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India's First Venture Relating to Subsurface Drainage by Horizontal Drains

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SYNOPSIS Landslides in the Nilgiris district in 1978-79, caused heavy damages to property and human life. The field studies indicated that in certain spots, the build up of excess hydrostatic pressure, caused by direct and indirect ingress of water into the soil mantle, is the main cause for certain landslides in the region. The paper attempts to give the total case history relating to a pioneering venture of its kind towards the correction of landslides undertaken in India. The case history assumes special significance in as much as the horizontal drains successfully installed for the first time in this country, provided the needed ocular demonstration of the efficacy of horizontal drains to the practising engineers in India.

INTRODUCTION

The landslides are a recurring phenomena in the Nilgiri plateau. The unprecendented rains caused more than a hundred landslides within an area of two hundred fifty square kilometers in 1978. And in 1979, the incidence of landslides was on a much larger scale and nearly two hundred landslides were recorded in Nilgiris district.

The Porthimund dam, impounding a feeder reservoir for Emerald hydroelectric generating station is one of a series of the eighteen dams comprising the Kundha hydroelectric project in the Nilgiris district. The landslide occurred on the down-stream side of the Porthimund dam. A panoramic view of the landslide that occured at the Porthimund dam site is shown in Fig.1.

Fig.1 Panoramic View of the Landslide.

The crust of the slide is currently very near to the top of the hill approximately 200 m due east of the right abutment of the dam and 40m above maximum water level.

The landslide has been in existence since well before the construction of the dam. It is still active and an extension of the slide area has been noticed in recent years and it has been observed that the activeness of the slide is closely associated with the monsoon rains. The slide appears to have developed due to the slope erosion caused by seepage water and surface run-off.

LOCAL GEOLOGY OF THE AREA

The present geotechnical investigation carried out for the installation of horizontal drains around the Porthimund landslide has shown that the material involved consists of charnockites, biotite schist of an acidic nature, medium to coarse grained, varying in colour from light greenish gray to dark grayish black. The charnockites in the area are of high grade metamorphic origin and of precambrian time, and had undergone considerable deformation. The rocks include gneises and schistose rocks. They are mostly covered by a thin soil layer of lateritic type. The outcrops are exposed along the road cuttings and stream beds in the landslide area. The properties of the top soil layer are as given below:
The coefficient of the permeability is 2×10^{-5} cm/sec.

The plasticity index is 10
The clay content is 20%
The silt content is 25%
The sand content is 45% and the rest is gravel.

The geomorphic features suggest that this particular unstable hill is very small in dimension when compared to the surrounding hills on the other three sides. So the surface and subsurface water coming from the three directions entering into the earth mass through cracks and fissures aggravated the instability of the hill slope. The well developed joints and the foliated nature of the bed rock have weakened the rock mass making it susceptible to weathering agencies.

At the Porthimund landslide, it was observed that water was seeping along the hill slope during the rainy seasons. The nature of the rock formations and the topographic features suggest that the surface water travels vertically down through the loose soil and starts flowing outward, only when it touches the weathered but comparatively harder formations. The central zone between the two different types of formation i.e. the soil and the weathered biotite gneiss is the place where all physical properties are found continually changing. It can be inferred that this represents the failure zone. The closely spaced joints trending NNW-SSE and steeply dipping 80^{O}-85^{O} SW direction, also allows water to enter into the rock and in course of time the rock mass loses its strength and tends to slide downhill.

After a careful study of the failure mechanism of the landslide, it was concluded that if only the excess hydrostatic pressure build up in the soil mass due to the seepage of drain water at the higher reaches of the slope is reduced successfully and maintained at the reduced level, the slope would remain stable. In order to remove the excessive hydrostatic pressure from the interior of the soil mass overlying the bed rock, the technique of horizontal drains in combination with vegetative turfing for the erosion control of the slope were thought to be the appropriate remedial measures to control the landslides.

