Industrial Science
ISSN 2347-5420

Impact Factor : 1.5015(UIF)
Volume - 2 | Issue - 1 | Oct - 2015

EFFECT OF RESIDUAL ENERGY OF WATER OVER TAIL CHANNEL EROSION

P. R. Muke
ME Student , Department of Civil Engineering, Sinhgad College of Engineering, Pune.

co - Author Details :

N. J. Sathe
Associate Professor , Department of Civil Engineering,
Trinity Academy of Engineering, Pune.

ABSTRACT

In Maharashtra region there are many dams having tremendous erosion of tail channel. Two of them are selected for this project; Bhama Askhed dam and Ghod dam. Bhama Askhed dam is situated near Waki (Pune district) and Ghod dam is located near Shirur about 95 km from Pune. Residual energy is mainly responsible for erosion at tail channel. Residual energy can be calculated by using model. Rock scour can occur when the erosive power exceeds the ability of rock to resist it. So it is also necessary to understand the failure mechanism of rock, structural geology and geological failures in that particular area. Electrical resistivity method is used in this project to study structural geology of tail channel area. Survey of tail channel is very helpful to draw eroded profile of tail channel. Hydraulic aspects are important for the design and treatment purpose but geological conditions also plays important role in it. All conditions which are explained above are necessary to understand before giving any treatment.

KEYWORDS : *Rock scour, Residual Energy, Tail channel, Electrical Resistivity.*

I.INTRODUCTION

Scouring of the Rock is the erosion of the rock due to the velocity exhibited by the stream channels and different localities (Bollaert, 2001), generally this phenomenon takes place at the downstream of spillways in plunge pools, along the tail channels& around a bridge pier founded on hard rock. As the phenomenon of rock scour is difficult for analysis. Rock erosion may takes place by the complex processes like Uplift/ Ejection, Brittle failure, peeling off or by fatigue failure (Bollaert-2002).

The exposed rock may first of all be weakened by weathering before flow impact. During flood situations, distinct rock block available at the exposed water rock interface may be ejected or displaced towards downstream. If the blocks cannot be ejected, instantaneous fractured or peeled off from the surface layers, they still may scour by progressive fracturing into smaller pieces or being tumbled inside the pool by turbulent eddies until they get smaller or finally break into pieces that may be ejected and displaced towards downstream. This process is known as fatigue fracturing. Knowledge of how scour will occur is important for development of economical design solutions.

As the Rock scour is a totally time dependent phenomenon, Also the physics involved for breaking of rock samples cannot be analyzed into a laboratory scale.

Residual energy is mainly responsible for erosion at tail channel. So in this study it is important to quantify residual energy responsible for erosion. Energy dissipation is one of the important aspects in life of dams. Also location of hydraulic jump plays an important role in energy dissipation. Many dams all over the world have problem associated with the energy dissipation arrangements. So it is necessary to protect and maintain these hydraulic structures.

II.LITERATURE SURVEY

1. Hinge G. A., Balkrishna S., Khare K.C. (2010): "Pawana Dam Energy Dissipation-A case study", AIBAS.

Location of hydraulic jump plays a vital role to accomplish the task of energy dissipation. Performance of energy dissipator for existing dams can be confirmed by model study. In case of ogee spillway when flood water is discharged, by the time it reaches the toe of spillway, the potential energy gets converted into kinetic energy. The flow turns into supercritical flow having lot of erosion potential. The flow can be converted into subcritical flow by forming a jump on downstream apron. In this paper a model study of single bay of Pawana dam spillway is carried out with 1:50 scale. The performance of stepped weir geometry is experimentally verified as the location of front of hydraulic jump is restricted near the toe of spillway for different discharges.

