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Structural and constructive interventions on old buildings: a methodological framework

Abstract

The main purpose of this article is to present and discuss intervention methodologies, focusing on structural and constructive work undertaken on old buildings of common architecture that are considered to be of cultural interest. Lying at the origin of this paper is the understanding that many of the interventions currently being made on such buildings are typically façadist in nature, frequently involving the complete reconstruction of the buildings themselves and showing a total disregard for the cultural values that their actual materials and traditional construction techniques confer upon them. A brief review will first be made of the main recommendations currently proposed for the conservation and rehabilitation of old buildings, while a general intervention methodology will also be established. In this way, an attempt will be made to discuss the various approaches and procedures that are commonly adopted in practice, in keeping with the nature of the different buildings that are subject to intervention, the aim being to present a summary of some recent studies that have recognised the need for a specific approach to the group of old buildings of common architecture that display a significant cultural value. This is followed by the discussion and development of different solutions and approaches that can facilitate the adoption of good practices in the rehabilitation of old buildings, with particular emphasis being placed on the bourgeois houses in Porto.

Keywords

Old buildings. Structural and constructive interventions. Methodological framework.

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INTERVENÇÃO ESTRUTURAL E CONSTRUTIVA EM EDIFÍCIOS ANTIGOS: ENQUADRAMENTO METODOLÓGICO

Resumo

O presente artigo tem como principal propósito apresentar e discutir metodologias de intervenção, focalizadas nos domínios estrutural e construtivo, em edifícios antigos de arquitetura corrente portadores de valor cultural. Na sua gênese, está o entendimento de que grande parte da intervenção que atualmente impende sobre este edificado, se caracteriza pela sua natureza fachadista, frequentemente de reconstrução integral do edifício e com total desconsideração dos valores culturais que os próprios materiais e técnicas construtivas tradicionais que o materializam lhe aportam. Procura-se, assim, através de uma breve revisão das principais recomendações hoje estabelecidas em matéria de conservação e reabilitação de edifícios antigos e da correspondente definição de uma metodologia genérica de intervenção, discutir diferentes abordagens e procedimentos correntes na prática, em correspondência com a natureza dos edifícios intervencionados, para, reconhecida a necessidade de uma aproximação específica para o grupo dos edifícios antigos correntes com valor cultural, apresentar sumariamente alguns estudos recentemente conduzidos, visando a discussão e o desenvolvimento de soluções e abordagens que facilitem a adoção de boas práticas nas respectivas obras de reabilitação, tomando como referência o caso particular da Casa Burguesa do Porto, do século XIX.

Palavras-chave

Edifícios antigos. Intervenções estruturais e construtivas. Enquadramento metodológico.

Introduction

Despite the long way to safeguard the architectural heritage, difficulties still exist regarding the definition of the nature and extent of the interventions to be carried out, aiming at their conservation and / or transformation, being easily verified that, in most cases, they are between the strict restoration and, at the other extreme, the deeply transforming intervention.

Regardless of the above statement, it is considered possible to establish a generally accepted principle: the primacy of the object to intervene as subject – the central defining element of the solution – and, as a corollary, the need for as exhaustive knowledge as possible of the same object (that is, contemplating all its dimensions: historical, social, urban, architectural, constructive, etc.).

There are numerous documents, recommendations and theoretical texts that seek to reflect and frame the interventions in the architectural heritage aiming, however and in most cases, the buildings of monumental nature that have always been the central object of all orientations.

In this context, it is understandable that the old buildings of current architecture which, when bearers of cultural value, constitute the identity matrix of the oldest urban centers of many of our cities, remain less studied, recognizing, however, the need for a specific approach to this set of constructions, which responds positively to the challenge represented by the conciliation of the necessary increment of functional, structural and constructive performance, required by their adaptation to the requirements of today, with the safeguarding of their cultural value.

In this work, we seek, by referring to some recently conducted studies, and focusing on the Bourgeois Houses of Porto, to present and discuss some solutions and approaches that, particularly in the structural and constructive domains, highlight the need to adopt, in the rehabilitation of these buildings, different approaches from those of new buildings.

Principles and recommendations

Until a relatively recent past (eighteenth century), the restoration of old buildings was primarily aimed at their reuse, adapting them to their intended functions. These works, as a rule, were made according to the art of designing and building current at the time of the intervention, with no special concerns regarding the preservation of the testimonies of the past, which were thus accumulating in successive layers, when they were simply not wholly or

partially suppressed. Exceptions to this practice occurred only in buildings of rare value, thus recognized for their antiquity, historical or religious importance, artistic and cultural attributes, etc.

In the Western world, the first expressions of interest in the systematic recovery and preservation of past testimonies occurred in the Renaissance period – a cultural and artistic movement born in Italy in the mid-14th century – and deserves mention in this context and by way of example, the action of Pope Martin V, promoting the maintenance and repair of roads, bridges and buildings in Rome (papal bull *Etsi in cunctarum orbis* of 1425) or, later, by Pius II – through the papal bull *Cum alman nostram urben* (1462) –,to safeguard the buildings of classical antiquity to which they were frequently subjected.

It was, however, in France, as early as the eighteenth century and in reaction to the destruction of many religious buildings of monumental character during the period of the French Revolution, that the first state-led movement promoting the safeguarding of monuments emerged, a practice that would be reinforced later in response to the nostalgic and celebration feeling of the past that emerged at the advent of the industrial age.

Having defined this objective, the discussion of the intervention methodology to be adopted in the conservation and restoration of the architectural heritage, a matter hitherto absent in the architectural treaties, was immediately imposed, except for the contribution of Leon Battista Alberti (2011/1485) to the construction of a design theory directed at the restoration of old buildings, included in his treatise "*De re aedificatoria*".

Not being within the scope of this work to develop on the history of conservation and restoration theories[1], it is still important to highlight the contributions of Viollet-le-Duc – whose thinking, grouped under the name of stylistic restoration, was of decisive importance during much of the nineteenth and mid-twentieth centuries. Not only in France, but throughout Europe – from his opponents John Ruskin and Willian Morris – romantic defenders of the intrinsic value of the ruin and, consequently, of a minimalist conservation – as well as Italian theorists – from Camillo Boito and Gustavo Giovannoni, apologists for a restoration classified, respectively, as philological and scientific, to Roberto Pane and Cesare Brandi, representatives of the critical restoration – to which we could also add the closest names, Choay or Solà-Morales, among others, who, in different ways, very significantly influenced the theory and praxis of restoration in Europe from the second half of the nineteenth century to the present day.

In a different context, it is also worth mentioning the letters and conventions which, notably under the auspices of the International Council on Monuments and Sites (Icomos) and since the beginning of the second quarter of the twentieth century, have also been a source of enormous relevance in definition of good practices with regard to heritage intervention[2].

Of the countless letters, resolutions, statements, etc. produced to date, exceeding four dozen documents, the Charter of Athens (ICATHM, 2011/1931), the so-called "Charter of Restoration", approved in 1931, at the time of the First

[1] For further study of this subject, it is suggested to consult the works of Jokilehto (1986), Choay (2000), Solà-Morales (2001), Aguiar (2002) or Rivera Blanco (2008).

[2] Due consideration will be given to the circumstances and historical context that led to the preparation of the various documents.

International Congress of Architects and Technicians of Historic Monuments, and the 1964 Charter of Venice (ICOMOS, 2004a), the latter due to the enormous importance achieved in the recent past, which was reflected, in particular, in the influence produced in Portuguese legislation and in many other countries, although, in the Portuguese case, such circumstance occurred late, in the 1980s.

Mention is also made of the European Charter of Architectural Heritage, approved by the Council of Europe (COUNCIL OF EUROPE, 1975), which recognizes the cultural value of ancient buildings in many European cities, towns and villages and develops the concept of integrated conservation[3], encompassing a set of principles that are best suited to safeguarding this important and fragile heritage.

Finally, a reference to the 1987 Charter of Washington (ICOMOS, 2004b), which specifically addresses the conservation of urban areas of heritage value and a reference to the Charter of Krakow, of 2000 (ICOMOS, 2004c), which, with the express objective of conserving the architectural, urban and landscape heritage, seeks essentially to update and clarify the orientations expressed in the Charter of Venice. And, more recently, the Declaration of Paris (ICOMOS, 2011a), which addresses heritage issues as a development factor, and the Valletta Principles for safeguarding and managing historic cities and urban complexes (ICOMOS, 2011b).

[3] Introducing the consideration of social and urban values, in addition to heritage values - see also the Declaration of Amsterdam on Integrated Conservation (ICOMOS, 2011c).

