COST AND TIME OVER RUN IN THE CONSTRUCTION OF TEHRI DAM PROJECT

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EXECUTIVE SUMMARY

The Tehri Dam Project, the fourth highest Dam in the world is under construction. It has suffered enormous time and cost over runs. The sole cause of delay and consequent cost over run was the agitations on concern of Dam safety and inadequate R & R. The issues were attended to by the Govt.of India and several committees were appointed to help in the solution of the problems. The R & R package was improved upon. The Dam proved to be safe and sound for credible earthquake of 8.5 magnitude. The time frame of construction is considered as inadequate, but 6 to 7 years would have been sufficient, had there been no agitations.

The cost rise was due to normal inflation, interest on capital, change in foreign exchange rates and duties. The design changes on Dam safety considerations were not responsible for abnormal increase in the cost. The various construction packages undertaken by contractors were also delayed by agitations.

Geological investigations were adequate during preconstruction and construction stage. They, however, fell short of international standards. There were no geological surprises either. During the construction stage investigations, the stipulations made during investigations were found correct. **The basic designs formulated by U.P. Engineers hold good with minor modifications.**

Various Governmental agencies like Survey of India, Geological Survey of India, Central Electricity Authority, Central Water Commission etc. provided consultancy on various aspects and a Technical Advisory Committee gave overall guidance on important technical matters.

The issues of land acquisitions and R & R assume very important place in the future development of hydro- power potential. The faster clearances from various regulatory agencies will help in a big way in speedy construction of future projects. The selection of the projects and the active **involvement** of the concerned state is very crucial.
Detailed investigations for any future project is very important as practically all activities depend on the adequacy and reliability of investigations. The results help in preparing realistic plan, designs, quantities of work, the cost of the project, construction strategy and financial viability of the venture.

CHAPTER-1
INTRODUCTION OF THE PROJECT

1.1 Background

The Ministry of Statistics and Programme Implementation entrusted the study of Tehri Dam Hydro Power Project, Uttaranchal, to M/S JPS Associates (P) Ltd. in December, 2004. The Ministry is keen to know the deficiencies in the system and procedures which have to be addressed in future. The in depth study of intricate problems faced while implementing the project will help in formulating a vision for planned way of implementation of the future projects at the very inception. This will help immensely in executing a scheme in a trouble free manner.

1.2 Objectives and Terms of Reference of the Study

The following are the Objectives and the stated Terms of Reference of the Study:

Objectives:

- To study as to why there was such an enormous time overrun in completing the project.
- To study the reasons for cost overrun and link it up with delays in completion of various packages comprising the project.

Terms of Reference:

- To examine the project schedule initially chalked out along with the time period for achieving various project parameters.
- To study the delay in achieving various milestones and find out the reasons.
- To study the adequacy of project contractors to undertake the work.
- To examine the performance rate of contractors for various works / packages undertaken by them.
- To find out the adequacy of geological studies of the dam sites conducted before undertaking this project.
- To suggest ways and means of avoiding these type of problems in new hydro electric projects in the Himalayan regions.
- Suggest a model format for completion report for the Hydro Electric Projects

The following terms of reference were added vide letter no. 11025/21/2004-IPMD dated 11/01/2005.

(i) Adequacy of Survey & Investigation at the time of preparation of DPR
(ii) Terms of Contract and Contract negotiations
(iii) Contract Management; and
(iv) Aspect of Human Resources

1.3 Study methodology and Activities

1.3.1 The Consultants adopted the following methodology and undertook the related activities for conduct of the study:

- Initial discussions held with the concerned officials of Infrastructure and Project Monitoring Division, Ministry of Statistics & Programme Implementation to gain their perspective on the objectives of the study and to fine tune consultants understanding of the assignment, related approach, methodology and deliverables in consultation with the Client.
- Collection and review of secondary data/information including published reports/material as available from the client and through desk research **and consultation.**
- Obtaining introduction/authority letter from the Ministry of Statistics & Programme Implementation.
- Development of a framework for interviews with key functionaries and concerned project officials at the Project Site.
- The consultants studied the problems of projects constructed in the past and used the information in developing a document for expeditions construction of future projects. The present study will be helpful in evolving a strategy for faster execution of future projects.
- The proposed study has concentrated on understanding the effects of various factors which caused enormous set back to the project execution.
- With a very long experience of constructing major hydro-electric projects our technologists are in a position to advise on steps/mechanisms to correct the mistakes committed in the past. The present study may help in evolving a **methodology** for trouble free construction of future hydro-electric power projects. The study is therefore focused on learning lessons and evolving correction strategies for future.
- Schedule visits to the Project Implementing Authority viz. THDC, New Delhi/ THDC Site Office at Tehri, Rishikesh, Dehradun and Consultant's office for secondary and primary data collection. Visited project site, THDC site office & the offices of the Contractors Consultants through two separate visits (preliminary & follow-up) during February & April, 2005 for collection of relevant information as well as for personal discussions with the concerned officials.
- The list of Officials/Individuals contacted in connection with the assignment is given under:

(A) Officers met at Rishikesh/ Tehri

(1) Sri R.K.Sharma, Chairman and Managing Director, Tehri
(2) Sri S.C.Sharma,Director (Technical)
(3) Sri Y.K.Sharma, General Manger (A & H)
(4) Sri L.K.Bansal, General Manger (Design)
(5) Sri S.Srikanthan, A.G.M (HRD)
(6) Sri S.K.Shukla, General Manger Project
(7) Sri A.Bishnoi, Manager (Civil)
(8) Sri H.L.Arora, Dy. GM (Planning)
(9) Sri R.Sharma, Director JIL
(10) Sri H.S.Kalsi, Ad. GM (Thapar)
(11) Sri S.K.Goel, Sr. Manager (Contracts)
(12) Sri R.K.Chawla, AGM (Contracts)
(13) Sri P.K.Agarwal, Sr. Manager (MTS)

(B) At Dehradun

(1) Dr.P.C.Nawani, Director, GSI

(C) At Delhi
(1) Sri. Gurdayal Singh, Member Hydro., CEA
(2) S.M. Dhiman, CE, CEA
(3) Sri M.Sikdar, Director, CEA
(4) Sri D.G.Kadkade, Director (T), JIL
(5) Sri K.K.Agarwal, President (Cord.), JIL
(6) Sri R.K.Jain (Chief contracts), JIL

- To pursue the collection of relevant documents including the following from project authorities:
  (1) The report of standing committee was obtained from the Ministry of PI and studied, and notes were prepared on relevant matters only.
  (2) Original work schedule of different packages (Tables).
  (3) The Monthly reports June 2004 and Feb. 2005.
  (4) Relevant pages from DPR and notes by other officers.

All the above officials where requested to provide information as per the Questionnaires prepared for the purpose. They promised to provide information if instructed by their superiors.

1.4 Limitations of the Study

(1) The study is based upon the information made available by the concerned officials and institutions.
(2) The gap between the needed information and that made available was made good to some extent, by personal interviews.
(3) The issue of contractors performance and the THDC views on the subject can not be brought out realistically as the work is still going on. The interdependence of client and the contractor during the construction period may preclude any in depth study at this stage.

1.5 Brief Details of the Project and Implementation Activities.

The envisaged construction of the Tehri Dam Project was approved **in principle** in year 1986, the Government had **cleared** the implementation of Tehri Hydro Power Complex, as a joint venture of the GOI and the erstwhile Government of Uttar Pradesh. The **project** had the following features:

(i) A 260.5 M high earth and rock fill Dam, with 4x 250 MW Hydro power plant at Tehri.
(ii) Koteshwar Dam and 4x 100 MW Hydro Power Plant(HPP), downstream of Tehri,
(iii) 4x250 MW Tehri Pump Storage Plant and
(iv) Associated Transmission system

The Government of U.P had sought assistance from the then USSR for implementing the Tehri Power complex. However, with disintegration of the then USSR, the financial assistance could not be availed. Keeping in mind the

disintegration of USSR. Government of India approved to implement the Tehri Dam & HPP(1000 MW) stage in March 1994. The Govt. of India approved the first stage as the stage I of the Tehri complex (2400MW) which comprised of Tehri Dam and HEP (1000MW) along with works of Koteshwar Dam and HPP and essential works of Pump Storage Plant at a total cost of Rs. 2963.66 crores (March, 1993) price as per the following break up.

Item	Cost in Crores Rupees
Major Civil works including Hydro Mechanical works	1325.76
Electro Mechanical Equipment	543.03
Infrastructure	152.02
Rehabilitation & resettlement	412.22
Environment	66.00
Establishment	249.53
Others	180.24
Sub total	**2963.66**
Interest During Construction(IDC) and Financing Charges	427.74
Total	**Rs. 3357.04**

It was expected that the project would be commissioned, fully in 1998-99 (all four units). A time period of about five years, a really tough time schedule.

The main features and the benefits are given in Annexure I which includes fig. 1-5 giving sketches of main components.

1.5.1 This project was to be executed by the funds from Central and State Government, where in Central Government's share in the ratio of 75: 25. the government approval to the Project was finally accorded on 15.03.1994, with the schedule of commissioning of 2 units in 1997-98 and the project completion in 1998-99.

1.5.2 However this approved time schedule was not drawn on the time frames given by the project authorities and was considered to be inadequate for completion of all the construction work. Project authorities had attributed a total time of 7 years for project completion and six years for the commissioning of first unit.

1.5.3 The DPR for the above Project as well as the feasibility study is an old document prepared by the Uttar Pradesh Irrigation Department is with THDC and has undergone many changes in terms of the design and scope of work from time to time. **The DPR is therefore merely a concept document only.**

1.5.4 But due to a spate of agitation and uncertainties on various issues like Dam Safety, Environmental issues, R&R issues and the project suffered a number of delays on account of this and work could not be started as per the original schedule in 1994.

1.5.5 Due to delay in project commissioning and startup the project was effectively started in 1997 and Subsequently this project was again approved by the CCEA with Revised Cost estimates and involving a number of design, safety, environment and R&R changes calling for a number of expert consultation and committee constitutions for the same owing to the various agitations caused by the residents of Tehri Town. The second phase involved additional work in terms of :

- Consulting Services for supplementary feasibility study (Seismic safety of the bridge) and detailed design GIS investigations
- Design changes as per the recommendations of safety concerns
- Land Acquisition; and R & R packages redefined

1.5.6 Due to these agitations lot of valuable construction time was lost and there was delay in the start up work. The project revised cost estimates as per March 2002-03 **is as follows.**

Item	Cost in Crores Rupees
Major Civil works including Hydro Mechanical works	3034.59
Electro Mechanical Equipment	1107.85
Infrastructure	159.67
Rehabilitation & resettlement	983.14
Environment	141.74
Establishment	346.93
Others	287.40
Sub total	**6061.32**
Interest During Construction(IDC) and Financing Charges	560.00
Total	**6621.32**

1.6 Contract for Services

The contractors were assigned the task to construct the various components of the project within a time frame of 60 months from the start date. They entered into a legal agreement for the work with the THDC.

1.7 Scope of Work for Contractors

Following was the scope of work for contractors:

1. M/S Jaiprakash Industries

They were assigned the task of construction of Dam and Spill ways as per the specifications laid **down** by the Engineer in-charge of THDC. The company has to arrange all the needed materials (except some to be provided by THDC) and execute the work, as directed within the contracted time frame. The main work involved excavation, transport and laying soils/ rocks in a planned manner to construct the dam. Chute spillway and shaft spillway were also to be constructed as per the laid specifications and directions of the engineer- incharge.

2. M/S Thapars

The Thapars were assigned the task to construct the underground power house, transformer hall, intake/ tail structures, head race tunnels, hydropower plant with all necessary appurtenant works.

The contractors entered in to legal contract with the THDC to execute the entire work as per contract document. The scope in general was to construct all the components of the project to the satisfaction of Engineer-In-Charge of the project.

It may be mentioned here that the contractors were assigned the remaining part of the work only as existing on the date of award of contracts.

CHAPTER-2

PROJECT FUNDING AND COSTS

2.1 Funding

Funding Pattern

THDC is a joint venture of Govt. of India and the composite State of Uttar Pradesh (now Uttaranchal) on 75:25 basis.

The funding pattern of the current project is as follows

Equity-		Rs. 2548.44 crores
Debt-		Rs. 2548.44 crores
Irrigation Component-		Rs. 1114.74 crores
	Total	**Rs. 6211.82 crores**

The loan component is tied up as below

ECB (for ERN equipment)	Rs. 707.97 crores
Commercial loan (PFC)	Rs. 1206.00 crores
GOI loan	Rs. 634.47 crores
	Rs. 2548.44 crores

The above figures are on September 2002 price line. The U.P Irrigation Department started the work in 1976. There was funding problem and help from the then USSR did not materialize. Govt. of India took a decision to execute the project as a joint venture and constituted THDC, which took over the execution of the project in 1988.

2.2 Costs Analysis

2.2.1 The Govt. of India approved the first stage as the stage I of the Tehri complex (2400MW) which comprised of Tehri Dam and HEP (1000MW) along with works of Koteshwar Dam and HPP and essential works of Pump Storage Plant at a total cost of Rs. 2963.66 crores (March, 1993) price as per the following break up.

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Establishment	249.53
Others	180.24
Sub total	**2963.66**
Interest During Construction(IDC) and	427.74

Financing Charges	
Total	**Rs. 3357.04**

It was expected that the project would be commissioned, fully in 1998-99 (all four units). A time period of about five years, a really tough time schedule. The main features of the project and benefits are given in ANNEXURE – I.

