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Comparative Statement on Stability Analysis of Optimized Fly Ash Percentage and Cohesive Untreated Soil Nature with Different Height and Side Slope of Highway Embankment In SLOP/W

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ABSTRACT

Huge democracy India having large population day by day. Due to massive population there are so manydesirable needs India has to fulfill. Out of those desire Coal is one of the major requirement for thermal plant, electricity generation etc. So there is huge demand and usage made in India. After the production there is residual product fly ash generation is also great in amount. Due to progressive increase in coal based thermal power plants, production of fly-ash has risen immensely in India. But only 40- 50% of the produced fly ash out ofwhole is being re-used for engineering purposes. Hence here is major concern that we have to store as well as dispose this residual product. So we can use fly ash as a strengthening embankment slopes effectively.

This paper represents comparative studies on various fly ash percentages with respect to unreinforced soil in highway embankment slope. Also studies on various shear parameter changes with different side slope such as 1:2, 1:2.5, 1:3 etc with their satisfying factor of safety and stabilized depth for example 3m, 6m, 9m, 12m etc. with SLOPE/W Modeling. The results obtained are comparing and merged with other considerations relevantto embankment design and construction and used to develop guidelines on coal ash utilization in highway embankment slopes.

Keyword: - Fly ash percentage, untreated (natural soil deposited), Different height and side slope of embankment. SLOP/W.

1. INTRODUCTION

According to IRC: SP: 58-2001 report says that due to industrialization and rapid economic growth, demand for electricity has risen tremendously. To meet this demand, a number of coal based thermal power plants have been set up. At present, in India thermal power plants produce about 90 million tonnes of fly ash per annum, and hardly 13 per cent of it is utilized.

When pulverized coal is burnt in the furnace of the power stations, about 80 per cent of the ash produced is very fine in nature. This part gets carried along with flue gases and is collected by using either electro-static precipitatoror cyclone precipitator. This is called fly ash. The remaining ash sinters and falls down at the bottom of the furnace. This is known as bottom ash. Fly ash may be disposed in dry form (in ash mounds or through water slurry in a pond.When fly ash and bottom ash are mixed and disposed in the form of water slurry to ash ponds, it is called pond ash. For the purpose of embankment construction either pond ash, bottom ash or mound ash can be used. Fly ash being a

very fine material is not recommended for embankment construction. However, it may be noted that the term "fly ash" is commonly used as a generic term to denote any type of coal ash. For the purpose of these guidelines the term fly ash would denote Pond Ash/Bottom Ash/Mound Ash, which is to be used for embankment construction.

Fly ash is causing environmental pollution, creating health hazards and requires large areas of precious land for disposal. Due to increasing concern for environmental protection and growing awareness of the ill effects of pollution, disposal of ash generated at thermal power plants has become an urgent and challenging task. Fly ash can be utilized in many ways as shown through extensive R&D efforts as well as field demonstration. But bulk utilization is possible in the field of civil engineering applications especially construction of road embankments. Typically, in developed urban and industrial areas, natural borrow sources are scarce, expensive or inaccessible.

The environmental degradation caused due to the use of topsoil for embankment construction is very high. Moreover, many power plants are situated in urban areas, and therefore, fly ash can provide an environmentally preferable alternative to natural borrow soil.

Table I. Typical Geotechnical Properties of Fly Ash

Parameter	Range
Specific Gravity	1.90 —2.55
Plasticity	Non-Plastic
Maximum Dry Density(gm/cc)	0.9 —1.6
Optimum moisture Content(%)	38.0 —18.0
Cohesion (KN/m^2)	Negligible
Angle of Internal Friction (cp)	30°- 40°
Coefficient of ConsolidationCv (cmVsec)	1.75 x 10 5 - 2.01 x 10 3
Compression index Cc	0.05-0.4
Permeability(cm/sec)	8xl0^{-6} -7x 10^{-4}
Particle Size Distribution (%of materials) Clay size fraction Silt size fraction Sand size fraction Gravel size fraction	1-10 8-85 7-90 0-10
Coefficient of Uniformity	3.1- 10.7

