THE 1974 LANDSLIDE IN CENTRAL PART OF PERU

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Introduction

Peru is a country continually affected by different natural disasters. Through his history events have been registered so they have caused destruction of housing, building and have caused death to many people.

This report is a summary about a landslide happened in Peru some years ago. It explains causes and effects occurred in that cases, in addition, conclusions to mitigate future disasters for save of citizens' live.

1. What are Landslides?

Landslides and related phenomena belong to one of the types of erosion adjusting for gravity fields through the movement of geologic material from a higher state of potential to a lower state along a slope in a specific terrain of geologic constitution, tectonic condition, geomorphological stage and climatic condition. If a mass constituting a part of a slope moves totally downward along the surface of rupture, it is called a landslide. Slide surface and slip surface are synonymous with the surface of rupture. Ideally, the surfaces must not have any thickness. However, such a case is a very rare in natural phenomena. Usually, most of slide surfaces have some thickness from a few milimiters to several meters. Strictly speaking, such a thick surface of rupture should be called a layer of rupture.

Ideally again, the displacement of a landslide should take place only along the slide surface. However, measurement of displacement in profiles often indicates that the displacement is distribuited in thick layers or whole masses of landslides. The word "Landslide" was used for those phenomena of rather fast movements which can be idetified by naked eyes but recently is applied for those of slow movement which is only detected by instruments. This terminology belongs to a narrow meaning of landslides. The word "landslide" is also used for the general term including most of mass movements.

In order to have a better understanding see Fig. 1.

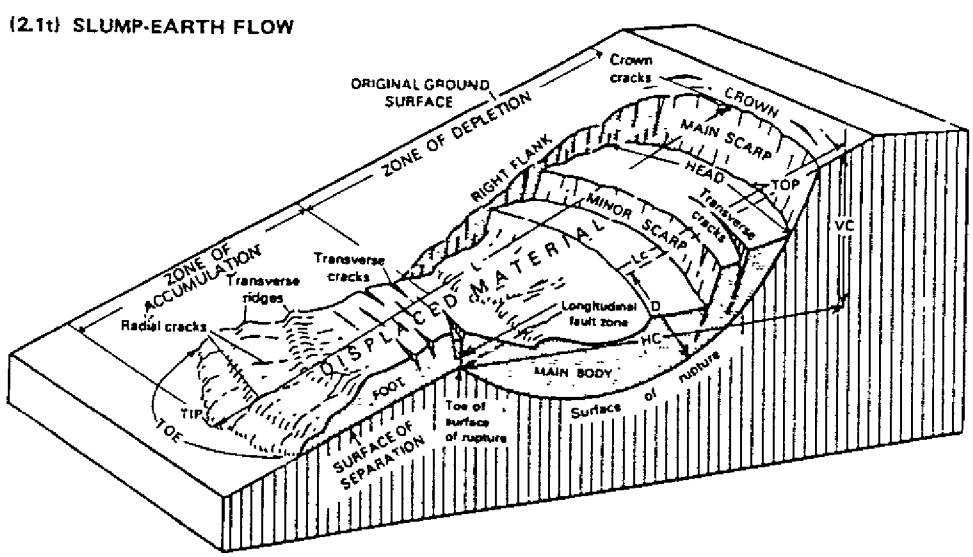


Fig 1. Caracteristics of a Landslide

Where:

Main Scarp	A steep surface on the undisturbed ground around periphery of the slide, caused by the movement of slide material away from undisturbed ground. The projection of the scarp surface under the displaced material becomes the surface of rupture.
Minor Scarp	A steep surface on the displaced material produced by differential movements within the sliding mass.
Head	The upper parts of the slide material around the contact between the displaced material and the main scarp.
Top	The highest point of contact between displaced material and the main scarp.
Toe of Surface of Rupture	The intersection (Sometimes buried) between the lower part of the surface of rupture and the original ground surface.
Toe	The margin of displaced material most distant from the main scarp.
Tip	The point on the toe most distant from the top of the slide.
Foot	The portion of the displaced material that lies downslope from the top of the surface of rupture.
Main Body	That part of the displaced material that overlies the surface of rupture between the main scarp and toe of the surface of rupture.

