LABORATÓRIO NACIONAL
DE ENGENHARIA CIVIL

DEPARTAMENTO DE MATERIAIS
Núcleo de Materiais Pétreos e Cerâmicos

Proc. 0205/11/17687

SOME CONCEPTUAL TOOLS FOR DECIDING AND PLANNING IN BUILT HERITAGE CONSERVATION

Plano de Investigação Programada do LNEC

Lisboa • janeiro de 2013

I&D MATERIAIS

RELATÓRIO 2/**2013 – DM/NPC**

SOME CONCEPTUAL TOOLS FOR DECIDING AND PLANNING IN BUILT HERITAGE CONSERVATION

ABSTRACT

Conserving the built heritage today entails decisions and planning at several different levels. Firstly, analysis is necessary regarding what to conserve: values, authenticity and integrity are the key concepts at this macro level. Then, decisions on how to conserve them should consider the chief principles of good conservation practice, among which compatibility, retreatability and minimum intervention are prominent today.

This report analyses these concepts and the different ways in which they were translated into the decision support systems that are nowadays resorted to, from values-based decision making and risk management in conservation to intervention planning and performance assessments. The ultimate goal of this analysis is to compile tools that promote a more rational decision making in conservation.

ALGUMAS FERRAMENTAS CONCEPTUAIS DE APOIO À DECISÃO E PLANEAMENTO NA CONSERVAÇÃO DO PATRIMÓNIO CONSTRUÍDO

RESUMO

Hoje em dia, a conservação do património construído envolve processos de decisão e planeamento a níveis muito diversos. Em primeiro lugar, é necessário analisar o que se pretende conservar: valores, autenticidade e integridade são os conceitos chave a este nível macro. Seguidamente, as decisões relativas à sua conservação devem ter em consideração os princípios de boas práticas em conservação, entre os quais atualmente se destacam a compatibilidade, a retratabilidade e a intervenção mínima.

O presente relatório analisa estes conceitos e as diferentes formas encontradas para a sua tradução em sistemas de apoio à decisão, desde decisão baseada em valores e gestão de risco em conservação ao planeamento de intervenções e avaliações de desempenho. O objetivo último desta análise é a compilação de ferramentas que promovam uma maior racionalidade na tomada de decisão em conservação.

TABLE OF CONTENTS

TABLE OF FIGURES

INDEX OF TABLES

SOME CONCEPTUAL TOOLS FOR DECIDING AND PLANNING IN BUILT HERITAGE CONSERVATION

INTRODUCTION

Resources are needed for preservation. These include money, people, knowledge, and institutional continuities, and are available to individuals, to institutions or to society as a whole. There can be no absolute specifications of resource need and resource allocation because levels of preservation and the will to preserve vary. This is so even if it were possible to agree on the desirable degree of preservation being sought. Circumstances vary culturally and nationally. The fraction of resources available for preservation in any one time frame or set of social circumstances is variable. Resources available for heritage protection often compete with resources for other social priorities.

M. V. Orna *et al.* (1992)

Conservation interventions are generally characterized by the vast extent of subjects and problems that must be addressed, as well as by the correspondingly large array of methodologies and materials involved. This vastness often poses relevant approaching difficulties, not only from a technical and scientific viewpoint, but also at a practical application level. For these reasons, both feasibility and performance of conservation and restoration interventions are, frequently, very hard to fully assess. On the other hand, the increasing level of multidisciplinary work involved in conservation projects, although undeniably beneficial, often lacks a systematic planning that allows for all the information to be available for an integrated analysis. Hence, all the different parties involved would benefit from an assessment tool allowing for a better planning and a more efficient resource allocation, particularly in the analysis of large-scale interventions, such as those concerning the built heritage.

The theme of the research presented in the current report could be summarized in the following question: <u>What tools exist to reduce the degree of subjectivity in decision making and in the assessment of heritage conservation actions/phases/projects?</u>

The choice of this topic surfaced with the recent proposal of a methodology designed to assess and evaluate conservation interventions, which uses compatibility as key operative concept.

One of the goals of the research that motivated the current report is to determine the applicability of this compatibility-based approach in the analysis of conservation and restoration interventions. Although this determination should desirably be extendable to any type of heritage object, this work is focused mainly on built heritage objects, which will sometimes be referred to simply as monuments, as defined by the Venice Charter[1].

Considering recent trends in the conservation field towards policies that prioritize more integrated decision-making, the current study aims at providing some tools required for a more efficient resource management; the obtained results are furthermore expected to promote an increasingly quality-based approach at planning level, thus raising the qualification demands on conservation practice. Significant cultural and economical benefits may potentially be gained with a global approach to heritage conservation, so that it adequately meets the new challenges and perspectives brought by the concept of sustainable development.

The research starts with a review of some of the most relevant pillar concepts and principles that preside in conservation decisions today, presented in Chapter 1. Since these concepts lay the ground for assessment guidelines or methods, an attempt was made to analyse how they influenced, and/or were translated into, decision-making processes; Chapter 2 is thus devoted to these topics.
The concepts and principles described in Chapter 1 are chiefly pertinent in the context of Western culture, and do not necessarily coincide with the ones that guide conservation in societies with traditions rooted in other civilizations. The valorization (and the valuing) of objects deriving from different systems of thought, and hence being conceptually distinct, will originate different approaches to the conservation of these values. The choice of assessment guidelines or methods will stem from and incorporate each culture's approach to (conservation) objects, and thus, decision-making processes are described from a Western perspective as well.

Two final notes: the term 'conservation' is used throughout this report in its broadest sense, i.e., encompassing research, planning and technical actions undertaken with the ultimate goal of contributing to extend the existence of heritage; the term 'heritage', in turn, refers especially to tangible heritage. All citations from sources in French or in Portuguese are quoted as free translations by the author of this report.

[1] The Venice Charter defines monument in its first article, which reads: "The concept of an historic monument embraces not only the single architectural work but also the urban or rural setting in which is found the evidence of a particular civilization, a significant development or an historic event. This applies not only to great works of art but also to more modest works of the past which have acquired cultural significance with the passing of time." (I.C.A.T.H.M., 1964)

1 CONTEMPORARY PERSPECTIVES ON CULTURAL HERITAGE CONSERVATION

The future challenges of the conservation field will stem not only from heritage objects and sites themselves but from the contexts in which society embeds them. These contexts—the values people draw from them, the functions heritage objects serve for society, the uses to which heritage is put—are the real source of the meaning of heritage, and the raison d'être for conservation in all senses.

E. Avrami, R. Mason and M. de la Torre (2000)

In spite of being a relatively new discipline, conservation of cultural heritage has known various shifts during the past decades, mirroring both the societal attitudes towards history and heritage and the lessons learned from new findings and experience.

In recent years, the evolution in conservation trends has reflected the strong development of (1) cultural tourism, which can act as a financing source for the preservation and protection of cultural heritage; and (2) the rehabilitation of historic buildings and urban centres, which may contribute to the financing of some preservation actions as well (MOROPOULOU, 2000a). For conservation to cope with these new challenges entailed "the employment of new tools, like planning and management of the integral natural, human and cultural environment in the direction of a sustainable maintenance" (MOROPOULOU, 2000a, p. 78).

On the other hand, the first decade of the XXI century will mark a turning point in conservation theory, namely "a philosophical shift from scientific objective materials-based conservation to the recognition that conservation is a socially constructed activity with numerous public stakeholders" (RICHMOND & BRACKER, 2009, pp. xv-xvi). In fact, the role of hard sciences in the understanding of decay processes and of the best forms of dealing with them in each unique case prompted an ever-firmer bond between conservation and sciences, both technology- and methodology-wise. Nevertheless, the objectivism of hard sciences and technology cannot provide an adequate theoretical support for conservation, since it places its emphasis uniquely on the materiality of the object (the *how* to conserve) and it generally does not acknowledge the ground reasons behind the act of conservation (the *why*), nor does it contemplate the role of the diverse stakeholders involved in each given conservation intervention (the *for whom*).

Conservation today should work towards constructing a coherent body of work that allows it to adequately respond within three main spheres of challenges: (1) questions related to the <u>physical condition</u>, undoubtedly the sphere where more research effort has been put with practical application effects so far; (2) management issues, and namely questions dealing with resource allocation, professional training, regulations and policies, etc; and (3) significance and values attached to the objects, particularly the definition of the *why* and of the *for whom* a given object is conserved (AVRAMI et al., 2000).

Any process of conserving a given object should bear in mind the purpose of doing so, so that the goals of said conservation process may be clearly established from the outset. Why we choose to conserve certain objects is a complex question with many possible answers (MUÑOZ-VIÑAS, 2005), but current perspectives suggest that there are “three main reasons for conservation” (MUÑOZ-VIÑAS, 2005, p. 175), which amount to *preserving* or *improving*:

> the scientific meanings of an object, that is, to make sure that it can be used as scientific evidence now and in the future; […] the social, hi-cult symbolic meanings that an object has for large groups; […] the sentimental symbolic meanings that and object has for small groups or even for individuals (MUÑOZ-VIÑAS, 2005, p. 175).

The concept of “meaning” has been rapidly taking over the objectivist notion of “truth”[2] in the understanding of conservation objects. Indeed, an object evolves throughout its history, and thus its nature is true – the object exists – in any moment of that history; hardly can there be shades of truth in the state of an object at a given moment in time as opposed to its condition in another moment. From here it derives that we cannot base a conservation decision in the choice of a “truer” condition. Stating the meanings of an object and choosing which ones are to be conserved, however, provides a framework for the intervention and acknowledges the intersubjectivity[3] of the choices made. Of course this implies a clearer responsibility for the decision-makers, but it also supplies them with a tool for trading and negotiating the meanings at stake and those that are to be preserved.

Nonetheless, it has been noted that the precise statement of meanings is often complex, implying it to be a somewhat diffuse concept that may pose some difficulties

---

[2] Concept made popular through Boito’s restauro scientifico, that “stressed that truth was objectively determined” (MUÑOZ-VIÑAS, 2005, p. 175), and generally followed by classical conservation theories, this “truth” is normally related to the object’s physical, aesthetic and historical integrities (MUÑOZ-VIÑAS, 2005).

[3] Noun formed from the adjective ‘Intersubjective’, defined as “involving or occurring between separate conscious minds; accessible to or capable of being established for two or more subjects (in http://www.merriam-webster.com/dictionary/intersubjective, consulted in November 24, 2011).

negotiation-wise (MUÑOZ-VIÑAS, 2005). The concepts of "function" and "value" have also been put forth, and maybe provide more practical tools for decision making.

The notion of "function" applied to a conservation object, besides considering its (for example) historical and aesthetical features as functions at a historical and aesthetical level, respectively, also highlights the importance of the object at levels normally deemed more commonplace, such as its touristic/economic function or service function, among others, contemplating also iconic functions and the like:

> 'cultural heritage' is not just 'cultural', since it can function in many ways [including political and economical]. If – and how – a conservation process is to be performed should be decided after considering all the possible functions performed by an object, as even the damage that conservation is thought to repair or prevent can be considered as directly related to functionality (MUÑOZ-VIÑAS, 2005, p. 178).

As for the concept of "value", this report shall borrow the following definition:

> value is used to mean the characteristics attributed to heritage objects and places by legislation, governing authorities, and/or other stakeholders. These characteristics are what make a site significant, and they are often the reason why stakeholders and authorities are interested in a specific cultural site or object. In general, these groups (or stakeholders) expect benefits from the value they attribute to the resource. (MASON, MACLEAN & DE LA TORRE, 2003, p. 2)

The notion of value was always more or less close to that of a heritage object, but it gained new dimensions with the thinking of Alois Riegl (see below) and a more contemporary light with William D. Lipe (see below). More recently, the concept was reinstated in the form of value-led conservation (see below), which simply proposes the analysis of the set of values attached to the conservation object and, from there, reaching a consensus, between the stakeholders involved, concerning which values are to be preserved and which ones may eventually have to be disregarded. Besides providing some technical tools to assist the evaluation process, a values-based approach acknowledges the importance of negotiation and of intersubjectivity in conservation decision making; on the other hand, "the idea of value is applicable to a wide range of conservation ethical issues" (MUÑOZ-VIÑAS, 2005, p. 179).

The concepts of "meaning", "function" and "value" are, in fact, not too distant from each other, and, as Muñoz-Viñas points out, may be used interchangeably: "an object with artistic value has an artistic meaning; an object that fulfils an economic function has an economic meaning" (2005, p. 180). In fact,

> theories developed around the notions of meaning, value and function are very similar in their conclusions: conservation increases some of an object's possible

> functionalities or values, very often at the cost of decreasing others [...] In all cases, the final decisions regarding these topics must be the result of a compromise, of a negotiation, of a dialogue, regardless of whether we are using the notion of value, meaning or function. (MUÑOZ-VIÑAS, 2005, pp. 180-181)

In the present report, greater emphasis was put on the concept of value, since more consistent conservation approaches were found departing from this notion, at least in the field of built heritage conservation.

In the early XX century, Riegl had already recognized that conservation objects, or monuments, are considered as such because of the values we – subjects – attach to them. Though dismissed for some time in the name of objectivity, this subjectivism inherent to conservation decision making is nowadays widely acknowledged. Thus, in the light of the new paradigms proposed by contemporary conservation thinking, the importance of subjectivism, and intersubjectivity, is growingly being recognized as not only unavoidable, but also desirable in conservation decision-making. These new paradigms acknowledge the ultimate role of decision-makers and suggest that the focus on the (conservation) objects (and the objectivism proposed by classical conservation theories) be withdrawn and transferred to the subjects affected by these decisions – the users for whom the objects have values, functions or meanings (MUÑOZ-VIÑAS, 2005).

Evidently, this intersubjectivism has nothing to do with the subjectivity that this research aims at dimming when conservation decisions are being considered. Quite the opposite, the fact that merely object-related information is insufficient for the decision makers is acknowledged and the relevance of subject-related aspects is highlighted, including the need of understanding the role and importance of the heritage object within relevant social groups and of their involvement in its conservation, and the impact of the adequate training and education of the relevant stakeholders.

The current chapter is thus devoted to the grounds of contemporary perspectives on heritage conservation, followed by some of the ethical implications these perspectives bring about; it tries to answer the two following questions: (1) what is at stake when we conserve an object today? and (2) what guidelines and restrictions make good conservation practice today? This exposé does not intend to be thoroughly exhaustive (that would call for a dissertation in its own right), but simply to provide a framework for the ensuing decision support systems (DSS) used in conservation today, described in Chapter 2.

1.1 What to Conserve – Analysing Heritage Values

Conservators-restorers will benefit from accommodating in their field some "conceptual tools" issued from philosophy or from aesthetics, since it is in the core of their actual practice that questions are born for which they have, sometimes alone, sometimes in teams, to find answers and solutions. The intellectualization of the profession, as it is emerging in higher education programs implemented in recent decades, calls for an autonomy that is no longer the artist's, the craftsman's, the technician's, but that of whom […] is required to "evaluate": that is to say, literally, to express the values connected to the objects and works. The conservator is therefore an unconscious axiologist.

M. Verbeeck-Boutin (2009)

As mentioned earlier, the notion of value has been increasingly called upon in the definition of a heritage object. In fact, even if not specifically mentioned, such objects are assumed to possess an array of values which, among other things, justifies their preservation.

Given the diversity of objects that society believes to merit a conservation effort, which include works of fine and applied arts, ethnographic and archaeological objects, buildings and musical instruments, among others, it is reasonable to say that

> these objects do not answer to the same function, they are not the result of the same intentionality. Their status varies: the values we ascribe them vary as well, since the fact that we conserve them endows them with a teleological dimension. We conserve and we restore because we found them to have a particular interest, and that is what we contribute, consciously or unconsciously, to put in evidence. (VERBEECK-BOUTIN, 2009)

The precise stating of those values is, therefore, crucial for our successors to contextualize and understand our conservation options – as Verbeeck-Boutin puts it, "the understanding of the subjectivity of values is our best chance of achieving objectivity" (2009).

The concept of value applied to conservation evolved from Riegl's recognition of the role of the subject in the early XX century to the Brandian object-focused approach of the 1960s; more recently, the term value gained new dimensions and its intersubjectivity is highlighted. This evolution is briefly described in the subsections below.

1.1.1 Riegl's Values

If, for the rest, it be asked us to specify what kind of amount of art, style, or other interest in a building makes it worth protecting, we answer, anything which can be looked on as artistic, picturesque, historical, antique, or substantial: any work, in short, over which educated, artistic people would think it worth while to argue at all.

William Morris (1877)

Alois Riegl (1858-1905) was one of the leading theorists trying to define what was implied by the use of the word 'monument', and also "the author of the first systematic theory of conservation" (JOKILEHTO, 1986, p. 378). The Austrian art historian considered that the 'historical and artistic' values, officially used in his time to characterize monuments, could lead to misunderstandings, because of the shifts in the perception of 'artistic value' over time. Instead, Riegl prefers to use the concept of commemorative value[4], which all monuments are said to be imbued with, and which is the key-defining concept behind the use of the word; it differs from present-day values, which may be found in monuments, but can also be applied to contemporary non-monumental objects. Still according to Riegl, monuments can be deliberate or unintentional, depending precisely on whether the recognition of their commemorative value depends on prospective or retrospective cultural memory, respectively.

Riegl's genius and importance are highlighted by Françoise Choay in her introduction to the French translation of *Der moderne Denkmalkultus: sein Wesen und seine Entstehung* ("The Modern Cult of Monuments: Its Essence and Its Development"):

> for the first time in the history of the notion of historical monument and of its applications, Riegl distances himself. […] In the favour of such distance, he is able, firstly, to undertake the inventory of non explicit values underlying the concept of historical monument. Suddenly, the latter loses its pseudo-transparency of objective given. It becomes the opaque support of historical values that are transitive and contradictory, of issues that are complex and conflicting. In this fashion, Riegl demonstrates that, in terms of both theory and practice, the destruction/conservation dilemma cannot be absolutely determined, that the what and the how of conservation never comprise *a single* solution – just and true – but *multiple* alternative solutions of relative pertinence." (CHOAY, 1984, pp. 16-17, italics by the author)

[4] A more literal translation of the term used by Riegl, *Erinnerungswert*, would be 'remembrance value', which, in my opinion, would convey its meaning more precisely. However, 'commemorative value' was the term chosen by the translators in the English source consulted and also by Jukka Jokilehto in his dissertation "A History of Architectural Conservation" (1986), and was thus preferred.

In Riegl's conception, three categories of commemorative values can be distinguished – historical value, age value and deliberate commemorative value. The historical value that all monuments, by definition, hold, stems directly from them constituting "evidence that seems to represent especially striking stages in the development of a particular branch of human activity" (RIEGL, 1996, p. 70). Of course, which historic stages are considered 'especially striking', and thus valued, is a societal choice; Riegl thought the first manifestations of this valorisation to have come into light during the Renaissance.

The age value, on the other hand, has an aesthetic component recognizable in every monument that evidences signs of weathering – "imperfection, a lack of completeness, a tendency to dissolve shape and colour, […] in complete contrast with […] newly created works" (RIEGL, 1996, p. 73). Riegl considered age value not only to be of relevance for the majority of the monuments, but also to be "the most modern one and the one that will prevail in the future" (1996, p. 72), highlighting its appealing to the popular opinion, rather than being perceived only by intellectual elites. On the other hand, notwithstanding the fact that Riegl foresaw the age value to overcome the historical value in importance due to its appeal to the masses, it was still indisputable that there was a relationship between the two, since not only the appreciation of age value inherently presupposes a certain (even if just basic) knowledge of art history, but also, and more importantly, the recognition of the age value naturally develops the perception of historical value by the increasingly subjective viewpoint of the late XIX century individual (RIEGL, 1984).

As stated earlier, the fact that we refer to a certain monument as such presupposes our attributing it a commemorative value. In the majority of cases, this attribution is retrospective, i.e. we attribute it ourselves; but to a (relatively low) percentage of monuments this valorisation is prospective, i.e. a deliberate commemorative value was originally bestowed upon the monument by its creators, with the intention of celebrating a certain moment and of passing it on to the future; these works embody the original meaning of the concept of monument. By definition, deliberate monuments aspire at an "eternal present" (RIEGL, 1996, p. 78) that can only be achieved through protective laws and restoration procedures that maintain the monument in its *Werdezustand* (original form)[5].

[5] The *Werdezustand* is a term coined by Riegl to designate the condition or form of a work of art at the precise moment of its completion, i.e., the culminating of the creative process. The word is formed by combining the verb *werden* (to become) with the noun *Zustand* (condition), resulting in an apparent contradiction in terms (RIEGL, 1984), and would be more literally translated as "state of becoming".

In what they can meet the expectations and requirements that societies would normally deposit in newly created works, monuments may (and indeed do, in most cases) incorporate present-day values. Riegl defines present-day values as encompassing two main categories – use value and art value; art value can be furthermore decomposed into newness value and relative art value.

Use value, as indicated by its name, is granted to objects that are called upon to serve any given function. In the case of monuments, this holds true for most architectural works, though it is also verifiable for some smaller scale objects, such as historical trams or funiculars. If, on the one hand, it is known that the utilization of the built heritage is vital for its preservation, it is no less true that the replacement of every historical building by a modern one constructed to serve the same purpose is not realistically conceivable, as already noticed by Riegl in the dawn of the XX century. Furthermore, it is worth noting that the age value, "based on the perception of the lively play of natural forces" (RIEGL, 1996, p. 79) expects that monuments are made use of when possible, and would be diminished otherwise. These features stand at the very core of both the complexity and the uniqueness of architectural conservation; and they highlight why the use value is equally important whether one views it from the building or from the society's perspective.

The newness value emerges in Riegl's work as the conflicting opposite of the age value. As suggested by the designation, newness value arises from the "completeness of the newly created […] expressed by the simple criteria of unbroken form and pure polychromy" (RIEGL, 1996, p. 80); the progression of weathering and decay upon a monument will distance it further and further form the modern *Kunstwollen*[6]. The newness value is, in fact, an elementary requirement of the art value, inasmuch as it existed in any age of the history of art in the appreciation of a work of art in its completion and absence of degradation.

Conversely, the relative art value is rooted in what disrupts the *Kunstwollen* of each art period from that of preceding ones, and it is therefore related to "the specificity of the monument in what concerns its conception, its form and its colours" (RIEGL, 1984, p. 94). The term "relative" emphasizes not only that it cannot be objectively formulated, but also that it is an ever changing art value requirement. The immediate corollary is that "newness value has always been the art value of the mass majority of the less

[6] Literally, the "art-will", or artistic volition. *Kunstwollen* is yet another of Riegl's neologisms, and its interpretation has been greatly debated upon over the last century, not the least because the noun seems to take slightly different meanings in different works by the author. In the context of the quotation above *Kunstwollen* seems to refer to contemporary artistic drive (or impulse) that constantly sets artistic value requirements. According to Jokilehto, Riegl introduced, for the first time, "a teleological conception of art" (JOKILEHTO, 1986, p. 378).

educated or uneducated; whereas relative art value […] could only be evaluated by the aesthetically educated" (RIEGL, 1996, p. 80).

One should furthermore note that a monument will hardly possess a fully consistent newness value, as it will, to a higher or lower degree, have suffered consequences from the passing of time. It is entirely possible, however, that a monument, regardless of its age, is imbued with relative art value, either positive, if "the monument pleases our contemporary artistic volition" (RIEGL, 1984, p. 112); or negative, when "a monument appears shocking, stylistically awkward and ugly to the contemporary artistic volition" (RIEGL, 1984, p. 115).

The question, then, is to ascertain how the cult of each value, which substantiates the cult of monuments, will influence conservation.

1.1.2 Riegl's Values as Defining Concepts of Conservation Decisions

Heritage is valued in a variety of ways, driven by different motivations (economic, political, cultural, spiritual, aesthetic, and others), each of which has correspondingly varied ideals, ethics and epistemologies. These different ways of valuing in turn lead to different approaches to preserving heritage.

E. Avrami, R. Mason and M. de la Torre (2000)

Commemorative values

From the aesthetic appreciation of the age value in monuments by the modern man, i.e., the man in the beginning of the twentieth century, for whom "the reign of nature, including those destructive and disintegrative elements considered part of the constant renewal of life, is granted equal standing with the creative rule of man" (RIEGL, 1996, p. 73), Riegl concludes that "signs of decay (premature aging) in new works disturb us just as much as signs of new production (conspicuous restorations) in old works." (1996, p. 73) Thus, "the cult of age value would not only find no interest in the preservation of the monument in its unaltered state, but would even find such restoration contrary to its interests." (RIEGL, 1996, p. 73) There are limits to this non-interference of man in the deeds of nature over monuments; according to Riegl, from the standpoint of age value, avoiding the "*premature* demise" (1996, p. 73) of a monument is not objectionable, as age value is lost when the action of nature erases the last trace of human work upon the monument. Nevertheless, up until that limit, age value is intensified[7] by non-violent weathering actions of nature.

Yet, when one considers the historical value of a monument, and remembering the aforementioned definition, it can immediately be derived that this value varies together with the proximity of the monuments to their original state of man-made creations, a state in which the information they contain is at their highest peak. Hence, and oppositely to the age value perspective, historical value is better defended by preventing the occurrence of signs of weathering and decay. These signs are to be removed (supposedly by the scholars that defend historical value), "however, this must not happen with the monument itself but only with a copy or merely in thoughts or words"; Riegl furthermore emphasizes that "historical value considers the original monument fundamentally inviolable" (1996, p. 75). The historical value motivations, of course, are different from those of the age value and its aesthetic considerations on the influence of nature upon monuments; the need for preservation is, from the historical value point of view, justified by the necessity of minimizing the risks of human error upon the monument: "the original document must remain preserved whenever possible as an intact, available object, so future generations will be able to control our attempts at restoration and, if necessary, replace them with ones that are better and more well founded." (RIEGL, 1996, p. 75)

[7] It is actually a trade-off between the extension of the value, which is lowered by the weathering processes, and the force (intensity) of that same value, which is heightened by the progressive fading or disappearance of building elements.

Figure 1: Engraved horses in the Ribeira de Piscos Site – Côa Valley Archaeological Park © José Delgado Rodrigues. The submersion of the Côa Valley engravings was prevented by a remarkable social movement defending, from a Rieglian perspective, historic and age values.

As for the monuments possessing deliberate commemorative value, it is clear that their fundamental function of immortalizing a given moment, keeping it "perpetually alive and present in the consciousness of future generations" (RIEGL, 1996, p. 77) highly relies on the restoration of the evocative material elements.

Consequently, the cult of a particular value will influence preservation decisions:

> Prior disintegration by the forces of nature cannot be undone and should, therefore, not be removed even from the point of view of historical value. However, further disintegration from the present day into the future, as age value not only tolerates but even postulates, is, from the standpoint of historical value, not only pointless but simply to be avoided, since any further disintegration hinders the scientific restoration of the original state of a work of man. Thus the cult of historical value must aim for the best possible preservation of a monument in its present state; this requires man to restrain the course of natural development and, to the extent that he is able, to bring the normal progress of disintegration to a halt." (RIEGL, 1996, pp. 75-76)

On the other hand, "the fundamental requirement of deliberate monuments is restoration" (RIEGL, 1996, p. 78).

Present-day values

Notwithstanding the fact that present-day values are not exclusive of monuments, they still have to be taken into account when their conservation is contemplated.

As defined by Riegl, use value cares not about the treatment given to a monument, up to the point where the safety of the users (or passers-by) is not an issue; beyond this point, "the negative demands of use value are […] imperative", since "the respect of physical values is unquestionably more important than that of the age value" (RIEGL, 1984, p. 90).

On the other hand, as stated earlier, age value relies on the perception of natural forces at work, and these include those of man, even if "age value reveals its fully undiminished charm in the remains of those monuments that are no longer of practical use to us and in which we do not miss human activity as a force of nature" (RIEGL, 1996, p. 79). That is to say, the age value perspective is far from being the sole reasoning that should guide decisions concerning monuments:

> We still distinguish more or less accurately between monuments that can and cannot be used […]. In the latter, we take historical value into consideration, in the former, we take use value along with age value. Only unusable works […] can be viewed and enjoyed exclusively from the standpoint of age value" (RIEGL, 1996, p. 80).

In the context of preservation perspectives, the newness value is, by definition, the strongest opponent of the age value, since it is derived from a completeness of form and colour that abhors any trace of decay and that is only made possible by full restoration. According to Riegl, the prevailing conservation perspective throughout the XIX century was "an intimate fusion of newness value and historical value: any striking trace of natural decay was to be removed, any loss of fragment was to be repaired, the work was to be restored to a complete, unified whole" (1996, p. 81). This supremacy started to be questioned precisely due to the age value perspective stemmed from the emergent subjectivity in the thoughts of the late XIX century individual.

Although the differences between age value and newness value may seem entirely irreconcilable at first, there are some nuances that are important to mention. To begin with, the age value recognizes the rights of the newness value in every work except monuments, i.e., objects with a commemorative value; this recognition even becomes demanding in the case of new works:

> We demand of recent creations a full integrity not only of shape and colour, but also of style. In other words, the modern work must not remind us of former works neither by its conception nor by the treatment of details of shape and colour. (RIEGL, 1984, p. 100)

On the other hand, and as clarified earlier, age value must yield to use value whenever the safety of users is an issue, but on this subject Riegl furthermore states that "practical use value corresponds aesthetically to newness value" (RIEGL, 1996, p. 81) and, as such, the cult of age value must grant some space for newness value in monuments of the modern age that are still usable. Thus it is not shocking for age value followers that a usable monument sees a damaged element restored to its original *known* condition because newness value demands it.

Riegl explains the controversy that dominated restoration policies throughout the XIX century as an opposition between age value and newness value, but with the latter yielding in favour of historical value. This opposition became vivid in the specific case of monuments that were not preserved in their original form, that is to say, monuments whose history included (man-made) stylistic modifications. As Riegl puts it, before the start of the age value cult, historical value was the most influential one and it relied on *stylistic originality*, i.e., on the “clear recognition of an original form” (1996, p. 83), which demanded for any additions to be removed for the appreciation of the original forms, “whether those had been documented accurately or not. Even a mere modern approximation to the original seemed to be more satisfactory to the cult of historical value than an authentic, but stylistically foreign, earlier addition” (RIEGL, 1996, p. 83). The newness value cult promptly relates to these options, since “any addition that did not belong to the original style destroyed completeness and was considered a symptom of degradation” (RIEGL, 1996, p. 83), even if the newness value defends these renovations in the name of *stylistic unity*.

The emergence of the cult of age value considered these renovations “a sacrifice of virtually everything that constitutes age value in a monument” (RIEGL, 1996, p. 83) and thus started a fierce resistance to all the postulates defended by the historical and newness values, even those that were legitimate. Albeit some initial radicalism on both sides, in time, the cult of age value did manage to impose its own legitimate considerations on the preservation of monuments, and by the time Riegl published this work, an agreement seemed to have been reached with the progressive abandonment of the stylistic unit postulate and the recognition of the historical value of many additions of different stylistic ages.

As for relative art value followers, the decisions relating to the preservation of a given monument will depend on the value of the latter being positive or negative. In the case where the monument pleases the contemporary artistic volition, people will tend to shun traces of weathering or age, either by trying to prevent the evolution of degradation or by erasing traces of this degradation, or even by restoring the monument to its original condition, depending on which condition is believed to be the most pleasing (RIEGL, 1984). Either one of these options, and particularly the latter, will represent a conflict with the perspective of age value. Considering that these two perspectives both stem from contemporary aesthetic conceptions, it is worth asking which one will prevail; but the answer seems to lie in the value analysis of each particular case.

If, however, a monument is considered displeasing to the contemporary artistic volition, i.e., if its relative art value is negative, then those who mind this value the most will prefer not to be faced with the monument at all. While renovation with new additions is a possibility, since “relative art value is pleased by the presence of modern elements in ancient works”, full destruction may be contemplated, although “it is certainly very rare, nowadays, for a monument to be destroyed solely because of its relative art value” (RIEGL, 1984, p. 115). Either way, Riegl underlines that “this negative aspect should not […] be neglected, in the practice of conservation. In fact, if it joins a present-day value (use value or newness value) in another conflict, it can contribute to harm the age value” (1984, p. 115).

Throughout his work, Riegl illustrates how values attached to cultural heritage may be, and indeed often are, conflicting. Monument preservation decisions are entirely dependent on which values society attaches to each particular monument, and, more importantly, on which values prevail; the following table tries to summarize this dependence.

Table 1: Riegl’s values versus Intervention decisions.

Commemorative Values			Present-day Values			
Historical	Age	Deliberate	Use	Newness	Relative Art value	
					positive	negative
preservation of the *status quo*	**non interference** (except in the case of a catastrophe)	**restoration**	**renovation or recovery** (whenever user safety is an issue)	**restoration** to the original known condition	**restoration**	**destruction** (or renovation with new additions)
Regarding monuments with stylistic additions						
removal of additions and renovation aiming at stylistic originality	**non interference**	–	–	**removal of additions and renovation** towards stylistic unity	**removal or maintaining of additions** depending on the more pleasing option for the contemporary artistic volition	

1.1.3 Boito and Brandi

Restoration is an effort that consumes the brain and never leaves your soul to rest. This great venture is composed of an infinity of details, that eventually become obsessing; moreover, it is necessary to maintain an exact balance between the demands of archaeology and of the picturesque, of statics and of aesthetics. Such a balance is often impossible to meet. One has to make choices: to lean towards one side or the other.

