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Large Scale Method to Assess the Seismic Vulnerability of Heritage Buidings: Modal Updating of Numerical Models and Vulnerability Curves

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Abstract : Mediterranean area is characterized by numerous monumental or vernacular masonry structures illustrating old ways of build and live. Those precious buildings are often poorly documented, present complex shapes and loadings, and are protected by the States, leading to legal constraints. This area also presents a moderate to high seismic activity. Even moderate earthquakes can be magnified by local site effects and cause collapse or significant damage. Moreover the structural resistance of masonry buildings, especially when less famous or located in rural zones has been generally lowered by many factors: poor maintenance, unsuitable restoration, ambient pollution, previous earthquakes. Recent earthquakes prove that any damage to these architectural witnesses to our past is irreversible, leading to the necessity of acting preventively. This means providing preventive assessments for hundreds of structures with no or few documents. In this context we want to propose a general method, based on hierarchized numerical models, to provide preliminary structural diagnoses at a regional scale, indicating whether more precise investigations and models are necessary for each building. To this aim, we adapt different tools, being developed such as photogrammetry or to be created such as a preprocessor starting from pictures to build meshes for a FEM software, in order to allow dynamic studies of the buildings of the panel. We made an inventory of 198 baroque chapels and churches situated in the French Alps. Then their structural characteristics have been determined thanks field surveys and the MicMac photogrammetric software. Using structural criteria, we determined eight types of churches and seven types for chapels. We studied their dynamical behavior thanks to CAST3M, using EC8 spectrum and accelerogramms of the studied zone. This allowed us quantifying the effect of the needed simplifications in the most sensitive zones and choosing the most effective ones. We also proposed threshold criteria based on the observed damages visible in the in situ surveys, old pictures and Italian code. They are relevant in linear models. To validate the structural types, we made a vibratory measures campaign using vibratory ambient noise and velocimeters. It also allowed us validating this method on old masonry and identifying the modal characteristics of 20 churches. Then we proceeded to a dynamic identification between numerical and experimental modes. So we updated the linear models thanks to material and geometrical parameters, often unknown because of the complexity of the structures and materials. The numerically optimized values have been verified thanks to the measures we made on the masonry components in situ and in laboratory. We are now working on non-linear models redistributing the strains. So we validate the damage threshold criteria which we use to compute the vulnerability curves of each defined structural type. Our actual results show a good correlation between experimental and numerical data, validating the final modeling simplifications and the global method. We now plan to use non-linear analysis in the critical zones in order to test reinforcement solutions.

Keywords : heritage structures, masonry numerical modeling, seismic vulnerability assessment, vibratory measure
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