



ICOMOS

Tangible Risks, Intangible Opportunities: Long-term Risk Preparedness and Responses for Threats to Cultural Heritage

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Foreword

Pamela Jerome, Scientific Council Officer

Since the concept of an ICOMOS Scientific Council (SC) became reality with the adoption of the Eger-Xi'an Principles at the 2005 ICOMOS General Assembly in Xi'an, one of the tasks of the SC has been to coordinate the one-day scientific symposium that takes place at the Advisory Committee meetings. These symposia have been organized on a tripartite basis, starting with the first series under the umbrella theme 'Changing World, Changing Views of Heritage', which explored Global Climate Change (Pretoria, 2007), Technical Change (Valletta, 2009), and Social Change (Dublin, 2010).

At the 2011 ICOMOS General Assembly in Paris, a new interdisciplinary theme for the Scientific Council Triennial Action Plan for 2012-14 was discussed. Taking into consideration increasing risks to tangible and intangible cultural heritage due to various natural and human-caused factors, the themes for scientific symposia for the 2012, 2013 and 2015 Advisory Committee meetings come under the umbrella of 'Tangible Risks, Intangible Opportunities: Long-Term Risk Preparedness and Responses for Threats to Cultural Heritage', and focus on risks resulting from natural and human-caused disasters (2012), globalization and uncontrolled development (2013), and loss of traditions and collective memory (2015). Consideration of risks also marks a shift from reactive to a preventive approach to conservation that seeks to put emphasis on risk reduction and preparedness.

The three themes bring forward the underlying causes for risks to cultural heritage; tools and methodologies for their assessment; and policies, strategies and techniques for reducing potential threats to the future of cultural heritage aimed at protecting and managing our irreplaceable cultural resources for present and future generations.

The theme of the Beijing symposium 2012 resonated with ICOMOS members. Three times more abstracts were submitted than the typical Advisory Committee symposium. The papers presented in Beijing were particularly strong and provocative. This publication presents the proceedings of the Beijing symposium on 'Reducing Risks to Cultural Heritage from Natural and Human-Caused Disasters.'

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Cultural heritage is exposed to numerous disasters resulting from natural hazards, such as earthquakes, floods, and cyclones, and increasingly from human-induced hazards, like arson, armed conflict and civil unrest. The great East Japan Tohuko Earthquake and Tsunami (2011); Thailand Floods (2011); Haiti, Chile and Christchurch earthquakes (2010); and recent civil unrests in Afghanistan, Libya, Egypt, Yemen and Syria have caused serious damage to tangible and intangible attributes of cultural heritage sites ranging from historic buildings, museums, historic settlements, as well as cultural landscapes.

Undoubtedly, the frequency and intensity of some disasters has increased recently due to the impact of global climate change, as well as social, economic and political changes. Considering these challenges, the ICOMOS Advisory Committee symposium in Beijing on 'Reducing Risks to Cultural Heritage from Natural and Human-Caused Disasters' aimed to assess these risks and formulate policies, strategies and techniques for reducing risks to disasters, responding to emergencies and recovering from disasters. A brief was prepared for the one-day symposium soliciting position papers and case studies on the following five sub-themes:

1. Techniques and strategies for mitigating risks to cultural heritage from natural and human-caused disasters
   - How can we develop appropriate techniques for mitigating risks to cultural heritage from earthquakes and floods, cyclones/hurricanes and fires by considering factors of safety, as well as values?
   - What are traditional materials, skills and knowledge systems for disaster mitigation of cultural heritage, and how can we utilize them in the present context?
   - Which maintenance and monitoring strategies can be adopted for reducing risks to cultural heritage due to disasters?
   - How can we enhance the security of cultural heritage sites to prevent risks of terrorism and theft?
2. Methodology and tools for undertaking risk-assessment of cultural heritage
   - What are various approaches and tools for assessing risks to cultural heritage sites from natural and human-caused disasters?
   - What are good practices in documentation, inventorying and mapping for recording and analysing risks due to natural and human-caused factors?
   - How can we communicate these risks to decision makers?
3. Protecting cultural heritage in times of conflict and other emergencies
   - What kind of policies, techniques and strategies can be adopted for protecting cultural heritage sites in the times of conflicts and other emergencies?
   - How can we effectively use international legal instruments and coordinate with organizations such as Blue Shield?
4. Planning for post-disaster recovery of cultural heritage
   - How do we avoid hasty destruction of vulnerable materials and structures (earth, stone and wood) of architectural heritage located in disaster-prone areas?
   - How do we undertake post-disaster damage assessment of cultural heritage?
   - How can we develop monitoring and evaluation strategies for post-disaster interventions and reconstruction?
   - How do we evaluate costs of post-disaster recovery and rehabilitation of cultural heritage?
   - How do we engage various international and national stakeholders for post-disaster recovery of cultural heritage?
   - How can intangible heritage be utilized effectively for post-disaster recovery and rehabilitation?
5. Awareness-raising and capacity building for managing disaster risks to cultural heritage
   - How do we engage communities for disaster-risk management of cultural heritage sites?
   - How do we build the capacity of craftsmen, professionals and decision-makers for managing risks to cultural heritage from natural and human-caused factors?

Opening Speeches

Tong Mingkang, President, ICOMOS-China

Beijing is renowned for its crisp sunny autumn weather during October. It is therefore most fortunate that the 2012 ICOMOS Advisory Committee series of meetings is being held in Beijing during such a wonderful season. This year is the fortieth anniversary of the World Heritage Convention, an occasion of celebration and commemoration. Please allow me on behalf of all ICOMOS China representatives to express my whole-hearted congratulations for convening this series of meetings associated with the ICOMOS Advisory Committee. I would also like to express a warm welcome and pass on my best regards to the distinguished attendees and colleagues present here today.

The Fifteenth Assembly of ICOMOS was successfully convened in Xi'an in 2005 and provided many colleagues with favourable impressions. Some seven years later, more than 100 ICOMOS representatives from almost 60 countries are meeting together here in Beijing. Over the course of the next week a series of meetings such as the Advisory Committee, the Executive Committee, the Scientific Council meetings and a scientific symposium will be held. These meetings provide China with another occasion to convene large-scale ICOMOS meetings in China as well as an important opportunity to promote sustainable development in the conservation of China's cultural heritage.

Since ICOMOS China was formed in 1993, we have established ourselves as a professional advisory body for the conservation of immovable heritage and World Heritage properties in China. We continue to improve our capacity building and have greatly expanded our area of work; our ability to influence our profession continues to grow. There are presently 69 institutional members and 667 individual members of ICOMOS China. Almost 100 members have had an opportunity to participate in International Scientific Committees. ICOMOS China plays an important advisory role in the nomination, conservation, management and monitoring of World Heritage properties and undertakes the organization of academic exchanges and professional training courses.

In recent years we have been particularly proactive in fulfilling our international responsibilities. Many countries, including China have experienced natural disasters. We have sent professional experts to disaster stricken countries to provide professional assistance in the conservation of cultural heritage properties in those areas. In order to celebrate the fortieth anniversary of the World Heritage Convention, ICOMOS China, the State Administration of Cultural Heritage and its provincial and municipal level counterparts have organized a series of commemorative activities. Some of the activities undertaken include the Wuxi Forum entitled 'World Heritage: Sustainable Development' in Wuxi, Jiangsu Province; a ceremony for the commencement of works for a major conservation project in Chengde, Hebei Province, as well as an ICOMOS information day; a World Heritage workshop at Luoyang, Henan Province; and in October we organized a World Cultural Landscape and Heritage International Symposium in Hangzhou, Zhejiang Province.

ICOMOS China has also worked hard to prepare for the series of meetings that will be held by ICOMOS in 2012. Under the guidance provided by ICOMOS International secretariat, ICOMOS China has worked closely with the Beijing Municipal Cultural Heritage Bureau in preparation for the meetings. We established a dedicated steering committee which has in turn set up a series of working groups responsible for meeting arrangements, logistics, reception, security, media and information. In addition, ICOMOS China has arranged with the China Cultural Heritage Information Consulting Centre to create a website for these meetings and to disseminate information about the meetings as well as servicing the needs of the meeting participants in these areas. We have also prepared an exhibition, 'An Exhibition of Photographs and Illustrations of World Cultural Heritage Properties in China' and also published an English edition of China's World Cultural Heritage Properties to celebrate this series of meetings as well as the fortieth anniversary of the World Heritage Convention.

During the preparations for these meetings we have been greatly supported and assisted by the Ministry of Foreign Affairs, the Ministry of Culture, the State Administration of Cultural Heritage and the Beijing Municipal Peoples Government. Here, on behalf of all the representatives of ICOMOS China, I would like to express my sincere appreciation to these organizations for their efforts and assistance.

After many years of unrelenting efforts, ICOMOS has accomplished some important achievements in the conservation of humanity's cultural heritage. The cause of cultural heritage conservation in China has also made great progress and has entered a new phase of development and prosperity. We believe that the series of ICOMOS meetings held here in Beijing will play a positive role in promoting the conservation of China's cultural heritage.

It is with great anticipation that we look forward to the future days of meetings where colleagues from around the world will focus on the themes of the meetings and present their different views on various agenda topics, will engage in free discussion contributing their thoughts and ideas to the overall discussion and will work together to formulate various strategies for the conservation of cultural heritage. Autumn is the season of harvest in China. Let us hope that there will be an even greater harvest in the conservation of cultural heritage as a result of these important deliberations.

It is my sincere hope that with the joint efforts of all the participants and colleagues here, as well as the enthusiastic support of the various central government departments and organizations and the Beijing Municipal Peoples Government, the 2012 ICOMOS Advisory Committee meeting and the series of other related meeting that will be held this week will achieve resounding success.

Opening Speech

Mme Liu Yandong, State Councillor

Today, on this wonderful Beijing autumn day, we are gathered here to mark an important occasion with the opening of the 2012 ICOMOS Advisory Committee and Executive Committee meetings here in Beijing. On behalf of the Government and People of China, I would like to express my congratulations to all involved. I would also like to welcome the experts and representatives from the various Chinese and international organizations. At the same time I would like to express my highest admiration for all those dedicated to the cause of cultural heritage conservation.

Society has undergone a long historic process culminating in the creation of a rich and diverse cultural heritage. Good conservation practice as a way of preserving this cultural heritage not only respects and retains the achievements of humanity, but is also the natural outcome of the sustainable development of humanity. In 1972, UNESCO adopted the World Heritage Convention. As a result of more and more countries joining the movement to conserve cultural heritage – the common wealth of all humanity – outcomes based on equality and respect were encouraged, drawing on each other's experiences and achieving broad based cooperation.

China is an ancient country with a long history and deep-rooted civilization. China is presently going through a rapid period of industrialization and urbanization. The conservation of cultural heritage is facing unprecedented pressures. The Chinese government attaches a great deal of importance to the conservation, use and sustainable development of cultural heritage. The government has included heritage conservation as part of the overall goals of its sustainable development strategy and public cultural services network. For many years we have passed legislation that continues to improve on previous versions of legislation; additional funding has been provided, as well as improved training for professionals and the development of more technology for use in conservation. We have undertaken a national survey of heritage sites, used scientific means to develop plans for the conservation of large-scale archaeological sites, and created a network of national archaeological parks. We have established monitoring and warning systems for World Heritage properties, introduced a policy of free public admission to museums, and enabled the general public to enjoy the benefits of the conservation of cultural heritage. We continue to explore an effective way to conserve heritage sites of ancient civilizations located in large developing countries. In the past five years government funding provided to culture has increased by an average of 22.5% per annum. China presently has 43 World Heritage properties, 2,352 national priority protected cultural heritage sites, 208 national famous scenic places, 119 national historic and culturally famous cities, and 350 historic and culturally famous towns and villages. We hope that our efforts will play an important role in sustaining cultural heritage well into the future, as well as in providing services to the public, promoting development and improving peoples' quality of life. The conservation of the cultural foundation of Chinese civilization, raising public awareness of culture and cultural confidence will enable our glorious history and contemporary civilization to form a symbiotic relationship.

ICOMOS is the peak professional organization in the field of cultural heritage conservation. It draws its membership from renowned experts, academics and site managers from around the globe. Over a long period of time ICOMOS has played an important role in promoting the development of theory and practice in the conservation of cultural heritage. Ever since China became a member in 1993 China has enthusiastically participated in ICOMOS activities and has been warmly supported by our ICOMOS colleagues in many countries. In 2005 the Fifteenth ICOMOS Assembly and Scientific Symposium was successfully held in Xi'an in China enabling China to strengthen its cooperative relationship with ICOMOS in all fields.

This year is the fortieth anniversary of the Convention Concerning the Protection of the World Cultural and Natural Heritage. The convening in China of the ICOMOS Advisory Committee and the Executive Committee meetings on this auspicious occasion is not only an opportunity for ICOMOS colleagues from around the world to gather at their annual meeting, it is also an important event where we can all celebrate forty years of cultural heritage conservation.

1. Implementing the aims of the Convention, jointly conserving humanity's heritage

Cultural heritage is the priceless and irreplaceable wealth of all humanity. The conservation of cultural heritage is not only the historic responsibility of the country where the heritage property is located, it is also the joint responsibility of all people from all nations. All countries should enthusiastically support developing countries and countries with less recognition of their heritage in nominating and protecting World Heritage. The World Heritage List should continue to be diversified so that is it more representative, balanced and credible. It should be a dynamic and effective international system that enables us to all work together to conserve cultural heritage.

2. Respect for different history and culture and protection of cultural diversity

The value of cultural heritage is rooted in the cultural setting where it has evolved, been nurtured and grown. In today's world where cultural dissemination and cultural exchanges are increasing in breadth and depth, countries around the globe should strengthen exchanges and dialogue based on equality to promote mutual understanding and respect for our particular history, culture, traditions and values. This is the only way to genuinely gain understanding and share the great wisdom and creativity that cultural heritage contains and to promote joint prosperity and progress. Today, many valuable sites are no longer extant, thus there is an even greater need through conservation to make even better use of existing cultural and historic sites and regional civilization. We need to employ modern methods to interpret and restore sites so that the general public around the world can experience and understand the rich and diverse tapestry of the world's civilizations.

3. Improve our conservation capabilities, ensure sustainable development in the conservation of cultural heritage

Improving our understanding of the conservation of cultural heritage along with improving professional conservation capabilities is extremely important for the conservation of humanity's heritage. All countries should include conservation of cultural heritage as part of the education curriculum. Conservation awareness should be improved amongst the general public, and among young people in particular. The local community, general public and stakeholders should be encouraged to actively participate in heritage conservation.

Capacity building should be boosted at cultural heritage sites and funding increased. There should be improvement in scientific research as well as the training of professionals and experts. The level of conservation, monitoring and management needs to be continually improved. The conservation of cultural heritage isn't just simply rescuing heritage from destruction and preserving it in isolation; heritage conservation must be integrated into people's daily lives as part of their overall education and upbringing.

Cultural heritage sites should be used in an appropriate manner and developed to an appropriate degree to satisfy the public's cultural needs and act as an economic driver for the local economy based on the premise of ensuring good conservation and the principle of public good. At the same time over-development and commercialization should be avoided as this can damage a site's cultural heritage values. The local community should also benefit from heritage sites while ensuring that cultural heritage is used in a scientific manner and in a sustainable way.

In conclusion, Marcus Tullius Cicero of ancient Rome once said, 'History is the witness that testifies to the passing of time; it illumines reality, vitalizes memory, provides guidance in daily life and brings us tidings of antiquity'. Improving the conservation and use of humanity's cultural heritage and its maintenance and development is something that links history together with the present and the future. China is more than willing to work together with countries from around the world to jointly share the responsibility of conservation while jointly enjoying the outcomes of conservation. We want to work with you hand in hand to continue to improve the overall conservation and management of cultural heritage. We hope that UNESCO along with ICOMOS and other international organizations will play an even more important role in conservation in terms of communication and providing a platform for initiating good conservation. I believe that with the joint efforts of all delegates present here today these series of meetings will be a resounding success. I sincerely wish all delegates an enjoyable time here in China.

Theme 1: Techniques and Strategies for Mitigating Risks to Cultural Heritage from Natural and Human-Caused Disasters

Risk Preparedness and the Limits of Prevention: Safety versus Authenticity in the Conservation of Urban Waterfronts

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Abstract. Cultural heritage has always been exposed to the risks of natural disasters, but preventive mitigation strategies have only recently begun to be investigated. While an overall increase in human safety has priority, practical measures in turn have side effects: they pose new risks or may even do harm to the environment and to the often fragile structures and landscapes which constitute our built heritage. A comprehensive risk-benefit-analysis is needed, involving cooperation between planners and conservators. Risk-reduction projects are predominantly aimed at protecting the population and its material assets, but the intangible values of cultural heritage are being increasingly recognized by cities and regions. Defying quantification, they cannot easily be weighed against material values or against the costs of mitigation projects. By using flood control as an example, this paper asks to what extent general strategies for disaster mitigation are appropriate for the protection of cultural heritage. Conflicts and compromises between safety and authenticity are addressed and practical approaches are discussed with examples.

Ten years ago, in August 2002, unprecedented amounts of rainfall in Saxony (Germany) and Bohemia (Czech Republic) turned small creeks into terrifying torrents and calm rivers into devastating masses of muddy water. Major cities such as Prague and Dresden as well as numerous smaller towns and villages were affected by severe flooding. The loss of lives, buildings, property, workplaces and infrastructure abruptly raised people's awareness of the high risks of living by a river and of the need to meet that risk through preventive measures.

The dramatic situations resulting from such disasters require immediate reaction to facilitate a return to normal life. Shocking images increase the pressure to take technical and political action and spur a willingness to help, but they also can promote desperate, hectic activism, which sometimes may lead to short-sighted decisions. The watchword of citizens and politicians at this point is usually: 'Never again!'. That is the moment for the engineer and his visions of new, safe solutions. As soon as the worst is under control, however, another goal often prevails: to restore everything as it was before. 'Dov'era e com'era!', the motto for the reconstruction of the Campanile in Venice after its collapse in 1902, comes to mind.

These basic modes of reaction following disasters are to be found throughout the history of preservation: whereas in traditional contexts we usually find the desire to restore what has been lost; however, if a break in tradition has already occurred or is sealed by a disaster, there is a desire for new solutions that would prevent any repetition of the damage. Major changes in the structure and the appearance of cities often go back to such bursts of innovation in the aftermath of urban fires, floods and earthquake disasters (Meier and Will 2008).

Not long after the flood in 2002, I received a call from the planning office of Grimma, a small city near Leipzig in Saxony. Situated on a terrace in the Mulde River valley, this town features an unusually well-preserved setting in the river landscape with a largely intact medieval city wall still bordering the riverbank. Historic monuments along the waterfront, such as the former palace, the Convent Church, the Princes' School and the baroque mill ensemble, as well as the urban and landscape ensembles of great beauty make the city's riverside attractive to both inhabitants and visitors.

Because the city had been hit extremely hard by the flood, it had become the focus of a major flood control project by the State Dam Authority. But the initial, technically-conceived proposal had promptly been rejected by both the city council and the permit authority. In this preliminary project, the citizens were confronted with the prospect of being blocked off from the river by a monolithic concrete wall stretching 1200 m and rising about 3-4 m. [FIGURE 1]

It was obvious that realization of this scheme would involve severe and lasting damages not only to the waterfront aspect, but also to the cultural heritage and to functional and aesthetic qualities of the city. Heated discussions led to the agreement that for a place such as Grimma, with its valuable stock of historic buildings, flood control planning based solely on hydraulic and monetary parameters is insufficient. It may even prove counterproductive, since it is likely to screen off, damage or even destroy those elements and features that (in addition to its foremost task of safeguarding the population) it is supposed to protect.

At that point, our team of conservation and landscape architects from the Technical University in Dresden was called in for consultation (Will 2008). Since then we have been involved in Grimma as planning advisors to assist in integrating the concerns of flood protection and heritage conservation along the historic urban waterfront.

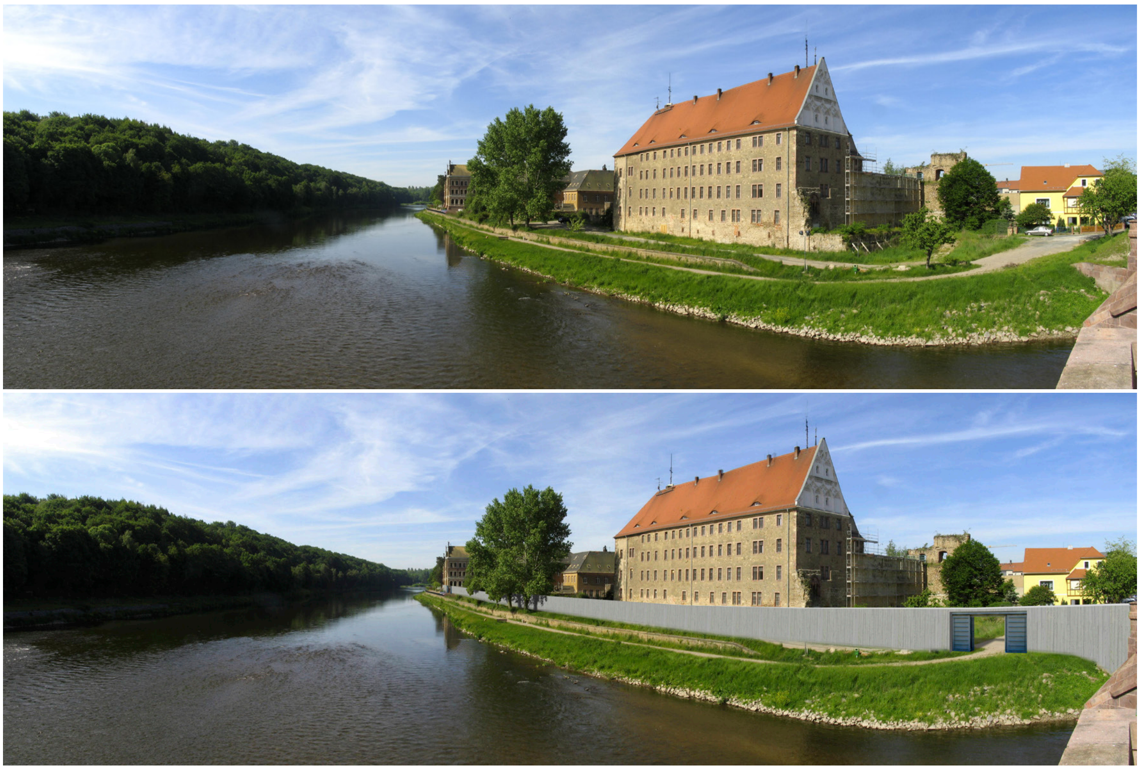

Figure 1. Grimma, Mulde River (Saxony): the former palace as seen from the baroque bridge. Status quo (top) and rejected preliminary flood protection proposal (bottom).

The example of Grimma, to which I will return later, highlights the usual course of what happens after a natural disaster. This may be roughly conceived as a causal cycle: the disastrous event leads to damages and losses; they call forth an immediate reaction which may take, as already pointed out, two directions:

a. Reestablishment of the original state of things – following the enduring forces of tradition, or

b. A new solution that aims at preventing a recurrence of the disaster.

The straightforward repair of damages attempts to achieve a return to life before the catastrophe with as little rupture as possible, but it must take into account continued vulnerability to similar events, whereas new planning solutions seek to learn from the disaster and to react with strategic, preventive measures.

However, and this will be a central argument of my paper, preventive measures also have their price. They are tied to a longer planning process and they pose new risks because they often have side effects. They may do harm to the environment and, in particular, to the often fragile structures and landscapes which constitute our built heritage.

1 Cultural Heritage and Risk Preparedness

What is new about the preventive approach in historic conservation? Cultural heritage has always been exposed to the risks and threats of disasters. Certain natural events have left a lasting mark on cultural history and historic consciousness; the destruction of Pompeii by the eruption of Vesuvius in 79 A.D. comes to mind in this context, as do the earthquakes in Shaanxi (1556), Lisbon (1755), Tokyo (1649 and 1703) and San Francisco (1906), the floods of the Huang He (1887) and the Chang Jiang (1911 and 1931) or the inundation of Florence in 1966 (Meier and Will 2008).

Up until recent times, 'classic' natural disasters had been perceived as isolated, sudden local or regional events, even if the broader context of their seismic or atmospheric causes was known. But as the number and intensity of natural disasters have been rising dramatically (World Bank 2006, 3) and is expected to continue to rise in the course of the climatic changes observable today, we are now faced with a new dimension: it seems that the interconnectedness of all physical and biological processes on earth in a single, complex, self-regulating system – first formulated by Lovelock and Margulis as the Gaia principle in the 1970s (Lovelock 2000) – is now also shaping our awareness of natural disasters. We are confronted with slow but worldwide transformations, the effects of which can be experienced as a single, global catastrophe that takes many forms and evolves over an extended period of time (Meier and Will 2008).

That situation allows and calls for a new awareness also in preparedness and strategic prevention planning. On an everyday basis, preventive measures were of course always part of conservation: conservation laws are such precautionary steps, as are weatherproofing coats or protective shelters; even in Ruskin's concept of radical conservation we find the classic metaphor of the crutch put up to prevent a wall from falling over.

Risk preparedness depends not only on the likeliness and size of the natural events themselves, which we are increasingly able to explain, but also on public perception of the disaster as something that is not necessarily far away, but could occur tomorrow on our own doorstep. The almost instantaneous, worldwide depiction of such events by the media impresses their destructive force upon our consciousness in an entirely new way. This intensified and accelerated flow of information is changing our readiness to undertake preventive measures (Meier and Will 2008). Whereas in former times the stoic, often fatalistic acceptance of unavoidable hazards and losses was the rule, the new evidence and collective awareness of increasing and systemic threats by disasters has stirred manifold research activities in the field of environmental risk assessment and management, leading to wide-ranging measures for prevention or mitigation such as improved construction, tighter building codes, land-use and water legislation, and forecasting systems.

For our own field of cultural heritage, the question of prevention and mitigation is of special importance because immovable cultural property, from historic buildings to open spaces and cultural landscapes, is by its site-specific nature particularly endangered by natural disasters. Heritage conservation should therefore be seen as an integral part of all efforts in risk prevention and mitigation, but there is a great need for clarification of specific, fundamental issues, such as conflicts of goals and the best ways to balance priorities in a socially and economically responsible manner.

- In response to recent major natural disasters, in 2006 the German National Committee of ICOMOS in cooperation with the International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM, Rome) organized an international conference on 'Cultural Heritage and Natural Disasters – Risk Preparedness and Limits of Prevention' (Meier, Petzet and Will 2008). From the key questions addressed at that time, I want to mention three that seem crucial to my topic:
- Where are the limits of safety and feasibility, and for that matter, to what degree should vulnerability be accepted for the sake of authenticity?
- How should the possible benefits of protective technical measures be weighed against their adverse side effects on cultural property?
- How can high-tech solutions be evaluated in comparison to traditional methods (retrofitting vs. authenticity)?

The discussion of such questions should help to fill a gap by picking up at the critical point where accounts of natural disasters often end. Such reports tend on the one hand to document the disaster itself – reflecting the dramatic impression such an event makes – or, on the other hand, to focus on often admirable reconstruction work. In contrast, the social, economic, cultural and ecological considerations of long-term preventive measures are less spectacular. In the long run, though, they are all the more important (Meier and Will 2008).

Our task in heritage conservation therefore encompasses both modes of reaction to the risks of and damages caused by disasters. We have to find the best compromise between the path of traditional repair and restoration and that of new solutions, in order to preserve the historic heritage as authentically as possible – sometimes also in its very vulnerability – while at the same time reducing future risks through contemporary mitigation measures without failing to recognize the limits of such efforts. While immediate help for quick recovery and repair have to remain a priority also in heritage conservation, strategic planning for prevention and mitigation has to take into account the interest of future generations as well; it has to cope with the more ambitious questions of not only restoring what has been damaged or lost, but also of preventing future losses.

2 What Should Be Protected and Why? Consideration of Heritage Values in Disaster Mitigation Project

How is cultural heritage generally accounted for in disaster mitigation policies? There are different concepts that are related to particular cultural and economic situations. On the one hand, we find a tradition of civil disaster protection that confers special status to cultural property within the hierarchy of objects to be protected, independently from their current market or use value (for instance, in Switzerland and Canada). On the other hand, disaster prevention is influenced by theoretical models used in the insurance industry. Here, cases of damage are considered according to the cost of their reconstruction or their insurance value, which is oriented on replacement costs. In these models, cultural property does not yet seem to have its own definable status.

Because of the difficulty of putting a value on the non-market nature of many cultural heritage objects (Ebnöther and Thurnherr 2008), or because of the absence of a replacement price for them, important historic buildings, characterized by their uniqueness and often by the vulnerability of their materials, are ranked in terms of their insurance damage assessment beneath mere material property such as industrial complexes or consumer goods. This often results in reluctance by decision-makers to invest in mitigation measures for cultural monuments (Meier and Will 2008).

In order to reasonably judge whether certain precautionary measures are economically and socially effective, and therefore politically responsible, we need appropriate methods of assessing and balancing the values that are at stake. This should also help, for instance, to determine and communicate in which cases a 'primitive', traditional approach of continual repair might be preferable to ambitious retrofitting techniques.

Risk reduction projects are predominantly aimed at protecting the population and its material assets. To include the values of cultural heritage and local character is difficult, as these intangible values defy quantification and cannot easily be weighed against material values or against the costs of mitigation projects. It would be worth investigating how and to what extent the intangible values of architectural and landscape heritage are being accounted for in the process of introducing double-entry bookkeeping in public budget management. How is the cultural value of a medieval city wall to be accounted for in the balance sheet of a city's assets? Or even the 'outstanding universal value' of World Heritage sites? In Germany the assessments applied in these cases are, as far as I can see, unsatisfactory.

Such methodological difficulties notwithstanding, the values embodied in architectural and landscape heritage are being increasingly recognized by cities and regions. Like environmental and economic aspects, their consideration belongs today to the requirements of a balanced public service, as it has become apparent that these 'soft factors' are the very factors that constitute the identity of a place and thus contribute to its attractiveness. This has become especially evident in the emerging competition amongst cities. In a dynamic, post-industrial economy that no longer follows the traditional criteria for location, a historically and aesthetically rich and meaningful urban environment has become a key factor as decisions are made about where to live, establish businesses or services, or visit as a tourist.

With the development of cities and regions now depending more than ever on their cultural identity, protective measures that adversely affect the built heritage can trigger negative feedback. To put it bluntly: What good is an attractive townscape that has been cared for over generations and often has been restored with public funding, if it disappears behind flood walls? This conflict between ends and means that is typical of large-scale technical projects can be expressed in an exponential saturation curve: initially, preventive measures may increase the safety of a place or a structure, but they also can produce disruptive side effects on cultural or natural assets upon which the value and integrity or the attractiveness of what is being protected depend. If the protective measures are increased, the negative side effects will eventually outweigh the gains. Protection efforts, as efficient they may be in a narrow sense, will then miss their true goal. [FIGURE 2]

Depending on the various effects of a preventive measure, specific threshold levels can be determined for

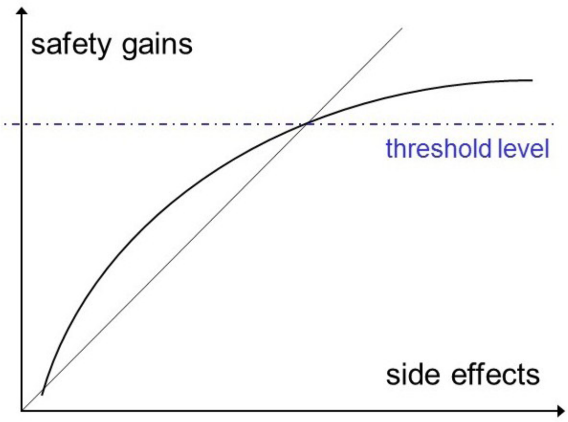

Figure 2. Safety gains have to be weighed against loss of authenticity or integrity.

individual local situations. For example, the erection of flood dams in coastal regions may be appropriate in certain areas to protect the hinterland, whereas it would be inacceptable in situations where it would cut off rural fishing communities from their source of life. In order to determine optimal levels and acceptable limits, the assessed gains of a preventive measure need to be set in relation to the expected effects on the cultural heritage – for each step of the planned actions. This balancing of risks and benefits – well-known from environmental impact studies or also from pharmaceutical testing procedures – requires the maximizing of protective effects, the minimizing of side effects and the mutual optimization of both imperatives. Measures which are reasonable from a statistical hydrological perspective, for instance, have to make sense in the long run also from the wider and practical perspective of the user. In establishing a responsible risk acceptance policy, these differing perspectives have to be accounted for. This does not mean, in strict terms, objective, impartial decision-making, but rather disclosure of the relevant arguments and the applied prioritization of values.

3 Flood Protection: Balancing Opportunities and Risks

Technical flood control provides a vivid example of the conflicting goals that can occur within risk prevention strategies. There is a long history of success in flood protection, but the limits of appropriate uses of technology have also been revealed. Measures that indisputably serve the safety of the population and its tangible property can cause serious damage to or even the loss of cultural and natural heritage.

Today, due to the consequences of global climate change with its risk of increased flooding in many parts of the world and ground-breaking advancements in hydraulic sciences and technology, hydraulic engineering and inner-city flood protection are facing entirely new and challenging circumstances, which mean new opportunities, risks and areas of conflict. Flood protection is an example for today's dominance of science-based engineering solutions over the traditional acceptance of regular flooding with small-scale adaptations and frequent need for repair.

River cities are specific risk habitats because of the concentration of people, material, and intangible values affected by flooding. Conventional protection measures have for a long time been focused on the construction of dams, reservoirs, and flood walls. Recent advances in hydrological modelling as well as public debate and political discourse, including European legislation (WFD 2000), have now placed emphasis on non-structural measures, such as disaster management plans, designation of flood plains excluded from development, early warning systems, and, as a priority, on flood prevention by providing retention of rainfall in catchment areas. The effect of this latter policy, however, is frequently limited, since it is subject to natural and anthropogenic conditions that often cannot easily be altered (Lieske 2012). Structural measures in or close to the areas threatened by flooding therefore remain indispensable despite their possible side effects on waterfronts and river landscapes.

