MID-COURSE CORRECTIONS IN SIGNIFICANT PROJECT PARAMETERS DUE TO EXTREME EVENT OF FLASH FLOOD IN VISHNUGAD PIPALKOTI HYDRO ELECTRIC PROJECT (444MW), UTTARAKHAND, INDIA

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ABSTRACT

Vishnugad Pipalkoti Hydro Electric Project (VPHEP) is a run of the river scheme, located on river Alaknanda, spanning between Helong and Birahi Villages in Chamoli district of Uttarakhand, India. The Project envisages construction of 65m high Concrete Gravity Dam, three nos. underground Desilting Chambers of 390m length each, 13.4 km long Head Race Tunnel of 8.8m diameter, 3 km long Tail Race Tunnel of 8.8 m diameter etc.

During June 15 to 17, 2013, cloud bursts and heavy to very heavy rainfall hit higher reaches near to project. This unprecedented rainfall resulted in a sudden increase in water levels giving rise to flash flood in Alaknanda river basin, caused extensive river bed and toe erosion, landslides at various locations and huge transportation/deposition of sediments in downstream area. Flash flood had eroded the river bed profile significantly in dam area, affected the designed diversion arrangements - tackled by lowering of Inlet and Outlet levels & discharge capacity of Diversion Tunnel. Parallelly, this event led to some deposition at Power House area and caused steep rise in bed level. Immense quantum of silt got deposited in power house exploratory drift, huge deposits of silt and muck was left by river at Tail Race Tunnel outlet area also. All of this was tackled by reviewing the layout and design of structures elaborately. This paper describes the impact of furious extreme flood event on the project planning and how in the middle of construction, this was tackled.

1. INTRODUCTION

VPHEP is a run of river scheme under construction, across the river Alaknanda utilizing a gross head of 237m to generate 444 MW of power envisaging above mentioned structures. During detailed project report (DPR) stage power intake, desilting chamber, head race tunnel and power house are planned on right bank of the Alaknanda river while diversion of the river was planned through left bank (Figure 1).

Figure 1 : Location Map of Vishnugad Pipalkoti HEP.

The river diversion arrangements for the project envisages to divert the river through a 10 m diameter circular shape diversion tunnel of 497m length plus open cut portion of 65m which also includes the length of cut and cover duct on left bank of river Alaknanda, with two coffer dams oneat the upstream side of main Damwith top at EL.1242m while riverbed level of EL. 1228m and other on downstream side with top at EL. 1229m while river bed level of EL. 1224m. In this case, overtopping of cofferdams vis-à-vis over the constructed structure is considered permissible to the extent that at least 8 months construction period in a year must be available for construction of the proposed dam structure. With this in view, the river diversion system has been approved by Central Water Commission (CWC) for 725 cumecs which corresponds to 1 in 25 year non monsoon flood. The location of the inlet & exit portals and the alignment of the diversion tunnel have been proposed in the tender documents based on the geological investigations which were carried out initially for project. Gradient of river Alaknanda at VPHEP Dam & Power house is shown in Figure 2.

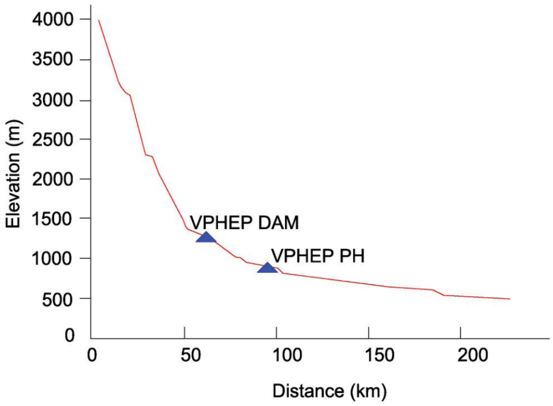

Figure 2 : L Section of river Alaknanda along with location of Dam & Power House of VPHEP

To access the underground powerhouse complex, invert level of Main Access Tunnel (MAT) and Cable cum Ventilation Tunnel (CVT) portal at EL 1066m and EL 1054m respectively were finalized during DPR stage.

2. GEOLOGICAL SETUP OF THE PROJECT AREA

The project is located in the tectonic window known as Pipalkoti Window (Carbonate suite of Chamoli) exposing Lesser Himalayan meta-sedimentary rocks enveloped by low to medium grade metamorphic rocks of Higher Himalaya. The Higher Himalayan crystalline rocks thrust over the Lesser Himalayan rocks along a major tectonic shear known as the Main Central Thrust (MCT) Zone, about 2 km upstream of Dam (Figure 3).The rocks of window zone are grouped under the Garhwal Group represented by low-grade quartzitic sandstone, dolomitic limestone and slates with metabasic sills and dykes. The rocks of the project area are folded in a wide open regional domal structure known as the Pipalkoti Anticline, which is intersected by a number of faults complicating the structural setup.

