Proceedings of the 16th International Conference on Soil Mechanics and Geotechnical Engineering

doi:10.3233/978-1-61499-656-9-2477

Lanslide in a shale slope in Kabylie

Glissement dans un talus schisteux de Kabylie

Hocine Bendadouche
Département of civil engineering, Universiy of Bejaia
Salah Lazizi
L.N.H.C.

ABSTRACT

After soil settlements caused in great mass by the building of shop premises, an important landslip has affected the limb of a strongly broken hill at Barbacha village, a locality situated the Kabylie region. During these soil settlements, the resulting disaster has involved to downstream the embankment and the altered shale. To build a school play-ground a large platform was first realized. Thus great quantities of fill were deposited on a very inclined ground. For the construction company, it was not judged useful to drain the superficial water flowing on the slope.

The landslip, witch is relatively deep, has caused significant damages .It fact, several classrooms of a school complex and a shop premise at downstream were completely dislocated.. The boring s and the earthworks carried in-situ out have shown the rock mass is exclusively constituted by the shale .This metamorphic rock witch break in fines layer, is widespread in the mountainous zones of Kabylie. Many landslides have been observed in this ground all over the region.

The aim of this study is to present in detail the characteristics of the site , the results of the geotechnical investigation and the solution of soil confortement.

RÉSUMÉ

Suite à des terrassements en grande masse en vue d'implanter des locaux commerciaux. Un important glissement a affecté le flanc d'une colline assez accidentée dans la ville Barbacha située en kabylie. Au cours de ces terrassements, le sinistre a eu lieu, entraînant vers l'aval le remblai et le schiste altéré. Pour construire une cours de récréation aux élèves, on a édifié une grande plate-forme. C'est ainsi que de grandes quantités de remblai ont été déposées sur le terrain en pente assez forte. Il n'a pas été jugé utile de drainer les eaux de ruissellement qui se déversent directement sur le talus.

Le glissement relativement profond a provoqué des désordres importants. Certaines classes du groupe scolaire et un local commercial en aval, ont été complètement disloqués. Les sondages et les terrassements in-situ nous ont permis de constater que le massif est constitué exclusivement de schiste. Cette roche métamorphique qui se débite en feuillets, est très répandue dans les zones montagneuses de la Kabylie. L'action de l'eau transforme cette roche en un matériau très meuble. On a observé de nombreux glissements dans ce type de sol.

Enfin, cet article présente en détail, les caractéristiques du site, les résultats de la reconnaissance géotechnique et la solution de confortement adoptée.

1 INTRODUCTION

The mountainous zones of Kabylie in the area of Bejaia are characterized by the bad quality ground. The slopes are generally in the limit balance. The earthworks in-situ enabled us to note that the solid mass is made up exclusively of schist. The least earthwork can cause and a landslip similar to witch produced in the school complex build on a small hill in the town of Barbacha when an excavation was stared. It now threatens the unit of the hill. The observations show that this slip is due to the excessive overload of the grounds, the presence of water and the bad quality of the grounds. The landslides frequently affect the movable covers plated on a compact inclined substratum. It is thus urgent to set up a system of confortement before the winter period.

1.2 *Situation*

The ground is in Barbacha inside the school of May 8 45. It is limited as follows:

- In North, by a way which carries out towards the centre town
- In the South, by the trunk road driving N°75 with Bouandas
- A East, by a private property

Dimensions of the ground are approximately 45 X 55m.

Figure 1. Sight on the course fissured

1.3 *Relief ground*

The ground localised on a shaley inclined solid mass

2. GEOLOGIQUE CONTEXT

After prospect ion and analyses geological formations places from there, it arises that the ground is made up primarily of schist. The analysis of the schists on the spot reveals a ground very sensitive to water. This characteristic corresponds to evolutionary grounds. Various factors were combined to start this slip, one will quote:

- suppression of the thrust
- overloads due to the embankments of the court
- surface water abundance.

Figure 2. a shale échantillon. Kabylie

3. FIELD RECOGNITION

Our investigation was based on visits of the ground and in-situ tests and laboratory tests. We carried out a cored survey, tests with the heavy dynamic pénétrométre, the wells and tests laboratory.