C. Boito (2000)

The relative importance of values and their role in conservation decisions had been noted, prior to Riegl, by Camillo Boito: the Italian scholar participated in several notable restorations in a context torn by the Manichaeism of the positions of Ruskin and Viollet-le-Duc, and had the remarkably perceptive insight of "denouncing the fallacy of this alternative and of having, fifteen years before Riegl, placed the restoration of monuments under the sign of relativity and questioning." (CHOAY, 2000, p. 13)

As Choay notes, even if his writings lack the clarity and elegance of the Austrian author, Boito had the practical experience that Riegl missed, and his considerations on conservation are the fruit of auto-analysis rather than abstract thinking; this causes Boito to take the relativism in conservation farther than Riegl:

> For him [Boito], the complexity of the intervention on historical monuments renders the problem insoluble. As Riegl, Boito shows that the conservator must «make choices». But these choices are not separable from a «cruel uncertainty», they constrain the practitioner to constantly question himself, to «review his opinions and retract himself», to never be able to conciliate the absolute respect towards the past work and the necessary creative urge of the architect, in brief, to admit the impossibility of the empirical synthesis to which Riegl's dialectic leads (CHOAY, 2000, p. 17 (with citations from Camillo Boito)).

Boito proposes that the conservation of monuments be divided in three groups, according to the prevailing monument feature: "archaeological importance" would call for an *archaeological conservation*, typically destined for Antiquity monuments; the "picturesque aspect" would demand a *picturesque conservation*, generally suited for mediaeval monuments; "architectural beauty" prevailing would require an *architectural conservation*, which Boito found the most adequate for monuments from the Renaissance onwards (BOITO, 2000, p. 34).

In archaeological conservation, every fragment of the monument is considered to have an intrinsic importance as a subject allowing for the study of the techniques and original building configuration. Boito recommends the exhaustive analysis of all the elements and, in cases where there is reliable information, that the monument be restored by anastylosis, providing that missing structural elements are added in materials or techniques different from the original ones, and executed in broad lines, i.e., without decoration. Picturesque conservation, in turn, advocates only a structural reinforcement where necessary, "leaving the skin untouched, with its flesh and muscles" (BOITO, 2000, p. 36), with the help of hard sciences for the mitigation of degradation agents such as salts or for consolidation treatments, where necessary. As for the more recent buildings, in which "the organic unit has remained untouched" (BOITO, 2000, p. 38), the historic and documental value of individually considered elements become overshadowed by the importance of an aesthetical integrity, and thus their conservation allows not for renovations but for the use of similar materials and techniques that complete the missing parts, provided that they are discernible upon close inspection.

Boito's practical experience allowed him to make a few proposals to help resolving some of the conflicts encountered in architectural conservation, e.g. the advocating of making additions discernible to the viewer, which is consecrated in the Venice Charter and still practiced today.

Cesare Brandi, one of the most inescapable references in conservation theory, does not acknowledge the importance of a "use value" as defined by Riegl[8]. Brandi defends that any instrumental value that an object may possess is to be overshadowed the instant of its recognition as a work of art:

> For works of art, even if there are some that structurally possess a functional purpose (such as architecture and, in general, objects of the so-called applied arts), the reestablishment of the functional properties will ultimately represent only a secondary or accompanying aspect of the restoration, never the primary or fundamental aspect that respects a work of art as a work of art. (BRANDI, 1996, p. 230)

In his widespread definition, Brandi defines restoration as "the methodological moment in which the work of art is appreciated in its material form and in its historical and aesthetic duality, with a view to transmitting it to the future" (1996, p. 231). Thus, only the historical and aesthetical angles are deemed crucial in the conservation process; nevertheless, and similarly to what Riegl verified when it came to monument values,

[8] Verbeeck-Boutin finds Brandi to "take a backward step relatively to Riegl, in the sense where he presents, in an idealistic viewpoint, values as objective and inherent to the work [of art]; this option […] is one of the points that make Brandi's *Teoria* of delicate application sometimes" (VERBEECK-BOUTIN, 2009, italics by the author).

these two approaches may prove antagonizing when conservation actions are to be decided upon.

To solve this conflict, Brandi suggests that the historical significance should prevail in conservation decisions regarding works that had lost their *potential unity*, which could not, therefore, be re-established through restoration; this is namely the case of ruins. Thus, when considering the historical significance alone, “any direct intervention is explicitly excluded if it goes beyond conservation monitoring and consolidation of materials” (BRANDI, 1996, p. 233).

For works that still conserved their *original potential unity*, though, the aesthetical requirement was to prevail above the historical one, and restoration had the main goal of re-establishing this *unity of the whole*.

The conflict between the two approaches, however, arises again with the consideration of *additions*[9] and *reconstructions*[10]. Historical requirements demand that additions, as documents of human activity and part of the history of the object, be conserved, “while its removal always needs justification, or should at least be done in a manner that will leave a trace both of itself and on the work of art.” (BRANDI, 1996, p. 234) Reconstructions, however, in spite of constituting historic testimonies, may “lead to a conviction of nonauthenticity or falsification for the entire work of art” (BRANDI, 1996, p. 235) and must, as such, be removed. An aesthetical approach to additions, however, defends their removal, so that the original unity of the work of art may be regained. Reconstructions, on the other hand, are acceptable if they achieved in giving the work a new artistic unity, or when its removal would imply the destruction of the physical integrity of the object. Although Brandi’s writings lean towards the primacy of the *potential unity* whenever applicable, in practice the conflict between the historical and aesthetical sides should be solved in a case by case basis.

1.1.4 Lipe’s Value System

> *… the things of the world have the function of stabilizing human life, and their objectivity lies in the fact that – in contradiction to the Heraclitean saying that the same man can never enter the same stream – men, their ever-changing nature notwithstanding, can retrieve their sameness, that is, their identity, by being related to the same chair and the same table.*

---

[9] “An addition can *complete* a work or can function, particularly in architecture, differently than was originally intended. With addition there is no imitation; there is, rather, a development or an insertion.” (BRANDI, 1996, p. 235, italics by the author)

[10] “A reconstruction […] seeks to reshape the work, intervening in the creative process in a manner that is similar to how the original creative process developed. It merges the old and the new so that they cannot be distinguished, abolishing or reducing to a minimum the time interval between the two creative moments.” (BRANDI, 1996, p. 235)

Arendt, cited by Lipe (1984)

In 1984, William D. Lipe, a notable archaeologist, proposed that certain materials that have survived from the past are kept because of their character as cultural resources, i.e., because they may "be of use and benefit – in the present and future" (1984, p. 2). In this sense, the author speaks of *resource values* – "to the extent that value is defined in relation to some end or use" (1984, p. 2), which underlines that, of course, some advantages are expected from conserving given objects. Basically, objects inherited from the past will be potential cultural resources; these will be evaluated within specific social contexts and they will be deemed worth preserving if resource values are recognized. According to Lipe, four types of resource values exist:

- associative/symbolic: describes the "ability that [cultural resources] have to serve as tangible links to the past from which they have survived" (LIPE, 1984, p. 4), i.e., of functioning as "symbols of, or mnemonics for, the past" (LIPE, 1984, p. 4). This symbolic capacity of past objects lies at the very core of human behaviour and its adaptive nature: symbols make intra- and intergenerational cultural transmission possible (thus allowing knowledge to be shared and surpassing learning by imitation or personal experience); to use tangible objects as symbols permits social groups to broaden the information fund beyond the capacity of the human brain – "Because they are durable, material items are the most stable kinds of symbols" (LIPE, 1984, p. 5).
- informational: refers to the fact that all past objects are, to a higher or lower degree, sources of information about the periods they crossed. The associative/symbolic value of cultural resources is strongly conditioned by the knowledge that societies possess about them; this knowledge may be traditional or common in character, or it may stem from scholarly research, which will eventually influence common perspectives held by non-specialists. The informational potential of cultural resources is only fully realized if "we have the wit to ask the right questions and the methods with which to extract the appropriate answers" (LIPE, 1984, p. 6). The key to extracting this knowledge lies heavily in formal research, which is crucial to accomplish the symbolic role that past materials possess. For periods where documentation is scarce, surviving objects will be the primary sources of knowledge; but even if documentation is abundant for a given period, the objects that the latter created will be able to supplement, corroborate or shed a new light in the existent knowledge.
- aesthetic: relates to the appeal that certain objects exert over their observers because of their shape, form, colour and/or other sensory qualities. While there is

an individual component to this appeal, there will also be a strong influence of social standards and overall cultural contexts to which the individual belongs to, and even of the contexts where the object originated from.

- economic: in what they coexist, and often compete, with other resources today, cultural resources, and decisions pertaining to them, will necessarily have an economic facet. One of the most relevant components to this value comes from the utilitarian dimension of some cultural objects, “which derives not from a property’s connection to a past cultural context, but from its ability to serve a present-day material need” (LIPE, 1984, p. 8) – a dimension which becomes particularly relevant in the case of built heritage. Other manifestations of economic values are conveyed by the resources (especially time and money) spent by individuals to gain access to heritage objects, be it in an exhibition ticket or in the auction of a famous painting or object; in these cases, people pay to access the symbolic and/or aesthetic values of the cultural resource, but this spending does not directly translate them:

> though economic value can be one indicator of public support for cultural resources and one tool for preservation of and public access to these resources, it cannot be our only criterion for what should be saved and managed for public enjoyment and education. (LIPE, 1984, p. 9).

Albeit with some conceptual differences, Lipe’s values are akin to those of Riegl. Holtorf (2000-2008) and Cohoon McStotts (2006) drew parallels between the two authors by relating Riegl’s age, historic, use and art values to Lipe’s associative/symbolic, informational, economic and aesthetic values, respectively. While the similarity between Riegl’s historic value and Lipe’s informational value is undeniable, the others need some more careful analysis for their relation to be grasped – the connection between age value and associative/symbolic value, for instance, is not as clear. Holtorf seems to consider age value to consist largely of aesthetic qualities, which slightly escapes Riegl’s (and Lipe’s) definition. Granted, there is an aesthetic side to the appreciation of age value, but there is also a (much more important) symbolic aspect, which is common to both author’s values and seems to better correlate them: for Riegl, the age value translated “the subjective and affective effect of the monument” (RIEGL, 1984, p. 57), representing the connection that the turn-of-the-century individual felt towards objects that stood the proof of time; for Lipe, the associative/symbolic values gain strength with the ability of cultural resources of providing a sense of continuity in our fast-paced era by permitting a direct contact with the past, and of serving as repositories of information, thus enhancing intra- and intergenerational communication. Both values have a symbolic component, and as such may be related, even if the eight decades of history that separate the authors brings them to necessarily different evaluations of their contemporaries' attitudes towards heritage objects. Also, in what they are shaped by the knowledge gained through their historic or informational values, the definitions of both age and symbolic/associative values seem in fact to be closely linked.

Lipe's aesthetic value, on the other hand, is relatable to Riegl's art value, and particularly with the relative art value: both speak of complying with the contemporary *Kunstwollen*, which relies on parameters that "will never be [clearly formulated] because they change incessantly from subject to subject and from moment to moment" (RIEGL, 1996, p. 71).

Finally, the connection between Riegl's use and Lipe's economic values is apparent in what the latter mentions the utilitarian dimension of some heritage objects. Nevertheless, Lipe seems to expand the concept by mentioning the resources that people are willing to spend to gain access to cultural objects, thus including phenomena such as the art market and cultural tourism. Furthermore, Lipe's economic values have a monetary side to them that Riegl did not mention, nor was Riegl's use value able to translate aesthetic or associative features into monetary (or other) terms; again, the value systems of the two authors are not exactly coincident, but the importance of the economic drive was hardly as pressing in the early 1900s as it became towards the end of the century.

In short, one finds more joining than separating elements to Riegl's and Lipe's value systems, and their main differences seem to largely emerge due to the great shifts in knowledge and thought that characterized the XX century. In this sense, and although very important conceptual tools are to be found in Riegl's theory, Lipe's values seem somewhat better adjusted to today's reality.

Implications in Conservation

Although not clearly directed to conservation, Lipe does mention some conflicts that may arise between the different values when it comes to deciding how they should be preserved. However, unlike Riegl, for whom societal choices will ultimately dictate conservation decisions, Lipe's considerations in this regard are mostly of an ethical nature, i.e., while acknowledging the importance of a social context in defining values, the author points some reasons why caution is needed when preserving these values.

For instance, while it is possible to produce fakes, imitations or reconstructions using new materials, the historical pathway that actual past objects crossed may not be falsified or changed; however, it may be “misunderstood and misrepresented […], as can the past cultural contexts from which the material objects have emerged” (LIPE, 1984, p. 5), be it for political or historical manipulations, economic ends, erroneous popular interpretations, or even on aesthetic grounds. Then,

> if we know that the history is false for which, e.g., a monument, building, or battleground is made to stand, we have the obligation to speak out about it. To do less is to declare that the associations of historic things and their meanings are, after all, only conventional, and that any information whatsoever can be attached to these things, for whatever purpose, if only enough of us agree to do so. (LIPE, 1984, p. 6)

Thus, historic meanings are not and may not become the fruit of conventions.

Also, new uses and meanings may be added to cultural objects, as it often occurs in the built heritage – and “we as cultural resource advocates must attempt to see that whatever function is added to a resource, the thread of association with its actual historic context is not broken, falsified or entirely submerged in its new fabric.” (LIPE, 1984, p. 6) Even if these new uses or meanings are added on aesthetical grounds, the link to the past must not be severed – aesthetic values cannot prevail over symbolic or informational values.

Other value conflicts are rooted on decisions driven solely by economic motives. For example, although “Adaptive reuse has saved many historic buildings and districts” (LIPE, 1984, p. 8), to consider the utilitarian dimension alone in preservation planning may risk informational and/or aesthetical values and even damage associative/symbolic values. Likewise, non-economical values (particularly informational values, which are not prone to translation into monetary terms) may be sacrificed to tourism or speculation in art markets. Caution is therefore advised, since, as mentioned above, economic tools are unable to convey all of the values involved in a cultural resource (see below).

Another relevant problem emerges when judgements are made today about how to keep cultural resources for tomorrow. This concern is manifest when dealing with informational values, i.e., when deciding what to preserve for future research, since many analytical methods are destructive and there are no certainties about the directions that the diverse disciplines devoted to heritage studies will follow. Evidently, this problem may also arise when considering associative/symbolic values; however,

> it is the nature of symbols that one or a few can stand for the whole, while it has been the trend of recent informational research to deal with large aggregates or

> samples of artefacts, sites, or whatever, and also to emphasize areal distributions of both cultural and natural phenomena (LIPE, 1984, p. 7)

Hence, anticipating and managing informational needs seems to be much more complex than setting priorities for associative/symbolic values. On the other hand, the interest groups defending resource preservation on grounds of informational values will be relatively small (compared, for instance, with supporters of symbolic values), and thus will need to present each case ever more carefully and consistently.

Stewardship institutions today choose to evoke other values when assessing the importance of a heritage object – or, better said, its *significance*. Many new values are added to the more traditional historical and aesthetical ones and reflect the ever-changing perspectives with which societies regard their culture and history, and objects as tokens of these: listed below are concepts such as universality and communal values, which highlight the social importance of heritage objects nowadays. Also included in this section is the concept of authenticity and that of integrity, which are not strictly values (nor strictly new at that), but gained an extreme relevance throughout the XX century and are at the centre of many conservation-related debates, and as such found their way here. Finally, there is a brief reference to universality, a relatively recent concept which has been gaining some importance and whose influence over conservation decisions is yet to be more clearly defined.

1.1.5 Significance

Value is a social construct dependent on social relationships [and] is bound to change through time and between cultures. […] It is an extrinsic property that cannot be directly detected by the senses, it does not exist without a social context.

J. Ashley-Smith (1999)

The Burra Charter (1999) uses *cultural significance* (or *heritage significance* or *cultural heritage value*) as the basic concept that should preside to conservation decisions; its definition rests upon the concept of value: "*Cultural significance* means aesthetic, historic, scientific, social or spiritual value for past, present or future generations" (ICOMOS-A, 1999, art.1, italics in the original document). Furthermore, "Cultural significance is embodied in the *place*[11] itself, its *fabric*[12]*, setting*[13]*, use*[14]*, associations*[15]*,*

[11] The Charter defines place as "site, area, land, landscape, building or other work, group of buildings or other works, and may include components, contents, spaces and views." (ICOMOS-A, 1999, art.1)

meanings[16], records, *related places* and *related objects*[17]" (ICOMOS-A, 1999, art.1, italics in the original document). Although some authors choose to consider significance as a concept that, albeit depending upon the values of each given object, is more about "the different ways in which people interpret and use it" (PYE, 2001, p. 60), this report will follow the Burra Charter definition. In this Charter, retaining cultural significance is the primary goal of conservation, and the values which consubstantiate this significance, "given alphabetically", are defined in the Guidelines to the Burra Charter as follows:

- aesthetic value: "includes all aspects of sensory perception for which *criteria can and should be stated*" (ICOMOS-A, 1999, p. 12); these criteria may be related to tangible or intangible features of the place, from scale or colour to smells or sounds;
- historic value: defined as an underlying value relatively to the others, for embracing aesthetical, scientific and social history; it is imbued in any place that "has influenced, or has been influenced by, an historic figure, event, phase or activity [or was] the site of an important event" (ICOMOS-A, 1999, p. 12);
- scientific value: present where there is relevant research data, and varying positively with its "rarity, quality or representativeness, and on the degree to which the place may contribute further substantial information" (ICOMOS-A, 1999, p. 12);
- social value: comprises the features that caused the place to "become a focus of spiritual, political, national or other cultural sentiment to a majority or minority group" (ICOMOS-A, 1999, p. 12).

The Charter further states that these are not by all means restrictive and thus other value categories may be found necessary or useful when characterizing the significance of a place.

---

[12] Fabric is defined as "all the physical material of the *place* including components, fixtures, contents, and objects." (ICOMOS-A, 1999, art.1, italics in the original document)

[13] Setting is defined by the Burra Charter as "the area around a *place,* which may include the visual catchment." (ICOMOS-A, 1999, art.1, italics in the original document)

[14] The Charter defines use as "the functions of a place, as well as the activities and practices that may occur at the place." (ICOMOS-A, 1999, art.1)

[15] In the scope of the Charter, associations refer to "the special connections that exist between people and a *place*" (ICOMOS-A, 1999, art.1, italics in the original document)

[16] The term meanings is used to "denote what a *place* signifies, indicates, evokes or expresses" which "generally relate to intangible aspects such as symbolic qualities and memories." (ICOMOS-A, 1999, art.1)

[17] A related place is a "place that contributes to the *cultural significance* of another place" (ICOMOS-A, 1999, art.1); whereas a related object "means an object that contributes to the *cultural significance* of a *place* but is not at the place." (ICOMOS-A, 1999, art.1, italics in the original document)

Also in the spirit of the Charter of Venice, the New Zealand Charter (2010) prefers *cultural heritage value* as operative concept, defined as: “possessing aesthetic, archaeological, architectural, commemorative, functional, historical, landscape, monumental, scientific, social, spiritual, symbolic, technological, traditional, or other **tangible** or **intangible values,** associated with human activity.” (p. 9, boldface in the original text) Cultural significance ceases to be synonyms with cultural heritage value and takes a slight shift in meaning from the Burra Charter: “means the **cultural heritage value** of a **place**[18] relative to other similar or comparable **places**, recognising the particular cultural context of the **place**.” (ICOMOS-NZ, 2010, p. 9, boldface in the original text)

For English Heritage (EH), the significance of a place[19] corresponds to the ensemble of all the values that can be attached to that place; these values are considered to fall into the following categories (EH, 2008):

- evidential value: based in the ability that places have to function as documents of past periods. This value generally augments with potential for knowledge gain, age and scarcity of other sources of knowledge for the context in question; it diminishes with removals or replacements;
- historical value: either *illustrative* or *associative*, historical value resides on the ability of a place to link past and present people: illustrative value relies on visibility and “has the power to aid interpretation of the past through making connections with, and providing insights into, past communities and their activities through shared experience of a place” (EH, 2008, p. 29); associative value ensues from places that are linked to “a notable family, person, event, or movement” (EH, 2008, p. 29). Historical value is generally not as reduced by change as evidential value: “The authenticity of a place indeed often lies in visible evidence of change as a result of people responding to changing circumstances. Historical values are harmed only to the extent that adaptation has obliterated or concealed them, although completeness does tend to strengthen illustrative value” (EH, 2008, p. 29);

[18] The New Zealand Charter defines place as “any land having **cultural heritage value** in New Zealand, including areas; **cultural landscapes**; buildings, **structures,** and monuments; groups of buildings, **structures,** or monuments; gardens and plantings; archaeological sites and features; traditional sites; sacred **places**; townscapes and streetscapes; and settlements. **Place** may also include land covered by water, and any body of water. **Place** includes the **setting** of any such **place**.” (ICOMOS-NZ, 2010, p. 9, boldface in the original text)

[19] For EH, the term ‘place’ is “a proxy for any part of the historic environment, including under the ground or sea, that people (not least practitioners) perceive as having a distinct identity, although recognising that there is no ideal term to cover everything from a shipwreck to a landscape” (EH, 2008, p. 13).

- aesthetical values: relatable to "the ways in which people draw sensory and intellectual stimulation from a place" (EH, 2008, p. 30), these values may yield from (conscious) *design* or from *fortuitous* evolutions in the use of the place, and these my combine or conflict. Design values vary with the quality of both design and execution, as well as with the innovative character of the place, and must be maintained with appropriate care measures endeavouring at maintaining the design concept.

- communal values: deriving from "the meanings of a place for the people who relate to it, or for whom it figures in their collective experience or memory" (EH, 2008, p. 30). These include *commemorative* and *symbolic* values, when places act as sources of identity or evoke an emotional response from (at least some) people; *social* value also exists in places "that people perceive as a source of identity, distinctiveness, social interaction and coherence" (EH, 2008, p. 32); and *spiritual* value, which is linked to feelings of worship, wonder, inspiration or reverence one experiences in a place.

This division is not, however, rigid – it may accommodate some adjustments to a particular site, as it happens for Hadrian's Wall, for example.

Figure 2: Cawfield Crags, Hadrian's Wall. © Roger Clegg. The strong connection of the Wall to the landscape is one of the key reasons why the site is listed twice as a UNESCO WHS.

Indeed, the current Hadrian's Wall management plan, in which English Heritage plays a determinant role, dedicates a whole chapter to the listing, assessment and description of the values that the site encompasses, accompanied by specific references to the features of the Wall that materialize each value; the list includes (HWMPC, 2008):

- Outstanding Universal Value (OUV): “means cultural and/or natural significance which is so exceptional as to transcend national boundaries and to be of common importance for present and future generations of all humanity. As such, the permanent protection of this heritage is of the highest importance to the international community as a whole.” (UNESCO, 2011, art.49)
- Evidential values, manifested in: *complexity*, *group value*, *archaeological evidence*, *landscape value*, *scale*, *rarity* and *international influence*;
- Historical values, which unfold into: *documentation*, *associative value* and *illustrative value*;
- Aesthetic values;
- Communal values, here decomposed in: *academic value*, *educational value*, *recreational value*, *social value* and *economic value*;
- Natural values.

For various reasons, mostly related to changes in peoples’ perceptions, values evolve. Throughout history, societies seem to have initially valued sites for reasons strictly connected to their original function (military, religious, and so forth); but new values were progressively added, while others were lost or dimmed. Today, historical and aesthetical values are joined by others more contemporary in character, such as those related to tourism, setting, local economies or international influence. These new values all share a more or less close relationship with the fabric of the place, or the materiality of the object. It is interesting to note, for instance, that social values, as defined by EH, seem to “tend to be less dependent on the survival of the historic fabric” (EH, 2008, p. 32), quite the opposite to spiritual values, which seem to evolve in a manner closely connected to the fabric of the place. It should come to no surprise, then, that, as already asserted by Riegl, it is this straight link between the values and the materiality that embodies them that will eventually dictate conservation decisions.

1.1.6 Authenticity | Integrity | Universality

Authenticity

The definition of authenticity should, in fact, be related to the historicity of the heritage resource; only then does it achieve its true significance to modern conservation.

J. Jokilehto (1999)

Authenticity has often been thought of as a value intrinsic to the object, suggesting that conservation objects have fixed values and that these are not dependent on social context (and therefore on time and space). For the Venice Charter, according to Jokilehto, authenticity is built upon the diverse "historical stratifications" (JOKILEHTO, 1988, p. 267) of each monument, and these must therefore be preserved. This perspective of authenticity, which specifically prevented the removal of any of the elements that materialised the historic layers of a monument (allowed only under exceptional circumstances), made perfect sense within the Western approach to art and conservation but its application proved inadequate in different civilization and tradition contexts.

The Nara Charter (1994) defines authenticity as "the essential qualifying factor concerning values" (1994, article 10) and so it must be a requisite, not only of the (heritage) object, but also, and especially, of all sources of information used to understand and value it. Authenticity is described in the Nara Charter as strictly linked to the credibility and truthfulness of information sources; these may be of the most diverse nature, adding to the understanding of the object – with information on aspects such as "form and design, materials and substance, use and function, traditions and techniques, location and setting, and spirit and feeling, and other internal and external factors" (UNESCO & ICOMOS, 1994, article 13) – in its multiple dimensions.

Pillared on the importance of cultural diversity, the Nara Charter clearly states the impossibility of imposing rigid criteria for the assessment of both values and authenticity; these assessments will always depend, first and foremost, on the specific cultural contexts that generated the heritage object and, also, on the ones that tend for it.

Clearly acknowledging the importance of Nara, the recent revision of the New Zealand Charter defines authenticity as "the credibility or truthfulness of the surviving evidence and knowledge of the **cultural heritage value** of a **place**. Relevant evidence includes form and design, substance and **fabric**, technology and craftsmanship, location and surroundings, context and **setting**, **use** and function, traditions, spiritual essence, and sense of place, and includes **tangible** and **intangible values**. Assessment of **authenticity** is based on identification and analysis of relevant evidence and knowledge, and respect for its cultural context." (ICOMOS-NZ, 2010, p. 9, boldface in the original text)

Other than a value in itself, authenticity may be considered, then, as a qualifier for values.

Perhaps more clearly, authenticity may be considered as "Those characteristics that most truthfully reflect and embody the cultural heritage of a place" (EH, 2008, p. 71).

For Lipe, authenticity lies at the very core of the associative/symbolic value of a cultural resource:

> Physically, cultural resources participate in both the past and the present. Their authenticity is the basis for creating in the contemporary viewer the subjective knowledge that he has experienced a contact with the past that is direct and real, however incomplete that experience may be. (1984, p. 4)

Authenticity may refer to tangible or intangible object features, and "These references can be understood to cover the aesthetic and historical aspects of the site, as well as its physical, social and historical context, including use and function" (JOKILEHTO, 1999, p. 298). This broadness, however, may prevent a clear definition of what is to be considered authentic or not, particularly in the case of buildings and structures; to prevent misunderstandings and/or misinterpretations, Jokilehto suggests that the "historicity of the heritage resource" be the key-defining element when approaching authenticity (1999, p. 298).

Integrity

The integrity of a monument typically refers to its state of completeness, i.e., it characterizes the degree to which the monument is whole or unified, as opposed to divided, impaired or with elements removed. This integrity is to be preserved, as defended in the Charter of Venice reads: "Items of sculpture, painting or decoration which form an integral part of a monument may only be removed from it if this is the sole means of ensuring their preservation." (I.C.A.T.H.M., 1964, art.8) On the other hand, integrity is a requirement for the sites listed as World Heritage, and UNESCO defines it as "a measure of the wholeness and intactness of the natural and/or cultural heritage and its attributes" (UNESCO, 2011, art.88). Implementing the World Heritage Convention means periodically assessing and submitting statements of authenticity and integrity within the recommended reports.

Jokilehto points out the risks of approaching integrity from a material perspective alone: it "may stress the trend to reintegration, stylistic restoration, or reconstruction" (1999, p. 299). However, the author highlights the value of the concept as an operative tool for establishing the relative importance of each element within the whole of the site, thus assisting in significance analysis.

Universality

At the same time that globalization has standardized certain lifestyle elements among many of the world's populations, it has also led to an increased awareness of the multiplicity of cultures worldwide and helped individual cultures recognize their own uniqueness. A better *understanding of the culture and heritage of others raises one's consciousness and estimation of one's own culture.*

John H. Stubbs (2009)

Today, it appears that "there is a great deal of evidence to suggest that local, place- and community-bound values (i.e., those not, by definition, universally valued) are a more important impulse behind conservation" (AVRAMI et al., 2000, p. 69). As pointed out earlier, "culture is a set of processes, not a collection of things. Artifacts are not static embodiments of culture but are, rather, a medium through which identity, power and society are produced and reproduced" (AVRAMI et al., 2000, p. 6). This would mean a greater emphasis put on specific contexts as grounds for preserving certain objects, i.e., on the relativity, rather than on the universality, of the values of heritage objects.

Other opinions contrarily defend that, today,

> with the acceleration of the pace of manufacture and discard, and of the rate at which our landscapes are being changed, […] we have become explicitly concerned with the loss of human continuity and contrast brought about by too rapid a change in our cultural environments, both build and natural. (LIPE, 1984, p. 1)

In other words, and according to Jokilehto, in today's multicultural urban centres that progressively traded a connection to traditional values for individualism and efficiency, sacrificing diversity for mass production, "cultural properties can play an important role in providing physical references for the re-establishment of cultural memory and cultural identity" (1999, p. 298).

In fact, the concept of "rules of inheritance" was recognized as a cultural universal, meaning that the tendency to keep things from the past and pass them on to future generations is cross-cultural (ASHLEY-SMITH, 2009) or, as Lipe puts it, "as old as human culture" (1984, p. 1). So, it seems that there are, in fact, some universal values about heritage objects that are inherent to them and that transcend specific socio-cultural constructs, in what they foster "shared human longings for love and beauty and cooperation [since] the need for access to one's culture, one's heritage, crosses all cultures and contributes to human flourishing and happiness in the Aristotelian sense" (AVRAMI et al., 2000, p. 7). Of course, which kinds of things are kept will differ within each social group. Although there is some disagreement on the importance of specific social contexts, i.e. on the relativity or universality of some heritage values, both sides seem to agree on a dependency of time and place.

The universality of some heritage objects is a traditional assumption in conservation that “emphasizes the positive role of heritage in promoting unity and understanding” (AVRAMI et al., 2000, p. 69) and finds a most eminent application example in the UNESCO’s World Heritage List. For a long time, this feature, thought to distinguish some selected few objects, was considered as a fundamental support of the conservation of these objects. The influence of this universality status is undeniable and plays into conservation decision-making; for instance, in Hadrian’s Wall the preservation of the OUV bestowed upon the site by two listings within the UNESCO convention became a key value in the planning strategy – as reinstated in the current management plan, “The protection and enhancement of this OUV forms the basis for the management of the WHS” (HWMPC, 2008, p. 26). The UNESCO World Heritage Operational Guidelines are to be consulted for the management of World Heritage Sites (WHS), a designation which is a strong tourism propeller.

Nevertheless, conservation is a social activity, and thus inherently subjective, evolving according to “cultural contexts, societal trends, political and economic forces” (AVRAMI et al., 2000, p. 7). Thus, the awareness of cultural relativism demands further investigation towards what should be the scope of application of the universality concept in conservation, namely by assessing the cultural significance of each object.

1.1.7 The Contribution of Economics

[Material] heritage is valued in a number of different, sometimes conflicting ways. The variety of values ascribed to any particular heritage object […] is matched by the variety of stakeholders participating in the heritage conservation process

R. Mason (1998)

Between 1998 and 2003, the Getty Conservation Institute (GCI) promoted a research project that intended to draw conservation and economics nearer, so that each discipline would benefit from the expertise of the other. One of the departing points for this project was the laying down of some concepts and assumptions from where the research could develop, and these included distinguishing between the economic and cultural valuing systems. These stem directly from two different approaches to cultural objects: “while economists discuss the exchange and use values of objects of cultural heritage, culturalists [anthropologists, sociologists, historians, etc] will focus on their cultural and social values” (KLAMER & ZUIDHOF, 1998, p. 23) – even if from an economics perspective, one may read “I would characterize cultural capital as the ability to inspire or to be inspired” (BLUESTONE, KLAMER, THROSBY & MASON, 1998, p. 20).

In economic terms, the following values have been suggested as attributable to heritage objects (KLAMER & ZUIDHOF, 1998):

- option value: describes the hypothetical satisfaction withdrawn by an individual from the possibility of consuming a given (heritage) good;
- existence value: describes the satisfaction withdrawn from knowing a given (heritage) good exists (but not from actually using it);
- bequest value: describes the value of the (heritage) good for future generations;
- prestige value: describes the satisfaction withdrawn from the status conferred by the possession of a given (heritage) good;
- education value: describes the educational benefits provided by the (heritage) good.