In urban areas, flood control projects require a special approach. Settlements are places not only of concentrated activity and capital, but also of condensed history and meaning. Architectural monuments and gardens, places of interest and livability, as well as consolidated socio-spatial relations make for a living environment that cannot easily be subjected to profound structural alterations. Yet, there is also a special dynamic along rivers: in the last decades, bodies of water and waterfronts in urban settings have undergone a substantial change in public recognition. Places for shipping, sewage disposal, trade, and industry, which were subject to neglect over much of 20th century, now face an upsurge in public appreciation (Lieske 2012).

To date, such conflicts between conservation concerns and safety requirements have rarely been taken into account, either in the planning and construction of protection systems or in related research fields. However, along with the recent, rapidly growing political and research interest in risk management, issues of environmental side effects of flood protection are increasingly being dealt with. And, occasionally, questions about the compatibility of flood protection and heritage conservation are also being raised (Lieske and Will 2011; Meier, Petzet and Will 2008; Lieske, Schmidt, and Will 2012).

4 Grimma: From Disaster Reaction to Integrated Planning

I will now return to the case of Grimma – a work-in-progress report – to discuss more concretely to what extent large-scale technical structures used for disaster mitigation are compatible with the protection of historic settlements and sites.

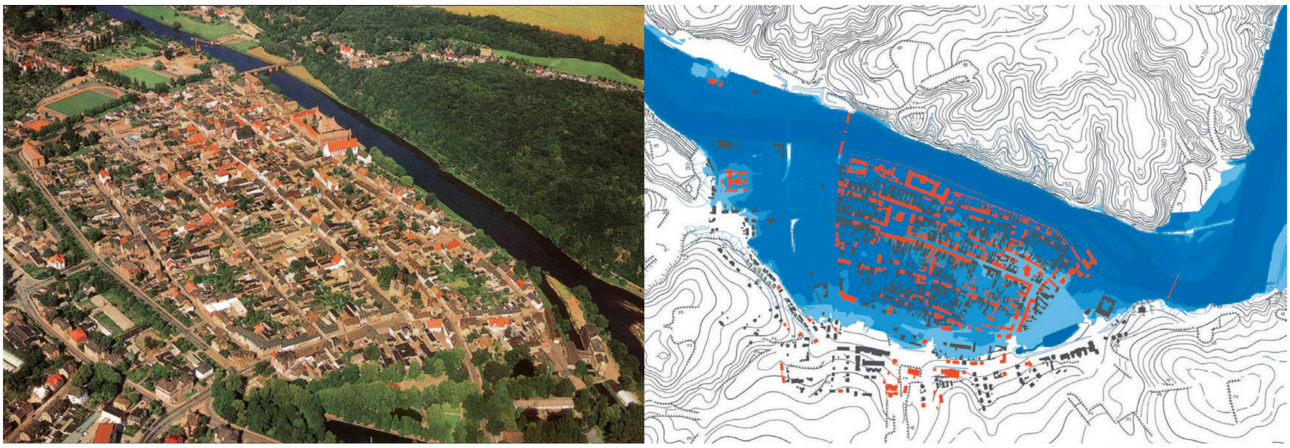

Figure 3. Grimma: aerial view and area flooded in 2002, listed historic buildings in red.

In the flood of 2002, the Mulde River, a tributary of the Elbe, reached the highest water level ever recorded, putting the historic centre of Grimma under as much as 3.5 m of flood waters. The steep gradient of the river valley contributed to the very high velocity of the flood waters, which destroyed or badly damaged almost 700 houses. [FIGURE 3]

Similar events, though mostly on a less devastating scale, occurred in many other towns. Soon after, the state government updated public flood protection policy on both a regional and a local scale. Comprehensive concepts for all the bigger rivers in Saxony and their catchment areas were prepared by the Dam Authority; the protection concept for the Mulde River was approved in 2004 and is the basis for planning in Grimma (Will 2008).

In accordance with legal requirements in Saxony, flood control structures have to be dimensioned to withstand flooding events up to a 100-year base flood elevation. Given a flood forecast lead time in Grimma of only about 8 to 12 hours, there is no chance to employ temporary elements such as stop logs there. Comprehensive investigations were undertaken to determine the extent to which other preventive measures – reservoirs, retention areas upstream, clearing off of foreland, flow ditches or tunnels, etc. – could help avoid or diminish massive flood walls in the town. However, hydrological analyses and extensive hydraulic engineering models showed that under the specific hydro-morphological conditions precautionary regional flood prevention measures, as used effectively to protect other towns, would not be sufficient to significantly reduce the danger of flooding in Grimma (Will 2008).

In order to devise flood control structures that would meet hydraulic requirements without destroying or unduly damaging the cultural, spatial and landscape values of the Grimma riverside, our team developed alternatives. Analyses of the topographical, spatial, environmental, historic, aesthetic and functional qualities of the city and its relationship to the river led to the formulation of site-specific design strategies and principles.

The type and purpose of the protective structure suggested striving for unity in diversity, since a barrier more than a kilometre long and as much as one story high needs to be appropriately subdivided and carefully integrated into the existing waterfront. [FIGURE 4]

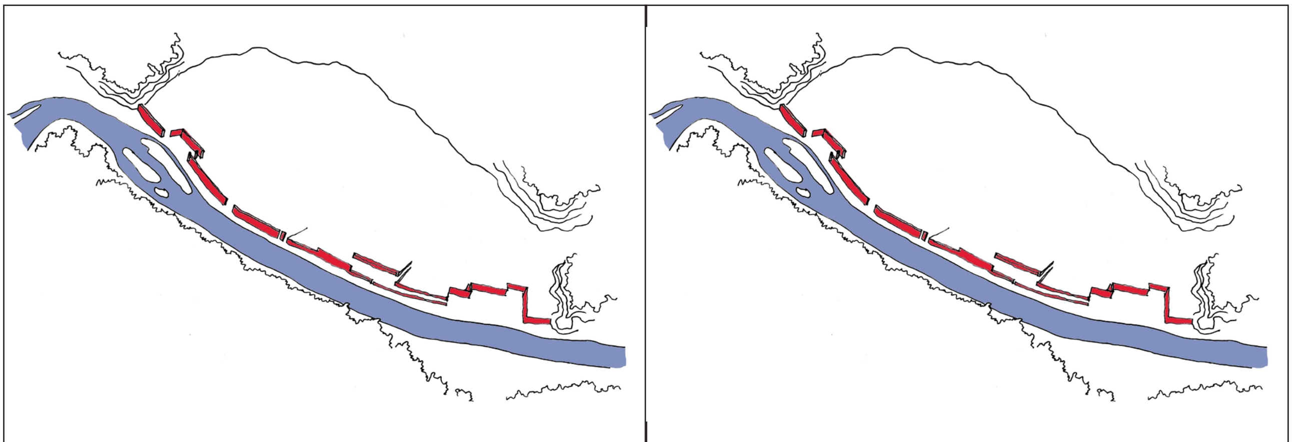

Figure 4. Grimma: hydraulic defence alignment and site-specific differentiation

Yet, merging the wall into the rich urban fabric should not mean hiding it from perception. Flood protection measures, as exceptional endeavours in response to severe disasters and threats, should be given adequate legibility and visible presence, and they should be recognizable for what they are. To meet these demands the conceptual variation and recurrence of certain geometries, materials, details and finishes was proposed.

Since the protective structure could not be isolated from the town but rather had to be integrated into it, it needed to respect the town's special character. If designed contextually, it even had to be able to strengthen certain characteristic features. But due to its size and necessary linearity, it would also introduce something visibly new, and thus had to be designed to make a valid contribution to the development of the waterfront.

Careful aesthetic integration, however, would not have been enough. Such a large and complex protective structure also presents a challenge and a chance for the development of the riverbank area. The more comprehensive goal was not to degrade the waterfront to a mere protective zone for the rare case of a disaster, but rather to enhance its value for the city by improving its usability and quality for residents and visitors. Examples have shown that flood protected, well-designed and easily accessible riverfronts improve the living and recreational conditions in the dense cores of old cities (Will 2008).

Citizen and expert meetings supported the generation of new and unconventional alternatives. Finding out about the image of the city as perceived by its inhabitants, about their shared values and expectations, and about their hopes and fears regarding flood protection contributed as much to the planning process as did the expertise of engineers and our own analyses. Stakeholder participation and town hall meetings allowed for rating the perceived benefits of some of the main issues like flood control, compatibility with heritage and townscape protection, and public access to the waterfront. Subsequently, the exposure of alternative design proposals to professional and public scrutiny led to either their rejection or refinement and eventually to a general agreement regarding solutions tailored to the special needs of Grimma. Because the weighing of public interests had been a constant issue already in the concept and planning phase, this method proved to be a practical path toward a technically competent, culturally responsible and politically acceptable solution (Will 2008). In 2009, the project successfully passed one of the most complex plan-approval procedures in recent years.

Some of the monumental riverside buildings were examined and proved to be substantial for withstanding floods. These buildings have thus become components of the overall flood protection system, yet visually, the existing situation remains almost unchanged. Measures are being taken to seal joints on the outer wall masonry, while windows and doors have been fitted with hatches and stop logs.

The arched bridge by the famous Baroque architect M. D. Pöppelmann marks the main entrance to the town, adjacent to the former palace. It was partially destroyed by the water in 2002. Because of the damming effects caused by its original piers during floods, the bridge has been rebuilt in a modified version in order to avoid the need for even higher flood walls (an independent decision by the city not favoured by the conservation office). A continuous concrete wall right along the riverbank, as suggested initially, would have severely and irreversibly damaged the view toward the city, its historic buildings and the river landscape. [FIGURE 1] Our studies showed that the riverside wall of the former palace could be treated to integrate flood protection into the building, so that it nearly disappears from sight. They also suggested moving the alignment away from the river, following the remnants of a wall along the former moat, and thereby allowing for a much lower protective structure. [FIGURE 5]

Figure 5. Grimma: the former palace as seen from the baroque bridge. Integrated flood protection proposal (Photomontage)

However, more in-depth study led to the conclusion that this unobtrusive integration of the protective structure would cause too much interference with an archaeological site along the former moat between the palace and the bridge. The necessary underground sealing, requiring the use of large equipment, would destroy valuable traces of the city's oldest history. Thus, it was necessary to weigh townscape protection, which made integration desirable, against protection of these archaeological relics. In the final solution, this section of the protective wall is positioned close to the river and used for direct pedestrian access from the new promenade to the bridge. [FIGURE 6] As a result, the area behind the wall can remain largely in its original state (Will 2008).

Figure 6. Alignment adapted to protect the archaeological site

One outstanding feature of Grimma is its city wall, stretching 450 m along the waterfront. [FIGURE 7] Since flood protection structures on the city side of the wall were ruled out because of adjoining garden and property walls, the engineers' preliminary proposals called for construction of a new concrete wall directly in front of the city wall on the river side. We later commissioned structural investigations of the historic wall, hoping that it could be injected and stabilized by bored micro piling in order to enable it (with some additions) to meet flood protection requirements on its own. This retrofitting would have largely preserved the wall in appearance as well as in terms of its historic fabric.

Figure 7. Grimma: medieval city wall along the river.

Unfortunately, the analysis revealed that the old structure is not suitable for retrofitting through structural reinforcement, given the requirements of safety and economy. Committed citizens argued that the old city wall had defied flood waters for centuries, even in 2002, and that it therefore could also be adequate for the future. This observation does not take into consideration, however, that up until now, during major floods, the city wall was inundated from both sides and thus, was never subjected to one-sided water pressure, which would be the case if it was in fact itself acting as a flood wall. Furthermore, it became clear that structural retrofitting would have severely damaged the historic wall. Following a heated discussion of the wall's considerable historic and scenic value, it was decided by the state government that the old wall will be closely flanked by a new concrete flood wall.

For this painful compromise we worked out a set of principles in agreement with the Heritage Preservation Office: for the sake of the integrity of the traditional townscape, the new wall will be clad with local stones much like the ones that constitute the medieval wall, not in order to erect a deceptively perfect copy, but rather as a new yet harmonious interpretation, using an analogous masonry facing and following the rules of good craftsmanship. At the transition points and in sections where the old wall is higher than the new one needs to be, the layering of old and new structures will be legible (Will 2008).

Can we consider the Grimma project a success with respect to the goals discussed here? It has become clear that many conflicts occurred between the desire for safety and the concern for the authenticity of historic buildings and spaces. Difficult compromises had to be made in deciding between either technical retrofitting or more conservative ways to keep the original state of a building or site. Our occasional arguments in favour of smaller, less intrusive alternatives were not always heard. The option of partially reducing the safety standards in certain areas and allowing the individual adaptation of building use at ground floor level was rejected on several grounds: the enormous insurance values at stake; the awareness of the unusually high relief funds already spent on reconstruction, combined with the realistic assertion that a repeated disaster would not yield similarly generous assistance from outside; and, last but not least, the technological argument that such a costly flood protection system must, literally speaking, not have any leaky points. No part of the city should be left out – in terms of safety, economy and social equality. These altogether valid arguments made it difficult to flexibly combine different mitigation strategies and safety levels – a general characteristic of advanced technical solutions; being intrinsically based on universal standards and norms, they tend to be inflexible for the integration of alternatives, such as local or traditional solutions.

As these difficulties show, it is all the more necessary for the planning of advanced, large-scale flood protection structures to be carefully integrated with concerns of urban function, cultural heritage and environmental protection, city and landscape aesthetics, local infrastructure, recreation and tourism. This extra planning effort, including comprehensive public participation, more than pays off, if long term flood protection structures can be designed to merge successfully into the valuable fabric of historic towns and landscapes (Will 2008). In many cases, the protective measures can even lead to additional improvements and can add extra benefits and amenities.

The history of flood protection, like the histories of city walls, railway tracks and other large-scale constructions, gives evidence of the fact that such structures do not necessarily interfere with their respective urban or landscape environments in a degrading or disintegrating way. Planning for flood protection may provide opportunities to enhance conditions along the waterfront, for example by improving pedestrian and bicycle access and reviving visual and functional city-river relationships (Will and Lieske 2011).

5 Conclusions Based on a Comparative Study

The work for Grimma has stimulated our interest in similar cases, other experiences and best-practice examples in this field. As we became aware of the limited attention that is being paid in flood protection projects to the questions addressed here, in 2009-2011 we conducted a nationwide comparative study on heritage conservation and urban development confronted with large-scale flood protection schemes (Lieske, Schmidt and Will 2012). In situ investigations covered architectural analyses, surveys of the local heritage stock, and guided interviews with authorities, planners and experts. Results were presented as detailed case studies, in a critical comparative commentary and in recommendations for authorities, planners and politicians. This empirical research project focused on two issues:

1. Processes and policies: What procedures are being implemented for the planning and construction of flood protection schemes? To what extent is the public involved in these processes? What effects have these procedures and processes on the consideration of cultural heritage and urban qualities?
2. Physical planning: What hydraulic and architectural constructions are used in the various projects and what are the design principles? What effects have these construction and design solutions on the cultural heritage and on urban qualities?

By reviewing flood protection schemes for more than 50 towns, historic gardens and monumental ensembles, we were able to systematically assess and describe the current state of the art for such projects and also to identify certain lines of conflict that frequently occur in large-scale hydraulic projects. The controversies that were regularly observed fall into three main categories: socio-spatial conflicts, discrepancies between various planning sectors, and problems with heritage conservation. To mention just two examples: residents living next to the river, although even more exposed to flooding than others, frequently opt against any flood-proofing structures because these are likely to alter the views to and from the river landscape they are familiar with and fond of. Secondly, discrepancies often arise between parties committed to the protection of a historical neighbourhood and those demanding a maximum in safety from flooding (Lieske 2012).

Besides these conflicts at the level of the citizenry, there are competing demands about political and planning issues that touch on matters of social justice and sustainability in urban development. In particular, we found our Grimma experiences corroborated this again and again: heritage aspects are usually considered too late and not enough. Rather, seldom are they as systematically accounted for as, for instance, concerns for the natural environment (which enjoys more rigid legal protection in Germany then cultural heritage). Flood control projects therefore frequently cause damage to valuable aspects of the waterfront and to the cultural heritage. They can easily spoil the attractiveness of those special historic places.

Even if concerned citizens call for accelerated action and uncompromising steps after a flood, large-scale inner-city flood protection structures are tasks for generations, comparable to the erection of city walls in former times. Only with a long-term perspective and a clear political and civic commitment to a location will the high costs and the extensive planning and construction process of an urban flood protection system be plausible and acceptable to the general public. Integrative planning procedures provide opportunities to combine up-to-date flood protection with the preservation of the urban heritage and a general upgrading and stabilization of historic river cities.

The common goal, then, of all those involved in planning such projects must be to avoid a situation in which protective measures, which are often extremely costly, produce negative overall effects. This calls for interdisciplinary processes of forecasting and weighing the possible gains and losses of prevention efforts. Our task thereby is to clarify and emphasize the role of heritage sites as socially and economically effective factors in urban and regional development, in order to help integrate cultural heritage concerns into general disaster mitigation plans and programs.

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Was Haiti 2010 the Next Tangshan 1976?
Heritage Structures Reveal the Hidden Truth about Risk and Resilience during the Haiti Earthquake

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Figure 1. Like a scene from Dante's Inferno, central Port-au-Prince, 4 months after the earthquake

1 Tangshan 1976 and Haiti on January 12, 2010

On the 27th of July 1976, the ground shook in Tanghan, only 150 kilometres from Beijing. When the shaking stopped less than 15 seconds later, the city was veritably destroyed, and the official estimates reported that almost a quarter of a million people died. Unofficial casualty estimates were as high as 655,000. At the time, this event was believed to be the largest loss of life in an earthquake in 420 years, and the second largest in all of documented human history. The record for loss of life in an earthquake is reported to have also been in China – an earthquake on the 1st of June 1556 near Huaxian Shaanxi (formerly Shensi). It was reported to have killed 830,000 at a time when the human population of the planet was far less than that of the 20th century.[1]

Thirty-eight years after the Tangshan earthquake, and on the US Geological Survey (USGS) web page referenced above, the second item under 'Earthquakes with 50,000 or More Deaths' is the 2010 Haiti earthquake. Thus, Tangshan 1976 is listed third! The Government of Haiti's publication of the 'official' death toll of 316,000 exceeds that of the official number for Tangshan, placing the Haiti quake as the second most devastating in history with respect to human lives lost. Ironically, the earthquake's magnitude of 7.0 was identified as the lowest magnitude for any earthquake with over 50,000 fatalities.

This paper is not intended to verify or refute this figure. That is a task reserved for others, and it is a controversial and perhaps thankless duty. However, earthquake casualty data has two contrasting effects on the international political spectrum:

1. International aid contributions are often sized in response to the body count, which is an incentive to overstate the fatalities.
2. It highlights the apparent failure of national and local governments to oversee and regulate building design and construction quality in the public's interest, thus providing an incentive to understate casualties.

In the case of Haiti, casualty estimates range from as low as 50,000 to as high as the over 300,000.

Regardless of the figures, the irrefutable evidence is that it was the collapse of vast numbers of formal contractor-built, downtown commercial and residential buildings that led to such high losses. We may then ask: What about the many published images of large areas of destruction of informal, unauthorized housing in the hillside and coastal shantytown squatter settlements? This paper will explore that issue and evaluate how it compares to that of the formal construction.[2]

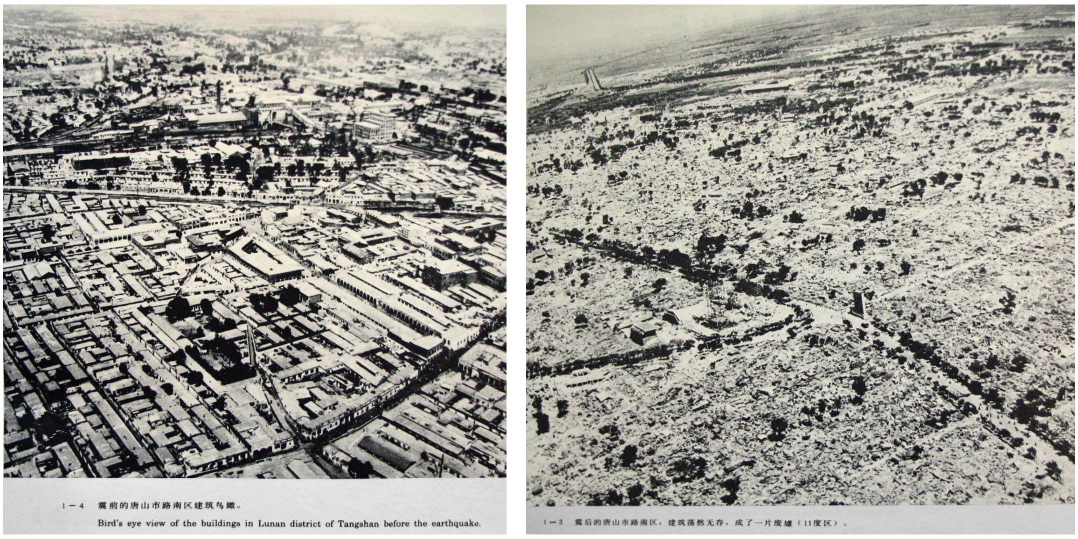


Figure 2. Tangshan before and after 1976 earthquake.
(Source: The Mammoth Tangshan Earthquake of 1976 Building Damage Photo Album, China Academy of Building Research)

2 Oblique Views from the Air

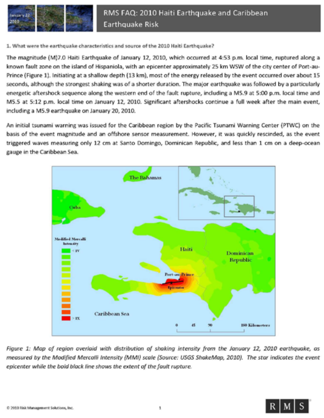
Whether the death toll in Haiti is a 250,000 or less than 100,000, it is still inarguably high, particularly for a 7.0 earthquake. Research on the causes of these high casualties is of importance beyond the shores of Haiti, because most of these casualties were in buildings of recent origin – most of which were of reinforced concrete, a structural sysem which has rapidly become the predominant choice for new buildings in urban, and even many rural areas in many parts of the world.[3]

My recent research on Haiti stems from access to an unusual source of data – the oblique aerial photography of the damage district in and around Port-au-Prince, generated in the weeks following the 2010 earthquake by Pictometry International Corp.. For the first time, it was possible to survey the damage patterns over a much larger area than would be possible to do from the ground, and with greater clarity than is possible from satellite imagery.

Figure 3. A detail from a Pictometry oblique aerial view of central Port-au-Prince one week after the earthquake. The collapsed unfinished building in Figure 1 is visible in the upper left
(© Pictometry International Corp.)

Following most disasters, news photographers as well as government inspectors and engineers head to the most evocative and extensively damaged areas. Their photographs quickly blanket the information pathways with poignent images of devastation and distress. Such points of view from the ground usually fail to document and thus properly recognize areas with fewer collapses – and therefore fewer casualties.

The World Bank sponsored an extensive preliminary damage survey from high resolution straight-down aerial imagery using Google Earth as a platform, and this was published on the web and used extensively in the post-disaster planning work.[4] However, the Pictometry oblique imagery provides a chance to glean more complete information of the architecture and structural systems of both the collapsed and still-standing buildings. The oblique views of the framework and still-standing walls of those that are partially and totally collapsed are more clearly visible, and thus provide an opportunity to see better the nature of their failures. This allows for the classification and rough dating of the affected building types, as well as a more accurate assessment of whether or not partial or total collapses have occurred, while a straight-down view of the roof can be misleading, as collapse of the walls may then only be revealed by a view of debris on the ground.


January 22 2010

RMS FAQ: 2010 Haiti Earthquake and Caribbean Earthquake Risk

1. What were the earthquake characteristics and source of the 2010 Haiti Earthquake?

The magnitude (M)7.0 Haiti Earthquake of January 12, 2010, which occurred at 4:53 p.m. local time, ruptured along a known fault zone on the island of Hispaniola, with an epicenter approximately 25 km WSW of the city center of Port-au-Prince (Figure 1). Initiating at a shallow depth (13 km), most of the energy released by the event occurred over about 15 seconds, although the strongest shaking was of a shorter duration. The major earthquake was followed by a particularly energetic aftershock sequence along the western end of the fault rupture, including a M5.9 at 5:00 p.m. local time and M5.5 at 5:12 p.m. local time on January 12, 2010. Significant aftershocks continue a full week after the main event, including a M5.9 earthquake on January 20, 2010.

An initial tsunami warning was issued for the Caribbean region by the Pacific Tsunami Warning Center (PTWC) on the basis of the event magnitude and an offshore sensor measurement. However, it was quickly rescinded, as the event triggered waves measuring only 12 cm at Santo Domingo, Dominican Republic, and less than 1 cm on a deep-ocean gauge in the Caribbean Sea.

The Bahamas
Cuba
Modified Mercalli Intensity
< IV
> IX
Haiti
Dominican Republic
Port-au-Prince
Epicenter
Caribbean Sea
0 45 90 180 Kilometers

Figure 1: Map of region overlaid with distribution of shaking intensity from the January 12, 2010 earthquake, as measured by the Modified Mercalli Intensity (MMI) scale (Source: USGS ShakeMap, 2010). The star indicates the event epicenter while the bold black line shows the extent of the fault rupture.

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Figure 4. The RMS report showing shakemap based on USGS shakemap dated 13 January 2010 (See Endnotes (5) for link to a copy of the report)

3 USGS Shakemaps, the Modified Mercalli scale, and the First Casualty Estimates

Prior to exploring the results of the Pictometry imagery, it is worth revisiting the days following the earthquake, when the first technical data was issued by seismologists from around the world, including the United States Geological Survey (USGS). Ten days after the earthquake the California-based risk and loss estimation firm Risk Management Solutions (RMS) published a report in which they estimated that the earthquake had caused 250,000 fatalities. This number is uncannily close to the 222,570 reported by the United Nations Office for Coordination of Humanitarian Affairs (UNOCHA), citing a USGS 'Newsroom' page released on February 22, 2011, thirteen months after the earthquake.'5 By that time, according to the Haiti government, the body count had risen to 316,000, as claimed by Prime Minister Jean-Max Bellerive on the first anniversary of the earthquake. This is almost 100,000 higher than that cited by the UNOCHA, and higher even than the 300,000 reported by the USGS as the number who suffered injuries.[6]

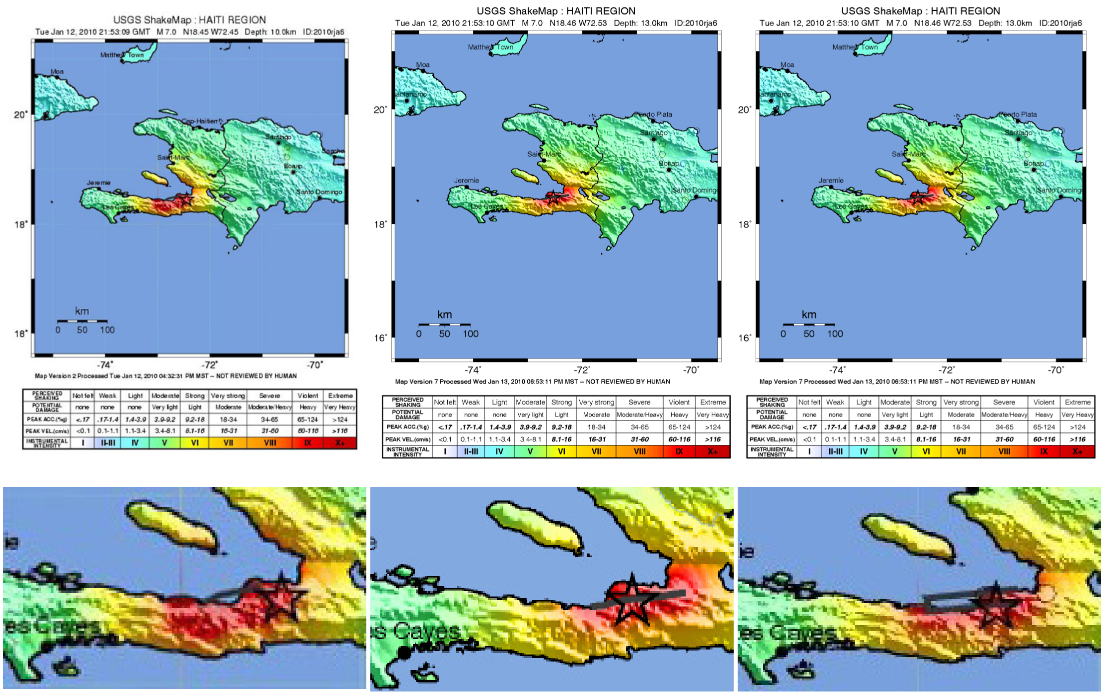

Figure 5. USGS Shakemaps with details of each map. Left: Version 2 (January 12-Day of earthquake); middle: Version 7 (January 13); right: Version 10 (March 4)

Interestingly, the RMS estimate just days after the earthquake a year earlier was stated as based on a 'USGS Shakemap published on January 13, 2010', just one day after the earthquake. The USGS shakemaps customarily go through a number of revisions as more data is processed and interpreted, but only the latest report (in this case Version 10, dated March 4, 2010) is made available on the USGS site. The earlier versions are no longer available from USGS, and in order to locate them, one has to search the internet for copies that may have managed to be reproduced into reports and posted on other websites. Using desktop research, I was able to locate USGS Shakemap versions 2, 3, 7, as well as 10. If one compares these versions to one another for the Haiti earthquake, it appears that both the precise location of the fault and the rupture zone on that fault were shifted on the map as the later versions were published.

Versions 2 and 3 were produced immediately after the earthquake on January 12 at 4:30PM and 6:30PM respectively. The version most resembling the map in the January 22 RMS report and of the date cited by RMS; was found on Wikipedia linked to their page on the 'Mercali Intensity Scale'. This shakemap is marked as version 7, published at 7PM on the 13th. This was probably the most up-to-date shakemap available at the time that RMS prepared their report.

The version 7 shakemap shows the city of Port-au-Prince as having been subjected to a shaking equivalent to an Modified Mercalli Scale (MMI) IX, while version 10 shows a reduceduction in shaking to an MMI-VII or VIII. The transition from the yellow for VII, to orange for VIII extends over part of the area. An undated UN/ European Commission shakemap classifies all of Port-au-Prince as having a value of VII. Interestingly, USGS versions 2 and 3, published on the day of the earthquake also show Port-au-Prince having been subjected to a MMI-VI to MMI-VII, considerably lower than version 7 a day later, but not much different from the latest and final map version 10 of March 4.[7]

Figure 6. Bodies laid outside a Port-au-Prince hospital. Counting of fatalities was done by measuring the body count in squares such as this and reporting on how often they were refilled after they had been cleared for burial. It was also done by counting truckloads of dead bodies, but this process was informal and prone to large errors (Source: AP)

To put this in perspective, as stated above, a quarter of a million fatalities places this earthquake as equivalent to the Tangshan earthquake of 1976, which caused more fatalities than any other in the 20th century by an order of magnitude. The RMS estimate was considered to be plausible when the intensity was calibrated to be an MMI-IX, given the poor construction known to exist in Haiti. However, what if the actual shaking is more correctly classified as an MMI-VII?

At the time of the earthquake, it was the widespread collapse of the legally constructed buildings in Port-au-Prince that most probably suggested a classification of the intensity as an MMI-IX and possibly even an MMI-X (as continues to this day to be reported in Wikipedia).8 This information seemed at the time to be accurate, not just in the epicentral area near Léogâne, but also extending through Port-au-Prince and including Pétionville. In fact, two buildings in particular that may have influenced the figures are the five-star Hotel Montana, and the former five-star hotel used by the UN to house its staff in Haiti [FIGURES 7 and 8]. Both of these hotels pancake collapsed, killing most of their occupants. The Hotel Montana was heavily used by visiting governmental officials from the USA, so knowledge of its collapse spread fast, including to the USGS. Since it was thought that these buildings would be much more structurally sound than the shantytown houses, early knowledge of their collapse may have influenced the USGS decision to show the steep rise in intensity in the version 7 shakemap, over that in those published the day of the earthquake. With access to more technical geological data, the subsequent USGS shakemaps show a return to a lower MMI for Port-au-Prince.

The lead author of the RMS document, Patricia Grossi, reported that if USGS had published on the 13th of January the lower MMI that they later determined was correct, the RMS estimate of casualties would have been significantly lower. She pointed out that since there were no seismographs in Haiti at the time of the earthquake, the interpretation of data from the more remote instruments is all that scientists had available to generate the shakemaps and this took time.[9]

Figure 7. Five-star collapse in Pétionville. Left: Hotel Montana before. Centre: after the earthquake

Figure 8. UN headquarters after the earthquake (Source: Google Images)

To try to assess the differences, one can look at how the Modified Mercalli scale calibrates damage. This intensity scale was updated from the late 19th century Rossi–Forel scale by Italian volcanologist Giuseppe Mercalli and given his name in 1902, and was later re-written slightly by Charles Francis Richter in 1958. For the lower intensities, the scale is based on an extrapolation of intensity based on peoples' perceptions of the ground shaking. In the higher intensities, it is based upon damage to buildings. Since the buildings in Italy at the time and place of Mercalli were primarily buildings of unreinforced masonry, earthquake damage to these served to calibrate the scale.

As a source for the estimate of 250,000 fatalities, the RMS report on page 7 states:

> 'The initial casualty estimates were developed using publically available information including population data, ground shaking intensities, and the Haitian construction materials and practices, as previously summarized…The building vulnerability was assumed to map on average to unreinforced masonry construction, which is extremely susceptible to collapses and heavy enough to cause significant casualties to occupants. This is consistent with the prevalent construction type in the urban regions of Haiti (i.e., blocks/concrete), but actual construction practices vary and include reinforced concrete, reinforced masonry, and unreinforced self-constructed buildings.'

