Integrated Kashang Hydroelectric Power Project

Background

Himachal Pradesh is blessed with abundant water resources in its five major rivers i.e. Chenab, Ravi, Beas, Satluj and Yamuna, which emanate from the Western Himalayas and flow through the state. These snow-fed rivers and their tributaries carry copious discharge all year round which can be exploited for power generation. All the river basins and valleys are connected by roads, other communication network and strong base of other social infrastructure like health and education etc. The power generation potential of the state is 20,386 MW, which is about 25% of the total hydel potential of the country, out of which around 6150 MW stand harnessed so far. The balance potential, if harnessed expeditiously in a judicious manner, can provide adequate resources to the state to promote its developmental activities.

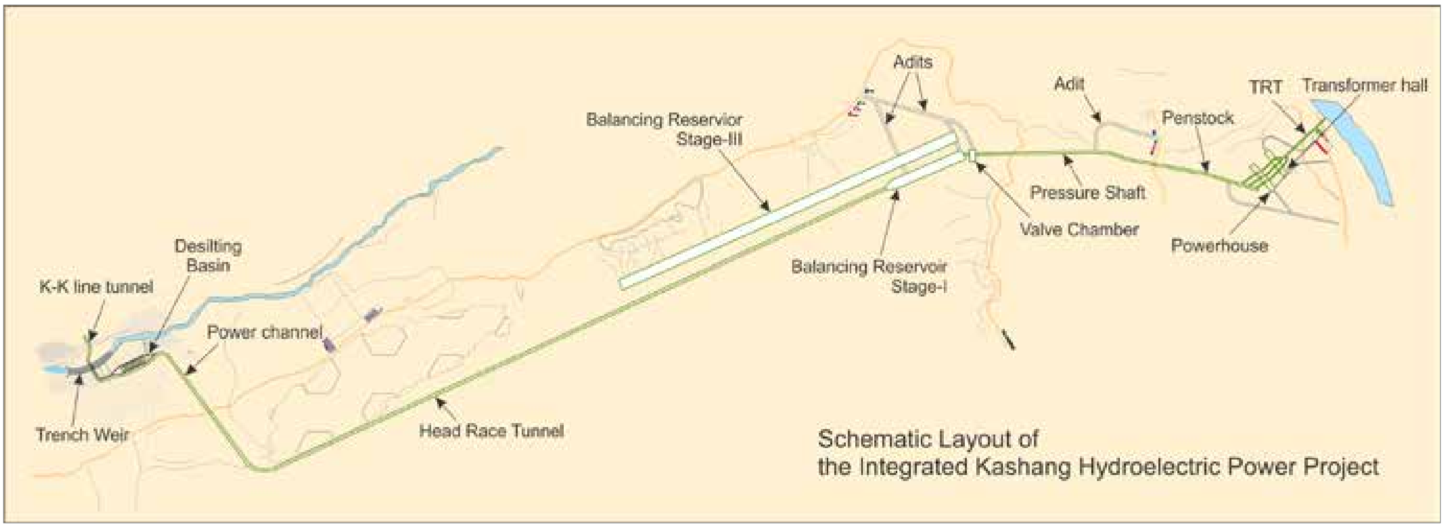
Project description

The Integrated Kashang Hydroelectric Project is located in Kinnaur District in the north east corner of Himachal Pradesh. The district is bounded by Tibet (China) to the east, Shimla district in the West and Southwest, the state of Uttarakhand to the south, Lahul and Spiti district to the north and Kullu district in the north-western fringe. It has a total geographical area of 6401 sq. km. Satluj river divides the district into two parts. In its traverse the Satluj River crosses three more or less parallel mountain ranges viz. Zaskar Mountain, the Great Himalayas and the Dhauldhar ranges. The significant tributary streams and rivers that flow into river Satluj from south or along its left bank are successively the Tidong, Hogis, Gymthing, Baspa, Duling, Sholding and Manglad etc. Likewise those entering from the north or its right bank are Spiti river, Ropa, Kerang, Kashang, Pangi, Choling, Bhabha, Sorang, Kut and Ganwi streams.

The project area falls in the Upper Himalayan zone. Kashang and Kerang streams are two right bank tributaries of Satluj river with the catchment area aligned approximately North-West. Both of these are typically hilly rivulets mostly fed by snow melt from large glacial bodies present in a substantially sizeable chunk of their catchment areas. There is glacial flow in the upper reaches of both streams. The valley slopes are prone to landslide at several places but are generally stable. The elevation of the project site varies between 3155 m (trench weir site of Stage-IV at Toktu) and 2000 m above msl (power house site at Powari).