With the possible exception of education value, all of the above are non-use values. As descriptors, they seem to fail in encompassing the full richness of what makes a heritage object valuable. The interest of these values, however, resides mostly in their helpfulness as instruments of economic analysis; for that purpose, they try to translate heritage values into categories that will allow for value measurement, generally in terms of utility. Below, there is a brief mention to the input that economics may bring to heritage conservation, and especially to value analysis.

Measuring Economic Values

To measure is to know: this is the motto of all economic investigations into the valuation of cultural heritage.

A. Klamer and P.-W. Zuidhof (1998)

The increasingly more consistent involvement between economics and cultural heritage acknowledges the vast influence of the former in nowadays' globalized society, and aims at a better understanding of some of the social processes implicated by cultural heritage conservation, while additionally contributing to empower the social role of the conservation field.

One of the most significant contributions of economics to cultural heritage conservation concerns the measuring of values. Processes of decision making are always based on the assignment or definition of the values involved – even if they are not clearly stated sometimes – and on the appraisal of the expected shifts in these values induced by the different possibilities one has to choose from. Decision making in cultural heritage is, as seen throughout this chapter, no exception, and thus the valuing process is a capital one in conservation:

> First, valuing processes underpin conservation and should even be seen as *part of* the conservation process. Decisions of *what* to conserve and *how* to conserve are made in the context of many different valuing systems […]. Second, the valuing process consists of two distinct but intertwined parts: *valuation* (the assessment of the existing value) and *valorization* (the addition of value). These are essential parts of the conservation process, and the distinction between them helps explain why economic values (which, in broad brush, are the result of valuation) are often seen as quite separate from cultural values (which result more from the process of valorization) (MASON, 1998, pp. 5-6, italics by the author).

This separation between economic and cultural values was already hinted in the previous sub-section. On this note, one should also bear in mind that "valuation involves the assessment of values that people actually attach to heritage goods, whereas valorization is the (re)appraisal of the heritage goods by means of deliberations, pleas by art historians, debates in public media, and so forth" (KLAMER & ZUIDHOF, 1998, p. 31).

In economics, the valuation tool *par excellence* is, of course, the market. However, the public good[20] character of cultural heritage objects, as well as the occurrence of externalities[21], cause markets to fail when dealing with this kind of goods. These two features objectively prevent markets to provide cultural goods in an efficient manner; besides, normative failure is also a possibility, which occurs whenever said goods are not provided in a way that satisfies people's expectations, i.e., in a way considered unjust, inappropriate or immoral[22]. These normative failures are social and cultural and therefore may change over time and across social groups (KLAMER & ZUIDHOF, 1998).

Although market-based evaluation methods are still employed, market failure in many instances has led to the use of alternative tools to analyse the mechanisms through which cultural heritage goods are provided and allocated in society. As highlighted earlier, scarcity of resources forces choices to be made; and the evaluation of possible uses for said resources is crucial for rational decision-making; economically speaking,

---

[20] In economic terms, a public good is a good displaying both non-rivalry and non-excludability, which mean, respectively, that its consumption by one given individual does not hinder its consumption by others and that no individual can be prevented from consuming it.

[21] An externality is a positive (benefit) or negative (cost) effect, issued from a good, that is not priced in the market, i.e., it does not incur in a market transaction.

[22] Merit goods, for example, are defined as commodities that are good but that will be underproduced if it depends on markets alone, because the consumer does not have enough information to realize the benefits of this good. On the other hand, if the market fails to provide the expected heritage protection for the future, we speak about (lack of) intergenerational equity.

this implies measuring costs and benefits. Thus, alternative economic tools for the valuing of heritage are now being increasingly used to try and provide more solid bases for decision making in conservation; these tools are all based in the economic principle of consumer sovereignty in trying to ascertain the utility actual or potential consumers withdraw from heritage goods, and include (KLAMER & ZUIDHOF, 1998) (RIGANTI & NIJKAMP, 2005) (RIGANTI, 2006) (NIJKAMP, 1991):

- **Social cost-benefit analysis (market-based)**
  1. revealed preference willingness-to-pay (WTP): WTP studies may assess actual (revealed) or hypothetical (stated) behaviour; whenever possible, WTP analyses actual consumers' behaviour – revealed preferences –, for instance by assessing admission fees for the right to use a heritage good. Nevertheless, when no fees are charged (or chargeable), other forms of measuring revealed WTP study (1) consumers' averting behaviour, i.e., the circumstances leading to not using the good; (2) the price paid for complementary goods, using a weak complementarity approach and (3) the price paid for other goods, using hedonic pricing (for instance, comparing prices of similar objects with and without heritage value); (4) the travel and time costs to visit the monument (travel cost method);
  2. impact studies: these measure the economic significance of a heritage good in terms of the income that it generates directly and indirectly. Albeit extremely popular in the past decades, "their inability to account for opportunity costs and for the variety of values ascribed to heritage" (MASON, 1998, p. 17), has been recently causing them to loose credibility.
- **Survey-based techniques**
  1. contingent valuation method (CVM): this method surveys a pertinent group of people's willingness-to-pay for a (hypothetical) good in a (hypothetical) market or willingness-to-accept the (hypothetical) ceasing of access to the good, i.e., the compensation amount people would demand for a (hypothetical) loss; CVM allows for obtaining a WTP via the analysis of stated (as opposed to revealed) preferences. Although it is the only technique that acknowledges option, existence and bequest values, there are important shortcomings to CVM, such as its high dependence on survey design and the reliability of preferences stated for hypothetical situations; issues regarding the selection of people to survey or the fact that these methods do not allow differences between specific and general heritage goods to be distinguished, along with decision anomalies (BONINI, 2007), among others, may also prevent their use for other than qualitative conclusions; "Unfortunately, the non-market nature of many cultural

resources makes the use of methods like CVM a regrettable necessity" (NOONAN, 2003, p. 172). Their use together with other methods, such as referenda, is sometimes advised.

2. conjoint analysis/choice experiments: it is a survey-based technique where the respondents are required to choose between different commodities, each one featuring a set of attributes. Respondents have to trade-off between different attributes, and the analysis of these trade-offs allows for the preference elicitation regarding these attributes; one of the attributes generally being the price, conjoint analysis also estimates WTP through stated preferences. Albeit dealing with environmental sciences, Stevens *et al.* (2000) provide a summarized comparison of CVM and conjoint analysis that sheds some light into differences in the WTPs obtained by the two methods.
3. direct referenda: the referendum provides a combination of actual and hypothetical preference statement by asking "a constituency to vote on a public expenditure for the arts that they have indicated in the CV study to be worthwhile" (KLAMER & ZUIDHOF, 1998, p. 34); however, the influence of propaganda and limited information and participation, as well as the costs, may somewhat deter its generalized use.

- **Multicriteria analysis**

Multidimensional approaches to valuation rose from difficulties found in reliably assessing public investment projects, including heritage conservation ones, with resort to the traditional economic tools mentioned above, as it is extremely difficult to find a common denominator in which to render the multiple objectives (resulting in multiple welfare criteria) and social costs that are characteristically involved in such projects. Assessments of a given project or object based on these approaches integrate diverse information, both qualitative and quantitative, be it of social, economical, historical, cultural or environmental nature, among others. Intended both as a policy planning and assessment instrument, multidimensional impact assessment builds decision matrixes that attempt to describe all the possible outcomes of alternative policies; departing from these multidimensional impact analyses, multiple criteria analysis develops policy evaluation models, trying to capture the (multidimensional) social benefits of heritage and analysing it with resort to multidimensional utility theory;

- **Benefit transfer**

Benefit transfer consists of transferring information from studied sites (or objects) to sites (or objects) that lack their own specific data, with the purpose of ascribing valuation estimates to the latter. Notwithstanding the challenge posed by the site specificity of heritage, and hence of its valuation studies, as well as the methodology heterogeneity of valuation studies, new attention has been brought to these because of the high implementation costs of CVM. Besides requiring several departure assumptions, benefit transfer must meet diverse criteria; consequently it must be resorted to with caution and more research is still needed before it becomes an acceptably reliable valuation tool for the cultural heritage field.

Each method has its own advantages and shortcomings that make it more or less adequate to each specific case (RIGANTI & NIJKAMP, 2004). Still, none of the listed methods is considered to provide exact answers, and results seem to be somewhat dependent on the chosen valuation method, which does not reassure their reliability (RIGANTI & NIJKAMP, 2005). Notwithstanding these limitations, valuation studies may still prove helpful for decision making about allocating resources for conservation, namely by integrating their results in the cost-benefit analyses of conservation projects (TUAN & NAVRUD, 2008) (BÁEZ & HERRERO, 2012).

Despite their usefulness in the context of decision making, the tools issued from economics must be used with caution in a discipline such as conservation, avoiding over-mechanistic approaches that place too much emphasis on the economic values of cultural heritage rather than on social and cultural values. The use of merely economic reasoning for conservation, based on jobs, income or wealth generation may be counterproductive, with the risk of "economic arguments [being] articulated in a way that begins to atrophy the other [social and cultural] arguments for conservation" (BLUESTONE et al., 1998, p. 20).

Perhaps the greatest shortcoming found in the approach of economics to cultural heritage lies precisely in its limitations in converting aesthetic, symbolic and cultural values, among others, into merely economic values, normally measured in monetary units (MASON, 1998). Also, cultural objects are not necessarily produced because of consumer demands; in most instances, they were created for other, varied, reasons, and are defined as heritage objects by art-historians, anthropologists and the like.

A final aspect should be highlighted concerning the influence of economics in the value of heritage. Though, as highlighted earlier, economics mostly directs its efforts towards valuation processes, it too, as a social science, may influence the valorization of a given object via, precisely, its valuation. In other words, shifts in the price of an object may cause shifts in the values ascribed to that object (e.g., realizing that a given object has a higher than expected market price may trigger interest for its history). The opposite is, evidently, also valid: the valorization process is what, in principle, economists will try to measure via valuation, and thus shifts in the values attached to an object will have an effect in the economic value of that object. Going further, some economists defend that the specific form of financing a heritage object – be it the market price, a government subsidy or a non-governmental organization (NGO) gift[23] – will affect its valorization (KLAMER & ZUIDHOF, 1998); what is certainly true is that the valorization process will have a large influence on heritage financing possibilities.

1.2 How to Conserve – Principles of Conservation Practice

To the extent that our lives are made meaningful by culture, it is by this ability of acts, works, and a way of life to persist, carried on through time in the memories of humans, and also in the cultural things and landscapes that humans create.

William D. Lipe (1984)

The most important conservation principles today are consecrated in international charters and include: minimum intervention; reversibility/retreatability & compatibility/removability; discernible restoration; interdisciplinarity; and sustainability. A brief description of some relevant aspects to these principles may be found below – while the previous section mostly dealt with *what* is being conserved; this section is devoted to the *how*.

Most conservation principles that are held today evolved throughout centuries of object conservation history, particularly over the past century, when conservation became a more consistent and reflected upon human activity. Conservation practice plays an important role – from his experience as a metal restorer, Ashley-Smith suggests the possibility of practical experience dictating these principles and not the other way around: “behaviours interpreted in retrospect as ethical, and therefore fitting universal guidelines, may well have developed independently and without external influence within specific trades and disciplines” (2009, p. 14). But what conservation behaviours are considered ‘ethical’ today?

The introduction to the Venice Charter (I.C.A.T.H.M., 1964), to this day a pillar document in the conservation of cultural heritage, emphasises two central points: how cultural heritage is increasingly considered as a *common heritage*; and how it is our *duty to preserve the authenticity* of monuments for future generations; Jokilehto regarded these two issues as the “crystallization of the essential ideas in the

[23] A gift is a good that is transferred without a clear or formal agreement upon a specific restitution, albeit, economically speaking, gift-giving relies on reciprocity.

conservation of cultural property" (1988, p. 267). These points logically lead to the need of considering both the present and the future generations *for whom* heritage is stewarded, and this means to acknowledge the full richness of values that may be attached to that heritage.

Considering present stakeholders, Muñoz-Viñas (2005) proposed that conservation ethics must be *adaptive* in order to accommodate the primary goal of preserving the values and meanings that each heritage object has for the group that is affected by it; this means that no conservation principle should be rigidly applied. On the other hand, since the focal point in conservation are the values of the object, "ethical principles (reversibility, minimum intervention) are not recognized as actually being principal, but rather as added values relative to the goal of the treatment" (MUÑOZ-VIÑAS, 2005, p. 175). Also, the application of all principles in one given intervention may prove conflicting, and there may be a need to privilege certain amongst them, depending on the objectives of said intervention.

Our responsibility towards future generations is translated by the concept of *sustainability*, which has been suggested to be a "terribly useful" replacement for the historical-aesthetical paradigm that traditionally presided over our appreciation of heritage (BLUESTONE et al., 1998).

It is from this present and future commonality of heritage – that we must strive to preserve – that the principles that guide modern conservation should be derived.

1.2.1 Minimum Intervention

The professional guidelines endorsed by the European Confederation of Conservator-Restorers' Organisations (ECCO) recommend that indirect methods of conservation – preventive conservation – take precedence over direct actions on the object and that the latter be limited to the absolutely indispensable: "The Conservator-Restorer should take into account all aspects of preventive conservation[24] before carrying out physical work on the cultural heritage and should limit the treatment to only that which is necessary." (E.C.C.O., 2003, art.8) The Burra Charter also consecrates the principle of minimum intervention, stating that conservation "requires a cautious approach of changing as much as necessary but as little as possible" (ICOMOS-A, 1999, art.3). As a term, minimum intervention first appeared in the Code of Ethics and Guidance for

[24] "Preventive Conservation consists of *indirect action* to retard deterioration and prevent damage by creating conditions optimal for the preservation of cultural heritage as far as is compatible with its social use. Preventive conservation also encompasses correct handling, transport, use, storage and display. It may also involve issues of the production of facsimiles for the purpose of preserving the original." (E.C.C.O., 2002, Preamble)

Practice of the Canadian Association for Conservation of Cultural Property and of the Canadian Association of Professional Conservators in 1986; as a concept, it seems to have stemmed from the late XX century realisation that direct actions upon a heritage object were, in general, potentially harmful, and that science was not always capable of providing fully safe treatment options (ROUDET, 2007). Today, minimum intervention is solidly anchored as one of the key directives to bear in mind when planning a conservation intervention.

The issue remains, however, of defining what should be considered a minimum – meaning absolutely necessary – intervention. From a purely materialistic viewpoint, many actions would not be considered indispensable for the conservation of a heritage object. Nevertheless, Brandi, defending restoration as a critical act, proposes the (discernible) reintegration of lacunae as a necessity for regaining the potential unity of the artwork, without which a lacuna would stand out and relegate the image to the background, thus hindering its apprehension (BRANDI, 1996). Paul Philippot defended, in turn, that restoration implied the critical interpretation of the artwork and, regarding lacunae reintegration, this meant that "the minimum is in itself suggested by the lacuna, in particular by its location; the hiatus is created regardless of its size" (ROUDET, 2007, p. 55), and illusionist reintegrations might apply. Concerning cleaning, however, Philippot was somewhat more restrictive, warning against the perils of losing critical interpretation in favour of scientific or technical solutions applied systematically and without judgement and adverting that "Patina, in fact, is precisely that «normal» effect of time over matter. It is not a physical or chemical concept, it is a *critical* concept" (Philippot, cited in ROUDET, 2007, p. 56, italics by the author).

Because of its contingency upon the object and its characteristics, including values and context, materials and condition, it is not possible to rule which specific actions pertain to the domain of the minimum indispensable and which ones do not. Decision should always start, however, with a posture of humility before the object, and a conscience of the potential harm that may be caused by a direct action upon it. According to Roudet (2007), elements that should be considered when pondering over a minimum intervention include:

- the values that we bestow upon the object and their relative importance: as seen with Riegl, values may conflict, and it is the prevailing value(s) that will ultimately dictate both actions and amplitude of the required intervention;
- the use that is and will be made of the object;
- the cultural context that originated the object and the elements that grant its authenticity;
- the intention that created the object.

As a corollary, and as defended by Philippot, only a critical interpretation of the cultural object, comprising its context and specificities (including, but not limited to, material aspects), allows for defining what a minimum intervention should consist of.

1.2.2 Reversibility | Retreatability & Compatibility | Removability

Reversibility was a conservation principle adopted mainly due to the failing of some past treatments, in an attempt to protect the monuments from the harmful effects they might potentially induce (SASSE & SNETHLAGE, 1996b); with time, it became highly accepted in conservation practice, maintaining its authority for many years.

Recent conservation guidelines still contemplate reversibility as a desirable principle – the Burra Charter states that "Changes which reduce *cultural significance* should be reversible, and be reversed when circumstances permit" and ads, in the explanatory notes, that "Reversible changes should be considered temporary. Non-reversible change should only be used as a last resort and should not prevent future conservation action." (ICOMOS-A, 1999, art. 15, italics in the original text) One should nevertheless note that this is applicable only to "changes which reduce *cultural significance*" and that allowing future treatments is considered mandatory.

In recent years, however, reversibility became "not a requirement, but an ideal to be pursued whenever possible" (MUÑOZ-VIÑAS, 2005, pp. 191-192). As such, it does not validate interventions that are aggressive to heritage values simply because they are reversible: "Unless of very short duration, crude and intrusive changes are certainly not justifiable simply because they are theoretically temporary or reversible, for they risk becoming permanent" (EH, 2008, p. 47).

Verification either of the unfeasibility or of the contradictions raised by the criterion of reversibility – which in stone conservation, for instance, fails whenever impregnation or cleaning treatments are necessary –, along with critics that relate its use to reducing responsibilities in conservation practice, directed the emphasis towards different principles, and the concepts of retreatability and compatibility were put forth (TEUTONICO et al., 1996) (SASSE & SNETHLAGE, 1996b).

The concept of retreatability was already present in Brandi's *Teoria del Restauro*: his third principle of restoration reads "every restoration should not prevent but, rather, facilitate possible future restorations" (BRANDI, 1996, p. 341). According to Muñoz-Viñas, the term retreatability was proposed by Appelbaum as an ethical guideline asserting that treatments performed upon a conservation object should not preclude the future treatment of the latter. Retreatability, as removability (see below), is a

concept that emerged with the realization that full reversibility of a treatment is seldom a practical possibility, providing those involved in conservation with a feasible ethical alternative (MUÑOZ-VIÑAS, 2005).
Compatibility, on the other hand, is a term that may be defined[25], when classifying conservation interventions, very similarly to what the International Council on Monuments and Sites (ICOMOS) Australia and the ICOMOS New Zealand designated by compatible use: "a use which respects the cultural significance of a place. Such a use involves no, or minimal, impact on cultural significance" (ICOMOS-A, 1999, art. 1); "a **use** which is consistent with the **cultural heritage value** of a **place**, and which has little or no adverse impact on its **authenticity** and **integrity**." (ICOMOS-NZ, 2010, p. 9, boldface in the original text). Likewise, it may be said that a compatible intervention should respect and be harmonious and consistent towards the values of the heritage object, without jeopardizing its significance, integrity or authenticity.

Removability is a conservation guideline which asserts that, when applying materials onto an artefact being conserved or restored, preference should be given to those which are believed to be removable. It should be noticed that this concept implicitly accepts that these materials may (and probably will) have an effect on the material of the artefact, and that these effects may be irreversible; the term was firstly proposed by Charteris (MUÑOZ-VIÑAS, 2005).

1.2.3 Discernible Restoration

As mentioned earlier, Boito suggested discernible restoration as a form of solving the architect-restorer's dilemma of responding to his creative urge while respecting the history of the object. Brandi appropriates this concept and turns it into a restoration requirement, necessary for the legitimating of restoration as a part of the history of the object: "the act of restoration, in order to respect the complex historical nature of the work of art, cannot develop secretively or in a manner unrelated to time. It must allow itself to be emphasized as a true historical event – for it is a human action – and to be made a part of the process by which the work of art is transmitted to the future." (BRANDI, 1996, pp. 232-233)
More recently, the Burra Charter states that reconstruction – which, for the purposes of this Charter, is defined similarly to restoration but, unlike the latter, implies "the introduction of new material into the fabric" (ICOMOS-A, 1999, art.1) – while

[25] Because of the central role that this concept has in the current dissertation, a more comprehensive definition may be found in a subsequent chapter.

defendable in certain circumstances, "should be identifiable on close inspection or through additional *interpretation*." (ICOMOS-A, 1999, art.20, italics in the original document)

In his defence of adaptive ethics, Muñoz-Viñas reminds us that, in some contexts, discernible restoration may be contrary to the best interest of the persons affected by interventions on a given object; under these circumstances, it may be more ethically correct to make reintegrations invisible, if that is the form of better preserving the values of the object (MUÑOZ-VIÑAS, 2005).

1.2.4 Interdisciplinarity

In some way or another, conservation of cultural heritage always maintained a strong connection with history of art, and one may venture to say (as did Françoise Choay (2000)) that these two disciplines *as such* developed hand in hand and that this development finds its roots the same social motivations and attitudes towards heritage. In time, and with the necessity of better understanding decay processes and the best way to tackle them, multidisciplinarity definitely arose within cultural heritage conservation with the critical contributions of several hard sciences; on the other hand, besides history of art, other soft sciences also began engaging in the conservation field.

Nevertheless, professionals involved in the conservation of cultural heritage have, in recent years, remarked that, albeit the need for multidisciplinary work is duly acknowledged, there is often a lack of interaction – interdisciplinarity – among the several disciplines drawn in: "If one were to map, simply and generally, the current shape of conservation policy and practice, one would find a rather linear path with different groups of professionals engaged in distinct steps along the way" (AVRAMI et al., 2000, p. 3); schematically:

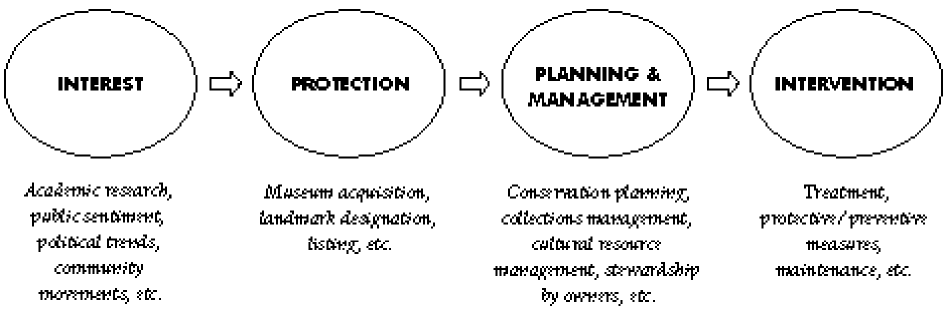

Figure 3: Current pathway of a heritage object, from its production (meaning its recognition as cultural heritage), through its conservation process, until eventually a technical intervention is required – "different aspects of conservation activity often remain separate and unintegrated, retaining the sense that conservation is insulated from social contexts" (AVRAMI et al., 2000, p. 4). (source: GCI (2000)).

Two main reasons are suggested for this lack of interdisciplinarity: “the rather fragmented and unbalanced body of work that supports the work of conservation; [and] also […] the specialization of work in different disciplines” (AVRAMI et al., 2000, p. 4). The fact that the bulk of the research effort in the conservation field has mainly focused on the physical condition of the object has been highlighted earlier; other fields, such as history or history of art, have contributed with knowledge about specific objects, but this research is not generally undertaken within the field of conservation and it is not necessarily integrated in an object conservation analysis; finally, the knowledge of disciplines such as anthropology, philosophy, sociology and economics, to name a few, has been lacking research addressing specifically the conservation field that would contribute to a better understanding of contexts and, maybe, help binding these different conservation-oriented expertises together.

The fact is that the need for integrated approaches is considered pivotal for conservation to keep up with the challenges of nowadays rapidly changing society. Furthermore, other disciplines, such as economics, and new branches of already implicated social sciences, are being called in to fill the research gaps that arise as social and cultural circumstances evolve. The urgency of involving policy-makers and other relevant stakeholders in the process of conservation, with a strong focus on the more directly concerned communities, has been stated as critical for the development of conservation as well (AVRAMI et al., 2000).

1.2.5 Sustainability

The decay of familiar objects and structures is congenial evidence of our compatibility with the world we inhabit. Prior wear and tear provide comfort as proof that a building or artifact was not created for our use alone or to exert control over us. Its marks of longevity show that we are mere temporary tenants and caring stewards. Participants in the ubiquity of decay, in time we also leave our own mark, alike enriching and aging any object.

D. Lowenthal (1992)

The most widely adopted definition of sustainability may be found in what is commonly known as the Brundtland Report, which reads: “Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (BRUNDTLAND, 1987); which means considering both intra- and intergenerational equity.

Sustainable Conservation is a term proposed by Muñoz-Viñas (2005) as one of the core principles of contemporary conservation theory – in fact, as *the* core ground from where ethical considerations regarding conservation may be derived. More precisely, the notion of sustainability highlights the interests of future users as the main impediment for freely disposing of conservation objects in the present; leading the author to suggest that "the conservator has the moral duty to find out the reasons why an object is to be conserved and to learn about its tangible and intangible uses before making decisions that can compromise its usability", considering that "it is the conservator who will likely have to represent the interests of future users" (MUÑOZ-VIÑAS, 2005, p.204).
Nevertheless, the same author alerts to the fact that the concept of sustainable conservation may be a paralyzing one if taken to its extreme interpretation: as we cannot be sure of all the potential values that an object may have for future generations, only no-touch conservation actions, i.e., preventive conservation, would be allowed. This is undesirable whenever it means not meeting the needs of present generations also affected by the object (MUÑOZ-VIÑAS, 2005).

From a different perspective, the concept of sustainability was considered to provide workable common ground to the heritage and economics fields, much due to the advances in environmental conservation – a field from which heritage conservation may draw many useful analogies, as long as one bears in mind (1) that "whereas the environmental issues and interventions are developed on the strong basis of ecological science, heritage issues have no such theoretical model on which to rely" (MASON, 1998, p. 16) and (2) that "direct comparisons to environmental economics" may cause one to "loose sight of distinctive characteristics of cultural heritage, such as its value for national identity" (KLAMER & ZUIDHOF, 1998, p. 27).

1.2.6 Impact on values

It became clear, with Riegl, that the perception of the values bestowed upon a given object is the main determinant factor when it comes to conservation decisions. But conservation decisions will also affect the way an object is valued, by introducing changes in the way it is perceived and represented – value and conservation have been said to share a symbiotic relationship (TAYLOR & CASSAR, 2008). Taylor and Cassar (2008) suggested potential effects on value caused by different conservation decisions:

Table 2: Potential effects on value caused by intervention decisions – by Taylor and Cassar (2008, p. 5)

Seven degrees of intervention	Possible repercussions on value
Prevention of deterioration	Intended to reduce change but certain kinds of value may be given priority, so values change at different rates.
Preservation of the existing state	Many values kept; utility and possibly aesthetic and information values slowly decrease.
Consolidation of the fabric	Utility increases but information decreases, e.g. DNA information.
Restoration	Utility and aesthetics may increase but information and material authenticity may decrease.
Rehabilitation	Contextual value increases, potential uses may decrease.
Reconstruction	Material authenticity decreases, information may increase.
Reproduction	Reproduction is different, since the original object is not necessarily irreversibly affected by this intervention.

A special reference should be made to the impact of preventive conservation (or prevention of deterioration): because no direct handling is involved, preventive procedures are not generally considered as introducing immediate significant changes to the object, but the fact is that choices are made to decrease specific deterioration rates, thus changing the evolution of the materials and, therefore, eventually having an impact on the values these materials embody.

1.3 Some Conclusions

Riegl was one of the first authors to recognize that it is the values societies attach to heritage objects that distinguish them from common objects, and that those values have suffered, and will continue to suffer, shifts in their definition. Even if there are universal values voiced by society through its heritage, these are not intrinsic to the objects but, rather, are bestowed upon them by social groups of variable size, in variable moments in time.

Today, a multitude of values joins the aesthetical and historical values that were traditionally conferred to heritage objects; these contemporarily recognized values are largely communal in character, including touristic, educational and recreational values, among others, thus reinforcing the role of the subjects (or stakeholders) in building and conserving heritage. Given the inclusiveness of what may be considered to possess cultural value, one of the chief merits of the Burra Charter, or of the EH guidelines that followed, it is precisely to draw attention for the necessity of defining these values and thus better understand the object.

Authenticity and integrity are other concepts that must integrate heritage analysis. Although they may be contemplated as values, they belong in a slightly dissimilar category, characterizing different heritage aspects. For World Heritage sites, and along with a statement of significance, describing the values that each given site embodies, UNESCO recommends that statements of authenticity and integrity are periodically issued as well. An authenticity assessment will ascertain the veracity and reliability of the information sources pertaining to the site, while assessing integrity means to evaluate the wholeness of the site when it comes to conveying its values.

Economic tools may prove helpful in the assessment of heritage values by measuring the utility that people withdraw from heritage existence; techniques used for the valuation of heritage may assist cost-benefit analyses and, thus, decision making in site management. They cannot, however, represent the sole ground for basing decisions, as they are unable to convey the multiplicity of values involved in a heritage object.

Another important aspect to Riegl's work is the theorizing of the conflicts between values when it comes to conservation decision making; this was also pointed out by Boito and, later, by Brandi, albeit in different terms, and by Lipe, although more from an ethical perspective. As a corollary, the concept of value seems to provide a useful framework for analysing these conflicts and for negotiating and deciding in conservation, as long as the choices are clearly formulated, so as to make interventions **legitimate** and **intelligible** to future generations.

As already hinted by Riegl, and clearly asserted more recently (TAYLOR & CASSAR, 2008), the concept of value is not of a homogenous nature, since many kinds and typologies of values make up the overall value of a heritage object. As such, *value* should be contemplated as a "multifaceted matrix" (RICHMOND & BRACKER, 2009, p. xiv) or, better still, a spectrum that cannot be considered under a single scale of measure (TAYLOR & CASSAR, 2008); those different types of values that compose the overall value of the object will shift at different rates (in time, space, or whenever the object suffers an intervention), demanding for a multi-perspective approach that tries, as much as possible, to understand these shifts and their impact in the overall value of the object, i.e., its significance.

From here follows the definition of *conservation* proposed by EH: "the process of managing change to a significant place in its setting in ways that will best sustain its heritage values, while recognising opportunities to reveal or reinforce those values for present and future generations." (EH, 2008, p. 7) Likewise, a conservation intervention should be seen in the broader context of the continuum that forms the history of the object, i.e., as part of a process, rather than as a discrete occurrence.

Conservation principles assist decisions concerning *how* conservation should be performed. It is presupposed, then, that *what* should be conserved in given object is assessed prior to making conservation decisions. In other words, as we assume the responsibility of conserving heritage for present and future generations, we should firstly assess the significance we are trying to preserve and only then discuss the best ways of preserving it. These will largely depend on the people affected by the object, i.e., those that bestow values upon it, but the uncertainty relatively to future values has to be contemplated as well.
This is why the need for adaptive conservation principles, i.e., principles that respond to the various reasons for which each given heritage object is preserved, has been highlighted. On the other hand, the concept of sustainability advises on the uncertainty about future generations, suggesting caution when approaching the conservation of an object (albeit not to a paralyzing extreme) – our actions and choices, including the choice of taking no direct actions, will have an impact on the objects and, thus, on the values we aim at preserving.

The following chapter will elaborate on how values and conservation principles will influence decision making in heritage site management.

2 DECISION-MAKING PROCESSES

Negotiation and decision-making processes are key to understanding the role heritage plays in society.

E. Avrami, R. Mason, & M. de la Torre (2000)

Scarcity of resources such as time, money and effort force the deciding between alternatives to allocate them; hence, managing a site means daily decisions regarding the interpretation, access and conservation, including intervention planning. In principle, these decisions should be anchored in a conservation strategy that mirrors the concerns of society when tending to its heritage.

This chapter aims at describing some decision-making processes that are currently used in the conservation of monuments. These processes are very diverse in terms of provenance – we find DSS ensued from the conservation world and others that were adapted from tools originally developed for other fields –, and scale – meaning they serve to support different stages of planning, from a macro to a micro level.

The presentation of these processes, given below, is divided in four main groups: Values-based Decision Making; Risk Management in Conservation, the Prodomea DSS and Performance-based Assessments.

In recent years, management strategies have become more explicitly based on the conservation of the values of a site, as exemplified by the Burra Charter Process, the ensuing Conservation Management Plan and the English Heritage Guidelines. On the other hand, a growingly preventive approach to heritage led to the adaptation of risk management procedures to conservation. In what it aims at minimizing risk, risk management seems to be the perfect complement to values-led management and its safeguarding of values. Works on the risk management of museum collections and of World Heritage sites, which help coping with the most important threats to heritage objects, are nowadays widespread.

When it comes to planning interventions, however, neither the minimization of risk nor the safeguarding of values seem to have been translated into operative tools. The Prodomea DSS is a recent method that supports intervention planning using compatibility as the operative concept, advising that choices are made that minimize the (in)compatibility of the action towards the heritage object. This method may be assisted by performance-based assessments, which answer many questions at the products and techniques level, even if clear performance-based decision criteria are yet to become consensual.

This analysis should permit to understand what is nowadays deemed crucial when deciding in conservation, and namely if there are robust criteria that allow for rationalizing intervention planning.

2.1 Values-based Decision Making

Management planning should focus on values, using them as an explicit basis for decision making.

