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Importance of the Geological-Geotechnical Investigation Program (GGI) in defining the type of foundation: Case study

Importância do Programa de Investigação Geológico-Geotécnica (IGG) na definição do tipo de fundação: Estudo de caso

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ABSTRACT

This paper presents the importance of the geological-geotechnical survey in order to subsidize the implementation of a building in the Administrative Region of Samambaia, Federal District, Brazil. The study was developed in stages, in which, at first, the geological-geotechnical study was carried out for the area of implementation of the work, subsidized by pre-existing analyses and studies. Then, in possession of the analyses carried out in the area of the project together with the field investigations (SPT and rotary soundings), added to the topographic survey, they helped to define the type of foundation and containment adopted, but also, a higher degree of correctability of the subsoil material in the excavation area. For the studied area, considerable soil variability was observed, with a predominance of sand, clayey sand and sandy clay. In addition, there is considerable presence of rhythmites with quartzites and clayey, silty and sandy laminar intercalations. Such surveys and studies were of paramount importance for choosing the appropriate executive process and necessary adjustments during the excavations of the land.

Keywords: Importance, Study, Geological-Geotechnical, Federal District.

INTRODUCTION

This paper presents the geological-geotechnical study carried out for the implementation of a project located in the Administrative Region of Samambaia Norte, in the Federal District, Brazil, with a view to greater knowledge of the material to be excavated for the implementation of the basements of garages, foundation, lower drinking water reservoir and reuse water reservoir. Previous studies showed that considerable variability would be found in the subsoil

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material, a fact confirmed when the piles of the containment system were executed and the subsequent excavation of the work area. In addition, the work considers the relevance of the programming of subsoil investigations with a view to less unpredictability in the process of excavation and execution of the foundation.

INITIAL CONSIDERATIONS

For the development of this work, a broad bibliographic survey was sought, which could more faithfully represent the knowledge about the region where the project was implemented. Next, we present mainly geological-geotechnical issues related to the region and area studied.

GEOLOGY OF THE FEDERAL DISTRICT

In the Federal District (DF), the rock sequences are inserted in the Brasília folding belts. From a regional point of view, the DF area is composed of metasedimentary rocks that include the Paranoá, Canastra, Araxá and Bambuí groups and the respective residual or colluvial soil covers (FREITAS-SILVA; CAMPOS, 1998). Figures 1 and 2 show the general geological map and the soil map of the Federal District, respectively.

Figure 1. General geology of the Federal District (CODEPLAN, 2017).

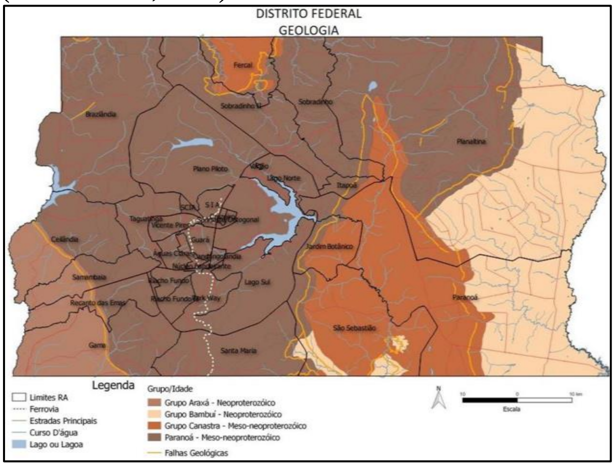
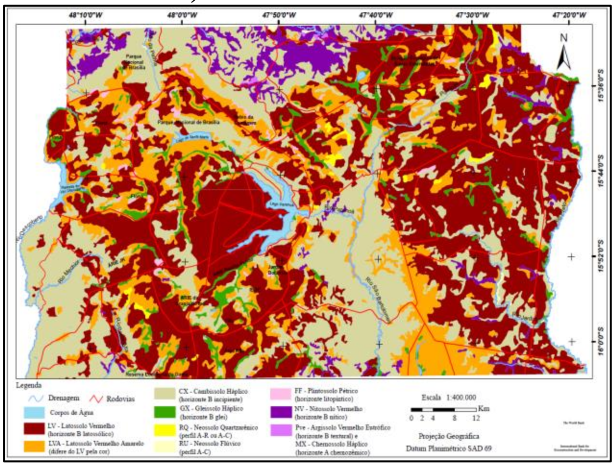


Figure 1. Soil map of the Federal District (ADASA, consulted in 2019).