As mentioned above, the estimates are based on an MMI of IX for central Port-au-Prince including the shantytowns, known as 'bidonvilles' (French for 'tin can cities') on the surrounding hilllsides. An MMI-IX is described in part as 'Violent: …Damage to masonry buildings ranges from collapse to serious damage unless modern [ca. 1958 – the time of Richter] design. Wood frame structures, if not bolted, shifted off foundations. Frames racked.' If it were an MMI-VII quake, then the calibrating description would be the following: 'Strong:… damage to some poorly built unreinforced masonry buildings. … Some cracks even in better built masonry buildings if not reinforced.'

4 Rubble Stone Masonry versus Reinforced Concrete Moment Frames

It is exactly the MMI scale's damage descriptions that indicated potential flaws in the early estimates of high intensities on which the casualty figures were based. My first opportunity to see the earthquake damage came while on a post-earthquake historic preservation mission to Port-au-Prince in April 2010 to survey the condition of the late 19th century historic timber and masonry houses that had come to be known as the 'Gingerbread' houses. One of them was the Oloffson Hotel, the original construction of which is concurrent with Mercalli's publication of the scale. It is of URM construction with good quality brickwork (which in the MMI scale would be termed 'better built'). It came through with only minor cracks, as specified for an VII quake and never had to be closed [FIGURE 9]. As evidence that the Oloffson was not on a site subjected to less shaking, a nine-story RC hotel structure immediately behind the Oloffson pancake collapsed.

Figure 9. The unreinforced brick masonry of Hotel Oloffson, Port-au-Prince after the earthquake

The other historic masonry buildings were most often constructed with a mixture of brick with round-rock rubble stone set in clay or lime mortar – many of which had been poorly maintained during the decades leading up to the earthquake. The damage to these ranged from medium [FIGURE 10, left and middle], to heavy [FIGURE 10, right]. However, very few suffered collapse, except for the falling out of some of the empaneled rubble stone. This is also consistent with the MMI-VII classification. All the affected buildings were within the central Port-au-Prince damage district, making it difficult to explain these phenomena as only a consequence of extreme differences in local site effects.[10]

Figure 10. Brick and empanelled rubble stone construction, as is typically found in many of the Port-au-Prince 'Gingerbread' Houses from the late 19th century, showing different levels of damage from onset, to collapse of the rubble panels. Surprisingly few houses with this construction collapsed overall, despite the weakness and vulnerability to earthquake shaking of this construction – a further verification that the intensity did not exceed MMI-VII at these Port-au-Prince sites.

This then leads to my hypothesis of how the RMS casualty estimate and other initial estimates immediately after the earthquake end up being very close to the casualty totals reported more than a year after the earthquake, despite the the later scientific updates in the intensity levels.[11] There are three possible scenarios:

1. The total chaos after the earthquake and a lack of any record of how many people were in harms way prevented any actual reliable count of fatalities, and thus the body count remained at those original hypothetical estimates because of their rapid publication and circulation on the internet just days after the earthquake, and/or
2. The later shake maps may have failed to recognize localized higher levels of shaking in certain areas because of the lack of instrumentation in Haiti, and/or
3. The structural resilience of the buildings in which people were at the time of the earthquake was far worse than the '…map of unreinforced masonry construction…' that RMS used to come up with its estimate.

In reference to scenario number 1 (fatalities), while many sources cite casualties in the 225,000 to 300,000 range, they are quoting what can only be classified as impressionistic comments by people who individually could not know the true number. Many sources make it clear that due to a lack of quantitative data on the populations prior to the disaster, the exact number of fatalities may never be known. With no official census or figures of the number of citizens living in Port-au-Prince prior to the disaster, thefore assumptions were used to calculate the total figure of casualties after the earthquake. A paragraph from Wikipedia explains scenario (1):

> 'In the weeks following the earthquake …the Red Cross stated that 40,000-50,000 may have died, while Haitian Interior Minister Paul Antoine Bien-Aimé estimated that the dead were between 100,000-200,000. On 12 January Haitian Prime Minister Jean-Max Bellerive stated that the death toll could be 'well over 100,000.' Later Red Cross officials issued a death toll estimate of 50,000 killed, while Haitian Interior Minister Paul Antoine Bien-Aimé stated that … 'there will be between 100,000 and 200,000 dead in total, although we will never know the exact number.' Prime Minister Bellerive then announced that over 70,000 bodies have been buried in mass graves. … Haitian President Rene Preval reported on 27 January that 'nearly 170,000' bodies had been counted. On 10 February the Haitian government reported the death toll to have reached 230,000…. Edmond Mulet, who was appointed head of the United Nations after the quake, stated that 'I don't think we will ever know what the death toll is from this earthquake.' And the director of the Haitian Red Cross, Guiteau Jean-Pierre, noted that his organization didn't 'have time to count' bodies…'[12]

Engineer Kit Miyamoto, who led teams of inspectors for over a year after the earthquake, believes that the higher range of estimates of fatalities are plausible. However, on June 2nd, a draft of a USAID report by PhD anthropologist Timothy Schwartz was obtained by Associated Press, which estimated that between '46,000 to 85,000 people' were killed in the earthquake, contrary to initial higher estimates. Despite the discrepancy between the estimates, Schwartz's numbers demonstrate a more rational relationship between the number of deaths and the number of injured, while taking into account the residents still living at their original addresses.

In reference to scenario number 2 (earthquake intensity), the lack of local instrumentation makes representations of enhanced shaking due to the geology of the affected areas plausible, but only speculative. Subsequent research of the geology of the Port-au-Prince area does illustrate subsoil and geological strata that could have resulted in shaking differences. However, because of the range of damage within each of these strata subdivisions, the differences cannot justify the discrepancy between the overall poor performance of the reinforced concrete moment frame buildings, when compared with either the masonry buildings, or the non-engineered self-built houses in the 'bidonvilles' regardless of the construction material used. Many of the comparisons were made during the reconnaissance of buildings that were near or adjacent to each other, sharing the same geological strata.

In reference to scenario number 3 (collapsed buildings), this may be the only variable that can be used as a scale to measure destruction, because it is possible to investigate it in detail, particularly with the Pictometry images. Thus the Pictometry imagery provides insight into where it was that most of the people probably died. It is clear in this data, as well as the views from the streets, that the earthquake performance of buildings in central Port-au-Prince of recent construction was particularly poor.

5 Downtown versus Shantytowns

Unlike most recent earthquakes that have stricken developing countries where the affected buildings are largely rural, this one struck a capital city. The RMS report expected that the preponderance of the fatalities would be in the 'bidonvilles' because of their belief that the owner-built houses mostly of cement block masonry and concrete slabs would be most vulnerable. However, the Pictometry images have revealed that the majority of the building collapses were not, as anticipated by RMS, in the 'bidonvilles', but in the formal, contractor-built multistory reinforced concrete buildings in and around the city center [FIGURES 1,3 and 11].

Figure 11. A downtown commercial building in a near state of collapse, illustrating the brittle vulnerable nature of many of the formal, contractor-built reinforced concrete buildings in Port-au-Prince. Many buildings of this type did pancake collapse, but as demonstrated by the buildings on either side that are still intact, everything did not fall down. Approximately 40% of the buildings in the central city were partially or totally collapsed; but of the remaining 60%, many suffered little damage[13]

This also includes the 5-star Hotel Montana well to the East. Shockingly, almost every Haitian government building collapsed, including the 1916 National Palace and the more recently constructed Legislative complex. In addition, the devastation included the hundreds of offices and retail buildings in the city center. Thus, the worst building performance was with the pre-designed, 'engineeered' and contractor-built buildings. Almost all of these were of reinforced concrete with concrete block masonry infill, mostly located in the commercial downtown area of Port-au-Prince and in some of the more permanent and formal parts of the outlying areas to the north and east.

The collapse of these buildings may in fact require the setting of a new lower limit for damage in the MMI scale definitions – collapse risks at levels of shaking not anticipated by either Guiseppi Mercalli or Charles Francis Richter. They based the calibration of the building damage portion of the scale using the performance of unreinforced masonry buildings not unlike the 1890's Oloffson Hotel (originally constructed as a private home) at the high quality end, and of the brick and rubble stone houses in the Gingerbread District at the lower quality end.

The more recent single-wythe low-strength cement block masonry buildings with (and sometimes without) poorly designed and built non-ductile concrete frames would not have existed at the time the Modified Mercalli

Scale was created. They may now best be classified as having less resilience than even what is defined for MMI-VII as 'damage to some poorly built unreinforced masonry buildings'. The description of MMI-VI includes 'Weak plaster, adobe buildings, and some poorly built unreinforced masonry buildings cracked'. It is hard to imagine that this category should now contain a phrase such as: 'pancake collapse of poorly built multi-story reinforced concrete frame with infill buildings, particularly' - but how else can one explain the situation?

Figure 12. Views of a bidonville near central Port-au-Prince showing (left) a view of an area with extensive collapses, and (right) an area with very few collapses. A careful review of the Pictometry of the Port-au-Prince damaged district as a whole has shown that the number of areas with minimal evidence of collapsed buildings, were higher than those with greater damage. (Left: Source: UNDP Global from RMS Report; right © Pictometry)

This situation in Haiti contrasts sharply with the outcomes which followed Chile, and a year later Japan. It was only the buildings of reinforced concrete and steel that remained standing after the remarkable onslaught of the Tsunami in Japan. Some smaller RC buildings were even found on their side with their superstructures intact, having been turned by the tidal wave and carried away from their original location by the great wave [FIGURE 13, right]. In Haiti, which is frequently subjected to hurricanes, the resistance from weight of concrete buildings makes that system more favorable over wood and lighter materials.

Figure 13. Left: Pancake collapse of a reinforced concrete building on the East side of Port-au-Prince. Pancake collapses of the heavy floors of multi-story RC buildings are particularly lethal and make it hard to extract the survivors. Right: A reinforced concrete building in Rikuzentakata Japan, swept onto its side and carried upstream by the March 10, 2011 earthquake and tsunami (Source: AFP/Getty)

Ironically, the introduction of modern materials and systems such as reinforced concrete, concrete block or even light weight steel (as demonstrated by the Bam earthquake where the use of steel and masonry jack-arch roofs on adobe walled buildings caused countless fatalities) may have led to an increase rather than a decrease in risk of total collapse of buildings. Due to the abundant use of these new materials and systems where quality control and inspections do not exist and a skilled workforce is not available, the results are devastating. Reinforced concrete buildings can be exceedingly strong if well designed and constructed. However, when the workmanship is of poor quality, they are more subject to faults which can dramatically reduce their inelastic capacity and ductility. These faults can easily lead to collapse in earthquakes specifically because it is with design level or greater earthquakes for which inelastic response is expected to occur.

Concrete construction came to be used in Haiti relatively early. The view of the collapsed National Palace, with its heavy white square domes scrunched down over the ruins of the building below was broadcast around the world in news reports after the earthquake [FIGURE 14]. This building, dating from 1916-18, is reported to have been finished by the U.S. Navy when the United States occupied Haiti.[14] It has a reinforced concrete frame infilled with masonry composed mostly of rubble stone. The Catholic Cathedral was also reinforced concrete except for its steel truss roof. The upper level walls and towers collapsed, bringing down the roof. The steel reinforcing, which was minimal to begin with, had corroded over the century of exposure to the tropical elements. Many of the other churches in Port-au-Prince had collapsed for the same reason.

Figure 14. The 90-year-old National Palace in Port-au-Prince after the earthquake and partial demolition, revealing the reinforced concrete frame infilled with rubble stone. The steel reinforcing bars in the exterior portions of the frame and poured concrete walls (visible on left side of left photo) were heavily corroded in this over 90 year old structure.

Most of the collapsed buildings where people died were of much more recent construction, a problem with modern buildings with moment frames of reinforced concrete infilled with masonry that increasingly has been observed in other earthquakes around the globe. However, in Haiti, there is another story that needs to be explored: it is to see what happened with the buildings initially thought to be most lethal – the illegal and unregulated owner-built housing on the mountainsides and water's edge around central Port-au-Prince.

6 The '*Bidonvilles'* – Are They Only Slums?

As one scans the news photography of the 'bidonvilles', not surprisingly the impression one gets is that most of the houses were destroyed. There are many views of hillsides of shattered houses. The Pictometry flights however were designed to uniformly cover every part of the urban landscape – and while the smashed areas are also visible in the Pictometry views, they must be searched for. This search, I found, passed over vast areas with little or no evidence of collapsed buildings.

On the hillsides to the east and south of Central Port-au-Prince, there were some areas where whole clusters of buildings were devastated while other areas were largely intact. In most of the areas which had large swaths of damage, after making 3D images from the overlapping areas of the Pictometry aerial photographs it was possible to see that the most destroyed areas were located on the steepest slopes (for example as seen in FIGURE 15a). This then served to explain the most likely cause for the concentrations of damage. The foundations and retaining walls of many of the destroyed houses had been constructed of undressed river rock which is the most vulnerable of masonry types. The failure of these walls often would cause a mini-landslide carrying other houses with it.

It is also worth investigating areas where steep hillsides are not a factor. One such area is presciently called 'Cité Eternal'. It is located immediately adjacent to the devastated city center at the edge of the sea, on fill and unconsolidated alluvium, land where one would expect to find the most damage [FIGURES 16 and 17]. The area consists mainly of one, two, and three story buildings constructed with concrete block masonry, slabs and roofs.

While the largest number of houses in 'Cité Eternal' were one story buildings, there were many two-story and even a significant number of three- and four-story concrete block masonry buildings with RC floors and roofs. Some buildings and parts of buildings did collapse, but they were isolated examples. This contrasts very conspicuously with the city center where block after block was in ruins. The question is: why did so many of these hillside and seaside shanty town houses survive?

One hypothesis is that poorer people tend to build smaller rooms, and therefore the honeycomb of small rooms contributed a redundancy of walls that added to the buildings' resilience. Perhaps also, in the case of *Cité Eternal,* the soft soil at the seaside actually proved to be beneficial for the stiff masonry construction. Stiff buildings tend to resonate less with earthquake vibrations when on soft soil, so long as it does not suffer from liquifaction. Perhaps it is the simple fact that the buildings – essentially being solid wall masonry and confined

Figure 15. 3D aerial view of shanty town on the hills immediately to the south of Port-au-Prince city centre. One can see that only occasional houses on the less steep areas are collapsed, but massive slides and collapses are along the steep slopes of the ravine. The 3D image made from Pictometry images with overlapping sections
(To view in 3D, cross your eyes until so that you can see the two images exactly overlap) (© Pictometry).

Figure 16. Aerial view of ‘Cité Eternal’, located on a combination of fill and alluvial fans in central Port-au-Prince (© Pictometry; mosaic of images into a single view by Randolph Langenbach)

Figure 17. Left: Typical detail of 'Cité Eternal' showing that two story buildings with one four story building, most of which are constructed using reinforced concrete

Figure 18. Right: View of collapses in Cité Eternal showing buildings with evidence of moment frame construction rather than block masonry (© Pictometry)

masonry buildings with few windows and openings – actually conformed more closely to the calibrating measure used originally by Mercalli and later modified by Richter in the setting of the damage thresholds in the Modified Mercalli Scale. If this is so, then, as observed above, they are one level more robust than the performance of the collapsed reinforced concrete infill-frame buildings in the city center. In fact, consistent with this theory, one cluster of collapsed buildings in 'Cité Eternal' was revealed by the aerial photography to be RC moment frame buildings [FIGURE 18].

Shocking? Perhaps – but then again, maybe not.

While most downtown commercial and residential buildings in Haiti were contractor built, many were not more than rudimentarily engineered. Architects and engineers are only involved in the design of the larger and more complex structures. Even for those that are designed by professionals, construction quality is unpredictable, and often of low quality. There are no building codes in Haiti, and inspection is almost non-existant.

Even in those areas of the world that have building codes, as well as government inspection and code enforcement, reinforced concrete buildings have been subject to collapse in large earthquakes, at least until the introduction of ductile detailing in the quantity and layout of the reinforcing steel. When the damage from the large earthquakes that struck Turkey in 1999 was compared with that of a smaller one in 2000, it was evident that RC buildings that lack ductile detailing can go from little apparent damage to full collapse very quickly, once the forces exceed their elastic capacity and the columns begin to break.

7 Reinforced Concrete Moment Frame Construction With Masonry Infill Walls

The Haiti earthquake highlights the serious flaws in the increasingly common use of reinforced concrete moment frame with infill masonry construction as a default choice for new construction. A full understanding of what happened in Haiti as well as other recent earthquakes around the world mandates a review of some of the recent history of building construction.

Over the past half-century, RC frame construction has displaced almost all other structural systems for new construction in many parts of the world. This has been particularly true where traditional forms of solid wall masonry construction had previously been common. This displacement has often been actively promoted, and even subsidized, by governments and large corporations. This has transformed the local building process from an indigenous one to one dependent on outside contractors, specialists, and nationally-based materials producers and suppliers of cement, extruded fired brick, and hollow clay tile. In places like Haiti, reinforced concrete has been introduced into a building construction process that is dependent on local builders with a rudimentary knowledge of the science of materials. This was sufficient so long as they were working with timber, unfired clay, and stone and fired brick masonry. However, with concrete moment frames, it has proved woefully inadequate.

In fact, there is a fundamental engineering problem with standard reinforced concrete moment frame construction that has been recognized for decades, but which has not yet been fully resolved. In addition to the supporting loads along the axis of the members, moment frames achieve lateral stability from the shear and flexural capacity of the rigid joints of the frame. Their lateral capacity is primarily determined by the strength and ductility of the joints between the beams and the columns. The enclosure and partition walls that turn this open framework into a useable building with rooms are generally ignored in the engineering design, and simply treated as dead weight in the structural calculations.

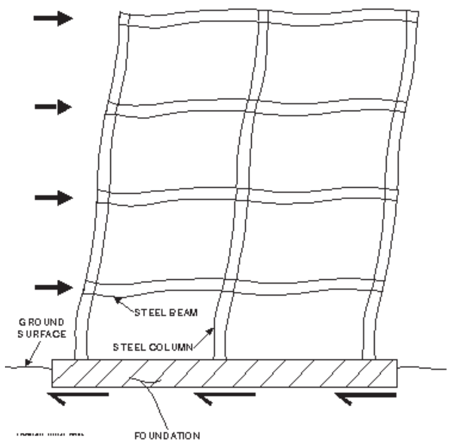

Figure 19. Moment frame showing uniform bending of the frame in response to a lateral force without infill masonry walls.[15]

The advantage of this approach is that it has allowed for a coherent mathematically-based engineering approach to building design, by separating the infinite complexity of a finished building with all of its parts from that of its primary structural frame. But there is an important caveat that in practice has largely been forgotten: standard portal frame analysis is predicated on the existence of 'frame action'. This means that the building design is based on the assumption that the frame will deform in a geometrically coherent way, so that all of the elements can share the loads [FIGURE 19].

There is a significant problem with this assumption. In most parts of the world the enclosure and partition walls are most often of stiff brittle masonry. However, this masonry is strong enough to prevent the 'frame action' on which the portal frame analysis is predicated. Because these walls are considered by the design engineers to be 'non-structural,' these infill masonry walls are often not themselves designed to resist the lateral forces of an earthquake but nonetheless, they are strong enough to prevent the 'frame action' until they crack and collapse, which then can initiate a progressive collapse of the building.

As a result, moment frame buildings are severely handicapped when subjected to a design-level earthquake. To understand the roots of this problem, we must first understand an aspect of the early 20th century origins of the modern skeleton frame system of steel and concrete construction is in order.

8 From the Invention of the Skeleton Frame to the 'Modern Movement'

Structural engineering has gone through its own revolution over the past century. The 19th century was an era of enormous ferment, producing engineering giants like Brunel and Eiffel, along with Jenny and the other engineers of the first 'skyscrapers'. In the first decades of the 20th century, buildings went from a height of 10 to 20 stories to over 100 stories. At the same time, engineering practices shifted from a largely empirical process of working with masonry walled structures, to one of rigorous mathematics, and the focus shifted to working almost exclusively on the design of frames.

For the longest time, structural calculations for the increasingly taller buildings consisted of analysing and calculating the frame for each floor separately. In order for this method to work, the frame at each floor level had to be very rigidly braced, with pin connections at each floor level so as not to transmit bending forces from floor to floor. A more efficient way to design a multi-story frame was invented in the mid-1990s with the introduction of portal frame analysis based on the contraflexure methodology for isolating moments [FIGURE 19]. This method involves the subdivision of the frame not at the floor levels, but at the point in each member where there is zero moment (bending) forces. This then allows the designer to calculate each section of the frame using the three equations of equilibrium. [FIGURE 19]

This method provided the theoretical basis on which the 'invention' of the skeleton frame system of construction used for what then came to be called 'skyscrapers' in Chicago, New York City and San Francisco. This portal frame analysis method was both simple and precise enough for it to have remained in use until now for the design of most multi-story frame structures. This method accounted for the value of the cantilever effects of beams and columns that run from floor to floor, and across the building as continuous members with moment connections at the beam/column intersections. Contraflexure portal frame analysis made a substantial reduction in the size of the members of a frame possible. However, the exterior walls of the first generation of skeleton frame 'skyscrapers' continued to be of thick and heavy masonry in the same tradition as pre-skeleton frame architecture. Although no longer load-bearing to the ground, these walls still shared significant loads with the internal steel frame, as well as protecting the frame from exposure to fire.

As late as 1901, a contemporary structural engineer, Joseph Kendall Freitag, in a textbook for designing tall buildings observed: "Skeleton Construction' … suggests a skeleton or simple framework of beams and columns, dependent largely for its efficiency upon the exterior and interior [masonry] walls and partitions which serve to brace the structure, and which render the skeleton efficient, much as the muscles and covering of the human skeleton make possible the effective service of the component bones'. Even more interesting is that he raises the problem of the need to calculate the contribution of the masonry infill, a problem that plagues engineers even today: 'While the steel frame is more or less reinforced by the weight and stiffening effects of the other materials, still no definite or even approximate values can be given to such items, except their purely static resistance or weight' (Freitag 1906).

Many architectural historians of the early skyscraper era have described the evolution of skeleton frame building design as one almost like that of a genie waiting to come out of the bottle. True transformation, they said, could only come when this traditional masonry envelope was shed, and the open frame itself made the basis for the architectural expression with flexible systems of open spaces and moveable walls. The

Figure 20. Flatiron Building in New York City under construction in 1902 showing the heavy stone masonry façade resting on the steel frame. The upper walls are constructed separately probably to ensure the weight is bearing on the frame rather than the lower masonry walls.

Figure 21. View of San Francisco after the 1906 earthquake and fire. The three tall buildings visible in this view were burned out by the fire that followed the earthquake, but all three were in good enough condition despite the earthquake and fire to be repaired. They are still standing to this day.

architectural precursor for the liberation of the skeleton frame 'genie' is often identified as Swiss architect Le Corbusier's 1915 drawing of the prototype, bare concrete skeleton for multi-story residences, known as the Dom-Ino house. It became the icon of what he called the 'New Architecture'. As described by Le Corbusier's contemporary, Sigfried Giedion: 'Corbusier created…a single, indivisible space. The shells fall away between interior and exterior. … There arises…that dematerialization of solid demarcation…that gradually produces the feeling of walking in clouds' (Siegfried and Georgiadis 1995).

Influenced by the Dom-Ino prototype, the reinforced concrete moment frame spread through Europe and then the rest of the world. Unlike northern Europe, this included earthquake hazard areas. The problem with Le Corbusier's ideal form, the 'dematerialisation' of the walls clashed directly with the usual enclosure requirements of completed buildings. As a result, masonry did not disappear. Instead, the thick infill walls of the first skyscrapers evolved into thin, weak, and discontinuous membranes while at the same time, engineers eliminated the infill masonry from their engineering calculations, except for calculating only their dead weight on the structural frame.

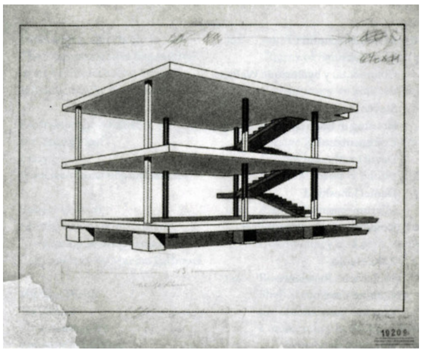

Figure 22. Dom-Ino House by Le Corbusier, 1915 (Source: Public Domain)

Figure 23. Building under construction in Gölcük, Turkey shown after the 1999 earthquake. Because the masonry infill walls had not yet been installed, frame action was able to occur, and thus the building was not collapsed by the earthquake.

Figure 24. Building in Gölcük close to the one shown in Figure 23 collapsed by 1999 earthquake. The heavy masonry infill walls together with open (soft) ground floors were often contributors to such collapses.

This was believed at the time to be a conservative approach, as it was thought that the infill walls would add strength to building rather than break the frame. However, the rigid and brittle infill walls attracted increased earthquake forces which they were too weak to resist, yet, their weight added significantly to the inertial forces that had to be resisted by the frame. To make matters worse, as described previously, these walls interfered with the flexural movement of the structural frame on which the portal frame analysis was predicated. Compounding this problem was the frequent use of open ‘piloti’ on the ground floor as advocated by Le Corbusier, a feature which in engineering has come to be known as a ‘soft story’. This has come to be identified as the single greatest threat to the safety of these buildings in earthquakes. When these design ideas are combined with the common construction faults endemic to reinforced concrete construction which occur most often in developing countries like Haiti, which lack building codes and construction inspection, then, the threshold for collapse can indeed move down the MMI scale to below that of the unreinforced masonry used to calibrate the Modified Mercalli scale.

Concrete construction requires more than just good craftsmanship; it demands a basic understanding of the science of the material itself. The problem is that the builders are often inadequately trained to understand the seismic implications of faults in the construction. This has left a looming catastrophe hidden beneath stucco that was troweled over the countless rock pockets, and exposed rebars that characterize construction that was executed without the equipment necessary to do it properly, such as transit mixers and vibrators.

The treatment of infill masonry by engineers only as part of the ‘architectural finishes’ may also be due to the fact that the structural contribution of the infill masonry is very difficult to quantify mathematically, exactly as Freitag observed in 1901. It certainly does not fit within portal frame analysis. However, outside of earthquake hazard zones under all but the most severe wind loading, ignoring the effects of the infill rarely leads to a collapse. This is because the value of the load sharing that in reality occurs between the frame and the infill can offset any unaccounted for behaviour of the frame resulting from the infill. However, in a design level earthquake the situation is very different. Unlike for wind, a building’s structural system is expected to deflect into the nonlinear range. This is true even with regard to code-conforming new building design in Europe and North America, because earthquake codes are intended to reduce the likelihood of collapse, not prevent damage. In other words, the underlying structural frame is expected to go inelastic in a design-level earthquake and thus by definition, structural damage occurs.

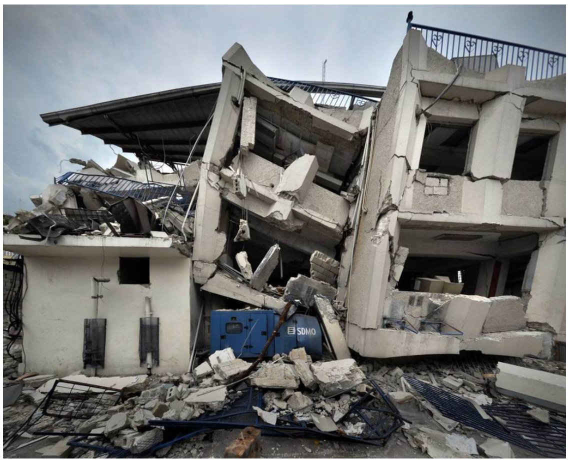

Figure 25. Reinforced concrete building in central Port-au-Prince nearly collapsed by the 2010 Haiti earthquake

Figure 26. A formerly four story building in Port-au-Prince showing weak story collapse

For frames, this has been recognized in codes through the use of ductility factors which are assigned based on the individual elements that make up a structural frame. Such factors, however, are unresponsive to the conditions that exist when non-structural infill masonry is added to the system, because the masonry is a stiff and brittle membrane confined and restrained by the frame like a diagonal strut. This rigid diagonal strut changes the behaviour of the frame sometimes with catastrophic results. The standard analysis method for code-conforming design, which is based on linear elastic behaviour unencumbered by the infill masonry, is thus quite different from the actual inelastic behaviour of the infilled frame.

9 What Was it That Saved the ‘*Bidonvilles’*?

What then can be the difference between the concrete block squatter housing and the more formal buildings? While the survival rate in ‘Cité Eternal’ was remarkably high, there were areas on the hillsides around Port-au-Prince where there were many collapses, and had the earthquake been stronger than MMI 7, more undoubtedly would have collapsed. Nevertheless the study of the Pictometry imagery showed that a vast preponderance of the squatter housing – much of which was of concrete frame and block construction – remained standing.

One theory is that the shanty housing, unlike the buildings in the center of PAP, while made of concrete, were not moment frames. This was true, even for those of more than one story. While some of these informal houses were of unreinforced concrete block, many were also of a construction known as ‘confined masonry’, where instead of forming and pouring the reinforced concrete frame and then infilling it with the walls, the walls are constructed first, with gaps left for the reinforced concrete columns. The rebar was then inserted and the concrete was poured. The shuttering for the concrete is only needed on two sides of each column and along the top of the wall for the beam or edge of the floor slab. As a result, the column is securely bonded to infill masonry.

The buildings in the city center, by contrast, had their frames cast first followed by the construction of the infill walls. This may sound like a distinction without a difference, but increasingly it has been observed that confined masonry is less likely to demonstrate catastrophic failure. This has proved to be true even when there are serious and conspicuous faults in the construction quality of both the RC frame and masonry. See, for example Figure 28 which shows buildings that survived the earthquake with only incomplete ‘confined masonry’ frames. Standard RC moment frames by contrast have proven to be less forgiving.

Figure 27. View of 4 Carrefour Feuilles area bidonville, close to the city center, Port-au-Prince (© Pictometry)

Almost all of these itinerant confined masonry buildings are not the product of an engineering analysis or calculations based on architectural or engineering design work. The engineering difference from moment frame structures is that the framework in the ‘confined masonry’ system is never expected to behave as a moment frame in the first place. The buildings instead behave as solid wall structures due to their small rooms and there are sufficient numbers of walls to provide redundancy. More importantly, the multi-story ‘bidonville’ buildings are less likely to suffer from soft story, because the confined masonry system is based on building the structure of the masonry walls first. Thus the masonry walls cannot be left out at the ground floor level. Therefore a soft or weak story collapse is ruled out.

Figure 28. Left: View of 4 Carrefour Feuilles area bidonville, close to the city centre, Port-au-Prince (Source: Carlos Barria-Reuters);
Right: Confined masonry construction photographed in Zihujatanejo, Mexico

10 The Resilience of 19th Century Steel Cage Confined Masonry

These buildings have more in common in terms of structural typology to the pre-modern timber and masonry buildings that were originally used to calibrate the Mercalli Scale, and their indigenous owner-built context is also much closer to pre-modern handicraft culture of Haiti and other developing countries such as Mexico [FIGURE 28, right]. In fact, there are three historical buildings in central Port-au-Prince that reinforce this hypothesis about the informal construction. They stand as remarkable examples of an unexplored direction for future earthquake-resistant construction, perhaps even as a potential models of a better approach to reinforced concrete. The largest of these buildings is as high as the National Cathedral was before its collapse, and almost similiar in volume to its nave. This building, the Church of Saint Louis de Gonzague Chapel, is over a century old, and yet it came through the earthquake with almost no visible exterior damage, apart from broken glass in its large upper story windows. [FIGURE 29]

This church was constructed of load bearing masonry surrounded and embraced by lightweight riveted flat steel bars and angles imported from France, which form a cage that is an integral part of the elegant architectural detailing of the building. During the earthquake this metal cage served to hold it together, much like confined masonry. Unlike standard reinforced concrete or reinforced masonry construction, the reinforcing is not hidden on the inside of the wall except for connector pieces from the exterior to the interior. Remarkably, despite its over a century of exposure to the moist tropical environment, the steel cage is not seriously corroded. The metal cage is exposed as part of the architecture on both the inside and the outside but it is not, structurally, a frame. The building's structure is primarily that of a solid load-bearing masonry wall which is embraced and confined by the steel. During the earthquake the steel and the masonry worked together, with the cage preventing disruption of the masonry, while the low-strength lime mortar and the subdivision of the masonry into panels giving the building significant flexibility.

Figure 29. Left: Saint Louis de Gonzague Chapel ca. 1890 in central Port-au-Prince; right: detail of Chapel at National Cathedral

Figure 30. Left: interior of Saint Louis de Gonzague Chapel ca. 1890 in central Port-au-Prince; right: warehouse structure on Gonzague Chapel grounds, ca 1900

This good performance was confirmed not only with this chapel, but also a nearby warehouse as well as a smaller chapel next to the collapsed National Cathedral, both of which also came through almost unscathed. Another example was a two story commercial building also near the National Palace which had thinner walls, but survived with only a few missing panels.

Because of its size, the Gonzague Chapel stands as an icon that proves that with earlier construction technology and a more limited pallet of materials at their disposal, the means was there in Haiti in the late 19th and early 20th centuries to build large complex structures that have proved to be both durable and resilient a century after their construction. Unlike their contemporaneous reinforced concrete neighbors such as the National Palace and Cathedral which collapsed, these structures stood tall during the onslaught of the earthquake that felled as much as 30 to 50 percent of the modern buildings around them. In fact, next to the Church of Saint Louis de Gonzague Chapel, which had been constructed by the Freres de l'Instruction Chretienne (F.I.C) (Brothers of Christian Instruction), was this same order's school building of reinforced concrete, as well as a warehouse that was built using the same system as the church. The concrete school collapsed, while along with the church, the brick with steel cage warehouse survived undamaged.

11 Conclusion

The purpose of this paper was not to investigate the fatalities from the earthquake. Be it 80,000 or over 300,000, any loss of life constitutes a serious tragedy. The paper is really about the unacceptable, even scandalous, fact of how large numbers of buildings of recent origin with structural systems in wide use around the world today have collapsed onto their occupants. These buildings were perceived by most as stronger and more resistant to earthquake collapse than were the many older timber and masonry buildings that proved to be more resilient. They certainly were also perceived to be better and stronger than the tens of thousands of informally built dwellings on the hillsides that surrounded Port-au-Prince most of which remain standing today.

