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Importance of building maintenance at the time of architectural design of buildings rehabilitated with heritage value

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Abstract: During architectural conception phase, building maintenance problematic is mostly a result of the unintentional use of preconceived architectonical solutions rather than a consequence of a specific influence of maintenance requirements. Hardly the architect in the act of design understands the importance of these solutions in the service life span of a building. Being aware of this, is it possible for the architect to be supplied with a decision support system that allows him to consider the implications of building maintenance since the early design phases? Having awareness of this problem and its consequences in the early design phases a research project was started at the Faculty Engineering of the University of Oporto(FEUP), under which the implications of building maintenance in the act of architectural design is studied. This article presents the methodology developed to identify the needs of maintenance of buildings based on a DSS-decision support system that provides simple tools the architect can use in design phase. This methodology is based on decomposition of building parts-Elements Source of Maintenance ESM-, and subsequently, a set of functional requirements that determine the performance regarding building maintenance on account of architectural decisions. Relevant maintenance actions are defined: Inspection, Pro-action, Cleaning, Correction, Replacement, Legal enforcement, Limits of use. One can thus set up a relationship between the act of design and its performance framework based on behavior, intervention and the ownership of the work of architecture. Using a Multicriteria Analysis (MCA) a qualitative evaluation of different options based on maintenance requirements accomplishment. Conclusions on the importance of architectural conception concerning the building maintenance were clearly arrived at and the utility of the developed decision support tool was also highlighted.

Key words: *architectural design*; *building maintenance*; *decision supporting system*

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1 Introduction

It's inevitable that tradition and modernity go hand in hand, as do the past and the present. Over time, each society builds and transforms the spaces it inhabits, in other words, its whole environment, according to its understanding of the place and its identity.

Over time, architecture has framed this dichotomy in different ways: The different architectural styles appeared and naturally overlapped each other; the Romanic came before the Baroque; the Gothic cleared away what already existed; the Renaissance provided new knowledge and new ideas; Modernism cut ties with the past altogether and with the excessive use of new materials. Awareness of the importance of preserving our historical legacy in the cities, as a mark of our identity, and the need to preserve and protect those venues from increased aging and its subsequent degradation, combine to make the building maintenance issue a relevant aspect to be considered in practical terms. Indeed, the solutions that have been found as early as at the project stage, or during construction, whenever fail to ensure good performance, can definitely affect the quality of intervention.

Additionally, in the specific case of building rehabilitation, many buildings are in poor condition,

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due to a lack of articulated policies for urban regeneration, and the different situations generated by economic, social and cultural issues. And it also lacks the recognition of specificities or the attribution of values to the interventions made upon the built Heritage.

Following the research and development work by Ana Roders[7] on the topic "Rearchitecture", the present study aims at highlighting the importance of building maintenance at the project design stage, through a decision-making support system which makes a set of tools available to the architect, while rehabilitation of buildings with heritage value is being assessed.

2 Conceptual framework

2.1 Architecture

The main architectural options appear at the conceptual level. However, an architecture doesn't stand in the void, in other words, with no references, but, rather, in a direct and dialectic relationship between the architect and the specific knowledge of architecture and its history. The design is the support for defining an architectural work. Out of all possible approaches during the design stage, we consider only those which can better render the way their guidelines develop.

• The space of architecture is a culturally well defined and accommodated living space. Considering the space, there are some architects who only or almost only perceive it as a pre-existing structure, from which they draw a few portions into their projects. An example is Mies Van der Rohe, in which case one could say that the expressive richness of the spatial matter is ambiguous.[1]

• There are architects who understand the different systems in which architectural space is defined, and so they decide to install their own expressive space, as ingeniously done by Lloyd Wright. Some architects may deliberately cultivate ignorance of the sense of architecture's spatial space, but these are the most limited.[1]

