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MEMO

Master thesis wireless underground sensor network

1. Introduction

For many different Boskalis activities, information about the subsoil is essential. In the execution phase it is important to monitor soil behavior for example in order to safely perform these activities or to optimize the productions. Nowadays sensors with a data cable (wired) are used in the subsoil, but this gives some practical problems and too often sensors are not placed for that reason. Recent developments make it possible to use wireless sensors in the subsoil.

2. Wireless underground sensor network

Wireless communication through the soil is significantly complex compared to wireless communication through the air. An example of wireless underground sensors is shown in Figure 1. Literature studies can be found which refers to a wireless underground sensor network (WUSN) (Akyildiz & Stuntebeck, 2006) or Internet Of Underground Things (IOUT) (Vuran *et al*, 2018). These studies are mostly related to applications in agriculture in which the topsoil refers to the first 30cm of soil and the subsoil to 30-100cm (Vuran & Silva, 2010). However for geotechnical applications related to Boskalis activities much higher depths are required, for example up to 10m.

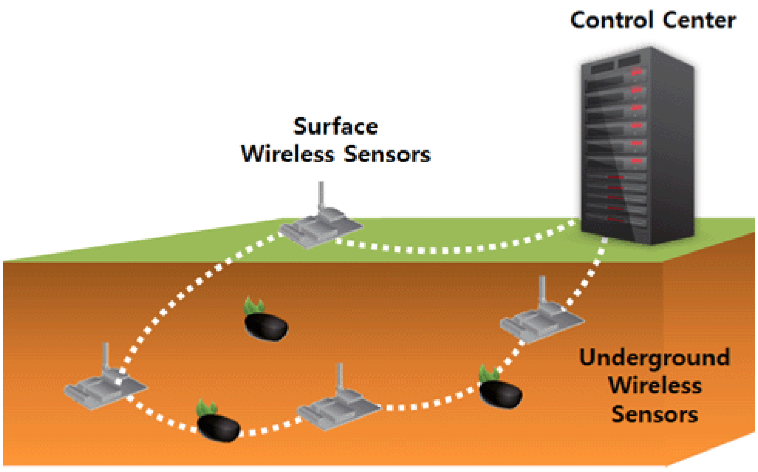

Figure 1: Underground wireless sensors. Retrieved January 16, 2019 from http://uc.cse.cau.ac.kr/sensor.html.

3. Applications

There are various applications of wireless underground sensors with major advantages compared to non-wireless sensors. A few examples are described here.

3.1 Settlement

Monitoring of the settlement of the subsoil during and after land reclamation (onshore and offshore) is important in order to predict the final settlement and to optimize the productions. An example of an offshore bund construction is shown in Figure 2. Generally, the settlements are monitored with settlement beacons (Dutch: zakbaken) as shown in Figure 3. A steel plate with a connected tube is placed on the original surface level (or seabed level). Sand is placed on top of the steel plate and during and after filling the height of tube is measured at different times. A disadvantage of this method is that it is practically impossible to place a settlement beacon under water and above water it is an obstacle for construction traffic.

Figure 6.9 *Bund construction using rainbowing.*

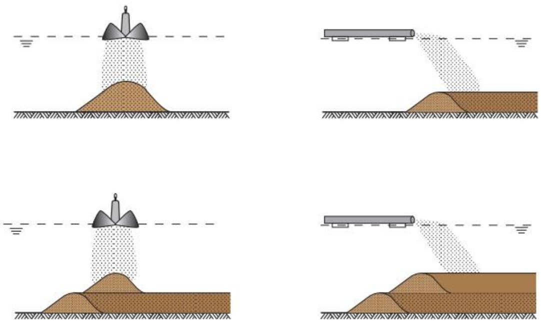

Figure 6.10 *Staged bund construction under water using a grab dredger.*

Figure 2: Bund construction under water (from van 't Hoff & van der Kolff, 2012)

Figure 3: Settlement beacon

A sensor can measure for example the water pressure and total pressure. When placed under water, it is theoretically possible to calculate the settlement. However it is never done in practice as it costs quite some effort to place a sensor with cables. Besides that, it is preferable if the sensor is able to measure its own depth directly. If a wireless sensor could be placed at surface level or seabed before filling with sand, data should be transmitted through several meters of sand to for example a station above the soil. This sensor should operate for several months to a few years.

3.2 Slope stability

A slope of an embankment or dike can fail during construction or due to other circumstances, for example a high water level. In order to predict the soil behavior and to calculate the safety against a possible slope instability, several measurements are very useful such as the water pressure and deformations. These measurements are performed in the embankment or dike or in the subsoil (sand / clay / peat) underneath up to a depth of 10 to 20m. Nowadays, it is common to place water pressure sensors in the subsoil with a cable to surface level where the data is send through the air to a control center. However, it costs some effort to maintain the cable and to avoid damage during construction. A wireless sensor solves these disadvantages.

More sensors can be placed if it is relatively easy and cheap which gives more insight into the soil behavior. Probably there are many more applications in different fields (not only geotechnical engineering).

4. Master thesis

Boskalis is looking for a student with a background in communication systems. The study, which can start around August 2019, should include a literature study and experiments with wireless communication through soil. The full details of the thesis subject can be decided between the supervisor and student. The study will be carried out at the in-house engineering department of Boskalis (Hydronamic), and at the University of Twente.

5. Company profile

Boskalis is a leading global services provider operating in the dredging, infrastructure (land and water) and maritime services sectors. The company provides creative and innovative all-round solutions to infrastructural challenges in the maritime, coastal and delta regions of the world with services including the construction and maintenance of ports and waterways, land reclamation, coastal defense and riverbank protection.

References

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