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IMPORTANCE OF GEOLOGY IN FINALIZATION OF PROJECT COMPONENTS: A CASE STUDY OF RANGIT II HYDROELECTRIC PROJECT, SIKKIM.

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ABSTRACT

Hydroelectric power is renewable & clean energy. Himalaya is the best location to establish hydroelectric projects. The hydroelectric project requires, best geological studies for safe, viable and cost effective project construction. Rangit II hydroelectric project located in middle Himalaya, Sikkim. During finalization of project component such as dam axis, Head race tunnel, Surge Shaft, Penstoke and Power house site, requires not only the geological & geotechnical investigation but best possible interpretation also play an important role. During the detailed project study in Rangit II HEP, it observered that the project component which proposed in pre-feasibility stage, are not much viable in view of geology, safety & cost of the project. In this paper, we discussed about the finalization of the project component in view of geology and viability of the project.

Keywords: Dam axis,shear zone, River bed material, geological cross section, Penstoke .

1. INTRODUCTION

Rangit hydroelectric project (HEP) Stage-II was conceived in the master plan of Sikkim in 1974. The Rangit-II HEP is proposed to be located near the Rimbi village nearGayzing, West Sikkim district in Sikkim; which is about 120 km from the Gangtok, the state capital of the Sikkim. It envisages the utilization of the water from the Rimbi Khola, a tributary of Rathong Chu River, which in turn is a tributary of the Rangit River. A 47.0 m high dam, 163m long underground desilting chamber to take the water from its right bank of Rimbi Khola to generate 66 MW power generation capacity surface power house at the left bank of river Kalej Khola as part of the trans-basin arrangement of the project with the help of 3.4m diameter (dia) horseshoe shaped 4.66 km long head-race tunnel (HRT) and 2500 m long penstock with 3.2 m finish diameter.

2. OBJECTIVE AND METHEDOLOGY

Earlier proposed project component was located in very poor geological strata and not safe & cost effective. So project authority proposed to relocate/viable location of project components.
It's only possible with the help of surface geological mapping, drilling, drift, Geotechnical & Geomechanical test and best geological result interpretation.

3. LOCAL TECTONIC AND GEOLOGICAL SETUP

3.1 Local Tectonic setup

The previous studies (Gangopadhyay and Ray, 1980, De Celles, P.G, et al., 2000, Dasgupta, S, et al., 2004; Tiwari, V. M, et al., 2006; Neogi, S, Ravikant, V., 2008; Saha D, 2008, Bhattacharya and Mitra, 2009and others) suggestedthat in the Darjeeling-Sikkim Himalayas, the Main Central Thrust (MCT) sheet is carried by two distinct thrust zones, as MCT I and MCT II. The MCT-I separates the Higher Himalayan Crystalline (HHC) and its substrate consisting of the Darjeeling Gneisses and metamorphics of the Lesser Himalaya, showing inverted metamorphism at higher structural level. At a lower structural level another thrust zone (MCT-II) separates greenschist-facies Daling Group of the footwall and the inverted metamorphic sequence of the hanging wall. The MCT-II zone and its footwall contain slivers of deformed Lingtse streaky biotite gneisses, considered reworked basement of the mesoproterozoic Daling Group.

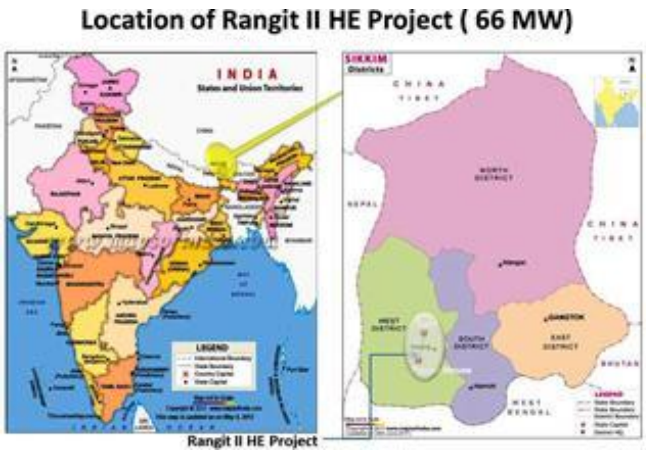

Fig.1:Location Map of Rangit II HEP.

An important feature of the MCT is that it is associated with an inverted metamorphic sequence where the grade of metamorphism increases towards the higher topographic and structural levels and characterizes rocks that immediately underlie the thrust. If one assumes MCT as basal thrust, the inverted metamorphic isograds generally starts from chlorite-biotite grades, garnet and reaches the kyanite-sillimanite grades with migmatites and anatectic granites in the highest tectonic levels. The project area falls in seismic zone-IV.

