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Construction of Hydel Power House in Weak Rocks

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SYNOPSIS : Geological uncertainties have always played an important role in planning of a hydel power house. This paper presents case study of a power house which was subjected to major revisions in its planning due to inherent instabilities in rock slopes. Initially the power house was planned with service bay and other facilities on its left hand side, but the weak and instable slopes and sliding of large rock masses necessitated its thorough revision by bringing service bay and other facilities to its right hand side alongwith addition of many new features and flattening of slopes. There were many alternatives under consideration and final selection was based on techno-economic balance of the project.

INTRODUCTION

The power house-I of Mahi Hydel Project, Banswara (India) is an indoor type surface power house located in 64 m deep open excavated pit with installed capacity of 2x25 MW generated through 40 m head of water. The lowest foundation level is at El-217.0 m whereas general ground level of the area is at El-281.0 m. Location of this power house is latitude : 23° 32'30" North and longitude : 74° 28' 00" East.

GEOLOGICAL DETAILS

Geological investigations of the area were made prior to starting the excavation work. It was revealed that power house pit lies in pre-Aravali gneisses and schists. The country rocks are granite, gneisses, schists, amphibolites and pegmatite veins associated at places with graphite schists all moderately to steeply dipping towards south with foliation striking from North West-South East and overlain by horizontal basaltic lava flow and a thin layer of residual and transported soil.

EXCAVATION OF PIT

The excavation of power house pit was started in Oct. 76. Excavation plans, pit slopes, berms etc. were designed on the basis of geological findings and functional requirements. It was suggested to excavate the pit in a slope of 1/4 : 1 from top upto El-240.0 m and in 1/8 : 1 below El-240.0m. However, the Geologist had warned in the early stages to excavate with great care in view of extreme metamorphism and alterations of heterogeneous assemblage of rock types.

The pit in the course of excavation showed signs of distress in the slopes. It was feared that presence of unfavourable discontinuity surfaces dipping at an angle of 50°-60° towards free face on the right hand side may not allow excavated slopes to remain stable. Situation was further aggravated due to occurrence of heterogeneous

rock masses consisting of mixed gneisses with graphite schists.

Finally in the month of May, 1980, when the pit had been excavated upto El-235.0m, the northern slopes failed and there was a major rock slide on the right hand side of pit between 'C' line and 'A' line.

MAIN FEATURES OF INITIAL LAYOUT

On the basis of available geological details and other technical requirements, the initial layout plans for the power house complex were prepared. Fig. 1 and 2 shows the plan & section of power house as per this planning. Main features of this initial planning were as under.

(a) Erection bay was placed at El-247.5 m on left hand side of power house.

(b) Approach to erection bay at El-247.5 m was arranged from main highway at El-281.0 m by means of a service road located along surge pool in a regular slope of 15:1. This service road was to come down over berms of tail pool area.

(c) Pit slopes were prepared in a slope of 1/4 : 1 from top upto El-240.0 m and in a slope of 1/8:1 from El. -240.0 m to El-218.0m.

(d) A counterfort retaining wall was provided on RHS from El-235.0m to protect the right side of power house.

(e) Intake dam was placed 54.50m upstream of power house with penstock length of 82 m. But in the very early stage, the intake dam was shifted towards RHS by 12 metres due to geological constraints. This shifting resulted in increase of penstock length to 92 m. Fig. 1 shows later position of penstock.

