Calibration of Ultrasonic Testing for Faults Detection in Stone Masonry

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Abstract

Building preservation is a complex problem to deal with, especially for building of historical relevance so as inspection and monitoring of structural conditions is an essential part of proper management of buildings rehabilitation. In the field of assessment methodologies, particular importance is given to Non-Destructive Testing Techniques (NDTs) that aspire to achieve the highest number of information about materials and structures without altering their condition. Among NDTs, Ultrasonic Testing (UT) exploits the transmission and reflection characteristics of mechanical waves with appropriate frequencies passing through the investigated item [1]. Elastic waves propagate in different manner through solid materials and cavities, thus enabling fault detection. When a signal passes through a specific item, certain frequency components are altered, the item behaving like a filter. The frequency attenuation increments with the frequency of the signal, meaning that the higher frequencies are more rapidly attenuated than the lower ones. Moreover, the frequency analysis is immune against disturbs such as spherical divergence, reflection and transmission effects and coupling receiver-transmitter, which can affect the interpretation of the received signals. When dealing with stone masonry buildings, UT is still much challenging, mainly because of the high degree of intrinsic non-homogeneity of the materials, which causes both a reduced transparency to vibrations and an additional difficulty in defining physic and mechanical parameters. That being so, an experimental program has been started with the aim of exploiting UT potentiality in stone masonry faults detection [2].

A trachite stone wall with an inside cavity has been built made of trachite blocks settled as shown in Figure 1 and Figure 2 and jointed with cement lime mortar. The block in the central position was not settled, thus realizing a macro-cavity assumed as a structural defect. NDTs on masonry have another issue with respect to those on homogeneous materials like metals. Indeed, the materials used are inherently characterized by heterogeneity, also strongly linked to the building process itself, so as it is difficult to define the parameter that characterize them. Furthermore, it has been empirically found that such parameters as modulus of elasticity, Poisson's ratio, density, sound velocity, have wide range of variation. This results in problems in the prior establishment of materials parameters when a numerical model has to be implemented with the aim of simulating and improving testing procedures. Therefore COMSOL Multiphysics is used for modeling the ultrasonic signals propagation in the frequency domain in stone masonry, aiming at calibrating the values of physic and mechanical parameters by using data obtained from the experimental tests. Frequency domain rather than the time domain has been chosen to solve the model in order to decrease the size of the resolution matrices, with significant reduction of processing time and computational errors. In the

full paper two sub-models will be considered: one for the transducer (2D axisymmetric) and another for the wall (3D). The two models will be coupled to perform the acoustic propagation in the wall (modeled by the Acoustics Module) of the signal generated by the transducer (modeled by the piezoelectric device interface).

Reference

[1] J. Krautkramer, H. Krautkramer, Ultrasonic testing of materials, Springer Verlag, New York, 1990.

[2] M. Camplani et al., Acoustic NDT on building materials using Features extraction techniques, ICCSA 2008, Part II, Springer Lecture Notes in Computer Science 5073, 2008, pp. 582–595.

Figures used in the abstract

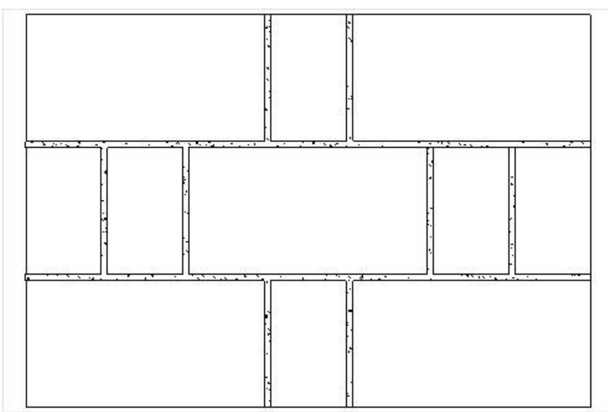

Figure 1: Front view of the wall.

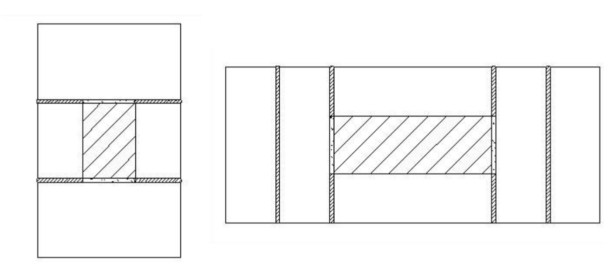

Figure 2: Vertical plane section: position of the cavity (left) and Horizontal plane section intercepting the cavity (right).