EFFECT OF MOISTURE ON ELECTRICAL RESISTIVITY OF OTTAWA SAND

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Abstract: In this study a few tests were performed on Ottawa sand. The focus was to characterize the relevant electrical properties and then investigate the relationship between resistivity (material property) and resistance (used to monitor).

1. Introduction:

Electrical resistivity is a fundamental material property which has seen usage in widespread areas, such as defect detection in liners [1], identification of potential seepage paths [2],
detection of soil salinity [3], and even estimating soil corrosiveness [4]. Several studies have been done on the effect of water content, degree of saturation, pore fluids and soil structure on the electrical resistivity of soils.

2. Objectives:

The objective was to investigate how water content and density changes may affect the critical electrical property for moist sand. Also investigate the relationship between resistivity and resistance.

3. Materials and Method:

For the first part of the test a cylindrical mold of height 4 in and diameter 2 in was used. Four insertions were made on the curved surface of the mold, both being diametrically opposite to each other, for wire probes to be inserted. Ottawa sand, weighed to 290 gm, was then added to the mold. Tap water was added to the sand specimen in increments of 15 ml. For each increment in the water content the weight of the sample was recorded followed by a measurement of the resistance and reactance values using an LCR device over a frequency sweep ranging from 10 Hz to 300 kHz. For the purpose of this experiment readings were noted at the following frequencies: 20 Hz, 40 Hz, 60 Hz, 80 Hz, 100 Hz, 1 kHz, 10 kHz and 100 kHz. A soil conductivity meter was used to measure the conductivity of the specimen. This was later converted to get the resistivity value. Figure 2 depicts the impedance plot for different water content of Ottawa sand over the previously considered frequency range.

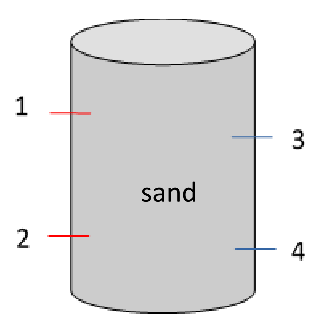

Figure 1: Configuration for electrical resistance measurement

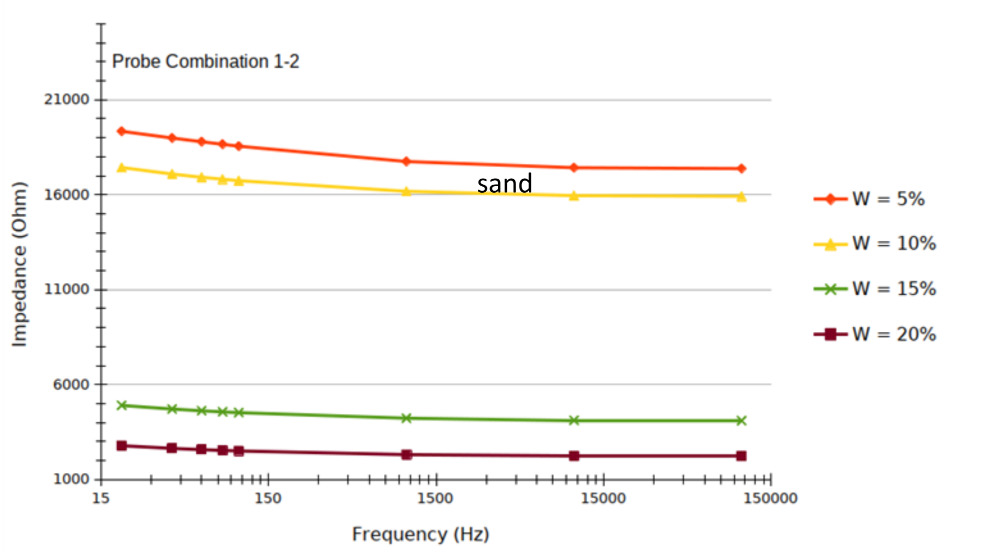

Figure 2: Impedance vs frequency plot for probe combination 1-2 for varying water contents

From Figure 2 two observations can be made. First, that as the water content is increased from 5% to 20% there is a decrease in the impedance value. Second, the impedance value over the different frequency ranges for a given water content does not change much in value. In fact, at 100 kHz the impedance value levels off. This corresponds to case 2: Special bulk material – resistance only [5]. This means that the impedance of the sand is mostly influenced by the resistance of the material.

Figure 3 depicts the resistivity and resistance as a function of the water content. It can be seen that as the water content is increased the resistivity value drops rapidly. It can be seen that after 15 % water content there is not much change in the value of resistivity. This phenomenon corresponds to the onset of saturation conditions in the sand for which the resistivity value remains nearly constant.

