CHAPTER - 4

Survey, Geo-technical Investigation and Investment Approval

Geo-technical investigation for a hydro project needs to be undertaken with adequate understanding of the local and regional environment as it significantly impacts the design, construction and operation of the hydro power projects. The data thus collected through geo-technical investigations should have detailed description of the geological situation and assessment of the history of the site for appropriate engineering drawing and design.

Policy on Hydro Power Development 1998 envisaged inter-alia thorough survey and investigation of the potential hydro sites on an advanced scientific basis before preparation of detailed project reports. Planning Commission, while finalising the XI Five Year Plan also emphasized on the necessity of bankable Detailed Project Reports, which should be based on a detailed survey so as to avoid geological uncertainty. COPU also while conducting (December 2008) horizontal study of power generating companies observed that advanced technology is yet to become part of Indian practice which indicates importance of the geo-technical studies.

Audit examination disclosed the following inadequacies in the geotechnical survey and investigation.

4.1 Gaps in survey and investigation

Drilling is one of the important techniques of survey and investigation apart from other techniques like Topographic mapping, survey, Geomorphological mapping, Geotechnical mapping, Sluicing, etc. The main objective of drilling is to use the knowledge obtained from surface mapping to provide control for the interpretation of any geophysical investigations and to provide access for test equipment *e.g.* for measurement of water levels, pore pressures and permeability, etc.

4.1.1 Inadequate survey

Survey and investigation activity which underpins the effective designing of the hydro projects was not properly taken up by the CPSEs as is brought out from the following audit analysis.

NHPC Limited

- Out of total expenditure of ₹263.72 crore under the head survey and investigation, only ₹63.10 crore (24 *per cent*) was incurred on actual survey and investigation activity of 11 projects while the balance 76 *per cent* was spent on establishment expenditure. The project-wise percentage of establishment expenditure ranged from 26 *per cent* to 93 *per cent*. Thus, it is evident that only a small portion of allocated funds was utilised on actual survey and investigation activities. Resultantly, there was a variation between the rock classes[38] envisaged in DPR and classes actually encountered during excavation in respect of all projects due to inadequate survey and investigation.

  Ministry/NHPC Management stated (March 2012) that reasons for higher establishment cost are (i) prolonged establishment set up even after submission of DPRs waiting for the necessary clearance from the respective authorities and (ii) NHPC does most of the investigations in-house i.e. survey, drilling, geological mapping, geophysical survey, construction materials survey, etc. Further, rock classes as given in DPRs or in tender documents are for the estimation of rock supports so that the quantities are prepared in a scientific manner.

  Ministry/Management's reply corroborates the Audit observation regarding higher establishment cost *vis–a-vis* survey and investigations which is necessary for preparation of DPRs. The stand regarding variation in the rock classes is also not justifiable as bill of quantities is prepared and included in the tender documents based on available survey and investigation reports and the prospective bidders quote for a particular package based on such data.

- In case of Parbati-II project, DPR provided for back hill slope stabilization[39] of Power House, shotcrete[40] and rock bolting. However, due to measures in the DPR not being adequate, the back hill slope failed thrice and was finally stabilized by additional work involving 842 cable anchors of 35 meter length, 2324 rock anchors of 12 meter length, 469 pre grout hole of 15 meter length and

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[38] ***Class-I (Rock Mass Rating above 80%), Class-II (Rock Mass Rating between 60 to 80%), Class-III (Rock Mass Rating between 40 to 60%), Class-IV (Rock Mass Rating between 20 to 40%) and Class-V (Rock Mass Rating below 20%)***

[39] ***In case of surface power house, it is necessary to stabilize the back hill slope in order to avoid any eventuality in future by way of suitable measures viz. shotcrete, anchors, bolts, etc.***

[40] ***Shotcrete is concrete (or sometimes mortar) conveyed through a hose and pneumatically projected at high velocity onto a surface, as a construction technique.***

712 pressure relief holes of 10 meter length. This not only resulted in additional expenditure of ₹59.88 crore but had other consequential impacts like delay of 44 months in completion of Power House package and contractual claims of ₹71.27 crore in respect of Electro-Mechanical contract on account of extended warrantee charges, idling claims, additional amount as agreed and additional price variation.

Back hill slope stabilization of power house of Parbati-II

NHPC Management stated (October 2011) that as per standard practice, the design adopted for back hill slope was based on geological information which could be gathered at the DPR stage. The design was further revised considering site conditions/geological conditions by providing additional strengthening measures.

Management's reply corroborates the audit observation that DPR was prepared on the basis of inadequate data as even the stabilization process of back hill slope failed thrice. Records also revealed that design opted for back hill slope stabilization was revised as measures recommended in the DPR were inadequate.