The analysis of the MMI intensity also serves to highlight an even more disturbing detail. Based on the findings that the intensity in Port-au-Prince was as low as an MMI-VII, one must ask what would happen if it were higher. In fact, EQECAT, another catastrophic risk modeling company issued the following warning only two days after the 2010 earthquake:

> 'Had the rupture been directed toward Port-au-Prince, the city would have experienced even more devastation. While this is little solace in light of such a human tragedy, it is relevant considering that this earthquake, which ruptured only a portion of the fault, increases the chances of another large earthquake in coming decades on the eastern portion of the same fault. This is because stress relieved by a rupture is transferred to adjacent segments of the fault. If additional stress on the eastern segment of this fault were to trigger another earthquake, it could impact Port-au-Prince with equal or greater severity as the recent event.'[16]

One of the problems that plague the assessment of existing buildings including those with archaic structural systems is the basic difficulty of establishing a norm for earthquake safety and performance when 'no damage' is not required by most building codes, nor is a viable or cost effective objective. With wind one uses real expected maximum wind speeds with an added safety factor. With earthquakes, however, it has been determined that to require all buildings to remain within their elastic range for design-level earthquakes is economically infeasible. Earthquakes of a damaging magnitude are simply too infrequent to justify the more stringent and costlier design and construction that would be required to prevent structural damage.

This problem is not just academic; it is integrally connected to the longer-term issues of post-disaster recovery and regional development. Modern construction materials and methods have brought with them extraordinary opportunities for new architectural forms and ways of building. Reinforced concrete frame and concrete block construction has been promoted to the local populations as being a safe and modern way of building. However, in many parts of the world they have also been disruptive of local cultural and construction traditions, resulting in building forms and ways of building that are alien to the local society – particularly long-held traditions of self-reliance that comes from the mastery of traditional crafts of carpentry, masonry and other locally available materials.

The finding that the historic and deteriorated 100 year old timber and masonry buildings as well as the more recent concrete frame and block buildings in the informal 'bidonville' settlements in Haiti did better than the formal reinforced concrete buildings of the city centre does not mean that the aging heritage structures or the shantytown buildings are acceptably safe, but only that the formal concrete buildings are excessively dangerous. What the informal shantytown buildings also show is that the correction to this problem may not be in moving to even more sophisticated and complex engineering solutions – but rather, towards simpler forms of construction based on the kind of flexibility, redundancy and energy dissipation that is the only means available for earthquake resistance with unsophisticated and non-engineered owner-built construction.

The 'bidonville' settlements are part of a long tradition in the history of human settlements and building construction. The buildings found there are basic, unsophisticated, and certainly not engineered, but the way to improve them and the rest of the buildings in Haiti must be derived from the local culture and crafts tradition. Imposing engineering and high-tech requirements is not a solution because they would rarely be followed because they would not be understood. This then mandates a return to traditional construction practices, but for this to happen, these practices need to be rehabilitated in peoples' minds to overcome the years of association with backwardness and un-modern ways of living. In other words, when it comes to building construction, traditional IS modern.

There needs to be a certain amount of humility and willingness to learn, that is, to 'listen' with our eyes to the message our ancestors are telling us through the cultural artifacts they have left behind. As the world moves from an era of profligate energy use to one where fossil fuels are gradually depleted, sustainability and green ways of building have become the catchwords in building design and construction. Wood is nature's most versatile renewable building material. Stone and unfired earth, together with wood, represent the most energy efficient building materials that can be used today. To this can be added fired brick and lime mortar, both of which require far less energy to manufacture than Portland cement. Finding traditional vernacular construction practices that have performed well against devastating events such as earthquakes, serves to provide us with examples for which preservation of vernacular buildings represents far more than the saving of frozen artifacts. It is an opportunity for cultural regeneration – a reconnection with a way of building by people who traditionally had learned how to build successfully for themselves with materials readily at hand.

Endnotes

[1] www.USGS.gov

[2] The terms 'formal' and 'informal' are used in this paper, rather than 'approved' or 'illegal' because in the case of Haiti, the government inspection, regulation, and formal approval of building construction has been to a large extent non-existent, so this distinction between formal and informal reflects mostly the legality of the construction based upon the underlying land ownership. 'Formal' is where there is likely to be legal title (although this was not specifically researched for this paper), and 'informal' applies to squatter settlements.

[3] It is hard to imagine how the Haiti earthquake could have been worse, but the second EQECAT report on this earthquake predicts that another one is a possibility. See the quote by EQECAT later in this paper.

[4] http://www.unitar.org/unosat/node/44/1425

[5] RMS FAQ: 2010 Haiti Earthquake and Caribbean Earthquake Risk, http://www.rms.com/publications/Haiti_Earthquake_FAQ.pdf & 'Haiti Dominates Earthquake Fatalities in 2010' Released: 1/11/2011 12:44:35 PM, http://www.usgs.gov/newsroom/article.asp?ID=2679#.UGn8wE3A_nh

[6] Canadian Broadcasting Corporation news report on 1st anniversary of the earthquake.

[7] The difference between the maps prior to version 7 is that the fault was first mapped further to the north, under the waters of the bay (thus the fears at first of a tsunami) and later it was found to be under the land, while the later map version 10 shows the fracture zone as not extending as far east as it does in version 7, explaining the drop in estimated intensity in Port-au-Prince.

[8] http://en.wikipedia.org/wiki/Mercalli_intensity_scale (most recently checked on 20 September 2014) Interestingly, when this same page was accessed in April 2011, it listed the fatalities in Haiti at the Haiti Government's number of 316k, but when accessed in September 2014, the fatalities listed were only 100k, while the intensity remained listed as a X.

[9] From a phone conversation between Patricia Grossi, PhD, Research Director, RMS Corp., Newark, Ca. with the author on 14 April 2011.

[10] Geologist Ellen Rathje of the University of Texas does see some evidence of site effects, but it is inconclusive as an explanation for such extreme differences in building performance between two adjacent structures only 175 feet away from each other.

[11] There is even a widespread perception that the shaking in Port-au-Prince was an even more extreme '10' on the MMI scale, as reported on several internet sites, including Wikipedia.

[12] http://en.wikipedia.org/wiki/Casualties_of_the_2010_Haiti_earthquake

[13] (UNITAR and Haiti UNOSAT 2010) and (Haiti 2010)

[14] Wikipedia

[15] Source: www.propertyrisk.com

[16] http://www.eqecat.com/catwatch/m-7-0-earthquake-in-haiti-region-update-2010-01-14/ EQECAT notes that the fault rupture zone was to the west of the city, leaving the unruptured segment beneath Port-au-Prince, as shown in the version 10 of the USGS shakemap.

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The World Monuments Fund, FOKAL, and the Princes Claus Foundation for their sponsorship of the mission to Haiti after the earthquake for the preservation of the Gingerbread Houses in Port-au-Prince, and to Pictometry International Corporation for their generous access to their oblique aerial survey of the earthquake damage district.

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For more information

Please go to www.conservationtech.com, www.traditional-is-modern.net, and to www.haiti-patrimoine.org. For an extensively illustrated slide lecture by the author on this subject delivered in December 2011 at the World Bank, please go to:
http://web.worldbank.org/WBSITE/EXTERNAL/TOPICS/EXTURBANDEVELOPMENT/EXTCHD/0,,contentMDK:23125122~pagePK:210058~piPK:210062~theSitePK:430430,00.html

Figure 31. A Port-au-Prince house of colombage construction showing slight earthquake damage behind the rubble pile of a collapsed reinforced concrete building

Manmade Risk by Lack of Compaction of Backfilling after Excavation for Archaeological Study on Earthen Heritage
A Proposal of Technical Guidelines for Backfilling Archaeological Excavations

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Abstract. This paper presents examples of problems of archaeological excavation sites where ground was excavated and backfilled without compaction work. In Cambodia, ancient Khmer engineers used artificially compacted sand layers in Angkor as foundations for masonry structures and stone pavements. It has been a common practice in archaeology that no concern has been paid to the necessity of requiring backfilling and most of the excavated sites have been backfilled in a loose state.

Compacted ground is one of the important characteristics of the authenticity of the cultural heritage and should be respected as well as keeping the integrity and the structural safety.

1 Introduction

The archaeological unit of JSA (Japanese Government Team for Safeguarding Angkor) has been performing field excavations since 1995. One of the sites in 1995 was the re-excavation of the EFEO (École Francaise d'Extrême Orient)'s trench site of the pavement at the foot of the foundation mound to study the underground structure of the Northern Library of Bayon [FIGURE 1]. According to the geotechnical report, the ground that had been backfilled was in a very loose state. After this experience, JSA adapted backfill compaction as a common practice for archaeological trenches in Angkor.

Bayon is the central temple located at the center of Angkor Thom and has been attracting people due to its unique layout and complexity. The structures of Bayon stand upon compacted soil mounds of terraces in three levels. The first terrace is the lowest level inside the Outer Gallery and the second terrace is the mid-level in height inside the Inner Gallery. The third terrace is the top level soil mound that supports the central tower.

Since the beginning of the early stage of conservation work, the EFEO has excavated many archaeological trench points in the Bayon. Figure 1 shows a general plan as well as a few points that will be referred to in this paper. Figure 2 shows the distribution of the archaeological excavation sites in the north-eastern corner of Bayon temple. The EFEO trenches were backfilled without any compaction effort. Some of them were already in a dangerous state and some countermeasures have been applied. This paper will introduce the state of the problems and try to propose solutions to avoid these manmade disasters to the cultural heritage.

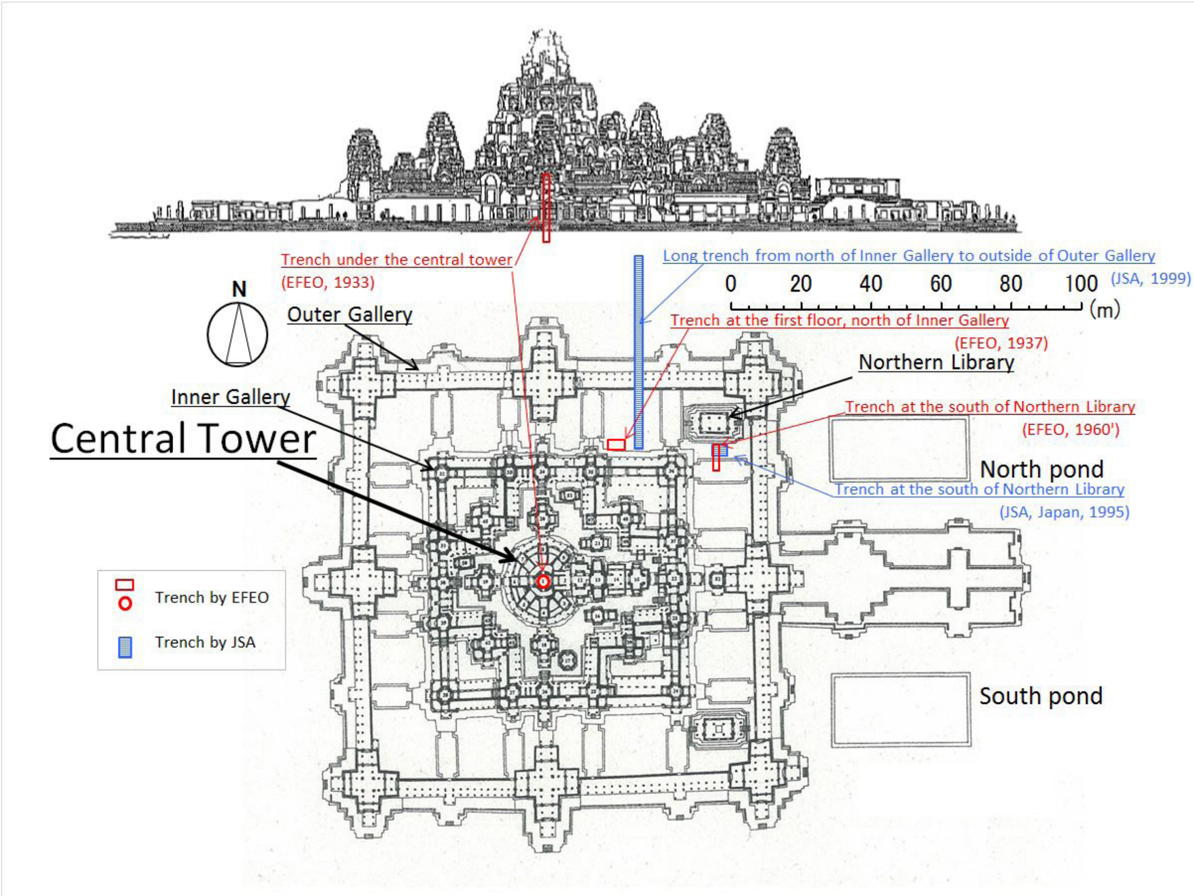


Figure 1. Plan and Section of Bayon temple with some of the trench sites

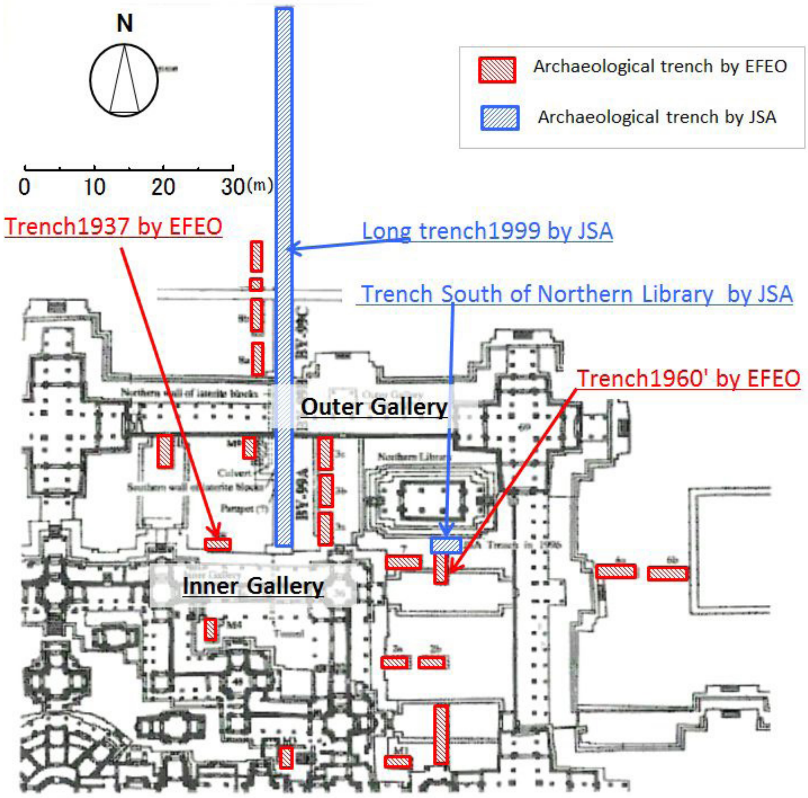


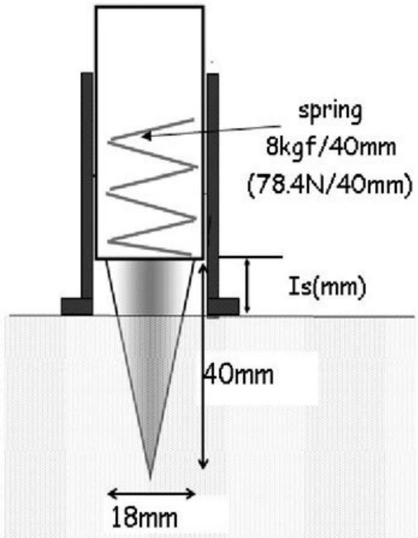
Figure 2. Distribution of Archaeological trenches in north-eastern corner of Bayon

2 Re-excavation of Archaeological Trench at the South of Northern Library (JSA 1996)

The Northern Library at Bayon was one of the independent structures where JSA had planned to carry out conservation work. For safeguarding the work of the Northern Library at Bayon Temple, JSA needed to study the structure of the foundation. Since EFEO had performed an archaeological trench in 1960, the archaeological unit of JSA had selected a way to re-excavate the same trench so as to have minimal impact on the site. Based upon the EFEO record, the trench location was studied. A little sag and disorder of stone pavements were noticed at an area that corresponds to the record. The re-excavation work was started at this point.

After excavating the ground below the pavement, the vertical wall of the previous trench appeared. The vertical wall was rather dense sandy compacted ground while the re-excavated trench was very loose.

The Geotechnical Unit of JSA carried out some field tests on manmade fill during the excavation. One of the tests was the Yamanaka penetration tester. Figure 3 shows the Yamanaka soil hardness tester, which measures the maximum penetrating depth of the cone tip into the soil. The measured depth in millimetres is called the Hardness Index and may be converted into the bearing capacity of the ground. Figure 4 shows the structure of the tester and the converting chart from the Index to bearing capacity. The results are shown in Table 1.



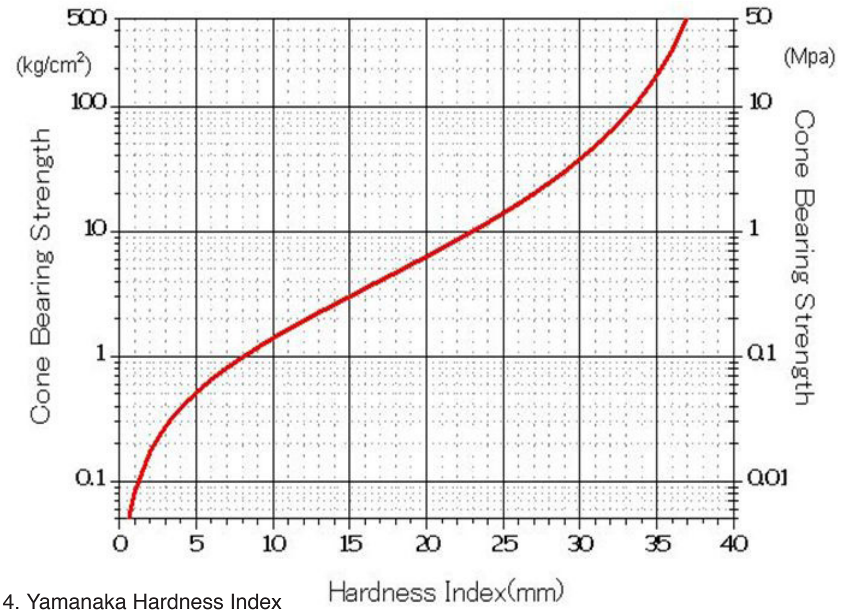


Figure 4. Yamanaka Hardness Index

Figure 3. Yamanaka soil hardness tester

TABLE 1. Comparison of bearing strength of original and backfilled ground

Soil	Bearing Capacity (kgf/cm²)	Source
Original fill	10-38.6 (av.20.5)	EFEO trench, 1960' at Bayon
Backfilled	2.0-6.4 (av.3.2)	Geotechnical Report,1996

The backfilled ground showed very low bearing ground capacity of 3.2 kgf/cm^2 in average compared to 20.5kg/cm^2 of the original fill. The strength was decreased about 7 times. It was estimated there was no effort of compacting soils during backfill after the trench.

3 Safeguarding Work for Damaged Pavements at Old EFEO Trench

At the request of APSARA (Authority for the Protection and Management of Angkor and the Region of Siem Rea), JSA consulted with the EFEO office in Siem Reap and carried out safeguarding work and restoration of the trench pit that had been excavated in 1937 at the first terrace, north of the Inner Gallery [FIGURES 1 and 2].

3.1 Stone pavement before restoration work (Han 2001b)

Sixty years after excavation/ backfilling, the pavement stones near the Inner Gallery were found to have sagged and be inclined towards the Gallery [FIGURE 5].

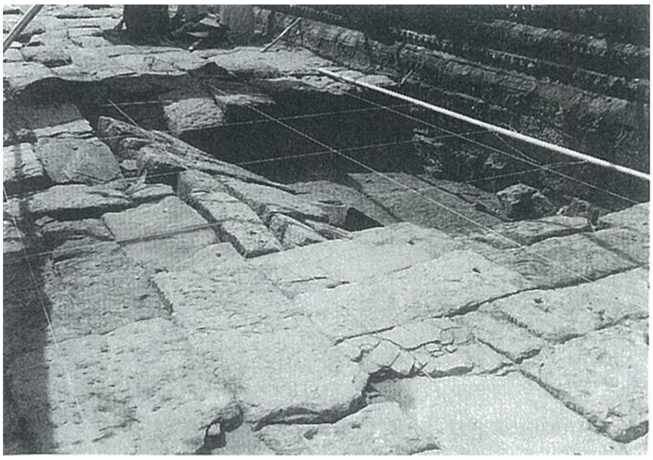


Figure 5. Damaged Pavement 60 years after archaeological excavation/backfilling (Source: JSA 2001)

The ground surface at the center showed the largest sagging of about 75 cm. Figure 6 shows a North-South vertical section of the pit before the restoration work. The ground surface levels are shown in solid and dotted lines for the center and edge positions of the trench. Sagging might have been caused by compaction by wetting for loose fill. Many pieces of sandstones and laterite blocks that had covered the ground surface were missing.

The hardness of the ground in the pit was in the range of 0.7-2.5 kgf/cm^2, which is an extremely low value.

3.2 Restoration works

The initial process of restoration was to excavate the whole volume of soils filled by EFEO in 1937.The volume of the excavated soil reached about 14.14 m^3. The back filling process was performed by the following three stepwise methods with different soil material. Figure 7 shows the completed section after restoration.

JSA has been working on keeping the authentic character of the foundation of the structure as well as manmade ground in Angkor. The well compacted dense sandy ground is one of the characteristic elements of the ancient Khmer structure. JSA had introduced an improved soil ground of compacted soil with slaked lime and used the soil with slaked lime as one of the important fill materials at this site as well as the excavated soil material from the pit, which will be explained in detail in a later section.

The original basic ground structure at the site consists of sandstone pavements at the top surface, the first layer of laterite blocks, compacted sandy soils, and the second layer of laterite blocks as shown in Figure 6.

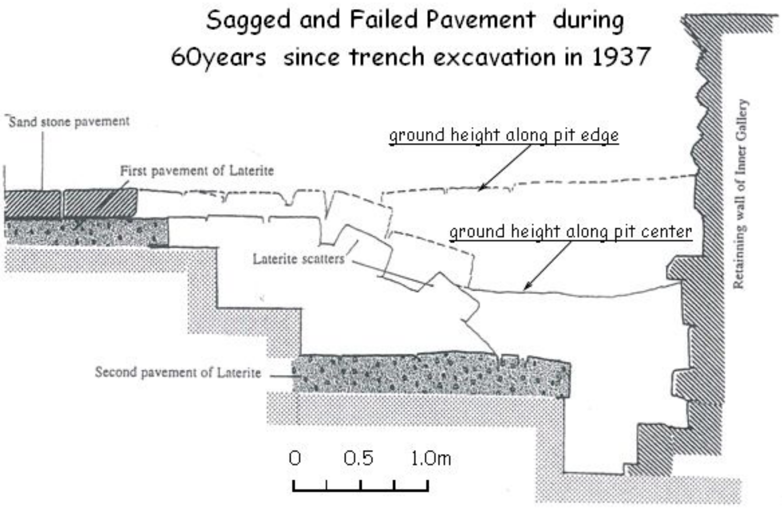


Figure 6. Vertical section of stone pavement with ground surface lines
(Source: JSA 2001)

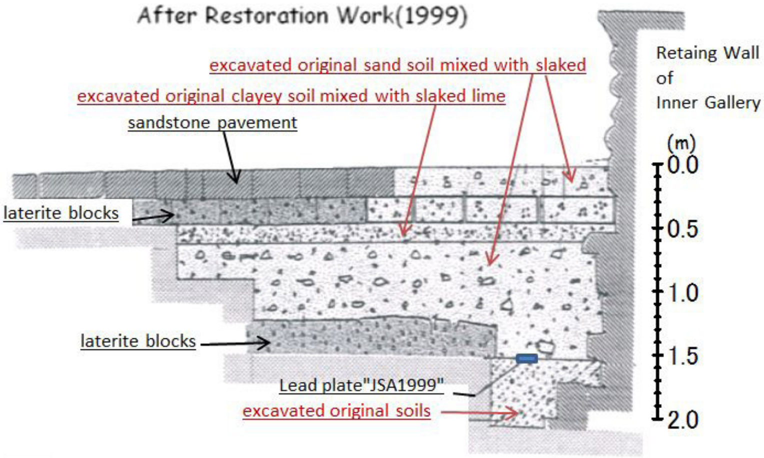


Figure 7. Vertical section after restoration work of backfilling with compaction
(Source: JSA 2001)

The soil material used for backfilling the pit was basically the excavated soil, which was separated into two groups of sandy and fine soils by sieving with a mesh the size of 0.06mm. When additional soil is required, borrow soils are arranged with the same grain size characteristics.

The first bottom layer of 2.0-1.5 m from the excavated level to the bottom of the second laterite block was backfilled by the original sand. The compaction was carried out using a compaction rod and elephant foot while controlling the water contents of the soils.

The second layer was backfilled by slaked lime mixed with sandy soils with the initial thickness of 15 cm. At the boundary between the original sand and slaked lime mixed layer, a lead plate of dimension of 5 x 50 x50 mm was inserted with the letters 'JSA1999'.

The third layer of the ground, 15cm in thickness beneath the pavement blocks, was slaked lime mixed with clayey soils, which has lower permeability than sandy soils and is expected to prevent seepage into the ground form the surface.

4 Compacted Soil Foundation System Revealed by Long Trench at Northern Yard at Bayon

For restoration work on the Northern Library at Bayon, it was necessary to bring some heavy construction machines like cranes. To avoid any damage to the pathway due to the heavy load of the machinery, it was decided to make a special access road for bringing the machine onto the site. Stones on the access had been dismantled and stored for later reconstruction. After completion of the restoration work, JSA excavated an archaeological trench from the Inner Gallery to Outer Gallery and further extended it to the north as shown in Figure 1 as a long trench (Ishikawa 2000).

This long trench had revealed characteristics of a soil mound system used as a foundation of the temple and stone structures (Narita et al. 2000). The long trench was excavated to study the ground structure and backfilled from November 1999 to September 2000.

4.1 Characteristic elements of authenticity of foundation

The southern section of the long trench is shown in Figure 7. If the foot level of the foundation of the Outer Galley is assumed to be the ancient ground surface, the original ground surface was about one meter (GL=NLB-3 m) from the present ground surface.

Digging ground work was identified within the area of the first terrace, Outer Gallery, and outside yard of the Outer Gallery with a width of about 10m. The depth of the digging ground work from the original ground surface is about 2m. Another digging work was found at the foundation area of the Inner Gallery, where the depth became one meter deeper than those for the Outer Gallery, due to a much larger load than the Outer Gallery.

The court yard of the first terrace is covered by a pavement of sandstones. Beneath the sandstones, an upper layer of laterite blocks was found. Another layer of lower laterite blocks was found about 1.5m below the surface pavement [FIGURE 8].

The excavated zone within the foundation trench by digging work had been backfilled by the excavated natural soils with rammed compaction. Ancient Khmer engineers had used sand soils as borrow material and compacted it to make a soil mound at the level higher than the original natural ground surface.

The systematic layout of the use of compacted soils for a foundation mound for the Khmer temple is considered one of the characteristic elements of authenticity of the shrine stone structure.

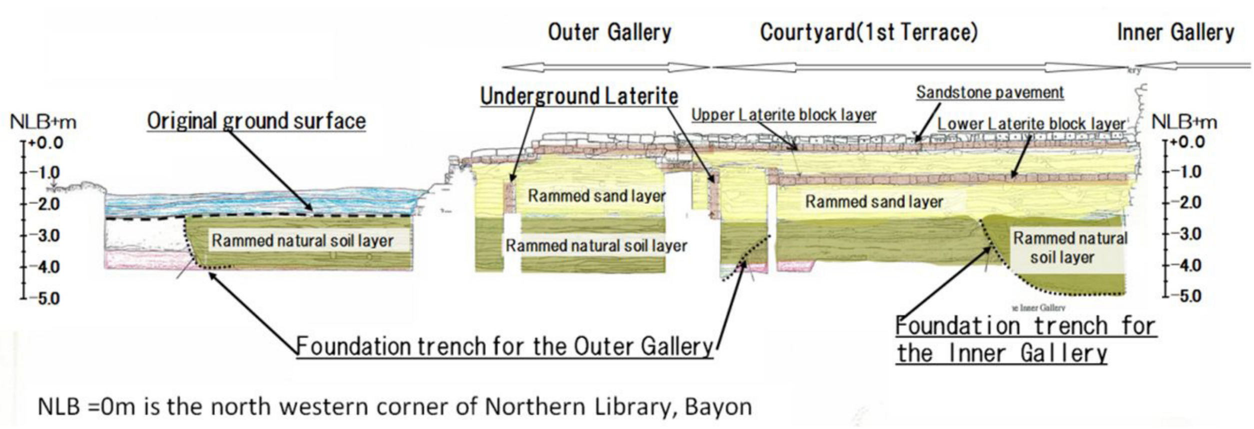


Figure 8. South section of the archaeological long trench to the north of the Inner Gallery (modified color Fig.1. Source: JSA 2000)

4.2 Backfilling the excavated long trench

The excavated trenches were divided into two groups based upon the expected load after completion of restoration work. The excavated trench of BY-99B is a part of the foundation for the outer gallery and carried a larger vertical load of the stone structure. Other sections are only to support much smaller loads of the top surface stone pavements (Akazawa 2001).

4.2.1 Backfilling material

The grain size distribution of ancient manmade fills in Angkor shows basically two kinds of soils of sand and clayey sand. Figure 9 shows grain size distribution of these soils as Type I sand and Type II of clayey sand. The ranges of grain size of sand, silt, and clay are 2 mm > sand > 0.06 mm > silt >0.006 mm > clay > 0.001 mm, respectively. Type I sand is found in most of the soil mounds. Type II clayey sand was usually used at the boundary between the sandstone and the soil mound, probably intended to prevent water infiltration.

EFEO failed to build the sand mound higher than about 5 m during their restoration work of Baphuon Temple at Angkor Thom, and adapted it to construct a concrete retaining structure to support the soil mound.

JSA has searched another way to solve the problem and developed a method to improve the strength characteristics of the original soil by mixing slaked lime. This soil mixed with slaked lime is used when the height of the mound becomes high and/or a heavy load is expected; otherwise, only Type I or Type II soil are used.Table 2 shows material mass (=weight) ratio, uni-axial strength, which increase with aging period, and permeability.

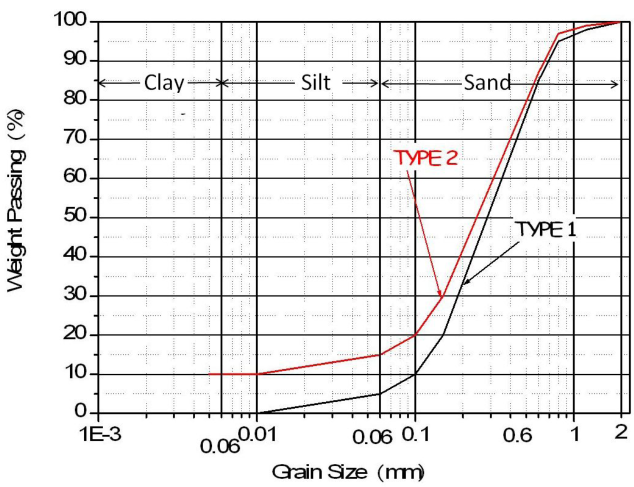


Figure 9. Grain size Distribution for Type I and Type II sands

TABLE 2. Material Characteristics of Type I and Type II soils mixed with slaked lime

	Soil Type	I	II
Mixing mass ratio	sand	10	10
	fine=<0.06 mm)	1	2
	slaked lime	1	1
	water	1	1
Uniaxial Strength (MPa)	curing period		
	2 days	0.07	0.2
	14 days	0.32	0.29
	180 days	3.2	2.9
Permeability	k (cm/sec)	2.4×10^{-4}	6.1×10^{-5}

The intent was to increase the strength while keeping the grain size distribution as the original characteristics. A chemical additive of slaked lime, which has been historically used for cementing material in conservation, was confirmed to result in a sound strength when mixed with the original soils.

The difference of Type I and Type II lies mainly in their permeability. Type II soil shows less permeability and is used to prevent infiltration.

When additional soil was needed, sand was purchased and used based upon the grain size distribution.

4.2.2 Control of water contents

The water content of the soil at the time of compaction could seriously affect density. 'Optimum water content' corresponds to the water content value (mass ratio of water to solid soil) at which soil reaches its maximum density under constant compaction effort. The water contents were checked to determine if they are within a range of WC=6-9 %.

4.2.3 Compaction

Soil was spread about 10 cm in thickness before compaction and compacted until the thickness became 7cm. The compaction began with foot stepping, then striking soil with a rod at every corner first and other various points subsequently, and finally with an 'elephant foot (i.e., a square-shaped iron plate of 15x15 cm^2).'

The degree of compaction was controlled by a Yamanaka Tester. Figure 10 shows a comparison of the cone bearing strength of the original filled ground and backfilled ground using the Hardness Index, Yamanaka Cone Bearing Strength formula, and trafficability comparison for reference.

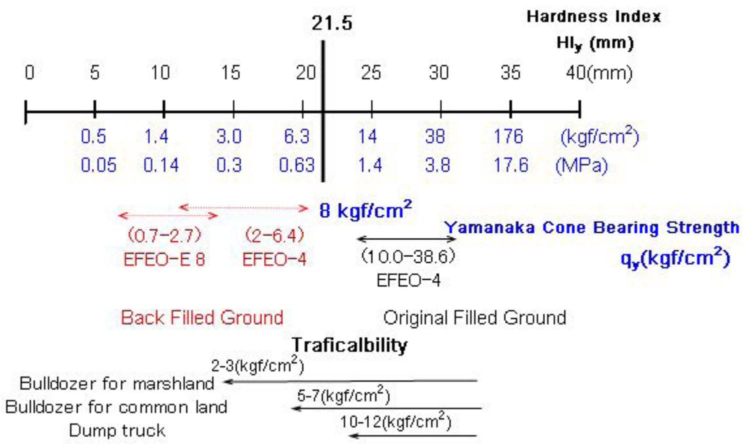


Figure 10. Controlling Compaction by Yamanaka Index

In Figure 10, a vertical line at HIy=21.5(mm) or qy=8(kg/cm^2) is drawn as the boundary for compaction control. As already shown in Table 1, the boundary of a Yamanaka cone bearing strength in loose back fill and the original rammed ground is 7-9(kg/cm^2) and qy=8(kg/cm^2) was the value selected by JASA to control the compaction of soils in restoration work at Angkor.