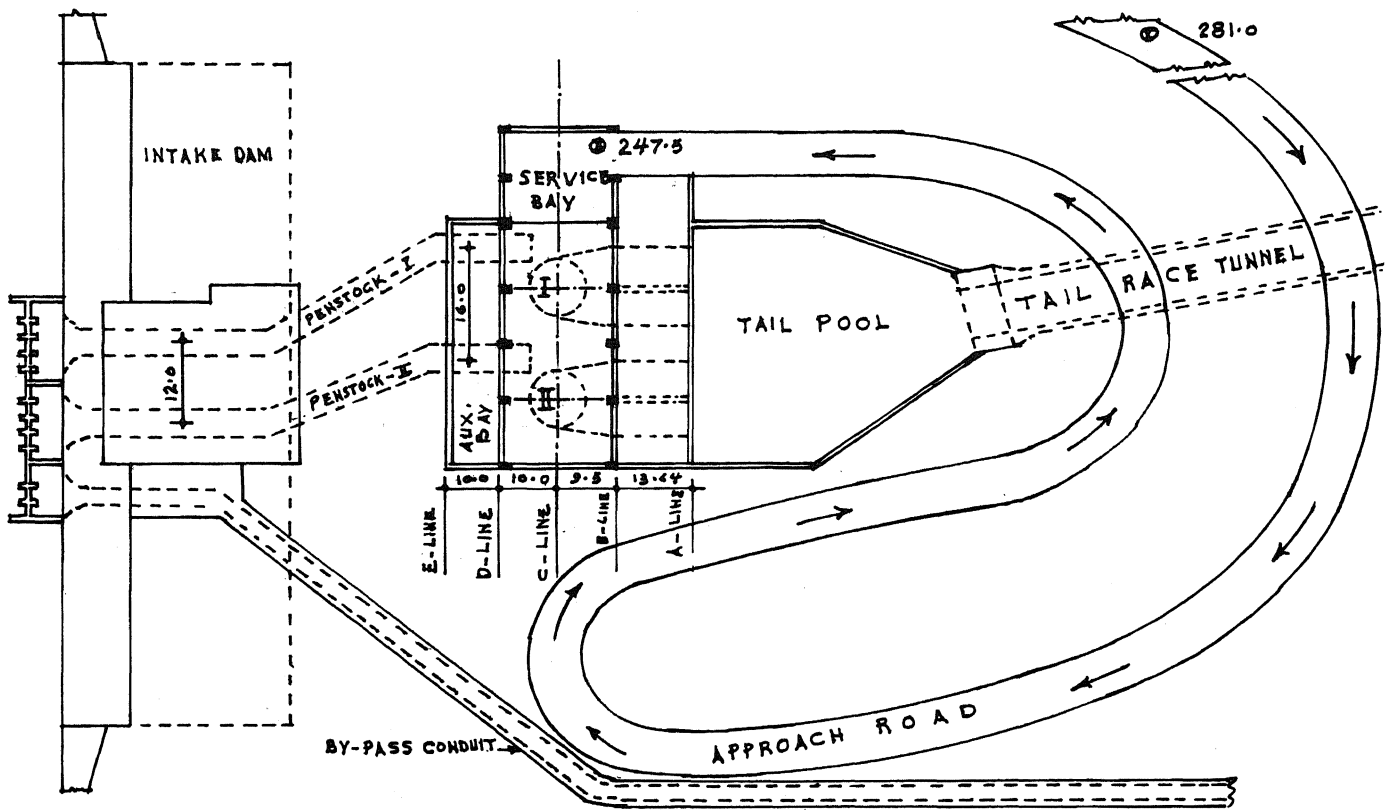


Fig. 1 Original layout plan of power house complex.