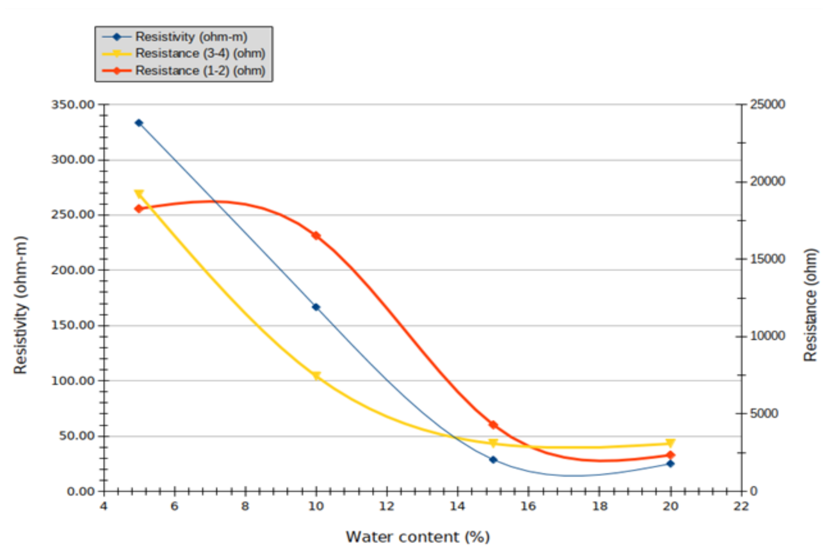

Figure 3: Resistivity and resistance as a function of water content

This observation can be explained by the fact that dry sand has a very high value of electrical resistivity [6]. The resistivity of sandy soil primarily depends on the amount of permeating fluid, the porosity and the pore continuity of the sandy soil. Hence, for a slight increase in the water content we can see a significant amount of decrease in the resistivity value.

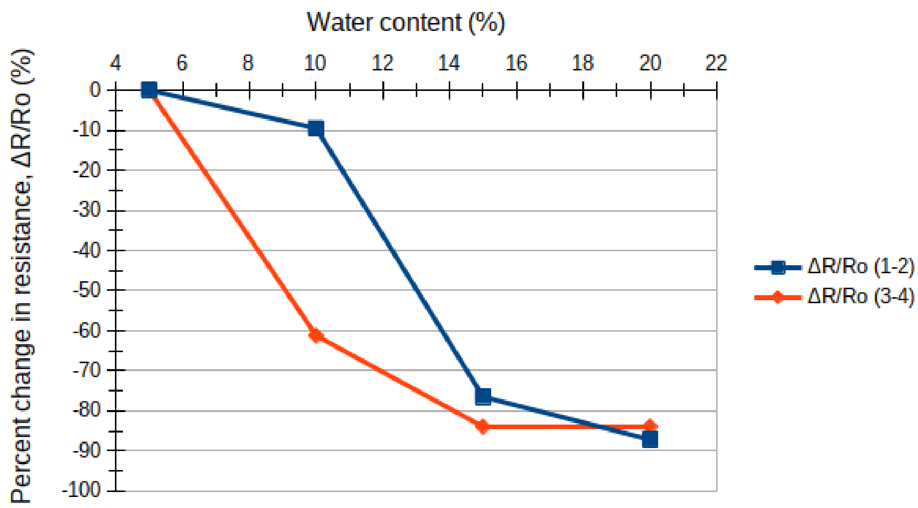

Figure 4: Change in resistance and resistivity with increasing water content

From Figure 4 it is evident that maximum percent change in resistance occurs when the water content is increased from 5 percent to 15 percent for both probe combinations 1 and 2. Also, percent change in resistance is low in when the water content changes from 15 percent to 20 percent water content. Similar behavior is observed for percent change in resistivity. Thus, it can be seen how sensitive change in water content can be towards resistance and resistivity change in sand.

4. Conclusion:

From this study we were able to draw certain conclusions:

1. The resistivity of Ottawa sand is dependent on the amount of permeating fluid, the porosity and pore continuity of the sand specimen. Thus, the resistivity value drops for higher water content and after saturation the value remains constant.

2. The impedance value of Ottawa sand over the frequency range of 20 Hz to 100 kHz (for a given water content) is nearly constant. This behavior shown by Ottawa sand signifies that the impedance of the sand is mostly influenced by the resistance of the sand. Hence, it follows case 2 [5].

3. Maximum change in resistance and resistivity occurs in the range of 5 to 15 percent water content. After that the change is rather minuscule.

5. Acknowledgement
This study was supported by the Texas Hurricane Center for Innovative Technology (THC-IT), University of Houston, Houston.

6. References

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