

**UNIVERSITY OF PORTSMOUTH
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Ph.D. THESIS

**Investigation of
Pile Foundations in
The Al Hasa Area, Saudi Arabia**

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ABSTRACT

The Eastern Province of Saudi Arabia is experiencing a building boom of midsize and large scale construction projects. The expansion of these development projects is at risk due to the relatively unstudied soils of the area which pose serious problems for new foundations. As larger, heavier buildings are proposed for the region, an appropriate foundation system is needed for these problematic soils.

One populated area of the Eastern Province is *Al-Hasa*, a densely populated oasis of agriculture and communities experiencing a boom in construction. The foundations of these new, heavier buildings are experiencing settlement due to the weak soils of the oasis. A comprehensive study of foundation solutions tailored to these specific conditions is now available.

The main problem for construction in the *Al-Hasa* area of Saudi Arabia is the presence of clay layers, which extend to a depth of 50 meters below the ground surface and are covered with a weak soil, such as Sabkha, cavities and expansive soil. Shallow foundations on this type of clay experience considerable settling problems throughout the life of the building. Therefore, to overcome this problem, a pile foundation is a logical alternative foundation system.

Existing information on using pile foundations is examined and advanced through numerical analyses and analytical studies of the geotechnical characteristics and geological conditions of the area. A definitive understanding of the characteristics of *Al-Hasa* soils supports the need for a more successful foundations system. Field and laboratory tests were carried out in the *Al-Hasa* area to ascertain the characteristics of the soils in relation to known soil characteristics. Crucially, two case-studies of large building foundations, one a hotel, the other a hospital, are documented and the application of value-engineering to foundations is investigated.

Four main applications result from this study. The first is a parametric study of the bearing capacity of single piles detailed for different sizes, depths, and loads in the unique soils of *Al-Hasa*. In the second, the settlement of single piles and pile groups, as well as a group action ratio, for different scenarios is researched for predictive applications. In the third, a formula for the critical depth of piles and liners is concluded for the local conditions. Finally the cost optimization of pile groups is analyzed in order to form a basis for pile design guidelines in the *Al-Hasa* area of Saudi Arabia. The software program ELPLA was utilized to calculate the optimum raft and pile rafts foundations for these problematic soils.