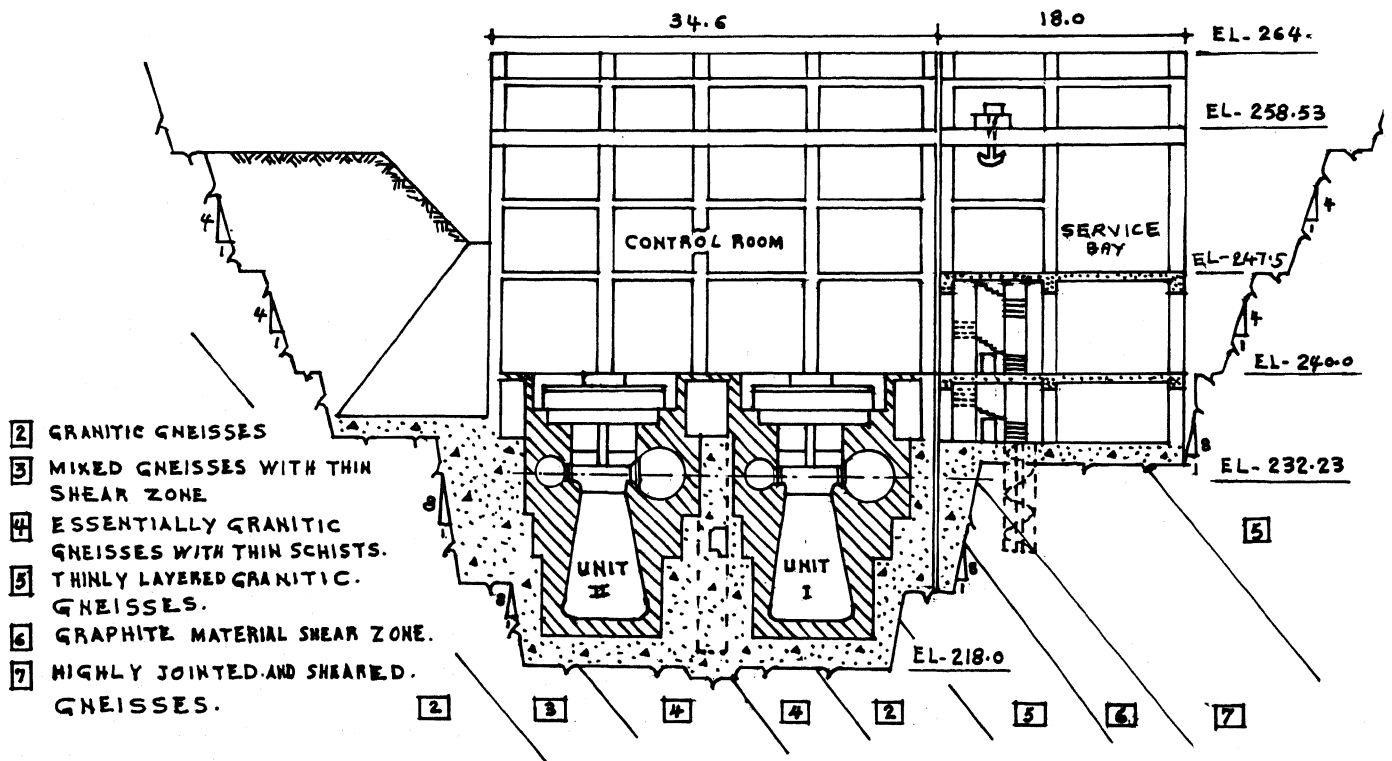


Fig. 2 Section of power house as per original plan.



Fig. 3 Photo showing rock slide

DIFFICULTIES ENCOUNTERED

Excavation as per initial planning had been started but in May, 1980 there was a major rock slide and this failure of rock slopes raised many doubts about the future of this power house and its safety. Further, in this rock slide, a large portion of approach road collapsed indicating unsafe approach to the power house. Due to this mishap, an attempt was made to again examine the whole area geologically. It was revealed that country rocks are deeply weathered and decomposed upto a considerable depth. Rocks above El-250.0 m were found to be highly weathered and upto El-235.0 m slightly to moderately weathered. The fresh rock configuration was found to be highly irregular between El-225.0 m to El-240.0 m due to structural peculiarities which controlled the extent of weathering.

It was also revealed that on the RHS of the pit and in tail pool area there is a thick graphite inter-calated zone and as such the area is unstable and unsafe for carrying approach road. It necessitated for finding some alternative to the earlier planned road for reaching upto erection bay.

At that stage it was not possible to relocate this power house at any other place and therefore it became a main challenging task to construct this power house in such weak rocks. Due to such weak condition of rocks, Geologist suggested for flattening of the rock slopes with provision of berms at suitable interval. At one stage it was advised to reshape the pit slopes in 1:1 gradient but this would have involved very heavy increase in excavation quantities, excessive expenditure and delay in completion of the project. Therefore, it was essential to find a safe and economical proposal for replanning the whole power house complex suitably.

MAIN FEATURES OF REVISED LAYOUT

Failure of power house pit slopes compelled for making major revisions in the layout of power house. The revisions mainly based on techno-economic balance of the whole scheme. Following are the main features of revised layout.