The properties of fly ash vary depending upon type of coal, its pulverization and combustion techniques, their collection and disposal systems, etc. Ash collected from the same ash pond may exhibit different physical and engineering properties depending on point of collection, depth, etc. Obviously, ash from two different thermal power plants can be expected to have different properties. These factors can be easily taken care during characterization, design and quality control operations during construction. In spite of variations in its properties, fly ash possesses several desirable characteristics, such as, lightweight, ease of compaction, faster rate of consolidation, etc. Also, spreading and compaction of fly ash can be started much earlier in comparison to soil after a rainfall. Fly ash would be a preferred material for construction of highway embankments slopes over weak subsoil.

In this research paper we were analyzing various aspects of fly ash and natural soil criteria for achieving stabilized embankment slope in Slope/w software. So we will find stable and economical highway embankment slope and with excellence strength. In this modeling we consider the cohesion value is negligible and angle of internal frictionis safe about 24 degrees.

We were doing analysis on fly ash up to 30% and this analysis is done for completely drained soil and our analysis isfulfill all the recommendation as per IRC 075 2015.

In IRC Code 075 2015 the stability of fill slopes built of cohesion less gravels, sands and silty sands, depends on; (a) the angle of internal friction of the fill material, ø', (b) the slope angle, (c) the unit weight of the fill, and (d) the pore water pressures. The critical failure mechanism is usually surface raveling or shallow sliding which can be analyzed using simple infinite slope analysis.

The values of ø' for stability analyses may be determined by drained triaxial or direct shear tests. Pore water pressure due to seepage through the fill reduces the stability of the slopes. But static water pressure with the same water level inside and outside the slopes has no effect on stability. The maximum stable slope angle of sandyembankment is related to the peak friction angle ø'. However, ø' is a function of void ratio, i.e. the density and the confining stress at which the sand exists. For dry loose sands, as in case of dumped sand or gravel, ø' is essentially equal to angle of repose. But slope steeper than angle of repose can be built in stable condition when the angle of friction is improved by compaction in thin layers.

It is important to note that the angle of stable slope of cohesion less materials is Independent of the height which may be indefinite. Sand dunes represent examples of natural slopes of varying height but constant slope. Furthermore, weight of the material does not affect the stability of slope, so that the safe angle for a submerged sand slope is the same as that for a slope composed of dry sand, with the exception of the special case of damp sand which has a high angle of repose due to capillary attraction. However, limitation is imposed on height by other considerations like base failure and erosion. work Introduction related your research work Introduction related your research work Introduction related your research work Introduction related your research work.

2. LITERATURE REVIEW

In As per our previous literature studies, we were keeping same reference of literature studies for proceeding analysisas follows:

Fabio santos,lin li,yadong li and farshad amini(2011): Fly ash has a potential to be beneficially used in roadway constructions, including embankment slopes. The paper describes a study of the optimization of fly ash-soil mixture for highway embankment construction. Tests were conducted on soil sand fly ash-soil mixtures prepared at optimum fly ash and water content, including compaction, permeability, and unconfined compressive strength(qu).the effect of mixing ratio and compaction water content on the geotechnical properties of fly ash /soil mixtures was discussed.

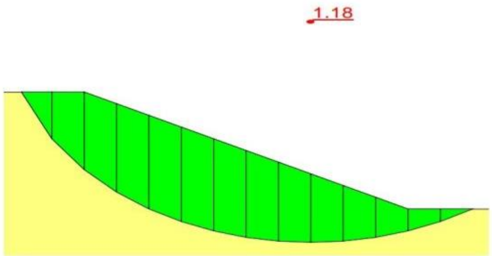
Tarun Kumar,Rajak Laxmikant yaduand Sandeep kumar(2017): In this study, fly ash has been used as a soil stabilizer for its effective utilization in the construction of an embankment in north east region, Tripura, India. The fly ash has been mixed at different percentage (i.e.10%, 20%, 30% and 40%) by dry weight with embankment soil.

