Chapter 9

Optimized Foundation Design in Geotechnical Engineering

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ABSTRACT

The design of foundations constitutes a major step for each civil engineering structure. Indeed, the stability of those structures relies on cost-effective and adequately designed foundation solutions. To come up with an optimized design of a foundation, the geotechnical study passes several steps: the geotechnical survey including in situ and laboratory tests, the synthesis of geotechnical parameters to be considered for the design, and the suggestion of foundation solution avoiding over estimated cost and ensuring suitable method of execution. In this chapter, the three currently practiced categories of foundation are briefly introduced. Then, two illustrative Tunisian case histories are analyzed to explain, first, when the practiced foundation solution was inadequately chosen how a non-cost-effective solution can be avoided, and second, why an unsuitable foundation solution can lead to the stopping of the structure functioning and then how to proceed for the design of retrofit solution to be executed for restarting the functioning of the structure.

INTRODUCTION

Optimized foundation design (OFD) first passes by an adequately planned geotechnical survey which usually includes boreholes, in situ tests and laboratory tests. Such a program is decided on the basis of the structure dimensions (or area), load intensities and soil conditions. A well planned geotechnical survey (number, location and depth of boreholes and in situ investigation) is followed by a suitable synthesis.
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of geotechnical test results allowing the adoption of realistic geotechnical soil parameters. The latter constitutes the best starting point to think about an optimized design of foundations.

Three categories of foundations are currently practiced for civil engineering structures namely: shallow foundations, deep foundations and intermediate foundations related to reinforced or improved soils (Das, 2014). For each category the adequate type of foundation is decided on the basis of an optimized solution, e.g.; cost effective and acceptable time of execution.

Shallow foundations include the following types: isolated footings; strip footings; crossed strip footing (either in one or in two directions) and rafted foundation.

Deep foundations also comprise a big variety of pile types (bored, driven, etc.), the optimized solution rather relies on the installation method of pile to warrant a reliable and cost-effective solution.

Ground improvement techniques represent the third category of foundation which can be considered in between the shallow and deep foundations. Several techniques can be adopted depending on the accorded priority for the project, i.e. to increase the bearing capacity and/or to reduce the settlement, or to accelerate the consolidation of compressible soils: stone columns, rigid inclusions, etc. (Indraratna et al, 2015).

In this chapter it is intended to highlight either the benefits or the disadvantages that can result from well planned or unsuitable geotechnical survey that can also lead to adequate or inadequate foundation solutions. Two Tunisian case histories are presented in detail to capture the learned lessons in regard to unsafe design in terms of non-cost effective or unsuitable foundation solution.

Foundation of Post Office in Tunis Centre: Case Study 1

The design of foundation of the post office in Tunis City, a ten-floor building (basement, ground floor, eight floors) is discussed. Due to the existence of deep soft clay layer the Tunisian Ministry of equipment decided the execution of 1 m diameter bored piles reaching 52 m depth. The foundation cost was approximately 40% of that of the whole project. Such an expensive solution was dictated by unacceptable long-term settlements compromising the stability of the structure. However, the applied load by the building is equivalent to quasi-uniform vertical stress of about 90 kPa. As such, in view of studying a foundation solution at a reasonable cost, the stone column and the sand compacted piles reinforcement techniques have revealed potential cost-effective solution (Datye and Nagaraj, 1981). Those techniques, however being adopted only for some oil tank projects in Tunis City, leads to a significant reduction in settlement to admissible limit. From the geotechnical survey which included boreholes and pressure meter tests up to 40 m depth it was concluded that crossed soft soil layers are under-consolidated silt-clay with limit pressure less than 1200 kPa.

Consideration of rafted foundation (Figure 1) leads to admissible bearing capacity equals to 100 kPa as estimated from the pressure meter method (Fascicule 62, titre V, 1994). It follows that the admissible bearing capacity of the oil tank complies with the applied load of 90kPa (Bouassida and Guetif, 2000). The estimation of long-term settlement at the axis of rafted foundation resting on the unreinforced soil using the Terzaghi’s method was of 45 cm, while at its border it equals 16.3 cm. Given these non-admissible values of settlement, the building tilting is with high risk such it has been observed for several other buildings in the same area of Tunis City like for six floors building located at the street Zaghloul which became out of service after about ten years (Bouassida & Klai, 2016). Therefore, before studying a piled foundation solution which is not cost-effective, it is obvious to analyze the reinforcement option using either stone columns or sand compacted piles. In fact, the reinforcement using by stone columns will
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