The cost and time schedule was revised to Rs. 5209.10 crores at August 99 price line (excluding the committed works of Koteshwar, interest and financing charges) and the commissioning date was extended to Dec., 2002. It was tagged to the condition, T-3 & T-4 being closed by March, 2001 to facilitate work on the stilling basin and right bank chute spill way. These tunnels could not be closed, due to agitations in March, 2001, but it could be achieved only in Dec., 2001, pushing the project schedule to Dec., 2003. The Dam safety was further reviewed by a high level committee, which submitted its report only in Jan., 2002, declaring the Dam to be safe. The rehabilitation issue also got heated up. This issue was also resolved. The rehabilitation package further pushed up the cost **through marginally**. There had been some design changes also and some more money had to be found for infrastructure development.
A comparison of the design provided in the DPR in 1987 and the construction in 2003 as per Central Electricity Authority Approval is annexed at Annexure II.

Hence the project was again approved by **Govt. of India** in November 2003 at a cost of Rs. 6061.32 crores (excluding committed work of Koteshwar, interest and financial changes. By including these changes the cost was Rs. 6621.32 crores.

The breakup of the costs are as under:

Item	**Cost in Crores Rupees**
Major Civil works including Hydro Mechanical works	3034.59
Electro Mechanical Equipment	1107.85
Infrastructure	159.67
Rehabilitation & resettlement	983.14
Environment	141.74
Establishment	346.93
Others	287.40
Sub total	**6061.32**
Interest During Construction(IDC) and Financing Charges	560.00
Total	**6621.32**

In view of the above the commissioning was rescheduled to 4th quarter of 2004-2005.
Up to Feb. 2005 an expenditure of Rs. 6896.84 crores was incurred. The issue of cost and time over run was reviewed periodically and corrective steps were taken. This issue has been dealt with an in-depth analysis by consultants, and the findings of the same are presented below:

Project Cost Escalation and completion time through the year is as follows.

S. No.	Description	Amount in Rs. Crores
1	Total Cost of Project March 93 Price level to be completed in 1999	2963.66
2	March 2003 Price level To be commissioned by 2005 (March)	6621.32 crores
3	Feb. 2005, (Expenditure to date) To be completed by March 2006	6896.84 crores

As It can be seen from the above table that there has already been an escalation in the cost at 2003 level to the tune of Rs. 275.52 Crores.

R & R Issues

The land acquisition and R & R costs increased as follows.

S. No.	Description	Amount in Rs. Crores
1	Provisions for March 93 Price level	412.22
2	Revised March 2003 Price level	983.14 Crores
3	Feb. 2005, (Expenditure to date)	989.50 crores

Land acquisition and rehabilitation and resettlement (R & R) were the main causes for delay and consequent cost escalation. The R & R had a dominant effect on the construction schedule, consequently hiking the cost. The various agitations erupted during the construction of the project had an origin prior to the THDC days. The agitations affected the project in the following ways:

(1) Stoppage of work at all the sites for long periods
(2) People not actually surrendering the acquired area even after payment of compensation.
(3) R & R package being an open ended exercise pushing cost and delaying commissioning
(4) Material, specially rip-rap not reaching to the project site in time from quarries. Land acquisition for quarries, delays and hurdles in transport being some of the causes. Rip-rap placement therefore not being contemporaneous with the dam rising, needed extra efforts, costing time and money.
(5) Agitations after agitation affected the morale of construction engineers reducing their efficiency. Agitations turning in to law and order problem were frequent.

The rise in cost was due to delay in commissioning, caused by agitations. The rise was mainly due to inflation over a period of ten years. Had the R & R problems been solved in time, the cost rise would not have been so much. If, initial cost of R & R, about **13.90**% of the project cost had been agreed in the beginning, probably, the project would have been completed by 2002, in spite of initial delays. The R & R and the land acquisition had been outsourced to the State Government. Usually, for all land acquisition activities the concerned states are the most suited for the job as they are the custodian of all the resources of the State and regulate to a great extent their exploitation. Probably this activity might have been slow due to geo-

political realities. The agitations against the dam and another one for the creation of Uttaranchal State merging with each other might have been the cause of delay.

The state Govt has a Directorate operating from Dehradun, this prepares plans for R&R and Land acquisition and also prepares cost estimates. The rehabilitation concerns the Rural as well as the Urban population. For the Urban population the Tehri Town has to be shifted which is now complete and all the inhabitants of Old Tehri Township have been resettled with new Tehri Township. The project affected people included the Government Orgnisations and teaching institutions also besides the private people engaged in various activities

The initial provisions under R & R and land acquisition were further liberalized by the Hanumant Rao Committee (HRC) and it should have accelerated the process of rehabilitation and resettlement. However, during our analysis it was known that the R&R there are still some more villages, which are yet to be acquired to start the initial impounding of water later in 2005.

Agitations erupting due to dam safety concern and R & R package inadequacy were the sole causes of cost and time over run. The time lost increased the cost by way of normal rise in cost with time, interest burden and foreign exchange rate increase.

The land acquisition and R & R cost were marginally different from the original provisions. In reality the R & R cost was not abnormally high, as may be received.

Accepting the major causes as stated above, efforts have also been to look into other avoidable causes, which are discussed below.

2.2.2 Consideration of reasons for the time and cost over-run

The reasons for Time and Cost overrun have been examined in details by the Standing Committee and consultants have also arrived at the same conclusion. The Committee, in its Report submitted in Jan., 2001 has concluded that Time & Cost over-run, of Tehri Project Stage –I was because of factors which cannot be attributed to the project authorities and are beyond their control. The Standing Committee report, interalia, stated that:

- The delay in project implementation was due to various agitations and dharnas which delayed the raising of Coffer Dam to a safe height.
- Agitation necessitated constitution of two Expert Committees to review the seismic safety aspect of the dam design and rehabilitation/ environmental aspects of the Project. Reports of these committees were examined and processed for Govt. decision, which took time.
- Project time overrun is also partly accounted for due to inadequacy in time-schedule for completion of the Project, incorporated in Govt. approval.
- The major portion of cost increase of Rs. 2279.80 crores was due to normal inflation variations in statutory levies and duties, foreign exchange variation, and on account of implementation of Govt. decisions on the HRC Report relating to rehabilitation and environmental issues for Tehri Project.

- The additional work carried out and the provisions and scope of DPR (originally prepared by U.P Irrigation Department) were for additional safety measures and not for any short comings in the DPR.
- Keeping in view its importance for project commissioning, the Committee recommends that the State Govt. may be requested to complete vacation of Old Tehri Town on most urgent basis, to enable closure of Division Tunnels T-3/ T-4 by THDC without further loss of time.

The issue of Time and Cost over run was meticulously gone in to by the Standing Committee. The following are important points.

- R & R and land acquisition related problems, the main causes for cost and time over run.
- Design change due to safety concerns
- Agitations after agitations delayed the work progress substantially. A chronology of the events leading to time over run is provided at Annexure-**III.**

The Committee analysed the causes of delay very minutely and it is thus reliable document to learn lessons from. The various components were delayed, with huge time over runs primarily due to agitations erupting from time to time. There are no instances of any critical component execution delay leading to delays in eventual commissioning. The land acquisition is still going on and some villages are yet to be possessed. These villages lie in dam submergence area and are critical for filling up of Dam slated for later quarter of 2005. This may delay the commissioning of the project if these villages are not in possession before the impounding starts.

CHAP TER 3

EVALUATION OF THE PROJECT OBJECTIVES VIS-À-VIS DPR AND APPROVED TIME AND COST

3.1 Comparison of the DPR and the Actual Progress (Actual v/s Targeted Achievements)

Project schedule as chalked out in DPR

The project was initially planned to be taken up by UP Irrigation Department as a Project to be funded by erstwhile USSR.The Detailed Project Report was prepared by UP Irrigation department in 1979. This old Document was amended from time to time i.e. in 1983 and 1987. The document did not propose any date wise construction Schedule. It is, therefore, not possible to **do** any analysis of Project Schedule keeping the DPR as the sole source document

The schedule had two main components, Dam and Power House. Both had a time frame of 60 months. Dam is the most critical component and its completion is most important. **The** anticipated commissioning date of 1998-99 was revised in the Eigth five year plan of THDC **to** 2000-01. The project **completion** schedule has changed many times. The project could not **be executed as per plans** due to a number of agitations and reasons beyond the control. **T**he GOI revised the cost of the Project in 2003 at RS. 6621.32 Crores with a commissioning Schedule of 2004-05 which is now again revised to be completed by March 2006. **The schedule changes were due to delay in completion of different components.**

3.1.1 Current Status

The project is nearing completion and is expected to be commissioned by the 31st March 2006. Following are the brief details of various important works.

3.1.2 Dam

The Dam is yet to be raised by another 0.15m and the placement of rip-rap is in full swing, grouting of foundation has already been completed. The main packages were for dam and spillway, being large works. The drainage galleries are complete in all respects. Most of the instruments have been installed and data acquisition system installation is in progress. Chute as well as shaft spill ways are almost complete. Only minor works are left to be done which will be completed well before the commissioning dead line, yet to be fixed up.

3.1.3 Power House

Intake structures are complete with bifurcation chamber and Butterfly valve chamber. **P**enstocks are complete. All the civil works are complete for the power house complex which include all the works under package I and II. Electromechanical works of all the four units have been completed. Unit I and II are ready for spinning and the work on control panels is in progress.

Hydromechanical Gates Package I (spillway and ILO have been completed. Gates Package II (Power House) are in progress and are scheduled to be completed by February 2005.

The progress is as per the continuously changing schedules worked from time to time. The comparison with the DPR of the actual progress will not serve the purpose as DPR is an old document and it is a situation of changing goal posts.

3.2 Evaluation of Attainment of Original Objectives of the Project With Reference to DPR (1987)

3.2.1 The general requirements of Tehri Dam at Tehri, which have been complied with in the main during the design and project execution, are given under:

Power
The Tehri Dam would benefit the Northern region of its power crisis by addition to the installed generating capacity in the Northern Region to the tune of 2400 MW(1000 MW on completion of Tehri Stage-I) and also by provision of Annual Energy availability (Peaking) is 6500 MU (3568 MU on completion of Tehri Stage-I).

Irrigation
The Dam would lessen the dependency of agriculture on the Unpredictable Monsoons for farmers of Uttar Pradesh by providing Irrigation facilities to 2.7 lacs ha. of additional land in Uttar Pradesh and Stabilising irrigation in existing 6.04 lacs ha. of land in Uttar Pradesh.

Drinking Water
The Project on its completion would be providing drinking water to the City of Delhi at the rate of 162 million gallon per day (300 cusecs) which will cater to a population of 40 lakh people. And also to various towns of Uttar Pradesh at the rate of 108 million gallon per day (200 cusecs) drinking water to various towns of U.P. which will cater to 30 lakh population.

Flood Control
The Project is proposed to moderate the major floods which have been causing loss to lives of cattle and Humane both in terms of Physical and financial resources in Gangetic plain.

Other Benefits
Integrated development of Garhwal Region, including construction of a new hill station viz. New Tehri Town (NTT) with provision of all possible facilities like improved communication, education, health, tourist traffic, setting up of non-pollution industries, development of horticulture, fisheries, afforestation of the Region etc. much to the advantage of the people of Garhwal Region. This would also be amajor revenue Generation source for the State of Uttranchal

Lifetime Requirements

The design working life of the Dam shall be 100 years. The design life is the

period for which the structures are to be used for their intended purpose with anticipated maintenance, but without loss of reliability or structural, operational and aesthetic integrity.

Seismic Safety

The present Design of Dam is expected to be structurally safe to withstand the Maximum Credible Earth quake during the economic performance life of the dam reservoir system. The Dam has been designed as a fail safe structure **for credible earthquake of 8.5 magnitude**. There were a number of Seismic and design safety studies undertaken by the Committee constituted by the Ministry of Power. **The basic design prepared by U.P. Engineers was modified by Russian experts. Some features were added to enhance safety of the structure. (Annexure –IV give more details)**

Cost of Energy Generation

The cost of energy generation from the project at constant cost (March 03 level) works out to 151.89 Paise per kwh, based on 50% dependable year. The sale rate of energy works out to 312.90 paise per KWH on 50% dependable year

The cost of energy generation from the project at completion works out to 153.19 Paise per kwh, based on the 50% dependable year. The sale rate of energy works out to 315.44 paise per kwh on 50% dependable year.

Power Purchase Agreement

Power Purchase agreements for purchase of Power has already been tied signed with Beneficiary states of Uttar Pradesh, Punjab and Chandigarh. The States of Rajasthan, Delhi & Harayana are in the Final stages of signing the PPAs

All these benefits are to be realized once the project gets completed.

Package Delays and Costs

As per the information collected from the contractors and the project authorities examined and discussed in the following paragraphs :

The Detailed Project Report (DPR) was prepared by U.P.Irrigation Department (1979) and it is still the source document. **The project as amended in 1987 was the final document.** The tenders floated for different packages gave time of completion of the Dam and Power house component as 60 months. Both the contractors gave their time schedule within this directed time frame.
The following were the main packages

(1) Power House
(2) Dam
(3) Spill way

Besides the delays due to agitations, which had a domino effect on the project as a whole, these were other reasons for delays. Agitations, however are not **wholly** responsible for delay in proposed scheduled commissioning.

- Diversion tunnels, two each on both the right and left bands were constructed prior to the take over by THDC. These tunnels were meant for diversion of Bhilangana and Bhagirathi waters from the proposed area for the construction of Dam.
- There was a time lag of 3 years and 4 months between the project approval and award of contract, leading to the award of the contract. Probably the delay was primarily due to **wide differences in cost proposed by different bidders**. **The tenders were floated again.** The revised price bid was submitted by JPI on 27/05/96. The first and second bid had a time gap of about 2 years and six months. Usually this may not require more than an year, thus a time of a little over 2 years was lost in the tendering process alone. This seems to be an avoidable delay.