2.Mundhe, M. S., Kulkarni, S. R., and Hangekar, C. (2007): "Engineering geology in dam safety" ICOLD 75th annual meeting, Saint Petersbarg, Russia, June 24-29

An analysis of dam failures of the past has shown that failure to recognize or to treat properly defects in foundation rocks was responsible for a substantial number of them. Divisional planes such as joints, bedding planes etc are of great importance from the point of view of dam as they are the main source of trouble during dam foundation. Water tightness is also an essential feature of any dam. Leaking foundations are also responsible for unsafe dams. Favorable conditions cannot be taken as granted because of the possible occurrence of unfavorable features such as dykes, jointed rock, fractures, tachylytic basalts volcanic breccias, hydrothermal alteration etc and it is essential to carry out proper geological studies to ascertain beforehand what the geological conditions are along the alignment.

3.E. F. R. Bollaert (2004): "Scour prediction at Srisailam Dam (India), Aqua Vision Engineering, Switzerland.

Scour of rock due to high velocity jets has been of concern to practicing for a long time. Empirical and semi-empirical methods do not entirely describe the physics behind the phenomenon. Therefore a new model has been developed which allows estimating the time evolution of scour by accounting for turbulent jet diffusion in plunge pool and specific geomechanic characteristics of the fractured bed rock. This paper presents a comprehensive evolution of 20 years of plunge pool scour development at Srisailam dam, Andhra Pradesh, India.

4.T. D. Bhosale, G A Hinge & N. J. Sathe (2014): "Effect of Scouring in Basaltic Rock on Hydraulic Structures in the Vicinity of Pune Region" Paper Published in National Journal of Industrial Science, Vol. No. 1, Issue 5, ISSN: 2347-5420, PP 1 – 11.

This paper describes the scouring effect of Basaltic rock on hydraulic structure in the vicinity. In this paper attempt is made to show rocks scour due to high velocity of water jet in the tail channel. For this study Panshet damand Chaskaman dam were selected. Geology of both the sites was studied. Also maximum and minimum stream power responsible for rock scour was calculated. Cross section were plotted and average change in the elevation across the width of the channel was used to determine the amount of erosion throughout the length of the channel for both the sites.

III.METHODOLOGY OF PRESENT WORK

1.Visit to the dam site- First step of the project is visit to the selected site which is necessary for better understanding of the site conditions. Bhama Askhed and Ghod dam are selected for this project.

2.Quantification of residual energy using model- A model study proves beneficial before applying any conventional method to the dam or to any structure after failure. So we are going to test the model to understand the problems before suggesting the necessary treatments.

3.Survey at tail channel- As most of the time survey of tail channel is neglected before construction of the dam. We are going to find out elevations (RL) at different points along tail channel using dumpy level/total station.

4.Comparison of new RL with old RL to determine eroded profile of tail channel.

5.Sub surface exploration- An important step of investigation that is usually neglected while investigating dam sites is the geology of tail channel which carries flood water overflowing the spillway. We are going to apply Electrical Resistivity Method or Seismic Method to study structural geology and geological failures of the area. From this process we are going to study the presence of joints, bedding planes, presence of Red tachylytic basalt and geological failures such as dykes, depth of dyke, strikes of bed etc. Also, RQD (Rock Quality Designation) will be carried out for the rock samples from tail channel.

6.Necessary treatment methods/ design for existing problems at the dam site-Hydraulic aspects are important for the design and treatment purpose but geological conditions also plays important role in it. All conditions which are explained above are necessary to understand before treatment.

IV.IMAGES CAPTURED DURING SITE VISIT

1.BHAMA ASKHED DAM

Plate 1: View of tail channel.

Plate 2: View of spillway when gates were open.

Plate 3: Image shows existence of dyke at tail channel.

The present study area comprises of the three distinctive rocks i.e. Columnar basalt, Red Tachylytic basalt and Zeolitic basalts. The dam is located on the massive basalt, but the spillway has been constructed on the columnar basaltic rock where the red Tachylytic basaltic flow is also observed during the field visit. Structurally the area is sound but the existence of the dyke which runs longitudinal to the spillway channel shows uneven changes in the rock strata. The dyke rock is gabbroic rock and it is exactly to the centre of the spillway (Plate 3). The extension of the dyke from the spillway gate is upto 350 mtrs in the spillway while it extends beyond that from the spillway.

2.GHOD DAM

Plate 4: GHOD DAM spillway.

