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Integrated and Multi-Scale NDT Tests for the Study of Artifatcs and Architectural Heritage

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The preservation of artistic and architectural heritage represents a bench mark of the cultural development of a society. To this end it is necessary the conservation of the material components and the knowledge of those values (historical, artistic, symbolical etc) which represent the intangible aspect of the cultural heritage. These two scopes can be reached by means of a multidisciplinary and interdisciplinary approach in which Non-destructive testing (NDT) provide a significant resource of information on materials, state of conservation and building techniques. In particular, some case histories (Binda et al. 2001, 2003; Masini et al. 2007) show how complex it is to design the repairing interventions on historic stone masonry buildings. Most of them are characterized by load bearing structure which are highly inhomogeneous which make the structural modelling very difficult. For this reason any repairing work need the knowledge of the technique of construction and the characterization of the state of conservation with particular reference to voids, cracks and decay. To do this in the past the only way was based on destructive survey through coring or local demolition. Fortunately, today an increased awareness of the cultural value and the brittleness of artifacts and monumnents to be restored do not allow anymore destructive investigations. This favoured the use of NDT as thermography, sonic and ultrasonic tests, GPR as well as laboratory analyses for the material characterization.

The paper outlines the advantages and the drawbacks in the use of sonic, ultrasonic and electromagnetic systems (Ground Penetrating Radar,GPR) and the exigency to integrate them; thus allowing to obtain a reliable reconstruction of the internal characteristics of building elements from the physical and geometrical point of view and the detection of defects. As well known the techniques are based on different principles,

because the emitted waves have different origins: stress waves for sonic and ultrasonic tests and EM waves in the case of radar. The theoretical capabilities and limitations of the techniques are strictly related to the frequency content of the signals. The parameter involved by the stress waves are the density , dynamic modulus of elasticity, and Poisson's ratio; which the velocity depend on. Whereas EM wave velocity in a homogeneous dielectric material is basically a function of the permettivity. Both the stress wave and EM wave velocity allow to recognise defects and features, with a resolution depending on the dominant wavelength of the incident wave and the size of the investigated element. As well known the wavelength is a function of velocity and frequency. For a given velocity, the frequency is in inverse relation to the wavelength. In its turn frequency is in direct proportion to the resolution as well as to the rate of energy absorption, thus limiting the size of the building element that can be tested and characterized. Therefore, the attenuation signal and resolution requirements have to be considered in order to choise the optimal frequency.

This is not the only aspect to consider. Both of test methods present some drawbacks. As regards the stress wave based test the input frequency changes with the characteristics of the superficial material. In particular the high frequency components can be filtered by the presence of a thick plaster or a partially detached plaster as well as the presence of discontinuities in the masonry core. This reduces the resolution and the capability detecting in detail the inner morphology of masonry structures. In such situation the radar tests show some advantages. On the contrary radar has more problems in the presence of moisture because the absorption is proportional to the water content of the material. For this reason GPR is not capable to evaluate the effectiveness of grout injection. In this sonic tests are employed with good results just to control the distribution of the grout injected in the masonry. On the contrary GPR is a reliable technique to detect inner metallic elements which were employed in ancient times (Greek and Roman Age) to join each other dressed blocks, elements of columns and architrave as well as in the Middle Age to connect columns and capitels of rose windows (Masini et al. 2007).

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