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PLANNED MAINTENANCE AND CONSERVATION: A MAINTENANCE PLAN FOR RESTORATION PROJECTS THE CASE STUDY OF ROSCIGNO VECCHIA

II LEVEL MASTER'S THESIS

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"*It is essential to the conservation of monuments that they be maintained on a permanent basis"*

Carta di Venezia, 1964

"Maintenance planning is an art which needs cultural and ecological sensitivity"

Management guidelines for world cultural heritage sites

"Il controllo periodico della costruzione [...] rappresenta il principale strumento per una conservazione consapevole."

Linee guida per la valutazione e riduzione del rischio sismico del patrimonio culturale

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Abstract

The thesis is focused on the planned maintenance of the historical architectural heritage in the field of restoration projects. The purpose of the thesis is to analyse both the theoretical considerations, concerning the definition of maintenance actions directed to the heritage according to the theory of restoration, and the practical applications, analysing the instruments needed for the planning of maintenance and monitoring.

The subject is very topical, in fact now a new culture of maintenance is spreading out both in Italy and in Europe, with the diffusion of preventive and planned maintenance and with the development of the concept of planned conservation. It is obligatory since some years to arrange a maintenance plan for all the public projects, and it could be very useful if this obligation was extended to all the projects, particularly for the restoration projects. Especially for this kind of project is very important to plan several actions of maintenance and monitoring to make the results more efficient, in fact usually the lack of maintenance thwarts the intervention. The conservation of the historical architectural heritage, particularly regarding the so-called minor architecture, can be improved with the diffusion of the planned maintenance and monitoring.

The problem is theoretical and connected to the concept itself of maintenance and to its application. Analysing the different definitions of maintenance it is clear how can be difficult to apply this approach to the historical heritage. The purpose of the maintenance is to maintain the efficiency, a good state of working and the economic value of an object. The approach to the maintenance is based on the performances that the object must satisfy, but this is right for a machine not for an historical building. The value of the heritage is not only economic or based on its use but also, and especially, it is a cultural value, thus it can be dangerous to apply this approach. The conservation implies that must be preserved the whole building and all its components, when is possible off course, and that necessity is more important than the performances that the building, or some of its components, must have. Usually the maintenance implies the substitution of the component that is not still able to satisfy the performances needed for its use, but in the case of the historical heritage this can not be possible. It is necessary that the restoration projects and the planned maintenance are made to satisfy the performances needed but at the same time avoiding alterations that could

compromise the authenticity and the integrity. This is particularly important for the maintenance that is normally subjected to less control respect to the restoration project and there are a lot of examples of bad maintenance that have caused consistent damages to the heritage. To find a solution is necessary to define an instrument to plan the maintenance actions that can combine this two different purposes: the satisfaction of the performances needed and the respect of the conservation needs.

The thesis consists of three parts and an applicative example on the case study of the restoration of Roscigno Vecchia.

The first part of the thesis is focused on the concept of maintenance both in the regulations and in the history of restoration. The thesis analyses the Italian laws and the definitions that can be found in the regulations concerning the maintenance in order to illustrate that most of them are not specific for the heritage, and even the specific ones have a limited application. Analysing the last fifty years, starting from preventive restoration in Cesare Brandi's theory, going on with the work of Giovanni Urbani, concluding with the Risk Map of Cultural Heritage, the thesis illustrates that the influence of maintenance is growing up: now is increasing the concept of planned conservation. The thesis describes an overview of the current approach and the future trends regarding the planned maintenance around Europe and Italy.

The second part of the thesis is focused on the practical application: the maintenance plan, that is the instrument to plan all the maintenance activities. All the information concerning the maintenance plan can be found in the Italian Law about the public works, that is the reference point to the drafting of the plan. The maintenance plan as it defined by the law is not completely suited to be apply to the historical heritage, the thesis determines the different aspects of the maintenance plan that are not fit for the restoration projects. So the thesis analyses guidelines for the drawing of the maintenance plan of the historical architectural heritage made by Regione Lombardia. The guidelines define a specific maintenance plan characterized by a new approach that is based on the planned conservation of the heritage: the conservation plan. Critically analysing the maintenance plan provided by the law and the conservation plan proposed by the Regione Lombardia in its guidelines, the thesis define a specific maintenance plan suited for the restoration projects.

The third part of the thesis proposes guidelines in which defines the principles, the methodologies and the documents that are needed in order to plan maintenance following restoration. The thesis proposes to consider restoration as a continuous

process that is fulfilled through the intervention and continues with following maintenance and monitoring, that extend and in the meantime verify its efficacy. Thus the maintenance plan becomes an integral part of the project. The approach to plan the maintenance has to be conservative and not only based on performances; therefore it needs to focus on the element and not on the performance. This aspect involves the necessity that maintenance actions do not expect substitutions on the contrary guarantee the material permanence of the elements. Thus it becomes unavoidable to anticipate the deteriorations that can involve the loss of the elements, and in case they come true, detect them timely. In fact the periodical control of the building is the main instrument for a conscious conservation. The strategy to plan the activities has to be a combination of preventive maintenance threshold and preventive maintenance condition-based.

It needs to define the requirements and the risks and to individualise the possible anomalies and the more vulnerable areas. On the basis of this analysis has to be planned both preventive maintenance and constant controls; moreover curative actions have to be anticipated regarding the expected anomalies that can occur. To those activities the eventual actions of completing of the restoration have to be added, that have to be done after the intervention, and in some cases the corrective actions, concerning the interventions that could turn to be non efficient. Thus it becomes fundamental to define the parameters and to individualise the priorities to establish the typology and the sequence of operations, defining a general methodology to apply to the specific cases.

The thesis will apply the approach to maintenance and the methodology proposed on a case study: the restoration of the Borgo Vecchio of Roscigno. Roscigno is a little village in the south of Italy. The historical centre has been abandoned at the beginning of the twentieth century because several geological and seismic problems and now nobody lives there and a new town was built. The local administration organized a preliminary project to preserve the site with the purpose of experimenting new strategies of conservation and management, for this reason the committee established some permanent laboratories. The first step of the project is to prevent irreparable damages by the strengthening of the buildings. The thesis analyses the restoration project of one of the buildings and indicates what is needed to plan maintenance and monitoring activities. In particular the thesis will focus on some interventions of strengthening and a-seismic improvement. The interventions will be analysed in detail, through the division in work sequences in order to define the significant aspects that have to be considered to plan the monitoring and the

maintenance. This methods allows to take into account all the aspects regarding the interventions carried out to restore the building, from the design to the realization, evaluating both the execution and the results

The Concept of Maintenance

Introduction

The thesis will focus on the planned maintenance of historical architectural heritage in the field of restoration projects. The purpose is to analyse both the theoretical considerations, concerning the definition of maintenance actions directed to the heritage in accordance with the theory of restoration, and the practical applications, analysing the instruments needed for the planning of maintenance and monitoring. After all that, it will illustrate how to apply these instruments to a case studio about the restoration of the Borgo Vecchio in Roscigno.

This subject is very topical: in fact now a new culture of maintenance is spreading out with an evolution that develops concepts of preventive and planned maintenance, with several examples both in Italy and Europe, On the other hand, from several years it is mandatory in Italy to make a maintenance plan for all the public projects. Therefore, a large spread of this practice is to be hoped for public and for private project too, not only for new buildings but also for old ones. In fact it is clear that a good result of restoration is connected to subsequently maintenance and monitoring of the architectural object, especially because an intervention can modify the equilibrium that the building has reached during time. But often the lack of maintenance and monitoring thwarts the restoration, so after a while the object looses all the benefits gained from restoration and returns to a conservation state similar to the previous state in which it was before the project.

The problem is theoretical and connected to the maintenance concept and definition. The general definition of maintenance is: *"the act of keeping something, such as instruments, roads, buildings etc, in a good condition by checking or repairing it regularly"* (cfr. Dizionario Italiano Garzanti). So, It is clear how it is difficult to apply this definition to the intervention on historical architectural heritage. How to establish the efficiency of an historical building? How to interpret the good state of the historical architectural heritage?

Parameters based on performances that are appropriate to establish how to intervene on a technical system, on a machine, or also on a new building, are not

perfectly applicable to an historical building, the value of which is not only economic and based on the utilization, but is also and especially a cultural value. An historical building has to be protected and preserved because it is a document and the evidence of the past. This need implies that any intervention of restoration and maintenance must preserve the integrity of the building and its parts, also physically. The economic value of an historical building is intrinsically linked to its cultural value, and its cultural value depends on authenticity and integrity. The classical components of the economic value of a building are its commercial value and its use value; when the building is an historical one then there is a third component that is the cultural component, and this one is more important than the other two. This aspect entails that the satisfaction of determinate performances could be difficultly to reach without deep alterations of the building, but alterations can imply a waste of cultural value. Restoration and especially maintenance interventions should take into account this need and they should be not only based on the performances that current standards impose, but also they should look for equilibrium between these different needs. When planning restoration and maintenance it is necessary to satisfy the need of performances but also to preserve the buildings from alterations that could imply a loss of authenticity, integrity and cultural value. Thus, it can be helpful to think of a use of the building that implies performances in the respect of its conservation.

How to conciliate maintenance and conservation? Is it legitimate to replace historical building components in the view of keeping the building alive in spite of the risk of compromising its authenticity and reducing its cultural value? How to establish and to evaluate the performances that an historical building or a part of it should be able to satisfy? On the other hand, if it is necessary not to alter the historical buildings in favour of their conservation, at the same time it is still more essential that they continue to exist and to have a function. A correct and respectful utilization is the best guaranty for the building conservation and makes possible to find resources, hard to obtain for an unused building, unless it is a monument. That means to realize restoration and maintenance interventions able to increase the building life cycle. To find a solution to these problems it is indispensable first to adapt planned maintenance instruments to these two needs of satisfaction of performances and conservation.

In the past it was common to regularly maintain a building, increasing the life of a whole building or a part of it. Afterwards, because of the industrialization, this

practice was abandoned, together with the technical and handicraft abilities. Because of the industrialization, the correlation between material and labour costs was reversed, therefore the opinion that it was better to remove than to repair spread. If this statement can be true when it is referred to a machine or to a technical system, it is wrong when it is applied to an historical building. The replacement of an historical building component can cause a reduction of its cultural and also economic value and therefore it is not favourable but disadvantageous.

The concept of a "useful life" and its application to the historical architecture is the most important topic to analyse. Primary it is necessary to establish the durability of an element of an historical building and evaluate the useful life that it could have. It is quite easy to estimate for a modern element the performances it can satisfy and its durability because we know all the production processes and we know that the plan concerns also these two parameters. However, we cannot state the same if the object of the evaluation is an element of an old building. In this case, it is essential to do a complete analysis about the element, the building, the materials, any eventually past intervention, and the external factors. It is also basic to compare historical information about similar elements, even though they were handicraft elements hence with numerous unknown factors. In relation to that it is interesting to make out what it is preview about that in the Italian Technical Regulations.

The new *"Norme Tecniche sulle Costruzioni 2008"* presumes an approach based on performance for the design of new structures and for the verification of the existent constructions. Concerning this approach, the law provides the *durability* and the *nominal life [vita nominale]*, that is the equivalent of useful life *[vita utile]*. Durability is defined as "*conservation of physical and mechanical characteristics of materials and structures, that is essential in order to guarantee security for all the brickwork life, that it must be warranty by a correct choice of materials and a right structure dimension, included eventually protective measures and maintenance"*. The nominal life of a structural work is the "*numbers of years which a structure has to be able to work for, condition that is strictly related to a routine maintenance.* The law establishes that a structure has to be designed in a way that deterioration during its life cycle, regardless of routine maintenance, does not imply a reduction in performance below the level required by the law in force. The general dispositions provided by the law are directed to both new and existent constructions. Regarding existent buildings, the law defines the following categories of intervention:

adjustments [interventi di adeguamento] to reach the security levels required by the law; *improvements [interventi di miglioramento]* to increase the security levels even without achieving the levels provided by the law; and *repairs [riparazioni]* or local intervention to single elements to improve past security levels.

It is interesting to notice that about interventions on existing constructions the law does not use the word "restoration", because it concerns not the all building but only its structure, and also it is mentioned the word "maintenance" but without any specific indication. In fact, the law establishes that it is mandatory to carry out a routine maintenance, but it does not define what does it mean "routine". In the definition of durability the law refers to protective measures and maintenance but again without giving any more information about them. Moreover, analysing the categories of interventions on existing buildings, the law once more is not clear and interventions could include procedures of maintenance, routine or extraordinary measures, but also restoration or *renovation* or strengthening interventions, without giving any clarification about them. The definitions of these categories of intervention on existent constructions are defined by the Italian Law 457/1978 and will be analysed in the thesis. Foremost, it is necessary to pay attention on the fact that the concept of durability and useful life defined by the law is based on a performance approach and is not precisely refer to historical buildings, which are subject to restoration or maintenance.

If it is complicate to evaluate the durability of a historical context, the application of useful life idea is even more complicated. Actually, regarding the durability, it is very complex to provide a definite estimation of an historical element because of several unknown evaluation factors, such as the effective realization or the interaction between old and new materials and elements, or the effectiveness of the interventions. Moreover, with careful studies, specific analyses and monitoring it is possible to arrange a hypothesis about the durability or at least to keep under control its evolution. The concept of durability does not imply theoretical problems but only practical ones: how to evaluate it and what it is essential to do to increase it. Instead it is necessary to pay attention to the concept of useful life because it is the concept itself that has many application problems in the historical architectural heritage. In fact it is based on the utility, which is the use of historical goods related to a specific function. But how has to be intended the use and the function of historical goods? The role of the heritage is to continue to transmit and testify the

values of its history and its material permanence. This means that the conception of useful life is not applicable to the historical cultural heritage because its *utility* cannot decline during time at least for its cultural value. But it is exactly the expression "*useful life cycle"* that presupposes a constant substitution of what decays inside a mechanism that ought to keep working.

On the other hand utilization of goods cannot be only contemplative. The opportunity that a building is enjoyable and capable to house a function inside is to be hope for it, with the statement that its use has to be compatible with its conservation. For that reason it is absolutely not to be ignored that the building elements have to satisfy some performances that its use and function require. Use and function guarantee, at least theoretically, a regular maintenance. In general the use consents to find resources to carry out maintenance and to justify the cost, especially for the non-monumental heritage. Consequently, it is basic to establish the performances that the building has to satisfy to be used also in the future and it is crucial to evaluate how long it will be able to keep that performance level, bearing in mind the fundamental assumption that it must maintain not only its performance but also and mainly its material permanence. It has to be estimate if there is the prospect of a use related to the performances necessary or if alternatively the performance level of the building and its elements implies a different use. In any case it is impossible to admit that cultural goods, like historical buildings, lose their utility, ending their life cycle, since their utility is not just material but above all cultural. At the same time their *cultural utility* is strictly related to their material permanence, thus their useful life ends when they lose their material permanence and they become not enjoyable anymore, not only in a functional but also in a cultural meaning. Therefore concepts of durability and useful life have to be shaped on the basis of the main proposition that is the material permanence and not the performance level that has to be obtained.

So it is very important to establish how to apply this approach to the conservation of the historical heritage and it is clear that it is indispensable to express a specific law. This kind of law implies that the performance necessary for the security purpose has to be apply to any intervention, even when it concerns existing constructions and not only for the new buildings. Thus, especially considering the seismic vulnerability, it could be indispensable to perform some interventions in order to achieve the security level required, interventions that could be incompatible

with the purpose of conservation. This thesis will try to give a complete scheme of the Italian laws about maintenance and restoration and to clearly indicate the aspects that need to be improved or that should be consider from a point of view closer to restoration.

From another point of view it is significant to look at the history of restoration and to notice that maintenance was abandoned for a long time because of the theory of restoration itself which, especially for monuments, in order to bring them back to a complete state, preferred to realize heavy restoration intervention than small and constant punctual interventions like in the times before. At the same time, also for theoretical motivations but diametrically opposed, the loss of affection in maintenance is due to the Ruskin's opinion about the appreciation of the signs of time, on the basis of which the buildings are untouchable and thus have not to be subjected to maintenance. From the sixties with Brandi's theory, going on with Urbani's work, and finally with the current restoration theory, the concept of maintenance has been reintroduced. For that reason nowadays the specific literature refers to term of preventive maintenance and especially to planned conservation, hence trying to avoid any kind of misunderstanding like in the past. This testifies the evolution of the restoration theory that tries to overcome the contrast between the two most diffused trends of opinion: conservationist against restorer. Furthermore it shows the need to consider several important matters, like the heritage vulnerability, which is particularly important in a seismic country like Italy; or like the prevention of an excessive deterioration that causes an irreparable damage; or also the management of restored buildings and the maintenance of the results of restoration. The trend is to go for a project that is not only a punctual episode but becomes a continuous process that deals with the conservation of the heritage through prevention, restoration, maintenance and monitoring.

The aim of this thesis is to define some concepts that are necessary for a correct application of planned maintenance on the historical architectural heritage, particularly in the specific case of buildings under conservative intervention of restoration or strengthening. Thus it is necessary to analyse maintenance practical aspects and then the instruments necessary for its application. The main instrument becomes the maintenance plan. Two examples of maintenance plan will be analyse: the one defined by the Italian Law about public works and the one proposed by the

Region of Lombardia for the conservation of its historical architectural heritage. The research is focused on the maintenance aspect combined with restoration, considering the planning of maintenance and monitoring fundamental part of the restoration project. One the one hand it is interesting to study the prevention of deterioration of the heritage undertaking preventive maintenance, on the other hand it is absolutely necessary to understand how to operate in the case of an intervention on existent buildings, both during the design and after the intervention. It is indispensable to complete the restoration project and to improve its efficacy through the monitoring of the intervention effects combined with a planned maintenance, which has to be flexible regarding the results of the monitoring itself. In fact the building reacts to interventions, which modify its static, physical and chemical equilibrium by setting new elements and materials, especially in the case of strengthening. Hence, it is mandatory to arrange at the very time of the project an instrument for the planning of maintenance able to adapt itself to the building evolution. It is also necessary to pay attention and to coordinate the various actions directed to the different elements of the building: the elements directly interested in the intervention and the element not directly interested in it, the new elements introduced and the interactions between different materials. It is the project itself that has to be considered as a continuous process the aim of which is the conservation of the building that has been restored. For that reason the restoration cannot be considered concluded with the intervention but it must include the preliminary analysis, the project and the realization but also the following monitoring and the maintenance, i.e. the management of the project.

To deal with these topics the current thesis will analyse a case study about the restoration of Roscigno Borgo Vecchio, in particular some interventions of strengthening and aseismatic improvements. This project is a good case study because it deals with the restoration of a whole historical centre that was abandoned and therefore unchanged. Obviously this abandonment implies a completely lack of maintenance for nearly one hundred years, as a result now there is a state of serious deterioration, that demonstrates the necessity of maintenance in order to preserve of the heritage. This case study is very relevant also because the project provides different kind of interventions, some experimental, and its purpose is also to install some permanent laboratories to examine various subjects about restoration, maintenance, monitoring, management and the increase in value of the heritage, thus

becoming an intervention model. All these topics are deeply related to the course study.

The concept of maintenance: definitions and problems

The first step is to define what is maintenance and to analyse the different typologies of maintenance.

The regulations UNI 11151:2005 at the point 3.3 define the project of intervention on existing buildings as: *a continuous or discontinuous process of knowledge and decision about building goods for all their life cycle and it is organised in different modalities in accordance with the predominance of the purposes (maintenance, re-qualification, reuse) and the appropriate*. This definition, very generic because it does not consider whether the building is historical or not, states that the application field of maintenance is the intervention on the built. It points out that one of the aims of this kind of intervention is the maintenance project. This is one of the strategies needed for the planning, which is considered as a process. Consequently it seems more appropriate to talk about conservation project, reassuming with this word the interventions of prevention, restoration, monitoring and maintenance.

But how to define the maintenance project? From the regulations and from the specific literature we can have an overview of some definitions useful to understand the concept of maintenance and its evolution. The British Standard 3811:1964 individuates maintenance as: *combination of works done to preserve or to bring back an object to acceptable conditions*. There are three interesting aspects in this definition: first that the maintenance approach is systematic. In fact the expression *combination of works* clearly shows that different actions combined together are needed to reach the prefixed purpose. The second interesting aspect is the double purpose of maintenance: to preserve or to bring back, referring to the functioning. In the case of conservation the maintenance aim is preventive, that's why it is essential to identify the deterioration processes, the prevention and the probabilities of damages, and what's more the interventions needed. But In the case of bringing back the maintenance purpose is to correct the damages and to bring back the object to its working state. The information necessary will be then related to the

identification of damage, its causes and the modalities of intervention. The coexisting of these two different purposes implies that there should be an acknowledging machinery and a decisional board able to establish which strategy of intervention apply. Then the third issue, one of the most problematical, is the right meaning of "acceptable conditions". Therefore first of all it is mandatory to define the level of acceptability of the maintenance, which has to be established before the intervention, based on performances.

Two considerations appear clear. The first one is that the approach is based on performance, which is difficult to apply to an historical building. The second one is that the concept of acceptability is extremely relative and dynamic. There is not a standard absolutely acceptable and fixed. A standard acceptable when the building is constructed will probably then become of inferior level. But this means that maintenance could also increase the level of standard acceptability thus valorising the object. Subsequently in 1972 a new definition of maintenance was provided by the Building Maintenance Committee (UK): *work undertaken to maintain, restore, or improve every equipment, such as every part of the building, its services and the surrounding area, to obtain a current acceptable standard and to guarantee the functioning and the value of the building complex (Report of the Committee on Building Maintenance, HMSO)*. A third category of maintenance, again with the preventive and the conservative, is then introduced: the improving maintenance. This kind of maintenance regards the obsolescence of components and technical systems of the building. Moreover the introduction of the concept of "current acceptable standard" expresses the variability of requirements during time. But the problem is that it is difficult to recognize the boundary line between maintenance and re-qualification. The directive UNI 10147:1993 tries to resolve this ambiguity defining improving maintenance as: *a set of actions of improvement or of small modification, which do not increase the value of an estate.* The ambiguity remains and the difficulty to apply this definition to the maintenance of historical buildings is even bigger, because the meaning of value is more complex.

A definition more current and general is provided by the law UNI 9910:1990, updated in the UNI 10147:1993, where it is stated that *maintenance is the combination of all technical and administrative actions, included supervising, in order to maintain or to bring back an entity to a state such as to perform the required*. The interesting thing is the extension of the maintenance concept not only

to technical operations but also to administrative ones. That introduces a very important and present aspect that regards the supply of the professional services of maintenance. To complete this definition we can refer also to the directive UNI 10604:1997, which defines that *the purpose of maintenance of a building is to guarantee the good utilization, keeping its value and its initial performances to a level acceptable for all its useful life and helping the technical and regulative adaptation to initial or new technical performances required by the manager or by the law*. Specifically, it is the goods utilization that determinates the functioning state and the acceptable limits of maintenance during their lifetime. Consequently maintenance has to deal not only with the deterioration process and the interventions to realize to contrast it, but also with the obsolescence and the adaptation to the new requirements.

Finally we can draw two interesting conclusions from these definitions. The first one is that the concept of maintenance evolved a lot during time. This evolution can be reassumed with a last definition, the UNI EN 13306:2003, which introduces the concept of maintenance management, intended now as the whole of *all management actions that define maintenance aims, strategies and responsibilities, and that realise through instruments like planning, control and supervision of maintenance, the improvement of organization, included economic aspects.* Therefore maintenance is not only about prevention or correction but it is a process regarding different fields, with different purposes, thus needs a right structure.

The other conclusion, more relevant for this thesis, is that maintenance and its common meaning, as defined by the regulations, by the Italian Law about Public Works, is not specifically directed to historical heritage but to buildings in general, hence it is more suitable for new buildings. In fact all the parameters discussed are not appropriate for the maintenance of architectural historical heritage. All of them are based on a performance approach. This approach is realized on the performance-requirement law [normativa esigenziale-prestazionale]. That law defines a scientific method, which consents to rationally justify the project choices analysing the works connected to single functions that respond to the user's-purchaser's requirements. Performances are the specific behaviours that different components can reach in order to work and represent the answers to the project requirements.

Because the concept of maintenance is to keep the performance level or a conservation state the most close to the initial state, it is clear that this concept, in its

common meaning, is more suitable for machines. Machine maintenance is needed for its functioning. In the industrial field, the performance maintenance on machines is carried out through intervention on damages *[interventi a guasto]* and cyclic planned operations to remove elements because of their wear. The building maintenance has also acquired procedures from industry, such as interventions of repair and substitution based on the building value and the knowledge of life cycle and durability of its single components.

Actually the basic concept is the same, but when it is referred to historical buildings the value is not only economics but also cultural. Thus, the priority is the conservation of the building and its components, therefore preserving its authenticity and its material integrity, as far as possible, with the possibility of a decline in performances. However, this does not mean that an historical building does not have to satisfy some performances, but that it is necessary to adapt them to its conservation without irreversible alterations. The logic of maintenance is the same whatever it is its object. Conservation means also to keep the building functionality related to its use.

The problem is that in the case of a technical system or also a new building the substitution of a element that is not more able to satisfy its performance increases its economic value, or at least do not allow its reduction. That is not true in the case of an historical building because of a reduction in its the cultural value, which implies also a reduction of its economic value. Actually that is not completely true because there are several speculators not really interested in the cultural value of a building.

There are two possibilities to reach or to maintain certain performances. Nevertheless, some performances cannot be satisfied, thus it is necessary to change the utilization in favour of another type that satisfies performance with the principle of conservation. The parameter defining performance is obviously related to the use and the functioning. But an historical building does not necessary have a function or a use, which are subordinated to other factors. Conservation needs can prevent a use of the historical building that can cause a loss of its cultural value. Conservation needs can be more relevant than utilization ones, but this is not mentioned in the foresaid definitions. This solution is evidently not always right. Some performances about structural security, especially about the reduction of seismic vulnerability, have to be absolutely reached to preserve the building.

The other option, more interesting particularly for the maintenance approach, is to create a evaluation system of performances that considers the historical building as an exceptional entity and that combines both performance and conservation requests. It is indispensable to evaluate performances not only on the current standards but to define them close to current ones, but related to the effective possibilities of intervention on an historical building. It can be impossible and dangerous to apply a performance approach based on current standards in the field of historical heritage. On the one hand, if the building is under protection, it is often impossible to intervene to increase its performances. On the other hand, if the building is not under protection, the intervention can be dangerous and there can be the risk of damage. That is what happened in Italy during last fifty years in several historical centres, especially regarding the minor architecture. The improvement, through the overcoming of technical obsolescence and the adaptation to new regulations, for an historical building requires a particular approach that cannot be the same, as for building of the seventy's. It is the forced adaptation of historical goods that can be unfeasible and very dangerous.

In short, the values applied to evaluate an existing building are not the same if the building is historical. Those values are not only economical or related to its use. Its cultural value is a restriction to its free utilization and to its adaptation to performances. Conversely, it is necessary to intervene to avoid deterioration and to keep heritage living not only as an open-air museum but also maintaining, as far as possible, the function and the use designed for it. It is then necessary to compare the building value before and after intervention. The difference between these two values will be probably negative concerning its residual information, but at least it can measure a limit condition, which allows evaluating the opportunity of intervention. This limit condition has to be also evaluated regarding the standards which performances are based on, comparing the optimal standard for a new building to the one reachable by an historical element with the respect of its conservation.

These points do not only regard maintenance, but also interest the whole process of heritage conservation. About maintenance, there are more problems because often these kinds of intervention are subjected to a lower control than the restoration work realized by the authority. Often users and purchasers are used to think to maintenance as an opportunity to modify buildings avoiding controls. It is necessary to establish a clear and unique definition of maintenance suited for

historical architectural heritage. At the same time, it is mandatory to adjust and to finish the instruments necessary to carry out planned maintenance of historical heritage.

Strategies and typologies of maintenance

There are different maintenance strategies, which are not mutually exclusive. These strategies are setting up in relation to the various types and modality of failures. The principals are the following:

- *Emergency or accidental maintenance (manutenzione di emergenza o accidentale):* it concerns unpredictable damages and it is carried out when the damage is occurred. It is not part of the planning and it can be avoided doing a preventive maintenance rightly planned.
- *Preventive-predictive threshold maintenance (manutenzione preventiva/predittiva di soglia):* it is formed by all of the maintenance actions regularly made on the basis of historical and experimental data. It provides actions of preventive maintenance regularly accomplished by reason of the estimation of physiological deterioration phenomena due to the natural aging. It is considered opposed to the decay caused by a pathology, which produces an anomalous deterioration due to different factors. In this case the decay produced is different in time of development and quantity and it results unexpected and clashing with the concept of natural aging. This strategy depends on the possibility to discern with certain reliability the durability of the different components and of the system and the probabilities of damage. This kind of maintenance results adequate for those situations with a high level of criticality, whose objective is their constant conservation and whose durability and damage rate are known.
- *Preventive maintenance condition-based (manutenzione preventiva secondo condizione):* it is made up by the interventions of preventive maintenance carried out with the knowledge of the durability and the life cycle of the elements acquired by means of a constant monitoring. But normally an element breaks down after a period of progressive deterioration but not

suddenly. There are some signals that display the degree of decay. These signals can be pointed out with a series of measures, visual inspections, non-destructive checks and proof of conformity. On the basis of the results obtained it is possible to decide which interventions planned have to be modify and the frequency of inspections and controls. Actually the very objective of the planning is the monitoring itself, which determines the actions of maintenance needed. Probably the costs linked to this kind of strategy can result bigger in relation to the type of monitoring necessary, but at the same time the constant control of goods condition allows to avoid irreparable or severe damages. For that reason this strategy is very effective when it is applied to historical buildings, particularly if they are of great cultural value, because an irreparable damage could have a cost not quantifiable or at least much more bigger than the one necessary to guarantee a constant monitoring. Moreover this strategy is also particularly suitable for interventions of restoration and especially of consolidation. That ‘s because it permits to verify the response of the building to the intervention, from a static point of view and from a point of view of the interaction between materials and both existing and new components introduced by the intervention. The difficulty is to organise a structure capable to collect, to list and to interpret the data gained by the monitoring.

- *Opportunity maintenance (manutenzione di opportunità):* ensemble of planned interventions that are anticipated thanks to an opportunity that allows to ascribe to another reason the appropriateness of those interventions. The aim is to take advantage of a particular situation, like in the case of an installation or in case of resources already invested in interventions realized in other parts of the building. The preventive-opportunity actions have to be in any case previously evaluated on parameters linked to the life cycle of the element that has to be repaired. That’s because it is necessary to state the real opportunity of the intervention, the absence of incompatibility between different interventions and the chance of temporally overlapping in the execution of the works. If it is well conducted, this kind of maintenance lets to save economic resources, because it joins in just one session different interventions, thus reducing the cost.

All these strategies can be divided in two categories that define the typology of maintenance. These categories are present up till now in the law, in the Public Works Law as well as in the building code of the town planning. These are the *Routinary Maintenance* and the *Extraordinary Maintenance*. Although they are related to fiscal, accounting or licence reasons, they finally influenced and restricted the strategic vision of maintenance. From these two categories comes the praxis to consider maintenance as the ensemble of punctual, isolated and circumscribed interventions directed substantially to repair the element. The law 457/78 – title IV art.31 defines these two categories and that definition is still valid.

Routinary Maintenance includes all the oeuvres of repairing, renewal and substitution of building finishings and all the interventions necessary to integrate or maintain in a good state of efficiency all the technological systems existing.

Extraordinary maintenance consists of all the works and modifications necessary to renovate and replace building elements, also structural, let alone to realize and integrate the sanitary fittings and the technological services, as long as all that does not alter volumes and surfaces of the single property units and does not change their use.

In the definition of these two categories it is possible to discover different weak points. First of all prevention is not mentioned at all. They single out that the maintenance interventions have to be carried out when the damage is already occurred. This scheme is far away from the new scenario that now shows up regarding maintenance plan and prevention. Moreover, the included oeuvres are more about replacement instead of conservation. They do not mention the possibility to contrast the decay or to use systems that could lengthen the useful life of an element. This vision is still of industrial mould, based on the cyclic replacement of elements when they are broken. In the definition of extraordinaryroutinary maintenance there is also a certain grade of ambiguity about the renewal, therefore the extraordinaryroutinary maintenance can be considered as a requalification and vice versa. Finally the sphere of activity of maintenance is not specifically defined. This means that there is a certain level of freedom of action. In particularly, on historical goods it is possible to truly modify their meaning, their cultural and material value, working partially and without any specific control. All that is clearly visible on a large part of the architectural historical heritage, which is not under tutelage and therefore it, was and it is still victim of an uncontrolled maintenance,

routinary and for the most part extraordinaryroutinary. The problem has to be analysed looking at the definitions settled in the Law 457-1978. At the article 31, the law defines four categories of intervention on existing goods. The first two are the routinary and the extraordinaryroutinary maintenance. The others are the *restoration and conservative redevelopment* and the *renovation*. But again these definitions are not perfectly clear.

The restoration and conservative redevelopment interventions are defined as the works carried out to conserve the building body and to ensure its functionality by an ensemble of oeuvres, which allow using it in the respect of its integrity, its typology, its shape and its structure. These oeuvres include the consolidation, the restoration and the renewal of the building elements, the introduction of additional elements and of the services needed for its use. They include also the elimination of any element, which is unrelated to the building body. This definition presents again some questionable points. It states that the building has to maintain its functionality, in the respect its integrity, but the preservation of its functionality can be obtain with interventions that could not respect the principle of conservation. For example, in the case of a renewal, this can be realized by substitutions of some elements or by the elimination of the elements unrelated to the building structure, not therefore taking into account the principle of conservation. That's because of the freedom of action due to the lack of a more accurate definition of maintenance. Moreover the introduction of elements necessary for its utilization, the restoration and the renewal of its constitutive elements are interventions preview by the extraordinaryroutinary maintenance. The only distinction appears to be the needs, in the case of extraordinaryroutinary maintenance, to maintain volumes and destination of use. Renovation stands for *the ensemble of interventions carried out to transform a building through a systematic ensemble of oeuvres, which can totally or partially transform the building structure. They include the renovation or the substitution of some constitutive elements of the building, the elimination, the modification or the insertion of new elements and systems.* This group of intervention concerns something far away from the principle of conservation and restoration. In this group can be included interventions of extraordinaryroutinary maintenance, such as the renovation or the substitution of a constitutive element. As a consequence of this ambiguity, most of the problems are therefore due to these definitions, which allow different kind of interventions not truly included in the sphere of maintenance.

Those ambiguities found in the Law 457-1978 are more marked when they concern the historical architectural heritage. Actually, the most appropriate definitions of maintenance are expressed in the "Testo Unico" that concerns the provisions of the law about the cultural and environmental goods (law by decree 29, October 1999, number 490). This "Testo Unico" gathers for the first time a series of laws and definitions expressed by various provisions of the law, trying to solve the previous ambiguities. But it is necessary to state in advance that the definitions present it the Law 457-1978 are still valid and represent in many cases the point of reference. That depends on the application of the "Testo Unico" to the goods that have been declared as cultural goods. The category of cultural goods is very vast and it concerns not only the historical buildings and most of them have not been declared of cultural interest. A part of their general meaning, these principles are valid and perfectly applicable to the historical architectural heritage, with the specifications needed. The all Section II of the "Testo Unico" addresses to the conservative measures and the Article 29 states that *the conservation of the cultural heritage is guarantee by a coherent and planned work, consisting of a revision process, of interventions of prevention, maintenance and restoration.* Thus it also defines prevention, maintenance and restoration.