The project is owned by HPPCL and comprises four distinct stages of development:

- Stage-I, comprising diversion of the Kashang stream to an underground powerhouse located on the right bank of Satluj, developing a head of approximately 830 m;



- Stage-II, comprising diversion of the Kerang stream into an underground water conductor system leading the upstream end of Stage-I water conductor system;
- Stage-III, consisting augmenting the generating capacity of Stage-I powerhouse using Kerang waters over the 820m head available in Kashang Stage-I powerhouse.
- Stage-IV, comprising of more or less independent scheme harnessing the power potential of Kerang stream, upstream of the diversion site of Stage-II.

The project would have a total installed capacity of 243 MW: 195 MW in the Kashang powerhouse and 48 MW in the Kerang right bank powerhouse. HCC was awarded the contract to build sections of stage I, II and III totalling to 195 MW.

All four stages of the Integrated Kashang HEP would generate 1659 Gwh energy annually on 90% dependability. In order to generate this power by a thermal power plant, considering specific fuel (coal) consumption as 1.06 kg/KWh, about 1.76 million tons of coal would be required annually.

Thus with the implementation of the Integrated Kashang HEP, a saving of equal amount of coal i.e. 1.76 million tones/year shall accrue which implies a direct benefit to the tune of Rs. 5280 million per year assuming the rate of coal of plant of Rs. 300/ton. In addition to this, there shall be reduction in Greenhouse Gas (Carbon dioxide) emission, if a thermal power plant were established.

Assuming about 997 gm/KWh emission factor for CO_2 generation (based on CPCB Study) about 1.65 million tons of CO_2 will be emitted from a 243 MW coal fired thermal power plant for generating 1659 Gwh power. Thus with the implementation of the Kashang hydroelectric power project, an equal amount of carbon emission will be eliminated.

Besides this, the pollution load caused by other major pollutants like NO_X and SO_2 shall be reduced annually to the tune of 450 tons and 6500 tons respectively. Thus, the project will help in reduction of emission of 'Green House Gases'.

The scope of work:

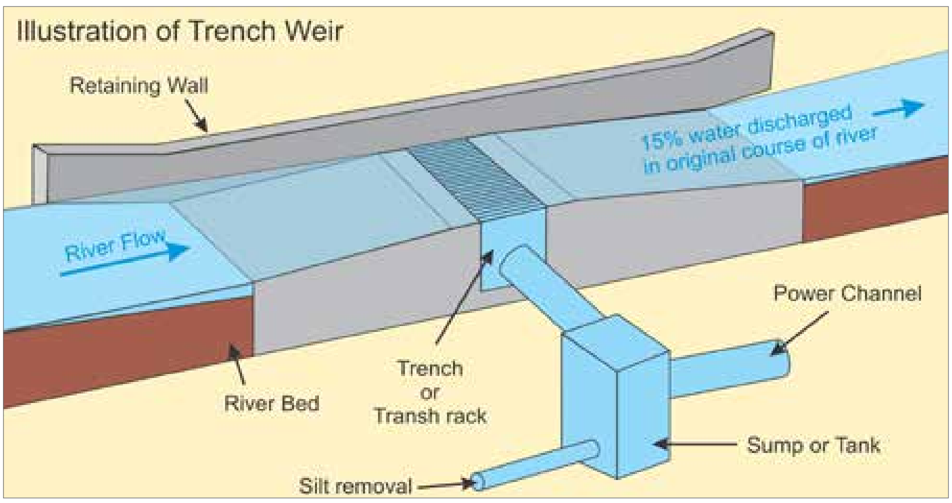
HCC was awarded the civil works comprising river diversion, intake structure, conveyance channel, de-silting basins, power channel, head race tunnel, underground balancing reservoir, pressure shaft, valve chamber and various adits. HCC commenced its mobilization at the site with the right earnest and immediately from the date of commencement.

Intake Structure and River Diversion Scheme

The main speciality of this project is that instead of a dam structure there is a trench weir. When the water flow is smaller, either a small dam or a weir is constructed to divert the water for power generation. Trench weir allows the water to flow over its top while a trench or a trash rack built within the structure traps the water and diverts it to a channel for power generation. The opening of trash rack is so designed to collect only the quantum of water required for power generation. This is how, a trench weir is slightly different from the conventional weirs. Trench weir also ensures that 15% of flowing water is discharged back in to its original course, even during the minimum flow seasons, as per the Indus water treaty.

