Geotechnical Challenges in Mountainous Terrain of Himalaya

Sushil Kumar

Abstract

In India twentieth century has witnessed commissioning of many dams /tunnels/ power houses and multipurpose irrigation schemes on diverse geological environment but the experience gained in one project can not be utilized on others due to changes in climatic conditions and their effect on physical -mechanical properties of the rock types. It, therefore, points out the peculiarities of the various earth features of the mountainous terra in which offer challenges to the geotechnical engineers.

To overcome these problems each segment of the mountainous belts is governed by certain dictum which may or may not be inducted in others due to variations in their setting, lithological assemblage, geomechanical properties of the material, altitudinal behaviour and seismicity of the belt. It would therefore be prudent for a competent engineering geologist to formulate a suitable line of action before launching any geotechnical project.

Paper deals the challenges posed by the mountainous terrain of Himalaya particularly in the north-western segment.

Introduction

Himalayan Mountains, generally, are the manifestations of deep sedimentation of geosynclines where sedimentation and subsidence are parri pasu. The topographical elevations in the rolling landmass are sometimes confused with the mountains. They are in fact the plateau mounds which have different geo-engineering characteristics as compared to Himalayan mountain chain.

Himalaya is the active and comparatively younger mountain belt of the world. The geo-engineering projects seated on this complex belt therefore pose many problems of active stress responsible in destabilizing the excavation activities for launching a new project. The active stress not only destabilizes the work but may infuse many changes in the physical-mechanical properties of the rock mass and its impact on the ecosystem. As a sequel, regional longitudinal discontinuities and transverse nature of faults bring many tectonic changes, emerge geothermal gradients in the openings made and destabilize the slope morphometry of the area creating new landforms. They all are unforeseen and unprecedented but their awareness make the site engineers, designers and planners to incorporate suitable safety factor in the design of the project.

Configuration of mountainous region

Mountainous region or the orogen cover 47,770,000 sq km area on the globe (Dearmen et. al. 1989). Out of which geographical spread of Himalaya is confined to 7,20,000sq km(approx). The relief is highly rugged separated by deep antecedent valleys formed by Indus, Ganga and Brahmaputra. Himalayam orogeny is not only due to the thick sedimentary pile of Tethys geosyncline but also due to the collison of Indian plate with the Eurasian plate inserting many cratonic plates of Precambrian and Palaeozoic – Mesozoic era which were later on intruded by Tertiary granites. The old precambrians in Himalaya comprising crystallines, and magmatic rocks form the axial zone which on the limb zones contain metasedimentaries of deep water origin followed by carbonate sequence of (Garhwal,

Director (Retd.), GSI, B- 643 Rajajipuram Lucknow

Krol, Shali and Buxas) over lapped by arenaceous rocks and covered by coarser molasses deposits of Siwaliks which is separated from the former by regional discontinuity(MBF).

Characterization of Himalayan Mountain Belt

The Himalayan folded belt in an arcuate length of 2400 km attained a maximum height of 8,884m on Everest. The highest portion more than 6,000m constitute only 5% of the area. The average height of the southern margin of this belt is only 100m while in northern margin it is 4000m. The snow line reaches to 4500-5000m. Thick 19-26km long glaciers are confined in the central part of Himalaya. The relief of Higher Himalayan Zone is very rugged. It has transverse deeply dissected, medium textured drainage with sharp crested ridges and glaciers. Its southern contact with lesser Himalayan zone is marked by break in topography defined by main central thrust (MCT).Lesser Himalayan Zone is further separated from Outer our Sud Himalayan Zone by a regional dis- continuity (MBF).

Ghosh et.el.(1989) have delineated conspicuous geomorphic anomalies in the higher Himalayan zone such as discontinuity of individual mountain ridges, transverse course of major river channels, dissecting ridges not acting as the major watershed for rivers despite being located at very high elevation.

The clusters of hot springs around MCT are very common. Flash floods, landslides, cloudburst and avalanches trigger by seismic activity and pose threat to hydroelectric project.

Challenges posed by the individual characters

1. Active stresses reduce the strength of the rocks.
2. Locked up stresses underneath in the Precambrian rocks create problems in the underground openings.
3. Presence of massifs underneath contain maximum accumulated stresses which create squeezing ground, if tunnel is advanced through it.
4. Most of the epicenters are confined in and around central crystalline belt which influence the geodynamic processes such as landslides, collapse of structures and natural daming of rivers.
5. High ruggedness of relief in conjunction with intense folding promotes slope failure and landslides with the down slope development of slicken slides.
6. High moisture content of the area stimulates slope failure during strong tremors.
7. Karstification in Himalaya is not prevalent but solution channels and removal of sheared gouge have given rise many caves which may collapse if over loaded.
8. Intense weathering of rocks produces clayey soil which may have swelling characteristics, if enriched with montmorillonite.
9. Thermal water presents a medium hazard to concrete and metals thus creating an unfavourable engineering geological and hydrogeological environment for construction.
10. High thermal gradient upward makes upper crustal layers hot reducing workability in the project.
11. Presence of thin shear zones, not detectible by any means, create havoc in tunnels.Maneri-Bhali Stage –2 tunnel at Joshiyara and Dharasu got stuckup for a long period.
12. Intense tectonic processes in the epigeosynclinal mountain system penetrate deep upto the Mohorovicic discontinuity and opens the passage for lava flows in the sedimentary rocks thus endangering the engineering geological nature of the environment.
13. Neotectonism reforms the hydrographical network of the area.

