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Stability Analysis of Bhimdi Earth Dam

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***Abstract* — The design of earth and rock-fill dams involves many considerations that must be examined before initiating detailed stability analyses. Such as geological and subsurface explorations, the earth and/or rock-fill materials available for construction should be carefully studied. This paper focuses on the verification of stability of "Bhimdi earth dam" situated near Warud Dist. Amravati (Maharashtra) by changing different parameters such as changing berm width, changing position of filter drains and to gain desire stability how much strengthening required that was carried out by using software Geo-studio. The Existing design results are compared with the simulated results obtained from software.**

***Keywords* — Design Parameters, Geo studio Software, Slope Stability, Strengthing.**

I. Introduction

Traditionally uncertainties in design parameters are assumed to be accounted for through the use of safety factors. By assigning generous safety factors dam performance (capacity and safety) is assumed to remain in an acceptable range and it is customarily presumed that dams never fail. Nowadays, in most modern engineering codes and society, the appropriateness of the safety factor approach is being questioned. This approach does not allow for transparent accounting of uncertainties and for numerical quantification of safety. It does not permit for optimizing safety and economy uniformly across the system by associating.

The specific patterns of water effect of stability analysis while changing parameters by conventional method and computer software controversial issue that attracted several researchers. The conventional solutions and method of design earth dam is too tedious and lengthy. So many checks formulation are to be use while design. Computer base analysis is comparatively easy to compute and check stability analysis.

II. Literature Review

The literature shows considerable working on the study of stability of earthen dam by changing various parameters. Slope stability analysis by using limit equilibrium method in 2d and 3d shows Two dimensional limit equilibrium methods will always estimate lower factors of safety compared to three-dimensional methods.

Slope side effect should be considered in 3D limit equilibrium methods to produce more realistic simulation of the problem. Side resistance using the at-rest earth pressure coefficient should be considered can produce lower bound 3D factors of safety while using the active earth pressure coefficient can produce upper bound factor of safety.[1].Upstream side slope stability under sudden drawdown condition by computer programming shows the effect of horizontal drains on upstream slope of earthfill dams during rapid drawdown using finite elements and limit equilibrium methods. Changing of pore water pressure, outpouring seepage flow and factor of safety are inspected. By using Geo studio 2004 [2].

Effect on factor of safety for varying thicknesses of core by using software SLIDE 5.0 were studied on construction of earth and rockfill dams. The study shows that stability of the dams depends on its geometry, materials properties and the forces to which it is subjected.[3]

III. Geostudio Software

Geo studio software is mostly used in varies civil engineering application and their problem analysis by considering different consideration. Now days it's widely used this area mostly for finite element analysis, slope stability, seepage analysis and so on other applications. Following are steps for used Geo studio 2004 software.
1) For slope stability Open the Geo Studio SLOPE/W Define module2) Identify the individual toolbars available.3) set the working area4) to set the working page size5)set the scale 6)set the grid spacing 7) set and display the grid 8) to save the data to a file 9) to sketch an axis 10) sketch the slope stability problem 11) specify the analysis methods 12) specify the options used in the analysis 13) define the soil properties 14) draw the first region of the problem 15) draw the piezometric line 16) Draw entry and exit location 17) turn off the points and the point numbers 18) Display soil properties 19) Verify the problem 20) Save the problem 21) viewing the results.

IV. Stability Analysis of Earth Dam By Changing Parameters

A.Details of Bhimadi Earth Dam

The details of Bhimadi earth dam is as shown in Table I.

Topo sheet no.	55K/2, K/6
Latitude	29^0 12'
longitude	78^0 2'
Name of river	Local Nalha
sub basin	Wardha
Basin	Godavari
Total catchment area	7.152626 Sq km
free catchment area	7.15 Sq km,
Avg.Annual monsoon	904.75mm
Total yield available	3.2598 Mm^3
Annual utilization	3.22 Mm^3
Gross storage	3.5961Mm^3

Live storage	3.4645Mm^3
Dead storage	0.507 Mm^3
Type of dam	Earthen Dam
Maximum dam height	20.28 m
Length of dam	1230 m

B. Stability Analysis of Earth Dam by Changing Width of Berm

Study of stability analysis of Bhimdi earth dam by changing width of berm was carried out by using Geo studio software. The effect of variation in width of berm on factor of safety is as discus below and existing soil properties are as shown in Table II.

