

**University of Mosul
College of Engineering**



**NUMERICAL AND EXPERIMENTAL STUDY OF
PILED-RAFT FOUNDATION SYSTEM IN GYPSEOUS
SOIL**

PhD Thesis Submitted
by

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Abstract

The presence of gypsum in the soil is considered a complex problem facing the geotechnical engineers when structures are constructed on/or over this type of soil. Gypseous soil distributed in many regions in Iraq. Reduction in strength and increase in compressibility occurs when gypsum dissolves in water, especially in saturation state. This problem becomes more severe, when there is losses for soil mass due to leaching of gypsum during water flows through medium of soil.

The present study investigates the behavior of piled-raft foundation system in gypseous soil. The system concept for this type of footing depends on that the total load for the structure is taken partly by piles and the remaining load is taken by the raft.

The soil used in this study was brought from a region located in Al-Qayiara town, 60 km south of Mosul city. According to the Unified Soil Classification System (U.S.C.S), the soil can be classified as (CL) sandy lean clay. The soil characteristics such as physical, chemical, mechanical and index properties are measured by carrying out laboratory tests.

In order to simulate the actual scale of the field problems and meet all requirements related to the scale dimensions and boundary conditions, a laboratory model has been designed. A number of devices and machines have been manufactured to assist the preparation of the testing model such as electrical grinder machine, hydraulic press machine and laboratory model.

The investigated parameters include vertical loading and number of piles effects on load-deformation behavior at saturation condition, stresses in soil and pore water pressure variation during loading stages and the sharing load by the piles. The experimental results show that the increase in number of piles to 4, 9, 16 leads to increase in the ultimate piled raft capacity Q_{ult} by about 9%, 45% and 72%, respectively.

The numerical analysis using Plaxis 3D foundation program version 2013 show that, the Q_{ult} value from numerical analysis is closed to experimental result. The stress due to external loading decreases with depth and the large reduction occurred at the first 100 mm, the stress reached to minimum values at a depth about twice of footing width (2B). Due to these stresses, the pore pressures within the

piles block are negative under small loading and then increase to be positive with increase in applied load. The pore water pressure near the pile base increased negatively with loading. Also, the pore pressure bellow the raft center is greater than bellow the edges. The load carried by the piles from numerical analysis is greater than experimental and the differences are reduced as the number of piles increased except in 16 piled-raft model, the load sharing ratio α_p for experimental model is greater than numerical model. The load carried by piles increases with settlement and the increasing is more clear with a high number of piles. Also, the rate load shared by piles is higher at small settlement values and then falls rapidly to be constant with increase in settlement.

Behavior of full scale piled raft foundation in gypseous soil at different conditions has been studied numerically. The studying parameters include the effect of piles number and spacing on pile-raft behavior at saturated and unsaturated states. Collapse and consolidation process due to soil saturation are simulated numerically. According to the results, the load-deformation relation has not been affected by changing the spacing between the piles in both saturation and unsaturation states, while the load shared by the piles is different from pile to another depending on the spacing and position of piles in the group. The ultimate failure load at unsaturated state is greater than saturated state by about 500% in case of 4 piled raft and 220% in 9 piled raft system. The load shared by the piles increases as the number of piles increases and it is evident that at saturation condition, the sharing load is greater than unsaturated condition about 65% and 72% in case of 4 and 9 piled raft systems, respectively. The pile load sharing not affected by increasing the collapse potential from 1% to 5%. While, it is increases clearly till reaching 20% c_p then the rate of increase becomes small.

The load sharing ratio by piles is studied with pile group-raft area ratio (A_g/A_r) and net area of piles-raft area ratio (A_p/A_r) and equivalent pier-raft stiffness ($E_{eq}A_{eq}/E_rA_r$). It is found that pile load ratio increases as the (A_g/A_r) increases. Additionally, the increase in settlement leads to increase in the maximum load-sharing ratio. The comparison between effect of pile group-raft area ratio and effect of stiffness ratio showed that the stiffness ratio effect is more significant than pile group-raft area ratio.



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اطروحة دكتوراه فلسفة في
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