

IMPROVEMENT OF STABILITY OF SLOPES AND REDUCING THE SEEPAGE USING GEOTEXTILE IN EARTHEN DAM

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Abstract: Reinforcing the soil is now well established technique for geotechnical application across the world. This paper represents the application of Geotextiles in reinforcement and geomembrane for the stability of slopes and decreasing the seepage loss through the body of the earthen dam respectively. The dam section like slope designed by Kandi Area development organization Chandigarh has been considered to be reinforced with horizontal layers of geotextile and Factor of safety with and without reinforcement has been studied. Moreover, the parameters such as spacing and length of reinforcement are also varied. Inclined geomembrane is used on u/s face of the dam to reduce the seepage lose through the dam body. It was found that by providing geotextile and geomembrane as a reinforcement increases the factor of safety at the d/s and u/s slope with satisfactory results to reduce the seepage lose.

Index terms: Geotextile reinforcement, Geomembrane, GeoStudio, Factor of Safety.

I. INTRODUCTION

Structures for retaining the water from natural sources are quite common and it's not a recent technology. Throughout the history of mankind, dams have been considered fundamental for the adaptation process of the civilizations to the environment. There is many types of dams, embankment dams are defined for its complex structure and materials. Represent 75% of the total dams in the world. They are composed by earth, rock or mixtures, and some of them must comprise a impervious curtain. Due to its nature, they are characterized by its large base/height ratio and large ductility and capacity to follow the deformation of the foundation. This type of dams is recommended when the foundation has a not so good performance and when the vales are wide

The conventional method of earthen dams for stabilizing the slope for a given height may involve considerable expenses in material, construction time and increase the base area of embankment dam. While for low height dams this problem may not be concerned, but for high dams provided flatter slop should be provided which cause considerable amount of cost increases. Also if suitable construction material is not available nearby site, then there will be an additional increase in cost of transportation of suitable material.

The solution of this issue is to make the dam slopes much steeper than obtained by conventional design procedure. The slopes of earthen dam can be made steeper by reinforcing them. Reinforced soil is a technique where tensile elements are placed in soil to improve stability and control deformation. To be effective, the reinforcement must intersect the potential failure surface in the soil mass. The strains generate in the soil masses due to internal stresses causes the straining in the reinforcement which in turn development of tensile stresses in the reinforcement which is strong in tension and wear these stresses and resist the movement of the soil mass and also imparts the shear strength.

Generally geo synthetic is describing as the thin and flexible sheets which are used in the soil or in connection with soil materials with the goals such as reinforcing, separating, moisture insulation, corrosion inhibition, playing the role of a filter, drain and In the most of cases, these sheets may take combination of the mentioned duties.

II. STUDY AREA AND DATA DESCRIPTION

Shivalik hills which are situated at the foothills of Himalayas form the eastern boundary of the state along the state of Himachal Pradesh. The semi-hilly area in this part is locally known as 'Kandi' area. The Thana Dam is earthen dam across Khwaja Khad in Hoshiarpur district. The dam lies adjoining to the Dholabaha watershed and is situated about 3km u/s of village Manohta on Hoshiarpur-Haryana-Manohta Road. The longitude and latitude of the site is 31°47'12.5" & 75°52'41.4"E. The purpose of the dam is flood control and irrigation. Catchment area of the dam 16.58 km². The total cross sectional area of the dam is 3954.125 m²



Source: <https://www.google.co.in/maps/@31.7893989,75.8716379,1841m/data=!3m1!1e3>

Figure 1: Satellite view of the Thana Dam

Table .1 Material description of the earthen dam

Particulars	Unit Weight (KN/m ³)	Angle of Friction	Cohesion (kpa)	Hydraulic Conductivity (m/s)
Impervious core	19.2271	29°	0	2.88e-005
Pervious Zone	20.286	27°	15.696	2.8e-010
Foundation	19.2271	29°	0	2.88e-005

III (a) Properties of Geotextile material used in analysis

- 1) Geotextile Reinforcement is FORTRAC 110/30 having a tensile strength 110KN/m
- 2) Geomembrane is Polypropile filter membrane having hydraulic conductivity 4.5e-007 m/sec.

