each Axial stifness was tested by using 0 kN and 100 kN loading. The result settlement value from 950 kN/m shown that the location of geogrid at bottom was minimize compare to using 13.5 kN/m at bottom eventough the loading use are 0 kN and 100 kN. It can concluded that the bottom location for reinforced geogrid is the best.

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