14. Cloud burst in constricted valleys bring loss of men and property.
15. Transverse faults in Brahamaputra valley and Meghalaya become active and change the landforms. They are Bombdila, Jamuna, Kopili and Dudhani.
16. Piedmont low lands and intermontain basins subside by several cm in a year.
17. Fossil valleys are the potential source of leakage in the river valley projects.
18. Search for clay in Himalaya for core material of earth and rock fill dams poses a great challenge before engineering geologist.
19. Dispersive nature of the Siwalik soils in sub Himalaya gives rise in effectiveness of reservoirs.
20. Huge thickness of glacio-fluvial material in river valleys debars to seat a dam there, in as was the case at Harshil in Uttarkashi.
21. Low values of fineness modulus (F.M) of natural sand of Himalayan rivers prevents mortar to withstand properly in building construction.
22. Acidic nature of Himalayan soil retards the soil productivity. Suitable liming material to neutralize it needs to be searched. It was searched in Buxa Group of rocks at Jorthang, Sikkim.
23. Lack of infrastructure in Himalaya deters to augment the transportation of material. Granite blocks for flooring in diversion tunnels were brought from Bundelkhand in two transshipments because Tertiary Granites of Himalaya are neither competent nor their extraction is easy.
24. Himalaya has witnessed many earthquakes of more than 6magnitude on Richter Scale, so high dams in Himalaya are little risky.
25. Transportation of wood logs through rivers sometimes create blockade by interlocking which creates hindrance in natural water flow of perennial streams. This was once observed upstream of Dakpathar in Tons valley, Dehradun.
26. Glacial movement in transverse valleys at higher altitudes pose threat to the dam sites located below in the main longitudinal valley. The dam site proposed at Loharinag Pala Hydel scheme in Uttarkashi was shifted on account of triggering of glacier avalanche in Lod gad.
27. The bed rock configuration in highly landslide prone zone poses difficulty particularly when the overburden and country rock is of the same material or there is accumulation of different layers of debris having different material. This problem was faced to finalize location of foundation for an aqueduct pier across Bechu Khola for Lagyap Hydel Project in Gangtok
28. Huge size rock blocks in Himalaya confuse to separate them from basement rock for placing the bridge foundation in highly landslide prone zone e.g. Mangan Landslide Sikkim.
29. Interconnection of solution cavities in carbonate sequence of Himalaya may deter the reservoir to we impounded over them. Garhwal group of rocks in Himalaya have many solution Channels in Pithoragarh calc zone. It was surveyed for the proposed Chamgad dam accors Sarju in Pithoragarh distt.
30. Loose sandy rocks, weakly compacted rocks are comman in Siwalik Group of rocks where intense mud flows, erosion and landslide were observed while excavating Padampuri-Hedakhan road in Nainital distt. Proper remedial measures may be planned before hand particularly in the zone of tectonic fault (MBF) or intrusive Amritpur granite or on deep bare slopes developed due to jungle cutting.

Overcoming the challenges

To over come the challenges posed by the active mountain belt of Himalaya, a systematic survey of the core and buffer zone of the project is a prerequisite. It requires the preparation of thematic maps of the area showing location of observatories for monitoring the earth quakes, roads for providing infrastructure, railways to reduce surface cutting, short communication tunnels joining roads and rails to provide all weather facilities, and above all the engineering geomorphologic studies to show bridge site locations, portals, embankments, gully erosion features, unstable slopes, fan accumulation sits, talus, scree and mud flow zones on a detailed thematic map The foregoing challenges have been successfully tackled at some of the projects in Himalaya where continuous monitoring is called for by instrumentation technology.

Thematic map showing the borrow areas may be prepared and a data bank established to have an off hand information of specific standard for sand, silt and clay approved by BIS.

Need for preparing our own standard to determine the Q values is long overdue. Still Barton's table is used for SRF and other parameters to calculate Q of Indian rock mass. This may be emphasized more vigorously.

In order to avoid the arbitration cases a better appreciation of the rock condition from mining point of view may be presented in the detailed project report.

The age old practice of town ship development on the confluence of river tributary with the trunk channel should be encouraged in future developmental schemes. It reduces the toxin effect of the trunk channel and keeps the environment pollution free. Minimum distance between two township along the trunk channel should be 45 km .

The ISEG may create awareness to the masses by arranging seminar/ workshop and T.V-radio talks. The placard at the working sites highlighting problematic features may be a quick source of disseminating the societal relevance of engineering geological studies in mountainous terrain.

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