3.1 *Cored survey*

A survey cored energy with 9m of depth was carried out with an aim tto know the geological nature of the formations constituting the supporting soil and to take samples for laboratory tests.
The visual description of the recovered samples of the survey, enabled us to establish the following cut:

0.00-1.00 m Fill
1.00-6.00 m Laminated faded schist marly color variegated
6.00-9.00 m Not very compact marly schist grey color

3.2 *Penetrometric tests*

In addition with the cored drilling carried out, we carried out a series of tests with the dynamic penetrometer. The thirteen (13) tests penetrometric distributed on the ground were carried out in order to determine:

- penetration resistance by beating the ground
- to check the degree homogeneity of the ground
- to locate a potential depth of basis foundations

All these tests were beaten until the refusal. According to the position of the tests, the refusal is reached between 0.40m and 6.80m, the depth of investigation in this case thus exceeds the depth of the embankments.

Table 1: Values of resistances at a peak

N° PDL	Depth Of the refusal	Resistant at a minimal in bars	Resistant at a maximum in bars
1	5.4	12.5	80
2	6.4	12.5	140
3	7.00	12.5	120
4	6.00	15	100
5	5.00	10	135
6	3.20	-	-
7	4.80	75	200
8	2.40	60	-
9	3.60	65	380
10	3.20	37	175
11	1.20	>>	-
12	0.60	>>	-
13	1.40	>>	-

4. LABORATORY TESTS

From the undisturbed and altered samples taken from the cored survey and wells, we carried out tests at the physical identification and mechanical soil study laboratory .

4.1 *Physical identification*

The given parameters are: density, water content, the degree of saturation to various depths.

4.1.1 *Wet density: γ_h (g/cm ^{3})*

The value of the wet density lies between 2.10-2.24 g/cm ^{3} . It is a compact ground

4.1.2 *Water content: W (%)*

8.30 < W < 13.3 %: except for the sample extracted the depth of 1.00-1.20m where the water content is about 5.1%. This is probably with drying. The water content is rather weak in general, it is thus a ground of good compactness.

4.1.3 *Degree of saturation: Sr (%)*

65< Sr < 81 %: partially saturated ground

4.1.4 *Granulometric analyses*

The granulometric analyses carried out on the recovered samples of the survey and the various wells present various forms of curves because of the variety of the ground in place. On the level of the slipped zone, the ground consists of 60 to 86 % of fine elements whose diameter is lower than 0.2 mm
The same observation exists for the taken samples of the excavations. The ground consists of 60 to 95 % of fine elements (muddy, argillaceous grounds), Except for the excavations K1, K2 and K3 where the nature of the ground is different (presence of argillaceous gravelly earth).

4.1.5 *Limits of Atterberg*

The limits of Atterberg enable us to determine the nature of ground and its state. According to the tests carried out, the liquidity limits of the taken samples of the cored survey vary between 30% and 40%. They are thus lower than 50 %.
According to the Casagrande's diagram, one can classify them as follows: the recovered samples of the survey and the wells consist of not very plastic clays.

4.2 *Mechanical properties*

The rectilinear shear tests with limps Casagrande (UU) carried out on the samples give us a natural angle of repose of 10° and 15° and a cohesion of 0.96 and 1.35 bar.

5. STABILITY CALCULATION

Three (3) profiles on the slip were established starting from the topographical survey. The absence of tests at the time of the slip does not make it possible to know the actual values of C and φ. A first approach was to fix the parameters of shearing the angle of friction φ and cohesion C in order to check a minimal stability with a safety coefficient equal to 1 (Fs=1).

The parameters of shearing corresponding to Fs=0.999 are:

- Profile 22 - Profile 33

C = 34 KPa C = 12 KPa

φ = 12° φ = 12°

The plan is given on the basis of observation of the cuts geotechnics. Once the determined surface slip, one took again the definition of the total safety coefficient to calculate the efforts of slip to be taken again with an improvement of Fs of 30%.

