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Analysis of Engineering Interventions on Various Soil Combinations using PLAXIS-2D

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Abstract: Slope Stability is a fundamental concept in geotechnical engineering as it plays an important role in the safety and sustainability of civil infrastructures. Rapidly increasing population and the demand of urbanization has made it necessary to utilize all the available area in different terrains. This makes it necessary to study the stability of slopes. The objective of this study is to analyse the stability of slopes with different soil combinations. It also sheds light on the changes in the displacement values when we use engineering methods, retaining wall, Diaphragm wall & anchors and geotextile. This study also shows the changes when loading conditions are applied on the soil combinations. To carry out this research we are using PLAXIS 2D, a finite element analysis software.
Keywords: PLAXIS 2D, Slope, Stability, Displacement, Soil, Geotextile, Anchors.

I. INTRODUCTION

Slope Stability in the simplest terms refers to the capacity of a slope, natural or man-made, to resist deformation. A previously stable slope can also become unstable due to various reasons. Some factors that could potentially be the reason for instability of slopes are increased loading or lateral pressure, weathering or any changes in pore water pressure. For the safety and long-term viability of civil infrastructure, the stability of slopes is very crucial. Slope failures can cause minor as well as severe accidents which can lead to human as well as environmental safety risks. This work focuses on the analysis of slope stability of various soil combinations with various engineering methods and loading conditions with the help of PLAXIS 2D, a finite element analysis software.

II. OBJECTIVE

1) The objective of this study is to analyze the total maximum displacement of various soil combinations using PLAXIS 2D.
2) To study the displacement when retaining wall, diaphragm wall & anchors and geotextile are used.
3) To study the displacement when loading conditions are applied.

III. LIST OF CASES

The list of cases used for this study is given below:

1) Case 1: Loam (Upper Layer) + Sand (Lower Layer)
2) Case 2: Loam (Upper Layer) + Clay (Lower Layer)
3) Case 3: Peat (Upper Layer) + Loam (Lower Layer)
4) Case 4: Peat (Upper Layer) + Clay (Middle Layer) + Clay (Lower Layer)
5) Case 5: Loam (Upper Layer) + Sand (Middle Layer) + Clay (Lower Layer)
6) Case 6: Sand (Upper Layer) + Peat (Middle Layer) + Clay (Lower Layer)

IV. METHODOLOGY

The project work is divided into two sections with all six cases under each section.

Section 1: For the first part, we have the different soil combinations as listed in the list of cases. All the cases are in drained condition. They are analysed using the PLAXIS 2D software and the total maximum displacement is recorded for each case. Then we apply retaining wall, diaphragm wall & anchors and geotextile to compute the displacement values once more, individually. Comparison is then made among all three values.

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Section 2: In the second part, the soil combinations are analysed under loading conditions. The load value taken in this study is 10kN/m. Again, retaining wall, diaphragm wall & anchors and geotextile are applied on the soil combinations under varying loading conditions. The recorded values of total displacement can then be compared.

V. PLAXIS 2D ANALYSIS

Case 1: Loam (Upper Layer) + Sand (Lower Layer)

Section 1:

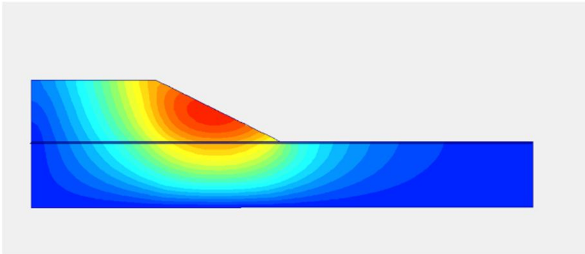

Figure 1: Total max displacement (Without Load)

Total Maximum Displacement = 4.93 x 10^{-3}m

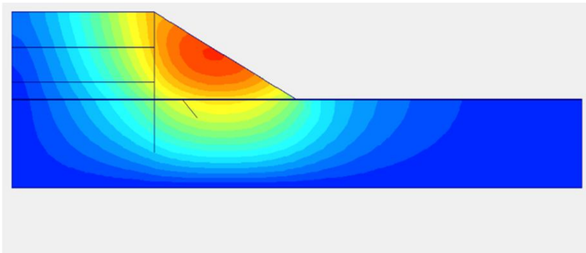

Figure 2: Total max displacement with retaining wall (Without Load)