Flank	The side of the landslide.
Crown	The material that is still in place, practically undisplaced and adjacent to the highest part of the main scarp.
Original Ground Surface	The slope that existed before the movement which is been considered took place. If this is the surface of an older landslide, that fact should be stated.
Left and Right	Compass directions are preferable in describing slide, but if right and left are used they refer to the slide as viewed from the crown.
Surface of Separation	The surface separating displaced material from stable material but not known to have been a surface on which failure occurred.
Displaced Material	The material that has moved away from its original position on the slope. It may be in a deformed or undeformed state.
Zone of Depletion	The area within which the displaced material lies below the original ground surface.
Zone of Accumulation	The area within which the displaced material lies above the original ground surface.

2. Occurrence Condition Of Slope Failure

A natural slope has complicated topography, geology and soil qualities. It is often difficult to study its stability on the basis of calculations. However, it is generally said that the collapse of a slope is caused by topographical and geological factor, soil qualities which are primary causes and heavy rainfall and earthquake which are exciting causes.

Primary causes, Fig. 2 shows several types slope failures related to topography, geology and soil qualities. When investigating the slope failure, it is necesary to watch ground conditions and also surface conditions such as vegetation as seen in aerial photograph. Exciting causes, Fig. 3 shows the relation between continous rainfalls ans slope failures and also Fig. 4 shows the relation between intensity of rainfall and slope failures. In addition, care must be observed when strong earthquakes and earthquakes associated with rainfalls occur.

