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# THE SETTLEMENT OF A BUILDING ON A SLOPE SOIL SUSCEPTIBLE TO SLIDE

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***Abstract:*** *The slope soils susceptible to slide, make part of the difficult soils foundation category and in order to choose an adequate foundation system is necessary to know the real geotechnical condition of the settlement. For this, the geotechnical data obtained ago of the drills effected on the settlement of the future building are very important. In this paper, it is presented a case study concerning the factors which has determined the change foundation system after the diggings works have begun.*

***Key words:*** *soil foundation, geotechnical study, soil stratification, drill, dig.*

## 1. General data presentation of the settlement

The settlement considered in this article is located in the slope area from the north of Dealul Melcilor (The Hill of Snails), a sub-unity of Brasov Depression.

Geographically speaking, Dealul Melcilor is situated within Brasov's perimeter, being a small rocky hill, part of a chain of small limestone hills spread along the mountains' base and tied to Tampa's mountain.

The area considered is situated on deposits of Triasic age, being made of Anisian and Ladinian stages. The Anisian presents in its inferior part bituminous limestones in boards and ledgers with bedrock shale interpolations. Through the superior part lighter limestones are developing, in thick banks/slopes, locally with siliceous rocks.

The Ladinian, the last term of the Triasic from Brasov's series is presented by grayish-white massive limestones, with a rich fauna (Dealul Melcilor), inventoried by E. Jekelius and comprising spongiae, corals, sea slugs, lamellibranchiate, very numerous branchiopoda and echinoderms.

Topographically speaking, the slope, with a medium tilt of 17 degrees, presents in these area different inclinations, ranging from 7 to 25 degrees.

On the settlement studied, there follows to be built a block of flats with the height system of S+P+2E+3R. The overcharge given by the positioning of the construction on the slope is of approximately 150kN/m$^2$.

From the point of view of the seismic hazard for construction/projection, the settlement is characterized by the peak value of the horizontal acceleration $a_g$=0,2g, determined for the medium interval of recurrence IMR=225 years. The local conditions of the land are given

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through the value of the period the upper limit of the period of the constant spectral acceleration branch $T_c$=0,7s.

Fig. 1. *Settlement view*

## 2. The geotechnical investigation of the settlement

The geotechnical investigation of the soil stratification has taken place in two stages: the initial situation on the basis of which a solution of direct foundation was designed, and the second variant where a solution of indirect foundation, on piles, embedded in the primary rock, has been recommended.

### 2.1. The initial situation

In the initial phase of the infrastructure's projection, the probings conducted on the studied settlement revealed the following lithological sequence: under a blanket of heterogeneous fillings, mildly compacted, whose thickness ranges from 0,50 to 1,10m, there were encountered adobe deposits made of a succession of powdery clays, sandy clays, sandy powders and loamy sands, being mostly in a stiff condition.

The passing from the adobe coat and the primary rock is made through an area of alteration of the rock encompassed by blocks of different dimensions, of calcarous nature, and fragments of rock detritus with the interspace filled with argillaceous sands consistent and stiff, of a thickness of approximately 0,50-0,80m. The probings conducted have intercepted powerful water infiltrations on the east side of the studied perimeter, to depths comprised between 5,20m and 5,90m from the altitude of the natural soil.

According to the first study, the primary rock (greyish yellow limestone, massive or stratified, highly cracked) was encountered at depths ranging from 2,8m to 7,2m from the altitude of the natural soil.

In some probings (S1 and S7) the soil is very irregular, with depths ranging from 2,3m to 2,4m, comprising also in his components vegetable residues.

Regarding the stability of the soil in the area, it has been observed that the slope on which the construction is to be built, it could be affected by possible landslides.

There was assumed the potential formation of some plans of subsidence that can be formed between 5,20 - 5,90m (probings S1 and S7) from the altitude of the natural soil at the moment of the drilling, primarily because of the water infiltrations that are leaking on the surface of a clay deposit whose inclination concurs with the slope's inclination.

The recommended foundation conditions are that the foundations should be embedded 0,5m under the possible plans of subsidence, in the deposits formed of altered limestones or blocks of calcareous nature with their openings filled with argillaceous sands found in the probing made at depths comprised between 2,80m (S6) and 7,20m (S1).