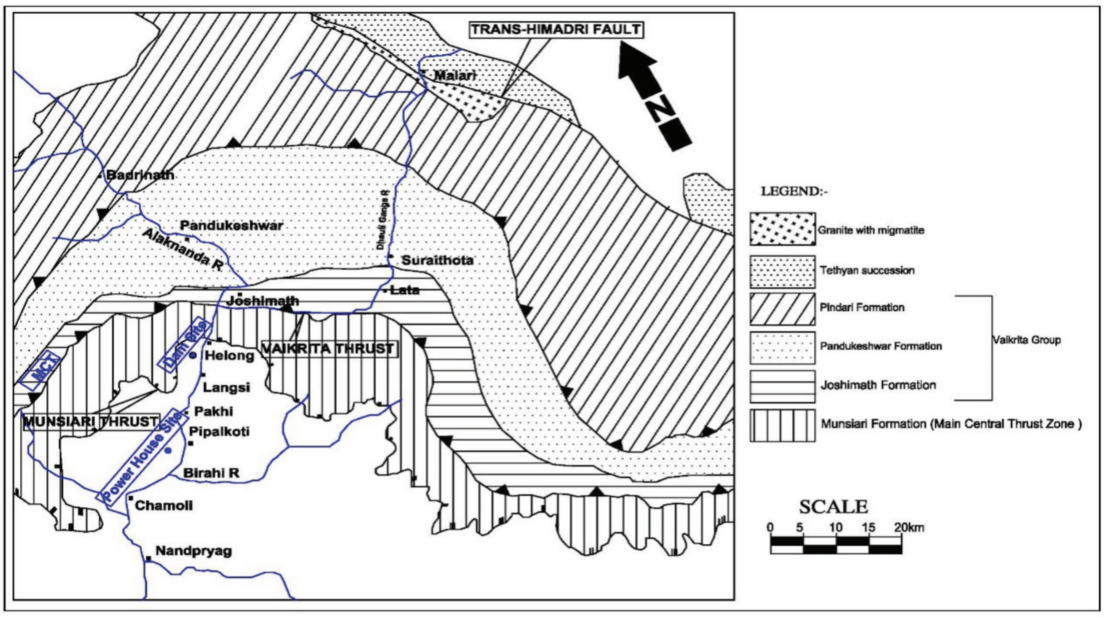

Figure 3 . Regional geological map of VPHEP area (after Valdiya).

At Dam site, the left bank on which river diversion planned, comprises of quartzite rockmass with bands of amphibolite overlain by river borne material along with slope wash material in diversion tunnel area (Figure 4). The upstream cofferdam is located on alluvial materials more than 20m in depth. Diversion tunnel has been driven through quartzite with bands of amphibolite, characterised with moderately steep foliation and three other set of discontinuities. The rockmass condition along the diversion tunnel varies between Class II (193m) and Class III (255m) of RMR with a very small patch of Class IV. Power House complex has encountered mainly the Pipalkoti Formation of Garhwal Group consisting of slates, alternate bands of slate & dolomite with different set of discontinuities and folding within the Pipalkoti Formation. There is a narrow gorge section just downstream of power house exploratory drift / MAT & CVT portal which leads to ponding of the river in the vicinity during rainy season.

