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FOUNDATION SOLUTIONS OF A BUILDING ON SATURATED GROUND, COMPRESSIBLE IN BRAŞOV CITY

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Abstract: *Construction of a building with 5 floors on saturated, very compressible ground, without the possibility of water drainage, required further study and monitoring of its behavior in time. Avoiding differencial settelments required cement injection in a rectangular grid with a side of 1.50 m. It was found that injection consumed 60% more solution than the volume of the borehole, which to a diameter of 30 centimeters, with an average porosity of 35%, highlighted a radius of 46 centimeters influential. This article aims to review the phases of research, execution and monitoring the behavior of the construction.*

Key words: *soil investigation, soil improvement, uniforming the foundation soil*

1. Introduction

The need of reusing built land in urban areas often leads to the emergence of difficult situations from a geotechnical conditions' point of view. Most of the time there are, especially on the site of old industrial plants, infested land, networks, buried construction and so on.

The terrain in discussion is situated in Brasov and it is relatively flat, but it should be noted that the current layout is the result of urban improvements made over the years. Until recently, bearing masonry construction up to four floors, some with basement, has existed on site. The eastern side of the terrain is bordered by the canal, currently covered with tiles. On the opposite side there is a canal through which Timisul Sec river was conducted, and which has obvious flaws; the canal is made by prefabricated slabs and protected from exterior with masonry. This is the case of a proposed project on the site of a former mill in Brasov. A flat building with a height of B + GF + 6F will be build there.

The construction will have the structure strength made of reinforced concrete with brick infill on isolated foundations under the posts and continueunder the walls.

2. Geological Context

The site in this case belongs, in view of geomorphological punch, to the plain alluvial of Brasov.

The study area lies between Mill Hill and the Timis canal, which is currently covered.

In terms of lithology, we find cohesive materials (silt, silty sand) and noncohesive materials such as gravel and sand (of Quaternary age, which dominate the whole Brasov depression).

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Inhomogeneous stratification is not retrieved as identical in any of the three points of investigation. The inhomogeneity of the soil has two causes:

- natural: the soil being made up of accumulated proluvial at the downhill with cross-bedding laminate
- the soil was affected over time by various municipal facilities or due to industrial buildings.

On the ground surface we met a filling blanket unorganized, unconsolidated, with a thickness of approximately 4 meters, consisting generally of topsoil, debris – on top gravel, dust, etc.; we assume that this filling resulted from the demolition of buildings from the site and from urban works which were carried out in the area in the past.

3. Direct Field Investigations

To identify the stratifications we executed two penetrations doubled by boreholes (see fig. 1), according to NP 074-2014 [1]. The boreholes were executed in depths up to 12.00 meters (positioned on the situation plane).

Fig. 1. *Geotechnical surveys Location Plan*

Penetrations were performed with super heavy dynamic penetration facility SCPT 73/75 - Deep Drill. The penetrometer is of superheavy type, with the hammer weighing 73 kg. and a drop height of 75 cm; the cone has a diameter of 5 cm and an angle of 60 °.

The penetrations results were processed with the "WIN-DIN" application, provided by the instrument manufacturer.

Boreholes were studied and other work was also performed in the area. The boreholes were performed by Borros 8659 facility, with continuous coring, 112 mm diameter. From the cohesive material, undisturbed samples were collected into Shelby tubes and standard dynamic penetration tests (SPT) were executed in the ground with coarse fragments.

The stratification found in boreholes as ilustrated in figure 2 is as follows:

- 0.00 to 4.30 m filling blackish color (topsoil, debris - the top, gravel, silt etc.);
- 4.30 to 5.00 m gravel with reddish clay sand filling appearance;
- 5.00 to 6.00 m gravel with grey sand
- 6.00 to 12.00 m red sandy clay plastic consistent, wet. Between depths of 10.00 to 10.40 m there is a dry yellow sand lens.

Fig. 2. *The stratification identified in geotechnical borehole*

Groundwater under strong seepage was met between the depths of 5.20-6.00 meters. The assumption that the presence of this type of water is due to the existence of the canal, which may leak (although it is concreted in principle), is proved real during some heavy rain that occurred during the execution of the general excavation.

Fig. 3. *Image from the execution after heavy rain*

4. Investigation Results

As a consequence, several foundation solutions were proposed see [4], [6]:

- indirect foundation, on a thickness cushion of ballast from 1.20 to 1.50 m, with continuous foundations;
- direct foundation on a slab at a depth of 5.00 meters from ground level, partially on a layer of reddish sandy clay, partially on gravel in sandy clay matrix.

