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Austrian Slope Stabilities Experience for Afghanistan

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Abstract

This paper discusses how to use the Austrian slope stabilities experience for Afghanistan. In Austria the geotechnical engineers have used a lot of methods with very successful results in this area. We know that landslides are very dangerous and a big disaster for a country and it is people. As we further know, Afghanistan is a mountainous country and about 70% of this country is covered by mountains, therefore when we will construct some engineering structures in this area, faced with a lot of slops and hillsides, we need to study about the stability of these slopes.

The Austrian scientists have great experiences regarding the *slope stabilization with pier walls, stabilization of deep cuts in unstable slopes, ground support – reinforcement, composite structures sand slope stabilization with piles*. Regarding Afghanistan situations and conditions we can use these experiences too. Each of the above issues, especially the slope stabilities with pier wall and slope stabilization with piles, in which the resistance provided by the piles and piers is accessed via an analysis of their response to lateral ground movements. Pier walls are also used in connection with prestressed anchors. I think all this experience will be acceptable and suitable for the use in our country after the deep study. Here we focus on *stabilization of deep cuts in unstable slopes with piers wall and slope stabilization with piles*, because in Afghanistan during each road or highway design the designer will face these problems.

Introduction

In mountainous regions the soil and rock parameters frequently exhibit scatter, even within a small area, to such an extent that geotechnical design procedures seem to provide not more than limit values and serve for references only. Due to the steeply inclined slopes, there is also the uncertainty of the seepage flow.

The main force responsible for mass wasting is gravity. Gravity is the force that acts everywhere on the Earth's surface, pulling everything in a direction toward the center of the Earth. On a flat surface the force of gravity acts downward. So long as the material remains on the flat surface it will not move under the force of gravity. On a slope, the force of gravity can be

resolved into two components: a component acting perpendicular to the slope and component acting tangential to the slope.

- The perpendicular component of gravity, helps to hold the object in place on the slope. The tangential component of gravity causes a shear stress parallel to the slope that pulls the object in the down-slope direction.

- On a steeper slope, the shear stress or tangential component of gravity increases, and the perpendicular component of gravity, decreases.

- The forces resisting movement down the slope are grouped under the term *shear strength* which includes frictional resistance and cohesion among the particles that make up the object.

- When the shear stress becomes greater than the combination of forces holding the object on the slope, the object will move down-slope.

Thus, down-slope movement is favored by steeper slope angles which increase the shear stress, and anything that reduces the shear strength, such as lowering the cohesion among the particles or lowering the frictional resistance. This is often expressed as the safety factor, F_s , the ratio of shear strength to shear stress.

$F_s = \text{Shear Strength/Shear Stress}$

If the safety factor becomes less than 1.0, slope failure is expected.

Although water is not always directly involved as the transporting medium in mass-wasting processes, it does play an important role. Think about building a sand castle on the beach. If the sand is totally dry, it is impossible to build a pile of sand with a steep face like a castle wall. If the sand is somewhat wet, however, one can build a vertical wall. If the sand is too wet, then it flows like a fluid and cannot remain in position as a wall.

- Dry unconsolidated grains will form a pile with a slope angle determined by the *angle of repose*. The angle of repose is the steepest angle at which a pile of unconsolidated grains remains stable, and is controlled by the frictional contact between the grains. In general, for dry granular materials the angle of repose increases with increasing grain size, but usually lies between about 30 and 37 degree.

- Slightly wet unconsolidated materials exhibit a very high angle of repose because surface tension between the water and the solid grains tends to hold the grains in place.

- When the material becomes saturated with water, the angle of repose is reduced to very small values and the material tends to flow like a fluid. This is because the water gets between the grains and eliminates grain to grain frictional contact.

Another aspect of water that affects slope stability is fluid pressure. In some cases fluid pressure can build in such a way that water can support the weight of the overlying rock mass.

When this occurs, friction is reduced, and thus the shear strength holding the material on the slope is also reduced, resulting in slope failure.

“Calculated risks” are to be accepted in the design of roads and expressways through valleys in mountainous areas where hillsides with a slide potential extend over a distance of several kilometers.

Pier Walls and Prestressed Anchors

Pier walls may be considered as pile walls with extremely large diameters. According to the lateral slops pressure, elliptical cross- sections of the piers are generally preferable (Fig.1). A prerequisite for arbitrary cross- sectional areas is an open shaft construction, using shotcrete (1) for the lining, of thickness about 5-30cm, frequently reinforced (1-3 vertical mats or fabric depending to the pier diameter, soil or rock parameters, vertical seepage water, depth, etc.