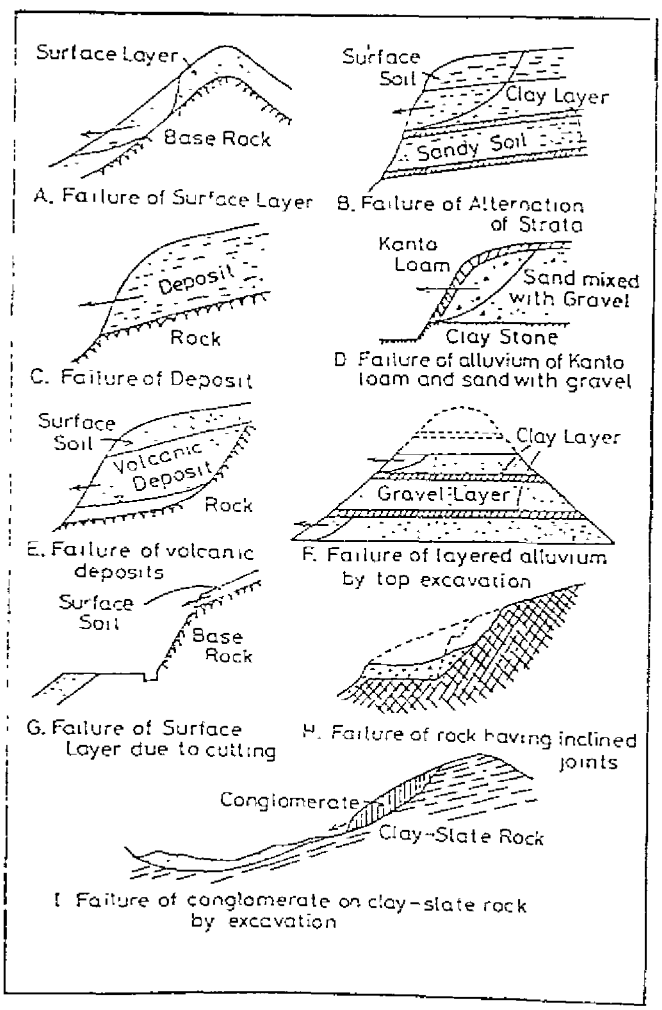


Fig 2 Types of Slope Failure

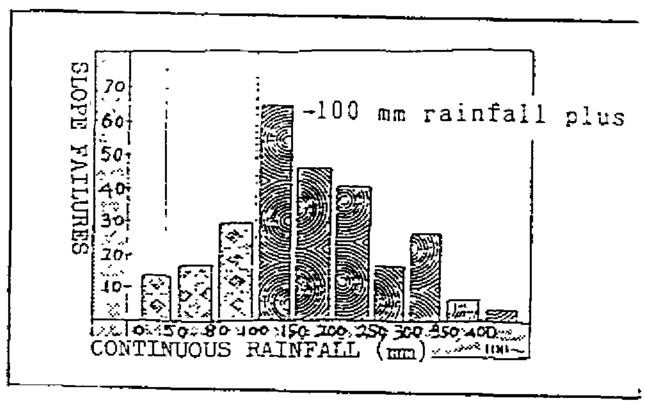


Fig. 3 The relation between continuous rainfalls and slope failures

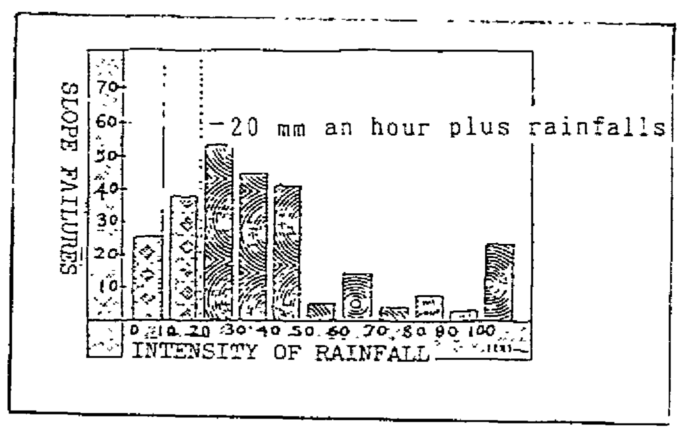


Fig. 4 The relation between intensity of rainfall and slope failure

3. Case Study: Manyumarca Landslide

This report is a summary about the landslide of Mayunmarca. The landslide of Mayunmarca occurred on April 25, 1974 in Huancavelica Department, devastating in 3 minutes Mayunmarca town with 140 km/h of velocity burying Ccochacay and Huaccoto haciendas. This landslide killed more than 460 people. The Fig. 5 shows the landslide situation, at the center zone of Peru, in Huancavelica Department.

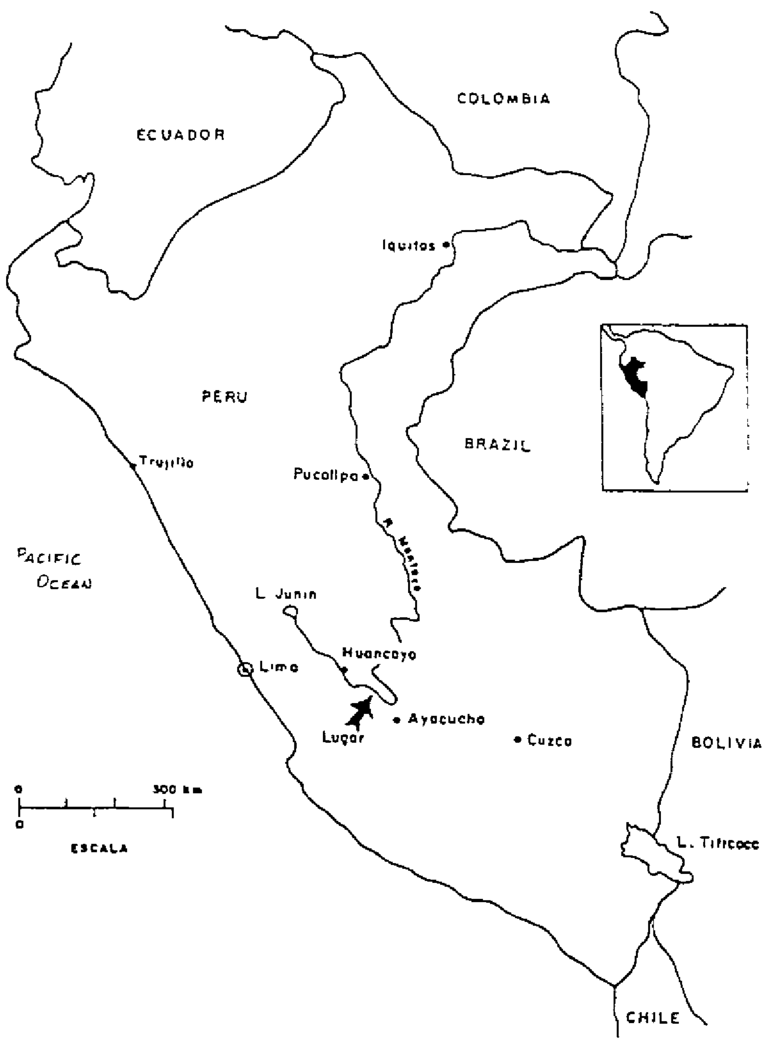


Fig. 5 - Map of location of landslide of Mayunmarca.

