RAIN INDUCED LANDSLIDES AND DEBRIS FLOW CHARACTERISTICS FEATURES IN COLOMBIA

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First of all, I want to thank the Organizing Committee for inviting the Colombian Geotechnical Society to present this conference. It was going to be given by Eng. Manuel García López, Professor of Slope Stability at the National University of Colombia, but he was not able to make it to the Conference. I will try to do my best to present the Colombian experience regarding large landslides and mudflows.

Colombia is located in the northwest corner of South America, in a highly complex tectonic and orogenic setting, in which the Nazca, Southamerican and Caribbean plates converge. Consequently, the colombian territory has been affected by different natural disasters. Earthquakes, volcanic eruptions, flooding and mass movements have inflicted heavy human and material losses. Slope failures of varied types and sizes are of common ocurrence, most of them related to very high rainfalls and weathering. Earthquake-induced landslides are frequent along active fault systems in the mountainous area. Lahars associated with the recent El Ruiz volcanic eruption caused the worst natural catastrophe in Colombian history. A National System for Desaster Attention and Prevention was implemented as an answer to the effects of this event. Landslide dams and the subsequent debris avalanches and mud flows caused by the dam breakage are also frequent. Several cities and towns and rural communities are located in high risk zones, so that public awareness, hazard zoning and research have been increased in the last decade.

LANSLIDE AND MUDFLOW CASE HISTORIES

Let's see some examples of the very serious lanslide and mudflow problems which may be encountered in Colombia.

Blanca Creek Landslide, 1974

It took place in the steep and narrow canyon of the Blanca Creek, on a stretch of the road that runs from Santafé de Bogotá (the Capital of Colombia) to the eastern praires. There exists a large terrace deposit resting high above metamorphic rock units (mainly phyllites and quartzites) highly fractured and crossed by a system of geologic faults. The highway ran near *the contact between the granular materials of the terrace and the underlying rocks.*

A long history of inestability had been registered in the area with periodic landslides and debris flows. As a result of this, several retaining walls had been built and the bridge on the creek had been relocated many times. Furthermore, a very sophisticated corrective system was under development by the time of the landslide.

In spite of that, failure conditions of the whole sidehill (250m x 400m) evolved at a higher rate and after repeated debris flows and mud flows ar both flanks and at the base of the deposit, a bid wedge of the terrace detached slight from its main body. A head scarp developed and slumping of the wedge started moving down hill at an increasing rate. One of the debris flows went down to the top of the road bridge removing its platform.

Finally, after reaching stumping rates as high as 1 m/day (27th) and 1m/hour (the 28th in the morning) near mid afternoon the final collapse of the wedge took place. Near 1/2 half a million m3 of terrace material came down suddenly and unknown number of people and cars were covered by the debris. Unfortunately after waiting for several days, drivers got desperate and decided to ocupy the stretch of the road opposite to the failing sidehill.

The creek was impounded 3 days and then broke the dam and a debris avalanch formed. A detour of the road 2.6 Km long including a long span bridge and two (2) tunnet tunnels were built.

EL RUIZ NEVADO INDUCED MUDFLOW (1985) .

A mild eruption of the snow capped El Ruiz Volcano on the Central Cordillera of Colombia took place the 13th of November 1985. Debris avalanches involving recent and old volcanic materials, weathered lava, rests of ancient mudflows, ice and snow rapidly evolved to lahars along the rivers which are born in the volcano slopes. The largest lahars followed the Lagunilla river course leaving marks on the slopes of the course fifty five (55) km east of the volcano and some 4800 below it there was the city of Armero where 23.000 people died. It was estimated that in the upper part the lahar volume was on the order of 25 million m3, whereas in the plain area it increased by about three (3) times covering 3330 hectareas with an average thickness of 2 to 4 meters. Cattle herds, crops, stretches of highways and rural roads, oil pipelines and water supplies systems, bridges, railroads were destroyed.
As a result of the event, the Colombian Government organized in 1986 the National Office for the Attention and Prevention of Desasters, depending from the Presidency of the Republic.

THE UTICA DESASTER (1988)

The town of Utica is located 119 Km northeast from Bogotá, at the deltaic type confluence of the Negra creek and the Negro River. The Negra creek and its four tributary all display a high hydraulic gradient and are one of a torrential nature. The litology of the Negra Creek valley consists of shales, siltstones and some limestones in the western hill slopes and of sandstones and some shales in the eastern flank. All the rocks are intensively faulted and most of them are covered by abundant colluvial deposits succeptible to mass movements.

On the .night of november 17, 1988 a debris flow avalanche from the Negra Creek affected a part of the town covering several streets and causing large economic losses and some casualities. The avalanche originated from a temporary dam formed on one of the tributaries of the Negra Creek and is subsequent failure. Approximately 3 to 4 days after, a landslide of 1.5 million m3 developed on the left side of the Negro River, 5 km upstream from Utica, which buried 600m of the railroad track and temporarily dammed the river. After the fortunately gradual failure of this small dam, it heavily damaged cultivated land and dwelling within the municipality but only barely touched the town of Utica itself; no human casualities were reported.

A study was performed to decide on whether relocated Utica or to consider the construction of the structures and facilities required for the protection and prevention of damages and loss of lives caused by the expected ocurrence of avalanches. This late alternative resulted more economical.

THE PARADISIAN CREEK LANDSLIDE (1992)

This slope failure took place in an agricultured and forested zone in the mountain valley of the Paradisian Creek in May, 1992.

The movement was very complex as it included a block slide with local successive slumps in the upper half of the main body and earth flows in the lower half. It reached 1500m in lenght, 350m average width and 20 to 50m in depth.

Coluvial deposits and residual soils from cretaceous shales plus weathered shale, slided on a soft carbonaceous shale with interbedded thin sandstone 5 to 10m thickness.In turn they lay on a firm cemented sandstone depping downslope. A volume higher than 15 million m3 has been estimated. Two earth flows formed as big tongues descending towards the Valley bottom around a small elongated hill where two peasant´s houses survived.

The left hand flank of the landslide is an almost vertical rock scarp 20 to 50m high and 800m long formed a large fracture zone of the rock mass. In the flank local folding corresponding to ancient gravitational mass movements of the shaly formations on the sandstone strata can be seen.

As the soil mass forming these flows desentegrated and increased their water content they evolved to wide and deep mudflows. A silly clay with fragments of shale and carrying sandstone blocks, some of them with sides in the range 5 to 10 meter long formed the flow. Both the thin colluviam and the thick residual mantle (silly clay) are o f the structured soil mass type and anesotropic strenght characteristics, contributing to a highly fragil and metastable behaviour.

The peasant´s houses, a raw sugar cane mill, 45 hectares of agricultural land and 10 of forest were destroyed. A 1 km stretch of a very important oil pipeline 20 in diameter was also destroyed.

The landslide remains active at the present time. Besides simple and partial remedial measures, a rerouting of the pipeline around the instable area 2.5 km in lenght had to be built in a record time.

CONCLUSIONS

From the case histories. What can we conclude?

1. *Although we do not have control on most natural phenomena, a a lot of work has to be done to update the knowledge of the gene ral community about landslide disaster prevention and landslide planning.*

2. *Large inestability problems cannot be handle without an appro piate integration of Geology and Geotechnics.*

3. *In spite of the advances in research and practice of Geotechnical engineering ,problems like the one just presented have to be faced with humility.*