Design of Remedial Measures at Lukhbir Slide on NH-31A Near Sikkim

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Abstract

National Highway 31A (NH 31A) links Gangtok to Sevoke and runs along the banks of the River Teesta. Lukhbir slide, active since 1968, is located at km 26.8 on NH 31- A as shown in photograph 1. It covers 400m length of road & approximately 50m active portion & remaining several meters of probable failure area above the road & downhill up to the bank of river Teesta. Several agencies like GSI, CRRI & CWPRS carried out studies on this landslide and suggested a variety of remedial measures like benching of slopes, ceiling of cracks, retaining walls, Brest wall etc. All the time, the remedial measures implemented by BRO, didn't stand up to the violent nature of the slide, particularly during rainy season.

Photo 1. Lukhbiur slide on NH - 31A

The damaged stretch of the road extended to the length of around 400m. The road level (RL) noticed at 230 and the HFL 205. As the Teesta dam project is being constructed actively, it is estimated that the water level will rise up to RL 223, that is in close proximity to the road level involving the landslide affected downhill slope as well. In view of the coming dam & importance of the only highway linking the area, it was pertinent to investigate the area & suggest the appropriate remedial measures to prevent the slope as well as the road from the rising water level of proposed dam.

The preliminary investigation included the onsite observations & judgement for probable remedial measures etc. Going through the history of the landslide it was learnt that the initial triggering factor was the intense toe erosion particularly during the high flood instances. Due to this reason repeated damage/subsidence of the highway had been occurring. With frequent damage of highway, to restore the same, instead of strengthening downhill side slope the uphill slope was cut. This practice was repeated almost every time the road was damaged. As a result the uphill slope had become active and continues to be same till date. The focus on preventing the slope uphill side has therefore become a priority and no attention was paid to the need of toe protection. The gradual cutting of the toe may become a cause of concern in years to come. It was therefore required to think holistically to undertake all the measures in view of the long term stability of slope instead of very short term approach.

Photo.2 : Downhill slope damaged due to river meandering

During on site observation it was observed that the rock type is mainly, mica schist, which is a very fissile and breaks along its plane of schistosity & can be easily powdered by a bit rubbing. Though the planes are dipping away from the slope but the rock type itself is dangerous in its nature. It would not sustain any compact of structure on its surface due to its fissile nature. It can be easily weathered to break along planes forming powdery soils or small blocks of rock, if weathering agents like water etc and over loading of slope is there. Since the rock is highly fragile, build up of stress on its surface can cause the development of cracks very easily in the rock and once initiated cracks can further enlarge to cause fragmentation of the rocks into blocks along other surfaces other than the plane of schistosity also. In dry condition the rock breaks along fissile planes and in saturated condition remain as damp & muddy soil.

We know that landslides occur as a result of slope instability associated mass movement of hill slopes. In order to predict the landslide occurrence, a quantitative assessment of slope stability is necessary. Selection of suitable remedial measures follows the estimation of stability. The assessment of degree of safety is calculated through factor of safety (FOS) which is conventionally defined as the ratio of average shear strength to the average shear stress along a potential failure surface. The selection of potential failure surface essentially depends on the geology of the site as revealed from site investigation & material properties. The direct shear test results of soil conducted at average field dry density value (saturated, i.e., after soaking the sample for 24 hours) showed that cohesion, $c' = 0$ and angle of internal friction (ϕ') = 250 have been taken as parameters for slope stability analysis. The stability analysis of slope was carried out by using GEO 5 software. The factor of safety of the slope ranges from 0.89 and 1.04 without and with earthquake factors respectively.

As River Teesta takes a turn (meandering) at the base of the slide resulting in direct impact of the water particularly during the monsoon season (photograph 2), it was proposed to protect the toe from the onslaught of high velocity water. At the same time the uphill & downhill slope from the road was also required to be prevented for long term stability.

The design of remedial measures, based on the onsite observation, probable causative factors & stability analyses, was performed as indicated in figure 1. The details however, shall be presented in the final paper. The measures are implemented & the performance may also be discussed in the paper.

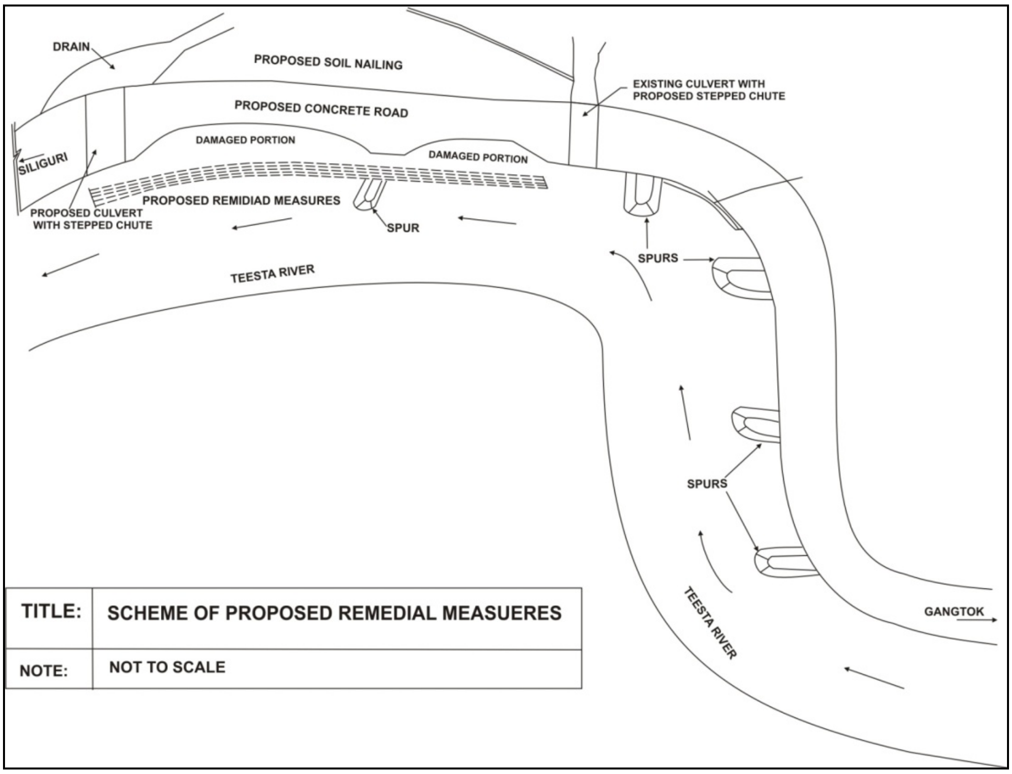

Figure 1. Suggested remedial measures