Health monitoring test of heritage structures by MEMS accelerometers: application to multi-tiered pagoda temples

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ABSTRACT

The paper presents health monitoring tests conducted on heritage structures by means of micro-electromechanical systems (MEMS) accelerometers. The monitoring test was adopted to two multi-tier pagodas in Nepal. The monitoring continued for six months in each case. During the monitoring period, the MEMS accelerometers captured a number of vibrations caused by earthquakes. This helped detecting eigenvalues and eigenvectors of the tested structures.

The peculiarity of the present research is derived from the efficacy of the used accelerometers. They measure acceleration tri-axially under the condition set by the internal MIDI processing unit. The noise level is less than 1/5000 g and to an inclination of 0.01 degree. The sampling rate can be set between 10 Hz to 200 Hz. It is possible to apply higher sampling rate only when strong vibrations are observed. It can be controlled by the trigger criterion. This allows the MEMS to record detailed data of only strong vibrations and to save the battery and disk space. Theoretically, the monitoring for two years at maximum is possible without changing the battery or downloading/removing the stored data.

MEMS were commonly used in the automotive and mobile technologies [1]. Recently, the MEMS are used also in the civil and structural engineering field. The MEMS permits the monitoring in the wireless environment. This is convenient especially for heritage structures since the installation of sensors can be restricted due to the access limitation in some structures. Thanks to the development in the MEMS technology, today MEMS can perform much higher resolution monitoring than decades ago [2]. However, still further investigations are necessary for reliable monitoring of historical structures by means of the MEMS. For instance, when sufficient excitation does hit the structure, the MEMS accelerometers may not capture higher modes as clearly as piezoelectric accelerometers [3].

The paper introduces health monitoring tests adopted to heritage structures. Taking advantage of the vibrations observed by the MEMS accelerometers, the principal mode of the tested structures was detected. The identified eigenvalue and eigenvector was close to those observed by the previously conducted dynamic identification test. The present research provides insights on efficient strategies for monitoring of heritage structures by means of MEMS accelerometers.

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