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Economical Design of Initial Bund and Raising of Bund Successively for Disposal of Wonder Material Flyash

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Abstract - An ash bund, also called a coal ash basin or surface impoundment is an engineered structure used at coal fixed power station for the disposal of two types of coal combustion product bottom ash & fly ash. The ash bund is used as a landfill to prevent the refuse of ash into the atmosphere.

The Khasara ash bund having total area 314.00 Ha is used for deposition of ash generated by 3X660MW, KTPS, Koradi. There is peripheral toe drain around the Khasara ash bund to drain out seepage water from ash bund towards waste weir and further, it is lifted through ash water recovery pump house for re-utilization of ash water for various purpose of 3X660MW KTPS Koradi. Like sprinkling of water on roads & for gardening etc.

However in the vicinity very less amount of fly ash is utilized by consumers like bricks manufacturing roadway authority etc. in spite of the promotion of fly ash application in various industries. With the current rate of ash deposition in ash bund. It occupies vigorously & acceleration for ash bund rising. Before exhausting of existing capacity of ash bund, it is very necessary to raise the bund (Dyke wall) to accommodate the ash generated continuously of 3X660MW KTPS, Koradi. Otherwise water level is to be very close to free board level and that, may cause the overtopping of ash mixed water or failure of ash bund (Dyke wall) which can create several damage to nearby villages & surrounding area.

Index terms: Earthen dam, Material properties, Stability check, Ash storage bund, Design of successive raising, Cost comparison.

I. INTRODUCTION

An ash Bund, also called a Coal Ash Basin is an Engineered structure used at coal based Thermal Power Station Plant for the disposal of two types of Coal Combustion products.

1) Bottom-Ash 2)Fly-Ash

The ash bund pond is used as a land fill to prevent the release of ash into the atmosphere. Ash Bund Pond used gravity to settle out large particulates from Power Plant based water.

Ash Bund Pond I generally form using a ring embankment to enclosed the disposal site. The embankment 1 design using similar design parameters as embankment dams, including zoned constructions with clay cores. The design process is primarily focused on handling seepage and ensuring slopes stability. The wet disposal of ash into the ash bund ponds is most common ash disposal method but other methods include dry disposal in landfills. Wet disposal has been preferred into economic reasons. The wet method of disposal ash consists of constructing a large-Ash Bund Pond and filling it be fly ash slurry allowing the OD water to drain and evaporate from the fly ash pond over time The flow of water through the fly ash slurry into the ground water is controlled by using low permeability clay layers and cut off trenches. Horizontal flow through the embankment are controlled using clay zone within the embankment. After reaching the full capacity of initial ash bund pond, it requires raising, the process e raising of ash bund has been done to enhance the capacity and life of ash bund pond. At Koradi 3x660 MW Thermal Power Plant, Khasara ash bund is constructed for filling of fly ash slurry and 2nd raising of Khasara ash pond is in progress. However some part of the Khasara ash pond has been raising upto 3 raising. Our project includes the initial design of ash bund pond and successive raising of ash bund and also includes the study of ash disposal system at Koradi 3x660 MW Thermal Power Station.

II. LITERATURE REVIEW

A. Dr. Punmia B.C (1992) – Irrigation and Water Power Engg Laxmi Publication, New Delhi, (Page No. 395-471)

The artificial application of water to land to aid crop production has enabled man to increase his ability to

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produce food and cash crops. All-the-year round crop production is now possible instead of the previous restriction to rain fed agriculture. However, conserving water and delivery it to the fields in an efficient manner has continued to be a challenge. The design of small-scale irrigation project will provide supplementary irrigation for many farmers. This paper presents design of small scale irrigation in Dara Wereda by assessing irrigation agronomy, analyzing hydrological condition of the area and designing different engineering structures like the headwork structure, main canal, cross drainage structure, etc. and also analyzing the stability of the structure which already designed. The structure we design in this project will resist the 50 year return period peak flood. Design considerations of canals naturally vary according to the type of soil. Again, the velocity of flow in the canal should critical. The canals cross the natural drain or gullies so suitable structure must be selected and designed. Finally, we put our conclusion and the necessary recommendation for the government, society, university and stakeholders.

III. MATERIAL PROPERTIES

A. Properties of Material

S. No.	Material Properties	B.C. Soil	Murum	Fly Ash
a.	Saturated unit weight Specific gravity Angle of internal friction Cohesion Dry unit weight Depth of material below foundation Submerged unit weight	18.7	20.1	15.8
b.		2.50	1.15	24
c.		17°	34.99°	28.81°
d.		20.0	5.0	25
e.		14.0	16.0	11.66
f.		6m 8.89	- 10.29	- 5.99
g.				

IV. METHODOLOGY

A. Design Criteria for Earthen Bund

Like most other damages to engineering structures, earthen dam failures are caused by improper design frequently based on insufficient investigations and lack of care in construction and maintenance.

