New Method for Landslide Stabilization

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Abstract

Landslide of North Alborz land slope is one of the geological phenomena, that its occurrence is affected by various natural and unnatural factors.

Statistical studies of more than 520 Landslides occurred in Mazandaran Province states that one of the most basic and effective factors in landslide is the existence of water in the land where layers are susceptible to slide.

Removing water from land slope can increase shear resistance of soil and to some extent stabilize it and fix the landslide.

Therefore, identifying the exact path of underground water flow of risky upstream areas of slope land, and stopping water from entering to the landslide place, can present a useful solution to stabilizing landslides and preventing the continuous mass movement process. wherefore the underground water flow usually enter the sliding mass through the fractures and faults in the upstream landslide place, and reduce soil shear strength and thus create a surface and sliding mass down the slope lands .

In this new method of landslide stabilization, by using the Electromagnetic Method (also Geoelectric Method can be used), underground water flow path in upstream areas of the sliding mass can be identified, and the exact depth of lush layers can be specified and then drilling the wells and water pumping automatically can be done, before the mass slid.

By stopping water from entering the slope lands susceptible to slide and sliding mass, the depth of water table in sliding mass place loss and therefore the soil shear resistance increase. Finally the landslide can be stabilized to some extent.

It is necessary to dig some observation well in the slope lands susceptible to slide in order to have the statistic of water table depth level range.

In this study for three villages in Mazandaran Province (Estakhr-posht in Neka – Chouret in Sari – Shahroud-kola in Qaemshahr) that have suffered from landslide, the stabilization operations with this new method was implemented that have had good results.

For example, in Shahroud-kola a 30 meter depth well was dug in upstream sliding mass and in the line of Underground water flow. After pumping the water automatically for some day, the amount of 5350 liters per day were drained, that causes loss of water table in sliding mass.

Key words: *1 – Electromagnetic2 – Landslide 3 – Arashk4 – Hydrogeology 5– Stabilization 6 – Control Well*

Introduction

Landslide is one of the geological phenomena in the North Alborz slope lands. According to the definition, Landslide is movement of a part of slope materials along the specific surface of rupture.

Although various factors such as underground water, slope, soil type, vegetation, tectonic, thickness of soil, the direction of slope layers, Azimuth, rainfall amount and human activities on land are involved in the slope landslide incidence, but The role of water in a Landslide incidence is considerable as a major factor.

Usually the most important direct reason that unbalances the shear stress and shear strength of soil is underground water.

By increasing the water content in the mass, soil shear resistance will be decrease. And by increasing the moisture of soil's weight per unit mass, the share stress will increase [FAO].

If the underground water could be controlled in a suitable way in susceptible zone of landslide or slipped slide area, to some extent, proportional stabilization of the zone will be achieved.

Subject definition

Landslide occurrence in different areas such as villages, roads, agricultural lands, forest regions ... especially in residential areas will cause lots of damage, harm and loss.

From field surveying of landslide which occurred continuously in different parts of Mazandaran province during fifteen years (I have visited more than 200 cases and studied them), and also from reviewing statistical information about more than 520 registered Landslide of different parts of Mazandaran province in the form Landslide Database of Iran (landslides review group(2000), Ministry of Agriculture), all indicate that the most fundamental factor is water, and for some of them the damages and the costs of executive consolidation has been remarkable.

As a practical example, stabilizing one zone in Sari - Kyasr road in Mazandaran province by piling method that costs more than 10 million dollar, can be mentioned.

By the way, if the exorbitant costs of landslide stabilization could be reduced by using one of the new appropriate methods alone or as a complementary solution, it will lead to saving national resources and some good results will be obtained.

Research objectives

1) Reducing executive costs of stabilizing landslide to down to approximately 0.1 percent of usual methods.
2) Prevention of landslides in susceptible zone.
3) Prevention of morphological changes and land damages, for early stage moving landslides.
4) Optimal use of underground water extraction for agricultural purposes and in some cases even for drinking.

Research method

Methodology is based on electromagnetic and the most important success factor of this method is Identify the exact underground water resource of upstream areas.

Common methods such as Geo-Electric, seismic and other methods are very expensive and time consuming, but in this method an electromagnetic devices (Arashk) – invented by Seyed Ali Hamidi – is used.

The device detection method is based on absorption of invisible infrared waves. Underground water flow usually enter the slip mass through fractures and faults that are in the upstream of slip location and reduce soil shear strength and thus create slip surface and cause slip mass movement down to the slope .

In this method, the underground water flow path in the upstream of slip mass will be identified, and then the number and the exact depth of lush layers are determined. The next step is to determine the exact drilling pumping wells point and drilling depth.

Drilling specified wells and continuously pumping underground water, result drop in water table in slip mass and thus the shear strength of soil of the slope will increase and at the end landslide will be stabilized.

It should be mentioned that in order to record the statistics of water table Changes it is required to drill a control well in slip mass and in slope zone that are susceptible to slip.

Research results

This new method was applied in three villages in Mazandaran Province (Estakhr-posht in Neka city, Churetin Sari city, Shahrud-kola in Qaemshahr city) that have suffered from slippage, and then the executive operation of the landslide stabilizations result to success. Here are the statistics of Shahrud-kola as an example:

Landslide of Shahrud-kola cause damage to five residential units, one old public bathroom, 195 m of the village entrance asphalted road and some orange gardens.