4.2.4 General procedure of compaction process

After confirming that the water content is within the allowable range, the soil material is spread out with an initial thickness of 15 cm. The compaction procedure consists of three consecutive methods (foot stepping, followed by rod, and elephant foot) and is continued until the thickness becomes about 10 cm and the hardness becomes greater than qy>8 kg/cm^2.

4.2.5 Compaction beneath the stone pavement

Filled ground of 15 cm in thickness directly beneath the pavement of stone and laterite block was constructed of slaked lime mixed with Type II soil. Type II shows much smaller permeability and prevents water infiltration.

The compaction procedure was done by foot stepping, with a rod, and then with an elephant foot from an initial thickness 10 cm until it became 7 cm and its Yamanaka hardness was greater than qy>=8 kgf/cm2.

4.2.6 Compaction at the Outer Gallery Zone

In the Outer Gallery zone, the weight of walls and roofs of stones are to be supported by the foundation. Soil material of Type I mixed with slaked lime was compacted with the same three-step process as described in the preceding section (Han 2001a).

Figure 11. Rod compaction

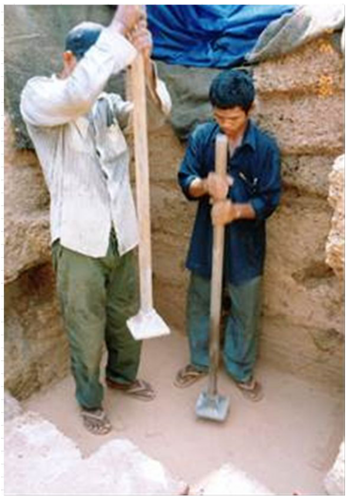


Figure 12. Elephant foot

5 Cavity Shaft in the Foundation Mound of the Central Tower, Bayon

In 1933, G. Trouvé excavated a vertical shaft at the center of the Central Tower, Bayon temple [FIGURE 1]. His team found a broken statue of Buddha at the depth of about 12m from the floor of the chamber of the Tower. [FIGURE 13]

In March 2009, JASA carried out a geotechnical boring at the central chamber in the Central Tower at Bayon. During the boring, standard penetration tests (SPT) were conducted, which count the number of blows from dropping a weight of about 63.5 kg from a height of 76 cm. Based upon the SPT N-value, the relative density is evaluated in Table 3.

TABLE 3. Relative density of Sand Ground by SPT

SPT:N	0-4	4-10	10-30	30-50	50<N
Relative Density	very loose	loose	medium dense	dense	very dense

As shown in Figure 10, the obtained SPT value shallower than 12 m was less than 4, which indicates the backfilled soil is in a very loose state. It became clear that no compaction effort had been made during backfilling.

The vertical load of the central tower is estimated to be as large as around 4 MPa (40 tons/m^2). It is amazing how the manmade ground could support the huge stone structure of the Central Tower with a vertical shaft without any lining. Backfilling without compaction in the shaft left us another challenge for the conservation of the whole structure from the foundation of manmade fill to the top of the stone masonry structures of the Central Tower at Bayon in Angkor Thom.

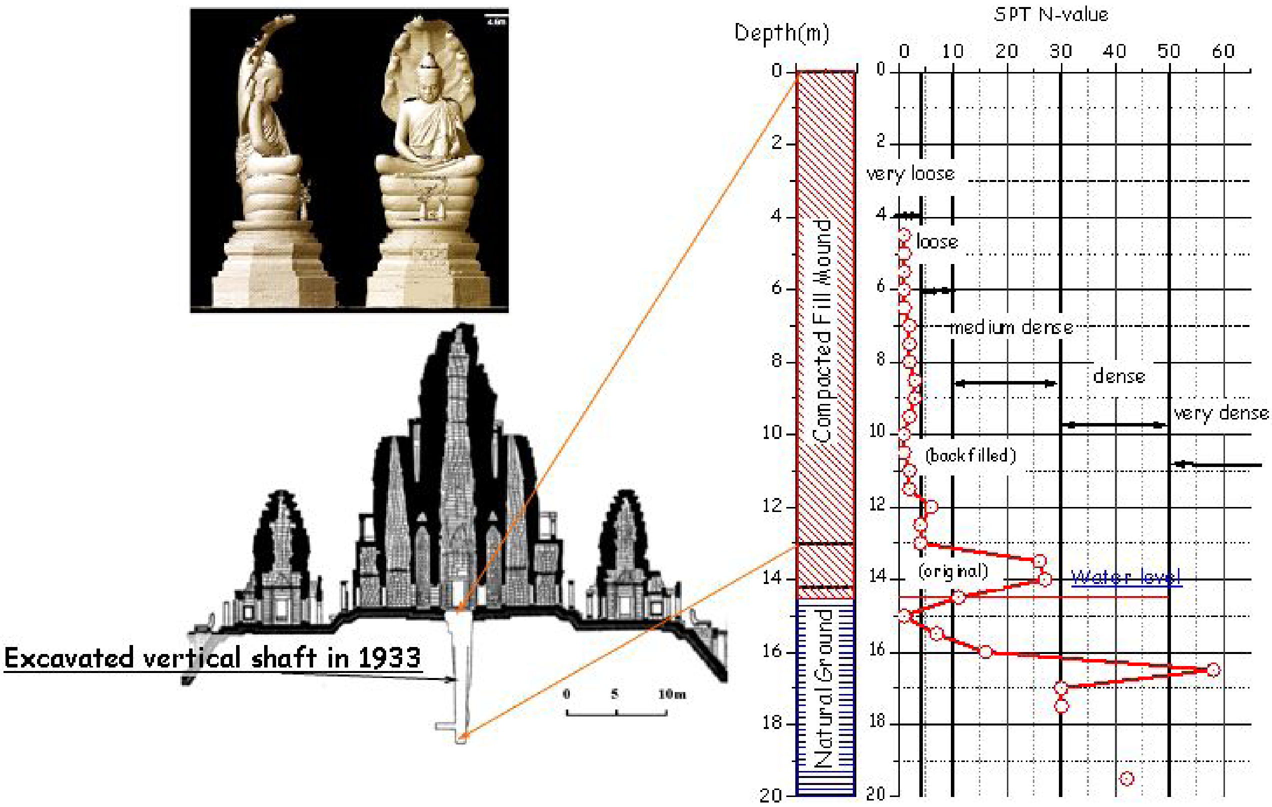


Figure 13. Underground shaft at the Central Tower, Bayon (Source: Iwasaki 2009)
(Reconstituted Buddha statue and boring log from the floor of the central chamber)

6 Conclusions

1. The experience of JSA and JASA in Angkor since 1995 has demonstrated that the excavation of archaeological trenches has caused structural stability problems. The conclusions obtained are as follows:
2. Backfilling of the excavated site without compaction has caused sagging and displacement of pavement and requires restoration work.
3. During the archaeological excavation, soil layers are identified and described as manmade or natural with their hardness recorded. It is recommendable that a Yamanaka tester be used to record a numerical index.
4. When excavated ground is identified as artificially compacted, the geotechnical properties should be studied in terms of soil compaction.
5. The degree of necessary compaction may differ from site to site. Characteristics of soils and compaction should be discussed with geotechnical engineers.
6. In an area like the Angkor site, where a soil mound is utilized as a foundation for structures, the compacted rammed ground is an important part of the authenticity of the Khmer culture. If the excavation pit for archaeological study is not filled back with appropriate compaction, the authenticity of the Angkor monument could be lost.
7. To keep the integrity of the soil culture in Angkor and any other areas where soil was compacted and used as foundations, those conducting an archaeological survey should cooperate with a geotechnical engineer and make an effort to keep the integrity of the cultural site.
8. Technical guidelines in the Angkor site were provided and have been implemented by JSA and JASA. Since the geotechnical conditions are different at other sites, the guidelines could be different from region to region. For each cultural region, the technical guidelines for backfilling archaeological trenches should be established to avoid any adverse effects that might be caused by backfilling without appropriate compaction.

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Seismic Performance Problems and Antiseismic Strengthening Methods of Ancient Chinese Wooden Buildings

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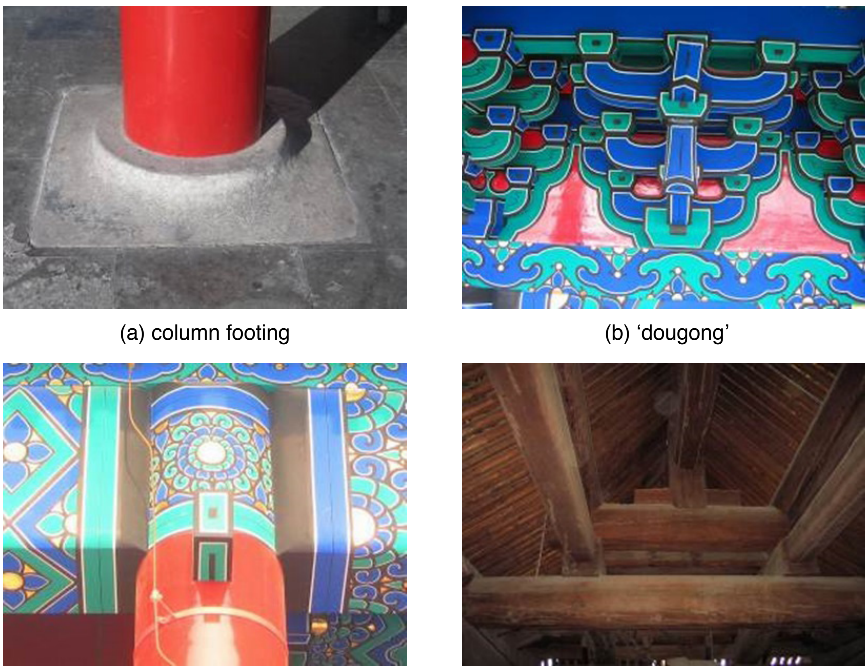
Abstract. Ancient Chinese wooden buildings generally have good resilience to survive various types of natural disasters; however, damage do occurs particularly during earthquakes and therefore seismic performance is an issue. To protect these buildings, typical seismic performance deficiencies of structural elements as well as strengthening methods of these elements were studied on a large number of ancient Chinese wooden buildings by qualitative and quantitative methods. Based on the survey, the typical seismic performance deficiencies were categorized, their causes analysed, and the corresponding strengthening mitigation measures were proposed. Using two examples, the effectiveness of typical strengthening methods were further demonstrated. Results show that typical seismic underperformance of ancient Chinese wooden buildings was due to decay of column bases, slack in brackets (‘dougong’), dislocated tenon and mortise joints, cracks in beams and columns, etc... To solve these problems, methods such as replacement, wrapping, connection, and reassembly are proposed.

1 Introduction

Ancient Chinese buildings are mainly made of wood and usually composed of a basement, columns, bracket sets (‘dougong’), roof trusses and roof. [FIGURE 1] For thousands of years they have survived all sorts of natural disasters due to their design characteristics (Zhou 2007). For example, the column base provides vibration isolation by sliding against the stone footing; the tenon and mortise joints absorb seismic energy by friction and compression; bracket sets provide vibration isolation by sliding horizontally and compressing vertically; and the ratio of height-to-width of the roof trusses meets the requirements of slide and overturn resistance.



(a) column footing

(b) ‘dougong’

(c) tenon and mortise joint

(d) roof-truss

Figure 1. Earthquake resistant structural elements in ancient Chinese wooden buildings

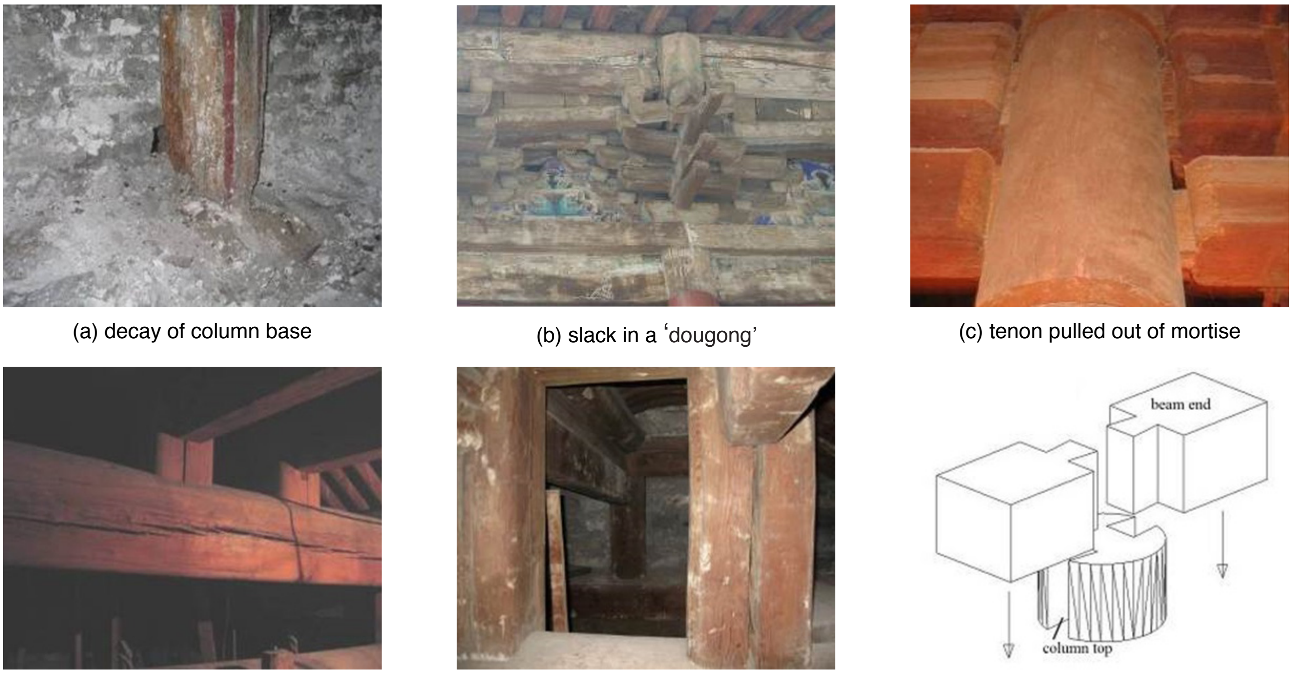
Earthquakes damages still occur on some ancient Chinese wooden buildings. Taking the 8.0 magnitude Wenchuan earthquake in 2008 as an example, according to preliminary statistics for Sichuan province only, there were more than 83 cultural relics of national importance under protection of the state and 174 provincial important historical and cultural sites that were damaged during the earthquake, which led to the huge loss of life and built assets. [FIGURE 2] During the earthquake, damage in ancient Chinese wooden buildings were found to be (Zhou et al. 2010): the destruction of the basement, displacement of column bases, skewed columns and roof trusses, tenons pulled out of their mortise, damaged decorative elements, loss of roof tiles, collapse of partition walls, etc.… Even though the Wenchuan earthquake was of powerful intensity, another reason for the damage to these ancient Chinese wooden buildings is that they already had developed structural weaknesses prior to the earthquake but these were not strengthened in time. These problems as well as mitigation measures are discussed in the following section. The resulting outcome will be helpful for the development of anti-seismic protection for ancient Chinese wooden buildings.

Figure 2. An ancient building before and after Wenchuan earthquake

2 Typical Seismic Performance Deficiencies

Based on the survey results of a large number of ancient Chinese wooden buildings, it was found that typical seismic performance problems in Chinese ancient wooden buildings stem mainly from the following (Zhou et al. 2011):

1. Decay of column base. According to the building code for ancient Chinese wooden buildings, some columns were built between partition walls. The base of these wooden columns was heavily deteriorated due to the infiltration of humidity. [FIGURE 3a] This weakened the load-bearing capacity of the columns, which led to their fracture during earthquakes.
2. Slacking of ‘dougong.’ A ‘dougong’ is usually composed of many little components. It transfers loads from the roof and absorbs part of the seismic energy by relative compression and friction between its components. Under constant load, the ‘dougong’ components can easily loosen. [FIGURE 3b] This problem may weaken the joinery between the components, which reduces its anti-seismic performance and affects the stability of the roof.
3. Tenon pulled out of mortise: Beams and columns of an ancient Chinese building are usually connected by mortise and tenon joints. During earthquakes, friction between the tenon and mortise can produce energy dissipation. Usually, a tenon can easily be pulled out of its mortise [FIGURED 3c] because of constant loads or deformations of the mortise and tenon joint, which weakens the connection between the beam and the column and may lead to instability of the whole structure. Thus a mortise and tenon joint has to be strengthened using preventive measures.
4. Cracks in beams and columns: This problem mainly occurs along roof trusses. [FIGURES 3d and 3e] The cracks are mainly due to the weakening of the section of the beam end, and of the column top [FIGURES 3f]; which leads to the failure in the beam and column. If this problem is not solved in time, the roof trusses may shift during an earthquake.



(a) decay of column base
(b) slack in a 'dougong'
(c) tenon pulled out of mortise
(d) cracked beam
(e) cracked top of column
(f) joinery at beam end

Figure 3. Typical seismic damages to structural elements

3 Strengthening Methods

For typical anti-seismic structural elements in ancient Chinese wooden buildings, the following strengthening methods were proposed based on engineering experiments as well as analysis results (Xie et al. 2008, Yu et al. 2008, Zhou et al. 2009):

1. Replacement method. This method is used for column bases whereby the damaged part of the column base is cut off and replaced by a new one of the same size. Iron bands are then affixed to the repaired location to enhance the strength of the column base. [FIGURE 4]

Figure 4. Replacement method

2. Wrapping method. This method can be used to strengthen fractured beams and columns, or detached mortise and tenon joints. The strengthening material is usually flat iron straps (about 5-15 mm thick) or CFRP (Carbon Fibre Reinforced Plastic. [FIGURE 5] Both materials are high in strength and light in weight, and can be wrapped around damaged locations of wooden components to enhance their load-bearing performances.

(a) flat iron straps for beam (b) flat iron for column (c) CFRP for tenon and mortise joint

Figure 5. Wrap method

3. Connection method. Usually a flat fastener 5-15 mm thick is used to connect the mortise and tenon joint. The flat iron is bent 90 degrees on both ends. One end is inserted at the end of the beam and the other end is inserted into the column. [FIGURE 6] The flat iron fastener may partially bear the load transferred to the mortise and tenon joint, and can restrict the tenon from pulling out of the mortise. The rotational performance of the mortise and tenon joint is enhanced and has good energy absorption capacity during earthquakes.

Figure 6. Connection method

4. Assembly method. As a 'dougong' is composed of many small components, the assembly strengthening method is appropriate to address slackness, by taking apart and reassembling tightly by resetting or replacing loose or deformed elements with new ones. As a result, the reassembled dougong has better seismic energy dissipation performance.

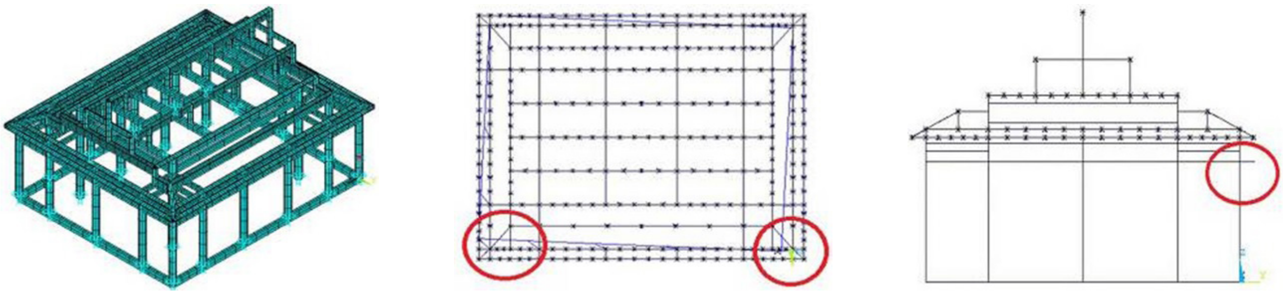
4 Illustrative Examples

(a) front view (b) tilted column (c) tenon pulled out of mortise

Figure 7. Photos of Da-Xiong Palace after earthquake

The first example is of Da-Xiong Palace, an un-strengthened structure, in Guangyuan city (Zhou et al. 2009) [FIGURE 7a]. Built in 1457 AD, it measures of 15.8 × 13.1 × 10.1m (Length × Width × Height), and was damaged during the 2008 Wenchuan earthquake. Following a condition survey, it was found that there were over 50 damages, including 13 cracks in walls, 9 shifted columns, 21 cases of tenons pulled out of their mortises. The most serious problem was found to be the shifting of some inner columns by nearly 22cm, [FIGURE 7b]. According to the collected data, more than 4 tenons at tie beams at the damage locations were pulled out of mortises by 8cm prior to the earthquake. It was therefore deduced that the main cause of shifts in columns was the fact that the tenons were pulled out of their mortises at these locations.

Figure 8 is a finite element model and main mode shape of the palace. It was found that the main mode shape of the un-strengthened structure exhibited rotation of beams in a horizontal direction near the joint locations, while the upper roof truss remained relatively still (see circled locations in Figure 8), which is consistent with the damage symptom. Thus, the tenon loosened from the mortise prior to the earthquake and without preventive strengthening is the main cause for damage at the Da-Xiong Palace.



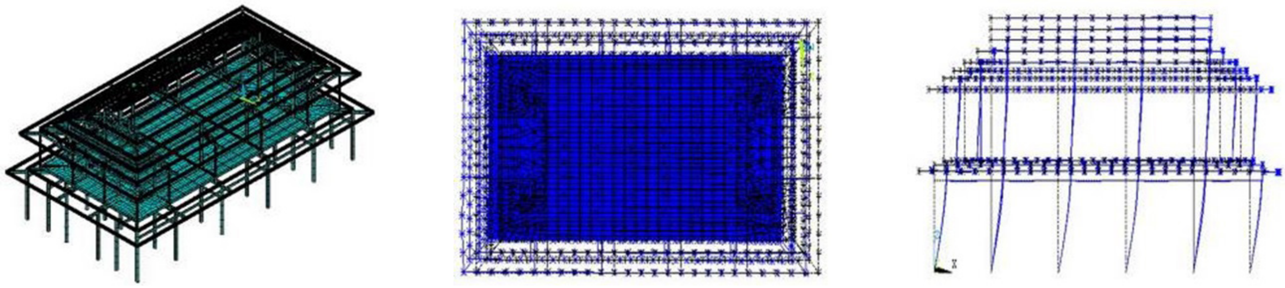
(a) finite element model (b) plan view of main mode shape (c) side view of main mode shape

Figure 8. Finite element analysis on Da-Xiong Palace

The second example 2 is of Xiao-Yao Palace, a strengthened structure, Xiao-Yao Palace in Guangyuan city (Zhou et al. 2009). [Figure 9a] Built during the Qing dynasty, it measures 25.0 × 12.7 × 12.0 m (Length × Width × Height), and was only slightly damaged during the 2008 Wenchuan earthquake. The ancient building was strengthened in 2005, tilting columns were reassembled [Figure 9b], and slacking mortise and tenon joints were strengthened by iron hooks. [FIGURE 9c] Due to this preventive strengthening, the Palace was still in good condition after the earthquake. Figure 10 shows a finite element model and main mode shape of the building. It was found that the main mode shape of the strengthened building appears to translate in level plane, which is helpful for earthquake resistance.

(a) front view (b) column (c) mortise and tenon joint

Figure 9. Photos of Xiao-Yao Palace post-earthquake



(a) finite element model (b) plan view of main mode shape (c) side view of main mode shape

Figure 10. Finite element analysis on Xiao-Yao Palace

Conclusions

1. In addition to the strength of an earthquake, the existence of seismic performance deficiencies is a main cause of damage in ancient Chinese wooden buildings.
2. Typical seismic performance deficiencies of ancient Chinese wooden buildings include decay of column bases, slacking in dougong, tenons pulled out of their mortise, cracks in beam and columns, etc….
3. Typical strengthening methods for solving the problems include replacement, wrapping, connection, assembly, which should be applied to buildings preventively in order to minimize damage during an earthquake.

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Protection against Deterioration and Enhancement of Interpretation: Preservation of Hong Kong's Rock Carvings

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Abstract. This paper focuses on outlining the major problems with the preservation of rock carvings in Hong Kong and conservation measures adopted by the Antiquities and Monuments Office (AMO) over the years, to reduce the risks to these monuments and improve their overall protection, with valuable inputs from various heritage professionals and government departments. It also examines how the challenges give rise to an opportunity for AMO to reposition the role and functions of the rock carvings from heavily protected items to more accessible resources for public interpretation and appreciation. The paper concludes with some reflections on heritage conservation as demonstrated in the development of rock carving preservation in Hong Kong from 1977 to present.

1 Protection of Rock Carvings in Hong Kong

There are currently eight rock carvings[1] in Hong Kong which have been declared as monuments under the Antiquities and Monuments Ordinance. [FIGURE 1]. They are Rock Carving at Big Wave Bay, Rock Carvings on Po Toi, Rock Carving on Tung Lung Chau, Rock Carving at Shek Pik, Rock Carving on Kau Sai Chau, Rock Carvings on Cheung Chau, Rock Carving at Lung Ha Wan and Rock Carvings at Wong Chuk Hang. [FIGURES 2-55] They form a homogeneous group with basic geometric patterns, some of which give hints to human or animal images. It is difficult to establish when, how and by whom the carvings were made. Since their patterns resemble strikingly those on the Bronze Age stamped pottery and bronze vessels unearthed locally, it is believed that the rock carvings belong to Hong Kong's Bronze Age, i.e. about 3,000 years ago. It is important to point out that the above rock carvings are scattered mainly along the coastal areas and have undergone weathering for many years.

The earliest initiative of AMO to protect the rock carvings was the commissioning of the consultancy study conducted by Mr. Richard L. Thomas, an expert in geotechnical engineering, in 1977. This consultancy was meant to study and develop proposals to supress the weathering process and improve the physical stability of the rock carvings on Po Toi. In his report, Thomas highlighted that the primary force of weathering was the chemical process caused by ground water in the rock joints and surface water or sea spray on the rock surface (Thomas 1977). A further study covering all the rock carvings was conducted in 1979. Both studies recommended the construction of sturdy protection structures, such as surface channels to intercept groundwater and surface water flow, viewing platforms and shelters to protect the rock face from wave attack and sea water spray, and the concrete buttress to enhance the overall stability of the block of rock.

Consequently, AMO implemented the protective measures over the past decades with assistance from the former Public Works Department, the Architectural Services Department (ArchSD) and the respective District Offices. Although these measures were the most advanced we had at that time, some of the facilities have deteriorated and a number of the measures are obsolete judging from the present international standards of heritage conservation and interpretation as stipulated in the ICOMOS Charter for the Protection and Management of Archaeological Heritage (1989), European Convention on the Protection of the Archaeological Heritage (Revised 1992) and ICOMOS Charter for the Interpretation and Presentation of Cultural Heritage Sites (2008).

Legend
1. Rock Carving at Big Wave Bay
2.Rock Carvings on Po Toi
3. Rock Carving on Tung Lung Chau
4. Rock Carving at Shek Pik
5. Rock Carving on Kau Sai Chau
6. Rock Carvings on Cheung Chau
7. Rock Carving at Lung Ha Wan
8. Rock Carvings at Wong Chuk Hang

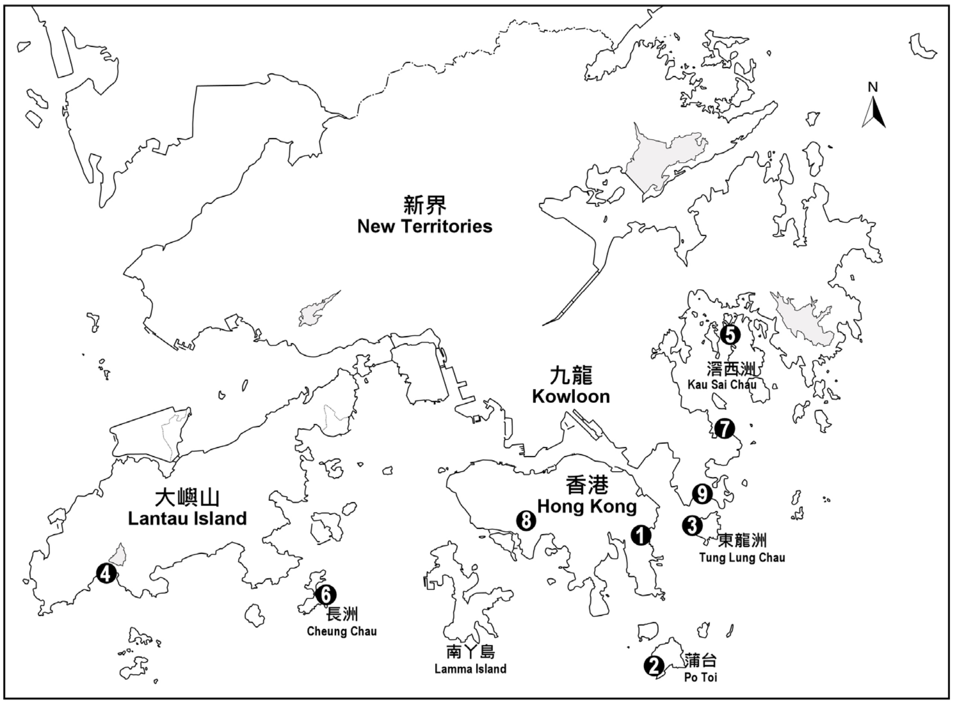

Figure 1. Location map of the eight rock carvings in Hong Kong

2 Major Problems with Preservation of Rock Carvings

The problems with rock carving conservation are numerous and complex and there seems to be no consensus about the best strategy for addressing them (Sanders 2005). In general, conservation problems can be attributed to natural deterioration and human impact.

Wind and water erosion can cause damage or even destruction of the rock carvings. It is probable that all the rock carvings exposed to natural forces will eventually succumb to them. However, it should be noted that the process could be controlled so as to supress the deterioration process. In fact, the rock carvings in Hong Kong have been standing at the sea front and survived countless tropical storms over thousands of years.

In order to review the effectiveness of the protective facilities of the rock carvings, AMO invited Dr. Richard Engelhardt, a heritage preservation expert, Mr. William Meacham, a local archaeologist, Mr. Andrew Thorn and Dr. Valérie Magar, rock art conservation experts, to conduct a consultancy study, which identified the following major problems with the preservation of rock carvings. [FIGURE 2-55]

2.1 Harmful effects caused by cement structures

The cement structures of the water diversion dams, shelters, visitor platforms, pathways, staircases not only changed the landscape of the heritage sites but also altered the natural and archaeological context of the rock carvings, adversely affected the interpretation of these heritage sites (Meacham 2010).

Besides, the cement structures facilitated water accumulation and acesslerated the chemical and biological processes. The cement water diversion dams, for example, could not stop water flow because the bonding of cement structures with rock is poor. Water with harmful soluble salts leached out from the cement could be slowly released through the joints between the cement and rock surface. The bulky cement structures of the protective facilities could also block the flow of underground water and alter the water table near the rock carvings (Engelhardt 2010; Magar 2010; Meacham 2010; Thorn 2009).

2.2 Creation of micro-climate

The iron shelters with Perpex screens were constructed to protect the rock carvings from wind blow, sea wave attack and vandalism; however, they created a micro-climate inside the shelters with temperature and humidity contrasting with the environment outside. The micro-climate disturbed the equilibrium that has long existed between the rock carvings and the natural environment as well as sped up the weathering process indirectly (Engelhardt 2010; Meacham 2010).

2.3 Damage of bio-growth

The existing humid environment, which was further accentuated by the construction of the water diversion dams, fosters the bio-growth that would affect the stability of the engraved surface. Although the application of water repellent and biocide is effective to repel water and control the bio-growth respectively, the water repellent or consolidant only affects the moisture on the rock surface but not within the rock (Engelhardt 2010; Magar 2010; Thorn 2009), and most importantly, both chemicals could cause irreversible damage to the rock carvings.

2.4 Viewing obstruction

The shelter, the viewing platform and the concrete buttress may have facilitated the viewing and protection of the patterns of the rock carvings; it was however at the expense of blocking the view of the whole natural setting of the rock carvings. Moreover, the deteriorated Perspex screens of the shelter are an obstacle to appreciating the rock carvings (Engelhardt 2010; Magar 2010; Meacham 2010; Thorn 2009).

3 New Conservation Measures in Practice

In order to tackle the aforementioned problems, improve the overall protection, and enhance the public visitation of the rock carvings, AMO has been collaborating with the Conservation Office (CO) of the Leisure and Cultural Services Department (LCSD), ArchSD and the Civil Engineering and Development Department (CEDD) of the Government of Hong Kong Special Administrative Region to follow up the recommendations of the consultancy reports. Implementation of the new conservation measures have been carried out in phases.

After considering the harmful effects caused by cement structures, AMO decided to remove the cement structures at the rock carving sites. ArchSD has assisted in removing the shelter for the Rock Carvings on Kau Sai Chau [FIGURE 31], Po Toi and Tung Lung Chau [FIGURE 20] and the cement water diversion dams above the rock carvings at Big Wave Bay [FIGURE 6] and Po Toi [FIGURE 14]. Conservators of LCSD have also removed the cement capping on the surface of the rock around the carving at the site on Cheung Chau [FIGURE 38]. To prevent leaching of soluble salts from the cement structures, the conservators also studied and recommended suitable materials, such as siliceous grout, for reconstructing the water diversion dams above the rock carvings at Cheung Chau, Po Toi, Shek Pik and Wong Chuk Hang, if applicable.

