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RACCOMANDAZIONI PER LA REDAZIONE DI PROGETTI E L'ESECUZIONE DI INTERVENTI PER LA CONSERVAZIONE DEL COSTRUITO ARCHEOLOGICO

RECOMMENDATIONS FOR DRAWING UP PROJECTS AND CARRYING OUT INTERVENTIONS FOR THE CONSERVATION OF THE ARCHAEOLOGICAL BUILT HERITAGE

CUZZOLIN

Recommendations for drawing up projects and carrying out interventions for the conservation of the archaeological built heritage

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PART I

The archaeological built heritage

1. Foreword

These recommendations concern all the ancient buildings or other constructions which contribute to giving form and structure to archaeological sites. They constitute an archive of documents of material history and thus a source of historical knowledge.

The use of intuitive laws of stability, techniques based on long experience and reproduceable construction modules also makes these structures an archive of the history of building, and hence an essential source of knowledge when it comes to planning conservation interventions.

1.1 *Material knowledge and historical knowledge*

In an archaeological context, material knowledge concerning the structure has to be confronted with knowledge of the historical events which determined its creation and survival or partial destruction. A scrupulous analysis is necessary so as not to overestimate the destructive force of natural and catastrophic events, or indeed the capacity of the structure itself to withstand decay. Historical and archaeological analyses can in fact show how a ruin arrived at its current state having been stripped and plundered, and how materials and construction techniques remained substantially unchanged for centuries, up until the introduction of modern technologies. This continuity made it possible, in the modern city just as in ancient ones, to re-use the same materials from one building to another, introducing new configurations into the structure.

Discontinuity, transformations existing for centuries and intentional damage can themselves serve a function in preventing or protecting from decay, and this can only be evaluated through a careful diagnosis of the structure's vulnerability.

2. General criteria

2.1 *Nature and identity of the archaeological built heritage*

Every artefact produced in a specific phase of human civilization that has run its historical course can be considered as "archaeological". It is susceptible of knowledge and can be considered a "source" of information about the material culture, art, life style, and economic and cultural standing of a site in the past. In fact the nature of an archaeological resource lies quite as much in its material identity as in its formal values and the information it attests.

Thus the "archaeological built heritage" may have an artistic or monumental standing, but may also represent a simple attestation of aspects of human activity in the past. In any case the archaeological resource constitutes a document of the material history of humanity. In most cases, following episodes that have occurred in the course of time, it will have undergone a process of alteration and fragmentation such that today it appears incomplete and modified with respect to its original form. Except for specific cases (churches, amphitheatres, castles, etc.) the archaeological heritage is generally made up of artefacts in a state of ruin, no longer fulfilling a practical purpose, whose use is restricted to scientific and cultural interests.

2.2 *The archaeological ruin as document of material history*

The ruin is an element which has come down to us from the built heritage of the past and which in the lengthy intervening period of time has undergone a process of transformation for a whole series of different factors. This has brought about a change in the structure that has almost invariably made it different to what it was originally; it derives it *raison d'etre* and value from its current configuration and material conformation, acquiring new relevance as a *historical document*. As we acquire knowledge concerning the archaeological ruin, it becomes an attestation of a past which is 'fixed' in its image and intimate material structure, whence the over-riding priority of conserving its identity.

Any arbitrary modification can constitute an alteration to a specific historical memory. The ruin undergoes a process of consumption which is only partial and may indeed be reversed, or in any case retarded,

through a correct use of the tools made available by technology. There are also some large-scale architectonic complexes which take on an emblematic value as monuments. In these cases the ambiguous features of the ruin are more limited, while our interpretation of the monument becomes more complex, benefiting from the considerable historical stratifications which are almost always discernible.

2.3 *The archaeological built heritage and use*

As we have said, the archaeological heritage serves above all scientific and cultural purposes, and ought to enhance our historical, aesthetic and social knowledge of the past, and scientific research. Thus it is appropriate to prepare diversified, well laid out itineraries both to foster a better knowledge of them at various levels and to protect the archaeological resources from an excessive human impact. A proper use of innovatory IT applications can ensure a vast, diversified series of possible uses.

User security can be guaranteed by two distinct strategies:

- limiting the extent to which the site can be visited by means of protection systems such as fencing off and using alternative routes and viewing points;
- allowing site visiting while adopting the strict minimum of necessary interventions.

3. Risk evaluation: vulnerability and hazard

Quantitative risk evaluation is generally defined in the context of seismology, but the concept can be extended to other environmental hazards. Risk derives in practice from the relationship between hazard, vulnerability and the value of the resource in question. Since these concepts are not very familiar in the archaeological world, we can start by saying that the difference between vulnerability and hazard consists in the fact that the former indicates a liability, as it were, to *incur* damage, the latter to *cause* it. The first term thus refers to a construction or area, and the second to environmental or man-made features; the third element is the value of the resource in question. The changing relationship between these three elements determines the risk to which an artefact or archaeological area can be exposed.

Thus the vulnerability of an archaeological artefact lies in its predisposition to be damaged or its state of decay (to the point of collapse) due either to an environmental event (earthquake, landslide, freak conditions) or a man-made one (destruction, demolition, excessive use etc.). Hazard in the broad sense, on the other hand, identifies the probability that it will fall victim to such an event according to the frequency and magnitude of events posing a threat to the artefact's integrity. Risk is the possibility/probability of undergoing damage, at different levels of gravity, on account of the events taken into consideration and in relation to the value of the resource.

In this perspective, a knowledge of the different causes which may have produced the current state of an ancient artefact is particularly important for a correct evaluation of the environmental and man-made risks to which archaeological areas are exposed. In particular it is essential to know the various environmental hazards facing archaeological areas, which means having a good knowledge of the frequency and magnitude of natural or man-made event which may have affected such areas throughout history so as to assess their incidence for the future.

Comparison of environmental data with the results of calculations and mathematical models relating to the construction features of archaeological artefacts makes it possible to ascertain whether or not there is any correlation between the two spheres of observation. By taking into account both environmental hazard and calculation models one can obtain:

- a more complex and precise evaluation of the state of the artefact and its possibility for withstanding hazards in the future;
- a verification of the validity of the technical options adopted by the ancient builders to erect the construction in that particular spot of the territory.

3.1 *Geological and morphological aspects*

The geology and morphology of the area influence the conservation of the ruin on account of such surface manifestations as landslips, subsidence, coastal erosion, variations in subterranean water levels, etc.

Geological hazard can be ascertatained in qualitative or probabilistic terms by means of specific studies. That deriving from surface movement can be limited with maintenance type actions, or else by monitoring the phenomenon's physical magnitude. For example periodic to-

pographic precision monitoring of the vertical and horizontal movements of the earth surface relative to a series of fixed parameters, and that of water table levels, will show the behaviour of the area in question over time, the succession of events and their correlation with physical phenomena in particular, and also meteoric phenomena, which may lead to, or accentuate, conditions of risk. Satellite monitoring systems can also be used to control vast archaeological areas with the interpolation of archaeological, geological and hydraulic data, etc. This gives rise to a new important system of control which with access to an archive in which the possibility of matching "historical" data gathered over time and over extensive areas enhances the identification of points which are "in movement", to be indicated as "critical points" on which to concentrate a specific activity of monitoring and direct control.

Maintenance requires constant observation of the evolution of phenomena affecting the area which may influence its geomorphological evolution, in particular in the case of steep inclines: it is particularly important to regulate the run-off of surface water and the control of vegetation.

In general geological hazard cannot be contained by "active", structural interventions. Interventions that set out to block or profoundly alter the area's natural geomorphological evolution by means of large-scale buttressing (in particular using continuous walls or stilts) or in-depth consolidation using stapling, coating in reinforced concrete, etc. are to be avoided.

3.2 *Structural aspects*

The structural vulnerability of an archaeological artefact depends on the configuration it has taken on over time, on typology, geometrical dimensions, material and state of conservation. Occasionally substantial modifications have been caused by interventions of archaeological excavation which have modified the equilibrium between the structure above and below ground.

We would stress the identity in ancient times of "construction" and "structure" according to a conception which recognized multiple functions for each artefact, with static security as just one aspect. This gave rise to artefacts endowed with infinite durability, for which the action of incidental functional loads on the masonry structures appears completely negligible. In terms of construction conception and purpo-

se, a ruin's structural vulnerability must thus be evaluated merely in terms of the forces of gravity and meteoric actions. In the case of monuments which are open to public access, it is necessary to take into account the incidental loads which can, wherever necessary, be appropriately limited.

In analysing the ruin's structural vulnerability the following elements must be considered: form, geometric dimensions, nature and quality of the materials and their state of conservation, and the relationship between excavated and non-excavated sectors. It is particularly important to analyse the situation of cracks, which may have been generated by previous actions and hence do not reveal active hazard phenomena. It may prove helpful to define the historical situation of cracks as reported by project manager, structural expert and archaeologist. A detailed analysis of these factors will provide guidance for interventions of ordinary and extraordinary maintenance to be carried out according to the methodology set out in the section "Technical intervention operations".

