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Correlations Between Well Logs and Geotechnical Properties

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Abstract

Very little work has been done concerning the natural gamma and the neutron tools of near surface marine sediments and their practice in geotechnics. This paper focuses on the application of natural gamma radiation and the neutron absorption for predicting geotechnical properties of marine sediments. Preliminary results indicate positive relationship between the natural gamma radiation and the undrained shear strength as expected, since the natural gamma is proportional to the clay content and therefore, to undrained conditions. On the other hand, a negative relationship has been found between the neutron absorption and the water content. The neutron absorption is inversely proportional to the hydrogen index in the porous media and thus, to the water content. These relationships have been found to be site-specific but the good agreements amongst the properties suggests that geotechnical properties of shallow marine sediments, such as the water content and the undrained shear strength, can be traced with a reasonable degree of reliability by the use of well logs.

Introduction

The fact that well logs can be measured continuously and over large depth intervals makes them especially useful in, for instance, slope stability analysis as critical surfaces may be missed by conventional geotechnical sampling and testing. On of the advantages of using well logs is the measure of in situ measurements of various physical characteristics of the formations penetrated. In situ measurements are more closely related to true conditions than most measured properties in sediment cores. In this sense, correlations among in situ geotechnical tests, such as the Cone Penetration Tests (CPT), and well logs represent a large amount of in situ data that can be used for stating theoretical relationships among properties.

The natural gamma logs are made by measuring the natural gamma radiation released during the integration of radioactive elements, mainly potassium, thorium, uranium, which occur naturally in strata. These elements are mostly concentrated in feldspar, mica, glauconite, and the shaly rocks derived from these minerals such as clays, marls and shales (Rider, 2002). The natural gamma log is the standard lithological log allowing differentiation between the high gamma clays and marls and the low gamma sandstones and carbonates (Asquith and Krygowski, 2004).

Neutron logs are porosity logs that measure the hydrogen concentration in a formation. Neutrons are created from a chemical source in the neutron logging tool. The chemical source is usually a mixture of americium and beryllium, which continuously emit neutron. When these neutrons collide with the nuclei of the formation, the neutron loses some of its energy. Because the hydrogen atom is almost equal in mass to the neutron, maximum energy loss occurs when the neutron collides with a hydrogen atom. Therefore, the energy loss is dominated by the formation's hydrogen concentration. Because hydrogen in a porous formation is concentrated in the fluid-filled pores, energy loss can be related to the formation's porosity. Therefore, the neutron log response is inversely proportional to the hydrogen index (HI) present in the porous media and thus, to the porosity.

This paper gives an overview of the results of a study conducted to establish correlations between well logs and geotechnical properties. Particularly, the natural gamma radiation and the neutron absorption measurements have been correlated with CPT measurements and results from laboratory tests. The research is based on datasets in the Eastern Mediterranean Sea and the Bay of Bengal, which have been merged into the same database. All properties have been cross-correlated and their correlations analyzed statistically.

Data and Methods

The database contains data from 5 engineering borehole logs and 5 CPT from the Bay of Bengal (BH1, BH2, BH5, BH6 and BH8) and 1 engineering borehole and 1 CPT from the Eastern Mediterranean Sea (BH1E) (see Fig. 1). All sites correspond mainly to normally consolidated clays. The exact location and stratigraphic description of the boreholes is not revealed for reasons of confidentiality. The natural gamma and neutron logs were obtained by the neutron tool with natural gamma measurements. In all locations, geotechnical properties