Prevention is *the ensemble of works necessary to limit the risk for historical goods in their contest.*

Maintenance is *the whole of works and of interventions to control the conditions of cultural goods and their elements, and to maintain their integrity, their functional efficiency and their identity.*

Restoration represents *the direct intervention on the object effectuated to guarantee its material integrity and its conservation and to protect its cultural value).*

These definitions appear more appropriate because they take into account different aspects related to the planning and the coordination, linked to prevention and maintenance of the integrity and identity of the building, its efficiency and its cultural value. They consider the evolution achieved by the theories of restoration and they deal particularly with the historical architectural heritage. For the evolution of maintenance and for the strategic concepts of prevention and conservation, it appears clear that it is necessary to put on one side the notion of routinary and extraordinaryroutinary maintenance. The dilemma is that in the contractistic

(contrattistica) the distinction between these two categories is very important because it outlines a boundary of technical and economic responsibilities. That is demonstrated by the spread of management services for the maintenance of performances. The Law UNI 11063 – 2003 had a try to define again but to get through these two categories of maintenance. That Law introduces important landmarks to the planning, to the strategies and to the prevention of the decay. Thus, routinary maintenance includes the recurrent works of maintenance that do not alter the dimensions, the structure and the destination and that have the purpose to conserve the integrity and the efficiency of the object and that try to prolong the useful life and to curb the decay. The interventions are effectuated when the damage is already occurred or on the basis of the maintenance planning. Extraordinary maintenance also includes interventions that do not alter the original characteristics of the building and its destination with the intention to prolong its useful life, to improve hence the efficiency, the reliability, and the output and to facilitate the maintenance and the inspections. These operations are not routinely effectuated and are particularly expensive compared with its replacement value and the annual interventions of routinary maintenance. Practically the definitions of routinary and extraordinary maintenance stated in the Law 457-1978 remain valid and the ones currently used. The UNI Laws give an excellent contribute, but they represent something voluntary but not cogent. The "Testo Unico" of Cultural Goods has an application reduced in regard to the whole historical architectural heritage and on a large scale gives principles but not obligations. By now the point of reference for the maintenance and for its planning is the Statutory Law for Public Works (Legge Quadro), which describes the principal instrument for the maintenance planning, such as the Maintenance Plan.

The statutory law on public works

This law, number 109/94, is fundamental in the field of maintenance. It has been review four times, the last time with the Law 166/2002. The nucleus of this Law compared to the others, is that in the Merloni Law maintenance is consider of strategic relevance for the quality of the construction. In the Article 4-paragraph 3 this law predisposes that the theme of maintenance has to be decided already during

the general planning of interventions. *The three-year plan must preview an order of priorities. Within it, maintenance, reclaiming of existent heritage, completion of works already started have to be consider priority.* In fact the law outlines the importance and the strategic role of maintenance and it illustrates when and how it has to be made. All that is demonstrated by the presence of a Maintenance Plan, which is finally the last step. The law provides a chain of programming and planning activity. When programming, it is requested to the purchaser to express his needs in relation to the future interventions of maintenance. These needs must be included in the planning. The planning is indicated by the law as the Preliminary Document of the Planning. This document encloses the maintenance interventions that are intended to be realized. During the planning it is essential that the designer manages to interpret and to realize by technical chooses the needs expressed by the purchaser, in the respect of the maintenance feasibility, reliability and availability. Finally, it is obvious that the executive project has to be built on the maintenance plan, which must be linked to the needs expressed by the purchaser. Thus the maintenance plan has to be considered as the way to realise the strategies and the objectives, also of global cost of intervention. The same law, at the article 16, paragraph 5, provides that the executive project must be furnished with a proper maintenance plan of the building and its elements. This plan has to be draft by the terms, with the modalities, the contents, the stages and the gradualness stated by the regulation in the article 3.

In the article 40 of the same law the maintenance plan is defined as *the document complementary to the executive project, which provides, plans and programs, on the basis of the interventions really carried out, the maintenance activity in order to preserve during time the functionality, the characteristics of quality, the efficiency and the economic value.* In the following paragraphs of the same article the law states in detail the plan instrument, composed by the operative documents and indicates the modalities of compiling them. The plan is formed by three elaborates: the manual of utilization, the manual of maintenance and the plan of maintenance. These elaborates must be drafted during the planning and have to be verified by the supervision of works that can eventually updates them on the basis of the effective realization of the opera.

The manual of utilization refers to the use of the most important parts of the goods, in particular of the technological system. It is addressed to the user and illustrates the correct use of goods, thus avoiding a wrong utilization, which can

cause damage. It allows the user to realize a number of maintenance interventions that do not require a specific knowledge of maintenance and teaches how to recognize the signs of deterioration, thus letting a more rapid intervention.

The maintenance manual follows the manual of utilization. It indicates the most important parts of the goods, principally the technologic systems, and how maintenance has to be carried out and the assistance points of reference. Nevertheless, it is not only addressed to the user but especially to who will realize the interventions. The maintenance plan provides a system of controls and interventions that have to be regularly performed to guarantee a good management of the goods and of their parts. It is organized in three parts: services, controls and maintenance interventions.

By the way, the interventions of private initiative are not mentioned at all in the Law. It would be hoped that all kinds of interventions, private or public, would be included in the Law prescriptions. In particularly, that is true especially for restoration interventions. In these cases a maintenance plan could lead to better results. It is note-worthy that the Law correlates the maintenance to the executive plan. This means that the maintenance plan concerns only the elements subjects of maintenance and not the whole heritage. But the conservation of the historical heritage in its entirety requires by force of circumstances the compiling of a maintenance plan which must take into account the whole heritage and not only singular elements of it. Therefore it is necessary to combine and regularly plan the maintenance and the conservation of the heritage in its totality, to guarantee its integrity during time. In this area, it is better to avoid damages by prevention of themselves than to intervene when the damage is already occurred. Sporadic interventions of maintenance could compromise the heritage because of the difficulty and the cost of these interventions, with consequent problems of financing. The preventive maintenance has the purpose to conserve the heritage but also to preserve it from morbidities. It would thus be desirable and advantageous to extent the obligatoriness of the maintenance plan to a greater number of historical architectural goods. All together, it ought to be possible to draw up the maintenance plan without the obligation to start the intervention at the same time. The obligatoriness of maintenance and the independence of the plan from the intervention itself could improve the conservation of the historical heritage. It is remarkable that in the same Law there is a specific section, title XIII, about cultural goods. It establishes three

categories of interventions: excavation, restoration and maintenance. *Restoration* is meant to be the series of technical operation specifically made to preserve and increase the historical and artistic value of cultural goods and to conserve their material consistency. *Maintenance* comprehends all the specialized technical interventions periodically made to maintain the historical and artistic characteristics, the materiality and the functionality of the object thus guarantying its conservation. Therefore the Law regulates the planning activity of cultural goods and introduces three important aspects. The first one is the need to adequate during the works the plan on the basis of what is carried out and what is found. The second one regards the maintenance. When working on cultural goods, because of their nature and of the type of intervention, the maintenance works cannot require all the specifications preview by the preliminary and definitive planning. The last one sets that the works manager, when the works are finished, has to compose the scientific balance sheet, which consists on the updating of the planning elaborates on the basis of the interventions really realized. After all, this step represents the final part of the restoration and knowledge process. All these dispositions are similar to the general ones, but they take into account the exceptional character of the object. This exceptionality is due to the real nature of cultural goods and to the context which work on. In addition, there are several unknowns that cannot be consider in advance in the cases of cultural goods, therefore it becomes necessary to put aside this disposition that results rigid and more adapted to the new buildings. However, a part of these specific indications, the planning instrument is regulated by the article 40 of the Law. It would be appropriate that the prescriptions previewed for the cultural goods were extended to the whole historical architectural heritage, with of course an adaptation of the maintenance plan to these kind of goods and interventions.

This thesis will also analyse in detail the instrument for the maintenance plan as it is provided by the Statutory Law on Public Works. The aim will be to establish which aspects of the plan are valid and which ones are not appropriated for historical goods and it will attempt to draw some guidelines helpful to adapt the maintenance plan to the historical heritage field.

General regulations

To have a summary of reference, we will resume the maintenance and restoration regulations, indicating the law and its argument as follows:

Regulation in force:

- Statutory Law on Public Works, Law 109/1994 and successive modifications; last draft, Law 166/2002 and relative Accomplishment Regulation, DPR 554/1999 and successive modifications. This law represents the principal reference for the maintenance plans: it introduces the obligation to draft a plan during the executive phase; it defines the plan and its elaborates.

- "Testo Unico" for Cultural Goods, Decree 490 of 29/10/1999. It collects all the disposition in force for cultural goods and goods under tutelage. It defines the categories of intervention, such as restoration and maintenance.

- Law 457/1978, Regulations for Housing. This law is used for its definitions of restoration, renovation, routinary and extraordinaryroutinary maintenance.

- 2008 Technical Regulations for Constructions. It is used for interventions on the constructed and for the anseismic adaptation. It contains the definitions of performance approach, reliability and useful life.

Voluntary Regulations:

- UNI 11151:2005: it states the definitions of interventions on the constructed.

- British Standard 3811/1964: it clears the definition of maintenance.

- Building Maintenance Committee, Report of the Committee HMSO 1972: it provides the definition of maintenance, it introduces the concept of bettering maintenance and current acceptable standard.

- UNI 10147:1993: it provides the definition of bettering maintenance.

- UNI 9910:1990 and UNI 10147:1993: it contains the definition of maintenance and it extends the practice of the maintenance to the administrative field.

- UNI 10604:1997: it includes the definition of maintenance, it starts to overcome the concept of obsolescence

- UNI EN 13306:2003: it states the last definition of maintenance in the UNI Regulations.

- UNI 11063:2003: it draws the definitions of routinary and extraordinaryroutinary maintenance.

- UNI 10874:2000: it indicates how to write the manual of use and the manuals of maintenance.

- UNI 11257:2007: it clears how to compile the maintenance plan.

The evolution of the maintenance concept in the restoration theory

In the building trade, maintenance has a precise definition, but the same definition is not always correct when it concerns restoration. However, the maintenance concept presents a lot of affinities with restoration and reclaiming disciplines, especially when it concerns conservation. The evolution of maintenance practice and its more and more frequent application in the field of restoration, especially in the last fifty years, has proceeded at the same pace with the evolution of restoration theory and with its new conservative approach. From the idea of a preventive restoration postulated by Brandi, with the introduction of the integrated conservation theory in the 1975 Amsterdam Declaration, passing by Urbani experiences, this evolution arrived to the formulation of a hazard card for the cultural heritage, which represents the beginning of a new conservation approach, based on

preventive maintenance. This new approach is represented by the principle of planned maintenance. To better comprehend this evolution, we will also present two fundamental examples for the maintenance planning that are the Umbrian Pilot Plan for the conservation and the Hazard Card of Cultural Heritage.

Cesare Brandi introduces the concept of preventive restoration. He defines it as *the stage of restoration when the work of art is recognized for its double aesthetic and historical polarity*. This stage, that is the *methodological moment*, underlines the fact that the recognition of goods value by individual consciousnesses will influence any future behaviour regarding their conservation and their transmission to the postery. The individual recognition embodies the universal consciousness to which is demanded to preserve and conserve the cultural heritage. Therefore the restoration duty is to protect the work of art by means of an accurate examination of its image and its conservative state. Only this methodological investigation can clear the authenticity of the goods and the conservative state of their materials, thus guiding any interventions on them. Therefore, restoration includes not only the practical interventions, but also the initial investigation. But the theoretic principles must be confirmed by the empirical practice, so that the interventions planned do truly result necessary. Brandi means that restoration is not only limited to interventions on the materials which compose the goods, but includes any measure directed to preserve their structure and image. He distinguishes the preventive restoration from the effective one, but just for practical reasons, because they have the same duty of preservation. He retains necessary to theoretically justify the preventive restoration as one justifies the effective one. That's because the preventive measures are not of minus importance of those effectives and often they requires even more resources. This represents an important reason to support the theory of a preventive maintenance and it disagreed with the mentality at that time, sometimes still widespread, for which maintenance included just emergency interventions. And damages in emergency cannot often be completely repaired, with an incomplete rescue of the goods. That is why Brandi outlines the importance of prevention. Brandi divides the preventive restoration in several branches and indicates some general guidelines. Because of the polarity of artistic goods, the first thing to do is to determine the conditions necessary to take delight in them, by a point of view of their image and of their historical value. Then, a constitutive part of a work of art is its

building material. Therefore it is necessary to assess the level of its conservation. Finally it is mandatory to consider also what is nearby the building, which can eventually preserve or even damage it. These are the general guidelines for the practice. It is obvious that for any kind of art there will be a number of specific interventions, not always identical, because of the uniqueness of each work of art. The last two directives concerning the building material and surroundings do not require particular justifications, because they are based on practical surveys and scientific deductions. But the first one has to be analysed to understand how it can be insert under the concept of preventive restoration. Brandi asserts that the work of art must be perfectly enjoyable as image and as historical monument, putting aside the possibility of removal any eventual obstacle. Thus, the building surroundings become really importance in this vision and it turns out to be necessary to also preserve it in the view of guarantee the building perception. An example he indicates is the Sant'Andrea della Valle façade in Rome. After the enlargement of its street, this church has lost its visual effect wanted by Carlo Rinaldi. This enlargement has moved the observer focus on the façade and has decreased its effect. A preventive maintenance could have avoided this damage, even if a material damage did not occurred. And this is true also when looking at the work of art not only for its image but also for its historical value. About it, Brandi presents another example, the one of Via Giulia in Rome. In this case, the substitution of a building of not a particular value, but integrated in a monumental environment, with a new one, even of the same size, height and colour, implied in any case an alteration that lead to a worst enjoyment of the monument. That why it is mandatory to conserve the entirety of the monument and its environment.

The 1975 Amsterdam Declaration, drafted by the European Council of Ministers Committee, confirms this concept of preventive restoration expressed by Brandi. It introduces the concept of integrated conservation, that is the need to conserve the monument in its environmental context, with the employ of restoration technique and the search for appropriated functions. The attention is focused on the totality of the architectural heritage and not only on the monuments, as it was indicated by Brandi. Maintenance becomes an important instrument to conserve the whole heritage, especially the so-called "minor" heritage, the one that creates the background and the historical architectural milieu of monuments, like old town

centres. After all, this minor heritage needs more attentions, even if it is often ignored, and preventive-conservative maintenance interventions can definitively improve its conservation, improving consequently the whole architectural heritage. This Declaration clearly affirms this principle, outlining the benefit derived by permanent maintenance, also in terms of cost. Moreover, it suggests to always hold traditional techniques, arts or materials and to keep using them. And this objective is allowed by constant maintenance, too.

Then, it is Giovanni Urbani in his turn that is interested in maintenance and starts his study from these considerations and these theoretic innovations, especially about the context and the historical environment. Firstly, he indicates how it is difficult to conserve an old town centre because of the number of buildings which compose it. Up to the seventies, restoration did not consider the so-called minor architecture, but it intervened mostly on the monuments, or in any case on just one building. Consequently, this did not allow preserving the entirety of the architectural heritage. But the problem was not simply solvable by expanding the intervention to the whole architectural environment. The next step was to pass from monumental restoration to the town planning type. But this approach did not resulted in a better conservation of the heritage, bar the effect was only a distinction between what is old, rigid and not suitable for building and what is modern, flexible and adaptable to the new social-economic needs.

The historical system does not still but evolves at the same time and in conflict with the modern. The evolution of old and modern is represented by the decay, which is more evident in the historical system, like old town centres, because of natural processes of aging. Furthermore, besides their fragility, the natural decay of old town centres quickened because of migration of the old inhabitants to the new suburbs with the consequent settling in the old town centre of poorer social classes, with a loss in attention to building maintenance. On the other hand, paradoxically, the more valuable areas of old town centres were occupied by well-off social classes but anyhow with a deterioration due to the new functions required. The consequence was a series of radical and ruining renewals of internal spaces and structures. In consequence of all those ruining interventions, the attitude was nearly of not to intervene, so that in the building codes there are several bureaucratic steps which finally block most of interventions. In the end, restoration interventions become more

and more infrequent and occasional, but any maintenance practice is hence cut out. Always in the seventies, restoration specialists used to consider maintenance as a minor activity and under their abilities, therefore avoiding doing it. Urbani ranges over this subject, dealing also with social, politic and administrative problems, but his conclusion is quite simply. Besides all the fore-mentioned complications, the principle objection is that at that time restoration preferred to take care of the aesthetic aspect of buildings and not of their conservation, considering therefore any intervention of restoration as something exceptional and not a constant and routine practice. But maintenance must be constant and regular to be efficacious; therefore maintenance must be planned. Then Urbani individuates a strategy based on the analysis of the factors that cause the decay to understand how slacken this process by means of regular interventions. This strategy could also consent to obtain under the same conditions of resources used, better results than isolated intervention of maintenance. However, if the decay phenomena are slackened, the restoration costs are reduced, because interventions are carried out on buildings in better conditions, without irreparable or severe damages. But Urbani warns us about the possible risks linked to a conservation based only on maintenance interventions. Actually maintenance is as much effective as is frequent and in the long run it cannot distort the building nature. A loss of the building nature can nevertheless occur after an intervention of restoration, but in the case of maintenance this effect is less under control because it is regularly performed and consequently it is impossible to foresee the effects in the future. The question is also theoretic and Urbani gives an example about plaster maintenance. Patching up during centuries a façade already plastered instead of patching it up ex-novo when necessary, belittles the protective function of plaster, a renewable protection for the underneath masonry. But on the other hand the signs of aging on a historical building are generally appreciated and the need to transmit to the postery the cultural value of a building could impose to conserve also the original plaster. It is now important to understand which one is the better solution to achieve the principle of conservation and to decide when intervene with maintenance actions or when realize truly restoration interventions. Urbani faces up to another problem present in the restoration theory of Brandi that is the problem of ruins. Theoretically conservation itself of a ruin poses various dilemmas there is no need to face up in this thesis. But what it is important to outline is the necessity to realize both direct and indirect interventions preventive, which can at least in part be

considered of maintenance. Urbani example is about Roman ruins. To conserve them, it should be necessary to maintain them precisely as they are. But after all their surfaces have lost the most of the protective coat the Romans normally used. Therefore maintenance could mean to replace that sort of renewal transparent plaster, which finally represent a real instrument of conservation.

The Umbrian Pilot Plan for planned conservation of Cultural Goods

Urbani theories find an application in the Umbrian Pilot Plan on 1976. This plan was compiled but never realized. But it remains one of the first and most important example of planned conservation and of application of maintenance to the architectural heritage. The plan basis is that interventions carried out when the damage is already occurred can repair but obviously not prevent the damage. To prevent damages it is necessary to convert conventional restoration to the preventive type introduced by Brandi. Brandi calls it planned conservation and its objective is the control of the causes of deterioration to slacken the decay by appropriated interventions on different materials. The plan tries to individuate the cognitive and technical instruments necessary to realize it, which comprehends the investigation to understand the conservation state of the heritage and the interventions that have to be carried out. The Umbrian territory constitutes the sample, which is collected with a methodology that can be applied to similar samples. Urbani wanted to describe a model plan to be then used nationwide. That happened later and without Brandi's contribute by the Central Institute for the Restoration that illustrated of the Hazard Cart of the Cultural Heritage.

The plan included a series of investigations with three principal objectives: evaluate the effects of decay factors; define the techniques of survey and interventions and institute a territorial technical body for the accomplishment of surveys and practical interventions. The first step was to collect information about the heritage, to plan the methodology of survey and to assess the conservative level of goods. For that purpose, on the basis of the type of goods, different conservative forms, a critical folder related to the structures and synoptical tables for any commune have been prepared. The fundamental concepts of reference have been stated to organise and define the conservation activities, using an empiric

methodology for the planning based on logical and mathematic setting. On the basis of these preliminary inquiries, the plan gives the indications necessary for the investigations to be realized, divided in different parts. The first one assesses the level of knowledge by means of critical inspections in the form of didactical texts directed to the employers. The inspections regard the techniques of characterization, the measurement of the environmental factors of decay and the materials and structures of the buildings. Then, to improve the level of knowledge, it is necessary to carry out various researches and experimental trials to be executed on the ground. Then the results obtained guide the following investigations to check the environmental conditions and the level of pollution. A part of them regards in particular the environmental factors of deterioration, such as hydro-geologic and seismic factors.

Therefore, the conservative forms represent the principal instrument to realize the different investigations. All of these investigations are made for the Planned Conservation. They indicate how to apply the results obtained to the operative practice. The Plan previews a series of complementary and coordination activities correlated to the previous investigations. They are directed to deepen the knowledge of the heritage, to analyze the conservative state, to assess the condition of the others elements not included in the basic investigations, to evaluate the conservative interventions to be carried out on the entirety of the heritage, to define the possible alternatives and to elaborate training and updating plans. Finally, it clears the times and financial and human resources needed to draw and realize the plan. It appears obvious that the first aspect to be faced is the lack in knowledge and in technique. Therefore the follow steps foresee the necessary studies to overcome these gaps. There are two fundamental conditions necessary to carry out an effective conservation; the first one is the chance to assess the conservative state of the heritage so as to periodic control the interventions necessary and to timely intervene. The second one is the possibility to integrate the traditional reparative techniques with the planned conservative ones. The planned conservation is defined by Urbani as *the ensemble of all the periodic preventive measures to maintain as constant and low as possible the decay rate of old materials.* Thus it represents a kind of preventive or successive interventions of maintenance to allow controlling and preventing the mechanisms of deterioration. What is innovative is the planning of maintenance interventions and their organization in constant periodic interventions

on the basis of the results obtained by regular monitoring of the conservative level. However, Urbani gets over what Brandi postulated about preventive maintenance. He considers the goods not isolated but integrated in their environment, which is after all one of the greater causes of deterioration. To conclude, this plan is very topical especially for all the innovations it brought about.

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The Hazard Card of Cultural Heritage

The next step in the evolution of restoration theory towards the concept of planned conservation is made by the Central Institute for the Restoration that draws the Hazard Card of Cultural Heritage (Carta del Rischio del Patrimonio Culturale Italiano). This card is a plan that follows the idea of Brandi preventive restoration and develops with the Urbani's consideration of planned maintenance. The aim is to single out which systems and procedures can allow planning restoration and maintenance interventions on cultural, architectural, archaeological and artistic goods on the basis of their conservation and the characteristics of the surrounding environment. The planning has the function to obtain useful information so as to delineate which interventions must be immediately carried out to avoid the risk of losses or damages. It concerns not only the timing of intervention but also the cost to be backed. That is very important in Italy, because of the great relevance of its cultural heritage and the scarcity of means. This plan is organized in three parts: the first stage is the compiling of the Thematical Cards of Environmental Hazard. The information collected are reproduced on the maps by means of the Gis system (geographical information system) and grouped in three categories linked to the risk factors and to their distribution on the Italian territory. These three categories represent the three main kind of dangerousness: anthropic, static-structural (hydro-geological or seismic) and environment-air (pollution-related). Together with these risk cards there are the Thematical Cards of Cultural Heritage, which give full information on the Italian heritage. These cards are organized commune by commune and are cross-linked to the others to have a complete knowledge of the areas more in danger. The second phase is the collection of the data related to the conservation and the vulnerability level of cultural goods. The first step is to analyse four sample areas with the support of local superintendents. In the future it would be

hoped to extend it to the whole territory. Then the data collected are recorded in informatics databases. The relative vulnerability indexes are assigned to any component of the heritage. Vulnerability concerns building surfaces, structures and uses and it is utilized as the indicator of risk exposition. In a number of sites chosen for their environmental characteristics, stone materials, environmental pollution and climate are also evaluated. The last stage is the synthesis on a unique record of the data collected in the various phases. It is the final elaborate of the Hazard Card and it is given to the various administrations to plan the required maintenance.

But the problem is that the Hazard Card is quite expensive, on terms of economic but also human resources, and it requires a long time to be planned. That means that probably when it is finished, the data are already old. What is more, the updating is even more expensive. This elevated general cost could imply that the investigations on the single elements could be fast and with few resources, so less precise. By the way, other risk evaluation systems are more effective than this one, as the ones used by the Civil Protection.

The present situation and the future trends

In the last years planned conservation has received more attentions, with the search for more effective procedures. One of these regards the Maintenance Plan that has to become an informative system. Thus it turns out to be fundamental to educate the workers and to spread the concept of maintenance, as prevention but also as a common practice that should follow any restoration interventions. Maintenance represents a central argument of restoration and conservation issues. It is also mentioned in the Article 29 of the Cultural Goods and Landscape Code. In there, conservation is defined as a *coordinate and planned practice of study, prevention, maintenance and restoration.* The article also clearly defines the three fields of conservation. The first one in prevention, which is defines as *the ensemble of interventions suitable to limit the risk linked to the goods contest.* The second one is maintenance, which is *the group of activities and interventions carried out to control the goods conditions, to maintain their integrity and efficiency and to preserve the identity of the whole goods and their elements.* The last one is restoration that is *any intervention carried out to preserve and protect the material and cultural integrity of*

goods to guarantee their transmission to the postery. These definitions are more appropriated and adapt to the historical architectural heritage. This description of maintenance follows the principles stated at the article 4 in the 1964 Venice Card. This article clearly affirms that *maintenance must above all be a preventive practice with the purpose to avoid the damage and to limit the substitution*. The principle of authenticity is also reaffirms by the 1994 UNESCO Nara Card. However, there are several different cultures, with different conception of heritage and authenticity. For example, what is more important in Japan is to transmit the knowledge; therefore it is common to rebuild ancient buildings generations by generations. This practice is diametrically opposite to the Western Culture, where it is also important to materially conserve the heritage. Substitutions represent a loss in cultural value and maintenance must avoid them. Finally, maintenance must include a regular and periodic control of the heritage which can consent to early identify the signs of decay and can allow planning an appropriate prevention. Therefore the knowledge of the preliminary and successive state of the heritage is very important and the monitoring consents to improve it and allows adapting the interventions to the necessity of the moment. Thus, maintenance plan must be flexible and has to include the planning of monitoring, inspections and updating.

The importance and the increasing interest on maintenance and preventive actions are demonstrated with the attention given to them by the ICCROM, the international organizations regarding the conservation of the heritage. The general assembly of ICCROM (Rome, November 2005) highlights the decline on direct government supports for the public institutions responsible of conservation. This trend is reflected in the reduced funding support and in the decentralizing responsibility for the cultural heritage. Among all the shortages, which this kind of maintenance creates, one is the lack of maintenance and of monitoring. ICCROM points out the needs of supports to professional state employee who can ensure regular maintenance and monitoring of the cultural heritage. Respect to what proposed the SD2 in 2001, for the following four-six years this assembly introduces some new points regarding the integration of risk preparedness that has to be encouraged, the preventive conservation and the maintenance strategies that must be part of the national conservation policies. Within the programmes proposed for the biennium 2006-2007, the second one concerns preventive conservation, for both

collections and built heritage. The Furthermore, the sixth programme of them focuses on the preventive approach and management of built heritage.

Since 1998 ICCROM publishes the "Management Guidelines for World Cultural Heritage Sites", in which a relevant role on conservation of the world heritage sites is attributed to the maintenance and particularly included a preventive maintenance strategy, developed on a multidisciplinary approach. Actually, management objectives includes also regular inspections and formal reports by professionals with suitable qualifications and experience and a strategic maintenance plan leading to the formulation of resources projects which are incorporated into an annual work programme according to their priority. The guidelines defines maintenance as a continuous process that includes all practical and technical measures that are needed to keep the site in condition at a standard that permits enjoyment of the cultural resource without damage. Moreover it is necessary to monitory the maintenance programme and to assure its implementation by its re-evaluation based on results and time expended. The guidelines indicate also that maintenance can enhance the beauty of cultural resource but that over-maintenance can destroy its beauty, therefore maintenance planning is an art, which needs cultural and ecological sensitivity. The aim of maintenance is to keep the cultural resource in a manner that will prevent the loss of any part of them.

Maintenance is strictly connected to prevention; and prevention is indicated as the highest form of conservation. Therefore, if the causes of decay can be removed or at least reduced, something worthwhile would be achieved, and a good maintenance strategy can prevent a great deal of damage and decay. Thus, these guidelines define preservation, conservation and consolidation, very interesting for the thesis because refer also to maintenance. In fact, in all those definitions, maintenance is included among the different measures and treatments needed to achieve their respective aims. Preservation has to collect the measures necessary to keep the site in existing state, including regular inspections and cyclical and routine maintenance. Conservation implies keeping in safety or preserving the existing state of a heritage resource from destruction or change, with various types of treatments, such as maintenance, repair, consolidation, reinforcement. The primary aim of conservation is to preserve the authenticity and integrity of the cultural resource. Finally consolidation,even if it do not refer directly to maintenance but is anyhow interesting for the case study of this thesis, is considered as the physical addition or

application of adhesive or supportive materials to the actual fabric of the cultural property in order to ensure its continued durability or structural integrity.

The issues of integrity and authenticity are very important in the case of treatments done to the heritage, therefore also for maintenance. The guidelines indicate some principles that must be respected in order to ensure the integrity and the authenticity of the cultural heritage during the managements through treatments. To maintain integrity, it is necessary to have a policy based on minimum interventions, generally proven to be the best policy for ensuring an effective conservation. And the best way to preserve buildings or sites is to keep them in use. Preventive maintenance is very suitable in order to achieve those purposes, it should forestall the need for major intervention. Moreover, maintenance can help to keep the building functioning and can protect it against hazards. The first aim of the management of cultural resources is to guarantee that the values, that are not only economic but especially cultural, are maintained. To achieve this objective is necessary a comprehensive maintenance strategy that includes regular inspections. Treatments are related to authenticity in materials and workmanship, thus maintenance actions have to be done to keep the values and the authenticity of the heritage. Regarding materials, the aim of treatments, such as preventive actions, is to prolong the life span of the original materials and structures, to keep them in the original position and to preserve the age value retaining the traces of its history. Concerning the workmanship, the aim of treatments, particularly conservation and maintenance, is to prolong the life-span of any materials and elements that exhibit the evidence of workmanship, and to guarantee that is not falsified by the interventions. Thus it is fundamental to use compatible traditional skills and materials.

In 1998 ICCROM publishes also the “Risk Preparedness: a Management Manual for World Cultural Heritage”, about the topic of the prevention of the hazards. This publication stresses on the importance of the monitoring to improve the preparedness to the risk. For this reason, the guidelines indicate that the maintenance programme for historic properties should integrate a Cultural heritage-at-risk perspective. Actually, a good management including monitoring and maintenance plan is fundamental to reduce the risk, particularly against earthquake, as it will be pointed out by the case study.

We can now mention some European examples. Since last two years, the European Union finances a congress about maintenance and monitoring, such as the SPRECOMAH (Seminar on PREventive COnservation and MAintenance of the Architectural Heritage). The SPRECOMAH Seminars intentionally involves many different experts and practitioners related to preventive conservation activities. The themes are the decay analysis, the monitoring, the maintenance and compatibility of interventions. The purpose is to increase the level of interest in maintenance and preventive conservation in Europe, to share the results obtained, publishing the guidelines which promote these two practices. At the moment the guidelines still have to be completed and revised by the European Union. But in any case it is interesting to have a look at their proposals. Before introducing the different conclusions and considerations, this basic debate needs to be pointed out. Preventive conservation is defined as *"any measure that prevents damage or reduces the potential for it"*. However, the interpretation and the extent differs, it ranges from stabilization of built structures in seismic areas in order to avoid further damage, to inspection and daily maintenance of buildings. Further, it embraces all techniques to adequately monitor changes as well as the use of proper repair materials – all to avoid further damage. Last but not least, it encompasses also heritage management and the involvement of all stakeholders since preventive actions – same as in health care – primarily counts on the awareness and understanding of the individual. Therefore, considering the level of preventive conservation in Europe, the guidelines indicate the objectives proposed that encompass different fields. There are proposals to extend the obligatoriness of the maintenance plan to other European countries other than Italy or to the historical heritage in general. Other proposals suggest to involve more and more figures in the conservative procedure. That begins with the disposition of new European laws and with the involvement of the local administrations. Then it goes on with the importance of teaching the conservation attitude even to the non-workers. Preventive conservation starts from the people who are the first caretakers and without whom this primary care is lost. Consequently, interest needs to be raised amongst inhabitants to take care with small action of their environment as well as to recognize the value and maintain their traditional activities. Then, another important way to develop or implement preventive conservation and maintenance could be provided by an adequate research. Research policy should make sure that existing methodologies and newly developed ones are compatible and

can be integrated. A starting objective should consist in merging existing methodologies and techniques. Finally, some examples of practices strongly related to preventive conservation and identified by the participants at SPRECOMAH are reported. This part is quite interesting because it consents to evaluate different methodologies and instruments analogous to the instrument of maintenance plan. Some of them are briefly reported: the scoring system for the assessment of vulnerability of individual historic buildings, a score of the vulnerability of buildings as a ratio between the natural hazard and earthquake resistance index; the three dimensional representations of the historical heritage; the MDDS, the software, devised to help defining the different pathologies and deterioration of material on historic buildings; the SIRCOP, a new Maintenance Management System software made by Lombardia Region developed within a larger project on planned conservation; and finally non-destructive techniques of analysis.

But one of the most attractive is the Monumentenwacht. That is an NGO in Holland and Belgium that promotes a cost-effective approach to built heritage through regular maintenance and inspections services. The members are the public or private owners of the historical goods that are involved actively in the maintenance of their goods and are educated to conserve them. With just a modest entrance fee, they have the chance to receive some small interventions of maintenance but to a smaller prize. The interventions are simple but effective, such as the analysis of the microclimate, or the control of the roof. But even if simple, they can prevent the deterioration worsening due to the owner's negligence or carelessness. A part of this, what is interesting is the creation of a detailed and continuously updated database of interventions carried out, which in turns shows the state of conservation of the heritage. The continuous inspections, even if made by technicians, can consent to intervene in goodtime. And consequently the owner's involvement increases his conscience of the risk. Something similar is going on in Italy, where Lombardia region in association with the Politecnico di Milano is preparing the guidelines for the planned conservation of the heritage, taking especially into account the maintenance activity. The idea is to begin with the Maintenance Plan that must be adapted to the historical buildings and diffuse. It is based on the Hazard Card of Cultural Heritage, but it has to focus on the singular building and not only on the whole territory. After that a regional planning of preventive maintenance interventions and monitoring is provided with the guidelines that will be analyse in

the thesis. There is also the regional software SIRCOP fore-mentioned which will help the experts to prepare the plan, but what is more, it will allow exchanging of information between experts, workers and authorities.

The history also shows how maintenance was always important, even in a context where restoration had a different meaning than in the last two centuries. From the end of the eighteenth century till the middle of twentieth century the restoration prevailed over the maintenance. But from the middle of twentieth century till now maintenance has progressively gained importance and acquired a conservative aspect which has a central role in the restoration practice. But there are still different positions in conflict about it, from a maintenance-restoration trend to a pure conservative attitude and it would be opportune to talk about conservative maintenance. However, on the one hand conservation could consent to better preserve the architectural historical heritage, including the "minor" heritage which is the most present but often the most neglected heritage, because of a lack in attention and resources. On the other hand it is also interesting the development of restoration practice. Maintenance together with restoration could consent to think about restoration as a continuous process, constituted by the first initial study and intervention and subsequently by the maintenance interventions with the purpose to preserve the effectiveness of the intervention but also to evaluate its efficacy and results. This evaluation, as already explained, could in turn allow improving the whole plan. A part of these more technical aspects, it would be also possible to verify the goods management and eventually to search for types of management more aware of the necessity of conservation and also able to find the resources required to carry out the conservative interventions. The planning of the maintenance activities could be particular useful when some basic conditions change, like the destination of use or the utilization of goods; therefore the maintenance plan becomes fundamental to correctly manage the goods.

The maintenance plan specific for restoration interventions outlines the necessity to control by means of a plan not only the punctual interventions but also their outcome, with maintenance and monitoring activities planned during time.