1. The dam must be safe against overtopping during occurrence of flood and also by wave action.

2. The seepage line should be well within the d/s face so that no sloughing of the slope takes place.

3. The foundation shear stresses should be within safe limits.

4. There should be no opportunity for the free passage of water from upstream to the downstream face.

5. The dam and foundation should be safe against piping

6. The upstream slope must be protected against erosion by wave action and the crest and downstream slope must be protected against erosion due to wind and rain.

7. The dam as a whole should be earth quake resistant.

8. The upstream and downstream slope should be so designed that they are safe during and immediately after the construction.

9. The downstream slope should be so designed that it is safe during steady seepage case under full reservoir condition.

10. The upstream slope should be stable during rapid drawdown condition.

B. Design Procedure

1. Depending upon the availability of material the type of the Dam section to be adopted is decided

2. Tentative section of the Dam is chosen considering the following factors

i. Free board

a. Free board for wave action Hw=0.032 √v. f +0.763-0.271 (f)¼

Where hw=ht of wave in meters, f= fetch in km. v = wind velocity

For F less than 32 Km and for F > 32 Km hw = 0.032√ vf For sloping surfaces the wave height should be taken as

1.5 hw

b. Free board due to settlement It is generally taken as 2% settlement is considered for earthquake consideration.

Total of (a+b) is considered as freeboard

ii. TOP WIDTH: According to Indian standard, no dam should have crest width of less than 6m. However the top width of Dam can be selected as per the following recommendations

A = H / 5 + 3	FOR very low dams
A=0.55 VH+0.2 H	FOR Dams lower than 30 m
A = 1.65 (H + 1.4)⅓	FOR Dams higher than 30 m.

H = height of the dam,

A= top width and a general rule for calculating the top width is as given by A = 5/3 √H

iii. SIDE SLOPES : No specific rules can be given for determining the side slopes of earth dam, the design slopes of u/s and d/s embankment may vary widely depending upon the character of the materials available, foundation conditions and the height of the dam it also depends on the type of the dam

3. FOUNDATION SHEAR

1. Shear Stress in foundation

$S = \gamma_a (h_1^2+h_2^2)/2 \tan^2 (45-\phi_1/2)$

γ_a = Average effective weight of composite material considering unit width

$\tan\phi_1 = (C+\gamma h_1 \tan\phi)/\gamma h_1$ Average unit shear.

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Sav = s/b

Maximum unit shear Smax = 2Sav and this occur at 0.4b from point C

S1 = Unit shear strength below toe (AT A)

$= C + \gamma_1 \, h_2 \;\; \tan\phi$

S2 =Unit shear strength at Point C

$= C + \gamma m h_1 \;\; \tan\phi$

γf =Unit weight of foundation material

γm = Mean unit weight of the dam and foundation weighted in proportion to the depth of each

$S \quad = (S_1 + S_2)/2$

Overall factor of safety against shear

= S/Sav > 1.5 Therefore O.K

a) Factor of safety at maximum shear S = C +γav h tan ϕ

γav = mean effective unit weight at B

S = unit shear strength at point of maximum shear (B)

F.S. = S/Smax >1 Therefore O K.

4. POSITION OF PHREATIC LINES: It is absolutely essential to determine the position of phreatic line as its position will enable us to determine the following things

i. It gives us a divide line between the dry and submerged soil

ii. It represents the top stream line and hence help us in drawing the flow net.

iii. The seepage line determination help us to ensure that it does not cut the d/s face of the dam This is extremely necessary for preventing softening or sloughing of the Dam.

C. Determination of Phreatic Lines

1. When the dam section is homogenous and provide with a filter equation is given by

$S = (d^2+H^2)^{1/2} - D$

Where S = focal distance:

2. When the dam section is homogenous without filter for a less than 30 degree

$a=(d/\cos\alpha)-\{(d^2/\cos^2\alpha)-(H^2/\sin^2\alpha)\}^{1/2}$ for a 30 to 60 degree

$a = (d^2+ H^2)^{1/2} (d^2-H^2 \cot^2\alpha)^{1/2}$

D. Phreatic Lines for Zoned Section

In case of zoned section having a central impervious core the effect of outer zone can be neglected. The phreatic lines can then be drawn as usual.

5. STABILITY OF SLOPES

Analysis of stability of slopes are carried out with the following methods.

i. Circular are method

ii. Sliding wedge method.

Circular arc method is also known as swedish or slipcircle method, and is generally applicable for analyzing slopes of homogenous earth dam.

