Triggering mechanism vis-a- vis landslide susceptibility in the high altitude areas of North Eastern Himalaya – Observations from Se La Pass Road corridor, Tawang District, Arunachal Pradesh.

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Abstract

Landslide inventory data base worked out during the landslide susceptibility mapping in higher altitude areas of Se La pass covering the National Highway corridor of Baishakhi-Se La Pass-Jaswantgarh-Jang area of the Tawang district, Arunachal Pradesh helped to identify various triggering and causal factors responsible for initiation of landslides and slope failures in the terrain. The strategic road corridor connecting the Indo-China frontier via Tawang Township and vehicular traffic including that of Army convoys are vulnerable with respect to the landslide hazards in the area. Se La-Pass is often blocked from January to March as a result of heavy snowfalls. The road corridor is part of the Higher Himalayan regime with extreme rugged topography characterised by lofty mountains and deep valleys with numerous small lakes and has altitude variations from 4050 m in Se La pass to 3280 m in Jaswantgarh, 3400 m in Baishakhi and 3310 m in Nuranang. Seasonal and diurnal thawing & freezing effects, snow melting, high anomalous snow and rainfall, wind action, ground vibrations, seismicity and excavation for road widening could be attributed as the triggering mechanism for initiation of landslides and slope failures. The triggering factors at various space and time acted on the upper exposed surface of the variably thick, loose to well compacted boulder laden older debris mass and resulted the slope distress.

Landslides and slope failures at 14 locations were identified within the loose to variable compacted older debris mass/slope wash material, which are the dominant slope forming material in the area and formed due to the effect of the dynamic Quaternary to Recent geomorphologic processes on the crystalline rock masses around. Majority of the landslides and slope failures documented are active to suspended type and has significant variation of affected slope areas from as low as 1000 sq m to 4800 sq m. The most important of triggering effect of landslides in the

area could be attributed due to rapid descent of large volume of snow melt during the onset of warm seasonal period. Such phenomena of triggering of landslide by the water released after rapid snowmelt has been reported from the mid-latitude area of Europe and Japan by some workers. Besides the snow melting, the other triggering mechanism for initiation of landslides in the area can be attributed to heavy rainfall, high (directional) wind speed, thawing and freeing of snow and ice and even ground vibration caused due to heavy movement of heavy artilleries. Landslides triggered by the rainfall and snow melt were not homogeneously distributed in the region. This may be due to different meteorological conditions as well as to the different geological and morphological settings. The significant observation documented adjacent to Nuranang and at a place about 1 km south east away from Jaswantgarh is the fall of boulders and loose debris from the exposed slope due to the effect of strong wind and ground vibration caused due the movement of convoy of heavy vehicles. The said phenomena are mostly observed in the barren slope and in the relatively dry cohesion poor sandy matrix. Because of the prevalence of the similar material in the slope along the road corridors it is likely that in the event of a moderate to large earthquake and consequent ground acceleration the dominant slope forming material will experience similar distressing. Another very significant feature observed near Nuranang area is a linear old rock flow zone in which huge equi-dimensional boulders of quarzo-feldspathic rocks are disposed in a strikingly linear fashion for a distance of about 200 m . The disposition of the rock boulders along the slope descended from the crest of a granite hills and their mode of disposition clearly suggests sudden flow of jointed rock mass from the hill crest which might have been triggered during some past seismic events.

The nature of surficial deposits as encountered in the area is result of climatic interferences through ages over the crystalline mass and as such the slope forming material along and across the slope shows significant variations. Following general variants along the slope has been noticed; i) Near the hill crest dominantly feldspar rich boulder quarzo-feldspathic rocks, ii) In the middle slope loose to variable compacted boulder laden older debris material and iii) Younger loose boulder material at the base of the slope. The thickness of the boulder laden older debris material and Younger loose boulder material shows variation in the range of 10 -15 m as observed in the road section.

The nature and distribution of landslides/slope failures, the causal and triggering factors responsible for the slope distressing in the terrain can be related to variable amount of snow melt, rainfall, high directional wind speed, seismicity, diurnal and seasonal temperature variation, and anthropogenic activity over dominantly loose to variable compacted boulder laden debris slope forming material. The fixed rating guideline of the BIS (1998) and modified one by GSI (2005) for landslide hazard Zonation as such may not be able to accommodate the significantly varying triggering mechanism of slope distressing in the kind of terrain for assessment of the landslide susceptibility and hazards.

Various models are being attempted for quantitative assessment of the slope stability based on physical parameters including topography, precipitation, air temperature, wind speed and direction, humidity, down-welling shortwave and long wave radiation, cloud cover, surface pressure and their variation in space and time. Temperature index methods; Snow accumulation/melting model (SAMM) are also used in similar terrain elsewhere in regional scale landslide prediction. These models are proposed for a regional scale early warning system based on statistical rainfall thresholds for occurrence of landslides taking in to account snow accumulation and depletion.