Construction of Head Race Tunnel of Vishnugad - Pipalkoti HE Project (444MW) in Extreme Geological Conditions: Issues and Challenges - A Case Study

by

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INTRODUCTION

Vishnugad Pipalkoti HEP with the installed capacity of 444 MW is one of the major ongoing Hydro Electric Projects envisaged to harness the huge potential of river Alaknanda. The Project shall utilize about 240 m of water head of the Alaknanda River, available in a stretch from Helong in Upstream to Birahi in Downstream. It Is a Run- of- the river (ROR) scheme using a diurnal storage.

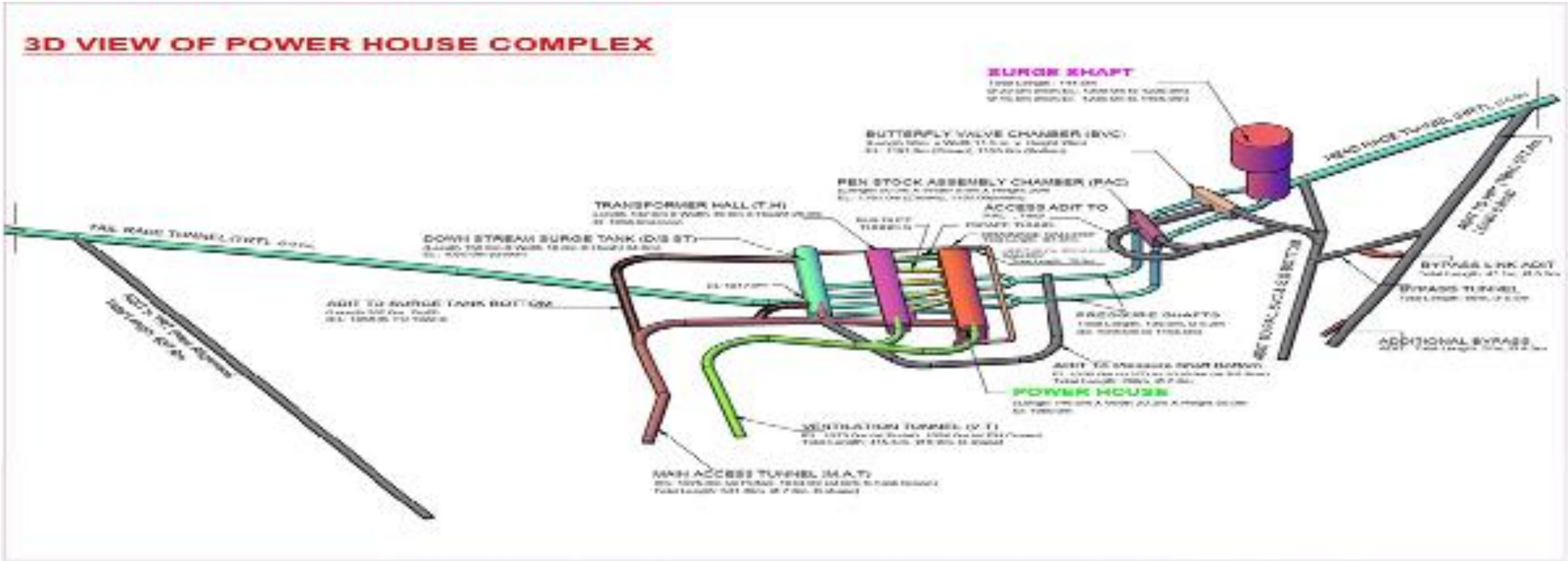
- The Main components of the project are as below:

- Concrete Gravity Dam of 65 m height with four under sluices for passing 8004 cumecs of flood discharge.
- Three Power Intakes followed by 03 Desilting chambers each with a size of 390 m (L) x 20 m (W) x 17.5 m (H).
- One Head- Race- Tunnel of 8.8 m finished dia and 13.5 Km length, to be bored with the TBM and DBM methods.
- An underground Machine Hall sizing 146 m (L) x 20.3 m (W) x 50 m (H).
- An underground Transformer Hall measuring 142 m (L) x 16 m (W) x 24.5 m (H).
- An underground Surge tank measuring 120 m (L) x 16 m (W) x 35 m (H)
- One Tail Race Tunnel of 8.8 m finished dia and 3.07 Km length.