The Paranoá Group occupies the largest area in the Federal District and concentrates the largest number of urban centers (the Pilot Plan and all Satellite Cities, with the exception of São Sebastião and Vale do Amanhecer), being the most important unit, approximately 65% of the territory. It is divided into six units, according to stratigraphic column, correlated from base to top in clayey metasiltstone, slate, sandy metarhythmite, middle quartzite, clayey metarhythmite and psamo-pelith-carbonate lilothagies.

The Canastra group, which covers about 15% of the total area of the Federal District, is subdivided into three formations, which are Paracatu, Serra do Landin and Serra dos Pilões (FREITAS-SILVA & DARDENNE, 1994). This group consists of low-grade metamorphic rocks, chlorite, carbonaceous phyllites, fine marbles, and mostly quartzite-lensed phyllites. The Araxá group occupies a small part of the soil of the Federal District, about 5%. It is represented by muscovite schists, muscovite quartz-schists and singular micaceous quartzite lenses (FREITAS-SILVA & DARDENNE, 1994). Finally, the Bambuí group covers 15% of the DF extension, which is made up of metasiltstones, clayey metasiltstones, metaargillites and rare archosean intercalations.

SOILS OF THE FEDERAL DISTRICT

Most of the soils in the Federal District are characterized by porous soils with a thickness of more than 10 meters. Due to the various processes that occurred in its genesis, this cover presents peculiar characteristics and distinct geotechnical behavior. This soil is very susceptible to erosion, and gullies appear in urban settlements, highways, and loan areas.

Among the classes of soils that occur in the DF and in the area under study, the main ones are presented and described based on the work of reclassification of soils by Embrapa (2004) in which there are latosols and cambisols with an approximate sum of 85.48%.

Oxisols

They are highly weathered soils, popularly called old soils, resulting from the removal of silica and exchangeable bases from the profile. Because of this, they agglomerate secondary minerals of the kaolinite group, oxides, hydroxides and oxyhydroxides of Fe and Al such as hematite, goethite, gibbisite and others. Because quartz is very resistant to weathering, it persists as a residual mineral in the alteration profile. They cover about 54.5% of the area of the Federal District and comprise the red latosols, with 38.92% of the area; and red-yellow oxisols, with 15.58%. They contain a reduced content of silt, which is between 10% and 20%, and clay, ranging from 15% to 80%. They can be excessively drained, depending on the nature of the texture, structure and topographical situation. Due to its composition, it is a soil that contains a high water permeability.

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Cambissolos

These are soils that point to a subsurface horizon subject to little physical and chemical alteration, considered a new soil, but sufficient for the development of color and structure. In general, they have easily weatherable primary minerals, higher silt contents, indicating a low degree of weathering. They correspond to about 30.98% of the area of the Federal District. Generally, they are associated with busier reliefs (wavy and strong undulating) that range from shallow to deep, reaching from 0.2 to 1 meter. They are yellowish-brown soils on the surface horizon and yellowish-red on the surface. The structure is quite variable, with subangular blocks predominating. They have a varied texture, from very clayey to sandy loam, with or without gravel.

AREA OF STUDY

Samambaia (Figure 3) is an administrative region of the Federal District that is located at the geographic coordinates of latitude 15°52'13.8"S and longitude 48°5'24.72"W, 25 km from the capital of Brazil. The area of the project under study is located in the eastern portion – central to the structural dome of the Federal District. In this place, the terrains are made up of metasedimentary rocks of the Paranoá Group, as shown in Figure 4, which include: quartzite, schist, biotite, phyllite slates, clayey metarhythmite and carbonate psamopelite. In addition, Figure 5 shows an overview of the construction site.

Figure 2. Map of the Federal District. Featured Samambaia (CODEPLAN, 2017).

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Figura 3. Tipos de solos na área de inserção da obra (IBGE, 2002).