When Mantaro river damming occurred farming lands and roads were destroyed up to 30 km up streams from dike. The dike had 3800m length, 2550m width and 170m height. After undamming of 670 million m^3 of water were destroyed 76 km of roads, Perseverancia hacienda, part of Mayoc town and many bridges.

The factors which produced this phenomena were environment condition, geology, topography, rain fall and faults. Near to landslide, the plane area is near to 4000 to 4500 m.a.s.l, while valley floor in at 2500 m.a.s.l.

The Landslide

The landslide occurred on April 25, 1974 at 9:00 p.m. The Fig. 6 shows topography characteristics before landslide and the Fig. 7 shows plant view of landslide zone. Mayunmarca town was buried and Huaccoto and Ccochacay haciendas too. Vibration caused by landslide movement were transmitted as seismic wave and were recorded by many seismic stations, registering 3 minutes of movement duration. From there was possible to calculate the velocity which was approximately 140 km/h covering 7 to 8 km. The debris flow dammed the river completely, which was dried down stream without filtration, up to the undamming at June 6, after 42 days occurred the slide.

Causes of the Landslide

1.- The landslide could be caused due to high saturation as result of hard infiltrations from rainfall water, Minascocha and Yanacocha lakes and from Pumaranra river.
2.- The hard erosion on weak material, producing unstable slopes.

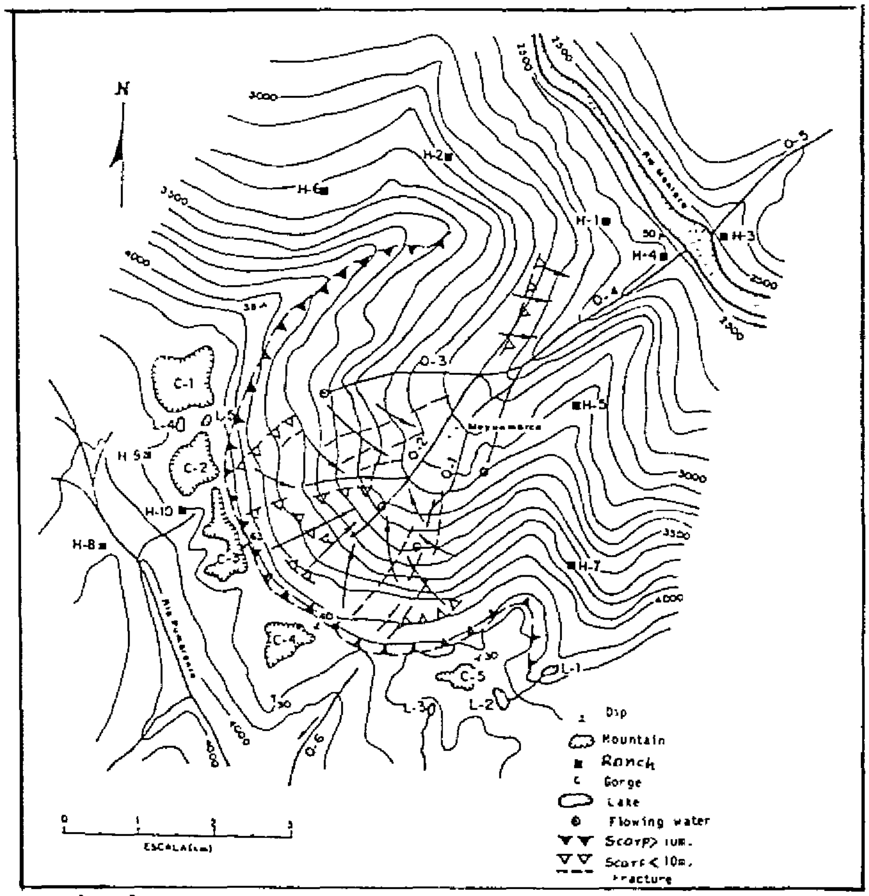


Fig. 6 - Topography caracteristics before landslide of Mayunmarca.