B. Feilden and J. Jokilehto (1998)

The management of a heritage site generally focuses on three central goals: conserving its heritage resources, presenting them to visitors and researching them. The implementation of these critical goals generally unfolds into other management objectives, related to activities as diverse as technical conservation interventions, heritage objects interpretation, public managing, infrastructural control and development. These activities are, in principle, assigned to different wardens, and often lack a unifying thread clearly underpinning each separate effort and framing them under the abovementioned ultimate goals (MASON et al., 2003).

The GCI has recently proposed that a values-based approach constitutes the most adequate framework for the management of cultural heritage sites (MASON et al., 2003). This type of approach consists chiefly in analysing the values associated to the monument and ascertaining the overall significance of the latter, in order to assess the most effective options for the preservation of this significance. One of the main advantages of values-based approaches is their unifying character, promoting the integrated analysis of the often very diverse and sometimes seemingly irreconcilable issues related with the management of a cultural resource, since all the values and stakeholders' expectations are brought into discussion. In fact, a values-based management lies heavily on the consultation of all the involved stakeholders, while realizing how this group has been progressively broadened for most cultural resources, once new values were acknowledged to contribute to the significance of said resources. In a nutshell, the use of a values-based approach to site management "is characterized by its ability to accommodate many heritage types, to address the range of threats to which heritage may be exposed, to serve the diversity of interest groups with a stake in its protection, and to suggest a longer-term view of management" (MASON et al., 2003, p. 1).

The assessment of values for a given monument may resort to a variety of sources, of which the most traditional ones are historical and research records, as well as the professional opinion of traditional cultural heritage stakeholders, namely researchers and experts in the areas of history, art history, archaeology, architecture and the like. Today, as new values are recognized to play a part in the significance of a monument, so are new stakeholders admitted into the circle of managerial influence; thus, cultural heritage stakeholders (the "connected people" of the New Zealand Charter) are now defined as "people for whom the place has special *associations* and *meanings,* or who have social, spiritual or other cultural responsibilities for the place" (ICOMOS-A, 1999, art.12, italics in the original text) or, more pragmatically, "individuals or groups who have an interest in a site and who can provide valuable information about the contemporary values attributed to the place [; they] can be communities living close to a site, groups with traditional ties or with interests in particular aspects of the site" (MASON et al., 2003, p. 1).

Most of the values recognized by these different stakeholders are legitimate and, in principle, traditional values, be they aesthetic, historic or scientific, are not to overshadow other more recently acknowledged ones. This does not prevent the fact that some sites have their significance and, where applicable, a subsequent designation based in the recognition of some specific values, and thus these may gain some ascendancy over the others – although never at their expense, as underlined in the Burra Charter.

Once the values are assessed and the significance of the site is established, it is necessary to determine which site (material) features convey which values. This step means answering questions such as: "What about [the material features] must be guarded in order to retain that value? If a view is seen to be important to the value of the place, what are its essential elements? What amount of change is possible before the value is compromised?" (MASON et al., 2003, p. 2) From this analysis, a clearer understanding of the elements responsible for the significance of the site should ensue, from where protection and conservation plans may be designed.

Worldwide, notable heritage-stewarding institutions that implemented values-based management include English Heritage and the Australian Heritage Commission – that abides by the Burra Charter; their site management recommendations are briefly described below.

2.1.1 The Burra Charter Process

Conceived in the spirit of the principles of the Charter of Venice, one of the major contributions of the Burra Charter was the formalization of values-based management in cultural heritage. As Mason *et al.* have put it, it is "a site-specific approach that calls for an examination of the values ascribed to the place by all its stakeholders and calls for the precise articulation of what constitutes the site's particular significance" (MASON et al., 2003, p. 2).

In the Burra Charter, conservation is viewed as a process, rather than discrete endeavours, which integrates a larger process of site management. In the context of the latter, "the aim of *conservation* is to retain the *cultural significance* of a *place*" (ICOMOS-A, 1999, art.2, italics in the original document); as seen earlier, for this Charter, the cultural significance of a place incorporates the complete array of values that said place embodies.

Yet another interesting aspect to the Charter is the emphasizing that the usage of the place may contribute to its cultural significance; notwithstanding the fact that compatible uses should be sought, practices that help build the significance of a place should be fostered and protected.

The Burra Charter Process is a management model based on cultural significance, where "a sequence of collecting and analysing information before making decisions" (ICOMOS-A, 1999, art.6) should allow for the understanding of this significance, which, in turn, should take precedence (and preside) over policy development and subsequent management. The Process begins with the identification of place and associations (definitions above), prioritizing its securing and safety; and, once those are assured, the sequence *significance understanding – policy development – management* may begin.

Figure 4: The penitentiary building of the Port Arthur Historic Site. © Marta de la Torre, GCI. The management of the site for the past decade is regarded as a successful example of the application of the Burra Charter Process, which submits decisions to the preservation of the site significance while fostering negotiation among stakeholders and providing enough latitude for the consideration of economic viability concerns.

Understanding the significance of a site starts with the collection and recording of all the information deemed necessary, be it documentary, oral or physical in nature, for the ensuing significance assessment; a statement of significance may then be built. This statement will be built upon interpretation[26], which is key to significance understanding, as “The cultural significance of many places is not readily apparent” and “Interpretation should enhance understanding and enjoyment, and be culturally appropriate” (ICOMOS-A, 1999, art.24).

Policy development will then follow, beginning with the identification of “obligations arising from significance”, which of course include the conservation of what embodies this significance – “the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects”, as quoted earlier –, and may include some degree of change to these elements, if necessary to retain the significance they represent; the use of the site will have to be analysed as well. This identification should be complemented with information about “other factors affecting the future of a place such as the owner’s needs, resources, external constraints and its physical condition.” (ICOMOS-A, 1999, art.6) Furthermore, the policy should be developed taking into account different options and carefully analysing the consequences of their implementation upon significance; the chosen policy should then be issued as a statement, and explicitly guide subsequent actions.

[26] “*Interpretation* means all the ways of presenting the *cultural significance* of a *place*.” (ICOMOS-A, 1999, art.1, italics in the original document)

Statements of cultural significance and of policy both need to be “justified and accompanied by supporting evidence” and “should be kept up to date by regular review and revision as necessary.” (ICOMOS-A, 1999, art.26)
Strategies may be developed and implemented – the management proper – according to the statements. The management plan should additionally contemplate (1) the careful documentation of the place prior to any changes being introduced and (2) the monitoring and reviewing of procedures and plans.

The Burra Charter Process is an iterative one, and statements and strategies must be periodically reviewed. Guidelines to the Burra Charter are provided that help preparing the significance statement by guiding the planner through specific elements that the process should include. As Mason et al. have put it, “the Burra Charter is an adaptable model for site management in other parts of the world because the planning process it advocates requires the integration of local cultural values.” (2003, p. 2)

2.1.2 English Heritage: Managing Change

> *Values-based site management is the coordinated and structured operation of a heritage site with the primary purpose of protecting the significance of the place as defined by designation criteria, government authorities or other owners, experts of various stripes, and other citizens with legitimate interests in the place.*
>
> R. Mason, M.G.H. Maclean, M. de la Torre (2003)

In its “Conservation Principles, Policies and Guidance for the Sustainable Management of the Historic Environment”, English Heritage (EH) stresses its intention “to strengthen the credibility and consistency of decisions taken and advice given by English Heritage staff, improving our accountability by setting out the framework within which we will make judgements on casework” (EH, 2008, foreword). The words *credibility*, *consistency* and *accountability* are symptomatic of nowadays’ need for more explicit principles and decision-support tools in the realm of heritage conservation. Even if each case is unique, decisions should be framed by a common ground of principles that meet the each society’s perspectives on their own heritage; these should be clearly stated, so that decision making becomes increasingly transparent and intelligible.

As noted earlier, EH defines conservation as “the process of managing change to a significant place in its setting in ways that will best sustain its heritage values, while recognising opportunities to reveal or reinforce those values for present and future generations." (EH, 2008, p. 7) The definition emphasizes the *inevitability of change*[27]; nevertheless, "Considered change offers the potential to enhance and add value to places, as well as generating the need to protect their established heritage values." (EH, 2008, p. 15)

This "Considered change" plausibly translates into management framed by the six Conservation Principles that are to guide all decisions pertaining to the historic environment. These principles, which unfold into guidelines, address EH's *major concerns* regarding conservation and could be summarized as follows:

- emphasizing the communal character of heritage (Principle 1);
- actively involving, assisting and advising all those who wish to have a role in the sustaining of heritage (Principle 2);
- acknowledging the critical role of understanding the significance of (heritage) places (Principle 3);
- directing managerial decisions, first and foremost, towards value sustainability (Principle 4);
- demanding for consistency, transparency and reasonability in all decisions related to change (Principle 5);
- promoting constant reviewing and learning by carefully documenting decisions (Principle 6).

According to EH, the sustainable management of a *place* (definition above) must necessarily be mandated by a thorough *understanding* of its significance – a complex task that entails:

(1) comprehending the fabric of each place and its changes throughout time;

(2) identifying the social groups that ascribe values to each place, and why;

(3) understanding the relations between values and fabric, and to what extent objects that are no longer incorporated in the fabric but that are historically associated with it participate in those values;

(4) clarifying how the values are articulated and what is their relative importance;

(5) analysing the roles of setting and context in the construction of these values; and

(6) comparing places that are endowed with similar values.

The process is described to greater detail in the "Principles…"; it should be "systematic and consistent" and applied in a manner that is "appropriate and proportionate in scope

[27] "Change in the historic environment is inevitable, caused by natural processes, the wear and tear of use, and people's responses to social, economic and technological change." (EH, 2008, p. 22)

and depth to the decision to be made, or the purpose of the assessment" (EH, 2008, p. 35).

Defining and characterizing the significance of a place is to be followed by the *communication* of that significance to all the concerned stakeholders – so that decisions affecting the place are made in awareness of the values in question. Going further than involving those directly acting upon heritage, the "Conservation Principles…" place the emphasis on the participation of all those who wish to contribute to heritage conservation, promoting an approach inclusive of all possible heritage audiences.

The understanding of significance stands at the core of the definition and implementation of *management* strategies, including those pertaining to specific conservation interventions, maintenance or repair, in a way that the heritage values are sustained in the most adequate way. The EH document highlights the role of all those affected in conserving a place, and acknowledges that involving the stakeholders whose decisions have a direct impact upon the place is crucial for strategy implementation. The management of Hadrian's Wall World Heritage Site, for instance, involves hundreds of stakeholders, including farmers, government agencies both local and national, and ONG; "the basic structure of the site's management regime [features] flexible policies and a wide latitude for the actions of individual partners, held together by a mutual commitment to a common core of values" (MASON et al., 2003, p. 12) – concerting the efforts of all the stakeholders in an operative structure is crucial.

Moving from significance understanding to conservation means, for each given place, using the gained knowledge to: (1) assess the vulnerability of values; (2) promote the actions and constraints that best sustain those values; (3) moderate possible conflicts between the conservation of different values; (4) guarantee that the authenticity of the place is preserved (EH, 2008).

This managing of change implies, evidently, decision making. Special attention should be paid to verifying if the gathered information is enough to support decision – investigating the impact of each possible change upon significance is crucial and may require targeted research. Similarly, impacts upon authenticity and integrity must be analysed as well. Tensions may arise when balancing the conservation of the different values, and also when considering authenticity and integrity – all of these rely on the fabric, design and/or function of the place but may demand different options to be made upon these different features. Only a thorough understanding of significance and of the impact of change upon that significance may legitimate decisions concerning which values will prevail.

Given its definition of conservation, it is clear that EH considers conservation in the broadest sense possible: “Conservation is not limited to physical intervention, for it includes such activities as the interpretation and sustainable use of places.” (EH, 2008, p. 43)

The use of a place is considered vital for its conservation: “It is the potential of significant places to be used and enjoyed that generates value in the market or to a community, and so tends to motivate and enable their owners to exercise positive, informed stewardship.” (EH, 2008, p. 43)

When it comes to intervening upon a place, it “may be justified if it increases understanding of the past, reveals or reinforces particular heritage values of a place, or is necessary to sustain those values for present and future generations, so long as any resulting harm is decisively outweighed by the benefits.” (EH, 2008, p. 22) EH offers some guidelines to direct the planning of different kinds of interventions, which must be read in the framework of the Principles:

(1) *Routine management and maintenance* of the place are basic for its conservation, and these should be assisted by a regular monitoring that also detects repair or renewal needs;

(2) A “physically and visually compatible” (EH, 2008, p. 51) periodic *renewal*[28] of some elements of the fabric should be undertaken whenever the alternative will result in a serious loss in fabric and values and provided that the loss in values implicated by the renewal is only temporary;

(3) When *repair*[29] is necessary, preference should be given to proposals that do not preclude future interventions and that keep conflicts among different values to a minimum – decision must be supported by enough information on the possible impacts; repair materials and techniques should be well-known and of proven efficacy and durability, which does not necessarily mean that they are the same as the original ones, as well as compatible with the existing fabric;

(4) Because it will imply the loss of evidential value, an intervention “*to increase knowledge of the past*” (EH, 2008, p. 54) requires (i) a team with the necessary skills, (ii) arrangements for the analysis, deposit, conservation and reporting of

[28] “Renewal: Comprehensive dismantling and replacement of an element of a place, in the case of structures normally reincorporating sound units” (EH, 2008, p. 72).

[29] “Repair: Work beyond the scope of maintenance, to remedy defects caused by decay, damage or use, including minor adaptation to achieve a sustainable outcome, but not involving restoration or alteration” (EH, 2008, p. 72).

the findings and (iii) a strategy that protects the remainder of involved elements and values. Non-destructive techniques should be preferred and, while the intervention should be kept to a minimum, it should also be "extensive enough to ensure that the full research potential of what is necessarily to be destroyed in the process can be realised." (EH, 2008, p. 55)

(5) The acceptability of *restoration*[30] will depend on its: offsetting the values that would be lost by those that would be restored; having enough evidence to support the intervention; not changing the form if it is associated with an event of great historical significance (unless loss is the only alternative); showing consideration for earlier forms, i.e., not affecting integrity with incongruent elements; having a sustainable maintenance programme. Because of their potential threats to authenticity, restoration interventions must be carefully considered. Adequate documentation should be produced within every restoration; this documentation should be integrated and compared with the information on which the intervention was grounded.

(6) As for *new work* or *alteration* of a place, they are desirable (particularly in places of lesser significance) in what they generate heritage for future generations; nevertheless, these should be contemplated only if: there is enough information for the impact upon significance to be fully understood; they imply no material damage to the existent values, "which, where appropriate, would be reinforced or further revealed" (EH, 2008, p. 58); values are created for posterity relying on design and execution quality; in the long-term, they do not preclude alternative solutions or they are considered beneficial. Besides significance, it is the safeguard of authenticity and integrity that should set the acceptability limits for loss of fabric. As a corollary, "Innovation is essential to sustaining cultural values in the historic environment for present and future generations, but should not be achieved at the expense of places of established value." (EH, 2008, p. 58) As for alterations that aim at minimizing disaster impact, they should be analysed from a risk assessment perspective and, carefully balanced against the losses caused by the works and compared with solutions focused on "improved management as an alternative to, or in conjunction with, lower levels of physical intervention" (EH, 2008, p. 59) In all cases, materials and techniques face the same requirements as those listed for repair works.

[30] "Restoration: To return a place to a known earlier state, on the basis of compelling evidence, without conjecture" (EH, 2008, p. 72).

EH emphasizes the importance of heritage planning in a fashion that is articulated with other public objectives as the best form of reducing conflict and defending heritage interests. This entails that changes that are harmful to the significance of a place may be considered if: (i) these changes are proven to be indispensable because of sustainability or public policy necessities; (ii) no harmless alternative exists; (iii) the harmfulness of the change was minimized (subject to its intended goal); and (iv) a significant prevailing of the foreseen public benefit over the harmed values is proven.

Finally, it should be stressed that the management of a place must accommodate shifts in values. If values are dynamic, then, evidently, a values-based analysis and planning has to be periodically reassessed; also, the efficacy of the chosen options and their impact on the significance of the monument needs to be evaluated at regular intervals, and thus values-based management should always function on the basis of periodic plans. This of course does not prevent the necessity of drawing long-term (thirty years) goals, which prove invaluable to guide medium-term (five years) planning (HWMPC, 2008). Each new plan should therefore include the detailed revision of its predecessor – learning from its shortcomings, understanding which objectives were not attained and why and analysing new contexts that may have come into play and how the plan responded to them.

2.1.3 Meanings-based Planning

The need for stating precisely which values are being preserved is also a concern for museum objects, and although this thesis is principally dedicated to the built heritage, it was considered worth mentioning the proposal of a model that defends the concise definition of the values found relevant for each particular object as a crucial step for conservation decision-making. Refusing the Brandian vision of values emanating uniquely from the object, Verbeeck-Boutin suggests that these relevant object values have to be derived from the perspectives of each person involved with the object, from its conception to its public presentation, including the artist, curators, historians, the owner, the public and, of course, the conservator. The author proposes that a conceptual model be created that enhances the definition of these values, to systematize and articulate them, thus "[promoting] the objectivation of choices and favouring the interdisciplinary discussion before decision making" (VERBEECK-BOUTIN, 2009). This definition would not only provide a framework for future generations to better understand current conservation options, but would also allow for all the intervenients to have a clearer idea of the different values involved.

Verbeeck-Boutin's proposed model is particularly adapted to high-art museum pieces, listing the possible values that may be attached a given work of art according to each specific intervenient group; these values may be intentional or attentional (VERBEECK-BOUTIN, 2009):

- intentional values are defined by the artist;
- attentional values relate to the apprehension of the object by different groups or persons, e.g. curators could define collection, historical, aesthetical and societal values; museographers would maybe list mediatisation, pedagogical and emblematic values; conservators would plausibly find aesthetical, historical, cognition and expertise values, among others.

This approach goes along the lines of the one developed in the end of the XX century by the Foundation for the Conservation of Modern Art / Netherlands Institute of Cultural Heritage (SBMK/ICN). The SBMK/ICN model was conceived for modern and contemporary art conservation and relies fundamentally on the analysis of the role that materials play in the meanings – a concept which, as stated earlier, may be used interchangeably with that of values – of each piece. Since meanings depend more or less heavily on the physical condition of the works and because each conservation action will have an effect on this condition, these meanings must be carefully analysed and defined before decision making.

In broad lines, the SBMK/ICN model consists of the following sequential steps: (1) data registration of pertinent information concerning the object and its author; (2) survey of the object physical condition; (3) investigation of the meanings of the object and of the material elements that convey those meanings; (4) ascertaining of whether or not there is a discrepancy between the object condition and its meanings; (5) in the case of a discrepancy calling for a conservation intervention, analysis of the conservation options; (6) for each option, weighing of the risk for the meanings of the object; (7) the outcome of the previous steps will be the chosen treatment, described in this step, including preventive and curative conservation measures.

Seeing as steps (1) and (2) already had institutional guidelines to be followed, the model pays more attention steps (3) to (6), which progress via the answering of the questions found relevant to build a consistent conservation proposal. Thus, the path to define each object's meanings develops around questions "grouped around various aspects of the object: aesthetic considerations, authenticity, historicity and functionality. Moreover, the questions can be answered from various perspectives: that of the artist (or of his/her surviving relatives and studio assistants), that of a forum of authoritative art critics and art historians, and that of those responsible for making a decision (the curator and/or conservator)" (SBMK/ICN, 1999, p. 3). Considering the conservation options available means analysing their influence in the detected meanings, verifying not only aesthetic considerations, authenticity, historicity and functionality, but also the relative importance of the artwork, financial limitations and possibilities, legal aspects, the artist's opinion on the intervention, technical limitations and possibilities and restoration ethics (SBMK/ICN, 1999).

Although somewhat specific to contemporary artworks and relying heavily on qualitative appraisals of the material features of the object, this methodology forces a comprehensive analysis of the conservation object by its custodians and, with a few adaptations, would profitably be applied to other conservation objects. Nevertheless, other values, such as social or economic values, and also the relative importance of the artwork, should additionally be considered in the initial meanings definition.

2.2 Risk Management in Conservation

Cultural heritage is always at risk. It is at risk from the depredations of war. It is at risk in the face of nature's occasional eruptions and irruptions. It is at risk from political and economic pressures. It is at risk from the daily forces of slow decay, attrition and neglect. It is even at risk from the hand of the over-zealous conservator!

H. Stovel (1998)

In broad terms, Risk Management provides scientific support to decision making in a context of uncertainty. This support is developed along two main spheres: one, concerning the assessment of risk; and the other, which deals with the forms of mitigating it. In the past decades, risk management has known an increasingly widespread development in several fields, among which those related to Engineering are prominent. Depending on the specific field where risk management is applied, the necessary tools for risk assessment and mitigation vary, but there are, of course, common principles that characterize this type of approach.

The application of risk management to cultural heritage has known important developments in recent years, reflecting the growing importance placed by society in preventive, rather than curative, approaches to heritage conservation. Some of the most well-known examples of this application include the risk assessment methodology proposed for museum collections by Robert Waller (1994), the ICOMOS Heritage at Risk Programme and the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) guidelines developed for world heritage sites (STOVEL, 1998). The following subsections will address a few general notions on risk management and some examples on how its tools were used in the conservation field.

2.2.1 Some Concepts: Risk Analysis, Risk Evaluation, Risk Control

First of all, it is necessary to define some concepts, as used in the context of risk management (CALDEIRA, 2005):

- Risk: value(s) corresponding to the combination of the probability of occurrence of undesirable events with their possible consequences; it implies looking into (at least) the scenario, its probability of occurrence and its related outcomes, although progressively complex systems may demand further analyses, such as initiating events, system responses and outcomes, exposure factors and consequences.
- Risk Analysis: procedures aiming at identifying and quantifying, within a given system, the undesirable events, the mechanisms that may trigger each event, the respective system responses and the associated consequences – including estimates of extension, amplitude and probability of loss occurrence.
- Risk Evaluation: involves considering the admissibility of the estimated risk; when coupled with Risk Analysis, it is designated by Risk Assessment.
- Risk Management: comprises both Risk Assessment and the ensuing decision-making processes aiming at risk control, including mitigation, observation/monitoring and reporting/communication.

In a nutshell, risk management implies the identification, analysis, evaluation, communication, mitigation and control of risk(s) and thus, when systematically applied, it is helpful not only in increasing safety, but also in raising quality, productivity and/or revenues and in lowering costs and/or production time frames. Risk management may also lead to changes in the concept of projects and/or to the sharing of risk by the different intervenient parts (CALDEIRA, 2005).

Risk analysis is the first phase of any informed risk management process; and it should be performed in sequential steps, starting with the (1) identification of its scope and goals; followed by the (2) identification of the possible hazards; the (3) identification of the consequences, including estimates of their magnitude and probability of occurrence; and, finally, by the (4) estimation of the risk.

The scope, as well as the detail, of a risk analysis will depend on which questions need to be answered and on which decisions need to be made. It may be delimited by time, space, nature of risk, consequences, degree of uncertainty, and so forth; it may be the study of the total risk or it may focus on a specific risk (CALDEIRA, 2005). As for the goals, they will generally be related to safety factors and social impact of collapse events; again, in certain situations and due to the complexity of the analysis, it may be useful to limit the study to specific risks.

Identifying the possible hazards and their consequences means listing, for each identified hazard (1) its causes or trigger events; (2) its damaging mechanisms; (3) the possible scenarios, i.e. the system responses to the hazard; (4) the vulnerability factors affecting the system; (5) the possible consequences. This data will permit to estimate the risk, which amounts to combining the occurrence probabilities of the hazard causes, mechanisms and ensuing scenarios, as well as the probabilities and dimension of each possible consequence.

Because the consequences need to be defined, more often than not dealing with risk means dealing with values (or with the number of lives, where applicable), and the way they shift with the occurrence of an undesirable event. This implies a valuation process that allows for different risks to be ranked and prioritized, since larger losses in value (or utility, or benefits) are synonyms with greater risks (for risks with the same probability of occurrence).

In the *risk evaluation* phase, the previously identified risks are appraised in terms of their admissibility. This step will depend on the perception and acceptability that is socially accorded to each specific risk, which will, in turn, depend on (1) ethical, cultural, economical and political factors, among others; (2) the origin of the risk (natural, imposed or volunteer) and its incidence (individual or societal); and (3) the available information. These will therefore be determinant for the valuation of risks, which will increase, for each society, with exposure, limitedness of information and danger aversion (CALDEIRA, 2005).

The definition of acceptability and tolerance limits is also within the scope of risk evaluation and the most widely used approach, originally defined for societal risk, divides the risks in three regions (MANSOUX, 2000):

- unacceptable, where only in extraordinary circumstances can risks be justified;
- tolerable or ALARP (as low as reasonably possible), where either “risk reduction is impracticable or its cost is disproportionate to the improvement gained”, bordering the tolerance limit, or, at least, the “cost of reduction would exceed the improvement gained”, bordering the acceptability limit (MANSOUX, 2000, p. 11);
- acceptable, where the concerned population finds the risks to be low enough and adequately controlled.

Within the tolerable and acceptable regions, the reduction of risks always implies a trade off between costs and benefits and thus, when the loss of human lives is not at stake, the limits are based in cost-benefit analyses and generally expressed in monetary values (CALDEIRA, 2005).

Risks considered acceptable need to be periodically monitored and reviewed, so as to ensure they remain acceptable; unacceptable risks, on the other hand, need to be mitigated. *Risk control* includes all actions and decisions leading to the maintaining or reducing either of the probabilities of occurrence of the undesirable event (preventive actions) or of the seriousness of its consequences (protective actions). Besides risk reduction, other possible risk mitigation strategies may include (1) avoiding the risk, either by eliminating it or by detouring it; (2) sharing or transferring the risk, via insurances or outsourcing; and/or (3) retaining the risk, where acceptable, and include it in budget planning.

Risk control should also involve the monitoring and periodical re-evaluation of the effectiveness of the undertaken measures. Choosing which measures to undertake will call for a cost-benefit analysis that also takes social and political consequences into account (CALDEIRA, 2005).

Risk management may be implemented at different scales, with different scopes; in some situations, resorting to risk analysis solely may be sufficiently fruitful. Risk analysis may prove useful in project planning, for comparing different options, choosing the best tender format, for quality control, etc.

As for risk assessment, it may be performed globally, relatively or specifically, meaning it may assist different planning levels – a global assessment (at a macro level) may help define tolerability and acceptability limits and guide strategic and policy planning, including resource allocation; relative risk assessment will be needed for the prioritization of interventions, providing a more rational understanding of undesirable events (probabilities of occurrence and potential damage) in given time frames; specific risk assessment will guide specific works, especially during the project phase, allowing for the comparison of alternatives, viability analysis and definition of specific tolerability and acceptability limits, for instance. When applied to a specific intervention, the benefits of risk management include (CALDEIRA, 2005):

- during the intervention: it facilitates the communication among the diverse actors and it promotes a group problem-solving approach, thus allowing for the sharing of the risk between the site manager and the contractor, which minimizes the negative impacts of uncertainties associated with the intervention;
- after the intervention: it facilitates observation and monitoring, as well as the planning of maintenance and of warning/alert tools.

Depending on how they describe the probabilities of occurrence and the potential damage, risk analyses may be qualitative (descriptive) or quantitative (numerical). Quantitative risk estimates commonly resort to Event Tree Analysis, often very complex; descriptive risk analyses that use numerical scale rankings, such as the one proposed by Waller for museum collections (see bellow), may prove more feasible and still provide extremely helpful guidance.

2.2.2 Risk Assessment in Museum Collections

Preservation is then [when taking a risk management approach] the cost-effective reduction of the total of all predicted risks.

R. Waller & S. Michalski (2004)

In his widespread 1994 article, Waller describes how risk assessment may become a powerful tool in managing museum collections from a preventive conservation approach. Its primary goal, Waller asserts, was not to "present an optimal method of assessing risks" (WALLER, 1994, p. 12), but merely to demonstrate that exercising risk assessment in the context of a museum collection may offer invaluable insights on the risks that threaten it, and on the best ways to cope with them. Knowledge limitations then prevented these assessments from attaining their full potential; today, the blooming of research in the preventive conservation field allows for more complete assessments, and even for the development of expert systems (WALLER & MICHALSKI, 2004).

As mentioned earlier, the first step in a risk analysis is the identification of scope and goals; these amount to defining the space of the risk assessment within the larger context of the institution, its objectives and also its incidence – answering questions such as: what objects will be subject to the assessment?; are objects on loan to be included?; what is the timeframe to consider? Assessment units may also be defined, if necessary, dividing the collection according to material features, administrative sections, storage equipment needs, etc, depending on the defined goals or management needs (WALLER, 2007). Once this is decided, the risk assessment proper may begin.

In the aforementioned paper, Waller starts by *identifying the risks* that weigh upon the collection of the Canadian Museum of Nature (CMN); this collection, considered over a 100-year timeframe, constitutes the scope of the assessment. These risks correspond to agents of deterioration which may be grouped in categories, including "the nine identified by Michalski: physical forces; criminals; fire; water; pests; contaminants; light, UV; incorrect temperature; and incorrect relative humidity” (WALLER, 1994, p. 12) and a tenth one, custodial neglect. This categorization system proved to have the necessary comprehensiveness to embrace all threats conceivable by the museum staff.

Waller proposes additional grouping of the risks according to their severity and frequency, from “rare and catastrophic” (type 1 risks) to “sporadic and intermediate in severity” (type 2) to “constant and gradual” (type 3) (WALLER, 1994, p. 12).This way, different risks may be categorized according to the nature of the agent combined with the severity they may attain, which contributes to the comprehensiveness of the system and simultaneously stresses that estimating the magnitude of each risk will require distinct sources of information, from national statistical data to conservation literature to specific museum reports.

Next, *estimating the magnitude of the risks* means analysing, for each risk category, the probability of its occurrence and its impact upon the collection. Although the lack of information prevents precise results, Waller defends that values may be obtained “within one order of magnitude of uncertainty” (WALLER, 1996, p. 3).

Each risk category will have a given *probability* (P) of occurrence over the considered timeframe. For type 1 risks, this probability is typically obtained by experts such as seismic engineers or from fire and flood protection services, for instance. As for risk types 2 and 3, their probability of occurrence is, by definition, very close to 1, particularly when long timeframes are considered. For all risk types, the probability is combined with the *extent* (E) to which damage will occur, a measure which is especially useful for risks of types 2 and 3.

Estimating the magnitude of risks also needs assessment of the *loss in value* (LV) caused by the event upon the *fraction susceptible* (FS), i.e., the part of the collection prone to be affected by a particular risk. While this fraction may correspond to a precise subset of the collection, there are cases in which the collection vulnerability may be continuously variable, and so the definition of the fraction susceptible may be subject to a simplification where the objects only negligibly affected by the risk are excluded from the FS. As for the LV, assessed in terms of utility and not in monetary terms, it is expressed as a fraction of the total value, with all future values discounted to the present day.

All estimates and assumptions are to accompany each assessment, so as to explain the values and the rationale behind them. Finally, the *magnitude of risk* (MR) for each category may be estimated via the equation (WALLER, 1996):

$$MR = FS \times LV \times P \times E$$

The global risk will correspond to the simple sum of all the MR calculated for each category; "In most instances, the use of the proper combinatorial calculations, rather than simple multiplication and summation, changes the results by an amount that is insignificant compared to the uncertainty of the estimated values used." (WALLER, 1994, p. 14)

Waller recommends that result analysis begins by plotting each category of risk against its probability of occurrence over one century, in order to guide risk mitigation policies. Next, it is important to depict collection units versus risk per century, which should immediately highlight which risk categories need to be minimized more urgently; once these are addressed, this plotting will allow for the prioritizing of the remaining ones (WALLER, 2007).

The ensuing risk control measures will either act on the source of risk or on the risk agent, or by creating a barrier between the risk and the object. In the case of museum collections, these measures may be undertaken at seven different levels – location, site, building, room, storage unit, object and policy / procedure (WALLER, 1996). Evaluating mitigation options will imply the comparison of costs, benefits and risks, both during and after implementation.

Another recommended step consists in the ascribing of categories to the collection objects, according to their value. Based on the Dutch Delta Plan, the CMN chose a five-category system, ranging from 1 (most valuable) to 5 (least important) to group its objects. Institutional priorities may then be defined more precisely, since it is assumed that the primary responsibility of the museum is towards category 1 objects. A risk-based evaluation, combined with the categorization of collection objects, will allow for a reliable ranking of different options and thus ensure a cost-effective decision making (WALLER, 1996).

The application of this methodology to the collections housed in the CMN allowed to conclude that the main cost of performing a risk analysis may be measured in staff time – Waller estimated an expenditure of around 10% of the Museum collection care budget, a cost which will likely be higher for smaller institutions. Nevertheless, this cost may be reduced with the process repetition, since there is an economy of scale generated by the knowledge gained.