• On the other hand, the reality of architecture is something concrete, taking shape and gaining mass and space—its body. There are no ideas, except in things[5]. It is thus important to understand the knowledge of Man's (the user) ways, his interpersonal relationships, the relationships of use that manifest his preferences, and the way they will appropriate the spaces they occupy. In other words, not only his preferences, but also the meaning are conveyed to their dwelling and the related symbolism. Man and space are crucial parts for understanding architecture. The house as his residential refuge is the centre of his life. This is where Man finds his safety, his comfort, his power and above all, a sense of belonging. As Gaston Bachelard[2] put it, the "house" contains the ideal of the past, a "house" is regarded as such only when man dwells in it, when he impregnates it with values, emotions, habits, dreams, culture, and without man it's just a matter of space, voids and surface. To speak about inhabiting is to speak about humanizing. In this regard, architecture is also closely related to human activities.

• Another aspect has to do with the roots of our architectural understanding which is found in our earliest experiences: our bedroom, our home, our street, we unconsciously feel them and we compare them with the landscapes, cities and houses that were added on. The task of designing intends to boost this process.

However, we shouldn't place ourselves at the opposite extreme: architecture is limited to inheriting a functional scheme pre-determined by different contributions and that, ultimately and all it does is cover a skeleton with precisely defined demands. In fact, this type of thinking corresponds to an attitude taken up by a growing number of experts. It is, however, legitimate to think that architects, undergoing a transition in the meaning and goals of their work, end up all too often taking shelter in

their academic tradition, and generating intrinsic needs in them to live in a permanent formal and conceptual revolution.[8]

2.2 Building maintenance

Since the 1st standard on building maintenance was published, the BS3811 in the United Kingdom, in 1964, which is specifically related to industrial maintenance, an important path has been developing. However, the maintenance issue is yet to have a level of discussion actually corresponding to its true scale. We still see a growing degradation in buildings and their loss of functionality, and, in most cases, this is due to the lack of maintenance with the existing building. New buildings are still erected with minimum initial costs in mind.

Maintenance of a building in service can be defined as a set of combined and concerted operations applied to the different parts of the building in question with the purpose of guaranteeing its working performance. When looking at a building, we can see that, during the same period of time, it doesn't undergo an overall degradation; In other words, degradation is the result of a set of "causes", as a building is made up by different elements, each having its own degradation mechanisms and different behaviours during its service life. Thus, there was the need to subdivide the building into different elements, thus facilitating the characterization of each one and for which maintenance interventions are to be carried out. These different elements are called the maintenance source elements.[4]

On the other hand, any successful maintenance strategy requires an accurate identification of the main maintenance operations. We can consider the following as the main ones:

· Inspection / Cleaning / Pro-activity / Correction / Replacement / Conditions of use;

These procedures also include the conditions of use as a fundamental aspect of all maintenance operations. Although there are other actions, these are the ones most commonly used in practice.[4]

2.3 Building rehabilitation

Architecture is not only complex but also contradictory, and it is the only art that accepts the transformation of its work. And now we must deal with the issue of the relationship between what is new and what already exists. One cannot fall into the redundancy of just adding to or subtracting an existing part from a new one. The existing part becomes different by coming in contact with what is new. However, throughout the history of architecture, this relationship has always been regarded as a relationship of continuity. Still, the actual existence of what is new shall always create an interruption in time and shall place a different order into what exists, i. e. a discontinuity. However, this cannot be seen as a paradox. Architecture is made of discontinuities, since firstly we have to acknowledge what exists, take possession of it and then transform it into a new identity.

The very first reference found to the use of the term "rehabilitation" was in the articles of association of ICOMOS in 1965, constantly recommended along with conservation, protection and valorisation of monuments, groups of buildings and sites". Ever since, it has always been a topic of discussion, with increasing use and implementation over time. The concern over the degradation of historic quarters and the importance of their preservation has been a recurring topic.

More recently, the need for sustainable and strategic management of historic urban quarters has been argued, particularly in the Charter of principles for the conservation and restoration of built heritage.[6] However, architects and experts in this area are still faced with a challenge, a reflection on what shall be the future legacy of our testimony of the past, on the criteria to be selected, on what should be preserved, on the principles to be adopted during the interventions and in the role of maintenance.

