Abstract

This thesis examines the development of the concept of structural modelling of architectural heritage, from the first historic experiences on physical models, passing through milestones such as the model corroboration and updating, for finally proposing novel hybrid simulation and testing procedures for use in the field of architectural heritage.

Model corroboration techniques are known to be a powerful tool to adjust a predictor, be it analytical or numerical (e.g. Finite Element Model), so that the outcomes of simulations are as consistent as possible with data available from experimental campaigns. To this aim, several algorithms have been established in the past, with increasing complexity. Sometimes these procedures have given satisfactorily results, in terms of both accuracy and reliability. However, for very complex structures, as those one belonging to the architectural heritage, the application of standard procedures has proven to be not reliable. This is mainly due to the inability of models to consider, in the calibration process, the high uncertainties intrinsic in this type of buildings, as their complex geometry, the material behaviour and the old construction techniques that makes, for example, the connections between the different physical components of an historical building an important unknow factor.

Thus, in this thesis work, an ensemble model corroboration technique is firstly proposed to increase the reliability of the corroboration process, as well as the accuracy of models in a broad sense (i.e. reducing overfitting). The technique is here demonstrated on the typical problem of calibrating a linear dynamical model from results of an experimental modal analysis, however, the same technique can be applied to corroborate nonlinear models, as those addressed in this thesis to identify hysteretic degrading models for masonry structures. In the last part, the thesis establishes a hybrid simulation/testing design procedure to allow the simulation and testing of mass distributed systems with distributed interfaces between the subcomponents of systems (i.e. if the system is substructured, the interfaces between the components can be represented by at least of lines), very frequent characteristic in structures relating to the architectural heritage. Combining the proposed corroboration technique and the assumed nonlinear identification methods (that consider time-frequency distribution of records coming from real monitored systems), and thanks to the proposed hybrid

simulation/testing design procedure, nonlinear corroboration of hybrid models for architectural heritage structures can be carried out, also within a probabilistic framework, as will be stated in the conclusions.

The advantage of using hybrid methods in corroborating models, lies in the fact that the information received from the physical part are used to suppress the high uncertainties of different phenomena, as for example the dependence of material parameters from the load amplitude, typical of masonry structures, without the need to carry out destructive or invasive tests on the real system, thus in full compliance with the deontological guidelines on testing on cultural heritage.