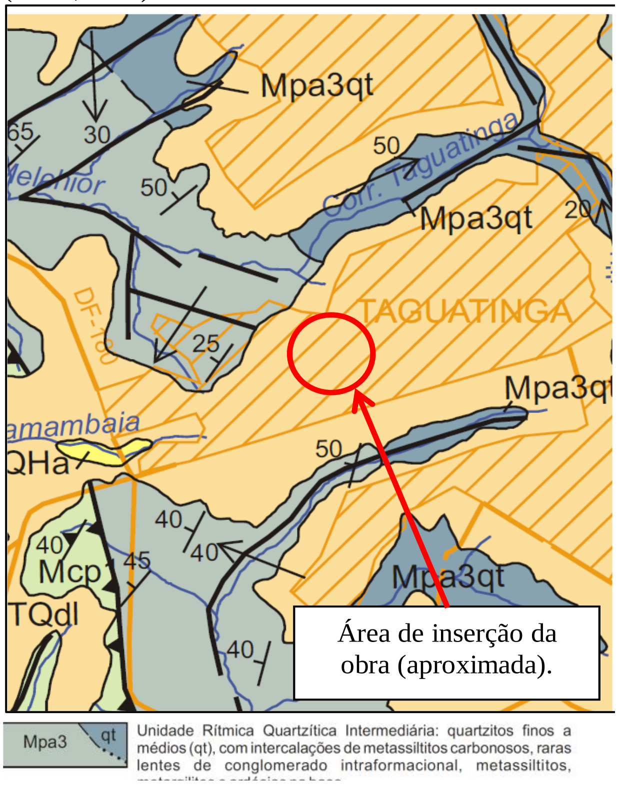
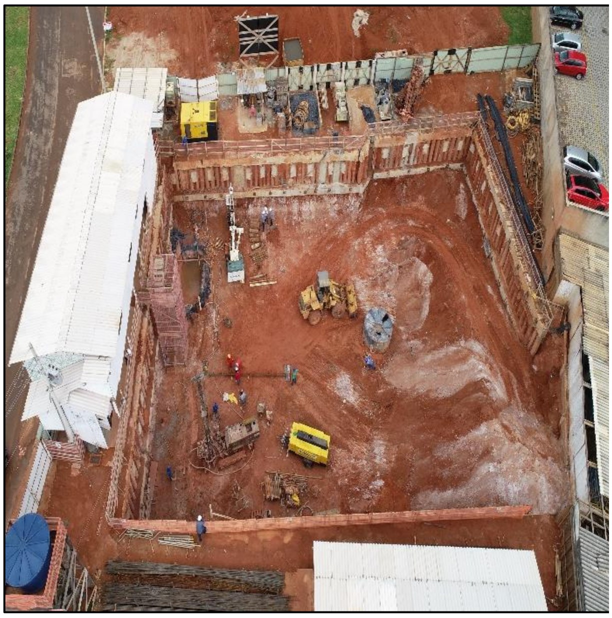


Figure 4. Overview of the construction site in the year 2019 with the containment system executed. On the left, in the figure, you can see the temporary office of the work.



Figures 6 and 7, obtained during the excavations, are consistent with what the map in Figure 4 shows. In general, quartzite rhythmic material is observed (Figure 6) and the presence of clayey, silty and sandy laminar intercalations (Figure 7).

Figure 6 Quartzite material

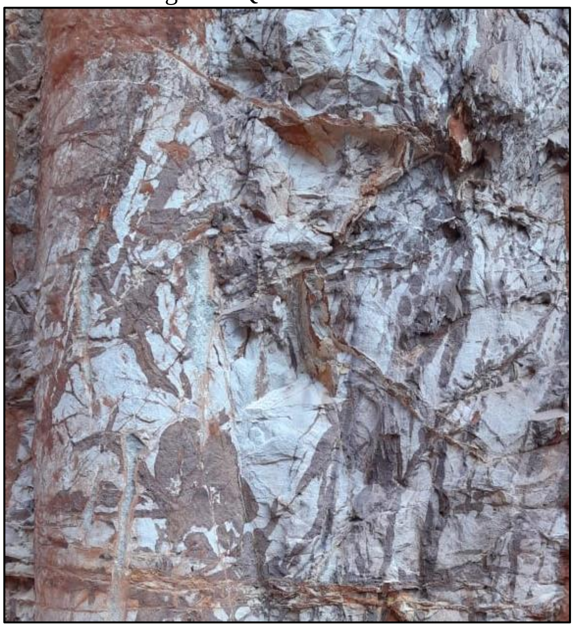


Figure 5. Clayey, silty and sandy laminar intercalations.