3.3 *Geotechnical aspects*

Geotechnical vulnerability depends on interaction between the nature and the mechanical characteristics of the terrain, as well as the typology and geometric and constructive characteristics of the foundations and the artefact.

In general geotechnical vulnerability is linked to excessive deformations of the underlying terrain with the ensuing damage. Shifts of terrain cannot usually be detected visually and are normally revealed by interaction of the buildings which on account of their greater fragility show cracks even following small shifts in the terrain. Thus as a rule buildings reveal the symptoms of the geotechnical vulnerability of the artefact. Study of the geotechnical aspects of the problem is thus necessary to identify the causes and where possible to establish the origin of the instability.

The nature and mechanical characteristics of the terrain can be determined in quantitative terms by means of a geotechnical survey using experimental procedures and tests, both on site and in the laboratory, typical of geotechnical engineering. The geotechnical survey constitutes a phase in the study of the terrain, closely linked to the purposes being pursued and the features of the structure to be safeguarded. Thus

it cannot be carried out irrespective of the approach taken in the vulnerability study, but has to be planned and conducted by whoever has the responsibility for the choice and implementation of any safeguarding interventions performed.

The typology of the foundations, their geometric and constructive characteristics, and the depth of the foundation level of the archaeological artefacts are often unknown and difficult to ascertain. In the absence of data on the interaction of terrain and construction it can only be the subject of highly approximate qualitative considerations. In view of the above-mentioned sensibility of constructions to deformations in the terrain, valuable indications on the origin and evolution of damage and on the geotechnical vulnerability of the ruin can be derived from examining the situation of cracks of the structures above ground, taking periodic measurements of their evolution. Merely identifying a state of cracking does not in itself demonstrate a condition of vulnerability: in fact the damage may have been produced by previous, occasional situations which no longer exert a significant influence on the static conditions of the artefact. By analogy, the qualitative observation of a current state of deformation in the masonry is not sufficient to identify the evolution of the phenomena. In this respect, by researching the graphic and/or photographic documentation made in the past concerning the artefact, one can make a comparative study of the state of cracking and/or degradation which will help in evaluating any states of alteration to have occurred in the course of time. Such a comparison will benefit comprehension of the evolution of the states of alteration of the construction over time, the succession of events and their correlation with physical phenomena or transformations which may have determined or accentuated situations of hazard and/or risk. Topographical measurements in particular, and precision surveying, provide information on the behaviour of the terrain. In order to be of use in defining geotechnical vulnerability, all the observations on constructions have to be repeated regularly in seasonal phases and in specific environmental conditions in terms of levels of humidity, temperature and position of the water table.

The artefact's static conditions are particularly affected by the horizontal actions produced by terrain masses that have accumulated over time through natural causes or man-made actions. The pressure of earth on a construction becomes particularly serious whenever there is an accumulation of water or seismic action.

3.4 *Hydraulic aspects*

Hydraulic vulnerability depends on the artefact's physical characteristics, its altimetric and planimetric collocation with respect to water courses and basins, the nature of the soil and the physical environment in general. Even temporary immersion of materials can produce irreversible chemical/physical alterations, with damage to or total loss of the archaeological resource. Erosion of the terrain produced by temporarily swift running surface water can constitute a source of significant damage and collapse for the masonry. The absence of damage attributable to the action of water over recent decades or the last century does not *a priori* signify freedom from hydraulic vulnerability.

Among the possible forms of hydraulic vulnerability, one that must be considered concerns areas liable to subsidence. In these cases the ruin undergoes a progressive lowering which can produce conditions of temporary or permanent immersion in the water table, or the risk of submergence by rainwater. Subsidence is a large-scale geological phenomenon, produced by natural and/or man-made causes which is currently quite widespread in Italy.

Hydraulic and geotechnical vulnerability are often interlinked and should be evaluated together. In particular it should be borne in mind that lime-based or sandy terrains may have the appearance of cohesion, making the cut-aways of excavations, trenches and tunneling look perfectly stable. Such conditions of equilibrium can be rapidly lost through the abolition of apparent cohesion on account of variations in water content.

3.5 *Environmental and geographical aspects*

Geographical vulnerability is linked to the territorial situation of the biophysical context of the archaeological site or artefact. The transformation of the territory as a result of the realization of infrastructures and the implantation of structures for primary, secondary and tertiary activities has undoubtedly altered the equilibrium of the original ecosystem, giving rise to a new physiognomy which can compromise the conservation of the archaeological built heritage. Factors like pollution and environmental degeneration are often the cause of damage to the archaeological heritage. Monitoring the effects of the immediate envi-

ronment on the artefacts concerns the whole territory and requires careful, constant observation of the phenomena which concern the area and can influence the conservation over time of the construction features of the archaeological heritage.

3.6 *Seismic aspects*

Archaeoseismology is charged with investigating the relationship between earthquakes and the archaeological heritage, so as to analyse, interpret and date seismic evidence (collapses, dislocations of material in masonry, constructions on top of previous collapses, ancient restoration, antiseismic precautions, etc.). Such indicators of seismic activity are not immediately discernible; they can be used from various perspectives in order to:

– identify and date unknown earthquakes, which represent extremely important data in areas considered of little or no seismic risk, or to identify the cyclical recurrence of major earthquakes;

– improve knowledge of the seismic impact of events which have gone largely unreported in written sources;

– integrate the history of a site with evaluation of the destructive events which have affected and modified it.

Thus archaeology can provide historical seismology with important sources of information since it can broaden the temporal scope of observations on past earthquakes, of great interest for seismology and other earth sciences. Archaeologists have an important and unique role to play in this recent research sector.

By now the level of seismic hazard regarding each area of Italy is quite well known and classified. Several decades of specific studies have produced a detailed overview specifying seismic effects, representing the state of the art in this sector internationally. Archaeologists can consult maps of the hazard level of a particular area in on line data bases, viewing descriptions of local seismic effects. It is also appropriate to evaluate the distance of archaeological areas from known seismogenetic sources (also reported in specific data bases). While the state of our knowledge on the seismic hazard is very advanced, knowledge concerning the vulnerability of monuments and the archaeological built heritage has to be assessed case by case. We can confidently assert that architecture in the state of ruin is mostly not very vulnerable to seismic action. In general collapses due to earthquakes in archaeological areas

come about on account of the state of degeneration due to inveterate neglect of the archaeological monuments.

These considerations set archaeological areas apart from the widespread studies of seismic vulnerability carried out for the historical built fabric. One only has to reflect on the different uses to which the two categories are put, and the very different concept of security which has to be elaborated for the one and the other. These general considerations become much more cogent when one recalls that for ruins standing some four metres high, the effect of an earthquake predicted in current norms is generally inferior to the impact of an exceptional event which, moreover, occurs in cycles which come in much quicker succession than seismic events.

In the case of monumental buildings a more complex analysis has to be carried out case by case, always bearing in mind the particular form they have assumed over time and the specific state of conservation.

3.7 *Intrinsic and induced vulnerability*

Vulnerability with reference to the historic built heritage, and all the more so for its archaeological counterpart, can be divided up into two components: "intrinsic", because linked to the structure's construction conception and the process of modification that has taken place through history; and "induced" in being caused by the state of degeneration. Intrinsic vulnerability is based on the typology, volumetry and nature of the materials and construction techniques used, all elements endowed with a cultural value. "Induced" vulnerability is the reduction in the course of time of the quality of the construction on account of ageing and both natural and man-made phenomena..

Acting on the first component often means adopting radical interventions which can alter important features of the artefact, while it is very often possible to modify the second by means of interventions restricted to restoring deteriorated construction elements; such interventions are nonetheless indispensable to avoid any worsening in the degeneration of the historical and/or archaeological artefact.

The experience of recent earthquakes has shown that only rarely does intrinsic vulnerability cause significant damage, clearly a consequence of two factors. In the first place the historical built artefact has endured many seismic episodes during its long life, which have eliminated or reduced to ruins the constructions affected by "congenital" de-

fects. In the second place historical, and in particular monumental, building was realised according to a conception of infinite durability, as a symbol of civilization to be transmitted to future generations.

Intrinsic vulnerability expresses the security philosophy of past societies. In this sense we may adopt an approach which varies between two extremes. The first implies respect for that philosophy, and thus the intervention strategy to be applied to the historical artefact fundamentally requires restoration operations which reduce the intrinsic vulnerability, eliminating the degeneration so as to permit the construction to express all its resources. The second approach consists in imposing on the monument levels of security conceived and "calculated" according to the criteria of the new structural engineering, which tends to reinterpret the ancient organisms without even knowing them; thus such interventions involve a strategy of reinforcement and radically modify the intrinsic vulnerability. No one should be in any doubt as to the irrationality of applying theories and models of calculus conceived for modern structures to the historical and/or archaeological heritage.