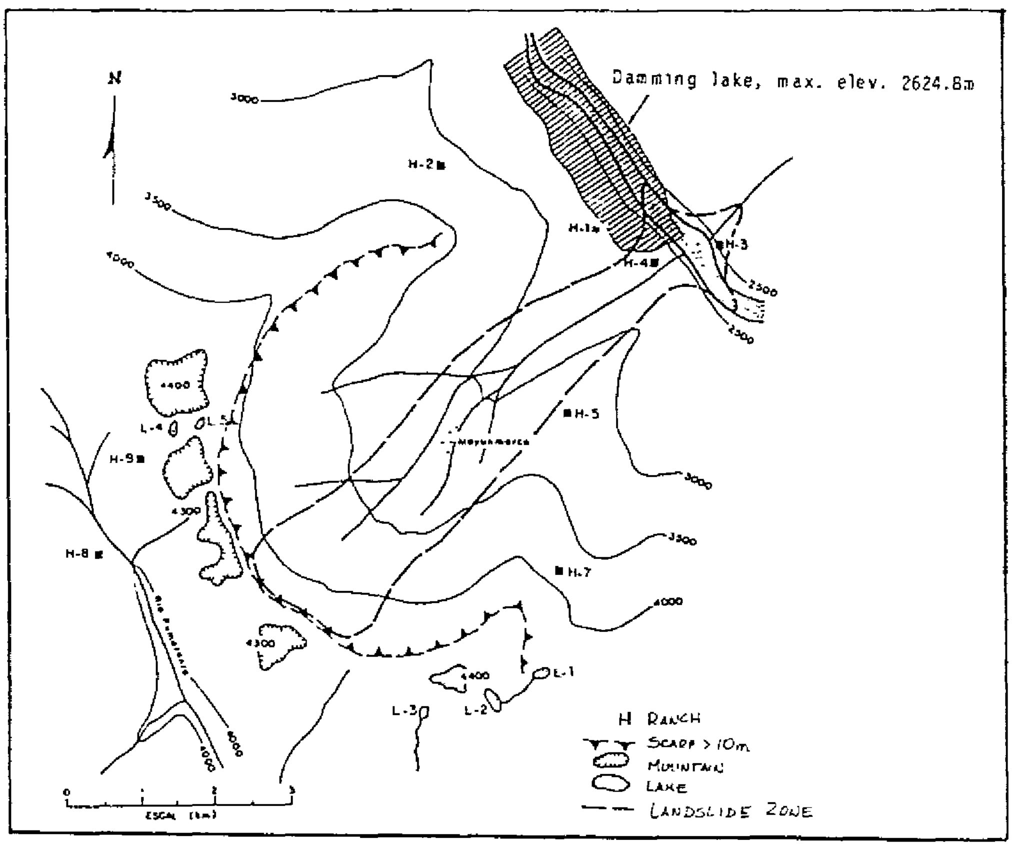


Fig. 7 - Map of Ccochacay gorge showing landslide area limits

3.- The hard rainfall at the region, occurred in October and March, making the material loses its strength.

4.- The slope of material is parallel to the main slope to Mantaro river direction.

5.- The material slope and cuaternary material with slope from 45 to 60 degrees.

6.- The water level.

The Fig. 8 shows the map of landslide area and the Fig. 9 shows the cross section of landslide area before the landslide.