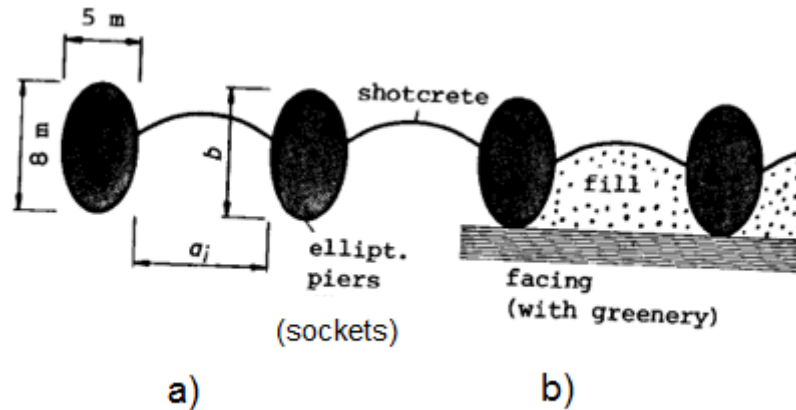


Fig.1. Schematic ground plan of a pier wall (a) non- treated type (b) structure with special facings (the concrete wall or masonry)

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- (1) **Shotcrete** and gunite are two commonly used terms for substances applied via pressure hoses. Shotcrete is mortar or (usually) concrete conveyed through a hose and pneumatically projected at high velocity onto a surface. Shotcrete undergoes placement and compaction at the same time due to the force with which it is projected from the nozzle. It can be impacted onto any type or shape of surface, including vertical or overhead areas

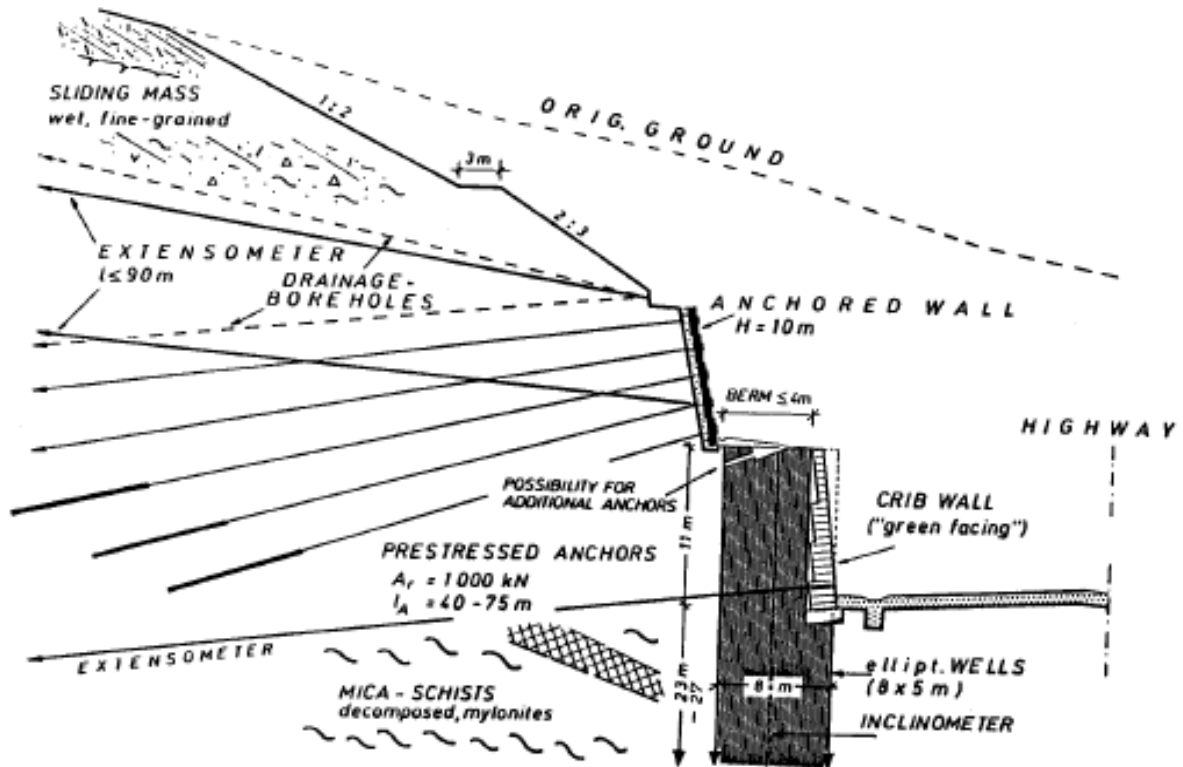


Fig.2. An anchored element wall and a pier wall for stabilizing a cut in an unstable slope, crib wall for green facing as an alternative to an untreated retaining structure.

