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USE OF GEOFABRICS FOR CONTROLLING LANDSLIDES - CASE HISTORIES

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ABSTRACT

Four case histories on erosion and rock fall control by the use of natural and synthetic geogrids are described. Each of the affected area was analysed and treated adopting different techniques of installation of geofabrics mantle as control measures which resulted in significant improvement of slope stability. Treatment also helped in maintaining ecological balance of the hills.

KEY WORDS

Rock fall control, erosion control, landslides, natural geogrids, synthetic geogrids, monitoring.

INTRODUCTION

In the Himalayan terrain of India, landslide incidents are frequent and wide spread. Landslide activities denude hill slopes which further aggravate the incidence of landslides specially during monsoon. Use of natural geofabrics has been proved to be very effective for promoting growth of vegetation and improving stability of the slopes. Similarly, control of rock fall was done effectively by the use of synthetic geogrids.

USE OF SYNTHETIC GEOFABRICS FOR ROCK FALL CONTROL AT RATIGHAT, U.P. HIMALAYA.

The rock fall prone area at Ratighat landslide complex consists of thick bands of phyllites and quartzites which are in highly distressed state due to the interaction of different planes of discontinuities. After a detailed field survey, an area of about 150 sqm . of the hill slope was identified as the prime source of rock fall. Use of synthetic geogrid mantle was preferred here because of its high tensile strength, impact and abrasion resistance. The material is light weight, flexible, resistant to ultraviolet light, chemically and biologically inert. Several numbers of geogrid rolls were stirched together to cover the entire rock fall prone surface. The upper end of each roll of synthetic geogrid was fixed by (I) surficial bolting technique and (ii) trench bolting technique.

In the surficial bolting technique, four holes of 15cm to 20cm dia extending to a depth of about 80 cm were dug on a long flat bench having 1.5m width constructed slightly beyond the periphery of the crown. Four bolts of 1cm dia and 90cm length with one end threaded and exposed to the surface for a distance of 5cm above the ground and other end bent in the form of "L" inserted in the holes were fixed by lean concrete. A pair of drilled iron flats in the form of brackets holding the synthetic geogrid mesh by nuts and bolts were then fixed with these four bolts on the bench. In the other procedure of trench bolting technique, holes of 20 cm dia and 90cm depth at an interval of 2m were dug at the base of a long trench having 0.5m width and 0.5m depth for fixing bolts in the similar manner as explained earlier. Afterwards with these bolts the synthetic geogrid mantle which was held by a number of small pairs of drilled iron flats (each of which is 50cm long) by nuts and bots arrangments was fixed at the base of the trench. The trench was then refilled with boulders and soil as such to achieve the original slope profile. After fixing the upper end of synthetic geogrid mantle, the remaining portion of the mantle including the other free end was rolled down over the rock fall prone slope . The lower edge of the mesh was then fixed within the slope either by directlly driving "T" shaped iron rods into the rock or by making cement concrete bolting arrangement. To maintain a firm contact of the geogrid with the rock slope surface, several number of "T" shaped rods were also driven into the rock slope face at several locations as seen Fig.1.

Fig.1 Fixing of the synthetic geogrid for rock fall control.

Observation made for three years revealed that this methodology is very effective and useful for not only controlling rock fall activity but also it helps for promoting natural growth of vegetation which improves stability of the affected hill slope area as seen in Fig.2.

Fig.2. Panoramic view of the treated area.

USE OF NATURAL GEOFABRICS FOR CONTROL OF SLOPE FAILURE AT DOLMAR, U.P. HIMALAYA.

Detailed field investigation of the landslide affected area at Dolmar, reveals that the severe erosion had affected both slope surface as well as toe portion due to which about 250sq.m. area of the hill slope was denuded. Use of natural geofabric was chosen for minimising the influence of erosion and also for promoting growth of vegetation which increased stability of the denuded slope. The slump slope comprised of soil and loose scattered boulders of varying sizes ranging from a few cm to more than 2 m. The slope was graded. The strewn bhoulders were systematically reset like small check wall type of structures within the gullies. Boulders of 0.5m - 1.5m size were commonly used for the lower most region and it kept on decreasing while going upwards within the gulley., Fig.3.

