Development of Environmental Monitoring Sensor for Steel Corrosion in Concrete based on Micro-Electro-Mechanical Systems (MEMS)

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Many bridges located near marine environment usually have high risk to lose their structural performance due to corrosion of reinforcing bars with chloride attack. While a huge amount of budget to maintain may be consumed for the structural maintenance methodologies, an efficient monitoring system for RC structures in the corrosive environment is strongly demanded. Thus, structural health monitoring in real situations is significant for bridge asset management. The alternative way for preventing severe damage propagation is proactively monitoring the environmental condition containing chloride condition and its effect on the durability of concrete structures, for which numerous methods have been conventionally suggested such as dry gauze method to capture chlorides in air. In this study, a Micro Energy Harvester (MEH) based on Micro-Electro-Mechanical Systems (MEMS) is technically applied to develop a sensor to measure and identify the corrosion environment with chlorides in the exposure condition. MEMS is a rapidly evolving device, which enables to monitor the changes in natural frequency and amplitude at nodal locations of the targeting structure due to vibration-based electrostatic power generation induced by the corrosive environment. The purpose of this research is to develop a system for detecting the high corrosion-prone areas and finding the suitable metal sheet material for various chloride ion condition, using the metal sheet as a cantilever structure for the MEMS device. 4 types of metal, aluminum, copper, iron and zinc are considered for the parametric experiments. Several scenarios are considered including chloride ion concentration, temperatures, and wet/dry conditions to compare the dominant frequency changes of each metal sheet and determine their sensitivity to corrosion environment. From the preliminary results, iron and zinc have a significant drop in frequency with the elapsed exposure period, which indicates that they are highly sensitive to external chloride ion environment. These results offer an innovative and proactive approach to structural health monitoring for further developed applications. It enables prompt maintenance and early detection of potential issues for corrosion of steel bars in concrete, ensuring the longevity and safety of RC bridge structures.