

Landslide Mitigation and its Risk Controlling

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Abstract: In this paper, different types of landslides controlling methods and the importance of their controlling in a multipurpose project is investigated. Site mobilization duty includes managing the facilities placement to keep risks down using the best arrangement of facilities. This duty can be assisted by computer programs. A landslide is a geological phenomenon which includes a wide range of ground movement. Landslide is one the most important problems that can harm site mobilization. That's why it should be identified in a large project such as dam construction. Thus, in this paper site mobilization and its landslide risk controlling is presented. Also, different landslide controlling methods are presented.

Key words: Multipurpose project • Landslide controlling • Risk controlling • Site mobilization

INTRODUCTION

Generally, risk controlling is the process of measuring, or assessing risk and then developing strategies to manage the risk. It is followed by coordinated and economical application of resources to minimize, monitor and control the probability and/or impact of unfortunate events [1] or to maximize the realization of opportunities. Risks can come from uncertainty in project failures, accidents, natural causes and disasters [2, 3]. Once risks have been identified and assessed, all techniques to manage the risk fall into one or more of four major categories: Avoidance, Reduction, Sharing and Retention [4].

Megaprojects are extremely large scale investment projects. Megaprojects include bridges, tunnels, airports, power plants, dams, etc. Megaprojects have been shown to be particularly risky in terms of finance, safety and social and environmental impacts. Risk management is therefore particularly pertinent for megaprojects and special methods and special education have been developed for such risk management using different methods such as information technology [5-8].

A landslide is a geological phenomenon which includes a wide range of ground movement, such as rock falls, deep failure of slopes and shallow debris flows, which can occur in offshore, coastal and onshore environments. Although the action of gravity is the primary driving force for a landslide to occur, there are other contributing factors affecting the original slope stability [9-11].

Landslide is one the most important problems that can harm site mobilization. That's why it should be identified in a large project such as dam construction. Thus, in this paper site mobilization and its landslide risk controlling is presented. Also, different landslide controlling methods are presented.

Site Mobilization Management: Site mobilization management is an interdisciplinary field primarily devoted to optimize facility placement. Risk reducing can be achieved by optimizing facilities placements such as batching plants and crushing plants, having harmful effects on workers noise health. The duty includes managing the facilities placement to keep risks down using the best arrangement of facilities. This duty can be assisted by computer programs.

Risk Management: Risk management is very often applied in engineering, but all sciences have risk management. In ideal risk management, a prioritization process is followed whereby the risks with the greatest loss and the greatest probability of occurring are handled first and risks with lower probability of occurrence and lower loss are handled later [12].

In practice the process can be very difficult and balancing between risks with a high probability of occurrence but lower loss vs. a risk with high loss but lower probability of occurrence can often be mishandled. There are different methods to control a project risk as follows [13-15]:

Risk Avoidance: Includes not performing an activity that could carry risk. An example would be not placing a facility in a risky zone. Avoidance may seem the answer to all risks, but sometimes avoiding risks also means losing out on the potential gain that accepting (retaining) the risk may have allowed.

Risk Reduction: Involves methods that reduce the severity of the loss. This method may cause a greater loss by choosing a wrong reduction method and therefore may not be suitable.

Risk Retention: Involves accepting the loss when it occurs. True self insurance falls in this category. Risk retention is a viable strategy for small risks where the cost of insuring against the risk would be greater over time than the total losses sustained. All risks that are not avoided or transferred are retained by default. This includes risks that are so large or catastrophic that they either cannot be insured against or the premiums would be infeasible. Also any amounts of potential loss (risk) over the amount insured is retained risk. This may also be acceptable if the chance of a very large loss is small or if the cost to insure for greater coverage amounts is so great it would hinder the goals of the organization too much.

Risk Transfer: Means causing another party to accept the risk, typically by contract. Insurance is one type of risk transfer. Other times it may involve contract language that transfers a risk to another party without the payment of an insurance premium. Liability among construction or other contractors is very often transferred this way.

Some ways of managing risk fall into multiple categories. Risk retention pools are technically retaining the risk for the group, but spreading it over the whole group involves transfer among individual members of the group.