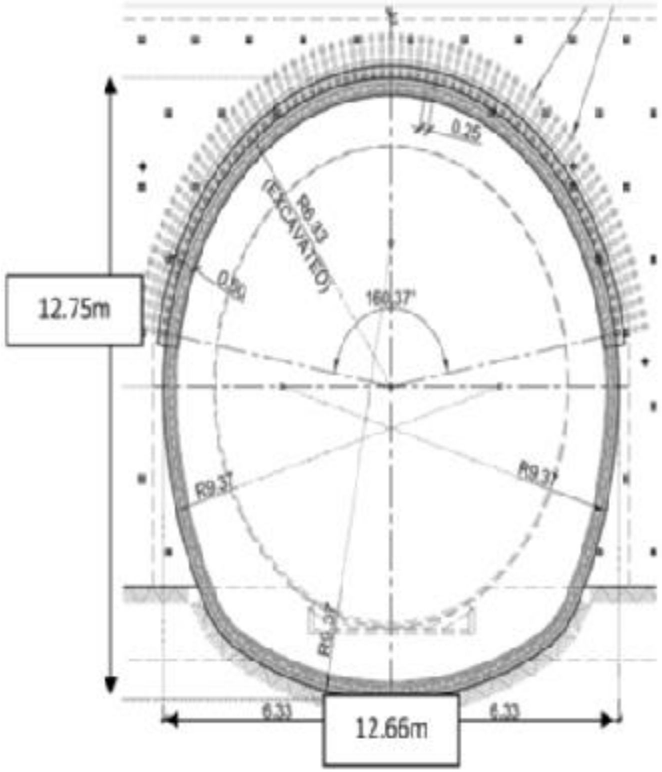
Length by TBM	12.3 km
Tunnel Slope	1: 321; 1: 131
Tunnel cover	Minimum: 50 m Maximum: 825m
Typical section	Precast lining 8.8 m Dia