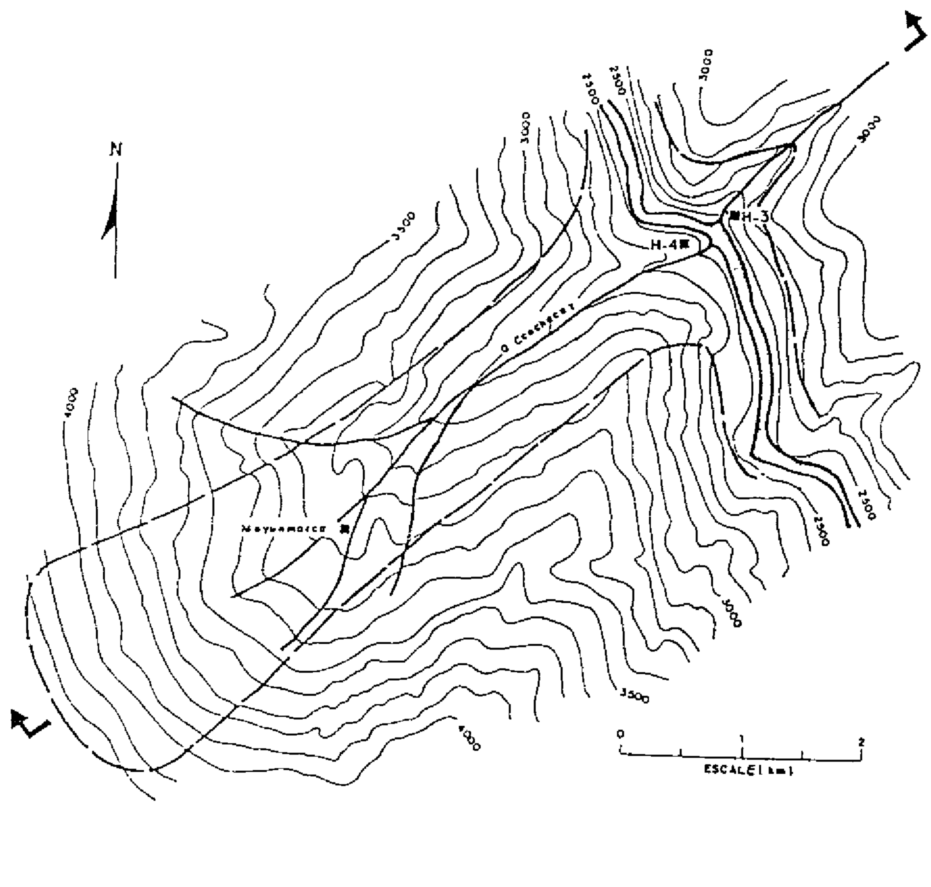


Fig. 8 Map of Landslide Area

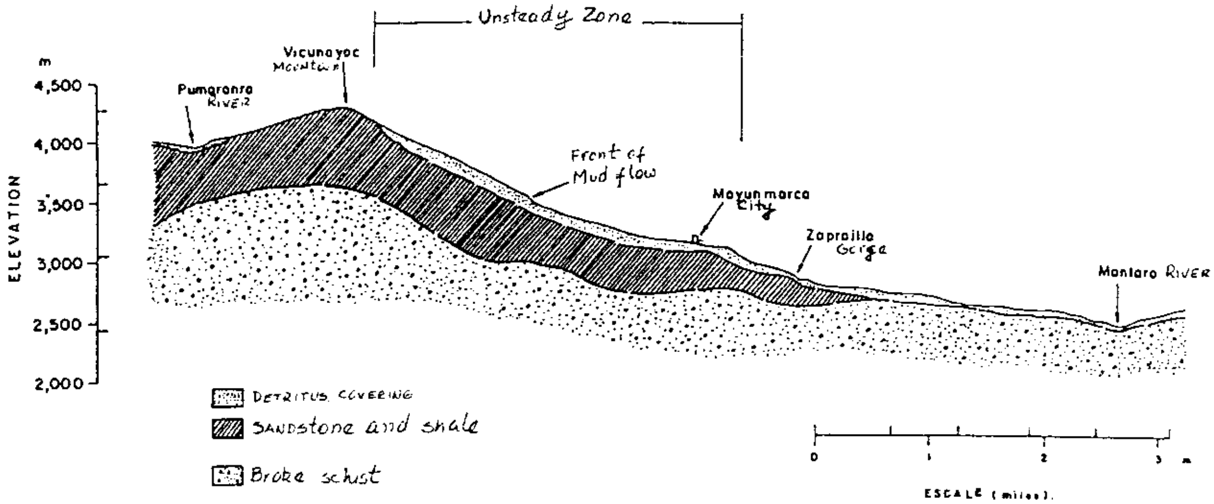


Fig. 9 Cross Section of Landslide Area Before the Landslide

Data About the Landslide

Total volume of material sliced	$1.6x10^9$ m^3
Volume which dammed the river	$1.3x10^9$ m^3
Remaining material on the valley	$0.3x10^9$ m^3
Scarp length	7.5 km
Scarp height	1.9 km
Slide time	3 min
Slide velocity	140 km/hr