[4] See also, in this regard, the Declaration of San Antonio (ICOMOS, 1999).

In the specific field of structural interventions in buildings, special mention should be made of the Recommendations for the Analysis, Conservation and Structural Restoration of Architectural Heritage (ICOMOS, 2011d), established in 2003 by the corresponding International Scientific Committee of the aforementioned Icomos and, given its undeniable timeliness and relevance, the *Guidelines for evaluation and mitigation of seismic risk to cultural heritage* (MINISTRY FOR CULTURAL HERITAGE AND ACTIVITIES,2007), established in July 2006 for application to all buildings of cultural value in Italy.

From this significant body of documents, what principles and recommendations can be extracted to justify and guide the intervention on the architectural heritage?

In the first place, it is important to highlight the difficulties of an already long journey, which can hardly be characterized as clear and linear in the progress of the pursued knowledge. This finding is exemplarily reflected in the divergence of many heritage intervention practices from the orientations of doctrinal documents, and which reflect the numerous controversies that often accompany them everywhere.

On the other hand, difficulties of various kinds prevail, both theoretical and eminently practical, among which stand out:

– The complexity inherent in the criterion of authenticity[4], which is absolutely central to the whole body of theory developed around the theme of conservation and restoration, and which remains difficult to conceptualize,

despite the numerous discussions it has undergone, many of them substantiated in the 1994 Nara Document on Authenticity (ICOMOS 2001). And revisited very recently, twenty years after the publication of the original document (ICOMOS, 2014);

– The unresolved divergence between conservationist and interventionist approaches, making it difficult to discuss and critically assess all the different modes of intervention that fit between these two extreme positions;

– The balance, not always well achieved, between the recognized need for use of historic buildings and understood as a key factor in ensuring their preservation, and the often detrimental consequences of adapting buildings to the requirements arising from such use, exemplary is the excessive degree of intrusiveness found in many interventions, with the consequent damage to the value of authenticity, even in situations of reasonable adaptability of the original building to the new or continuing functions assigned to it;

– The always difficult questions raised by the integration of contemporary interventions, whether in historic buildings or within old urban complexes[5];

– The specificity, or not, of intervention in the 20th century architectural heritage[6];and finally,

– The multiple issues of necessary, but difficult, compatibility posed by interventions in the ancient urban fabric, whether in defense of their identity and authenticity (historical-cultural value), or in the creation of conditions that ensure social vitality and economic competitiveness (socioeconomic value), or in meeting the current sustainability requirements of cities, which established the increase of energy efficiency of buildings as one of their priority actions[7].

Despite these difficulties, the following values are still identified as fundamental values to be considered in heritage interventions: (i) to safeguard the authenticity of the building; and ii) its appropriation by the social body in which it operates.

Clarifying these two concepts, it will be said, from the authenticity, that it presupposes, ideally[8],an integral respect for the building as a testimony of a certain architectural and constructive type (or types), that is, an attitude of preservation, not only of the image of the building, but also of the materials and construction techniques that embody it.

Other criteria and guidelines of a more specific nature arise from the satisfaction of this general principle, including the criterion of minimum intervention, which aims to minimize its impact on the original building, thus highlighting the historical value of the construction. In the same vein, there is a choice for non-intrusive, ideally reversible or, more pragmatically, adaptable technical solutions (that is to say, which do not compromise the adoption, in later interventions, of other solutions which prove to be more appropriate at the time) and, in any case compatible with the original construction.

[5] On this subject, see the Symposium Resolutions on the introduction of contemporary architecture into ancient urban ensembles (ICOMOS, 2012/1972) or, more recently, theVienna Memorandum (UNESCO, 2005).

[6] Referring to this topic, see, for example, the minutes of the International Conference on Intervention Approaches in the 20th Century Architectural Heritage (2011), held in Madrid, as well as the Madrid document (ISC20C, 2011).

[7] For issues related to the concept of sustainability within the framework of urban development policies of European cities, see the Aalborg Charter (ECSCT, 1994).

[8] Without prejudice to other less restrictive readings of this principle.

Ownership, on the other hand, refers to the need to maintain, or redefine, a function for the building that meets the aspirations and needs of the social group to which it belongs.

However, in addition to other issues that are part of an eminently social plan, this satisfaction raises technical problems that generally result from the obligation to promote an increase in the performance of the original building, either as a result of its necessary adaptation to a new function framework, or due to the need to adapt it to new standards of greater behavioral demand.

In either case, the increase in question will entail, in the overwhelming majority of situations, conflicts that are difficult to resolve with the equally important and cited value of authenticity, whose solution, which is necessarily case by case, will require the designer team, in addition to the necessary technical competence, to have a high sense of responsibility in selecting the solutions to favor in the different interventions.

The most appropriate methodologies and strategies for meeting the above requirements will be dealt with in the following points.

[9] On this subject, see the Icomos Recommendations (2003), cited above, or the publication of the *Conseil International du Bâtiment* (2010).

Intervention methodology

The intervention methodology in old buildings consists of a set of phases and procedures that aim to ensure the necessary conditions for the development of the intervention solution and, in short, imply: obtaining data that allow an adequate characterization of the object to be intervened; conducting an assessment, however brief, of its condition; and finally, considering the information resulting from the two described phases, the development of an intervention proposal.

Explaining, to facilitate the understanding, for the particular case of structural intervention, rehabilitation or reinforcement projects in buildings[9], he respective methodology can be organized, synthetically, according to the following phases: a) data acquisition – this phase aims to provide an adequate knowledge of the existing structure, identifying, in particular, the state of degradation; b) analysis and diagnosis – by assessing the safety of the existing structure, an attempt is made to determine the possible need for an intervention and its extent; and c) consolidation and reinforcement project – definition of intervention measures to be adopted in accordance with the conclusions resulting from the previous two phases.

Analyzing now, in more detail, the tasks and objectives included in each of these phases, we have:

a) Data acquisition

The acquisition of data aims to provide, as mentioned, as faithful a picture as possible of the current state and the past history of the building, allowing to establish, from a detailed identification of the damage present in the structure, a judgment about its state of conservation.

The methodology to be favored is based on multiple approaches and is iterative in the sense that, by moving from the simplest to the most complex and costly procedures, it seeks to establish the need and extent of the latter, by identifying the relevant gaps in the knowledge of the building, which will seek to fill, through successive and differentiated returns to the object of study.

Accordingly, the first approximation is a visual inspection of the building, which should provide a first understanding of the type of structure present, constituent materials and general state of degradation, and which will necessarily be complemented by a geometric and constructive survey (if none), including a detailed mapping of visible damage.

In parallel to this work of recognition, a historical investigation should be conducted that enables the knowledge of materials and techniques used in the construction of the building, the definition of its phases (if relevant) and, if any, the recording of significant interventions or extensions after the initial construction phase, as well as the identification of extraordinary occurrences (earthquakes, for example) that may possibly justify some of the damage observed.

The knowledge base resulting from the accomplishment of the described tasks should lead to the establishment of the necessary set of tests for a more complete characterization (already of quantitative nature) of the structure, that includes, in particular, the identification of the mechanical, physical and chemical characteristics of the materials, the characteristics of the dynamic response of the structure, etc.

In this context, priority should be given to non-destructive on-site testing. When these prove insufficient, moderately destructive inspections and testing (on-site and in laboratory) should be carefully considered, comparing the benefits of performing the test with the damage to the structure (which can and should be minimized by judicious selection of the locations chosen for the removal of specimens and cores or for drilling holes and openings for observation).

The presence of presumably unstabilized phenomena (related to the deformity variation, the opening and development of cracks, etc.) may make it necessary to monitor the structure for a certain period, sometimes resorting to the use of computerized monitoring systems.

b) Analysis and diagnosis

Once the first phase is concluded, and in possession of the relevant structural and constructive data, the probable causes of the observed damage and degradation are investigated, as well as their eventual permanence or expiration. In addition, a safety assessment of the structure in its current state is carried out through a structural analysis, which should be performed with the degree of sophistication considered adjusted to the building under analysis.

The results of this quantitative analysis should be adequately filtered by a second qualitative analysis, which, based on the experience of the design

team and from the comparison with the behavior of other similar structures and in a similar state of degradation, allows a critical re-evaluation of the results obtained in the structural analysis previously performed, avoiding any errors resulting from the uncertainties involved in the structural analysis model adopted.

Ideally, this qualitative approach should guide the definition of a new structural analysis model that will lead to more reliable results, in the light of the experience gained in previous cases with identical structures to the one under assessment.