(ii) Project Geological setup

The project area is located in a succession of metamorphic rocks of Proterozoic age and mainly comprises of the Darjeeling and Darling formations that have been folded, faulted, fractured and sheared by intense tectonic deformation during the later deformational histories. The most prominent tectonic element within this region is the Main Central Thrust (MCT) separating the Daling and Darjeeling Group of rocks. The lithologies mainly consist of quartz biotite gneiss, migmatite gneiss, quartzite, chloritic schist and bands of biotite schist at various places. Detailed project geology, as observed during field study of the project area and referred with geological mapping done by Geological Survey of India; is given in table no 1 below.

4. DISCUSSION

Hydroelectric project can easily divided into three main components, first dam site includes dam, spellway, desilting chamber; second HRT and third one are Surge shaft, Pen stroke, Power House and Tail race tunnel. Stepwise project component finalization is given below:

4.1Dam site

The study relates to the three alternative dam axis, under study for a 40m high concrete dam, across Rimbi river. These axis are designated as Axis-1, Axis-2 and Axis -3 on figure 3. Axis -1 was proposed at the first D.P.R. stage and Axis -2 later on due to the unfavorable subsurface geology of dam axis 1. Axis -3 is located at about 36m upstream of Axis -1.

The note incorporates the results of surface and subsurface studies carried out for these axes along with the recommendations for the selection of one of them.

Group	Formation	Strata	Age	Project Component
Lingtse	Lingtse Gneiss	Magmatic /Granite Gneiss	Ordovician	Some part of HRT, Surge Shaft, Some part of Penstroke
…………………Thrust………………………				
Daling Group	Gorubathang F^m	Lw grade Chloritoid and Chlorite Schist, Biotite Phyllite/ Mica Schist	Proterozoic	Some part of penstroke and power house area
Central Crystalline Gneiss Complex (CCGC)	Kanchanjunga/ F^m	Garnet bearing Biotite Gneiss with/ without Kyanite, Sillimanite		Dam site to major part of HRT
	………………Fault………………			………….
	Chungthang F^m	Quartzite, calc-Quartzite, Calc-granulite, Calc-silicate Rocks		Two band of Quartzite about 100 & 300m in HRT alignment.

