# Natural damming in the India Himalaya and its Impact on Hydropower Development

(Extended Abstract)

Yogendra Deva

Indo Canadian Consultancy Services Limited
Email: yogendradeva@gmail.com

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 Himalaya play host to three major river basins, viz. Indus, Ganga and Brahmaputra that give rise to a sprawling alluvial plain all along its base. Divided into three major tectonic zones, viz, Indus-Shyok Belt, Main Himalayan Belt and Frontal Fold Belt, a host of tectonic planes like Karakoram Fault, Indus-Tsangpo Suture, Main Central Thrust and Main Boundary Thrust and Frontal Thrust, along with numerous transverse faults, dissect the Himalaya into discrete blocks and segments.

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. The investigation and implementation of the hydropower 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. Some of the well known cases involving Quaternary natural damming, characterised by thick lacustrine deposits, include an over 180m thick lacustrine deposit below a 400m thick fluvioglacial deposit at Kishtwar in Chenab Basin, a 100m thick lacustrine deposit at Zimithang in Tawang Basin, a 150m thick lacustrine deposit at Sangla in Satluj Basin, etc. On the other hand, formation of several small and large natural dams with serious construction and maintenance implications is seen as a fairly common ongoing process.

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 techno-economic 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 ran across the 2 km x 8 km plateau at Kishtwar that was suspected to be overlying a buried course of the mighty Chenab River. Problems in drilling beyond 260m through the bouldery fluvio-glacial overfill using conventional machines constrained confirmation of bedrock at tunnel grade. The project construction as EPC contract commenced with buried valley crossing as grey area. Deep drilling of about 600m using imported wireline drilling machines proved absence of bedrock even down to the drilled depth of 100m below the tunnel grade. The modified "Loop" tunnel alignment bypassing the buried valley is an "S"-shape and is about 10% longer than the original "Straight" alignment (Fig.1). The buried valley turned out to be over 500m deep and the result of natural damming close to powerhouse area at Hasti village. It is believed to have led to the re-routing of the Chenab and capture of about 11 km length of the Marusudar River.

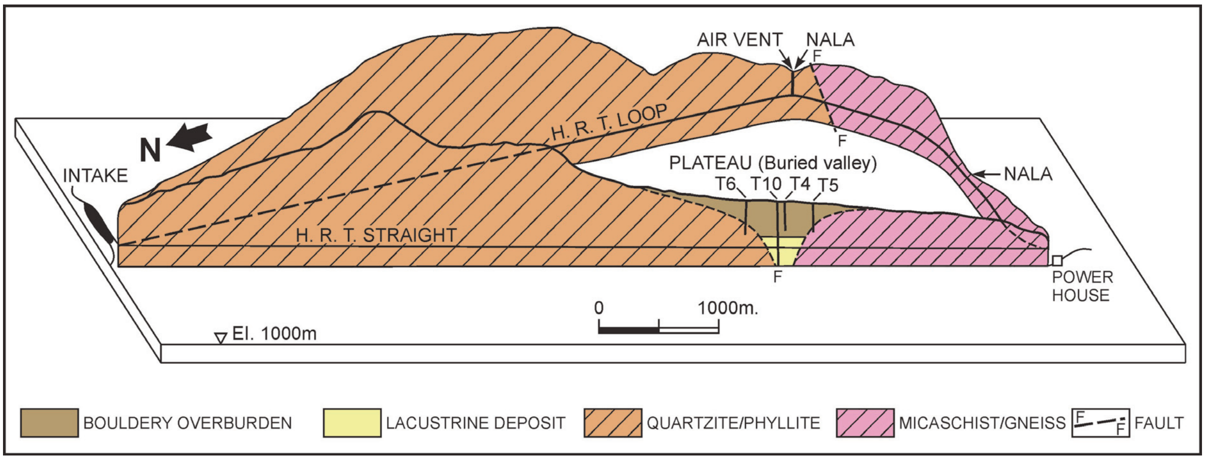


Fig.1: Straight and Loop alignments of HRT, Dul Hasti HE Project, Jammu & Kashmir, India.

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 headworks structures for the Nyamjang Chhu Project (Fig.2). 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 overall site specific requirements and terrain condition were major impediments in relocating the proposed barrage at alternative locations.

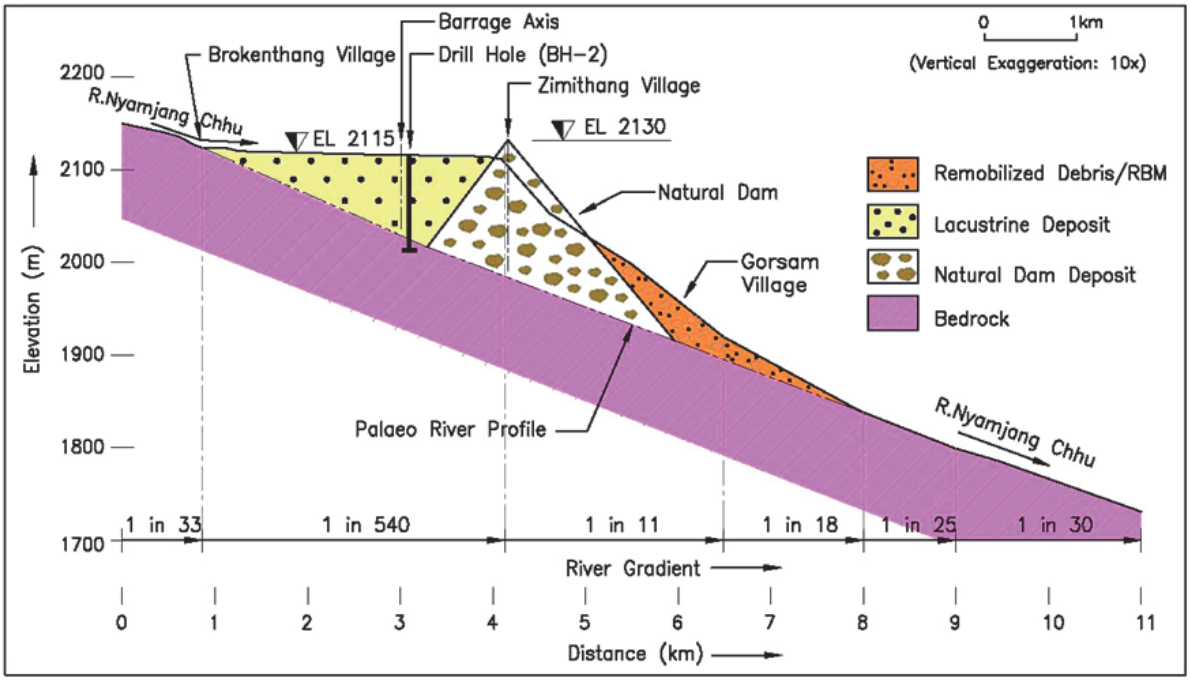


Fig.2: Natural dam at barrage site, Nyamjang Chhu HE Project, Arunachal Pradesh, India.

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. Studies and subsurface exploration through drilling reveal that the 200m wide and more than a km long lacustrine deposit could be as deep as 150m. The general ground level of the lacustrine deposit is El 2519m and the river gradient about 1 in 82. Immediately downstream, the river has a very steep slope of about 1 in 4 before assuming the general gradient of 1 in 40 after dropping about 150m. 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 with special reference to Dul Hasti, Nyamjang Chhu and Baspa-II Hydroelectric Projects.