Maintenance Plan and Conservation Plan

Introduction

After having tackled the aspects connected to maintenance in general, both from a normative and definition point of view and from the point of view of the theory of restoration, in the second part the research will specifically analyse the Maintenance Plan. The object of the analysis is to closely examine the data which makes up the maintenance plan and to evaluate the methods which are expected in their drafting. The existing information on the theme is contained mainly in the Skeleton Law on Public Works 166/2002 (last up-date of the Law 190/1994), in the UNI (Italian Organization for Standardization) regulation and in the guidelines for the maintenance plan, drawn up by the Region of Lombardy in 2003. the maintenance plan will initially be analysed as provided under the Law on Public Works, making use of the UNI regulation, as far as detailed analysis of the data and their drawing up are concerned. As was pointed out previously, the plan structured in such a way is not specific for restoration works and of conservation, in general for works on historic buildings. As a consequence the guidelines prepared by the Region of Lombardy for the programmed conservation of historic heritage will be analysed, but which mainly refer to works of preventive maintenance. The research will try to define, on the basis of these two examples, an instrument of programming for the maintenance activity specifically for restoration works. The intention is to structure the plan on the basis of the regulations of the legislation, which will be drawn up in the event of a job and not before hand, but following one's own methodology, the procedures and the necessary logic to tackle the programming for the maintenance in a historic contest, through the ideas given by the so-called plan of conservation.

On the basis of these critical observations and of the indications provided, the estimated maintenance plan for a number of projects in the area of the development of the old suburbs of Roscigno, will be analysed, with particular attention on the structural reinforcement works. These jobs particularly lend themselves to the predisposition and to the study of a series of maintenance jobs to be programmed in time. In the first place for the particularity of the site, which has suffered from the

complete lack of any kind of maintenance action for almost a century and which for this reason allows us to evaluate the effects of this lack. Then for the character of the works As a matter of fact there are various projects brought about by several professional, some cases are experimental jobs. Besides the reinforcement works, maintaining is generally needed following the completion to evaluate the effective responses of the building to the applied systems, which involve the coexistence of different materials and of new elements combined with those already existing. In particular at Rossigno, reinforcements will be carried out which will need constant regulating through time, in a particularly sensitive contest from a seismic point of view. The presence of building works during writing of the research thesis allowed us to approach the studies with particular attention to the practical and executive aspects.

The Maintenance Plan

As seen in the previous chapter the drafting of the Maintenance Plan for public works was made obligatory through the Skeleton Law on Public Works which sanctions: the Maintenance Plan is the subsidiary document to the executive project which provides for planning and programming, taking into account the project data actually brought about, the task of maintenance works with the aim of maintaining functionality in time, the characteristics of quality, the efficiency and the economic value. It has already been said that this law does not refer to all operas but only to those which are public and that it is not specific for restoration works but the regulation of the law is the main source of information about the Maintenance Plan furthermore the drafting of the plan has to be done according to the principles and guidelines dictated from the same law. The research will try to understand how to adapt and improve this instrument with the aim of its specific use in restoration works. With such an aim, use will be made of the indications given in the guidelines of the Region of Lombardy for the Conservation Programme of its historical, architectural heritage.

Starting from the law, the first aspect which stands out is the reference to the works. Logically speaking it could be deduced that the planning of the maintenance

must be referred to the operas that from the subject of executive planning and to its specific data so limiting itself to only the workplace area and not the whole building. It seems obvious how on the contrary; it is more opportune to extend the plan to the whole complex subject to works, including in the plan all the elements which interact with one another, subject or not to direct intervention. In the case of restoration works, this aspect is of fundamental importance in the aim of the conservation of the building and of the efficiency of the intervention.

Still referring to the works we can identify three cases of the application of the plan, relative to restoration works, on the basis of the moment in which they are completed. In the first case, which is closely provided for in the law, the plan is completed in the context of an executive project and of its implementation in the workplace. In the case of buildings subject to restoration the unknown facts in the workplace are so numerous that it becomes of fundamental importance the up-date after the completion both of the project data and of the maintenance plan, concerning this one talks about Scientific Survey. The *Scientific Survey* is a document which contains the final technical-scientific report drawn up by the works management after the conclusion of the building-yards works it is also a specific fulfilment for cultural assets. It forms the last phase of the process of knowledge and of restoration as well as the foundations on which predisposes every future programme of works on assets. Its predisposition is provided for in the Article 221 of the regulation of the Skeleton Law on Public Works, which guarantees the conservation on the contracting site and transmission to the supervisory authority. In effect the survey corresponds to the maintenance plan up-dated to the actual completion of the works, it is infact drawn up by the works manager who the drafting of both devolves on. As said the scientific survey is obligatory for public works on protected assets, its use would be desirable in all restoration works.

The second case concerns the completion of a Maintenance Plan on works previously carried out which could be greatly developed. as a matter of fact there have been many restoration works carried out in the last few years in which the project did not provide for the drafting of the plan due to non-obligatoriness, of which is specifically connected to the context, for example in the case of non-public works or in the case of works carried out before the actual coming into effect of the law. It would not be about an obligation due to law but it would be desirable that this

practise spread in the prospective of the conservation of heritage. The difficulty would be that of collecting data on the conditions previous to the restoration, on the problems emerged during the works, on the actual realisation of the works.

The third case is that in which no kind of restoration works are provided for in the perspective of a conservation programme of heritage, on the basis of sited example in the first part of the thesis, for example the Risk Card. A large part of the public opinion, in particular the administrators and the owners, often believe that it is not advisable to invest in the maintenance of a building before it is subject to restoration which would bring it back to a state of conservation or of efficiency, to maintain. As mentioned previously this policy has brought about a widespread increase of deterioration of historic heritage and of the carrying out of urgent restoration, with the consequences of projectual and conservative difficulties in addition to the need to have considerable financial resources. Actually tackling the subject of maintenance seems on the other hand appropriate to regulate and programme this activity with the aim to make it efficient and to limit its risks due to an incorrect application. It concerns preventive action, therefore it is not provided for by law but this would also be a field of great potentional development. This research poses the attention on the first case, to be precise that with the predisposition of a maintenance plan in the area of restoration works.

The regulation of the Skeleton Law on Public Works, approved by the Decree "DPR 554/1999" and successive modifications, defines the maintenance plan, its structure and guidelines for its processing. For the buildings subject to conservation, the law provides a series of particular and of specific applications which are found in the deed XIII of the law in the articles 221-224. The article 221 specifies that *for cultural assets; it means the things subject to the provision of the law 1089 of June 1st 1939 and successive modifications*. Today this law has been incorporated in the Sole Text on the subject of cultural and environmental assets approved through the Order in Council number 490 of October 29th 1999. It can be noted that the heritage to safeguard is much vaster than the heritage actually under conservation indeed it would be more appropriate to intervene precisely where the law does not arrive but this is not the place to face this matter.

The article 40 of the specific regulation as to how the Maintenance Plan is structured and which working documents it is made up of: the handbook,

maintenance manual and maintenance programme; beside this specifies in detail the contents of every drafting. We will analyze in detail each drafting but there are some common aspects which would be better to state straightaway.

Obviously these three instruments are closely connected and they have to share the same system of classification and anagraphic coding. This is one absolutely indispensable aspect with the aim of the efficiency of the process of obtaining, managing and using the necessary information for the drafting of expectations on which the maintenance programme is based. This is also because the drawing up of these three drafts proceeds parallelly during the various stages of the project and it is necessary an exchange of data and information. The information system represents the control panel of the whole maintenance system and its construction is the first action to take. The essential characteristics derive from the UNI 10604 regulation which must have the information system of a maintenance plan:

- the possibility to conduct a distribution of estate heritage in single components through a hierarchic process in successive sub-division on different detailed levels;
- the ability to define basic maintenance jobs, for which the necessary resources need to be identified, in terms of labour force, materials, equipment and costs;
- the ability to collect the information into temporary plans, identifying the works and the resources;
- the ability to guarantee the comeback of information, useful to create historic and statistical models necessary for the analysis of the results to establish reliability, the means of malfunction, the amendment of the initial hypothesis.

This regulation answers to the criteria established for the quality system. It can be noted how these characteristics cited in the UNI 10604 are particular suitable for the management of estate heritage and geared towards societies specialised in supply of maintenance services. We will now look closely at the drafts which make up the Maintenance Plan.

Handbook: it refers to the use of the assets, in particular the technological plants and is geared towards the user. It contains the whole of the necessary information for the user to benefit from the assets and the elements which it contains a series of indications for the carrying out of maintenance works which do not require specific knowledge for the speedy recognition of the phenomenon of abnormal deterioration with the aim of spurring specialised works. It is made up of a series of documents:

- the collection in the works of the mentioned parts;
- the graphic representation;
- the description;
- the modality of correct usage.

The maintenance manual: it refers to the maintenance of the most important parts of the assets, in particular the technological plant. Provides, in relation to the different technological units, to the characteristics of the materials or to the components, the necessary indications for the correct maintenance and to the resort of help centres. It is made up of:

- the collection in the works of mentioned parts;
- the graphic representation;
- the description of the necessary resources for the maintenance works;
- the minimum level of performance;
- the traceable abnormalities;
- the maintenance carried out directly by the user;
- the maintenance to be carried out by specialised personnel.

The maintenance programme: provides a system of control and works to be carried out in a short time or otherwise stated, with an aim of correct asset management in the course of time. It is structured in three subdivisions:

- *the performance subdivision:* takes into consideration, through class of requirements, the performance provided by the asset and of its parts in the course of time;

- *the control subdivision:* defines the check and control programmes to be carried out with the aim of registering the level of performance, both qualitatively and quantitatively, during the lifecycle of the asset, identifying the dynamics of the drop in performance having as extremes the testing level and that of the minimum established by law;
- *the works subdivision:* reports in chronological order the maintenance works carried out with an aim to provide the information for a correct conservation of assets.

The three drafts are compiled in executive project stages, even if some references can already be found in the preliminary and definitive projects. They are subject to validity checks and verifications on behalf of the works management at the end of the works operation and eventual up-dates on the basis of the works actually carried-out. This is a particular important aspect in restoration works where the existing unknown factors are generally in great number and the works actually carried out may vary quite noticeable based on the progress of the work site. Regarding which one refers to the predisposition of the scientific survey on behalf of the works management at the end of the works operation in case of safeguarded cultural assets.

The three documents mainly refer to the technological plants, both expressed in the law and for its contents. An interesting aspect is that they address different entities: the handbook addresses the user, the maintenance manual addresses the maintenance firms, the programme addresses both subjects. What is not clear is whether the three documents need to be integrated or separate, evidently this choice is left to the project manager. Their mutual autonomy is not clear either as they have various information in common: for example the position in the works of the mentioned parts and the graphic description must be present both in the handbook as in the maintenance. Therefore they could be easily autonomous documents which are attached to both manuals but it seems obvious being geared towards different entities, users and firms, they must have different languages and details. Furthermore the maintenance manual does not include the description of the part under examination, which instead is present in the handbook, but includes the maintenance carried out directly by the user (even though it is geared towards the firms) and

which strangely on the other hand is not present in the handbook exactly geared towards the user who should implement it. This leads us to think that the three drafts should be integrated. Even the use of the term "*intervento*" leaves perplexity as it is used with different meanings: as with the meaning of project, or with the meaning of works carried out or with the meaning of maintenance works.

The maintenance plan can acquire a different relevance seen in the logic of Article 15 of the regulation. ll comma 1 states that: the project has as fundamental aim, the realisation of a quality operation and technically valid, as regards to the best relationship between the benefits and global costs of construction, maintenance and management. The project considers, among other things, as principle the minimisation of the use of non-sustainable material resources and to maximise the reuse of natural resources used in the works and of maximum maintenance, durability of materials and components, replaceability of the elements, compatibility of the materials and smooth controllability of the works service in time. These propositions are particular interesting if the project is a restoration operation. As a matter of fact it is stated that the analysis must cover the whole lifecycle and must apply to the costs – but the concept must not only be economical but also of overall study of all the aspects connected to the project along the whole lifespan of a building – of construction, maintenance and management furthermore the requirements of maintenance and durability. In the viewpoint of understanding the project and the restoration works as a continual process in time aimed to the conservation of the building and not an isolated action, these aspects are of fundamental importance. As a matter of fact the conservation needs to operate on different levels and with temporal continuity , the restoration project must include the maintenance and the monitoring, its success is connected to the correct management of the asset following the works. The law mainly refers to works on new constructions therefore it also speaks about replaceability and of controllability of the performance in time. The replaceability presents various problems when one talks about the restoration and maintenance of historical buildings. Closing the field, in this case advisably, to only the area of the works, that is to say only referring to the eventual new elements added, then the concept of replaceability is compatible with the restoration, in the scope of the minimum intervention and of the removability of

the intervention. The same general validity, and particularly applicable to restoration, have the compatibility of the materials, fundamentally to guarantee that the restoration preserves the building and does not increase the phenomenon of deterioration and the use of materials and sustainable resources, aspects which contribute to the safeguard of the environment and as a consequence also to the protection of the historic heritage. The possibility to check the performance in time is also a parameter which needs evaluating with specific attention on the restoration works, in particular as far as the definitions of the performance levels, but of fundamental importance in establishing the typology, modality and frequency of the maintenance interventions are concerned.

The relevance of this directive is underlined by the fact of its own presence in the Article 15 which defines the preliminary document, then the strategy. The vision of the legislator is greater compared to the previous regulation and defines a process which is interested in the whole lifecycle on the subject of the project. If this is a fundamental aspect when one builds ex-novo then it also is when one intervenes on the existing. The problem is that this ample and dynamic vision which stands out in Article 15 is not adequately developed in Article 40, that is to say where the instrument with which to carry out this strategy is defined. Article 40 limits itself to list a series of documents and drafts, surely useful for the drawing up of a maintenance plan but do not seem capable of transmitting operatively all the intentions of the legislator in addition they seem static and purely bureaucratic. It would be more efficient to think about the instrument of maintenance as a true and proper dynamic informative system, capable of adapting to different needs relative to the typology of intervention, to the characteristics of the assets on which are being intervened and to the changes which can happen during its lifecycle. This must obviously be formed by a series of drafts, of which some obligatory by law, others may be due to specific needs, but that which the law should specify better is the logic and the methodology with which the proposed results are brought about. These considerations need to be evaluated on the basis of the procedure of drafting of the plan provided by the law and above all by the UNI legislation.

The Skeleton Law on Public Works does not clearly define the methodology and the necessarity for the drawing up and execution of the plan, which are instead

indicated more completely in the legislation UNI, with the 10874 of 2000 and the 11257 0f 2007 which deal with the criteria of the drawing up of the handbook and of the maintenance manual. There are a few differences between the two legislative systems and to establish a relationship is not always easy, the UNI legislation however incorporates, despite some differences, the fundamental reference to the drafting of the maintenance plan under the Skeleton Law. The differences emerge due to the fact that the UNI legislation distinguishes two stages of planning: the first stage regards the so-called "orientative maintenance plan", or rather the one drafted by the project manager and attached to the final or executive project, this is to say the one strictly provided under the Skeleton Law; the second stage regards the management of the assets after the implementation of the works on behalf of those responsible for the management of the property or by the body which receives the tender for the maintenance service during the lifecycle of the property and therefore they must carry out the works programmed by the project manager, developing from the maintenance plans. The legislation, therefore, sees the maintenance plan drafted by the project manager as in the first stage of a single process which is brought about through the active participation of those responsible in the course of time equal to the lifespan of the real estate. It refers to the second stage of the process, the management of the real estate plus the documents and procedures which it describes they are therefore slightly different to those which must be drawn up by the project manager. Nevertheless the second stage is based on the first, to be exact on the projectual choice and it reconfirms the indications of the Skeleton Law which remains the main legislative reference for the maintenance plan therefore the maintenance plans which the managers must draw up are similar to that attached to the executive project. The logic is the same and the UNI legislation, taking into account these conditions, it may be useful to evaluate the modality of drafting and the typology of the documents of the plan, in so much as it allows to understand better the objects and the developments implicated in the plan as expected under the Skeleton Law.

As a matter of fact the Skeleton Law lists the documents which make up the plan but it is not detailed as far as the description of the documents and their drafting are concerned, furthermore it presents some ambiguity in its terminology which on the other hand the UNI legislation resolves. Under the logical and terminological

profile in the law, the distinction between plan and programme is not clear, which on the other hand the UNI legislation clarifies. The plan is understood as the complete maintenance procedure which consists of the estimate of the complete maintenance works and of the strategy of implementing these works in mid or long term, therefore making use of the instruments to estimate. On the other hand the programme consists of the complete maintenance works, chronologically defined and programmed, provided for by the plan, it therefore makes use of the instruments for planning. The UNI legislation also redefines the two manuals in a synthetic way very clearly representing what is provided for under the Skeleton Law and clarifying some ambiguity: the user and maintenance manuals or handbook, hold the instructions and procedures of technical and maintenance conduct necessary for the user of the asset, limiting itself to the operation for which no specialised technical ability is required; the maintenance manual holds all the relevant documents together with the maintenance module, inspection and checks of components, technical elements and functional unit of the asset, it is intended for the technicians.

The first step for a correct drafting of the plan is to define the objects which are inscribable in three categories: techno-functional, financial and legal-regulations. The final objective is obviously that of the increase of the lifespan of the asset and its components but it may be broken down onto a series of objectives of which their achievement will bring about the overall final result. The techno-functional objects are the most interesting on the subject of research and which intervene mostly in the maintenance plan which must be drawn up by the project manager. In the first place one needs to form a system of collecting and categorising the underlying information which become up-dated with the comeback information following the works. Its implementation and its constant up-dating consent to knowledge of the asset therefore to evaluate the actions to be carried out on the basis of the initial programming and to following events. The other fundamental object is the identification of the strategies which may reveal themselves as more suitable in rapport with the characteristics of the assets. To make these two objectives achievable one needs to place a third: for the proposed bodies, technicians and users, on the modality of use and maintenance of the asset, defining and communicating, an important aspect, the necessary procedures. Simultaneously to the technical objectives, to make the maintenance truly efficient and sustainable, one needs to pose

the economical and legal objectives. From the economical point of view one needs to optimise the use of the asset and extend its usefulness by means of maintenance works which preserve its value. The reduction in the degradation and malfunction factors consent to obtaining a saving in the running and of the non-fruitfulness of the asset time. From a legal point of view it is necessary to establish the responsibility and the competence, respect the security criteria and identify the risks pertinent to the expected works. The achievement of the overall final objective inevitably connects to the achievement of the specialised technical, financial and legal objectives and therefore needs a checking and controlling procedure.

As far as the drafting is concerned the legislation underlines that they must be drawn up according to the principles of descriptive clarity and of completion of the subject, even deferring to other documents made available. The information to be inserted must be obsolete of projectual dates, of legislations, of the constructors of the components, of technical literature, of other sources which may reveal useful, of the feedback which consent the up-date.

As far as the typology of the manuals are concerned, the legislation describes the manuals, which trace those define under the Skeleton Law but with the introduction of some elements. First of all it contains a *manual of technical supervision* designed for the suppliers of the maintenance works and aimed at describing the modality of standard practise, of the working unit, of the technical elements and of the components and to define the relative instructions to the inspection and regulation works. It is implicated in the typology and in the contents that its application is prevalently geared towards the supervision of the structure, but could be adapted to reinforcement or redevelopment works which introduce elements which need inspection and above all of regulation to implement in time. The contents in this manual can be structured in a series of drafts:

- an anagraphical list of elements;
- the graphic drafts;
- the technical files;
- the legal files;
- the instruction for the use;
- the procedure of technical supervision;

- the control procedure.

The legislation then specifies the two manuals user and maintenance designed for the user and the maintenance firms. The *user and maintenance manual or handbook* are designed for the user edited in a simple language, not too technical, and aimed to avoid or limit the improper use and individualise abnormalities or malfunctions. It further contains the instructions for maintenance interventions which can be carried out by the user themselves. The draftings which make up this handbook are:

- an anagraphical list of elements;
- the graphic drafts, mainly geared towards localising and identifying the elements;
- the technical files, with the identification and the simple description of the maintenance elements of the user;
- the instruction for use;
- maintenance plan, relative to the works that the user may perform, with the frequency of the works inspection;
- a list of referred technicians to consult.

Being aimed at the user the legislation repeatedly specifies the need that the information is simple and consultable by non-qualified persons, compared to the user manual defined by the Skeleton Law, filled with gaps of which was previously mentioned.

The *maintenance manual* is geared towards the maintenance firms and works suppliers, which can be incorporated to that of the technical supervision. In this case contained information must be complete and expressed in a specialised technical language. The objectives of the manual are those which are of interest to the whole maintenance process: the gathering of the necessary information for the maintenance and for the monitoring, the instructions on the works to be carried out, the procedure to follow for the implementation of the chosen strategy, the modality of

categorisation and up-dating of feedback obtained through the monitoring. The documents with which the manual is made up of are:

- an anagraphical list of elements;
- the graphical drafts;
- the technical files;
- the diagnostic files;
- the clinical files;
- the legal files;
- the instructions for the maintenance;
- the instructions for the discharge and destruction;
- the maintenance plan;
- the plan and the procedure of periodical controls;
- the referent legislation which was adhered to at the time of the drafting of the plan with the scope of adapting it to any eventual legislative up-dates.

As can be seen, there are various documents which appear in all the manuals, one needs to evaluate who they are aimed at to establish with which language they must be drafted and which on the other hand may be adapted to be used indistinctively. Another aspect to disclose is that among the drafts present in the manuals, the maintenance plan emerges. It should deal with the preliminary maintenance plan, that is the one drawn up by the project manager outline of the final project, on which the second stage of management is based, in which these manuals are prepared. It refers to the typology and to the estimated temporary measures for the works and the inspections, from which the necessary feedback is obtainable in order to implement the maintenance plan. The manuals described under the UNI legislation are the instruments with which one executes the layout of the edited plan of the project manager and the documents with which it is made up of are the same as those with which the plan must be made up of and they are substantially up-dated due to the enforcement.

The legislation describes the contents of each individual draft which make up the manual. In the first place a *structure identification file* must be present. All the necessary information to individualise the structure is gathered in this document: the

location, the dimension, the designated use and a series of legal-regulations, of which owner, management, constrictions and establishment. Therefore an *anagraphical list of elements* needs to be prepared, where the functional units, the elements and the components subject to the technical supervision and maintenance activities are identified. The elements must be classified with an unambiguous code which also consents to the identification and indication in all the other drafts. To complete the description of the structure all necessary *graphic data* needs to be brought together: therefore the project as built, that is how it was effectively brought about, all the drafts that concern the actual state of the structure at the time in which the plan is compiled or is up-dated and that adherent to the maintenance activities and their execution.

Afterwards the legislation describes the *technical files*, for each functional unit and technical element relevant to the maintenance goal. These files must hold a great quantity of information: first of all technical and commercial identification, including the construction and installation companies; the materials; the modality of assembly plus in the case of removable equipment and elements the dismantling; the description of the modalities and of the working schemes. Then the estimated requirements need to be indicated with pointers to the minimum thresholds admissible and parallelly the estimates pertinent to the maintenance, that is regarding the reliability, maintenance and durability requirements expected, upon which the works to be completed and the results are to be evaluated. The inspection modality needs to be indicated starting from the accessibility and indicate eventual equipment adapt to favour it. There are then a series of regulations relative to the controls and checks expected from the manuals and from the law plus those connected with security. The technical files, as in the preceding drafts, are the same as those in the maintenance plan drawn up by the project manager, with the except of eventual up-dates.

The *diagnostic files* and the *clinical files* are inserted into the technical files, with which the relative information on the monitoring and maintenance activities which are carried out during the structure lifespan, are collected. One needs to distinguish between the *diagnostic files* and the *diagnostic monitoring files*. The first hold the information, the evaluations and the judgements expressed in the diagnostic action and they must report the feedback relative to the successive diagnosis in

connection to any possible alterations, defects or found failures. The diagnostic monitoring files contain the procedure and the instructions to follow for the monitoring, they must contain the necessary information to carry out the diagnosis of the conditions of deterioration and the modality of gathering feedback following the monitoring. With such an aim they must indicate the elements to control, in particular the parts which may be subject to decline, malfunction and pathology and the modalities with which to carry out the controls, indicating methods and instruments. In relation to the inspections they must indicate what the signs of traceable abnormalities and defects are, the symptoms of deterioration, the most frequent modality of malfunction and how eventually they can travel. Therefore they indicate the criteria with which to evaluate and interpret the results of the monitoring, the entity of the deterioration or of the malfunction, the individualisation of possible causes. Finally the deadlines to forecast and the methods to adopt for successive inspections.

The *clinical files* must registered the works carried out and the feedback relative to the inspections and to the maintenance activities. They must indicate precisely the location, the type of activities carried out, a description of the executed works both as far as the procedures and the materials used are concerned, the times and the costs, the workforce, the equipment and the tools and finally the risks and the arrangements on the subject of security. The diagnostic files and those clinical form the nuclear of the maintenance plan and are the instruments through which the operations and the strategies indicated by the plan itself are brought about and verified.

Next to these files the *legislative files* are prepared which must indicate the necessary activities to unfold the regulations of the law and those responsible for each activity. They hold all the documents connected to the legislation, of which the certificates, the concessions, the testings and authorisations and the certificates of conformity.

The *operations manual* contain the indications for the technical supervision and the correct function of the asset and its parts with the aim of making the use and the management of the structure more rational and economic. Those geared towards the user must be edited in a not too technical language and relative to the works

carried out by the user; those geared towards the bodies in charge of the maintenance must be more technical and refer to all the elements and all the activities. A similar draft, but aimed only at those in charge of the maintenance is formed by the *procedures of technical supervision*, which compared to the operations manual specify the procedures in which the establishment must be exposed or the working units pointing out the sequence of the works and the limit of the intervention of each operator. The check to be carried out before the start must be indicated, the put into practise stage by stage, the emergency, breakdown and back into action procedures, etc. etc. The operations manual and the procedure of technical supervision are drafted so they refer specifically to the technological plants.

Finally the *instructions for maintenance*. They must contain the indications on the maintenance carried out by the user, for example regulation or cleaning and those carried out by authorised personnel. The technical regulations need to be indicated: frequency of intervention, human resources, instrumentation, materials, estimated time, the relative warnings of risks and of the prevention. One must also indicate the modality of eventual isolation from the working contest of the element, the relative warnings of the eventual indisposition of the asset or its parts, the indications to bring it back into action. The instructions are a very important document because they explain in detail the estimated works in the maintenance programme, of which the final result is closely connected to the correct execution of the works. In restoration and conservation works this aspect is particular decisive.

As said these documents are those drafted during the management and on the basis of the maintenance plan edited by the project manager in the final stage, even though they are slightly different the predisposition of the UNI legislative are perfectly adapt to the compilation of analogical documents present in the true and proper maintenance plan. The largest part of these drafts are effectively the same as those edited by the project manager and just simply up-dated on the basis of the jobs carried out or estimated. The documents which seem more interesting are the files, in a particular way the clinical and diagnostic ones. It seems obvious that in the drafting of the plan they must trace the analysis files prepared in the projectual stage, of which forms a sort of up-date following the execution of the works, therefore it would be opportune that the codification and the cataloguing are of the same used for

the project, such as their structure. The UNI legislation 10874 fully describes the manuals, but does not deal with the maintenance plan. This seems to be in all effects the main document for the maintenance plan, in so much as it indicates the activities to be carried out and the timing. We will analyse in detail the programme and subprogramme to see what is provided under law, both under the Skeleton Law on Public Works and under the UNI legislation, in particular the 11257 of 2007, on how it is structured, what it must contain, how it is drawn up. As seen in Article 40 of the Regulation of the Skeleton Law on Public Works the maintenance programme is structured in three subprogrammes: that of the performance, that of controls and that of maintenance works.

The *subprogramme on performance* it can refer to the selection stage for the requirements to be verified and to the registration of the initial performance level, or rather the traceable one in the testing stage. In relation to these initial stages one needs to estimate a declining performance and to establish the minimum acceptable performance levels, in general never under those indicated by the technical regulations. The approach is performance but as pointed out previously in the cases of restoration, it would be more opportune to think about parameters not exclusively performance orientated but also subjective, to establish each time taking into account the particularity of historical assets and of the conservation need. One must also take into account the obsolescence, which are in general hard to estimate, therefore it is necessary to estimate future up-dates in the parameters of performance.

The *subprogramme on controls* is substantially an inspection plan in which the structure and its parts are subject to with the aim of verifying the satisfaction of the estimated performance parameters. It is necessary to estimate the deadline times, the priorities, the modalities and procedures with which to carry out the checks, the necessary instruments and the workers to use. Two case can be substantially individualised: the programming of checks according to arranged deadlines, with the scope of evaluating the conditions of the assets in order to establish whether to carry out maintenance works or not; or the programming of works and controls, in the case where it is necessary to evaluate the state of conservation in conjunction with the realisation of an intervention already organised. One must prepare check-list that are

able to guarantee that all the elements, for those established, are subject to inspection and to establish the inspection criteria relative to each element, specifying the type of necessary inspection, the modality of execution, the frequency, the proficiency of who carries out the inspection and obviously the procedure for the collection of the information obtained. To optimise the inspection the elements need to be grouped on the basis of a series of criteria: siting, periodicity, professional requirements of those in charge of the inspection. The aims of the inspection are the knowledge of the state of conservation, the determination of eventual shifts from the estimated standards, the assessment of the causes of such shifts, the entity of the works to be carried out, the possibility to verify the precision of the works already carried out. For each element the instruments need to be indicated, the equipment, the necessary workforce and the method the inspector must use in order to examine the element, taking into account the disposition on the subject of security.

Finally the *maintenance works programme* reports in order of timing the different programmed maintenance works to be carried out, which are described as far as the modalities and instructions in the maintenance manual. The programme concerning the out and out programming, including the choice of strategy to be used and therefore should include a operation schedule for the works on the level of organisation. There can be two strategies, not necessarily alternatives but which may actually be combined: a works programme according to the established deadline times, in the case in which it is possible to foresee with certain precision the mechanism of decline and the frequency of the malfunction or in the case in which the action is principally of a preventive type. The deadlines need to be established basing itself on the nature deterioration of the performance, the natural aging of the materials, the sources of pathologies plus taking into account the use of the structure and the needs of the user. The other strategy is based on the malfunction maintenance works which however foresees a programme based on the possibility and frequency of malfunction and which establishes priority, necessary resources, works organisation without setting precise deadlines.

In restoration works, it would be better to favour a strategy based on a programme with fixed deadlines, this is because the malfunction can cause irreparable damage. On the other hand to conduct an exact estimate of the

phenomenon of deterioration which may trigger off in a historic building is not always easy and different unknown factors may present themselves. Hence the need to programme the maintenance with great care to combine prevision to an accurate control programme which allows to establish speedily the source of the pathologies, abnormalities and eventual malfunction in addition to a programme of urgent actions to be done in relation to the discovery, by means of the monitoring notes on this phenomenon. That is a combination of strategies: preventive maintenance and a programme dedicated to condition directed maintenance, based on constant monitoring and on chance maintenance. In general the predictive maintenance or condition directed maintenance is structured in a series of works:

- *time directed*, aimed to prevent the verification of malfunctions, it is executed by dismantling the element, even only partially, the inspection, the eventual works and reassembling;
- *condition directed*, geared towards the individualisation of the malfunctions, estimating through the monitoring some fixed parameters with which to evaluate the deterioration of the performance, the decline, the presence of phenomenon which may forerun a malfunction;
- *failure finding*, geared to discover hidden malfunctions, it is brought about through periodical preventive maintenance works which maintain the levels of established performance and consent to the discovery of eventual abnormalities;
- *run to failure*, deliberate decisions to not carry out works until malfunctions are verified, generally done when no applicable interventions for the specific case exist, the costs are too high or the probabilities are very low.

These types of intervention stem from industrial maintenance and are particularly adapt for technological plants. Adapting them to building maintenance, in a particular way to that aimed at architectonic historic heritage and for restoration works one needs to evaluate with particular attention which strategy or which right combination of strategies to follow. The condition directed and failure finding works should be privileged which seem to be the most appropriate to perform the

conservation of a historical building. The programme must however take into account all the possibilities and to evaluate which general strategy to follow, but also which particular strategy, based on the element under examination, basing itself on the concepts of applicability, efficiency, costs and in the case of restoration works, in addition, of conservative needs. The maintenance programme must contain the relative information for: working time, or rather deadlines and frequency of a long-term, annual or even a short-term plan for specific works or elements; typology of works, indicating the character, job and type of maintenance, inspection or control, the necessary professional specialisation, the most appropriate strategy; the site and the dimension of the job; the cost of the job including the materials, equipment and workforce.

The objectives of the maintenance programme must consent obtaining jobs that are brought about with the maximum economy and efficiency, intending as efficient a necessary job and performed in a adequate way. An unnecessary job or a job carried out in an incorrect way can be very dangerous, above all when the context is a historical building and the stability is fragile, therefore the works programme must be based on the performance and on the inspection, to be sure of the need of the works, and on the correct choice of the works to be performed. The important aspects to take into account in the programming, are the ability to foresee the damage and the mechanism of decline and as a consequence the layout of the procedure capable of preventing the malfunctions, to counter the deterioration, to consent flexibility to adapt itself to the evolving building frame, finally one should foresee all possible accidental eventualities and the modalities with which to deal with these eventualities. One needs to find a technical and economical balance between the two possible systems of maintenance: the preventive one and the malfunction one, choosing the appropriate strategy to apply, reducing to a maximum the works of uncertain character and unproductive costs.

To obtain the established results the programmes need to be structured in a way to contain all the necessary information, evaluating action by action which estimated level can be reached and therefore on which timescale they are programmed. The information data should be classified and catalogued in an analogical way as those in the manuals and without creating possible ambiguity, for that reason codified files must to be prepared. Analogically, specific files need to be

prepared for the three subprogrammes which have the possibility to be up-dated on the basis of information arriving from the programmed and executed works. This is precisely one of the objectives of the programming. For this reason the programmes must be structured in a way to proceed gradually to the increase of the level of improvement to carry out exactly through the progressive collection and elaboration of the feedback and the consequent implementation of the informative system. Two levels of improvement can be identified. Initially, initial information will be an available, taken from the executive project, the effective execution, the values found in the testing stage, the obtainable data in literature, the technical characteristics given by the constructors/producers of the materials and components. Afterwards this initial information will be up-dated and improved on the basis of inspections and the works carried out. In the case of restoration works, this is a fundamental aspect, therefore the monitoring becomes in all effect the core of the programming.

Four stages of editing and operativeness of the programmes can be individualised. The first is the layout of the operation model on the basis of the type of management which is intended to be used and on which to elaborate the programme and the relative instruments. In this first stage it will be necessary to choose a strategy and procedure for the division of the structure in subsystems.

The second stage is that of the drafting of the files of the programmable works, in which the structure of the maintenance programme is set out. The technical files containing the base data of each element needs to be prepared, and the jobs to be carried out need to be individualised, the inspections, the checks and the relative procedures. One needs to collect all base data relative to: functional state, components, materials, dimensions, technical solution adopted and present documentation. For each element one needs to individualise the possible defects and the most frequency pathologies, the procedures and the frequency of the inspections to verify the eventual sources of these phenomena, the procedure to use when these phenomena bypass the acceptable threshold.

In the third stage the drafting of the comprehensive structure of the programme proceeds, or rather with the completion of the files of the programmable works, with the relative deadlines and with the checks to perform. It is important that in the previous stage the useful data has been collected and has been catalogued in a way to be used in the whole draft. The annual costs need to be evaluated both for the

maintenance programmed as for that of eventual urgency following the occurrence of malfunctions and of relative costs of monitoring or of checks.

Finally the fourth stage regards the running and the execution of the programme, the following of the estimated activities, acquiring feedback, up-dating and implementing the programme. One needs to perform checks which consent to improve the frequencies, typologies and modalities of the works and to evaluate the results of the inspections. For this reason it is necessary to register all the operations carried out, that is, the works, the inspections and the controls.