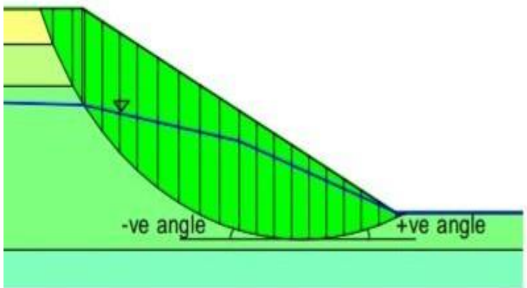
Laxmikant yaduta (2016): This paper discusses the shear strength parameter soft the soil stabilized with fly ash. The soil has been mixed with 10%, 20%, 30% and 40%fly ash by dry weight. Results indicate that the dry density and cohesion value of soil decreases where as the angle of internal friction increases with increase in the percentage of fly ash. The analysis revealed that the slope with native soil was stable up to 12.0 meter height under both summer and rainy season. Withfurther increase in height, the slope becomes critically stable and failed under rainy season at 14.0 meter height. The addition of fly ash enhances the strength and provides resistance to slope instability under both the conditions up to 14.0 meter height. It has been found from the analysis that the factor of safety increases with increase in percentage of fly ash at a particular height.30% fly ash is obtained as optimum amount as stabilizer for a slope of certain height.

Shfaq Ahmad Bhat (2017): This paper shows the experimental result on use of geogrid. Large progress In the bearing ability was observed in reinforced soil over the unreinforced soil by bringing in geogrid reinforcement. The decrease in the cast was 1.5% of total cost.

S.Andavan, Mohamed Hassaan. (2018): A study is carried out to check the improvements in the properties of expansive soil with fly ash and lime in varyingpercentages. The increase of dry density compromises higher strength. One of the most effective and economical method is addition of stabilizing agents such as lime or fly ash to expansive soil stabilized with various proportion offly ash i.e.0%, 5%, 10%, 15%, 20% Addition of fly ash to clay reduces the optimum moisture content but the dry density increases up to fly ash content of 20%, there after, the same decreases with further increases in fly ash content.

Dilipkumar, Ashish gupta&Neetesh kumar (2020): This paper shows the research on sand alone or in combinationwith fly ash at equal or similar proportion can be used as construction material in most geotechnical application. Using different proportion as 80%soil+20%fly ash, 60%soil+40%fly ash, 40%soil+60%fly ash and checking their result in laboratory.





Sign convention of inclination angle used in SLOPE/W

3. METHODOLOGY

According to IRC CODE 075 2015 it state that Failures may occur slowly or suddenly, and stability analysis is meant to determine whether the proposed embankment slope will meet the safety requirements against failure arising from shear stress exceeding the tolerable limits. The analysis is generally made for the worst conditions which may occur during the service of the embankment. Stability of high embankment depends on various factors like foundation profile, fill material quality, extent of compaction, drainage arrangement both surface and sub- surface, and embankment geometry like height of embankment, slope angle, ground profile etc., external factors liketraffic or earthquake load or presence of any water body by the side of the embankment or development of pore water pressure due to infiltration from heavy rain.

As per IRC: SP: 58-2001: The density of fly ash is considerably lower than density of many types of soils. So, unlike soils, fly ash with low MDD value should not be rejected for using it as a fill material. However, in general, fly ash of density lower than 0.9 gm/cc may not be suitable for embankment construction. The design parameters should be rechecked, when fly ash of lower densities is encountered.

All these parameters and conditions will make significant impact on overall stability of the embankment. Hence, itis very important to understand and evaluate these site specific conditions and interpretation of design parameters correctly before proceeding with design. According to various experiments have performed in which technical characteristics and physical and chemical properties of fly ash have determined in the laboratory.

Using this authentic and certain data and with reference of IRC 075 2015 we have found the optimized value of fly ash which can give maximum increase in strength from existing research, existing embankment properties, and we can improve the phi percentage or its value from 24 degrees to 27.5% value we can increase stability by adding 30%of fly ash in completely drained embankment soil.