Sliding mass dimensions were 500 meters length and 195 meters width and the settlement at the cross point with road were about 1.5 m.

First, by using Arashk the transversal profile of slip mass along the road was considered to define the underground water flow.

Thus three path of underground water flow that were feeding sliding masses were identified, which their specification are as follows:

Point A: The coordinates: (4031462 - 666263) UTM

Underground water flow path direction (N 80 E) and total length of the water table is 750 meters which 300 meters is located in upstream and 450 meters is located in downstream.

Four hydrous layers were identified in this direction: the first layer with a depth of 10 meters, the second layer with a depth of 16.5 meters, the third layer with a depth of 22.5 meters and the forth layer with a depth of 37.5 meters.

* We ignore to mention the number and depth of soil layers for all of points here.

The width of underground water flow path has been recorded as 6 m using Arashk.

Point B: The coordinates: (4031540 - 666240) UTM

Underground water flow path direction (N 85 E) and total length of the water table is 780 meters which 450 meters is located in upstream and 330 meters is located in downstream.

The number and depth of hydrous layers are recorded as Point A.

The width of underground water flow path has been recorded as 7 m using Arashk.
Point C: The coordinates: (4031567 - 666234) UTM
Underground water flow path direction (N 75 E) and total length of the water table is 850 meters which 400 meters is located in upstream and 450 meters is located in downstream.
Three hydrous layers were identified in this direction: the first layer with a depth of 12 meters, the second layer with a depth of 18 meters, the third layer with a depth of 30 meters.
The width of underground water flow path has been recorded as 5.5 m using Arashk.
The elevation of all points is 100 m.
Then, in order to identify the main current path of underground water which supplies the sliding mass, we survey upstream slip mass precisely using Arashk that lead to identification of mainstream underground water flow in direction (N 10 W) and a height of 160 meters above sea level.
The specifications are as follows:
Point K: The coordinates: (4031432 - 666419) UTM
Total length of the water table is 2100 meters which 1400 meters is located in upstream and 700 meters is located in downstream.
Three hydrous layers were identified in this direction: the first layer with a depth of 12.1 meters, the second layer with a depth of 19.1 meters, the third layer with a depth of 25.1 meters.
The width of underground water flow path has been recorded as 8.5 m using Arashk.
After drawing all points and directions of underground water flow on the map, it was specified that all three directions of A, B and C cross point K direction.
It means that the mainstream underground water flow of point K direction were feeding three directions of A, B and C.
So in order to stop underground water flow of A, B and C we suggested to drill a 30 meters deep well at point K.
The job was done and pumping results is given in the table (1).
The recorded statistical data indicate that:
1) 5350 liters of water per 24 hours has been pumping.
2) Recording water table level of control well on sliding mass indicates a loss of 20 cm after 24 hours of pumping.
3) After 7 days of pumping we could stop entering of about 37450 liters of water to sliding mass. This lead to a loss of 140 cm in water table level in sliding mass.

Conclusion

The result of this study will answer to many questions such as:
Is it impossible to use new method like ours to stabilize some landslides with a lower cost?
Whether it is better to use drainage method or prevent entering of water to a sliding mass, yet many of experts are discussing about it.
And there is another question: Can we increase the depth of drainage down to slip surface?
Certainly it is impossible for landslides with slip surface depth of grater than 3 or 4 meters; but in our new method the depth of the slip surface isn't important.
The other problem in drainage method for stabilizing a sliding mass is the type and density of drainage net, because the tissues of clay have poorly drained feature.

The other question is if it is sufficient to construct only a retaining wall at the toe of slip mass and ignore the path of underground water?

As a practical example, there was a sliding mass in Mohammad Abaad – Pole Sefid road (Savadkoh-Mazandaran Province).

To stabilize the landslide, they construct a retaining wall for several times and each time it was destroyed, and finally they have spend a lot of money to remove most of the sliding mass and they have spend much more money to construct a costly retaining wall and it was temporarily stabilized.

Isn't this research a better solution? Or at least, isn't it a appropriate complementary solution? Loss of water table in slip mass is directly related to increasing soil shear strength and increasing soil shear strength is directly related to stability of slip mass and so in this method, only by omitting a single factor (water) and without any other executive operations, we will be able to prevent the sliding mass movement.

Suggestions

According to the information and discussions presented in this article, in order to reduce the cost of stabilizing landslides and also to prevent repetition costs, the followings are recommended:

1) Identifying the on-ground and underground water supplies and upstream and downstream springs of slip mass accurately.
2) Controlling on-ground and underground water and leading them properly to an area out of landslide zone.
3) A professional experienced geologist in the filed of underground water resources and the ways of Landslide Stabilization should manage the planning type and style of stabilization.
4) Electromagnetic method can be used to know underground water resources better, because the precision is higher and the error is less than the other methods.

Table (1): Pumping results data

parameter / Date	The amount of water dischared (L)	water table depth of control well before pumping (m)	water table depth of control well after pumping (m)
22-04-2009	-	2.30	-
23-04-2009	5350	2.30	2.50
24-04-2009	5350	2.50	2.70
25-04-2009	5350	2.70	2.90
26-04-2009	5350	2.90	3.10
27-04-2009	5350	3.10	3.30
28-04-2009	5350	3.30	3.50
29-04-2009	5350	3.50	3.70

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Sources

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