Landslide: Humans have historically used soil as a material for flood control, irrigation purposes, burial sites, building foundations and as construction material for buildings. First activities were linked to irrigation and flood control, as demonstrated by traces of dykes, dams and canals [16].

Landslides occur when the stability of a slope changes from a stable to an unstable condition. A change in the stability of a slope can be caused by a number of factors, acting together or alone [17]. Natural causes of landslides include, groundwater pressure acting

to destabilize the slope, erosion of the toe of a slope by rivers or ocean waves, weakening of a slope through saturation by snowmelt, earthquakes adding loads to barely stable slope, earthquake caused liquefaction destabilizing slopes, volcanic eruptions and loss or absence of vertical vegetative structure, soil nutrients and soil structure [18].

Landslide Mitigation Types: Landslide controlling is to execute specialty foundation projects, soil improvement all geotechnical applications in the construction area. Target project list includes subway stations, railroads, bridges, tunnels, expressways, dams, etc. as well as industrial facilities, power plants, petrochemical complexes, refineries and others. Landslide controlling has many different ways. However, most important methods are listed below:

Concrete Diaphragm Walls: There are a great variety of concrete diaphragm walls, these can be armed (structural) or not. Within the armed diaphragm walls (structural), we have the retaining walls excavated under concrete mud, used mainly to contain the soil once begun the excavation, being able to support great axial loads. As far as the nonstructural walls, these can be made for the containment of water flows and to protect highly contaminated zones.

The concrete diaphragm walls are excavated from the surface by means of an excavation clamshell, in thickness that goes from 0.50 m to 1.50 m. As far as the depths, they can reach 50 m.

In order to guarantee the stability of the structural walls, anchors are installed, in anticipated soldiers as the soil excavation process is made. The anchors can be provisional or definitive, depending on the later use of the wall (Figure 1).

Shooting Concrete Walls: These are retaining structures, which can be used for slope protection, or as support for the excavation of structures under earth (basements, underground stations such as subways, etc). Depending on the use, the screens can or cannot contain anchors and these can be provisional or definitive according to the case. The construction of screens, takes place as the soil excavation progresses, outlining and combing it manually. After that, are reinforced by means of meshwork or steel skeleton, following with the shooting concrete over the surface until the required thickness is reached, this technique mold to the surface allowing variable shapes (Figure 2).



Fig. 1: Concrete Diaphragm Walls



Fig. 2: Shooting concrete walls



Fig. 3: Watertight Slurry Walls



Fig. 4: Deep Foundations

Watertight Slurry Walls: These walls are built using the same technique as for Concrete Diaphragm Walls, but unlike them, these walls are constructed without armors and with a "plastic" deformable concrete, which results from the mixture of cement, well graded aggregates and concrete.

Walls thickness goes from 0.50 m, being able to reach 1.20 m and with a depth that can reach 50 m. These walls are particularly useful in dam constructions, where the water tightness plays a special role (Figure 3).

Deep Foundations: These elements are able to support great precise loads. They can be excavated in the dry or with concrete mud. As far as the diameter, they can be made from 0.55 m to 2.00 m. The excavation is made by means of rotation equipment, with buckets or spirals and great depths can be reached (Figure 4).

Barrettes: Barrettes are foundation elements, where the basic characteristics rely in the form and the way of the excavation. They are recommended in presence of elevated loads, since they have much greater resistance to the horizontal efforts, than circular piles of the same section. The excavation is made with clamshell and dimensions can be:

Thickness: 0.50, 0.60, 0.80, 1.00, 1.20, 1.50•
and Length: 1.80 and 2.20. The possibility to voluntarily increase its surface, grants them an insurmountable characteristic. Compositions that can be obtained are, simple barrettes, in cross (+) and H (Figure 5).



Fig. 5: Barrettes



Fig. 6: Micro piles

Micro Piles: They are foundation elements, whose technique is derived from the conception of the soil anchors. They are elements of small section (100 to 200 mm) and of low to average capacity. The mechanical characteristics obtained from micro piles, allow them to support indifferently, as much compression as traction (Figure 6).