3 Design process and building maintenance

Degradation of built heritage is a current problem for all historic quarters in most cities, and in some of them the levels of degradation are worrisome, due, to a great extent, to the excessive regulations imposed on construction without a properly cohesive and articulated urban rehabilitation policy.

Presently we can even go a bit further by trying to understand how to persist over time by taking the best possible advantage from existing resources, in other words, by continuing in a sustainable way. Aware of this matter, we are now more attentive to environmental issues. Some scarcity regarding some natural resources, and on the other hand, the obvious climate changes that have been seen are symptoms that have generated many discussions and concerns in relation to the topic of sustainability. Maintenance as a promoter of sustainability can undoubtedly be one such tool, when assimilated during the designing process—a process of advancements and retrogressions, of continuities and discontinuities, and of contradictions and complexities. Tables 1 and 2 show how maintenance should follow the whole process at the early staze of architectural designing. (Table 1: building rehabilitation.)

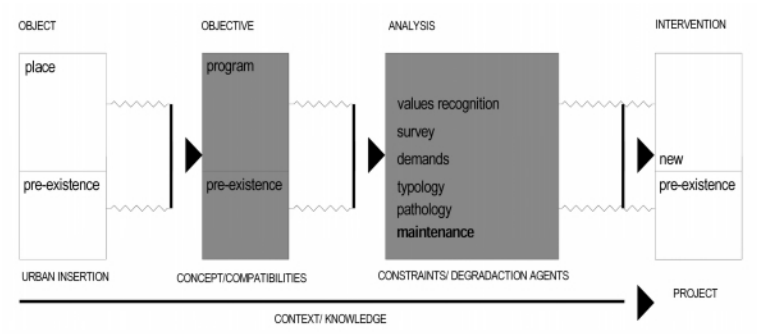


Table 1. Design/rehabilitation process

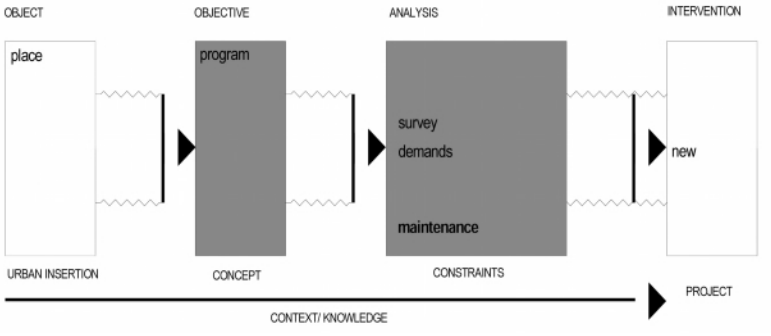


Table 2. Design/intervention process from scratch

From the study of the urban relationship with the building, its historical and heritage value and from the analysis of all the anomalies that developed over time, one can understand what should be preserved and how the new elements can interfere with the character of the existing building.

4 Development of the identified purposes

Thus, the way an architectural work stands the test of time is a crucial matter in this whole design process. We must also consider, on one hand, the construction's performance, and, on the other hand, its appropriation by the user, both of which are decisive for its success. As we can see in Table 3, the building process is the guiding line which starts with the program and ends or becomes transformed with its deconstruction. What is missing is awareness of the role of maintenance during the design process and understanding how to intervene and what is involved.