Waller found the main benefits of risk analysis applied to museum collections to be (1) the systematic recording of information allowing for the prioritizing of decisions concerning collection care, thus providing an invaluable management tool; and (2) the

raising, among the staff, of both involvement (since their knowledge and experience are key in the analysis and thus valued and recorded) and awareness (enhancing team spirit, decision understanding and receptivity to necessary changes).
As for the difficulties encountered, these include (WALLER, 1994):

- in the cases where degradation phenomena are caused by the combined action of different agents, only one risk category must be chosen, so that there is no double counting of the same risk; likewise, sometimes joint control of parameters often provides a more efficient risk reduction than the analysis of separate categories would denounce.
- insufficient knowledge on deterioration mechanisms of some categories of risk (particularly of types 2 and 3) and on their impact in the loss of value add to the incertitude of the estimates;
- assessing the loss in value was found to be largely subjective; in the CMN, it was estimated by the collection manager alone and ultimately based on the foreseen use impairment of collection items – "Improving the ability to estimate loss in value will require effective communication between conservators, collection managers, and researchers and other users of collections over many years" (WALLER, 1994, p. 15);
- the degree of estimates uncertainty is very variable, and hence the author suggests that two estimates are obtained for each risk category, limiting uncertainty within an interval.

Risk estimates considered unreliable were found to fall into one of four possibilities: (a) risks known to be high enough to deserve a high mitigation priority; (b) risks known to be low enough to be dismissed; (c) risks where the cost of mitigation to a known (low) level is less than the cost of conducting the necessary research for a correct estimate to be obtained; and (d) risks where research for an accurate estimate must be undertaken (WALLER, 1996). Rather than impeding risk management, these possibilities suggest courses of action to deal with unacceptable uncertainty in risk magnitude estimates.

In general, Waller found that the benefits seemed to compensate the considerable effort put into performing a risk analysis: approaching preventive care from a risk minimization perspective (as opposed to control measures implementation), "ensures the maximum possible return on our investment in terms of maintaining collection value" (1996, p. 7).
Nevertheless, the risk management of museum collections stems from a preventive approach to conservation and, while providing invaluable clues regarding collection

care, no examples of its application in conservation and/or restoration interventions were found.

2.2.3 Risk Preparedness for the Built Heritage

The 2010 revision of the New Zealand Charter states the need of risk assessment for places of cultural heritage value, listing natural disasters (e.g. floods and earthquakes) and human-induced threats (e.g. vandalism, neglect, building and development works) as main risks for the integrity of this value. To complement risk assessment, and whenever applicable, “a risk mitigation plan, an emergency plan, and/or a protection plan should be prepared, and implemented as far as possible, with reference to a conservation plan.” (ICOMOS-NZ, 2010, p. 8)

The ICCROM document on risk preparedness for World Cultural Heritage, endorsed by UNESCO and ICOMOS, acknowledges the destructive weight of occasional catastrophes and continued use, claiming that both need to be managed in a way that minimizes losses. While emphasizing that the shift in the conservation paradigm, from curative to preventive, has been slower for the built heritage than for museum collections and movable goods, it stresses that it is still a desirable shift in that preventive conservation may prove to be more relevant in the protection of heritage than the traditional curative-oriented approach:

> It has come to be understood that this [prevention-focused cultural-heritage-at-risk] framework offers a more holistic outlook than conventional approaches to conservation; an outlook viewing all sources of deterioration as linked in a single continuum, from the daily attrition of use at one extreme, to the cataclysmic losses occasioned by disasters or conflicts at the other. (STOVEL, 1998, p. 2)

The principle behind the ICCROM document, that has site managers as its main audience, is to integrate risk strategies for the cultural heritage into already existing disaster-preparedness measures for people and/or general property and/or the environment. This ICCROM manual is less of an orthodox risk management tool than a guidebook to develop and implement risk-preparedness strategies, using the document as a guideline checklist. Within these guidelines, it is recommended that planning in risk-preparedness occurs in three phases: preparedness; response and recovery.

The *preparedness* phase should depart from the documentation and inventory of the characteristics and condition of the site and endeavour (1) at reducing the hazard impacts or the hazards themselves; at strengthening the risk resistance of the site; (2) at implementing systems for detection and warning; and (3) at improving the response of site users and emergency-response professionals. The *response* phase will largely depend on the previous planning: there should be a plan supporting response prepared in advance and made available to all those involved; exercise drills and having a conservation team ready to respond are recommended. Finally, the *recovery* phase planning should foresee measures for the mitigation of the hazard impacts; for rebuilding both physical and social structures affected by the hazard; and for monitoring, assessing and enhancing the risk-preparedness measures defined. The effectiveness of this phase is also strongly dependent of the soundness of the previous phases.

The ICCROM document contemplates five categories of risks: fire, earthquakes and related disasters, flooding, armed conflict and other hazards; this last category includes tsunami, avalanches, land and mudslides and flows, winds or tropical storms, and also hazards caused by human error, such as vandalism, inadequate maintenance, industrial pollution and accidents. For each hazard, planning advice is provided, always starting with the list of the major possible hazard consequences and following with guidelines for developing mitigation strategies, from the preparedness to the recovery phases.

Typically, contributions to the risk management of built heritage will largely focus on disaster preparedness and, similarly to what was verified in the previous section, assist decision making especially within the scope of preventive conservation. Even if both (a) exhaustive documentation and inventory and (b) monitoring and maintenance are more or less widely acknowledged as critical in heritage conservation, attention is drawn to the insights that a risk management approach permits in the development of systematic methodologies to tackle preventive conservation in general and the aforementioned critical fields of heritage conservation in particular.

Nevertheless, and similarly to what was pointed out for the risk management of museum collections, no developments of risk management were found that included, or specifically focused on, conservation and/or restoration interventions. This may be due to the still relative newness of the application of risk management to heritage conservation, or to the broadness of aspects involved in a conservation intervention and consequent difficulties in the systematization of the necessary assessments, or a combination of both. In theory, it seems reasonable that a management approach that minimizes risk would be applicable to the highly risky activity of intervening upon heritage objects, but maybe the preventive, rather than active, character of risk management would render this type of approach insufficient; in any case, no elements were found to dismiss or support the application of risk management to the planning and execution of conservation interventions.

2.3 The Prodomea DSS

> *The difficulty that characterises management of the conservation process lies in identifying the specific motivations that influence decisions on the strategy to follow and on the action to be taken.*
>
> J. Delgado Rodrigues and A. Grossi (2004)

The main goal of Prodomea – "PROject on high compatibility technologies and systems for conservation and DOcumentation of masonry works in archaeological sites in the MEditerranean Area" – was "to transform existing and scattered conservation strategies on archaeological masonry into a more compatible, structured and sustainable one" (PRODOMEA, 2004, p. 4).

The fact is that a conservation intervention does not encompass strictly technical conservation necessities alone; and even these cannot always be fully anticipated and thoroughly planned for in a systematic manner:

> While it is true that recovery and maintenance often comprise a great number of microactions, dependent on situations that are rather unpredictable and therefore conducted unsystematically, there are also some parameters, such as urgency, timeliness, control, opportunity, convenience and economy that predominantly or in combination govern the decision of whether or not to undertake an action. Then there are non-technical but strategic factors that determine the necessity of an action. (DELGADO RODRIGUES & GROSSI, 2004, p. 4)

On the other hand, as previously highlighted, conservation should be seen as a process within a larger strategy of site management, and hence the quality and its maintenance over time should be ensured, as much as possible, from the outset of each given intervention.

International charters provide guidelines for decision, but they largely consist of broad directives that leave plenty of room for different choices. Nevertheless, concepts such as retreatability, compatibility, minimal intervention and sustainability may frame approaches to assist decision making.

The Prodomea DSS, as its alternative name, the Compatibility Approach, indicates, builds upon the concept of compatibility, using it as the key criterion for the classification and selection of conservation interventions. The concepts of retreatability and minimal intervention are, however, also given significance –, along with compatibility, they constitute the "three key issues related to the concept of quality of conservation and restoration actions" (DELGADO RODRIGUES & GROSSI, 2004, p. 8). Furthermore, it is noted that the concepts of minimal intervention and compatibility share a common purpose of risk minimisation.

Within this Approach, one of the interesting features of the concept of compatibility is its adaptivity to different levels, from a smaller to a larger scale, i.e., permitting to classify a given product or its application technique, an action composed of a set of procedures or a conservation intervention as a whole; this versatility, however, is only possible if the concept is not too rigidly defined. On the other hand, "It seems clear that «compatibility» cannot be defined in absolute terms and independent of the case in consideration, but rather it should be defined and applied within well-defined contexts, and it requires that the situations and the problems are known with enough detail." (DELGADO RODRIGUES & GROSSI, 2004, p. 24)
The Prodomea DSS was designed in a way that permits it to be used either for the evaluation of past interventions or for the planning of future ones. In both cases, the user is assisted by the Compatibility Procedure, which guides the user through the analysis of the degree of compatibility of conservation interventions or actions towards the monuments they refer to. In the case of past interventions, this procedure may help analyse or monitor performed treatments and identify best and bad practices; in what concerns planning, "the aim is to help in choosing the less Incompatible intervention processes, or the best intervention concept, or the more appropriate intervention actions" (PRODOMEA, n.d.), by accompanying the planner through each phase of the conservation process. The procedure is briefly described in the following section.

2.3.1 (In)compatibility Assessment

In the assessment of compatibility between ancient masonry and conservation actions (especially those involving new products and techniques), the quality of the relationship becomes of primary importance, more so than the quality of a product defined in terms of its range of performance characteristics.

J. Delgado Rodrigues and A. Grossi (2004)

The Prodomea First Technical Report highlights that

> most conservation interventions, even in archaeological sites, carry a certain level of risk and that it is neither technically nor economically feasible to advise that only interventions without risk should be acceptable. Therefore, the ultimate achievable aim is certainly *not to find «perfectly compatible» actions, but to find*

those that minimise the degree of incompatibility (2004, p. 4, italics in the original document).

The Compatibility Procedure, as proposed by Delgado Rodrigues and Grossi (2007) in the framework of Prodomea, is a tool to assess the performance of conservation interventions, but also to tackle the complexity of decision-making in conservation; it is “the heart of the relationship between the site and the Conservation action” (PRODOMEA, 2004, p. 4). The approach endeavours at verifying to what extent a given intervention was or will be compatible with the monument it is designed to conserve; considering the broadness of the term, the authors propose furthermore that this compatibility be ascertained by analyzing the different aspects that, together, make up for the overall impact of the intervention on the monument.

In effect, due to their complexity, conservation interventions cannot be analysed with resort to one parameter alone. Thus, in order to fully appraise all the aspects involved, the authors propose that the analysis of the overall performance of interventions should rely in a set of “simpler and workable components”, designated by Compatibility Indicators (CIs) and relatable to what other disciplines refer to as performance indicators (DELGADO RODRIGUES & GROSSI, 2007). The interest of this decomposition is its allowing us to separately quantify different aspects involved in a conservation process that are inherently too heterogeneous to be evaluated concurrently. On the other hand, these separate assessments should ultimately allow for the overall judgment of the process under appraisal, and thus should be performed in a fashion that permits a final computing of the influence of all the chosen parameters.

In order to better structure the proposed methodology, the authors suggest the definition of an intermediate level of categories, also labelled the ‘first order branches’ of a ‘compatibility tree [analysis]’, under which the CIs deemed necessary will eventually be grouped. These categories encompass broad groups of factors that the authors believe to influence the conservation interventions, and are, as follows (DELGADO RODRIGUES & GROSSI, 2007):

(i) the <u>physical content</u> encompasses the set of parameters that measure the performance of the intervention in physical-chemical terms, including the (material) impact of products and actions on the conservation object;

(ii) the <u>operational background</u> aggregates indicators for the evaluation of operative (immaterial) aspects that impact on intervention quality, namely possibilities and constraints related to planning, practice, skills, tools;

(iii) the socio-cultural context aims at translating the effects that the intervention will have on the social setting (particularly local communities) that frames the object and vice-versa;

(iv) the environmental constraints cover the potential impact of the environmental setting upon the intervention action and products.

These first order branches are applicable to different steps of the conservation intervention, allowing for technological assessments but also contemplating management and planning issues. The latter should define the conservation process quality, and may be evaluated by measuring, via operational and social parameters, the interactions of the intervention with its broad (exterior) context and within its own framing; technological assessments will chiefly depend on the physical and environmental parameter sets.

The CIs grouped under each of these branches are “assumed to be quantifiable in terms of their potential influence in the overall incompatibility” (DELGADO RODRIGUES & GROSSI, 2007, p. 36). By definition, each indicator is only supposed to mirror a partial aspect of the whole incompatibility degree, and thus must not be taken isolated or out of its context, at the risk of misleading the assessment process; also, as stated, this procedure assumes that the relative importance of each CI in the overall analysis is rateable. Because of “the large number of potential CIs that can be individuated and in the large differences that can be ascribed to their respective roles” (DELGADO RODRIGUES & GROSSI, 2007, p. 36), not to mention that many prospective CIs may be correlated, the precise choice of CIs must be conducted with caution, as well as the rating of their relative importance in the final incompatibility value. Similarly, defining some indicators as critical (i.e., forcing its appraisal) or complementary for the final result will only add to a more reliable analysis if carried out with caution.

While listing a set of CIs for each first order branch that cover most typical situations found in conservation interventions, Delgado Rodrigues and Grossi stress that the listings are not (and may not be) rigidly defined to cover every situation and that “the users of this methodology have to adapt it to the specific context of their interest, namely according to the combination of internal and external factors, the availability of data and the importance of the problem in question.” (2007, p. 36)

The rating system of the CIs translates them into quantified components of the final (in)compatibility degree, thus allowing to compute very distinct features, originally expressed in different units or even qualitatively; each CI is rated on an integer scale from 0 to 10 according to its incompatibility potential. Again, the authors stress that “The rules suggested for the rating process are a first approach to the problem and although some of them found some support in personal research data or in the available literature, some others are just based on logical and comparative reasoning." (DELGADO RODRIGUES & GROSSI, 2007, p. 37) Tables listing these proposed parameters and respective ratings are presented below.

The Physical-chemical branch

Table 3: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for consolidants for stone surfaces (2007).

Criteria	Compatibility indicators	Incompatibility risks (rating scale)
Chemical and mineralogical composition	Presence of clays	Absent → 0 Minor amount → 5 Significant amount → 10
	Presence of salts	Absent → 0 Minor amounts → 5 Significant amounts → 10
Pore space	Total porosity	Risks depend on the substrate and on the type of product. Of little value for compatibility approach
	Type of voids	Equidimensional pores → multiply the final risks by 1.5 Fissures type voids → multiply the final risks by 0.6
Visual properties	Total colour difference (ΔE^*)	Lesser than 3 → 0 Between 3 and 5 → 5 Higher than 5 → 10
Thermal properties	Thermal expansion coefficient of the stone substrate (ε_s) Thermal expansion coefficient of the treated stone (ε_{ts})	$[0.9\varepsilon_s < \varepsilon_{ts} < 1.1\varepsilon_s] \rightarrow 0$ $[1.1\varepsilon_s < \varepsilon_{ts} < 1.2\varepsilon_s] \rightarrow 5$ $[\varepsilon_{ts} > 1.2\varepsilon_s] \rightarrow 10$
Mechanical properties	Bending strength Compressive strength Modulus of elasticity Drilling resistance (S & TS)	Values different by less than 10% → 0 Values between 10 and 25% higher → 5 Values higher than 25% → 10
Treating ability	Penetration depth	Higher than 20 mm → 0 Between 5 and 20 mm → 5 Less than 5 mm → 10
Hydrophilic behaviour	Water absorption coefficient Water vapour permeability Drying index (S & TS) Hydric swelling	Values different by less than 10% → 0 Values between 10 and 25% lesser → 5 Values lesser than 25% → 10 Lesser than or equal to untreated → 0 Higher than untreated → 10

S, stone; TS, treated stone.

Table 4: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for water repellents for stone surfaces (2007).

Criteria	Compatibility indicators	Incompatibility risks (rating scale)
Chemical and mineralogical composition	Presence of clays	Absent → 0 Minor amount → 5 Significant amount → 10
	Presence of salts	Absent → 0 Minor amounts → 5 Significant amounts → 10
Pore space	Total porosity	Risks depend on the substrate and on the type of product. Of little value for compatibility approach
	Type of voids	Fissures type voids → 0 Equidimensional pores → 5
Visual properties	Total colour difference (ΔE^*)	Lesser than 3 → 0 Between 3 and 5 → 5 Higher than 5 → 10
Hydrophilic behaviour	Contact angle (TS)	Higher than 90° → 0 Lesser than 90° → 5
	Microdrops absorption time (TS)	Higher than 100% → 0 Lesser than 100% → 5
	Water absorption coefficient (S & TS)	$TS < 0.5S$ → 0 $TS > 0.5S$ → 5
	Water vapour permeability (S & TS)	TS different by less than 10% of S → 0 TS between 10 and 50% lesser than S → 5 TS lesser than 50% of S → 10
	Drying index (S & TS)	TS different by less than 10% → 0 TS between 10 and 50% lesser than S → 5 TS lesser than 50% of S → 10
Treating ability	Penetration depth	Higher than 2 mm → 0 Lesser than 2 mm → 5
	Hydric swelling	Lesser than or equal to untreated → 0 Higher than untreated → 10

S, stone; TS, treated stone.

Table 5: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for repair mortars for traditional masonry (2007).

Criteria	Compatibility indicators	Incompatibility risks (rating scale)[a]
Chemical and mineralogical composition	Type of binders (S & R)	Similar → 0 Different → 10
	Type of aggregate (S & R)	Similar → 0 Different → 5
Pore space	Porosity (S & R)	[0.9Ns < Nr < 1.1Ns] → 0 [0.7Ns < Nr < 0.9Ns] → 5 [Nr < 0.7Ns] → 10
Visual properties	Total colour difference (ΔE*) (S & R)	Lesser than 3 → 0 Between 3 and 5 → 5 Higher than 5 → 10
Thermal properties	Thermal expansion coefficient (ε) (S & R)	[$0.9\varepsilon_s \leq \varepsilon_r \leq 1.1\varepsilon_s$] → 0 [$1.1\varepsilon_s \leq \varepsilon_r \leq 1.5\varepsilon_s$] → 5 [$\varepsilon_r \geq 1.5\varepsilon_s$] → 10
Mechanical properties	Bending strength	Values different by less than 10% → 0
	Compressive strength	Values between 10 and 50% higher → 5
	Modulus of elasticity (S & R)	Values higher than 50% → 10
Hydrophilic behaviour	Water absorption coefficient	Values different by less than 10% → 0
	Water vapour permeability	Values between 10 and 50% higher → 5
	Drying index (S & R)	Values higher than 50% → 10
Presence of salts	Salt content (S)	Free of salts → 0 Sparse presence of salts → 5 Heavily loaded with salts → 10

S, substrate; R, repair mortar.

[a] The ratings are typified, in this and in the subsequent tables, for 0, 5 and 10 as references for low, medium and high risks, although admitting that any value between 0 and 10 can be applied.

The Operational branch

Table 6: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for the operational conditionings at planning level (2007).

Criteria	Compatibility indicators	Incompatibility risks (rating scale)
Intervention phasing and conceptualisation	Definition of objectives and targets Elaboration of a conservation concept	Good → 0
	Diagnostic phase and incorporation of existing information	Fair → 5
	Filling gaps in information Definition of actions/Project	None → 10
Intervention planning	Sequence and hierarchy of actions Interaction among actions	Logical and justified → 0 Some gaps and doubts → 5 No planning → 10
Team composition	Identification of needed skills Available skills Definition of responsibilities	Properly done → 0 Relevant missings → 5 Critical missings → 10
Scientific and ethical principles	Minimum intervention Compatibility concern Effectiveness and harmfulness	Properly considered and assumed → 0 Relevant missings → 5 Critical missings → 10
Costs	Alternatives Cost control plan	Considered → 0 Not considered → 5
Maintenance plan	Durability assessment Inspection and monitoring	Considered and well done → 0 Relevant omissions → 5 Absent or critical omissions → 10
Documentation of the intervention	Of the start-up situation Of the works carried out	Considered and well done → 0 Poorly done → 5 Absent or with critical errors → 10

Table 7: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for the operational conditionings at the execution level (2007).

Criteria	Compatibility indicators	Incompatibility risks (rating scale)	
Availability of operators	Skilled operators available in the region	Yes → 0	No → 5
Training of local craftsmen	Considered and implemented	Yes → 0	No → 5
Conservation team	Well structured	Yes → 0	No → 10
	Conservator restorer	Yes → 0	No → 10
	Testing lab available	Yes → 0	No → 10
Tools and instruments	Belonging to the team	Yes → 0	No → 5
	Available in the region	Yes → 0	No → 5
	Protocol to obtain them outside	Yes → 0	No → 5
Costs	Well justified	Yes → 0	No → 10
Documentation of the intervention	Of the start-up situation	Considered and well done → 0	
	Of the works carried out	Poorly done → 5	
		Absent or with critical errors → 10	

The Socio-cultural branch

Table 8: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for the social and cultural parameters (2007).

Criteria	Compatibility indicators	Incompatibility risks (rating scale)		
The local community	Involvement of local workers	Yes → 0	No → 5	
	Training of local workers	Yes → 0	No → 5	
Traditional arts and methods	Consideration of local arts and methods	Yes → 0	No → 5	
	Intervention integrated in traditional background	Yes → 0	No → 5	
Social resources	Use of local resources	Significant → 0	Minimum → 5	Nil → 10
	Immediate profits for the local community	Significant → 0	Minimum → 5	Nil → 10
Cultural issues	Consideration of the local perception existing about the site	Duly taken into account → 0	Not considered → 10	
	Plans to inform the community about the intervention	Considered and well planned → 0	Not considered → 10	
Scientific and technical issues	Involvement of the scientific and technical community	Considered and well represented → 0	Minimal representation → 5	Not considered → 10
	Plans to diffuse the results of the intervention	Public presentations, written reports and scientific papers planned → 0	Only part of these topics planned → 5	Not considered → 10

The Environmental branch

Table 9: Delgado Rodrigues and Grossi's (in)compatibility indicators and ratings for the environmental constraints in temperate regions (2007).

Criteria	Compatibility indicators	Environment constraints (rating scale)
Climatic	Temperature	Frequent crossings to negative values → 10 Frequent daily amplitudes over than 10 °C → 10 Positive temperature and low daily amplitudes → 0
	Relative humidity	Mostly over 80% → 5 Mostly lesser than 40% → 0 Mostly varying between 40 and 80% → 10
	Annual rainfall	Lesser than 200 mm → 0 Between 200 and 1000 mm → 5 Over 1000 mm → 10
	Wind	Frequent strong winds inland → 5 Frequent strong winds near the sea → 10 Other situations → 0
	Sun radiation	Over 2000 h of sunlight, indirect exposure → 5 Below 2000 h → 0 For direct sun exposures add 5 to the ratings
Pollutants	Gaseous	Heavy urban and industrial → 10 Moderate → 5 Rural → 0
	Particulate	Heavy urban and industrial → 10 Moderate → 5 Rural → 0
Groundwater (GW) conditions	GW level at depth less than 2 m below foundation	Very saline water → 10 Low salinity → 5 Highly contaminated → 10 Low contamination → 5
	GW level absent or at depth always higher than 2 m below the foundation	All water qualities → 0
Soil conditions	Acidity Contaminants	Very acidic soils → 10 Neutral soils → 0 Very contaminated soils → 10 Low contaminated soils → 0
Sea	Distance to the sea	<500 m → 10 <5000 m → 5 >5000 m → 0
Natural hazards[a]	Floods Avalanches Landslides Earthquakes Fires	Situation in the flood plains → 10 Hilly, unstable ground → 10 Earthquake prone zone → 10 Fire hazard risk high → 10

[a] 5 and 0 are given to, respectively, moderate or low risks.

Finally, a global incompatibility degree is obtained by integrating all the rated parameters in a formula such as (DELGADO RODRIGUES & GROSSI, 2007):

$$ID_n = \sqrt{\frac{R_1^2 + R_2^2 + \ldots + R_n^2}{n}}$$

Where:

ID_n = Incompatibility Degree

$R_1, \ldots, R_n$ = ratings of the *n* parameters deemed relevant

Since it may be found that some parameters have a higher incompatibility-inducing potential than others, weights may be ascribed, above or below 1, to account for their corresponding influence in the overall ID_n; the formula then becomes (DELGADO RODRIGUES & GROSSI, 2007):

$$ID_n = \sqrt{\frac{\sum_{k=1}^{n} W_k R_k^2}{\sum_{k=1}^{n} W_k}}$$

Where:

ID_n = Incompatibility Degree

W_k = weight of the *kth* parameter

R_k = rating of the *kth* parameter

n = number of relevant parameters

The final result will vary between 0 and 10, which correspond, respectively, to a fully compatible or to a fully incompatible action.

Attention is drawn by the authors to the importance of unequivocally stating the number of parameters, since a lower number may produce a lower ID_n and lead to misinterpretations. On the other hand, the parameter listing may also serve as a checklist to identify the most compatible options within a given conservation intervention. The authors furthermore highlight that “important benefits can arise from the analysis of the individual values given to some specific indicators, namely to those considered as critical ones” and that it is recommended to “revisit the indicators that have received ratings in the upper third part of the scale (8–10), discuss the impact of those indicators and seek for adequate measures to deal with the expected consequences of such high ratings.” (DELGADO RODRIGUES & GROSSI, 2007, p. 42)

2.3.2 The Eight-Step Planning Model

Without a formal structure or a common assessment scale for all items, judgments are impossible to evaluate objectively. They can be inconsistent, biased, or both.

R. Waller & S. Michalski (2004)

While the (In)compatibility procedure described above might be enough for the assessment of past interventions, the planning of future ones needs a more detailed methodology guiding the planner through each step in a sequential structure. Within the frame of Prodomea, eight steps were identified as critical for structuring a well planned conservation intervention, grouped under pre-project, project and post-project phases. Following these steps will imply a control of the (in)compatibility of the different options, using the procedure described above. The figure below illustrates the sequence of the Compatibility Approach eight-step decision model and how the (in)compatibility assessment procedure plays into the different steps.

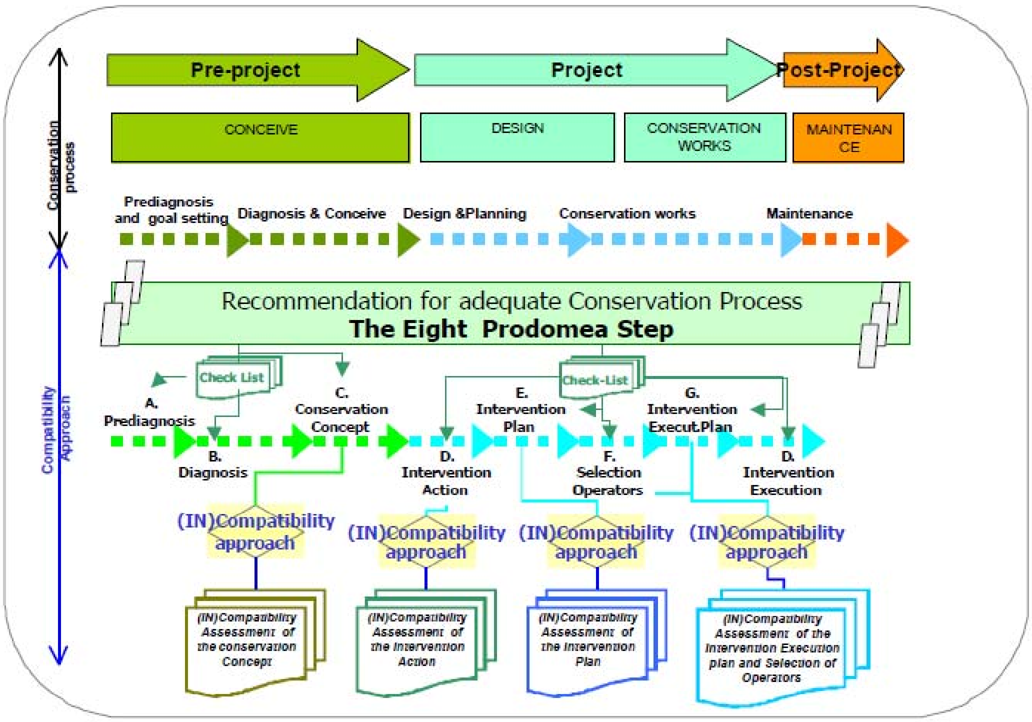

Figure 5: "The (In)Compatibility Approach as a Design Tool of new interventions" (source: (GROSSI, 2005, p. 7))

The table below describes the different steps in terms of specific planning items, key-actors and (In)compatibility assessment requirements:

Table 10: The Compatibility Approach to planning conservation interventions (adapted from (PRODOMEA, n.d.))

Step	Key-actors	Required actions	(In)compatibility assessment
Prediagnosis	Site manager (coordinator) and consultants	- production of photographs - architectural investigation - archive investigation - mapping of degradation forms - mapping of distinctive materials - preparation of report on Prediagnostic Phase	none
Diagnosis	Site manager (coordinator)	- sampling planning - lithological and petrological characterisation - characterisation of material properties (stone, mortars, plasters, etc.) - structural stability and seismic hazard - interpretation of damage processes (damage assessment) - production of report on Diagnostic Phase	none
Conservation concept	Site manager (coordinator)	- definition of the objectives to be achieved - consider traditional arts and methods and options between modern/traditional materials - identification of actions to be avoided - involvement of the local community - involvement of the scientific community - taking into account local social & cultural issues - taking into account the natural and anthropic dynamic of the territory - definition of the intervention phasing - production of report on Conservation Concept	- operational - socio-cultural
Intervention action	Conservation scientist	- consideration of environmental stress	- environmental
		- selection of materials to be used	- physical-chemical
		- definition, execution and interpretation of trials experiments - definition of application procedures - understanding hierarchy and sequence of actions - understanding interaction between actions - production of report on Intervention Actions	- operational

Step	Key-actors	Required actions	(In)compatibility assessment
Intervention plan	Site manager or consultant	- definition of the logistics requirements - interference and identification with other site actions - identification of needed skills - planning the sequence & hierarchy of the actions - definition of a safety plan - production of report on Intervention Plan	- operational
Selection of operators	Site manager	- consider the team composition - consider the availability of operators - consider the training of craftsmen - consider the relevant tools, instruments and methodologies - consider the costs - consider the documentation issues - production of report on Selection of Operators	- operational
Intervention Execution plan	Contractor and Site manager as supervisor	- make up the appropriate team composition - consider the incorporation of local operators - consider the training of local craftsmen to be inserted in the team - guarantee the availability on the site of the necessary tools and instruments - define the appropriate methodologies - prepare the detailed expenses plan - define a documentation plan	none
Intervention execution	Contractor and Site manager as supervisor	- respect the intervention plan - respect the safety plan - interaction with site responsible - register all the intervention actions - complement the damage mapping - prepare the detailed report on Intervention Execution - control the execution - control the materials - control the execution process	- operational - socio-cultural - physical-chemical

2.4 Performance Assessments – Material Properties-Related Criteria

The success or failure of a conservation treatment depends on a number of factors, spanning the condition of the artefact being treated, the overall design of the treatment, the products and *tools selected and the operators' skill. However, there is no doubt that the application of the right products and the right methodologies is a necessary if not sufficient condition.*

M. Laurenzi Tabasso & S. Simon (2006)

Purely physical-chemical approaches to conservation options usually come to light when the decision of intervening upon a given object is already taken. These approaches prove helpful not only in the diagnosis phase, but also in the treatments decision-making phase and represent the most significant contribute that hard-sciences make to conservation. As highlighted earlier, for many years and up until recently, conservation was chiefly approached from the standpoint of these contributions, following classical approaches that defended objectivity when dealing with cultural assets, which accounts for the relative abundance of research dealing with the physical condition of the objects.

When assessing a given product and its suitability for the conservation of a cultural artefact, physical-chemical approaches resort to a variety of test procedures that normally depends on several factors, including the nature of the intended intervention, the object condition, the environmental context, the available means, etc.

However, in the *evaluation* of treatment procedures and materials, and contrasting with the amount of literature dedicated to the dissemination of testing methods and/or results, not many proposals have been put forth concerning criteria and requirements to support decision making, including the specific statement of critical parameters or suggestions thereof[31].

There are, however, some notable exceptions, which are presented in the current section; they mainly regard physical-chemical evaluation criteria and, given the focal point of this report, only research concerning the conservation of built heritage is mentioned.

When it comes to the built heritage, intervention criteria proposals stemming from the analysis of material properties are better analysed if divided into four major categories: cleaning, consolidants, water repellents and repair mortars. Within each category some papers were found that propose criteria to support the choice of a product or material for conservation and/or that propose which material testing methods should be

[31] There is, nevertheless, an awareness of these deficiencies, noted for example by Zacharopoulou (1998), Diaz Gonçalves (1998) and Charola & Henriques (1998). Tabasso & Simon note that, at least, "a good level of agreement among laboratories has been reached concerning which parameters to measure" (2006, p. 72).

considered when making such a choice; a brief exposé of these articles is given in the subsections below.

On the other hand, the proliferation of literature dealing with material testing, needed both for the diagnostic analysis of the monuments and for the choice of conservation products, led to the need of standardizing testing methods, and some noteworthy examples are also highlighted below.

A whole subsection is devoted to a paper by Sasse and Snethlage (1996b), given its importance as the most comprehensive evaluation criteria proposal found in stone conservation literature. Two other subsections follow with other, simpler, attempts at decision-support systems based on material performance assessments.