Table II: Properties of Soil used Table

Specificat^n	casing of dam section	Filter layer	Base found^n (F2)	Found^n soil (F1)	hearting
Unit Weight in KN/m^3	17.39	15	17.39	16	16
Cohesion in KN/m^2	8	10	8	22.5	22.5
Phi in degree	30	30	30.96	16.7	16.7

The change in factor of safety for downstream side with respect to variation in berm width for existing dam section and relative factor of safety after providing variation in number of anchors and nails for strengthening of existing dam section with variation in length was computed and as shown in Table III.

Table III: Factor of safety for different condition‘s of dam section on Downstream side

Condition of dam	Nos	Length of strengthening in (m)	Factor of safety (For both Berm width)		
			5 m	4m	3 m
Existing dam section	-	-	2.43	2.33	2.25
With Anchor’s	3	5	-	2.67	2.35
	5	5	-	2.75	2.41
	9	5	-	3.25	2.56
With Nail’s	3	5	-	2.39	2.35
	5	5	-	2.5	2.42

The variation in factor of safety for upstream side with respect to change in top and bottom berm width for existing dam section and relative factor of safety after providing variation in number of anchors and nails for strengthening of existing dam section considering water table condition with variation in length was computed and as shown in Table IV.

Table IV: Factor of safety for various berm condition’s on upstream side with strengthening

Berm condition’s		Strengthening system			Factor of safety	
Bottom berm width in m	Top berm width in m	Material	Nos	Length in m	With out WT	With WT
6	5				2.50	2.45
5	5				2.48	2.43
		Anchor	3	5	2.57	2.52
			4	5	2.61	2.56
			6	5	2.71	2.66
		Nail	1	5	2.55	2.46
			2	5	2.64	2.46
			3	5	2.69	2.46
4	5				2.45	2.40
		Anchor	2	5	2.53	2.48
			4	5	2.62	2.57
			6	5	2.69	2.63
		Nails	1	5	2.45	2.40
			5	5	2.52	2.45
			7	5	2.56	2.52
3	5				2.43	2.38
		Anchor	2	5	2.51	2.46
			4	5	2.58	2.54
			6	5	2.67	2.62
			8	5	2.74	2.69
		Nails	2	5	2.43	2.38
			4	5	2.43	2.38
			6	5	2.46	2.41
			8	5	2.46	2.46
3	4				2.41	2.36
		Anchor	2	5	2.49	2.44
			4	5	2.58	2.52
			6	5	2.65	2.59
			8	5	2.73	2.65
		Nail	2	5	2.41	2.36
			4	5	2.41	2.36
			6	5	2.44	2.39
			8	5	2.44	2.39
3	3				2.37	2.32
		Anchor	2	5	2.45	2.40
			4	5	2.54	2.48
			6	5	2.61	2.52
			8	5	2.65	2.57
		Nail	2	5	2.37	2.32
			4	5	2.37	2.32
			6	5	2.41	2.35
			8	5	2.41	2.35

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IV. Interpretation of Results And Discussions

From The results obtained the factor of safety against berm width was plotted and is as shown in figure below.