The purpose of the design process is to cause the architectural work to stand the test of time while ensuring its service performance during its service period. Through different procedures, building maintenance intends to contribute towards such performance, so that the architect may analyse and assess these aspects as early as the design stage. In the case of building rehabilitation, he must define the guiding values, the degrading agents and the respective functional requirements. Thus, building

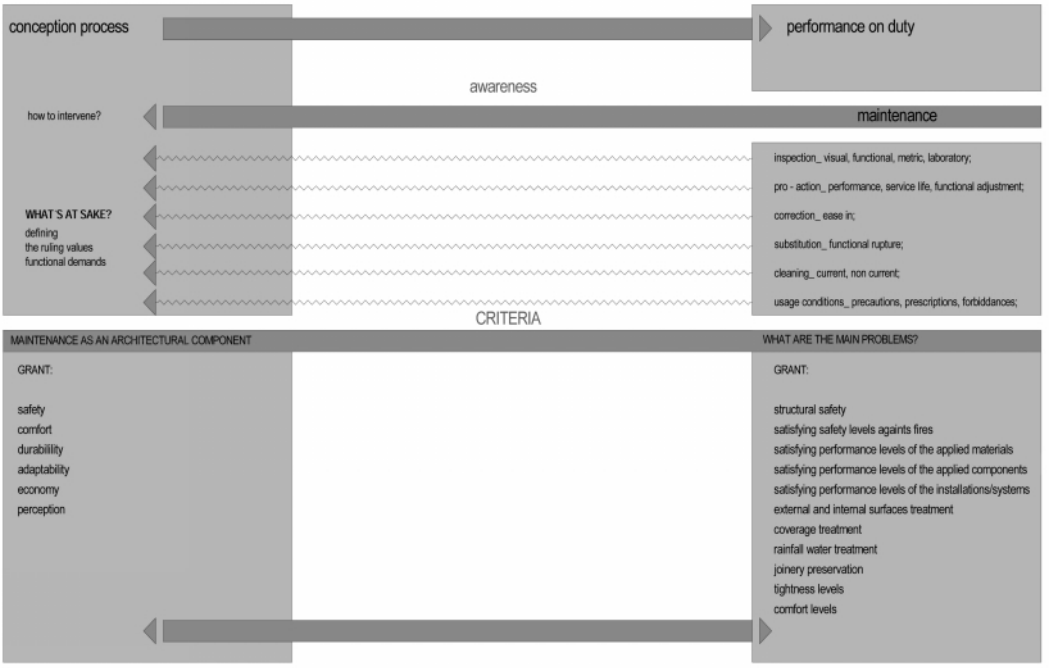


Table 3. Criteria involved in design and maintenance

maintenance aims at ensuring a set of requirements that may prevent pathological situations and improving the incorporation of certain aspects during the design stage which are already underlying to some extent, although often in an intentional or unconscious way.

Thus a set of functional requirements has been defined: safety (sf), comfort (cf), durability (db), adaptability (ad), perception (pc) and economy (ec), while simultaneously, a scale of qualitative appreciation is also assigned.

Regarding building maintenance, it should be highlighted that any successful maintenance strategy requires an accurate identification of the main maintenance operations and procedures.

For the architect and for the architectural design process, what is more important is to guarantee that according to certain specific functional requirements for the element in question, one may determine what the issues can be in terms of the architectural work and which may condition it in terms of its maintenance, so as to predict these aspects while striking a balance between the act of designing/performance/intervention/ appropriation, making it possible to choose the one that best brings about its basic concept he defined for his work. From a broad set of maintenance initiatives, a group of eight were defined as having an influence upon the design process [Performance] Inspection, Pro-action, Cleaning, Sustainability, [Intervention], Correction, Replacement [Appropriation], Legal compliance, Conditions of use.

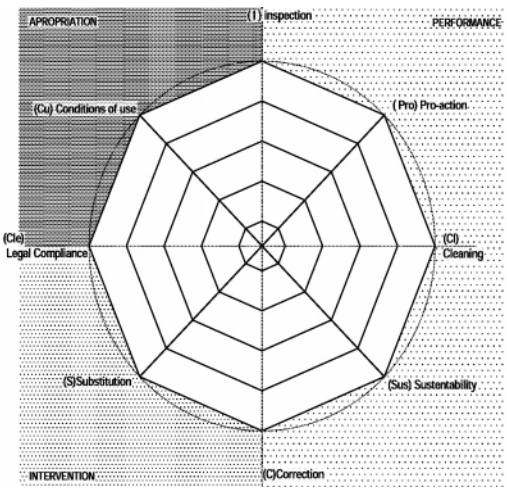


Diagram 1. Summary diagram of the relevance of the Maintenance/Design initiatives