Ministry/NHPC Management stated (March 2012) that Parbati-II surface power house was investigated by detailed geological mapping, geophysical survey, three drill holes and two long drifts and rock mechanic tests.

The reply is not justified as the back hill slope of Parbati-II project failed thrice, as a result of which NHPC had to incur additional expenditure of ₹59.88 crore and face claims of ₹71.27 crore besides delaying the power house completion by 44 months. Non inclusion of appropriate measures for stabilization of back hill slope in the DPR resulted in the extra expenditure, claims and time overrun.

SJVN Limited

In the execution of Naptha Jakhri Hydro electric Project (1,500 MW) in the Himalayan range, the Company faced many geological surprises like collapse and rock falls, heavy ingress of water under artesian conditions. Notwithstanding this specific experience, the Company did not focus adequately on survey and investigation pertaining to their Rampur project in the same region due to which eight geological surprises[41] and wide variations in the rock classes[42] were encountered during project execution which impeded the project execution and delivery schedules by 18 months with a cost overrun of ₹184.49 crore (in both Package-I and Package-II). Out of this, cost overrun of ₹13.64 crore was due to:

- Introduction of additional Adit at Kasoli between Khunni and Goshai Adit at a cost of ₹5.20 crore.
- Change in the scope of work due to increase in depth of surge shaft from 128 meter depth to 149.5 meter, resulting in extra cost of ₹8.44 crore.

Ministry/SJVNL Management stated (October 2011 and March 2012) that introduction of Kasholi Adit was necessitated due to encountering of adverse rock conditions. It further stated that very poor rock mass quality near bottom of surge shaft was encountered. The Ministry further stated (March 2012) that for the purpose of surge shaft, three holes were carried out and a total depth of 159 meters was explored.

The reply is not tenable as adequate survey would have prevented the variations. Despite drilling up to 159 meters at investigation stage, failure to correctly assess the geological conditions led to increase in depth of surge shaft to 149.5 meter from original 128 meter.

4.1.2 Geological surprises due to inadequate drilling

Despite Policy on Hydro Power Development of GOI (1998) emphasized for thorough survey and investigation of potential hydro sites on an advanced scientific basis before preparation of DPRs, NHPC and SJVNL did not focus adequately on the

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[41] ***Reasons of geological surprises were ingress of heavy water seepage, cavity formation, gradual collapse of tunnel, shear zone, etc.***

[42] ***During excavation in HRT, 35.64 per cent of class I to III rock and 64.36 per cent of class IV & V rock was encountered against 62.5 per cent and 37.5 per cent respectively envisaged in the DPR.***

critical activities of project survey and investigations. Although, NHPC was incorporated in November 1975, it did not have any in-house guidelines up to December 2006 for survey and investigation. No norms for drilling holes along the head race tunnel were prescribed. In January 2007, NHPC issued guidelines which provided a norm of drilling at least one hole after every 1,000 meters along head race tunnel (HRT) alignment.

Audit examination revealed that in the absence of norms, for nine of the 16 projects selected, drilling of holes for the HRT alignment during survey & investigation in the projects was significantly less as these CPSEs[43] drilled only 0 to 4 holes along the length of 4 to 31 Km of the HRTs as below:

Sl. No.	Name of the project	Length of the HRT as per DPR (in kms.)	Desired numbers of drill holes	Actual number of holes drilled during survey & investigation	Expenditure incurred on extra items of work (₹ in crore)
NHPC Limited					
1.	Parbati-II	31.20	31	3	72.95
2.	Parbati-III	7.98	8	2	21.85
3.	Chamera-III	14.70	15	1	5.46
4.	Teesta-V	17.78	18	2	28.95
5.	Subansiri Lower	7.12	7	2	77.36
6.	Sewa-II	10.00	10	4	0.98
7.	Uri-II	4.27	4	2	4.83
8.	Chutak	4.32	4	0	Not furnished
				Total	**212.41**
SJVN Limited					
9.	Rampur	15.08	15[44]	3	184.49

The maximum depth of the holes drilled was only around 60 metres whereas the HRT was constructed way below this depth ranging between 29 metres to 1550 metres. Insufficient drilling in terms of number as well as depth of the holes resulted in NHPC encountering 58 'geological surprises'[45] during execution of three projects[46] which took up to 20 months to be resolved and consequently impacted the project delivery

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[43] ***There was no HRT or required numbers of holes were drilled in remaining projects of NHPC and THDC.***

[44] ***Based on best industry practice (i.e. NHPC Limited)***

[45] ***20, 16 and 22 geological surprises like cavity formation and water ingress, collapse or loose rock fall, etc. in Teesta-V, Sewa-II and Parbati-III projects.***

[46] ***Further, data in respect of remaining five projects was not maintained by NHPC.***

schedules. Similarly, eight 'geological surprises' were encountered in the execution of Rampur project of SJVNL for which up to about 5 months were taken for rectification. Consequently, NHPC and SJVNL incurred extra expenditure of ₹396.90 crore on extra items of work due to geological surprises.

