Smart self-powered RFID based tagging system for concrete pavements

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ABSTRACT

Several parameters significantly impact concrete pavement strength, durability and performance from the time that it is placed onwards. These parameters include: environmental factors during construction such as ambient temperature, humidity, and wind speed; system properties such as mixture constituents, air voids, pavement geometry, fresh concrete properties, subgrade friction and support, and steel location (for reinforced pavements); and other properties such as moisture gradients, cement heat of hydration, moisture loss, chloride concentration, sodium and potassium ions, and nonlinear built-in temperature gradients. Furthermore, any discrepancies between projected design properties and actual mix properties during construction constitute one of the major problems leading to erroneous long-term performance predictions. Such comparison data is particularly useful during forensic analysis to identify the potential causes of unexpected failures.

Though recently there has been significant research activity in distributed wireless sensors for monitoring industrial process parameters and environmental conditions, all of the commercially viable sensors developed to date would not be practical for embedded distributed sensing. The size limitations and power consumption requirements are usually prohibitive. The currently available technologies, as well as the traditional data storage and recovery techniques, are cumbersome and impractical for the management of large networks. There is a need for a smart easy way to access systems that would allow the preservation of critical data, facilitate the flow of information, and eliminate the need for bulky and hard to track data bases.

In this paper, the development and prototype testing of a low cost tagging system are presented. Prototypes were installed at the Turner-Fairbank Highway Research Center - FHWA. The prototypes were able to withstand the compaction process. The tagging system was able to store and transmit information. The system has the following attributes:

1. Small size suitable for integration in fresh concrete without affecting its properties and performance;
2. Zero-power consumption (self-powered operation) to allow for extended operating lifetime and autonomous capabilities;
3. Wireless communication: Information collected during construction (mixture properties, weather, etc) is stored in a long-term memory and embedded in the structure. The information can be wirelessly accessible at any time during the lifetime of the pavement. These construction conditions data can be useful for performance prediction using the Pavement ME software, as well as for pavement management purposes (inventory information) and forensic investigations;
4. Robustness to withstand harsh environmental conditions;
5. Low cost (<$1), and possibility of networks deployment; and
6. Ease of use: A user interface was developed to facilitate the use of the pavement tagging system by highway agencies.