The distance between the piers should usually not exceed the length of the main axis of the pier ellipse. Figure 2 illustrates as example an especially extreme situation: Contrary to geotechnical recommendations a highway had to be constructed in an unstable slope, requiring a 50m deep and 120m wide cut, and threatening the building uphill.

Geotechnical Investigations

Subsoil conditions and soil properties shall be intensively studied: internal friction angle, shear strength, residual shear strength and seepage flows are very important and have to be determined. From the geotechnical point of view rock and soil have to be considered likewise. For estimation of soil parameters the key parameters required for a complete analysis of the lateral response analysis of a pile are:

Young's modulus of the soil E_s

Limiting lateral pile- soil pressure p_u

Assessment of these parameters is usually made on the basis of:

1. Correlation with strength of soil
2. Correlation with in-situ test data(CPT and SPT)
3. In- situ test measurements(via the pressuremeter of the dilatometer)
4. Interpretation of lateral pile load test data

**"LOADING" EARTH PRESSURE
DISTRIBUTION e (kN/m²)**

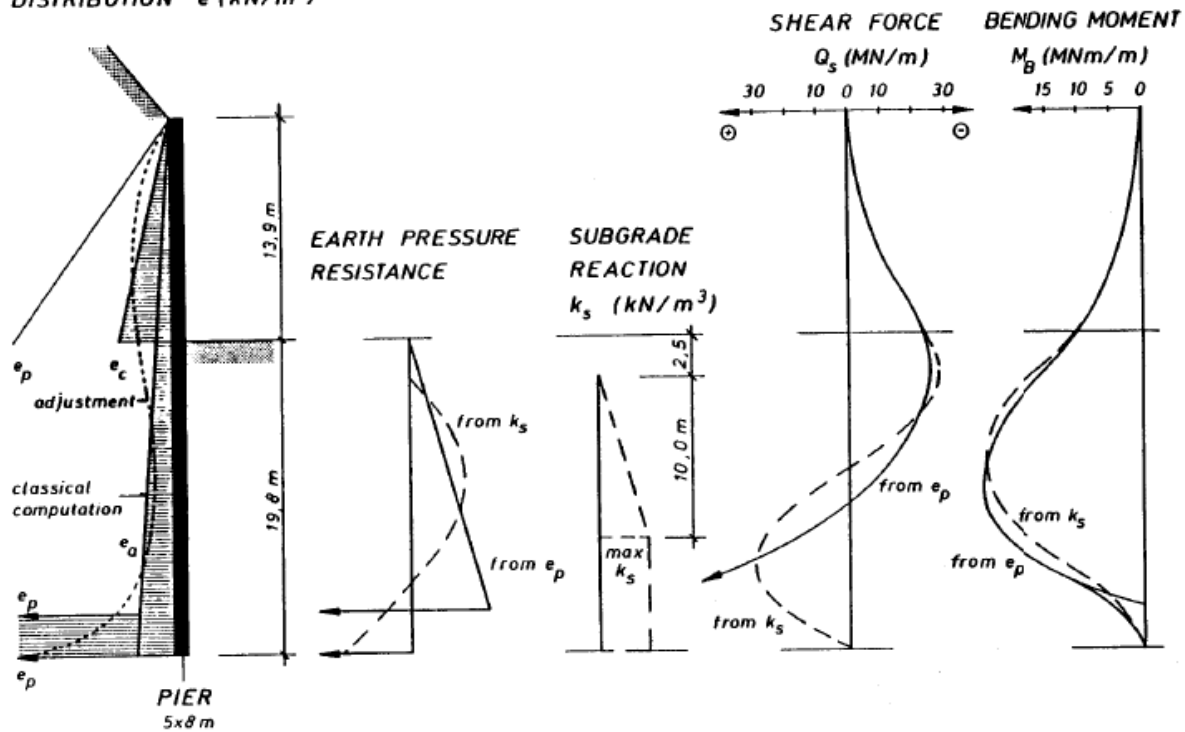


Fig.3. Predominantly horizontally loaded piers. Comparative calculations according to earth pressure theory and theory of subgrade reaction.

For calculating the shear force and bending moments in pier walls the earth pressure theory and the theory of subgrade reaction have proved. But both methods must be compared and used critically as they are based on theoretical simplifications.