Conveyance Channel

A Conveyance Channel is a box type structure designed as part of the water conductor system. The construction methodology adopted is cut and cover. The length of



Conveyance Channel is around 80m. The design drawing specified that the length of a single reinforcement bar to be used in wall and raft construction should be 12m long. However, it was practically not possible to transport 12m reinforcement bars to the Intake site. So, HCC advised the client's design team about the practical constraints and asked them to review the same. Accordingly, the entire design was reviewed and revised duly incorporating the 6m long reinforcement bars.

Desilting Basin

The general principal being adopted in the design of De-silting Basin is; Flow = Area x Velocity. As one increases the cross-sectional area of flow, the velocity will decrease as the quantity of flow remains same. When the velocity is reduced considerably, the sediments will settle down. There are several types of Desilting basin viz. Hopper type, DuFour type settling basin, Bieri type settling basins and Basin with Vortex tubes. The vortex tube type Desilting basin is being adopted in Kashang project.

Power Channel

The water, after removal of silt, enters into the Power Channel. The Power Channel is the confluence point of water from the Kashang stream and the Kerang stream. The Power Channel is a cut and cover type structure. The dimension of the Power Channel's cross-section is designed so as to accommodate the design discharge for the generation of power from three turbines.

Head Race Tunnel

Head Race Tunnel (HRT) is one of the major structures in an underground water conductor system. The 2 Km long HRT is a D-Shaped tunnel of 3.5m width and 4.115m height. The HRT carries water from the Power Channel to the Balancing Reservoir. It is designed to maintain a slope of 1 in 900. The velocity of nominal discharge through HRT is 2m/s. The excavation of HRT is carried out by drilling and blasting method due to its acceptability in a wide range of geo-mining conditions. Faster tunnelling rates are made possible with recent developments in explosives, initiating devices and drilling systems.

Balancing Reservoir

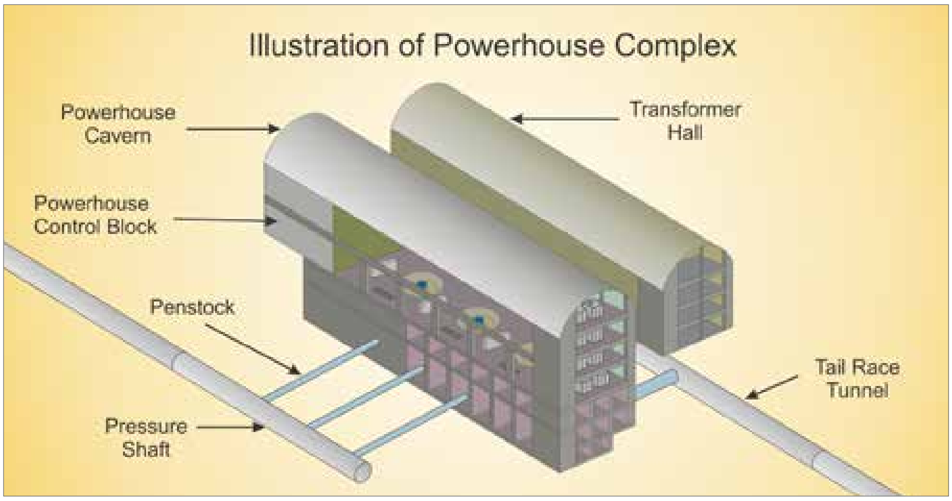
The Balancing reservoir is a huge underground water storage area. Since the Kashang powerhouse was conceived as a peaking station, a balancing reservoir is required to ensure guaranteed generation during peak hours. There are two balancing reservoirs in the integrated Kashang Hydroelectric Power Project. The first reservoir is 360m long with a 9m finished width. The bed of the balancing reservoir has a downstream slope thus increasing the depth of the Balancing Reservoir from 13.5m to 22.5m. The second reservoir is 1238m long with 8m finished width and depth ranging from 13m to 21m (the second reservoir is not in the scope of HCC).