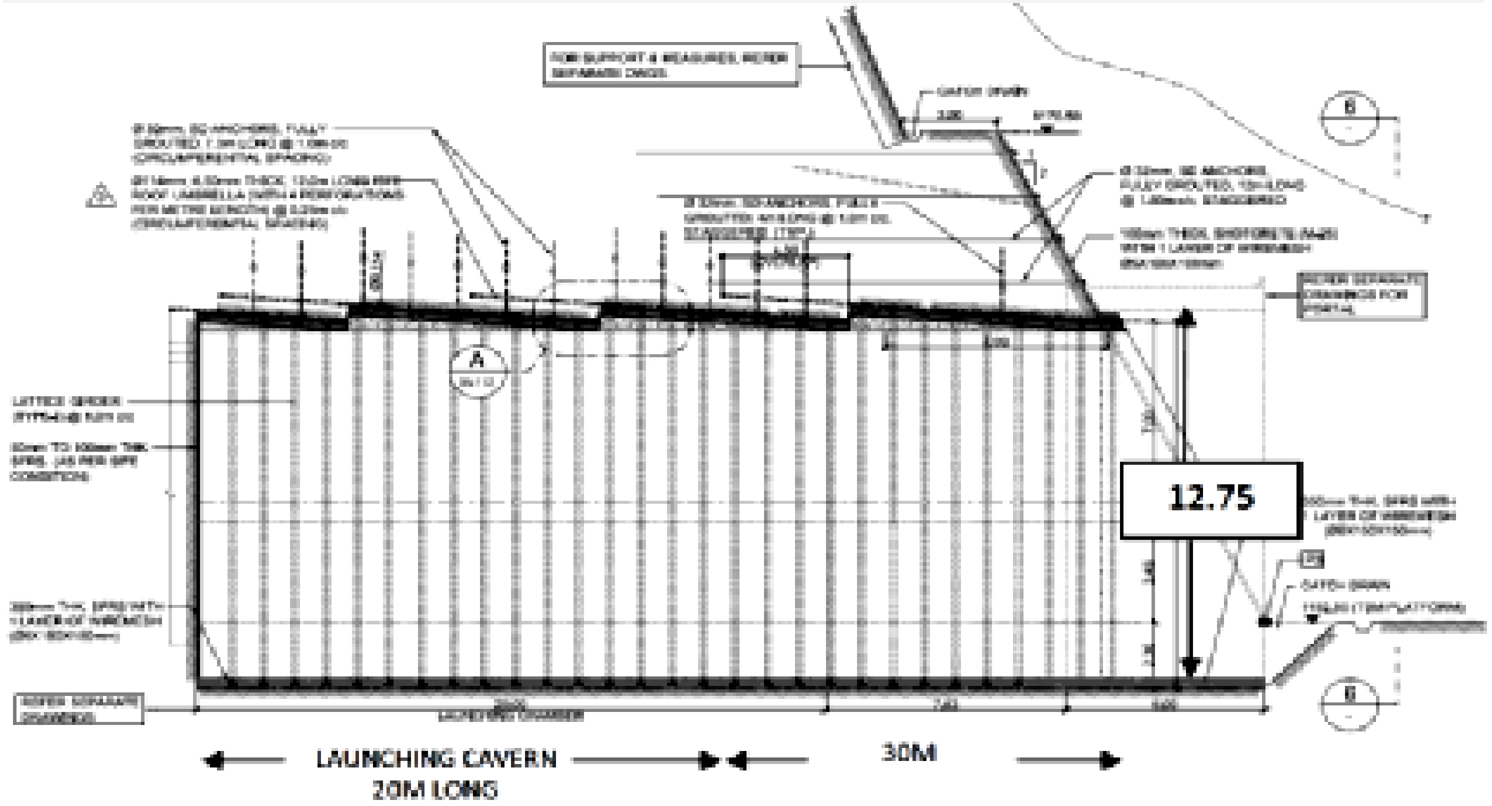
It plans out an excavation of a 12.3km of Head Race Tunnel using the Double Shield Unit Rock Terratec TBM. The HRT is proposed to be bored from the Surge -Shaft end of the HRT and will move up the slope towards the Dam-site end of the HRT.

Layout of Vishnugad Pipalkoti Project in Uttarakhand, India



Cross-sectional details of Adit and DBM Adit portion of TBM adit





GEOLOGY ALONG THE TUNNEL ALIGNMENT

PIPALKOTI FORMATIONS									
			LIMESTONES	SLATES	THRUST ZONES	FAULT ZONES	SHEAR ZONES	TOTAL METERS	TOTAL %
LENGTH		m	4098	7882	50	70	200	12300	
		%	33,32%	64,08%	0,41%	0,57%	1,63%		100,00%
RMR	81-100	I	0	0	0	0	0	0	0,00%
	61-80	II	1801	5836	0	0	0	7637	62,09%
	41-60	III	2297	2046	0	0	0	4343	35,31%
	21-40	IV	0	0	50	70	200	320	2,60%
	1-20	V	0	0					
UCS Mpa	0,25-1,0	EXTR. WEAK	0	0	50	70	200	320	2,60%
	1,0-5,0	VERY WEAK	0	0					
	5,0-25	WEAK	121	0	0	0	0	121	0,98%
	25-50	MOD. STRONG	954	1127	0	0	0	2081	16,92%
	50-100	STRONG	939	5068	0	0	0	6007	48,84%
	100-200	VERY STRONG	2084	1687	0	0	0	3771	30,66%
	>250	EXTR. STRONG	0	0	0	0	0	0	0,00%