To monitor the physical condition of the rock carvings, AMO launched a number of phased studies, including geological surveys of all the rock carving sites and hydrological assessments of Rock Carvings on Po Toi and Cheung Chau. These studies were conducted by CEDD, and the climatic studies within the shelter of Rock Carvings on Po Toi were carried out by the conservators of LCSD.

Although the experts of the consultancy study have different views on the use of chemicals to control the bio-growth and moisture on the rock carvings, it is generally agreed that the chemical treatments should be continued with careful monitoring of their impacts on the rock carvings. Conservators of LCSD have adopted the chemical treatment recommended by the consultants to arrest the bio-contamination on the rock surface and monitored the effect of chemical treatment closely at all the rock carving sites.

With assistance from ArchSD, the Perspex screens of the shelters at Lung Ha Wan [FIGURE 46], Po Toi and Tung Lung Chau [FIGURE 20] have been removed to let visitors appreciate the engravings clearly.

For better management of the rock carving sites in the future, AMO has sought advice from CEDD to arrange 3D laser scanning for collecting information on the monuments and monitoring the rock carving surface. Appropriate mitigation measures would be arranged based on the scanning findings.

4 Opportunity arising from Challenges: Enhancement of Public Appreciation of Rock Carvings through New Protection and Visitor Facilities

The challenges of preserving the rock carvings in the past decades have provided AMO with a good opportunity to comprehensively review and improve the conservation measures through the consultancy study. The consultancy reports recommended enhancing visitor interpretation of each rock carving and its linkage with other rock carving sites in Hong Kong to promote public awareness as well as the value of the rock carvings as a public educational resources. This approach would help educate the visitors about the historical value of the sites, and also convey a message against vandalism in a gentler and visually pleasing way. During the implementation of the recommended measures, it is important to strike a balance between conservation and public appreciation so that the rock carvings would not be overly-protected or aggressively promoted.

In April 2011, the Community Project Workshop (CPW) of the Faculty of Architecture of the University of Hong Kong (HKU), was commissioned by AMO to prepare the proposals for the design of protection and visitor facilities for the rock carvings. CPW reviewed the recommendations of the consultancy reports and consulted the four experts as well as the conservators of LCSD before writing up the design proposal report. It was based on the premise that an equilibrium condition should be achieved by keeping all the rock carvings in their natural setting while protection could be achieved by keeping a safe distance between the monuments and visitors. The level of protection varies according to the natural landscape, accessibility and number of visitors to the rock carving sites. CPW submitted a report to AMO in March 2012 with recommendations of the following three design approaches for new protection and visitor facilities at the rock carving sites. [FIGURES 7 and 8, 15 and 16, 21 and 22, 26 and 27, 40 and 41, 47 and 48, 54 and 55 – examples of controlled pathways; FIGURE 32- example of psychologial barrier]

4.1 Controlled pathway

In areas with heavy tourist traffic and easy accessibility, construction of bypasses with balustrades will keep visitors at a reasonable distance from reaching the rocks while still be able to view the carvings clearly. For example, to prevent vandalism by increasing the distance between visitors and the rock carving, CPW suggests constructing an extended walkway starting from the existing concrete platform at the rock carving site on Tung Lung Chau. An interpretation plate is also suggested for incorporation into the railing to provide more background information on the rock carvings, and educate visitors about protecting the cultural heritage of Hong Kong (Community Project Workshop 2012).

4.2 Physical barrier

Physical barriers which are visitor-friendly yet can prevent vandalism are proposed (Community Project Workshop 2012). This approach is not applicable to any of the eight rock carving sites.

4.3 No physical barrier / psychological barrier

For sites with infrequent visitors, construction of a barrier is not recommended. Eye-catching signs or structures will not be installed, but an information panel will be added as a psychological barrier. This approach is applicable to the rock carving site on Kau Sai Chau where only a standalone interpretation plate is suggested to provide more background information on the rock carving and educate visitors about protecting the cultural heritage of Hong Kong. The above suggestion complies with the views of the experts that the site not be developed into a popular tourist destination to ensure minimum disturbance to the rock carving and the environment (Community Project Workshop 2012).

It is believed that the new protection and visitor facilities will be able to reinstate the interaction between the rock carvings and the natural environment. Protective screens would be replaced with a controlled pathway or psychological barrier to facilitate the visitors' appreciation of the rock carvings. Visitors could also understand more about the sites and their important heritage value through the enhanced interpretation plates. AMO is seeking assistance from ArchSD and other government departments to implement the new architectural design works in phases.

5 Heritage Conservation: An Evolutionary Process

From Thomas's Report of 1977 to Community Project Workshop's Report of 2012, the approaches to preservation of rock carvings in Hong Kong have been undergoing remarkable changes. The integration of human-object interactive elements into the conservation measures reflects that heritage conservation is an evolutionary process which keeps pace with the latest international trends and standards.

In the 1970s, the concept of preservation of rock carvings in Hong Kong focused mainly on physical protection. Initially, AMO used protective facilities, such as shelters, to protect the rock carvings against direct potential threats from sea wave attack, weathering and vandalism. These traditional object-orientated conservation measures were, however, subsequently proved to be inadequate to meet the requirements of international charters and principles of heritage conservation and interpretation. For better protection of the monuments, AMO started to review the conservation measures and reposition the role and functions of protection and visitor facilities since 2009. The incorporation of human-object interactive elements into the design proposals for the new protection and visitor facilities, is an experimental attempt in Hong Kong. The ultimate goal is to allow the public to understand more about the rock carvings and to standardise preservation methodsand to limit continuous human intervnetions, as well as limit the effects of these changes to the natural settings of the carvings. Therefore, the new preservation strategy of AMO not only emphasizes the physical protection of rock carvings but also stimulates visitors' understanding and appreciation of their heritage value. This approach will enhance the public education and awareness as well as prevent the vandalism of the rock carvings.

Apart from the evolution of preservation approaches, it is not difficult to find that heritage conservation has been developing into a multi-disciplinary subject which brings together professional knowledge from various fields. In the consultancy study of 1977, Mr. Thomas, an expert in geotechnical engineering, recommended the conservation measures primarily from an engineering point of view. In the course of reviewing the conservation measures in 2009-10 and designing the new protection and visitor facilities for the rock carvings in 2011-12, AMO collaborated with Dr. Engelhardt (heritage preservation expert), Mr. Meacham (archaeologist), Mr. Thorn (rock art conservator), Dr. Magar (rock art conservator), the Community Project Workshop (academic institution with expertise in architecture) and various specialists in government departments (conservators of LCSD, architects of ArchSD and engineers of CEDD) to ensure that all recommended conservation measures and design proposals were thoroughly studied from various professional perspectives, and could strike a balance between conservation and public appreciation. This collaborative experience demonstrates that the engagement of heritage conservation professionals can inspire high quality, technically feasible ideas and concepts.

With the provision of new conservation measures as well as new protection and visitor facilities, AMO hopes to bring the rock carvings back to nature and get them closer to the public at the same time. There is no perfect method to prevent the rock carvings from deteriorating, which makes preservation of rock carvings an ongiong and challenging task. Nevertheless, AMO will keep doing its very best to provide them with appropriate protection and interpretation in compliance with the latest international trends and standards.

Endnotes

[1] The term ‘rock carving’ in this paper is referred to as ‘rock engraving’ and ‘petroglyph’ in international rock art literature which describes a motif that has been pecked into the bedrock resulting in a lowering of the surface to form the motif.

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Figures

1 Rock Carving at Big Wave Bay

1.1 Basic Information

Year of Monument Declaration	Size (W) x (H)
1978	Approx. 200cm x 110cm
Location	**Pattern**
On a rock cliff at the eastern end of the Big Wave Bay, Hong Kong Island	Geometric and animal patterns

Figure 2. Rock carving at Big Wave Bay

1.2 Major preservation problems

Figure 3. Shelter obstructs the view of the natural setting of the rock carving

Figure 4. Rock carving inside the shelter

Figure 5. Leaching of soluble salts caused by an ineffectiveness of water diversion dam to intercept water flow

1.3 Immediate conservation measures

Figure 6. Rock carving after removal of the water diversion dam

1.4 New protection and visitor facilities

Key proposals:

1. Construction of a controlled pathway;
2. Removal of the roof and cement structures; and,
3. Incorporation of an interpretation plate into the balustrade

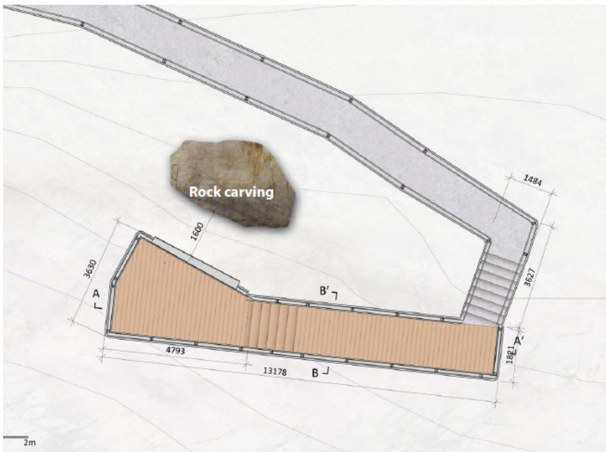

Figure 7. Design of the controlled pathway for the rock carving

Figure 8. Virtual image of the controlled pathway for the rock carving

2 Rock Carvings on Poi Toi

2.1 Basic Information

Year of monument declaration	Size (W) x (H)
1979	Left side: Approx. 160cm x 200cm Right side: Approx. 200cm x 140cm
Location	Pattern
On two coastal rock cliffs located at the southern part of Po Toi	Patterns on the left consist of lines resembling stylized animal and fish patterns, while the right is arranged in spirals with inter-locking style

Figure 9. Left side

Figure 10. Right side

2.2 Major Preservation Problems

Figure 11. Shelter and Perspex screen

Figure 12. Shelter and Perspex screen affect the visibility of the rock carvings

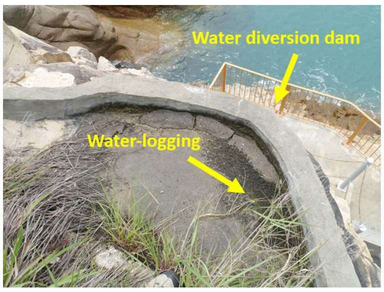

Figure 13. Water diversion dam above the rock carving causes water-logging

2.3 Immediate conservation measures

Figure 14. Top view of the rock carving
after removal of the water diversion dam

2.4 New protection and visitor facilities

Key proposals:

1. Construction of a controlled pathway;
2. Removal of the metal cage and Perspex screen; and,
3. Incorporation of an interpretation plate into the balustrade

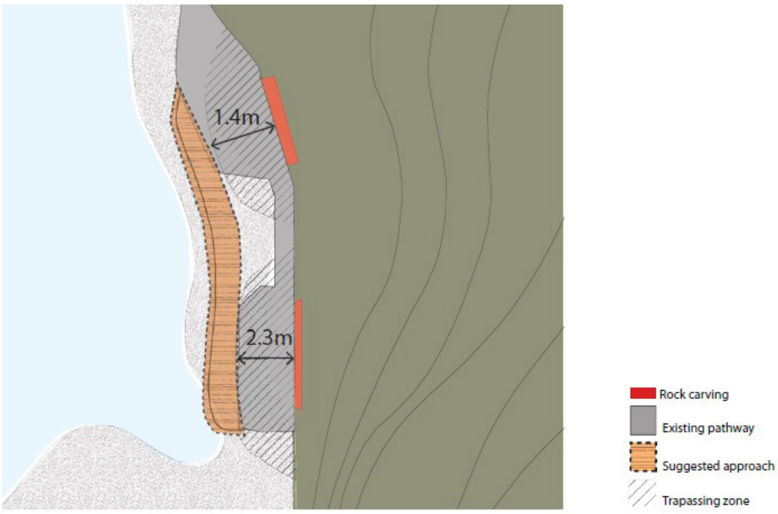

Figure 15. Design of the controlled pathway for the rock carvings

Figure 16. Virtual image of the controlled pathway for the rock carvings

3 Rock Carving on Tung Lung Chou

3.1 Basic information

Year of monument declaration	Size (W) x (H)
1979	Approx. 300cm x 200cm
Location	**Pattern**
On the northern coast of Tung Lung Chau overlooking Joss House Bay	The carving features a dragon pattern

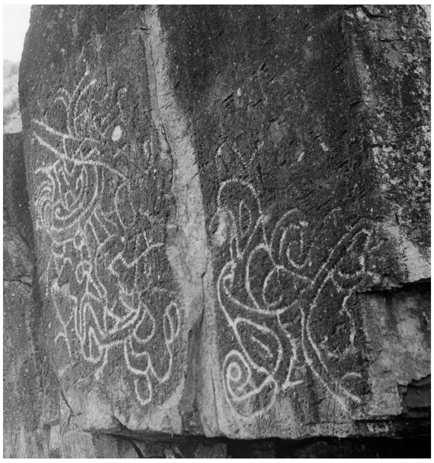

Figure 17. Rock carving on Tung Lung Chou

3.2 Major preservation problems

Figure 18. Perspex screen affects the visibility of the rock carving

Figure 19. Micro-climate is created inside the shelter enclosed by the Perspex screen, which disturbs the equilibrium that had long been existed between the rock carving and the natural environment as well as speed up the weathering process indirectly

3.3 Immediate conservation measure

Figure 20. Rock carving after removal of the Perspex screen

3.4 New protection and visitor facilities

Key proposals:

1. Construction of a controlled pathway;
2. Removal of the Perspex screen and metal cage; and
3. Incorporation of an interpretation plate into the balustrade

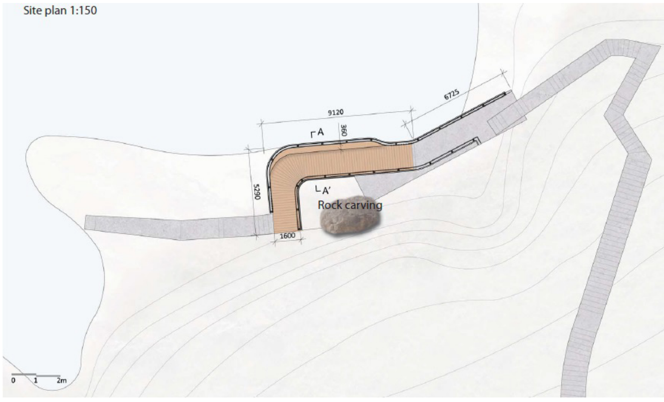

Figure 21. Design of the controlled pathway for the rock carving

Figure 22. Virtual image of the controlled pathway for the rock carving

4 Rock Carving at Shek Pik

4.1 Basic information

Year of monument declaration	**Size (W) x (H)**
1979	Approx. 30cm x 80cm
Location	**Pattern**
On a slope near the base of the Shek Pik Reservoir dam	Geometric patterns composed of spiral squares and circles

Figure 23. Rock Carving at Shek Pik

4.2 Major preservation problems

Figure 24. Shelter cannot cover the entire rock carving to provide protection

Figure 25. Refuse collection point at the footpath leading to the rock carving site

4.3 New protection and visitor facilities

Key proposals:

1. Construction of a controlled pathway;
2. Removal of the roof structure and existing concrete; and
3. Incorporation of an interpretation plate into the balustrade

Figure 26. Design of the controlled pathway for the rock carving

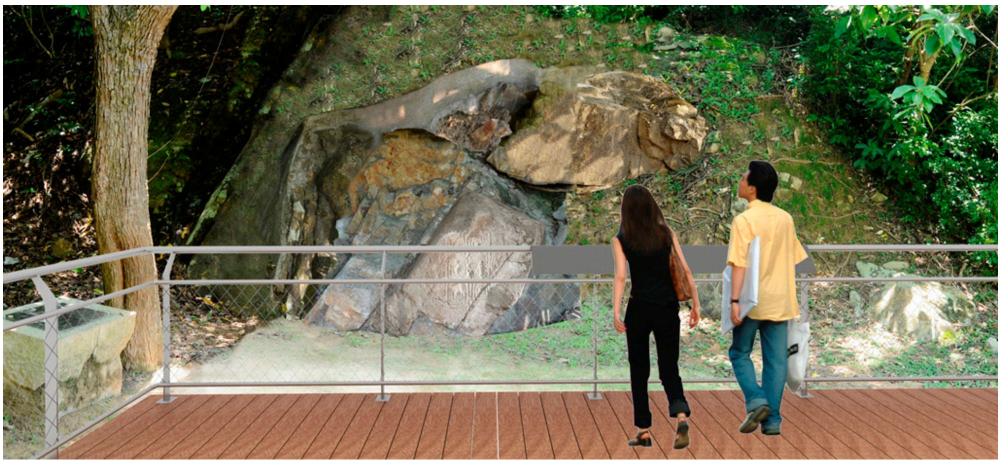

Figure 27. Virtual image of the controlled pathway for the rock carving

5 Rock Carving on Kau Sai Chau

5.1 Basic Information

Year of monument declaration	Size (W) x (H)
1979	Approx. 80cm x 100cm
Location	**Pattern**
A flat vertical rock surface at the north-western coast of Kau Sai Chau	Zoomorphic motif similar to other rock carvings

Figure 28. Rock carving on Kau Sai Chau

5.2 Major Preservation Problems

Figure 29. Landscape of the surrounding area of the rock carving site

Figure 30. Shelter obstructs the view of the natural setting of the rock carving and may draw the vandal's attention

5.3 Immediate conservation measure

Figure 31. Rock carving after removal of the shelter

5.4 New protection and visitor facilities

Key proposals:

1. Construction of an interpretative panel as psychological barrier;
2. Removal of all existing concrete structures; and
3. Incorporation of an interpretation plate into the balustrade

Figure 32. Virtual image of the psychological barrier at the rock carving site

6 Rock Carvings on Cheung Chau

6.1 Basic information

Year of monument declaration	Size (W) x (H)
1982	Left side: Approx. 30cm x 40cm Right side: Approx. 110cm x 250cm
Location	**Pattern**
On a boulder below the Warwick Hotel, East Bay, Cheung Chau	Carvings consist of two groups of similar design with several carved lines surrounding small depressions

Figure 33. Left side

Figure 34. Right side

6.2 Major preservation problems

Figure 35. Glass enclosure creates a micro-climate which disturbs the equilibrium that had long been existed between the rock carvings and the natural environment as well as speed up the weathering process indirectly

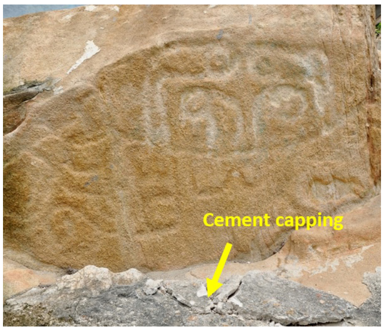

Figure 36. Cement capping at the base of the rock Carving

Figure 37. Planter above the rock carvings causes water seepage

6.3 Immediate Conservation Measures

Figure 38. Rock carving after removal of the cement capping

Figure 39. Planter above the rock carvings after removal of some plants

6.4 New protection and visitor facilities

Key proposals:

1. Construction of a controlled pathway (viewing platform);
2. Removal of the glass enclosure and cement structures; and
3. Incorporation of an interpretation plate into the balustrade

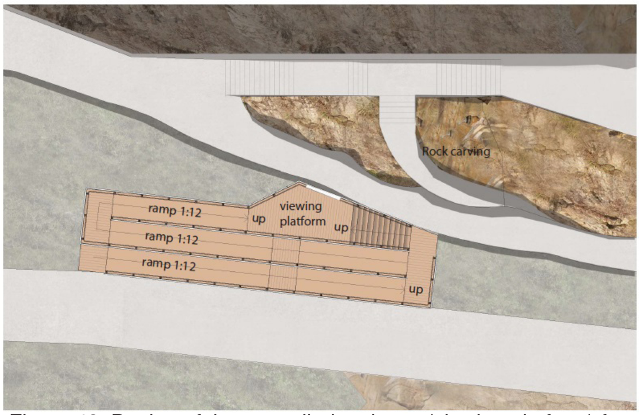

Figure 40. Design of the controlled pathway (viewing platform) for the rock carvings

Figure 41. Virtual image of the controlled pathway (viewing platform) for the rock carvings

7 Rock Carving at Lung Ha Wan

7.1 Basic Information

Year of monument declaration	**Size (W) x (H)**
1983	Approx. 140cm x 140cm
Location	**Pattern**
On a vertical face of a badly weathered boulder facing east at Lung Ha Wan	Geometric patterns that may resemble stylized animals or bird forms

Figure 42. Rock carving at Lung Ha Wan

7.2 Major preservation issues

Figure 43. Perspex screen of the rock carving and the viewing platform which is too small for visitors

Figure 44. Perspex screen affects visitors' appreciation of the rock engraving

Figure 45. Staircase leading to the rock carving

7.3 Immediate conservation measure

Figure 46. Rock carving after removal of the Perspex screen

7.4 New Protection and Visitor Facilities

Key proposals:

1. Construction of a controlled pathway (remove steps);
2. Removal of the Perspex screen; and
3. Incorporation of an interpretation plate into the balustrade

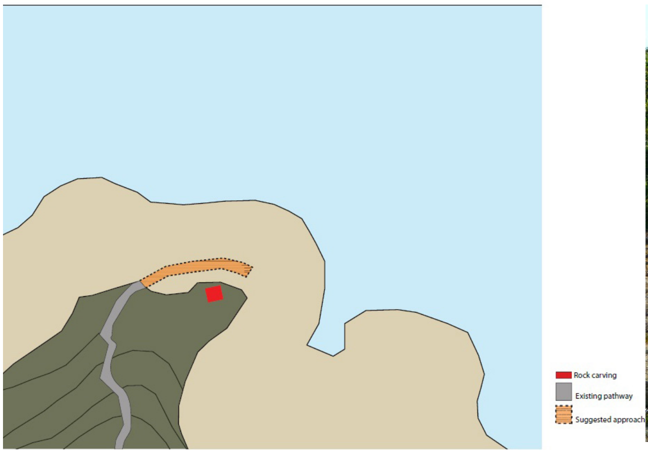

Figure 47. Design of the controlled pathway (remove steps) for the rock carving

Figure 48. Virtual image of the controlled pathway (remove steps) for the rock carving

8 Rock Carvings at Wong Chuk Hang

8.1 Basic information

Year of monument declaration	Size (W) x (H)
1984	Approx. 200cm x 300cm
Location	**Pattern**
Three main groups of carvings on a vertical rock surface at the side of a stream course at Wong Chuk Hang	Meandering and spiral designs suggesting stylized animal motifs

Figure 49. Rock carvings at Wong Chuk Hang

8.2 Major preservation problems

Figure 50. Walkway to the viewing platform of the rock carvings

Figure 51. Bio-growth affects the stability of the engraved surface

Figure 52. Water diversion dam above the rock carvings cannot drain away water effectively

8.3 Immediate conservation measure

Figure 53. Cleaning of the rock carving surface

8.4 New protection and visitor facilities

Key proposals:

1. Construction of a controlled pathway (viewing bridge);
2. Removal of the water diversion dam, remnants of squatter huts and concrete capping on the slope; and
3. Incorporation of an interpretation plate into the balustrade

Figure 54. Virtual image of the controlled path-way (viewing bridge) for the rock carvings

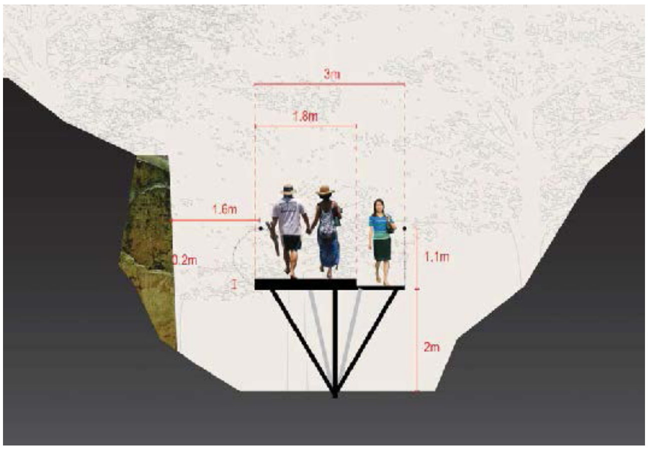

Figure 55. Virtual image of the controlled pathway (viewing bridge) for the rock carving

Study on Mechanism of Community-based Disaster Management for Historic Areas in Kyoto City

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Abstract. Historic areas of Kyoto, Japan have been chosen as the subject of this study. A literature review was conducted as well as a field survey of three historic areas and interviews with experts, community members and the local disaster management agency to verify the mechanisms of community-based disaster management in historic areas. The purpose of this research is to try to analyse the performance of community-based disaster management in historic areas with a high-density of cultural and historic buildings as is the case in Kyoto, Japan. The research found that disaster mitigation and prevention mechanisms for historic areas in Kyoto are correlated with several factors such as fire drills, the type and grade of heritage, social environment, local leadership, regional business and tourism policies, and training. As an outcome of the study, a mechanism for community-based disaster management for historic areas is proposed.

1 Introduction

Japanese neighbourhoods are usually comprised of high-density wooden buildings which are highly flammable. In the case of traditional historic areas, most heritage buildings are made of wood. Fire-prevention strategies combining community-based disaster-mitigation practices for similar regions have become an important issue. Since June 2003, the Cabinet Office, the Ministry of Land, Infrastructure, Transport and Tourism, the Fire and Disaster Management Agency, and the Agency for Cultural Affairs set up a ‘Review Committee for the Protection of Cultural Properties’. This committee is meant to develop disaster and fire mitigation programs (especially post-earthquake conflagrations) for historic areas in Kyoto and Tokyo in cooperation with local residents, the local public sector, non-governmental organizations, etc.(Cabinet Office 2004). In 2005, the Cabinet Office and the Agency for Cultural Affairs jointly announced the ‘Kyoto Declaration on Protection of Cultural Properties’ to emphasize the importance of international cooperation, academic exchange and further study to develop comprehensive disaster mitigation strategies and the legal, financial, technical and administrative measures to support their implementation, as well as community-based disaster mitigation programs for heritage protection (World Conference on Disaster Reduction 2005). Furthermore, from July 2008 to February 2009, the Japanese Government also set up the ‘Review Committee for General Disaster Prevention Measures for National Treasures’ to discuss the issues and content of community-based disaster mitigation plans for areas where important heritage buildings are located (Cabinet Office 2009).

From the overview described above, the key issues to be addressed under general disaster-mitigation measures for cultural properties and historic areas is fire safety and the development of a community-based disaster mitigation program. In this study, three historic areas in Kyoto, Japan were chosen as research subjects. A literature review, field survey of these three areas, and interviews with experts, community members, and the local disaster management agency were conducted to verify the existing mechanisms for historic areas. The purpose of this research was to analyse the existing performance of community-based disaster management in historic areas with a high-density of cultural and historic buildings in Kyoto, Japan, to clarify the relationship between heritage-based disaster management and local resilience empowered to fire, and also to suggest an appropriate operating model or mechanism for community-based disaster management for historic areas based on case studies in Japan and in other Asian countries such as Taiwan, China, etc. where there are also similar historic areas.

2 Relationship between Heritage Conservation and Disaster Management

The system of protecting cultural properties such as structures, works of art and crafts and cultural artefacts started in 1871 with the Plan for the Preservation of Ancient Artefacts. After World War II, following with the destruction by fire of the wall painting at the Horyu Temple in Nara, the Japanese Government regarded conservation of cultural properties as a serious issue to be addressed; the Law for Protection of Cultural Properties was enacted in 1950 as a consequence. After several revisions, the law gradually became very robust. With the 1975 amendment, the law extended protection measures by creating two new designations ‘Preservation District for a Group of Historic Buildings’ and ‘Important Preservation District for a Group of Historic Buildings’. These two designations applied to ‘groups of traditional buildings’, a new category introduced as part of the

1975 amendment. This category refers to groups of traditional buildings and their environment which are selected based on the following criteria established in the Law for Protection of Cultural Properties administered by the Agency for Cultural Affairs and local governments (Agency for Cultural Affairs 1993):

1. Groups of traditional buildings with excellent design as a whole
2. Groups of traditional buildings and their land distribution that have kept their original conditions and characteristics
3. Groups of traditional buildings and their surrounding environment that show remarkable regional characteristics.

Since the system of protecting cultural properties started from the fire incident in Horyu Temple in 1950; fire-prevention planning for cultural properties became very important (Fire Department of Kyoto City 2011). Fire-prevention planning includes the preparation of a fire management plan, and concurrently equipping the important heritage building with firefighting facilities to match the special requirements of the fire code. In addition, managers of heritage buildings usually have to check for fire safety by equipping firefighting facilities without destroying heritage buildings and maintaining original status for heritage buildings. The fire-prevention responsibilities incumbent to the manager of heritage buildings are the following:

1. To develop a firefighting plan including firefighting management plan, fire-protection plan and education plan;
2. To implement fire drills including extinguisher training, information practice and evacuation training;
3. To check and prepare fire protection measures as stipulated by the fire code;
4. To supervise and control fire including patrolling and inspecting any areas where smoking and fire use are forbidden;
5. Other works including the maintenance and management of facilities, cleaning and tidying buildings, and securing fire escape routes, and so on.

Besides these measures, heritage buildings or traditional historic areas must be equipped with guards, alarms, hydrants, hoses, pumps, lightning rod, emergency access and water supply, a buffer zone, etc….

Several principles should be followed in the process of developing fire-prevention or disaster mitigation plans for traditional historic regions, such as:

1. To reduce the risk factor of a disaster happening by implementing fire prevention measures or using technology for disaster mitigation, which will decrease the risk of the fire spreading;
2. To reinforce fire prevention or disaster mitigation programs through added measures, such as: monitoring system, community-based disaster management organization, evacuating routes planning and etc.;
3. To provide disaster-prevention equipment for an entire neighbourhood, such as: fire hydrants, sprinkler and information system, and so on;
4. To improve the performance of disaster mitigation, such as: fire-resistant or earthquake-resistant buildings, emergency evacuation system;
5. To include community organizations by developing community-based disaster management, such as implementing drills, raising awareness through outreach, forming disaster-mitigation organizations, etc.

3 Case Study for Disaster Management of Preservation Districts in Kyoto

Disaster-prevention programs in preservation districts Kyoto, Japan is well known for its traditional culture. The numbers of national treasures and cultural properties represents one tenth of total quantities in Japan; besides, fourteen heritage are identified as the world heritage property and eleven areas are designated traditional buildings regions (Agency for Cultural Affairs 2012). Thus, how to protect cultural properties and heritage buildings in Kyoto Prefecture and Kyoto City has become a key issue. To safeguard a large number of cultural properties, heritage-based disaster prevention strategies involving the community living in preservation districts have recently been considered in Kyoto. The following three case studies will illustrate Kyoto's current efforts. [FIGURE 1]

3.1 Area of Kiyomizu Temple and Sannen-zaka

The area of Kiyomizu Temple and Sannen-zaka began to develop during the Heian Period (8th-12th century CE). Kiyomizu temple became the centre of the area during the Edo Period (17th-19th century CE). This area was designated as an 'important preservation district' in 1972. Furthermore, it was designated as a preservation district of a group of traditional buildings in 1976. Three million visitors visit this area yearly; in addition to the age and flammability of these traditional buildings, there is a high concentration of timber structures and narrow paths. This is a hazard and a threat to cultural properties, as well as human safety should an earthquake or a conflagration occur in this area. To face such environmental vulnerability, the central government selected, in 2005, the area of Kiyomizu Temple and Sannen-zaka to develop a community-based disaster prevention plan involving the City of Kyoto and local organizations, as a pilot project to promote community-based fire and disaster prevention planning for all regions.

Figure 1. Map of three historic areas in Kyoto City

The pilot project to prepare a fire and disaster-prevention plan for the area of Kiyomizu Temple and Sannen-zaka will cost 2.9 billion Yen. The plan consists of implementing fireproofing and earthquake-proof measures. Water hoses and water supply systems have been installed as a whole to ensure fire prevention. To ensure earthquake resistance, heritage buildings have been retrofitted with base-isolating structures and cultural artefacts have been installed on base-isolated devices. Furthermore, the plan also encourages residents to participate in community-based disaster prevention activities to improve emergency rescue procedures and fulfil disaster-prevention educational materials (Cabinet Office 2004).

There are three issues in the neighbourhood of the Kiyomizu Temple which are regarded as follows:

1. Buildings: there are not enough fire-resistant and earthquake-resistant buildings here; rescue and evacuation routes are also not clear;
2. Blocks: a high concentration of timber structures would lead to risk of conflagration and it would be extremely difficult to evacuate people from this area; and,
3. Community: it is necessary to develop community-based disaster-management autonomous activities.

The fire and disaster prevention plan was prepared to mitigate these three issues, according to the following three principles. [TABLE 1]

TABLE 1. Principles of disaster prevention plan for the neighbourhood surrounding the Kiyomizu Temple and Sannen-zaka

Principles	Contents
To use local disaster-prevention resources thoroughly	To use existing disaster-prevention resources such as evacuation procedures of the temple or shrine, underground water sources and local agricultural techniques for firefighting or for preventing fire from spreading.
To establish community-based disaster management and to ensure that residents have practiced the operation of fire-fighting equipment	To promote cooperation between each community for fire prevention and firefighting; To ensure residents are familiar with fire-fighting equipment; To prepare emergency food and water supply for the community.
To cooperate with residents and the local public sector	To integrate the local public sector, fire stations and social welfare agency in responding to residents' requirements for disaster prevention measures.

Figures 2 and 3 show practice drills for the operation of a fire hydrant and water spray gun apparatus at Kiyomizu Temple.

Figure 2. (Left) and Figure 3. (Centre) Disaster-prevention drill in Kiyomizu Temple (Source: Kiyomizu Temple)
Figure 4. Hydrant matching the color design with traditional building

3.2 Daihouon Temple Area

Daihouon Temple Area located in Kamishichiken District is the oldest pleasure quarter in Kyoto. There are two national treasures which are Daihouon Temple and Kita-teman Shrine and some traditional cultural buildings such as theatres for apprentice geisha and tea houses. The area is characterized by the traditional Nishijin handicraft, traditional housing of Kyoto, and narrow stone slab streets. These historic and traditional buildings are also vulnerable to earthquakes.