The project **under reference** was approved in 1994 but the work could start only in 1997, resulting in delay of three years in initiating the project execution. **There had been minor changes in design. The changes cost the project to** the tune of Rs. 174.81 Crores which are as under:

S. No.	Description	Amount in Rs. crores	Details of design
1	**Civil works**		
	DAM	15.53	In crease in length of Drainage Galleries, Provision of geo grid, Transportation of Clay
	Chute Spill way	34.45	Increase of quantity of high strength Concrete & stabalisation measures
	RBSS	28.72	Increase in quantity of reinforcement
	LBSS	13.96	Increase in quantity of reinforcement
2	Power Plant		
	Intake Structure	33.53	Increase in quantity of concrete & reinforcement
	MGS	2.46	Stabilization measures due to poor rock stata
	HRT	2.96	Increase in steel sports & concrete due to poor rock stata
	BVC & PAC	2.93	Installation of pre stressed cable anchors and construction of buttress due to rock data
	Penstocks	6.78	Increase in reinforcement, concrete & steel liners, due to increase in length & size
	Link Shaft	1.41	Addition of link shaft from Adit-1 to Adit 4
	Drainage Gallery & Pump House	1.05	Increase in length of galleries
	Interface Facility & oil Handling Plant	28.34	Increase in quantity of concrete & reinforcement due to restriction of area, location replacement along river side &

			mockery
	TRT's	2.74	Increase in length & lining thickness
	Total	**174.81**	

Project cost as approved in March 93 was Rs. 3357.04 and the design changes were only of Rs. 174.81 crores. It is a mere 5% which is rather insignificant increase for such a major project. Underground works were revised extensively and the machine hall was enlarge. This enlargement cost 28% more money over and above the original designs and estimates.

A sample study for Dam and Spillway was done to look into the time over run. This is provided at Annexure VI

The Consultants have gone through various reports and also through field visits have analysed following are the reasons for delay :

- primarily due to agitations,
- delays in completion of related components,
- materials supply delays and delay in supply of drawing etc. were also the other reasons.

Dam :

Add details about the features of Dam

(Already given in Appendix I)

*3.2.2 Contracting **and Execution** Delays*

3.2.3 **Dam**

- The issue of construction of main dam was taken up only after the project was approved by Govt.of India in March 1994. The THDC was already in the process of inviting bids for the different components of project complex. In April 1993 the tenders were floated and the bids were slated to be opened on 16/08/1993 for Dam component. The pre-qualified bidders were considered for the price bid.

The contract of Dam was awarded for Rs.898.45 crores in 1997 with a schedule of 60 months. It may complete in 111 months with an expected cost of Rs. 1310.00crores. The time is almost double and the cost is 1.46 times. The Spillway has a similar story. The original cost was Rs. 474.81 crores and time schedule 60 months, but it is expected to be completed in 108 months, at a cost of Rs. 885.00 crores.

The work on spill way was started after the agreement was signed on 28.12.98. The spillways are nearing completion in all respects, barring some minor works. **Appendix V give detailed mile stones and the completion time details.**

3.2.4 **Power House**

3.2.5 **Underground Works**

Works were in progress since U.P. Days prior to THDC take over and THDC days between 1988 to the date the contracts were awarded in 1995-1997. The packages contracted were for the work yet to be executed. In the following paragraphs brief details of the packages are given.

Package I

Intake structures, balance works of 4 HRT'S, control gate shafts, bifurcation of HRT'S, Penstock assembly chambers, approach adit and related works.

Contracted cost Rs. 69.08 crores in 1995
Cost as on Feb 05 Rs. 170.30 crores

Package II

Machine hall 188m x 24/22m x 46m with service bay, Station Control Area of 7 storied building and machine hall for 4 generators. Transformers hall, bus ducts, draft tubes, upper and lower expansion chambers, cable tunnel, ventilation tunnel, drainage gallery, approach adits.

Contracted cost – Rs. 96.81 crores in 1995
Cost as on Feb 05 – Rs. 152.85 crores

Package III

Access adit, TRT 1 & 2, allied works of tunnel, transition, bifurcation and out let structure.

Contracted cost - Rs. 44.95 crores in 1995
Cost as on Feb. 05 – Rs. 64.55 crores

The machines were mostly important and installation etc. were also out sourced to Bharat Heavy Electricals Ltd. (BHEL) under separate contracts.

The cost escalation were primarily due to normal cost rise due to inflation, increases in levies, taxes and foreign exchange rates.

The total cost of Package I, II and III was Rs. 387.48 crores (Feb 05 date line). About 80% of contracted work has been completed by that time.

All the works were to be completed within a period of sixty months (Five Years), however it took twice as much.
The cost rose due to the following reasons.

The construction of underground power house was not affected by agitations. The work awarded to the contractors was in continuation of the work they were doing during the U.P. Irrigation times and there after under THDC from 1988 to 1993 when the process to award contract for completion of the remaining part of the work was initiated.

Underground construction is a job usually done on the basis of accurate geological predictions. Geological surprises may cause delays and uncertainties. The predictions made by the Geologists indicated the presence of bad rock zones, low rock covers and some critical joints configuring to create unstable wedges, prone to failure. The rocks in such sections needed careful handling. In MGS- 3 AND 4, deformed rock zones were predicted for a length of about 40m. These zone needed controlled blasting and immediate supports. This had not been done at places, causing rock falls and consequent delays.

Collapse of HRT-4 has been reported which remained blocked for 18 months. The rocks here were poor and there was a junction. Such a situation needed care which might not have been exercised. These problem occurred in the year 2000 and were over come later on. The delays, however, may not affect the over all commissioning the project.

The agitations etc did not affect the progress of the underground construction. The delayed construction of Dam provided extra time for the power hence construction, to cover up delays if any.

+Some more to be added about delays.

Contract tenders award for Power House

The lenders for package I,II,III were floated on 10.5.93 and the bids were opened on 15.12.93. The contract was awarded on 09.11.95 after a period of about 2 years and six months. This is also a fairly long time for the process.

3.2.6 Contract Award Process

For contract award there is along drawn process. The following are the main points.

(1) Prebid meetings, amendments and their incorporation
(2) Technical Evaluation, appointment of Standing Committee for the job.
(3) Evaluation by the Standing Committee and submission of final report
(4) Acceptance of the above report by the THDC Board of Directors
(5) Opening of price bids
(6) The clarifications on formulation of mechanism to limit the THDC liability in view of anticipated disruptions and disturbances
(7) Assessment of financial status of the bidders by going through their balance sheets
(8) Approval of the contract award to the lowest bidder and most competent to do the job
(9) Award of contract
(10) Signing of contract document with the THDC and the concerned contractor.

The Power house work was awarded to M/s Thapar Group on January 3, 1996 and work started on January 5, 1996. The Power House work was for three packages

Package I, II and III. Due to the design changes and geological investigations done during the project execution and construction there were changes in the scope of work of the contractor. Owing to this the cost of the construction for contractors also got revised as under :

S. No.	Description	Amount at time of award in 1996 Rs. Crores	Amount on completion as per Revised cost estimates of 2003 in Rs. Crores
1	Package I	69.80	180.00
2	Package II	96.81	160.00
3	Package III	44.95	67.50

Work for all the three packages are nearing completion and scheduled to be completed by December 2005.

3.2.1 Progress as of March,2005

- The 260.5m high Tehri Dam has been raised to an average elevation of EL 839.35m. Balance height to be raised is only 0.15m.
- The Open Excavation for the entire spillways has been completed. The concreting of Approach Channel, Control Structure and chute Spillways has been completed. The Underground Excavation of ILO, Gate Shaft of ILO, Shaft T-1 & T-2, Drainage Galleries around Stilling Basin has also been completed. Open Excavation in the Stilling Basin area has been completed and concreting is in progress. The supply of Embedded parts of ILO Gates and Lines have been completed and erection is in advance stage of completion.
- The underground excavation of complete Water Conductor System, Machine Hall, Transformer Hall, Butterfly Valve Chamber and Penstock Assembly Chamber have been completed. The concreting of Intake Structures has been completed and concreting in Control Gate Shafts, Penstocks and Power House is in an advanced stage of completion. The concrete lining in Tail Race Tunnels is also in advanced stage of completion.
- Supplies of Generating Plant and equipment from Russia/ Ukraine, with financing arrangements by way of Supplier Credit, are complete and supplies received at Project site. Computerised Control System supplies from ABB Germany, with financing arrangements by way of Buyers Credit from Kf W Germany, have also reached the Project site. The supply of 306 MVA Generator Transformers, manufactured by M/S BHEL, have been received.
- Supplies under ICB for 420KV Gas Insulated switchgear and Busduct awarded to Siemens, Germany with Financing under Buyers Credit from KfW, Germany are completed.
- The Supplies/ Erection of Hydro-Mechanical Equipment are at an advanced stage of completion.
- Left Bank Diversion Tunnel T-1 have been closed by lowering gates in Nov.,03 & plugging completed in Jan., 2004 and Division Tunnel T-2 is yet to be closed.
- Boxing of First & second unit has already been completed and that for the balance units is at advance stages.

Most of the works of Stage I are complete and only some finishing touches are being given. Some are in the advanced stage of completion and are expected to be completed by the commissioning dead line.

3.3 Evaluation of Attainment of Original Objectives of the Project With Reference to Approved Time and Cost

The original objectives of 60 months completion schedule and cost estimates of Rs. 2815.00 crores were soon out dated and it can be concluded that the cost could not hold good. As already explained in the earlier section the project was revised at a cost estimate of Rs 6621.00 Crores by the ministry of Power in March 2003 and as per the revised schedule the project was scheduled to be completed by the 4th Quarter of 2004-05. But due to the still on going Land Acquisition and R&R problems. The agitations on the concern of dam safety, inadequate land acquisition and R & R package was the real causes of time and cost over run. The issue had been gone into by a standing committee which also echoed the above sentiments. The studies done by the consultants also confirm the causes of time and cost over run.

The Consultants are of the opinion that the Tehri Dam has incorporated all the geo technological and other problems faced in the Himalayan region. It was first of kinds Dam in with modern technological features for potential replication in Himalayan regions and that the Dam would be providing the much needed hydro power energy and Irrigation benefits as per the objectives originally envisaged. These Objectives are yet to be realized. There has not been major cost deviations from the revised estimates of 2003 and it can be attributed that the project would be commissioned by March 2006.

3.4 Yearly Progress of the Project – Physical and Financial Progress on Quarterly Basis for last six years

The construction of the Project was started in 1976 by the U.P. Irrigation Department. Due to financial problems the pace of work was very slow and till 1988 when it was taken over by THDC, all the four diversion tunnels, part of head race tunnels and approaches to the power house cavern were more or less completed. The work of land acquisition and R & R was in progress and the sites for R & R activities were also in the process of being acquired. The work progress was very slow. The work started in real earnest after 2000 when the construction of the Dam started though intermittently threatened by agitations. The construction is expected to be over by 2006.

The construction work is thus taking 30 years. The available physical and financial progress of the project for different works for the last 7 years is as under :

PHYSICAL PROGRESS AND MILESTONES TEHRI STAGE – 1 (1000 MW)

Sl. No.	Milestones	Quarter	Completion Month
	Year - 1998-99		
1.	Stripping for core trench o Left Bank for Main Dam	Ist	Achieved

2.	Completion of Crane Beam Concreting in Power House	Ist	Achieved
3.	Completion of Adit – 4B	Ist	Achieved
4.	Stripping for Core trench of Right Bank for Main Dam	Ist	Achieved
5.	Raising of Dam upto EL 620.0 m	IInd	Achieved
6.	Transformer Hall Excavation upto EL 605.0 m	IInd	Achieved
7.	Machine Hall Excavation upto EL 605.0 m	IInd	Achieved
8.	Concrete Lining in Shaft–3 above EL 795.0 m	IInd	Achieved
	Year 1999-2000		
9.	Dam Fill Placement upto EL 660.0 m		Jun., 1999 (Achieved in May' 99)
10.	Machine Hall Excavation upto EL583.0 m (Two units)	IInd	Achieved
11.	Start transportation of Draft Tube Liner	IIIrd	Achieved
12.	Plugging of Diversion Tunnels T-3 & T-4	IIIrd	Refer progress of Nov. 99
13.	Shifting of old Tehri Town		-do-
14.	Unit IV pit excavation upto EL 568.5 m		Achieved
15.	Control Gate Shaft Excavation (HPP)		Achieved
16.	Excavation of Approach Channel & control structure of Chute Spillway		Achieved
17.	Dam fill placement upto EL 700 m		Achieved
18.	ILO Tunnel Excavation		Achieved
19.	Excavation of TRT-1 (excluding Rock Plug)		Achieved

YEAR 2000-2001

Sl. No.	**Milestones**	**Quarter**	**Completion Month**
1.	Pilot Shaft Excavation of T-2 (EL 685-842 m)	Ist	June, 2000 (Achieved in May 2000)
2.	Dam Fill Placement upto E.L. 720 m.	Ist	June, 2000 (Achieved)
3.	Aeration Tunnel	Ist	June (Achieved)
4.	Pilot of ILO Gate Shaft	IInd	July, 2000 (Achieved)
5.	Excavation of Upper Expansion Chamber	IIIrd	October, 2000 (Achieved in Sept. 2000)
6.	Concreting upto EL. 584 m. in Unit IV	IIIrd	November, 2000 (Achieved in Sept. 2000)
7.	Excavation of Penstock Assembly Chamber	IIIrd	November, 2000 (Achieved)
8.	Excavation of Lower Expansion Chamber	IIIrd	December, 2000 (Achieved)