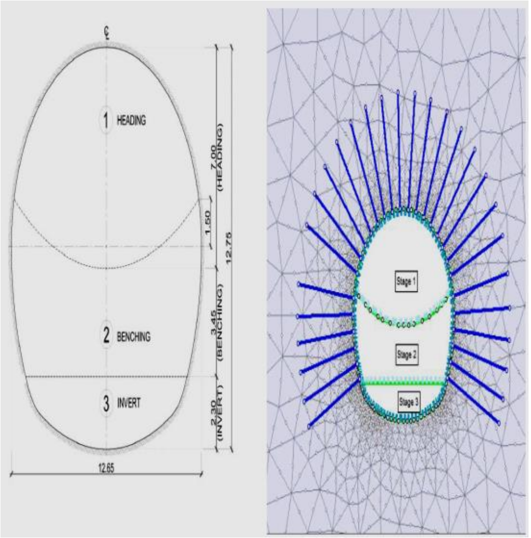
TBM TRANSPORTATION, CONSTRUCTION OF LAUNCHING ADIT CAVERN, AND ERECTION.

Transportation of TBM to site

Transporting such a large -dia TBM to the project site was a difficult task in and of itself. Several issues arose, as detailed below:-

- More than 132 containers containing various TBM parts had to be transported to the site 225 kilometres away from Rishikesh yard using 8-10 transporting companies.
- Transporting in such steep terrain was tough because stretches were very narrow, and for safe transit the trailer, JCB, hydra cranes and loading equipment were always ready to meet with any eventuality.
- Despite these safeguards, one container carrying a cutter-head bearing slipped. It was first brought to THDCIL's Tehri workshop, and after checking, it was transported to VPHEP TBM site.
- During the day, convoy progress was prohibited because of the Char Dham yatra, border supplies and constant military convoy movement. As a result, transporting the TBM parts to the site took more than three months.