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CHARACTERIZATION OF THE PROJECT

The work in question is on a lot of 1,111.08 m² with a total built of 7,970.75 m². It is intended for multifamily use with fifteen floors, thirteen of which are pilotis and ground floor, plus three basements for garages and water reservoirs (potable and reuse). In structural terms, there are forty-nine pillars reaching the foundation with a total load of 12,513.40 tons. Among these pillars there are two plants with loads close to 1,000 tons on each pillar.

The foundation project was developed using isolated footings, i.e. a footing was dimensioned for each pillar in the foundation, making a total of 49 footings. The volume of concrete expected for the execution of the footings was close to 190m3 with steel consumption, also approximate, of 7.2 tons. The laying levels of the footings were close to 12 to 14 meters of excavation from the ground level of the building. The final stresses at the bases of the footings were variable, with an average of 5.5 kgf/cm2 and a maximum of 9.2 kgf/cm2. Figures 8 and 9 show the sectional view of the building and the floor plan of the 3rd basement with part of the footings, columns and lever beams.

Figure 8. Cutaway view of the development (FHE, 2019).

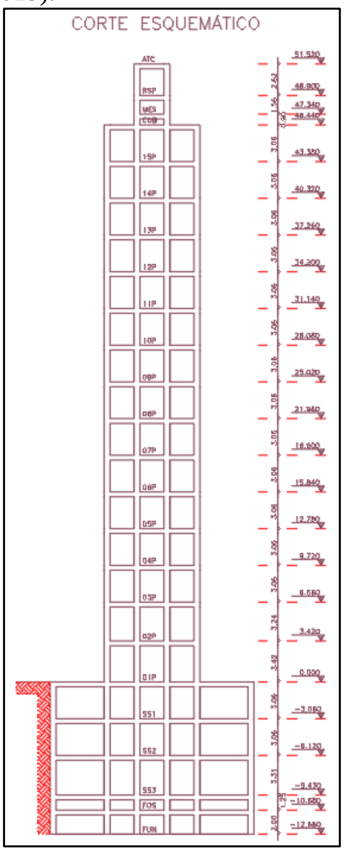
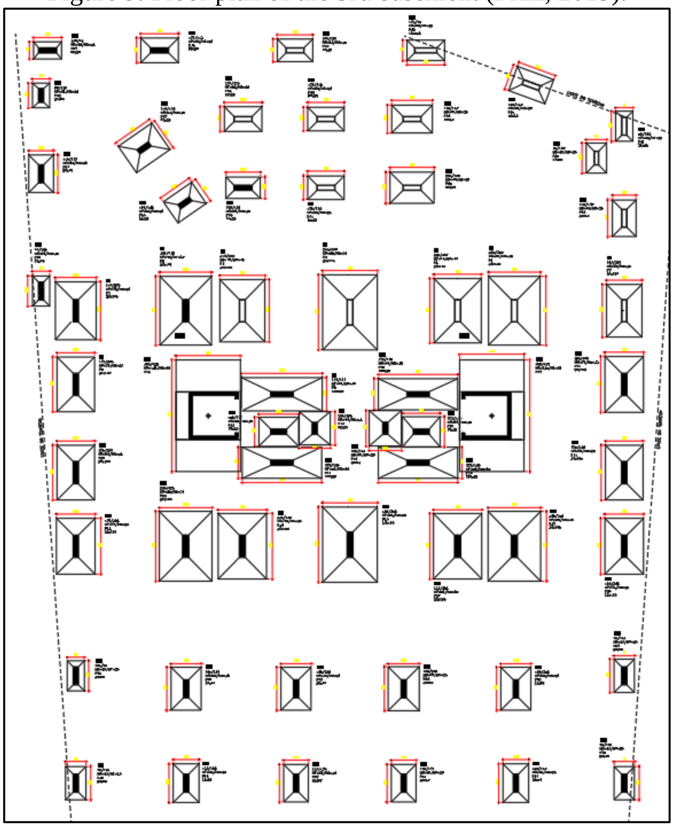


Figure 9. Floor plan of the 3rd basement (FHE, 2019).