From Diagram 1 the different functional requirements set forth for each maintenance action shall be defined, according to a qualitative assessment scale. This may produce a portion representing a given degree of ex-

pected compliance and according to a minimum criterion, through a pre-defined section profile. As it is an auxiliary method for the architect, it is considered that the design process cannot be addressed in an extremely direct and objective way, nor can the result be quantified, as the decision has to always intrinsically be of significant subjectivity. Thus, although there is a criterion supported by a simple decision-making system, the result should logically and incisively translate the various options, in other words, simple without being simplistic, coherent without being pretentious, as with any architectural work.

(Cu)conditions of use	(I) inspection	(Pro) Pro-action
(Cle)Legal compliance	construtive system element X	(Cl)Cleaning
(S)Substitution	(C)Correction	(Sus)Sustentability

Diagram 2. Summary diagram with the degrees of compliance of the requirements/assessment scale

5 Practical application

As the degradation of built heritage is a current problem for the historic quarters of cities, we choose to apply the defined model to the historic quarter of the city of Porto, classified as World Heritage Site by UNESCO in 1996, with an area of approximately 50ha and a population of around 13,000.

Figure 1. Pictures before the intervention

Located at Rua Corpo da Guarda, the building was erected during the Mercantilist stage[3] and is at an advanced stage of degradation. In this specific case, the maintenance source element (MSE) which is being analysed is the element-exterior arch, which was fully replaced with another one projected and designed by the architect at its advanced stage of degradation.

Figure 2. Pictures after the intervention

This building is made up of a ground-floor plus two floors, with two facades but with no back yard. We can identify a multi-functional use, where the ground floor is an independent space, generally taken up by shops or services, and separate from the remaining floors used for housing purposes. There is one house per floor, characterised by very small spaces with poor architectural relevance.

This intervention dates from 2005. And then in 2010, the eventually associated anomalies were analysed and their causes were defined:

Anomaly	Cause
Loss of waterproofing	Poor sealing;
Some seepage	Excessive permeability;
Functional deficiencies	Existence of sources of humidity;
Some permeability to the air	Joint-cover stoppers, joint ends, window seals were not used;
Small warpings	Absence of appropriate clearances in the relation between the frame and the wall, and in the fixed frame with the mobile frame;

As a way to establish a criterion for the solutions proposed as alternatives to the solution defined in the project, three solutions were drafted, all of which tried to keep the idea of formal design as proposed by the architect, in which Solution A corresponds to an improvement to the existing solution, and so only the causes of the anomalies that were found were drawn and corrected.

In solution A the causes of the anomalies that were identified were corrected with the introduction of a joint-cover stopper, with the application of joint ends on the frames, and by correcting the clearances and adding window seals. The thickness of the double-glass windows was also changed. Regarding manoeuvring actions, the fact that the double-door is connected to the door generates some difficulties in terms of accessibility and functioning of both doors. In terms of framework performance, some significant improvements were achieved.

In solution B a new framework solution was designed to keep the architect's formal design, and, in this regard, the main change was the separation between the double-door and the door. It could make sense to keep it the way it was if, despite the constraints mentioned in the previous solution, there were limitations in terms of free space, which is not the case. Thus, the double-door is independent from the door, enabling both to function better while providing the respective accessibility. This new solution design also makes it possible to improve certain other aspects such as thermal and acoustic comfort, air permeability, resistance to hygrothermic requests, contributing, as a whole, toward significantly improving durability and comfort in terms of functional requirements.