Construction of Launching Adit

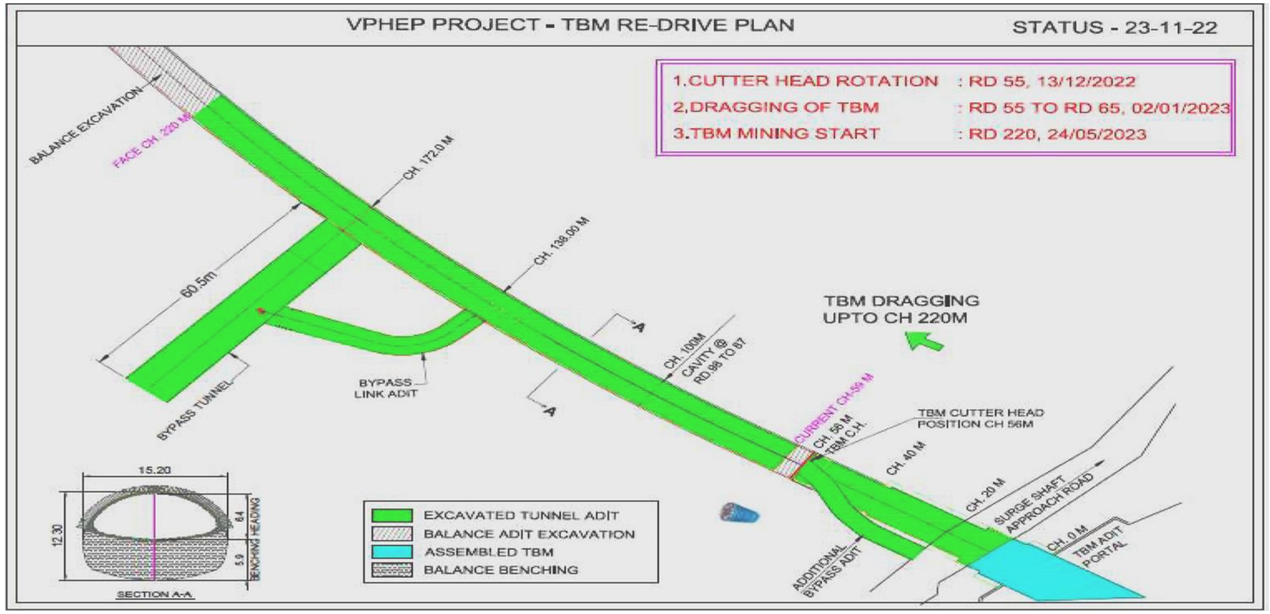


- The geology in the early stages of the TBM Adit was discovered to be exceedingly poor, consisting of Clay with Quartzite Boulders. Thus, it was suggested to build the Adit using the Conventional Drill and Blast Method (DBM) until the right geological strata were met before launching the Double Shield Unit (DSU) Tunnel Boring Machine (TBM).
- Based on geological and geophysical investigations, this DBM segment of the Adit was calculated to be around 50m inside the hill.
- It was decided to build the adit as a shell structure with Self Drilling Anchors and Lattice Girders in a 350 thick SFRS layer.
- The Adit was excavated in three phases, with each heading of 7m being followed by benching Cross section in two benches.
- The crown was supported by a 114mm diameter pipe roofing throughout the excavation of the heading. FRP bolts/SDA anchors and facial SFRS helped to keep the face stable.
- After completion of the excavation, in-situ, 20m long RCC lining was fixed near the face of the Adit for launching the TBM.

FAILURE OF TBM LAUNCHING CAVERN

- Following TBM erection, it was driven within the adit cavern by placing below the bottom-precast- segment and rail lines.
- The boring began by mobilising the cutter head after taking it 50m inside, towards the face. As planned, it rose to 7m and muck was discharged via conveyors. The entire team was overjoyed with the outcome.
- Suddenly, we noticed numerous large, isolated rocks more than 1m3 in size making a lot of noise against the cutter head.
- The Technical team had to open the cutter head's shutter after discovering that so many large rocks had built up in front of the cutter head.
- The entire strata was RBM, with sand layers surrounding it. Lot of seepage observed at the face.
- Thorough dewatering system was installed to remove the water.
- It was decided to halt the boring and take corrective action to clear the pebbles from the face.

RECTIFICATION OF FAILURE OF TBM ADIT



- Site team comprising THDCIL, HCC, and consultants chose to build an additional bye pass adit to reach the face.
- This was done to clear the boulders and strengthen the face and crown.
- One bottom adit was also suggested to reach the core of the TBM adit to determine the exact geology , so that the TBM could be begun as soon as possible, eliminating all uncertainties in the operations.

RECTIFICATION OF FAILURE OF TBM ADIT

CONSTRUCTION OF ADDITIONAL BYE-PASS ADIT AND BOTTOM ADIT

- To reach the location ahead of the TBM cutter head at RD140m, it was determined to build an additional bye-pass adit (ADA) directly above the current TBM adit and a bottom adit through the access adit for surge shaft.
- We were able to reach the face and clear the damaged pipes used in fore-poling and stones piled up in front of the cutter head.
- The face was treated with chemical grouting with microfine cement and colloidal silica to repair the face.
- After strengthening the ADA face and crown, the bottom adit excavation operations began with the goal of reaching RD140m of the TBM adit's 200m weak stratum reach.
- Fortunately, we discovered a soft rock line strata in lieu of the RBM strata at the confluence of the bottom adit and TBM adit at RD140m.
- At this point, we tried on two faces and continued to strengthen them both directions at the crown with fore-poling and 114mm-dia pipes.
- The face towards the TBM cutter-face area received the most attention. Finally, TBM adit was successfully finished and TBM Pushed to front face and started boring successfully.

CONCLUSION

The geology of the Himalayas is unpredictable, and some scientists believe that TBM tunnelling is not feasible in this location. However, the VPHEP team has learned a lot from this setback and **Finally started TBM boring in the HRT successfully**.

We were successful in the Kishan Ganga Project, where similar geology was encountered for boring a 14km long stretch using the TBM, and our team completed the project effectively. With this hindsight, we recommend that before beginning any TBM project in the Himalayan region, the following issues be considered:

- Proper rock geology examination and mapping of the area.
- The area's logistics and the state of the access routes
- Arrangement of specialised personnel
- Automation of equipment installation and development of casting yards and stockpile areas working crew training.
- In-house developments based on site conditions
- Client, contractor, and consultant cooperation and coordination
- Collaboration with a singular emphasis on project completion.

THANK YOU FOR YOUR ATTENTION