In reality there are a series of complications caused by the fact that protection of human life and cultural heritage from seismic risk creates a diverse range of problems. In terms of human life the accepted limits of risk in the current historical phase are heavily conditioned by the context of evaluation (wars, road safety, natural calamities). For the cultural heritage there is still a lot of work to be done to arrive at an appropriate estimate of risk because the strategies for the evaluation of the various types of vulnerability are inadequate and discontinuous.

What has been said so far gives rise to two common negative tendencies: underestimating the monument's intrinsic resources, and modifying the construction to make its behaviour similar to that of a modern structure susceptible to theoretical modelling.

3.8 *Meteoric aspects*

This vulnerability, present in all the built heritage, becomes more serious for archaeological ruins because the surfaces of the masonry in the ruined state are particularly affected by the action of rain water, the corrosive action of wind, the infestation of vegetation and the presence of micro- and macro-organisms. This type of vulnerability, which affects ancient decorative elements such as plasterwork, mosaic work,

frescoes and flooring, can only be contrasted by an efficient programmed maintenance able to balance the effects of degeneration and the conservation interventions.

3.9 *Thermo-hygrometric aspects*

Hygrometric vulnerability depends on the interaction between artefact and water, whether on the surface or in the water table, as well as the presence of adjacent embankments; in the first case we are dealing with progressive humidity or rising damp, and in the second humidity from embankments.

Rising damp is caused by the water present in the terrain rising up through the masonry, all the more so when this is porous, determining the construction's degeneration; an analogous phenomenon occurs in the case of humidity from embankments, with the difference that here the penetration of water into the construction does not require an upward movement. To reduce the risk, in the case of rising damp it is important to establish whether the agent is surface water or that from the water table.

Thermo-hygrometric vulnerability is linked to conservation interventions which tend to block ventilation inside the structures. This refers in particular to situations in which the artefact, generally below ground, is protected with the application of transparent film so as to permit use; such coverings, by blocking ventilation, make it impossible for steam to escape, in certain seasons in particular, so that it condenses on the transparent surface and forms water droplets.

3.10 *Man-made hazard*

Man-made hazard is due both to effects induced by interventions linked to the use of the structure and those provoked by interventions associated with transformations in the territory. Among the former we can mention the modifications designed to ensure the absolute security of visitors, and wear and tear, alterations and transformations of the structure due to interventions of maintenance and restoration. The latter include modifications of the areas due to new excavations or constructions, and degeneration due to pollution, industrialization, etc., as well as the difficulty of setting up properly protected archaeological areas.

PART II

4. The specific character of the archaeological context

Archaeological remains represent a significant record of both urban centres and the territory. For many centuries, and up until the most recent urbanization, medieval, renaissance and modern constructions took their form from the ancient structures and infrastructures, using their building materials, construction systems and architectonic models, and the same was true for roads, water supply system and major construction projects slicing through hills and valleys. The conservation of such a complex and stratified heritage requires particular attention in planning and carrying out conservation interventions, because it is often poorly known on account of the transformations it has undergone, difficult to learn about from historical documents and indeed difficult to classify in even an approximate typological framework.

Where historical constructions have completely modified pre-existing archaeological remains and incorporated them in new structures, the main concern must be to conserve the built heritage as a whole, drawing on architectonic and topographical surveys, direct measurements and stratigraphical excavations so as to identify as far as possible the material history. When on the other hand interventions of restoration and adaptation carried out in the course of time in order to rescue ancient artefacts have only modified the original aspect in part, projects of conservation and safeguarding can be very different, according to the scale and state of conservation of the archaeological built heritage, the magnitude of the area and the collocation of the artefact in an urban or rural context.

For many archaeological areas, even ones which are very large, a lot of the problems due to excavations and urbanization projects have still not been resolved. Often the boundaries of the ancient structures are not known precisely, or else they have been redrawn in such an arbitrary manner as to mortify and render impossible a correct comprehension of the visible remains. In any case it is necessary to formulate in-

tervention hypotheses case by case so as to preserve the ancient artefact and make it, at the same time, an integral part of the modern urban and territorial structure. Moreover use of the archaeological site which is compatible with conservation and the selection of permissible activities can orient the planning choices and operative strategies.

Conserving evidence of the past, defending it and safeguarding it against degeneration have always denoted a respect for culture. The safeguarding intervention which selects the compatibility of transformations and new designations and the patient work of conservation which contrasts the natural vocation of every artefact to deteriorate, making good the gaps with care, are based on a knowledge of the morphology of the sites, comprehension of the historic construction process and recognition of the craft of master builders.

In fact the restoration works site becomes a tool for updating our scientific knowledge of each artefact, by means of archaeological and architectonic surveys, stratigraphical excavations, direct observation of the building itself, diagnosis, and any other form of research designed to improve the state of our knowledge.

5. Normative context

These recommendations have been drawn up in order to provide the institutions charged with supervising monuments and the territory, together with planners, with a tool to ensure that interventions of safeguarding, maintenance and conservation are coherent and homogeneous. The definition of the criteria for operating on the archaeological built heritage cannot ignore a knowledge of the qualities and material characteristics of whatever is to be conserved, while at the same time using the most advanced study techniques to evaluate the opportunity of resorting to technologies which are different to the historical ones. While the adoption of traditional reiterated interventions can in any case be done respecting the principle of minimal intervention, verification of congruence between the techniques and materials used in restoration and the original construction, to ensure homologation in the application of modern technologies it is necessary to evaluate with care the numerous contributions made by scientific research in various domains, including them in the domain of conservation only after scrupulous verification, case by case. The use

of new materials and technologies must in no circumstances involve alteration of the original construction conception, and be based on a documented scientific experimentation which ensures reversibility, whenever possible, and a durability to match the intrinsic durability of the artefact in question.

The objective of establishing, within one monumental complex or across a vast territory, the correct intervention priorities will make it necessary to unify the criteria for acquiring the data on the state of conservation. These will be duly collated in records registering the quality and quantity of damage and the levels of the artefact's vulnerability and hazard for prospective visitors, as well as the efficacy and duration of previous interventions. By comparing the various situations recorded it will be possible to establish interventions which are one-off and cannot be postponed, and others more widespread and recurrent which will nonetheless be grouped in a single intervention programme.

The project must respect the current normative context, but it should be borne in mind that the normative techniques are contingent prescriptions which tend to be updated increasingly rapidly, while the archaeological ruin is an "eternal" document and cannot be subjected to continuous bureaucratic revision. Moreover, while a strictly technical approach tends to view each norm as a general principle, it is clear that it is up to the cultural sensibility and professional capacity of the planner to arrive at an appropriate interpretation of the normative context, interpreting it according to the specificity of the archaeological context, working closely with the organism responsible for safeguarding.

6. Planning indications

6.1 *Preliminary considerations*

The aim of the project must be to conserve a unique document and make it accessible in the modern world; this means that even though the conservation of the archaeological heritage generally only has a cultural purpose, it is essential also to give due consideration to urban planning implications. Where there is no effective policy of control and territorial development which extends to evidence from the past, the safeguarding measures laid down for protected archaeological sites all too often produce effects of marginalization and degeneration.

The conservation project must relate ancient monuments to the urban and territorial context, establishing the principles for a plan for the archaeological sector able to interact with the other operative plans drawn up by the local authorities. This will make it possible to incorporate the features of the safeguarding project in the norms of the P.R.G. [regional planning blueprint] and development schemes. In this way any structural intervention on the territory will have to take into account the presence of scattered archaeological artefacts or isolated monuments, as well as the safeguarding already in place for protected areas. To this end it is essential for each local authority to draw up a specific Archaeological Map for its territory.

The conservation of archaeological finds and their integration in the activities that characterize a city or territory are essential requisites for a modern society. This is why it is necessary to rectify the situation in which the conservation of the material documents of the history of our civilization has been in opposition with the planning of spaces destined for society at large. The archaeological built heritage and modern living space can encounter each other in a planned city, each taking on the most significant qualities of the other. When it comes to restoring the ancient fabric, the capacity of modern technical culture must be expressed in reducing intervention to a minimum without altering the original construction conception of the artefact being conserved.

Recognised projects of conservation, enhancement and restoration of archaeological monuments and areas are only some of the possible cases, whereas widespread interventions involve complex situations generated by the transformation of ancient constructions. The restoration of ruins, even on the large scale, occuring in complex urban stratigraphical realities may not only make the most of the potential of what exists and anticipate future needs, but may also constitute an effective response to the demand for widespread urban quality, initiating an on-going process of the selection of use, materials and technologies compatible with the historical context.

The semantic value of artefacts reduced to ruins, often highlighted by a state of romantic abandonment, is comparable to that shown by whole monuments and can lie in sheer grandiosity, the architectonic quality visible or evoked, and the ability to take on an autonomous role in the urban fabric, attesting an important phase of the past. The intervention criteria will obviously vary according to the value to be attributed to the historical artefact in the local urban context and to the general guidelines for territorial or metropolitan development.