III. COMPUTATIONAL ANALYSIS

- 1) Selecting the general parameters such GEO SLOPE/W for Stability analysis of slope and GEO SEEP/W for seepage analysis.
- 2) Selecting method of analysis namely Morgenstern Price, Bishop Method for Stability analysis and static or transient for seepage analysis.
- 3) Defining the units of analysis.
- 4) Plotting the section of dam such as foundation impervious core, pervious zone, cut off trench, drainage filter etc.
- 5) Assigning material properties such as unit weight, cohesion and angle of friction, saturated water content, type of soil, hydraulic conductivity etc.
- 6) Setting Reservoir water level.
- 7) Defining the reinforcement load, their outside and inside coordinates and tensile capacity and geomembrane depend upon the type of analysis.
- 8) Defining the slip surface by defining the Entry and Exit Point of the slip surface and Boundary condition such as potential seepage face, zero pressure and reservoir head.
- 9) Data should be analyzed
- 10) Check the results and plot them in tabular and graphical form.
- 11) Conclusions based on above findings.

IV. RESULTS AND DISCUSSION

IV(a) Stability of slope without Geotextile reinforcement

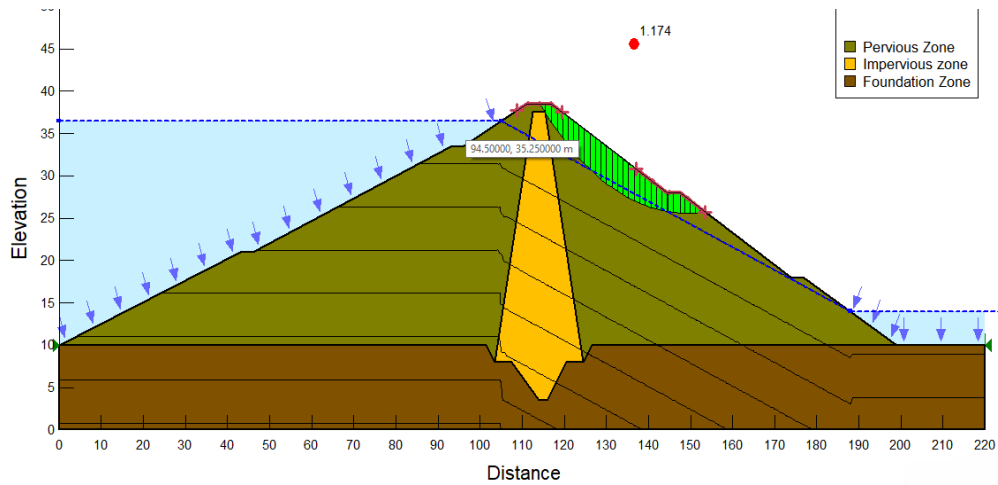


Figure 2: Stability of slope without Geo Reinforcement in Slope 1

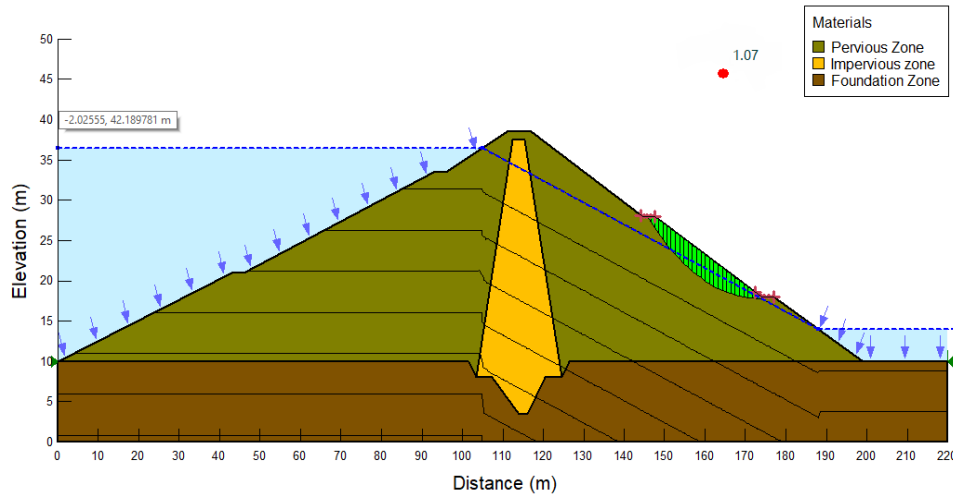


Figure 3: Stability of slope without Geo Reinforcement in Slope 2