2.4.1 Cleaning

The cleaning of monumental stone may become necessary wherever harmful deposits are to be found, especially biological colonization, salts and/or black crusts, or it may be required in the case of deposits that hinder the aesthetic appreciation of the monument. Once the features of the substrate and of the deposits are correctly ascertained, as well as the desired level of cleaning, there are several methods, mechanical or chemical in nature, which can be used, single or in combination, in cleaning procedures. Cleaning operations may seem deceptively straightforward, but they are potentially harmful and always irreversible interventions and therefore adequate planning is crucial to achieve satisfactory results (DELGADO RODRIGUES, ALESSANDRINI & BOUINNEAU, 1997).

In the case of biological colonization, it is common to resort to biocides, commonly “available in aqueous solutions [that may be] applied by spraying, by brushing or with impregnated pads” (DELGADO RODRIGUES, 1996, p. 235). Independently of the method of application, a study carried out in the framework of the European project STEP CT90-0110 – “Conservation of Granitic Rocks with Application to the Megalithic Monuments” suggested for the action of some biocides tested on granites to be assessed in terms of (DELGADO RODRIGUES, 1996):

- **efficacy**, resorting to <u>optical microscope observation</u> of the surface and of thin sections of the sample cut perpendicularly to the surface (to verify effects on deep seated organisms);
- **harmfulness**, namely using <u>polarizing microscopy</u> and <u>X-ray Diffraction</u> (XRD) to analyse the possibility of mineralogical and or chemical transformations; and colour measurements with the help of a <u>colorimeter</u>.

2.4.2 Consolidants

In the history of stone conservation literature, one of the first papers to address the subject of consolidant testing criteria was presented by K.L.Gauri *et al.* at the Second International Symposium on the Deterioration of Building Stones, held in Athens in 1976. In this paper, the authors propose "relative, yet **quantitative**" performance criteria based on the comparison of the behaviour of treated and untreated specimens subjected to accelerated ageing (GAURI, GWINN & POPLI, 1976, p. 143):

- for polymer (UV) resistance, one method is proposed (UV spectrophotometry) and another is suggested (contact angle measurements), since both proved to be sensitive to film alterations after ambient and accelerated UV exposure. A polymer with a known poor UV response (epoxy resin) is taken as reference and the others should display a UV **resistance at least ten times higher** (i.e., show no signs of decay before absorbing ten times the radiation that discolours a film of epoxy);
- for CO_2 reactions: the treated specimens should lower the reaction rate of calcite dissolution due to water and CO_2 by **at least one-half**, when compared with untreated specimens under the same CO_2 exposure conditions (measured by monitoring the liberation of Ca^{2+} during a ten hour exposure of samples immersed in deionised water to a dynamic atmosphere containing 2% CO_2);
- for SO_2 (gas[32]) reactions: the treated specimens should lower the percentage of calcium sulphite formation **by at least one-half**, when compared with untreated specimens under the same SO_2 exposure conditions. The comparison between $CaSO_3 \cdot 2H_2O$ values is made possible through X-Ray Diffraction;
- concerning water transport: the multitude of factors that influence the degree and rate of water absorption of building stones (pore size, pore size distribution, pore linkage, etc; added to other material properties in treated specimens) is noted, and the capillary water absorption is proposed as a parameter that can satisfactorily represent the sum of those effects. Thus, the criterion proposes that the vertical capillary rise curve for the treated specimen should not exceed **one-half of the height** of the same curve plotted for the untreated one;

[32] Reaction by immersion in deionised water in a chamber with constant SO_2 partial pressure, and subsequent measurement of the Ca^{2+} concentration, is not proposed due to the unsatisfactory agreement between lab and natural conditions verified by the authors – the SO_2 is very easily transported, and "unlike CO_2, SO_2 reacts all the time rather than just in periods of rainfall." (GAURI et al., 1976, p. 146).

- concerning permeability: the treated specimens should not reduce the stone permeability by **more than one-half;**
- concerning stone resistance: the authors propose that a minimum of a **10% increase of the stone compressive strength** should be achieved in the weathered area of the treated specimen, relatively to the values obtained for the unweathered area of an untreated sample. It is furthermore suggested that the unweathered area of the treated specimen should exhibit some increase in compressive strength, so as to assure that no strong resistance interfaces are created by the treatment.

The criteria suggested by this approach seem to rely on common sense rather than exhaustive scientific studies on exact acceptability limits. Nevertheless, it shows a concern that was never fully answered since then. As Gauri mentions in the discussion that followed his presentation, "the primary purpose of my presentation was to propose performance criteria for stone treatment especially for architects so that they know what to include in job specifications for restoration of historic structures" (GAURI et al., 1976, p. 152).

A different type of approach was followed in the context of the earlier mentioned European project STEP CT90-0110, which included the evaluation of different conservation products, including water-repellents and consolidants. The research goals concerning the assessment of these treatments "assumed that the main object was not the selection of the «best» products but rather the identification and testing of criteria that might lead to that selection. The questions of method are thus more important than the eventual final hierarchization of the treatments through their laboratory performances, although this aspect should not be considered irrelevant for practical purposes" (DELGADO RODRIGUES, 1996, p. 225).

The approach based the assessment of each type of product along three different lines: efficacy, non-harmfulness and durability analyses. Regarding the testing of consolidants in granites, the following tests were chosen (DELGADO RODRIGUES, 1996):

- for **efficacy** testing: since "consolidants are expected to increase the cohesion of the decayed layers of the stone and to anchor the consolidated part deep enough into the more resistant part of the sound substrate" (DELGADO RODRIGUES, 1996, p. 229), increase in strength and penetration depth were considered the critical parameters to test. Strength increases were assessed directly via <u>bending strength</u> and <u>point load strength</u> tests and indirectly via <u>ultrasonic velocities</u> measurements; the penetration depths were appraised with resource to microdrop absorption time and absorption coefficient measured along sample profiles; Scanning Electron Microscopy (SEM) was used as a complement to the study.

- for **harmfulness** analysis: because “any treatment product is an alien component introduced into the stone […] it should bring the least possible harm to the treated object” (DELGADO RODRIGUES, 1996, p. 231). Harmfulness assessment relied on water vapour permeability variations, which should be small, and colour modifications, which should not surpass acceptable limits – “although very precise definition of what could be the variations appropriate for any of these parameters is not currently available” (DELGADO RODRIGUES, 1996, p. 231). Interface effects were additionally assessed by analysing the contrast in thermal and mechanical properties between treated and non-treated samples; the coefficient of thermal expansion and Young’s modulus were the chosen variables to be determined[33].
- for the **durability** study: this is considered to be synonyms with the assessment of product stability over time, which is generally analysed with resort to accelerated ageing tests, even if “it is understood that acceleration of the decay phenomena is not exempt from problems, namely because it is virtually impossible to know the exact meaning of the acceleration factors and up to what extent this acceleration may give biased information by not representing the true reactions and decay processes” (DELGADO RODRIGUES, 1996, p. 233). Fully and partially impregnated samples were subjected to different types of cycles, specifically: relative humidity/temperature (RH/T), ultraviolet (UV) radiation and salt crystallization, as well as to long term imbibition periods. RH/T cycles and long term absorption periods were followed by the testing of the specimens’ mechanical properties, including bending strength; UV radiation exposed samples were characterized with Fourier Transform Infrared Spectroscopy (FTIR) and colorimetric measurements; samples subjected to salt crystallization cycles were assessed in terms of mass variation.

Yet another recently proposed consolidant evaluation method suggests that an algorithm be used in order to find an *Efficiency Index* that enables a choice between the available options. This algorithm was proposed by Theoulakis *et al.* (2008) for the choice of consolidants based on their performance in several tests, that are to be carried out according to relevant European and National standards whenever possible;

[33] Other tests were performed but are not reported, including: capillary absorption, resonance frequency and surface hardness.

the authors made a selection of the properties deemed necessary to make this evaluation and base the algorithm in the improvement of the tested properties, using untreated stone values as reference. The properties to be tested can be grouped according to the characteristic being analysed, as follows (THEOULAKIS et al., 2008):

(1) **internal cohesion**: because "the main goal of consolidation is to strengthen the weakened stone and to reinstate the lost cohesion of the weathered areas, a number of properties should be chosen in order to provide sufficient quantitative data on the internal cohesion of the treated stone" (THEOULAKIS et al., 2008, p. 283); the authors suggest the tests proposed by RILEM, which include dynamic modulus of elasticity, pull-out test, tensile strength, compressive strength and bending strength, or three points bending strength. Mechanical properties of the stone surface may additionally be studied via scratch width or rebound test and abrasion resistance.

(2) **durability**: this feature is regarded by the authors as dependant on the weathering resistance of the stones, and thus a consolidant should be able to "decrease the deterioration rate of the treated stone" (THEOULAKIS et al., 2008, p. 283) but, however, and as required by conservation ethics, it "should allow deterioration to take place at the same rate and from the same deterioration agents than those of untreated stones" (THEOULAKIS et al., 2008, p. 283). Durability is to be analysed with resort to ageing tests, as defined in several international standards or credited researchers, including: salts crystallization by total or partial immersion, frost resistance and freeze thaw cycles, and tests that assess the effects of air pollutants, acid solutions and biological organisms, emphasizing the tests representing the main weathering agents.

(3) **absorption and evaporation of water**: these are relevant since "many of the deterioration processes in stone monuments are associated with the presence and movement of aqueous solutions through their mass, encompassing salts crystallization, frost damage, thixotropy, acid attack, dissolution phenomena and biological growth" (THEOULAKIS et al., 2008, p. 284). The tests that are proposed to assess the behaviour of treated stones towards the presence of water are capillary water absorption, water absorption at low pressure, the saturation coefficient, the water vapour permeability, the linear strain due to water absorption and the water drop absorption; additionally, measuring the static contact angle may be helpful to analyse eventual water-repellence properties.

(4) **pore space properties**: "consolidation treatments have a major impact on the microstructure of the treated stone, since a new material is deposited inside the mass of the original stone" (THEOULAKIS et al., 2008, p. 284). The analysis of the stone pore structure may provide valuable information on the changes on mechanical properties, water movement, surface properties and durability, and it can be performed via mercury porosimetry, gas absorption and image analysis techniques. Results, however, may be difficult to interpret quantitatively, and may be insufficient to verify open-porosity blocking or pore-size distribution change requirements; nevertheless, qualitative interpretations are important to complement the consolidant assessments.

(5) **aesthetic issues**: the changes in the colour, reflectance or texture of the stone surface caused by the application of a consolidant should, in principle, be kept to a minimum; likewise, the used product is expected not to modify its colour in the long term. The authors suggest for colour changes assessed after application to be measured in the CIE-Lab system, that the roughness may be determined via surface roughness testers or image analysis techniques, and that results should ideally match untreated stone values.

All the performance parameters underlined above are to be computed into an algorithm described by the equation below, which allows for the calculation of an Efficiency Index (EI) (THEOULAKIS et al., 2008):

$$EI = \frac{CI_{treat}}{CI_{ref}} \cdot \sum_{i=1}^{k} f_i\left(\Delta P_i\right)$$

where,

EI – efficiency index: will vary positively with the adequacy of the product, i.e., the product with the highest EI should be chosen;

CI – consolidation index; in this case the authors propose that the inverse of the crack sensitivity index [34] (i.e., the inverse of the ratio dynamic modulus of elasticity over flexural strength: σ_f / E) be used;

ΔP_i – absolute difference between values before (untreated weathered stone) and after treatment for performance parameter *i* (though a modification in the algorithm is necessary in the cases where lower values of ΔP_i are evidence of a better performance, such as colour differences).

[34] Proposed by Bromblet (1999) for mortars; a higher index indicates a higher sensitivity to cracking.

The chosen product should be the one which allows for the obtaining of a higher EI; in the case where only small differences set two options apart, the authors suggest that the cost of each option should be taken into account.

It is worth noting that a ratio of the E-modulus over the biaxial flexural strength had already been proposed by Sasse & Snethlage (1996b) (see below) as a parameter for the evaluation of stone consolidants, since its value "may be considered as a characteristic material property for each type of stone" (1996b, p. 237). However, these authors take the next step and define acceptability limits for this parameter (among others) – a development that is missing from the EI proposed by Theoulakis *et al*.

Furthermore, this EI is a comparative index, allowing only for the appraising of *relative* performances for a given set of products chosen for testing; its result will indicate the *best* product from the set, but that may not necessarily correspond to the *right* product. Even if the authors state that "the values of the above properties can be modified according to the dominant deterioration mechanism or any other specific requirement" (2008, p. 285), a clearer emphasis on the need for the definition of acceptability limits would be advised. The authors do propose to disregard any products that do not fulfil some compatibility requirements, but these are listed somewhat generically and thus do not offer an unambiguous guidance.

2.4.3 Water Repellents

In the assessment of water repellents, the European project STEP CT90-0110 – "Conservation of Granitic Rocks with Application to the Megalithic Monuments" followed a line of reasoning similar to the one used for consolidants and biocides, starting with the definition of efficacy, harmfulness and durability for these products and then suggesting how to analyse these features. As such, the following analysis were proposed (DELGADO RODRIGUES, 1996):

- for the **efficacy** assessment: two levels of efficacy were considered, namely "the increment of the water repellence and the reduction of the water absorption induced by the product" (DELGADO RODRIGUES, 1996, p. 226); the former was analysed by measuring the <u>contact angle</u> and the <u>microdrop absorption time</u>, while for appraisal of the latter the <u>pipe method</u> and the <u>capillarity test</u> were used.
- regarding **harmfulness**: the most serious stone features that may potentially be undesirably changed by the used of water repellents are the <u>water vapour permeability</u> (reduced) and the <u>colour</u>; both parameters can be directly measured resorting to their specific testing standards.

- for a **durability** analysis: similarly to consolidants, the durability of water repellents should be assessed by subjecting treated and untreated samples to RH/T, UV and salt spray cycles in accelerated ageing chambers and then measuring some notable properties, including colour, mass, water absorption and water repellence.

2.4.4 Repair Mortars

In the field of repair mortar selection, Moropoulou proposed **reverse engineering** as the guiding concept, considering that traditional mortars displayed durability features and a non-harmfulness towards masonry constituents that held the key to design adequate repair mortars (MOROPOULOU, MARAVELAKI-KALAITZAKI, et al., 1998) (MOROPOULOU, CAKMAK & BISCONTIN, 1998) (MOROPOULOU, 2000b). According to this author, "a systematic research on scientific and technical level is urgently needed to investigate the proper restoration [mortars], based on the analysis and classification of the traditional ones, concerning composition proportions and gradation of raw materials, as well as physico-chemical and mechanical properties, which should fall within the acceptability limits determined by historic mortars in the area." (MOROPOULOU, MARAVELAKI-KALAITZAKI, et al., 1998, p. 56) The reverse engineering methodology for the formulation of restoration mortars that basically involves the following sequential steps (MOROPOULOU, BAKOLAS & MOUNDOULAS, 2000):

- Characterizing the original mortars so as to obtain "synthesis directives": testing should permit mineralogical, chemical and physical-chemical evaluations from which it is possible to select the materials to use in formulation testing, as well as the performance "acceptability limits" that the new mortars should comply with;
- Preparing different mortars according to the directives but with variations in granulometric trace, binder to aggregate and additives ratios and operating conditions;
- Evaluating the mortar samples during setting and hardening, verifying workability, carbonation rates, density, air content, volume change, water transport features, etc;
- Applying the "acceptability limits" defined earlier to select the most adequate mortars for final testing;
- Testing the behaviour of the mortars in the lab and in situ.

The selection of materials for the new mortars seems to be grounded on the similarity of constituents: once the composition of the traditional mortars is ascertained, repair mortars should be devised using alike features, namely similar binder to aggregate ratios; similar gradation of aggregates and relative proportions of the different aggregates should be used; and the mortar constituents should preferably originate from identical or akin sources. However, the definition of the "acceptability limits" for mortar selection remains slightly unclear: more precisely, the rules for exclusion are not directly stated: should the mortar samples fall precisely under the ranges defined by the traditional mortars or is it possible to accept some deviations? If so, how small should these deviations be? Would these be applicable to all the tested mortar features or not?

Using reverse engineering would also, in principle, assure the compatibility of the new mortar towards the masonry constituents, as demonstrated by the traditional mortars and defined in the referenced papers mainly in terms of physical-chemical properties. More specifically, compatibility is a concept used by the authors to appraise the coexistence of mortar and masonry structure, and it is considered to relate chiefly to the elastic behaviour of mortars, i.e., their capacity of deformation, when subjected to the "physico-chemical behaviour of the capillary systems of the various building materials, governing the percolation and evaporation of salt solutions within the historic masonry" (MOROPOULOU, KOUI, CHRISTARAS & TSIOURVA, 1998, p. 251); and to the vulnerability of mortars to weathering, "defined by the physicochemical and the mineralogical characteristics of the mortars, their microstructure and the adhesion of the binder to the aggregates" (MOROPOULOU, 2000b, p. 85), since mortar deterioration will have a direct effect on the surrounding masonry.

Moropoulou's approach leaned towards repair mortars formulated as closely as possible to the traditional ones. Nevertheless, mortars prepared by following traditional recipes do not necessarily exhibit the same properties; and the continuing of her research proved that "historic mortars with the same ratio and gradation could be classified to different microstructural patterns or could be characterized by different cohesion and adhesion bonds, which are the determining factors of the performance of the mortars on historic masonries" (MOROPOULOU, 2000b, p. 102). In spite of this, the analysis of repair mortars prepared by following the traditional ones' ratios and gradations shows that they "satisfy the requirements derived by the acceptability limits of the historic mortars regarding the microstructure" (MOROPOULOU, 2000b, p. 103). Again, these acceptability limits, which one can infer to be located in the proximity of historic mortars' values, are not clearly defined except for the tensile to compressive strength ratio ($f_{m,t}/f_{m,c}$), but based on the satisfactory results obtained, Moropoulou provides several guidelines to be followed when choosing a repair mortar, which include (MOROPOULOU, 2000b):

- regarding lime putty: minimum $CaCO_3$ content for the raw material and a maximum baking temperature for the obtaining of the putty; minimum (CaO+MgO) content and maximum free water content in the lime putty.
- regarding hydraulic lime: maximum baking temperature; mandatory presence of certain components, namely C_2S ($2CaO.SiO_2$) and CA ($CaO.Al_2O_3$); specific hydraulicity index range.
- regarding sand: some recommendations on its nature, impurities to be aware of and grain size distribution features.
- regarding crushed brick: tile should be used, for the obtaining of which baking temperature and a low Ca content are suggested.
- regarding natural and artificial pozzolanic materials: besides specifically stating how these cannot be used as a binder on their own, recommendations are given concerning minimum compressive strength results from the pozzolanicity test and minimum percentage of reactive silica.
- regarding other additives: the addition of aluminium powder is recommended.

The idea of playing with similarity to obtain good compatibility is, to some extent, contradicted by Zacharopoulou, that points out a trend in conservation literature defending that "the objective is not to copy the ancient mortars completely, but to use the possibility of obtaining certain mechanical properties by varying several different parameters, and therefore optimize the repair mortar for its specific application" (ZACHAROPOULOU, 1998, p. 104).

Concerning renderings in particular, Veiga suggests that the factors that condition decision making when planning interventions are threefold, including (VEIGA, 2007, pp. 106-107):

- "the value of the building in general and of the rendering in particular"
- "the condition of the rendering"
- "the availability of means, in terms of technology, workforce, time and funding".

Furthermore, Veiga defended that substitution renderings, whenever needed, must be compatible, defining the requirements for this compatibility as follows:

- non-harmfulness towards the substrate, which translates into the substitution mortar: (i) not overstressing the substrate; (ii) not changing water transport features; (iii) not containing contaminating soluble salts; (iv) being of reversible, or at least repairable, application;

- ability to protect the substrate, which is the main function of renderings; this implies specifications for mechanical resistance, water and vapour permeability and chemical and biological resistance features, along with a high durability;
- aesthetical non-harmfulness, which requires for the substitution rendering to have colour and texture features similar to the historical one, both in the short and long run, something which "generally implies the use of materials of similar nature" (VEIGA, 2007, p. 88).

While acknowledging the importance of similarity in mechanical and water features between historical and substituting mortars, there might be cases where some of these features are not known. Based on her experience with ancient mortars analysis and substitution mortars formulation, Veiga quantifies the "demands for the features considered more relevant for the fulfilment of the compatibility requirements" (VEIGA, 2007, p. 88) for Portuguese buildings, as follows:

Table 11: "General requirements concerning some characteristics for rendering and repointing substitution mortars for ancient buildings" (VEIGA, FRAGATA, VELOSA, MAGALHÃES & MARGALHA, 2007, p. 3):

Type of render	**Mechanical characteristics at 90 days (N/mm2)**			**Water behaviour**	
	Rt	**Rc**	**E**	**Sd (m)**	**C ($kg/m^2.min^{1/2}$)**
Exterior render	0.2 – 0.7	0.4 – 2.5	2000 - 5000	< 0.08	< 1.5; > 1.0
Interior render	0.2 – 0.7	0.4 – 2.5	2000 - 5000	< 0.10	-
Repointing mortar	0.4 – 0.8	0.6 – 3.0	3000 - 6000	< 0.10	< 1.5; > 1.0

(**Rt:** flexural strength; **Rc:** compressive strength; **E:** elastic modulus; **Sd:** water vapour permeability; **C:** capillarity absorption coefficient)

As for durability assessments, Veiga recommends artificial ageing tests, even if the correlation between these and natural ageing is still unsatisfactory. These tests should be chosen according to the environmental conditions that the mortar will face, the most common involving wet-dry, freeze-thawing and temperature cycles; it may also prove helpful to subject the mortar samples to saline solutions or to UV light. The durability assessment proper, after artificial ageing, is to be performed by visual observation, and may need measurements of mechanical characteristics and water behaviour (VEIGA, 2007); however, no quantified limits for these parameters after ageing are presented.

Testing Methods

According to Zacharopoulou (1998), authors devoted to ancient mortar testing seem to generally lean towards the use of:

- scanning electron microscopy, “to examine the mechanism of carbonation and the binder aggregate adhesion […] and can help us to understand the technology of mortar manufacture” (ZACHAROPOULOU, 1998, p. 100);
- plain chemical analysis combined with petrographic analysis and X-ray diffraction, for chemical and mineralogical determinations;
- physical analysis, for resistance and water behaviour analyses, as well as for studying the degradation phenomena; however, many difficulties remain both in mortar strength measurements and in the mortar/structural unit bond testing;
- radiocarbon dating or thermoluminescent dating, whenever the estimations of historical and archaeological research need further verification.

Veiga adds optical microscopy, thermal analysis (for a quantitative analysis of contents in lime and some hydraulic components), X-ray fluorescence (for oxides identification and content), FTIR (for non-crystalline component analysis), ionic chromatography and atomic absorption spectrophotometry (both may provide information on soluble salts) to the list, highlighting that the precise choice of analysis techniques will also depend on which questions are to be answered and on the means available (VEIGA, 2007). The Portuguese National Laboratory for Civil Engineering (LNEC) has developed both a comprehensive sequential methodology for the chemical and mineralogical characterization of ancient mortars (Santos Silva, cited by Veiga (2007)), and a complete diagnostic methodology, also sequential, for ancient renderings, which, besides the aforementioned lab analyses, includes in-situ tests for the assessment of the renderings condition (VEIGA, 2007).

For in-situ assessment of overall rendering anomalies, Veiga suggests resorting to imaging techniques such as thermography or geo-radar (to detect different layers, adhesion and cohesion features, presence of water-impregnated areas, voids and inclusions), and other methods such as: ultra-sound velocity measurements, pendulum sclerometer and, if necessary, micro-drilling and sphere shock tests (for mechanical properties assessment); and Karsten pipes and salt detection colorimetric strips (for water behaviour and salt presence analyses) (VEIGA, 2007).

In the context of repair mortar formulation and performance, assessments should be “done by interpreting the results of laboratory tests, of long-term field tests and/or of a combination of both” (ZACHAROPOULOU, 1998, p. 103). However, a problem remains in that “The lack of standardized tests and of generally accepted guiding values renders the interpretation of the results more or less subjective” (ZACHAROPOULOU, 1998, p. 103). Nevertheless, Moropoulou suggests the following tests to be used (MOROPOULOU, 2000b):

- for the testing of the raw materials: thermal analysis (differential thermal analysis and thermogravimetry – DTA-TG); X-ray diffraction; X-ray fluorescence; porosimetric analysis; pozzolanicity test; determination of soluble silica (according to the European norm EN 196-2); granulometric analysis (according to the ISO 565); specific weight measurements.
- for the assessment of mortar pastes: the author suggests the creation of an International Standard that includes the determination of: air content, bulk density, consistence, retained water and volume change upon setting.
- for the assessment of mortars during setting and hardening: DTA-TG, porosimetry; mechanical strength tests.

It seems that, even if some degree of consensus is reached regarding the necessary tests, and even if some of these testing procedures are defined by national, regional or international standards (see below), evaluation criteria and/or guidelines seem to remain tentative at best for all of the categories (cleaning, consolidants, water repellents and repair mortars) described above, as pointed for Zacharopoulou for the specific case of repair mortars performance assessments.

2.4.5 Standards

Several national and international standards organizations have developed norms concerning testing methods that are recurrently resorted to by conservation scientists, even if they were not necessarily designed for the cultural heritage context. Commonly used standards include the ones issued by institutions such as the Deutsches Institut für Normung (that develops DIN norms), the Ente Nazionale Italiano di Unificazione (responsible for UNI and NorMaL), the British Standards Institution (BS), the ASTM International (formerly American Society for Testing and Materials; issues ASTM norms), the International Union of Laboratories and Experts in Construction Materials, Systems and Structures (RILEM norms) and, of course the International Organization for Standardization (that issues ISO).

These standards regard mainly testing procedures, and thus the criteria for the evaluation of the results is generally defined case by case, typically based on references for untreated samples; also, “In a majority of cases several products are tested together and compared, giving the results a relative validity rather than an absolute significance” (LAURENZI TABASSO & SIMON, 2006, p. 72). On the other hand, given that, sometimes, different norms exist for the same test procedures, attention has to be paid to the different characteristics of each method.

CEN TC 346

In an effort towards the harmonization of methods and procedures in the field of cultural heritage, both movable and immovable, an European Technical Committee 346 – Conservation of Cultural Property was recently formed and charged with the task of developing standards in a broadness of areas that extends from terminology definition to transport and packaging specifications, to material and product testing and intervention guidelines.

The European Committee for Standardization (CEN) had already developed some standards that are sometimes referenced in the cultural heritage literature, such as the EN 12370:1999 – *Natural stone test methods: determination to resistance to salt crystallization* and the EN 1015-21: 2002 *Methods of test for mortar for masonry – Part 21: Determination of the compatibility of one-coat rendering mortars with substrates*. Nevertheless, standards developed specifically for the cultural property context should prove more adequate in the field of conservation science, once they are available.

RILEM TC COM 167 – Repair Mortars

In an attempt to establish standards to be followed on the preparation and application of repair mortars onto historic monuments, a group, working under the framework of RILEM, proposed a set of requirements that ranges from the definition of the philosophical background that should guide the intervention to the mortar mix design, encompassing conceptual, functional and technical requirements as well.

The philosophical aspects are closely linked to the recognition of the authenticity of the monument and stem directly from the concept definition in the Nara Document. The authors propose that an intervention must commence with a consideration of the diverse possible factors where authenticity can be recognized in a heritage object, from artistic, historic, social and scientific perspectives. In its help to ascertain the values of a monument, documentation is a crucial step in this phase, furthermore helping to assess the causes and extension of damage and intervention design and planning (VAN BALEN, PAPAYIANNI, VAN HEES, BINDA & WALDUM, 2004).

Proposed conceptual requirements, in turn, mirror the western contemporary perspectives on conservation, and start by dismissing the concept of reversibility, on grounds of practical application difficulties. Following the proposal of Teutonico *et al.* (1996), the authors prefer to retain the concepts of compatibility and retreatability/repairability, which they consider to be more “realistic” (VAN BALEN et al., 2004).

Compatibility is defined here as non-harmfulness, whereas retreatability/repairability require for the new materials not to "preclude or impede further treatment in the future" (VAN BALEN et al., 2004, p. 156). Additionally, the authors propose that an interpretation of the compatibility and retreatability concepts would, at least in terms of repair mortars, imply the use of materials having similar performances to those of historic mortars, in order to prevent damage situations. Hence, the historic materials have to be carefully analysed, so that "proper boundary conditions of more functional and technical requirements" (VAN BALEN et al., 2004, p. 156) may be defined.

Other conceptual requirements include: (1) long term resistance/durability/longevity, which is economically important and focuses especially on the mortar's resistance to weathering; (2) sustainability, with a highlight on the obtaining the materials locally; and (3) harmonization, referring to aesthetic compatibility between the historic and the added materials, which, in the case of repair mortars, also implies the consideration of techniques, craftsmanship and historical context (VAN BALEN et al., 2004).

Functional requirements are to be designed according to the role that the mortar is to perform in within the masonry where it will be applied and depending also on the role of the masonry within the building; specifically, a distinction is made for repair mortars that are to be applied on building façades, where aesthetical requirements acquire a heightened importance. Apart from aesthetical considerations, functional requirements are chiefly of technical order, and should include, for repair mortars, that (VAN BALEN et al., 2004):

(1) the load bearing capacity of the wall be assured and, if appropriate, that the mortar has a good earthquake behaviour;

(2) the water penetration through the wall is prevented, which can be achieved with layers of mortars featuring different pore size distributions.

(3) the mortar resists, as much as possible, environmentally induced damages; macroclimate and microclimate conditions should be ascertained to help the mortar design;

(4) the main degradation mechanisms are established in the diagnosis stage of the intervention.

(5) the durability of the masonry is enhanced.

In what concerns technical requirements, these basically represent the practical translation of the conceptual and functional requirements presented in the previous paragraphs. Evidently, the establishment of technical requirements has to be preceded by the chemical, mineralogical and physical analysis (including damage analysis) of the historic mortars in particular and of the building in general. The repair mortar requirements may then be defined, considering that the technical compatibility between historic and repair mortars will mainly depend on (VAN BALEN et al., 2004):

(1) Surface features, including colour, texture and surface finish, which can be assessed by the naked eye and/or by microscopic analysis.

(2) Composition, which will depend on the type of binders, aggregates and grain size distribution, that must be chosen according to the results of the old mortars characterization and that must take into account what is known about new materials' behaviour. Also the sustainable requirement of finding the materials locally may be analysed here.

(3) Strength, namely compressive, tensile and bond strength, which also give information on the elastic behaviour of the materials; once these properties are ascertained for the old mortars, estimations can be made for the new mortars, taking also the environment and the mortar function (pointing, rendering, etc) into account.

(4) Elasticity, implying the determination of the deformability and of the modulus of elasticity, which can be obtained through the compressive strength.

(5) Porosity properties, including total porosity, apparent specific gravity, pore size distribution and hygric properties. All these properties help to characterize the mortar hydrothermal behaviour and will influence its deformability, so the goal is to design repair mortars that are as close as possible to the original ones in terms hygric properties, so as to minimize the occurrence of undesirable boundary interfaces. Factors that influence these properties, and particularly the pore morphology, must all be considered in the moment of designing the mortar: binding system, aggregate gradation, water content, additives and changes occurring during hydration and carbonation.

(6) Coefficient of thermal dilation, which should be as similar as possible between the old and the new mortars (even though this can mean quite different coefficients between mortar and masonry).

(7) Other requirements that must be specifically established, including: (a) low salts and/or impurities contents; (b) resistance to freeze-thaw cycles and driving rain; (c) mortar workability should match its purpose (pointing, rendering, etc); (d) curing conditions must be taken into account; (e) good workmanship will obtain better compacted mortars, which will thus be stronger, more homogenous, show a better adhesion to the substrate and therefore be more durable; (f) a good quality control system is needed to monitor the process between the obtaining of constituents, their mixing and the mortar application, as well as their post application behaviour.

One of the most interesting contributions to this standard seems to be the philosophical framework used for its development, which highlights the importance of the authenticity analysis from different perspectives and emphasizes the importance of documentation, both of which are perhaps especially crucial for materials such as mortars, sometimes viewed as sacrificial. On the other hand, when formulating repair mortars, the concept of sustainability is introduced, along with the one of “harmonization”, which is chiefly aesthetical but that should be sought considering techniques, craftsmanship and historical context.

2.4.6 Sasse & Snethlage’s *Methods for Evaluation of Stone Conservation Treatments*

However, the results of the scientific research will only be valuable if they are formulated into simple and feasible rules and are disseminated to everybody involved in conservation practice.

G. Zacharopoulou (1998, p. 106)

In the context of performance assessments, the papers by Sasse and Snethlage (1996a, 1996b) undoubtedly deserve a special reference. In fact, these authors proposed one of the most comprehensive methodologies for the evaluation and assessment of the main categories of procedures used in stone conservation, namely: cleaning, consolidation, repair mortars application, coating and water-repellence treatments.