For urban and extra-urban archaeological parks, just as for historical city centres or residential quarters, the relationship with the contemporary city can be ensured by locating the necessary service structures required to integrate the new with the old in open spaces, or else using for this purpose buildings originally designed for industrial production or obsolete transport infrastructures whose architectonic quality and urban value can thus be safeguarded, or again transforming former industrial zones with appropriate interventions.

Conservation and restoration alone cannot ensure the survival of the ancient artefacts if the planning of the contemporary city does not recognise the permanence of the historical structures as an essential feature. Hence the necessity of making explicit the modalities of intervention able to orient urban planning decisions in a sectorial plan for the safeguarding of archaeological areas and monuments.

The conservation of the material substance of the artefact can also be ensured by means of the phases laid down by law – preliminary project, definitive project, executive project – as long as these phases are planned as a single sequence and contain safeguarding measures to be taken on the territorial or sectorial scale together with verification of the conservation projects, maintenance programmes and efficiency of the monitoring. The project has to coordinate the verification of feasibility, environmental objectives and costs, ensuring a compatible use for the artefact.

The following instruments are indispensable:

• historical/critical analysis of the archaeological resource taking as reference the built fabric of which the artefact is or was once a part; thus it is necessary to research the artefact's original form, also by means of typological comparisons, as well as the function it performed in the ancient urban context, for the variations in form and context brought about by historical events may have led to its destruction or favoured its conservation. Knowledge of the structural conception and construction techniques adopted makes it possible to recognise any additions or transformations which are not part of the original configuration, as well as the effects produced by such transformations. Thus the historical investigation must include a typological analysis at both the urban level and that of the single structure, so as to identify convincing references and parallels; this will enhance knowledge of the construction system and any transformations it underwent, so as to make a correct assessment of damage and vulnerability.

• a geometric survey and where appropriate metrological analyses providing indications as to the criteria used in the artefact's conception and to gain a full understanding of its dimensions; a partialized structure can be understood with the help of typological analysis, construction repertory, the existence of repeatable construction modules, and knowledge of the techniques and materials that went to constitute them. To this end the survey must make use of direct measurements taken on the existing artefacts and theoretical matching with known or knowable types. Lastly the survey should accurately describe the configuration of any structural damage and surface degeneration; a critical interpretation of the measured geometries can be the starting point for the project outlines.

• a logical and documented anamnesis of the transformations, distortions and interventions of restoration and maintenance, identifying their motivations and coherence with the artefact's conservation, necessity and efficacity.

• as complete as possible a diagnostic study concerning the mechanical, chemical and physical properties of the materials used, involving analysis of disturbances, knowledge of the construction techniques and the nature of the interventions which transformed the original form. This diagnosis aims at gaining technical and scientific knowledge of the ruin and will contribute to defining the conservation project.

6.2 *Preliminary project*

Knowledge of the artefact in question is always the first step in any conservation intervention. It can be based on written and iconographic records, on surveys or reports of previous restorations, on excavation logbooks or working notes, while in archaeological areas it cannot ignore the symbolic value of the ancient artefact, however this is documented. In addition, the project and operative phases will have to be calibrated according to the requisites of the contemporary world, responding to normative and standard restrictions without diminishing or distorting the ancient structures.

In defining the qualitative and functional features of the work to be undertaken, the overall requisites to be met, and the objectives, administrative and technical feasibility of the planned intervention, the preliminary project must give pride of place to knowledge of the material substance of the archaeological artefact and the historical events which

brought it about, ensuring correct identification of the criteria needed to contrast the progress of degeneration and complying with the standard of "minimum intervention". A procedural report will be able to outline the measures held to be urgent, necessary or opportune for safeguarding the artefact or site and the scale of the resulting interventions. It will then be possible to indicate the general criteria to be respected, the periodicity of applications and controls, and the scale of the works sites so as to draw up an efficient picture of material and economic feasibility. The preliminary project can draw on all the necessary disciplinary contributions with relation to the problems and importance of the work in question, as well as multidisciplinary analysis and comparative studies.

6.3 *Definitive project*

This has to conserve the material substance of the archaeological resource, designating functions and uses which are compatible with existing structures; it identifies what work is to be carried out, respecting the requirements, criteria, orientations and indications laid down in the preliminary project. In the case of extraordinary maintenance interventions it will be necessary to foresee the priorities, define the technical operations, establish the operative timescale and sequence of the work to be done in relation to the investment budget.

Excavation campaigns must also be planned in their entirety and must envisage adequate protection measures; since the results of an excavation do not always correspond exactly to forecasts, at least a significant part of the work has to be completed before going on to further investigations. Even when the archaeological areas only serve cultural purposes, conservation must be guaranteed so as to avoid situations of vulnerability for the artefacts and danger for visitors.

The project has to receive and organize the findings of the many disciplines which define the conditions for the conservation of the material and its place in its environment, composing, with new modes of equilibrium, images and data on the history of the territory and the ancient city as values for the modern city. Every spatial metamorphosis reflects the project culture which, starting from the specificity of the locations, is transformed into a valid instrument for calibrating the reciprocity of ancient and modern. Continuity and discontinuity in the materials used, new viewing areas and itineraries can express different and

more complex analytical and formal approaches, which are qualitatively related to architectonic objects as the repositories of a high information content, recomposing even fragments in images open to multiple interpretations, with a readiness to experiment a contemporary frequentation of successive phases of construction history without betraying the principles of conservation. Attention to this issue in conservation and restoration projects concerning the archaeological heritage can be expressed at the territorial level by prescribing excavations prior to the realization of infrastructures, defining areas of respect, identifying ordered sequences that can be freely followed, organized according to parameters which are congruent with the most ancient spatial values as obtained using instruments, materials and technologies which are reversible and non invasive.

In each of these cases the definitive restoration project will be based on the broadest possible knowledge of the artefacts, on conservation choices which are congruent with the various different situations, and on the criteria of minimum intervention.

6.4 *Executive project*

The executive project is designed to determine in detail the work to be carried out, enabling the organization and realization of a works site able to carry through the planned conservation tasks on a volume of the archaeological heritage which has been defined in advance. The tasks must correspond to the general principles laid down and achieve the improvements envisaged by the project, involving one or more works sites to be completed according to the established timetable; on conclusion of the tasks all the requisite documentation must be provided for a full comprehension of the work carried out, evaluation of its efficacy over time, and prescriptions for its maintenance.

The executive project must form part of the general intervention programme and be endowed with sufficient funding to ensure achievement of the minimum prescribed goals. It can, however, represent just one stage in the definitive project, with further investigations being contemplated concerning significant data that will permit subsequent stages in the executive project. The executive project must set up a maintenance plan which indicates operations to be reiterated according to an established timetable. In fact a conservation intervention can never be considered a finite or definitive operation; it inevitably involves

a continuity of interventions and constant confrontation between conservation and maintenance requisites.

The executive project must include a specific security plan for each works site to accompany the work. In organizing the works site it must be borne in mind that the image offered by the historical artefact and archaeological complexes is the result of the many and various transformations which from ancient times to the present have renewed the landscape and the urban scenario, with roles which differ in the course of time. The permanence of the ancient structures which underpins the city's topography and history, identifying spatial sequences for which it is possible to reconstitute architecture, technology, function and duration, can be made explicit and enhanced also during the phases of the intervention using various systems of communication.

Nowadays attestations of the ancient art of building, which grew out of practical experience and experimentation with forms and the durability of materials, confront structures conceived according to the modern epistemology of design and calculus. A commitment to the knowledge and conservation of the former is not in contradiction with the latter, but actually enhances the autonomous pursuit of innovatory spatial qualities which may not be so lasting but are undoubtedly more flexible, and it is the responsibility of the executive project to ensure any such joint presence without conflict.

The restoration project must not consist in a variety of incoherent indications but rather orderly on-going sequences which can be freely adopted, organized with instruments, materials and technologies which may also be modern but which respect parameters that are congruent with the older spatial values featuring light, water and earth, produced by human labour manipulating the materials of nature.

The transgression of the rules as a deliberate break with the past that began with avantgardes of the 1920s, in architecture just as in the visual arts, was based on a critical and in part political discussion of the role of the arts. Today this discussion has lost a lot of its meaning because the flouting of rules has come to be expected of every planning and aesthetic initiative; and when any manner of surprise is taken for granted, surely the only true surprise lies in a planning approach based on the rules which architecture has patiently pursued for centuries. Recomposition fragment by fragment, the reversibility of interventions, the poly-functionality of spaces can in fact come to be seen as a strikingly new expression of modernity.

The executive project should take into account the following considerations:

– the intervention takes place in an existing context which is already defined, even if not necessarily known, and takes the form of a complex process involving different phases based on a scrupulous examination of the technical and construction qualities of the artefact, on comprehension of the resulting space and on a recognition of its intrinsic qualities. The project involves conservation of the artefacts in their spatial and structural integrity and their "contamination" with modern materials designed to give the artefact a new functionality. This must be compatible with the quality and nature of the ancient structure, and in any case must respect minimum intervention and maximum reversibility.