DETAILS OF HORIZONTAL DRAINS

The principal function of horizontal drains is to remove excess subsurface water in hill sides, cut slopes and fills. They provide channels for the drainage of subsurface water either from the mass of sliding soil or from its source. The location and depth of ground water together with the topography of the area, would determine the location on which the drains be installed. Since the drains remove water by gravity, the starting points for the drain must be below the elevation from where the water is to be intercepted. The spacing of the drains depends on the drainage characteristics of soil quantity of water to be intercepted and magnitude of slide involved. Drains are often installed from more than one level if the slide area permits. The depth of drain is usually determined by the depth to which the drains will have to penetrate in order to intercept the water bearing stratum or up to the source of water to properly drain the water thereby bringing a progressive stable condition in the hill slope.

In certain cases, the quantity of water drained out in the initial stage is not necessarily an index of the flow that will occur later or the effectiveness of installation. In some cases removal of small quantity of water through these drains may produce stable conditions and in some cases even larger quantity may not produce stable conditions due to other interacting factors. In these circumstances the other adverse factors affecting the slide should also be controlled to improve the stability of the slope.

The site for the installation of drains was chosen where the steep slope had slipped. Two berms at different levels with approximately 6m of difference in height were constructed so that the drilling machine could be taken to work site and the drains could be installed at two levels along the affected slope. To drill the horizontal bores Voldril-90 was used Fig. No.2. The drilling machine, Voldril 90, is a rotary type

Fig.2 Drilling rig in operation

drilling rig capable of drilling holes in soil as well as in hard stratum by using diamond bits. The holes can be drilled either in the vertical direction as the drilling mast can rotate throug any angle. Since the special drilling rigs designed for installation of horizontal drains were not available in the country, it was considered expedient to use Voldril 90 available with the institute. No particular difficulty was encountered in the use of Voldril 90 during the field installations.

Rigid P.V.C. perforated/slotted pipes of 50mm dia and 3m length were used, Fig.3.

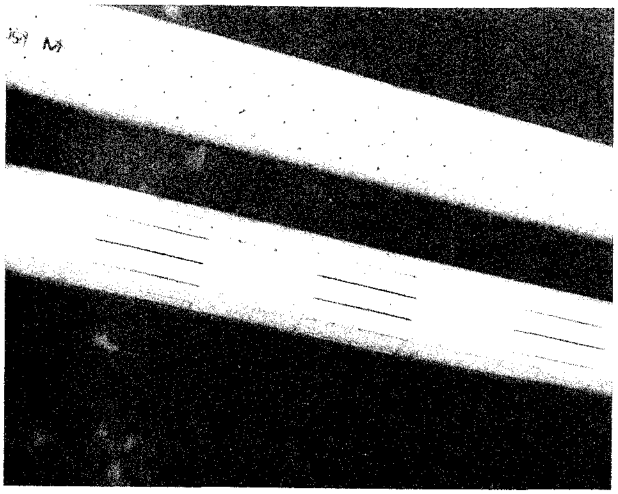

Fig.3 P.V.C. pipes used for the installation.

The perforation of 1mm dia holes were made at 1cm intervals in a zigzag fashion. The slots of 1mm width and 5 cm length were made alternatively along the pipe giving a gap of 5 cm in between two consecutive slots. The perforation/slots were made on the upper two third of the periphery leaving the bottom 1/3 of the periphery plain. In the present study, for the type of soil encountered in the field, the PVC pipes having the above size of perforations/slots proved to be very effective. The pipes were jointed by couplers with solvent cement depending upon the length of the drains required.

The farthest end of the drain pipe inside the hill slope was connected with a specially fabricated chuck, Fig.4 to prevent the pipes slipping out from the horizontal bores. The drains were inclined 6° to 10° to the horizontal. In all about 45 drains have been installed in two berms in a fan shape radial pattern as shown in Fig.5. The depth of the drains installed varied from 18m to 33m. The PVC pipes used were easy to handle for installation purposes, for making of perforations/slots and for maintenance.