Throughout the execution, an incompressible rock (cretacious conglomerate) was found in a corner of the site on a relatively small area, at the depth of the foundation.

Therefore we need to avoid the differential settlements that exceed allowable limits imposed by the structure. These differential settlements can occur due to great difference between the compressibility of the rocky area and the proluvial deposits.

Several remedial actions for this situation have been proposed:

- Execution of the construction in a slow rhythm, so that the primary settlements would be consumed before the higher levels are built;
- The excavation of the rocky area and its replacement with compressible material from the rest of the foundation area. This was proved difficult due their proximity to an existing historical monument, especially due to the presence of water.
- Improving the compressible ground with cement injections, this last one being agreed on by the customer.

5. Improvement soil works

The work of improving focused on the layer of cohesive material with the maximum depth of 6,00 m. This layer was targeted because it has a high permeability which makes the penetration of the injected agent easier. On the other hand, there is a red clay with better mechanical characteristics under this layer.

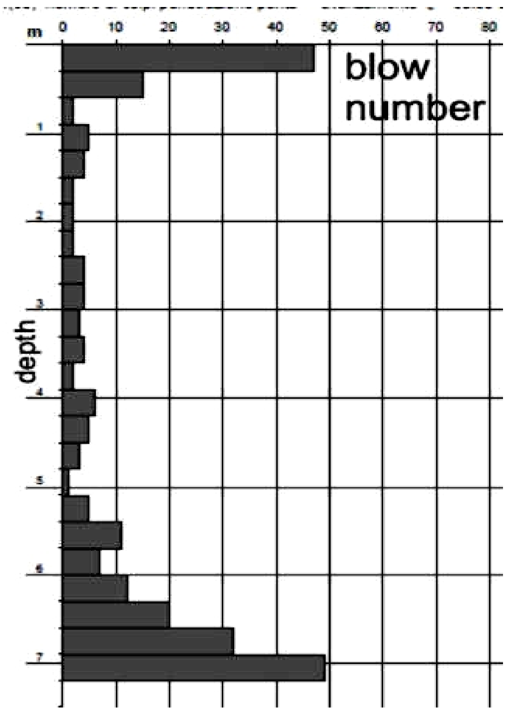


Fig. 4. *Diagram of superheavy penetration DIN2*

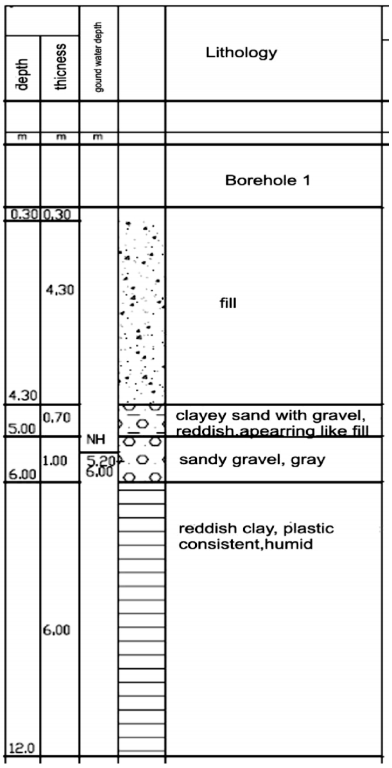


Fig.5. *Description of borehole F1*

Cement injection in a rectangular grid with a side of 1.50 m. was ordered.

The maximum depth that the injections were performed at exceeded the layer of clay or rock by at least one meter.

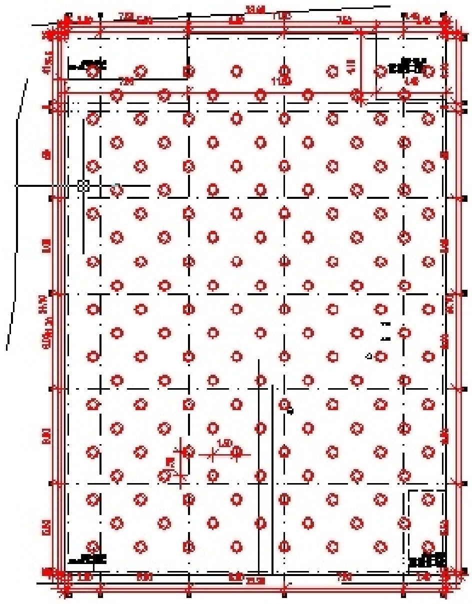


Fig. 6. *Cement injection plan*

It was found that injection consumed 60% more solution than the volume of the borehole, which to a diameter of 30 centimeters, with an average porosity of 35%, highlighted a radius of 46 centimeters influential.