(a) First and foremost necessity was to stabilise the rock slopes. For this purpose several alternatives were available such as deep anchoring of slopes, grouting of rock masses, adequate flattening of pit slopes etc. It was opined that unstable and weak rocks of power house pit should not be taken care by short term measures such as anchoring or grouting etc. Only flattening of pit slopes was considered useful & effective. Accordingly pit slopes were reshaped in 1:1 gradient from top upto El-240.0 m and in 1/2:1 gradient below El-240.0 m. This reshaping of slopes was more essential for right hand side face. The left hand side slopes were comparatively more stable due to their favourable dip inside the rocks.

(b) At that stage when all other connected works had also started, it was not possible to change or shift power units as this change would have involved change in position of intake dam, penstocks and tail race tunnel also. Further due to favourable dip of rocks on left hand side, it was felt not to disturb or do least excavation on that side. As such the erection bay and other facilities on left hand side were shifted to right hand side without effecting the position of power units.

(c) Most important point to be decided was to provide approach to the erection bay floor level through service road. Adverse geological features of tail pool area did not allow to bring down service road along berms of tail pool. Therefore, efforts were made to replan the service road through other route, but it was not possible without making excessive excavations to bring down the service road upto El-247.5 m i.e. the floor level of erection bay.

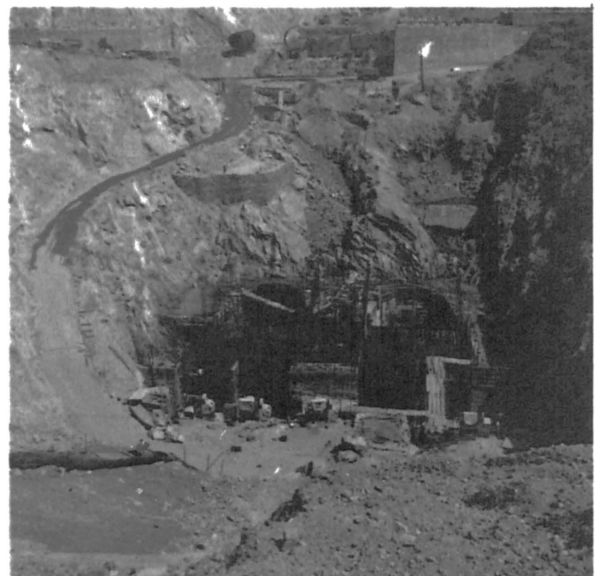


Fig. 4 Photo showing power house pit during initial stage of construction.