Problems

The greatest part of the drafts, procedures and of the criteria of drafting and implementation are valid whatever the subject of the maintenance plan and to be adapted to the specific case. These are the problems which emerge depending on the specificity of the subject which vary and need an approach and a different logic with which to impose the maintenance plan. In the case of restoration works the problems are tied to the types of intervention, typology of deterioration, the fragility of the historic building, the conservation needs which impose interventions which are conservative and not substitute, and to the need to use an approach which is not only and exclusively performance orientated. In general, the historical buildings also have a technological component, towards which the plan provided under the law is mainly geared, it is very inferior or in any case not predominate, compared to contemporary buildings. The materials and the construction techniques do not always have the corresponding characteristics for the projectual criteria and for the present standards therefore of which the performance is not immediately known. The logic, with which to tackle the subject of maintenance in a historical building must take into consideration these aspects, therefore the necessary drafts for the layout of the maintenance plan must be adapted to these needs.

The problem stems from the very concept of maintenance and of the maintenance plan when it is found in a historical context and the goal is the conservation. As a matter of fact the maintenance plan of a building of new construction is substantially the prediction of the modality and of the necessary funds

for maintenance of determined performance levels during its useful lifecycle. In the conservation such an acceptance must be different due to a series of reasons. First of all the concept of useful life needs to be evaluated carefully because for a protected building - but the concept should be extended to the historical buildings in its totality or nearly – the use can not decline in time, the very concept of useful life presupposes death, if not for any other reason than its cultural value. The problem, of which has already been mentioned, regards if anything its use which has to be cautious and respectful to the conservative needs but which is necessary. History proves how the survival of architecture is closely related to its use, the most evident example is the Pantheon in Rome. In the present socio-economic context a correct use, in a respectful sense, of the asset could be the opportunity for the finding of resources and for the implementation of the necessary maintenance for its conservation, in the viewpoint of the finances of cultural heritage which is developing greatly.

Another reason for which the maintenance has to have a different approach when the task is conservative and for which the instrument of its very programming needs to be adapted and implicated in the characteristics of historical buildings. The maintenance in this case, needs to be understood as a cure to administrate to a sick patient and thus as an integrated part of the complete restoration or conservation intervention, which becomes a continuous process. Therefore one must use the instruments and restoration techniques different to a new building where one may use the totality of present available techniques. In the historic architectonic heritage timing is different to that of new buildings where it is possible to have a speedy response which consents to intervene on the malfunction. In the case of historical buildings the maintenance has to be performed with a different perspection and with a much higher frequency of inspections, for that reason monitoring is fundamental, also due to the greater difficult to foresee. As a matter of fact in these cases the state of the malfunction can cause irreversible damage which could create the loss of cultural value and therefore of the very concept of conservation.

In addition the definition of the performance which a building or its elements should have needs to be evaluated taking into account that it is about a historical building and that the insufficient performance can not bring about its substitution but

maintenance must be also conservative. The performance needs to be evaluated taking into account of this need and calibrated on a scale of values which take into account more parameters to define the achievable performance respecting the needs due to the conservation of the building and of all its components. Besides compared to an element of new construction projected according to the present standards and for a specific function for the components of a historical building already placed in opera it is not possible to request a prior performance level.

It seems obvious, in the light of these considerations, how the maintenance plan has to be modified and adapted when it is used in a historical context. A valid example is given to us from the Guidelines for the Conservation Programme of Historic Architectonic Heritage laid out by the Region of Lombardy, which deal with the subject of maintenance programming in a conservative viewpoint, defining a definite instrument the Conservation Plan.

The Conservation Plan

The research conducted by the Lombardy Regional Pole on the Risk Card of Cultural Heritage starts from the general reference to the Law on Public Works and of the structure of the maintenance plan in handbooks, technical manuals, defined by the law maintenance manual and maintenance programme with the scope of developing a specific proposal to the conservation sector. The initial aspects put into light through the research which led to retain non deviation from the contents of the law in the field of historical architectonic heritage are the non obligatory of the maintenance plan and its dependence on the activation of building works. These aspects have already been discussed in the previous chapters of this thesis and it is pointed out how these are particular critical in the sector of cultural assets, where the need to implement maintenance policies is indispensable in the view of its conservation. As a matter of fact the conservation is presently understood as the preservation of historical-cultural witnesses as in the maintenance of the subject beyond morbid or pathological frames, in good conservative and functional condition. To achieve this result it seems obvious that there must be a series of maintenance works and monitoring scheduled.

Therefore it is necessary to define an instrument for programming of the maintenance works and monitoring which take into account the specific needs of conservation of historical heritage. The research on the conservation plan starts from this consideration and tries to resolve the issues regarding the concept of maintenance when conservation is mentioned: the redefinition of the performance approach, the respect of the conservative needs, the limits of the plan as provided under the law and its inadequacy to the application in the historical context, the conservation of the components and not their substitution, that is the issues of which have already been widely dealt with previously in the thesis. Guidelines for the definition and the drafting of the technical documents necessary for the elaboration of the maintenance plan to apply in the context of the conservation of historical heritage, have been developed. For this reason the maintenance plan editing has been replaced with that of the *conservation plan*, to be underlined the conservative approach. The same edition also shows how the plan is not linked to the restoration works and it is thought to be applied on all heritage independently of the realisation or not of restoration works. It is an instrument of action programming, specifically for historic heritage, of preventive maintenance which starts from the Risk Card and goes into building details. The aim of the research is how important the approach of the plan and the specificness of the drafts and the thought procedures are to take into account the conservative needs of heritage.

A particularly interesting aspect is the redefinition of the performance layout based on the conservative approach. The registration of the performance consents to evaluate the performance offered by the assets independently from the way of use in which it is found. The level may be compared to those required by the present usage modal or with the hypothetic usage modal for a change of destination. The levels compare themselves expressing the values on a scale that starts from the minimum level necessary to the optimal level in relation to the type of use. From the comparison one can obtain the difference of quality which would be necessary to add to achieve a required determined level. This kind of evaluation generally brings the substitution of the component which is not capable to reach the required performance level. The problem arises when the object of the evaluation is a historical or cultural asset and the substitution of the asset is not permitted, rather the persistence of the component could be an indefeasible object. Therefore it would be appropriate to add

only a part of the difference of quality and define the maximum level of performance achievable from that component. On the basis of this maximum value achievable, the possibility or not of a determined use of the asset will be then evaluated. In the case of restoration works and therefore with the aims of the research, one needs to underline that the definition of the usage model should have already been done with the restoration project but the concept of maximum achievable performance level is however applicable. The maintenance works must be programmed in the view of maintenance not of the absolute achievable value from one component relatively to its use but of the maximum obtainable value conserving the element.

This conservative approach in the evaluation of the performance becomes concrete in the method of analysis of the technological elements, contained in the technical manual, for which indications are given regarding materials, technologies, conduct in opera and state of conservation taking into account the remodelled performances according to the conservative motion. Simultaneously to this analysis, one needs to define the modalities of check and control to carry out, or rather the programme, which are not established through a sequence of repetitive works, as happens normally in the maintenance of new buildings. As mentioned before this is one of the weak points of the plan as provided under the legislation, because in the field of conservation a standard programme can not exist but depends case by case of the precise knowledge of the building organism which develops gradually in time. The guidelines resolve this problem because instead of listing only the drafts they indicate the logic, the approach and the methodology. They contain the necessary logical operative instruments for the drafting and the supervision of the maintenance plan: frequency, instruments, eventual legislation, threshold of acceptance, risks levels referring to different areas of the building. The need of development different to the process is function to the conservative needs but also to the interdisciplinary of the subject which joins the works and controls technology with cultural values, readability, permanence of materials, formal valorisation. This multidisciplinary needs the involvement of different figures both technical, project manager, diagnostician, workforce manager, filer, restorer and non technical user and committee.

The conservation plan merges with the risk card which is considered as point zero in reference in the building conservative affair. The base logic is that the

conservation project compared to that of maintenance must be characterised by activities which precede the restoration project or which are activated regardless of the project. With the aims of the research it seems on the other hand appropriate to think of the maintenance process as an integrated part of the restoration project: the process of conservation is implemented by means of the complete realisation of the restoration works, of the checks and successive maintenance. If in the drafting of the conservation plan the zero point, to mean temporal as the start of the process, is sparked off by the Risk Card and is made up by the layout of the necessary apparatus for the knowledge of the building, in the case of successive maintenance plans for a restoration operation the zero point is the project and the level of knowledge is provided by the project itself. However the plan must be understood as an integrated part of the very project which is implemented as a process structuring itself in knowledge, works and programmed maintenance successive to the works so the knowledge is functional to the works first and to the maintenance after. Furthermore as mentioned with the aims of the conservation a standard programme is not applicable but it depends on the knowledge level which is developed through the supervision of the maintenance plan. The knowledge itself is subject to the process and there is no stopping at the obtained data for the project and at those extractable from the execution of the works but it evolves simultaneously to the building.

As a matter of fact through the plan as time precedes, information is gathered from the maintenance actions and from the scheduled inspections and in the case of the programmed conservation of the undertaken diagnostics to evaluate the reliability of individual intervention which the risk conditions made necessary. In the case of restoration work the risks should have been taken into consideration in the project stage and eliminated, or at least reduced, through the action and the plan should contain the necessary actions to prevent the reformation, or the spread, of the risk factors. Therefore the plan must be seen as an instrument in progress which allows to up-date in time the knowledge of the progress of the state of health and on this basis foresees all the necessary actions for the maintenance of the state of health. The drafts which constitute the conservation plan are set up with this logic and substantially differentiate from those provided by the law in their conception: they are not static documents, predefined, purely bureaucratic, but they are conceived as work instruments which evolve in time on the basis of the evolution of the state of

the building conservation and not on the basis of predefined standard values, generally those of testing. It is necessary to up-date in time the historical building health state and the plan must be able to support the fine tuning of eventual specialist inspections and of specialist works if the risk conditions present themselves. In the restoration works and in particular in those of reinforcement this is an aspect to keep in great consideration because the efficiency evaluation and from the results of the executed works it is not easily foreseen at the moment of the drafting of the plan and so one needs to arrange the necessary apparatus for the up-date of the knowledge in the course of time, even after a certain distance of time from the works. The up-dating of the knowledge allows to highlight the necessary experience for the progressive calibration of the plan not only in its technological aspects but also in those financial of the estimated annual costs. The experience consents to reduce the operative redundancy or inspective, to improve the capacity of interpretation of the phenomenon, to individualise the necessary maintenance actions, to have a timing which consents to react speedily and reduce the risk of intervention of present malfunction.

For these reasons, even if thought as an instrument of prevention, the plan of conservation, specifically structured to be applied to historical architectonic heritage, provides an instrument with which the right measures may be applied successively to a restoration project. The drafts, of which it is made up of, are suitable to be appropriately adapted to the draftings for a specific maintenance plan for the restoration project. We will analyse these draftings highlighting which aspects are useable and which on the other hand are modified to prepare a specific maintenance plan for the restoration project.

The Technical Manual

The first document which we will analyse is the *technical manual*, which is equal to the maintenance manual defined under the Skeleton Law on Public Works. As previously pointed out a minimum level of performance which the element must be able to provide is required for the maintenance manual. For that reason the legislation requirement-performance instead of describing the physical

characteristics, chemical, technological, morphological or performance, examines the conduct in relation to a series of functions to absolve. This approach allows to objectively evaluate the new elements expressing the qualities not in a descriptive manner but in relation to a series of expressed needs by means of the definition of requirements to satisfy. For this reason, resulting evident to individualise what must be the performance, that is the answer to the requirements, provided and it is necessary to establish a minimum range on the basis of which to choose materials and technologies in conformity with the conditions of use and of practise. To apply this type of evaluation to elements already placed in opera and what is more historical, impractical and could bring in the majority of the cases to a series of indiscriminative substitution for all elements which are not able to satisfy the relative requirements. It is preferable, in the viewpoint of a conservative standard practise, to start from the performance which the element is able to provide and not for which should be priorly satisfied, analysing them individually in an analytical way and adapting them to the need of use. One needs to detach from a exclusively performance approach but also from a purely descriptive point of view based on the contemplation of the historic asset which do not take into account the importance of the functionality and of the use, which if compatible with the characteristics of the building is the guarantee of its conservation

To pursue this scope one needs to adapt the methodology of evaluation of the requirements uniting both the characteristics of the elements, or rather the physical and constructive characteristics and above all the state of conservation, and the conditions of building use, individualising the requirements. The guidelines however substitute the term requirement with *problematic* which underlines the complexity of the approach and it refers to all the different aspects to be analysed and to keep under control. The sense is not negative but of synthesis between the *requirements for the use* and the *risk for the conservation*. The attribution priorly to requirements to a component of historical buildings would not take into account the concrete problems which could, almost surely, arise in the conservation of the element. This is because the requirements would be identical for elements which fulfil the same function but which have a conservation state different from each other. Therefore it seems more appropriate not to assign the requirements priorly but to define and analyse the problems on the basis of the individual characteristics of each one, or rather to adopt

a logical performance taking into account the differences of those handmade. The consequence due to this type of structuring is the possibility to provide answers even only partially to the legislation in force moving the acceptance threshold in terms of the subject of conservation.

Obviously another problem is posed: the definition of the problems which determinate the performance. As a matter of fact also these will be adapted to the historical context hence the definitions which refer to the requirements to evaluate in the project of a new construction building, related to the field of the building production, need re-elaborating touching the field of historic architectonic heritage, taking into account the necessary performances but in terms of the state of conservation. The guidelines identify a list of significant issues in the area of conservation and regroup them in four categories:

- *reliability* problems*;*
- *durability* problems*;*
- problems of *adaptability in the variation of use;*
- *maintenance* problems.

On the basis of these categories of issues a plan based on checks in time is formulated. As far as the adaptability and the maintainability are concerned, they are initial requirements: in the case of our research they have already been dealt with in the project stage, in the case of the guidelines, on the basis of an eventual negative evaluation, they create a consistent intervention for which are indicated the necessary actions and the connected criticality. These issues are relative to the characteristics of the materials and to the position of the elements and should not vary in the course of time. As far as the reliability and duration are concerned they change and are evaluated in time, for this reason they transform into a testing programme. Thus consequently in the processes the deterioration which characterises the historic building presumably will show a decline in the performance for which periodic controls must be provided for, be in action to evaluate the condition for use, the disturbance factors and the interaction with the other elements and to speedily individualise the abnormalities. We will closely examine the different categories of problems.

The problems relating to *reliability* regard exact that, or rather the *capacity to maintain markedly invariable the very quality in conditions of determined use* (UNI 8290). The reliability needs to be referred to the building in its complexity taking into account of the correct function of the technological system in relation to the environmental conditions and its working order, they express the capacity of a single element to carry out a function to the advantage of the quality of the system and therefore correspond to some requirements. In relation to these requirements the inherent risk conditions need to be verified and the relative checks defined. The issues of reliability defined by the guidelines are:

- *thermal welfare,* or rather the ensemble of the environmental conditions which the element in working condition must check to guarantee a good conservation condition in relation to the use of the entire;
- *the function of finishing, mechanical organ and plants, as always in correspondence to the conditions of use and practise;*
- *intergradability of the technical elements,* for legislation adaptation or malfunctionment without suffering damages or modifications;
- *acoustic insulation,* which needs to be evaluated in comparison to the effective need compared to both the conditions of use and the environmental circumstances;
- *thermal insulation,* which also needs to be evaluated in comparison with the effective needs compared to both the conditions of use and the environmental circumstances;
- *mechanical stress,* or rather the capacity to efficiently contrast the static actions of the project with compatible effort with the link to the material components not creating damages or excessive deformation; the suitability of the structure should be evaluated, or bearable limits, with reference to the thresholds indicated in the technical regulation;
- *solidity,* or rather the capacity of the elements and of the subsystems to resist under the actions of dynamic loads or probable cycles in the conditions of use, it results in limitations relative to the use;
- *watertight,* relative to the materials but also to the eventual technological and protective solutions adopted.

The problems of the *durability* regard the capacity of a technological system to maintain in time the initial performance levels. The durability is *the result of a technological requirement in the functional characteristics to long term and its reliability which describe the component parts of a technical element for the satisfaction of the very requirement* (UNI 10838). The evaluation is linked to the characteristics both material and technological of the element in comparison to the working and interactive conditions with the environmental factors. The conservation approach actually consists in linking the intrinsic characteristics of the element to the external conditions which constitute a risk factor. For the reason maybe it would be more appropriate to use the term *vulnerability* which serves to define the risk level and the priority of the work. As a matter of fact the vulnerability is in terms of the existence and the use of the asset and does not simply indicate a pathology which concerns the element priorly but in relation to the surrounding conditions. In time a series of checks to evaluate these issues will be imposed. The issues on defined durability of the guidelines are:

- *adhesion to the support*, or rather to the cohesion problems between different parts, it typically refers to coverings;
- *exposure to biological attacks,* to mean the aptitude to present favourable conditions to the induction of living organisms;
- *exposure to the reactive chemicals,* how much the material reacts to contact with reactive chemical products, mainly solvents, including water, and reactants with which they may come into contact with during use; one needs to evaluate if the elements are chemically stable or may undergo transformation which would modify the chemical-physical characteristics;
- *exposure to intrusion,* of harmful animals or undesirable persons;
- *exposure to thermal variation,* or rather bear it without consequence related to the material properties, to consider in relation to the cycle of the phenomenon;
- *frost resistance,* the aptitude of the material to bear disgregation or variation in dimension and in aspect due to cycles of ice and de-icing; one needs to take into the account the cycle of events and the effective state of deterioration of the material placing great care of the overlap of

pathologies which can set off an variation in porosity and determine a grate sensitivity to the cycles of ice and de- icing also to materials generally do not freeze;

- *hydrophilic,* capacity to absorb fluid at the liquid state, in particular in the cases of humidity due to capillary return or to reduction of efficiency of eventual protective treatment for external coverings;
- *hygroscopic,* capacity of the material to absorb humidity from the atmosphere and to bear variations of form, dimensions or aspects; one needs to evaluate in relation to the conditions of practise of the system meaning the interaction between the element and the surrounding environment
- *radiation,* aptitude to bear variation in aspect and of chemical-physical characteristics due to the exposition of radiant energy, mainly solar radiation;
- *presence of soluble salts, attitude to bear processes of deterioration or alteration connected to the re-crystallization of soluble salts,* in relation to environmental condition;
- *dirt-resistance,* aptitude to amplify the effect of soiling substances, stagnant water, accidental contact and dust deposits, evaluating the tendency of the element to fix the deposits, for example due to conformation which block the natural scour;
- *transpirability,* aptitude to allow the passage of vaporous waters from the inside to the outside of the structure; the permeability to the vapour of the element in relation to the material and the environment conditions needs to be controlled, evaluating the impediment of the passage of the vapour which causes deterioration processes;
- *vulnerability to the actions of the atmospheric agents,* predisposition to the arising of phenomenon of decline or of alterations connected to the chemical and physical actions of atmospheric agents; the evaluation is in terms of the material characteristics of the element, of the environmental conditions, to the conditions of use and of the technologies used.

The issues on *adaptability* are relative to the predisposition of the subsystems to be dismantled, integrated with new components or equipment, partially demolished or replaced, in the terms of capacity of transformation in relation to the effects produced from the obsolete function. Being of parameters not subject to variations in time they do not give cause to a control programme but need to be evaluated in the initial stage. This means that in the case of the conservation plan the lacking correspondence to such aspects gives rise to the predisposition of measures and procedures to adopt. However in the case of a maintenance plan being part of a restoration project, these aspects have already been evaluated in the project stage. It is however possible that in the following years to the restoration works new regulations can enter into force, new technologies, above all relative to plants, or variations, even partially, of designated use which make the works necessary to adaptation to the arising conditions, even in our case one must foresee the eventual works in case of a possible obsoleteness in the future. The problems of defined adaptability from the guidelines are:

- *asportability,* aptitude to position technical elements or components in place of others;
- *aptitude to plant engineering integration,* the possibility to complete functional building objects non-plant engineering with plant engineering combined, fixed and incorporated objects;
- *fitment possibilities,* aptitude to consent the installation of equipment or furnishings;
- *retrievability,* aptitude to the technical elements and to the technological components to be reused, both in relation to the antique building and to the additional functions.

The problems of *maintenance* regard the ease to carry out controls, therefore the *inspectionability* of the element and to carry out repairs. The maintenance is *the result of a technological requirement in the characteristics of working maintenance which describe the component parts of a technical element for the satisfaction of the very requirement* (UNI 10838). In the same way as the adaptability issues also the maintenance does not give rise to a programme of control but to the predisposition of

eventual actions and procedures to adopt. Different to the previous, in the case of a maintenance plan for a restoration project the problems of maintenance, which were considered in the project stage, should not give cause to future works. They are issues of which to take into account because they regard the effective possibility to carry out the maintenance activities and thus they need to be carefully evaluated in the drafting stage of the plan. The maintenance issues indicated through the guidelines are:

- *ease of intervention*, or rather the possibility to operate the inspections and the maintenance works in a smooth way; the ease, more than physical, it must be evaluated in relation to the necessary financial resources and to the security and the protection of the workers;
- *cleanliness possibilities,* the aptitude to consent the removal of the dirt and undesirable substances evaluating the ease of extraction of the incoherent deposits without creating damage or alteration of the material;
- *adjustability,* aptitude to stand variations in a value or in a function induced intentionally by an operator; they are the problems generally geared to plants or to technological appliances and can adopt a greater significance in the works of reinforcement which expect the installation of adjustable equipment or in the course of monitoring activities which need instrumental adjustment;
- *reparability,* or rather the aptitude to re-establish the integrity, the functionality and the efficiency of parts or objects which are in a condition of malfunction; these problems also generally refer to the plants, but it could be interesting to evaluate it compared to elements which need to be reintegrated without demolition or total removal, as for example coverings, frames but also some types of brick or wooden structures; also in this case it deals with a project requirement already evaluated during the project planning of the restoration works;
- *replaceability,* aptitude to consent the position of elements in place of others, in some cases removal; this is an issue which presents different criticisms, as a matter of fact in the case of the historical heritage the basic argument is that the substitution of the element must be avoided and

reduced in extreme cases; however it is possible that it could present itself also this event and thus the plan must foresee the necessary measures; the risk is that the choice to replace an element or not, can happen in the area of the implementation of the plan without it being already in an evaluation process, which appears absolutely necessary in such cases.

Of fundamental importance for the manual is how to initially plan it; this takes two steps. The first is to break the building down into categories and collect all the relevant data on each part (materials, technical elements, construction, state of conservation etc). Having collected the data it is important to analyse it, which in the case of historical buildings means evaluating each element and its state at moment. While the Regional Council of Lombardy focuses on prevention, in the case of restoration followed by maintenance there should already be data collected and analysed. It should have been collected before restoration, during and after work completed. Evaluation will have been made on each element and the treatment given and all variations, and at this point durability and reliability would have come into play, parametres which are often overlooked at the planning stage. The drafting of the maintenance plan in the context of projecting restoration measures may highlight these parametres and improve the quality of the project.

The second step is to carry out what is the greatest influence on organising the plan; that is, to select the problems which have the most relevance on the basis of data collected and analysis of single elements. The selection of these problems comes out of an evaluation of different agents which have a direct or indirect influence on these single elements, and their interaction with each other, and their performance. The aim is not to set a level of performance to reach but rather to describe how each element behaves in relation to the problem. On the basis of this maintenance measures are decided upon in order to conserve the element in question. The conservation plan sees the necessity to impose strain limitations to which each element is subjected.

This is an aspect to be deliberated carefully when, on the other hand, the maintenance plan refers to restoration measures in course or completed, because certain aspects (mainly those which relate to checks to be carried out) are applicable while for others, or rather measures undertaken, it is the project itself which would

have taken care of it. Basically, in the technical manual preventative measures to relieve strain on the element will be shown, whereas in the case of restoration these measures will have already been adopted. Checks on them will be made over time, and become an integral part of the maintenance programme. These checks concern the plan in that they are connected to restoration measures (at least pre-emptively), and in that they are contextualised in the plan. Should checks discover that the element is not able to satisfy certain requirements, they will be more concerned about the efficiency and effectiveness of measures taken than with an evaluation of any eventual decay. A restoration project should create a situation in which all elements are able to satisfy established requirements, but it is important to keep in mind that the effects of any restoration work may diminish with time due to natural ageing or changes in surrounding conditions. Thus, the maintenance plan must indicate measures necessary and their effectiveness over time, evaluate this effectiveness, eventual measures to be taken and subsequent checks, and any decline in performance. This implicitly means the ability to undertake work that understands the relationship between the element and its reaction to the problem. In other words, it is necessary to relate the problem to the characteristics. To complicate matters further, there is also the fact that in any building under restoration there will be parts of it (literally or in the sense of new additions) which will have been introduced at different times of its life, and this too needs to be evaluated.

The selection of problems to deal with relates to the condition of use and so this leads to an update of the manual, with maybe the need for another section. Moreover, comparisons will also be made should there be unsatisfactory performance in any problem. This can't mean the replacement of the element as with new building work but means having to accept the lowest performance level possible, adapting the system to environmental modifications or modifications in use. Only should the performance level fall below the permitted threshold, meaning there is a threat not just to the durability but also the reliability of the whole system, should replacement be considered to restore its function, (triggering off, however, measures which should be assessed beyond the maintenance plan, with the consequent update of the manual).

In our case, an assessment on the suitability or a modal of use for heritage came during the project, as with performance evaluations in relation to problems and use. Concerning the model of use, however, we need to make a consideration. Being contemporary is characterised by being temporary, which is strongly reflected in architecture, above all in new constructions. The historical building cannot be considered temporary but can be used for different reasons very often. In Italy, often is the case that restoration occurs just because there are funds, with no clear idea as to what should be done with them exactly, and therefore no long-term plan. The assessment of performance has already become part of the restoration project in the sense of the use expected, but it doesn't necessarily mean it will remain unchanged.

Concerning any problem analysed it is possible to recognise and interpret certain forms of decay or damage and individual changes clearly present in each element, which can be defined as *anomalies in existence*. As has been said before, after restoration there shouldn't be any anomalies in existence left, that they should have been all treated. However, it is necessary to know the cause of such anomalies and to make sure that they do not reappear, that the problem has indeed been treated and resolved. Indeed by looking at these anomalies in existence one can identify the most likely form of decay that could appear later, *anomalies expected*, the weakest parts of the building or *areas at risk*. Areas at risk can be identified by the following criteria:

- *forms of alteration found, signs of decay, ruin, or obsolescence*. Cause of any decay that coincides with the area of risk can be hypothesized. In the case of restoration work done, resolved decay will be evaluated and the chances of it coming back again. Otherwise, the area of risk could be identified through another example of an element which shares the same characteristics in sense of material, technology, place, and environment (here, however, it is important to remember that any historical building has its own very unique history so comparisons cannot always be deemed foolproof.). In this case, an area at risk can be defined so though no signs are as yet present by pointing out other case-studies or even other similar parts of the building itself.
- *construction characteristics of the element*. Indeed an area at risk could correspond to a weak point which is part of the intrinsic nature of the element

(e.g. Material, workmanship etc.)

- *typical critical areas in certain technological constructions*. This would be to look up in books, for example any technical words connected to architecture.
- *Environmental context and function for building*
- *history of decay and repairs done*. This is the specific case for our research. During the restoration project there is a phase when one learns a great deal about the building so enabling those concerned to identify with great accuracy where likely problems are likely to occur. Here of great relevance is the scientific balance book produced which coincides conceptually with the maintenance plan edited or brought up-to-date after measures carried out. In the scientific balance book, first the project manager, then the works manager, will indicate the areas at risk on the basis of those which showed problems in the past or those which are lacking in something but which restoration couldn't counter.

Recognising anomalies in existence or expected in areas at risk is of fundamental importance for the drafting of the plan, because it is on the basis of these aspects that one can understand the decay and establish methods of control, measures to be taken, and maintenance necessary in order to avoid decay, damage or decline in performance.

Having defined the problem in terms of the pathology and performance of each single element it is necessary to indicate the methodology to be used for assessing performance levels which forms the link between the manual (which is concerned with functions of analysis) and the programme (which is concerned with checks). The fundamental aspect is the interpretation of data derived from analysis of the problem using effective and verifiable parametres during checks. Here, it is necessary to draw attention to the fact that in some cases there will be authorised technical norms with which to measure levels while for others there will be no official reference point. In this case, there will be need for a reference point based on the use of the element taking into consideration not just problems of conservation but also functionality and safety. Therefore it is necessary to establish with certainty that the building is able to satisfy the function assigned to it within the laws in existence. However, it is necessary to keep in mind that norms, written primarily for new buildings, in certain cases, would create conflict if followed to the letter of the law

for historical buildings in the sense of conservation work. Norms wouldn't be applied in a prescriptive way but in terms of performance, or rather requirements to be possessed. In the case of restoration the building would not be able to lack norms relative to the use for which it had been designed.

Effectively it is necessary to collect all existing documents and understand any points of the law in which the building is lacking, for example; structural safety, fire prevention measures (fire doors etc), health and safety, waste disposal, security, energy saving, system conformity, doorways etc). Therefore all project reports, authorisation, concessions and certificates will be collected. Since all this is the responsibility of the manager all this information will be contained in the manual of use.

The drafting of the manual depends on data storage and graphs. It is, indeed, a font of information collected together which enables interpretation of data and various aspects of the building, its use and conservation. This is an aspect which is crucial because in the models of maintenance plans it is exactly this presupposed knowledge which if applied to historical buildings would bring about a distorted assessment. Any anomaly would be catagorised as being negative because the fact that they are part of the passing of time and unforeseen events wouldn't be taken into consideration. Instead, every singularity should be identified, recorded and provided with elements to be interpreted and managed.

For the first part of the drafting the building is broken down into different technological elements with which to develop the plan's documents. It is necessary to refer the information to precise points, create a plan of the building (a sort of map which identifies certain elements present in the building and the connections between them). This break down of elements is to then lend itself to an eventual assessment of every single one. Indeed, this performance approach comes from suggestions made by the Framework Law on Public Works. In the case of the conservation plan this derives from the modals expected and adopted for the risk card. In the specific case of the maintenance plan for a restoration project, it must be based on the modality carried out for the project with the idea that it is an integral part of the restoration and conservation and to facilitate the transfer of project data. It will be necessary to adapt the project but also arrange the project to then be adapted to the plan.

An important point concerning the breaking down of the building into elements is that it is necessary to make a detailed map of the building subdividing it into subsystems without losing the sight of its entirety. There must therefore be the idea of how they co-exist and co-evolve together. Indeed, architecture cannot consider a building as just a sum of parts but as a sum of parts that make a whole and which develop together, and this is no more true than for historical architecture. The whole picture concerning these connections will change as this reciprocal modification of elements develops in time, and will be brought up to date, recorded and assessed as events transpire. Guidelines show typical connections that occur though much simplified compared to the reality;

- *element A support for element B.* It is intuitive that the conservation of element B depends on its behaviour from element A but it is also intuitive that changes may also be reciprocal. The links between elements and their interaction cause behaviour to develop over time, eventual degenerative and discontinued processes due to antropic factors. It is, therefore, necessary to carefully examine these links which apparently do not influence but may come about over time.
- *Element A determines the environmental conditions to which element B is vulnerable*. This is the typical relationship between installations and fixtures in relation to other elements, in particular those sensitive to variations in temperature and damp. It is a link which is particularly influenced by retroaction because it affects a balance which when broken, apparently advantageously, could actually trigger off processes which are difficult to govern.
- *Element A protects element B.* The concept of protection could be understood in different ways in relation to the vulnerability of the element protected. It is, moreover, necessary to understand whether the act of protection is voluntary or whether it is something that has come about by chance over time following reciprocal modifications or adaptations. If this protection of element B is considered useful it will be recorded in the manual and will be assessed positively in terms of efficiency and performance.
- *Element* A is adjacent to element B in such a way as to propagate deterioration. What is being assessed here is risk, in the sense that the closeness of A can pose a danger to the conservation of B. A possible breakdown or deterioration in A

could propagate the same in elements around it and an analysis of these links will also establish a criteria for the evaluation as to eventual preventative measures on element A.

Managing the plan's information requires an effective system of coding and adequate graphic representations. In terms of the system of coding this will take the form of document attachments, (therefore graphics, photographs, descriptive sheets, graphic sheets) and subjects of the study, i.e. the building broken down into its different elements or parts, and the same for anomalies in existence or expected. The conservation plan derives from the system of coding from the risk card. For our research it seems obvious that the system of coding is based on the one adopted by the restoration project, just like for the breakdown of its technological elements. It is indeed indispensible that element codes are unambiguous in all elaborations of the plan and in our case the project also. This is also essential for making the plan more information based and for data transmission.

As far as graphic representations are concerned there are various methodologies and techniques. The important thing is that the one chosen is wholly suitable and shows the building's elements, actual condition and its structure and materials using a suitable scale and with the right information technology support. In this too it seems obvious that this should be based on the project's work which forms the starting point, however detailed. Indeed the restoration project contains all the elaborations necessary and pertinent to the building and generally is accompanied by mapping showing where deterioration is and where restoration has taken place. The same detail must be true of the scientific balance book on measures and the mapping of areas at risk. These will be used for the plan and on the basis of this further work will be prepared. An aspect to keep in mind concerns the contemporary representation of anomalies in existence and expected. In the case of a restoration plan the anomalies in existence will be replaced by measures taken but the area of risk should still be shown as such. These will be listed as areas of risk. Therefore many variations exist for calling an area an area of risk; where there was a problem not completely resolved by restoration or due to a lack of technology or where the problem came back due to external causes where measures could not be taken, or eventual areas of risk that could derive from new conditions of use. The important

thing is that these areas of risk are clearly indicated on site, legible and not mistakenly superimposed, with confusion concerning other information present. Guidelines on this suggest that the area should be cordoned off in some way so that it is clear to all that it is an area of risk.

The acquisition of the technical manual constitutes the first step of a series of indepth examinations to carry out over time, bringing up to date the two main works from which it was formed; the *analysis sheet of problems* and the *analysis sheet of deterioration*. *The analysis sheet of problems* must show:

- identifying data for the building and location;
- identifying data for elements and typology
- the material and building techniques for element
- the problems to also assess in the future, which correspond to the problems of reliability and durability. In relation to them will be cited anomalies expected, areas of risk, the connection and relationship with other other elements, preventative measures and methods of assessment.

The problems to assess in the preliminary stages, corresponding to the ability to maintain them or adapt them. Also added will be crucial points, critical points, interaction with other elements, measures that will need to be taken in the future.
The analysis sheet of deterioration must show;

- identifying data for the building and location
- identifying data for elements and typology
- existing damage or deterioration together with a descriptive comment
- the seriousness
- the diffusion
- the level of urgency

We will analyse the cards more fully when specifying the maintenance plan inherent for restoration.

It must be noted that guidelines also specifically address the conservation of 'surfaces of value' and the role of the restorer. They are part and parcel of the building and cannot be considered separate because they have an undeniable link to the surroundings and the building to which they belong. It's obvious that their conservation be treated differently due to their own special qualities and physical behaviour. Therefore a different standard procedure will be necessary when compiling the conservation plan. Indeed if the standard procedure for an historical building needs to be based on basic conservation principles it is clear that the objective is to maintain its component's efficiency and function over time, even in cases where they are artistically or aesthetically valuable, and may mean eventually accepting inferior performance levels. For recognised objects of art however their function is not their use but fruition. This is true unless the object of art has been created for a special use which puts its conservation at risk, at which point it is put in a museum. This is not applicable of course if it is an essential part of the building, for example a decorated wall. In addition, a 'surface of value' will have to be treated by a professional restorer using specialised and specific aims and methods completely different to those used for non artistic elements of the building. Even the problems related to works of art will be different.