Total Maximum Displacement = 4.53 x 10^{-3}m

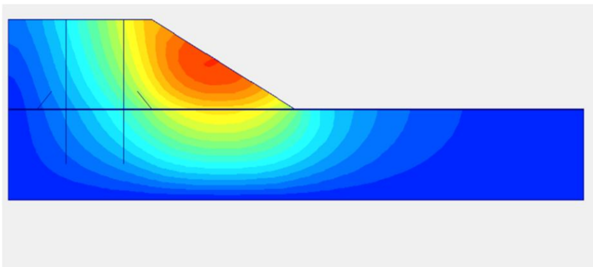

Figure 3: Total max displacement with Diaphragm wall & anchors (Without Load)

Total Maximum Displacement = 4.51 x 10^{-3}m

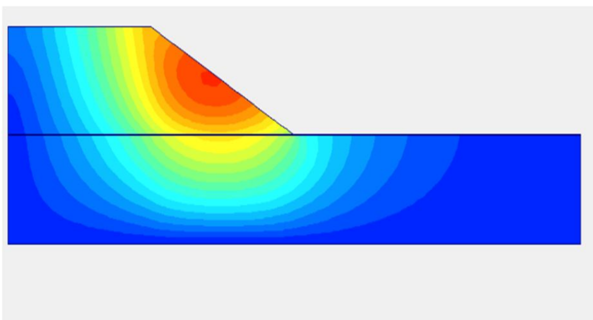

Figure 4: Total max displacement with Geotextile (Without Load)

Total Maximum Displacement = 4.53 x 10^{-3}m

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Figure 1 shows the total displacement when we have Loam in upper layer and Sand in the lower layer. Then, Figure 2, Figure 3 and Figure 4 show the displacement when we employ the engineering methods retaining wall, diaphragm wall & anchors and geotextile, respectively.

When we calculate the percentage difference between the total maximum displacement values before and after using engineering methods, it comes out to be 8.11%, 8.52 and 8.11% respectively.

Section 2:

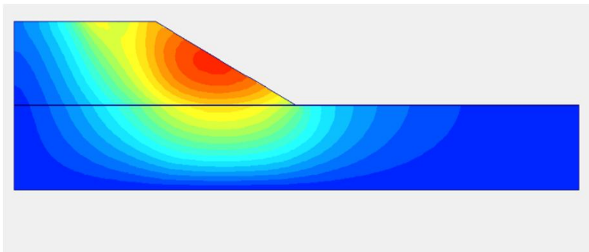

Figure 5: Total max displacement (With Load)

Total Maximum Displacement = 4.60 x 10^{-3}m

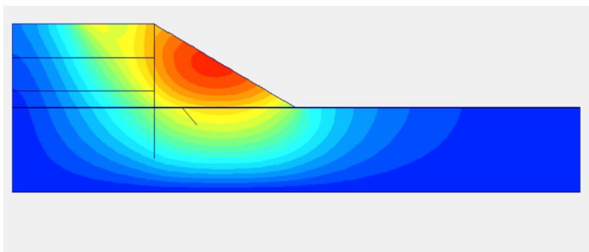

Figure 6: Total max displacement with retaining wall (With Load)

Total Maximum Displacement = 4.36 x 10^{-3}m

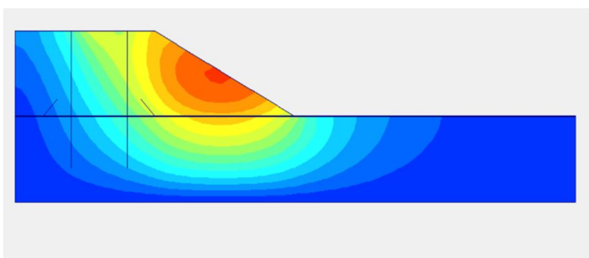

Figure 7: Total max displacement with Diaphragm wall & anchors (Without Load)

Total Maximum Displacement = 4.42 x 10^{-3}m

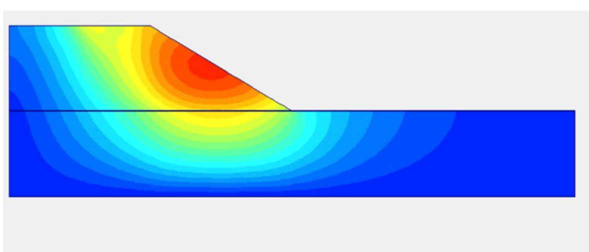

Figure 8: Total max displacement with retaining wall (With Load)

Total Maximum Displacement = 4.46 x 10^{-3}m

Figure 5 shows the total displacement when the soil combination in case 1 is put under a load of 10kN/m. Then Figure 6, Figure 7 and figure 8 show the total displacement after employing methods retaining wall, diaphragm wall & anchors and geotextile, respectively.