The results of the diagnosis and structural analysis should lead to the establishment of a decision on the solution to be developed, which will, in most cases, include the definition of a structural intervention proposal that explicitly explains its nature and extent.

All work done up to this stage and corresponding conclusions should ideally be part of an Evaluation Report, which will determine the last phase of the work, constituted by the completion of the structural consolidation and reinforcement project and the corresponding post-intervention maintenance and control program.

c) Consolidation and reinforcement project

The structural consolidation and reinforcement project, duly anchored in the studies referred to in the previous points, must be guided by a set of criteria which, overall, aim to achieve two fundamental, though often difficult to reconcile, objectives: i) to ensure adequate resilience for the functions assigned to the building; and at the same time, ii) to safeguard as much as possible the historical value and authenticity of the traditional technical solutions adopted in its construction.

It should be borne in mind that, in any event, compliance with the structural safety condition must be guaranteed, since intervention which, in strict compliance with the conservation criteria, does not ensure that the minimum safety levels required for the building concerned are met, it runs the risk of eventually proving to be highly burdensome, precisely for the integrity of the building it has been trying to preserve.

In practice, the problem essentially arises from the recognition of the degree of inaccuracy that necessarily affects the models of qualitative and quantitative analysis involved in the safety assessment, as well as the difficulty of setting the level of safety to be required of the structure under assessment, as in general the simple adoption of regulatory values set for new construction may prove inadequate.

The problem, however, is difficult to solve, and although this work does not need to develop in detail the complex problem of assessing the level of structural safety required for an old building to be rehabilitated, it is nevertheless important to clarify some of its essential aspects, which will be done in the next section.

First, however, and to conclude this point, a further reference to the need to accompany the consolidation and reinforcement project with a post-intervention maintenance and control program, which, through the establishment of the procedures necessary for a correct conservation, constitutes a fundamental instrument for the future preservation, at the same time economic and effective, of the intervention building.

Structural safety of old buildings

Traditionally, the safety formats adopted in the analysis of old buildings did not differ from those established for new buildings. Indeed, it has only recently been recognized the need to develop specific safety formats for old buildings, due in particular to the very significant size of the built heritage that requires consolidation and structural reinforcement works, whether under rehabilitation or due to the recognition of the existence of situations of vulnerability to possible actions in the structure, especially seismic action. On the other hand, and as has been duly stressed, the need to promote, in buildings of recognized cultural value, interventions that meet the criteria of conservation of these same values, has also led to the study of specific solutions for old buildings, which, given their specificities, can guarantee adequate levels of structural safety, while minimizing the degree of intrusiveness of the intervention to be carried out.

Examples of this effort can be found in the United States of America, where the Federal Emergency Management Agency (Fema) has been developing, since the 1980s, a set of activities aimed at reducing the seismic risk associated with existing buildings. As a result of this effort, in concert with other government agencies, universities and associations of various kinds, the ASCE / SEI 41-06 - Seismic Rehabilitation of Existing Buildings standard (AMERICAN SOCIETY OF CIVIL ENGINEERS, 2007) was established in 2006 – which, together with ASCE / SEI 31-03 - Seismic Evaluation of Existing Buildings (AMERICAN SOCIETY OF CIVIL ENGINEERS, 2003) - dated 2003, regulate the criteria and procedures that should govern the seismic assessment and rehabilitation of buildings. These standards are complemented by a very significant set of documents, mostly developed on the initiative of Fema, that address multiple aspects related to the theme in question, highlighting the documentFema547 – Techniques for the Seismic Rehabilitation of Existing Buildings (FEDERAL EMERGENCY MANAGEMENT AGENCY, 2006) –, 2006, in which a set of rehabilitation and seismic reinforcement techniques established for different types of buildings and damage observed, as well asFema356 – Prestandard and Commentary for the Seismic Rehabilitation of Buildings(FEDERAL EMERGENCY MANAGEMENT AGENCY, 2000) –which preceded the application of ASCE / SEI 41-06 standard.

Already in Europe, all regulations regarding the design of structures are unified in European standards which, under the designation of Eurocodes, cover the different materials (concrete, steel, wood, etc.) commonly used in the

construction of buildings and other types of work that fall within the scope of civil engineering. The Eurocode 8 (NP EN 1998-1, 2010) specifically addresses the design of earthquake-resistant structures and is the only case in the set of eurocodes where, in part 3 (CEN, 2005), the particular situation of the assessment and reinforcement of existing buildings is addressed, although, of course, focused on the seismic aspect. In any case, several European countries have been addressing this issue, producing reference texts on structural intervention in existing buildings. In this particular area, it is worth mentioning the work developed in France, with the recent publication of a guide aimed precisely at supporting the diagnosis and seismic reinforcement of existing buildings (BERTULI *et al.*, 2013a, 2013b). As well as in Switzerland, where the SIA 462 Directive – *Évaluation de la sécurité structurale des ouvrages existants* (SOCIÉTÉ SUISSE DES INGÉNIEURS ET DES ARCHITECTES, 1994) –, published in 1994 to assess the structural safety of existing buildings, which was partially updated with the 2004 publication of technical notebook SIA 2018 – *Vérification de la sécurité parasismique des bâtiments existants* (SOCIÉTÉ SUISSE DES INGÉNIEURS ET DES ARCHITECTES, 2004) –, specifically related to the verification of the seismic resistance of existing buildings. Finally, one last reference to Italy, where this theme has also been the subject of attention, with the additional circumstance of trying to frame with particular care the singular case of buildings with cultural value, as a result, naturally, of the grandeur of its architectural heritage. As a demonstrative example of the above, we have theGuidelines for evaluation and mitigation of seismic risk to cultural heritage (MINISTRY FOR CULTURAL HERITAGE AND ACTIVITIES, 2007), which are referred to herein, which seek to establish, in accordance with the applicable Italian regulations (ITALY, 2003, 2005), an intervention methodology adapted to the specificity of buildings classified as national cultural heritage, with special focus on resistant masonry buildings.

On a different but equally relevant level, it is also worth mentioning some European research projects conducted in this field, among which stands out the Onsitemasonry (2001/2004)[10] project. A project aiming at the development of a diagnostic methodology based on the combination of inspection methods (non-destructive, moderately destructive and destructive), allowing an adequate knowledge of the old masonry, along with the development of structural models specifically directed to the assessment of their ability to charge. Another highlight is the Risk-EU (2001/2004)[11] and Syner-G (2009/2012)[12], projects, both aimed at assessing the seismic vulnerability, and associated losses, of buildings and infrastructure on a territorial scale and, finally, a reference to the Perpetuate project (2010/2012)[13] aimed at establishing, for the European area, recommendations for the assessment and mitigation of the seismic risk of assets belonging to Europe's cultural heritage, both at territorial and building scale, following a methodology close to Italian recommendations already mentioned[14].

From all this documentary collection, it is possible to identify some distinctive elements between existing and new buildings, concerning the problematic

[10] Maierhofer and Köpp (2006).

[11] Mouroux (2004).

[12] Pitilakis *et al.* (2013).

[13] D'Ayala and Lagomarsino (2015).

[14] Also in Portugal, by the way, national researchers have been addressing this theme, in its various aspects, either by integrating international networks or by developing research projects with funding from national organizations.

related to the structural safety assessment. However, it is important for a proper contextualization and, before further development, to recall some of the fundamentals of the structural safety assessment.

Essentially, the problem of structural safety seeks to address in a rigorous, coherent and balanced manner (that is to say, without requiring excessive resource mobilization), the establishment, and consequent assessment, of the degree of structural reliability to be required in civil engineering works.

In the genesis of the problem lies in the degree of uncertainty, underlying the generality of the variables involved in its formulation. In fact, uncertainties of a random nature are present, associated with the inherent variability of the physical nature of the quantities related to the representation of the actions, materials and geometry of the structure, or epistemic, associated with incomplete or inaccurate information. A category in which the uncertainties arising from the degree of idealization introduced in the structural analysis models, as well as statistical uncertainties, related, for example, to the larger or smaller representativeness of the sample and its influence on the evaluation of statistical parameters.

To address these uncertainties, it is therefore necessary to resort to statistical models, which seek to determine the appropriate level of safety, introducing in this definition some kind of rationality that includes, inter alia, the degree of risk that the society is willing to admit[15], while considering the associated cost-benefit ratio, in a search for rationality in the allocation of available resources, by nature, always insufficient for the global needs of society.

