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Stability Analysis of Ash Dyke Raisings Under Static and Seismic Conditions

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Abstract:- The progressive consumption of coal generates bulk quantities of coal ashes which is disposed in the form of slurry in ash pond. The limitations of available lands may further results in the construction of pond ash dyke raising for higher storage. The stability of ash dyke raising has been a major concern over a year for a geotechnical engineer. In the present investigation, stability of pond ash dyke has been analyzed under different numbers of raising by Bishop's Method.Factor of safety value of ash dyke under static and seismic conditions have been determined using GEOSLOPE Software. The outcome of present investigation suggested an optimum number of raisings under static conditions and seismic.

Keywords:- *Pond ash, ash dyke, dyke raising, factor of safety.*

I. INTRODUCTION

In our country, around 150 million tons of coal ash is produced yearly from more than 100 thermal power plants, the utilization of ash generated has increased over the years for different purposes like in the brick making, concrete, agriculture and different kinds of embankments.

Even after this, there is a huge amount of ash is deposited as ash-pond near the power plants, as waste materials, which covers several acres of land which might be used for other purposes.

For new powerplants due to the limited amount of land available for them, the vertical expansion of ash-dykes isthe only possible way of storing the waste pond-ash.

The following table shows data for its generation and use in different years.

SN	Year	Fly ash generation (MT)	Fly ash utilization (MT)	Fly ash utilization (%)
1	1996-97	68.88	6.64	9.63
2	2006-07	108.15	55.01	50.86
3	2016-17	169.25	107.1	63.28
4	2017-18	196.44	131.87	67.13
5	2019-20	226.13	187.80	83.05

Table 1: Progressive fly ash generation and its utilization during the period from 1996-97 to 2019-20, (according to CENTRAL ELECTRICITY AUTHORITY, 2020)

The rest of fly ash is disposed off and restored. Storing these fly ash needs a huge amount of land area. And to minimize the wastage of land, ash dykes are constructed for its storage. Ash dykes are usually constructed nearby hydraulic power stations where coal ashes are stored. Construction of ash dykes is a process which is done continuously, and contains several steps of raisings.

Constructing an ash dyke is a huge challenge for engineers, because its failure may have devastating effects on the surroundings and the functioning of the power plant may also get effected. It may lead to the panic situation among the people living nearby, it may cause economical damage too. Rivers and ither water bodies may also get polluted which may be dangerous for aquatic and human lives. That's why, these dykes are constructed with optimum precautions and safety.

II. LITERATURE REVIEW

(Gandhi S. R., 2005) his paper explained different methods of dyke raisings by describing their merits and demerits. He suggested that a regular supervision of ash dykes is necessary and remedial measures should be taken.

(Jakka R. S., 2016) his paper checked if ash embankmentsby the upstream and downstream raising methods of construction is stable dynamically with pond ash materials being fine and coarse.He found that responses of embankments constructed with coarse ash is similar to earthen embankment in many respects. Meanwhile, he found that the fine ash embankments exhibitsmore vulnerability to liquefaction related to the failures of slope.

(Arindam Dey, Ruplekha Bora, Priya Talukdar, 2016) in their paper they analysed the stability of ash dykes in static, pseudo static and seismic conditions and found out upstream raising of the dykes give higher stability compared to other two methods.

III. MATERIAL PROPERTIES

The following table shows the material properties used for the study and analysis.

Soil type	Cohesion (KN/m^2)	Phi	Unit weight (KN/m^3)	K (m/sec)
Soil 1 (clay)	88	3.5	20	3.2×10^{-8}
Soil 2 (silty sand)	0.5	34	21	1.87×10^{-8}
Rock Toe	0	32	19	1×10^{-4}
Pond ash	6	30	12.5	4×10^{-6}
Ash filling	4	29	12	5×10^{-6}

Table 2: Material properties

IV. OBJECTIVES

To determine factor of safety for ash dyke raisings and evaluate the amount of pond ash that can be stored under static and seismic conditions being safe, by using geo-studio software.