WORK METHODOLOGY

The methodology adopted to carry out this work involved a broad bibliographic survey, field studies, execution of percussion and rotary drilling, monitoring of excavations and execution of foundations, but also analysis of all the content obtained during the study. The SPT and Rotary percussion soundings were carried out in accordance with the Standards and/or procedures contained in the ABNT/NBR's that guide methods of geological-geotechnical investigation of rocks and soils and aim at the elaboration of foundation and retaining wall projects.

SURVEYS OF THE PROJECT'S INSERTION AREA

In total, three drilling campaigns were carried out for the development of the containment, foundation and drainage projects. The first was carried out in 2014 to choose and design the aforementioned projects. In this campaign, six simple percussion boreholes (Figure 10) were drilled with a total perforation of 47.11 meters. The results showed the presence of very soft to soft wet red sandy clay at a depth of approximately 4.5 meters, i.e., a soil of low resistance. At the approximate depths of 4.5 to 7.5 meters, the predominant material of compact wet pink fine sand, except for the SP4 borehole, where silty material was found to be little sandy. The highest depth to the SPT was for the SP4 borehole with 9.30 meters, emphasizing the absence of the water level up to the probed depths. Figure 11 shows the profile for the SP1 borehole.

In view of this drilling campaign, the footing foundation project and the previous containment project in stapled soil were developed.

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Figure 10. Location of the boreholes in the 1st drilling campaign.

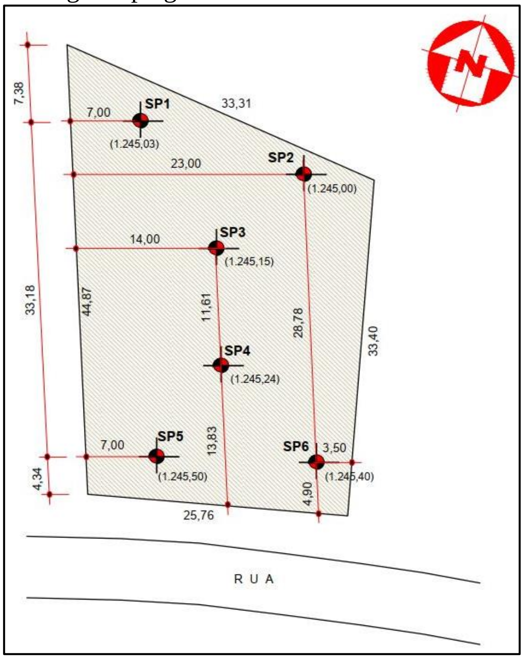
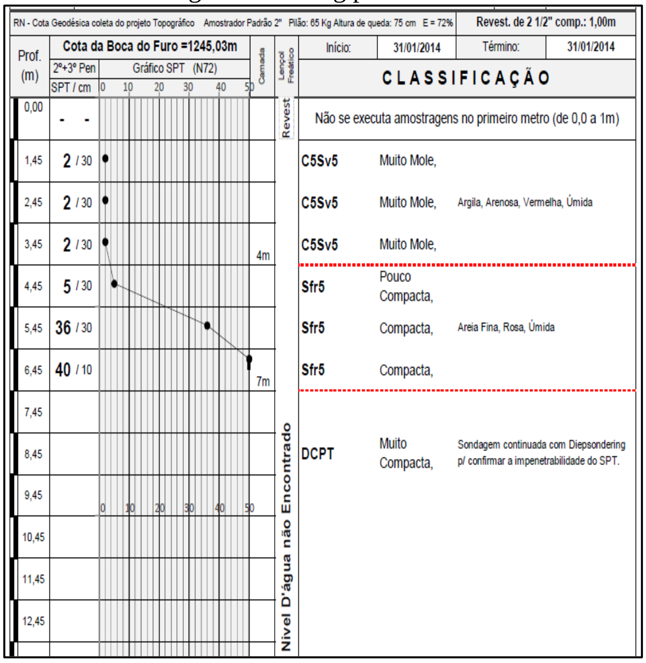


Figure 6. Polling profile SP1.