Formula used F.S. = (CLarc+ ∑NTANØ)/(∑T)
Where FS = factor of safety

T = Driving force C=cohesion

N= force normal to the arc of slice Φ = Angle of Internal resistance W= weight of slice

Larc = length of arc = πRθ/ 180

Sliding wedge method is generally applicable

(a) Where one or more horizontal layers of weak soil exists in the upper part of foundation;

(b) Where the foundation consists of hard strata through which failure is not anticipated and dam crests on it has a core of line grained solid with relatively large shell of dense granular material.

(c) The following conditions are usually critical for the stability of earth Dam

Case I Construction condition with or without partial full (for upstream and d/s slope)

Case II Reservoir partial full (for u/s slope) Case III Sudden drawdown (for u/s slope) Case IV Steady seepage (for d/s slope)

Case V Earth quake condition (for u/s & d/s)

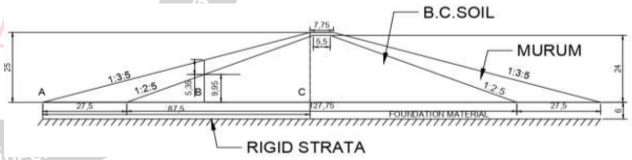

Fig.1: Design of Earthen Dam for storage of Flyash at Thermal power station upto 25m (B.C soil as a hearting material)

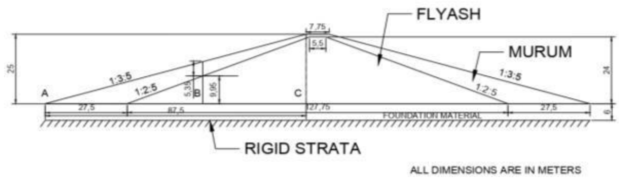

Fig.2: Design of Earthen Dam for storage of Flyash at Thermal power station upto 25m (Flyash as a hearting material)

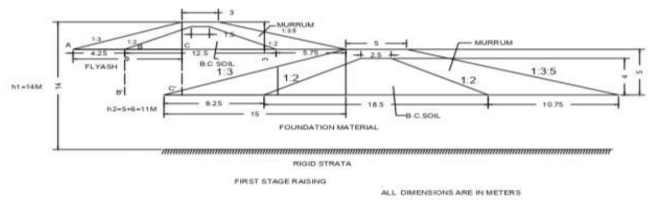

Fig.3: Design of Initial Earth Bund & Successive raising (B.C. soil as a hearting material)

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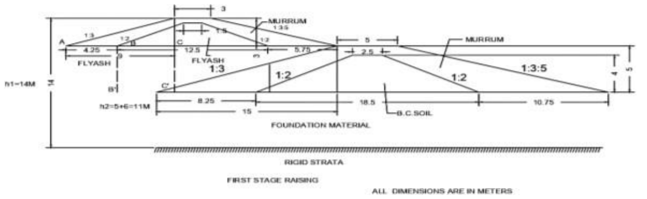

Fig.4: Design of Initial Earth Bund & Successive raising (In Initial B.C. soil as a hearting material)

(In Raising Fly ash as a hearting material)

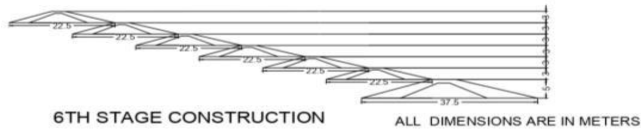

Fig.5: Design of Earthen bund (upto 6th successive raising)

V. CONCLUSION

From the comparison of cost per unit length under each proposal, shown in table. It can be clearly concluded that the cost of bund under proposed no. 4 comes out to be minimum. The overall cost under each proposed along with seeing percentage per unit length of bund are as under.

The table below shows the initial investment for construction of bund under proposal no.1 which is being followed by all thermal power stations is oxhorbitantly on higher side where as the expenditure incurred for construction of bund in stages and utilization of flyash as a hearting material are considerably economical with respect to proposal no. 1 that to finicial aspects to structures be incurred is spread over longer span of time.

S. No.	Particular	Unit Cost	Saving w.r.t Proposal No. 1	2	3
1.	Proposal No. 1 (B.C. Soil) as a Hearting material 25m Height	1393955.55	-	-	-
2.	Proposal No. 2 (Flyash) 25m Height	1065553.55	328402 **23.55%**	-	-
3.	Proposal No. 3 Raising B.C soil as a Hearting material	192158.405	1201797.15 **85.21%**	873395.145 **81.966%**	-
4.	Proposal No. 4 Raising Initial bund B.C soil as a Hearting material and in raising flyash as a Hearting material	168122.86	1225832.69 **87.93%**	897430.69 **84.22%**	24035.545 **12.50%**

Therefore, in view of the above table it is therefore recommended to adopt proposal no. 4 which is simplified section of Proposal no. 2 & Proposal no.3. So, that the huge expenditure being alone at thermal power stations for disposal of fly ash can be reduced and could contribute to national saving.

VI. REFERENCES

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