YEAR 2003-2004

Sl. No.	Details of Milestone	Scheduled Month/Year	Achievement
I	Tehri Dam & HPP (1000 MW)		
(A)	Main Dam		
i)	Dam Raising upto EL 839.50 m	June 2003	The 260.5 high dam has been raised to EL 830.30 m balance left to be raised is only 1.2 m. work stopped due to pending decision for provision of Inspection Gallery at Dam top
B	Spillway		
i)	Concreting of Stilling basin upto EL 612 M	Dec. 2003	Revised to August 2004
ii)	Closure of Diversion Tunel T-1/T-2	Nov.-Dec. 2003	T-1 closed in Jan. 2004 and Tunnel T-2 planned to be closed during 2nd quarter of 2004-2005
C	Powerhouse		
i)	Boxing of Unit-III	July 2003	Revised to June 2004
ii)	Boxing of Unit-II	Nov., 2003	Revised to Jan. 2005
iii)	Boxing of Unit-I	March 2004	Revised to Feb.05

YEAR 2004-05

Sl. No.	Activity	Scheduled Month/Year
A	Tehri Dam & HPP (1000 MW)	
1	Completion of Top Inspection Gallery of Dam	December 2004*
2	Completion of Dam upto EL 839.5	March 2005
	Power House	
3	Boxing of Unit –III	June 2004
4	Boxing of Unit – II	January 2005
5	Boxing of Unit –I	February 2005
6	Closure of Diversion Tunnel T-2	December, 2004

(*) Achieved

YEAR 2005-06

Sl. No.	Activity	Scheduled Month/Year
A	Tehri Dam & HPP (1000 MW)	
1	Completion of T-3 Water Conductor System	September 2005
2	Closure of Gate of Diversion Tunnel T-2	October 2005
3	Boxing of Unit – II	May 2005
4	Boxing of Unit –I	February 2005

Financial progress of the Project

Financial Progress:

(Amount in Rs Crores)

Expenditure Year	Planned Expenditure* in Rs. Crores	Actual Expenditure	%
Up to March 2002	Not Available	4201.66	
During 2002-03	Not Available	1050.08	
During 2003-2004	756.43	753.29	99.58%
During 2004-2005	645.26	717.95	111.26%
Main Contract	6621.3	6722.98	101 %

*Source: Ministry of Power, Government of India

It can be seen that there are slight cost overruns even in the revised schedule. The percentage wise and component wise financial details are not readily available with the project authorities.

CHAPTER-4

PROJECT FORMULATION AND PLANNING

4.1 Adequacy of Geological Studies

A storage dam stops the flow of river water and impounds it behind. The water may flow either by breaking the dam or seepage through the dam body and its foundation. The abutment rocks and the rocks supporting foundation should thus be reasonably water tight to permit any leakage.

The Tehri Dam is 246.50 metre high and 1125m wide, earth and rock fill dam. It will store 3540 million m^3 of water for a catchment area of 7511 sq km and forming a lake of 42 sq. km.

4.1.1 Geology as investigated

The Dam is situated in Lesser Himalayan geo-tectonic block which is bound by Main Central Thrust (MCT) in the south. The rock exposed in the area are Chandpur phyllite, having variable proportions of argillaceous and arenaceous constituents. These rocks are classified into four sub-classes as Phyllitic Quartzite Massive (PQM), Quartzite Phyllite (QP) and Speared Phyllite (SP). The over burden is 10 to 15 m thick below the river bed level at the Dam site. The bed rock is traversed by numerous major and minor shears classified as diagonal (D) and longitudinal (l) shears depending upon their geometric relationship with bedding and foliation of rocks, thickness of clay gouge and the width of the affected zone. These shears have affected the Geotechnical behaviour of rocks as revealed by detailed geological exploration.

During the execution of large hydro-power project civil works, numerous construction problem of different magnitudes arise due to adverse geological strata. Every geological problem is unique and, therefore, to tackle the same for achieving the target of construction needs patient tackling. Any desperate effort to expedite the construction works in adverse geological condition may create problems, hence be avoided.

Spillway structure in large dam all over the world reported failure. There is thus a need to take into account the geological complexities. Tehri Dam has one chute spillway and two shaft spillways. The Dam has been designed to a maximum flood of 15, 540 cumecs corresponding to a flood frequency of 1 in 10,000 years. (The monsoon system which brings precipitation is only 10,000 years old). Detailed investigations were therefore needed in the spill way area during construction of dam. The investigation of the Dam had been divided in to two phases. One before the construction and the other during construction. The pre- construction phase geological investigations were aimed at deciphering the following anticipated problems.

(1) Major river bed shear zones/ faults
(2) Disposition of bed rock and deep weathering of abutment rocks.
(3) Huge slide mass on the right abutment
(4) Lugeon value of rock mass permeability

(5) Seepage through shear/ weak zones.

The investigations led to the following important Geotechnical assessments.

(i) The fear of encountering major river bed fault was disposed off through extensive drilling/ drifting in the dam area. It was supplemented by electrical logging. The dam foundations excavations done in 1991 also supported the view of absence of any river bed shears.
(ii) The rocks dipped 40º-67º down-stream of dam. This posed no stability problem.
(iii) The thickness of overburden was estimated to be 15-30 metres, hence needed stripping before the foundation treatment.
(iv) The average thickness of weathered rock in the river section was found to be 1 meter, based on geophysical logging.
(v) The thickness of huge slide mass was found to be 40-50 metres.
(vi) The permeability value of 50 lugeon were mostly in the overburden and highly weathered rocks. The fresh rock in the dam foundation had permeability in the range of 1-2 lugeon.
(vii) Two major longitudinal shears were identified, which traverses across the dam seat, for treatment against seepage.

The above geological facts were helpful in deciding placement and design of the dam and its components. The area is highly seismic, hence the design of the dam had been done to prevent any ill effects. The width at crest is 20m and flared to 25m at abutments, 9.5m free board to take care of settlement/ slumping, dam slopes 2.5:1 (upstream) and 2:1 (downstream) and provisions of inspection galleries in the dam body, are some of the special features provided in view of the geological investigations done prior to the construction of the dam.

The construction stage investigation is done to ascertain the stipulations made after pre-construction stage investigations. Most of the stipulations were found to be correct and helped in giving adequate treatment to the rocks exposed during construction. Following are the details of investigations done during investigation stage.

4.1.2 Details of Engineering Geological Investigations & Explorations carried out at Tehri Dam site (during Investigation stage)

(A) Geological Mapping

i)	Project Area on 1:1000 scale (Dam site, spillway site, powerhouse site)	1.50km²
ii)	Dobata Borrow Area on 1:4000 scale	1.44km²
iii)	Reservoir Area on 1:16000 scale	65 line km (Traverse mapping)

Explorations

i)	Drifting (dam site, chute spillway, Dam site, spillway site, powerhouse powerhouse under riverbed drift)	30 drifts (1470 m)
ii)	Drilling	208 drill (total 10.5 km)

(B) Insitu Testing

(Dam site PH site etc.) — 300 tests (Tests include cyclic plate load, flat jack, block shear, Good man jack, pressure meter, time dependent plate load test, Elastometer, wave propagation)

(D) Geophysical Investigation: 28 line km geophysical logging in the project area.

The above figures speak for themselves about the efforts made during the investigation stage. The investigations were thus adequate.

4.2 Project Formulation and Planning

The time schedule proposed was inadequate. Instead of 5 years it should have been 7 years. The project was conceptualised, detailed feasibility report was made on the basis of contemporary technology and expertise available. Necessary secondary and primary data about topography, geology, hydrology, seismology and environment were used in technical formulation of the project. This is as per the norms prevalent in the country, however, far short of international standards.

There were no major changes in the project design. Minor changes were effected for safety considerations only. These changes were in no way responsible for delays. The basic designs were made on the basis of the information available and contemporary technology. Both got refined with time and one should take its advantage. This was done at Tehri Dam Project in view of long time available. Geological information available at the time of design gets refined during the course of project execution. Rock treatments were done to enhance its quality and extra reinforcement, grouting and concreting were done in view of the geology revealed in the course of construction.

There is a Technical Advisory Committee which oversees the project construction and helps in evolving solutions to the problems faced by the construction engineers. There is no single agency providing consultancy to the entire project complex but there are many expert agencies involved in providing needed expertise. The following are the important agencies:

(1) Hydro Project Institute (HPI), Moscow
(2) Geological Survey of India
(3) Survey of India
(4) Central Water Commission
(5) Central Electricity Authority
(6) Central Soils and Materials Research Institute

The above consultants were appointed on the basis of MOU signed between the THDC and the respective agencies. With the HPI there was a regular contract.

Most of these agencies are owned by Govt. of India. HPI however, is a foreign agency, which was associated with the project work since the very beginning.

The land acquisition and R& R are being looked after by a separate Directorate, wholely devoted to the task. Land acquisition and R & R are very difficult issues because they are linked to the local population and their interest where State Govt. has a major role. The local pressures, political influence, personal egos and individual interest very much influence the process, adding to the complexity. R & R was the sole cause for cost and time over run and this process is still going on. In any future project this has to be looked into thoroughly and appropriate steps be initiated to ward of its ill effect on the progress of any future project. The initial provisions in 1994 were about 13% of the Rs. 2851 Crores project cost which rose to about 15% as in March, 2005 figure of Rs. 6896 Crores, not a big rise, but its influence on time over run was very significant.

The project never suffered on account of finance after the Ministry of Power assured funds under joint venture with THDC and the state govt. There are instances of funds not being utilized with in a specified period.

In view of the above it is concluded that there was no major flaw in project formulation and planning. Had there been no agitations, the project would have been completed in time as planned in 1994.

In adequacies in Project Formulation and Planning

The time schedule proposed was inadequate. Instead of 5 years it should have been 7 years. The project was conceptualized, detailed feasibility report was made on the basis of contemporary technology and expertise available. Necessary secondary and primary data about topography, geology, hydrology, seismology and environment were used in technical formulation of the project. This is as per the norms prevalent in the country, which are far short of international standards.

The project formulation and planning was done by U.P. Irrigation Engineers. There was a Board of Consultants comprising of eminent engineers of those days who guided the entire process. The designs of the dam and the underground Power house were finalized and finally approved by the Board of Consultants. The designs were used for calculation of qualities of different items of work and the costs were estimated as per the then prevailing rate schedules. The process adopted for formulation and planning of the project was therefore reliable and flaw less.

The investigations, the project formulation and planning were therefore adequate in view of the available information.

CHAPTER-5

CONTRACT PLANNING & ADMINISTRATION

5.1 Evaluation of Contract planning and Administration

5.1.1 Performance of the contractor

6.1.2 Performance and Adequacy of the contractor

There were two project components one the Dam and the other Power House. There were undertaken by two different contractors. The Dam component is being executed by M/S Jaiprakash Industries and Power House part is being constructed by M/S Thapars. Both firms have high credibility in Construction Industry.

The Jai Prakash Industries Ltd. as well as M/S Thapars (underground works) as per were given a time frame of 60 months to complete the task assigned to them as per the details given in the tender documents. The contract bidding was as per the International Contract Bidding procedures (ICB) and bids were undertaken for various packages constituting the total work. It is a normal item rate contract. These procedures are prevalent in the construction industry in India and were acceptable to the THDC and Govt. of India.

The performance of the contractors were regularly monitored by the monitoring wing of THDC. The General Manger (Project) kept liaison with the contractors and work was undertaken as per the contract. There are appropriate penalty clauses in the contract and they will be followed, if any discrepancy is found on the part of the contractors. There is nothing on record to show any performance failure.

The THDC engineers have not given any specific information about inefficiency or lack of competence is doing the job. Difference of opinion between the client and contractor is common and unresolved issues are settled through arbitration process provided in the contract. To-date there are arbitration claims to the tune of over Rs. 300 crores, at various stages of arbitration process.

Consultants have visited the site and met the contractors and it was observed following: The Contractors have been performing as per the scope of work given to them. Both the contractors have performed as per the terms and conditions of the contract and there are no records to the contrary. Following information is given about the contractors engaged.

M/S Jai Prakash Industries (JPI)

Jaiprakash Industries (JPI) is a diversified group with an annual turn over of Rs.5000 crores involved in construction of hydropower projects since last 30 years. It has 13 hydro-electric power projects spreaded over 6 states of the country. The company has a 'CRI' grade of ICRA. The company is to construct 127 km of tunnels, mostly in the Himalayan region for the current THDC Project. It has recently ventured into EPC/ Turnkeys hydropower contracts in India and was the first to undertake hydropower projects on EPC basis, against stiff international

competition. The company has completed one project on EPC basis, ahead of schedule by 6 months and has two more such project in hand. It is currently involved in the following major projects.

(i) Tehri Dam, the tallest rock fill dam in the world
(ii) Sardar Sarovar Dam Project
(iii) Indira Sagar Project
(iv) Tala Hydro Electric Project, Bhutan

The company owns cement plants, hotels, resorts and has institutes of higher learning. The JP ventures, a design and engineering firm has been assigned CT-1 grade by Indian Credit Rating Agency (ICRA) and the Construction Industry Development Council (CIDC). This is the highest rating assigned to consultants. The company claims to have adequate and latest equipment machinery, plants and infrastructure facilities for construction of major project.

M/S THAPARS (KCT)

Thaper-Intra for Company of India Ltd. (TICIL) is a group company of M/S Karam Chand Thaper and Brothers (CS) Ltd. is a "flagship" company of Thaper Group which has business in coal trading and logistics, heavy construction, printing, selling of mining equipment, aquaculture, processed food and real state. The group is the fifth largest and has 65 manufacturing plants.

TICIL, the group company has helped in construction of many hydro-electric projects in India. In view of their mining background they are expected to perform better in the field of underground construction. The following are some of the works they have completed.