NHPC, while appreciating the need to encourage as much drilling as possible on long tunnels, expressed (October 2011) difficulty in following their own norms of one hole at every 1,000 metres in the rugged terrain of Himalayas with superincumbent cover and inaccessibility. However, there is no justification for drilling only 0 to 4 holes over the total length of 4 Km to 31 Km tunnels of the projects and NHPC needs to ensure compliance to the norms meant to reduce the geological uncertainties. Ministry/NHPC Management appreciated (March 2012) the concern of Audit regarding more drilling on long tunnels and stated that NHPC is striving hard in arduous terrain to achieve the norms set by it.

Ministry/SJVNL Management stated (October 2011 and March 2012) that required and feasible geological investigations were carried out as 17 holes have been drilled covering maximum length of HRT. The reply is not acceptable as only three holes were drilled along HRT alignment against the requirement of 15 holes as evident from the DPR. Drilling of remaining holes after preparation of DPR reflects inadequacy at DPR stage itself and which further forms the basis for determining the Bill of Quantities.

4.2 Selection of inappropriate technology

Tunnel Boring Machine (TBM) methodology for excavation in a 9.05 km stretch of Head Race Tunnel (HRT) between Adit-1 and Adit-2 in Parbati-II project was adopted by NHPC for timely completion of the project. Various concerns were expressed on the TBM as under:

- Geological Survey of India suggested (December 2000) that properties of Manikaran Quartzites may turn out to be problematic lithology for TBM to handle as was the experience in case of Dul Quartzites at Dulhasti project.

- Central Water Commission (CWC) suggested (November 2000) that TBM could be avoided without affecting the project commissioning by appropriately aligning the Adits and by undertaking excavation of Adit and Head Race Tunnel (HRT) by drill and blast method as well as concrete lining and grouting of HRT as parallel activities. CWC had also warned that with available geological information for TBM reach, delays on account of problems during TBM tunneling could be significantly more.

- MOP consistently advised (January 2002) NHPC that single technology should not be specified in the tender documents. Tender documents should specify the task to be achieved and the time frame instead of specifying the technology.

Audit observed the following:

- TBM technology was selected even after concerns expressed by various authorities. Before taking a decision to deploy TBM, suitability of rock for functioning of TBM was not established as all geological information was based on surface mapping and no drills or drifts were carried out in view of huge forest cover.
- PIB memo stated (May 2002) that use of 'TBM or any other technology' should be specified in the bid document for excavation of the portion of HRT instead of restricting the choice to only one technology. Against this, NHPC in its bid documents spelt out the use of only TBM to the contractor which was not in consonance with PIB's concerns.
- Decision to adopt TBM by ignoring the suggestions of various authorities was not judicious and TBM got stuck (November 2006) after tunneling only four kms and since then progress of the work has been adversely affected due to various consequential technical and contractual issues discussed in Para Nos.6.2(c) to 6.2(e). Ultimately, NHPC terminated (March 2012) the contract of the above works and new contract is yet to be awarded (June 2012).

NHPC Management stated (October 2011) that most of DPR studies were mainly based on surface geological mapping and remote sensing and all the investigations and testing required for geotechnical assessment were conducted before the use of TBM technology. Further, the problem of water ingress in HRT occurred in the area in which it was impossible to approach by a drill hole from surface. Therefore, keeping in view these difficulties, core drilling/probe drilling during construction from the tunnel face was recommended.

As accepted by the Management, DPR was mainly based on surface geological mapping and remote sensing. It only corroborates the fact that suitability of rock for functioning of TBM was not established before taking decision to deploy TBM. Further, if drilling from surface was not possible, NHPC could have explored the possibility of deploying alternate appropriate technology which would work in mixed geological conditions.

Ministry/NHPC Management further stated (March 2012) that due to the high forest cover and inaccessibility particularly in TBM portion, direct explorations by drilling could not be conducted. Further, Ministry/Management added that TBM technology

was kept in the tenders as per professional advice of the renowned international consultant and simply a reference to any other technology would not have served the purpose as the contractor has to base his bid on input data from the client.