In the given conditions, the conventional pressure for central loadings from the fundamental arrangement is $p_{conv}$=425kPa. For the other cases, the multiplication coefficients will be respected according to the projection's standard specifications. The level of foundation that is attained it is recommended not to be on deposits with net geotechnical different characteristics such as: the limestone cliff and earthy soils (sandy loam powder, powdery clays, argillaceous sands) to avoid the very brown differenced subsidence that do not align with the relative subsidence values admitted for the adopted structure.

Following this geotechnical study, the solution adopted in the infrastructure's projection was the direct foundation through some continuous foundations of the type reinforced concrete base, situated on a block of plain concrete.

### 2.2. The situation after the works of infrastructure digs have begun

The developments have been started based on the situation initially projected, but after the execution of the diggings for projected foundations, there was determined that the nature of the soil from the specified altitude it was not the correct one. The explorations extended into other areas as well, confirming the fact just mentioned. The signalled incongruities for all the foundations in progress, as well as the relative reduced depth of foundation, have determined the necessity of the execution a new geotechnical study, more detailed, with drillings of greater depth. The drillings executed have signalled the presence of diverse deposits, with pluvial character: argillaceous powders, argillaceous sands, powdery sands, breccia, shaly argillaceous sands and powders, limestone. There were also performed several geotechnical analyses: Atterberg limits, grading curve, volumetric loads and so on. The presence of the underground water was identified in drilling works of depths comprised between 6,00-6,20m on the basement area, and at 9,20m on the following platform. It is important to mention the fact that in the case of the first geotechnical study, the altitudes were measured related to the natural's soil altitude, in the second case the altitudes are reported to the tonometry of the settlement after the general diggings proposed in the first version were realized.

Therefore, the settlement of the future construction is divided in three areas, starting from the bottom to the top: the downstream area (of garages), the intermediary area, and the upstream area. In the superior area, there where the F5 drilling operation was executed, the deposition was the following: polymictic breccia, argillaceous powder, intraformational breccia, reddish-yellow sandy powder, after which, at an altitude of +6,80m from the natural soil, it follows the deposit of limestone.

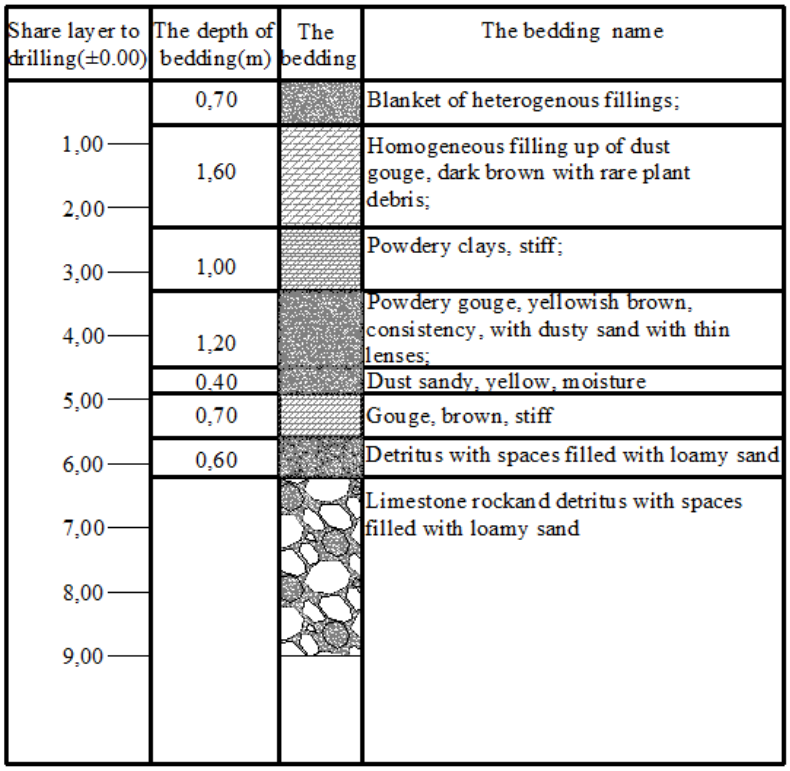


Fig. 2. *Drilling S1- The first geotechnical survey*

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Due to the projected construction's location on a hillside susceptible to sliding, there was effectuated a count verification of the earth massif's stability with the help of a specialized count program. The results obtained have shown that the slope's loading with the projected buildings, in the case of the direct foundation the slope becomes unstable, giving rise to a landslide. The initial plan of subsidence was identified as being situated in the deposit of sandy powder with a light consistency. In this case, it is recommended the indirect foundation, on piles, embedded in the primary rock.