Plate 5: Spillway gates and EDA portion at Ghod dam

Plate 6: Retaining walls at tail channel

Plate 7: Columnar jointed basalt at tail channel

The natural stream of the river ghod was diverted to the present dam axis. The area comprises with the basaltic terrain where lots of deformations are marked by the tectonic activity. This activity reflects the overturning of the columnar basalt, the orientation of these columnar structured basalts are found to be irregular. Some were they appear to be vertical, inclined and horizontal too. The occurrence of Red Tachylytic and Green Tachylytic basalt is also observed during the site visit of the Ghod dam spillway.

Hard rock exposed in the tail channel is columnar jointed basalt (Plate 7) and volcanic braccia which is soft and altered. A number of retaining walls were constructed to resist erosion but majority of them collapsed (Plate6).

V.EXPERIMENTAL WORK

Due to the insufficient tail water depth, hydraulic jump may have tendency to sweep out from the apron portion (Plate 2). For that, location of hydraulic jump plays an important role in case of energy dissipation phenomenon. To avoid the erosion at tail channel, hydraulic jump should be restricted to the apron portion, so that energy dissipation should be maximum. Residual energy which is responsible for erosion of tail channel can be calculated by model study.

Table 1: Details of Bhama Askhed model:

Parameter	Prototype	Model
Height of Spillway (H)	21.2 m	0.424m
Width of Stilling Basin (B)	55m	1.1 m
Length of Stilling Basin (L)	75 m	1.5 m
Design Discharge (Qmax)	1736 m^3/sec	0.098 m^3/sec
20% of Design Discharge (Qmin)	350 m^3/sec	0.0196 m^3/sec
Range of Submergence Ratio (Sr)	0.15 To 0.25	0.15 To 0.25
Range of Froude Number (Fr)	12.8 To 5.7	12.8 To 5.7
Design discharge of single bay (Max.)	434 m^3/sec	0.024 m^3/sec
Design discharge of single bay(min)	87.5 m^3/sec	0.02 m^3/sec

Scale of model- 1:50

Plate 8: Image of model (BHAMA ASKHED DAM)

Plate 9: Jump formation in the model

VI.EXPERIMENTAL RESULTS

Table 2: Readings of model testing

Q (m^3/s)	Gate opening (m)	Y_1 (m)	Y_2 (m)	Y_t (m)	Y_2 Ideal	Fr_1	Et	ΔE_L
0.0196	0.015	0.095	0.20	0.105	0.31	2.69	0.436	0.0152
	0.030	0.102	0.205	0.115	0.33	2.62	0.453	0.0130
	0.045	0.105	0.215	0.125	0.34	2.63	0.466	0.0147
	0.060 (full open)	0.109	0.226	0.1302	0.35	2.62	0.484	0.0162
0.0214	0.015	0.108	0.219	0.13	0.327	2.47	0.438	0.0144
	0.030	0.11	0.225	0.132	0.33	2.50	0.453	0.0153
	0.045	0.112	0.231	0.139	0.347	2.52	0.468	0.0162
	0.060 (full open)	0.1197	0.246	0.14	0.36	2.464	0.481	0.0171
0.0242	0.015	0.118	0.236	0.140	0.334	2.33	0.478	0.0147
	0.030	0.128	0.249	0.145	0.34	2.25	0.454	0.0138
	0.045	0.13	0.255	0.1595	0.35	2.28	0.469	0.01472
	0.060 (full open)	0.135	0.279	0.163	0.37	2.27	0.478	0.01981