(i) Entire water conductor system of Kalinadi Hydro –Electric Project in Karnataka.
(ii) Left bank diversion, de-aeration, cross tunnels of Tehri Dam project and vertical air vent shaft.
(iii) Investigations at Koteshwar Dam site.
(iv) Access tunnel to underground power house and tail race tunnel for Chamera Hydel Project.
(v) Tail Race Tunnel II for Salal Hydel Project.

Both the contractors were selected on the basis of open bidding process and were adjudged as the best for the job to be done by them. They are therefore expected to perform as expected.

Consultants have visited their sites and seen their work it was found to be satisfactory and as per the specifications laid out in the terms of reference given to them. The reasons for cost and time overrun as detailed out earlier have been due to other factors beyond the control of Project Authorities and not on contractors **p**art.

In view of the above, it is observed that the contractors are adequate for executing the work under reference.

The above information is compiled from the documents given by the companies.

5.1.2 Contract Negotiation and Management

The delay in finalisation of contract was due to various rounds of discussions to thrash out differences with the contractors passing through the technical bid and the bids had to be revised. This took lot of time. In view of being a major contract involving over Rs. 800 crores, the authorities were cautious.

Managing a contract had been smooth both for the contractor and the client. There are well set mechanisms at various levels to reduce any managerial problems. The unresolved issues are under various stages of negotiations. The claims on dam over Rs.300 crores are not large in view of the project dimensions and the inherent problems of agitations.

The contractors had been getting geological informations needed but more geologists might have helped in expediting day to day construction activities, they opined.

Dam

The tenders for dam were invited in 1993. The bidders gave wide ranging cost estimates and programmes. This necessitated rebidding. The important details of rebid are given below.

1. **Date of tender floated – 8th May 1996**
2. **Date of bid opening – 9th Aug. 1996**
3. **Date of Letter of intent – 10th Jan. 1997**
4. **Date of agreement – 27th Jan. 1997**
5. **Date start of work – 1st Feb. 1997**
6. **Value of contract – Rs. 898.45 crores**

The following were the bidders for the Dam.

1. **M/S Jaiprakash Industries**
2. **Hindustan Construction Company**
3. **Continental Construction Company**

Spill way

The bids for spillway were invited as per the following details.

1. **Date of tender initiated – 18th Sept. 1998**
2. **Date of opening of bids – 11th Nov. 1998**
3. **Date of issue of Letter of Intent – 15th Dec. 1998**
4. **Date of agreement – 28th 1998**
5. **Date of start of work – 1st Feb. 1998**
6. **Value of contract – Rs. 474.81**

The bidders were as follows

1. **Jaiprakash Industries**
2. **Karamchand Thapar**
3. **Hindustan Construction Company**
4. **Lanco**
5. **Gammons**
6. **Bhagirathi**

The contracts for Dam and spillway were awarded to M/S Jaiprakash Industries. The finalisation of contract for dam took nine months and for spillway it was 4 months. It is a reasonable time for the job.

Power House

The tenders for Power House (Package I, II, III) were floated in 1995. The following are the important acts.

(1) Tenders floated on 10.05.93
(2) Tenders opened on 15.12.93
(3) Amendments issued on 19.08.93
(4) Price bid opened on 03.01.95
(5) Contract awarded on 09.11.95
(6) Value of contract for the packages Rs. 210.84 crores

The processes took about 2 years and six months, a longer time for the activity.
Following were the bidders

(1) M/S Thapars
(2) Hindustan Construction Ltd.

The contract was awarded to M/S Thapars

5.2 Human Resources Development

The THDC does not have its own outfit for Human Resources Development. They however take advantage of specialized institutions in providing training and special knowledge to their staff. The project engineers are allowed to attend various courses, symposia and seminars to keep them abrest with the latest developments. The executives and non- executives are regularly sent for special courses run by institutions.

The project authorities have a senior officer who looks after the HRD. They are conducting in house HRD activities category wise separately i.e (A) Workers (B) Supervisors (C) Executives.

The topics predominantly covered for A & B above are pertaining to (i) Exposure about project awareness, employee benefits available in the corporation (ii) Broad perspective on individuals development including importance of time & their role, besides family & social responsibilities etc.

In respect of Executives (C) the HR exposure is predominantly on development of (i) Executive's personality traits, time management, project planning, CDA rules,

(ii) emphasizing disciplinary & motivational role of Executives in respect of non-Executives working with them, skill on number management etc.

Generally 03 programmes are conducted in a month, with each programme of 04 to 05 days duration.

Each month one paid programme of 02days duration is arranged through Central Board of Workers Education, Bareilly, of Union Labour Ministry through quarterly tie-ups.

Executives are also deputed (generally not exceeding one week) for training outside the organization keeping in view the corporation's need and the requirement of the individuals.

5.3 Quality Control of the Project:

In the Tehri Dam Project, the testing department is headed by a Manager level engineer. The quality control is done as per the quality policy of the organization. The quality control department is under the General Manager construction GM (C). GM (C) thus supervises the construction as well as goes into its quality control mechanism. This is not appropriate. The quality control department has to be responsible to an official above the rank of GM (C).

The issue of quality control and testing is getting much attention these days. Usually, the quality control should be under a neutral agency. This concept has not yet developed in our country. Efforts are being made to develop a system of quality assurance. The involvement of independent consultants and the academic institutions is being considered and in some projects the research institutions are already associated. These institutions suffer from lack of resource and staff. There is a need to look into the quality assurance problem at the national level to evolve a system and apparatus to attend to this very important issue of the construction industry.

CHAPTER 6
LESSONS LEARNT

7.1 Lessons Learnt

Tehri Dam Project is one of the important storage cum hydro energy generation complex is in the Himalayan region of the country. After Bhakara it is the biggest water storage dam and may provide benefits to the water starved areas of Western U.P., Uttaranchal and Delhi. The hydro- energy may add to the peaking capacity of the Northern Grid and may help in stabilising it. The project is nearing completion. The project construction started in late seventies as a project of U.P government. It was mired by controversies about its safety in seismically active areas with in the Himalayan region. Besides the safety, the rehabilitation and resettlement, infrastructure development and its accessibility had been the most important issues which contributed to the delays in its execution. The experience while constructing had been varied and numerous. Ardeous situations had been faced by the engineers. The engineers stood their ground and there is a hope of early completion of the project.

7.1.1 Problems of the project

Major projects done in far flung and inhospitable terrain with seismic risk, executed in younger Himalayan rocks may have many problems. Any project is normally executed with activities in the following chronology.

(1) Site identification, pre feasibility
(2) Detailed investigation
(3) Planning of the project and preparation of detailed feasibility report with realistic cost estimates.
(4) Designing of different components
(5) Arranging finances
(6) Rehabilitation and resettlement and land acquisition
(7) Infrastructure development
(8) Setting up base facilities for construction
(9) Construction
(10) Testing the system and operation

The above chronology was not followed at Tehri Dam, and most of the important activities went on simultaneously. These activities interfered with each other creating numerous difficulties at each and every stage of project implementation.

7.1.2 Geological Investigations

The Dam site and power house are located within a stretch of 2km×2km in the Bhagirathi valley. The Geologists of the Geological Survey of India, identified the potentiality of Bhagirathi river valley in the pre-independence period. The site was prima-facie considered an ideal place for construction of the dam. Probably, there were no geological surprises expected and the possibilities of river bed fault with in the Dam area were ruled out by undertaking detailed investigations through numerous drifts dug below the river bed, supplemented by many drill holes.

Geotechnical investigations aimed at evaluating design data for various surface and underground structures were also done reasonably well with the help of experts and the expert agencies engaged by the project authorities.

The issue of Dam safety agitated the minds of local people and the environmentalists. The matter was gone into details by various experts who concluded the Dam to be safe for maximum credible earthquake of 8.5 magnitude.

7.1.4 Rehabilitation and Resettlement

In the present project R & R Policy and Package originally evolved by GOUP in 1994 which was improved by THDC from time to time to account for escalations, however within the basic policy framework; a major package of improvement had taken place in November, 1995 after consultation with affected families. The process then continued and due to several agitation by Mr Bahuguna on various issues including R&R and Land Acquisition the Hanumant Rao Committee was set up in 1998 and a Govt. decision as announced on 09.12.1998, based on the recommendations of Hanumant Rao Committee (HRC), introducing attractive and liberal improvement measures, involving an additional expenditure to the Project.

The experience at Tehri had not been very encouraging. The R & R and infrastructural development in project area and its surroundings has to be evaluated critically while considering construction of any future project. There has to be elaborate R & R planning, execution to the satisfaction of the project affected people (PAP) and adequate and timely finance to look into this very important issue for future construction of any project. This issue should be settled prior to construction work starts. The project authorities should be made available the land they need and the affected people be settled amicably else where so that they may not be coming in conflict with the project construction activities. Such a situation may be an utopian idea and may not be possible in actual practice. However, efforts should be made to create the near ideal situation in realizing the goal of faster construction of any project.

Multiplicity of agencies operating in the project area, further complicated settlement of R&R, these are:

(i) State's agencies like revenue, forest, land and many other departments like education, health.
(ii) Private agencies NGO'S, private land owners, business community and service agencies like transport, building construction agriculturists etc.

The R&R and Land Acquisition have well set rules and regulations, which are to be satisfied and any dissatisfied person can go to the Court and seek stay like in the present case Mr. Bahuguna did that These things needs to be taken care of while formulating the project.

In effect the R&R procedures and Packages have not been frozen and still it is an ongoing activity.

The project is about 80km from the broad gauge rail head at Rishikesh. All weather road connects the project site now which used to be narrow and risky at many locations in the past. The project area needed local network for connecting various project sites and resettlement township of New Tehri Town. This was done simultaneously with the project construction.

7.1.5 Dam safety

Safety of Tehri Dam had always been an issue with the local people and the knowledgeable persons in the scientific field. In Feb. 1967, Mr. N.N.Yakovlov, UN Expert, recommended rockfill Dam to be the best solution. Mr. J.B. Cook, of USA in1972 also concluded that a high Dam at Tehri was feasible. In the year 1990 a high level committee was also constituted to look into it further. This committee also considered the Dam safe. After Utterakashi earthquake in October, 1991 the matter was once again looked into in depth. The Russians also studied the earthquake safety and declared it to be the gentle Dam to with stand severe earthquake shocks up to 8.5 magnitude.

7.2 Lessons Learnt for Future hydro Power Development

In Tehri Dam Project the agitations culminating into law and order problems had a dominating effect on the progress of the work schedule of every component of construction. The Tehri experience thus brings into forefront the importance of R & R and land acquisition and its viable solution before the construction of any project is taken up in real earnest.

7.2.1 Future Hydro Power Development Strategy

The experience of the past has shown the lack of investigation and appropriate R & R polices for tardy progress of hydro-power development. The first step is preparing Preliminary Feasibility Reports (PFR) to fixup priority for development. CEA has already got PFR prepared for 162 project. These reports have been prepared by various reputed consultants in the field of hydropower development. An overview has been prepared for these PFR'S and the documents contain state wise, capacity wise, tariff wise, head wise and storage wise distribution of all the 162 scheme. Low tariff schemes numbering 78 have been identified with a tariff of Rs. 2.50 per unit. These schemes have a total potential of 34020 MW and are accorded priority for phased development. The over views of PFRs contain details about location, capacity, cost estimates, work involved and required construction time. **There is a need to short list a few promising projects for preparing detailed feasibility reports. The short listing may be done in consultation with the states concerned.**

7.2.2 Impediments to Faster Development

The initiative for faster hydro-power development is laudable, but there are many impediment to implementation. Some of these are as following

(1) Land acquisition and R & R
(2) In-adequate investigations
(3) Geological and other problems

(4) Clearance delays
(5) Financing
(6) Management issues
(7) Power Purchase agreement and evacuation of power
(8) Financial viability of the venture
(9) Lack of interest for IPP
(10) Infrastructure development

The most important, relevant to Tehri Dam Project are given below:

7.2.3 Land Acquisition and R & R

Land acquisition and R & R had been the prime cause for delays and cost escalation in the case of Tehri Dam Project. More than five years were lost on its account. The process of land acquisition and R & R continued even till the late stage of project construction. No project should be taken up without ensuring land acquisition and R & R and advance planning is needed to accomplish the task. There is a need for policy initiative to ease the land acquisitions and R & R issues.

7.2.4 Geological and other Problems

Geological investigations are usually done in two phases. Pre-construction geological investigation usually provide some insight into the probable problems to be faced while construction of the project. Adequate designing and preparations are done to get over the problems posed by geology. During the construction, the investigations are continued to keep track of the geological features, likely to create problems and design and construction strategies are changed to lessen the effect of adverse geology. Inadequate pre – construction stage investigations were major impediments in the past. These are to be given appropriate priority in project formulation. There is a need to evolve codes for pre-construction investigations.

7.2.5 Clearance Delays

Various regulatory and expert agencies clear the project before the construction is started. The most important is the environmental clearance. Recently introduced public hearing clause looks into the problem of oustees and the over all impact of the project on the project affected people. Satisfaction of public hearing clause to some extent may reduce the problems of land acquisition and rehabilitation and resettlement. The clearance of the project by various regulatory bodies of central and state govts. also take time. Land use plan clearance also need lot of time. A forest land to be de-notified is a time consuming process. It is, therefore, necessary to seek all the necessary clearance before the actual work is started and the finances are committed. A check list of the clearance is needed and a time table to achieve them should be prepared and pursued. The Govt. has to evolve policy guidelines and regulations to accelerate the process.

7.2.10 Management Issues

Project management Issues should be decided in advance. Usually a contractor is appointed to execute the work. The finaslising process, evaluation of tenders, contract award and mechanism to resolve disputes between the client and the

contraction has to be structured and stream lined to avoid delays. The award of contract took more than three years in case of Tehri Dam Projects . this seems to be longer than expected and can be avoided. There has to be continuity in personnel handling work. Frequent charges, transfers etc. affect the pace of work. It is, therefore, necessary to groom a team of project personnel who work for the project with an object to complete the work faster.