To address this particular subject, a specific part of the plan was decided on to dedicate to works of art which in any case keeps in mind the interaction between surfaces of value or decorative items and other elements of the building. For artistic works, therefore, the technical manual will contain a series of specific cards:

- *an historical-technical card*, in which historical information has been collected concerning construction and conservation
- *a card on building materials and building techniques* with graphics
- *a card on restoration measures carried out* which can be adapted to non artistic elements too
- *a card on existing decay or damage*
- *a card recording damaging events,* understood to mean accidents over time to be linked with the card concerning breakdowns for architectural elements in order to make connections
- *a card on expected damage and areas of risk*

This is not the time to enter into a debate about the specific question of work of art conservation, but some of these cards will be analysed when coming to the plan of maintenance and the fact that , after restoration has been carried out, measures need to be taken on artistic elements of the building.

The Conservation Programme

This is the document which corresponds to maintenance and its actual definition, establishing the schedule required. Being based on a conservation approach and its project restraints, the essential difference here is that the maintenance plan defined by the framework law on public works is primarily of a preventative nature. This means that there are two types of interventions required; preventative maintenance (including both prevention and protection), and checks, or rather attention to monitoring. The implementation of the whole conservation project, and intrinsically, therefore, its programming, makes it not only a specific instrument when considering the historic architectural perspective, but also a research objective, or rather the starting point for a maintenance plan which aims at restoration, and requires an evaluation and reinterpretation of the project itself.

Indeed any conservation work planned is different to the traditional process of restoration in that it doesn't aim to intervene once deterioration has occurred but before it starts. In order to achieve this, it is necessary to carry out a series of preventative measures, and be continually on the lookout for tell-tale signs of decay with regular interventions to avoid leaving things to chance. Such expertise requires the ability to predict and evaluate the nature and extent of decay. The difference to restoration work, therefore, is quite clear; restoration usually entails a study of the building after (and not before) decay has set in, and entails a subsequent plan for remedy. However, if we look at maintenance work for buildings this difference is not so great. Maintenance work and restoration work have, indeed, the same role to play as conservation; that is, keeping buildings in good working order over time. What is effectively different is the starting point. Conservation plans concern buildings which are generally in a condition that can be termed 'intermediate'; not bad enough to

mean urgent restoration but not good enough to mean a simple 'touch up.' A maintenance plan coming after restoration, on the other hand, finds a building in a good state of conservation. These different starting points therefore require different approaches.

The plan envisaged starts from a definition of identified problems, and the necessary checks to carry out and subsequent maintenance. The crucial point is to establish which problems have effective relevance and therefore presuppose knowledge of the work required for the building in question. Thereafter, there follows an evaluation of how much work is acceptable; in other words, what can be done and what not. On the basis of this, preventative measures are planned. These measures fall into two categories; real preventative measures and those which are for protection. The difference is based on risk analysis criteria. Prevention is seen as all the work necessary to reduce the probability that some unforeseen event should happen, while protection is seen as reducing the consequences of such an event should it happen. Both categories concern work to be done in chronological order before such an event happens, but entail different strategies and have different impact on the building itself.

Prevention doesn't usually have an impact on the building and its materials in itself but on the regulation of its use, that is, to reduce strains on its wear and tear e.g. the adjustment of a central heating system. Such measures aim to avoid or limit any chance of deterioration, as seen, for example, in the daily cleaning of a building. Cleaning obviously aims to remove any dirt particles which if left could set in, and eventually call for restoration work and not a simple case of 'getting the cleaners in'. Once such a plan becomes part of a restoration project, it goes without saying that such regulations on use to reduce the chance of deterioration become part of the project itself. Far from being unnessary, it is essential to make sure that all is followed to the letter of the law, and updated. It is essential that, once restored, the state of conservation is maintained so that deterioration doesn't occur over time. This type of action is linked to the daily use of the building, and should be set out in detail in manuals of use.

Protection is more complicated. Generally, it means providing additional resourses for the building and its elements; structural reinforcement, coatings, new technology etc. It is obvious that such undertakings be carried out with extreme

caution as they could change the building substantially and could, in the long run, be damaging. The theory of conservation which guidelines should be based is *co-evolution*, that is, the consideration that buildings change over time, even if only slowly and partially, and acquire stratification and a history. This approach means minimum intervention only where necessary, compared to full-scale restoration. It wouldn't mean simply preventing changes that would mean a loss of materials but actually avoiding replacing elements that could still last. This is, effectively, the theoretical crux over which there has been much discussion, the relationship between maintenance and historic patrimony, and which is still yet to be agreed on. The concept of authenticity is what it is about, but this is not the time to discuss such questions now.

Research will have already been carried out before restoration takes place and will have played a vital role in the process of restoration in itself. Therefore all considerations concerning maintenance for the project will have already been set out by previous research. As far as maintenance work is concerned it should be done in such as way as to guarantee that any work done will last over time and help prevent further damage. A very interesting aspect is the evaluation of the consequences of measures taken which can change the equilibrium and produce different phenomena which were not predicted or desired. The aim of this thesis is to show that the plan is an integral part of the restoration project; the plan becomes the instrument with which to regulate and verify the work carried out during the project. The idea is that the maintenance plan is an instrument for the restoration project.

Protection measures carried out with restoration will be of two types; carried out after a problem has come about before restoration and as a post-remedy, or carried out to prevent a problem which has been deemed possible by way of preliminary studies of restoration. Checks to be planned are established on the basis of the causes which have provoked the problem with reference to situations before intervention. It is necessary to monitor the buildings evolution and its elements to determine results; it means evaluating efficiency and duration and, if measures are deemed inadequate an analysis of necessary courses to take. The monitoring of the building's evolution and its elements allows identification of those phenomena for which measures have been planned, to establish therefore suitability. Maintenance work will have the aim of maintaining effective measures taken and modify those

deemed necessary. Measures in order to correct and resolve problems which have been seen before are easier to resolve than those which are seen as potential problems. For both it is necessary to evaluate the interaction they have with the pre-existing ones and those unforeseen which could set in. For the former, there is already a font of data from pre-existing situations while for the latter there will be predictions for which they have been planned. This is a particularly important aspect for structural consolidation, especially if experimental, as in some of those foreseen for the old village of Roscigno, which constitutes this study. In these cases, therefore, it isn't easy to predict what will happen once solutions have been adopted, so monitoring becomes absolutely essential.

The question of authenticity comes up again and needs to be addressed. Should elements which have been installed and modifications produced by restoration also be conserved? Or should they be considered temporary solutions to be discarded to have no real value in terms of authenticity? It is apparent that this depends on the type of measure carried out and elements introduced. For example, some will obviously become obsolete, above all fixtures and fittings and installation systems which will be either repaired or replaced in the future, but which in any case have little importance when talking about a building's character. Others, on the other hand, may be elements which have been planned on purpose to be sacrificed in order to protect other elements, and in this case, require constant maintenance to keep up performance and will eventually need to be assessed on whether to repair them or replace them, and in what way. Others will be of a more permanent nature, even if the criteria on which they have been planned foresee their replacement with the progress of technology. These, too, are assessments that have to be made during the project but which have a consequence after intervention and which, therefore, concern the maintenance plan. Indeed, the aim of restoration measures is also to conserve the building and therefore measures adopted and their upkeep have the goal of conserving the building itself. As a result, certain considerations should be made.

From the theoretical point of view it would appear necessary to overcome the idea of authenticity as a concept based on attributing the subject as having a strong and unchangeable identity, which is not subject to evolution, and for which any modification equals degeneration. A strong identity, indeed, would not be altered with modifications carried out with attention and with respect, but would acquire

another layer, a new symbol that would become part of its history. Restoration measures, therefore, become an integral part of the building and its history, as with all other measures carried out in the past. These would be seen as more or less positive though from the point of view of the times, and therefore deemed as nothing more than yet another testimony to the building's history. Therefore, even measures are conserved, with an eventual assessment of single elements being as they are an integral part of the building and its evolution. Indeed, conservation is based on this principle of adding on layers, which goes beyond aesthetics. It is more about the preservation of knowledge, or rather the value of historical documentation, which includes all the modifications which have been carried out over the years. The question of authenticity, therefore, is assessed on the basis of the plan and project but the plan being an integral part of the project and designed to ensure project choices are seen to be efficient and lasting tends to want to conserve the building as it is once restoration is completed. The crucial point is that any maintenance must not entail substantial alterations or substitutions but instead be appreciated with the knowledge necessary at the moment of restoration.

The conservation project envisioned by certain guidelines seems to want to see conservation as something which replaces restoration, seen as a negative event. Maintenance work is therefore carried out with the minimal measures possibles. This idea has its limits because conservation work is only considered necessary when restoration is not required.

It would be far more interesting, however, to see the subject as not just that of prevention and in opposition to restoration but if anything as being integrated with restoration. It becomes necessary to define restoration in itself as a process which entails a measure and then maintenance with a conservation mentality. Therefore, when restoration is deemed necessary, it shouldn't be seen as a negative event but solely as one which, if carried out well, should be seen as positive and being part of the building's evolution and heritage, which conservation takes care of.

In order to complete the identification of maintenance measures, it is necessary to distinguish between preventative measures and protective operations (keeping in mind that the latter are usually planned during restoration), with an evaluation of the measures taken and work foreseen. With this in mind, it is

necessary to consider the building in its entirety acknowledging the possible interaction between its components, with particular attention to new elements introduced as well as foreseeing the prime causes of deterioration. In addition, there should be an assessment of specific situations and a verification of results required. An archive should be produced, therefore, with restoration as its basis, in which more and more information is provided; fundamental for the success of a maintenance plan and any restoration work. Indeed, it isn't easy to understand the effectiveness and durability of measures carried out on historical building and there is a continual need to go back and check again, and check up on a work's progress. It's absolutely essential to carry out checks, which in the case of heritage buildings takes on a central role in the programming of maintenance.

Even newly-built buildings are subject to a precise schedule when it comes to maintenance work, though they are not subject to such conservation implications as those cited here. This maintenance schedule is based on experimental data and statistics linked to durability and reliability. This is so for industrial products in general but is even more important for building works. They are indeed complex systems which are influenced by modals of realization, methods of use, the interaction between various components and the influence of the environment. If we draw attention to the heritage buildings, this is even more so for two reasons. First and foremost, there are more factors that can affect the system, not just due to a certain difficulty in establishing the modals of realization and the interaction between components (especially between those newly introduced and those which exist already) but also down to special conditions, often critical, of vulnerability to external environmental factors. Then there is the debate over what is damage in this context, something which is not easy to say when any historical building has its own character and uniqueness and which is in itself considered its treasure. This leads to the evaluation that damage repair cannot be based on shelf life or usefulness for a building of historical interest.

As has been stated before any problems or specific work concerning any one element will have been defined and developed in the technical manual. In order to make periodic inspections possible it is necessary to identify the parameters necessary to translate the work for each element into verifiable terms. For conservation this means in-depth examinations of materials in order to proceed with

the evaluation. In the case of an edited plan concerning restoration measures there needs to be a model which has been developed before and during the project which should provide all the information necessary and which provides in great detail on the situation at its start and which can be used as the basis for a programme of checks thereafter. In many cases a simple check or test is enough to take the necessary measure immediately. As a rule, any checks should follow codified and verifiable methodology with quantitave inspections of a non-destructive nature and on site. Different to empirical checks and visual inspections, checks using instruments cost and cannot be resorted to often for this very reason.

The matter concerning costs is one which is very important as if there is an attempt to keep them down, including diagnostic ones, these costs are expected and therefore less economical. If, on the other hand, the maintenance plan is included in the restoration project it is not necessarily so that there will be resources for its application. Logically, maintenance resources should be available to the building management, but it would be interesting to develop the idea that some of the funds for restoration be given for maintenance and monitoring work after measures are carried out (at least for measures which are absolutely necessary for the work to be a success). This would mean the work done would be seen as an ongoing restoration project which should continue even after such work has been seen to be completed so to speak. Indeed, the apparent undesirable costs expected for monitoring, prevention, and maintenance of a culturally important building of historical or artistic importance should be seen as well spent if considered a way to prevent any higher costs later due to a lack of such measures, which could lead to irreparable damage or loss of cultural value. To achieve this it is necessary to diagnose the anomaly rigorously with maximum interpretation of symptoms using a theoretical model which allows for other less apparent facts to come out into the open. Therefore it is necessary to activate a procedure of checks which, based on the resources available, the typology and relevance of symptoms and phenomenon evident, and the importance of the building being monitored, maximises all instruments and professional expertise necessary.

In general, in the sphere of restoration, diagnostic work for the project in question is carried out to provide the knowledge necessary to initiate measures necessary. At the same time, this has to be applied to restoration work that follows in

order to understand and study the evolutionary nature of the phenomenon. The advantage of making a diagnostic study is that it enables those concerned to know about situations before and after work begins and to be able to impose the checks necessary and interpret the results more easily. Systematic checks allow for an immediate and effective measure to be taken after the first symptoms of any damage to come, and to prevent or at least limit such damage from worsening. Such quick and effective measures, as has been highlighted, derive from a strong and solid pre-existing expertise which allows for analysis to be made with certainty and based on previous comparable models. The relationship between a diagnosis of checks and a preliminary one is clear; that the correct interpretation of checks and their results cannot be assured without preliminary knowledge and a detailed analysis. In the case of a plan which doesn't have a restoration project already available to draw on, (in other words, starting from nothing), it would be difficult for it to obtain a detailed level of knowledge necessary for successful restoration and also for reasons of economic resources at its disposal. In our case, on the other hand, there is a vast amount of information available, both quantitative and qualitative which means that even the smallest variation can be interpreted correctly. Another great advantage of this situation is that, knowing where the critical points of the building are, even the most difficult comparisons can be made easily, therefore enabling the introduction of monitoring systems in the right places, and identifying where inspections need to be made. One of the aims of monitoring is to spot unforeseen or unknown quantities.

In order that an excellent and in-depth programme of checks can be created, it is necessary to define the most suitable methods and instruments required together with relevant objectives. Such checks will therefore be of great use and have a definite aim in mind, and also cost-effective. Observing the market of diagnosis, one can see the high number of studies available, which highlights the problem of choice. First and foremost, it is necessary to choose between the simple or complicated methodologies available, but this is neither simple nor quick. Indeed, this choice should be based on an evaluation of the importance of data provided in relation to preset desired results and costs permitted. The use of sophisticated instruments does not always guarantee greater precision but rather a greater amount of data, and may make interpretation more difficult in these cases. On the other hand, in certain cases, it may be absolutely necessary to use sophisticated instruments for particular cases to

be studied or for certain phenomenon to be monitored. For example, a simple monitoring programme, if well-conducted, can produce all the results desired at low cost, whereas a monitoring programme that envisages ongoing checks may produce less, incurring high costs due to instruments, elaboration of results and the need for continual monitoring. However with ongoing monitoring it is possible to record cyclic changes in order to produce clearer data on any anomaly. In any case, the best approach seems to be to compromise between the two methods by maybe adopting a more complicated system at the start for a short period to then introduce a simpler one later.

In many cases, checks using instruments are not necessary, and in these cases inspections and empirical checks will suffice. This is particularly true when programming a series of checks after restoration. As has been stated before, any previous expertise developed before measures are carried out will have created a considerable amount of relevant data and information which can be drawn on again and again in terms of diagnosis, and often very sophisticated. On the basis of this knowledge and experience, it may be enough to plan a series of inspections in order to identify eventual problems or signs of dysfunction which could lead to more serious damage. If necessary, more sophisticated analysis can be arranged making use of instruments for restoration in order to compare results more easily. Whoever is responsible for the inspections should also make sure that the plan's prescribed maintenance measures, preventative measures and project orders be respected. Alongside this is the important figure of the user who, being the person most in contact with the building, should guarantee its conservation following the rules set out in its manuals, and should quickly alert those responsible to signs of decay etc.

Inspections should be supplied with photographs to compare at intervals decided on before, as well as others taken before or after measures have been carried out, so that evaluation can be made objectively by more people as the situation develops. To achieve this, the photographs must be standardized, indicating fixed references to be able to take the photographs from the same positions so as to have useful photographic material to draw on. Photographic methods should be indicated in the plan, especially concerning the use of digital technology or software. This should all be followed for all visual inspections, in order to overcome any

arbitrariness by the inspector, as well as for functional checks which, when possible, should be supplied with photographs.

Apart from visual inspections, there should also be empirical checks in which a series of specific operations and evaluations should be carried out by the operator at the moment of operation who should, based on his or her experience, be able to evaluate what is being examined. Whether for visual inspections or for empirical checks, the aim is nearly always to reduce costs and discomfort. The operator should record any anomaly or dysfunction and either resolve it or ask for measures to be carried out by specialised personnel. To this end it would appear in to be in everyone's interest to entrust such work to skilled professional personnel able to take the maintenance measures required by the plan directly, who should be clearly named in the plan. As with visual inspections, some empirical checks can be entrusted to the operator.

Obviously results from inspections or monitoring by instruments influence the programme of maintenance and could lead to instant modifications to checks or even the very same methods of checking, thus meaning an updating of the plan. Guidelines on this refer to the necessity to have a scientific consultant who should be contacted should there be new developments which could have procedural consequences. He or she shouldn't be a person to be involved now and again but someone who is officially named at the moment of writing the service contract to activate the programme. Indeed, it wouldn't be a bad idea to stipulate in any eventual call for tenders that such a person be named before any bid for maintenance work is considered.

Another aspect which influences and complicates the choice of methods of controls is the lack of normatives, which as far as restoration measures and the conservation of existing buildings is concerned is serious. In order to implement standard procedure of controls it is necessary to have a list of sub-divided and official reference points to guarantee quality and cost effectiveness. In terms of diagnostic studies, there are many sectors where there is no such list, but even in sectors where there is, the subject of check diagnostics is rarely touched on. A possibility is offered by the *'NorMal* Recommendation' which describes in detail characteristics and procedures but which is not an official normative reference, therefore meaning there is a vague and liberal use of it by inspectors. The *NorMal*

commission is arranging special regulations as a reference point for restoration measures with a specific section on building inspections. The existence of an official reference would help the project and ensure its quality, reducing the risk of high costs due to sophisticated checks which would not be justified or to poor attention paid to the problem of collecting data. NorMal, UNI, ISI or CEN, though not official references, need to be consulted to guarantee that the procedure chosen is correct, keeping in mind that not all analytical methods are cited. Moreover, for visual inspections or for empirical studies, no normative exists. Therefore, experience and professionalism are of extreme importance together with a detailed description of measures and methodology to be used.

The lack of normatives concerning diagnostic checks also leads to difficulty in estimating costs which, as has been stated previously, on one hand weigh heavily, while on the other are absolutely necessary in order to save money in the future, given that in order to maintain the value of any building these costs are fundamental and unavoidable. The market of diagnostic checks is still in its infancy, and lacking normatives to support it, which means that prices tend to vary greatly, both for checks in themselves and the interpretation of results. One aspect to consider is the predisposition of the building and its appliances for the safety of its users. As far as checks over a long period of time are concerned, either by instruments or inspections, and in order to evaluate costs, it must be kept in mind that any structure or appliance be permanent throughout the period of checks, or otherwise moved or prepared whenever necessary. There is a need to precisely define all relative points, above all, those concerning the safety and security of the user for whom it is important to indicate approaches to be used for intermittent checks and for the installation of useful systems of protection. These considerations for costs cannot be purely seen from an economic point of view but must take into account that a costly solution may prove the better one at the moment in which it occurs because it reduces the risk of further damage to the building in question. In the specific case of research, for any evaluation concerning inspections and maintenance of the building and its elements, there has to be a project criteria. Specific indicators must already be present, at least for the part directly concerning restoration.

Finally there is the need to state how urgently or quickly checks need to be made. This will be based on problems indicated in the technical manual, the methods

of checks chosen and assessments made case by case, the characteristics regarding the building as well as all other relevant conditions. Times to be allocated to checks is one of the most important tasks to be decided, and also the most difficult. Due to a lack of data, the extreme variety of real cases, each building's uniqueness, and the unreliability of estimates provided by the building industry for heritage buildings, it is very difficult to estimate times and frequency and thus standardize it. Times cannot be set therefore but must rely on each case taken by its own merits with its own conditions, but above all, as a result of checks themselves being made. Moreover, books available tend to consider only modern building practices, and concern themselves more with measures than with checks. Nevertheless, you can find prediction of times for the manifestation of signs open to interpretation in building maintenance manuals, which can be used to at least give some kind of indication of times to be allocated for checks, or periods during the year which are more suitable for measures on foreseen technological elements.

Guidelines limit themselves to simply providing information for maximum indications with advice on particular situations as models. They do, however, deal with three principles to use when making a programme of checks: Evaluation, flexibility, appropriateness.

Evaluation means that an initial assessment as to the seriousness of the situation needs to be stuck to, or the need to foresee how quickly the situation could worsen over time needs to made. Put into other words, are there signs that the problem will develop slowly and over a long period of time or not. In the case of the former checks can be made over time, in the case of the latter checks need to be made intensively to avoid dangerous risk of damage. It will thus be necessary to understand that if checks are made intermittently, for example less than once a season, will the seasons themselves influence these checks? This means will the data and assessments provide are erratic. Therefore, it will be necessary to make an initial study of all work to be carried out and its sensitiveness to environmental conditions in order to then have reliable data and results. There is no need to make this particular point if a preliminary study has already been made before restoration work starts. However, it needs to be emphasised that in the case of exceptional cases such as unusual meteorological conditions, earthquakes, dumping disasters, unforeseen events or accidents, intensive checks will have to be slowed down or suspended

temporarily. The indications regarding structural monitoring, which directly interests us for the case study of Rossigno, is that they were significant for periods of time which can be considered quite long, in general over eighteen months.

Less complicated and previously discussed here is the notion of *Flessibility;* that is, the idea that deadlines set at the start are subject to modifications after every inspection. So too with *appropriateness*, that is the idea that it is necessary to synchronize operations in such a way as to reduce the number of checks necessary and to minimize costs. It is stating the obvious to say that synchronization concerns both inspections and maintenance measures so as to enhance the appeal of the building (e.g. not leave scalfolding etc for too long).

The conservation programme is laid out in the programming sheet, relative to method and urgency of checks to be made, and in the inspection sheet, in which data collected during inspections are shown on the programming sheet. Above all, *the programming sheet* must show a number of items lifted from the analysis sheets concerning problems contained in the technical manual:

- identifying data for the building and location
- identifying data for elements and typology
- problems
- anticipated anomalies.
- Areas at risk
- preventive actions
- methods of verification

Here are the programming sheet's specific items:

- *norms of reference*, when there are existing choices to be made in terms of methods of verification for any requisite, o if they not, for visual inspections or empirical checks when there are summaries as to methods of working. In particular, for visual inspections/visual inspections, a photographic archive is advised for inspectors to be able to compare the present situation with that of the past.
- *Monitoring times*, established depending on the seriousness of the situation or the

risk involved and linked to environmental conditions or the element's characteristic. In certain cases, ongoing checks are envisaged. Some checks will not follow the envisioned schedule but will be affected by exceptional events.

- Specific operative procedures, each method of control is reported, supplied with how they were carried out compared to the method diagnosed or by the analysis of inspection under exam. This data enables the programming of eventual and appropriate checks to be carried out so that it is possible to assess the favourable conditions for the timing proposed. Concerning procedures, it is necessary to indicate the personnel necessary in terms of numbers and roles, and the security equipment available.

The *Inspection Sheet* serves to assess the effectiveness of measures adopted and the urgency of checks anticipated. It is the means to check the changes that the subject being tested undergoes and is able to suggest future actions when new damage or malfunctioning comes to light. It must list the following items, taken from the programming sheet:

- identifying data for the building and location
- identifying data for elements and typology
- anticipated anomalies.
- Areas at risk
- methods of verification
- norms of reference

Here are the inspection sheet's specific items;

- *result/value obtained*, or rather the results of the assessments made during the checks envisaged by the programming sheet. On the basis of the method used qualitative data will be listed, or a result to be expressed with terms or specialised language or by two choices “works/doesn't work” or in the case of precise damage “absent/present”. In the case of checks using instruments the results are generally quantitative, or rather *value obtained* depending on the instrument used.
- *Trends*, data which is compared to results during previous inspections. There are

two main situations; either there is an improvement or stability in the condition and so actions taken are seen as effective or there is a worsening in the condition at which point it is necessary to foresee other measures.

- *Measures*, indicated by the project manager on the basis of assessments and trends of process in progress. Evaluation is based on predicted planning set out on the risk card indicating the severity and urgency of damage, with a ternary classification; if there has been no worsening the programme will not undergo any changes and will continue as planned foreseeing simple variations in methods of assessment, methods of control which will be less sophisticated, in timing, to be thinned out. If, however, there has been a slight worsening in condition, posing no great risk, the programming sheet will call for measures such as intensification of checks or a modifying of evaluation methods. Finally if there is a worsening that is deemed dangerous and means the damage could threaten the element itself or elements around it, the project manager will have to show what measures are necessary to repair or limit the extent of the damage.

Both the conservation programming sheet and the sheet for the technical manual will be further analysed once the guidelines for the maintenance plan specific to the project of restoration has been prepared.

The manual of use

The manual of use is the last element of the conservation programming to be worked on, although the Framework Law on Public Works cites it as the first. Actually, the first two collect the necessary notions concerning the building and useful indications on how to keep it in a good state of conservation whereas the manual of use reworks this information in order to pursue conservation by way of correct management and ongoing care. The theoretical base for the manual is the same as for the other works for the plan and concentrate on building concepts understood as systems, the interaction between systems, management and care.

The first two concepts for the technical manual's theory have already been outlined, containing a description of the whole derived from a detailed analysis of single elements that make up the building. The technological break down is necessary for a description of individual phenomena but the an overview of the building as a whole should not be lost. The manual of use is written specifically with the user of the building in mind so the need for acute observation based on the logic of systems is of prime importance. Any notion of systems must also include the concept of time. Indeed, a building's peculiarity lies in the fact it is governed by the passing of time. Time also governs the interaction between different elements which can best be defined as the possibility that two elements interact together. The term possibility is more apt that probability in that maybe no elements will interact over long periods but then many may do so in a short period. It is these short periods that dictate the building's continuous state of change. This reasoning leads to the understanding why it is necessary to have an ongoing system of checks and an urgency when element appear that can change the building's state. Indeed it is possible to programme checks but extremely difficult to predict times and change with any certainty. The manual of use must be able to convey important information to the user so that he or she can understand the importance of continually looking out for any changes in the building's make-up. Indeed a description of the building changes with variations of time, which are irreversible and impervious, so that its description reflects the layers it has assumed through events it has lived through in its existence, or rather transformation.

The manual of use aims to introduce management logic to the building systems starting from consideration relative to the notion of oriented time. Prevention comes under its sphere, taking the building as a whole, with a series of items to be followed for its good. The central term is use, on which we need to make some considerations. Use means the what the building is commonly used for, therefore the functions it carries out. In the sphere of heritage, a building's value is not just in the function it performs but as a testimony to its past and to that of its location. Its practical use is of course still of prime importance for it is this that guarantees its survival. This means it is not enough to simply indicate for what the building is used for but also the correct ways it should be used based on what its purpose is intended to be. In the case of restoration, subsequent good management

and correct use are fundamental. Indeed, bad results after measures have been carried out are often down to a lack of the above mentioned. This is why the manual of use is so important because it outlines what is necessary for good management and correct use of its subject by the user. The adjectives 'ongoing' and 'constant' are what sets the manual apart from checks prescribed in the project which are of a temporary nature.

Parallel to the theoretical considerations that the guidelines set out for the manual of use are those set out in the Framework Law on Public Laws. The innovation of this law is that its concept of maintenance is seen as an understanding between all actions connected to programming and projecting and not as a simple cost item that shows whether maintenance has incurred greatly on the building's budget or not. This concept derives from a journey that sees it start at the programming stage and projecting stage of check procedures and measures, to then arrive at the editing of a complete project concerning the maintenance and management of the building over time and all that that requires. In the manual of use, this becomes a series of actions to be followed by the user or manager. The idea behind the manual is that it must render the user active, even if he or she does not possess the necessary skills, but who lives on a daily basis in the building and therefore can carry out ongoing checks.

In the case of cultural heritage the manual is particularly useful for the conservation and care of the building as laid out by the law. Therefore, the manual should lay out indications for management, for practicalities behind outlines, for methods of recognising and interpreting phenomena of decay, and for procedures for correct behaviour in the case of damage and breakdowns; basically all the information necessary to understand the building and its maintenance for the user and for more technical personnel and specialised firms in terms of measures to be taken. Therefore, as has been stated before, the manual contains non-technical language so that the user can feel more involved in the process of conservation. The law states that the manual should contain the following;

- a description of the building with anagraphic models
- advice and modals of use for single elements in order to avoid damage and reduce risks
- a modal to execute operations to be carried out by those involved

- indications on norms of cleanliness and on the management of equipment.

These points consist essentially in a series of technical cards.

Guidelines for the manual of use are based on the previous study (*Linee guida per la realizzazione del manuale d'uso per l'utente dei beni storico-architettonici – Guidelines to create a manual of use for users of historical and architectural heritage),* which are revised and developed. Basically, the idea is that in order to spread maintenance standard practice to workers and non-workers alike, the manual should be simple and easy to use, a real pocket-sized booklet of instruction which contains all the information deemed necessary. The first version, edited in the cited study, contained relevant information but due to the law at the time it could not promote the idea of carrying out small maintenance jobs. It simply indicated measures for correct management and the criteria for assessing worrying signs.

The subject under discussion, indeed, becomes greater. We now need to keep in mind another aspect which is making great leaps and bounds; the global service. Though the user is generally recognised as the inhabitant of the building, he or she may of course also be the manager, the owner or director, or contractor for integrated services; indeed, the global service.

This service also includes, when necessary the need for the introduction of measures. The tendency here is that more specialised persons are called in to offer a more complete service regarding maintenance, implementation and management, generally service companies. The property can organize its conservation programme in two ways; randomly or after a contract bid. The latter is the more complex but the one that is developing faster. Call for tenders are issued for conservation work to prevent and deal with decay and preserve existing materials. The norm UNI 10685 (Italian organization for standardization) has set out the following as the basis for a call for tenders;

- the monitoring and check of building
- constant fulfillment of operations that allow the prevention of decay
- the relative diagnosis of states of decay, of breakdown or anomalies found during checks
- the eventual intervention of urgent repairs.

In regards to the final form of the manual it may take on some changes, but due to the fact that it should be user-friendly in order that its users can feel involved and able to take part in the building's general evolution, the manual of use should be available in the same form. This means that it should contain the same information for the non-technical user as well as for the company or firm etc entrusted with the building's conservation in terms of its cleanliness and maintenance. The main points ensure that the user knows the building well, is supplied with a detailed list on how to treat the building well, how to avoid improper use and at the same time be able to identify anomalies, damage and decay when it arises. External persons, on the other hand, will be given instructions for what they are responsible for, technical cards and instructions for procedures to be followed for equipment. The manual should also be accompanied by a number of attachments with graphics of the building, codes for elements, documentation for certifications required and a glossary. The glossary, like the manual of use, must be printed in simple language for the layman to understand, and indispensible as a support tool with technical terms that the user needs to know.

In the light of this, the manual of use should contain information contained in other plans but organised in a different way; indeed its strength lies in the fact it is presented in a simple way, with different headings. It isn't organised into technical subdivisions as with the technical manual or in the programme of conservation but proceeds to explain actions and procedures necessary, case by case, which interested parties from different parts of the building will read. The manual should therefore contain the following paragraphs:

- introduction for the user: building as system; in which there is a brief summary to explain to the user the thinking behind the plan so as to emphasize the importance to the user of taking an interest in the interaction between the elements;
- building statistics; this is prescribed by law and picked up on by guidelines but on the basis of the sheet for risk card. In terms of graphics, photographs and location of elements there are attachments.
- Directions for the project manager; this is an interesting paragraph for the theme of this thesis; on one hand, this involves directions because it indicates measures to be taken in cases when, during the editing of the plan, there is a lack of

technology which leads to management problems. On the other, there is the information (provisions, limitations of use, regulation of systems, preventative measures) that the project manager needs to convey to the user after a recent restoration measure has been implemented. This means that, every now and again, there needs to be an update on measures, and cards are the most advisable means to do so.

- Note for intelligent use of product; the directions concern four topics; the conduction of maintenance plant, the conduction of lighting systems, the conduction of other installations, the management of the fruition of building.
- preventative actions entrusted to the user; these are preventative measures indicated by the technical manual which do not require expert knowledge. Users are instructed on conservation for evaluate costs that the user may incur.
- Improper procedures; this is important because, even with the best intentions at heart, any action taken by the user may in fact cause damage.
- Cleaning; here is contained information pertaining to correct cleaning methods that the user must employ or the cleaning service must follow (this will be stipulated in any contract signed as a guarantee)
- participation procedures for building checks for the user ; various checks to be implemented are indicated, taken from the technical manual and programme.

Finally the following will be attached to the manual;

- graphic diagrams of building, containing codes for elements
- diagram for plan of security
- the glossary.
- Card of intervention, to record relative news of modifications made on building
- certifications and manuals of equipment
- card for signs of anomalies, to indicate data and results and corresponding photographs.

Out of the three plans for conservation, the manual of use is the one which is most suitable for the publication of a maintenance plan which is specific to a restoration measure. Of particular interest is the completion of the paragraph

containing directions for the project manager in which project indications are specified in order to guarantee that they are respected.

Maintenance Plan for Restoration

Guidelines for a maintenance plan specific for restoration projects

After having studied in depth maintenance and its related problems, this thesis will propose some guidelines to build up a maintenance plan specific for restoration projects, based on the considerations expressed before and the examples given. These guidelines should indicate both the basic concepts to approach a maintenance plan combined with restoration project and the typology of instruments and documents suitable for this case. The proposal is formulated as guidelines in related to the critic moved to the concept of regulation that indicates static and univocal instruments that have to be applied indifferently to every case. This topic has instead two specificities; therefore it is impossible to define an instrument always applicable. It is more convenient to define the basic approach and the principles and then to indicate the general instruments that can be apply to the particular case.

The first specificity is about the historical architectural heritage: every single building is distinguished by its history, such as both constructive aspects and events happened, thus the main characteristic is the uniqueness of every historical building. It is obvious that there are various categories, which group the building with common characteristic in; for example: geographic area, historical period, materials, techniques, typologies, etc. However, there are still several differences and particularities between buildings grouped together, which imply a different approach. The problematic related to the single case is very specific and it could be necessary to change the structure and the contents of the plan documents. Moreover, the plan has to be flexible, regulated and adjusted on the basis of monitoring findings. What have to be fundamental are the approach and the general principles, whereas the choice of the practical aspects can be left to the designer. This consideration is related to the other specificity.

Therefore the second specificity is due to the planning of maintenance together with the restoration projects, so maintenance plan has to be based on the project. It does not mean to do not respect the theoretical approach proposed, but the practical aspects related to the drawing up, particularly about techniques, cannot be established a priori. The designer, considering the concepts and the methodology

proposed, has to adapt the documents to his work method; he has to chose and catalogue the techniques, to analysis the preliminary studies, and combine the disposable economic resources to the specific needs. However, there are several methodologies and techniques to draft a restoration project with many fresh progresses in this field. The documents proposed are due to regulation and the structure has to be necessary the same provided by the Italian Law about Public Works, even if this law does not regulate the intervention. Indeed, it is hoped to extend this habit to all the restoration projects. Single documents have to be drawn up basing on the law and adapted to the designer's methodology. At the same time, by reason of the proposal, the project has also to be adapted to the maintenance plan needs; hence designers have to modify their method of work in order to plan both the intervention and the following management: maintenance and monitoring. The interaction between project and plan is to be hoped for; it is necessary to consider the maintenance plan as an integral part of the project.

