Chapter 9
Non-Destructive Testing for Assessing Structural Damage and Interventions Effectiveness for Built Cultural Heritage Protection

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ABSTRACT

Non-destructive techniques - NDT are used in the field of built cultural heritage protection, as they are applied in-situ and do not require destructive sampling. Infrared thermography is used for materials/decay mapping, assesses the compatibility and effectiveness of restoration materials and interventions, and reveals moisture transfer phenomena within structures. Ultrasonic testing assesses the residual properties of historic materials, reveals the decay layers and evaluates the effectiveness of consolidation treatments. Ground penetrating radar reveals the internal structure of masonries, identifies and locates subsurface voids, structural cracks and incontinuities. Portable imaging systems, in conjunction with digital image processing, are used for in-situ materials characterization, and for the study of the decay typologies. Data management systems correlate data from NDTs, from other methods and from seismic/environmental impact assessment analyses to evaluate the preservation state of a historic structure and to plan interventions.

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1. INTRODUCTION

The safeguarding of built Cultural Heritage (CH) is of major concern to the Society as it is an important element of our living environment, our past and our future (UNESCO, 1972). The interest of the scientific community involved in the protection of Cultural Heritage was renewed at the middle of the previous century, in effect after the end of the World War II, when many monuments across Europe presented considerable damage and required imminent measures for their preservation (e.g. Cologne Cathedral, Coventry Cathedral, Dresden Frauenkirche, etc). This interest prompted technological advancements and research and development related to the systematic condition assessment of monuments, to the introduction of innovative materials and methods for more efficient maintenance, conservation and protection, and to the development of simulation tools that allow prediction of the monument's behavior against decay factors. As a result, several national and international research projects and educational programs have developed, utilized and assessed the effectiveness of innovative technologies and materials for the conservation, restoration and sustainability of built cultural heritage, and this effort continues apace.

The relevant research priorities can be summarized as focusing on two main fields: a) the preservation of built cultural heritage (documentation, assessment, diagnosis, materials, intervention techniques) and b) the sustainability and added value of cultural heritage (management, exploitation, monitoring, maintenance, City and territorial aspects, environmental issues). Important "instruments" for meeting these goals are (i) Research & Development with a focus on sustainability enhancement, (ii) development and universal utilization of directives, guidelines, technical recommendations and quality control, in all stages of built CH protection, (iii) adoption of decision making processes that have scientific support and take into account socio-economic aspects, (iv) implementation of interventions within an integrated strategic plan, (v) disaster prevention and risk management, (vi) utilization of information communication technologies, and finally (vii) education and training in the field of CH protection.

In the past, conservation and protection interventions were often implemented on built cultural heritage based on previous experience with similar cases and without fully identifying the prevailing problems. As a result, built cultural heritage was often placed at a higher risk, due to various reasons: The first was the design and realization of interventions while having limited information about the building itself, its structural behavior, its materials and construction technology, and most importantly about its interactions with the environment. This is attributed either to the limited technological capabilities of the contemporary characterization techniques and instrumentation (which did not allow scientists to have a "full picture" of the problem), to the limited access to appropriate documentation (as compared nowadays with the ease and range of resources available to the scientific community), or to the adoption of empirical and rule-of-thump approaches that did not require an integrated analysis of the problems but rather focused on the principle of using proved and tested solutions. Another reason is the issue of compatibility of the interventions. The use of inappropriate restoration materials (replacement; strengthening; protection) that are physico-chemically and mechanically incompatible with the historic ones has been proven to have increased dramatically the vulnerability of structures. Finally, the utilization of technologies that alter extensively the original structural system of the historic building and/or are based on concepts that - although reliable for modern structures - are applied to historic structures without prior validation, can also cause significant damage. Indeed, protection technologies and related legislation,