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GPS BASED STRUCTURAL IDENTIFICATION: A FEASIBILITY STUDY

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ABSTRACT

The Global Navigation Satellite System (GPS, GLONASS and the future GALILEO) has been proved to be a useful tool for precision monitoring applications in structural engineering. The American Global Positioning System (GPS) provides sampling rates which are sufficient to track tri-dimensional dynamic displacements of objects with high accuracy at a sub-centimetre level. Thus, in the past few years, the GPS has become an alternative to the common accelerometers to measure the vibration of flexible structures. It was successfully applied to monitor the structural response of many different structures like suspension or cable-stayed bridges, dams and tall buildings. Monitoring the performance of these structures means to collect, in real time, the change of position of critical points, by installing GPS receivers at key locations to capture static and dynamic displacements in all weather conditions. The drawbacks are mainly of two types: (i) these receiver must be installed with free sky (no obstacles between them and the reference satellites); (ii) the sensor resolution and the associated error strongly depend on the GPS network architecture.

Previous experimental work of the authors showed a significant dilution of precision (DOP) of the GPS signal, due to a deviation from the idealized geometric distribution of satellites, in the period of 24 hours. This fact have been attributed at the position chosen for the GPS sensors beside the building. The presence to the building itself could have obstructed, for some hours during the day, the tracking of a sufficient number of satellites (they must be at least four), and consequently caused a non-stationarity of the precision in real time positioning measures. Placing the GPS receivers on the roof would have satisfied some requirements necessary to improve the precision of the satellite measures: the GPS antennas have now a clear view of the sky above in order to track the orbiting satellites, from seven to twelve during the day, and the signal trail satellite-receiver is not affected by multi-paths errors.

This paper investigates the feasibility of a monitoring/identification/structural-health-damage-assessment via a GPS network (Fig. 1a) for a standard industrial building. For this purpose dual frequency GPS receivers are located on the roof of an industrial steel structure located in Pavia. A real time kinematic (RTK) configuration is necessary to guaranteed the transmission of data correction between the fixed and the moving

receivers and to avoid GPS positioning errors. The goal is first to compare the accuracy of the GPS technology in acquiring vibrations of the monitoring points, due to natural and man-made actions, with those acquired by three-axial accelerometers also placed on the roof nearby the GPS units. Then, from the results of some experimental tests, one tries to achieve the same structural identification conclusions. A finite element model of the structure is also realized (Fig.1b), wind action and bridge-crane movements are simulated, thus allowing one to detect the nodal displacements of the structure and to compare them with those acquired by GPS units. The main issue of this contribution is the way the GPS data have to be processed across the identification scheme.
Vibrations will also be induced by suitably driving a crane mobile along rails which is installed in the buildings. The goal here, secondary, but not less important, is to check the possibility of obtaining information on the lower part of the structure even if only roof measurements can be collected.

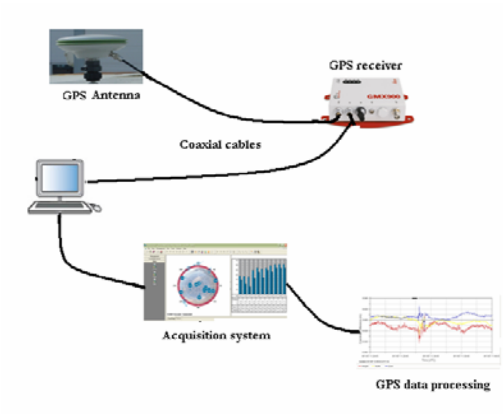

Fig. 1a GPS network architecture

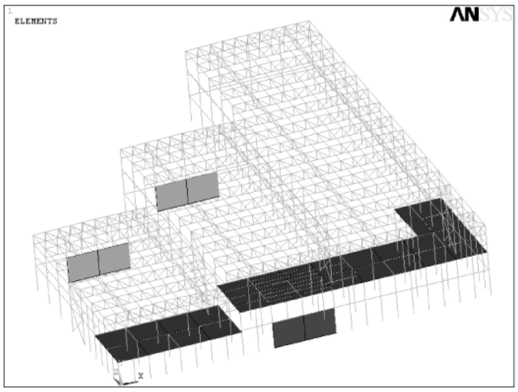

Fig.1b FEM model of the steel building

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