V. ANALYSIS

To analyse, we designed a three-stage of dyke raising by the upstream method, factor of safety for every stage was evaluated using geo-studio software.

Geometry of the project,

S.no.	Type	Height (m)	Length (m)		Upstream slope angle (^{0})	Downstream slope angle (^{0})
			Top	Base		
1	Foundation	5	150	150	90^0	90^0
2 a. b.	Starter dyke Total Dyke Base	 10.5 9	 6 6	 49.25 24	 22^0 45^0	 26.7^0 45^0
3	Rock toe 1 (first toe before starter dyke)	1	1	4	34^0	34^0
4	Rock toe 2 (toe before raisings)	1.5	0.5	5	34^0	34^0
5	Dyke Raisings (same will be applied to all raisings)	3.5	6	16.75	18.9^0	26.7^0

Table 3: Geometry chosen for the project

PART 1:

First, the starter dyke is designed in the software, then seep/w analysis is done. With seep/w analysis we determine the phreatic line required for further analysis. Then we conduct the slope/w analysis to evaluate the factor of safety of the project.

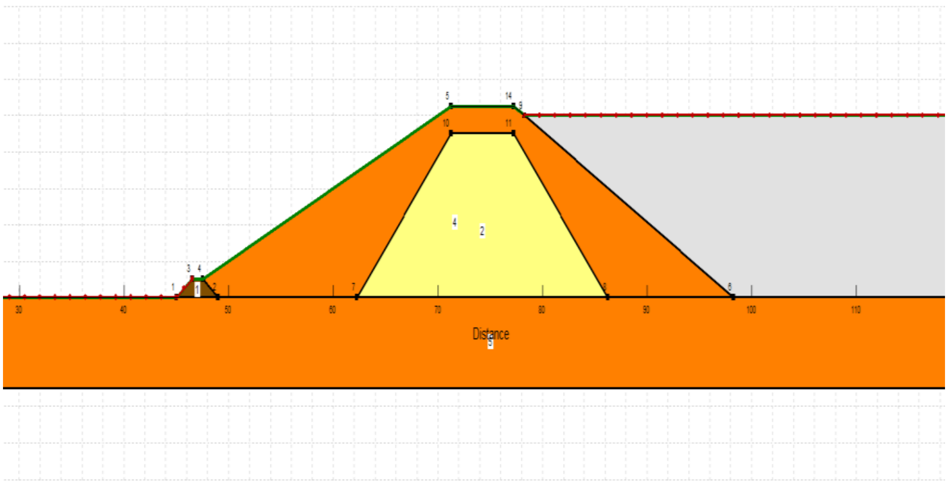

Fig. 1: The starter dyke

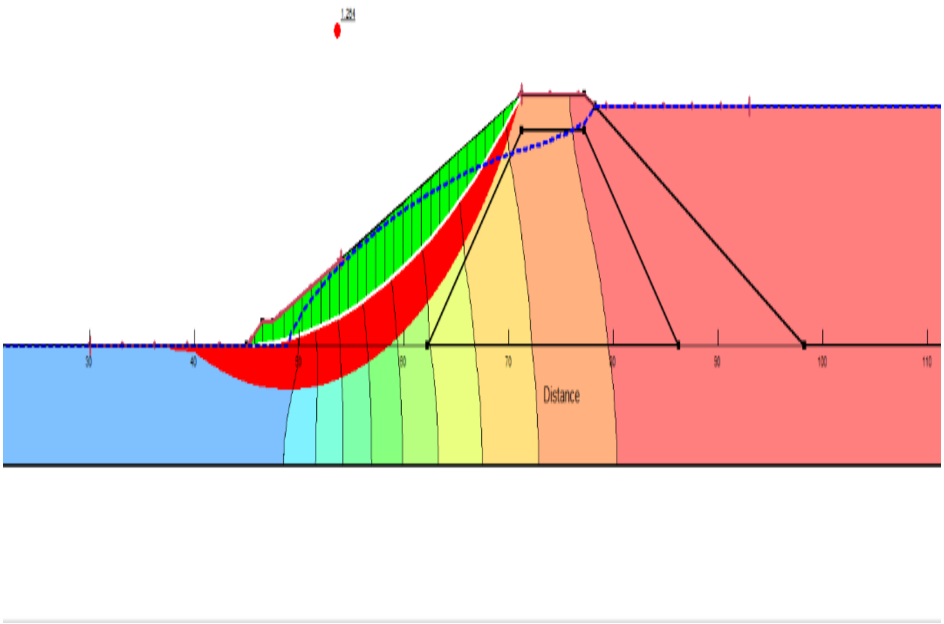

Fig. 2: Starter dyke after slope/w analysis under static condition

Then we add siesmic load to the project (0.01 horizontally, -0.05 vertically).

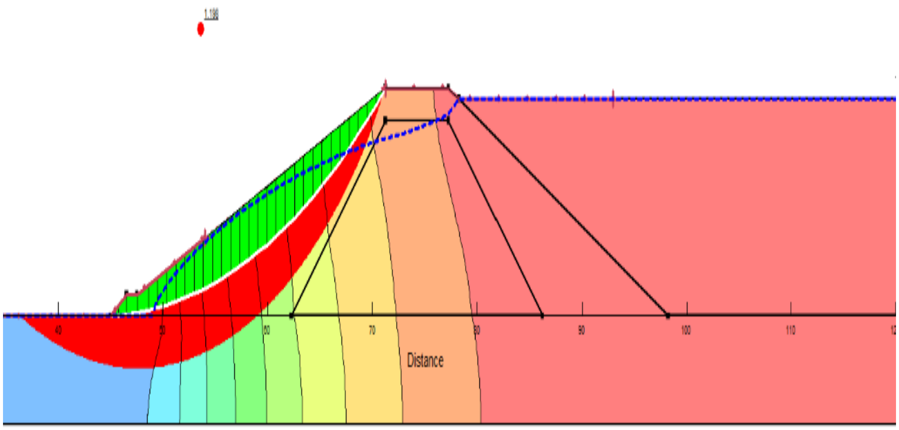

Fig. 3: Slope/w analysisof Starter dyke under seismic load.

PART 2:

After designing starter dyke we next draw raisings of the dyke, with every raising first we give it a rock toe, then the raising is drawn above it. Raisings are of 2 meters height (Y-Axis) from rock toe and its top is of 6 meters in length (X-Axis).