Micro piles supersede, technically and economically, from any other solutions for the foundation of building and bridges, under piling foundations, metallic towers foundations, containment of excavations (screens of micro piles) and reinforcement of soil, as well as in all the cases of:

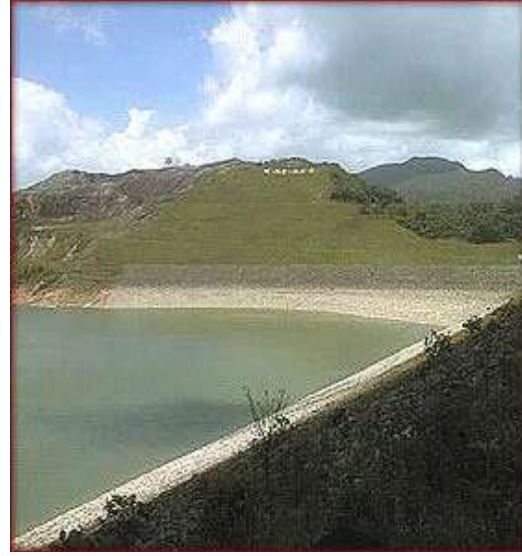


Fig. 7: Grouting for Consolidation and Waterproofing

Low and scattered loads. Natural ground is heterogeneous or contains obstacles such as boulders or early foundations, etc. Conditions are difficult for setting up and moving equipment (tight site or neighborhood). Compression and traction loads alternate.

Grouting for Consolidation and Waterproofing: This method of soil improvement, consists of injecting within a more or less permeable mean, a material that can be pumped (liquid, suspension, emulsion, mortar), called grout.

The "mean" to inject, can be the natural or artificial soil (masonry, concrete, etc.) and its primary target is to improve the properties of the material (to improve its mechanical resistance, or to reduce its permeability) (Figure 7).

Ground Improvement: Ground improvement is another method, in which diverse techniques are used to solve foundations problems in soils with terrible mechanical characteristics and in some cases, they can be used to avoid in particular, the possible risk of sand liquefaction by the action of an earthquake (Figure 8).

Soil Anchors: Soil Anchors are elements that transmit the tensile forces applied to them to a competent soil. The anchors consist of three parts or elements:

The head that transmits the force of the anchor to the structure via the bearing plate. The free length of tendon, that goes from the head to the near end of the anchorage. The bulb of anchor, which is the length of



Fig. 8: Ground Improvement



Fig. 10: Perforated Drains



Fig. 9: Soil Anchors

the tendon subject to the force of tensile transmitted to the competent soil, by means of the injection grout. The loads of tension of the braces vary from 15 to 120 tons, with perforations from Ø 2" to Ø 5". The anchors can be active or passive, according to the time when they are tightened (before or after the structure is made) (Figure 9).

Perforated Drains: Drains are often used when works (land fill, side slopes, etc.), are made in quite impermeable soils (clays, the slime, argillaceous sands, vegetal earth, etc.), since these can become unstable, due to the underground water presence.

The use of horizontal drains, allows to substantially improving the stability of the soil, capturing and evacuating the water. These drains are made within the soil, with light rotation equipment and equipped with plastic pipes, reaching lengths of 100 m.

Typical use of this technique has been successfully made in dam works, as well as in side slopes works (Figure 10).

CONCLUSION

The landslide frequently poses challenges in areas of engineering. Landslide hazard analysis and mapping can provide useful information for catastrophic loss reduction and assist in the development of guidelines for sustainable site mobilization planning. The analysis is used to identify the factors that are related to landslides, estimate the relative contribution of factors causing slope failures, establish a relation between the factors and landslides and to predict the landslide hazard in the site mobilization future based on such a relationship.

Risk controlling is the process of measuring, or assessing risk and then developing strategies to manage the risk. It is followed by coordinated and economical application of resources to minimize, monitor and control the probability and/or impact of unfortunate events. Thus, landslide risk controlling should be done in projects.

Landslide controlling is to execute specialty foundation projects, soil improvement all geotechnical applications in the construction area. Target project list includes subway stations, railroads, bridges, tunnels,

expressways, dams, etc. as well as industrial facilities, power plants, petrochemical complexes, refineries and others. Landslide controlling has many different ways. In this paper, these types of controlling are investigated and presented.

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