Monitoring Oscillations of Slender Structures with GPS and Accelerometers

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SUMMARY

Slender structures (such as the chimney of thermo-electrical power plants) oscillate due to dynamic loading by wind, temperature differentials and earthquakes. The Italian Centre for Experimental Electric Science (CESI) started a project, in cooperation with the Polytechnic of Milan, to monitor the structural integrity of an industrial chimney and to identify at any time signs of stiffness changes, perhaps due to breaches, enervations or material fatigue. To this aim, an integrated system combining GPS and accelerometers measurements, from very low frequencies up to 100 Hz, is being set up. The goals are first to identify the principal modes of oscillation to characterize the response of the chimney and later to monitor structure behaviour to detect critical situations in nearly real time. The prediction capability of the system will stand principally on tracking the evolution of the eigenfrequencies and of the maximum amplitude of oscillation of the chimney connected to the intensity of the loads.

The system will be installed on a chimney of the power plant of Piacenza (Italy), 120 m high. It will acquire data at a frequency of 10 Hz from 3 GPS (one rover on the chimney, connected to the acquisition and processing unit by a WI-FI system, and two masters) and at 100 Hz from 2 tri-axial accelerometers on the chimney. Simultaneous acquisition of anemometer data is also foreseen.

Data analysis rests on an initial DFT computation, followed by a l.s. interpolation of the rover movement which allows to estimate the accuracy of the frequency determinations. This in turn enables a time series analysis procedure based on statistical test, to highlight changes or trends in the principal mode of vibration coming from breaches or material fatigue.

After the system description, the data analysis procedure will be explained in detail and results on a series of tests prior to system installation will be described, showing the high sensitivity of the system to frequency changes.