When we calculate the percentage difference between the total maximum displacement values before and after using engineering methods, it comes out to be 5.21%, 3.91% and 3.04% respectively.

Similarly, we carried out the procedure for the rest of 5 cases and noted the values.

VI. RESULTS AND DISCUSSION

Section 1:

Table 1: Total Max displacement without load

Cases	Total max Dis.	Total max displacement with engineering methods ($x10^{-3}$ m)		
	($x 10^{-3}$ m)	Retaining wall	Diaphragm wall and anchors	Geotextile
Case 1	4.93	4.53	4.51	4.53
Case 2	11.75	10.91	11.23	11.06
Case 3	46.61	46.53	46.36	46.60
Case 4	16.09	15.79	15.66	14.67
Case 5	14.17	13.78	13.65	13.91
Case 6	85.87	84.98	83.01	84.25

Table 2: Percentage change in Total Max displacement without load

Cases	Percentage change in total max displacement (%)		
	Retaining wall	Diaphragm wall and anchors	Geotextile
Case 1	8.11	8.52	8.11
Case 2	7.14	4.42	5.87
Case 3	0.17	0.54	0.021
Case 4	1.86	2.67	8.82
Case 5	2.75	3.66	1.83
Case 6	1.03	3.33	1.88

We can see from the values given in the Table 1 and Table 2 that, after using retaining wall, diaphragm wall & anchors and geotextile, the total maximum displacement for all the cases has decreased. Case 1 (Loam in upper layer and Sand in lower layer) has the highest percentage change. Using retaining wall, diaphragm wall & anchors and geotextile changes the displacement by 8.11%, 8.52% and 8.11% respectively.

Case 3 (Peat in upper layer and Loam in lower layer) has the lowest percentage change. Using Retaining wall, diaphragm wall & anchors and geotextile changes the displacement by 0.17%, 0.54% and 0.012% respectively.

Section 2:

Table 3: Total Max displacement with 10kN/m load

Cases	Total max Dis.	Total max displacement with engineering methods ($x10^{-3}$ m)		
	($x 10^{-3}$ m)	Retaining wall	Diaphragm wall and anchors	Geotextile
Case 1	4.60	4.36	4.42	4.46

Case 2	54.52	53.22	52.87	51.39
Case 3	53.99	53.65	53.84	53.97
Case 4	22.32	20.73	21.03	20.78
Case 5	14.31	14.11	13.19	13.96
Case 6	121.22	118.4	112.89	115.95

Table 4: Percentage change in Total Max displacement with 10kN/m load

Cases	Percentage change in total max displacement (%)		
	Retaining wall	Diaphragm wall and anchors	Geotextile
Case 1	5.21	3.91	3.04
Case 2	2.38	3.02	5.74
Case 3	0.63	0.278	0.03
Case 4	7.12	5.77	6.89
Case 5	1.39	8.15	2.44
Case 6	2.32	7.12	4.34

From Table 3 and Table 4 we can see that even with a load of 10kN/m, after using retaining wall, diaphragm wall & anchors and geotextile, the total maximum displacement for all the cases has decreased. Case 4 (Peat in upper layer, clay in middle layer and clay in lower layer) has the highest percentage. Using retaining wall, diaphragm wall & anchors and geotextile changes the displacement by 7.12%, 5.77% and 6.89% respectively.

Again, Case 3 (Peat in Upper layer and Loam in lower layer) has the lowest percentage change. Using retaining wall, diaphragm wall & anchors and geotextile changes the displacement by 0.63%, 0.278% and 0.03% respectively.