CHAPTER - 7

7.3 Conclusions

Following are the important conclusions drawn on the basis of the study

(1) The project schedule of 5 years was rather tight, engineers wanted a minimum six years time.
(2) Time and cost over runs were due to numerous agitations related to land acquisition and R & R problems. The Dam safety was also a cause for agitation. This issue was thoroughly gone into by numerous experts and committees and the Dam was declared safe for credible earthquake magnitude of 8.5.
(3) The cost escalations were due to normal inflation, exchange rate rise, interests and duties.
(4) The design changes on safety considerations were normal for such a large project. It was not a cause for delay or major cost escalation.
(5) Consultants are mainly Govt. agencies or appointed by Govt. There are no complains of any deficiencies on the part of consultants.
(6) Contractors wee adequate to undertake the job and no deficiency reported so for.
(7) Geological investigations were adequate.
(8) Dam proved to be safe and sound as certified by numerous experts. Agitations on this count were therefore uncalled for.
(9) The project is yet to be completed and some land acquisition is still going on.
(10) Writing completion report should be made mandatory. It's preparation can be outsourced, if felt necessary.

7.4 Recommendations

(1) The projects in future be taken up in a phased manner. The pre-feasibility, detailed investigations must be done, before approving construction activities.
(2) Land acquisition and R & R must be completed before the project is started.
(3) Adequacy and timely finance should be assured.
(4) All regulatory clearance should be obtained before approving the project.
(5) There is need to evolve appropriate Guidelines and measures towards Quality control. The Future Projects should include a Quality controller as separate entity on the lines of procedures followed by the NHAI in road construction.

CHAPTER 8

GUIDELINES

8.1 Suggested Guidelines of best strategies for Handling Hydro electric projects in Himalayan Areas

The consultants have gone through the published literature about the construction of various projects in the past. The following guidelines are prepared on the basis of experience obtained in last 50 years of hydro power development.

8.1.1 Hydro-Thermal Proportion

The country had a very long experience in developing its hydro-power potential. The current hydro-thermal mix is 27:73 against an ideal of 40:60 which was there in sixties. The proportion gradually dropped over the years. There is thus a great need to prop up the mix to 40%.

8.1.2 Land Acquisition and R& R

The case study of Tehri Dam Project brought to the fore the inordinate delay in land acquisition and R & R. Many project suffer due to this reason. In Tehri Dam project agitations erupted intermittently and stopped the work on one or the other pretext. There is a need to develop a fast track mechanism to speed up the process so that Tehri Dam project like situations are not repeated.

No project should be taken up for construction before the land acquisition and R & R process are completed and the required land should be in the possession of the construction agency.

The following aspects could serve as a check list in respect of land acquisition:

- Whether land required for the project has been acquired from the following agencies by legal and rightful means:
  - Private land within the State.
  - Private land in neighboring State.
  - State owned land.
  - State owned land of the neighboring State.
  - Land owned by Central Govt.
  - Land owned by Forest Department.
  - Protected forest.
  - Reserved forest.
  - State Forest
- Whether land acquired is free from any encumbrances and with the necessary right of way to the contractor.
- Whether land has been handed over to the contractor as per project site delivery schedule.
- Whether any additional land is required subsequently due to additional work not included earlier and has been acquired before completion of the work.

- Whether the Competent Authority for Land Acquisition has paid for the private or common properties coming within the Row.
- Whether the contractor has no liability regarding rehabilitation/ resettlement of any persons affected thereby.
- Whether all clearances required have been issued by the competent authority, like NOC from State Pollution Control Board, clearance from MOEF etc.
- Whether all Applicable Permits for use of land have been obtained by the contractor in conformity with the Applicable Laws and are in compliance at all time.

8.1.3 **Inadequate Investigations**

Most of the projects in India were executed in the past without adequate investigations. This has resulted in geological surprises, faulty designs, delays in execution and cost escalations. Disputes between the client and the contractors were there and the cost of the projects increased many folds and the time frame going heywire. What should be the adequate investigation is a debatable issue.

The adequacy of the investigations can be judged by the persons investigating. The issue is site specific and optimum investigations level be worked out for individual projects and be implemented.

8.1.4 Equipment Mis- Match

The technology has advanced tremendously as well as the equipments to cope up with it. The performance of the equipments depends to a great extent upon its deployment within its capability ranges. The equipments are designed on geo-mining characteristics. A large change in these characteristics leads to miss-match and the equipment may fail to operate or may not give the desired results.

In underground works two methods are used i.e the conventional drill, blast and mucking (DBM) and tunnel boring machine (TBM). The DBM method offers lot more flexibility as compared to TBM, however, the TBM needs consistent rock mass behaviour over a long stretch. A tunnel boring machine may pay for its cost, if at least 15 km of tunneling is done by it.

In view of regional geology, the TBM may have better chances of success in the peninsular-region. In the Himalayan region, the TBM may not be suitable for the lower Himalayas. However, for the middle Himalays, having predominantly crystalline rock formations, the tunnel boring machine may be successful, provided consistent and long stretches of rock formations are available.

The selection of equipment should therefore be done with adequate care so that there is no mis-match. Here again a very well investigated project provides good information back up for the selection of equipments. Under Malabar Hill in Mumbai, TBM has been a success story and its failure in Dul-Hasti are note worthy.

8.2 Guidelines in terms of Contract planning & Administration for Future Projects in the sector:

8.2.1 The present rate contract system is a good old concept, and has well stood the test of time. The success depends to a great extent on good standard of pre-construction investigations. Lot of information is required for seeking clearance from various agencies. Infact a well documented Detailed Project Report (DPR) is a must, which had so far been a casualty. It is difficult to prepare a credible contract and its planning in the absence of a good DPR. It is suggested that:

- A detailed pre-investment feasibility study need to be undertaken including time lags due to land acquisition and other problems of the dam with a well defined long-term plan dictated by the emerging scenario in the project area. Changes in construction time **many a times for Tehri Dam Project** in are pointers to inadequa**cy of** planning processes. There is a significant resultant escalation in cost as well as time overrun from the original schedules on account of major problems at project construction and execution stages. For instance, the project was approved in 1994 in case of the subject project and the actual construction could be started in 199**7**. This time delay could have been avoided through proper project formulation and planning. These processes need to be expedited in future for speedy translation of projects on ground.

- The unwarranted time-lag between tendering and contracting of the Contractor should be minimized following the project financing arrangements and DPR. In the case of subject project, the tendering was undertaken in 1993 and contracting was finalized in 1997. The Owner needs to schedule all the activities related to the project as part of a Project Implementation Plan (PIP) which is documented well in advance and undertake rigorous variance analysis in respect of each of the tasks/sub-tasks as a feedback for timely corrective action. The responsibilities and roles of the key stakeholders need to be defined.
- All Pre-Project activities such as land acquisition, compensation, utility shifting, investigations, detailed design and tender documentation, project financing etc need to be sequenced in logical order and adhered to. The project implementation guidelines need to be developed and capacity building exercises of the relevant stakeholders in respect of project formulation, planning, monitoring and implementation should be integrated in to PIP.
- Contract should only be awarded after land acquisition and R & R are over and the needed land is actually possessed.
- There has to be a provision for close coordination between the stake holders. A schedule of meeting be prepared and adhered to.
- Day to day dispute redressal mechanism should be there to look into the problems between the client and the contractor. If possible a time limit be fixed for redressal.
- The owner should ensure closer coordination at District and concerned State Department levels along with the participation of Construction Supervision Consultant to address bottlenecks which impede the progress of work on an on-going basis through the project implementation period.
- The Guidelines on Contract Management System have been developed by Project Monitoring Division (PMD) of the Ministry of Statistics & Programme Implementation after consultations with several Government Agencies / Public Sector Enterprises. These guidelines in the form of Model Contract Documents are envisaged to provide a more effective and transparent system for good governance and result in ultimate savings to the nation by reducing incidence

of disputes in contracts, enhancing better cooperation among the participating parties and inculcating greater sense of responsibility, leading to speedy execution of projects. The ideas drawn up in the guidelines for management of contracts with sound planning and net-working of the related inter-linked activities would help the owner as well as the contractor in keeping a good control on the implementation of projects on day-to-day basis and in keeping the projects on proper track.

- Further, Guidelines for Standard Contract Clauses for Domestic Bidding have been approved by the Committee of Secretaries with a provision of periodic review by an expert body comprising experts drawn from Construction Industry, Public Sector Enterprises, and Government organisations. The Standard Contract Clauses, which, by and large, conform to the international practices followed by the World Bank, the UN Agencies as well as the FIDIC, would provide basic structure for preparing the Contract Documents, and the Standard General Conditions for domestic bidding would serve as guidelines for providing safeguards for specific work requirements. These would help clearly identify the responsibilities of the parties entering into contract to achieve the specific objectives within the prescribed specifications and boundary limits.
- Uniform contract guidelines as per above need to be adopted for all Hydro Power projects with minimum changes to the original clauses as per above guidelines for contracts.

8.2.2 **Contracting Alternatives**

The current project in question the old system of Rate contract was followed. This has its own advantages and disadvantages. Time is ripe to look for alternatives. The following forms may be useful to consider

(1) Design and built –**(**DMRC**)**
(2) Engineer, Procure and Construct (EPC) – Baspa, Vishnu Prayag, **Chamera)**
(3) Turnkey contract (Uri in J&K)

The adaptation of above mentioned systems lessen to a great extent contract planning and administrative matters, ensuring faster and escalation free construction of a hydro-electric power project. This aspect needs consideration in view of it being promising.

The rate contract system in vogue in India since a very long time has many deficiencies. It sometime becomes an open ended exercise delaying schedules and consequent cost escalation.

The owner has to prepare a very exhaustive project report. This needs detailed investigations which cost lot of money. The owner has to have a modern design office and has to have a field office to issue day to day drawings. Owner also keeps a large man power to monitor the progress and check the quality of construction. In the event of results of investigations proving wrong, the contractor may drawn compensation and may ask for arbitration in case of being dis-satisfied with the owner. This causes project

cost and time escalate putting both the owner and the construction in a tight spot.

The Engineer Procure and Construction (EPC) contract has helped to some extent in reducing the conflict between the owner and the contractor. Under the system the owner conceive the project and collects information for planning, designing and construction of the project. The owner invites the bids for the job. The most competitive bidder is awarded the contract. The contractor has to undertake further investigations to cover up the gaps if so felt. The owner asks for a time schedule and the cost to be paid as per the decided mile stone achieved. Any losses incurred due to any unforeseen cause are the contractors responsibility. The owner approves the designs of the project and evolves a mechanism for supervision and quality control.

The EPC contract system has already been introduced in the hydro-power sector. How for it has been successful is yet to be established but it is worth trying for future projects.

CHAPTER 8

MODEL COMPLETION REPORT FORMAT FOR HYDRO ELECTRIC PROJECTS

9.1 Suggested Format of Project Completion Report

The issue of completion report is very important one. The tradition of writing completion report has rather vanished and to-day we hardly have any well written completion report prepared for projects completed in the last fourty years. The completion report is basically historical document of project construction analyzing the problems faced, how they were solved and what lessons can be learnt which can be useful in future projects. The completion report of a project also helps in preparing operation and maintenance strategy for smooth functioning of the complex. Proposed format for writing completion report may be very useful and the project construction engineers will be tempted to write it for the project they constructed. The document will help the future generations to learn from the experience gained during the construction of a particular project. The Detailed Project Report (DPR) can be a good document to structure the completion report. In the following paragraphs a general format for the report is suggested. For a specific project report, it is necessary to add more items, if they are special to the project.

PART - A

(I) Introduction

(i) Purpose of Project
(ii) Location of Project
(iii) General Features
(iv) Salient Features
(v) Owned and assisted by

(II) Investigations done

(i) Geographical and Topography
(ii) Geology
(iii) Hydrogeology
(iv) Power Planning
(v) Contents of DPR, a brief resume

(III) Brief description of main project components

Dimensions of each component, capacities, etc.