The preliminary bearing capacity of a piles, determined based on the resistance on the peak and of the lateral frictions is of 713 kN for 600mm for the embedding in the deposit of shaly argillaceous powders, and of 5002 kN for limestone, respectively of 1501 kN for 1000mm, embedded in the deposit of shaly argillaceous powders.

### 2.3. The comparative analysis of the geotechnical investigation variants effectuated

The comparative analysis effectuated at the depth of the soil good for foundation indicated in the first geotechnical survey, respectively from 2,80 m to 7,20m, in the two variants of the soil's investigation, it was made on the following components:

- the nature of the foundation soil
-the corresponding conventional pressure
- the sliding plans' position
- the recommended foundation solution

The comparative analysis of the conventional pressure effectuated at the depth of the soil good for foundation indicated in the first geotechnical survey is processed in Figures 3 and 4.

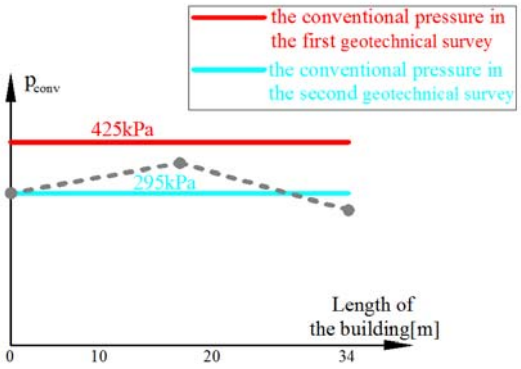


Fig. 3. *Bering capacity at the depth of the soil good for foundation the downstream area*

The analysis of comparative data for the construction area situated downstream and the intermediary is presented in Table 1.

For the building block from upstream, the configuration of the soil is nearly identical at the same altitude in both situations, highlighting the possibility of direct foundation in both variants of the geotechnical study, according to the initial infrastructure project.

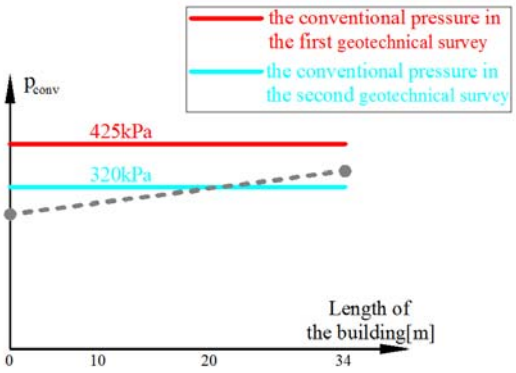


Fig. 4. *Bering capacity at the depth of the soil good for foundation the intermediary area*

*The analysis of comparative data* Table 1

| **Benchmarking data** | **The initial situation** | **The situation after excavation** | **Conclusion** |
|---|---|---|---|
| 1. The nature of the foundation soil | The primary rock: greyish yellow limestone, massive or stratified, highly cracked | The level of the initial situation: powder gouge, yellowish brown | The variation of bedding at greyish yellow limestone to powder gouge |
| 2. The corresponding conventional pressure | $p_{conv}$=425kPa | $p_{conv}$=295kPa on the downstream area | Percentage difference 44% |
| 3. The sliding plans position | Between 2,80m and 7,20m | Between 4,00m and 10,80m | Different positions of the planes of slip |
| 4. The recommended foundation solution | Solution foundation shallow foundation | Solution foundation: depth foundation | Different foundation solution |

The potential tendency of sliding is assured through the pillars associated with the building block from downstream embedded in the bearing deposit, made of calcareous cliff or shaly argillaceous powders.

Regarding the presence of the underground water result following aspects: if in the first geotechnical survey it was specified that is present at altitudes comprised between 5,20-5,90m, in the second study, the water was intercepted at higher depths 8,20-10,00m.

## 3. Conclusion

In case of soil susceptible to slide, the number, the position and the drill depth represent key elements in settlement geotechnical investigation and the dates supplied, serve farther to the make choice and designed of foundation system.

In case study presented in this paper the defectively investigation of settlement has conducted to the change of foundation system after the digs works have begun with major implication of technological order, execution expenses and temporary interruption of infrastructural works.

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