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Measurement of sand moisture composition for concrete mixture

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ABSTRACT – This study proposes a measurement device that monitors the volume of water in wet sand. The aim is to control the amount of water in the concrete mixture from over-watered sand that would affect the balance concrete mixture ratio during construction process. The proposed system would increase the quality of concrete produced. The system was programmed using a micro-controller to send an interrupt signal to the monitoring system depending on the soil moisture levels. The soil moisture/humidity levels are checked using soil moisture sensor. Whenever there is a change in moisture/humidity in the soil, the sensor sends an interrupt signal to the micro-controller and the data will be fed to the monitoring software.

1. INTRODUCTION

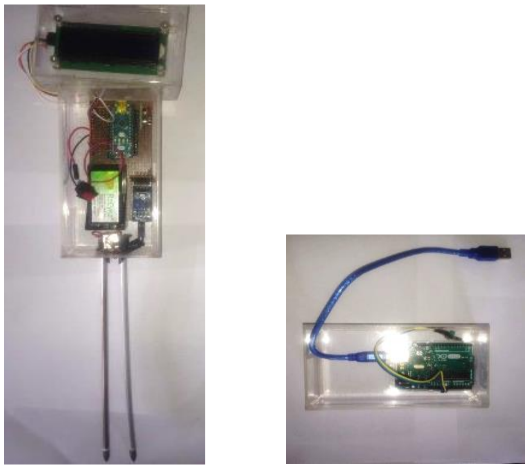
Concrete is the most widely used construction material in Malaysia. Aggregate is one of the essential components in producing a good concrete. Aggregate is useful in reinforcing the structure. Water in the aggregate is the most important things that must be controlled to produce a good quality of concrete. Water absorption or moisture absorbent is defined as weight of water absorb by dry aggregate particle in reaching the saturated surface dry condition. It is usually expressed as the percentage of dry weight [1].

Having the correct sand moisture level in processing mixtures is very critical in various stages of production, such as concrete manufacturing. The sand mixtures can easily become either too wet or dry. Too much water can be detrimental to both the fresh and hardened concrete properties, especially strength, long term durability and potential for cracking. These can be detected through the slump test, a test conducted to ensure the uniformity of different loads of concrete under field conditions [2]. The current practice of sand moisture detection in Malaysia is tedious. The sample of wet sand must be sent to a laboratory to obtain the percentage of moisture content.

This is obviously a time- and money-wasting process, which might affect the quality of the end product. Therefore, this study proposes a device to measure the moisture content in wet sand using dielectric technique, which measures the difference of dielectric constant of dry soil and that of pure water [3-6]. The relationship between the percentage and volume of water in sand is identified in the experiment. The prototype involves monitoring using (MATLAB) and the data of moisture will be calculated. In summary, the objectives of this study are to develop a device that can measure the quantity of water in wet sand with a wireless monitoring system for the purpose of data collection, and to study the relationship between the percentage of moisture and volume of water from the data recorded.

2. METHODOLOGY

The device was developed using two microcontrollers; Arduino Nano and Arduino Uno. The former was used for the sensing device, and the latter was used to feed the data into the software. The measurement of the moisture content was achieved through a soil moisture sensor, which was connected to the Arduino Nano. A graphical user interface (GUI) was developed in MATLAB for monitoring purposes. Figure 1 shows the proposed device. The length of the moisture sensor is 29 cm, which enables it to deeply penetrate into the sand.



(a) (b)

Figure 1 The proposed device. (a) The moisture sensor. (b) The receiver.

To validate the functionality of the device, several experiments were conducted. The followings are the steps taken during the experiment:

a) Preparing the materials.
b) Drying the sand for 24 hours.
c) Measure the weight of the sand.
d) Pour water accordingly into the sand.
e) Measure the moisture content using the device.
f) Record the data of the measurement.

The sensor used is a resistance type sensor. Its output is the resistance in the soil between the two probes. The measurement basis is that the resistance or impedance differs when the moisture content is different. In the experiment, the sands were categorised according to its weight: 2, 5, 10 and 20 kg.

3. RESULTS AND DISCUSSION

An experiment was conducted to evaluate the functionality of the device as shown in Figure 2.

Figure 2 Measurement of water content in the sand.

Water was added into the dry sand in steps of 0.1 litre and sensor value was recorded. The raw value recorded by the sensor for dry sand was identical across all weights. Upon adding 1 litre of water, the resistance value of the sensor was significantly reduced as depicted in Figure 3.

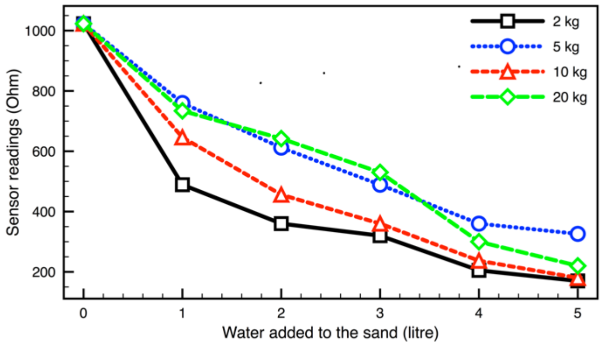


Figure 3 Sensor readings against water content.

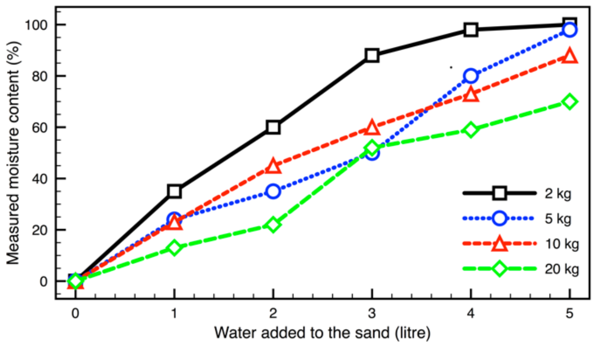


Figure 4 Percentage of moisture contents measured.

The sensor reading kept reducing with the increase of the amount of water added. After 3 litres of water was added, the sand resistance started to reduce at a much slower rate. This is because at this point the sand has become saturated with water, thus adding more water has only a slight effect on its resistance.

The graphs in Figure 3 are somewhat exponential. This is because an ideal sensor has a large and preferably constant sensitivity in its operating range. It is also seen that the sensor eventually reaches saturation, a state in which it can no longer respond to any changes.

The device was equipped with a liquid crystal display (LCD) display as shown in Figure 2. The display shows the percentage water content in the wet sand. It is evident from Figure 4 that the device is capable of measuring the percentage of water/moisture contents in the sand. As water was added into the dry sand, the percentage of water content increased. Nonetheless, for 2 kg sand, the increment is no longer linear after 3 litres water was added. This was due to the similar previously described reason.

4. CONCLUSION

A device to monitor the moisture levels of wet sand was developed. The device measures the moisture content and calculates the percentage of water in the wet sand. The aim of this device is to provide an effective way to control the amount of water in the concrete mixture to prevent over-watering of sand that can disturb the balance of concrete mixture ratio during construction. The proposed device is not only cost effective, but also time-saving as opposed to the current practice in measuring the moisture content of wet sand. This device would benefit many construction companies, not to mention government agencies such as the Malaysian Public Works Department.

ACKNOWLEDGEMENT

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