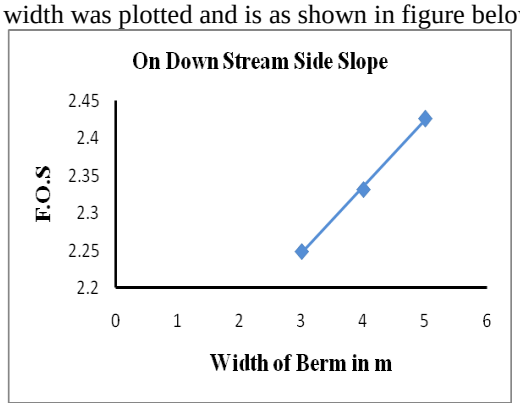


Fig.1 Plot between berm width and F.O.S. on downstream side

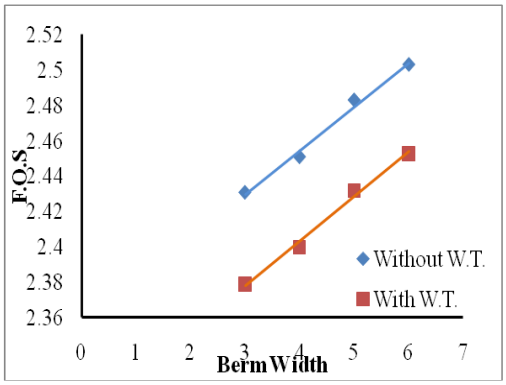


Fig.2 Plot shows variation of bottom berm width up to 3m with top berm width 5m

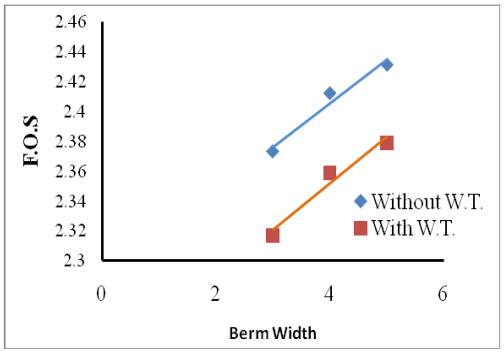
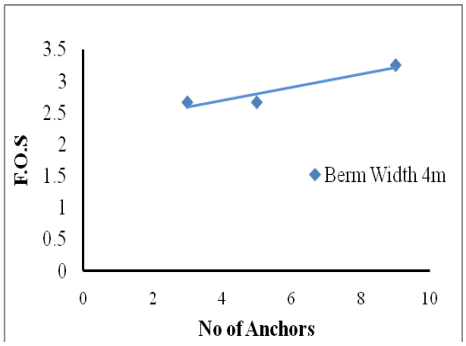
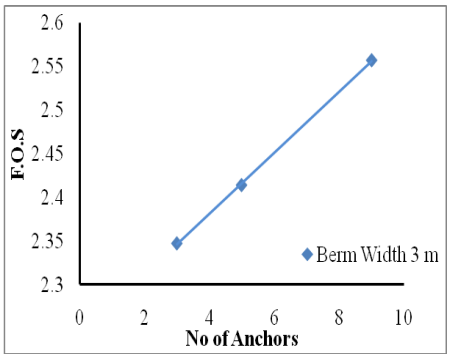


Fig.3 Both berm width is up to 3m on up stream side

From the above graph it was observed that the factor of safety deceases with decreasing in berm width. Various trials were performed to achieve design factor of safety by strengthening of dam with anchors and nails. The results obtained by considering the strengthening with anchor and nail for various berm widths are as shown Figure 4 and 5.

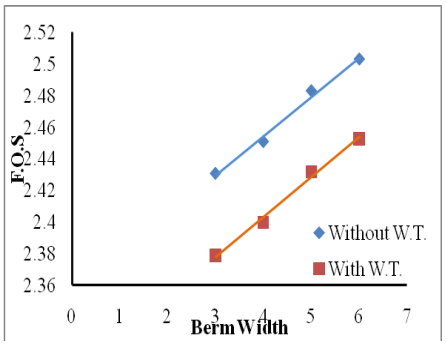


(a)For 4m berm width

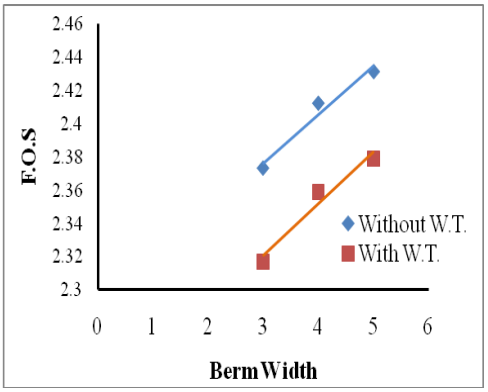


(b)For 3m berm width

Fig. 4: Effect of strengthening on factor of safety on downstream side of earth dam section.



a) Plot shows variation of bottom berm width up to 3m with top berm width 5m.



b) Both berm width is up to 3m on up stream side.

Fig. 5: Effect of Strengthening on Factor of Safety on Upstream Side Dam Section.

By considering the combination of bottom berm width from 6m to 3m, and top berm width 5m to 3m, the factor of safety is increases after strengthening by anchoring and nailing. Table IV. shows the variation however, It is observed that there is no variation in factor of safety after combination bottom berm width 3m and top berm width 5m (bottom berm width 3m and top berm width varies from 5m to 3m).

Computer base stability analysis is gives us fast result but basic data required such as soil properties as well as properties and availability of strengthening material such as anchoring and nailing and other are to be calculated manually. This is very advantageous for comparative calculation of analysis by computer base and traditional method.

V. CONCLUSIONS

Computer base analysis is comparatively easy to compute and check stability analysis. Variation in width of berm on upstream and downstream side of dam section is directly affected on factor of safety. It is conclude that by changing the berm width of earth dam the factor of safety can be restored by anchoring and nailing. The effect of anchoring and nailing on factor of safety is as shown in graph.

Anchoring and nailing is not so effective in water impounded area of dam section. As per USBR recommends for earth dam section of 6m height required minimum 3m berm. By using software results less than 3m width berm with strengthening is not so satisfactory. There is no such improvement in increment of factor of safety.

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