In one of the papers, the authors start by highlighting that they will be addressing “only the scientific and technical aspects of conservation” (SASSE & SNETHLAGE, 1996b, p. 224) and that “Materials and methods are discussed with respect to the question of whether they enhance or decrease future degradation, distress or decay” (SASSE & SNETHLAGE, 1996b, p. 224). Although conservation principles stated in the international charters ratified by several countries ultimately constitute the theoretical background for the research presented, ethical considerations are left out of this particular discussion and, on this subject, the authors opt to refer the reader to other texts.

Concerning the establishment of “tolerance limits”, stated by Teutonico *et al*. (1996) as a necessary requirement of the “compatibility” and “retreatability” principles, Sasse and Snethlage underline that the available knowledge did not yet allow for a rigid definition and, as such, all the requirements proposed by the authors “should therefore be considered preliminary, based on the present experience; further systematic research is needed to confirm their validity.” (1996b, p. 225)

In terms of structure, the proposal begins with the listing of the different testing methods that the authors deem necessary to accomplish the evaluation of each type of conservation procedures; in these tests, unweathered stone is used as reference material, “which can either be measured on the back side of sufficiently deep drill cores from the object or on freshly quarried stone samples” (SASSE & SNETHLAGE, 1996b, p. 226). This choice allows for the implementation of the general guiding principle that presides to the proposal: “it should be the aim of a treatment to return the altered properties to their starting point – not to make the stone «better» than would have been brought about by geology” (SASSE & SNETHLAGE, 1996a, p. 86).

Given the diversity of factors that play a role in the deterioration of historic stone, “it is evident that a single parameter cannot be sufficient to evaluate the effectiveness of a treatment. There is a set of selected properties that is needed to describe the behaviour of the material” (SASSE & SNETHLAGE, 1996b, p. 225).

Along with stating a set of tests for each procedure to be evaluated, the authors suggest, in one of the most innovative aspects of this research, the tolerance limits that should be met in each test method in order to assure the compatibility and retreatability required by their stated conservation principles. Although these tolerance limits are preliminary, as previously mentioned, and still need research for validity support, the comprehensiveness of the covered testing methods makes this one of the most solid departure points for a performance-based decision making.

Table 12: Sasse & Snethlage's requirements for the evaluation of cleaning methods (1996b).

Symbol	Property	Dimension	Test Method	Requirements[1]
–	Visual appearance	–	–	Not defined
CIE–LAB	X,Y, Z: standard colors, L*, a*, b*: CIE-LAB coordinates, ΔE^*, ΔL^*, ΔH^*, ΔC^*: color differences	–	DIN 5033, part 3 DIN 6174	Not defined (proposal: $\Delta E \leq 3$ within one ashlar)
w	Water uptake coefficient	$kg/m^2\sqrt{h}$	Karsten tube	$w_i \approx w_o$[1]
μ	Value of water vapor diffusion resistance	–	DIN 52 615, wet cup	$\mu_i \approx \mu_o$
–	Biological colonization	Number of cells or clusters	MPN test, etc.	Not defined
R_{max}, R_a, R_z, P_c	Surface roughness	µm	E DIN 4760 ff, E DIN 4770 ff Surface roughness meter	$Ra, i \approx R_{a,o}$ $Rz, i \approx R_{z,o}$ $Pc, i \approx P_{c,o}$ Abbott curve

[1]Subscript (o) relates to the unweathered stone, subscript (i) to the treated stone.

R_{max}: maximum roughness

R_a: arithmetic average roughness

R_z: mean roughness

P_c: number of registered peaks > x µm: the height x of the peaks must be defined for each material.

Table 13: Sasse & Snethlage's requirements for the evaluation of hydrophobic and nonhydrophobic stone strengtheners (1996b).

Laboratory Tests				
Symbol	**Property**	**Dimension**	**Test Method**	**Requirement**[1]
–	Visual properties	–	DIN 6174[2]	Slight color change only ($\Delta E \leq 5$), no darkening, gloss or increased susceptibility to soiling
–	Application	–	–	≤ 30% of the capillary pore volume filled with water
w	Water uptake coefficient	kg/m²√h	DIN 52 617[2]	$w_i \leq w_o$
B	Water penetration coefficient	cm/√h	DIN 52 617[2]	$B_i \leq B_o$
s	Penetration depth	cm	Capillary soaking for 5 min.	Deeper than zone of maximum mean moisture; w = 0.1...0.5, s = 1.0 cm; w = 0.5...3.0, s = 3.0 cm; w > 3.0, s = 6.0 cm (w = untreated stone). In cases of dense crusts and deterioration of rain-sheltered areas the thickness of the damaged zone is to be considered.
α_{Hv}	Hygric dilatation	µm/m	Hygric and overhygric range	No increase against untreated stone
α_{TH}	Thermal dilatation	K^{-1}	–20/0+20/+40	No increase against untreated stone
μ	Value of water vapor diffusion resistance	–	DIN 52 615[2] wet cup	Increase ≤ 20%
A_{SI}	Sorption isotherm (SI)	–	Storage under 0/ 15/30/50/65/75/85 /95% RH, 20° C	$A_{SL,i} \leq A_{SL,o}$; area under the SI after treatment ≤ area under the SI before treatment; no extra sorption in the raange RH 70...95%
–	Drying rate	h	20/65 $v \leq 2$ m/s	Drying time until moisture content at 20/65: $t_i \leq 1.2\ t_o$
β_{BFS}	Biaxial flexural strength	N/mm²	Drill core slices with double ring load, storage 20/65	$\beta_{BFS,i} \approx \beta_{BFS,o}$ homogeneous strength profile, strength increase of the weathered stone up to the strength of the unweathered stone
E-modulus	Modulus of elasticity	kN/mm²	Static or dynamic E-modulus	$E_i \leq 1.5\ E_o$
β_{POS}	Pull-off strength	N/mm²	Storage 20/65	$\beta_{POS,i} \approx \beta_{BFS,o}$; homogeneous strength profile, strength increases up to strength of weathered stone
–	SEM examination	–	SEM	Formation of grain–grain bridges, adhesion and grain surface filming, filling of clay mineral aggregates
Tests Applicable on the Objects				
–	Drilling hardness	–	Drill hardness meter	Homogeneous strength profile, strength increase up to strength of unweathered stone
w	water uptake coefficient	kg/m²√h	Karsten tube	$w_i \leq w_o$

[1] Subscript (o) relates to the unpainted stone, subscript (i) to the painted stone.
[2] Or comparable method.

Table 14: Sasse & Snethlage's requirements for the evaluation of stone repair mortars and washes (1996b).

Stone Repair Materials		
Property	Symbol	Requirement (after 1 year)
Dynamic *E*-modulus	*E*-modulus	20–100% (60)
Compressive strength	β_{CS}	20–100% (60)
Thermal dilatation coefficient	α_{Th}	50–150% (100)
Water uptake coefficient	*w*	50–100%
Value of water vapor resistance	μ	50–100%
Pull-off strength	β_{POS}	0.5–0.8 β_{POS} stone [1]

Washes on Natural Stone		
Property	Testing Method	Requirement (after 1 year)
Air pores content *L* of the fresh mortar	DIN 18 555, Part 3[2]	L = 5–10%
Water uptake coefficient of the whitewashed facade	DIN 52 617[2]	$w \leq$ 1–3 kg/m$^2\sqrt{h}$
β_{POS} Wash–substrate	DIN 18 555, Part 6[2]	β_{POS} = 0.2–1.0 N/mm^2
Value of water vapor diffusion resistance of the wash	DIN 62 615[2] μ dry cup	$\mu \leq 50$ Increase s_d max. 20%

Example for a Stone Repair Mortar on Schilf Sandstone				
Property	Dimension	Stone	Requirement	Property SRM [3]
Grain size aggregate	mm	0.3	0.1 ... 0.3 (0.2)	max. 0.25
Consistency (DIN 18555)	cm	–	firm, stiff	a_{15} = 12.1
Dynamic *E*-modulus	kN/mm^2	16	4–16 (10)	10
α_{Th}	10^{-6} K^{-1}	9	4.5–13 (9)	8.5
μ	–	26	13–26 (26)	29
β_{POS}	N/mm^2	0.8	0.4–0.8 (0.6)	0.5

[1] or to be defined in special case.
[2] or comparable method.
[3] designed stone repair material (example).
The requirements are related to the properties of the substrate.
The adhesion is desired to fail in the stone repair material or in the contact area, but not in the stone.
β_{POS}: pull-off strength of the surface; α_{Th}: thermal dilatation; μ: value of water vapor diffusion resistance.
Compiled according to IBAC (1993) and according to the authors (in parentheses).

Table 15: Sasse & Snethlage's requirements for the evaluation of coatings and paints on stone (1996b).

Laboratory Tests				
Symbol	Property	Dimension	Test Method	Requirement [1]
w	Water uptake coefficient	kg/m$^2\sqrt{h}$	DIN 52 617[2]	$w_i \leq w_o$ (see *sd*)
B	Water penetration coefficient	cm/$\sqrt{h}$	DIN 52 617[2]	$B_i \leq B_o$
μ	Value of water vapor diffusion resistance	–	DIN 52 615[2] wet cup	
sd	Thickness of the diffusion equivalent air layer	m	DIN 52 615[2] wet cup	Product $w \cdot sd$ shall remain constant or decrease: $w_i \cdot sd_i \leq w_o \cdot sd_o$
–	Drying rate	h	20/65 $v \leq 2$ m/s	Drying time until moisture content at 20/65: $t_i \leq 1.2\, t_o$

Suggestion for the calculation of sd_o, in the case of porous stones: on the unpainted stone a layer thickness *s* comparable to that of the paint layer on a painted stone cannot be exactly defined. It is therefore suggested to use the thickness of the zone, which is affected by short-term moisture changes (rain, condensation). This zone separates the air layer in front of the surface from the zone of constant moisture content in the interior of the stone, which is not affected by humidity changes (compare with the experimental instructions to measure μ). Approximately, its thickness *s* can be assumed as slightly greater than the depth of the maximum in the mean moisture distribution curve. As a general rule, therefore, *d* can be assumed as:
$w_o = 0.1\ldots0.5$: $d_o = 1.0$ cm; $w_o = 0.5\ldots3.0$: $d_o = 3.0$ cm; $w_o > 3.0$: $d_o = 6.0$ cm.

Test Applicable at the Object				
w	Water uptake coefficient	kg/m$^2\sqrt{h}$	Karsten tube	$w_i \leq w_o$

[1] Subscript (*o*) relates to the unpainted stone, subscript (*i*) to the painted stone.
[2] Or comparable method.

Table 16: Sasse & Snethlage's requirements for the evaluation of hydrophobic treatments (1996b).

Symbol	Property	Dimension	Test Method	Requirement [1]
			Laboratory Tests	
—	Visual properties	—	—	No color change, darkling, gloss, or increased susceptibility to soiling
—	Application	—	—	≤ 20% of the capillary pore volume filled with water
w	Water uptake coefficient	$kg/m^2/\sqrt{h}$	DIN 52 617[2]	$w \leq 0.1$
B	Water penetration coefficient	$cm/\sqrt{h}$	DIN 52 617[2]	No visual wetting
s	Penetration depth	cm	Capillary soaking for 5 min.	Deeper than zone of maximum mean moisture $w = 0.1–0.5$: $s = 1.0$ cm $w = 0.5–3.0$: $s = 3.0$ cm $w > 3.0$. $s = 6.0$ cm (w = untreated stone).
CA	Contact angle	° —	Water drop test depth profile	CA ≥ 90° —
α_{Hy}	Hygric dilatation	μm/m	Hygric and overhygric range	No increase against untreated stone
α_{Th}	Thermal dilatation	K^{-1}	–20/0/+20/+40	No increase against untreated stone
μ	Value of water vapor diffusion resistance	—	DIN 52 615[2] wet cup	Increase ≤ 20% dry cup Increase ≤ 30% wet cup
A_{SI}	Sorption isotherm	—	Storage under 0/15/30/50/65/75/85/95% RH, 20° C	$A_{SL,i} \leq A_{SI,o}$ Area under the SI after treatment ≤ area under the SI before treatment
—	Drying rate	h	20/65 v ≤ 2 m/s	Drying time until moisture content at 20/65: treated >> drying time untreated
—	Chemical resistance	%	Eluation of soluble matter in diluted acid	Comparison of amount of dissolved matter and after treatment
—	Protection index	%	Determination of gypsum formation	Not defined, gypsum formation as low as possible
—	SEM examination	—	—	Good film formation, no different thickness of the film, covering of basal planes of clay minerals
			Tests Applicable at the Object	
w	Water uptake coefficient	$kg/m^2\sqrt{h}$	Karsten tube	$w \leq 0.1$

[1] Subscript (o) relates to the untreated stone, subscript (i) to the treated stone.
[2] Or comparable method.

The authors furthermore suggest that a quality assurance system be developed for stone conservation products, so as to control their uniformity and quality at industrial level. The system that the authors propose is based on different "Test Categories", each integrating the testing methods necessary to achieve their specific targets. The ensemble of Test Categories is presented hierarchically, as follows (SASSE & SNETHLAGE, 1996b):

- *Category A: Basic Tests (General Effectivity Tests)*

This category comprises all the tests analysing fundamental suitability features of conservation products, so that "the basic principles of conservation are observed: effectivity, effectiveness (including compatibility; durability under artificial and natural weathering; fitness for site application; repeatability of the application (retreatability); and environmental compatibility (including worker safety)" (SASSE & SNETHLAGE, 1996b, p. 226).

- *Category B: Adjustment Tests*

These (laboratory) tests try to determine the applicability of the previous tests to the specifics of the intended intervention, including product application methods and information on weather conditions; trial applications on representative stones should be included here.

- *Category C: Application Tests*

These are to be performed on site, using non-destructive test methods, during and after product testing applications, in order to have information on the testing conditions, including temperature, humidity, quality and uniformity of workmanship, amount of used product, etc.

- *Category D: Identity Tests*

In this category, “tests are made to prove whether the used product is identical with that from the Categories A and B. Normally, physical properties of the unhardened products are determined and the chemical composition is analysed.” (SASSE & SNETHLAGE, 1996b, p. 229)

- *Category E: Production Control*

Category E tests deal with the uniformity of the building materials production process. According to the authors, some of these tests must be borrowed from categories A and D, but quality management control requirements, as stipulated by the ISO 9000 series (ISO 1994) need to be met as well.

- *Category F: Long-term Assessment Test*

This category is synonyms with the monitoring of the products and/or procedures' effectivity over time; of course, the specific testing methods to be used will depend on the property(ies) under analysis.

The testing methods to be integrated in each category may be selected from the proposed evaluation and assessment tests. Albeit these categories are rather exhaustive, and somewhat industrial in character, categories A through C do comprise the test methods that are normally resorted to by the major stone conservation research laboratories (LAURENZI TABASSO & SIMON, 2006).

It should be highlighted that, besides those proposed tests, legal requirements stated in directives or similar documents may call for extra compliance parameters (SASSE & SNETHLAGE, 1996b).

Another rather interesting side to the research presented in these papers concerns the development of a “Complex Effectiveness Evaluation” system. This system is presented solely for consolidants, and is based on the authors' own experience and on a proposal suggested in a PhD dissertation by D. Honsinger.

This effectiveness evaluation starts by defining, for a given monument (or stone type), *limits* of effectivity for each parameter; it is additionally recommended that *classes* of effectivity be established, where, for each given parameter, ranges of acceptable values between minimum and maximum effectivity are to correspond to percentages of the optimum value. The values of these limits, as well as the scale and range of the effectivity classes, are "to be decided by a competent authority" (SASSE & SNETHLAGE, 1996b, p. 232).

On the other hand, the system also allows for the weighing of the different parameters obtained from the tests for the characterization of each conservation procedure. It is quite evident that the several parameters listed for the consolidation (or any other given product/procedure) assessment should not have the same relevance in the final evaluation. However, the issue of deciding which parameters are relatively more important, and how much exactly they should weigh in the final decision, is a question that remains complex. Of course, no strict rules may be defined, and each case has to be examined carefully in its several facets, but some guidelines should nevertheless be possible. For consolidants, these papers clearly state that "Among the listed properties, penetration depth, hygric dilatation and *E*-modulus have the highest priorities" (SASSE & SNETHLAGE, 1996b, p. 237). The diagnosis of each particular monument, including environmental constraints, should allow for the establishment of the weight that should be ascribed to each parameter, again "to be decided by a competent authority" (SASSE & SNETHLAGE, 1996b, p. 232).

Once both limits of effectivity and importance weight are defined for each of the assessment parameters, the overall effectivity may be estimated, as follows:

$$E = \frac{\sum_{i=1}^{n} m_i . w_i}{\sum_{i=1}^{n} w_i}$$

, where:

m_i: measured values (as percentages of optimum values) for parameter *i*

w_i: importance weight for parameter *i*

This overall evaluation system is quite simple and logic, but one of the key aspects remains to be solved, namely the ascription of optimum values and importance weights by the "competent authority", whose responsibility is too large to take its constitution lightly. Questions on how many members, or experts, or authorities, or affected users, would it take for a reliable opinion to be issued, for instance, might pose some difficulties. Also, the authors highlight that "the method can only be used by experts and in no case schematically" (SASSE & SNETHLAGE, 1996b, p. 242). Another relevant issue before this method may be put in practice is, obviously, and as mentioned by the authors, the need for further research to support the definition of requirements, or tolerance limits, for each given parameter, seeing as these are also needed to define thresholds for the effectivity intervals. Finally, attention is drawn to the risks of computing linearly dependent variables, such as water transport and pore space parameters, into the system.

2.4.7 Zádor's *Determination of the Basic Conception of Conserving Stone by Means of Diagnostic Tests*

In the previously mentioned Second International Symposium on the Deterioration of Building Stones, Zádor also presented a paper concerning the decision-making process at the intervention planning stage. The author proposed a system where the choice of the best treatment option for a given stone building would issue from the computing of a set of different parameters and diagnostic tests, mainly physical-chemical in nature. These tests include (ZÁDOR, 1976):

(1) humidity measurement
(2) chemical tests, such as pH, wet pH and Ca, Mg, Cl, SO_4, NO_3, NH_4, $CaCO_3$ content
(3) biological tests
(4) petrographic tests, namely: porosity; porometry; water absorption and evaporation; capillarity; water and air permeability (maximum water content, critical water content, water absorption); swelling test; compressive strength; adhesion; bending; dynamic modulus of elasticity; heat expansion coefficient; rebound to sclerometer; surface hardness; scratch; indentation.

In his paper, the author suggests that the analysed stones should be classified into categories, divided by types of erosion, and that special attention should be paid to the testing of water absorption, saturation coefficient and capillary rise; ultrasonic speed measurements should additionally be carried out, in wet (i.e. with air moisture similar to that of the site) and dry conditions (ZÁDOR, 1976).

Zádor proposed as well that, for each stone type that is tested, optimal and critical values of "porosity, water permeability, etc" (ZÁDOR, 1976, p. 179) were determined, so as to help in the conservation planning process. The author furthermore drew attention to the need of developing tests that allow for the determination of the "liability to weathering", either qualitative or quantitative; these tests would specifically identify stone characteristics that caused some of them to be particularly prone to weathering. The paper stated that it was also necessary to develop and implement specific testing for the stone as a masonry element, that is to say, integrated in a structure; as opposed to testing the stone just considering it by itself (ZÁDOR, 1976).

Still in the diagnostic phase, in what concerns environmental analysis, the climate conditions should ideally be determined on macro (biological presence and air pollution), micro (wall moisture levels) and nano (conditions of temperature and precipitation) scales (ZÁDOR, 1976).

Once both stone and climate analyses are achieved, the author recommended that «sufficient» and «necessary» degrees of conservation should be determined – "by meeting the «sufficient» demands, the economicity of the work is ensured, while […] the achievement of the «necessary» degree is an indispensable condition of efficiency" (ZÁDOR, 1976, p. 180).

From the series of tests listed above, it would be possible to proceed to a classification of the monument stone, with the ascription of values, according to (ZÁDOR, 1976):

a) erosion condition (on a scale of 1 to 5, with higher values for more eroded stones);

b) chemical contamination (values from 1 (less contaminated) to 5 (more contaminated);

c) group of decay;

d) liability to weathering;

e) water absorption;

f) water absorption related to maximum water content;

g) capillary rise;

h) ultrasonic speed in wet conditions;

i) ultrasonic speed in dry conditions;

j) influence of environment:

macro: values ranging from 1 (high degree of biological damage) + 1 (heavy air pollution) to 3 (slight case of biological damage) + 3 (slight air pollution)

micro: values ranging from 1 (high degree of wall moisture) to 3 (slight case of wall moisture)

k) function: with possible values of 1 (ornamental plastic work); 2 (architectural unit, e.g. column) or 3 (façade)

After this classification, it would then be possible to calculate the "conservation modulus" *K*, as follows:

$$K = \frac{c+d+e+f+g+h+i}{j+k} + a + b$$

Depending on the value of *K*, the “way of conservation” would then be chosen, according to (ZÁDOR, 1976):

$K \leq 4$ = A (surface protection)

$K \leq 6$ = B (surface protection + slight consolidation)

$K > 8$ = C (total consolidation)

The author suggested furthermore that, in the long term, it would be useful to “determine the average value of the normal state of the different types of stone and relate them to value K” (ZÁDOR, 1976, p. 181).

The methodology proposed in this paper seems to suggest a strong concern with rationality in conservation decision making and places the most emphasis in the diagnostic phase. It may seem obvious today that a systematic diagnosis is crucial for the design of a conservation intervention, but maybe this was not so in 1976-Hungary. The author’s context was mainly influenced by two factors: (1) most stone masonry monuments were in a state of ruin, facing frequent freezing-thawing cycles and copious precipitation and (2) research in conservation had only begun to take its first steps (ZÁDOR, 1971). Probably due to the rapid decay of monumental stone, eventually accompanied by a more or less sudden awakening to the value of the built heritage, the lack of systematic approaches that allowed for more rationality in resource expenditure became pressing. It namely gave rise to assessments dividing monuments into four main conservation groups, including (1) the conservation of ruins with no resort to the replacement of stone elements; (2) the conservation of façades integrating different types of materials; (3) the cleaning of large buildings and (4) the conservation or restoration of carved stone elements, such as sculptures and doors (ZÁDOR, 1971).

Already in 1971, Zádor had suggested that a correct diagnostic analysis would allow dividing monuments according to their conservation problems into two main categories: “works in need of strengthening” and “works not in need of strengthening” (ZÁDOR, 1971, p. 244), with the latter further divided into six subcategories, depending on specific monument features. As the author puts it, “classification is decisive for determining the means of protection and for cost estimation” (ZÁDOR, 1971, p. 244).

It is important to notice that the formula leading to the value of *K* implies that (1) almost all the diagnostic analyses have the same weight in the final result, the only exception being the classification of the stones in terms of erosion condition and chemical contamination, which are the most important features; however, (2) it is not clear how the classification of stones into erosion classes is made from the suggested petrographic tests; (3) behaviour of the stone towards water is decisive for the obtaining of *K*, and yet there are no mechanical resistance tests with a direct influence in the final result, except maybe the ultrasonic sound measurements, which are an indirect way of evaluating resistance; (4) the function of the stone can also be decisive for the final decision, and, in extremis, it may occur that stones in the same condition receive different treatments (i.e., are consolidated or not) depending on them being part of a sculpture or of the façade. All of these pose very debatable questions, and no reports on the practical use of this methodology were found that could help answering some of these issues.

On the other hand, one of the major problems in trying to put forward a decision-making system for conservation based in performance measurements is the necessity of computing very different variables, and the form usually chosen is to convert these different values into classes that are ascribed workable (unitless) numbers or percentages. However, it is a great responsibility to define both the conditions of this conversion and the scale and number of classes that will be defined. In Zádor's methodology these definitions are quite straightforward, but seem more intuitive than scientific, and very few guidelines on the ascription of values are given.

2.4.8 Tassios' *On Selection of "Modern" Techniques and Materials in Structural Restoration of Monuments*

In a paper presented at the International Symposium on Restoration of Byzantine and Post-Byzantine Monuments, Tassios highlighted the need for clarity and explicitness in the stating of the requirements necessary in monument structural restoration planning, towards a "rational optimisation in selecting or rejecting modern materials and techniques." (TASSIOS, 1986, p. 358)

In this context, the author starts by drawing attention, using some illustrative examples, to the potentially misleading nature of the words "modern" and "traditional", since "what is traditional is spontaneously thought to be compatible, long-lasting and sound. However, this is not always the case" (TASSIOS, 1986, p. 357). In the choice of conservation materials and techniques, and because of the possibility of error-inducing terms, Tassios recommends that performance requirements are used instead: "a direct description of the required performance is needed each time, in terms of:

a) **Structural behaviour**: Strength, stiffness, thermal deformability, etc, as well as durability.
b) **Integrity** of the architectural form after the intervention.
c) **Reversibility** of the restoration measure." (TASSIOS, 1986, p. 358)

This triad of parameters configures the base of Tassios' proposed methodology for the assessment of restoration options; however, before this methodology is exposed, it is worth to take a closer look at the description of the structural behaviour analysis.

In what concerns **structural characteristics**, the materials to be introduced in the monument should display: (1) "adequate strength", measured in terms of compressive and/or tensile resistance, depending on the effects/actions considered desirable for each particular monument; (2) "appropriate elastic constants", to be judged by comparison with the elastic constants of the original materials constituting the monument; the author specifically mentions the Young's modulus and the Poisson's ratio, that have to be analysed according to "specific purposes of the restoration having to do with deformability" (TASSIOS, 1986, p. 359), and with the latter (Poisson's ratio) becoming fundamental whenever new and original materials are in close contact and lateral deformations may become an issue; finally, (3) "low-time effects", defined in terms of shrinkage, creep values, hygrometric expansion, that should be low or negligible, and thermal deformability, which should be similar enough for new and existing materials (TASSIOS, 1986).

Still in the context of structural performance requirements, attention is drawn to the problems that may arise **during the intervention**. This implies the specification of requirements dealing with (1) the "disturbance of stones during perforations", as the masonry may be put at risk by "heterogeneous materials, low quality of cutting devices, warped rods and inappropriate use of flashing water" (TASSIOS, 1986, p. 360); (2) "internal pressures of injected grouts", which should be as low as possible and agree with the tensile strength and weight of the walls upon restoration; also the "risk of non-reversible surface staining" should be minded (TASSIOS, 1986, p. 360); and (3) shoring, since the possibility of damage to the monument caused by the use of temporary support structures may be heightened "under shock conditions or in the case of long lasting operations (shrinking or setting props)" (TASSIOS, 1986, p. 360).

Finally, structural requirements are completed by the expectations on the **durability** of the intervention, for which a set of requirements also needs to be specified, for "durability is a monument's property par excellence" (TASSIOS, 1986, p. 360). These requirements should contemplate the following: (1) in general, but particularly in the case of employing recent techniques or materials, whose long-term behaviour is not well known, "alternative strategies for posterior corrective measures should be sought in advance" (TASSIOS, 1986, p. 360), whenever possible; (2) preference should be given to materials with longer lifetimes, considering especially their resistance to weathering via features such as "chemical stability, satisfactory pore size structure and distribution, as well as avoidance of leaking interfaces" (TASSIOS, 1986, p. 360); (3)

the interaction of the new constituents with the original ones should be minimal, with the specific exclusion of materials that might entail chemical interaction or soluble salt formation; and (4) a requirement for “minimum differential settlements possibly induced to the monument by the intervention itself” (TASSIOS, 1986, p. 360) may also become necessary.

Departing from the above considerations, Tassios is then able to propose a decision support system for the selection of restoration techniques and materials, and namely the ones that imply structural interventions. The author refers to this system as a “sort of «thinking algorithm»”, adding that “its triviality is obvious but its usefulness may be proved in some practical cases of decision making” (TASSIOS, 1986, p. 369).

Tassios’ methodology presupposes that a few preliminary steps are taken, including, sequentially:

1. “Estimation of available safety MARGINS against collapse” (TASSIOS, 1986, p. 369; capitalization by the author);
2. “Decision on the minimum STRENGTH-level to be imparted to the Monument”, where “appropriate factors of safety will be selected, depending on the life-time envisaged, the uncertainties recognized in [the previous] step, and the importance of the Monument” (TASSIOS, 1986, p. 369; capitalizations by the author);
3. Specification on the remainder of the “PERFORMANCE REQUIREMENTS (other than strength-level)” (TASSIOS, 1986, p. 369; capitalizations by the author), namely:

   - Durability requirements (D_{req});
   - Integrity requirements (I_{req});
   - Reversibility requirements (R_{req})

   The author adds that “obviously, the decision on these three minimum performance requirements will be based on the historical, social and architectural VALUE of the Monument” (TASSIOS, 1986, p. 369; capitalizations by the author), which introduces an interesting turn by calling for the appraisal of the society’s (or at least its heritage decision makers) opinion in a more or less direct way.

   Another interesting suggestion is the establishment of “relative importance factors” for each one of the above-mentioned requirements – f_D, f_I and f_R, respectively –, “so that a quasi-quantitative comparison between them would be possible” (TASSIOS, 1986, p. 369); these factors would sum up to 1. One should note that the choice of these factors introduces some subjectivity to the method.

4. "DESIGN of the intervention for each Technique + Material [set]" (TASSIOS, 1986, p. 369; capitalization by the author), disregarding any sets that do not verify the requirements specified in step 2. For each set, a calculation of quantities of both work and materials will permit to estimate total costs.
5. "Examination of suitability of alternative restoration TECHNIQUES + MATERIALS" (TASSIOS, 1986, p. 369; capitalizations by the author), for which the author suggests that "quality-indices" (D_i, I_i, R_i, i = 1, …, n possible technique + material sets), which may or may not be numerical, be derived for each alternative; a possible aid in this derivation would be to use the Delphi method, "among the members of an Interdisciplinary Decision-making Board" (TASSIOS, 1986, p. 370; capitalizations by the author). This is arguably the step where more subjectivity may be introduced, though the resort to the Delphi method may attenuate this effect.
6. Comparisons then should be made between the alternatives and the requirements established in step 3, with the exclusion of the options that do not verify:

   $D_i < D_{req}$; $I_i < I_{req}$ or $R_i < R_{req}$.
7. The remaining options can then be analysed by calculating the "HARMONIZED overall «performance margins» [H.P.M.] of each proposal" (TASSIOS, 1986, p. 370; capitalization by the author), using the "relative importance factors" defined in step 3, as follows:

   $H.P.M. = f_D (D_i – D_{req}) + f_I (I_i – I_{req}) + f_R (R_i – R_{req})$
8. Finally, the "OPTIMISATION index" (TASSIOS, 1986, p. 370; capitalization by the author) may now be calculated for each proposal, incorporating the cost information:

   $$\iota_{opt} = \frac{HPM}{C_i}$$

   This optimized H.P.M. will allow for the comparison of the different solutions performance surpluses, i.e., performances above the minimal requirements, taking the costs into account as well.

As the author puts it, "it is only under rare conditions that such a quasi-quantitative procedure will be applicable in practical cases of restoration. However, it is believed that it may be equally useful even if it is followed in a qualitative way, step by step. It may help to organize our decision making process in a more rational way, and to minimize arbitrary thinking" (TASSIOS, 1986, p. 370).

Tassios' methodology was clearly designed with structural conservation in mind, and thus its applicability would be more obvious in the cases of repair or renewal/rehabilitation interventions with structural engineering requisites. Nevertheless, attention is drawn to the parallels between this reasoning and that of Sasse & Snethlage and of Delgado Rodrigues & Grossi: indicators are chosen for which minimum or maximum requirements are set; indicators are then averaged (with or without weighing) for the obtaining of an optimisation, effectivity or (in)compatibility index, respectively.

2.5 Some Conclusions

This chapter tried to describe the current trends that influence decision making in the conservation of built heritage today. Firstly, at this point it should seem more or less consensual that a values-based approach to conservation appears to constitute the most aggregating form of handling the multitude of aspects that involve each heritage object, from its recognition to its active conservation. Avrami *et al.* (2000) propose that the future of heritage conservation be schematically depicted as follows:

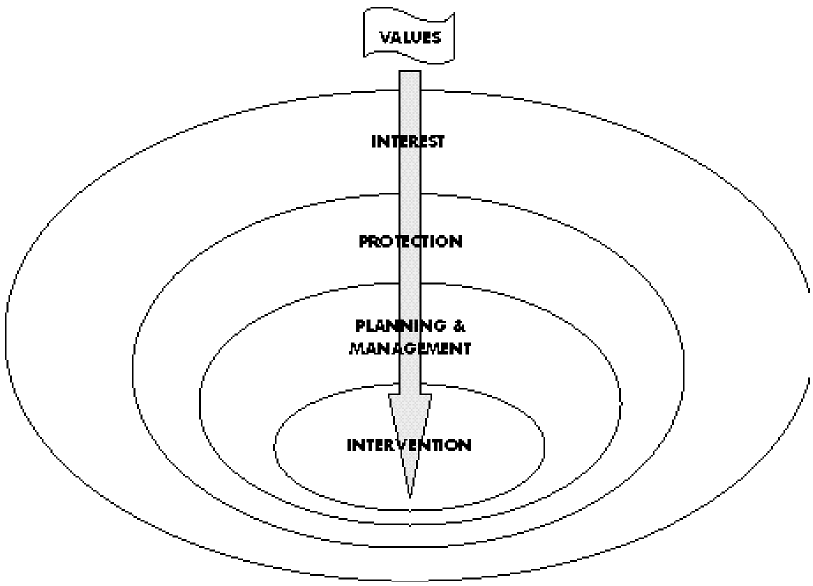

Figure 6: Perspectives for the future of heritage conservation: recognized values preside and integrate the pathway of each object, from its recognition to the interventions it may require (source: GCI (2000)).

