Geophysical Research Abstracts
Vol. 16, EGU2014-9427-6, 2014
EGU General Assembly 2014

Electromagnetic sensors for monitoring of scour and deposition processes at bridges and offshore wind turbines

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Recent increases in precipitation have resulted in severe and frequent flooding incidents. This has put hydraulic structures at high risk of failure due to scour, with severe consequences to public safety and significant economic losses. Foundation scour is the leading cause of bridge failures and one of the main climate change impacts to highway and railway infrastructure. Scour action is also being considered as a major risk for offshore wind farm developments as it leads to excessive excavation of the surrounding seabed.

Bed level conditions at underwater foundations are very difficult to evaluate, considering that scour holes are often re-filled by deposited loose material which is easily eroded during smaller scale events. An ability to gather information concerning the evolution of scouring will enable the validation of models derived from laboratory-based studies and the assessment of different engineering designs. Several efforts have focused on the development of instrumentation techniques to measure scour processes at foundations. However, they are not being used routinely due to numerous technical and cost issues; therefore, scour continues to be inspected visually.

This research project presents a new sensing technique, designed to measure scour depth variation and sediment deposition around the foundations of bridges and offshore wind turbines, and to provide an early warning of an impending structural failure. The monitoring system consists of a probe with integrated electromagnetic sensors, designed to detect the change in the surrounding medium around the foundation structure. The probe is linked to a wireless network to enable remote data acquisition.

A developed prototype and a commercial sensor were evaluated to quantify their capabilities to detect scour and sediment deposition processes. Finite element modelling was performed to define the optimum geometric characteristics of the prototype scour sensor based on models with various permittivity conditions. The experimental analysis was conducted using simulations and open channel flume tests in different sediment and temperature conditions. The density and salinity effects on the response of the sensors were also evaluated and reported herein.

The obtained results indicate that the sensors are capable of exhibiting high sensitivity to scour and sediment deposition processes under the different tested environmental conditions. Saline water and temperature induced electrical conductivity changes were also found to have inevitable influences on the sensor signals. Based on this research, it is concluded that the proposed monitoring system has considerable potential for field applications that will contribute to improving the resilience and sustainability of hydraulic and marine structures.