Implications of natural damming (debris flow) on infrastructure projects in the Indian Himalaya

Yogendra Deva (IAEG Vice President for Asia)
23 December 2015, Geology Department, University of Malaya

Abstract: Occurring as a prominent convex arc of mountain chain in north India, the 2400 km long Cenozoic mobile belt of the Himalaya is the product of collision between the Indian and Asian plates. The Main Himalayan Belt is host to major hydropower development in India that, at present, is focused in the Lesser Himalaya bound between the Main Central Thrust and Main Boundary Thrust, and is stepping out in to the Higher Himalaya north of the Main Central Thrust. Together with the infrastructure development, the hydropower project investigation and construction faces unique Himalaya specific engineering geological and geotechnical problems. The investigation and implementation of the infrastructure projects in this belt are governed by complex geotechnical implications arising out of unique site specific lithological and tectonic models. Not very infrequently, many of the project sites have come across natural dams with silted up lakes posing serious foundation and tunnelling problems.

Generally, the low bearing capacity and saturated nature of the lacustrine deposits lead to seriously adverse foundation conditions including liquefaction potential, and extremely difficult or even insurmountable problems in the construction and maintenance of subsurface structures like tunnels. It is, therefore, advisable to stay away from exceptionally thick alluvial deposits in wide valleys and, if that is unavoidable, to study and explore such a site thoroughly. This is not always possible and, if unavoidable, adversely influences the technoeconomic parameters of the project.

In particular, some of the major hydroelectric projects in Indian Himalaya that faced the geotechnical investigation and construction challenge include the 390 MW Dul Hasti Project across the Chenab River in Jammu & Kashmir, 780 MW Nyamjang Chhu Project across the Nyamjang Chhu River in Arunachal Pradesh and 300 MW Baspa-II Project across the Baspa River in Himachal Pradesh. The alignment of the 9.78 km long Head Race Tunnel for 390 MW Dul Hasti Hydroelectric Project runs across a buried course of the mighty Chenab River under the 2 km x 8 km plateau at Kishtwar. The buried valley turned out to be over 500m deep and the result of natural damming. The modified and adopted "Loop" tunnel alignment bypassing the buried valley is an unconventional "S"-shape and is about 10% longer than the original "Straight" alignment.

The thick lacustrine deposit behind a bouldery natural dam at Zimithang in Tawang District of Arunachal Pradesh, constituted the site for the 11m high barrage and appurtenant structures for the Nyamjang Chhu Project. Deep drilling at the barrage axis proved the bedrock depth to be about 100m. The subsurface geotechnical investigations comprising drilling and geophysics, and field and laboratory tests involving SPT, permeability, mechanical properties of sandy and silty overburden, grain size analysis, etc, confirmed the liquefaction potential of the foundation material. The ground improvement proposals against liquefaction, besides adding to the project cost significantly, turned out to be a major challenge for civil design of the barrage, desilting tanks, and approach channel to the Intake structure of the 24 km long Head Race Tunnel.

The site for the 60m long diversion barrage for the 300 MW Baspa Stage-II Hydroelectric Project across the Baspa River near Sangla in Himachal Pradesh lies over an enormously thick lacustrine deposit believed to have been formed due to a natural dam. The SPT 'N' values at the barrage site ranged between 18 & 25 and the average bearing capacity was worked out to be 0.5 MPa for the design of the barrage. Among other measures, the main design features included floor length of the barrage at 120m, a concrete cut off with a sheet pile at its downstream end as a safeguard against piping, sand drains for early release of excess pore water pressure, etc.

The presentation takes a critical look at the phenomena of natural damming in the Himalaya and its engineering geological and geotechnical implications.

Warta Geologi (Newsletter of the Geological Society of Malaysia), Vol. 41, No. 3-4, July-December 2015