Table II. Tabular result of Slope/w modeling withCondition of **No addition of fly ash in soil.**

SLOPE	**HEIGHT (M)**	**FOS**	**REMARK**
1:3	3	1.43	>1.4, Safe as per IRC (Critical)
	4	1.4	>1.4, Safe as per IRC (Ignored shallow)
	5	1.4	>1.4, Safe as per IRC (Ignored shallow)
	6	1.39	<1.4, Unsafe as per IRC (Critical)
1:2.5	3	1.18	<1.4, Unsafe as per IRC (Critical)
	4		Unsafe
	5		
	6		
1:2	3		Unsafe
	4		
	5		
	6		

Table III. Tabular result of Slope/w modeling with Condition of **Addition of fly ash up to 30%** in soil.

SLOPE	**HEIGHT(M)**	**FOS**	REMARK
1:3	3	1.43	No need of fly ash to be added for phi> 24 degrees.
	4	1.4	
	5	1.4	
	6	1.39	<1.4, Unsafe as per IRC (Critical)
1:2.5	3	1.18	<1.4, Unsafe as per IRC (Critical)
	4		Unsafe
	5		
	6		
1:2	3		Unsafe
	4		
	5		
	6		

In this SLOPE/W Modeling we have checked out various critical depths which are shown in **Table I. A**nd it also represents the Factor of safety values with respect to safety criteria as per IRC.

We have also found the max height up to where slope is naturally stable for side slopes i.e. (Hexisting-1:2, 1:2.5, 1:3) which is shown in table. .Also we increase the parameters to include effect of fly ash and find the new heighttill where slope is stable without any reinforcement (h1-1:2slopes, h2-1:2.5, h3-1:3, slopes). This is given in Table II. **A**fter addition of fly ash it seems that there are augmenting the properties of soil which becomes more stable and stiff without any reinforcement.

In **figure no 1& 2** it shows the resulting data from SLOPE/W with their also represent the slip circle or failure portion with integrated into no of slices. Figure also represents the sign convention involving in this analysis.

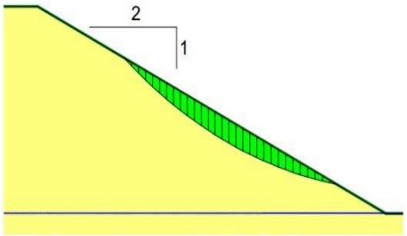


Figure 4-36 Shallow slip for purely frictional (c=0) case

Fig -2 SLOPE/W Analysis Result with phi value increase by 27.5%. As per literature Survey. After adding fly ash 30

4. CONCLUSIONS

Based on the analysis and research studies and experimental data the following conclusions have been drawn: The addition of 30 wt% fly ash.

In this research we found that byproduct fly ash we can use and implementing it for highway embankment. So we can make it as environment friendly disposal which is also good in economical design. It is also retarding and preventing exploitation of natural resources. In our research we just try to focus on improve strength of existing structure rather than building new.

Due to various climatic changes and abnormalities in behavior of soil. The highway embankment may get fail and it cause disaster situation. This research is done against for this kind of crisis and stability concern. We consider various embankment height (3m, 4m, 6m, 8m etc.) and side slopes (1:2, 1:2.5, and 1:3) for analysis and achieve the stable model and Factor of safety for safe embankment.

So basically motto of this research is that if there is any possibility of failure in highway embankment. So we will have at least some solution on it and we will somehow resolve the problem and for more accuracy we have used software modeling in SLOPE/W. In this modeling we notice that due to addition of 30% fly ash the percentage value of Angle of internal friction (‘ϕ’) is increased by 27.5% and we consider cohesion (c) for design is negligible. Whichis seems to be safer for Highway Embankment Slope analysis in SLOPE/W.

5. ACKNOWLEDGEMENT

The fly ash sample for this study was taken by various Thermal Power Station – From India .The experiments work was completed in the Soil Mechanics Laboratory – Civil Engineering Department- University of Indian institute, while the fly ash chemical and physical properties determined in Indian Geological researches Laboratories .Their specification taken from IRC CODE 075 2015.

6. REFERENCES

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