Butterfly Valve and Valve Chamber

In order to regulate and control the flow of water through the pressure shaft, a Butterfly Valve has to be installed downstream of the balancing reservoir in the centre line of pressure shaft. The inside diameter of the butterfly valve will be the same as the inside diameter of the pressure shaft, which is present on both sides of the pressure shaft. Usually, the opening of the valve is carried out under balanced head condition only. There is a main inlet valve located near the turbine, downstream of the pressure shaft and penstock. The balanced condition shall be created by filling the downstream portion of the pressure shaft through a bypass fill pipe, keeping the main inlet valve closed.

Inclined Pressure Shafts

The water from the balancing reservoir flows down through a 1400m long and 55^{o} inclined pressure shaft to the powerhouse cavern. There is a vertical head drop of around 830m, and the energy stored in the flowing water is converted into electricity using the turbines located in powerhouse cavern. The water drained off from the turbines is drained into the river Satluj through the tail race tunnels. The pressure shaft is a steel liner water conveyance system used to carry the water stored in the Balancing Reservoir upto the turbine with designed velocity and certain fixed head for the



generation of electricity. The pressure shaft is designed in two major limbs viz. upper inclined pressure shaft and lower inclined pressure shaft. Also, there are three horizontal limbs, one at the top, one in the middle and one at the bottom, respectively. This ensures that water flowing from the balancing reservoir will flow through the top horizontal pressure shaft, then to the upper inclined pressure shaft, the middle horizontal pressure shaft, the lower inclined pressure shaft and finally to the bottom horizontal pressure shaft.

The water flows from the bottom horizontal pressure shaft to three unit penstocks and these penstocks injects the water to the turbines. The major criticality of these shafts has aroused due its inclination. Lower inclined pressure shaft is 55° inclined from horizontal plane and at the same time, 9° inclined from the vertical plane. The upper inclined pressure shaft was also inclined at 55° from the horizontal plane. The construction methodology adopted is excavation from bottom to top using a raise climber machine. The diameter of the excavated shaft was 3.6m. This high pressure shaft has to be lined with high strength steel liner plates. The rock cover cannot withstand the high pressure being generated by the head of flowing water. Hence the inclined pressure shaft is designed with steel liners inside it. These steel liner plates are high strength steel.

Powerhouse Complex

The general arrangement of the Kashang Stage-I and Stage-III powerhouses has been developed for three, 65 MW, vertical axis Pelton turbines. Out of these, two units will be installed in Stage-I and the third unit will be installed in Stage-III, along with the implementation of Kerang-Kashang Link Scheme. The excavation required for both the Stage I and Stage-III of the project was completed within the scope of the Stage I works.

The machine hall cavern is 16 m wide and 87 m long. The control room, 16m x 20 m, is located at the north end of the machine hall cavern. The transformer hall cavern is 15.5 m wide and 88.2 m long and is designed to house 10 single-phase transformers and the GIS equipment.

Challenges encountered

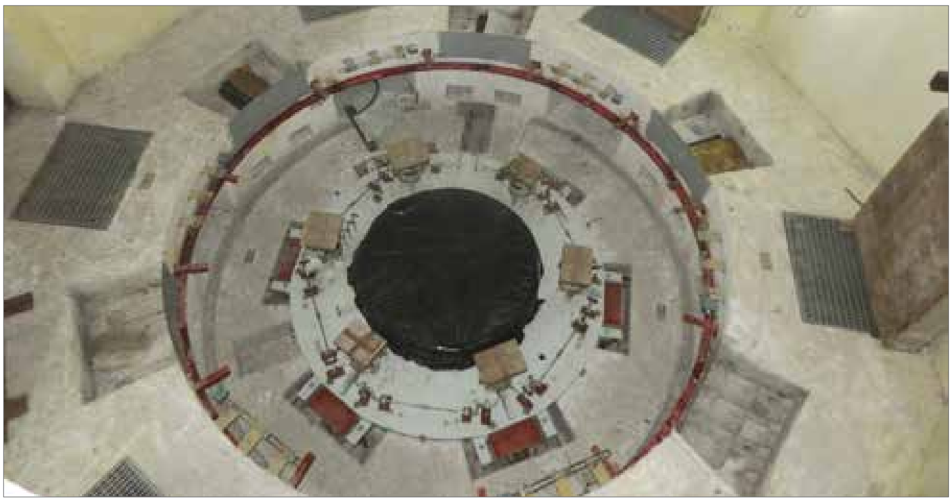
Excavation of the Inclined Pressure Shaft

It was a very tough task to ensure that the excavation of the Inclined Pressure Shaft is progressing exactly in the desired line and gradient. The same was accomplished with the use of very sophisticated survey equipment such as total station. The total length of the inclined pressure shaft was 1.3km and there is a total head of 800m. It was estimated that, the rock cover available outside the inclined pressure shaft will not be sufficient to withstand the huge pressure of the 800m high water column.