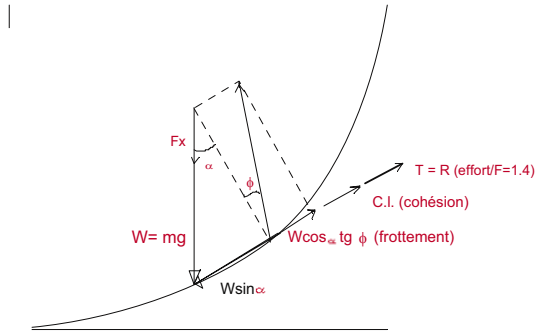

Figure 3 Study of Stability

5.1 *Determination of the effort to be begun again*

- With the following assumptions:

γ_h = 2.16 t/m²

Profile 22

W_1 = 78 t ϕ_1= 6°

W_2= 151 t ϕ_1= 15°

W_1= 82 t ϕ_1= 28°

Profile 33

$$F=\frac{c.l+W.\cos\theta.tg\varphi}{W.\sin\theta}$$

W_1 = 48 t ϕ_1= 27°

W_2= 165 t ϕ_1= 27°

W_3= 176 t ϕ_1= 29°

W_3= 30 t ϕ_1= 27°

$$F=\frac{c.l+W.\cos\theta.tg\varphi}{W.\sin\theta}$$

5.2 Design the collapse

This calculation is based on the balance of one ground to the rupture while being based on the resistance of materials. The effort taken again by the retaining wall R can for example, for a circular slip, being introduced into the expression of Fellenius by:

After earthwork (Fo≈1)

$$\sum_A^C W_i \sin\alpha_i = \frac{\sum_A^C [c'.l_i + W_i' \cos\alpha_i tg\varphi_i]}{Fo} \quad (2$$

After confortement (F = Fo + Δ F/Fo) safety coefficient of the slip

$$\sum_A^C W_i \sin\alpha_i = \frac{\sum_A^C [c'.l_i + W_i' \cos\alpha_i tg\varphi_i] + R}{F} \quad (3$$

R = (F – Fo). W. sinα

Profile 22: R = T = 0.3 X 208 = 62 T

Profile 33 R = T = 0.3 X 170 = 51 T

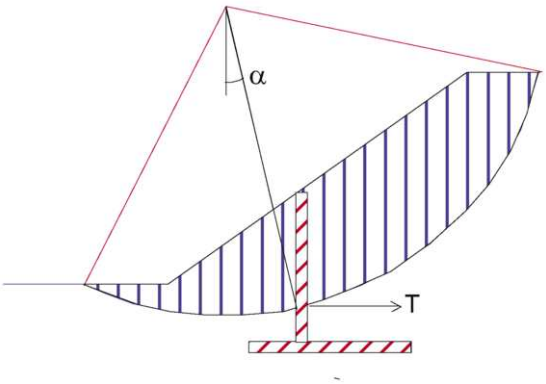

Figure 4 Calculation of the effort of nailing

6. CONCLUSION

We can conclude from our study that the important landslide that happened in the school complex of 8 May 1945 at Barbacha village region was caused by earthworks realized in January The studied ground is made up essentially of the shale, very sensitive to water. To consolidate this slip, a study of stability was started. Once the determined surface of slip, one took again the definition of the total safety coefficient to calculate the efforts of slip to be taken again with an improvement of Fs of 30%.

In order to preserve the school complex, the solution suggested consists in envisaging spurs draining in the slipping mass and to build reinforced a concrete retaining wall associated a drainage.

- the effort R taken again by the retaining wall will be 62 tons.

The slope must have a regular slope and be protected by a vegetable or different cover. This vegetation must last all the year and cover all the slipped zone. This work must be carried out in dry period.