Exemplifying for the particular case of seismic action, the regulatory provision set out in the above-mentioned Eurocode 8 – for a given location and aimed at meeting the requirement of no collapse in new buildings – defines the seismic action based on a payback[16] period of 475 years[17] . Alternatively, if we prefer, based on a probability of annual exceedance of 0.2% or, equivalent, a probability of exceeding 10.0% in 50 years. The same regulation proposes, under the same conditions, but for the satisfaction of the damage limitation requirement, a payback period of 95 years, equivalent to a probability of annual exceedance of 1.0%, which corresponds to a probability of exceedance of 10% in 10 years

Thus, the safety philosophy underlying these choices is easily understood. When it comes to safeguarding the collapse of the structure, a higher value is assumed for the payback period, the aforementioned 475 years, which necessarily corresponds to a higher intensity earthquake and, consequently, sizing the structure for this rare seismic event minimizes the likelihood of ruin.

On the other hand, it is also important to ensure that earthquakes of moderate intensity, but more frequently, do not cause excessive damage to the building or put limitations of use after its occurrence. For this purpose, the structure is dimensioned by an earthquake with a higher probability of exceedance, which necessarily corresponds to a shorter payback period (95 years in this case) and,

[15] By way of example, it is mentioned the risk collectively perceived as acceptable regarding the possibility of collapse of a building and the consequent loss of human life, certainly the determining factor in decision making, in addition to the consideration of property losses.

[16] The payback period can be defined as the average (or expected) time interval between two statistically independent successive events.

[17] In the present case, the seismic action will then be defined based on an earthquake with certain characteristics that, on average, will occur at intervals of 475 years.

consequently, a lower intensity. Naturally, in this circumstance, the sizing of the structure must meet criteria adjusted to the objective set (damage limitation), necessarily different from those established to satisfy the non-collapse requirement.

It can be added that, in the first case, the setting of the value established for the probability of exceedance essentially aims at guaranteeing the protection of human lives, while in the second case, it is the criteria of socioeconomic optimization of resources to determine the decision.

However, one final comment on this subject is necessary before addressing the safety formats specifically designed for existing buildings. Specifically, it refers to the fact that, in the case of new buildings, significant safety increases, that is, the imposition of lower probabilities of ruin can be achieved with small increases in the cost of structures. This fact is clearly reflected in the high levels of safety contemplated in the regulations applicable to the design of structures.

This situation does not occur in the case of existing buildings, as, as a rule, any increase in installed resilient capacity requires disproportionately large resources to be mobilized due to the constraints that result from intervening in an already constructed structure.

It will therefore be justified, in the light of the same criteria of economic rationality as set out above, that the safety levels required of existing structures following rehabilitation are not necessarily coincident with those established for new buildings, and it is therefore necessary to determine which values are appropriate for the different situations that occur in the existing building stock.

The answer to this question is a central aspect of this problem and, with reference to the documentary collection already mentioned, it is possible, albeit briefly, to identify some of the strategies proposed for its resolution.

First, however, it is important to highlight the most significant characteristics that differentiate interventions in existing buildings from new buildings. Thus, the following would be identified as relevant and distinctive aspects of interventions in old buildings:

a) Knowledge of the existing

Old buildings may, subject to certain limits, be subject to an inspection program (documentary, on-site, laboratory, etc.) of varying length. Which may: provide data on the geometrical characteristics of the structure and its structural elements; enable the identification of materials and the quantification of their most relevant mechanical characteristics as well as their condition; map any damage, structural or otherwise, present in the building, etc.

> However, in any event, a more or less extensive but always limited data set will be present with regard to the area of the building actually subject to inspection and thus the degree of confidence in the results obtained will always be a function of the extent and depth with which it was performed,

especially since the non-industrial character of the building that distinguishes the old buildings, enhances the possibility of significant variations in many of its structural elements, depending on its location, thus making it difficult to extrapolate data for the whole building, of data obtained in its circumscribed points.

Thus, and on this matter, the generality of the normative points to the weighting of the existing level of knowledge –through the establishment of different degrees, which correspond to confidence factors that will affect not only the values of the mechanical characteristics of the materials considered in the calculation, but also the definition of the analysis models themselves to adopt –, favoring a greater degree of knowledge for the acceptance of less conservative values for the different quantities involved in the analysis.

Finally, underlying this procedure is the assumption that a better knowledge of the existing structure allows the adoption of a less conservative analysis model, without the corresponding option to increase the risk of ruin or, more generally, a worse structural performance.

b) Existence of damage, visible or not, occurred prior to the intervention

The presence of damage or degradation in building and structural elements of the building shall be duly recorded by appropriate inspection techniques and, if relevant, integrated into the structural analysis to verify the actual strength of the building to be intervened. The depth and extent of the inspection will depend on the degree of confidence obtained with respect to the available data and, consequently, the greater or lesser uncertainty associated with them.

c) Changes in use and consequent variations in the loads acting on the building

The imposition of new programs on old buildings often determines the need to reinforce some of their structural elements, which would otherwise not occur.

d) Adaptation to new regulatory provisions (earthquakes)

In the same vein, even for different reasons, there are competing regulatory changes that may have occurred in the meantime, resulting in a worsening of structural performance requirements. Seismic action, in particular, is a paradigmatic example of the situation described, due to the many deep revisions that have been periodically carried out in its definition, methods of analysis, etc.

e) More complex structural design (historical buildings)

Modeling the behavior of old structures, particularly in the case of resistant masonry structures, introduces additional difficulties in their structural analysis compared to steel or concrete structures typical of industrial construction, which is an additional factor of uncertainty, which necessarily affects the results of the analysis.

As it turns out, there are several reasons that may determine the need for reinforcement, global or local, of a building to be rehabilitated. On the other hand, and as already mentioned, simple considerations of a socioeconomic nature justify the limitation of this need for reinforcement, so it is necessary to establish strategies that contribute to this objective. Moreover, in buildings with cultural value, the satisfaction of conservation criteria generally leads to the adoption of design strategies that obey the principle of minimum intervention, always aiming to minimize the degree of intrusiveness of the intervention.

So what strategies can be proposed to achieve the above goal? Firstly, one of the basic principles of action is to adjust the solution as much as possible to the building that will be the subject of intervention. To this end, as has already been duly pointed out, the implementation of an inspection program, as wide as possible, which enables the basic parameters characterizing the structural response of the building to be estimated with an appropriate confidence, with the consequent positive impact on the establishment of the applicable safety requirements. In addition, changes in use, with implications on the values of use overloads, should, of course, be carefully considered when in conflict with the established conservation criteria.

Finally, and to close this theme, it is also important to note, due to the relevance of these days, the correspondence that exists between the approximation presented for the structural design and all the other different projects, whether related to acoustic comfort, hygrothermal behavior or others[18]. Indeed, these projects should, with the necessary adaptations, share the same criteria of reducing the degree of intrusiveness of the solutions and of the socioeconomic optimization of the resources expressed here for the structural problem and which, duly assumed, would also lead to the establishment intervention criteria specific to old buildings, necessarily different from those adopted in new buildings.

[18] On the relevant and current issues of the energy adequacy of historic buildings, for example, see the interesting contribution resulting from the International Conference on Energy Efficiency and Historic Buildings (2014).

Intervention practices: approaches and solutions

The practical application of the principles, recommendations and methodologies referred to in the previous points should ideally be the rule in any intervention in the built heritage possessing some kind of cultural value, regardless of its nature, exceptional character, etc.

However, it is easy to recognize that, in practice, existing situations may differ substantially from each other, namely in the greater or lesser adequacy of the means available for the correct implementation of the methodology presented.

In this context, it may be useful, in operational terms, to perform a classification and grouping exercise of buildings according to their nature, discussing, accordingly, the different strategies and procedures that usually characterize the interventions performed in each of the defined sets.

Thus, and for this purpose, it is proposed to consider the following three groupings:

a) Singular historical buildings of exceptional patrimonial value, such as, in the Portuguese case and among others, the Jeronimos Monastery or the Convent of Christ;

b) Buildings classified with high patrimonial value, contemplating different typologies, such as churches, monastic ensembles, etc.; and finally,

c) Old buildings of current construction, integrated in urban or rural centers.

For the first group – that of historic buildings – the most relevant characteristic will be, for this matter, the recognition of the existence of a temporal and financial availability appropriate to the implementation of the most demanding intervention methodology, including, in particular, the possibility of forming large multidisciplinary teams, consisting of experts from different areas of knowledge involved in an intervention in buildings of this nature, namely: historians, archaeologists, architects, engineers of various specialties, conservatives, etc.