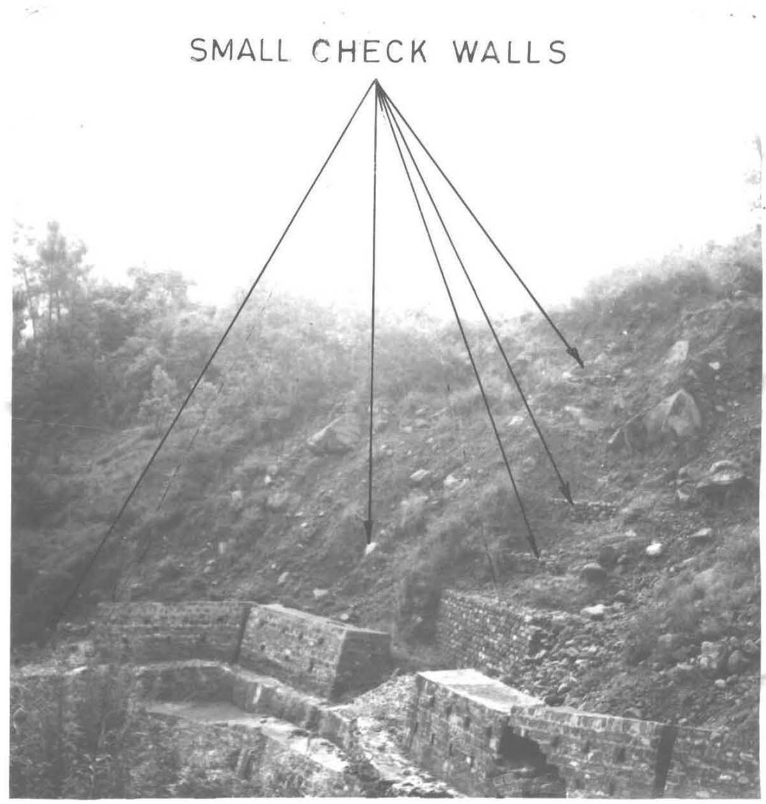

Fig.3. Resetting of boulders in the gulley before refilling.

The gullies were refilled with soil and rammed so as to resemble the original smooth soil profile. Two varieties of grass as "Kikyu" and "Dhuv" were dibbled on the slope at a spacing of 10cm. Some stems of quick growing plants, locally known as "Simel" were also planted. The plantation work was carried out from the uphill end to down hill end. After finishing the plantation work, a long trench having 0.5m depth and 0.5m width was dug slightly away from the crown and running parallel to the periphery of the affected hill slope area. The upper end of the coir net mantle prepared by stitching several number of rolls together were fixed into the trench by inserting wooden pegs or "U" shaped iron nails. The trench was then refilled with soil so that it resembled the existing slope profile. To keep a firm contact of the coir net mantle with the treated hill slope area several number of wooden pegs or nails were driven in to the slope, Fig.4.

Fig.4. Slope treatment with coir netting.

Post observation and monitoring of the treated area showsed very good effective results which was evidenced by good growth of vegetation and no further incidence of slope failures.

ROCK FALL AT KASHMIR HIMALAYA

The hill slope area comprised of grey coloured, highly jointed shattered slates. Uneven rugged and steeply dipping slope ranging from 50 deg. to 70 deg. was developed due to the interaction of different sets of joint planes leading to rock fall. Due to prolonged negligence and occurrence of rock fall incidences, a basin type of area developed near the crown of the slope which acted as catchment area for a small portion of the falling rock fragments. The accumulated rock fragments could also pose problems had a sliding took place. The detailed survey of the area revealed the prime sources of rock fall as (i) shattered rock beds at the periphery of the basinal part (ii) accumulated loose debris within the oval basin at the crown and (iii) other rock fragments randomly scattered over the slope area. Extensive use of the geogrid in various ways were considered to be suitable for controlling both the impact of rock fall on the moving traffic on the highway and for reducing slope degradation process.