The Daihouon Temple is equipped with sprinkler heads on the edge of the eaves; in addition, a firewall has been installed between the street and the traditional housing adjacent to either side of Daihouon Temple. However, earthquake resistance for the traditional buildings and an evacuation plan of this area were not confirmed. The key objectives of the disaster-prevention plan for this area were to improve fire-resistance performance, ensure earthquake resistance for the traditional buildings, and develop an evacuation plan for residents and tourists.

The presence of several traditional stores and the celebration of festivals by many tourists have caused traffic jams to occur frequently. The local community organization and shopping streets try to raise awareness on fire safety for the area, to control the traffic situation during regular hours, and prepare an evacuation plan in the case of an emergency.

The residents' attitude in Daihouon temple area is quite different than in the Kiyomizu Temple and Sannen-zaka area. Indeed, most residents of the Daihouon temple area are elderly. Residents living near the commercial street and running the shops were too busy to participate in discussions on environmental safety, and on how to improve disaster prevention measures. From this case study, it is clear that there is quite a difference in community-based disaster management for traditional historic areas in Kyoto.

Figure 5. View of Daihouon-temple area

Figure 6. Senbon Shaka-do Hall of Daihouon Temple

3.3 Miyoshin Temple Area

Miyoshin Temple was established in 1337 CE. There are 47 temples and shrines located in Miyoshin Temple area. As many old and wooden traditional buildings are located in this area, the Agency for Cultural Affairs and the Cultural properties Division of Kyoto Prefecture have undertaken a three-year project for disaster prevention measures and earthquake resistance retrofitting for important cultural heritage buildings such as Miyoshi Temple as well as all the temples and shrines of Miyoshin Temple area. The neighbourhood surrounding Miyoshin temple comprises a high concentration of old traditional buildings. A key issue here was to address both the Miyoshin Temple area and the old neighbourhood in the community-based disaster mitigation program.

Figure 7. Ryosenan of Miyoshin Temple

Figure 8. Hall of Buddha in Miyoshin-ji Temple

Issues and problems of disaster-prevention facilities in Miyoshin temple Area are listed as follows (Reviewing Committee of Disaster Prevention Measures for Miyoshin Temple 2011):

4. Disaster-prevention measures are too old and lack earthquake resistance performance. It is necessary to upgrade these measures right now.
5. Issues and problems with disaster prevention measures and emergency response include the following:

a. Due to the flammability of the building and roofing materials, fire will spread to other wooden buildings next to Miyoshin Temple by leaping flames.

b. It is difficult to secure enough water resources for firefighting, and to access sufficient water supply from the neighbourhood.

c. There is not enough firefighting equipment provided to residents, and it is difficult to understand if they would be able to operate this equipment in the case of an emergency.

d. Residents are not familiar with water sources and there are no organizations for protection and safeguarding

e. There is no existing coordinated response system between managers of heritage buildings and residents.

It would therefore be quite difficult to coordinate with managers of heritage buildings for firefighting and responding to any other disaster. It is necessary to strengthen community-based disaster mitigation capabilities and strategies.

4 Community-based Disaster Mitigation Program for Traditional Historic Areas in Kyoto City

From 1959 to 1961, Kyoto City positively helped every community by setting up a fire prevention committee. Until 1981, early developed areas in Kyoto City set up autonomous disaster prevention committees according to each school district and established a disaster prevention department for each community to develop fire and disaster management strategies. There were 6,233 autonomous disaster-prevention departments for communities and 277 autonomous disaster prevention committees for school districts. Both of them are under the guidance of the Fire Department of Kyoto City called the 'Kyoto City Disaster Prevention Centre'. Furthermore, the Fire Department of Kyoto City has also cooperated with other public organizations including the Cultural Properties Division of Kyoto City, the Cultural Properties Division of Kyoto Prefecture, the Culture and Education Division of Kyoto City, the Culture and Education Division of Kyoto Prefecture, the Life Safety Planning Division of the Police Bureau of Kyoto Prefecture, etc…, to set up a 'Joint Committee for Cultural Properties of Kyoto' to deal with cultural affairs and heritage-based disaster management in Kyoto. The results were assessed through interviews with the Fire Department of Kyoto City, residents or community leaders of the three historic areas described above.

4.1 Establishment of independent disaster prevention organizations supported by Fire Department

Disaster prevention programmes or plans set up by independent disaster prevention committees including improving fire and disaster prevention knowledge, inspecting neighbourhoods regularly, and implementing routine drill practices for the community. The Fire Department usually holds training courses for leaders within the independent disaster prevention organizations and provides basic rescue equipment to each disaster-prevention committee. The Fire department also promotes local enterprises to cooperate with local disaster-prevention organizations to build relief systems to support each other. Simultaneously, the Fire Department helps the independent disaster prevention department to implement disaster prevention action plans for Kyoto citizens. Through workshops and disaster risk information campaigns, the residents can discuss their community-based disaster-prevention plan based on disaster information or simulation. Finally, the community-based disaster prevention plan can be adjusted based on the results of practice drills.

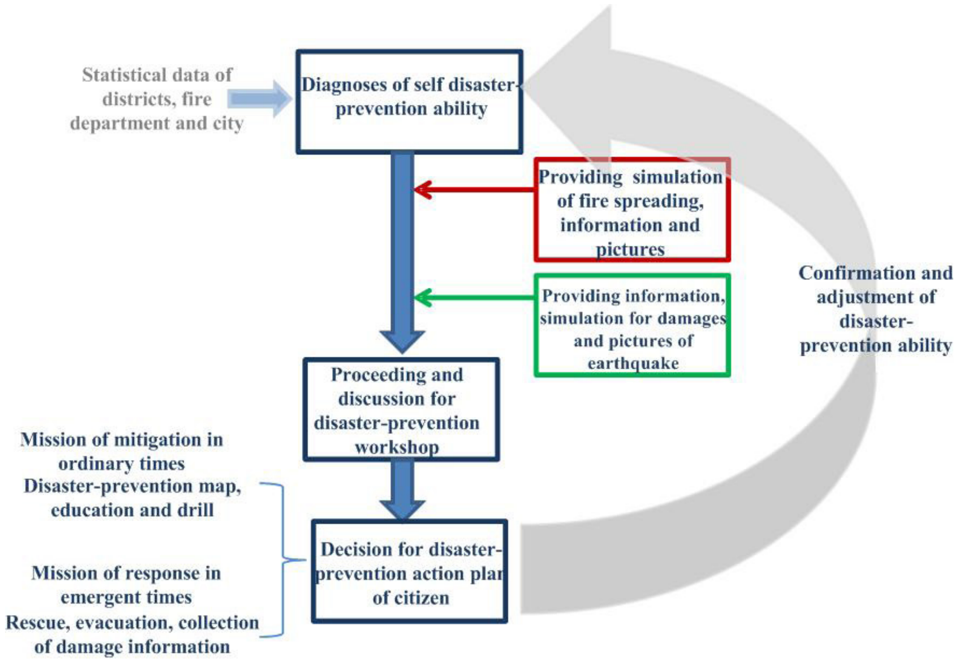

Figure 9. Implementation process of a disaster prevention action plan for Kyoto citizens

4.2 Rescue team of citizens for cultural properties

In 2000, the Fire Department of Kyoto City started to help residents and managers of heritage buildings to set up rescue teams of citizens for cultural properties. The rescue teams are intended to coordinate and cooperate with members of local disaster-prevention organizations, residents, managers of heritage buildings and the Fire Brigade in rescuing cultural artefacts from threatened places, for instance those that are near a fire. This system is supposed to build partnerships of self-reliant, collaborative and public support. By the end of 2009, it had achieved the goal of setting up rescue teams in 235 communities. The mission of rescue teams at ordinary and emergency times are shown as follows:

1. Mission during ordinary times

a. To publicize and implement community-based fire and disaster prevention with volunteer fire brigades

b. To confirm usage of disaster prevention facilities with managers of heritage buildings

c. To take precautions against fire, theft and high-risk events such as festivals

d. To carry out regular inspections

2. Mission during emergencies:

a. To confirm fire and to report it in time to managers of heritage buildings, residents and members of the rescue team

b. To dispatch the rescue team

c. To support initial fire extinguishing, to remove the cultural artefacts to safety, and provide evacuation guidance.

d. To provide information to the fire brigade

e. To collaborate with the fire brigade and volunteer fire-fighting team

In April of 2011, the rescue team of citizens for cultural properties began to support the Fire Department of Kyoto City to implement projects of 'Safety Card' and 'Tagging' of cultural artefacts. The 'Safety card' systems consists of preparing in advance a map locating all cultural artefacts and includes information related to their relocation, the persons responsible for the relocation, pictures of the artefacts and any damage which may have occurred. When a fire happens, a commander at the fire location, fire fighters, managers of heritage buildings, members of rescue team and independent disaster prevention organizations will compare the safety card and the tag to quickly rescue the cultural artefacts.

4.3 Drills in traditional historic areas

26th January marks disaster prevention for cultural properties day. On this day and in each important preservation district of heritage or traditional buildings, the firefighting team, managers of heritage buildings, and residents of the community hold fire and disaster prevention drills simulating different scenarios. This is also done in Kyoto City. Considering the past experiences with disasters and the damage inflicted on cultural properties and given the eagerness to protect cultural properties, human safety, etc., each manager of important heritage buildings decides on the scale, date, times, participants and topics for holding fire and disaster prevention drills including using disaster simulation games as drills [FIGURE 10] and fire drills in cultural properties [FIGURE 11].

Figure 10. DIG for fire fighters and residents.

Figure 11. Fire drill in Kiyomizu Temple

5 Analysis of the Experience with Self Disaster Prevention in Preservation Districts in Kyoto City

Based on the analysis of the case studies on fire prevention and disaster prevention in historic areas in Kyoto City, several lessons were learned. When we discuss the fire prevention for heritage buildings and historic areas, the local community should be involved in safety preparedness and cooperation with managers of heritage buildings, residents, the public sector, and experts to strengthen their disaster prevention capability. The following factors are affecting the implementation of disaster prevention programs in historic areas with a high concentration of heritage buildings in Kyoto City.

5.1 Past experience of conflagration within local communities and different types of heritage buildings

The past experiences of conflagration has had a significant influence on the promotion of fire and disaster prevention awareness. For example, there are 10 national treasures and important cultural properties in the Kiyomizu Temple area. Nearby residents regard the preservation of cultural properties as a duty. Moreover, the Agency for Cultural Affairs and the Cabinet Office designed for these communities a disaster prevention pilot project which made the local disaster prevention activities go much more smoothly.

5.2 Leadership in local community and changes in demographics

Most traditional historic areas have a problem of being comprised of an elderly population resulting in a low rate of population growth. How to improve the participation rate in disaster prevention efforts is an important issue. However, some communities are enthusiastic and staff within local communities can lead residents to participate in disaster prevention efforts by linking them with their daily life.

5.3 Regional development combined with local industries and businesses

Taking the Kiomizu Temple area for example, the stores located on both sides of the pilgrimage route called Sannen-zaka are important sources of income from tourism. For this reason, the members of the Chamber of Commerce have spontaneously joined the disaster prevention organization and keep patrolling the area. As a result, business, tourism, and disaster prevention can be carried out and be sustained through this cooperation;

5.4 School districts are considered in the cooperation

Since a school district was a unit used to promote fire prevention in the earlier period, the activities inherited from this past experience have ensured that disaster prevention is carried out successfully. However, recently, due to the low rate of population growth and fewer children, school districts have merged and this has weakened the promotion of disaster prevention efforts. How to lessen the impact of fewer babies is an important issue for the sustainability of disaster prevention activities within local communities.

5.5 A variety of drills

The Fire Department of Kyoto City holds fire drills in communities where important cultural properties and national treasures are located and these simulate different scenarios such as making use of firefighting facilities, teaching elementary school students about fire prevention, practicing with water hosing for heritage buildings, evacuation of tourists, and removal of important cultural artefacts. These drills, have strengthened awareness of disaster prevention for students, tourists, and residents and have also targeted different needs in disaster prevention planning.

5.6 To implement in daily life

Promoting disaster prevention should be a habit cultivated in the various aspects of daily life of residents in traditional communities. For instance, residents near Kyomizu Temple should be conscious of their daily water consumption so that it does not impact the water supply system for firefighting purposes. Raising awareness on this issue can be done through fire prevention drills.

6 Conclusion and Suggestions

Based on the outcome of these investigations and interviews, we have learned that the implementation of fire and disaster prevention for cultural properties in Japan was initially launched by the central government integrating the management of cultural properties within disaster prevention planning. Later, several laws on firefighting were issued to address the basic requirements for fire and disaster prevention. Finally, implementation for conservation and safety measures for heritage buildings was carried out by local governments, managers of heritage buildings, and residents in communities. [TABLE 2]

TABLE 2. Contents of disaster-prevention program for historic areas

Items of action adopted directly by local government	Items used to support historic community indirectly
1. Construction of underground cistern for disaster prevention, establishment of a command centre for disaster prevention, and a store for equipment	1. Installation of warning system and communication system for emergencies
2. Gathering of equipment for disaster prevention	2. Construction of fire blocks
3. Installation of family-size hydrants	3. Ensuring that evacuation routes are kept clear
4. Installation of extinguisher throughout the historic areas	4. Diagnosing the anti-seismic resistance of buildings
5. Planning of water-supply facilities, evacuation routes, and shelters	5. Strengthening the anti-seismic resistance of buildings
6. Preparation of educational materials on disaster prevention	6. Installation of street lighting for crime prevention
7. Purchasing water and food emergency supplies	7. Publicizing the formation of the disaster-prevention organization and its activities
	8. Others (e.g. planning the evacuation of tourists)

The following figure illustrates the procedures for disaster prevention for historic buildings and the historical areas in Kyoto City. [FIGURE 12]

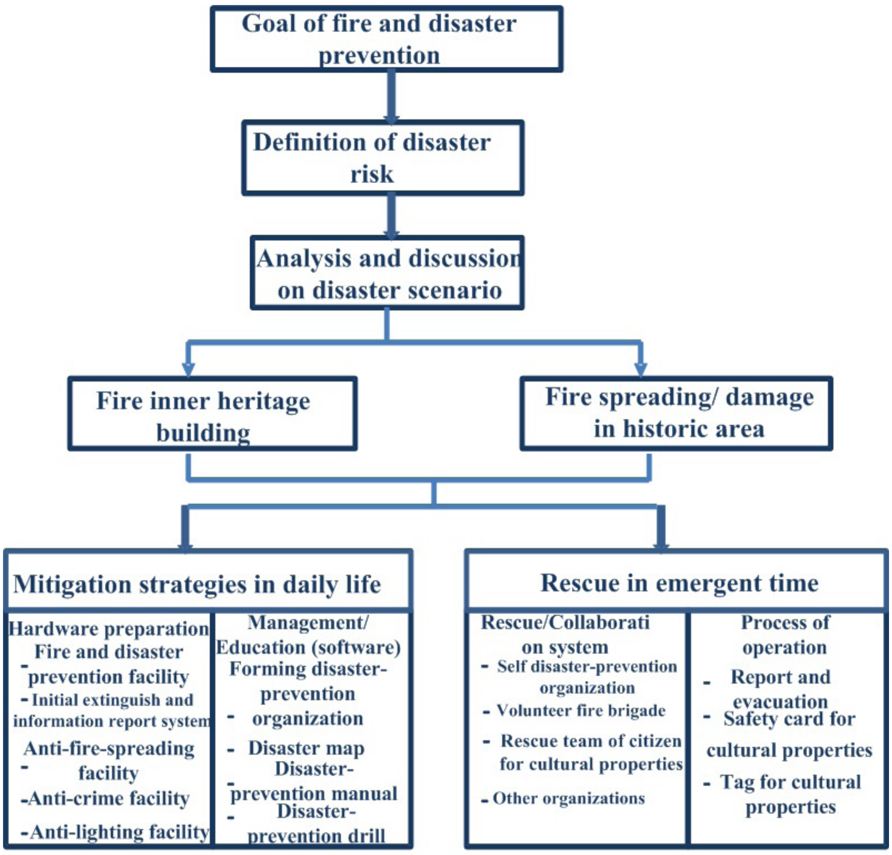

Figure 12. Mechanism for promoting fire and disaster prevention programs for heritage buildings and historic areas in Kyoto City

7 Strategies of disaster prevention under various conditions and cooperation across various departments

Based on the cooperation between the Kyoto Prefecture, Kyoto City, and Non-Governmental Groups, 11 organizations created the ‘Joint Committee for Cultural Properties of Kyoto’ to deal with issues of fire and disaster prevention for cultural properties and heritage buildings. The Fire Department of Kyoto City also set up a special unit named the Division for Cultural Properties Safety to focus on the works of disaster prevention for historic buildings and education. The outcome shows that disaster prevention for heritage buildings not only needs legislation proposed by the central government to impose safety criteria, but also requires the cooperation across departments from local governments to private organizations. The collaboration from various fields such as culture, tourism, safety and so on for building disaster prevention strategies would be important viewpoint in the future.

7.1 Necessity of disaster-prevention cooperation within local communities

Due to heritage buildings located in traditional historic areas, to build links within the community and residents to protect historical buildings becomes the key for local disaster-mitigation strategies in historic communities. Managers of heritage buildings in historic areas should define their own responsibilities, and then distribute tasks to residents, volunteers, firemen, community committee members, business committee members, citizen rescue teams for cultural artefacts. They should initiate education campaigns and drill for fire and disaster prevention, discuss important issues, and strengthen the community's capabilities of disaster prevention.

7.2 Disaster prevention strategies for historic areas to correspond with local issues and needs

Because the needs of residents in each historic area are different, the requirements for disaster prevention of residents are not the same either. Moreover, the level of significance of heritage buildings varies which leads to different attitude within residents. For example, Kyomizu Temple is on the World Heritage List and has a direct impact on stores and residents nearby. Residents regard conservation of cultural properties as their duty. On the other hand, the elderly residents living near the Daihouon Temple lack the enthusiasm to deal with the conservation of heritage. In the area of Miyoshin Temple, there is a lack of cooperation between the local government and residents when practicing drills for disaster prevention in heritage buildings. The cases addressed above show that different communities should have different disaster prevention strategies that are adapted to the community and the particular characteristics of the heritage buildings or historic areas.

From the experience in Kyoto, the development of disaster prevention for cultural heritage is influenced by experience of suffering through other disasters, the level of significance of the heritage building, changes in demographics, and leadership within the local community. Furthermore, local businesses, tourism, and cultural activities combined with daily life and various practice drill scenarios also affect the effectiveness of disaster prevention planning. Other Asian cities, such as on mainland China or Taiwan, can learn some lessons from the experience in Kyoto City because they both have heritage buildings and cultural properties in similar traditional and historic areas.

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Seismic Damage Causes and Strengthening Methods of Free-Standing Museum Cultural Relics

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Abstract. In order to protect museum cultural relics, causes of seismic damage as well as seismic strengthening methods for free-standing museum cultural relics were studied as the subject of this paper. Museums, cultural relics and their mounts were assessed to investigate the causes of damage to free-standing relics. Deficiencies in traditional domestic seismic strengthening methods were discussed, and foreign isolation techniques were introduced. Based on 2 typical examples, reasonable strengthening methods for museum cultural relics were further demonstrated. Results show that the main causes of damage to museum cultural relics during earthquakes relate closely to overly strong earthquake intensity, insufficient strengthening measures to the cultural relic, destruction of the display case or to the museum building and so on; museum, display cases, and the cultural relic itself are all important elements requiring seismic strengthening. To effectively protect cultural relics, traditional strengthening methods must be improved, and new isolation techniques must be developed and applied.

1 Introduction

Museum cultural relics are important parts of movable cultural heritage and worth protection for their historical and artistic values. As these cultural relics usually are free-standing, they can be easily damaged during earthquakes. A well-known example is the 8.0 magnitude Wenchuan earthquake on May 12th, 2008 in China, which caused damage to at least 3,169 movable cultural relics in 216 museums, and led to a huge loss of movable cultural heritage. Earthquake damage to museum cultural relics is usually due to sliding, swaying and overturning; some relics even fall off their bases and shatter. [FIGURE 1] Thus, it is important to strengthen these cultural relics without delay. To mitigate seismic damage to museum cultural relics, the causes of damage as well as strengthening methods for these relics are discussed subsequently; the results of this study will be helpful in protecting movable cultural relics in the future.


(a) on display


(b) in storehouse


(c) outdoors

Figure 1. Damage to museum cultural relics

2 Causes of Damage

Following a survey and analysis of results, it was found that the main causes of damage to museum cultural relics under earthquakes include the following (Zhou and Yan 2010, Wei and Chen 2008, Spyrakos et al. 2008):

1. Earthquake of powerful intensity: if the earthquake force exceeds static frictional forces between the cultural relic and its base, or if the seismic moment of the earthquake exceeds the resisting moment of the cultural relic, the relic will slide or sway.
2. Lack of early strengthening: as museum cultural relics are usually free-standing, they can be easily damaged during earthquakes, and especially unstable relics if timely strengthening measures are not undertaken [FIGURE 2a].
3. Damage to display cases during earthquakes, overturning or destruction of display cases may cause damage to the relics within [FIGURE 2b]

4. Damage to the museum building: if a museum building cannot resist seismic vibrations, collapse of its roof or walls, or collapse of its components may destroy the cultural relics [FIGURE 2c]

(a) lack of strengthening

(b) overturned showcase

(c) building collapse components

Figure 2. Cause of damage to cultural relics

3 Strengthening Methods

3.1 Traditional methods

In China, traditional techniques have mainly been chosen to strengthen museum cultural relics, such as enhancing the connection between the cultural relic and its base by bonding, supporting, adhering, and other measures (Zhou et al. 2010). Typical traditional methods include:

1. Decreasing the centre of mass of a cultural relic by filling it with objects. [FIGURE 3a]
2. Propping the cultural relic by providing side support to enhance its stability. [FIGURE 3b]
3. Connecting the cultural relic to its base with adhesive materials to reduce the amplitude of the vibration of the relic during earthquakes. [FIGURE 3c]
4. Setting plastic fasteners against the bottom of the cultural relic to restrict its displacement during earthquakes. [FIGURE 3d]
5. Connecting the top part of the cultural relic and its base by nylon lines to enhance its stability. [FIGURE 3e].
6. Using shock absorption material to mitigate vibrations of the cultural relic. [FIGURE 3f]

The advantage of these traditional strengthening methods is that they are low cost, easy to install, and mitigate effectively vibrations of the cultural relic. Traditional strengthening methods also have disadvantages as they may incur damage to the cultural relic, affect the visual appearance of the object and the quality of its presentation in an exhibition, and can have low strengthening results, etc..; thus the application of these methods is limited.

(a) lack of strengthening

(b) overturned showcase

(c) building collapse components

(d) Fastening

(e) nylon line fixation

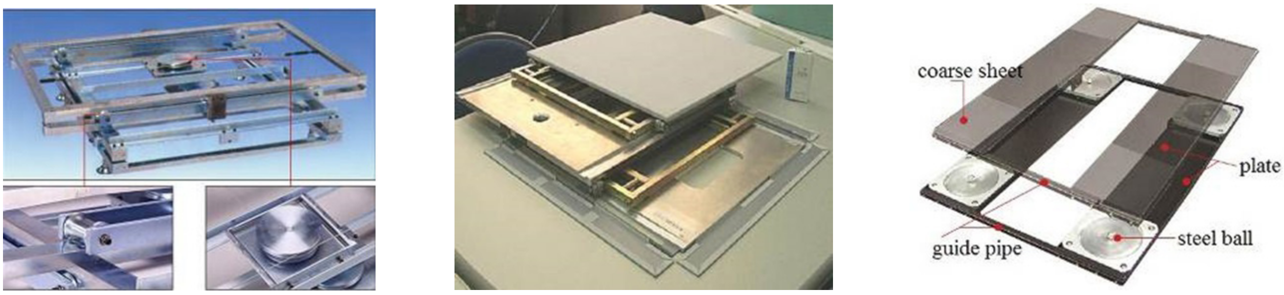
(f) shock absorption material

Figure 3. Traditional strengthening methods

3.2 Isolation device

The development of earthquake isolation systems has made it possible to find applications for isolation devices in the field of cultural relics' protection. In Japan, United States of America and other countries, various types of isolation devices for museum cultural relics have been developed. They are placed under the cultural relics or display cases, they can also minimize the natural frequency of earthquake waves, and absorb part of the earthquake energy; the relics can thus be well protected (Zhou, Yan and Ji 2012). In general, these devices can isolate earthquakes in horizontal, vertical, or 3-dimensional planes. Typical horizontal isolation devices include:

1. 'Roller type', which is composed of concave-shaped rails, rollers, dampers and so on. [FIGURE 4a] When two such devices are installed orthogonally in a vertical direction, horizontal isolation can be achieved.
2. 'Wheel type', where the main difference from the 'roller type' is that rollers are replaced by wheels. [FIGURE 4b]
3. 'Ball type', which isolates earthquake waves through the motion of the rolling balls between two layers of concave plates [FIGURE 4c]. At rest, each ball stays at the centre of the concave surface of the plate. When an earthquake occurs, the ball freely rolls along the concave surface, while the relic above stays balanced in a horizontal plane. As the natural period of the device only depends on the curvature of the concave surface, cultural relics of different weights may then be displayed.



(a) roller type (b) wheel type (c) ball type

Figure 4. Horizontal isolation devices

Typical vertical isolation devices include:

1. Parallel link system, which is composed of parallel links, hinges, horizontal and vertical springs, tables, dampers, etc… [Figure 5a] During earthquakes, the parallel links rotate simultaneously, which makes the table shift horizontally and vertically; the relic on the table can remain stable throughout the earthquake.
2. Negative stiffness system, which is composed of parallel links, extension spring, negative stiffness links, a table etc… [FIGURE 5b] The isolation mechanism of the negative stiffness system entails that during a vertical earthquake, the spring extends and increases the angle between the table and the link; however, the vertical support force of the link on the table decreases. This type of device cannot only reduce static deflection of vertical springs caused by their own gravity and that of the cultural relic above, but it also gives a low frequency for isolation.
3. Air spring system, which is composed of parallel links, table, guiders, air spring, air chamber, etc… [FIGURE 5c] Under vertical earthquakes, the air spring can produce a low frequency for the whole device, and also mitigate static deflection problems.

If a museum building is destroyed during an earthquake, collapsed components may also destroy cultural relics within it. Isolation measures therefore also need to be applied to museum buildings if conditions permit. Typical isolation devices for museum buildings include laminated rubber bearing, sliding bearing, rolling pendulum bearing and so on (Zhang 2002).

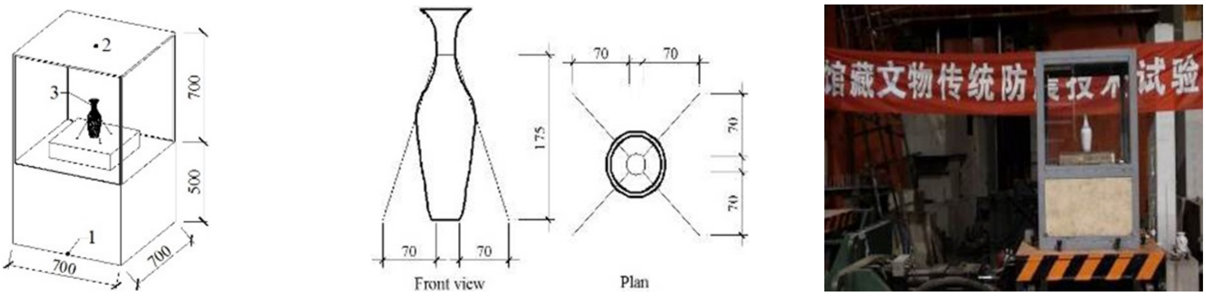
(a) parallel links (b) negative stiffness (c) air spring

Figure 5. Vertical isolation devices

4 Examples

4.1 Traditional strengthening method

In this example, the effectiveness of nylon lines in reinforcing traditional strengthening methods for museum cultural relics was tested (Zhou, Yan and Ji 2011). A display case model, measuring 700 × 700 × 1200 mm (length × width × height) was built. [FIGURE 6a] Four nylon lines were used to strengthen the relic. Each line had a diameter of 0.18 mm and an elastic ratio of 62.5 N/m. When strengthening the cultural relic, one end of the nylon line was affixed at the top of the cultural relic top, while the other end was affixed onto the display stand. [FIGURE 6b] Boundary conditions for different models are: the relic is free-standing (or fixed by nylon lines) on a display stand; the display stand was fixed to the display case which was free-standing and placed on a shaking table. [FIGURE 6c]



(a) size of showcase (unit: mm) (b) size of nylon lines (unit: mm) (c) display case on shaking table

Figure 6. Test models

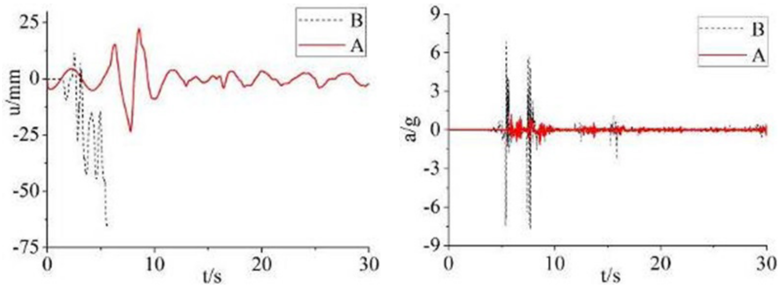
By simulating El-Centro earthquake waves with intensities of Peak Ground Acceleration (PGA) equalling 0.1 g, 0.2 g, 0.4 g and 0.7 g (where 'g' refers to the Earth's gravity, 1 g = 9.8 m/s^2), for a duration of 30 seconds, and space time interval of 0.02 s, it was found that:

1. For a cultural relic that was not strengthened, when the PGA was less than 0.4 g, it retained a stable vibration status; however, when the PGA was equal or exceeded 0.4 g, the cultural relic vibrated a great deal and quickly overturned due to the powerful amplitude. [FIGURE 7a]
2. After the cultural relic was strengthened with nylon lines, its swaying amplitude remained small during the earthquake simulation. It retained a stable vibration status even when PGA equalled 0.7 g. [FIGURE 7b] This shows that nylon lines can mitigate the oscillation response of cultural relics and can protect it from overturning by providing additional moment of resistance.

(a) before strengthening (b) after strengthening

Figure 7. Test phenomena

Figure 8 plots the response curves of the relic when PGA equalled 0.7 g of earthquake intensity, where 'B' represents the data for the cultural relic before strengthening and 'A' represents the data for the cultural relic after strengthening. It is clear that after strengthening with nylon lines, peak values of both displacement and acceleration responses of the relic decreased, and the response curves were also more stable. When PGA equalled 0.7 g, the peak acceleration response value of the strengthened relic was 1.18 g.

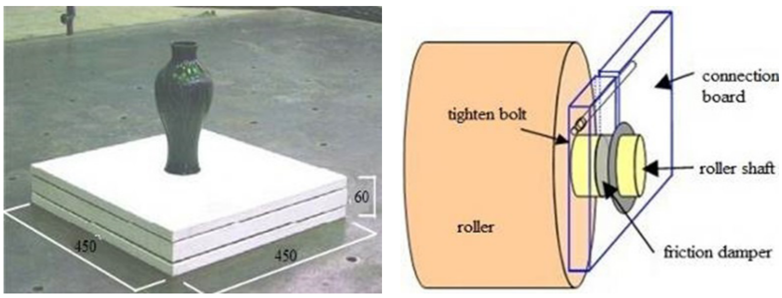


(a) displacement (b) acceleration

Figure 8. Seismic response curves of the cultural relic

4.2 Isolation method

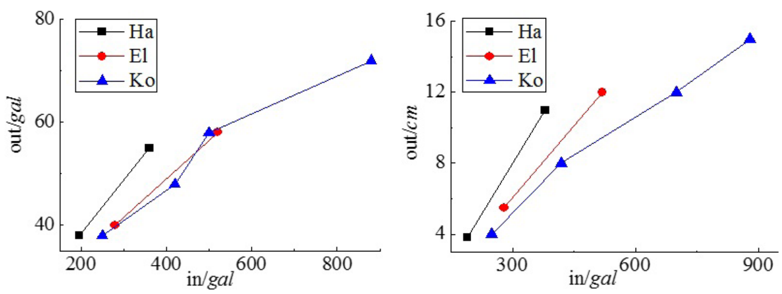
Figure 9a shows a type of isolation device developed by Okumura Corporation (Japan), which is used for small museum cultural relics. The device measures 450 × 450 ×60 mm (length × width × height).It is composed of two layers of cosine curve shaped rails, rolling wheels, dampers, etc… Both layers of components are set in orthogonal directions so that they can isolate earthquakes in 2 directions in horizontal plane. During earthquakes, the wheels of the device roll along the curve rails to avoid the natural period of the earthquake waves, and then the device restores to the original location by its own gravity. The damping force of the device is provided by restriction of tightening the bolt to the connection board which is about 5% of the device weight. [FIGURE 9b]



(a) Isolation device (b) sketch of damper

Figure 9. Roller type of isolation device

By inputting El-Centro, Kobe and Hachinohe earthquake waves to the device, peak response values of displacement and acceleration of the relic above are obtained [FIGURE 10] where 'in' represents 'input', 'out' represents 'output'. It is clear that the peak acceleration value of the cultural relic is about one tenth that of the input earthquake waves. For example, when PGA equals 0.88 g, the peak acceleration value of the relic is only 0.07 g, while its peak displacement value is 15 cm (within permission scope).Thus the device has a good aseismic performance. In comparison to nylon lines used in sample 1, the roller type of isolation device appears to be more effective.



(a) acceleration (b) displacement

Figure 10. Peak response values of cultural relic

5 Conclusions

1. Causes of damage to museum cultural relics during earthquakes relate to earthquake intensity, whether the relic is strengthened, the stability of the display case, as well as aseismic performance of the museum building.
2. Although Chinese traditional strengthening methods for museum cultural relics have advantages in that they are easy to install and are low cost, they have shortcomings and can sometimes cause the destruction of a cultural relic, affect the presentation of the object in an exhibition, and can have poor strengthening effect on the cultural relic.
3. Isolation devices can fully protect cultural relics. Their development and application is also low-cost and a much more effective means of protecting cultural relics during earthquakes.