In solution C the material used was changed to aluminium, and some considerations are to be retained. A few less favourable aspects of aluminium include poor acoustic performance, while being a good heat conductor, and so this can affect some conditions related to comfort. As it is a recyclable material, one shouldn't forget that this process involves the release of hazardous pollutants as well as the consumption of large amounts of energy. The solutions were designed taking into account a set of functional requirements applied according to the following table:

It was considered that the most relevant aspect for result assessment would be the comparisons between the solutions that were designed and their response to the requirements, according to a standard assessment scale with overall results, and not necessarily just merely quantifiable values.

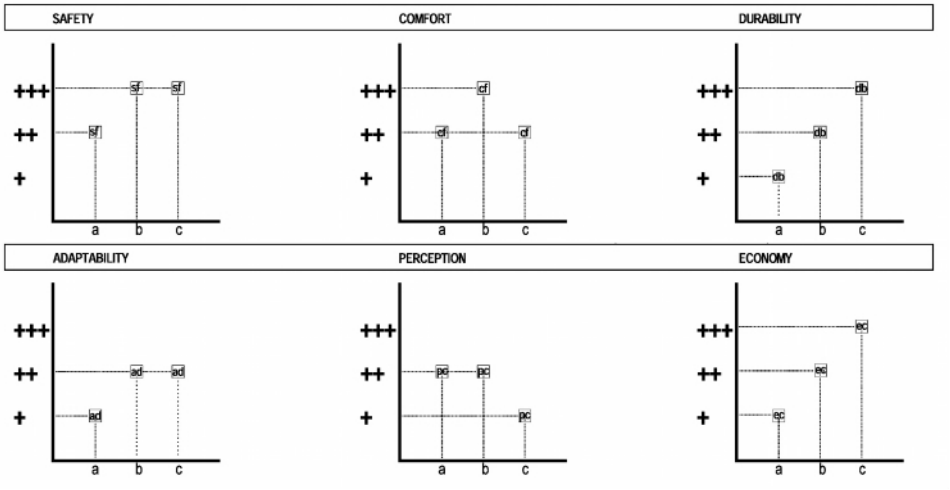
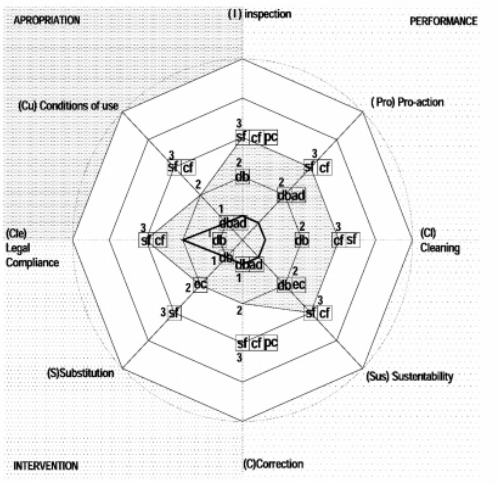
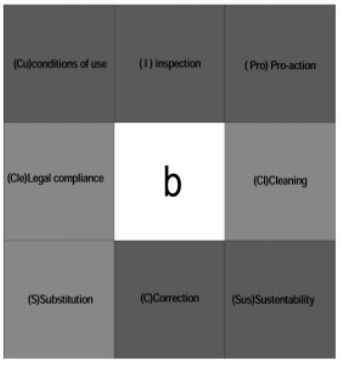


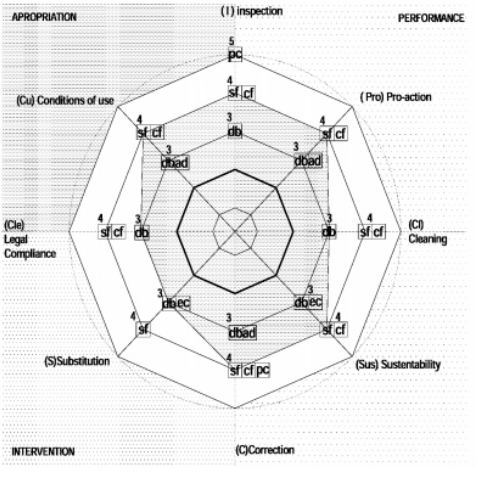
Table 4. Assessment of functional requirements