Reply of the Ministry/Management is not acceptable as various authorities (including MOP itself) had expressed concerns on TBM technology. Despite this, NHPC went ahead and the TBM got stuck after tunneling only four kms. Further, tender documents did not specify the task to be achieved and the time frame but only the technology. As a result, Parbati-II project is running behind the schedule by about 99 months.

4.3 Investment Approval

On completion of all preliminary activities including techno economic clearance/ concurrence by CEA, the investment proposal of each project is submitted by the MOP to Cabinet Committee of Economic Affairs (CCEA) for approval. On receipt of the investment approval from CCEA, further activity of awarding of contracts is carried out by the executing Company. Timely approval of the projects ensures efficient planning of further activities *viz.* awarding and execution of project.

4.3.1 Delays in Investment Approval and higher cost of construction

Scrutiny of records revealed that the time taken for investment approval after Techno Economic Clearance was 8 months in case Subansiri Lower of NHPC whereas it ranged between 10 and 29 months in respect of other 12 projects[47] (excluding Koteshwar Project of THDC[48]). Audit further observed that delays had a cascading impact on the time and cost of the projects.

The Working Group on Power for Eleventh Plan (2007-12) envisaged (February 2007) cost of construction at ₹4.50 crore per MW for the run of the river hydro projects.

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[47] ***Excludes two projects of NEEPCO as planning activities were not covered in this Performance Audit.***

[48] ***A time of 127 months was taken in respect of Koteshwar project of THDC after obtaining TEC (August 1989) as Committee of Secretaries decided to take up this project after the work of Tehri Stage-I project picked up.***

The approved and anticipated cost per MW in respect of 12 run of the river hydro projects[49] approved by CCEA between July 1998 and January 2007 is given below:

(₹ in crore)

Sl. No.	Name of the Project	Capacity (MW)	Date of Investment Approval	Approved cost	Anticipated cost (%age over approved cost	Cost per MW		Time taken for investment approval after TEC (in months)
						Based on approved cost	Based on anticipated cost	
1	Parbati-II of NHPC	800	11.09.2002	3919.59	5353.21 (37%)	4.90	6.69	20
2	Sewa-II of NHPC	120	09.09.2003	665.46	1108.83 (67%)	5.55	9.24	10
3	TLDP-III of NHPC	132	30.10.2003	768.92	1628.39 (112 %)	5.83	12.34	11
4	TLDP-IV of NHPC	160	30.09.2005	1061.38	1501.75 (41%)	6.63	9.39	21
5	Chamera-III of NHPC	231	01.09.2005	1405.63	2084.01 (48%)	6.08	9.02	22
6	Uri-II of NHPC	240	01.09.2005	1724.79	2082.82 (21%)	7.19	8.68	18
7	Nimmo-Bazgo of NHPC	45	24.08.2006	611.01	936.10 (53%)	13.58	20.80	29
8	Chutak of NHPC	44	24.08.2006	621.26	913.25 (47%)	14.12	20.76	28
9	Rampur of SJVNL	412	25.01.2007	2047.03	2047.03 (0%)	4.97	4.97	13
10	Parbati-III of NHPC	520	09.11.2005	2304.56	2715.92 (18%)	4.43	5.22	24
11	Subansiri Lower of NHPC	2000	09.09.2003	6285.33	10667.09 (70%)	3.14	5.33	8
12	Teesta-V of NHPC	510	11.02.2000	2198.04	2656.95 (21%)	4.31	5.21	11

It may be seen from the above that the approved per MW cost of construction of nine out of 12 projects examined ranged between ₹4.90 crore and ₹14.12 crore as against ₹4.50 crore per MW envisaged by the Working Group on Power for Eleventh Plan. However, the anticipated cost of construction of 11 out of above 12 projects is much higher than the approved cost and ranged between 18 to 112 per cent of the approved cost. Besides per MW anticipated cost of above 12 projects also ranged between ₹4.97 crore to ₹20.80 crore as against ₹4.50 crore per MW envisaged by the Working Group.

[49] ***Koteshwar project of THDC and Omkareshwar project of NHPC (JV with MP Govt.) are storage type.***

Ministry/NHPC Management stated (March 2012) that reasons of delay in obtaining investment approval is involvement of various Ministries and Departments whose observations on the proposals are to be satisfactorily replied.

The reply of the Ministry is to be viewed in the background of 8, 10 and 11 months taken in Subansiri Lower, Sewa-II and Teesta-V/TLDP-III projects respectively thereby indicating that with proper planning and monitoring, investment approval period could have been curtailed in other projects as well. The Management/Ministry did not offer any comment on higher cost of construction of projects.

4.3.2 Project financing

The Management of CPSEs took timely action for tying up the required finance for execution of the project and the progress of the project did not suffer due to shortage of funds.