This is the first concept of the thesis proposal: restoration has to be a dynamic process, it cannot terminate with the interventions but it needs to going on during time through specific actions to maintain the good conservation state reached after the execution. In fact restoration interventions, even the ones well planned and executed, lose their efficacy because of the lack of maintenance following. On a different scale we could say that the problem is the lack of management following the restoration, so a bad management thwarts the results achieved. The thesis cannot deal with the overall heritage management that is complex and includes several aspects, from politics to economy, but can study the technical management. It needs to observe that is necessary to manage the heritage in the respect of conservation needs, thus to preserve the heritage by a correct and conscious use that allows to find founds for maintenance and monitoring; but this is not the thesis topic. The thesis proposes an instrument for the technical management of restored buildings, which in the general context of its management gives the technical information needed for a correct management, meaning the respect of the building and the restoration. An instrument accompanying the life of building after restoration the manager/user has to refer about all technical aspects, because contains project directions, indicates correct modalities of utilization and maintenance and monitoring actions needed for the building conservation.

That statement is due to a fundamental characteristic of our time: the temporariness. The contemporaneousness is characterized by a big flexibility thus the architecture is temporary, able to adapt to frequent change of use. The historical building cannot be considered temporary, as the restoration, but its use can frequently change as the modalities of utilization. During the management it is possible to use the building or a part of it in a different way than strictly decided in the project, maybe only for few times. By one hand it is the project able to respond to this requirement, by other hand maintenance plan can help management to evaluate possibilities of different use based on the technical characteristics and performances in order to a specific use. However it is difficult during planning to anticipate the use of the building many years later because of the flexibility. Also often it happens that public restorations are done because there is the necessity to spend immediately some founds but without a management plan and the utilization not defined yet. Moreover the plan evaluates the eventual decrease of performances. Thus indicates both the necessity to change and limit the use or to begin the needed actions, provided by the plan, to bring back the building to the initial condition had just after restoration.

Management following intervention is one of the reasons the restoration project has to be a process. The main reason is to increase and extend the intervention efficacy. For the conservation of the heritage it is necessary to plan maintenance and monitoring in view of keeping it in good conditions and limiting deterioration. This proposal is particularly valid if the building was under restoration that bears deeply on building. The new trend is to prefer constant little actions of maintenance then complex and deep restoration, even more, when restoration is needed, it is absolutely necessary to avoid what is not efficient because not supported by a maintenance plan. Therefore the strategy of planned conservation has the purpose to delay the necessity of restoration keeping constant building conservation state, thus its application is suitable for a building that is in a good state after restoration.

Indeed the intervention efficacy decreases during time because of lack of appropriate measures, especially related to the aspects it was impossible to intervene on. Restoration generally resolves problems but cannot intervene on external causes, like environmental or also anthropic ones. Hence the monitoring is fundamental, particularly for the areas subjected to the causes individuated during restoration, to

prevent inducted phenomenon or to reduce the effect through maintenance. If causes were anthropic the maintenance plan should let to control or prevent the effects, becoming an instrument to control the effective respect of project directions. Maintenance is useful also for all the others interventions done. Measures adopted and solutions utilised will need to be maintained in a state that guarantee the efficacy and the functioning. Generally it is probable that the action is protective, destined to defend the building and its elements, so deteriorating faster e needing constant care. Moreover technical systems have to be maintained to extend their length and especially to avoid deterioration that can cause damages to building or to contiguous elements.

The meaning of the restoration as a process is due to keep of the efficacy but also to the evaluate it. This aspect is particularly relevant because it is difficult to be sure long term that the intervention is efficient. Restoration modifies the equilibrium the building has reached during time by the adapting of the elements to the respective transformations. The effects can be unforeseeable after several years and maybe could point out the intervention unfairness, as happened in the past. For example the insertion of a reinforced concrete girder that was illustrated by literature thirty years ago and now is strongly not suggested. So the importance is also related to the use of innovative techniques that need to be monitored to evaluate the effective efficacy. Controls have to be directed both to techniques and to their interaction with the building. Also for the secure intervention, related to uniqueness and particularity of every historical building it is possible that there are phenomenons to be controlled. This is true for all the elements, also for the ones that interact only potentially with the existing elements.

The evaluation of intervention efficacy after its realization is absolutely necessary also regarding materials utilized and their interactions with the ones proper of the building. And what is more, restoration cannot be considered concluded with the intervention. It is obvious that also in this case project choices are motivated; the choice of a material instead of another one is based on is fairness. But it is possible that the choice was motivated for different needs, for example aesthetic or formal reasons, so the conscious choice of a material not completely suitable is balanced by planned maintenance and monitoring. It is also true that in several cases there are not experimental information about some materials, especially if was innovative one. For example the utilization of FRP could provoke interaction problems, or resins and

glues could trigger off slow chemical reactions the effects will see only in the future. Despite materials are tested in labs before to be put in the market and utilized, the particularity of every historical building and of specific environmental conditions can provoke unforeseeable phenomenon. By the way the progress about materials and techniques is necessary to find innovative solutions very efficient, thus it needs controls to evaluate and to verify the results and maybe to correct, especially for experimental interventions. Restoration as a process gives this possibility.

Then it needs to consider the possibility of events that can provoke phenomenon and problems thwarting restoration. It is impossible to foresee all the possible events and not every event has big effects to be considered during project. But in the case of historical heritage even the events that seem non-relevant can cause big problems because of the delicacy and the vulnerability of the historical context. It is needs to operate opportunely through monitoring and maintenance to reduce the risk of damage and activate procedure to respond to determinate events, expected or not. Timeliness of intervention is fundamental and is the main difference between maintenance on new or historical buildings. In fact in the first case it is possible to estimate for certain the durability of components and is also possible to intervene to damages already happened. Instead in the case of historical building it is very difficult to estimate durability of components and restoration intervention thus it is necessary to plan monitoring. Moreover it is not acceptable to intervene on occurred breakdown because it can provoke irreparable damages. The characteristic of historical heritage is its uniqueness and its un-reproducibility, so it is impossible to change a damaged element, unless it is absolutely necessary in order to preserve the whole building. Timeliness has to regard also the effects of the restoration, the modifications introduced following, the interpretation of monitoring and the evaluation of planned maintenance operations.

Finally it needs to consider all the interventions that not conclude with the realization but going on. In fact there are several typologies of interventions that needs following regulations or operations and controls. Typically it is about monitoring equipment installed to give information about the building or its components after intervention, but not only. This category includes project solutions that needs following regulations, directly or not. For example in the case of structural consolidation the dynamic tie rods inserted have to be regulate during time related to stress are subjected to or provoke to the structure that adapt modifying itself,

generally becoming strained. But it can also be about indirect regulations due to the change inducted by the restoration or others factors. For example air-conditioning or dehumidification systems installed to obtain a thermo-hygrometical condition that can be modified dependent upon obtained results, the new equilibrium of the building, following modifies, or also season cycle. It is clear that in such situations it needs to plan also the following management that is part of the project but come true after, during the execution of the maintenance plan.

For all this reason the thesis proposal is to consider the maintenance plan as a relevant part of restoration project that has to be a process. The logic is based on the fact that the purpose is the conservation of the building, and at a larger scale of the historical heritage. In fact if the restoration aim is the building conservation it will be implied the non-conclusion of conservation process with the intervention, instead it will be necessary and fundamental to plan all the measure to keep conditions reached by restoration. This concept enables to reach two purposes: to increase and to evaluate the efficacy and the length of restoration and consequently to maintain a good state of conservation, delaying the necessity of a further restoration. Moreover it is possible to positively influence the following management of the restored good, giving to the manager/user an instrument that allows to make choices according with the conservation needs and to refer to a technical responsible: the designer. Restoration as a process implies also the definition of this figure, because the planner does not abandon the building but going on to follow it. This topic is very relevant when maintenance is externalised to a society of global service. In parallel in the case the manager coincide to the user, generally when the historical building is a home, the user is directly implicated in the conservation and become conscious of the importance both of the conservation process and his own role.

Looking at the heritage results could be notable, especially for non-monumental buildings generally uncared for. Instead this part of the heritage, that is the biggest one, needs more attention. The cultural values handed down by the historical built in its complex, like historical centres, are very important, maybe more than the ones handed down by the monument, because characterizes the way of living of a society in an historical period but at the same time is the evidence of all the occurred stratification. The lack of attention provoked several alterations that deeply damaged it and in parallel the lack of founds makes its conservation more difficult. The cost of maintenance and monitoring is anticipate, so often not accepted,

but makes possible to avoid heavy damages that needs very expansive interventions and thus are not economical sustainable for the historical “minor” heritage. So to preserve the historical architectural heritage it needs to plan maintenance and monitoring both not related to restoration and especially as part of intervention, thus that restoration become a conservation process.

The second concept is that the maintenance plan for restoration project has to be necessarily founded on is the conservation. The plan approach has to be conservative, meaning to keep efficiency, functioning and length of the building, its components and of the restoration, but also and especially to guarantee the material permanence of all the elements and materials. This aspect is the main difference between planned maintenance on new building and on the historical heritage.

In fact in the first case the basic logic is that a component that is not more able to keep its functioning and the relative performances needed have to be changed with a new same or analogous element. This logic become from industrial maintenance and is suitable for technological elements, generally technical systems. It could be applied to new constructions because the only requirement to be satisfied is the functioning of building and components. The value of the component depends only by the performances given and decays if they damaged. Thus the economic value of the whole building decreases and it is necessary to re-establish function and performances, removing the damaged element. As a result of this logic it is possible to hypothesize to intervene on several elements after damage occurred, because the loss of the element is not a problem. Despite the element is designed to satisfy determinate performances for some time, that can be estimate, and after the end of its life cycle it has to be changed. Moreover could be economically favourable to wait the element deterioration and then change it instead to preserve it, because its value depends only by functioning and not by its material permanence. It is also obvious that the aim of maintenance directed to new buildings is not only to change elements but to do some actions to prevent damages and extend life cycle too. The role of a new building is to carry on a function so the main aim of maintenance is to keep the functionality of the building and its parts.

Instead if the object of maintenance was an historical building this logic will cannot be applied. This approach is not correct for historical heritage so maintenance could not be more advantageous and the results could be negative. In fact the value

of an historical building is related to its material permanence, as a whole but also to all its elements, unless that does not compromise the building conservation. The characteristic of historical heritage is the cultural value, instead the economic and use value are less important. The cultural value is related to authenticity and integrity and decrease when the building suffered alterations. In spite of globalisation and cultural differences there are different meaning of authenticity, Nara Congress in 1994 is an example, in our society and culture authenticity is due to material permanence, thus it is so considered in the thesis. Different value scale imply that is not possible doing maintenance by the substitution of elements not more able to satisfy determinate performances. Also it is impossible to operate on occurred damages, because the element loss is not allowed. It does not exist any way to change the damaged element with another one equal or analogous even if the function and the look were the same. Historical building elements are unique and not reproducible because characterised by their history, they represent all the stratifications and testify the cultural value that is related to their material permanence. This is their main role. By the way it obvious that they have also to do the function they were designed to and that it is necessary to make them going on doing that function in the future. So the aim of maintenance is to keep both function and material permanence that is the priority. Those considerations oblige to reconsider maintenance when is directed to historical heritage. In fact the main function of an historical building is not merely material but mainly cultural thus the purpose is different: to guarantee the conservation.

That conservative logic is due to the aim of planned maintenance of the heritage that is the material permanence, therefore some general concepts of maintenance are not suitable and actions are completely different. In building definition of maintenance and application limits are clear and referred only to performances, not to material permanence. This is not acceptable in the field of historical heritage. If the aim was different the requirements to satisfy and the evaluation parameters will have to be different too. Thus the approach and the methodologies and procedures proposed are deeply different. The Italian Law about Public Works is the main reference to draw up maintenance plan, so procedures and documents have to be based on the ones provided by the law, but they need to be adapted.

The approach based on performance implies that a minimum performance level is required to the element. So the regulation based on performances and

requirements [normative esigenziale-prestazionale] in spite of describes the characteristics (physical, chemical, technological, morphological and performances) examines the behaviour related to the function. This approach allows objectively evaluating the qualities of an element related to its needs, defining the requirements to satisfy. It is necessary to establish performances, that are the answer to the requirements that the object has to be able to give, and a minimum level that allow the functioning. This methodology is correct to plan new elements because provide parameters to choose materials, constructive techniques and technological solutions. In parallel during the project it is possible to hypothesize the element life cycle thus evaluates the durability related to the performances needed.

This approach is not correct for the heritage. In fact it is extremely difficult to establish the performances of elements already installed, because there are several incognitos difficult to evaluate. Moreover because of the peculiarity of the historical building it is possible that several elements seem not able to satisfy requirements even if they are able to. This aspect is due both to their handcraft and to changes and deformations took place. The difficulty of evaluation is bigger than for standardised elements, designed ad hoc with the help of technology and controlled from construction to installation, like the new building. Consequently the application of this approach implies the substitution of all the elements not able to satisfy required performances. But the satisfaction of performances is subordinated to the material permanence: it is the element, not the performance that has to be preserved. So it is clear the complete unfairness of this approach to the heritage.

If the aim is the conservation it will need to begin from the performances the element is able to satisfy, and not from those ones that have to be satisfy a priori, analysing and adjust them to the use needed. Thus it is necessary to abandon an approach based only on performances, while at the same time an approach based only on descriptions is not correct. The heritage cannot only be contemplated, its function and use, if compatible, are the best guaranty for its conservation. To reach this purpose it is mandatory to adapt the methodology of performance evaluation combining element characteristics, especially conservation state, with the use. Consequently the proposal is to indicate requirements and risks: to combine the requirements related to a specific utilization with the relative risks regarding the conservation. In fact the attribution a priori of requirements to historical elements does not consider the problems of its conservation, because requirement is the same

for elements doing the same function but having different conservation states. It is more convenient not to assign requirements a priori but to define and to analyse problems related to specific element characteristics adopting a logic based on performances and considering at the same time the differences of manufactures.

These considerations came from the conservative approach proposed by the Guidelines for the Planned Conservation of the heritage provided by Regione Lombardi. It is necessary to examine closely because our case is quite different. Lombardia guidelines are about maintenance plan disjointed from restoration, thus indicate measures directed to guarantee the conservation through limitations or changes of the use. In the case of restoration those measures have already been considered during the project that selected the right building utilization related to its effective possibilities. Restoration increases performance up to a limit exceeding it the building could be altered irremediably and looses its cultural value. Unfortunately this auspice is not respected always, but the thesis cannot deal with this topic. The starting point is that project choices are considered valid and that the plan purpose is to keep as long as possible the performance level reached by the project. The utilization decided by the project is considered appropriate and respectful of the building and according to conservation needs. It is necessary to evaluate how long the building can be able to support that function and which step takes in order to allow the building going on doing it as long as possible.

The attention has to be pointed on the fact that the performances building and its elements are able to satisfy correspond to their conservation state: an element was brought back by restoration to a state that allows the function was designed for. There are two kind of actions needed: controls to evaluate the conservation state, thus its correspondence to determinate performances; operations to keep the conservation state. Therefore the conservative approach is needed because the object to evaluate is the conservation state and not the performances that are a consequence of it. That evaluation is obtained through controls and establishes the actions to plan. Only in some particular case, when it is no possible to maintain or to bring back the conservation state to the level reached with the restoration, the negative evaluation implies solutions like the ones provided by Lombardia Guidelines: to change or to limit the use.

The unfairness of the approach based on performances, usually utilised for maintenance planning, is due to the inapplicability of the main concept it is based on: the useful life cycle *[ciclo di vita utile]*. The New Italian Technical Regulations 2008 defines nominal life *[vita nominale]*, (that is the same of useful life *[vita utile]*) as: *numbers of years which a structure has to be able to work, on condition that is subjected to a routine maintenance [il numero di anni nel quale la struttura, purchè soggetta alla manutenione ordinaria, deve poter essere usata per lo scopo al quale è destinata]*. This definition makes sense if the role of the building was merely functional. Instead if the purpose was cultural, thus the main function is to keep transmitting cultural value, the number of years should be infinite. Therefore the useful life of an historical building that is characterised by cultural values cannot decay during time just related to this characteristic. If its role was to keep transmitting its cultural value it will have to continue to exist, to be authentic and integral, made by the same materials and elements. The expression life cycle assumes that it will be a moment the element utility ends up, but this is unallowable. So maintenance has to be stated to extend the useful life of the buildings and its element starting from the concept that the utility is not related to its functionality but mainly to its permanence, thus it cannot decay and the measures provided have the aim to keep living the element, to guarantee its material permanence.

The utility of the historical heritage is a "cultural utility", but in parallel it needs to consider that historical buildings have a function too, related to the use were designed for or adapted during their life. It is not possible to release the cultural value of an historical building from its function, or several functions like in the majority of cases, guest during their life, that is a testimony such as its constructive, material and artistic characteristics. This aspect becomes very relevant in case of restoration. In fact the restoration project generally has the aim both to preserve the building and to allow that it is able to guest a function, that can be the same or not that the one had before. Thus during the design the requirements the building and its elements have to satisfy were already established. Maintenance plan, moving from those requirements, individuates possible risks and provides activities of maintenance and monitoring needed to keep the project requirements during time and to limit risks. Conservative approach implies that performances have to be evaluated considering building conservation conditions. At the same time elements are subjected to different regulations expressed by criteria about performance. Some

regulations have to be respected because are absolutely necessary to the building survival, for examples about fire-fighting or static security related to seismic risks; others are less important and can be considered related to the peculiarity of the heritage. Anyway it is possible to suppose a not complete correspondence and to evaluate a maximum reachable level.

That maximum level has to be established related to element conservation needs, so it is the maximum level reachable by an element that persists and maintains its historical characteristics. Because this aspect has been evaluated during the design the performances obtained are the maximum ones reachable. Following maintenance has to keep this maximum level, but by the times it is possible that that level decreases. So performances have to be evaluated because their natural decline, even if contested by maintenance, could make the building no more suitable for its function. It will need to intervene directly on the building or elements planning interventions or indirectly limiting the use or reducing stresses. It should be hoped for that regulations, provided for new buildings, consider heritage peculiarities and conservation needs. In fact there are not specific regulations about maintenance of historical heritage, and all the others regulations are based on current standards too. Instead it is necessary to accept that an historical building cannot and do not have to necessary completely attend to regulations, because standards was built cannot be the same as current ones. The role of the maintenance plan is also to provide for the possibility of a not complete correspondence to current standards or to project standard after several years too. Thus it have to contain both the directions about how to reach they again, when is possible, and the needed limitation, if was not possible. Also that consideration demonstrates the necessity that restoration becomes a process and that maintenance plan has to be considered as an integral part of it. At the same time it demonstrates that an approach based on performances, evaluated in the basis of current standards, is unfair and that it is necessary to reconsider it in order to the conservation of the historical architectural heritage.

The approach to the maintenance plan coupled with interventions of restoration, conservation or strengthening, have to be based on those two principles. So the actions to plan are constant controls and maintenance operations, in order to preserve the building and to complete or to correct the interventions done. The purposes of controls are both the monitoring of conservation state, thus the

recognition of eventual deteriorations or damages and relative reasons, and the evaluation of the effective restoration efficacy and its interaction with the existent elements. Maintenance operations are based on the restoration done and on the following directions to keep its efficacy and to preserve the all the elements, even if they are not directly interested by restoration that anyway influenced them too. Especially maintenance operations have to be planned related to monitoring results and their purpose is also to correct the intervention. To put in practice those principles it is necessary to define which strategies, methodologies and typologies of actions are correct for the purpose. Moreover it is fundamental, in order to make maintenance plan an integral part of the project, to define how those two phases interacts between them.

First step is to analyse and establish the characteristics of the building and all its elements related to the specific use it was restored for. It needs to individuate the requirements and the relative risks for conservation in order to establish the parameters needed for the plan. For this reason it is necessary to do an analysis of the building and its elements that allows translating operatively the concepts proposed. In fact one of the aspects that make the plan provided by the law inapplicable to historical buildings is the approach based on performances, thus it is better an approach the combine performances and risks. For this reason the object of the analysis cannot be the performance but has to be the element, its technical, material and constructive characteristics, its conservation state, related to its role respect to the whole building. It needs to preserve the element and it has to be guaranteed its material permanence, not the performance. By the conservation of the element in a good state depend the keeping of the performance level needed for the conservation of the whole building. The basic concept is that performance a priori do not have to be required to the element, instead it has to be individuated the performances that the element can have.

To establish the performances the element is able to satisfy and the relative risks to its conservation it needs to do a descriptive analysis. The element performances satisfy the project requirements thus coincide to its conservation state after restoration. The analysis has to be about each element and at the same time regarding the whole building, thus the main aspect is the connection between different elements. The performance of a single element is functional to the global

behaviour of the building and at the same time is depending on that. So the analysis has to describe for each element not only the materials, techniques, static behaviour and conservation state, but its role in the building too, thus its connections and the effects that gives and receives to the others elements. In particular, about elements having a structural role, are exactly the connections that mainly influence their behaviour and that are subjected to deterioration. So all the connection have to be analysed too. Moreover this aspect will be very important if the element was inserted during restoration.

All those information can be found in the project therefore it needs only to collect and to catalogue them. The information has to be updated after the intervention as effectively built and collected in a specific document: the scientific report that becomes a part of the maintenance plan. Drawing up the "consuntivo scientifico" it is possible to have all the information about element characteristics and project requirements, to collect all information about restoration done, both about global and punctual interventions that are object of maintenance plan as the elements. The consuntivo has to collect also all the information about the previous state of the building thus it is possible to compare building state before and after restoration and evaluate following trend and intervention efficacy, thus evaluate possible anomalies and risks. The comparison allows to make previsions less uncertain and more efficient and especially to individuate areas and elements that could be more subjected to risks. Thus it is possible to point controls to the risk areas and to better evaluate monitoring results.

Before to do the descriptive analysis it needs to disassemble the building in elements *[scomposizione tecnologica]*. It is not necessary to give directions about that because it seems to be a foregone conclusion that it is opportune to begin from the one done to restoration. The individuation of the element through alphanumerical code is made for the survey, then utilized as a grid to interpret the others specific readings and to individuate project actions, and has to be used to draw up the maintenance plan too. At the same time it needs to point out the building elements rapports *[rapporti edilizi]*, fundamental to describe the relations characterising building system, especially in case of strengthening and a-seismic improvement that will be analysed in the case study. The project provides all the information needed for the maintenance and monitoring directed to the interventions done, the evaluation and eventually the completing.

In the basis of characteristics, requirements and risks individuated for the elements, connections and interventions it can be defined the expected anomalies and the risk areas where anomalies are expected. Maintenance and monitoring are established related to that prevision. The definition of anomalies expected and risk areas is based on the restoration project, considering the causes that made the intervention necessary, especially the ones the project could not intervene directly and that maybe can provoke again problems. In parallel it needs to do previsions about the natural ageing of materials. Risk areas generally coincide with the weak points of the building due to its own constructive lexicon and usually are the areas interested by the restoration, for example the connections. Having available all the information about building before and after restoration, knowing the causes the restoration was necessary and its purposes, it is possible to individuate the performance requirements necessary and obtained by the intervention, the risk factors related to the function, thus the expected anomalies.

In addition to that information it is opportune to describe the modalities of the preliminary analysis done before the restoration. To evaluate the efficacy of restoration and to interpret the monitoring results it is fundamental to know the conditions of the building before the intervention. For this reason it is very important to report the methodology, the instruments and the parameters used for the preliminary analysis. To have its results and to know how they have been obtained allows having a term of comparison to evaluate and understand the result of monitoring, that it will be very useful if the controls are the same kind. The comparison between the data before restoration, immediately following and the ones obtained during the plan execution, makes possible to find anomalies opportunely and to make previsions more reliable.

As told before the form to collect and to catalogue the information depends by the methodology used for the project. Usually the documents constituting maintenance plan are cards. The choice about the structure of cards, or other typologies of data collecting, is left to the designer related to its own work method. It is necessary to stress that maintenance plan has to be an informational system able to be updated. The informational system has to contain all the information needed, referring to project documents, draws, schemes and pictures. The description of the elements has to be complete and not necessarily synthetic, instead the documents to bring to the building to register the monitoring results and the maintenance actions

done have to be synthetic. Those documents have to be cards, drawn up like the cards used for expeditious surveys. The data collected will be catalogued and added to the previous information, updating the plan. Maintenance and monitoring are defined related to the descriptive analysis about the elements.

It needs to establish which activities have to be planned related to the element characteristic, but methodologically before it is necessary to choose the strategy. First question is: which strategy of maintenance is suitable to be applied in this specific case? To answer to this question and to establish which strategy chooses and which methodologies prefer it needs to have cleared the purposes of maintenance and the necessities to respect. Mainly purposes are due to conservation, thus the aim is to keep the conservation state reached by restoration of the building and all its elements, guaranteeing their material permanence. On other aim, in parallel and contributing to the previous, is to guarantee or to improve the restoration efficacy and to correct eventual negative effects. Secondly purposes are due to the functioning of the building and its elements. Secondly does not mean that this aim is less important, but it confirms the priority of the material permanence of the elements, even to the detriment of their performances. A distinction must be made between elements, because for some of them the first aim is to keep their functioning. Mainly it is about technological systems, especially those ones to reach specific environmental conditions and those ones the deterioration can provoke damages to the building. To this category belong also the elements inserted by the restoration to do a specific function of protection to the building and its elements and the equipment installed for the monitoring. But the elements more interesting their functioning upkeep is fundamental and contributes with determination to the building conservation are the structural elements. For these elements the two purposes are superimposed.

For this reason the interventions of structural strengthening and a-seismic improvement are the most interesting to analyse and to plan maintenance and monitoring, thus the applicative example will be about this topic. Usually maintenance, both that one directed to new buildings and that one preventive planned to the heritage, regards the building elements, to keep their functioning and their performances or their conservation state. Instead in the thesis topic maintenance and monitoring are directed also to the interactions between existing elements and those

ones inserted by restoration and the restoration itself. In fact maintenance will be directed both to the upkeep of the conservation state of the elements after restoration and to the techniques and solutions adopted, the evaluation of their realization and their efficacy, their eventual completing or regulation. In the specific case of strengthening and a-seismic improvement it needs to carefully evaluate the efficacy of the project and it will need to control the following building behaviour if the static scheme or the constraint conditions have been modified.

In addition to these specific purposes it needs to consider the general aims of maintenance: the efficacy of the planned activities, the effective possibility to do them, the security, and the economic sustainability, meant also as economic advantage obtainable compared to the cost in advance. All these different purposes can be reached planning maintenance activities with different complementary aims: prevention, care or completing. The achievement of a good result is due to the choice of the correct strategy and methodologies.

The necessities have to be satisfied are due to conservation and are the fundamental difference between general maintenance and its specific application to the historical heritage. Synthetically it becomes imperative to avoid substitutions, or to limit when it is absolutely necessary. Operatively it needs to prevent damages or deterioration irreversible that can provoke the loss of the element. On two different scales both the single elements and the whole building has to be evaluated, thus if the aim was the conservation of the building but maintenance operates on its elements, it will be clear that the conservation of a single element can damage the conservation of the whole building, and therefore the building has to have the priority. This aspect confirms the necessity to abandon an approach based on performance in advantage to a conservative approach. Conservation needs reduce the possibility of choice both about the strategy, because it needs to prevent irreversible damages, and the methodologies, that are the techniques to use for the maintenance. Moreover they imply that it is necessary to be able to intervene at the right time, thus constant monitoring has to be set up to take under control the conservation state and the risk factors. The conservation necessities can also imply the choice of indirect actions of prevention, like limitations or change of the use or the reduction of stresses.

After the definition of the purposes and the necessities it needs to evaluate which strategy choose, that influences the programming. The main maintenance strategies are four and they differ in their timing. Already stated that the maintenance

on occurred damages has to be excluded because not applicable in the historical context, the analysis has to be reduced to the other three ones: preventive of threshold, preventive by condition and by opportunity.

Preventive-predictive threshold maintenance: a strategy based on preventive maintenance actions to do on fixed-terms on the basis of expected natural ageing; it depends by the possibility of evaluation for certain the durability and the probability of damages.

Preventive maintenance condition-based: is constituted by operation of preventive maintenance following the knowledge about durability and life-cycle related to monitoring results; on the basis of monitoring results it is possible to modify the operations planned and their frequency, thus the real object of the scheduling is the monitoring itself from which depends maintenance.

Opportunity maintenance: can be defined as the whole operations done in advance on the occasion of opportunities that allow to attribute to one other cause their convenience; the aim is to exploit installations and resources already mobilized for others interventions or to seize the opportunity given by a sudden necessity of intervention on others parts of the building.

To understand which of these strategies is more suitable it is necessary to consider the provisional capacity. In fact it is difficult to evaluate both the durability of historical elements already installed and the interaction between new elements introduced by restoration and the existent ones. Moreover it is difficult to evaluate the effective results both of the restoration, especially regarding intervention characterised by innovative and experimental techniques, and of the maintenance actions. The insertion of technological system inside buildings not designed to contain them can provoke phenomenon that has to be monitored and that can imply subsequent regulations. Considering also the peculiarity of every single historical building and the specific environmental conditions the prevision is very difficult and uncertain. It needs to plan monitoring to evaluate these parameters and establish the necessity to intervene. Related to these considerations the strategy that is more suited for the specific case is the maintenance by condition. This strategy is based on the planning of monitoring to obtain results necessary to the definition and planning of maintenance actions.

The strategy of maintenance by condition can be divided in four different kind of interventions related to the timing, such as sub-strategies, derived by the

industrial maintenance but applicable to building maintenance too. These types of intervention of maintenance by condition were already discussed before, thus they will be briefly quoted and commented. *Time directed*, to prevent bad functioning; it is suited to technical systems and it is difficult to apply in the historical context. *Conduction directed*, based on monitoring results; it is particularly suitable for the heritage because allows to recognize opportunely the anomalies and to intervene rapidly. *Failure finding*, to discover bad functioning through preventive activities; it is right too. *Run to failure*, despite the recognition of the anomalies it voluntary waits the damage; it is not applicable to the heritage.

Therefore it is clear that it is mandatory to choose the interventions conduction directed and failure finding, combined related to the specific element and some considerations about efficiency, costs, applicability and conservation necessities. For some elements it is difficult to make previsions and it needs to intervene directly, like monitoring equipment, it could be possible to provide for intervention time directed. The strategy of maintenance by conditions depends by the monitoring results, but they will be neither immediate nor estimable in advance during the drawing up of the plan, thus it needs to couple this strategy with that one of preventive maintenance, at least for the initial phases.

This strategy will be used for all the elements and for all the intervention techniques; it is possible to exactly evaluate the durability and the problems related to the interaction with others elements. Therefore constant fixed-term activities will be planned, such as those relative to technical systems or protective treatments for material to be repeated quite frequently or cleaning operations. Generally this strategy can be used for all the element and techniques there is an historical survey available, but considering the peculiarity and uniqueness of every historical building. Anyway in the initial phases it is opportune to plan this strategy for all the elements, coupling maintenance actions with controls to improve and reschedule the frequency, thus moving to the strategy of maintenance by conditions.

The necessity to make use of this combination of strategies is due to the fact that is not possible to risk irreversible damages thus it needs preventive maintenance. Moreover regarding restoration interventions is related to the fact that the first period of life is very delicate and often anomalies can occur, due to execution or manufacturing defects, thus the initial death rate is always greater than that one checkable during the normal running. Thus to avoid the possibilities that breakdowns

happen and provoke irreversible damages it needs to plan several preventive activities that can relieve anomalies or bad functioning not always checkable or even preceding controls initially scheduled. Moreover maintenance actions and controls can coincide, for example the reading of stress of a tie rod through a dynamometric spanner and its eventual regulation is the same operation.

The necessity to schedule different activities of maintenance and monitoring, that sometimes can coincide or more frequently crowd, by one hand is a problem by other hand give the opportunity to concentrate them to optimise costs and times. Doing some operations could provoke inconveniences to the normal activity of building and requires security measures the fruition of the building cannot be allowed. Moreover the presence of determinate equipments, like the scaffolding, and human resources have to be exploited to optimise costs that are the main obstacle to the diffusion of maintenance. This is the strategy of opportunity maintenance and it needs to be utilised every time it is possible. Especially it needs to plan that during controls, especially about sensible elements, it could be possible to intervene immediately or to do another operation compatible with the others activities planned. It needs to evaluate the activities and the human resources needed in order to modify the timing of interventions to optimise them, foreseeing the flexibility but always anticipating an activity to exploit the opportunity and never the contrary. This strategy in fact is generally valid for every kind of maintenance, but in the specific case of the heritage the timing has to be evaluated with particular care.

In parallel to the adoption of this combination of strategies it has to be stressed that it is absolutely necessary to eliminate the distinction between routine and extraordinary maintenance and to consider only planned maintenance, apart from the size. To go over this classical distinction that normally is used for the contracts the best solution seems to be the assignment of maintenance service to a specialised global services society. The choice will be done not only based on the best offer but on the qualifies of the enterprise, due to the delicateness and particularities of the historical context. For this reason the designer, that draw up both the project and the maintenance plan, could a scientific referent.

Making use of this combination of strategies and according the descriptive analysis of the elements it is possible to establish the maintenance activities to plan. Single activities are planned related to the solutions adopted by the restoration

project and the characteristic of the elements. Maintenance activities are mainly of two kinds: preventive, directed to prevent eventual problems, and curative, thus directed to correct the problems occurred. Preventive maintenance is established related to the previsions about the supposed natural ageing and about the expected anomalies. There are two kinds of operations of preventive maintenance: those ones real preventive, like protective treatments on materials or the decisions about limitation of use; those ones protective, typically the insertion of element to sacrifice to preserve the others elements. Generally preventive protective activities are measures already established by the restoration project and maintenance and monitoring have to be planned to keep them efficient and to evaluate their efficacy. Instead curative maintenance is due to the anomalies relieved by controls and its scheduling depends by monitoring results.

Those two typologies of activities are fit to the maintenance of the restoration too, so when regarding directly the interventions done. In some specific cases to curative and preventive maintenance has to be added the completing maintenance. Those are all the activities strictly regarding to intervention, or a specific part of it, that cannot be completed during restoration or that needs following proceedings. For this kind of maintenance it needs to define methodologies and evaluation criteria already during the project, thus the project has to contain all the information about. In this case too it is clear that it is necessary the control by the designer, that knows all the intervention problems and the requirements.

This figure is fundamental for the activities of corrective maintenance, directed to correct eventual negative effects relieved by controls due to both restoration and maintenance. These kinds of activities are specific for the maintenance plan coupled with restoration, because related to the aim of the evaluation of the effective efficacy of the intervention done. If the intervention was not efficacy or lose it, it will need to correct it.

A fundamental aspect is that the plan has to contain all the detailed instructions to the execution of maintenance and monitoring activities. Activities have to be described through all the documents needed, arriving to a real project. It is clear that the level of detail is related to the complexity and risks related to the activity. Anyway it has to be indicated all the project directions, modalities of execution, instrument needed, including qualifies required to workers. Characteristics

and uniqueness of the heritage implies that activities are very heterogeneous and not standardised, unlike the maintenance planned t new buildings. After the conclusion of each intervention it needs to collect and to catalogue all the information about and to update the plan. Especially for the completing maintenance and generally for the complex activities it has to be drawn up document collect all the information about the execution, the previous and the following state, the needed maintenance and monitoring: a real consuntivo of the intervention done.

Also the instructions and the modalities of execution and result collecting regarding planned controls have to be described with full particulars, especially about those ones the role that makes the survey is fundamental. About instrumental monitoring it needs to indicate instruments, relative instructions and evaluation parameters, based to preliminary analysis carried out before the restoration. It can be useful to utilise NorMal regulation that is the only regulative reference, in spite is voluntary, available about monitoring of historical buildings. Visual controls have to be supported by pictures to make possible the comparison between previous and following controls and to make possible to verify the results by others experts too. About empiric operations it needs to be indicated the right and complete development of activities and the sequence. The activities of maintenance and control delegated to the user have to be illustrated utilising non-technical words and furnished with a glossary of the terms the use is absolutely necessary.