– in ancient structures the rules of the art of building constitute a unique document of material history, and knowledge of the design and executive canons becomes an indispensable tool for investigating and identifying the fundamental principles for their conservation. In fact the ancient construction conception, often adapted from nature with the mediation of geometry, together with experimentation on materials with a significant specific weight, inertia and durability, generate exemplary construction prototypes. Materials and adhesives, used with skilful and accurate experimentation based on observation, have contributed, through a long history of successes and failures, to determining the widespread convictions that for thousands of years have been at the heart of the principles of the historical built heritage.

Once no doubts remain as to the original form and technique, one may take into consideration the advisability of reconstructing some portions to ensure the structural improvement of parts of the ancient structure. In other cases, often with a view to use, surface elements can be reconstructed, such as flooring, plasterwork, etc.

Structural calculus based on rational mechanics which makes use of simplified theoretical models formulated analytically in interpreting nature is at the service of an ever greater specialization which divorces the planner from the practical know how of the works site and makes it difficult for him to appreciate the laws and potential behind the historical built heritage. We can state unequivocally that it is harmful for the planner to respond exclusively to the schemes proper to calculus and the inevitability of normative measures. Only recently has the development of calculus based on finite elements made it possible to ob-

tain a more reliable approximation of the static behaviour of ancient constructions, suggesting the possibility of bridging the irreconcilability of epistemological approaches which are so much at odds with one another.

– A different conception of construction and structure brings out, also in the planning phase, the dichotomy between the historical built fabric and its modern counterpart. While construction, carried out according to the rules of the art, gives form to a unitary spatial organism responding to all requisites, the structure is a material organism designed, according to the models of mechanics, exclusively to fulfil static functions and connect the load-bearing parts of the building, which can be made by assembling industrial components. If the project envisages even partial use of elements to be produced off the works site, with processes far removed from the handicraft reality of the historical built heritage, this must be taken into account when drawing up the construction details of the points of contact.

7. Technical intervention operations

Interventions in an archaeological context have particular aspects which often differentiate them from interventions on the historical heritage. First of all we can note that in general the levels of risk for people are significantly lower, while from the conservation point of view archaeological sites should not be used for large-scale public events.

The archaeological ruin is a built element which has come down to us in a modified, mutilated and transformed state with respect to its original configuration and function. It is what remains of ancient constructions about which we may not know very much and which it be quite difficult and laborious to identify. It is not what it was originally, and it makes sense and is of value in its current conformation, as a document in the "archive of material history". It has to be safeguarded and conserved for its cultural content and material substance. It is essential to conserve every part of an archaeological ruin, irrespective of the reasons behind its use.

An archaeological ruin can be classified as:

– large-scale ruins standing above ground (features which have always been present in the cultural landscape);

– remains recuperated by means of excavation, generally less significant in terms of configuration and complexity as well as scale.

Hence the need to respect the inalterability of the archaeological heritage; the inevitable and irreversible processes of wear and tear can only be retarded by a correct application of the technological progress, so as to employ all the currently available means and techniques (data bases, geometric and material surveys, etc.) in realizing the most comprehensive and exact documentation possible.

Ancient building materials and techniques have always been one of the fundamental domains of archaeological research. Since the middle of the last century this has been complemented by archaeometric research and engineering for cultural assets, two new developments which are now in the forefront of scientific research concerning the ancient world. This has accentuated the significance of archive documents of material history, so that now our greatest cause for concern is degeneration in building materials, whether natural or artificial, brought about by maintenance shortcomings. Protection from degeneration due to atmospheric factors and biological aggression thus constitutes a priority that outranks even seismic vulnerability.

Two fundamental criteria have to be adopted for interventions in the archaeological context:

- improvement;
- possible reversibility.

The criterion of improvement, referred to in art. 34 of the national Code for Cultural Assets in its definition of restoration, is not restricted to seismic vulnerability. Given the durability of the archaeological ruin over millennia, it tends to ensure stability and also protection from degeneration by means of homogeneous interventions which are compatible with the ruin's material nature, planning the various technical operations according to the criterion of minimum intervention. In other words the aim is to eliminate degeneration by repristinating, as far as possible, the original conditions of the structure, showing the maximum respect for the ruin's material integrity and longterm durability.

The concept of reversibility is intimately linked to a critical approach to historical knowledge, for which archaeology is a fundamental proving ground. The intangibility of the document derives first of all from the possibility of a reinterpretation in the light of a more complete historical knowledge. Unfortunately, however, while the intangibility of a paper document has been definitively taken on board by mo-

dern historiographical culture, the same does not hold for documents of material history, in particular for the history of building and the built fabric, of which the archaeological heritage represents the oldest manifestation.

This blind spot of historians concerning the material history of the built heritage has left room both for restoration interventions interested more in leaving their own mark than in safeguarding the identity of monuments, and for technical interventions designed to ensure stability and functionality which have used materials and techniques that are quite alien to conservation. If the focus is on the safeguarding and transmission of the monument-document, it is clear that the concepts of reversibility and durability become cogent, and they must be confirmed both in the conservation projects and in the process of programmed maintenance.

The criteria required to ensure the above principles are:

- respect for the construction conception of the archaeological artefact,
- use of materials and techniques which are compatible with reversibility.

These criteria must be adopted first of all as methodological references, while various difficulties may be encountered in their technical application. Moreover the "specific weight" of reversibility changes according to whether it involves interventions of deconstruction or whether it is above all a methodological touchstone for new interventions.

When interventions concern situations which have become firmly established in the course of time, it is necessary to act with particular caution since significant new documents of material history have become stratified over the long time span of the archaeological ruin. We can think for example of the major archaeological "inserts" occurring in a lot of religious architecture. In many cases reversibility can be safeguarded, awaiting technological developments which will specifically benefit conservation.

With reference to new conservation projects, the hope is that they will be drawn up in a historical/critical perspective which gives priority to the integrity of the monument-document. This means having the status of the artefact scientifically documented and then to draw up a conservation plan in full knowledge of both the possible reversibility and the need for the intervention to be readily identifiable.

When reversability becomes objectively impossible, as in the restoration of masonry structures, materials and techniques should be adopted which are entirely homogeneous with the ancient ones, so as not to alter the construction conception or distribution of stresses and conserve the artefact's durability. When requisites of restoration or use require the insertion of new construction elements such as horizontal axes, roofing, etc., architecture and modern structural engineering provide many technological possibilities for inserting these elements without altering the ancient artefact or its structural behaviour, reducing to a minimum the linking and transmission of stresses between ancient construction and the new structure.

Great caution must be taken in applying the recent structural norms to the archaeological heritage, and this is also the case for the recent guidelines for the evaluation and reduction of seismic risk in the cultural heritage issued by the Ministero per i Beni e le Attività Culturali, drawn up for the historical heritage without making any specific allowance for its archaeological counterpart.

Unfortunately the so-called consolidation interventions, which on one hand have ignored the ancient construction conception and on the other have applied the standard technologies of structures in reinforced concrete or metallised timber, have caused irreversible damage, making it urgent to proceed with a general review of strategy, putting an end to the concreting of the archaeological heritage and the interpretation of its stability in terms of standard structural coefficients

7.1 *Archaeological sites and geotechnical problems*

Archaeological sites often feature geotechnical aspects. The mechanical characteristics of the terrain influence the progress of excavation, the stability of embankments and the security of operators. In these brief notes it is clearly not possible to go over the principles of the mechanics of soils or go into the technical problems of excavation in general. We shall merely look at the situations which are most likely to arise, pointing out the relative geotechnical problems and the appropriate precautions.

In shallow excavations or when it is possible to extend the area of intervention and limit the slope of the embankments, obviously no difficulties or risks of instability arise. A trench in a terrain which is not stony exceeding 1.5 m in depth does however require attention. Fre-

quently archaeological sites concern deposits which are not natural in origin, such as in-fills or shifted earth, deposits of detritus or what remains from the collapse of preceding structures, containing stone elements or fragments of bricks and mortar; in general these materials conform to the mechanical behaviour of *terre incoerenti*.

Archaeological sites involving sloping embankments higher than a few metres require a preliminary analysis of stability carried out using the investigation methods and procedures pertaining to geotechnical engineering. Now there are means and modalities for intervention which are not so invasive and which make it possible to ensure stability of the embankment and the security of the operators, avoiding, or reducing to a minimum, the risk of damaging structures or features out of sight.