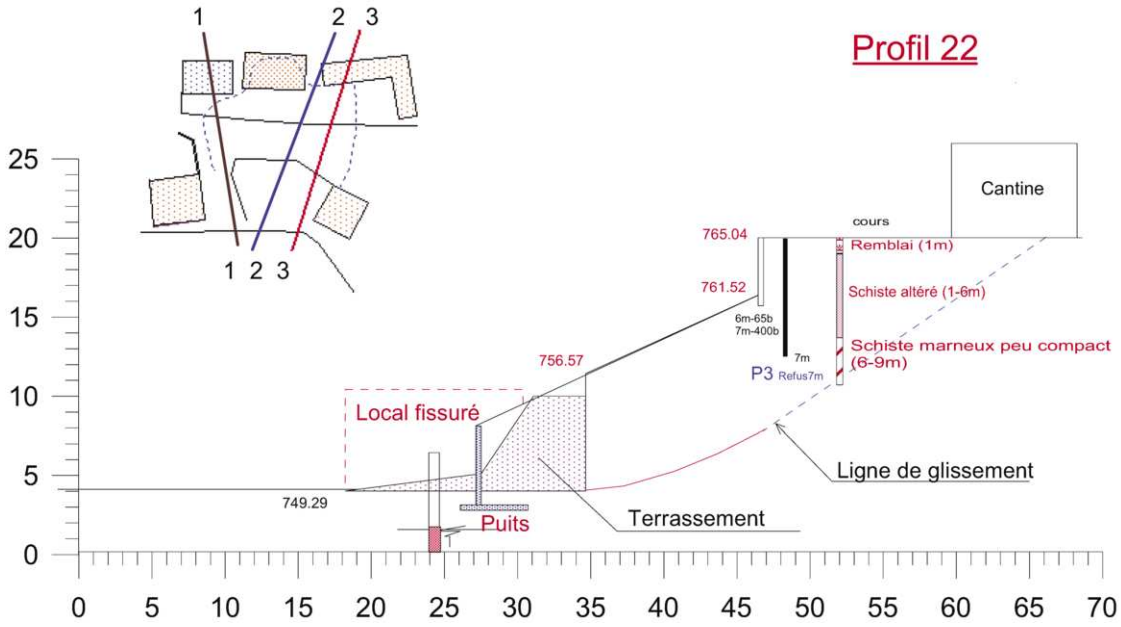

Figure 5. Crosses geotechnical of site of slip. High Kabylie

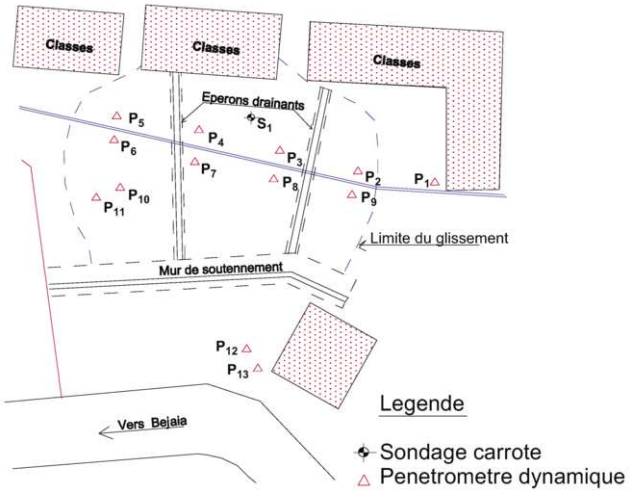

Figure 6 Plan of establishment of the tests

REFERENCES

Bendadouche. H. and Lazizi S. 1999. The frame and ground. Seminar on town planning with Bejaia' '.

C Gilles. 1986. Stabilization of the slopes by nailing. *Bulletin of connection. Laboratory of the Highways Departments. N°141*

Durville. J.l. Goin. T, Pouget. P., Seve. G 1994. ' ' Monitoring of the unstable slopes. *Guide technical. LCPC.*

Gerald. P., Bertrand. H. 1997. Ground foundations and works. *Eyrolles Editions*

Gilles. S., Frank. R. 1996. Experimental study of the stabilization of a landslide by piles of large diameter. *Bulletin of connection. Laboratory of the Highways Departments. N° 204.*

L.N.H.C. (National Laboratory of the habitat and Construction) Bejaia. 2003.Etudes of grounds.

Technical rules of Design and Calculation of the Foundations of the Works of Civil Engineering. 1999. *Geotechnical Booklet N°62.*

Sanglerat. G Barnoud. F, Sanglerat T.r.1975). ' ' Confortement by nailing of fill in site difficile' '. *Bulletin of connection. Laboratory of the Highways Departments. N° 78*