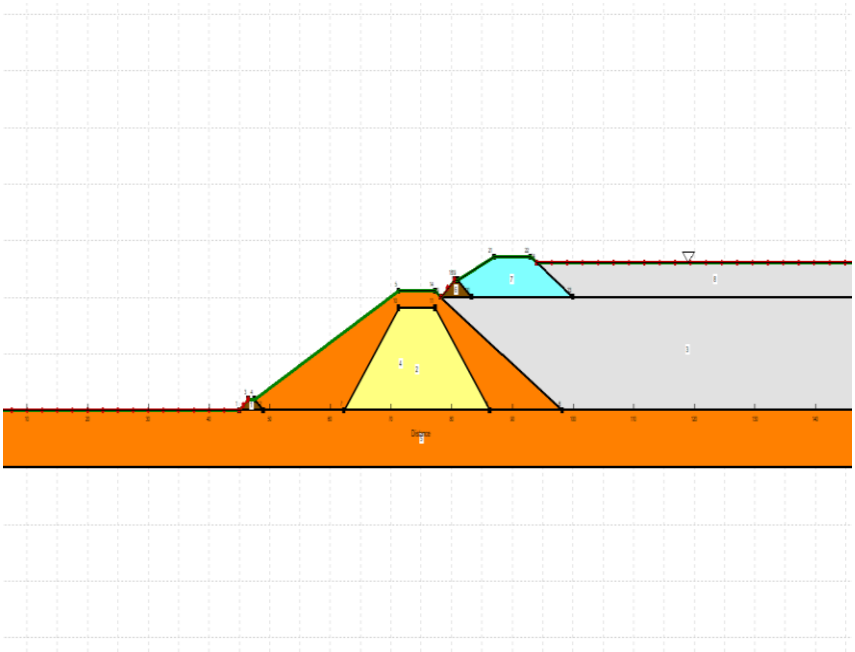

Fig. 4: Diagram after first raising

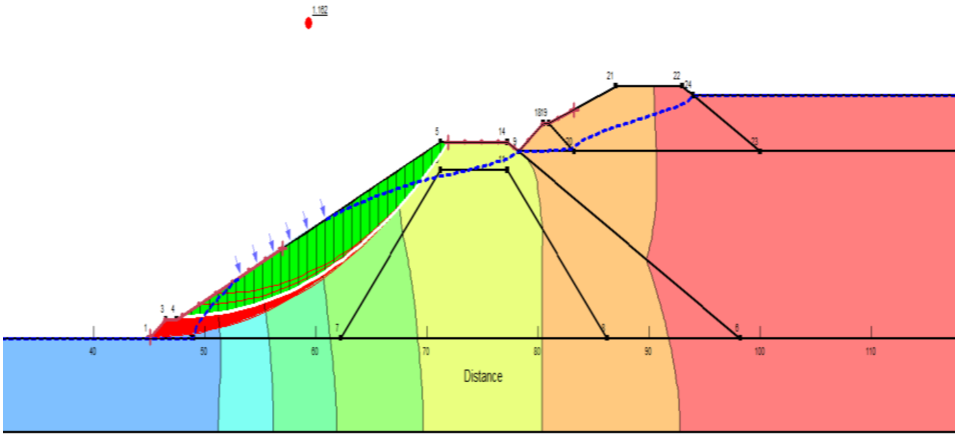

Fig. 5: First raising after slope/w analysis

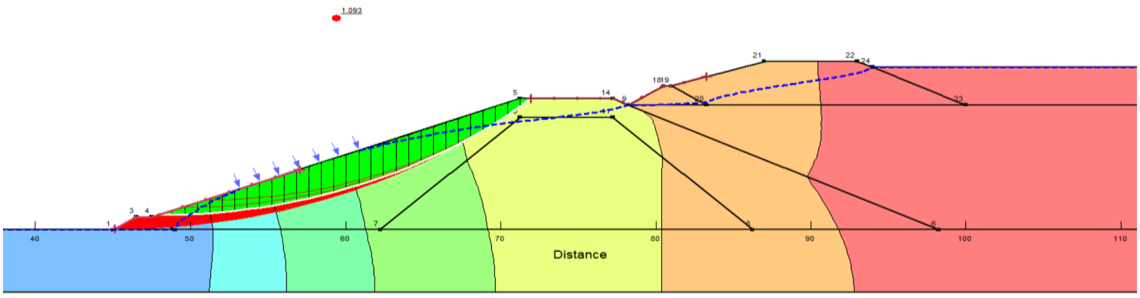

Fig. 6: First raising after slope/w analysis under seismic load

PART 3:

Now, the second stage of raising is added.