Slope stability analysis must be performed additionally to evaluate the horizontal forces on retaining structures. The anchored wall which was constructed prior to the pier wall (Fig.2) consists of reinforced concrete slabs (usually 3.8 x 2.0 m) on a filter concrete; the lateral service as drainage.

Slope stabilization with piers ("sockets")

One of the options for increasing the safety of potentially unstable slopes is to use stabilizing piers ("sockets"). For the stabilization of creeping slopes we can also use piles. Gudehus and Schwarz (1985) describe the use of piles as dowels to stabilize a creeping slope in Germany. An 8m high fill embankment was constructed on a 5° slope consisting of stiff tertiary clay.

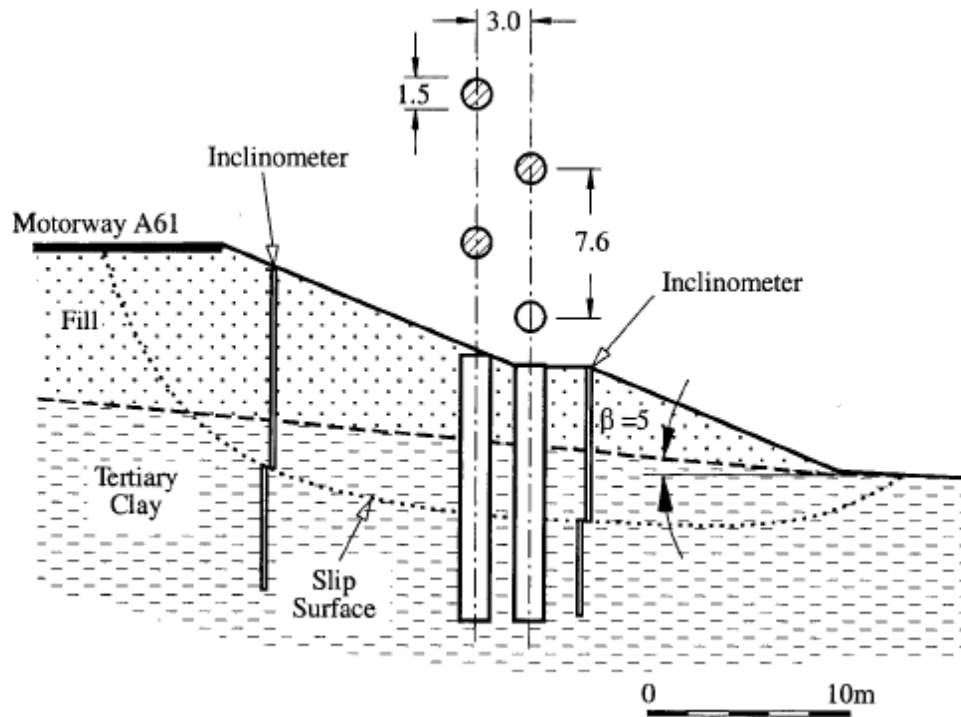


Fig.4. Slope stabilization with piers for a highway slope.

The landslide was stabilized by two rows of 1.5m diameter piles, as shown in figure (4). Prior to the piles being installed, the creep rate was 1 to 1.5mm per day; this was reduced to a rate which was not measurable after installation of the piles.

According to the principle of designs, control measurements have been performed since construction work started and during all construction stages; random monitoring will go on.

Conclusion

Pier walls, with prestressed anchors, have proved for the stabilization of unstable natural slopes and deep cuts where extremely high horizontal force must be taken over. Another advantage of such structure is the possibility of a large scale soil (or rock) investigation and permanent control during the excavation of the shafts for the piers.

Also piles provide a possible option for improving the stability of soil slopes. The interaction between the moving soil mass and the pile generates a shear force in the pile which tends to increase the factor of safety against failure.

These kinds of slope stabilization have been performed in Austria and other countries with very successful results in the engineering practice. In Afghanistan we have not yet used these kinds of stabilizations regarding to the Austrian experiences.

Suggestions

Afghanistan has similar areas like creeping slopes, high fill embankment and deep cuts for roads and highways. Regarding to the Austrian and other countries experience, we can use these kinds of stabilization but shall observe the following suggestions:

- 1- Investigation of the site (geotechnical and geological) and local construction materials is necessary
- 2- For pier wall structures stonemasonry facing can be used because stone is a good local material in Afghanistan
- 3- We can use the ordinary concrete up to the prestressed concrete technology in Afghanistan
- 4- Also, as we know, in Afghanistan usually retaining structures are built as gravity walls. Pier walls and piles for slope stabilization can be also used.

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