Results obtained for solution *a*:

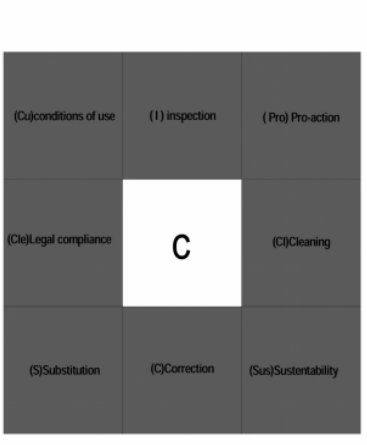


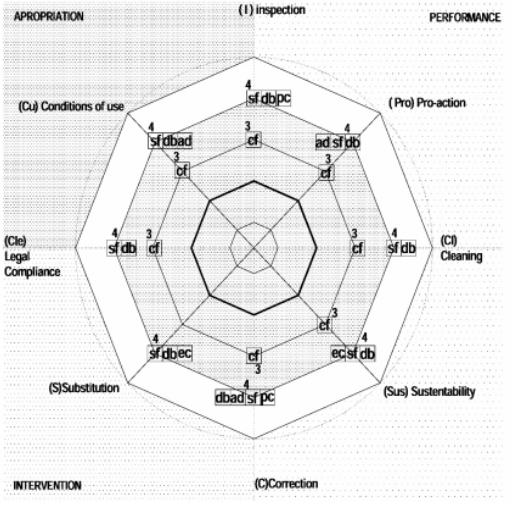
Results obtained for solution *b*:





Results obtained for solution *c*:





6 Conclusion

Design project is an exercise in creativity, inspiration and a great deal of understanding. The truth is that our feelings and understanding are rooted in the past. That is why the meaning we create with the building must respect the memory. If we allow the designing process to be repeatedly confus-

ed by subjective non-reflected ideas, we may accept the importance of personal feelings during the act of designing. Thus, it is very relevant along the entire process which is implicit in an architectural work that there are concrete support instruments that may help it without imposing upon the act of designing and perceiving what surrounds it.

From analysing the results, it is possible to conclude that it is vital to understand the role of building maintenance and more specifically during the design stage, and that, in order to design a work of architecture, one must first understand its elements and components, how they relate to each other, what their performance is, and how they will stand the test of time. To be able to anticipate and propose how to resolve a future problem, one shouldn't forget that the path is followed by walking along the same.

In the specific case of the three solutions that were analysed, it is possible to clearly define which one is the most unfavourable. Solution A is the most unfavourable one, considering its performance, either in case of needing an intervention, or already at the stage of appropriation. The other two solutions are very good at serving the purposes for which they were designed, although there are some less favourable aspects in case of the need for an intervention in Solution B, or in issues related to the replacement of some of its components, or even in cleaning issues.

Simultaneously to this global vision of [Performance], [Intervention], [Appropriation], we can also analyse some functional requirements and know which better ensure their application. We can understand that, in terms of durability, Solution C is better than Solution B, but in terms of comfort the opposite is the case. Regarding issues related to solution adaptability, Solution C is better at ensuring such a possibility than solution B. We can also analyse the issue of the initial cost of the element, and comparatively state that Solution C has the lowest initial cost.

This decision-making support system helps us clarify the solutions in question and the implications of choosing each of them, according to the different maintenance initiatives and respective framework, as well as the relationship of the various functional requirements with each maintenance initiative, and the assessment scale. For all these functional requirements, there is a section profile which is defined corresponding to a minimum level of guarantee for such requirement. Without this guaranteed fulfilment, the solution shall be excluded. This support tool allows the architect to have an effective support for his decisions covering decisive aspects for the preservation of his architectural work over time.

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