Starting from the consideration about the strategy and the activities to plan it is clears that controls are an integral and relevant part of the plan that contain a real project of monitoring. The periodical monitoring of the building is the main instrument for a conscious conservation. In fact the deep knowledge of the building is essential to plan a correct and efficient maintenance. It is necessary to know not only the conservation state of the building but also its historical, material and mechanical characteristics that are its lexicon. Planning maintenance coupled with restoration there is the advantage to have the complete and deep knowledge of the building, both regarding its state before and after restoration, thus is possible to make a comparison too. This starting point is very good and allows evaluating the conservation state, the requirements, and the risks for conservation related to the specific use and requirements. Moreover the comparison between the state before and after restoration gives many information about the causes of occurred phenomenon, the critical areas of the building, the efficacy of interventions done and

their evolution, thus there is a further parameter to evaluate the building evolution after restoration.

This evaluation is the main purpose of monitoring. In fact the planning of the activities is related to the effective conservation state of the building at the moment that is very difficult to foresee. The timing and the frequency of preventive and completing maintenance can be expected, instead curative and corrective maintenance are related to the survey of the phenomenon to take care. The planning is mainly about controls to establish the necessity of curative and corrective interventions and to tune the frequency of preventive and completing maintenance. The evaluation is fundamental to interpret the result of the interventions done and to plan activities to improve or to correct them. For this reason it needs to evaluate the efficacy of the techniques utilised, the performances of products, and the eventual not expected phenomena due to the modified conditions of the building. Moreover controls verify the correct execution of the interventions done.

The availability of the knowledge arranged for the restoration allows to recognise and evaluate the possible risks and problems and to individuate the areas at risk. Knowing the areas at risk is simpler to define controls and to point them; therefore it is possible to intervene with greater timeliness, also related to the fact that it is available the comparison between the state of the building before and after the restoration. In fact it is possible to identify the causes up stream, that should have been resolved or in some case merely taken under control, thus it is possible to expect with more reliability problems and risks thus phenomena and areas more subjected to. Moreover the possibility to plan targeted controls allows obtaining an economical saving that makes monitoring more sustainable.

To plan a monitoring programme it needs to do a preventive detailed analysis that is already available because was carried out for the project. The analysis is needed to interpret expected phenomena related to the previous ones and to identify the significant parameters that measured continuously or by fixed-terms, allows detecting eventual dangerous evolutions. Visual monitoring, meant as periodical control about the onset of deterioration and structure and environmental modifications, is the starting point of that activity. On the basis of those phenomena eventually noticed it could be necessary to have more information that can be obtained through an instrumental monitoring regarding the significant parameters individualised by visual controls or on the basis of expectations.

It is important to do not underestimate the possibility of the onset of not expected phenomena that have to be noticed timely. Thus controls have to be planned not only related to the areas phenomena are expected, but also extended to the sensible areas of the building, like connections, or that can be subjected to negative effects due to the interaction with the new elements inserted or the techniques adopted for the restoration. Visual monitoring allows to do that continuous control without spending too much and to evaluate the eventual necessity of deeper controls. Also in this case having the knowledge arranged for the project is fundamental, because the designer should be completely conscious about criticalities and know the entire building characteristic. This knowledge is useful also to understand all the relationships between the different parts of the building therefore both to evaluate possible interactions, even those ones less manifest, and to establish the areas more sensible related to constructive characteristics apart from the causes revealed. Therefore it is possible that unexpected phenomena occur but at the same time it needs that control are targeted. Preventive maintenance actions can be useful for this.

In fact during the execution of preventive maintenance actions, planned not related to control, it possible to combine controls to find unexpected problems thus to plan deeper controls. This controls combined with preventive operations allow to adjust the frequency of planned operations and to evaluate the efficacy of the operation done. The same is for the operation completing the intervention, that has to be meant as a verify of the intervention itself.

The fundamental aspect about controls, targeted or not, I the timeliness of the diagnosis and its interpretation that is essential in a context delicate and characterised by uniqueness like the historical one. It needs to activate a knowledge process that starting from a general level goes to detail so that describes first the conservation state of the building and its elements then, on the basis of that observations, diagnoses and interprets speedily the symptoms noticed. The right interpretation of the symptoms allows to choose the intervention or to evaluate and eventually to modify some details. About symptoms easily detectable, that have evident manifestations, generally visual controls are enough. Instead about that inconspicuous ones it needs to arrange a suitable monitoring system, able to detect even the apparently not relevant and marginal phenomena. If the relief directly

depends by controls instead the interpretation depends by the established parameters. Thus the nodal point about control planning is the definition of the evaluation parameters, as about maintenance was the definition of performances. All the possible parameters cannot be illustrated, because depending by the specific case, but it is possible to illustrate a methodological synthesis about the knowledge process to activate through monitoring.

Controls have the aim to give such knowledge level of the restored building as to evaluate the intervention, the modality and the timing. The knowledge process has to be carried out through following phases, both temporal and spatial. Initially controls have to detect qualitatively the noticed phenomenon noticed on an element. This first knowledge level has to be done utilising means and instrument that allow a fast and cheap evaluation, generally visual controls to identify the phenomenon and to obtain a qualitative estimation. This first level is about one single element, or a group of correlated elements, and individualises a determinate phenomenon. Subsequently it needs to reach a second knowledge level that is deeper and gives estimation both qualitative and quantitative, through careful controls and using all the instruments needed to obtain a quantitative estimation of the phenomenon. Finally it needs to reach a third level of knowledge that is global, meaning that the evaluation is about the whole building. The methodology is the same of the second level but extended to the whole building, detecting the effects induced by a phenomenon regarding one element to others elements or to the building itself. Those phases are both temporal and spatial and allow obtaining an evaluation about the progress or the stabilization of the phenomenon detected and its diffusion to the building. The diffusion can be direct, interesting others elements, or indirect, activating others phenomenon or mechanisms. Specific controls and instruments have to be planned relate to the phenomenon, its danger, and to the relevance of the building and the economic availability. Apart from the extent of controls it is fundamental the initial qualitative individualization in time, that allows choosing the following controls. Thus it seems opportune to plan more expeditious controls, even if simple and then the eventual needed monitoring, more complex and onerous.

Concluding, the specific case of maintenance plan for restoration projects involves some particular aspects that can be summed up in the following points:

- The necessity to collect all the information about the restoration done, the preliminary analysis and the conservation state before and after the intervention;
- An approach not only based on performances but also considering the conservation necessities, that effectively turns into a complete description of the element to define requirements and risks, thus to anticipate expected anomalies and areas at risk;
- The impossibility to do substitutions of the elements, unless it is absolutely necessary for the conservation of the whole building;
- The prevalence of maintenance actions of preventive nature and a strategy based on a combination of preventive maintenance threshold and preventive maintenance condition-based;
- The major importance attributed to controls, that become the main object of the plan;
- A special attention attributed to the interactions between elements and materials, especially between those ones inserted by restoration and the pre-existences;
- The necessity to do complete descriptions about all the planned activities, and the necessity of collect their results; especially about maintenance activities it needs to draw up a complete scientific report of the effective operations done;
- The purpose of the evaluation of the efficacy of the restoration done and the possibility to do corrective actions in case the intervention turns out to be inadequate;
- The purpose of the evaluation of the efficacy of the planned activities and the possibility to do corrective actions in case they turn out to be not efficient.

The documents to draw up are the same as provided by the Italian Law on Public Works, adapted to be applied to the architectural historical heritage and to the designer own method of work in the basis of the project done. In particular it is absolutely necessary to arrange the scientific report *[consuntivo scientifico]*, concerning all the information about the restoration done, its effective execution, the building conservation state before and after the intervention. The *maintenance manual* has to contain the description of the elements, the requirements that they have to satisfy and the risks are subjected to, thus the individualisation of the

expected anomalies. On the basis of those criteria it has to be indicate all the initial activities of maintenance and monitoring that have to be described in details. The *maintenance programme* concerns the temporal scheduling of the interventions. Thus it has to contain a chronogram about the activities to do, to collect all the information about the operations done, the obtained results and the trend of the conservation state. For the activities done, especially if very complex or concerning the completing or the correction of the interventions, it is necessary to draw up synthetic scientific report, like the *"consuntivo scientifico"*. On the basis of the results it has to be updated both the description of the elements and the description of the planned activities and has to be established the eventual new activities needed, adjusting the initial frequency. Finally the *usage manual*, directed to the user that contains all the instructions for a conscious and correct utilization of the building, the project directions, the instructions about the maintenance that it concern the user. For this documents it is particularly efficient the ones proposed by the Guidelines of Lombardy.

The realization can be summed up in a process of knowledge and execution that will be illustrated through a specific applicative example. The process is divided in three phases that correspond both to the phases of drawing up and to the running:

- The preliminary phase, concerning the collection of the initial information;

- The prevision phase, concerning the descriptive analysis of the element based on performances and conservation, the definition of the needed activities and the scheduling of the initial frequency;

- The running phase, that is cyclic; the planned activities are carried out and on the basis of their results the plan is updated, establishing the new needed activities and the new frequency.

The process is illustrated by a scheme that indicates the sequence of the operations. Then the operation will be described.

PRELIMINARY PHASE:

- Collection of the initial information.
- Drawing up of the *consuntivo scientifico.*
- Technological disassembling.

PREVISION PHASE:

- *Descriptive analysis based on performances and conservation:*
  - Requirements and risks.
  - Conservation state.
  - Expected anomalies and areas at risk.
- *Definition of the activities:*
  - Controls:
    - Targeted (elements / connections / interventions).
    - General (by opportunity).
  - Maintenance:
    - Preventive.
    - Completing.
- *Scheduling of initial frequency.*

RUNNING PHASE:

- Execution of planned activities and data collection.
- Updating:
  - Confirmation of previsions.
  - Modifies:
    - Updating of descriptive analysis.
    - Updating of planned activities.
    - Definition of new activities:
      - Controls:
        - Specific.
        - Concerning the activities done.
      - Maintenance:
        - Curative:
          - Expected anomalies.
          - Not expected phenomena detected.
        - Corrective.
- Scheduling of the new frequency.

Preliminary phase of collection of initial information:

- Drawing up of a *building card* concerning:
    - Building identification.
    - *Consuntivo Scientifico* about the restoration, it has to contain:
        - The description of the building and its conservation state before restoration;
        - The description of the building and its conservation state at the moment of the final general inspection;
        - The project "as built";
        - All the others documents of the project, like the preliminary analysis;
        - The description of the interventions done and the reasons;
        - The activities of regulation, completing and maintenance already planned during the project;
        - Eventual external factors of deterioration the project could not avoid; the expected results.
    - Eventual previous scientific reports, concerning previous restorations.
    - The collection of all the documentation concerning the building, like licences, certifications, regulations.

- *Technological disassembling of the building*: preliminary to the descriptive analysis has to be done the technological disassembling and the cataloguing through an alpha-numeric code; it has to used that one done for the project, eventually adapted to the specific necessities. The building is disassembled in:
    - Elements: single or in group, for example a floor, or also macro-elements individualised in the basis of a cinematic mechanism;
    - Connections: in general structural nodes, but also specific connections of elements, like the internal connections of a floor;
    - Interventions: general or punctual done during the restoration.

Prevision phase:

- *Descriptive analysis based on performances and conservation*: concerning all the elements and their conservation state. It will be individuated the requirements and the relative risks, on the basis of that considerations will be anticipated the expected anomalies and the areas at risk. That analysis has to be collected mainly in the maintenance manual. The information about the activities delegated to the user has to be collected in the usage manual, utilising a simple language. The objects described, on the basis of the technological disassembling, are: the elements (or group of elements or macro-elements), the connections and the interventions done. The information that has be analysed and collected are:

    - About the elements:
        - Identification.
        - It needs to be indicated if the element has been inserted by the restoration or if is a pre-existence; in the second case it needs to be indicated if it was restored or not; in case was restored all the information about have to be collected from the "consuntivo" (conservation state before and after restoration, reasons that motivated the intervention, solved problems, external causes not avoided by restoration).
        - Description of material and constructive characteristic.
        - Connections with others elements.
        - Role or function.
        - Conservation state.
        - Requirements that the element has to satisfy related to its function (corresponding to project requirements if the element was restored). Are

satisfied by the conservation state obtained by the restoration.

- Risks for its conservation related to its function; they can depend by intrinsic vulnerabilities or external factors.
- Expected anomalies and areas at risks: are due to the risks individualised or to the natural ageing.
- Effects induced by the anomalies on others elements.

- About connections:
  - Identification.
  - Elements connected.
  - It needs to be indicated if the connection has been inserted by the restoration or if is a pre-existence; in the second case it needs to be indicated if it was restored or not; in case was restored all the information about have to be collected from the "consuntivo".
  - Description of material and constructive characteristic.
  - Structural role and kind of constraint.
  - Conservation state.
  - Requirements that the connection has to satisfy related to its structural role.
  - Risks for its conservation related to its function; they can depend by intrinsic vulnerabilities or external factors.
  - Expected anomalies and areas at risks.
  - Effects of the anomalies on the elements connected.
  - Effects of the anomalies on the global structural behaviour.

- About interventions:
  - Identification.
  - Elements directly interested by the intervention.
  - “Consuntivo scientifico”.
  - Work sequences and significant aspect: each intervention must be divided in the work sequences in order to individualise the significant aspect that have to be controlled in order to plan the monitoring and the maintenance.
  - Requirements; usually are the same as the intervention purposes.
  - Risks; they can depend by intrinsic vulnerabilities or external factors.
  - Expected anomalies and areas at risk.
  - Effect of the anomalies induced to elements and connections.
  - Following operations already planned, that are the eventual operation that have to be carried out after the execution in order to conclude or complete the intervention.

- *Definition of the activities planned on the basis of the expected anomalies individualised by the descriptive analysis:* the activities can be divided in maintenance or controls. At their turn they can be divided in two categories: initial activities, based on the previsions, and following activities, based on the results obtained. In general all the activities have to be completely described. That information has to be collected mainly in the maintenance manual, some of them, delegated to the user, will be collected in the usage manual. The initial activities are defined during the preliminary phase; instead the following activities will be defined during the running phase.

- *Description of the activities* (concerning all the activities of the maintenance plan): initial activities are related to the expected anomalies and are preventive maintenance or operation concerning the intervention already planned during the project. Following activities are established related to the evaluations about the results of the controls, the onset of not expected anomalies or different evolutions of the expected anomalies. Anyway, both for initial and following activities, the description has to concern:

    - The reason of the activity: expected anomalies or preventive actions or regarding the restoration in the case of initial activities; results of the monitoring for the following activities.
    - Elements interested by the activity.
    - Complete description of the activity and instruction for the execution.
    - Qualifies and instrument needed.
    - Notes about relevant aspects; for example the influence to the normal function of the building or specific directions.

- *Initial controls*. Are controls planned in the in the first drawing up of the plan on the basis of expected anomalies; they concern the conservation state. They can be divided in:
    - *Targeted controls*: on the basis of the expected anomalies and of the areas at risk or directed to the restoration done.
    - *General controls:* usually visual controls, taking the knowledge level one (LC1) proposed by the "guideline for the evaluation and reduction of the seismic risk for the heritage" as a model; they are planned by opportunity.

- *Initial maintenance*. All the actions of maintenance planned during the initial drawing up of the plan on the basis of the expected anomalies or related to the operation concerning the restoration

that have to be done after the intervention and that were already planned during the project. They can be divided in:

- *Preventive*, on the basis of expected anomalies and areas at risk.
- *Completing*, concerning the restoration done, at their turn they can be divided in:
  - *Preventive completing*, for example following regulations or operation that have to be repeated at fixed-terms.
  - *Real completing*, are operations that have be done following the intervention but that are actually part of it.

- *Definition of the initial frequency:* is the phase of scheduling that makes clear the strategy proposed. Initially it has to be utilised a strategy based on the preventive maintenance threshold, defining the initial term and frequency of the activities. Then that strategy has to be integrated with the preventive maintenance condition-based, adjusting the frequency on the basis of both the results of monitoring (conduction directed) and the preventive maintenance actions (failure finding). To optimise the activities and to reduce the costs, every time it is possible, it needs to apply the strategy of maintenance by opportunity, grouping the activities that have similar terms (always anticipating and never delaying the activities) or doing activities exploiting the opportunity given by others activities planned; for example the execution of general controls in opportunity of the targeted controls. The frequency has to be inserted in the maintenance programme.

Running phase:

- *Execution of planned activities.*

- *Collection of the results*: results of monitoring have to be collected and interpreted. The maintenance actions done have to de completely described through scientific reports (like the consuntivo scientifico).

- *Updating of the plan*: all the information concerning the activities done have to be inserted in the respective documents, that are updated:
    - About the descriptive analysis of the elements/connections/interventions the following information has to be updated the following information:
        - Conservation state;
        - Requirements, that are supposed to remain the same, but it is necessary to stress that their satisfaction correspond to the conservation state the elements had after the restoration;
        - Risks, adding the risks due to eventual phenomena concerning others elements too;
        - Expected anomalies and areas at risk, on the basis of the new situation.
    - The description of the activities has to be updated with the results.

  Updating the plan there are two possibilities:
    - The previsions are confirmed, thus the cycle goes on with the same terms and frequency.
    - It needs to modify the plan on the basis of the new conditions.

- *Definition of new activities on the basis of the results:* it concerns both the initial activities updated and the new ones needed, that have to be described with the modality illustrated for the description of the initial activities:
    - *Following controls:* on the basis of the activities done:
        - *Specific controls* on the basis of general controls that detected not expected anomalies (*).
        - *Controls about the activities* of maintenance previously carried out, to evaluate their efficacy.
    - *Following maintenance* established on the basis of controls:

- *Curative:* concerning the anomalies detected, that can be divided in:
  - About expected anomalies, thus already anticipated by the plan.
  - About not expected anomalies detected by controls (*).
- *Corrective:* to correct eventual errors or bad effects about:
  - Restoration (*).
  - Maintenance (*).

(*) In this case it is absolutely necessary to contact the scientific reference that is supposed to be the planner.

- *Definition of the new frequency and updating of the programme:* after this step the cycle restarts from the execution on the activities scheduled. In the case the updating are very relevant and the activities determines a radical modification of the initial conditions it needs to update the whole plan and restart from the preliminary phase.

Conclusions

The thesis analysed maintenance and revealed the aspects that make problematical its use in the field of historical architectural heritage. Definitions and regulations concerning maintenance are directed to building in a broad sense, do not consider the peculiarities and the necessities of the heritage, thus are more suitable for the maintenance of recent buildings. At the same it has been pointed out that maintenance was an habitual practice but that it has been progressively abandoned. Beginning from sixties, on the basis of Brandi's theories and Urbani's works, the preventive character of maintenance and the contribution that it can provides to the conservation of the heritage, especially that one non-monumental, lead up to the development of a new culture of maintenance in order to the conservation. Some tools of prevention and conservation through actions of preventive planned

maintenance have been defined and introduced. This new spread of maintenance is testified by the increasing interest about this topic in Italy and in Europe.

The problems pointed out, that reflect the different necessities, have to be respected in case of intervention on historical buildings, are mainly due to the concept of useful life that is inapplicable in this context. In fact the heritage is characterised by a value that is not merely economic or related to its utilization but that is mainly cultural, therefore it cannot be assumed that its utility decays during time. At the same time it is obvious that it needs to act for lengthen the life of the building so that it can continue to transmit its value. The cultural value is related to the integrity and the authenticity, therefore it is necessary to guarantee the material permanence of the building and all its elements. Usually the purpose of maintenance is the keeping of the performances of the building elements. In the case of historical building the material conservation has to be added to this purpose, and it is preponderant respect to the keeping of elements performances and building functionality. Anyway performances have to be maintained in order to the conservation of the building and the functionality has to be guaranteed because allows to justify the conservation from an economic point of view too and to find the resources needed.

The thesis critically described the main instrument to plan the maintenance: the maintenance plan provided by the Italian Law on Public Works, that is the main normative reference about maintenance, but that is not appropriate to be applied to the heritage. The proposal of Lombardy Region is more interesting: the conservation plan, purpose-made for the conservation of the heritage through planning of preventive actions. However this plan it is disjointed form the restoration and it places almost in antithesis. Instead to pursue the purpose of the conservation of the historical architectural heritage it is necessary to combine restoration and planned maintenance.

On the basis of those considerations the thesis proposes to consider restoration as a continuous process that is fulfilled through the intervention and continues with following maintenance and monitoring, that extend and in the meantime verify its efficacy. Thus the maintenance plan becomes an integral part of the project. The approach to plan the maintenance has to be conservative and not only based on performances; therefore it needs to focus on the element and not on the performance. This aspect involves the necessity that maintenance actions do not

expect substitutions on the contrary guarantee the material permanence of the elements. Thus it becomes unavoidable to anticipate the deteriorations that can involve the loss of the elements, and in case they come true, detect them timely. In fact the periodical control of the building is the main instrument for a conscious conservation. The strategy to plan the activities has to be a combination of preventive maintenance threshold and preventive maintenance condition-based.

It needs to define the requirements and the risks and to individualise the possible anomalies and the more vulnerable areas. On the basis of this analysis has to be planned both preventive maintenance and constant controls; moreover curative actions have to be anticipated regarding the expected anomalies that can occur. To those activities the eventual actions of completing of the restoration have to be added, that have to be done after the intervention, and in some cases the corrective actions, concerning the interventions that could turn to be non efficient. Thus it becomes fundamental to define the parameters and to individualise the priorities to establish the typology and the sequence of operations, defining a general methodology to apply to the specific cases.

The thesis will apply the approach to maintenance and the methodology proposed on a case study: the restoration of the Borgo Vecchio di Roscigno. In particular the thesis will focus on some interventions of strengthening and a-seismic improvement. The interventions will be analysed in detail, through the division in work sequences in order to define the significant aspects that have to be considered to plan the monitoring and the maintenance. This methods allows to take into account all the aspects regarding the interventions carried out to restore the building, from the design to the realization, evaluating both the execution and the results.

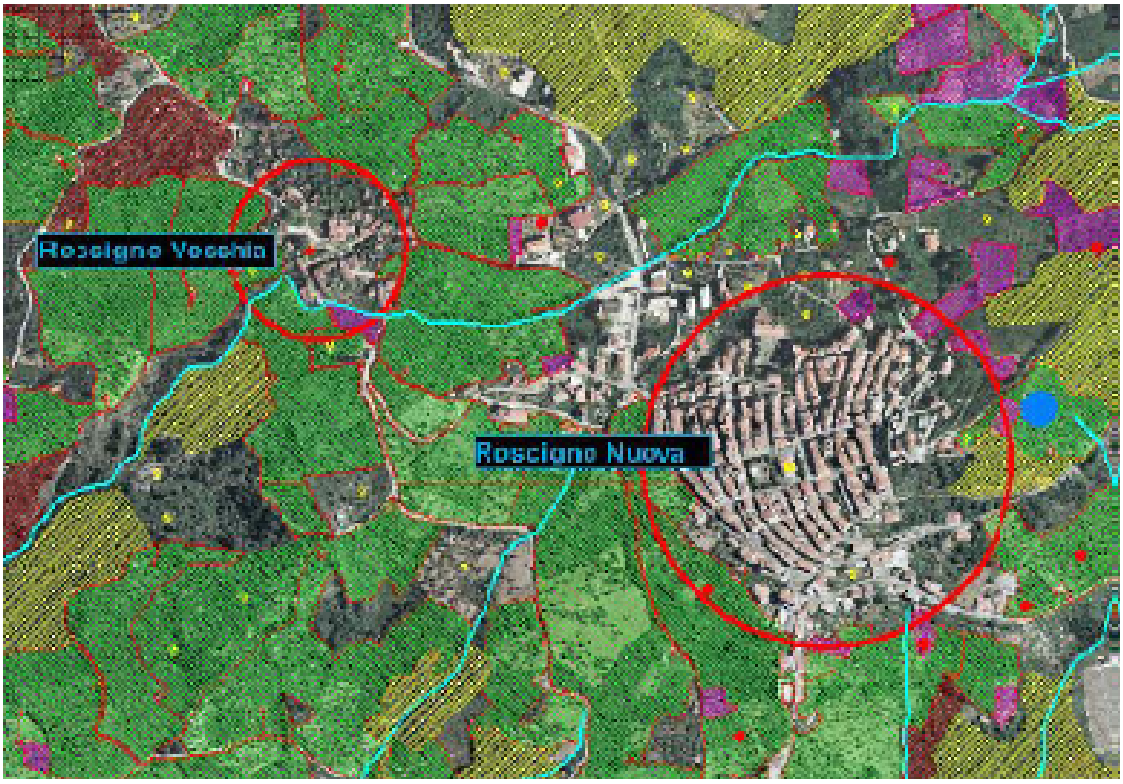
Case study

Application on a case study.

To complete the thesis some interventions of strengthening and seismic retrofit have been selected. The interventions selected are part of the general project of restoration of the Borgo Vecchio of Roscigno. The choice of this case study, and particularly the strengthening and a-seismic improvement interventions on the "G" building, is motivated by the fact that this is a pilot project, that utilizes innovative and experimental technologies. Thus the case study is functional to the thesis and gives several interesting cues. The aim of the pilot project is to define guidelines for all the interventions of strengthening and a-seismic improvement for the whole historical centre of Roscigno. Thus planned maintenance is necessary for two reasons. First to make the intervention more efficient and lasting, considering that the historical centre of Roscigno has been abandoned for more the one century and the lack of maintenance caused several problems. The lack of preventive conservation and planned maintenance is a weak point for the protection of minor historical centers, especially regarding the seismic vulnerability. The second reason, that is very interesting for the thesis, is the necessity of an evaluation of the effective efficacy of the intervention, that is based on the use of innovative not invasive techniques, thus it is a prototype. A maintenance and monitoring plan following the intervention can be an opportunity to verify and to regulate the project. The purpose is to obtain a practice code to be applied for this kind of interventions directed both to the historical centre of Roscigno and also to the others historical centers of that area characterized by the same constructive lexicon. Moreover the restoration of Roscigno has the aim to experiment new modalities of management through different ways of utilization, thus the maintenance plan is needed also to evaluate the different possibilities of use and to give the necessary indications to the eventual adjustments.

The restoration of the Borgo Vecchio of Roscigno

Roscigno is a little village in the south of Italy, inside the province of Salerno close to the border between Campania and Basilicata. In consequence of several hydrological and seismic problems - the old town was built on a hill that is slowly sliding down - the inhabitants had to leave their houses and a new town was built just 2 km away. Now nobody lives in the old town and the complete absence of maintenance caused a severe deterioration of all the buildings, and some of them are ruins. But at the same time the urban structure remained exactly as it was, without any modification during the last century. The abandon of the centre provoked the deterioration but protected the morphology of the centre by the modifications due to the modernization. The Borgo Vecchio of Roscigno represents a unique example of the traditional rural villages of the south of Italy as they were at the end of the XIX century. The village during the past was an important crossroad between Adriatic and Tyrrhenian areas of the south of Italy, shepherds used to meet at the main fountain. Moreover the village is inside the national park of Cilento and the whole area is an Unesco site, characterized by several archeological sites and by a well preserved environment.



The new and the old town.

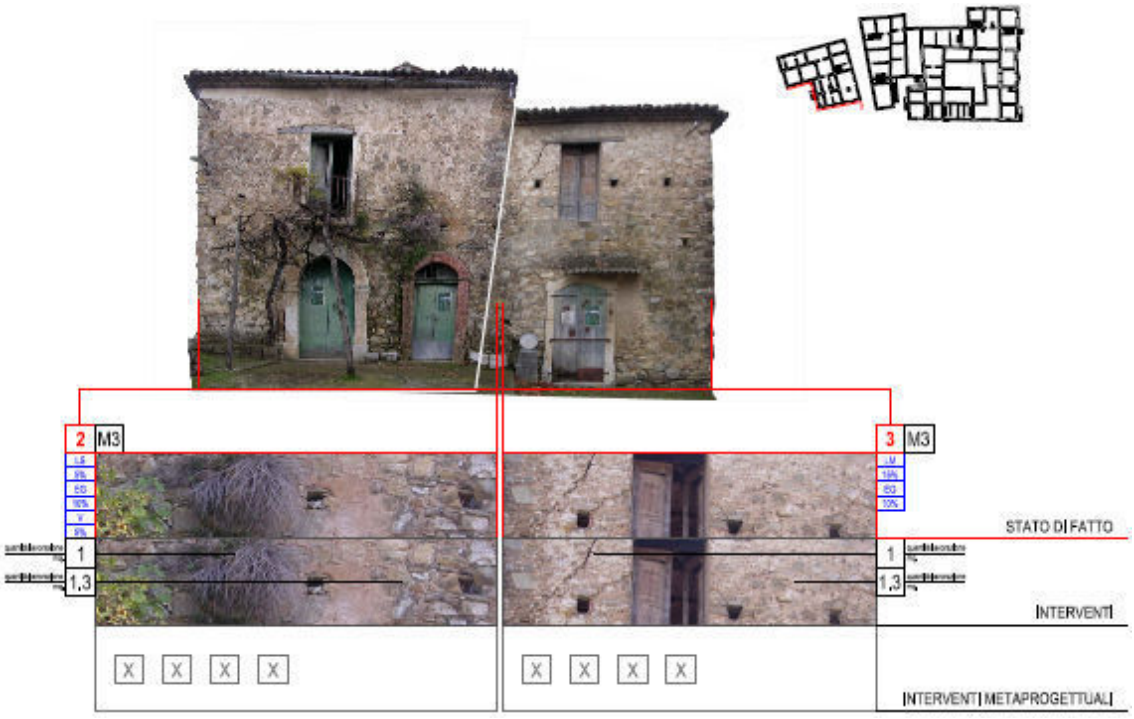
The entrance to Roscigno Vecchia.

The fountain in the main square.

Some pictures:

The local administration of Roscigno, with the help of the European Community (fesr_por Campania 2000-2006) organized a preliminary project to restore the old historical centre. The project involves several architects and restoration specialists: arch. I. Giarletta (coordinator), prof. arch. ing. P. Faccio (tecnical responsable), with their collaborators. The project want to preserve the site and to experiment new strategies of conservation and management. The committee established some permanent laboratories to study the whole process of conservation and to manage the site, experimenting different possible uses of the town in its particular condition of emptiness. The whole process want to be a general model that can be studied and apply to similar cases.

The first step of the project is to prevent irreparable damages by the strengthening and the a-seismic improvement of the buildings. The architects choose a building to realize the consolidation project. The project will be a guideline for the strengthening and a-seismic improvement of all the other buildings and ruins.



The "G" building.

Applicative example: analysis of a structural node

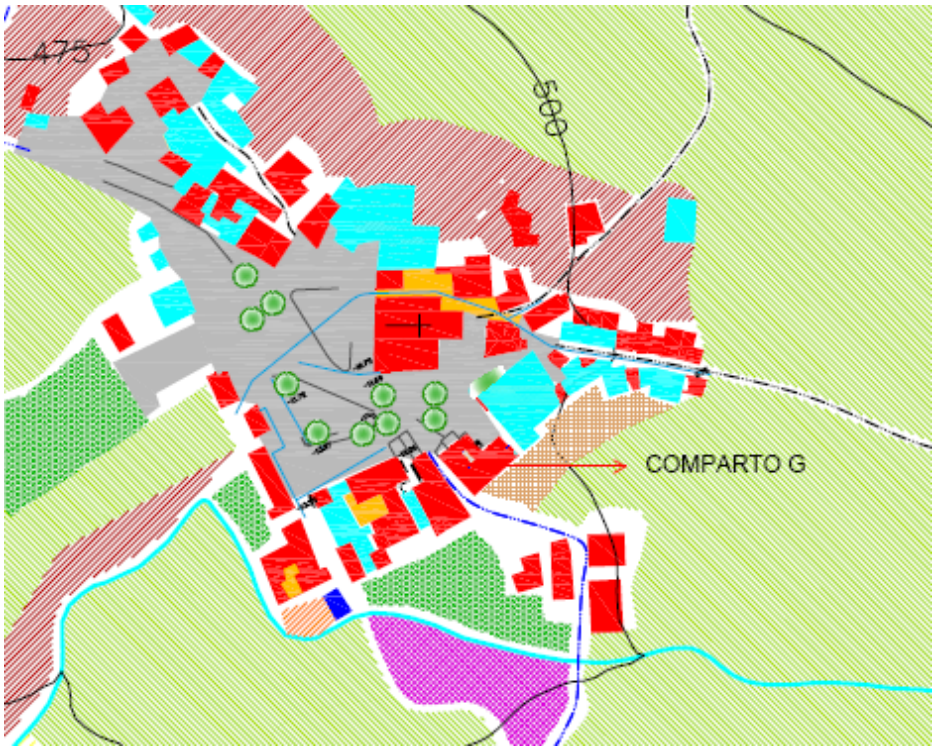
The selected interventions belong to the structural strengthening of the "G" building. The category of interventions of seismic retrofit of structures includes *all the intervention however aimed to increase the strength capacity of the existing structure to the considered actions [tutti gli interventi comunque finalizzati ad accrescere la capacità di resistenza delle strutture esistenti alle azioni considerate] ("Norme tecniche per le Costruzioni 2008")*. Thus seismic retrofit is a component of the consolidation that has to be coupled, in accordance with the specific case, to the repair or to the static strengthening and every time to maintenance. The repair has the purpose of repairing the effects of breakdowns and damages of building, such as its vulnerability, without increasing the resistance. The strengthening is directed to increase the efficiency and the structural capacity proved to be insufficient, intervening not only on the effects (repair) but also on the causes. Finally maintenance is directed to maintain the state of normal efficiency of the structure and to protect it. The typology of interventions selected for the applicative example gives several cues and an overall view of restoration, and it is suitable to be a case study concerning maintenance and monitoring arguments following those kinds of interventions. And what is more, it is a pilot project that utilizes experimental methodologies and techniques, which is another key point that strengthens its choice.