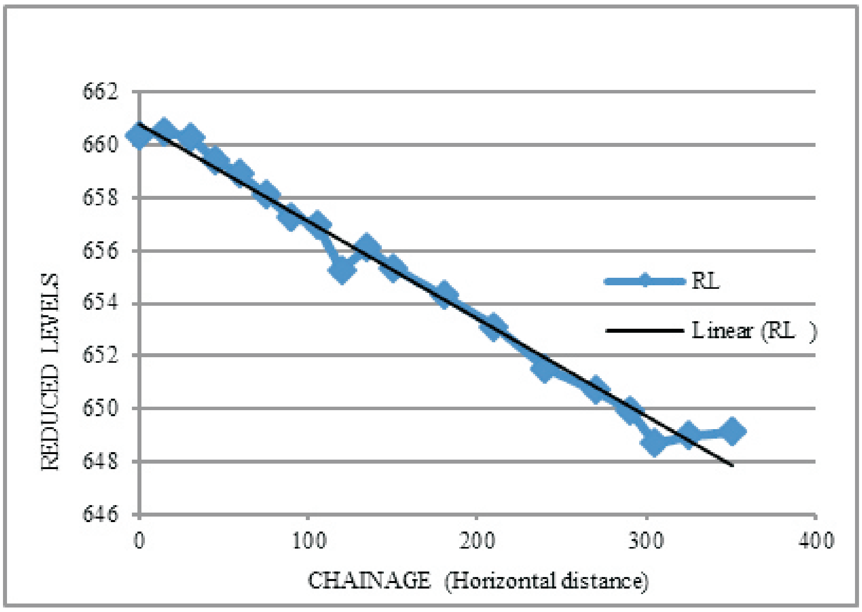
For different discharges Y_1, Y_2, Y_t is observed and residual energy (E_t) is calculated as shown in table 2.

VII.SURVEY AT TAILCHANNEL

Following table gives elevations (RL) at different points along tail channel of Bhama Askhed dam. From these values of RL, L section is plotted.

Table 3: Reduced levels at tail channel (Bhama Askhed dam)

Horizontal distance (m)	Reduced level (m)
00	663.175
15	660.48
30	660.325
45	659.465
60	658.925
75	658.125
90	657.265
105	657.02
120	655.295
135	656.125
150	655.365
180	654.315
210	653.120
240	651.555
270	650.725
290	649.95
305	648.71
325	650.465
351	649.115



Graph 3: L-section of tail channel

Comparison of Old L section and new L section is remaining. Survey at Ghod dam tail channel is very difficult due to rigorous erosion of the channel.

VIII.ELECTRICAL RESISTIVITY

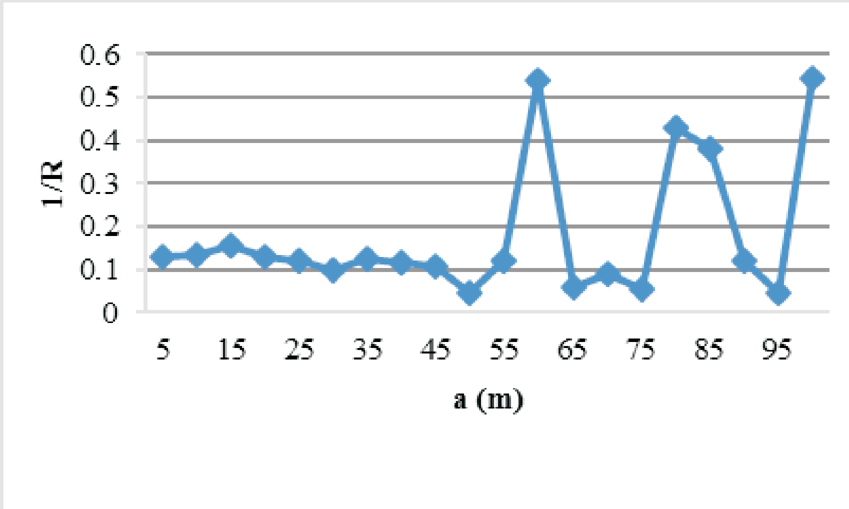
1.Electrical resistivity at Bhama Askhed dam and Ghod dam

Plate 10: ELECTRICAL RESISTIVITY instrument

Electrical resistivity method was difficult to use at tail channel due to the strata at both the sites. Therefore three readings were taken at Bhama Askhed dam along the dam axis and one reading at Ghod dam along its tail channel. Interpretation of this work is remaining. Sample reading is shown in table 4. From these readings graph 4 is plotted which will be helpful for further interpretation work.