Data about the Dam

Debris height which blocked the river	170 m
Debris length which blocked the river	3.8 km
Debris comb width	1.0 km

Casualties and Damage

Dead people	400 - 600
Evacuated people	2,500

Destroyed roads	3.8 km
destroyed roads due to flood	30 km

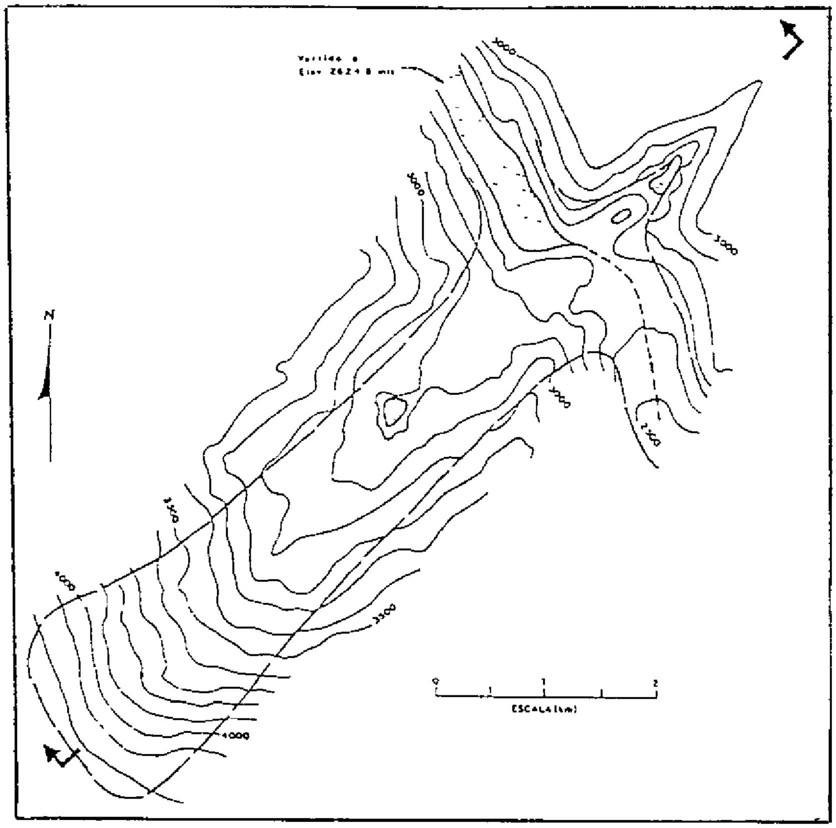
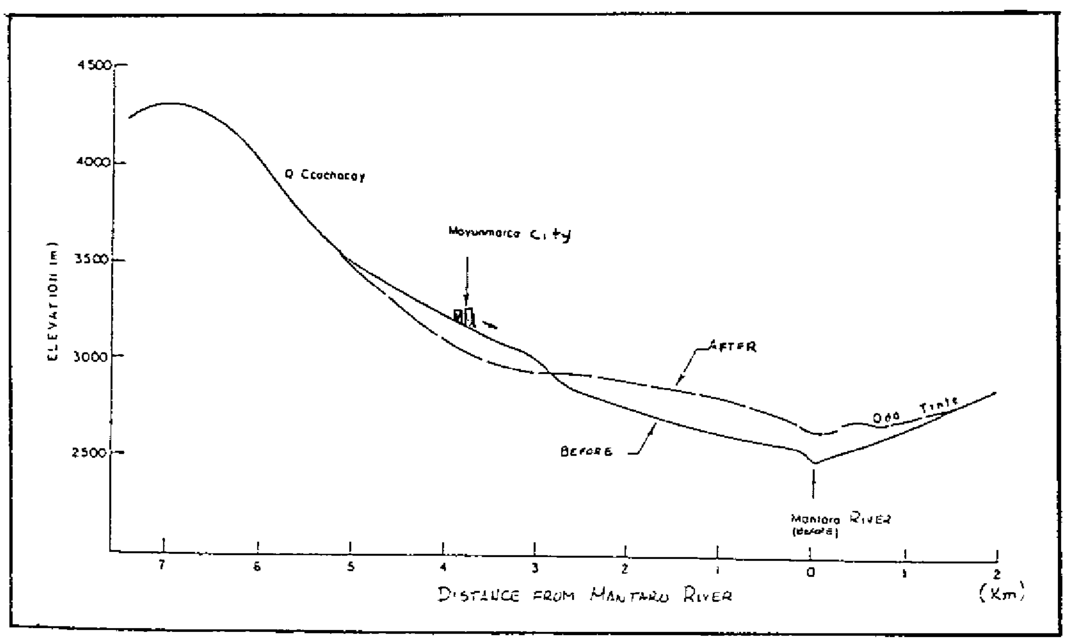