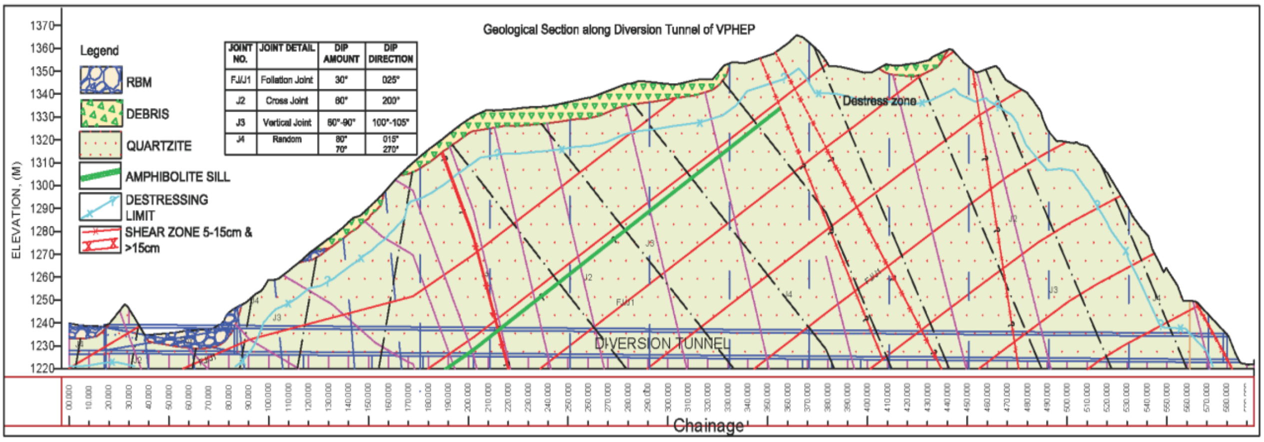

Figure 4 : Geological section along Diversion Tunnel

3. IMPACT OF EXTREME FLOOD EVENT ON DIFFERENT STRUCTURES DURING EXECUTION

In June 2013, a multi-day cloudburst and heavy to very heavy rainfall hit several parts of the higher reaches within the State. This unprecedented rainfall resulted in a sudden increase in water levels giving rise to flash floods in the Alaknanda and other river basins and also caused extensive river bed and toe erosion, landslides at various locations and huge transportation/deposition of sediments in downstream area. This extreme flood event caused deposition of debris at various locations (Power House area) of project resulted rise in river bed level and at places caused erosion which eventually lowered the river bed level in dam area.

3.1 Dam site

After June'2013 extreme flood event, revised cross-sections were taken to assess the latest river bed profile. A review of fresh cross sections indicated that there is a substantial level difference in the river bed levels at the inlet and the outlet of the diversion tunnel. The levels of river bed after flood event are EL.1222magainst EL.1228 m at inlet and EL.1214 m against EL.1224 m at outlet (Figure 5 and 6).

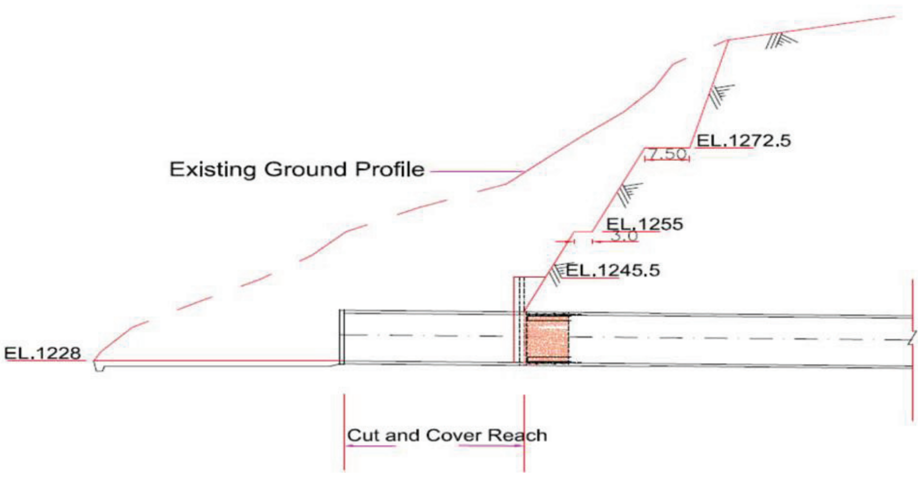

Figure 5 : Section at DT Inlet during Tender stage before flood.

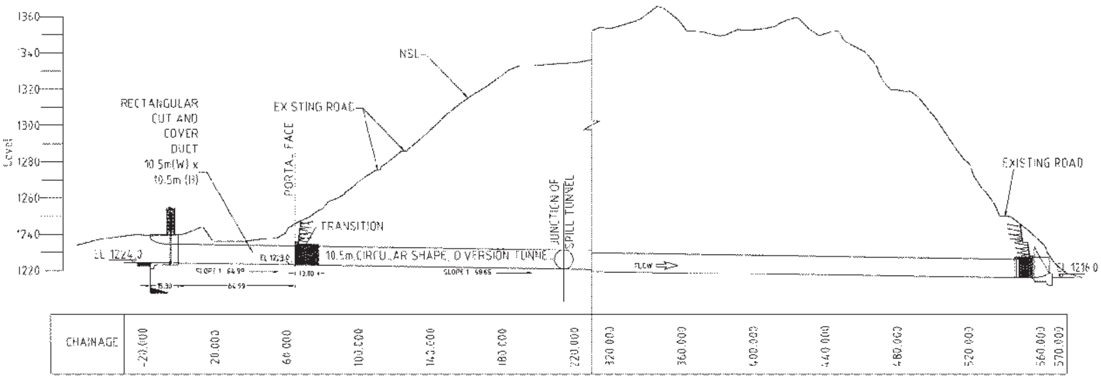

Figure 6 : Section along DT after flood.