Table 4: Readings of Electrical Resistivity at Ghod dam

SR NO	a	x Ohm	Mult-iplying factor	R	$2\pi a$	$2\pi aR$	1/R
1	5	7.7	1	7.7	31.429	242.0033	0.129
2	10	7.5	1	7.5	62.857	471.4275	0.133
3	15	6.5	1	6.5	94.286	612.859	0.153
4	20	7.75	1	7.75	125.714	974.2835	0.129
5	25	8.39	1	8.39	157.143	1318.43	0.119
6	30	10.29	1	10.29	188.571	1940.396	0.097
7	35	8.11	1	8.11	220	1784.2	0.123
8	40	8.5	1	8.5	251.429	2137.147	0.117
9	45	9.21	1	9.21	282.857	2605.113	0.108
10	50	2.16	10	21.6	314.286	6788.578	0.046
11	55	0.83	10	8.3	345.714	2869.426	0.120
12	60	1.86	1	1.86	377.143	701.486	0.537
13	65	1.73	10	17.3	408.571	7068.278	0.057
14	70	1.11	10	11.1	440	4884	0.090
15	75	1.9	10	19	471.429	8957.151	0.052
16	80	2.34	1	2.34	502.857	1176.685	0.427
17	85	2.64	1	2.64	534.286	1410.515	0.378
18	90	0.84	10	8.4	565.714	4751.998	0.119
19	95	2.21	10	22.1	597.143	13196.86	0.045
20	100	1.84	1	1.84	628.571	1156.571	0.543



Graph 4: Plot of a versus 1/R

Hydraulic aspects are important for the design and treatment purpose but geological conditions also plays important role in it. Suggestions to avoid future rock scour can be given only after completing above said tasks.

IX.REMAINING WORK

1.Comparison of old L section of tail channel with new L section.
2.Interpretation of Electrical Resistivity work.
3.Suggestions to minimize erosion of tail channel.

X.DISCUSSION

As the above project is a multi- disciplinary task which involves the different civil engineering aspects such as field survey work, Rock Mechanics, Hydraulic model study, Sub surface exploration work etc. so there are few difficulties in performing above task which are as follows.

- Rock erosion is a totally time dependent phenomenon, so analysis of breaking mechanism of rock in a laboratory is a difficult task at laboratory conditions.
- Techniques of sediment rock scour minimization (Splitter plates, Threaded piles, Use of Compound pier) are not applicable for this project work.
- Rock erosion is a typical phenomenon, so it can be minimized by adopting few techniques but can't be stopped in a permanent way.
- Field surveying work will be useful to determine average amount of rock erosion throughout the length of tail channel but we have only L-Shaped data of Bhama askhed dam, it won't be applicable for Ghod dam due to unavailability of data.

XI. ACKNOWLEDGEMENT

The first and 2nd authors of the paper are thankful to the Management and Administrative Officers of Sinhgad College of Engineering, Pune for their co-operation during the visits to the site. The first author is also thankful to the officers (Mr. Wayse-Deputy Engg, Bhama Askhed Division) of Irrigation Department, Government of Maharashtra, for providing permission to collect the data and

photo snaps during the field studies.

XII.REFERENCES

1.Mundhe, M. S., Kulkarni, S. R., and Hangekar, C. (2007): "Engineering geology in dam safety" ICOLD 75th annual meeting, Saint Petersbarg, Russia, June 24-29.

2.E. F. R. Bollaert (2005): "A Prototype scaled rock scour prediction model" Report to President Aqua Vision Engg. Ltd., Chemin des Champs - Courbes, Switzerland. pp 1269 – 1283.

3.Hinge G. A., Balkrishna S., Khare K.C. (2010): "Pawana Dam Energy Dissipation-A case study", AIBAS.

4.E. F. R. Bollaert (2004): "Scour prediction at Srisailam Dam (India), Aqua Vision Engineering, Switzerland.

5.T. D. Bhosale, G A Hinge & N. J. Sathe (2014): "Effect of Scouring in Basaltic Rock on Hydraulic Structures in the Vicinity of Pune Region" Paper Published in International Journal of Industrial Science, Vol. No. 1, Issue 5, ISSN: 2347-5420, PP 1 – 11.