Fig. 10 Map of Landslide Area after of Landslide.

Fig. 11 Cross section before and after Landslide.



4. Conclusion

Though landslide are a purely natural phenomena, they have been related to human activities especially recent years. We can delimit areas where landslide could occur in the future, since we know that this phenomena occur in zones where the climatic condition, steep slope, soil condition and human activities are favorable.

Although the man-made material used for control works have limited life time we must search new technology for prevent o mitigate this phenomena. Beside, is advisable to study the occurrence magnitude and probability of landslide and with this information to forecast the disaster.

Now we can see the development of new technology as satellite data, remote sensing and robotics engineering to help us to forecast the phenomena. For example here in Japan we saw a good works on slope control as show the next photo.

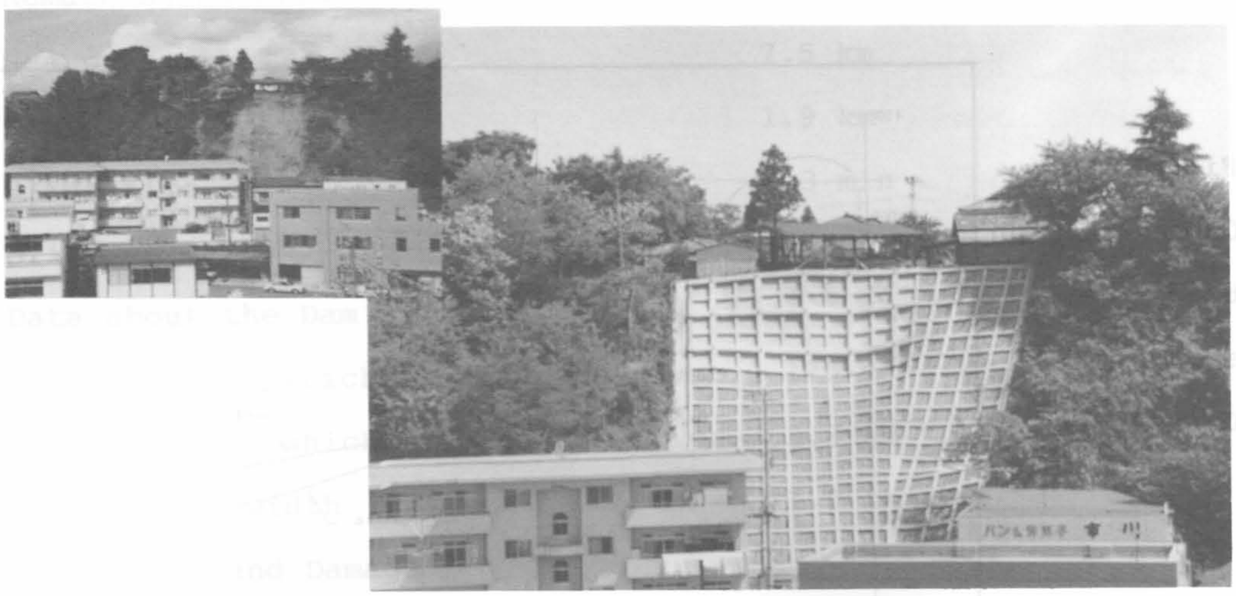


Photo 1. Slope Control Works in Japan

5. Acknowledgment

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Thank you very much JAPAN !

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