It is believed that it is consensual to state that, in this set of buildings, interventions must be guided by a strict compliance with all the principles to be observed by a correct conservation or restoration action, as mentioned above, thus imposing the constitution of a technical team that should incorporate the best specialists from the different disciplinary areas involved.

Ideally, and as long as the specificity of the intervention concerned justifies it, the establishment of a second team of experts should be promoted to review the intervention project proposed by the design team, thereby ensuring the highest quality to the final intervention project, reproducing in this context a current practice in engineering works of significant size and complexity.

The high degree of demands placed on the design of the intervention project (underlying the guidelines set out above) must, of course, be adequately pursued in the selection of the companies responsible for carrying out and supervising the works, requiring in both cases the establishment of quality assurance procedures to ensure its continuation.

From the foregoing, it is obvious that this whole process needs to be conducted by a project management team with the required technical experience and competence so that, without wasting resources, they know how to manage the necessarily high resources available, ensuring the highest quality in the intervention performed.

For the second grouping, consisting of churches, monastic ensembles and other classified buildings, it is important to emphasize, first of all, the fact that, in general, there is a much lower availability of financial and technical resources to carry out conservation and restoration actions, which in many cases has a reduced capacity on the part of the construction owner to properly conduct the interventions concerned.

This framework almost always determines an increased difficulty in the constitution of technical teams that guarantee a wide range of competences, as well as the lack of financial means necessary to carry out exhaustive and rigorous inspection and diagnosis campaigns, which adequately contemplate all set of tests underlying their implementation.

To overcome these limitations, and despite the unequivocal consideration of the unique character of each intervention, it might be useful to organize the set of buildings that make up this group, defining for each typology a frame of reference that will guide, methodologically and technically, the actions to be undertaken within the framework of the conservation and restoration project to be taken, and which may include, inter alia, a set of technical solutions of proven effectiveness, which will ensure that the intervention concerned achieves the desired quality levels.

In this situation, it is pertinent to consider that much of the knowledge necessary for the realization of the above framework is already available, albeit in a dispersed way, and now it is important to collect and organize this set of knowledge in such a way as to make it possible to as operative as possible under the terms mentioned above[19].

The technical difficulties resulting from the restrictive technical and financial framework that characterizes most of the interventions to be carried out on the buildings grouped together, in addition, in many cases the proposed solutions are imperative to satisfy programs involving, not infrequently major, changes (or enlargements) in the functions to date of the intervention buildings.

Although confining ourselves to the purely technical issues (the most general and perhaps the most difficult to address falling within the narrow domain of architecture are not addressed here), the difficulties arising from this situation to develop solutions that reconcile compliance with the regulatory provisions are obvious (increasingly numerous and demanding, when not conflicting, even in the framework of new work), with due regard to the recommendations already made for conservation and restoration interventions.

Finally, the third group, which is the main object of study of this work, includes all the old buildings[20], so-called current, bearing a recognized cultural value, which are integrated into urban or rural centers. Sharing, in a substantially aggravated way, many of the limitations pointed out by the previous grouping, this set of buildings is characterized, besides its enormous diversity (from the geographical point of view, with the consequent typological implications), by the non-negligible circumstance that the intervention projects to which it is submitted result from private initiative, mostly and increasingly. This fact, now significantly present in the national reality as a consequence of the urban renewal policies currently pursued by the central and local authorities, has obvious implications for the final result of the interventions made, due to their potentially very diversified objectives, given the multiplicity of agents involved (individual owners, real estate developers, etc.).

[19] There is now extensive scientific and technical literature on many of the topics relevant to the study, characterization and project activities resulting from the methodology described above. Restricting us, due to the dominant context in this work, to the Portuguese reality. Significant examples of the above, among others possible, are the references: Appleton (2003); Cóias (2006, 2007); Meeting on Pathology and Rehabilitation of Buildings (2003, 2006, 2009, 2012); Lopes (2008); Freitas (2012); Paiva, Aguiar and Pinho (2006); and Seminar "Heritage intervention: conservation and rehabilitation practices" (2002, 2006).

[20] See, in this regard, the critical discussion around the old buildings of current architecture and the recognition of the specificity inherent in their condition of architectural heritage (GIACOMINI; PÓVOAS, 2011).

On the other hand, the recognition of the very significant size of the built park represented by this set of buildings (in the order of thousands) and, consequently, their economic and social importance, together with the absolute need to adapt them to the performance requirements that today, particularly in the environmental area, makes the study of solutions especially relevant. Solutions that can harmonize the constructive and functional rehabilitation of these buildings with the cultural values with which they are embedded, and which are an effective alternative to the facades or total demolition solutions that proliferate today in the historic centers of our cities, often with complacency, when not even with their own incentive, from the entities responsible for promoting and regulating the urban renewal of these centers.

With this last objective in mind, the following section will proceed with a more developed discussion of this theme, in which, from a necessarily succinct characterization of the present situation, we will try to propose, taking as reference the case of the city of Porto , solutions and approaches that facilitate the adoption of established good practices for the renovation of culturally valuable buildings for the rehabilitation of buildings of cultural value, without prejudice to the effectiveness that the urgency of renovation of many of our urban centers requires today.

Current old buildings of cultural value

The cultural value given to a building determines, in accordance with the ideas expressed in the previous points, the adoption of a set of specific procedures, which distinguish this intervention from those aimed at the rehabilitation of current buildings without the mentioned characteristic.

In essence, the central issue is to set limits on the intervention to be made, that is, to define the delicate balance between the need to requalify the building and respect for its integrity, in particular as regards the construction and structural aspects.

In short, between the simple preservation of the facades that determine, in urban space, the reading of the building as "old" and, at the other extreme, the strict restoration of the building without meeting the highest and current performance requirements, it is to establish criteria to determine, on a case by case basis, the desired equilibrium solution between the two extreme situations mentioned.

In addition to these aspects, it should be noted that the high number of buildings that make up this universe poses specific problems (due to the size and scope of intervention actions, the financial and technical means involved, etc.) in the context of interventions in architectural heritage. In addition, there is the fact that these buildings are destined, in most situations, for housing (and, marginally, for commerce and services), including their rehabilitation within the framework of housing policies and urban renewal, and in whose actions they will necessarily have to fit.

But what answers are given when considering ongoing or recently completed interventions aimed at rehabilitating this significant building lot?

Recent studies, focusing on the city of Porto, have allowed us to register a set of solutions that, subject to a classification exercise based on the identification of a set of common characteristics understood as relevant, could be grouped into the following three categories (BAPTISTA, 2009; MILHAZES, 2010; PÓVOAS; TEIXEIRA; GIACOMINI, 2011):

a) Joint intervention with the block as its base unit;

b) Intervention resulting from the association of contiguous lots; and

c) Intervention in individual plots.

The first of the identified solutions is the one that has been favored in the interventions of Porto Vivo – Society for Urban Rehabilitation of Baixa Portuense, SA – and is characterized by the adoption of proposals that focus globally on the selected block, leading, in general, to significant changes in the original landings and volume.

The situations that use the association of contiguous lots essentially aim to obtain an increase in the available area per floor, allowing a different and more appropriate organization of the fires. In these cases, the spaces corresponding to the original public places are usually transformed into areas of common use, primarily intended for car parking.

Finally, in the interventions carried out in individual plots, the proposed intervention solutions are very different, corresponding to the diversity of both the buildings to be rehabilitated and the intervening agents (construction owners, architects, etc.).

It is interesting to note that, despite the remarkable differences between the studied solutions, namely in terms of scale, they present, as a common feature, the importance given to a set of project constraints, among which stand out: the integration of vertical accesses (stairs and eventually lifts); the improvement of service areas (kitchen and sanitary facilities in particular); and the provision of car parking.

Finally yet importantly, it is important to highlight the recurring and widespread option for industrial building solutions, to the detriment of the possible reuse of original building materials and elements, with the necessary adaptations to meet today's performance demands.

From the above, it is evident the need to establish procedures and intervention strategies that are appropriate to the size and characteristics of current buildings of patrimonial value, that is, which promote the maintenance of their cultural value.

Thus, when in the presence of buildings whose state of conservation enables a rehabilitation intervention based on the preservation, in completely or in part, of the original structural and constructive elements, it is important to comply with the previously mentioned intervention methodology.

However, the experience gained in this area leads to the conclusion that only very rarely, whether they are of a private or public nature, they are willing to secure the time and cost resources required to comply with good practices associated with correct intervention methodology.

Indeed, in most situations, the data acquisition phase rarely exceeds the geometric and constructive survey of the building – and often with large omissions as regards the characterization of the building elements –, complemented by the mapping of existing damage and degradation, almost always carried out from an inspection supported by some light equipment (camera, crack comparator, etc.).