7.2 *Foundations*

Often the foundations of a ruin go down into an area of archaeological deposit level or one which is in any case fundamentally stable. Where there has been no disruption on account of landslides, seismic events or floods, only very limited interventions are made on foundations as a rule. These must nonetheless be based on a comprehensive knowledge of the existing foundations as well as the geotechnical profile of the terrains in question. It will be necessary to ensure the greatest possible uniformity for the conditions of simple supported, repristinating and strengthening the horizontal connnections or where necessary underpinning the wall structures, a technique which can afford a better knowledge of the archaeological foundation area. In any case no use must be made of piles and micro-piles, for this causes the definitive concreting of the deposit level, obliterating all the archaeological evidence and altering the original relationship between foundation and construction.

7.3 *Masonry*

Archaeological masonry constitutes a precious and complex attestation of material history in general and construction history in particular. Its integrity has to be safeguarded now more than ever before in view of the fact that contemporary technological development in the applied sciences enables us to make investigations which transform

masonry into a historical document of outstanding value. Masonry enables us to determine the nature and provenance of the materials used and the mechanical, chemical and physical characteristics which determine their structural behaviour. From its dimensions, analysis of its foundations and, where possible, study of the built organism, it is possible to gain precious evidence concerning the "rules of the art" and the construction techniques on a given territory at a certain period in history. Further contributions can derive from a stratigraphical analysis, and in the near future methods for dating inorganic materials, currently at an advanced stage of research, will place analysis of masonry in the forefront of our historical knowledge of any construction whatsoever, enabling us to establish its origin and all the successive interventions. Also the definition and analysis of the cracks pattern and the different forms of degeneration, if analysed using scientific methods backed up by modern diagnostic, can provide new information about the recent evolution of the artefact, as well as being fundamental to defining the most appropriate conservation intervention.

In planning an intervention of improvement it is necessary to use materials with physical and chemical characteristics which are as homogeneous as possible with the original materials. In particular the stone or brick materials and adhesives used should be similar to those present in the artefact, while concrete and cement-based mortars must be avoided at all costs.

Using such materials, circumstances will determine one or more of the following actions:

- making localised repairs and making good parts showing fractures by closing up the lesions and, where necessary, "unsewing and resewing";
- repristinating existing alterations made to the artefact in successive phases which have been deemed inappropriate when the restoration was being planned;
- making integrations which are indispensable for ensuring the construction's stability.

In any case it is essential that the wall being treated should regain complete homogeneity of its fabric, uniformity of resistance and rigid continuity, carrying out where necessary the appropriate connections by means of an efficient refurbishment of the masonry. There can be no question of perforating the fabric with or without the insertion of rods in steel, glass fibre or whatever on four counts: their invasive ef-

fect on the ancient fabric, their evident irreversibility, the legitimate doubts as to their durability and finally the lack of evidence concerning their efficacy in particular in the face of earthquakes.

In the case of masonry with particularly poor mechanical characteristics, as also of microlesions and gaps in the masonry fabric, it is possible to draw on more modern techniques of cement-free adhesive compounds which must be given a preliminary trial in terms of feasibility and efficacy, making specific injections into the mortar joints and any cavities. There can be no question of reinforcing the masonry by concrete plating, whether reinforced or not, of using cement-based plasterwork. Such interventions obliterate the ancient fabric and cause major problems of humidity by preventing the wall from transpiring.

Clearly walls adorned with frescoes or mosaics represent particularly delicate cases. If the fresco is only on one wall surface then the intervention can be carried out with great care on the other surface. In any case such interventions must always be performed working with specialists in the specific sector.

7.4 *Pillars and columns*

It must be first be pointed out that pillars and columns were generally conceived to bear vertical loads with only a small degree of eccentricity: any action that affects such static behaviour will produce negative effects on resistance and stability. Actions of this kind are due above all to the pressures from arches, vaults and roofing, caused by such dynamic events as seism or wind.

In the interests of improvement interventions on pillars and columns involve the following:

- repristinating, where necessary, the original resistance under normal stress through such measures as hoops and inserts;
- eliminating or in any case limiting horizontal pressures by introducing chains into arches, vaults and roofing and providing or renewing buttressing;
- repristinating, where appropriate, connections designed to transmit horizontal actions to elements which are more rigid and resistant.

On the contrary one must avoid interventions designed to endow columns and pillars with resistance in the forms of bending and shear, such as reinforced perforations, pre-compression and the insertion of metal pins. Such interventions, as well as being invasive and non re-

versible, are generally of limited use and often damaging because they drastically modify the structure's overall behaviour.

Another technique to be avoided is swathing with carbon fibre or the like, and any other type of cladding which obliterates the construction element and modifies its static behaviour.

Situations of non verticality have to be analysed with care, identifying causes and effects and evaluating the advisability of correcting or conserving them.

To the extent that they can be applied, the considerations made in the preceding section concerning walls remain valid here too.

7.5 *Chaining and tie bars*

The technique of inserting "chains" in masonry structures has been practised for centuries. It has recently received new endorsement and should be adopted systematically, especially for interventions in seismic zones. It is preferable to use chains made of bars of stainless steel with fixtures "keystone" able to distribute pressure across large areas of the masonry, better if fixed onto the outside of the walls. Alternatively bars of glass fibre or innovatory materials may be used, as long as these have proven mechanical, chemical and physical qualities and durability. The chains serve to achieve the so-called "box effect", meaning the capacity to function structurally as a single spatial organism. To this end the chains will mostly be placed along the main walls, at all levels, using double chains round the walls themselves whenever possible. In the case of external walls generally a single chain will be used on the inside. Where it is indispensable to pierce the wall lengthwise (to be done as rarely as possible), lined bars rather than injected should be used, ensuring reversibility, the possibility of replacing the tension, and avoiding anomalous and harmful stresses.

As a norm chains will be horizontal. In some cases vertical or transverse tractions tie bars may have to be used. Whenever tractions are introduced the masonry must always be monitored to ensure that the induced actions are tolerated with ample security margins, also in the transitory installation phase. In some cases a masonry element in a state of ruin may be stabilised with the use of adequate tractions anchored to the ground or to adjacent constructions. The intervention should be left visible so as to demonstrate the ruin's vulnerability.

7.6 *Arches and vaults*

Construction elements featuring arches and vaults are characteristic of the whole of the historical built heritage. Contrary to widespread belief, based on knowledge restricted to the modern technical theory of the beam, which has had decidedly negative consequences for the conservation of ancient architecture, the behaviour of arches and vaults during earthquakes is actually very good, as becomes evident when assessing the damage suffered. It is no coincidence if structures built underground and on the lower storeys are traditionally covered with a vault, specifically to increase the construction's box-like behaviour. Besides, arches have been used throughout the Mediterranean region as an antiseismic connection between the various outbuildings of a complex, so as to dissipate the seismic energy over large masses or link up highly asymmetrical parts of a construction.

In ancient coverings made of masonry with flat extrados and vaulted intrados, resistance is provided by all the masonry and not just by the arch-shaped intrados, enabling the pressure curve to adapt to the various stress conditions.

As for the presence of crack patterns, the arches and vaults can be subjected to local integrative interventions similar to those indicated for masonry, bearing in mind that some lesions can be physiological, making it advisable not to repair them; this is true in particular for fiches at the top and the sides, as long as resistance to trust is ensured.

A judicious adoption of chains of the kind we have described can bring about a significant improvement; as a rule they will be applied to the trunk of arches and vaults. It is as well never to have recourse to lining techniques which use various materials to introduce a countervault to the extrados; such techniques not only make the structural behaviour of the two overlapping elements ambiguous but also give rise to a dishomogeneity in the materials with a very different durability, while also being largely non-reversible.

7.7 *Ceilings*

Ceilings are generally only subject to vertical loads. In the presence of seismic actions they take on the important role of link between walls and transverse bracing stiffening, helping to produce the "box effect" which is essential for the construction's spatial behaviour. To this

end it is necessary for the ceilings to be well connected to the load-bearing walls and to have an adequate rigidity on their own plane. This said the following may serve as intervention guidelines:

• the insertion of beams involving the constant bisection of the masonry must be avoided. Instead well placed external connections must be adopted, where necessary with chains and continuous fixtures in wood or steel framing united to the masonry by means of suitable fixtures. If the ceiling has to be replaced it is important for this intervention to be largely reversible.

• Usually wooden ceilings must be conserved; when this is not feasible, the replacement itself should be in wood. Beam heads must be well lodged in the masonry and rest on stone or brick underlays; where necessary they should be reconstituted, just as any trace of degeneration in the beams must be eliminated. Moreover it is advisable, wherever possible, to introduce an extra fixture presenting any significant horizontal movement. Finally the standard techniques for stiffening the deck will be adopted, and in any case adequate provision must be made for air to pass to avoid the risk of long term rotting.

• For ceilings with a beam and small-vaults or bricks it is advisable to provide stiffening by means of a reinforced ceiling linked to the girders, when necessary inserting chains and protecting the metal beams against corrosion.

• Ceilings in cemented brick are best replaced by new ceilings, preferably made of wood.

7.8 *Roofs*

Wooden roofs with tiles should be conserved; if they weigh unduly on the structure it is best to eliminate the pressure by simple devices such as tie bars. For their conservation the same guidelines hold as for ceilings, in addition of course to the realization of an effective and lasting waterproofing.

