Urban Dark Fiber Distributed Acoustic Sensing for Bridge Structure Monitoring

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Résumé

The collapse of several structures such as the Morandi bridge in Genoa in 2018 has made securing the operation of structures an important societal issue. Thus, some countries investigate the structural condition of buildings located on their territory in order to optimize maintenance and ensure the safety of users. The usual structure monitoring strategies are based on static or dynamic measurements sampled and applied periodically from sensors. Distributed Acoustic Sensing (DAS) technology is an alternative offering other observational possibility, by giving easy access to a multitude of experimental data along telecom fiber optic networks Involving various economic players (Febus Optics, Covage) and regional institutions (Métropole de Lyon, Région Auvergne Rhône-Alpes), the DASARA project (Tauzin et al., 2020) consists of using DAS technology to take measurements over a wide geographical coverage in an urban environment to extracting information of interest to civil engineering and geotechnics. The experiment made on the bridges is part of this project and aims to extract the dynamic responses of four bridges using 53 hours of DAS data acquired on a 24 km long telecom fiber running through the Lyon metropolitan area from West to East. This data were acquired in November 2021 with a sampling frequency of 400Hz. The dynamic response of each bridge was obtained by calculating the PSD of the temporal data using Welch's method. From this characteristic seismic signature, three physical parameters informing on the health of the structures were determined: the vibration frequencies, the damping and the modal shapes which reflect the deformations of the structure. The damping was calculated using the Random Decrement method and the modal shapes using the nonparameterized SSI-COV method. Our results showed that the amplitude of the vibration modes fluctuates with the intensity of anthropogenic activity before stabilizing at night. Therefore, it seems preferable to point the frequencies of structures at night when the amplitudes are not influenced by variations of the intensity of the seismic source which is the ambient noise. Also, areas of low amplitude have been identified along the bridges. These zones correspond to the position of the piles of the structures and testify to the soil-structure coupling existing between the deck and the underlying soil. By using the existing Internet network fiber, this study shows that it is possible to assess the spatial and temporal variability of the dynamic response of bridges. Thus, we have developed a tool to perform a spatio-temporal monitoring of the three physical parameters mentionned before in order to detect and/or follow the evolution of a potential damage. By following the evolution of these parameters with this tool, it is possible to detect structural damage and thus limit the risk of bridge collapse.

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