

#### **1.14.14. A WIRELESS MONITORING SYSTEM TO STUDY THE SETTING AND HARDENING PROCESSES OF CEMENTITIOUS MATERIALS**

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Traditionally, the study of cementitious materials has been performed using wired sensor technologies. Because these technologies are expensive and difficult to install, the use of wireless sensor networks has gained increasing importance.

There is plenty of literature dedicated to the study of the problematic use of wireless networks to monitor the structural integrity of materials. Considerable improvements have been achieved in the sensorization of different structures. But it is still necessary to enhance the reliability of these networks to evaluate and monitor structures during the setting and hardening processes. Power consumption of Wireless Sensor Networks (WSN) must be minimized for an efficient use of this technology in the above mentioned applications, since the continued use of WSN for long periods of time relies on the duration of the batteries. Since data communication/transfer between network nodes consumes more energy than data processing, it is essential that the data acquired by each node is significantly reduced before it is sent to the base station. Data reduction is especially important for dynamical monitoring processes, which require a huge sampling rate. The base station should receive the data from each node and provide diagnostics to detect anomalous states. Furthermore, the base station is the access point to the network through remote control and must allow monitoring, control and configuration of the network for storing and post-processing of the received data.

To accomplish all the above requirements, a monitoring system based on a WSN should incorporate a computation system distributed through the network. Optimization of the sensor sampling rate is also required.

In this paper we report the construction of a wireless sensor network using Cricket and Micaz motes to monitor the setting and hardening processes of cementitious materials. These motes were purchased from Crossbow Technologies. The basic computing power of a mote is provided by an Atmel ATmega 128 processor with 4KB dynamic data RAM, 128 KB program ROM, and 512 KB EEPROM. Cricket motes also have an onboard Chip-Con CC1000 radio transmitter/receiver capable of 38.4 Kbps with a programmable range of up to approximately 300 m. Micaz motes are provided by an IEEE 802.15.4 radio with a data rate of 250 Kbps. For our research, the most important capability of Cricket motes is that they host transmitter/receiver in the ultrasonic wavelength region.

Since Cricket motes were intended for indoor location systems and they have an ultrasound transmitter/receiver for time of flight ranging, they have been adapted by reprogramming the application for inspection of concrete structures. A through transmission method was used to compute the velocity of the ultrasonic signal in concrete.

Since the setting and hardening processes duration is optimum for the energetic capacity of these motes (1 month aprox.), it is possible to monitor the setting process using the velocity measurement and adding humidity and temperature sensors. Multi-hop data transmission techniques were considered for monitoring the velocity data. Power consumption has also been considered, since this parameter affects the life duration of a wireless network.

The Wireless sensor network proposed was tested experimentally using several motes in the laboratory and in a precast concrete company. The first preliminary results are promising.