(i) Dam
(ii) Tunnel
(iii) Gates etc.
(iv) Surge shaft
(v) Pressure shaft, Penstocks
(vi) Power House
(vii) Switch yard
(viii) Quality of water for irrigation

(ix) Capacities of Dam & Power house
(x) Cost of power per unit
(xi) Power Transmitted to
(xii) Water management, down stream canal system
(xiii) Power and water sharing arrangement

(IV) Construction

(i) Chronology of construction activities, mile stones etc.
(ii) Construction Method
(iii) Significant problems faced
(iv) Solutions evolved
(v) Details of time and cost over runs, reasons if any
(vi) Instrumentation
(vii) Environmental issues tackled

(V) Benefits

(i) Project cost
(ii) Power cost
(iii) Cost/ benefit ratio
(iv) Cost recovery road map

(VI) Lessons learnt

(i) Whether the work went as per plans
(ii) If not, what hurdles were faced
(iii) Any changes in original design and schedule
(iv) Typical construction problem faced
(v) Any advice for future construction
(vi) Changes in management structure
(vii) Financial strategies

(VII) Management of project

(i) Organisational chart
(ii) Mechanism for construction
(iii) Any issue worth mentioning
(iv) Problem with contractors, disputes arbitrations etc.
(v) Financial management, accounting, auditing etc.
(vi) Any specific advice for future

(VIII) Environmental Issues

(i) Problems due to implementation of environmental act
(ii) Environmental cost
(iii) Rehabilitation and resettlement issues
(iv) How they were tackled
(v) Land acquisition problems and resolutions

(IX) Social concern

(i) Residences for staff
(ii) Welfare of staff
(iii) Hospitals
(iv) Schools
(v) Upkeep of township

(X) Completion and thereafter

(i) Preparation of operation and maintenance manual
(ii) Use of infrastructure left behind
(iii) Procedures for project closure (construction stage)
(iv) Any important tips for operation staff

PART – B

List of illustrations

(1) Map of the Project area
(2) Key plan showing various components
(3) Intake structure
(4) Surge shaft, Power house, penstocks and tail race
(5) Contour survey plan of the river catchment
(6) Diversion structure, Dam weir, Barrage
(7) Lay out of Dam, spillways, etc.
(8) Layout of inspection galleries
(9) Penstock alignment
(10) Geological map of the project area
(11) Lay out of tunnels
(12) Diversion tunnel with plugging details
(13) Details plan of dam and abutment
(14) Details of rock treatment
(15) Layout of intake structure
(16) Trash rack
(17) Desilting arrangement details
(18) Silt flushing arrangement, if any
(19) Power House/ Lay out
(20) General Details of power House area
(21) Layout plan of control panels
(22) Power cable arrangement/ layout
(23) Generator layout from draft tube upward
(24) Schematic drawing oil/ water cooling system
(25) Schematic arrangement of evacuation system
(26) General layout of over head cables
(27) Organisational chart during construction
(28) Construction schedule
(29) Delay analysis flow chart
(30) Necessary sketches for operation and maintenance manual

It should be noted that the Department of Programme Implementation (DPI) have adopted the formats issued by the Bureau of Public Enterprises (now Department of Public Enterprises) vide their letter dated 14th February, 1980 in the case of projects costing more than Rs 20 Crores as far as DPI is concerned. Taking into account all aspects of evaluation of projects, a set of five (5) formats were designed for the preparation of Completion Report of public sector projects which are described below:

Project Description – this format gives an overall view of the project, including its capacity, production cost, phasing of expenditure, profitability, financial structure and employment. The information on actual achievement is compared with what was envisaged at the time when original/revised feasibility or project reports were approved by Government.

Pre-Construction Information – In this format, different parameters relating to pre-construction activities of the project are laid down for comparing the actual achievement with what was envisaged originally.

Physical Construction - This format briefly summarises the project construction schedule and completion of major activities, comparing the actual achievement with the original target and explaining various delays which might have taken place. In the last part of the format, the physical quantities of work are also compared with original estimates.

Cost - Apart from indicating different revision of the project cost estimate from time to time, it analyses the difference between the actual cost and what was originally envisaged, sub-dividing the cost escalation into different categories such as, inadequate or no provision, original price rise, increase in duties/taxes, change in scope, delays and other reasons for major project components.

Brief Narrative Report – This report is meant to highlight, in addition, project history, agencies involved, foreign collaboration, implementation achievements and failures, suggestions for future projects and any other qualitative observations. For various terms used in the formats, standard definitions of Department of Public Enterprises are to be adopted.

The above Model formats for Completion Report of Public Sector Projects adopted by Department of Programme Implementation are attached at Annexure – ???. The information in the above formats will provide valuable data for post analysis of the manner in which a project has been implemented to enable the Monitoring and Evaluation Authority in the Administrative Ministries and other concerned agencies in the Government to compare the information on the end results with those anticipated in the Project Reports and draw conclusions and improve Project Management in general. The Public Enterprises are required to furnish information in the above formats after formal commissioning of the project to the Administrative Ministry, Planning Commission. Ministry of Finance and Department of Programme Implementation.

ANNEXURE-I
TEHRI DAM & H.E PROJECT (1000 MW)

DETAILS OF THE SCHEME, SALIENT FEATURES AND BENEFITS

1.	**DAM** Type Top level Height Width at river bed Width at Top	 Earth and Rock-fill 839.5M 260.5M above deepest foundation level 1125M flared to 25M at abutments 20M flared to 25M at abutments
2.	**DIVERSION TUNNELS (Horse Shoe Shape)**	
	On Left Bank	2 Nos., 11.0M. Dia, 1774 & 1778M long
	On Right Bank	2 Nos., 11.0M. Dia, 1298 & 1429M long
3.	**RESERVOIR**	
	Catchment Area	7511Sq. Km.
	M.W.L.	835.0M
	F.R.L.	830.0M
	Dead Storage Level	740.0M
	Gross Storage	3540.0 Million Cub. M.
	Live Storage	2615.0 Million Cub. M.
4.	**SPILLWAYS**	
(A)	**Chute Spillway**	
	Crest Level	815.0M
	Waterway	3Bays @ 10.5M width, 2 piers 4.0M wide in between
	Design Discharge	5487 Cumecs
	Type & No. of Gates	Radial Gates, 3 Nos.
(B)	**Right Bank Shaft Spillways**	Ungated 2 Nos.
	Crest Level	830.20M
	Dia. of Shaft	12.0M
	Design Discharge	3946 Cumecs
(C)	**Left Bank Shaft Spillways**	Gated 2 Nos.
	Crest Level	815.0M
	Dia of Shaft	12.0M
	Design Discharge	3815 Cumecs
	Type & No. of Gates	Radial Gates, one for each shaft
5.	**INTERMEDIATE LEVEL OUTLET**	
	No. and Size	One 8.5 dia tunnel
	Discharge Capacity at EI	1200 Cumecs
	830.0M	

6.	**INTAKE WORKS**	
	Type of Structure	2 Nos. submerged structure
	Crest Elevation	720.0M
7.	**POWER TUNNELS**	
	No. and Size	2 Nos., 8.5M dia each
	Length	1676.0M
8.	**PENSTOCKS**	
	No. and Size	4 Nos., 5.75M dia each
	Capacity	146 Cumecs each
9.	**POWER HOUSE**	
	Type	Underground
	Design Head	188M
	Installed Capacity	1000MW (4×250 MW)
10.	**TAILRACE WORKS**	
	No. & Size of Tail-Race Tunnels	2 Nos., 9.0M dia horse Shoe shaped
	Length of Tail-Race Tunnels	1540.0M

BENEFITS

The main benefits from the Project when completed would be:

- Addition to the installed capacity in Northern Region: 1000 MW (2400 MW on completion of entire Complex)
- Annual energy availability peaking: 3568 Millon Units (6200 MU on completion of entire Complex)
- Additional irrigation in 2.7 lakh hectares area besides stabilization in existing 6.04 lakh hectares area.
- 162 Million Gallons of water per day (300 Cusecs) for drinking water supply to Delhi to cater to a population of 40 lac.
- 108 Million Gallons of water per day (200 Cusecs) for drinking water supply to the towns and villages of Uttar Pradesh.
- Integrated development of Garhwal Region, including construction of a new hill stations viz. New Tehri Town (NTT) with provision of all possible facility, improved communication, education, health, tourist traffic, setting up of non- polluting industries, development of horticulture, fisheries, afforestation of the region etc. much to the advantage of the people of the region.

Brief Description of Project Components

The project complex has two main components, the Dam and the Power House. They are interdependent and with out the dam being completed neither the power house can work nor the water for irrigation can be released. In the following paragraphs brief description of these components, with figures is being given.

Dam

It is an earth and rock fill dam 260.5 m above the deepest foundation level. The dam is 1.25 km wide at the rivers bed level and 25 m at the abutments. Fig. 1 give the general plan of the dam. The dam body is composed of clay core, shell material and rip rap. The clay core makes the dam body impervious and the shell material adds weight to the dam body. The rip-raps are laid on the body of the dam body to ward off against erosion caused by the water of the lake and the ripples caused. Fig.2 Plan of Dam, Fig.3 give a cross-section of the dam body. The dam body has inspection gallery with numerous instruments installed to monitor the behavior of the dam during operation.

Power House

Power House has several caverns and tunnels. The machine hall is the largest of all. Here the power generating machines are installed. There is a transformer cavern which is smaller as compared to the machine hall. Four head race tunnels (HRT) bring water from the dam through an intricately designed intake structures and surge shaft. The HRT'S terminate into penstocks, which ultimately feed water under head to turbines. The turbines are coupled to alternators which rotate at a given spaced to generate electricity at a rated voltage and currents. Fig.4 give general details of Head Race Tunnels and Fig.5 the 3-D Lay out of the underground power house complex.

ANNEXURE - II

COMPARISON OF DAM FEATUIRES AS PER CEA APPROVAL OF NOVEMBER 2003
TEHRI DAM PROJECT (STAGE -1) 1000 MW

SALINE FEATURES

Sl. No.		As per 1987 project report	As per present Construction
1	**Dam**		
	Type	Earth and rock fill	Earth and rock fill
	Top Level	839.5 m	839.5 m
	Height	260.5 m above deepest foundation level	260.5 m above deepest foundation level
	Width at river bed	1125 m	1125 m
	Width at Top Length at Top	20 m flared to 25 m abutments	20 m flared to 25 m abutments
2	**Diversion Tunnels (Horse Shoe Shape)**		
	On left Bank	2 Nos. 110 m dia 1774 & 1778 m long	2 Nos. 110 m dia 1774 & 1778 m long
		2 Nos. 110 m dia 1298 & 1429 m long 8120 cumecs	2 Nos. 110 m dia 1298 & 1429 m long 8120 cumecs
3	**Reservoir**		
	Catchment are	7511 Sq Km	7511 Sq Km
	MWL	835.0 m	835.0 m
	FRL	830.0 m	830.0 m
	Dead Storage level	740.0m	740.0m
	Gross Storage	3540 million Cu.m.	3540 million Cu.m.
	Live Storage	2615 million Cu.m	2615 million Cu.m
4	**Spillways**		
A	Chute Spillway	812.5 m	815.0m
	Crest level	4 bays @ 14.0m width, 3 Nos.	3 bays @ 10.5m width, 2 piers.
	Waterway	4.0m wide piers in between	4.0m wide piers in between
	Design Discharge	11800 cumecs	5487 cumecs
	Type & No. of gates	Tainter gates, 4 Nos.	Radial gates, 4 Nos.
B	Right bank shaft spillways		Ungated 2 Nos.
	Crest level	No provision	830.2m
	Dia of shaft	No provision	12.0m
	Design Discharge	No provision	3945 cumecs

Sl. No.		As per 1987 project report	As per present Construction
C	Left bank shaft spillways	No provision	Gated 2 Nos.
	Crest level		815.0m
	Dia of shaft		12.0m
	Design Discharge		3815 cumecs
	Type & No. of gates		Radial gates one for each shaft
5	**Intermediate Level Outlet**		
	NO. & Size	One No. 5.75m dia	One No. 8.5m dia
	Discharge capacity at EI		1200 cumecs
	830.0m		
6	**Intake works**		
	Location	Left bank of river Bhagirathi	Left bank of river Bhagirathi
	Type of structure	2 Nos. submerged structure	2 Nos. submerged structure
	Crest elevation	720.0m	720.0m
7	**Power Tunnels**		
	No. & Type	2 Nos. 8.5m dia each 1140+1250=2390m	2 Nos. 8.5m dia each 801+875=1676m
	Length		
8	**Surge Tank**		
	No. & Type	2 Nos.	???
	Crest level	250m dia	
	Top Level	El 883.0m	
	Bottom Level	El 725.0m	
9	**PENSTOKES**		
	No. & Type	4 Nos. 5.25m dia each 154 cumecs each	4 Nos. 5.75m dia each 146 cumecs each
10	**Power House**		
	Location	On Left Bank	On Left Bank
	Type	Underground	Underground
	Cavity Size	134mx 21.5m x 53.0m	188m x 22m x 47.2m
	Design Head	188 m	188 m
	Installed Capacity	1000 MW	1000 MW (4x250 MW)
11	**Tailrace Works**		
	No. & Size of Tail Race Tunnels	2 Nos. 11.0 m dia horse shoe shaped (part of diversion of tunnels)	2 Nos. 9.0 m dia horse shoe shaped (new provision)

Sl. No.		As per 1987 project report	As per present Construction
	Length of Tail race Tunnels	2x730=1460 approx.	1540 approx.
	Invert level at outlet	596.0m	596.0m
12	**Benefits**		
	Annual units generated on 90% availability	3091 million units	3091 million units
	Average year	3568 million units	3568 million units
	Additional Irrigation	2.7 lac. Ha.	2.7 lac Ha.
	Drinking water to:		
	Delhi	300 Cusecs	300 Cusecs
	U.P.	200 Cusecs	200 Cusecs

ANNEXURE - III

Chronology of events leading to the cost and time overrun (reproduced from Standing Committee Report)

Tehri Project has a chequered history, and has been subject of controversies and agitations on various issues, viz., safety of Dam, environmental issues, R&R etc. Project work had suffered on account of agitation and Dharnas. A chronological sequence of events, since project approval, affecting schedule of implementation is given below:

Mar'94	Government of India approved implementation of Tehri Stage-I
Oct'94 - Nov.'94	Work of Coffer Dam, which was prelude to construction of Main Dam, awarded.
Aug.'94 - Feb.'95	Uttarakhand agitation affected works and Rehabilitation, as agitators resorted to blockade State Govt. employee's strike also affected work. Raising of Coffer Dam commenced in Feb.'95 after removal of protective layer.
Feb.'95 – April'95	Population of nearby villages resorted to agitation in support of demands for employment and enhanced compensation, affecting movement of fill material to Coffer Dam.
April'95	Shri Bahuguna sat on dharna on approach road to dam site. Works suspended.
May'95	Shri Bahuguna removed from dharna site by the State Govt. but went on a hunger strike
Limited work of Coffer Dam could be possible before monsoon	
Aug.'95- March'96	Uttarakhand agitation continued, and works affected. Only intermittent working possible.
April'96	Shri Bahuguna started Upvas and Maun varta in support of his demands.
May'96	Govt. stayed shifting of affected population of Old Tehri Town
Jun'96/ Aug.'96	Based on assurance given to Shri Bahuguna, Govt. constituted Expert Group on safety comprising 5 experts, all nominated by Shri Bahuguna.
	Govt. also constitute expert committee under chairmanship of Prof. Hanumantha Rao (HRC) to examine Rehabilitation and Environmental aspects.