7.9 *Other interventions*

Sometimes elements in a state of ruin can take on very precarious configurations verging on instability, or are still stable enough in a normal conditions but become highly precarious in the case of seismic ac-

tions. This includes walls which are very slender or too high and not windbraced, or again fragments of vaults which now merely function as cantilevers. These problems can in general be resolved with traditional improvement interventions, for example by means of tractions or else limited integrations made using homogeneous materials which are in any case left evident, or finally by limiting use to spaces which are not at risk of collapse. In planning such interventions it is essential to constantly safeguard the ruin's identity and material integrity.

7.10 *The contribution of innovation: diagnostic and materials*

In the context of a historical/scientific theory of conservation of the archaeological built heritage, diagnostic is increasingly emerging as a key to scientific knowledge of material history. Over the last decade there has been a considerable development in geotechnical, structural, physical, chemical and biological diagnostic, and this is sure to continue in the immediate future, making it possible to achieve a reasonably certain dating of inorganic materials. Thus before planning a conservation intervention, and alongside the anamnesis of the relics in question, it is advisable to draw up a diagnostic plan for the specific case that can ensure a deeper scientific knowledge of the ruin's construction conception, the materials and techniques used, and the various aspects of the on-going degeneration. It is also indispensable to collect data from previous monitoring and analytical studies, of considerable value in interpreting the current and potential phenomena of destabilization.

In recent decades materials engineering has developed numerous innovatory materials including artificial stones, fibre glass elements, composites, etc. These materials must be used with extreme caution in interventions on the archaeological built heritage since there is no proof of their compatibility with traditional materials, nor indeed of their real reversibility or durability. Besides, recalling the damage done by widespread use of cement and construction elements in reinforced concrete, everything must be done to avoid such catastrophic experiences. We would emphasise that it is becoming increasingly possible to design materials with specific physical, chemical and mechanical qualities, so that one can envisage a further stage in the scientific interaction between archaeology and engineering.

7.11 *Protection against rising damp and control of microclimate*

In order to reduce the risks deriving from the presence of water in masonry it is necessary to identify causes and magnitude, through an accurate diagnosis. If rising damp is due to the presence of surface water one must proceed to channel, regulate, contain and drain off such water. It is normally possible, and in any case preferable, to make use of structures sunk into the ground as being less intrusive than constructions in masonry or concrete which mean excavating foundations and which are bound to hamper any future investigations. If on the other hand the rising damp is due to the water table, one must intervene on the terrain's filtering conditions by means of deep-lying drainage and the installation of pumping equipment which may be either temporary or continuous. These are of course particularly costly interventions, to be planned with extreme attention, evaluating not only the positive effects but also the possible risks. With respect to the risk linked to the presence of high degrees of humidity in the air, which can cause degeneration on contact with the artefact, it is indispensable to create a system of ventilation, either natural or mechanical according to circumstances, taking great care to ensure that enough air circulates to ensure values of relative humidity which are compatible with the requirements of conservation.

7.12 *Conservation of surfaces*

A correct conservation intervention on the surfaces of historical architecture has to recognise the fundamental importance of knowledge of the intrinsic characteristics of the constituent materials and their state of conservation. The validity of this method has been amply borne out by the important results achieved in defining the methodologies to adopt in restoration. These results show that a scrupulous verification of the material used in cladding, finishing, decorations and materials that make up the wall structure can have a considerable impact on historical and aesthetic evaluations, and represents a unique tool for formulating a correct diagnosis, planning the interventions required for the artefact's conservation, and drawing up the programme for ordinary maintenance.

The planning choices which concern the surfaces of the archaeological built heritage in particular are heavily conditioned by the need to conserve a multiplicity of features. As a result interventions must be

strictly conservative, involving operations of consolidation and/or renewal of adhesive properties. The conservation of the stratifications and, in particular, of the ancient plasterwork makes it possible to acquire and pass on a material archive of the transformations in working techniques.

The finishing materials which overlay the masonry, often found only in tiny fragments, require particular attention in the phase of firsthand observation, and specific tests may be needed to establish their identity. We must stress that the ancients made frequent use of artifices that imitated noble materials, using simple coats of mortar applied in various ways and coloured to ennoble the final aspect.

The first phase of the restoration intervention must consist in firsthand observation so as to establish the material substance and state of conservation of the surfaces, recording the forms of alteration, visible on the macroscopic scale, in specific graphic records that permit their precise localization. Close-up scrutiny of the wall surfaces must be possible, using provisional structures if necessary, as well as their stratigraphical investigation. A number of stratigraphical assays may be necessary to make a correct identification of the constituent materials and their state of conservation. The stratigraphical sequences constitute a precious record of the artefact's conservation history and the building techniques; in the specific case of an architectonic feature, it is important to identify the articulation of the single parts in relation to the idiom of the architectonic order as a whole. In the case of plastered surfaces, it is often the degeneration itself which reveals, albeit only in summary fashion, the succession of layers, offering numerous interfaces caused by destruction episodes, where larger or smaller portions of the surface have flaked off or been prized off. Only after firsthand observation of the surfaces will it be possible to programme detailed diagnostic tests both on site and in the laboratory. The taking of samples must be properly documented by means of permanent localisation and, when this is stipulated, with the due authorization of the competent bodies.

Preliminary observations prior to establishing the conservation interventions required for the surfaces of ancient artefacts in stone should be approached in the same way, once again respecting and preserving all the transformations which are not actually detrimental and which have come about in the surfaces in the course of time and events.

Prior to direct intervention on the artefact, one must evaluate the possibility of intervening on the external causes which have produced

the damage, whether connected to the environment (pollution, traffic, etc.) or the geometric configuration of the architectonic feature (structural deformations, splaying at the joins, lack of possibilities for water run-off, etc.).

In evaluating damage the extent to which interaction with the environment and the conservation interventions have affected the surface of monuments must be assessed. In the most serious cases of disgregation and erosion, this may even have modified the volumes of the structure. In situations of pronounced surface erosion, it is clear that the repristination of the original colour of the stones would not only require a major consumption of material but would result in an "original" colour scheme for a structure that has lost its original configuration. In view of such a limitation, conservation interventions regarding stone surfaces must take as their prime aim the removal of the products of alteration and non compatible materials which can constitute a further cause of degeneration over time, and the repristination of the cohesion and continuity of the materials.

The heterogeneity of the materials that can be identified on an architectonic surface (natural stone, brickwork and terracotta, plasterwork, stucco, mosaic, wall paintings, graffiti, etc.) may well require widely differing intervention techniques. The most common intervention methodologies refer to the typologies of wall surfaces in stone or masonry clad with plasterwork and/or stucco.

Prior to any cleaning intervention it is necessary to ensure the security of the materials displaying damage such as to compromise their conservation even in conditions of minimum interference. Once the chemical and physical characteristics of the single materials is known, and the environmental situations with which they interact, it will be possible to identify the techniques and products to use in limiting loss of the material. The complex issues and all too frequent failures which have accompanied interventions of consolidation of stone materials are all too familiar; the problems involved both scant penetration of the consolidating products applied by impregnation, and incompatibility of the products with the mineralogical/petrographical characteristics of the material in question with the ensuing chemical/physical alterations. The choice of product and the modalities of application must be established according to data which are absolutely reliable, ensuring their efficacy; where these are not available, preliminary testing must be carried out in the laboratory according to standard practice.

In the case of finishing made from artificial materials (plasterwork, stucco, etc.) ensuring their security may require both consolidation by impregnation, in the presence of forms of disgregation, and renewal of the adhesive properties, in situations where layers of plasterwork or stucco have flaked off, whether between one layer and another or away from the wall. The forms of disgregation can be treated using methodologies analogous to those indicated above for consolidating stone work, while the flaking of layers of different consistency requires the infiltration of suitable mixtures with low saline content accompanied, when necessary, by appropriate pointing.

The successive cleaning operations must always be preceded by extensive experimentation conducted first on site with products and techniques which match the chemical composition of the materials and the products of alteration in question. In choosing the techniques to be adopted, it is always advisable to favour methods which, with the same efficacy, can enable the restorer to operate in a gradual and selective manner, maintaining close control over the operation. When the conditions of the material permit the use of sprayed water, preceded by the appropriate consolidation and protection of parts at risk, this can usefully remove widescale deposits, after which precision cleaning can be carried out by mechanical means, or by the localised action of wads of solvents or again, in particular cases, instruments of greater precision still such as laser.

The surfaces of architectural features in archaeological parks are frequently affected by forms of degeneration due above all to biodeterioration. In such cases disinfection and disinfestation are particularly appropriate, and will normally precede any cleaning intervention. Disinfestation involves biocides and/or herbicides, according to the biological species to be eliminated. This operation can require several application cycles, and thanks to water's solvent power and the bland mechanical action of scrubbing generally results in a good level of surface cleaning, except in the presence of serious forms of degeneration such as tenacious forms of encrustation.