The selected interventions are part of the whole project of strengthening of the "G" building, ordered by the Comune di Roscigno, Salerno, Italy. The "G" building is characterized by quality and building consistency common to the whole centre, therefore it was chosen as a model to illustrate the methodology of intervention proposed in the pilot project. The "G" building shows a stratified construction result of the sum of some linear buildings, having different constructive characteristics, and it has had many transformations. It is the result of aggregations of many cells and of their unification at the ground floor that made it loose the unitary nature. The technical-constructive qualities of the whole built can be ascribed to the so-called minor architecture; the constructive lexicon shows several peculiarities inside the general characteristics. The particularities of the "G" building are the volumetric relations between body of buildings, the uncovered spaces and the building construction details typical of the local architectural tradition. The lack of maintenance and the

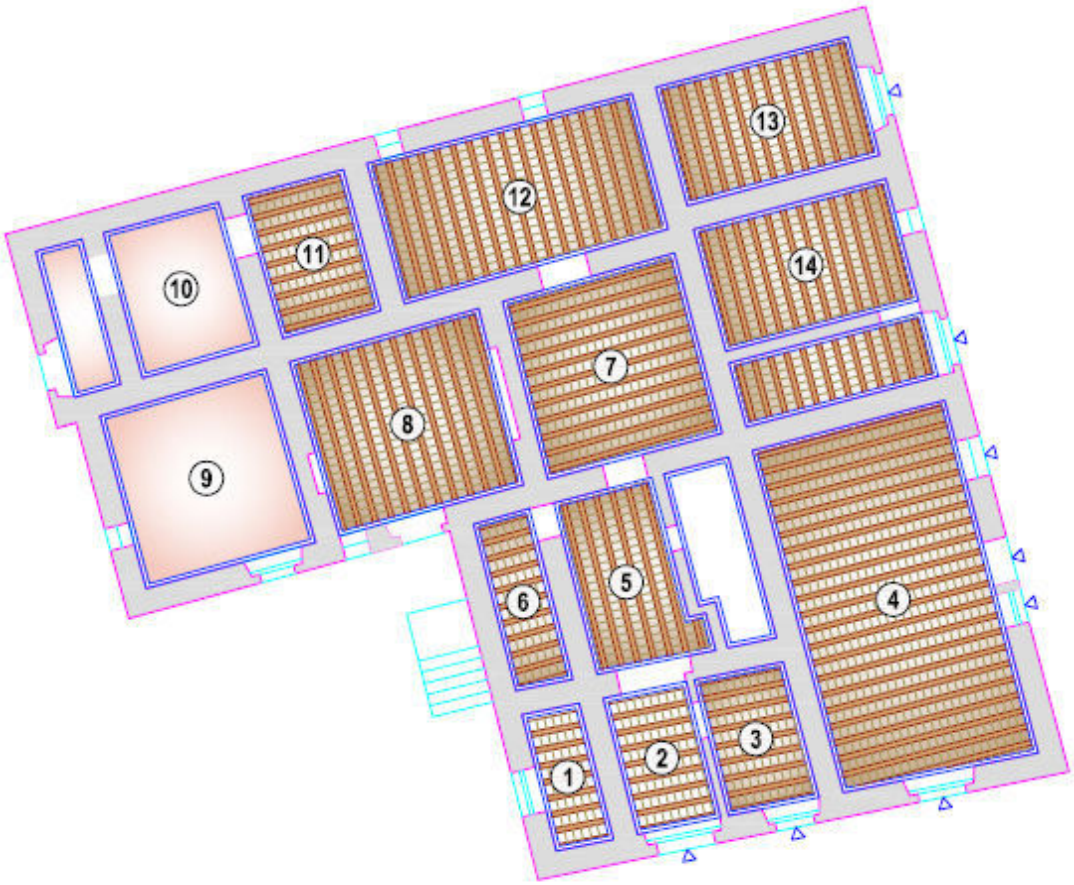
abandonment implied several damages, collapses and considerable losses, both in materials and in volume. The building, such as the whole historic centre, is particularly vulnerable, especially considering that it is located in a seismic area.

The project of the "G" building regards the improvement of structures, the evaluation of which is based on the increase in performances comparing the limited acceleration reachable before and after the interventions. The project is divided in a set of interventions that can be divided in two categories: the general interventions, directed to the overall improvement of the whole building, and the punctual interventions, directed to factors or parameters conditioning the performance of single elements. All the interventions are based on not-invasive and experimental techniques, responding to the *Ordinanza del Presidente del Consiglio 3274/2003 [direction of the Italian Prime Minister number 3274/2003]* and to the *"Linee guida per la valutazione e riduzione del rischio sismico del patrimonio culturale con riferimento alle norme tecniche e all'applicaione dell'OPCM 3274/2003" [Guidelines for the evaluation and reduction of seismic hazard of the cultural heritage]*, approved by the *Consiglio Superiore dei Lavori Pubblici* (Italian council of public works) on 21 July 2006.

The main purposes of the project are: the functionality of the wall as a "closed box" *[comportamento a scatola chiusa]*, that means that the whole building and all its walls move as a single unit; security measures for the ruins; the possibility of maintain some spaces without floor joists. For these interventions it is expected the draw of a maintenance plan and the activation of a monitoring programme, related to the experimental and innovative nature of the technologies utilized. Moreover, as the historic centre of Roscigno shows and as this thesis has demonstrated, the lack of planned maintenance is an obstacle to the conservation of historic buildings. The selected interventions regard mainly the floor joints, especially the floors, and they are functional to the static improvement reaching the concept of "*closed box behaviour"* through better connections between the walls. The insertion of stiffed in the plane is an essential condition to distribute the seismic actions into the walls and to apply the "closed box behaviour" principle. The attention is focused on the nodes between the walls and between the floors and the walls.



Plan of Roscigno Vecchia and the "G" building.



Plan of the first floor of "G" building and indications of floors.

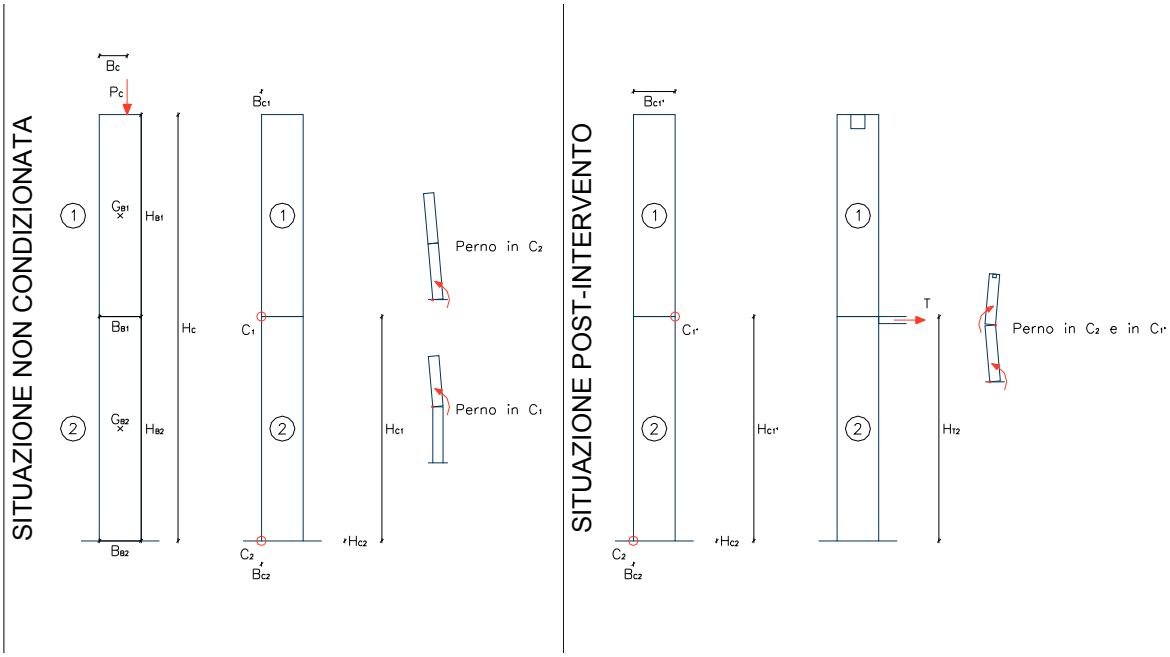
For the applicative example, three complementary interventions done in sequence have been chosen:

- The *masonry reorganization*, which consists of several interventions, the main and more relevant is the injections of mortar. That operation has to be done especially at the landing fillets, the areas at the storey height where floors fit in. To obtain a monolithic "behaviour" of masonry it is necessary to carry out injections in all of the parts of masonry that are damaged and to couple the interventions with the insertion of reinforced joints and the revision of the wall surfaces.
- The *ringing of walls*; after the consolidation of masonry, particularly by landing fillets, it is necessary to connect them. The intervention of ringing of walls consists in the installation of an annular stringcourse made in metallic carpentry.
- The *insertion of new floors to realize a stiff plane and to increase the function as tie rod*; it follows the two previous interventions; particularly the annual stringcourse gives the support for the floors and connects them to the walls. The new floor has a mono-directional structure made of lamellar wood beams and a plank made of two crossed wooden planks.

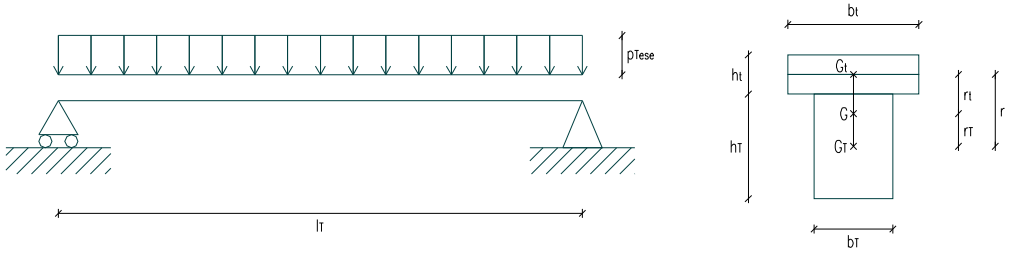
The general purpose is the improvement of the overall behaviour of the building related to the seismic actions. The specific aims of each intervention are:

- The improvement of the mechanical characteristics of masonry, particularly the landing fillets which floors will fit in, and their reorganization to obtain a monolithic behaviour.
- The mutual connection between walls and between walls and floors to obtain"close box behaviour" and to prevent the mechanisms of collapse of "first mode", that provokes the over-tuning of the exposed walls.
- The insertion of a new floor characterized by stiffness, to distribute the seismic actions between all the walls.

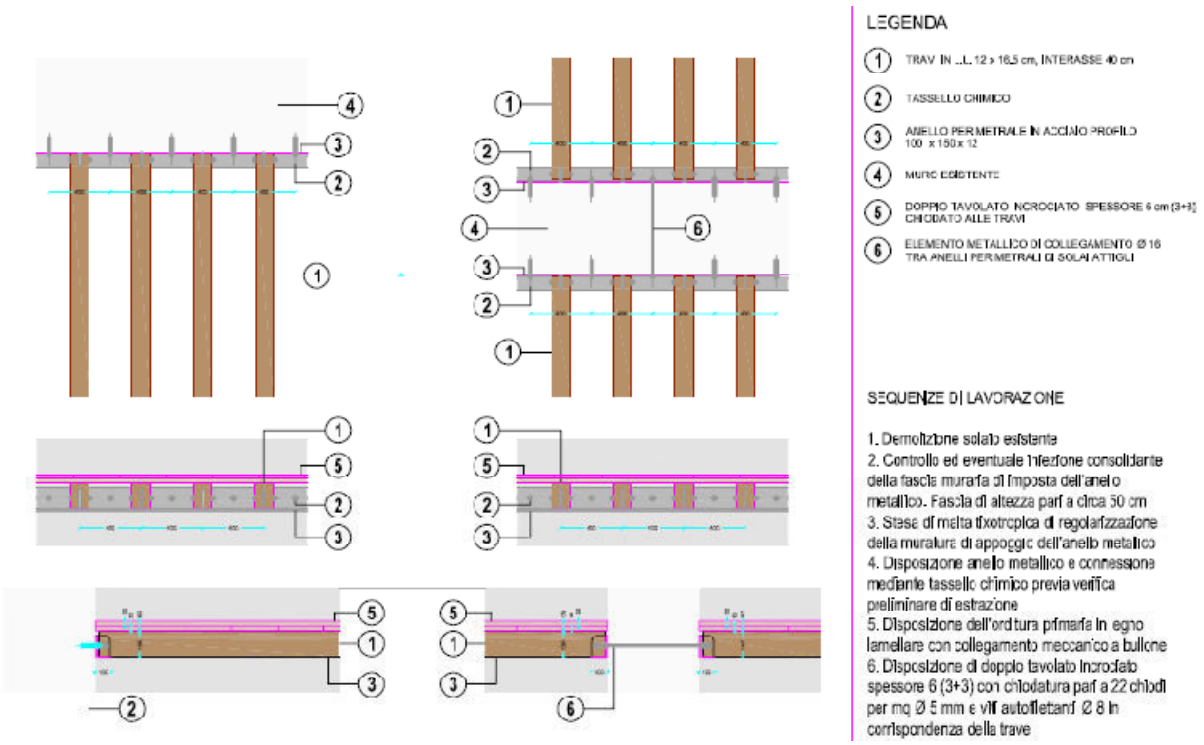
Structural analysis done for the project concerns two aspects: the cinematic mechanisms that provoke the over-tuning of masonries and the structural analysis of floors. About masonries, the normative reference are the "*Linee guida per la valutazione e riduzione del rischio sismico del patrimonio culturale con riferimento alle norme tecniche e all'applicazione dell'OPCM 3274/2003"* and the two correlated "Ordinanza del Presidente del Consiglio dei Ministri" *[direction of the Italian Prime Minister]*: the OPCM 3274/2003, and the OPCM 3431/2005. The methodology utilised for the structural analysis is the cinematic linear analysis, as defined by the OPCM 3274/2003 that consists in the calculus of the horizontal multiplying of loads that activates the mechanism of collapse and in the evaluation of the corresponding seismic acceleration at the ground. Therefore, the analysis proceeds to the verification of the ultimate limit state in comparison with the spectral acceleration of reference reduced through a factor of structure. For the analysis of masonry, it was sampled a portion of it one meter wide, whereas it was considered in its whole height; the analysis was carried out at the beginning for the not-conditioned state and after the interventions. The interventions made were the ringing of walls at landing fillets and the belt on the top, made by a concrete stringcourse. The initial hypothesis of analysis foresaw only the intervention of belt on the top and, if the verification was not satisfied, the ringing of walls too. However, the project foresaw the insertion of annular metallic stringcourses even if the verification was already satisfied with the belt on top, because they give an important auxiliary contribution. The possible mechanisms that have been examined by the analysis are illustrated in this scheme:



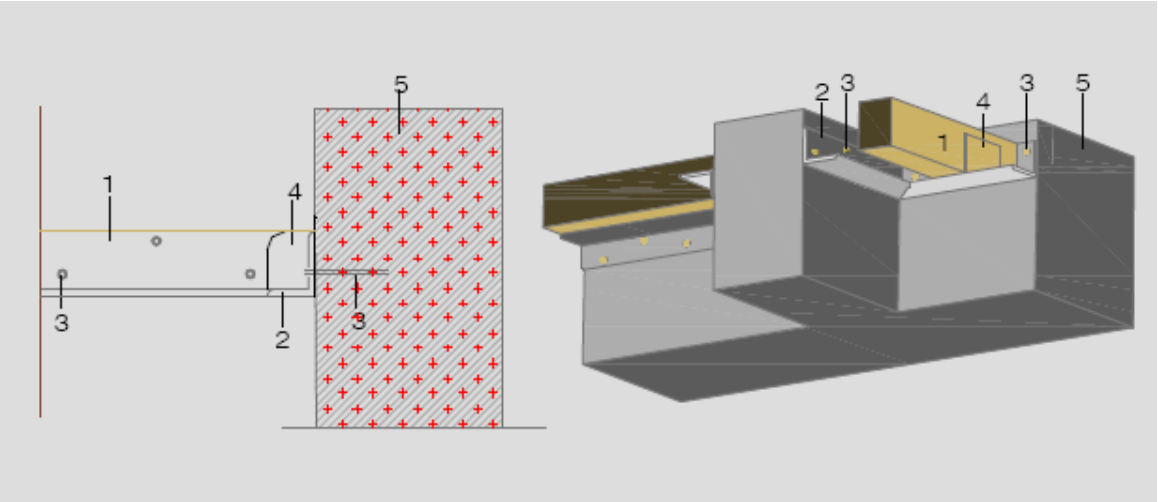
Regarding the structural analysis of floors, the normative reference is the Eurocode 5 that is specific for the calculus and verification of wooden structures. Considering the seismicity of the area and the typology of interventions, the Eurocode 5 has been integrated with the Eurocode 8 that is specific for the design of structure for earthquake resistance. The analysis considered all the new floors designed, in the project conformation, utilizing the semi-probabilistic method at the limit states. The analysis consists of three phases: the verification at ultimate limit state of the bending of beams and plank, considering the increase of stiffness due to the connection; the verification of shear stress of connectors, comparing it to the bearing stress of wood; and the verification at service limit state of the deformability of beams and plank, also considering the increase of stiffness due to the connection.



Geometry of structural components.



Project of ringing of walls and insertion of new floors.



Illustrative sketch of the intervention:

1 – Lamellar wood beams;

2 – Metallic annular stringcourse;

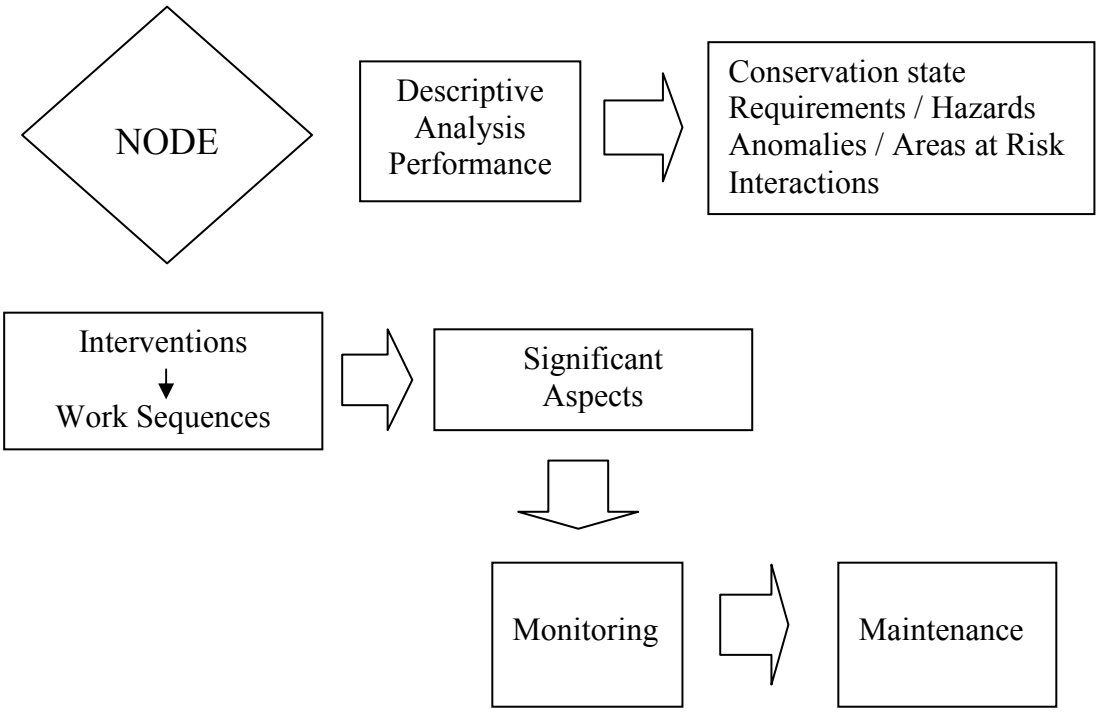
3 – Chemical nogs;

4 – Welded flange for the anchor of the beans to the stringcourse;

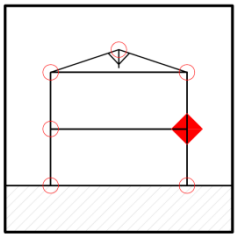
5 – Area of masonry to consolidate through mortar injections.

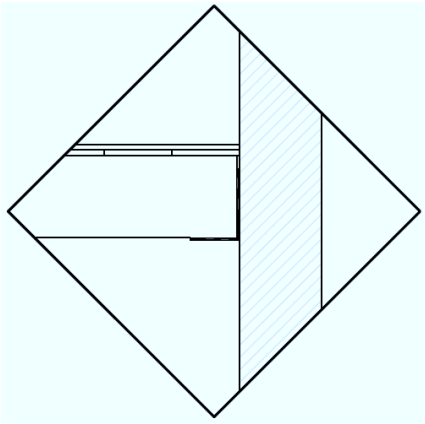
Example of realization of the intervention.

To apply the concepts of maintenance plan specific for historic buildings, the selected interventions will be analyzed. The concept of restoration as a process that goes on during time through planned maintenance, the aim is to prolong the effects of restoration and to verify, and eventually to correct, its results, can be just illustrated analyzing the interventions. The thesis proposes a general method to plan the maintenance of a structural node subject to restoration that is illustrated by an applicative example on the node wall-floor interested by the selected interventions. The node is briefly described based on the descriptive analysis founded on conservation and performances, but the attention is pointed up on the interventions. These are analysed in details and divided in their respective work sequences, individualizing for each of them the significant aspects that has to be considered during and afterwards the execution of the interventions. Thus, on the basis of the significant aspects, that reflect requirements, hazards and problematic that have to be considered, it is possible to individualize all the parameters that have to be controlled afterwards the realization. Some of the significant aspects are important only during the execution, whereas some others even afterwards, consequently these are the right ones that have to be considered to define the planned maintenance. On the basis of this analysis it is possible to establish the necessary monitoring and the consequent actions of maintenance related to the results of monitoring. The process can be schematized as follows:



The specific case of a node wall-floor:





State of conservation: good;
Requirements: to contribute to the reaching of a box behavior;
Hazards: bearing stress of wood, ineffectiveness of adherence of nogs, deterioration and reduction of the mechanical characteristic of masonry;
Anomalies: slackening of connections, cracking of masonry by supports;
Areas at risk: connections and supports.

Node wall-floor, carried out through an annular metallic stringcourse with chemical anchor to masonry and bolt connection to the beans of floor.

Interventions: - Reorganization of masonry RM
- Ringing of walls RW
- Insertion of new floor NF

Work sequences:
- RM01, RM02, …
- RW01, RW02,….
- NF01, NF02,….

Division of the interventions in their work sequence, brief description and identification through code

Significant aspects to consider for the evaluation of results and efficacy of intervention

Definition of significant aspects for each working; indication if are important during or afterward the execution

MONITORING
of the significant aspects to control after the intervention

Planning of controls regarding the significant aspects that have influence after the execution

MAINTENANCE
On the basis of the results of monitoring

Planning of maintenance actions and/or specific controls because of monitoring results

Division of the interventions in their work sequences, assignment of an identification code and brief synthetic description:

	INTERVENTION: ***Reorganization of masonry RM***
01	Evaluation of the state of conservation (RM01): *It needs to observe the structure of masonry, the percentage of voids and the presence of diffuse micro cracking.*
02	Cleaning and elimination of de-coherent parts (RM02). *Surfaces of masonry have to be cleaned and all the de-coherent parts have to be removed.*
03	Realization of a completely close masonry (RM03): *It needs to carry out plastering and sealing, on both surfaces, of all the cracks, disjointedness, little breaks of stone ashlars and of mortar joints.*
04	Execution of holes (RM04): *On the basis of cracking, porosity and the capacity of absorption of mortar mixture; have to be done from 2 to 4 holes each square meter, with a diameter of 16-24 millimetres, made nearly perpendicularly to masonry with a light slope, about 10%, to allow the introduction of the mortar mixture.*
05	Insertion of little pipes “revealing” (RM05): *They have a diameter of 20 millimetres, they are introduced for about 10 centimetres, sealed with the same mortar mixture of the injections, but more dense; they permit the discharge of the excess mixture and allow to verify the overlapping and communication of the injected areas.*
06	Cleaning of eventual slavering (RM06): *In the case of discharge of dripping those have to be cleaned immediately using absorbing sponges soaked in de-ionized water.*
07	Prewash (RM07): *Before the injections, at least 24 hours before, it is necessary to inject water in the closed circuit of injection in order to saturate the masonry and to keep the density of mortar mixture; moreover this operation allows confirming the portions of masonry interested by the intervention and indicating eventual cracks not evident.*

08	Eventual additional operations to obtain a completely closed masonry (RM08): *Additional operations of re-pointing of joints, sealing of cracks and roughing-in [rinzaffo] because of eventual cracks discovered through the prewash.*
09	Preparation of mortar mixture (RM09): *The mixture to inject is mortar base; it must be homogeneous, well blended and without lumps and impurities.*
10	Execution of injections (RM10): *The injections inside the holes have to be done with low pressure, approximately between 0.5 and 1 atmospheres; injections have to be done in parallel lines from the lower side of masonry to the top, starting from the sides symmetrically to the centre.*

	INTERVENTION: ***Ringing of walls RW***
01	Demolition of existent floors and choice of the elements eventually re-usable (RW01).
02	Control of masonry in which the stringcourse is inserted and execution of intervention of re-organization of masonry in the landing fillets at storey-height (RM).
03	Cleaning and elimination of de-coherent parts in the landing fillet (RW03).
04	Laying of a coat of thyrotrophic mortar (RW04): *In order to regularize the surface of the walls under intervention; increase the adherence.*
05	Realization of the annular stringcourse in metallic carpentry (RW05): *Made with an "L" steel section, having dimension 100X150 millimetres and 12 millimetres of thickness.*
06	Installation of the stringcourse to the retaining walls of floor (RW06): *The stringcourse is set with the major wing parallel to the wall and the minor one in the lower position; it is anchored to the wall through chemical nogs each 40 centimetres; steel sections of the respective walls are welded between them at the corners to obtain the stringcourse.*
07	Joint of contiguous floors (RW07): *Through a metallic bar with a diameter of 16 millimetres, that goes through the wall in common between two floors.*

	INTERVENTION: ***Insertion of new floors in order to realize a stiff plane and to increase the function as tie-rod NF***
01	Reorganization of masonry (RM).
02	Ringing of walls (RW).
03	Preventive protective treatment for wooden elements of floor (NF03): *Before hand inspection of the wooden element to verify the presence of anomalies, that can prejudice the result of the treatment, and eventual superficial consolidation; the treatment consists of application of a specific product.* *The treatment has to be repeated during time at fixed terms.*
04	Preparation of the elements of connection between stringcourse and beans (NF04): *Metallic flanges have to be welded to the stringcourse, which beans will be secured through bolting.*
05	Installation of beans (NF05): *The floor has a mono-directional structure made of beans in second category lamellar wood, having a section of 12x16.5 centimetres, set on edge, with an inter-axle of 40 centimetres; the connection with the stringcourse is made with bolting on the flanges previously welded.*
06	Installation of the first wooden plank (NF06): *The plank is made of a double crossed wooden plank of pinewood having a thickness of 3 millimetres; the first wooden plank, which the wooden boards are set in a perpendicular direction respect of beans and with staggered joints, is anchored to the beans through self-threaded screws with a diameter of 8 millimetres.*
07	Installation of the second plank (NF07): *The second plank is laid upon the first and crossed, the wooden boards have a direction perpendicular or at 45° respect to the below; the second plank is nailed to the first one through 22 nails, with 5 millimetre of diameter, each square meter.*

After the division of interventions in their respective work sequences, it is necessary to individualize the significant aspects that have to be considered to plan the monitoring; for each significant aspect it is indicated if it influenced the monitoring during the execution (I) or successively (S).

Reorganization of masonry RM				
PHASES		SIGNIFICANT ASPECTS	I	S
RM01	Evaluation of the conservation state.	Structure of masonry; Presence and percentage of voids; Diffuse micro-cracking; State of conservation of joints; Cohesion of mortar.	● ● ● ● ●	● ● ● ● ●
RM02	Cleaning and elimination of de-coherent parts.			
RM03	Realization of a completely closed masonry.	To avoid the eventual external transudation of the mixture to inject.	●	
RM04	Execution of the holes.	Right execution of the holes; To control the effective superimposition and communication of the areas to inject.	● ●	
RM05	Insertion of little pipes, “revealing”.			
RM06	Cleaning of the eventual slavering.	To avoid that eventual slavering could deteriorate in a not-reversible way the integrity of the adjacent facing.	●	●
RM07	Prewash.	To guarantee the saturation of the masonry; To keep the density of the mixture; To verify the presence of not evident cracks.	● ● ●	
RM08	Eventual additional operations to obtain a completely closed masonry.	To avoid the eventual slave ring of the mortar to inject.	●	
RM09	Preparation of mixture.	Right execution of mixture.	●	
RM10	Injections.	To verify the effective filling of the masonry; To avoid the forming of pressures inside masonry and the subsequent coactions with the external curtains.	● ●	● ●

Ringing of walls RW				
PHASES		SIGNIFICANT ASPECTS	I	S
RW01	Demolition of existent floors and choice of the elements eventually re-usable.	Preliminary interventions; It needs to evaluate their execution.	●	
RM	Control of landing fillets at storey-height and reorganization of masonry.	Evaluation of the state of conservation of the areas of masonry in which stringcourses have to be inserted, particularly about its mechanical characteristics; On the basis of results of evaluation it needs to do, or improve if already done, the reorganization of masonry.	● ●	●
RW03	Cleaning and removal of de-coherent parts.			

RW04	Laying of a coat of thyrotrophic mortar.	To give regularity to the surface on which the stringcourse have to be inserted; To improve the adherence.	● ●	
RW05	Realization of the annular stringcourse in metallic carpentry.	Control of the realization of the carpentry; Verification of eventual presence of oxidation in the welded joints of carpentry.	●	●
RW06	Installation of the stringcourse	Right installation and execution of the connections between steels sections; To control the adherence of anchor bars.	●	●
RW07	Joint of contiguous floors.	Control of the adherence of anchor bars.		●

Insertion of new floors in order to realize a stiff plane and to increase the function as tierod NF				
PHASES		SIGNIFICANT ASPECTS	I	S
RM	Reorganization of masonry.	Preliminary interventions; It needs to evaluate their execution.	●	
RW	Ringing of walls.			
NF03	Preventive protective treatments of wooden elements.	To protect wooden elements from infestant attacks; It needs to examine accurately the element before the application and to verify the eventual presence of infestant attacks.	● ●	●
NF04	Preparation of the elements of connection between stringcourse and beans.	Control of the carpentry; Verification of eventual presence of oxidation in the welding between flanges and stringcourse.	●	●
NF05	Installation of floor structure.	Control of the points of connection with the walls; Verification of eventual cracks by punching or by tensile stress on the internal or external faces; Control of bolting connection; Control of humidity at the moment of installation and during the following seasoning of wood.	● ●	● ● ● ●

NF06	Installation of the first plank.	Control of the point of connections with the walls; Control of the nailed connections; Control of humidity at the moment of installation and during the following seasoning of wood; The double plank has the task to stiffen the floor to control the load deformation.	● ●	● ● ● ●
NF07	Installation of the second plank.			

Once defined the significant aspects that have to be considered afterwards the realization of interventions, it is necessary to establish the actions of control and the monitoring to plan. The research concerns exclusively the aspects that have to be taken under control afterwards the execution, both in short-term and long-term, but excludes those ones that have to be considered only during the realization. The possible typologies of monitoring are of two kinds: visual or instrumental; the rate depends on the phenomena and can be at discrete or continuous intervals. For each significant aspect and the respective work sequences interested, there are indicated the typologies of control and the first frequency that will be updated during the running of the maintenance plan. However, all the controls have to be done at the end of the works, to evaluate the realization. On the basis of the results of monitoring it is possible to schedule a new frequency and to define and plan maintenance.

Control and monitoring of the state of conservation of masonry			
SIGNIFICANT ASPECTS		MONITORING	TIME
RM01 RM02 RM06 RM10 RM NS05 NS06 NS07	Structure of masonry; Diffuse micro-cracking; State of conservation of mortar joints; Eventual slavering of mortar on the facing of masonry; Forming of pressures inside masonry and the subsequent coactions with the external curtains; State of conservation of masonry in the areas in which stringcourses are inserted; Control of points of connections between walls and floors; Verification of eventual cracking by punching or tensile stress on internal and external faces of masonry.	CONTROLS: Visual inspections of the state of conservation of masonry **VIM** AIMS: Evaluation of the state of conservation of masonry; Survey and control of diffuse cracking; Survey and control of forming of swelling due to pressure of injections; survey and control of cracking of masonry by the supports of floors.	At the end of works After 3 months Then with annual frequency

Control and monitoring of efficacy of mortar injections			
SIGNIFICANT ASPECTS		MONITORING	TIME
RM01 RM10	Presence and percentage of voids inside the masonry before and afterwards the intervention of injection of mixture of mortar.	CONTROLS: Auscultation of percussion of masonry in the sensible areas, such as landing fillets at storey-height and corners **AP** AIM: Verification of the effective filling obtained through the injections.	During and at the end of works After 3 months

Control and monitoring of the conservation state of mortar joints			
SIGNIFICANT ASPECTS		MONITORING	TIME
RM01	State of conservation of joints; Cohesion of mortar.	CONTROLS: Test of extraction/pull-out of the blocks of masonry **POB** AIMS: Evaluation of the level of cohesion of mortar; Control of the state of conservation of mortar joints.	At the end of works After 3 months Then with annual frequency

Control and monitoring of the state of conservation of welded connections			
SIGNIFICANT ASPECTS		MONITORING	TIME
CM05 NS04	Signs of oxidation in the welded joints of metallic carpentry.	CONTROLS: Visual inspections of the welded connection of metallic carpentry **VIWC** AIMS: Survey and control of eventual oxidations; State of conservation of welded connections.	After 6 months Then with annual frequency

Control and monitoring of the anchor of stringcourse to masonry			
SIGNIFICANT ASPECTS		MONITORING	TIME
CM06 CM07	Adherence of anchor bars of annular stringcourse and to the retaining walls and to the contiguous floors.	CONTROLS: Tests of extraction/pull-out of anchor bars **POA** AIM: Verification of the adherence of the anchor bars.	At the end of works After 6 months Then with annual frequency

Control and monitoring of the state of conservation of wood			
SIGNIFICANT ASPECTS		MONITORING	TIME
NS03 NS05 NS06 NS07	Protection of wooden elements and prevention from infestant attacks; Control of humidity at the moment of installation and during the following seasoning of wood.	CONTROLS: Visual inspections of wooden elements **VIWE** AIMS: Evaluation of the conservation state of wooden elements; Presence of infestant attacks; Efficacy of the treatment done; Survey and control of cracking by shrinkage and twisting due to the seasoning; Presence of disconnectedness in the plank due to increase of the cross section of the wooden boards due to seasoning.	During and at the end of works. After 6 months Then with annual frequency Treatment have to be repeated every 5 years

Control and monitoring of bolting connections			
SIGNIFICANT ASPECTS		MONITORING	TIME
NS05	Control of bolting connections between beans and stringcourse	CONTROLS: Reading of the level of stress of bolts through a dynamometric spanner **LSB** AIM: Evaluation of the tightening of bolting connections.	At the end of works After 6 months Then with annual frequency

Control and monitoring of the stiffness of the floor			
SIGNIFICANT ASPECTS		MONITORING	TIME
NS06 NS07	Control of the nailed connections of planks; Evaluation of the effective stiffness of the floor.	CONTROLS: Visual inspections of planks and nailed connections **VIP**; Control of the load deformation of the floor **CDF** AIMS: Evaluation of the conservation state of the floors; Eventual ejection of nails due to the bearing stress of wood; Control of the load deformation of the floors to evaluate if its stiffness was the same required by the project.	At the end of works After 6 months Then with annual frequency

Once defined the initial monitoring programme, the running of the maintenance plan can begin. On the basis of the monitoring results it is possible to define the new frequencies of inspections or to start specific controls to monitor the phenomena found. On the basis of the monitoring results it can be executed the planned maintenance actions too. The operations of maintenance and the specific controls can be established only after the reach of the monitoring results planned. Some activities of maintenance, mainly preventive actions or regarding expected phenomena or those actions that can be done at the same time of the planned controls, add some specific controls, regarding the expected anomalies, and can be planned in that phase too. To illustrate the proposed methodology the thesis plans maintenance and monitoring that can be probable, assuming some possible results of controls, both positive and negative.

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
VIM	Presence of cracking	Specific controls to monitor the progression of the phenomenon, with a frequency of 3 months.

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
AP	Masonry does not have voids at the end of works	The deadline of the following control, after 3 months, is confirmed.

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
POB	The cohesion of mortar in some joints is not adequate	Additional operations of repair and repoint of mortar joints have to be carried out.

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
VIWC	Presence of signs of oxidation in some welded connection of the metallic carpentry	It needs to clean accurately the areas interested by oxidation, control the welding and eventually repair it.

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
POA	Anchor bars have a good adherence	The deadline of the following control, after 6 months, is confirmed.

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
VIWE	Presence of infestant attacks	It needs to carry out a biocide treatment to eliminate wooden parasites and to apply again the protective preventive treatment

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
LSB	The bolting connection is slackened	Tightening of bolts

MONITORING RESULTS		MAINTENANCE / SPECIFIC CONTROLS
VIP	The state of conservation of plank and of nailed connection is good	The initial frequency of the inspections is confirmed

MONITORING		MAINTENANCE / SPECIFIC CONTROLS
CDF	Result: Presence of load deformation	Specific controls and continuous monitoring to measure the load deformation and its progression.

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