- Formation of Expert Committee, affected R&R works, since affected families wanted to wait for revised rehabilitation package as per HRC Report. Non-shifting of population caused hindrances to site works.
- Initial 2 years period was most crucial for the project, but it met with maximum resistance during this period. It was important to achieve milestone of Coffer Dam raising to enable starting of Main Dam work.

- Due to agitations and various controversies surrounding the project, at times the very fate of the Project appeared to be uncertain. Under the circumstances, heavy financial commitments on major works had to slowed down.

- Jun'96: Coffer Dam raised to safe height.

- For Main Dam construction, zero date, therefore, was practically October 96, to be taken up after monsoon.

- Of the 2 years delay in completion of Coffer Dan, 6 months (3 months each year) attributed to monsoon period, and balance period to agitations and dharnas leading to stoppage/ suspension and slow down of Civil Works, and Rehabilitation process.

- Jan'97: Government on review decided to lift ban on shifting of population, however, directed that no forcible measures to be adopted for shifting of affected families with the result there was no shifting.

- Nov'97- Feb'98: Shri Bahuguna again went on fast. Government imposed ban on blasting and movement of heavy vehicles in Dam area in Nov'97 which was lifted in Feb'98.

- Work of core-stripping of Main Dam affected for a period of 3 months and working season of 1997-98 for raising of Main Dam was practically lost.

- HRC submitted its report in Nov'97. Government announced decisions in December'98. Government also decided that Govt. of U.P would take over full responsibility of R&R.

- Expert Group on Safety submitted its report in Feb'98. All experts unanimously concluded that design of dam is expected to be safe to withstand maximum credible earthquake during economic life reservoir system. Government order accepting unanimous conclusion of report on Safety issued in Feb'98.

Safety considerations were primarily responsible for changes in design which enhanced the construction cost to some extent. Details of cost increase are given below.

MAJOR FACTORS CONTRIBUTING TO INCREASE IN COST

CHANGES IN DESIGN	Rs. 387.78 Crs.	• Design Changes Design changes had to be made on safety considerations. (i) Increase in specifications and thickness of Rip Rap material, and provision of clay core in the Main Dam. (+Rs. 133.03 Crs.) (ii) Change in Spillway designs to ensure safety of Dam. Also, provision of Intermediate level outlet made to ensure committed irrigation releases. (+Rs.186.90 Crs.) (iii) Provision for Tail Race Tunnels, due to changes in Spillway Designs (+Rs. 15.94 Crs.) (iv) Provision for Butterfly Valves in place of Emergency Gates (+Rs. 51.91 Crs.)
ADDITIONS/ DELETION	Rs. 41.82 Crs.	• Addition on land for NTT and additional houses for resettlement of oustee categories (+Rs. 24.70 Crs.) • Addition due to improvement in Rehabilitation Package (1995), and expenditure on maintenance of essential services in resettlements colonies (+Rs. 26.26 Crs.) • Additional Reinforcements in Spillway structures and Stilling Basin, and removal of unstable over-burden on the Slopes, on safety grounds (+Rs.50.45 Crs.) • Decrease in cost of Buildings due to change of norms: (-)Rs. 45.23 Crs.) • Reduction in cost of construction equipment: (-) Rs.59.01 Crs.) • Provision for computerized Control System for integrated operation (+Rs. 32.65 Crs.) • Misc. Additions (+Rs. 12.00 Crs.)
INADEQUATE PROVISION	Rs. 437.14 Crs.	• Specialised consultancy arrangements (+Rs. 45.13 Crs.) • Increase in Cost of land and buildings of NTT

		(+Rs. 16.71 Crs.) • Increase in quantity of open excavation due to geological conditions and provision of curtain grouting in underground galleries (+Rs. 73.80 Crs.) • Increase in quantity of concerting in Spillways due to changes in design (+Rs. 159.00 Crs.) • Increase in cost of roads (+Rs. 27.56 Crs.) • Provision for additional equipments (+Rs. 14.02 Crs.) • Increase in bus and provision for GIS (+Rs. 70.83 Crs.) • Services of Russian Consultants for erection and design consultancy, and erection supervision (+Rs.30.09 Crores)

ANNEXURE – IV
SAFETY OF THE TEHRI DAM

In the year 1949, Nautyal and Pathak of GSI identified the Tehri Dam site for the first time. Various international Experts for found it suitable construction of high dam. Mr.N.N.Yakovlov, UN Expert, visited the project in Feb. 1967 and recommended an earth and rock fill dam for Tehri. Mr. Cook , famous Consulting Engineer of US, who visited the site in 1972, had concluded that the site geology, topography and available material combined to make the 800 ft. high dam feasible.

Tehri Dam Design

Earth and rockfill type dam for Tehri Dam, is the safest man – made structure in earthquake prone zones. The S-shaped valley, along which the Tehri Dam is located, provides additional stability and safety against seismic effects. Tehri Dam design further includes several defensive features to ensure its safety under severe earthquake which can occur in the area.

Consideration of Safety Aspects by High Level Committee

The Govt. of India in 1990 constituted a high level committee, under the Chairmanship of the Director General. Geological Survey of India, with Members from Central Water Commission, Director, National Geophysical Research Institute, Head of the Earthquake Engineering Deptt., University of Roorkee and Dr.V.K.Gaur, an eminent Scientist and also the then Secretary (Ocean Development), Govt. of India, as its other members. This Committee after examining the matter in all its aspects came to a unanimous conclusion that even for a worst case scenario of assuming earthquake of magnitude +8 occuring at a depth of 15 kms, right under the dam, the dam would be safe vis –a –vis the maximum earthquake potential. All dangers arising out of the seismicity have been taken note of and taken care of in the planning of the Tehri Dam project. The Committee also noted that there would be no additional threat posed by the reservoir induced seismicity to the dam and the civilian structures in the vicinity.

Prof. Jai Krishna, who was the President of the Indian National Academy of Engineers, a former President of International Association of Earthquake Engineering and also the former Vice-Chancellor of the University of Roorkee, went through the report of the above committee and agreed with views. He recommended that the proposed dam section for the TEHRI project is safe from the point of seismicity of the region.

The overall factor of safety of the dam is high enough to eliminate any risk from earthquakes of the future.

Studies by the Soviet Consultants

The studies done and the tests carried out by the Hydro Project Institute (HPI) Moscow in 1986, under the Indo-Soviet intergovernmental agreement of 1986, have

conclusively established the resistance of the dam to a large earthquake originating from any of the active sources of seismicity identified in the Tehri region.

A rockfill dam, as the term implies, is built by packing in rock material to high density. Thus unlike a concrete or masonary dam, it is not a rigid structure and it cannot be displaced as one single homogeneous mass. Rather, under the effect of the horizontal forces, like earthquake and the weight of the reservoir's water body itself, there is only a relative displacement of the various layers of the dam. So under such a shearing stress, as it is called, the dam adjusts itself, by loosening here or tightening there the compacted rubble.

Under a shearing stress, besides such settlement, the stability of slopes of the dam is another critical factor. As one layer tends to slip over the other, the slopes tend to become unstable and result in what is called the slip surface. Dam designers attempt to prevent such occurrences by making the slopes flat or gentle enough.

The dam slopes have been designed based on the experiences of other similar dams around the world. In the case of the Tehri dam, the upstream slope, or the base to height ratio, is 2.5:1. On the downstream side, the slope is 2:1. So once the height is fixed based on the envisaged reservoir capacity, these slope ratios yield a base width of 1.125km for Tehri.

Data on the great dams in seismic zones shows that the Tehri dam has one of the gentlest slopes.

In tests done by the Russion Experts the dam was first subjected to real destablising forces as experienced during the Gazli earthquake and two 'most unfavourable' simulated ones.

They found that the factors of safety are much higher than the specifications in the Indian code.

Even at worst, the experts found that there is an initial slip surface confined only to the upper surface of the slopes after which it stabilizes and the factor of safety increases. Indeed, the Soviet study points out that the seismotectonic situation, which produced very strong ground motion, is hardly comparable to Tehri where the ground motions are likely to much milder.

Review After October 1991, Uttarakashi Earthquake

Uttarkashi earthquake again brought into focus the safety of Tehri Dam. Inspite of being concerned by the safety of the Dam, Govt. of India, appointed another committee to go into the matter afresh. The Dam design safety were thus reviewed.

The Expert group of the committee examined the whole issue in details. The committee unanimously agreed that the dam was safe for maximum credible earthquake in the area. Some experts felt the need to do 3-D non-linear analysis which was subsequently dropped in view of the recommendations of the National Standing Committee on Seismic Design Parameters.

In view of the above the Govt. of India was fully satisfied with safety of the DAM. The Govt. did all that which was felt necessary and got examined the entire issue several times.

ANNEXURE - V
Table –1
MAIN DAM - Original cost - Rs. 898.45 crores
Agreement No. THDC/ ND/ CD – 145/ AG dated 24.01.97

SL. NO.	Milestone/ Activity (Original schedule 93-94)	Completion period in months from the date of notice to proceed with the work	Actual months ++ the work actually started in Jan. 1997, hence the milestone set shifted to January 1997 and onwards	Reasons for delay
1	Rising of the down stream portion of the dam upto 638.0m to serve as D/s Coffer Dam	End of first working season* October, 1997 **7-9 months**	12.12.98 14 Months	Restrictions imposed on working by the client and delays in availability of drawings, geological clearances, removal of DPH colony etc.
2	Dam top elevation 710.0m (with truncated dam section)	End of second working season* October 1998 **7-9 months**	29.02.2000 16 Months	Non-availability of adequate shell borrow areas, hindrances by locals reasons./ villages etc.
3	Dam top elevation 825.0m (with truncated dam section)	54 Months January 1997	08.12.03 108 months	Non-availability of adequate borrow areas and Asena quarry site, hindrances by local persons/ villagers. Delay in decision of Inspection Gallery at EI 700m etc.
4	Dam top raising to full height (Top elevation 839.5m)	60 Months January 1997	31.03.2006 (Anticipated) 111 Months	Non availabity of Asena quarry site, hindrances caused by local persons/ villagers etc.
5	Excavation of underground galleries	43 Months November 2000	18.10.02 34 Months	**Within schedule**
6	Concreting/ guniting of underground galleries	43 Months June 2001	30.06.2005 (Anticipated) 48 Months	**Marginally delayed**
7	Consolidation and curtain grouting	55 Months July 2001	30.03.2006 (Anticipated) 58 Months	**Marginally delayed**
8	Completion	60 Months	31.03.2006	Due to delay in

	and handling over of the works	January 1997	(Anticipated) 111 Months	completion of Mile-stone **4**.

Expected cost on completion – Rs. 1310.00 crores

(*Working season generally means from October to June) – **9 months, generally**
++ The mile stone may be starting from January 1997.

Table – II
SPILL WAY
Original Cost – Rs. 474.81 crores
Agreement No. THDC/ NDA/ CD – 165 (A)/ AG dated 28.12.98

Sl. No.	Milestone/ Activity (Original schedule 93-94)	Completion period in months from the date of notice to proceed with the work	Date of actual/ expected completion	Reasons for delay
I	Closure of tunnels/ stop logs & construction of u/s plug.	28.12.2000 24 Months	18.01.03 48 Months	Agitation by villagers
	(a) T-3 (b) T-4	28.12.00 24 Months	28.01.03 49 Months	Agitation by villagers
	(c) T-1	28.11.02 47 Months	31.01.04 61 Months	Delayed on account of delay in Mile-stone I (a) & 1(b)
	(d) T-2	28.12.02 48 Months	31.10.05 82 Months	-Do-
II	Intermediate level outlet complete in all respect	28.09.02 45 Months	12.03.05 74 Months	(1) Delay in deciding the portal. (2) Increase in quantity of excavation. (3) Revision in drawing s of tunnel section beyond ch. 175. (4) Modification of tunnel section beyond Ch. 175.
III	Sill portion of Chute Spillway and left side wall of chute spillway upto EI 620m	28.09.02 45 Months	05.01.05 52 Months	Consequent delay in Mile-stone no. 1(a) & 1(b), Non-availability of super plasticizer & Microsilica to be supplied by THDC.
IV	D/s River protection works	28.09.02 45 Months	31.05.04 45 Months	Consequential delay in Mile-stone no. 1(a) & 1(b)
V	Stilling Basin and wall of Chute Spillway upto EI 630m	28.09.02 45 Months	30.08.05 80 Months	Consequential delay in Mile-stone no. 1(a) & 1(b).
VI	Control structure	28.03.03	10.11.04	Related with erection of gate by

	with gates	51 Months	70 Months	other agency.
VII	Left bank shaft spillways (a) Excavation of shaft T-1 up to EI 670m	28.08.2000 20 Months	05.01.02 36 Months	Delayed availability of construction drawing of widening of the pilot shafts.
	(b) Excavation of shaft T-2 up to EI 670 m	28.12.2000 24 Months	20.03.02 39 Months	Delayed availability of construction drawing of widening of the pilot shafts.
	(c) Concrete lining of shaft T-1 up to EI 570 m	28.12.2001 36 Months	30.11.05 anticipated 83 Months	Consequential delay in Mile-stone 1(a) and (b).
	(d) Concrete lining of Shaft T-2 up to EI 670 m.	28.09.02 454 Months	28.02.06 anticipated 86 Months	-Do-
VIII	Completion of all works	28.06.03 54 Months	30.09.06 Months	Consequent delay in Mile-stone I to VII.

Expected cost or completion Rs. 885.00 crores