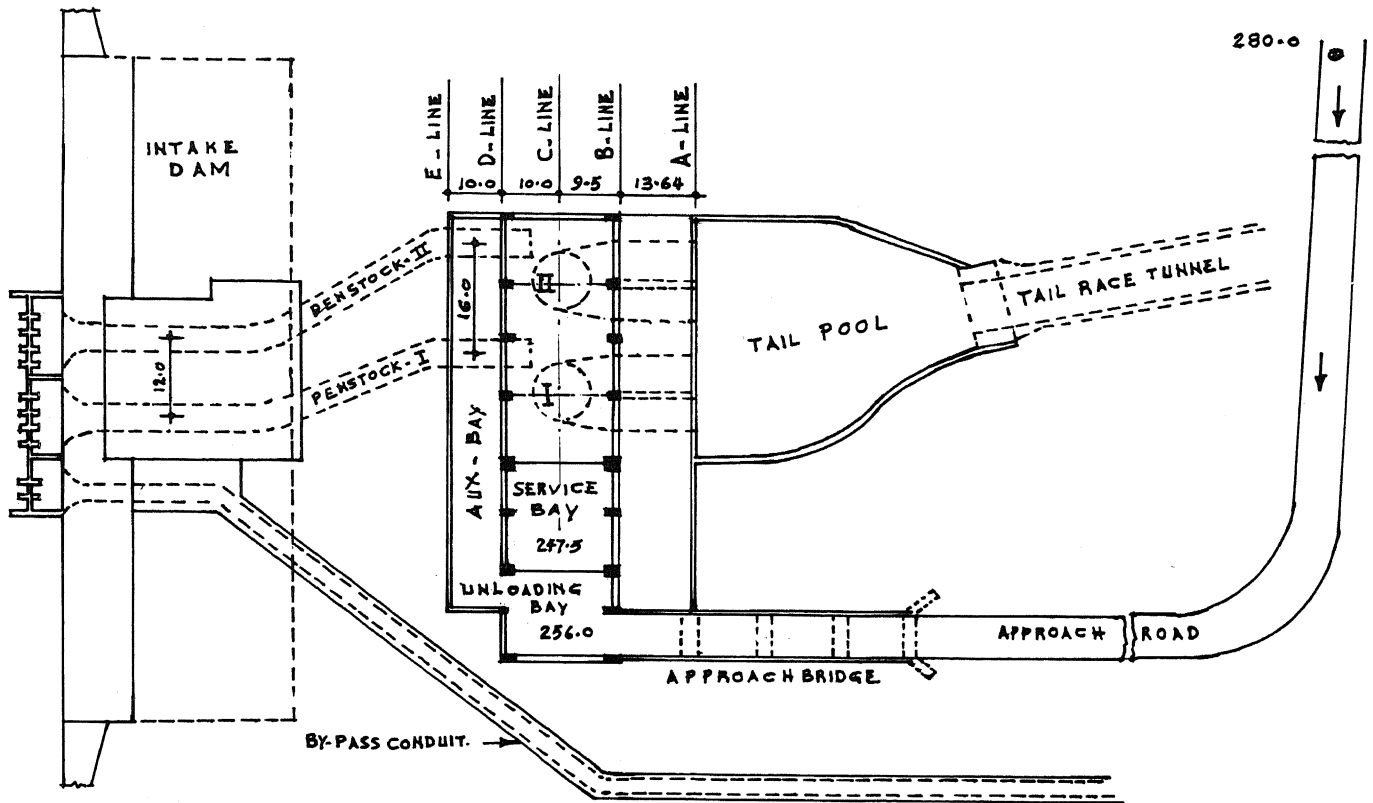


Fig. 5 Revised layout plan of power house complex.