As a result, the omissions regarding the characterization of the constructive and superficial elements of the observations related to the state of deterioration of the building are recurrent, undermining the quality of the decision regarding the nature and development of the intervention to be carried out.

The limitations mentioned may, however, be somewhat mitigated, or even overcome, when in possession of a more complete knowledge of the type of building subject to intervention, namely with regard to the different aspects contemplated in the various phases that comprise this process (constructive and structural characterization, current damage and standard solutions).

With this objective in mind, a research work was recently conducted, carried out within the scope of a doctoral thesis (TEIXEIRA, 2013), and, given its special relevance to the theme addressed in this paper, it will be very briefly described in the following paragraphs.

In the referred study, and taking advantage of the high degree of standardization that characterizes the construction system of the 18th and 19th century Bourgeois Houses of Porto, we sought to synthesize and systematize all the relevant information for the construction of a methodology of intervention in these buildings that, aiming at a qualification of the respective performance standards in all its aspects (functional, environmental, constructive, etc.), bring them closer to today's behavioral requirements for new buildings and, at the same time, favor the adoption of low-invasive solutions based on the preservation and recovery of materials and traditional building techniques, rather than the uncritical application of industrial building solutions, often technically inappropriate to the buildings concerned and disrespecting the cultural values present.

Thus, from the collection based on the significant set of surveys of old buildings available, as well as the consultation of various documents – work processes, documents integrating the legacy of the Commission for the Renewal of the Urban Area of Ribeira-Barredo (Cruarb), old treaties and craft manuals, relevant bibliography, etc. –, an architectural and constructive model was developed,

which constitutes an idealized representation of the Bourgeois Houses of Porto, where the previously identified construction solutions are synthesized as those that are most likely present in this set of buildings.

This model thus represents a building that, being abstract, intends to reproduce, as rigorously as possible, the dominant architectural and constructive features in this type of building (Figure 1).

In this sense, the constructive model is the basis on which the definition of drawn and written elements is based, which aim to support the accomplishment of the survey, inspection, diagnosis and design tasks, necessary for the development of an adequate intervention solution, in accordance with the methodology already presented.

From an identification grid of the main building elements of the building, the building model consists of a significant set of drawings and writings that, taking as an illustrative example the case of the houses, include:

a) Drawings and tables of constructive characterization (Figure 2);

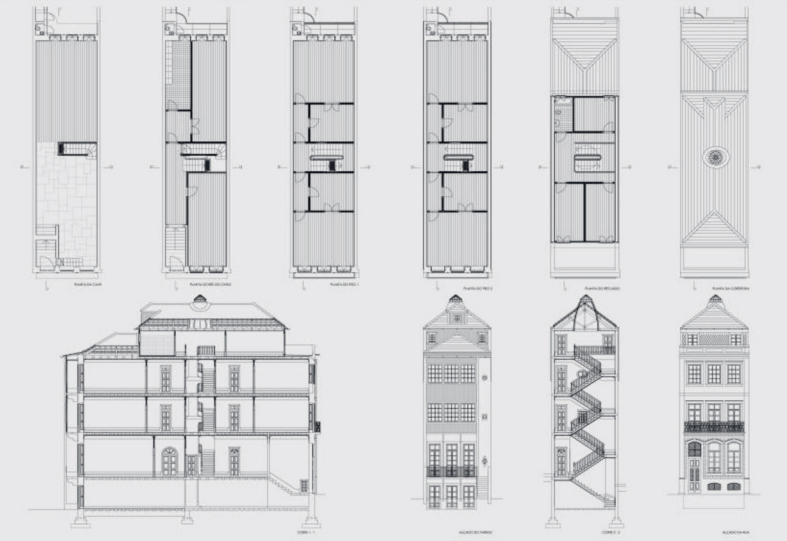

Figure 1 – Plans, sections and elevations of the construction model of the Bourgeois Houses of Porto

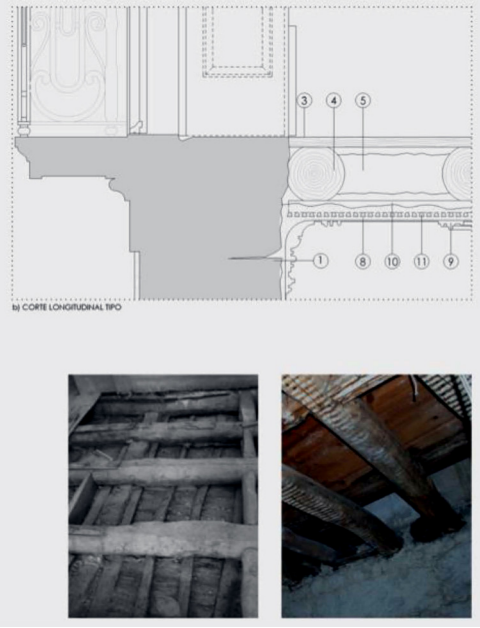

Figure 2 – Constructive characterization of a two-story house

Figure 3 – Amendments currently introduced to reinforce two-story houses

a) Floor b) Stucco ceiling

Figure 4 – Identification of heritage value elements

a) Rotation of beam b) Excessive ceiling deformation

Figure 5 – Damage and degradation in two-story houses

a) Mold stains b) Stucco detachment

Figure 6 – Damage and degradation in two-story houses

b) The identification of the changes currently introduced in these same elements (Figure 3);

c) The identification of elements of patrimonial value (Figure 4);

d) Illustrative figures of damage and degradation that may commonly occur in the building element, complemented by tables which include references to diagnostic techniques, probable causes, remedial solutions, etc. (Figures 5 and 6); and finally,

e) Representative drawings of different constructive solutions that can be considered in the rehabilitation of the building element, which are characterized according to the type of action recommended (structural reinforcement, damage repair, performance improvement, or others). By way of illustration, a performance improvement situation (acoustic and fire safety) is presented in Figure 7, with a reduced degree of intrusiveness and, in Figure 8,

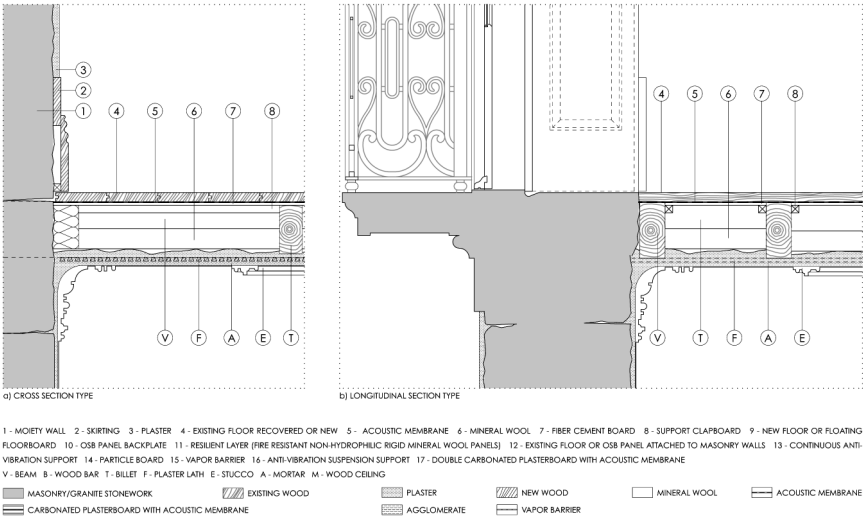

Figure 7 – Performance improvement in two-story houses through a low intrusive intervention

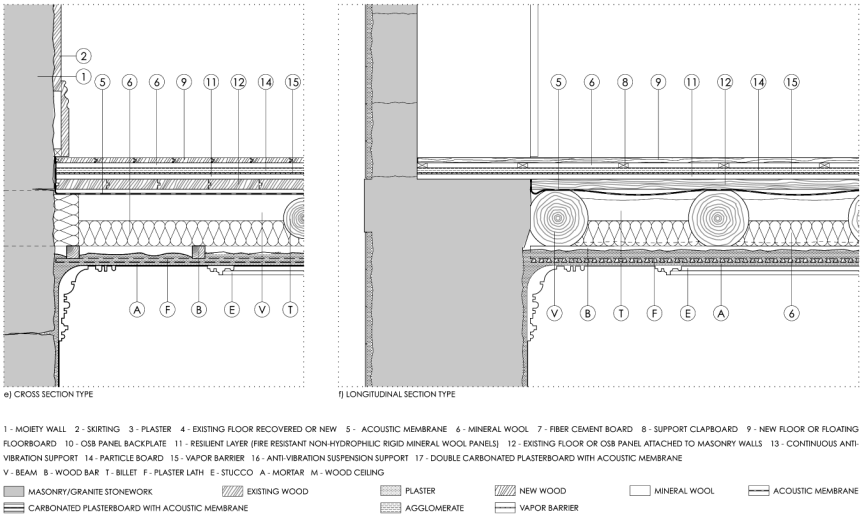

Figure 8 – Performance improvement in two-story houses through a moderate intrusive intervention

another proposed solution to the same problem, but requiring a greater degree of intrusiveness.