As per the Techno Economic Clearance (TEC), approved DPR/ Tender documents, the top of the upstream coffer dam was proposed at EL.1242.0m with a diversion tunnel diameter of 10m. As per the studies, the hydraulic capacity of the proposed system is inadequate due to lower level of river bed after flash flood. The capacity of the system had to be enhanced by either increasing the diameter/shape of the diversion tunnel or inlet level etc.

Proposed coffer dam was a semi-permanent gravity structure resting on the overburden hence it will not be desirable to place a gravity structure (temporary) of more than 15-16m high on this type of material.

It was evident to raise the height of U/s Coffer dam, if not the invert levels of Intake & Outlet structures are reviewed, which had been located on alluvial materials more than 20m in depth. Having further more height of coffer dam over such alluvial material was not at all suitable. This event compelled to review the diversion scheme thoughrolly in totality. Revision was required to release the required discharge.

With these considerations in view and to limit the heading up of water at upstream coffer dam, it was evolved to increase diameter of circular diversion tunnel upto 10.5m with supercritical flow conditions and impounding water level at upstream and downstream of coffer dams at El. 1238.23m and EL.1219.6m respectively. The top of the U/s and the D/s coffer dams have accordingly been adopted at EL 1239.0 and EL 1220.50m respectively indicating a height of 17m for the U/s coffer dam and 6.5m for the D/s coffer dam. Consequently, the invert of diversion tunnel was also lowered to El. 1224.0 M against El. 1228.0 M and El.1216m against El. 1224.0 M at inlet and outlet respectively.

3.2 Power House site

After June'2013 extreme flood event, revised cross-sections at Power House area were taken to assess the latest river bed profile.

During extreme flood event, the level of river Alaknanda went above the exploratory drift in the vicinity of power house area. Immense quantum of silt got deposited in power house exploratory drift for a stretch of more than 400m. Intensity of flood was so high that trolleys, exhaust fans and jack hammers etc. were washed away with the flood water. The drift had been inspected after lowering of flood water and observed that fine silt & sand is filled up to a height of 1m (Figure 7).

Figure 7 : Silt deposited in exploratory drift of Power House during flood event of 2013

The crate walls along with the drift muck have also been washed away with the water. During detailed engineering, probable maximum water level (level corresponding to PMF of 10840 cumecs) in river Alaknanda at location of MAT and VT is recalculated to ensure that invert level of MAT and VT are at a safe elevation. After detailed deliberations and reported discussion as well as taking into cognizance on the recorded data, it was decided that it would be appropriate to consider the invert level of 1075m as safe level for MAT and VT against portal at El 1066m and El 1054m respectively considered at tender stage.

Further, due to heavy river borne material accumulation along the right bank of the Alaknanda river near Tail Rail Tunnel(TRT) outlet, river channel drifted its course towards the left bank. At Gauge& Discharge site, cable way system and gauges etc. got washed away due to heavy flood and drifting of river towards left bank. The water level near TRT outlet touched ±1031m. This change in river bed profile also changed the morphometry of junction of Alaknanda and Birahi. Such changes in river bed profile compelled to review the flood protection arrangement and accordingly flood protection arrangements modified considering the existing river bed morphology after flood event of 2013.

4. CONCLUSION

Extreme flood event of June 2013 changes the river bed profile significantly in dam area as well as Power House area of project which affected the designed levels of various portals/inlets at DPR stage. The changes in river bed profile accommodated, by limiting the height of coffer dam as earlier, by lowering of Inlet and Outlet levels of Diversion Tunnel and increasing the size of Diversion Tunnel (finished diameter revised from 10 m to 10.5 m) to accommodate the water levels behind coffer dam. Gradient of tunnel has also been increased to ensure super critical flow (free flow conditions). Similarly, invert of MAT and CVT were relocated at higher elevation to protect from the events like of 2013. These changes due to extreme flood event also influenced the time and cost of the tunnel from what was planned in DPR/ Tender stage.

REFERENCES

Appraisal Note, 5th Project Review Panel, VPHEP, THDCIL.

Assessment of Cumulative Impact of Hydropower Projects in Alaknanda and Bhagirathi Basins, AHEC/2011.

Assessment of Environmental Degradation and Impact of Hydroelectric projects during the June 2013 Disaster in Uttarakhand, committee report submitted to Ministry of Environment and Forests Government of India.

Geotechnical Baseline Report (GBR), VPHEP Version 6.2, THDCIL.

Valdia K.S., 25 June 2014. Damming rivers in the tectonically resurgent Uttarakhand Himalaya. Current Science, vol. 106, no. 12: 1658-1668.

Vishnoi R.K.,Singh Gajendra, Kumar Ajay, Vishwakarma P., Impact of Extreme flood event on Planning and Execution of Diversion Tunnel - A case study of Vishnugad Pipalkoti HEP -THDCIL, EGNM 2015, India.