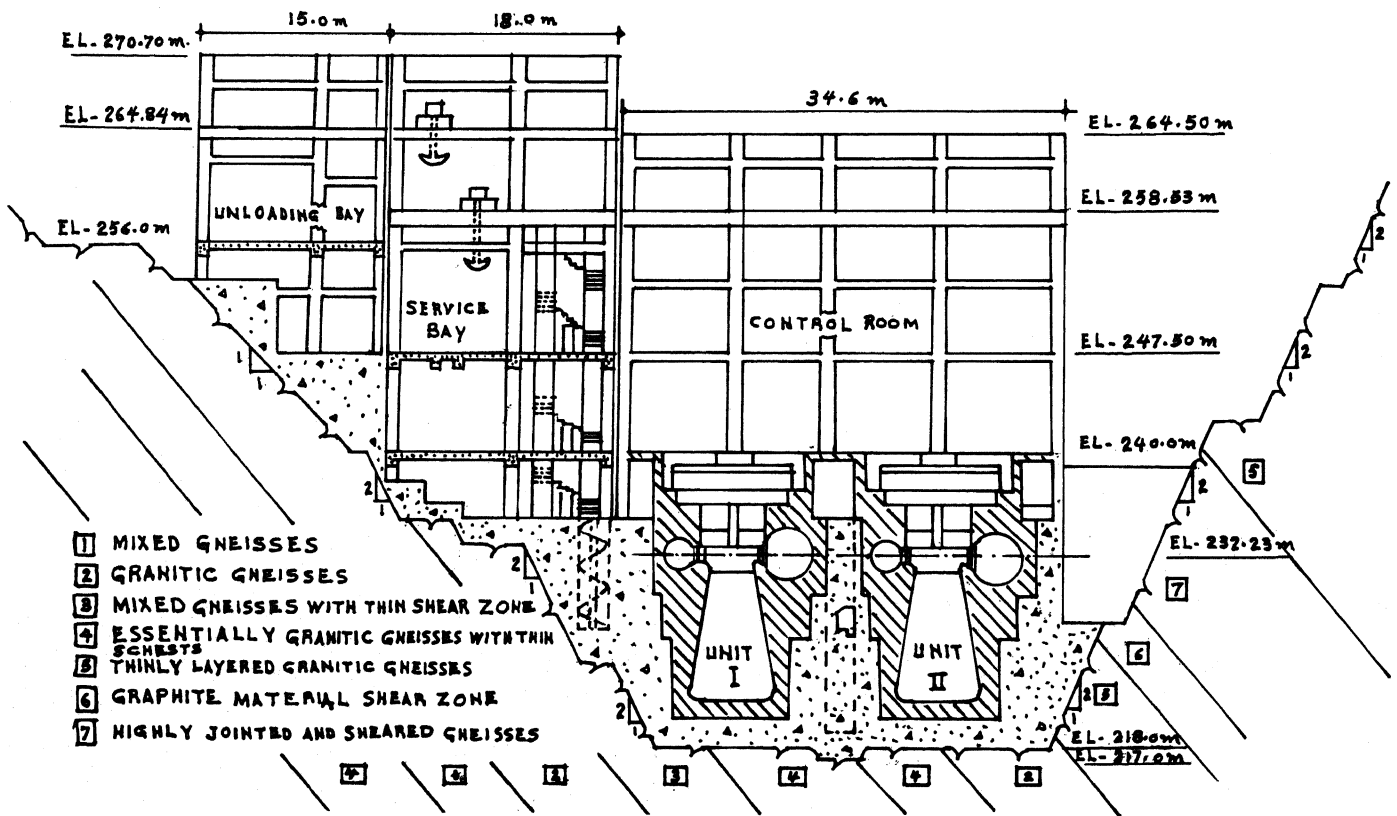


Fig. 6 Section of power house as per revised plan.



Fig. 7 General view of Power House.

Since direct access upto this level was practically not possible, idea of two level service bay was conceived and one additional floor 10 m wide at El-256.0 m was proposed to work as unloading bay. Service road from main highway was arranged upto this unloading bay at El-256.0 m by locating it along by-pass channel. Earlier only one E.O.T. crane was sufficient for this power house but now due to addition of unloading bay at higher level, it became necessary to provide one more E.O.T. crane to operate between unloading bay and service bay. The roof of the power house had also to be arranged in two levels.

(d) Approach portion of service road to unloading bay at El-256.0 m was earlier located on a gravity retaining wall curved in plan and having its foundation at El-240.0 m. The approach portion was to be provided on its back fill. But the geological advice restrained from adding so much load of gravity retaining wall and its back fill on the right hand side rocks. Then the idea of approach bridge with 4 spans of 8.8 m each was adopted and the service road was connected with unloading bay through this approach bridge. Foundations of this approach bridge piers were placed on El-240.0 m. Later on again on geological grounds the position of approach bridge was further shifted to right hand side by 5.0 m so that the rocks on which its foundations rested do not get daylighted in tail pool. This resulted in increase in the width of unloading bay by 5.0 m, thus making it total 15.0 m.

(e) Earlier provision was kept of counterfort retaining wall on the right hand side between 'B' line and 'D' line, but to expedite the construction work of service bay and unloading bay, it was replaced with mass concrete filling. Thus the right hand side slopes were supported with mass concrete filling for the main power house building portion.

(f) The shape of the tail pool was revised to semi circular mainly to minimise the rock cutting work in this area. This was done without affecting the total capacity of the tail pool.

CONCLUSION

Many problems were faced in construction of this power house due to unstable slopes and complex and critical geological conditions at the site. Revisions as stated above resulted into appreciable increase in the quantities of concrete and excavation, but the challenge of constructing this power house in such weak rocks was successfully met with. The power house was commissioned within reasonably good period without much cost overruns. It is generating power since Feb., 86 and working without problems. A constant watch has been kept on the stability of rock slopes around power house complex and so far nothing adverse has been noticed.