The fact that values affect conservation decisions is not new – Riegl clearly stated it a little over one century ago. Their unambiguous incorporation in the conservation process, however, is recent, but so far it appears to be fruitful in integrating different stakeholders and promoting a more interdisciplinary collaboration between conservation specialists, as well as in submitting all decisions to what is perceived as valuable in a heritage object, transcending material features alone.

On the other hand, it seems evident by now that values shift; these shifts must be integrated in the management process, and therefore a values-based management is contingent of time and contexts, even when it prioritizes traditional values. Social circumstances strongly shape the perception of stakeholders, so the management of a site has to acknowledge the different spheres of influence of the site in society and vice-versa, and preview forms of articulating them into the protection of the recognized core values, so that this protection may be sustainable; this implies the acknowledgement of, and action on, values that are critical for the development of local communities – aspects like tourism, access and standard of living viability.
If, in theory, values-based management means assessing the values of a site and planning for the best ways to preserve them, the process, when put into practice, is largely contingent of specific site features and specific social circumstances – as can be seen, for example, for the case of Hadrian's Wall World Heritage Site (MASON et al., 2003) (HWMPC, 2008); nevertheless, values-based management seems to provide an approach and negotiatory tools that may prove crucial for the conservation of a site.

When it comes to managing a heritage site, decisions have to be made, firstly, at a macro-scale, which more or less corresponds to designing a strategy for the site, including the definition of objectives to pursue, which are generally developed along three main axes: access – research – conservation. Hence, more specific conservation decisions start to unfold slightly more downstream within the management process, along with the needs dictated by site assessments and management objectives. When there is a need for a specific (conservation) intervention, progressively smaller-scale decisions must be taken, the dimension of each varies inversely with their absolute number. Schematically:

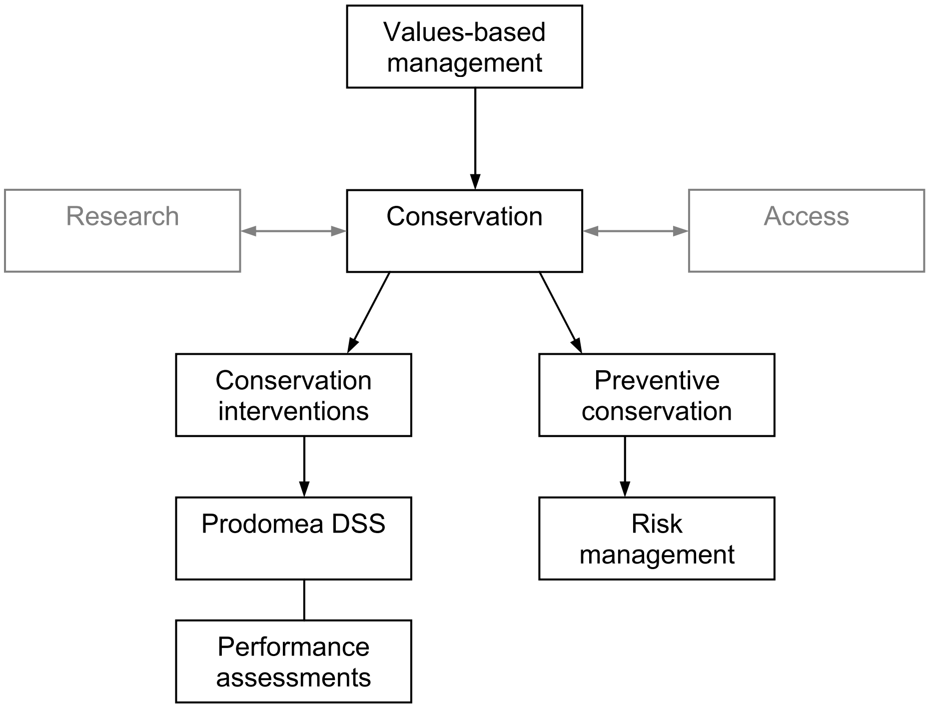

Figure 7: Flowchart describing the different decision levels in conservation, with an emphasis on the processes highlighted in this report.

The process described in the Burra Charter and the guidelines proposed by EH, and even the SBMK/ICN model, should constitute a good starting point for the values-based management process of a site or object. The reasons why they were presented here, however, are more closely linked to the possibilities they offer for the framing of conservation decisions, be it preventive or curative in character.

Risk management, which, as seen, is particularly helpful in the field of preventive conservation, may profitably resort to the guidance of these values-based methodologies for its definition of scope and goals. In turn, risk management may reveal some interest for the development of strategic goals for the site, notably regarding its conservation. Conceptually, risk management may prove helpful in heritage conservation in what it separates each risk in two components: the probability and the consequence of its occurrence. As shown above, there have been diverse attempts of rationalizing conservation choices, particularly in what concerns products and methods. These attempts mostly try to set requirements for harmfulness or efficacy, but they do not analyse the different consequences that each choice may yield; it is as if the value of the object is kept constant. However, some methods, such as Sasse & Snethlage's and Delgado Rodrigues & Grossi's, do mention the possibility of weighing each parameter according to its potential impact on the final result, and this has clear conceptual parallels with the value analysis promoted within risk management.

What about conservation interventions? The Prodomea DSS concerns this particular stage of the larger conservation process and, as such, should logically be framed by the same reasoning. The values-based management methodologies suggested above, and according to the institutions that conceived them, should not only be periodically revised, but also be recalled and reworked whenever an intervention is necessary.

The Prodomea DSS advocates that decisions must be made that maximize the compatibility with the site; more precisely, it is the compatibility with the *values of the site* that must be pursued. Of course, the Prodomea DSS presupposes a previous work of significance analysis that would have led to the decision of intervening, and namely if the intended intervention is to take the form of a repair, a restoration or a conservation *sensu strictu*. Nevertheless, the possibility that this presupposition is not met may impair the start of the process and thus it could be argued that significance analysis should integrate the DSS more clearly. This topic will be analysed in upcoming research.

Finally, the described performance-based methodologies share with the Prodomea DSS an attempt at rationalizing decision making in conservation, albeit more downstream, when decisions on specific actions – e.g. consolidation, mortar application, cleaning – are already taken. This type of analysis regards material aspects alone, and may not guide an intervention by itself. To frame it within a significance analysis would also be insufficient, since an intervention planning encompasses much more aspects, including social and operational ones, which have a strong impact upon the work and thus need to be considered.

Of course the body of knowledge and experience gained on material studies for conservation, as well as the appropriate standards, should be integrated in the decision making on material features. If, as seen, specific evaluation criteria are scarce, and oftentimes products seem to be appraised relatively rather than absolutely; some criteria do exist and may help to systematize these choices. In the follow-up to this report, some of the most widely recognized criteria, such as Sasse and Snethlage's, will be juxtaposed to Delgado Rodrigues & Grossi's (in)compatibility assessment, to see if it is possible to achieve a wider validity in the criteria proposed by the latter.

3 BIBLIOGRAPHIC REFERENCES

ASHLEY-SMITH, J. (1999). *Risk assessment for object conservation*. Oxford: Butterworth-Heinemann.

ASHLEY-SMITH, J. (2009). The Basis of Conservation Ethics. In A. RICHMOND & A. BRACKER (Eds.), *Conservation: Principles, Dilemmas and Uncomfortable Truths* (pp. 6-24). London: Butterworth-Heinemann in association with the V&A Museum.

AVRAMI, E., MASON, R. & DE LA TORRE, M. (2000). Values and Heritage Conservation - Report on Research. In E. AVRAMI & R. MASON (Eds.), *Values and Heritage Conservation*. Los Angeles: The Getty Conservation Institute.

BÁEZ, A. & HERRERO, L. C. (2012). Using Contingent Valuation and Cost-benefit Analysis to Design a Policy for Restoring Cultural Heritage. *Journal of Cultural Heritage, 13*, 235-245.

BLUESTONE, D., KLAMER, A., THROSBY, D. & MASON, R. (1998, 1999). *The Economics of Heritage Conservation: A Discussion.* Paper presented at the Economics and Heritage Conservation – Report of a Meeting Organized by the Getty Conservation Institute, Los Angeles.

BOITO, C. (2000). *Conserver ou Restaurer - Les Dilemmes du Patrimoine* (J.-M. MANCOSIO, Trans.). Besançon: Les Éditions de L'Imprimeur.

BONINI, N. (2007). Decision Anomalies and Psychology of Decision Making. In R. VAROLI-PIAZZA (Ed.), *Sharing Conservation Decisions* (pp. 34-37). Rome: ICCROM.

BRANDI, C. (1996). Readings from "Theory of Restoration" (G. PONTI & A. M. VACCARO, Trans.). In N. S. PRICE, J. M.K. TALLEY & A. M. VACCARO (Eds.), *Historical and Philosophical Issues in the Conservation of Cultural Heritage* (pp. 230-235; 339-342; 377-379). Los Angeles: The Getty Conservation Institute.

BROMBLET, P. (1999). *Properties and Durability of Air-based Lime Mortars for Limestone Repairs on Monuments.* Paper presented at the Workshop on Historic Mortars: Characteristics and Tests, Paisley.

BRUNDTLAND, G. H. (1987). Our Common Future: Report of the World Commission on Environment and Development (A/42/427) by the Brundtland Commission of the World Commission on Environment and Development Retrieved October 2008, from http://www.un-documents.net/ocf-02.htm#I

CALDEIRA, L. (2005). Análises de Riscos em Geotecnia - Aplicação a Barragens de Aterro *Programas de Investigação e de Pós-Graduação na Área Científica de Mecânica dos Solos, apresentados para obtenção do título de Habilitado para o Exercício das Funções de Coordenação Científica*. Lisbon: LNEC.

CHAROLA, A. E. & HENRIQUES, F. M. A. (1998). *Lime Mortars: Some Considerations on Testing Stantardization.* Paper presented at the Use of and Need for Preservation Standards in Architectural Conservation, ASTM STP 1355.

CHOAY, F. (1984). Introduction *Le Culte Moderne des Monuments: Son Essence et Sa Genèse*. Paris: Éditions du Seuil.

CHOAY, F. (2000). Prélude *Conserver ou Restaurer - Les Dilemmes du Patrimoine*. Besançon: Les Éditions de L'Imprimeur.

COHOON MCSTOTTS, J. (2006). The Second Fall of the Berlin Wall: Examining the Hildebrandt Memorial at Checkpoint Charlie. *Future Anterior, III*(1), 36-47.

DELGADO RODRIGUES, J. (1996). Study on Stone Treatments. In M. A. VICENTE & J. DELGADO RODRIGUES (Eds.), *Degradation and Conservation of Granitic Rocks in Monuments. Project STEP CT90-0110: Conservation of Granitic Rocks with Application to the Megalithic Monuments EC DG XII* (pp. 225-242). Brussels: European Comission.

DELGADO RODRIGUES, J., ALESSANDRINI, G. & BOUINNEAU, A. (1997). *Procedure for selection and control of cleaning operations. A proposal.* Paper presented at the Fourth International Symposium on the Conservation of Monument in the Mediterranean, Rodhes.

DELGADO RODRIGUES, J. & GROSSI, A. (2004). The Compatibility Approach. In PRODOMEA (Ed.), *PRODOMEA Project Publications* (Vol. Deliverable 03, pp. 1-69): INCO: International Scientific Cooperation Projects (1998-2002) Contract No ICA3-CT-2002-10021.

DELGADO RODRIGUES, J. & GROSSI, A. (2007). Indicators and Ratings for the Compatibility Assessment of Conservation Actions. *Journal of Cultural Heritage, 8*, 32-43. doi: doi:101016/j.culher.2006.04.007

DIAZ GONÇALVES, T. (1998). Compatible Renders for the Conservation of Ancient Buildings. In G. BISCONTIN, A. MOROPOULOU, M. ERDIK & J. DELGADO RODRIGUES (Eds.), *Compatible Materials for the Protection of European Cultural Heritage - PACT 55 - Revue du groupe européen d'études pour les techniques physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 29-38). Athens: Technical Chamber of Greece.

E.C.C.O. (2002). E.C.C.O. Professional Guidelines (I): The Profession. *E.C.C.O. PROFESSIONAL GUIDELINES - Promoted by the European Confederation of Conservator-Restorers' Organisations and adopted by its General Assembly* Retrieved Feb 14th 2012, from http://www.encore-edu.org/ecco1.html?tabindex=3&tabid=170

E.C.C.O. (2003). E.C.C.O. Professional Guidelines (II). *E.C.C.O. PROFESSIONAL GUIDELINES - Promoted by the European Confederation of Conservator-Restorers' Organisations and adopted by its General Assembly* Retrieved Feb 14th 2012, from http://www.encore-edu.org/ecco2.html

EH, E. H. (2008). Principles, Policies and Guidance for the sustainable management of the historic environment Retrieved November 14 2011, from http://www.english-heritage.org.uk/publications/conservation-principles-sustainable-management-historic-environment/conservationprinciplespoliciesguidanceapr08web.pdf

FEILDEN, B. M. & JOKILEHTO, J. (1998). *Management Guidelines for World Cultural Heritage Sites* (2nd ed.). Rome: ICCROM.

GAURI, K. L., GWINN, J. A. & POPLI, R. K. (1976, 27th September-1st October). *Performance Criteria for Stone Treatment.* Paper presented at the Second International Symposium on the Deterioration of Building Stones, Athens.

GROSSI, A. (2005). Compatibility Decision Support System design - Section One: Overview of the system. In PRODOMEA (Ed.), *PRODOMEA Project Publications*: INCO: International Scientific Cooperation Projects (1998-2002) Contract No ICA3-CT-2002-10021.

HOLTORF, C. J. (2000-2008). *Monumental Past: The Life-Stories of Megalithic Monuments in Mecklenburg-Vorpommern (Germany)*. Electronic monograph. University of Toronto: Centre for Instructional Technology Development. Retrieved from https://tspace.library.utoronto.ca/citd/holtorf/

HWMPC, H. s. W. M. P. C. (2008). Hadrian's Wall Management Plan 2008-2014 Retrieved October 2011, from www.hadrians-wall.org

I.C.A.T.H.M., I. C. o. A. a. T. o. H. M. (1964). The Venice Charter - International Charter for the Conservation and Restoration of Monuments and Sites (1964) Retrieved October 2008, from http://www.international.icomos.org/charters/venice_e.htm

ICOMOS-A. (1999). The Burra Charter: The Australia ICOMOS Charter for Places of Cultural Significance 1999 - With Associated Guidelines and Code on the Ethics of Co-existence Retrieved October 2008, from http://australia.icomos.org/publications/charters/

ICOMOS-NZ. (2010). Charter for the Conservation of Places of Cultural Heritage Value (ICOMOS New Zealand) Retrieved October 2011, from http://www.international.icomos.org/charters/ICOMOS_NZ_Charter_2010_FINAL_11_Oct_2010.pdf

JOKILEHTO, J. (1986). *A History of Architectural Conservation: The Contribution of English, French, German and Italian Thought Towards an International Approach to the Conservation of Cultural Property.* D. phil thesis, University of York, York. Retrieved from http://www.iccrom.org/pdf/ICCROM_05_HistoryofConservation00_en.pdf

JOKILEHTO, J. (1988). Conservation Principles and Their Theoretical Background. *Durability of Building Materials, 5*, 267-277.

JOKILEHTO, J. (1999). *A History of Architectural Conservation*. Oxford: Butterworth-Heinemann.

KLAMER, A. & ZUIDHOF, P.-W. (1998, 1999). *The Values of Cultural Heritage: Merging Economic and Cultural Appraisals.* Paper presented at the Economics and Heritage Conservation - Report of a Meeting Organized by the Getty Conservation Institute, Los Angeles.

LAURENZI TABASSO, M. & SIMON, S. (2006). Testing Methods and Criteria for the Selection/Evaluation of Products for the Conservation of Porous Building Materials. *Reviews in Conservation*(7), 67-82.

LIPE, W. D. (1984). Value and Meaning in Cultural Resources. In H. CLEERE (Ed.), *Approaches to the Archaeological Heritage: A Comparative Study of World Cultural Resource Management Systems* (pp. 1-11). Cambridge: Cambridge University Press.

LOWENTHAL, D. (1992). *The Value of Age and Decay.* Paper presented at the Dahlem Workshop on Durability and Change: the Science, Responsibility, and Cost of Sustaining Cultural Heritage, Chichester; New York.

MANSOUX, H. (2000). Acceptability and Safety Objectives, Use of Concepts Through Various Areas. *Contract EU/DGXXIV n°B5-1030/99/094994. Note SEGR/LSEES 00-99*. Retrieved from http://cryptome.org/0004/enviro-risk.pdf

MASON, R. (1998, 1999). *Economics and Heritage Conservation: Concepts, Values, and Agendas for Research.* Paper presented at the Economics and Heritage Conservation – Report of a Meeting Organized by the Getty Conservation Institute, Los Angeles.

MASON, R., MACLEAN, M. G. H. & DE LA TORRE, M. (2003). Hadrian's Wall World Heritage Site: A Case Study. In M. DE LA TORRE (Ed.). Los Angeles: The Getty Conservation Institute.

MOROPOULOU, A. (2000a). Innovative Education and Training for the Conservation of Cultural Heritage. In A. MOROPOULOU, G. BISCONTIN, J. DELGADO RODRIGUES, M. ERDIK, M. SIOTIS & S. ZOPPI (Eds.), *Compatible Materials for the Protection of Cultural Heritage - PACT 58 - Revue du groupe européen d'études pour les techniques* *physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 71-80). Athens: Technical Chamber of Greece.

MOROPOULOU, A. (2000b). Reverse Engineering to Discover Traditional Technologies: a Proper Approach for Compatible Restoration Mortars. In A. MOROPOULOU, G. BISCONTIN, J. DELGADO RODRIGUES, M. ERDIK, M. SIOTIS & S. ZOPPI (Eds.), *Compatible Materials for the Protection of Cultural Heritage - PACT 58 - Revue du groupe européen d'études pour les techniques physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 81-107). Athens: Technical Chamber of Greece.

MOROPOULOU, A., BAKOLAS, A. & MOUNDOULAS, P. (2000, June 19-24). *Criteria and Methodology for Restoration Mortars Compatible to the Historic Materials and Structures.* Paper presented at the 9th International Congress on Deterioration and Conservation of Stone, Istituto Veneto per I Beni Culturali - Venice.

MOROPOULOU, A., CAKMAK, A. S. & BISCONTIN, G. (1998). Criteria and Methodology to Evaluate the Hagia Sophia Crushed Brick/Lime Mortars. In G. BISCONTIN, A. MOROPOULOU, M. ERDIK & J. DELGADO RODRIGUES (Eds.), *Compatible Materials for the Protection of European Cultural Heritage - PACT 55 - Revue du groupe européen d'études pour les techniques physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 39-54). Athens: Technical Chamber of Greece.

MOROPOULOU, A., KOUI, M., CHRISTARAS, B. & TSIOURVA, T. (1998). Non-Destructive Evaluation of the Performance of Mortars on Historic Masonries. In G. BISCONTIN, A. MOROPOULOU, M. ERDIK & J. DELGADO RODRIGUES (Eds.), *Compatible Materials for the Protection of European Cultural Heritage - PACT 55 - Revue du groupe européen d'études pour les techniques physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 243-266). Athens: Technical Chamber of Greece.

MOROPOULOU, A., MARAVELAKI-KALAITZAKI, P., BORBOUDAKIS, M., BAKOLAS, A., MICHAILIDIS, P. & CHRONOPOULOUS, M. (1998). Historic Mortars Technologies in Crete and Guidelines for Compatible Restoration Mortars. In G. BISCONTIN, A. MOROPOULOU, M. ERDIK & J. DELGADO RODRIGUES (Eds.), *Compatible Materials for the Protection of European Cultural Heritage - PACT 55 - Revue du groupe européen d'études pour les techniques physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 55-72). Athens: Technical Chamber of Greece.

MORRIS, W. (1877). The Manifesto of the Society for the Protection of Ancient Buildings. Retrieved from www.spab.org.uk/what-is-spab-/the-manifesto

MUÑOZ-VIÑAS, S. (2005). *Contemporary Theory of Conservation*. Oxford: Elsevier Butterworth-Heinemann.

NIJKAMP, P. (1991). Evaluation Measurement in Conservation Planning. *Journal of Cultural Economics, 15*(1), 1-27.

NOONAN, D. S. (2003). Contingent Valuation and Cultural Resources: A Meta-Analytic Review of the Literature. *Journal of Cultural Economics, 27*(3-4), 159-176. doi: Doi: 10.1023/A:1026371110799

ORNA, M. V., ANDERSON, R., BENDER, B., CRAMER, F., DE WITE, E., DREVER, J. I., . . . WESTHEIMER, F. H. (1992). Group Report: What is Durability in Artifacts and What Inherent Factors Determine It? In W. E. KRUMBEIN, P. BRIMBLECOMBE, D. E. COSGROVE & S. STANIFORTH (Eds.), *Dahlem Workshop on Durability and Change: the Science, Responsibility, and Cost of Sustaining Cultural Heritage*. Chichester, New York: John Wiley & Sons Ltd.

PRODOMEA. (2004). First Annual Report - Covering period from 1st January 2003 to 31st December 2003. In PRODOMEA (Ed.), *PRODOMEA Project Publications*: INCO: International Scientific Cooperation Projects (1998-2002) Contract No ICA3-CT-2002-10021.

PRODOMEA. (n.d.). PRODOMEA Retrieved March 5th 2012, from www.prodomea.com

PYE, E. (2001). *Caring for the Past - Issues in Conservation for Archaeology and Museums*. London: James & James.

RICHMOND, A. & BRACKER, A. (2009). Introduction. In A. RICHMOND & A. BRACKER (Eds.), *Conservation: Principles, Dilemmas and Uncomfortable Truths* (pp. xiv-xviii). London: Butterworth-Heinemann in association with the V&A Museum.

RIEGL, A. (1984). *Le Culte Moderne des Monuments: Son Essence et Sa Genèse* (D. Wieczorek, Trans.). Paris: Éditions du Seuil.

RIEGL, A. (1996). Readings from "The Modern Cult of Monuments: Its Essence and Its Development" (K. BRUCKNER & K. WILLIAMS, Trans.). In N. S. PRICE, J. M.K. TALLEY & A. M. VACCARO (Eds.), *Historical and Philosophical Issues in the Conservation of Cultural Heritage* (pp. 69-83). Los Angeles: The Getty Conservation Institute.

RIGANTI, P. (2006). *Tourists' satisfaction vs. residents' quality of life in medium sized European cities: a conjoint analysis approach for cultural tourism's impact assessment.* Paper presented at the 46th Congress of the European Regional Science Association, Volos, Greece.

RIGANTI, P. & NIJKAMP, P. (2004, 25-29 August). *Valuing Cultural Heritage Benefits to Urban and Regional Development.* Paper presented at the 44th European Congress of the European Regional Science Association Regions and Fiscal Federalism., Universidade do Porto, Portugal.

RIGANTI, P. & NIJKAMP, P. (2005, 23-27 August). *Benefit transfers of cultural heritage values: How far can we go? (Draft).* Paper presented at the "Land Use and Water Management in a Sustainable Network Society" - 45th Congress of the European Regional Science Association, Vrije Universiteit Amsterdam.

ROUDET, L. (2007). *L'Intervention Minimale en Conservation-restauration des Biens Culturels: Exploration d"une Notion.* Mémoire de Master en Conservation-Restauration des Biens Culturels, Université Paris I Panthéon-Sorbonne, Paris. Retrieved from http://ludovicroudet.fr/consrest/pub/LR_IM_CRBC.pdf

SASSE, H. R. & SNETHLAGE, R. (1996a). Evaluation of Stone Consolidation Treatments. *Science and Technology for Cultural Heritage, 5*(1), 85-92.

SASSE, H. R. & SNETHLAGE, R. (1996b). Methods for Evaluation of Stone Conservation Treatments. In N. S. BAER & R. SNETHLAGE (Eds.), *Dahlem Workshop Report on Saving our Architectural Heritage: the Conservation of Historic Stone Structures* (pp. 223-243). West Sussex: John Wiley & Sons Ltd.

SBMK/ICN. (1999). The Decision-Making Model for the Conservation and Restoration of Modern and Contemporary Art Retrieved August 25th 2011, from http://www.incca.org/files/pdf/resources/sbmk_icn_decision-making_model.pdf

STEVENS, T. H., BELKNER, R., DENNIS, D., KITTREDGE, D. & WILLIS, C. (2000). Comparison of contingent valuation and conjoint analysis in ecosystem management. *Ecological Economics, 32*, 63–74.

STOVEL, H. (1998). *Risk Preparedness: a Management Manual for World Cultural Heritage*. Rome: ICCROM.

STUBBS, J. H. (2009). *Time Honored: A Global View of Architectural Conservation: Parameters, Theory , & Evolution of an Ethos*. New Jersey: John Wiley & Sons, Inc.

TASSIOS, T. P. (1986, 11-13 dec. 1985). *On Selection of "Modern" Techniques and Materials in Structural Restoration of Monuments.* Paper presented at the International Symposium on Restoration of Byzantine and Post-Byzantine Monuments, Thessaloniki

TAYLOR, J. & CASSAR, M. (2008). *Representation and intervention: The symbiotic relationship of conservation and value.* Paper presented at the Conservation and Access: Contributions to the London Congress, London.

TEUTONICO, J. M., CHAROLA, A. E., DE WITTE, E., GRASSEGGER, G., KOESTLER, R. J., LAURENZI TABASSO, M., . . . SNETHLAGE, R. (1996). Group Report: How Can We Ensure the Responsible and Effective Use of Treatments (Cleaning, Consolidation, Protection). In N. S. BAER & R. SNETHLAGE (Eds.), *Dahlem Workshop Report on Saving Our Architectural Heritage: the Conservation of Historic Stone Structures* (pp. 293-313). West Sussex: J. Wiley.

THEOULAKIS, P., KARASTASIOS, I. & STEFANIS, N. A. (2008). Performance criteria and evaluation parameters for the consolidation of stone. In J. DELGADO RODRIGUES & J. M. MIMOSO (Eds.), *Stone Consolidation in Cultural Heritage - Research and Practice, Proceedings of the LNEC Symposium* (pp. 279-288). Lisbon: LNEC.

TUAN, T. H. & NAVRUD, S. (2008). Capturing the Benefits of Preserving Cultural Heritage. *Journal of Cultural Heritage, 9*, 326-337.

UNESCO. (2011). Operational Guidelines for the Implementation of the World Heritage Convention Retrieved April 3rd 2012, from http://whc.unesco.org/archive/opguide11-en.pdf

UNESCO & ICOMOS. (1994). The Nara Document on Authenticity (Nara Conference on Authenticity in Relation to the World Heritage Convention) Retrieved October 2008, from http://www.international.icomos.org/charters/nara_e.htm

VAN BALEN, K., PAPAYIANNI, I., VAN HEES, R., BINDA, L. & WALDUM, A. (2004). Introduction to Requirements for and Functions and Properties of Repair Mortars. In C. GROOT, G. ASHALL, K. VAN BALEN, G. BARONIO, P. BARTOS, L. BINDA, K. CALLEBAUT, J. ELSEN, R. VAN HEES, J. J. HUGHES, J.-E. LINDQVIST, B. MIDDENDORF, P. MAURENBRECHER, I. PAPAYIANNI, M. THOMSON, E. TOUMBAKARI & A. WALDEN (Eds.), *RILEM TC COM 167 - Characterization of Old Mortars with Respect to their Repair*.

VEIGA, R. (2007). *Conservação e Reparação de Revestimentos de Paredes de Edifícios Antigos - Programa de Investigação e Programa de Pós-graduação apresentados para a obtenção do título de Habilitação para o Exercício de Funções de Coordenação de Investigação Científica*. Lisboa: LNEC.

VEIGA, R., FRAGATA, A., VELOSA, A., MAGALHÃES, A. & MARGALHA, G. (2007). Substitution mortars for application in historical buildings exposed to the sea environment. Analysis of the viability of several types of compositions Retrieved February 8th 2012, from http://conservarcal.lnec.pt/pdfs/Medachs-Substitution%20mortars%20f-rev%20FINAL%20REVISTA%20ENVIADA.pdf

VERBEECK-BOUTIN, M. (2009). De l'axiologie. Pour une théorie des valeurs appliquée à la conservation-restauration. *CeROArt. Conservation, exposition, Restauration d'Objets d'Art [online],* (4). Retrieved from http://ceroart.revues.org/1298

WALLER, R. (1994). *Conservation Risk Assessment: a Strategy for Managing Resources for Preventive Conservation.* Paper presented at the Preventive Conservation Practice, Theory and Research, The International Institute for Conservation of Historic and Artistic Works, London.

WALLER, R. (1996). Preventive Conservation Planning for Large and Diverse Collections. In A. I. f. Conservation (Ed.), Presession Preprints. Retrieved from http://museum-sos.org/docs/WallerAIC1996.pdf.

WALLER, R. (2007, April). [Risk Assessment for Heritage Collections: the Cultural Property Risk Analysis Model].

WALLER, R. & MICHALSKI, S. (2004). Effective Preservation: From Reaction to Prevention. *Getty Conservation Institute Newsletter, 19*(1), 4-9.

ZACHAROPOULOU, G. (1998). The Renascence of Lime Based Mortar Technology – an Appraisal of a Bibliographic Study. In G. BISCONTIN, A. MOROPOULOU, M. ERDIK & J. DELGADO RODRIGUES (Eds.), *Compatible Materials for the Protection of European Cultural Heritage - PACT 55 - Revue du groupe européen d'études pour les techniques physiques, chimiques, biologiques et mathématiques apliquées à l'archeologie - Conseil de l'Europe.* (pp. 89-114). Athens: Technical Chamber of Greece.

ZÁDOR, M. (1971, 1972). *Conservation Problems of Stone Monumental Buildings in Hungary.* Paper presented at the The Treatment of Stone - Meeting of the Joint Committee for the Conservation of Stone (ICOM, ICOMOS, ICC - Working Group on the Treatment of Stone), Bologna.

ZÁDOR, M. (1976, 27th September-1st October). *Preliminary Tests for Determining the Method to be Applied for Conserving Monumental Stone Facades.* Paper presented at the Second International Symposium on the Deterioration of Building Stones, Athens.

LIST OF ACCRONYMS

BLfD – Bayerisches Landesamt für Denkmalpflege (Bavarian State Conservation Office)

CEN – European Committee for Standardization

CMN – Canadian Museum of Nature

CIs – Compatibility Indicators

CVM – Contingent Valuation Method

DGEMN – Direcção Geral dos Edifícios e Monumentos Nacionais (Portuguese Office for National Buildings and Monuments)

DSS – Decision Support System(s)

ECCO – European Confederation of Conservator-Restorers' Organisations

EH – English Heritage

FCT/UNL – Faculdade de Ciências e Tecnologia da Universidade Nova de Lisboa (Faculty of Sciences and Technology / New University of Lisbon)

DCR-FCT/UNL: Departamento de Conservação e Restauro da FCT/UNL (Department of Conservation and Restoration of the FCT/UNL)

FS – Fraction Susceptible

GCI – Getty Conservation Institute

HWMPC – Hadrian's Wall Management Plan Committee

ICCROM – International Centre for the Study of the Preservation and Restoration of Cultural Property

ICOMOS – International Council on Monuments and Sites

MCSV – Monastery of Santa Clara-a-Velha (Coimbra, Portugal)

NGO – Non-Governmental Organization

OUV – Outstanding Universal Value

PRODOMEA – PROject on high compatibility technologies and systems for conservation and DOcumentation of masonry works in archaeological sites in the MEditerranean Area

RILEM – International Union of Laboratories and Experts in Construction Materials, Systems and Structures

SBMK/ICN – Stichting Behoud Moderne Kunst / Instituut Collectie Nederland (Foundation for the Conservation of Modern Art / Netherlands Institute of Cultural Heritage)

UNESCO – United Nations Educational, Scientific and Cultural Organization

WHS – World Heritage Site

WTP – Willingness To Pay

ACKNOWLEDGEMENTS

The invaluable insights and suggestions of José Delgado Rodrigues are hereby gratefully acknowledged.

The research was funded by FCT (the Portuguese Foundation for Science and Technology) through scholarship # SFRH/BD/37356/2007 and done within the Programmed Research Plan (PIP 2009-2012) of Laboratório Nacional de Engenharia Civil (LNEC) in Lisbon.

Lisboa, Laboratório Nacional de Engenharia Civil, janeiro de 2013

VISTOS

O Chefe do NPC

João Manuel Mimoso
Investigador coordenador do LNEC

O Director do Departamento de Materiais

Arlindo Freitas Gonçalves
Investigador coordenador do LNEC

AUTORIA

Maria João Revez
Licenciada em Conservação e Restauro,
Estagiária no LNEC