In short, the purpose of this constructive model proposal is to provide designers with a tool that, without prejudice to the particular attention that the specificity of each case requires, makes it possible to expedite all the tasks already mentioned, required by a methodologically correct intervention in Bourgeois Houses of Porto, thus contributing to an increase of interventions in this type of building, which promote the desired, but difficult, balance between conserving and benefiting.

Final synthesis and conclusions

In this work, we tried to discuss some of the problems and solutions that constitute the reason for the specificity of the interventions in the area of architectural heritage, with particular emphasis on those which have as their object the current old buildings with cultural value and taking as a fundamental reference the Portuguese experience in this field.

Choosing as scope the interventions of a structural and constructive nature, the procedures and their stages were presented, with their respective stages, which constitute the matrix of an intervention methodology that integrates respect for the precepts emanating from the main doctrinal documents dealing with this domain.

It was also sought to make explicit, based on the problem of structural safety assessment, the reasons justifying the adoption of different regulatory provisions in the case of interventions in old buildings, in view of the inadequacy of existing ones, developed for new constructions.

Finally, and after recognizing the specificity of the old buildings of patrimonial value, understood as current, we proceeded to present a summary of a constructive model aimed at supporting the execution of intervention projects in the 18th and 19th century Bourgeois Houses of Porto, which aims to contribute to the implementation of interventions in this important set of buildings, favoring the adoption of non-invasive solutions, attentive to the reuse of existing building elements, and that, cumulatively, ensure the fulfillment of environmental, energy, etc. performance requirements, established as appropriate, to safeguard the constructive and architectural identity that fundamentally contributes to the cultural value that is recognized to them.

In short, it is in the recognition of the specificity of each intervention that the conviction is based on the absolute necessity of having as thorough a knowledge as possible of the object to be intervened, as well as a consistent theoretical and methodological framework, which, together, contribute to the definition of grounded and valuing design solutions of the building to be rehabilitated.

This work is intended merely to make a small contribution to the creation of a culture of intervention that contributes to the satisfaction of the necessary requirements to safeguard such valuable and neglected urban heritage.

References

AGUIAR, José. *Cor e cidade histórica*:estudos cromáticos e conservação do património. 1. ed. Porto: Faup, 2002.

ALBERTI, Leon Battista. *Da arte edificatória*. Traduçãode Arnaldo Monteiro do Espírito Santo. Lisboa: FCG, 2011. (Edição original: 1485)

AMERICAN SOCIETY OF CIVIL ENGINEERS. *ASCE 31-03*: seismic evaluation of existing buildings. Reston: American Society of Civil Engineers, 2003.

AMERICAN SOCIETY OF CIVIL ENGINEERS. *ASCE 41-06*: seismic rehabilitation of existing buildings. Reston: American Society of Civil Engineers, 2007.

APPLETON, João Augusto da Silva. *Reabilitação de edifícios antigos*: patologias e tecnologias de intervenção. Amadora: Orion, 2003.

BAPTISTA, Maria Manuela Pestana de Vasconcelos Felgueiras.*Logradouros no edificado corrente portuense*: da horta ao terreno edificável: estudo de casos integrados em propostas de reabilitação arquitectónica. Dissertação (Mestrado Integrado em Arquitetura) – Faculdade de Arquitetura, Universidade do Porto, Porto, 2009.

BERTULI, Roger.*et al*. *Diagnostic et renforcement du bâti existant vis-à-vis du séisme*. Marne-la-Vallée: AFPS-CSTB, 2013a.

BERTULI, Roger.*et al*. *Annexes*: diagnostic et renforcement du bâti existant vis-à-vis du séisme. Marne-la-villée: AFPS-CSTB, 2013b.

CEN. *EN 1998-3*: Eurocode8:design of structures for earthquake resistance:part 3: assessment and retrofitting of buildings. Brussels: CEN, 2005. Disponível em: http://bit.ly/2OZYyP7. Acesso em: 6 dez. 2019.

CHOAY, Françoise. *A alegoria do património*. Lisboa: Edições 70, 2000.

CÓIAS, Vitor. *Inspecções e ensaios na reabilitação de edifícios*. Lisboa: IST Press, 2006.

CÓIAS, Vitor. *Reabilitação estrutural de edifícios antigos*. 2. ed. Lisboa: Argumentum/Gecorpa, 2007.

CONSEIL INTERNATIONAL DU BÂTIMENT. *Guide for the structural rehabilitation of heritage buildings*. Ottawa: CIB Publication 335, 2010.

COUNCIL OF EUROPE. *European charter of the architectural heritage*. Strasbourg: Council of Europe, 1975.

D'AYALA, Dina; LAGOMARSINO, Sergio. Performance-based assessment of cultural heritage assets: outcomes of the European FP7 PERPETUATE project. *Bulletin of Earthquake Engineering*, New York, v. 18, n. 1, p. 5-12, 2015.

ECSCT. Charter of European cities &towns towards sustainability. *In*: EUROPEAN CONFERENCE ON SUSTAINABLE CITIES & TOWNS, 1., 1994, Aalborg.Disponívelem: http://bit.ly/2Lwsekx. Acesso em: 6 dez. 2019.

ENCONTRO SOBRE PATOLOGIA E REABILITAÇÃO DE EDIFÍCIOS, 1., 2003, Porto. *Anais* […]. Porto: Feup, 2003.

ENCONTRO SOBRE PATOLOGIA E REABILITAÇÃO DE EDIFÍCIOS, 2., 2006, Porto. *Anais* […]. Porto: Feup, 2006. 2v.

ENCONTRO SOBRE PATOLOGIA E REABILITAÇÃO DE EDIFÍCIOS, 3., 2009, Porto. *Anais* […]. Porto: Feup, 2009. 2v.

ENCONTRO SOBRE PATOLOGIA E REABILITAÇÃO DE EDIFÍCIOS, 4., 2012, Porto. *Anais* […].Santiago de Compostela: Colexio Oficial de Arquitectos de Galicia, 2012.

FEDERAL EMERGENCY MANAGEMENT AGENCY. *Prestandard and commentary for the seismic rehabilitation of buildings*:Fema356. Washington, DC: Fema, 2000.

FEDERAL EMERGENCY MANAGEMENT AGENCY. *Techniques for the seismic rehabilitation of existing buildings*:Fema547. Washington, DC: Fema, 2006.

FREITAS, Vasco Peixoto. (coord.). *Manual de apoio ao projecto de reabilitação de edifícios antigos*. Porto: Feup, 2012.

GIACOMINI, Fernanda Corrêa; PÓVOAS, Rui Fernandes. Os edifícios antigos de arquitetura corrente em centros históricos no contexto do patrimônio cultural: especificidades e condicionantes para projetos de intervenção arquitetônica. *Pós*, São Paulo,v. 18, n. 29, p. 174-195, 2011.

ICATHM. The Athens charter for the restoration of historic monuments. *In*: INTERNATIONAL CONGRESS OF ARCHITECTS AND TECHNICIANS OF HISTORIC MONUMENTS, 1., 1931, Athenas. *Proceedings* […]. Paris: Icomos, 2011. Disponível em: http://bit.ly/34X66rn. Acesso em: 6 dez. 2019.

ICOMOS. The Declaration of San Antonio. *In*: INTERAMERICAN SYMPOSIUM ON AUTHENTICITY IN THE CONSERVATION AND MANAGEMENT OF THE CULTURAL HERITAGE, 1996, San Antonio. *Proceedings* […]. Washington, DC: US/Icomos, 1999.

ICOMOS. The Nara document on authenticity. *In*: CONFERENCE ON AUTHENTICITY IN RELATION TO THE WORLD HERITAGE CONVENTION, 1994, Nara. *Proceedings* […]. Paris: Icomos, 2001.

ICOMOS. Carta de Veneza, 1964.*In*: LOPES, Flávio; CORREIA, Miguel Brito. *Património arquitectónico e arqueológico*: cartas recomendações e convenções internacionais. Lisboa: Livros Horizonte, 2004a. p. 103-108.