5. Conclusions

Estimated settlements of foundations,

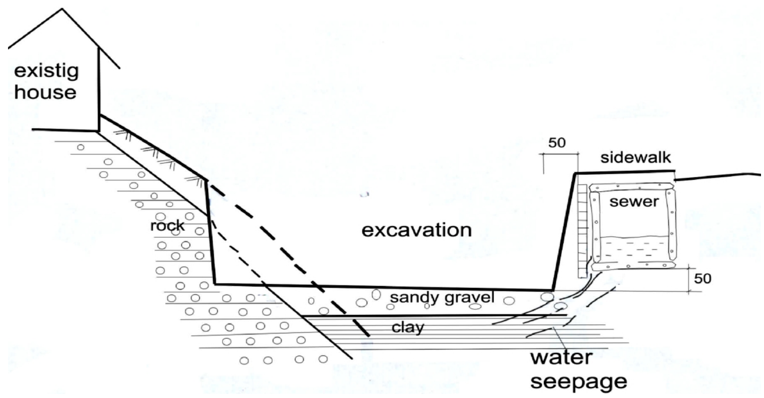


Fig. 7. *Geotechnical situation - sketch*

Fig 8. *Image of the general excavation*

considering the actual pressure communicated by the designer, led to differential settlements of about 0.0025 between the eastern and western sides.

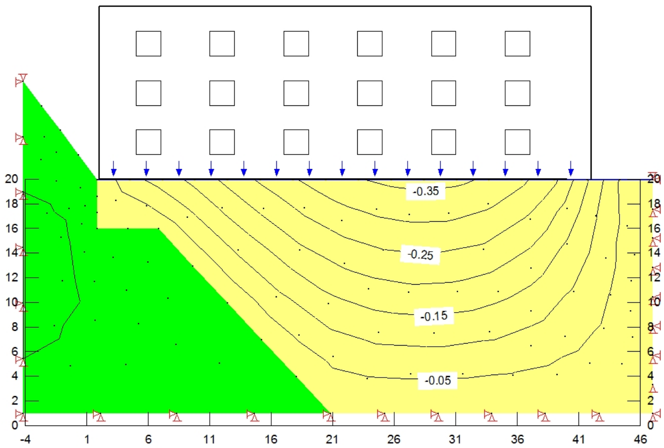
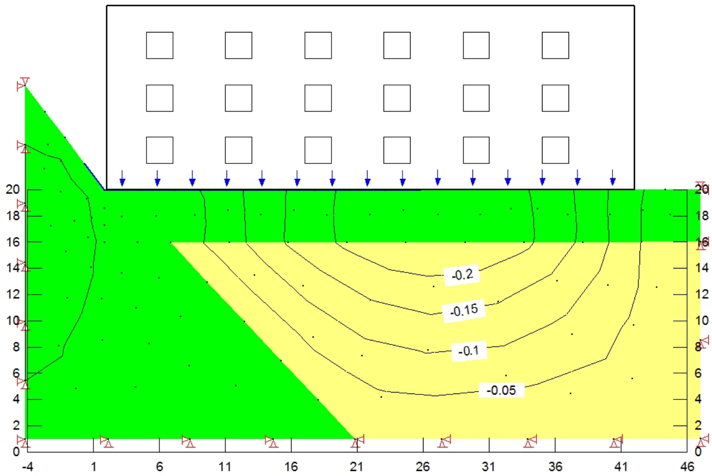


Fig 9. *Settelments' distributions before and after creating the cement blanket (principle sketch)*



The option for improving the foundation soil that we have proposed, among other possible ones, was the fastest and the cheapest that we have found. By improving the soil and reducing its compressibility by up to 66%, the relative settlement is reduced by at least 0.0008.

By monitoring the building, we believe that we will find that the entire load was transmitted to the stiff clay.

From our point of view, to interpret the data mechanically from direct or indirect exploration, including laboratory tests, is quite superficial. In general, direct investigations are made on a volume that does not surpass a millionth of the quantity of foundation soil considered. Therefore, in addition to the works that help to establish the foundation solution, we added the insight (understood as a synthetic result of the accumulation of knowledge) of the geotechnician or geologist. Extrapolation of the data obtained directly in the field or in the laboratory must be completed with the aspect of intuition.

Fig. 10. *Image during the building of the initial levels*

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