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STUDY AND ANALYSIS OF THE TYPES OF FOUNDATIONS USED IN CENTRAL IRAK (MESOPOTAMIA)

АЛЬ-РОБАЙ АЛИ А.А., СААДУН СУРА А.
Belarussian National State University
Minsk, Belarus

Irak (Mesopotamia) is a densely populated with most of its major cities located. High-rise and low-rise buildings co-exist in the metropolitan areas, and their foundation types may be very much different pending on the structural loading and subsurface condition. In general, shallow and deep foundations are used to support low-rise and high-rise buildings, respectively. Footings (strip and isolated) are classified as shallow foundations, while piles are considered as deep foundations.

Bearing capacity, settlement and uplift pressure are three factors that have to be considered for foundation design. A sufficient and good subsurface exploratory program is required to supplement the foundation design. In addition, engineering judgment also plays an important role in modeling the foundation problem and selecting the soil parameters. Construction of a deep foundation in metropolitan area involves potential danger. Failed to recognize adverse ground conditions or poor construction quality may lead to excavation failures or induce damage to adjacent buildings.

Soil Conditions in Iraq (Mesopotamia)

Various soil conditions are encountered in Iraq areas. In Mesopotamia area, ground conditions ranging from very soft clay to lose sandy, the ground condition is basically of alluvium plain nature[1,2], which consists alternating layers of sandy or clayey materials (table 1)

Table 1 - Soil properties for two samples clay and sand

	System of classification			Properties index			Void ratio e	C, kPa	ϕ
	Sand %	Silt %	Clay %	Pi %	LL %	PL %			
clay	7	22	71	43	62	19	0.7–0.95	20–60	1°–9°
	22	24	54	33	53	20			
sand	53	20	27	22	30	8	0.6–0.8	2–10	23°–36°
	52	21	23	17	25	8			

Ground water level is generally high in major metropolitan areas, which is typically at 1~2 m below ground surface. The high ground water level is a major obstacle to the construction of deep foundation, and sometimes it is the main culprit responsible for construction failure. Soft clay is especially difficult to handle for foundation engineers. Due to its low shear strength and high water content, soft clay may be a great threat to the safety of foundation excavation. And following the completion of foundation, large amount of consolidation settlement is sometimes inevitable.

Shallow Foundations

In general, shallow foundation is adequate to support the loading of most low-rise buildings. Residential or commercial buildings less than 4-story are considered as low-rise buildings, and these buildings apply an average loading of no more than 70 kN/m2 on the ground. Shallow foundation often exists in the form of single footing or combined footing, which usually rest at a depth of 1 m below ground surface.

To construct shallow footings, the highly compressible topsoil has to be removed first; otherwise, the shallow foundations may suffer large settlement afterwards. In addition, placing the footing at a suitable depth below ground surface would also provide better bearing capacity.

Deep Foundations

For most high-rise buildings, deep foundation is often required to support the structural loading and to minimize the differential settlement between columns. Since most high-rise buildings in Iraq are coupled with the construction of deep basements, the deep foundation could either be in the form of deep raft foundation or raft foundation with large diameter piles. In order to construct the deep basement as well as the raft foundation, a deep retaining wall together with an appropriate bracing system have to be employed first. Large bored piles with a diameter over 0.5-2 m and a capacity of more than 1000-10,000 kN are often used in Iraq. Construction of these large piles either adopts reversed-circulation or full-cased technique to stabilize the drilled shafts. Large-scale pile loading tests are routinely used to verify the design capacity of piles.

Design Considerations

Three major factors have to be taken into consideration while designing the building foundations, these factors are:

- Bearing capacity of foundation.
- Total and differential settlement of foundation.
- Uplift force acting on the foundation.

The bearing capacity has to be checked with an appropriate factor of safety to avoid catastrophic foundation failure. The use of an appropriate bearing capacity equation and the selection of soil parameters are of utmost importance. For example, if C, φ is used instead of Su (undrained shear strength) to calculate the bearing capacity of soft clay, one could significantly overestimate the bearing capacity, and possibly lead to an un-conservative foundation design. It has to be pointed out that these equations were derived based upon different failure modes, and engineering judgment cannot be ignored while performing a bearing capacity check.

To correctly estimate the settlement of a specific foundation is a difficult task. One can use the theory of consolidation [4]as a basic tool; however, engineering judgment has to be exercised to obtain realistic settlement estimation. As a design practice, soil is often considered as elasto-plastic springs in the structural model, subsequent computer analysis would yield reaction force as well as deformation of soil springs. This type of analysis requires modulus of subgrade reaction (Kv) as an input parameter. Kv is not an intrinsic soil parameter, and cannot be obtained from routine laboratory tests. By simplifying the soil response as springs and with the aid of computer program, the designer can have a better understanding on the overall performance of foundation. But once again, one has to rely upon experience and judgment to select an appropriate Kv for foundation design. Typical values of Kv can be found in reference (Bowles, 1988) [3].

Other than bearing capacity and settlement concerns, some structures may suffer from uplift problem owing to insufficient structural loading. For example, the dead weight of underground parking lot can be less than the buoyancy force of ground water, and it has a tendency to "float". Under this circumstance, auxiliary measures such as installing tension piles or adding extra dead weight has to be taken to alleviate uplift problem.

Recent Developments

In recent years, many high-rise construction sites encountered very soft ground condition. Instead of using large diameter piles to counter bearing capacity and differential settlement problems, the designer could opt to partially improve the foundation soil or revise the plan layout of diaphragm wall. To partially improve the foundation soil, jet grout or deep mixing technique is often adopted to construct discrete soil improvement piles. The partially improved soil mass apparently has a lower compressibility and higher strength than the original soil mass. Diaphragm wall usually serves as temporary earth retaining structure, but it can also be considered as long, slender piles if it is designed to take structural loadings. By using diaphragm wall as load supporting element, the rigidity of raft foundation is increased significantly, and the foundation settlement is minimized as a result.

Conclusions

Deep and shallow foundations are both extensively used in Mesopotamia. Design of the foundations is based upon well-established approaches, which is more or less considered as a routine. As for buildings resting upon soft grounds, engineering judgment must be exercised to reach a safe and sound foundation design. Footings, rafts as well as large bored piles are the three main foundation types in Mesopotamia.

As an alternative to expensive pile foundations, specially designed diaphragm wall or soil improvement can be adopted in conjunction with raft foundation to support the structural loading.

Construction of deep foundation requires good quality control of the retaining system, or the contractor may suffer unexpected excavation failure. The integrity and safety of buildings adjacent to the construction site is also an important issue. Failed to control the ground settlement around construction site may severely damage the adjacent buildings.

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