ICOMOS. Carta de Washington, 1987. *In*: LOPES, Flávio; CORREIA, Miguel Brito. *Património arquitectónico e arqueológico*: cartas recomendações e convenções internacionais. Lisboa: Livros Horizonte, 2004b. p. 215-218.

ICOMOS. Carta de Cracóvia, 2000. *In*: LOPES, Flávio; CORREIA, Miguel Brito. *Património arquitectónico e arqueológico*: cartas recomendações e convenções internacionais. Lisboa: Livros Horizonte, 2004c. p. 289-296.

ICOMOS. The Paris Declaration on heritage as a driver of development. *In*: GENERAL ASSEMBLY OF THE INTERNATIONAL COUNCIL ON MONUMENTS AND SITES, 17., 2011, Paris. *Proceedings* […]. Paris: Icomos, 2011a.

ICOMOS. The Valletta Principles for the safeguarding and management of historic cities, towns and urban areas. *In*: GENERAL ASSEMBLY OF THE INTERNATIONAL COUNCIL ON MONUMENTS AND SITES, 17., 2011, Paris. *Proceedings* […]. Paris: Icomos, 2011b.

ICOMOS. The Declaration of Amsterdam. *In*: CONGRESS ON THE EUROPEAN ARCHITECTURAL HERITAGE, 1975, Amsterdam. *Proceedings* […]. Paris: Icomos, 2011c.

ICOMOS. Principles for the analysis, conservation and structural restoration of architectural heritage. *In*: GENERAL ASSEMBLY OF THE INTERNATIONAL COUNCIL ON MONUMENTS AND SITES, 14., 2003, Victoria Falls. *Proceedings* […]. Paris: Icomos, 2011d.

ICOMOS. Resolutions of the Symposium on the introduction of contemporary architecture into ancient groups of buildings. *In*: GENERAL ASSEMBLY OF THE INTERNATIONAL COUNCIL ON MONUMENTS AND SITES, 3.,1972, Budapest.*Anais* […]. Paris: Icomos, 2012.

ICOMOS. NARA+20: on heritage practices, cultural values, and the concept of authenticity, *Heritage & Society*, Abingdon, v. 8, n. 2, 2014.

INTERNATIONAL CONFERENCE ON INTERVENTION APPROACHES IN THE 20TH CENTURY ARCHITECTURAL HERITAGE, 1., 2011, Madrid. *Proceedings* […]. Paris: Icomos, 2011.

INTERNATIONAL CONFERENCE ON ENERGY EFFICIENCY AND HISTORIC BUILDINGS, 2., 2014, Madrid. *Proceedings* […]. Madrid: Fundación de Casas Históricas y Singulares y Fundación Ars Civilis, 2014.

ISC20C. Approaches for the conservation of 20th century architectural heritage: Madrid document. *In*: INTERNATIONAL CONFERENCE ON INTERVENTION APPROACHES IN THE 20TH CENTURY ARCHITECTURAL HERITAGE, 1., 2011, Madrid. *Proceedings* […]. Paris: Icomos, 2011.

ITÁLIA.Opcm n. 3274: primi elementi in materia di criteri generali per la classificazione sismica del territorio nazionale e di normative tecniche per le costruzioni in zona sismica. *Gazzetta Ufficiale della Repubblica Italiana*, Roma, n. 105, 8 maio 2003.

ITÁLIA.Opcm n. 3431: ulteriori modifiche ed integrazioni all'ordinanza del Presidente del Consiglio dei Ministri n. 3274 del 20 marzo 2003, recante "Primi elementi in materia di criteri generali per la classificazione sismica del territorio nazionale e di normative tecniche per le costruzioni in zona sismica". *Gazzetta Ufficiale della Repubblica Italiana*: Roma, n. 107, 10 maio 2005.

JOKILEHTO, JukkaIlmari. *A history of architectural conservation*:the contribution of English, French, German and Italian thought towards an international approach to the conservation of cultural property. 1986. Tese (Doutorado em Arquitetura) – Universityof York, York, 1986.

LOPES, Mário (coord.). *Sismos e edifícios*. Amadora: Orion, 2008.

MAIERHOFER, Christiane; KÖPP, Christian (coord.). *Onsiteformasonry project*: on-site investigation techniques for the structural evaluation of historic masonry buildings.Luxembourg: Publications Office of the European Union, 2006.

MILHAZES, Fábio Machado Cadeco. *O reflexo da contemporaneidade na reabilitação do edificado corrente portuense*: três temas de intervenção: estacionamento; circulações verticais; zonas de serviço.Estudo de casos integrados em propostas de reabilitação arquitectónica. Dissertação (Mestrado Integrado em Arquitetura) – Faculdade de Arquitetura, Universidade do Porto, Porto, 2010.

MINISTRY FOR CULTURAL HERITAGE AND ACTIVITIES.*Guidelines for evaluation and mitigation of seismic risk to cultural heritage*. Roma: GangemiEditore, 2007.

MOUROUX, Pierre(coord.).*RISK-UE Project*: an advanced approach to earthquake risk scenarios with applications to different European towns:final report.Orléans: BRGM, 2004.

NP EN 1998-1. *Eurocódigo 8*:projecto de estruturas para resistência aos sismos:parte 1: regras gerais, acções sísmicas e regras para edifícios. NP EN 1998-1:2010. Caparica: IPQ, 2010.

PAIVA, José Vasconcelos; AGUIAR, José; PINHO, Ana. *Guia técnico de reabilitação habitacional*. Lisboa: INH/LNEC, 2006. 2 v.

PITILAKIS, Kyriazis. *et al*. *Systemic seismic vulnerability and risk analysis for buildings, lifeline networks and infrastructures safety gain*:Syner-G Synthetic Document. Ispra: Institute for the protection and security of the citizen, 2013.

PÓVOAS, Rui Fernandes; TEIXEIRA, Joaquim; GIACOMINI, Fernanda Corrêa. Reabilitação de edifícios correntes de valor patrimonial: uma proposta de aproximação metodológica. *In*: SEMINÁRIO "CUIDAR DAS CASAS": A MANUTENÇÃO DO PATRIMÓNIO CORRENTE, 2011, Porto. *Anais*[…]. Porto: Icomos/Feup, 2011. p. 1-8.

RIVERA BLANCO, José Javier. *De varia restauratione*: teoria e historia de la restauración arquitectónica. Madrid: Abada, 2008.

SEMINÁRIOA INTERVENÇÃO NO PATRIMÓNIO: PRÁTICAS DE CONSERVAÇÃO E REABILITAÇÃO, 1., 2002, Porto. *Anais* […]. Porto: DGEMN/Feup, 2002.

SEMINÁRIOA INTERVENÇÃO NO PATRIMÓNIO: PRÁTICAS DE CONSERVAÇÃO E REABILITAÇÃO, 2.,2006, Porto. *Anais* […]. Porto: DGEMN/Feup, 2006.

SOCIÉTÉ SUISSE DES INGÉNIEURS ET DES ARCHITECTES. *Evaluation de la se´curite´ structurale des ouvrages existants*: mandat d'e´valuation de la se´curite´ structurale, base de ve´rification de la se´curite´ structurale, ve´rification de la se´curite´ structurale, mesures propres a' assurer la se´curite´:directive/SIA, 462. Zurich: SIA, 1994.

SOCIÉTÉ SUISSE DES INGÉNIEURS ET DES ARCHITECTES. *Vérification de la sécurité parasismique des bâtiments existants*:directive/SIA, 2018. Zurich: SIA, 2004.

SOLÀ-MORALES, Ignasi. Teorias de la intervención arquitectónica. *PH Boletín del Instituto Andaluz del Patrimonio Historico*, [*S. l.*], n. 37, ano 9, p. 47-52, 2001.

TEIXEIRA, Joaquim. *Salvaguarda e valorização do edificado habitacional da cidade histórica*: metodologia de intervenção no sistema construtivo da Casa Burguesa do Porto. 2013. Tese (Doutorado em Arquitetura) – Faculdade de Arquitectura, Universidade do Porto, Porto, 2013.

UNESCO. Vienna memorandum. *In*: INTERNATIONAL CONFERENCE ON THE WORLD HERITAGE AND CONTEMPORARY ARCHITECTURE: MANAGING THE HISTORIC URBAN LANDSCAPE, 2005, Viena. *Proceedings* […]. Paris: Unesco, 2005. Disponível em: http://bit.ly/2PiYokM. Acesso em: 6 dez. 2019.

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