2. Traditional Approaches

Infrastructures in mountainous regions throughout the world have suffered from landslides, debris flows, earthquakes, outburst floods, heavy rainfall, and excessive flood discharges. Natural mass wasting and accelerated human activities have rendered infrastructures in the mountains highly vulnerable to unexpected and early failures.

The inherent geological weaknesses of the soils and rocks forming the mountains, when acted upon by the forces of nature and subjected to the negative impacts of human interference, give rise to instabilities that take a toll on life and property. Mountains, by virtue of the inherent heterogeneity of their soils and rocks, climate, elevation, topography, rainfall, river and stream behaviour, and ecology are not easy to manoeuvre nor manage.

Extensive activities, such as those related to agriculture, irrigation, roads, tunnels, railways, dams, mining, and buildings, have infringed upon the natural balance over a long period of time in rapidly harnessing natural resources for human prosperity.

Severe damage to these structures, caused by slope instabilities, has not only resulted in the direct loss of infrastructure but has also given rise to serious impacts on the balance of the ecosystem.

It is not true that the mountains have no room for these activities. The principal concern is how much we understand and care about the mountains and the negative impacts upon them from the **geodynamic** processes of nature and the activities of men and animals.

It can be argued that human impact has not been of long duration upon a planet that is thought to be approximately 4.5 billion years old. Even within an estimated timeframe of 40,000 years; the approximate period it has taken for the ascent of man; road building and canal construction, as recorded so far, only appear in the latter centuries of the 1st millenium B.C., e.g., the Great Wall of China was completed in 207 B.C. Engineering feats, during the last 2,000 years, have been more an outcome of art than science. Foundation engineering, as a science or as a combination of science and art, started with the application of soil mechanics by Karl Terzachi in 1925. All the advancements in soil mechanics since then have concentrated on transported soil. Geologists, nevertheless, have accumulated a vast amount of knowledge since the 17th century in trying to understand the mountain formations and the soils and rocks within them, but most of this geological knowledge was empirical and limited to wider spread of temporal and spatial disturbances.

Adaptation of a particular structure to the geological environment of the mountains with the aim of achieving stability, safety, and economy in constructing engineering structures required a knowledge of engineering geology, and this has advanced significantly during the last four decades only.

Acceptance of the validity of the continental drift theory and the paradigm of plate tectonics led to an unusual advancement in the history of earth science in the late sixties. This provided a powerful mechanism for explaining modern mountain belts.

Young mountain belts are now understood to be associated with highly seismic and volcanic belts adjacent to consuming plate margins. These associations occur at continental/ocean boundaries (e.g., the Andes) and where a continental collision has occurred (the Himalayas) or is impending (the eastern Mediterranean).

The formation of the Himalayas is now believed to have resulted from the plate, on which India was located, drifting northwards about 180 million years ago, and from the Indian plate commencing to push against the Asian plate about 53 million years ago.

Developments in rock mechanics in the last two to three decades greatly contributed to engineering geology and geotechnics for systematic and scientific approaches to establishing infrastructures in the mountains.

Engineering-geological surveys and explorations using geophysics, satellite and aerial remote sensing, borehole television, acoustic measurements, and transmission radar are the techniques available today. Modern engineering in mountain regions is now in a position to investigate, analyse, and characterise i) the properties of soils and rocks below the surface, ii) the stability of slopes, iii) the discontinuities, and iv) geohydrological and geometeorological regimes of the area. Nevertheless, except for large dams, little of the knowledge has been applied in constructing linear infrastructures such as roads, canals, and dams in mountain areas.