The importance of conserving the repertory of evidence linked to significant events that have taken place in the course of time must also guide the conservation operations that concern layers of mortar, whether at joins or in plasterwork. Here the objective of the intervention must be the integration of the existing mortars, eliminating or limiting any that are irremediably useless or those involving unsuitable recent

substances. Mortars can be integrated by making up traditional compositions, according to type and granular size of the inert components, so as to ensure continuity with the existing mortars or make good small gaps in the stone elements, especially when these constitute barriers against water. One should also pay particular attention to the introduction of new layers of mortar, in view of the levels of fragmentation of the aspect of the structure caused by possible excesses of philological scrupulosity.

In treating surfaces in stone and plasterwork exposed to the elements it may be appropriate to apply a protective surface at the end of the conservation intervention, to limit the harmful action of atmospheric agents and in particular rain water. The choice of product has to take into consideration the issues reviewed above concerning consolidation, and also the aspects concerning the limited durability of the intervention and the likely effects of a faster run-off for the surface water, leading to the formation of dark filiform deposits.

The conservation techniques used for prestigious architectonic surfaces and the archaeological built heritage must be left to specialist restorers who are able to operate with the requisite expertise.

7.13 *Protection systems for archaeological areas*

More often than not, ruins in archaeological areas are kept covered over. While such coverings undoubtedly benefit conservation by limiting the impact of rain water, they remain an alien element in the archaeological context. The Istituto Superiore per la Conservazione e il Restauro has carried out an accurate study of archaeological coverings, and this should become standard reference material prior to any planning decisions. In any case coverings must be conceived in full awareness of the many requisites that accompany the conservation of ruins, identifying the most appropriate environmental characteristics and ensuring an efficient maintenance.

7.14 *Emergency interventions*

Over recent years an analysis of emergency has been developed which can ensure its management and limit the scale of damage, all too often catastrophic. Emergencies can involve fire, flooding, earthquakes, acts of terrorism or serious acts of vandalism. Methodologies ha-

ve to be constantly updated, permitting the formalization of operations in the awareness that bad emergency management can cause irreparable damage to the archaeological heritage. It is clear that urgent action should never be improvised, and those responsible must be able to identify the scope and type of damage to be tackled as quickly as possible. Actions of forecasting and prevention should already be in place at the outbreak of the emergency.

One emergency to be tackled is seismic activity which, in cycles that are to a small extent already familiar, is bound to affect zones at seismic risk. The first requisite in situations of emergency is to have an accurate and reliable documentation. This must be easily available and familiar to managers, scientific staff and the people in charge of security and plant structures. A "team leader" has to devise an action plan which will establish the priority for a sequence of interventions alternating evaluation and action. The presence of a team leader is essential for formulating an emergency plan immediately, providing the forces of civil protection, army and volunteers with ample documentation and monitoring the intervention operations since, as as was only too often the case in recent seismic events, crude, uninformed interventions cause irreparable damage.

For each archaeological site or monument an intervention protocol should be drawn up containing all necessary information, to avoid wasting time and to curb injudicious interventions. To this end a squad of volunteers could be set up, receiving specific training so as to give an immediate response to the emergency. Finally, as the Civil Protection advises, it is important to carry out periodic simulations of a seismic event, designed to show up problems of knowledge and documentation and accumulating a store of experience that will be triggered automatically on the outbreak of an emergency.

8. Definition of technical operations

Technical operations constitute the result of a multidisciplinary approach involving all the various cultural, historical, technical and scientific input that goes into the conservation of architecture in the state of ruin. They thus require a very detailed study with an indication of the preliminary phases in the definition of the intervention project.

Without claiming to be comprehensive, or indeed a full-blown protocol even in general terms, the indications set out below may be use-

ful in guiding a correct intervention of constructive restoration involving both ordinary and extraordinary maintenance.

8.1 *Performance*

The implementation of an improvement intervention on a monument in the state of ruin is a very delicate operation which should involve continuity since it is precisely the quality of the materials used and the technique adopted that marks out the quality of the intervention, ensuring on one hand its efficacy in improvement and on the other the limitation of the monument's alteration. All too often the roles of project designer and site manager work against this continuity; this difficulty could be overcome through an effective control of the project's scientific direction exercised by the body repsonsible for safeguarding.

8.2 *Programmed maintenance*

The different degree of risk, intrinsic in a monument's life span, has to be carefully evaluated for each monument or archaeological area, using all the available diagnostic instruments, but always case by case. It will thus be possible to draw up for each site, in a continuous confrontation of theoretical and empirical data produced by the various disciplines as well as material data gathered from firsthand observation, a protocol which will reduce to a minimum the risks for conservation and use. On the basis of these evaluations, interventions can be programmed in the most efficient and least intrusive way possible, enabling the monument to stand up to exceptional situations like seismic events with a minimum of damage.

In urban archaeological areas, where great visitor throughput, the short-sightedness of town planners and pollution are the greatest enemies of conservation, only constant maintenance, recourse to obligatory routes and careful planning prescriptions can ensure that the relationship between the ancient and modern world does as little destruction as possible.

9. Contracting out the archaeological project

All work involving excavation and restoration, including that concerning an archaeological area, is contracted out according to the pro-

cedures laid down by the legislation for public works. The relative Ministry has never required or devised its own regulations for such contracts, simply adopting the categories of specialised work or archaeological excavation, without being able to exercise any real control over the quality of the results or establish a list of specialised sub-contractors. For contracts in the archaeological field provision is made for special measures in the project definition, so that it is possible to assign excavation work simply on the basis of the definitive project, endowing the works supervisor with a considerable degree of discretion if variations are introduced into the executive project following unforeseeable excavation developments. However, these legislative possibilities do not safeguard the central administration from incompetence on the part of sub-contractors, even if these are associated in provisional associations covering all categories of labour.

It is desirable that the rationale of the lowest tender should not be taken by the administration as an economic guarantee which is merely apparent but which actually leads to cost increases or reduction in the work performed on account of extended deadlines, poor quality work and expensive law suits concerning terms of contract.

Thus the greatest care has to be taken in administering the tendering procedures as to the project's real value. Considering must be given to offering bonuses in recognition of experienced workers on site, of time saving thanks to efficient project organization, and the availability of proven technologies, rather than opting for impossible economies that will sell the project short. Effective savings can be obtained by sequential planning of definitive projects designed to acquire data and executive projects for the realization of the intervention with adequate time scales and financing.

10. Works supervision

The restoration works site is a fundamental tool for updating our scientific knowledge of an archaeological artefact. The works supervisor is responsible for verifying the veracity of the documentary information on the monument's material substance, itself the most authentic of the available documents. The threefold necessity of not compromising the original techniques and materials through restoration, of not eliminating the significant marks left by history, and of not altering a

configuration which has acquired a historical authenticity, makes it essential to constantly verify the project's congruence and possible updating. This will ensure that it will be possible to repeat the investigation of the monument as organism again in the future, using different instruments, to arrive at new and convincing historical conclusion. Making a comparison of the documentary sources with the reality of the artefact can contribute to identifying the original architectonic conception of the building, so as to identify the missing parts and understand the reasons behind its ruin.

Knowledge based on the practice of the art of building must be made accessible to site workers as an expression of a widespread material culture which is indispensable in a restoration works site. The works supervisor will have to assess the competence of workers to carry out the tasks assigned to them, and when necessary take the responsibility for replacing them. The methods adopted in the building trade, an expression of the material culture and know how of master masons in the historical building tradition, change radically in the modern conception of project and works site, based instead on imposed practices which are further and further removed from the point of production. Thus in supervising the works it is necessary to take into account the culture and ability of the workers to take on board the relevant indications.

Particularly in an archaeological works site, where legislation enables the works supervisor to update the project to ensure greater safeguarding for an archaeological entity which could not be fully identified prior to excavation without compromising the agreement with the sub-contractor, it must be clearly specified in the contract terms that the supervisor may have to suspend non specialized workers.

11. Scientific findings

Every intervention project concerning the conservation of the archaeological built heritage has to be seen as a historical/scientific study designed to increase knowledge of the artefact prior to intervention to curb its degeneration. Thus each intervention must envisage solutions which are as little invasive as possible, always in the respect of the technique and materials used in the original construction and of the construction conception that guided the first builder.

Without ignoring the current norms, the project has to be evaluated case by case with all due caution in a serried multidisciplinary confrontation between archaeologists, architects and technical specialists, according to the theory of conservation which has prevailed for some time now in the sector of historical and artistic resources. Geotechnical, structural and technical interventions have to be evaluated with particular attention, since when these are left entirely in the hands of technical staff they all too often prove devastating for the conservation of the artefact, especially in terms of durability. Finally it is indispensable to put together a dossier containing all the existing documentation, studies, evaluations and the intervention project with any modifications introduced as work proceeds so as to constitute a point of reference for any future research or intervention.