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Editorial – Need of Long-term Planning & Engineering Attention for Developmental Works in the Indian Himalayan States

The term "Himalayan states" is used to group countries that straddle the Himalayas. It primarily denotes five countries namely Bhutan, China, Nepal, India, and Pakistan. The Himalayas is a mountain range separating the plains of the Indian subcontinent from the Tibetan Plateau (also known as Himalayan Plateau) which stretches approx. 1000 kilometre north to south and 2500 Kilometre east to west. Over 100 peaks exceeding 7200 metres in elevation lie in the Himalayas including Mount Everest- the highest mountain peak of the world lying between China and Nepal. Some of the world's major rivers, the Indus, the Ganges and the Tsangpo- Brahmaputra, rise in the vicinity of the Himalayas, and their combined drainage basin is home to some 600 million people; 53 million people live in the Himalayas.

The Indian-Himalayan region is spread across 11 Indian states and 2 Union Territories (namely J&K, Ladakh, Himachal Pradesh, Uttarakhand, West Bengal, Sikkim, Arunachal Pradesh, Meghalaya, Mizoram, Manipur, Assam, Tripura, and Nagaland) stretching across 2500 Kilometre. Approximately 16% of India's total geographical area is covered with Himalayan hills. Nearly half of the Himalayan population is at risk of hazards like landslides, monsoon floods, cloudburst, wildfires, major earthquakes, avalanches etc.

The Himalayas is one of the youngest mountain ranges on the planet and consists mostly of uplifted sedimentary and metamorphic rocks. According to modern theory of tectonics, its formation is the result of a continental collision occurred several million years ago (along the main Himalayan Thrust) between the Indo-Australian plate and the Eurasian plate. The highlands of Arakan Yoma (technically known as Southern Indo-Burman range in Western Myanmar) and the Andaman and Nicobar Islands in Bay of Bengal were also formed because of this collision.

The bank slopes of major rivers of the Himalayas are generally made of complex geological features making it weak and more vulnerable to intermittent landslides because thick layers of soil-silt stone strata / shear zones filled with erodible gouge material are flanked by hard and soft rocks. So long as the banks of the rivers are covered with dense forest, the roots of the trees act as reinforcing material to arrest the erosion of the trapped soil within the rock mass. Once the deep rooted trees are cut / removed during developmental works, the water present in the soily strata (soft rock), that used to get evaporated through the stems of the trees, is trapped as a water bearing strata and eventually the "Nature-made" reinforcement material loses its strength. As the banks of the rivers are made of weak and fragile rocks, it has a sliding tendency due to the heavily loaded population around the area and during intense rainfall periods. The trapped water acts as a mobilising agent for the landslides to occur. Whenever there is a slight instability due to any reason, the trapped water gets avenues to drain out through the cracks and fissures present in the rock mass, which keep on widening with the passage of time. Therefore, these slopes need to be stabilised properly after thorough geological/geotechnical investigation.

Recently some parts of Indian Himalayan states have experienced land subsidence. As per the media reports, Joshimath - a temple town known as the gateway for trekking, climbing expeditions and other thrilling activities has been severely hit by a geological phenomenon commonly termed - land subsidence, which is observed to have literally "sunk" a few inches to even a couple of feet in some places and hundreds of residents have been evacuated from their homes. Amid the din of evacuation

and demolitions in this holy town, the residents have registered their anger against Hydro Power projects which they blame for their town "sinking". Over the last few months, the man-made infrastructures including hotels, houses, roads in the town of over 20000 people started developing cracks, eventually forcing many families of most sensitive areas to abandon their homes and move to safer locations.

This small town of Uttarakhand is situated in the middle slopes of a hill bounded by the two streams locally known as Karmanas and Dhaknala on the West and East, and Dhaulinganga and Alaknanda rivers on the South and North. The town is located in the area prone to landslides and it has been reported that the first instance of subsidence occurred in 1976. The perennial streams, appreciable snow in the upper reaches and highly weathered gneissic rocks with low cohesive characteristics makes the area prone to landslides. The town sitting almost on a tectonic fault line is also very close to geological fault lines thereby bringing the towns under the impact zone of any tectonic activity.

Perhaps land subsidence at Joshimath can be termed as a classic example of multiple effects of natural and manmade activities. The town is located on the site of ancient landslides and covered with thick layers of overburden materials. So it is prone to landslides and highly vulnerable to subsidence due to scattered and highly weathered gneissic rock with low bearing capacity and loose soil to seepage from streams uphill. Satellite images show that mountain streams have expanded their channels significantly and also changed their course, thereby inducing more slope instability in an already fragile belt after catastrophic floods of 2013 and 2021.

Moreover the use of heavy machinery for construction works related to the surface and underground structures appears to affect the stability of water borne-strata adversely, which sometimes causes the inflows of water through fissures and cracks resulting in large-scale dewatering and subsequent creation of void space in the rock mass followed by occurrence of initial subsidence. During underground excavation, the problems generally encountered are heavy seepage, mudflows, debris flows, falling rocks, overbreak and squeezing. The infrastructural projects, if not properly planned, investigated, designed and executed, these structures generally choke the natural drainage systems of the area.

The causes of destabilisation of land at several tourist places in Himalayan region need to be thoroughly investigated so that such incidents can be avoided in future. There may be many reasons for development of cracks in buildings or roads and large-scale subsidence in the area. The cumulative effects of some important factors identified pertain to man-made activities and geological phenomenon, viz., adverse hydro-geological conditions, slope stability problems, improper drainage system, presence of fault / thick shear zones, deforestation, recurring earthquakes, damages of water borne stratas / aquifers present at shallow and great depths by natural catastrophic events or large-scale construction activities, and last but not the least the long-term weathering effects.

Generally weathering takes place in all environments but the process of fast weathering is most intense in wet, hot and rains affected climates where it may be expected to extend at great depths. The weathering of soft and fragile rocks is one of the primary causes of slope failure and shallow landslides in hilly areas. Weathering is also responsible for affecting the civil engineering works located on or within the rock mass. Goel & Mitra (2015, 2021) have discussed in details about the role of weathering in civil engineering works, which have attracted practising engineers and researchers from all corners of the globe as revealed by a popular social networking site-Researchgate as given below:

- Goel R.K. and Mitra Subhash (2015), Importance of Weathering in Rock Engineering;International Golden Jubilee Conference on Engineering Geology in New

Millenium (EGNM), Special Issue of Journal Engg. Geology, New Delhi. Also Available online at www.researchgate.net (with over 37000 reads.)

- Goel R. K. and Mitra Subhash (2021), Weathering and its Influence on Rock Slope Stability in Hilly Areas., JRMTT, Vol. 27, ,No. 1, pp 49-62, Also Available online at www.isrmtt.com

Tourism is one of the main resources of revenue generation and therefore tourist places of Himalayan States have been found to be "Over Stressed" with the growing population of locals and tourists on one hand and massive construction activities on the other. Too much tourism seems to have deshaped the natural beauty of our mountain towns. The floods of people coming from the plains are also responsible for traffic-jam-filled hilly roads that lead to a town centre lined with haphazardly parked vehicles. Hill stations are Nation's pride and it's key to ecological balance and therefore need to be preserved to the best possible manner.

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