Entire periphery basinal part of the rock slope was to be covered with the mantle of the synthetic geogrid in such a way that the mantle could have a firm contact with the rock slope. For retaining the accumulated debris intact at its own place, a series of perforated tin sheets nailed with the logs or iron rods fixed on the surface of the slope. This stabilisation measures could still leave a number of loose scattered rock fragments over a large rock slope surface which might create problem of rock fall hazard to the moving traffic on the high way in the near future. To control such incidence of rock fall affecting the moving traffic, a rock fall trap net was proposed in addition to the measures mentioned earlier. In such type of trap net, a series of mantles of geogrid were fixed one above the other with their one end fixed to the impregnated iron flats in errect position, whereas the other end hanged freely. Three rolls of such mantles were fixed transversely on the slope. The drilled iron flats were fixed into the slope by digging 1.5m holes and pouring cement concrete mix. The height of the iron flats were 2m to 3m above the slope surface. About 0.5m length of each iron flat was made to bend towards the downhill direction, Fig.5.

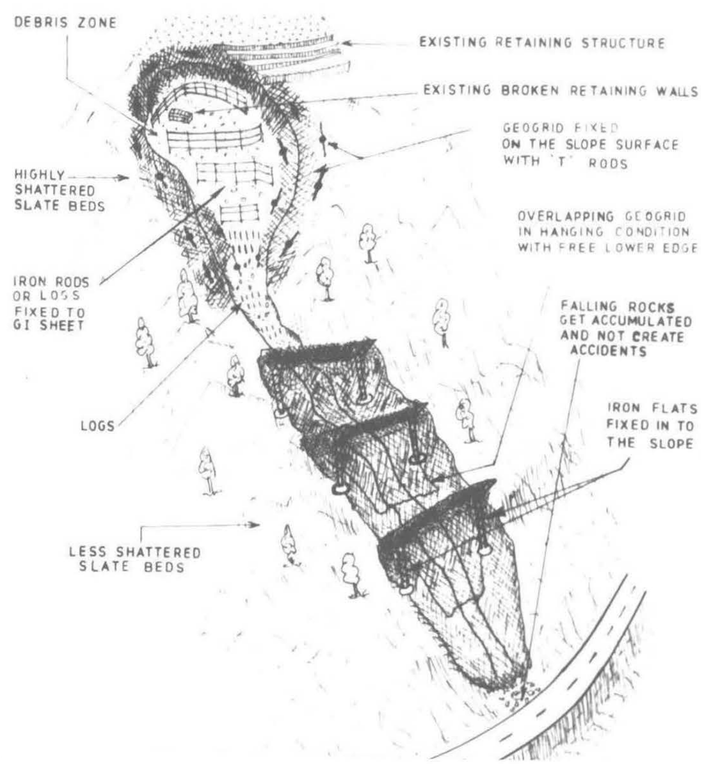

Fig.5. Geogrids used for rockfall control and trap nets.

The mantle of the geogrid was tightly fixed to the iron flats with the help of small pieces of drilled iron flats with 20cm to 25cm length and by nut and bolts. In this arrangement the geogrid mantle acted not only as obstacle to the falling rock fragments but also to trap the falling rock fragments.

LANDSLIDE CONTROL AT GATHIA, U.P HIMALAYA

The landslide affected area extended for a length of 150m along the road. The down hill slope experienced sliding and significant amount of erosion accompanied by development of almost black slate of variable thickness ranging from a few cm to 50cm. General strike of the rock is 12 deg NNW - SSE dipping at 24 deg SW. The predominant rock type is grey slate which is highly jointed and fractured. The affected slope is bounded by two hill sides streams which join together at the toe part of the slide. The mass movement was primarily initiated due the cumulative affects of the erosion of the toe and the interaction of the planes of discontinuities. Geological data of the rock was plotted on a stereonet dia. and the mechanism of the slide predicted, fig.6.