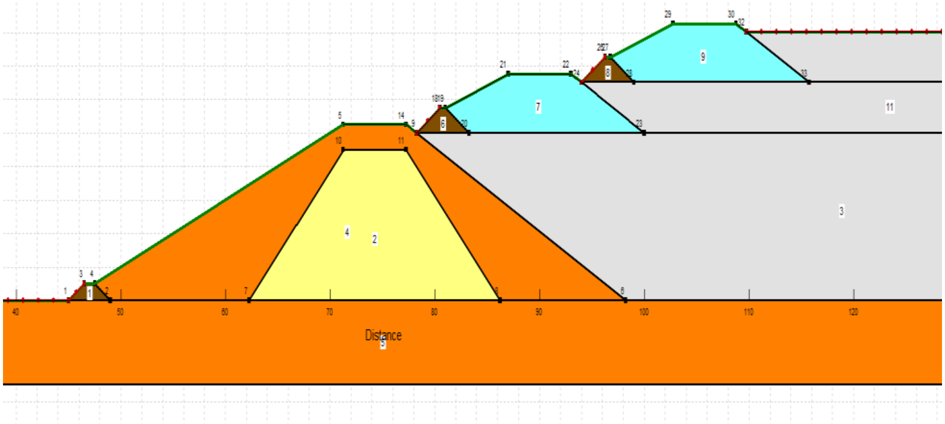

Fig. 7: Diagram after second raising.

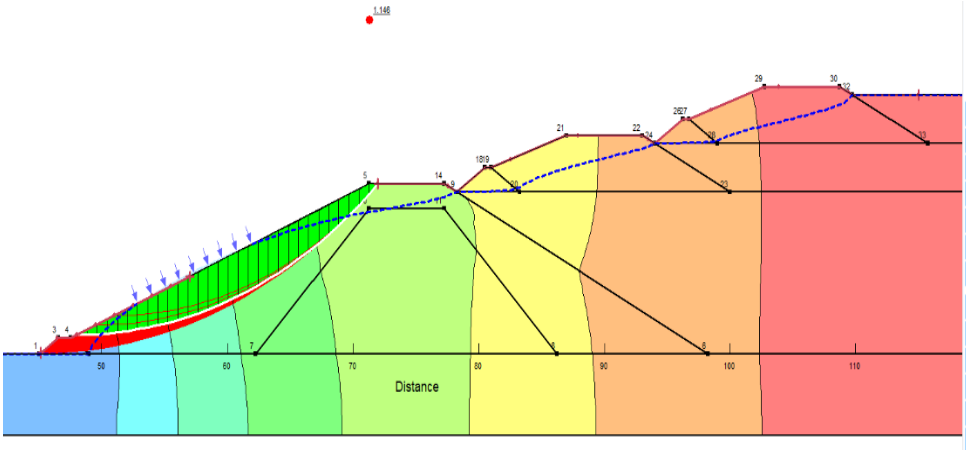

Fig. 8: Second raising after slope/w analysis

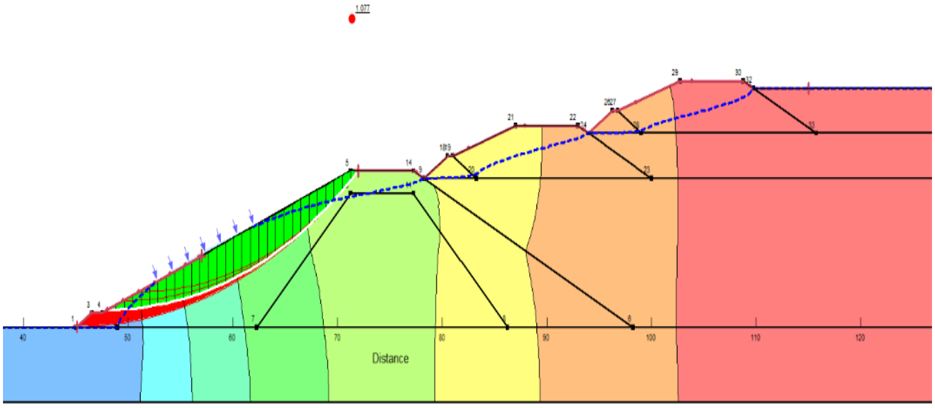

Fig. 9: Second raising after slope/w analysis under seismic load

PART 4:

The third raising is added to the diagram.