Table no. 1: Rangit II Project Geology

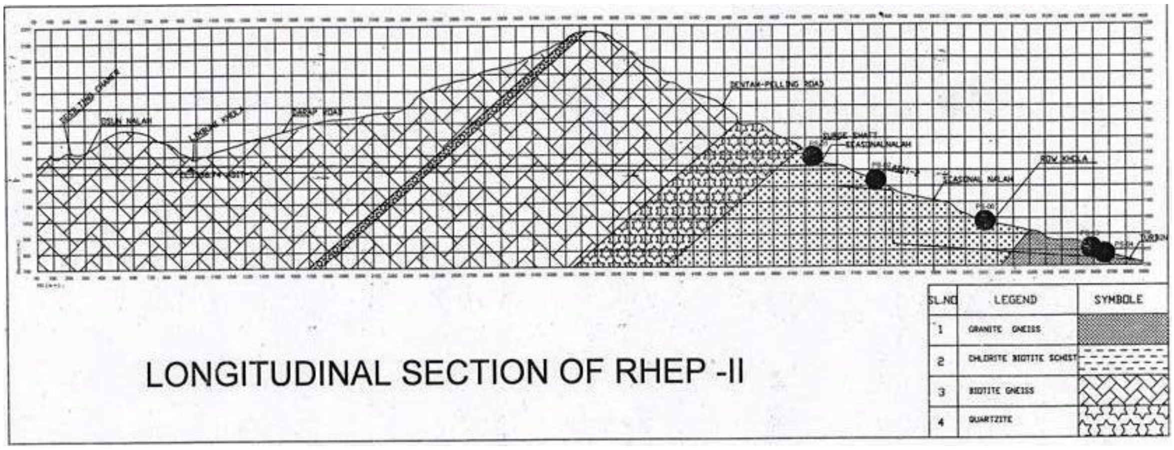

Fig.2: Longitudinal geological Section of Rangit-II HEP Project layout

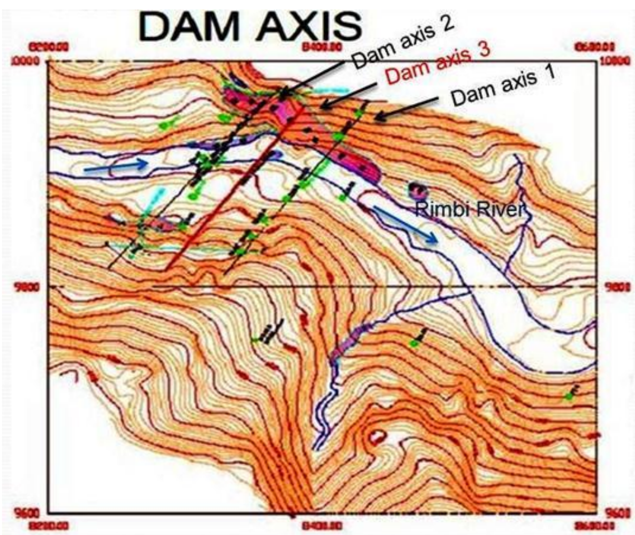

Fig. 3: Proposed Dam axis

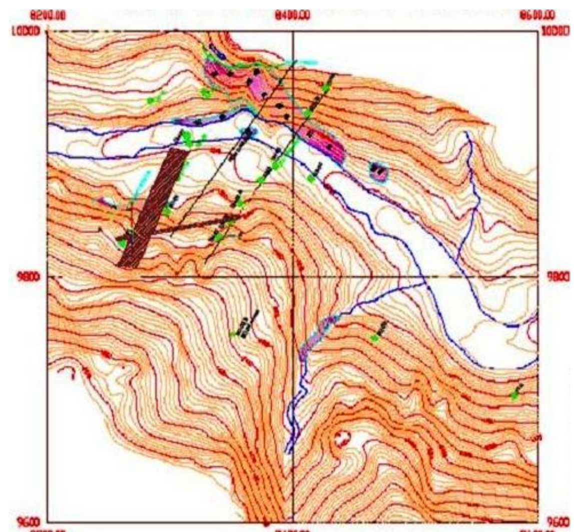

Fig.4: Shear Zone along dam axis 1 &2.

4.1.1 Dam axis-1

The bedrock at the Dam Site is Quartz biotite gneiss with a foliation strike of N81^{0}E, dip 40^0 in N9^{0}W direction. The rock is intersected by two sets of joints. The river section at the Dam axis is 120m wide and is covered with R.B.M. The right abutment is gentler and slopes at 45^0 and has a capping of shallow colluvium. The Dam axis has been explored by 8 bore holes and plotted on the Geological section (fig 5). It has been inferred that the maximum thickness of RBM in the river section is 6m. The lateral thickness of colluvial material on the right bank is of the order of 15-20m. On the left bank the colluvial cover has a lateral extent of 6to 8m .The rock below the R.B.M and colluvial cover is fresh and moderately to closely jointed. The contact of overburden and rock has been marked on the section. Due to poor subsurface geology, construction of earthfill dam was also considered, but due to unavailability of clay, this proposal was abundant and proposed to shift the dam axis about 65 m upstream.

4.1.2 Dam axis -2

The Dam axis -2 is located at approximately 65m upstream of dam axis -1. The axis was taken up for subsurface explorations in view of the fresh and sound outcrops on the left bank comprising Quartz biotite gneiss. Here also the same sets of joints have been observed. The river section is 25m wide and is covered with thick colluvium. The left abutment has mostly exposed rock. The site has been explored by 6 nos. of bore holes. One drift at El. 1347.45m has been excavated for a length of 31m on the right bank.

The bore holes and the drift have been marked on Geological section (fig 6). The bore holes have indicated, the lateral extent of colluvial cover is varying from 6m to 15m on the right bank and of the order of 5-10m on the left bank. The inferred thickness of RBM is 6m.

4.1.2.1Exploratory Drift

The drift is located on the right bank. It has progressed for a length of 31m, encountering Quartz biotite gneiss in the entire excavated length. A prominent joint with outwardly dip and opening has been observed at RD 18m. A bedding shear zone has been intersected at RD 21m with flowing water, causing collapse from the crown; the inferred thickness of the shear zone is 10m. The shear zone appears to extend along the dip as it could be correlated with the shear zone meet with in bore hole, however, its strike extension could not be established. Due to this shear zone, the extent of stripping of the abutment could be about 49m along the drift alignment depending upon the disposition of the shear zone (Fig 4).

4.1.3 Dam axis-3

Due to the shear zone, the dam axis-2 was also not viable and proposed another alternative dam axis, which were between dam axis 1 & dam axis 2 and prepared geological cross section on the basis of projected bore hole subsurface geology and trend of shear zone, which meet in drift and bore hole.

This axis is located at about 36m upstream of the Dam Axis -1 (fig 7). It has been proposed with a view to reduce the Crest length of the Dam in comparison to the Axis -1 and to avoid the shear zone encountered on the right bank of Axis-2.