VII. CONCLUSION

All the conclusions derived based on the analysis of various soil combinations is summarized below:

1) A total of six cases with different soil combinations in upper, middle and lower layer were analyzed to find the total maximum displacement.
2) When no load was applied, Case 1 has the highest percentage change in total maximum displacement. It means that the displacement for this soil combination has decreased and the stability has increased while using engineering methods.
3) When a load of 10kN/m was applied, Case 4 has the highest percentage change in total maximum displacement. It means the displacement has decreased and stability has increased with the application of engineering methods.
4) Use of engineering methods to increase the stability of any slope can be very beneficial as it can help decrease the total maximum displacement.

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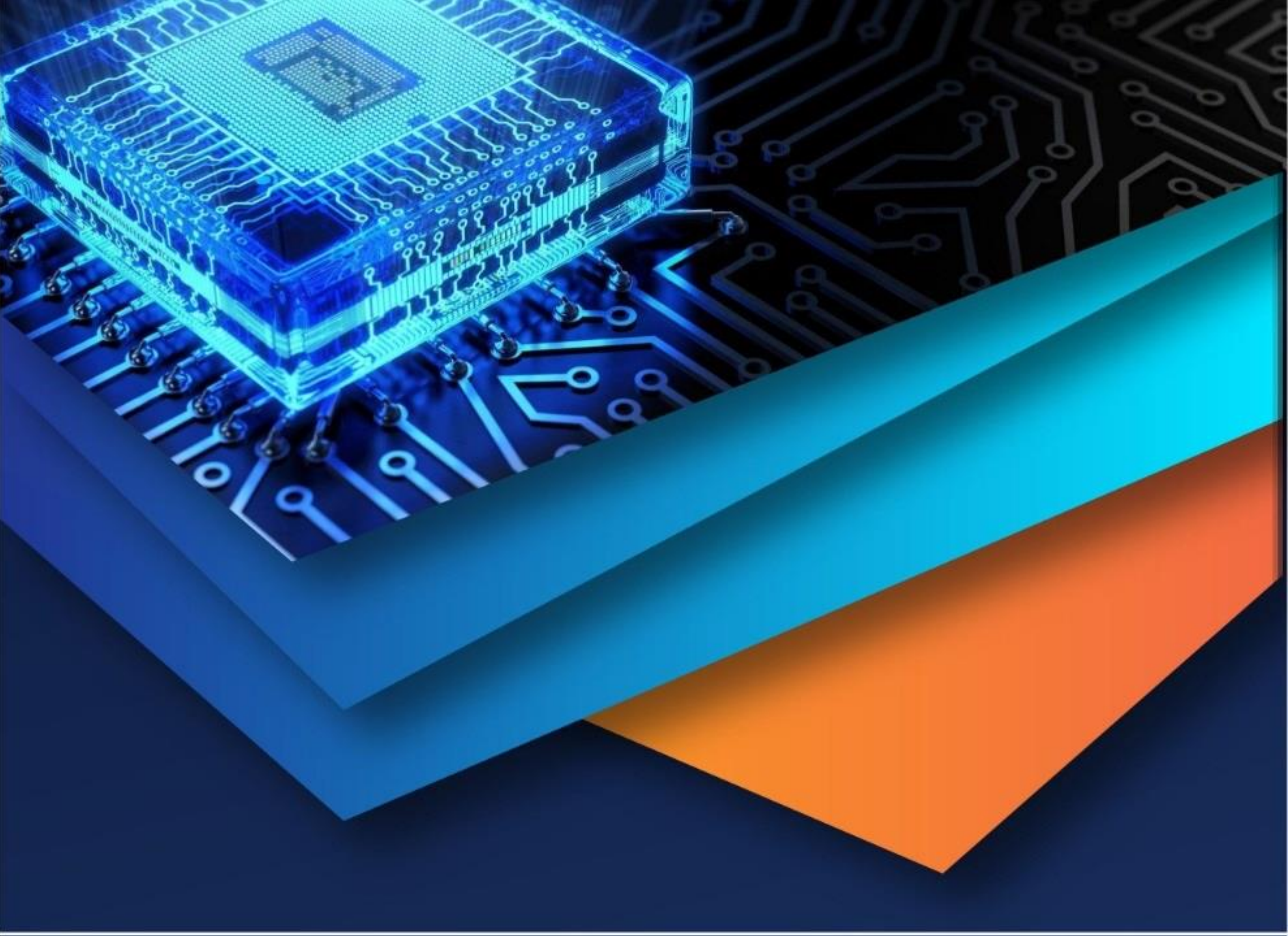

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