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Structural Health Monitoring of Cultural Heritage Monuments

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From the engineering point of view, scientists working for the restoration of stone temples of classical antiquity need: (i) Detailed data for the mechanical properties of the materials used (for the construction of the monument and its restoration), (ii) Accurate description of the mechanical response of structural elements made of natural building stones and reinforcing elements, and (iii) Tools for continuous Structural Health Monitoring (SHM) of the response of restored members.

SHM of restored elements of stone monuments is quite a challenging task taking into account the additional difficulties dictated by their unique cultural value and aesthetic splendor [1]. In this context, some of the techniques most widely used for SHM (Acoustic Emissions (AE), use of optical fibers, quantification of electric resistance changes of embedded fibers with carbon nanotubes) are here considered comparatively against a novel, recently introduced technique, which is based on the detection of very weak electric currents generated when brittle materials are mechanically stressed [2], known as Pressure Stimulated Currents (PSC).

In this study advantage is taken of the experience gathered from the ongoing pioneering project, implemented during the last twenty years on the Parthenon Temple on the Acropolis of Athens. Scientists working for this project restore fractured structural elements of the Temple using threaded titanium bars embedded in pre-drilled holes (which are filled with suitable cementitious paste), thus creating a three-material-complex. Long series of laboratory experiments, both elementary and structural (with specimens simulating restored epistyles), indicate that the recordings of the PSC technique follow closely those of the AEs. Moreover, it is concluded that the PSC-data provide clear pre-failure warnings [1] designating entrance of the system in its critical stage (impending fracture), indicating that the PSC technique could be indeed considered as a reliable alternative tool for SHM.

[1] S.K. Kourkoulis, Procedia Structural Integrity, 10, 3, 2018.

[2] D. Triantis, I. Stavrakas, C. Anastasiadis, A. Kyriazopoulos and F. Vallianatos, Physics and Chemistry of the Earth, 31, 234, 2006.