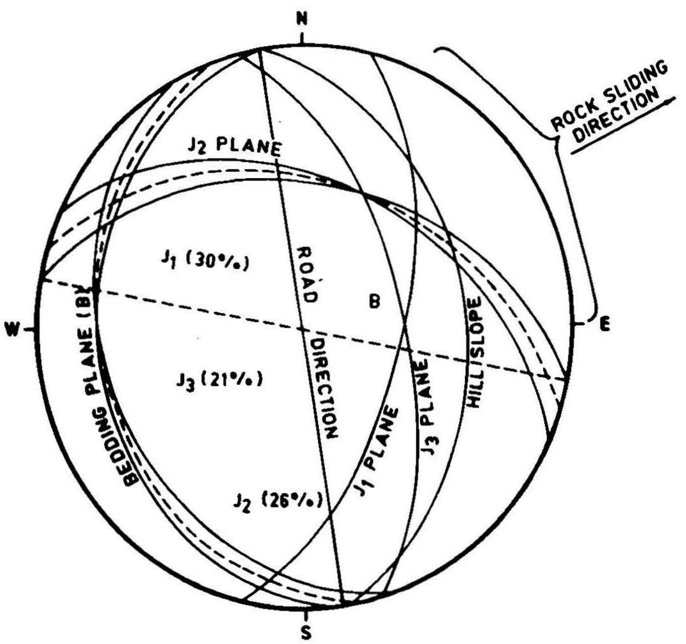

Fig.6. Stereonet diagram showing mechanism of slide.

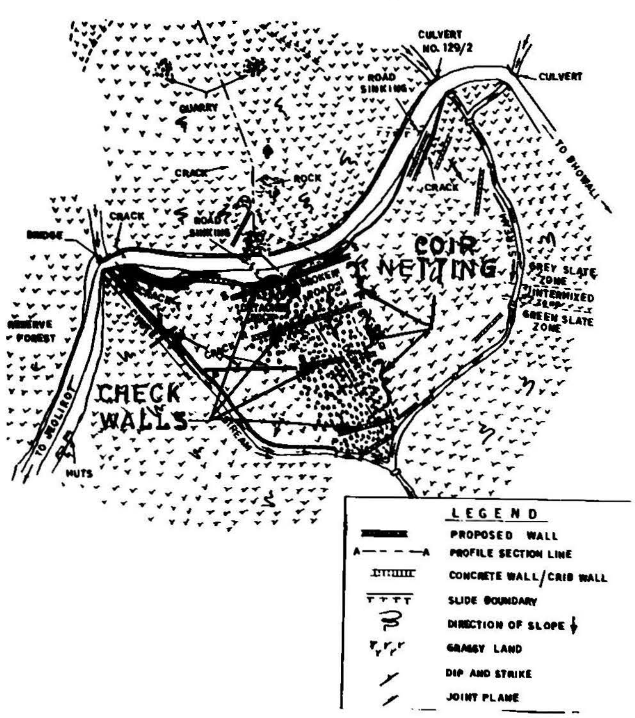

Fig.7. Slope treatment with coir netting and check walls

In order to improve the stability of the affected hill slope, plantation on the denuded surface was carried out before the onset of the monsoon and the toe walls along with small check walls were constructed. The follow up observation indicated improved stability condition of the affected slope, Fig.7.

CONCLUSIONS

In the preceding sections, the remedial measures for different landslides affected areas has been discussed. It has been observed that the mechanism and type of failure are controlled by an inter-play of environmental factor and the interaction of structural geological features along with the exact direction of slope and the road way at the particular location. Even same type of hill slope failures at different locations need different type of controlling measures which completely depend upon the existing geoenvironmental condition in that area. Hence, the most common factor is the eexisting field condition which is to be properly investigated before implementation of the best suitable economic remedial measures to control the landslide affected area.

Use of geotextiles, such as natural as well as synthetic, have proved to be effective for controlling both rock fall and erosion of denuded hill slope. Consequent improvement in the stability and growth of vegetation enhances the ecological balance.

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