integrating low-frequency and high-frequency geodetic techniques for structural monitoring

Castagnetti Cristina[1], Alessandro Capra[1], Bertacchini Eleonora[1]

(1) DIEF – Department of Engineering Enzo Ferrari, University of Modena and Reggio Emilia, via Vignolese 905 - 41125 Modena (Italy)

The research is focused on the integration of geodetic techniques for structural monitoring and movements identification. The final purpose is to integrate multi-sensors data collected in continuous mode both with high-frequency and low-frequency logging rates in order to underline how a multi-sensors approach plays a key role for providing a successful monitoring. Indeed, the integration among different and independent technologies for analyzing structures changes over time is essential for providing reliable results and for planning measures taken to strengthen the stability of the structure.

The research deals with the integration of traditional low-frequency sensors such as inclinometers and distanciometers together with innovative high-frequency GNSS systems. The first sensors are supposed to detect the long-period trend of the structure responding particularly to the environment conditions and to the natural long-period phenomena such as the subsidence or the interaction with the soil. The second sensors are meant to detect short-period effects on the structure due to the 'instantaneous' stresses occurring for unexpected events, such as earthquake or due to urban impacts such as the traffic.

Considering the importance of protecting the cultural heritage, the present research focuses on monitoring ancient towers, built by long and complex steps without concrete nor steels. The case studies are the Ghilandina Tower (Modena, Italy) and the famous Garisenda and Asinelli Towers (Bologna, Italy). The geometry (narrow section, no foundation, height up to 90m) together with the overhang and the inclination lead to a continuous monitoring by traditional sensors; moreover some tests with high frequency GNSS were carried out in order to investigate the potentialities in the identification of vibrations.

For each sensor raw data are deeply managed and analyzed in order to provide reliable time series which are then integrated and cross-compared in order to confirm and validate solutions obtained by a single technique. In detail the paper will go through the methodology in order to highlight the main steps of processing, de-noising, filtering and signal analysis before focusing on the integrated interpretation of results. Difficulties will be described; in particular the complex correlation analysis to identify the response of the tower to atmospheric conditions (mainly temperature and wind velocity/direction) or the way to remove the influence of the atmosphere from the time series of sensitive sensors in order to avoid misinterpretations.