4.2 Surge shaft, Penstock & Power House

The original routing for the downstream structures of the surge shaft, penstock and powerhouse were towards the west of the final alignment. The headrace tunnel had exited under low cover and proposed as a surface penstock to the powerhouse, including a bridge of the Row Khola. Based on the initial observations from drill hole and the site visit and structures reconnaissance and it was decided that the original DPR alignment for the last 500m of the HRT would encounter difficult geological problems of weak rocks, overburden and low cover. Thus an alternative alignment has been evaluated in order to optimize the length of the HRT, surge shaft and part of the pressure shaft within the best quality rock and the remainder of the pressure shaft in medium to poor rock. A number of alignments and variations in shafts and tunnels have been considered, resulting in a solution comprising 4 shafts and 4 tunnels each carefully located to benefit from the available rock exposures and feasible construction scheduling.

The new surge shaft location finalize that encounter the Darjeeling group comprising migmatites, garnetiferous biotite gneisses, along with the bands of biotite and ambhibolite schist. There are quartz veins traversing the host rock, running parallel to foliation, along with pegmatite veins (~3m) cutting across the host rock. The Daling (Lesser imalayas) mainly consists of phyllite, pelitic chlorite-biotite schist along with biotite gneisses. The Lingtse unit mainly contains the highly sheared phorphyritic streaky biotite granitic gneisses and appears to be in contact with the Darjeeling gneisses.

The lower section of the project from the surge shaft up to the powerhouse is considered to be the most complex in terms of both geology and geomorphology. Geologically the area consists of four different rock types exposed at different structural levels. The surge shaft will be located in good quality migmatitic gneisses with bands of biotite gneiss which is exposed up to EL 1200m. Quartz biotite gneiss is expected to be exposed up to EL 960m below which highly weathered biotite gneiss with schistose bands are exposed along the Row Khola. The power house area is in chlorite biotite schist which is highly foliated and laminated.

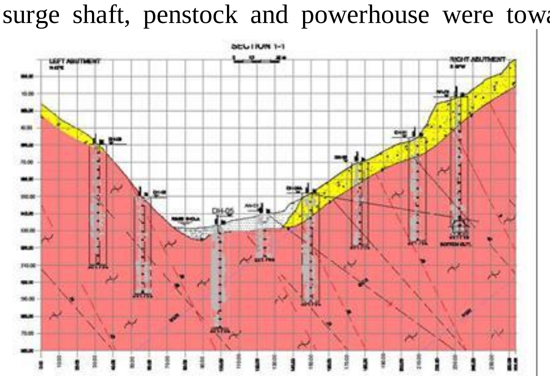

Fig5: Geological cross section- dam axis 1

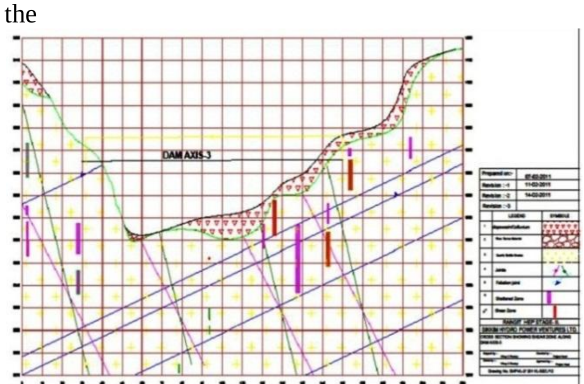

Fig 6: Geological cross section- dam axis 2

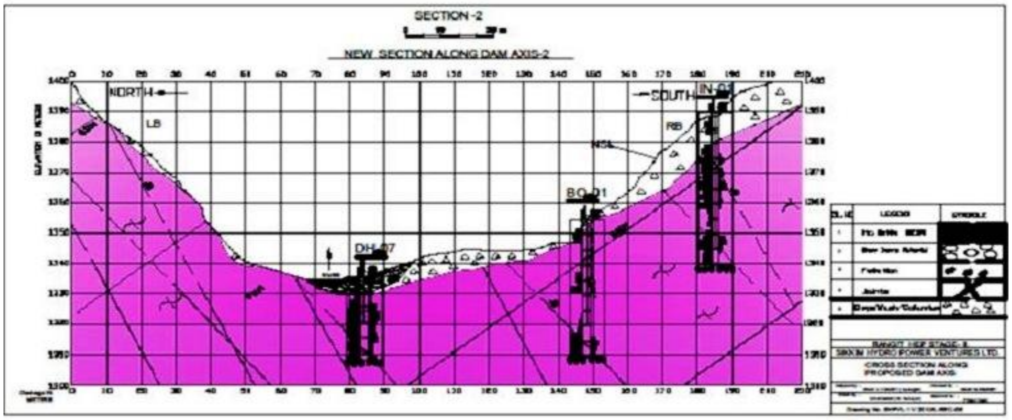

Fig 7: Geological cross section- dam axis 3.

5 CONCLUSION

On the basis of surface geological mapping, geo-technical & geo-mechanical investigation, drift excavation and best data interpretation by experts, project components, i.e. dam axis, surge shaft and penstock alignment; finalize under minimum geological risk, good rock condition and in cost effective manners.

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