From plate tectonics to the design of the Dul Hasti hydroelectric project in Kashmir (India)

Th. Winter, J. Binquet, A. Szendroi, G. Colombet, R. Armijo, P. Tapponnier

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Abstract

The Dul Hasti hydroelectric scheme, which consists of a 65-m high gravity dam, a 10.6-km long headrace tunnel and an underground powerhouse, is being built on the Chenab River, a tributary of the Indus River, - within the Himalayan Range of Kashmir, India.

This paper shows how the geological knowledge at the time of signature of the contracts between the National Hydroelectric Power Corporation and a French consortium in September 1989 was radically modified through successive on-site investigations, geological field surveys and seismotectonic analyses carried out at various scales.

The actual geological, tectonic, geotechnical and hydrogeological conditions discovered in the last three years (active faulting, deep infilled graben, sheath folds, general mylonitisation of the rockmass, confined aquifers with very high heads of water, widespread opening along joints filled with silty material highly susceptible to untamping and piping under even low heads of water) have led the designer to modify the tunnel layout, the tunnel design, and the construction methods.

In particular, the assessment of tunnelling conditions requires modifying the Tunnel Boring Machine and installing additional equipment for frequent advance investigations ahead of the tunnel face, and special treatments of zones of low mechanical properties.

An identified joint filled with silty material under a high head of water will be crosscut by (a) drilling a complete ring of pressure relief holes crossing the joint around the tunnel, (b) a special grouting treatment under very high pressure including cement grouts and silica gels or in some cases resins, and (c) increasing the final lining of the tunnel using a high strength concrete to bear the full ground-water pressure.

On crossing rock formations with reduced mechanical properties, (a) long and numerous rock bolts (or full-length adhesive anchors) will have to be implemented near the tunnel head to prevent further softening of the rock during radial plastic deformation and (b) the external diameter of the tunnel will have to be increased to maintain the final internal diameter and the minimum foreseen concrete lining thickness.

The sequence of investigations performed since 1960 highlights the fact that the acquisition of such an extremely complex geological and tectonic database is a long, difficult and ongoing process. Moreover, it shows that a reliable estimation of geological tunnelling conditions (geology, hydrogeology, old and active tectonics and geotechnics) depends on an understanding of the present and past geodynamics of a given region at different scales: from plate tectonics to fault scarps and microtectonics.