So it was decided to provide a high strength steel lining cover inside the inclined pressure shaft. It was designed to make a 2.6m diameter steel ferrules lining inside the 3.6m diameter excavated shaft. A fabrication yard was set up at Rampur, Himachal Pradesh. In order to ensure the soundness of welding each of these welds has to undergo thorough radiographic as well as ultrasonic examination. A detailed time cycle study of micro level activities involved in the fabrication of steel liner ferrules was done to expedite the work progress. It was observed that around 48 hrs were taken for welding 5m long ferrules inside the pressure shaft. The same welding with more precision was achieved in 24hrs in the fabrication yard. Also the ferrule lengths were increased from 5m to 7.5m; thus reducing the number of welds inside the tunnel from 105 to 71 in the lower inclination shaft and from 94 to 63 in upper inclination shaft. This resulted in estimated time savings of approximately 140 days.

Adverse geological conditions

There were several incidents of unanticipated/ unforeseen/surprising adverse geological conditions suffered by the project on various components / structures like HRT, BR, inclined pressure shaft, adits etc. Due to this adverse geology, huge cavity has formed at the crown and alongside the tunnel alignment up to the maximum height ranges from 6 to 10m. A shear zone was encountered in Adit to BR from RD 92 to 122 +/- m which is nearly parallel to the tunnel excavation direction which resulted in



failure, especially wedge failure. The treatment of such a shear zone was very time consuming. All the materials and other resources required for the treatment of cavity was necessary to be shifted through the 550 inclined shaft, with the Raise Climber.

Accessibility to the project site

A major challenge to overcome was getting access to the Intake site. The Intake area is located around 22km from the district headquarters, Reckong Peo. On this route, Pangi was the last village that had a sizable population with a narrow treacherous road of which almost 8 kms were very narrow with overhanging rock cliffs on one side and a deep valley on the other.

Mobilisation of heavy construction equipment and other resources to project site was a herculean task. One of the major bottlenecks while mobilising resources was the 'C' Shape Half Tunnel near Taranda Khad. The maximum height clearance available in some stretches was less than three meter. Besides, the curves were too sharp for long trailers to negotiate. Initially, the team tried mobilising the heavy parts in flat body low floor trucks, but the chassis of these trucks are too long. The road above Pangi Nala was a small bailey bridge. The turning radius available near this bridge is too small, making the crossing of any long chassis trucks impossible. Also the maximum load carrying capacity of this bailey bridge is upto 9 tons.

After lengthy brainstorming sessions, the team opted to mobilise the heavy construction equipment dismantled into parts and reassembling it at the site. Though this is a time consuming rework, there were no other, better options. Another challenging job was the mobilisation and erection of the batching and crushing plant at the intake site. After determining the concrete quantity requirements, it was planned to commission a concrete batching plant with a productivity of 30 cum per hour. Also, in order to meet the requirements of aggregates, erection of an aggregate/s and processing plant which can produce 120 ton aggregate in an hour was also installed. Similarly, locations were identified and developed for establishing workshops, office,

auto garage, storage facilities, officers/ workers colony, first facilities etc.

It was also decided to maintain a store with adequate inventory at the Intake area. It was also difficult for the workers and officers to do a daily up-down from the Intake area. So a camp for accommodating around 400 persons along with mess and other facilities were established near the site.

Landslide, rock falls and flash flood at site.

There were several events of landslides, stone shooting and flash-floods that hindered the progress of the project. The access to the TRT was almost washed away and also made several sections of the approach roads unstable for the movement of construction machineries and manpower. On 20th August, 2013, a massive slip failure occurred in the Regura region of Village Pangi resulting in a vast area land settlement in the region. As a result, 254m stretch of access road to IPS started sinking. With the joint efforts of HPPCL and HCC, access road to the intake area was restored for vehicular movement on 12th October, 2013 and access road to the powerhouse complex was restored for vehicular movement on 16th November, 2013.

Glacier Avalanches

The project site was hit by huge avalanches during the month of February every year. Avalanches blocked the access road leading to the intake area and Adits to pressure shaft and powerhouse complex. HCC deployed machines to clear the avalanche which it managed to reinstating work in the minimum possible time.