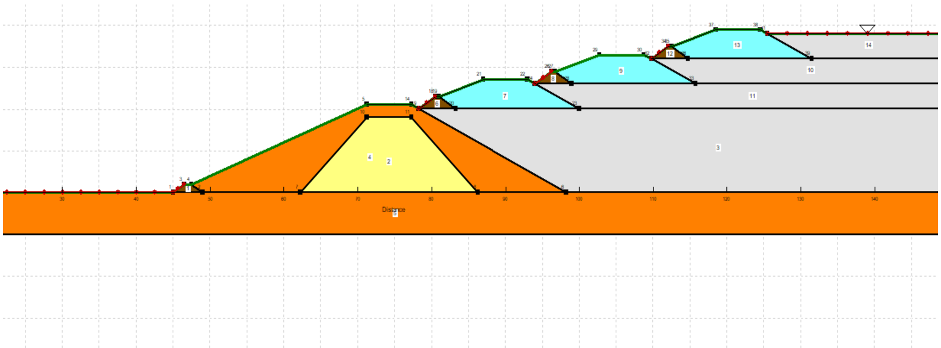

Fig. 10: Diagram for third raising

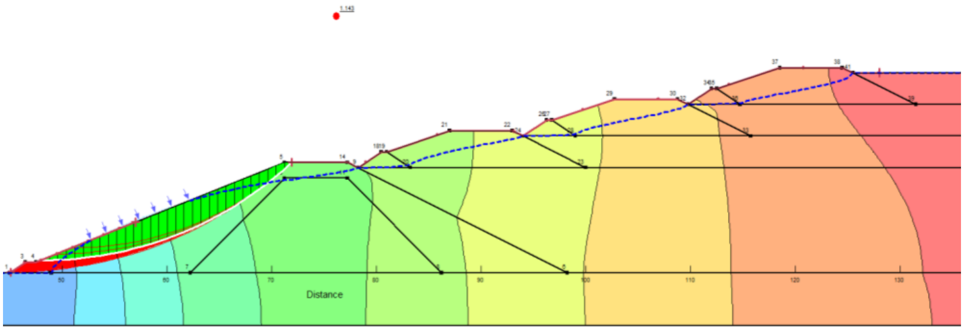

Fig. 11: Third raising after SLOPE/W analysis

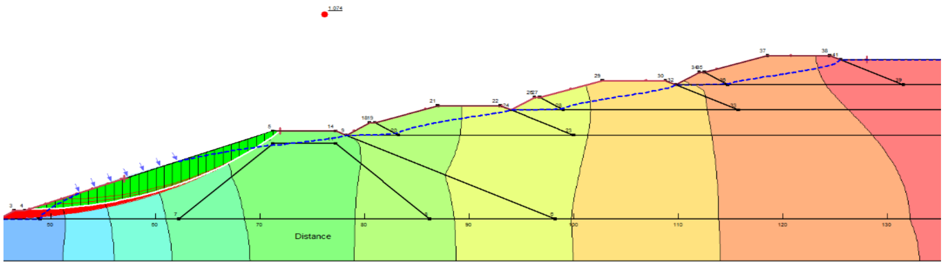

Fig. 12: Third raising after SLOPE/W analysis under seismic load

VI. RESULT

The factor of safety in every stage after performing the SEEP/W and SLOPE/W analysis is given in the following table.

S.no.	Type of dyke	Factor of Safety
1	Starter dyke	
a.	Under static condition	1.264
b.	Under seismic load	1.196
2	After First Raising	
a.	Under static condition	1.162
b.	Under seismic load	1.093
3	After Second Raising	
a.	Under static condition	1.146
b.	Under seismic load	1.077
4	After Third Raising	
a.	Under static condition	1.143
b.	Under siesmic load	1.074

Table 4: Factor of safety for all raisings under static and seismic load.

VII. CONCLUSION

In static conditions the ash dyke which is constructed by the upstream method gives a factor of safety above 1.14 in every stage. Meanwhile, in siesmic conditions the factor of safety reduces, and it comes out to be well over 1.07 in every stage.

The total area in which pond ash is stored after 3 stages of pond ash dyke raisings is 952.75m^2

So, the total mass of pond ash that can be stored under seismic and static condition, being safe is,

Area x ((unit weight of pond ash) x (101.97))

= 952.75 x (12.5x101.97)

= 1.214398969 million kg

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