Table.2 Factor of safety without consideration of Geo Reinforcement

Sloping Case	FOS
1	1.174
2	1.07

IV (b) Stability Analysis of Reinforced d/s Slope for Steady Seepage Condition

The d/s slope of the Thana Dam is considered to be reinforced with horizontal layers of geotextile thus results in increasing the factor of safety of the critical slip surface. The spacing between the reinforcing varies from 0.75 m to 1.25 m and length of reinforcement varies in Sloping case 1 from 1.25 m to 9.5 m and 2.5 m to 9.5 m in sloping case 2 in such a way that reinforcing layers remains activated as tensile by adjusting the offsets or inner coordinates of slip surface because prior to the slip surface the reinforcement have no effect. From the results computed shown in Table shows that at spacing 1.25 m in case 1 and spacing 1 m gives appropriate factor safety on behalf of stability and economy.

Table.3 Variation of factor of safety with variation of spacing in Reinforcement in different sloping case

Sloping case 1		Sloping case 2	
Spacing (m)	FOS	Spacing (m)	FOS
0.75	1.735	0.75	1.48
1	1.58	1	1.519
1.25	1.51	1.25	1.664

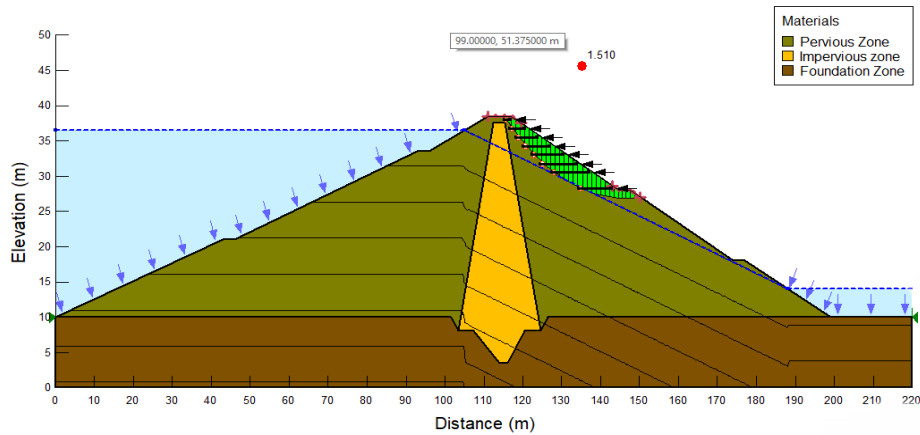


Figure 4: Geotextile Reinforcing of Slope 1

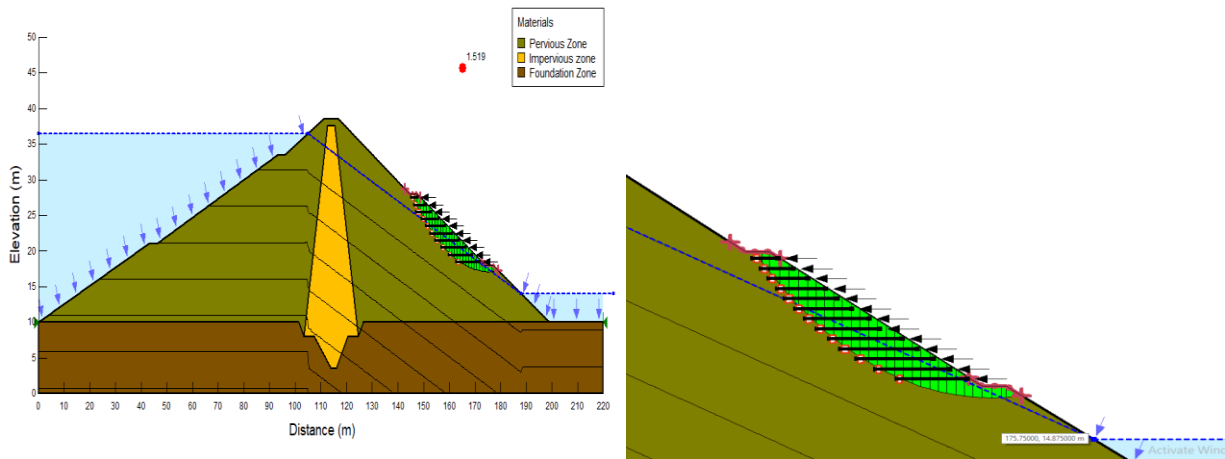


Figure 5: Geotextile Reinforcing of Slope 2

IV (c) Analysis of stability of Reinforced Slope at d/s side for Steady Seepage Condition