Fig.4 Chuck to check slippage of pipes

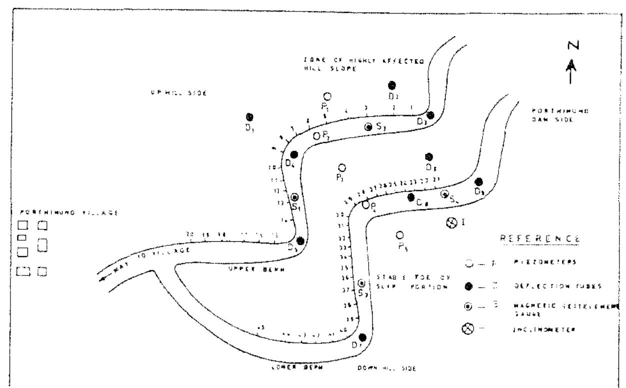

Fig.5 Plan showing the location of drains and geotechnical instruments.

INSTRUMENTATION

The affected hill slope is instrumented with geotechnical instruments like piezometers, magnetic settlement gauges and deflection tubes, to monitor the pore pressure build up in the subsoil, to determine the settlements or heave in the slope area and to observe the lateral movements in soil mass. In all five piezometers, four settlement gauges and nine deflection tubes were installed.

VEGETATIVE TURFING

Along with the horizontal drains, vegetative turfing was also implemented for controlling the surface erosion of the hill slope due to run off water. A mixture of assorted seeds of the promising species of the local grasses, shrubs were broadcast over the entire slide of denuded zone in three applications, mixed with sand to facilitate easy handling and for broader coverage. In addition to this, locally available kikiyu grass was planted flat on the slide slopes, Fig.6 to control the surface erosion.

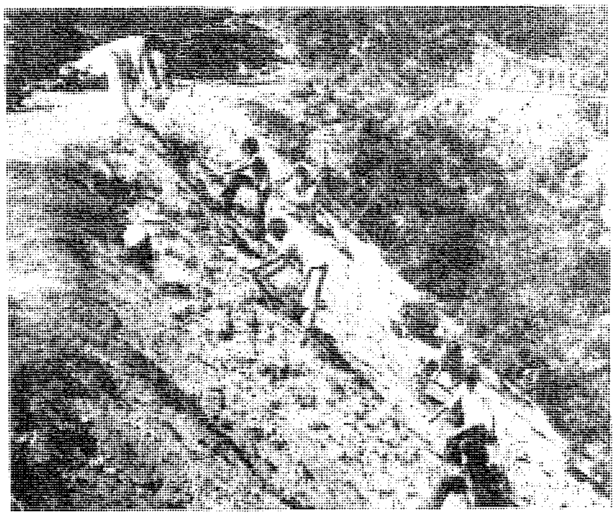

Fig.6 Planting of kikiyu grass on the hill slope

MAINTENANCE

The maintenance of horizontal drain installations is necessary if they are to be effective for longer periods. The maintenance required depends upon local soil conditions, vegetation, rainfall and other factors. It is found that use of PVC pipes with smaller perforations as drains considerably minimised trouble from root growth in the drains and eleminates the possibility of corrosion of the drain pipes. The periodic cleaning of the drains restore them to their original effectiveness. In the present field trials a small auger (25mm dia) type bit attached to 12mm hollow pipes has been inserted into the drains and rotated inside the drain pipes while water (under pressure) is pumped through the hollow pipe. This enabled thorough cleaning of the pipes as well as draining out of the soil and other organic materials accumulated inside.

CONCLUSIONS

1. Horizontal drains have a definite place in the correction and prevention of slides in embankments, cuts and natural hill slopes. When properly planned, installed and maintained they are doubtless effective.

2. Sub-surface drainage by means of horizontal drains represent a more effective solution compared to the prohibitive cost of adopting other corrective measures, in situations where the causes are due to excess hydrostatic pressure in the soil mass.

3. Subsurface drainage measures by horizontal drains require to be supplemented by vegetative turfing of the slope and by an efficient system of surface drainage measures to drain away water from the affected hill slope.

4. In formations where horizontal drilled holes are prone to caving in, there is need to use special types of drilling rigs which are explicitly designed for that purpose.

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