The second polling campaign was carried out in 2018 and aimed to advance from the impenetrable to the SPT when the first polling group was conducted. For this, three mixed boreholes (SPT and rotary) were drilled, with a total of 60.0 linear meters drilled. In the three boreholes, at depths of 7 to 20 meters, moderately compact sand, sandy-silt and friable quartzite were found with compatible strengths for footing-type foundation laying at the expected elevations, close to each other, from -12 to -14 meters.

With the execution of the mixed soundings, it was also possible to identify the water level on the date of execution, with a depth close to eleven meters. In general, the stratigraphic profiles of the boreholes corresponding to the second campaign showed that for depths, in addition to the impenetrable to the SPT in the first campaign, very heterogeneous and interleaved materials consisting mainly of medium to very compact clayey sand and friable quartzite.

The third campaign totaled 19.08 linear m in two holes, carried out in 2019, when nine meters of ground depth had already been excavated. This survey campaign showed that the deeper layers were also made up of considerable heterogeneous intercalations. The water level found was close to 1.8 meters above the level of the borehole's mouth, that is, at a depth of 10.8 meters from the ground level of the project.

PRESENTATION AND ANALYSIS OF RESULTS

The geological-geotechnical survey for the area where the work was implemented, supported by the analysis of pre-existing studies, such as geological maps, indicated the possibility of finding material composed mainly of quartzite, metarhythmite, but also clayey, silty and sandy laminar intercalations. This indicator gained strength with the execution of the second drilling campaign, which included rotary drilling in order to reach depths beyond what is impenetrable to the SPT. This possibility was confirmed during the excavations of the site. Figures 12 and 13 show materials found in these excavations, and indicated in the survey campaigns, also consistent with secondary data contained in the bibliographies consulted.

Figure 12. Constant quartzite in the excavation wall

Figure 7. Clayey, silty and sandy intercalations.

The studies carried out indicated that there could be a certain degree of difficulty and/or necessary adaptations both in the projects and in the execution. The nailed soil project underwent a change in the wall face to continuous helix piles, replacing the vertical slab foreseen in the initial project. This was due to the low cohesion of the soil of the initial layers, excavated in stages, which compromised the executive process.

When opting for continuous helix piles for the retaining wall face, we were already thinking about the probable difficulties that could arise in the executive process. Such difficulties were confirmed, so that in some sections, it was necessary to replace them with root piles due to the considerable resistance offered by the drilled material. In the execution of the containment face in juxtaposed piles with a continuous helix, at a certain moment, there was a loss of the drill bit in the drilling, seated above the expected level. Such situations were caused by the considerable strength of the material at the perforated point. Thus, in some sections of the projected containment, it was necessary to change the continuous helix pile to the root pile solution, evidencing the degree of unpredictability due to the geological-geotechnical characteristics of the subsoil in question.

Figure 14. Continuous auger bit lost during pile drilling and found in the excavation underground.

Figure 8. Continuous helix pile tip paralyzed before the expected elevation due to the strength of the material.

FINAL THOUGHTS

In view of the surveys, investigations, analyses, as well as the execution of the work, it can be considered:

a. The Geological-Geotechnical Investigation Program (IGG) can consist of a campaign with bibliographic survey, field and laboratory investigations in consideration of cost aspects, characteristics of the works and geological-geotechnical constraints. Such constraints as types of soils, rocks, hydrogeology, among others;

b. A good IGG Program should consist, whenever possible, of knowledge of the site of the work; identification of possible geotechnical problems that may intervene in the work, professional experiences, bibliographic research, consultations to local geological and geotechnical maps;

c. For greater reliability of the excavations of a work, there is a need for better knowledge to be obtained through the IGG;

d. The IGG program leads to a better knowledge of the distribution and behavior of the material (soils and rocks) of the subsoil layers that will be affected by the work, given the uncertainties related to behaviors that may affect the cost of the work;

e. It should also be noted the analyses that must be carried out in the pre-existing studies, but also in those carried out in the area of the enterprise, with emphasis mainly on SPT and rotary soundings;

f. It should also be considered the possible modifications to the original designs as a result of further investigations and that such changes may bring quite considerable costs not initially foreseen.

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