The u/s slope of the dam body is considered with geomembrane as a interface has hydraulic conductivity less than that of the pervious material. The flux label on the d/s of the impervious core shows the variation of discharge through the dam body and the results are in shown in the Table that shows that the reduce in the discharge 18%. The main reason of consideration of geomembrane on u/s slope is that

- 1) the vertical component of the water pressure contributes to the stability of the dam
- 2) It has less complications in the construction phase
- 3) It allows visual inspection and maintenance on the exposed solutions
- 4) Their eventual repair or replacement is easier than the internal system.

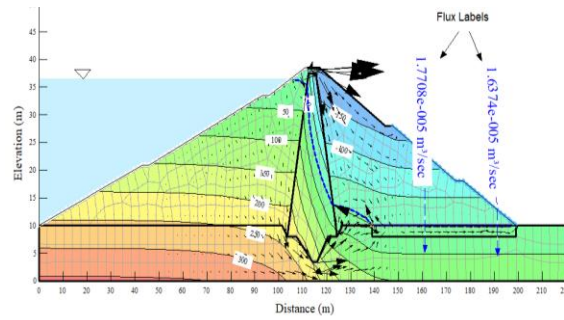


Figure 6: Seepage through dam body without Geomembrane

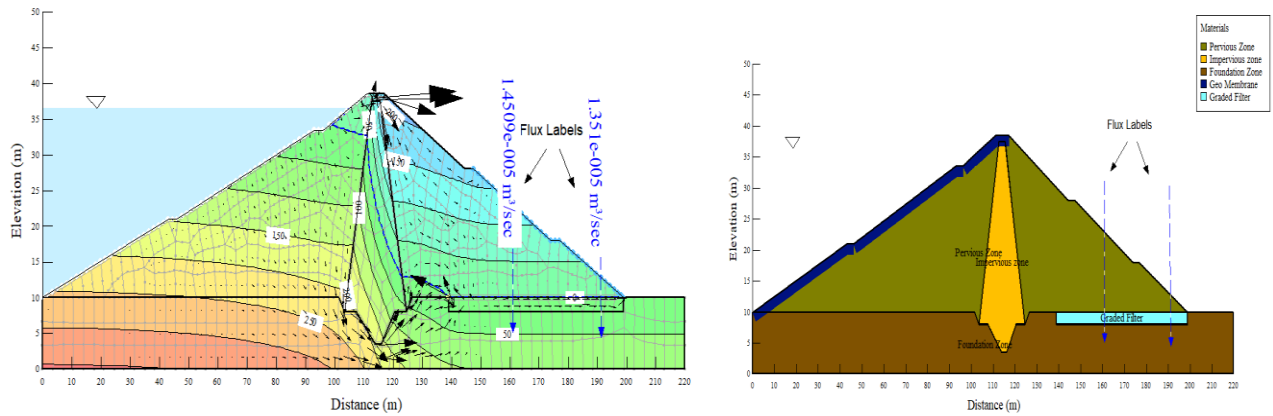


Figure 7: Seepage through dam body with Geomembrane

Table.4 Seepage analysis with and without geomembrane

Flux Label	Discharge(m ³ /s)		
	Without Geo Membrane	With Geo Membrane	Percentage Decrease
1	1.77E-05	1.45E-05	18.06%
2	1.64E-05	1.35E-05	17.68%

V. CONCLUSION

In the present study, Soil reinforcement is done using horizontal geotextile layer to strengthening the d/s slope of the dam body and increasing their factor of safety which further helps providing a steeper slope. By providing appropriate length of the reinforcement at a spacing 1 m to 1.25 m depending upon the Slope case for the utilization of the full strength of the reinforcement. Consideration of geomembrane on the u/s slope also gives satisfactory results to reduce the seepage loss up to 18%.

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