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3D Simulation and Integral Evaluation of the Lightning Protection System at the Architectural Complex of the Palace Museum

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Abstract. As the largest and best preserved historical palace complex so far existing in the world and one of China's most important properties inscribed on the World Heritage List, the Forbidden City with its complex timber structure system and high cultural heritage significance has been the subject of important lightning protection research. Many disasters in the Forbidden City's history were caused by thunder and lightning; entire buildings were even burnt down. In 1925, the Palace Museum was established as an institution. Power supply services, fire safety services and related metal wiring were installed then, which increased the risks of lightning strike.

The current design of lightening preventive measures does not provide comprehensive lightning protection at a particular area, causing duplicated layouts and omissions. In addition, the installed protective system affects the integral aesthetics of the architecture. At present, the lightning guards with rod or strip can protect the buildings only partially from lightning strike. Although the safety inspections of the lightning guards follow a protocol and are systematically documented, the outstanding historical and architectural significance of the Palace Museum complex warrants that lightening protection not only be installed on the large halls, but also on the small pavilions, corridors and historic trees.

This paper will show how the use of advanced photography and 3D modeling can virtually display and integrally evaluate the extent of the current lightning protection system in place at the architectural complex of the Palace Museum. In addition, the paper will review the protection capacity of the current system and identify its deficiencies. The 3D modeling method can provide graphic evidence to inform decision makers of where modifications of the lightning protection system are required as well as serves as a reference for developing design principles and specifications for the lightning protection of historical Chinese architectural complexes.

1 Introduction

The Palace Museum in Beijing, also known as the Forbidden City, is the largest and the most complete timber-framed architectural complex to date. In 1987, it was inscribed on the World Heritage List.

According to literature of the Ming and Qing dynasties, at least 29 serious lightning related accidents occurred in the Palace Museum, and more than ten have occurred there since the founding of the People's Republic of China. The damage caused ranged from mild damage to decorative tiles to severe destruction of entire buildings.

The expected number of lightning strikes per year at the Palace Museum was calculated using the national standard GB50057-2000 Design code for protection of structures against lightning (2011 Edition). Taking into account meteorological data and the fact that the Palace Museum is located in a vulnerable region where lightning is more frequent, as well as selecting values corresponding to the formula mentioned in the national standard, it was found that the expected number of lightning strikes per year at the Palace Museum was about 3 to 4 times. The main contributing factors are the following:

a. The Palace Museum is surrounded by a 50 metre wide moat, the Jinshui River traverses the Forbidden City and its network of underground streams passes under the entire Site;

b. The Palace Museum's entire foundations were laid on top of this network of streams and consist of a multi-layer artificial backfill of a mixture of 3 parts quicklime and 7 parts earth. This mixture has good water resistance, high resistance value and therefore low conductivity.

c. There are many plants and tall old trees in the Palace Museum, which have a high water content and wet soil.

These factors contribute to a mixture of both resistance and conductivity of the site, thus not providing a direct channel for the lightning current to run through vertically from point of contact to ground, favouring frequent lightning accidents under adverse weather conditions.

2 Overview of Lightning Protection at the Palace Museum

The lightning protection project for the historical architecture of the Palace Museum was first proposed in 1955. Targeting the architectural details of the Palace Museum, the important buildings in the Palace Museum were equipped with lightning rods in 1957, 1958, 1960-1965, 1984, 1990 and other subsequent years. In 1991, the Palace Museum developed The Regulations and Procedures on Lightning Protection in Beijing Palace Museum, which fully describes the overall planning, design code, maintenance and management methodology for lightning protection in the Palace Museum. In 1993, monitoring stations for the lightning protection devices were set up at the Department of Architectural Heritage of the Palace Museum by the State Administration of Cultural Heritage (SACH). These stations were used annually to test the devices and exclude potential risks of malfunction. Until 2000, a team of relentless staff equipped most of the buildings at the Palace Museum with lightning protection devices. This protection system has had satisfactory results in achieving effective lightning protection for more than fifty years. The existing lightning protection devices, which are mainly strip lightning guards, but also include lightning rods, have ensured the protection of the buildings to a certain extent.

3 Architectural Characteristics and Limitations of the Present Lightning Protection System in the Palace Museum

The architectural complex of the Palace Museum is composed of various sized single buildings and structures such as the 38 metre high Meridian Gate, 3 metre high houses, large single buildings surrounded by open plazas such as the Hall of Supreme Harmony, and large districts like the Imperial Garden and the Palace of Tranquil Longevity with its pavilions, apartments, gates and gardens. The latter account for 7.6% of the total area of the Palace Museum. [FIGURE 1]

Figure 1. Bird's eye view of the Imperial Garden

Within the six courtyards in the East and the six courtyards of the West, the only air-termination system installed has been the lightning rods placed on the decorative glazed animals at both ends of the top baluster of the tallest hall. The location of these two lightning rods is based on the priority to protect taller buildings and on the assumption that they can cover the entire courtyard of that particular location if they are in compliance with the design specifications.

It was historically recorded that electrical lighting was introduced in China in December 1908, during the reign of Emperor Guangxu of the Qing dynasty. Following the Palace Museum's establishment in 1925, telephone lines and other electrical lines were installed in the complex. The earliest indoor lines were affixed with porcelain clamps, porcelain columns, and porcelain bottles. The main conduit was laid outside. The architectural complex of the Palace Museum was not originally equipped with pre-laid infrastructure; the present infrastructure was gradually installed as needed. Most of the high and low current lines were laid outside along walls or buildings – most were installed on walls or ceilings, inside or outside, in order to protect the timber frame of the buildings. The majority of conduits were made of metal. In addition, metal was generally used for decoration during this period. Electronic equipment such as data storage servers were also installed to support the growing number of offices within the Palace Museum. These above factors have greatly increased the risk of lightning strikes.

In the Palace Museum, the existing lightning rods and strap lightning protectors have been installed in the following three situations:

a. For the gable and hip roofs, two lightning rods were installed on the glazed ceramic animal charms at either ends of the ridges;

b. A single lightning rod was installed on a pyramidal Cuanjian-type roof;

c. Metal roofs and metal roofing elements were used as an air-termination system.

At present, a large number of wires for these lightning protection devices are hidden under the imbrexes of the overlapping roof tiles to minimize visual impact on the historic buildings. The existing lightning protection system is outdated and the level of protection is incapable of reaching current regulatory requirements due to changes in climate, as well as constant modifications and improvements to the Design code for the protection of structures against lightning and local industrial standards. It is therefore necessary to update the lightning protection devices to ensure the comprehensive protection of the complex.

At present, the protection coverage of air-termination protectors in the Palace Museum have been calculated using the rolling sphere method. This method determines the protection coverage in the following five cases: single lightning rod, double equal altitude lightning rods, double non-equal altitude lightning rods, strap type lightning protectors, strap type lightning protectors used in conjunction with lightning rods. The calculated protection coverage of air-termination systems is only applicable to a single building. Whereas for historic buildings, the protection coverage should be considered for the entire area of architectural complex.

The construction drawings of lightning protection devices should be designed and drawn to fulfil the following five requirements:

a. The main drawings for external lightning protection facilities should be composed of detail drawings for air-termination system placement, down-lead laying, shielding and grounding devices.

b. The positions of air-termination systems should be shown in elevation drawings.

c. The lightning protection coverage of hazardous areas should be clearly shown in the drawings.

d. The lightning protection coverage drawing should show the position and height of the air-termination systems in the buildings.

e. The lightning protection coverage area drawings should be both in plan and in elevation.

If the above design requirements are fully implemented, the drawings will include 2D plans, as well as points and lines in elevations of the lightning protection devices and their protection coverage [FIGURE 2]. For non-professionals in lightning protection, it is very hard to check if any defect exists in a design and layout that is solely based on the lightning protection coverage of a single building or the rolling sphere method in conjunction with traditional diagrams and specifications. Any defect in design and layout may increase the risks of lightning induced disasters. Duplicating layouts to compensate for deficiencies is not only costly, but also affects a building's aesthetics.

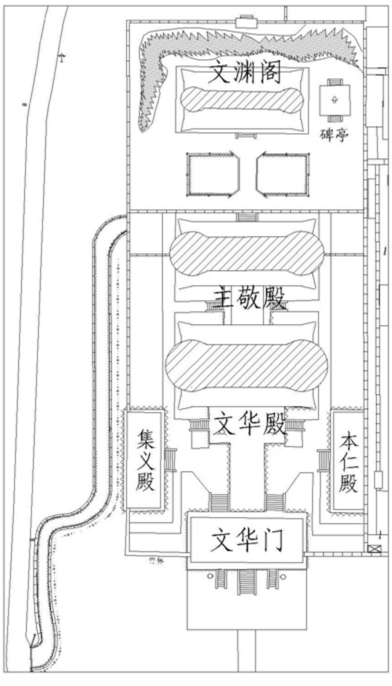

Figure 2. Schematic diagram of an air-termination system's vertical protection scope and horizontal protection coverage

4 3D Modelling of the Lightning Protection System at the Architectural Complex of the Palace Museum

At present, it is not sufficient to comprehensively evaluate the capability of the overall lightning protection of the complex based on the lightning protection design in place. In order to solve this problem, the Hall of Literary Brilliance was chosen as a case study. The Hall of Literary Brilliance is a complex comprised of several buildings and structures. Using a 3D virtual reality software, a model of the buildings and structures was created based on data collected on site. Data from the existing lightning protection device was also obtained. The model shows the lightning protection system in place in order to visualize the lightning protection coverage from various perspectives and identify defects and problems in the system's layout and design.

The Hall of Literary Brilliance has been equipped with the following lightning protection devices [FIGURE 3]: on the Hall of Literary Brilliance itself, one lightning rod on each glazed animal charm on both, east and west, ends of its roof ridge, one strap type lightning protector on its top ridge, and one deflector on the west side; on the rear palace (Zhujing Hall), one lightning rod on each glazed animal charm on both, east and west, ends of the its roof ridge, one strap type lightning protector on its top ridge, and one deflector on the west side; on the Hall of Literary Profundity, one lightning rod on each glazed animal on both, east and west, ends of its roof ridge, one strap type lightning protector on its top ridge, and one deflector on the east side.

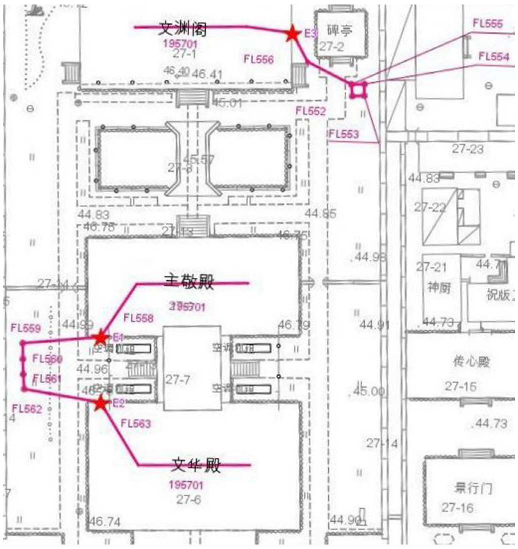

Figure 3. Schematic plan of lightning protection devices at the Hall of Literary Brilliance

From April to May, SACH's safety monitoring stations made routine tests and inspections on all lightning protection devices in the Palace Museum before the annual rainy season, and the existing testing data for 2012 are as shown in Table 1.

TABLE 1: Testing data of lightning protection devices in the Hall of Literary Brilliance in 2012

No.	Bld. name	Height	ATS height	ATS type	Earth pole well	Installation time	Down-lead type and material	Down-lead	Grounding resistance	Earth pole material
1	Hall of Literary Brilliance	17.6	18.8	rod	2	1957	12mm copper wire	1	2.44	Iron pole
2	Zhujing Hall	15.4	16.8	rod	2	1957	12mm copper wire	1	1.44	Iron pole
3	Hall of Literary Profundity	20	21	rod	4	1957	12mm copper wire	1	2.65	Iron pole

4.1 Research Steps

Research for the project was conducted in the following four phases:

4.1.1 Obtain the basic data on buildings and lightning protection devices in the Hall of Literary Brilliance

The following instruments were used to collect basic data through on-site measurements: total station, laser rangefinder, basic measurement tools, and SLR digital cameras. The error in three-dimensional modelling can be reduced if data is collected directly in the field than from existing drawings in order to accurately capture all the building details.

Parameters for the lightning protection devices is indexed and entered into the 2D diagram. A user can click on a point or line to read out the related information. [FIGURES 4 and 5]

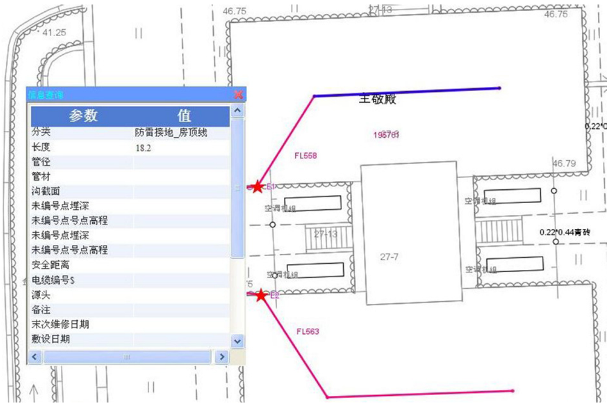

Figure 4. Schematic diagram of information parameters queried for lightning protectors in Zhujing Hall

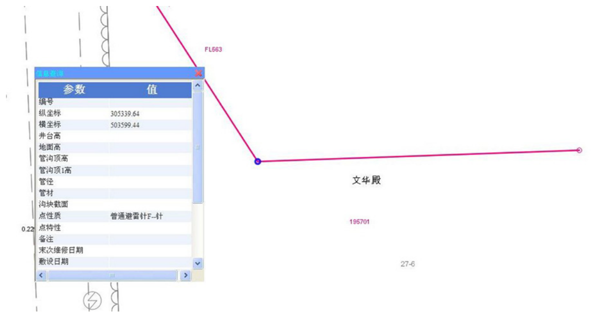

Figure 5. Schematic diagram of information parameters queried for western lightning rods in the Hall of Literary Brilliance

4.1.2 Create the 3D model of the building complex at the Hall of Literary Brilliance

The 3D model was created using the basic data collected on site.

4.1.3 Generate the protection coverage of air-termination systems in the 3D model

The geometry of the protection coverage of a single lightning rod looks like a spire conical tent or an unfurled umbrella. The internal space of the cone is the protection coverage of the lightning rod; therefore, the protection coverage of several lightning rods is represented geometrically by the calculated overlap of multiple cones. It is possible to calculate the protection coverage of air-termination systems at the Hall of Literary Brilliance, Zhujing Hall, and Hall of Literary Profundity respectively based on the building height, the air-termination system's height, and the rolling ball method formula. A CAD software can generate a 3D model based on this calculation. [FIGURE 6]

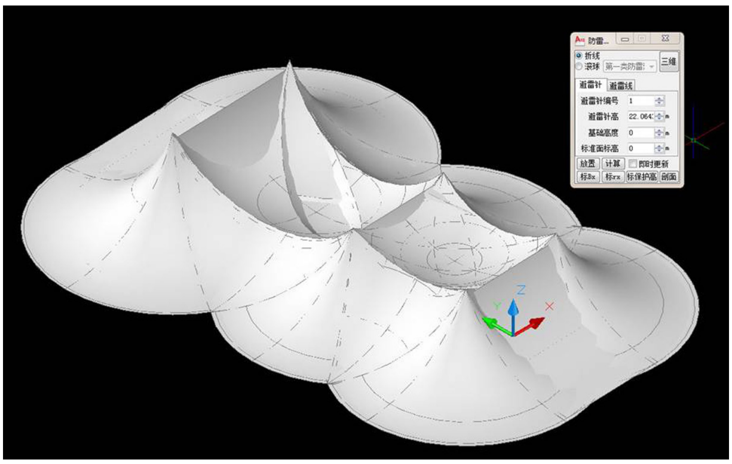

Figure 6. 3D schematic diagram of comprehensive coverage of lightning protection devices at the Hall of Literary

4.1.4 The lightning protection system is simulated in 3D

The 3D model of the lightening protection coverage was overlaid on the 3D model of the Hall of Literary Brilliance in a bright blue colour. It was thus possible to view the protection coverage from any angle. [FIGURES 7 and 8]

Figure 7. 3D simulation schematic diagram I of comprehensive protection coverage of lightning protection devices at the Hall of Literary Brilliance

Figure 8. Brilliance 3D simulation schematic diagram II of comprehensive protection scope of lightning protection devices at the Hall of Literary Brilliance

The blue area represents the area of protection coverage where the buildings are fully protected by the installed lightning protection devices. Any building outside the blue region is not protected. Using this simulation method, the deficiencies in the protection coverage can be clearly identified.

4.2 Results

It was found through this simulation that the lightning protection devices at the Hall of Literary Brilliance do not meet the safety requirements for lightning protection for this architectural complex. The top and trunks of trees as well as many of the buildings themselves fall outside the protection coverage area and are also exposed to risks. [FIGURE 9] In the case of a lightning storm, these areas are completely unprotected by the lightning protection devices in place and may be struck by lightning in all probability.

A taller or single tree is very vulnerable to lightning. Given the large number of old trees at the Palace Museum, lightning not only can harm old trees by bark peeling or causing serious fires, but can also be a serious threat to the nearby historic buildings and as well as the Palace Museum staff. A lightning surge can affect high and low current equipment used in a building and cause equipment failure or direct damage to the Museum staff. Therefore, inadequate lightning protection will result in costly damage.

Heritage conservation staff can put in place the appropriate preventive measures by utilizing the 3D modelling and simulation approach to ensure the lightning protection of any building or tree within the architectural complex of the Palace Museum. This approach can also be used to determine a cost-efficient protection program by identifying the gaps in protection coverage, ensuring that these gaps are covered by developing protective measures for such elements at risk (like single trees), and by updating the building's lightning protection devices.

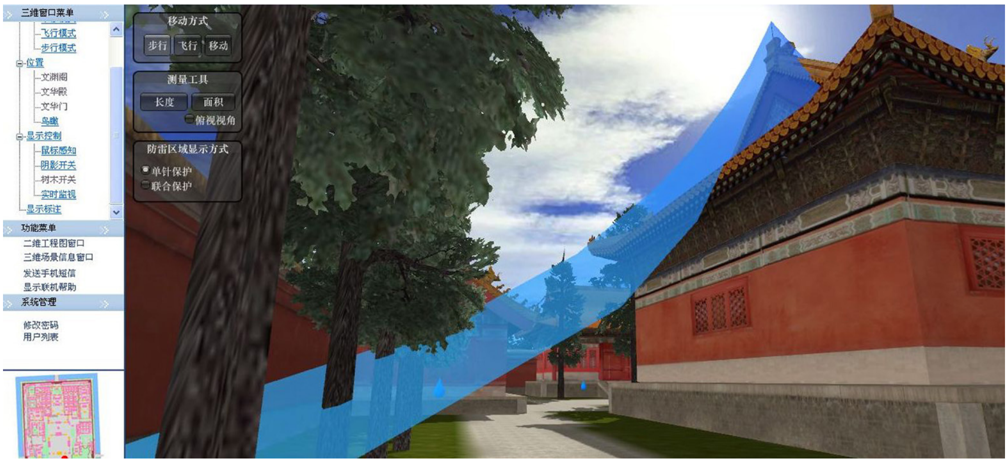

Figure 9. Simulation showing a gap in coverage on the trees at the Hall of Literary Brilliance

4.3 Impact of the Research

The simulation of lightning protection coverage is more advantageous than the conventional planar approach.

Figure 10. 3D virtual top view of the comprehensive protection coverage of lightning protection devices at Hall of Literary Brilliance

Figure 11. 3D virtual top view of comprehensive protection coverage of lightning protection devices at the Hall of Literary Brilliance showing device parameters

All the relevant data including the building configuration and the lightning protection devices in place are input into the software. By clicking on any lightning protection system, the user can see the basic information in a pop-up window. It is also possible to display single or overlapping protection coverage areas. [FIGURE 11] Compared with the 2D approach, this method can help query data more quickly and accurately.

It is also possible to compare the original appearance of buildings and lightning protection range with this type of simulation [FIGURE 12]. The layout of the lightning protection system for the historic complex can be determined by comparing single building protection coverage with complex protection coverage.

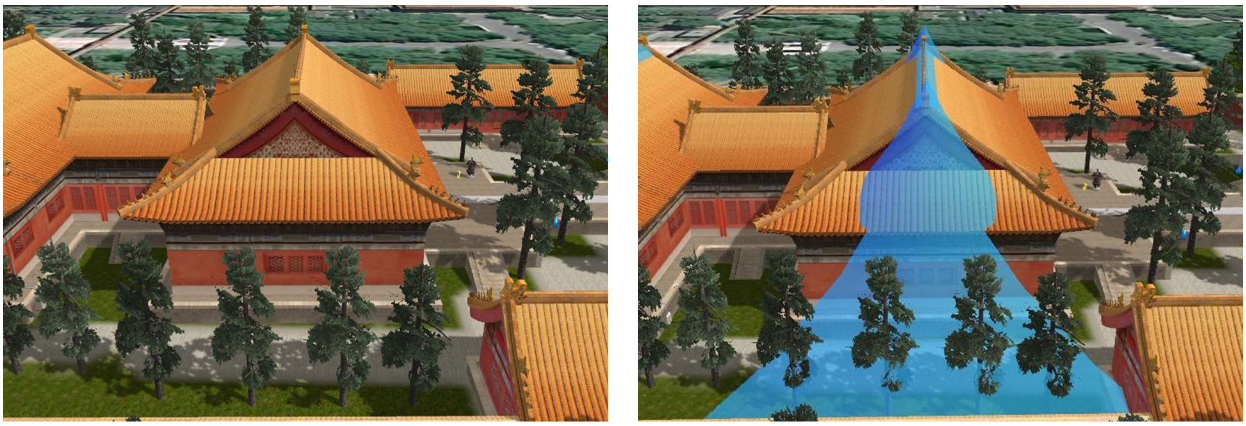

Figure 12. Comparison of the Hall of Literary Brilliance without and with lightning protection

4.4 Future improvements

Further research is needed to develop a method for calculating lightning protection coverage which is better suited for historic buildings. This calculation should be done in conjunction with the development of the 3D simulation, in accordance with the rolling sphere method and based on the special parameters of the historic architectural complex. This will achieve faster computation of real-time solutions directly in virtual reality.

5 Overall Evaluation and Recommendations for Lightning Protection System of the Architectural Complex at the Palace Museum

The deficiencies in lightning protection system were clearly visualized and identified using the 3D simulation method lightning protection coverage.

For heritage conservation, this project is of vital and lasting importance. A lightning protection program should be developed based on international and national standards and criteria. Lightning protection devices must be selected in strict accordance with lightning protection requirements for heritage buildings, such as high reliability, durability, and the capability of minimizing lightning strike probability.

At this stage, designers may still design lightning protection systems using 2D drawings; meanwhile, the reviewers may verify the compliance of these designs against the requirements and based on their expertise. During the design and review process, 3D modelling and simulation lightning protection systems can be used to quickly verify and correct deficiencies in the design, save working time, and improve the design requirements. In lightning risk evaluation, decision-makers, who are not necessarily experts in this field, can fully understand the evaluation conclusions through the simulation and can more ably analyse and review the proposed program.

According to Principles for the Conservation of Heritage Sites in China, Article 6.1 indicates that 'archival records are an important bearer of the values of sites. As a medium for passing on historical information, authentic and detailed records and documents have importance equal to that of the physical remains of a site'. Archival records include those related to regular monitoring actions on the lighting protection of the buildings.

At present, the Hall of Literary Brilliance has not been equipped with lightning counters, and historically is not known to have been struck by lightning; this doesn't mean however that the area has not been damaged by lightning strike in history. It is recommended to install lightning protection devices at the Hall of Literary Brilliance, including one down-lead on the east side of the Hall, one down-lead on the east side of Zhujing Hall, and one down-lead on the west side of the Literary Profundity. The six down-leads should be equipped with lightning counters. Each lightning counter should be able to properly record the instantaneous voltage, current and other basic data, while the lightning current passes through the down-leads, and conveniently transmit the data in real-time to the monitoring centre. The instantaneous voltage and peak current in a lightning counter can help accurately determine which lightning rod has led lightning current. In the Palace Museum, it is recommended to conduct a large scale 3D simulation of the lightning protection system and to install some lightning counters at appropriate locations. The detailed data recorded by the system will accurately reflect lightning activity at the Palace Museum. Long-term monitoring can help determine the frequent lightning zones and forewarn conservation staff of areas at risk, so that they may take preventative measures, install or replace lightning protection devices.

6 Promotion and Application of 3D Simulation of Lightning Protection System at Historic Architectural Complexes

The 3D simulation of a lightning protection system is conducive to improve the lightning protection at historic architectural complex. Heritage staff may propose a rectification program, based on the monitoring data. The implementation of such corrective measures should be guided by 3D simulation of the lightning protection system. Figure 13 depicts the flow chart for such improvement projects.

If it is applied to the lightning protection industry, 3D simulation will be a significant advancement for monitoring and upgrading heritage sites.

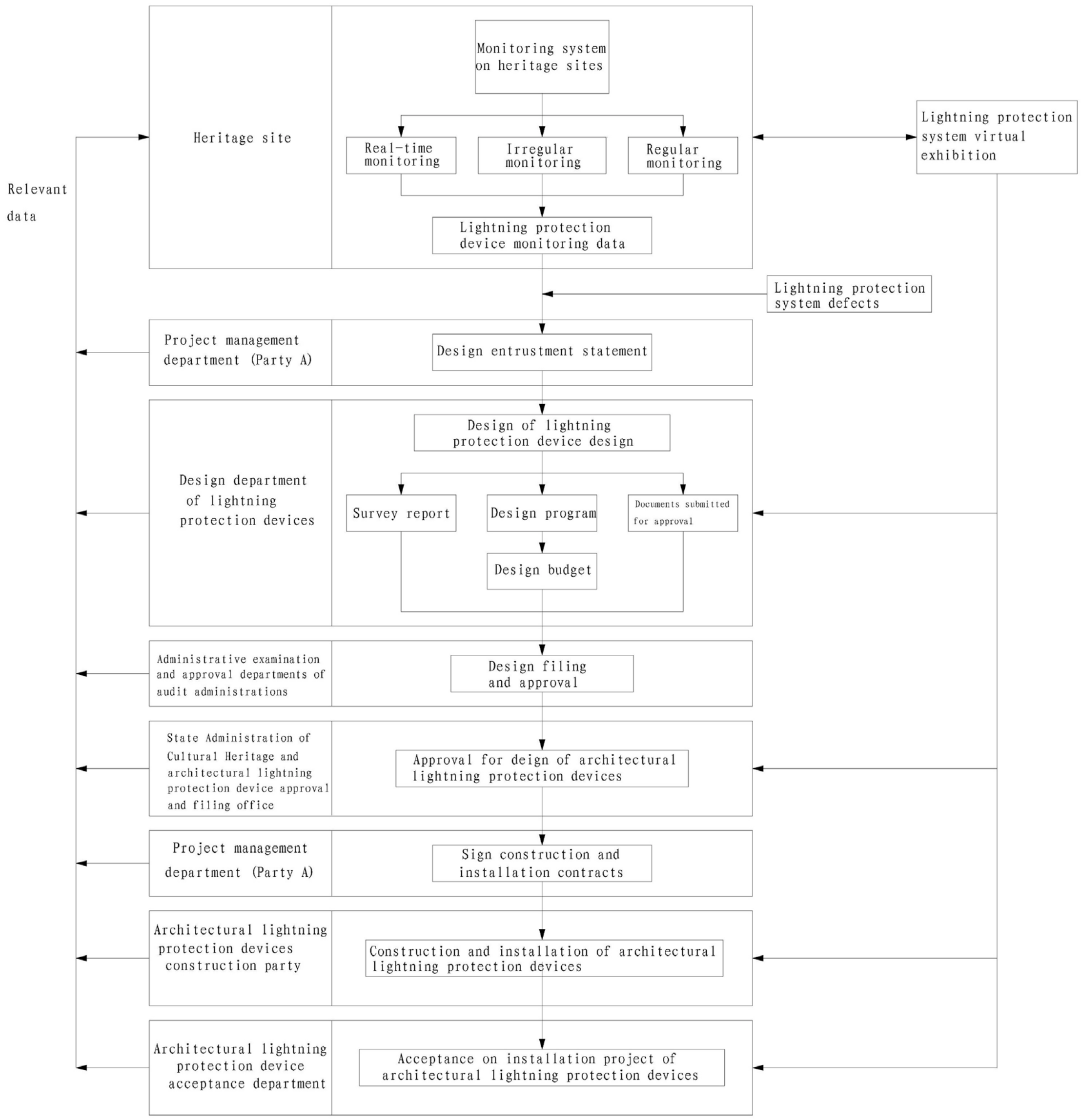

Figure 13. Flowchart of application of 3D simulation of lightning protection system at a heritage site

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Theme 2: Methodology and Tools for Undertaking Risk Assessment of Cultural Heritage

Development of a Risk Management Framework for Protecting Heritage Sites: A Case Study for Petra

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Abstract. Identification, assessing impact and mitigating risks, preventively or actively at heritage sites, require a holistic and systematic methodology. When applied, these measures may provide site managers the possibility to make appropriate decisions to protect the significance and integrity of sites and monuments, and to protect stakeholders, occupants, and visitors to the site.

The multiple facets of heritage sites makes this work very complex and requires the involvement of an interdisciplinary framework of collaboration and approaches for implementing action plans. This paper examines a ‘risk management methodology’ developed using existing risk management approaches and literature. The research further develops these methods to be applied at heritage sites to provide a systematic approach for site managers to identify, assess, and mitigate risks due to natural and anthropogenic threats. The use of simple documentation and information management tools in order to record and analyze the data is an important part of this approach.

This paper is based on the field application of the risk assessment developed as part of the mentioned risk management framework at the selected structures and areas (pilot area) of the Petra Archaeological Park (PAP). The works were carried out by a team of experts from the Raymond Lemaire International Centre for Conservation (University of Leuven), UNESCO Amman Office, Petra Development Tourism and Region Authority (PDTRA), and Jordan’s Department of Antiquities (DoA), as well as other experts from Jordan. The recording and documentation approach included in this paper is part of the efforts made to develop and implement this methodology for identifying and mitigating risks at the PAP.

The risk assessment has been performed using non-intrusive techniques involving ‘rapid’ visual inspection, use of available information management systems (MEGA-J, Middle Eastern Geodatabase for Antiquities-Jordan), simple global navigation satellite system (GNSS), and digital photography. The predefined categories of threats from MEGA-J’s inventory and management tool for archaeological sites, has been used to identify and record threats. Also utilized are quantitative and qualitative methods for risk assessment, which have been applied to assess the impact of risks. The approach takes into consideration the comparison of vulnerability to sites with their value assessment to prioritize monuments at risk. The sites are categorized by importance of significance and magnitude of risk. The authorities may then use this information to plan more in-depth assessment for those highly significant monuments or areas at risk. Further studies and fieldwork need to be done in order to analyse the results of the on-site risk assessment in this pilot area. The following step would be to implement methodically the entirety of the risk management plan in close involvement with the local authorities and site managers. A systematic approach for risk assessment and risk management and decision-making guidelines have been envisaged as outcomes of this project; these would be included as part of the overall management and conservation plans of the sites.

1 Introduction

Recording, monitoring and reducing risks are at the core of heritage preservation and conservation strategies. Understanding values and protecting a heritage site's integrity by identifying and mitigating threats are necessary steps towards the continuous amelioration of these plans. Risk assessment and management is a systematic way of detecting changes that continuously affect the fabric of heritage places and sites.

The proposed risk management strategy, developed and published as a UNESCO publication titled: Risk Management at Heritage Sites – a Case Study of the Petra World Heritage Site intends to provide a framework for the site managers and their team (Paolini et al. 2012). It also includes authorities and agencies responsible for the management of heritage sites in general, and for the Petra Archaeological Park (PAP) in specific. The methodology can be used to identify risks to the sites and assess their impact as well as the vulnerability of the monuments. This process provides a decision-making tool for the prioritization and mitigation of the identified risks. Such an approach, when institutionalized and implemented, contributes to the continued protection of the heritage integrity of a given site.

In the attempt to institutionalize the risk management approach in Petra, local authorities were fully involved and endorsed all steps for the development of the risk management strategy. The purpose of the developed risk management approach is to be incorporated as an integral part of the development of the overall conservation and management plan of the property.

1.1 Why a risk management for Petra?

Petra, a caravan city known as the capital of the Nabatean kingdom, is located in the southwest of Jordan at an important crossroads between Arabia, Egypt and Syria, and well as between the Red Sea and the Dead Sea. A World Heritage Site since 1985[1] and the most visited archaeological site in Jordan, Petra is currently threatened by a multitude of natural and anthropogenic risks impacting the integrity of the site. On one hand, the fragile sandstone forming the monuments of Petra is subject to natural erosion by wind and water, and on the other hand the increased development attracting an ever growing number of tourists are heavily impacting its deterioration. In recent years, the number of visitors per month has increased considerably beyond the advisable capacity of the site defined in the 1994 UNESCO Management Plan (UNESCO 1994). This large number of visitors and the non-implementation of regulation concerning visitors' accessibility to paths and monuments, have led to uncontrolled movement of these people throughout the site.

The lack of technically mapped and visualized boundaries and the absence of a clear strategy for a defined buffer zone or zoning regulation represent further threats to the site's integrity. The early inscription of the site in the World Heritage List, when no clear requirements were set for the outline of property boundaries, accounts for the inaccuracy in the definition of the boundaries of the property and the lack in the definition of its buffer zone. Despite the call for a Retrospective Inventory (UNESCO 2005), only scattered efforts were made to record the property boundaries until the start of the Risk Mapping project; thus no clear delineation has been defined for the buffer zone of the PAP.

Moreover, the site still lacks a comprehensive management system, which makes it difficult to map risks affecting the property, landscape and the visitors. Over the past four decades, Petra has been governed by several agreements and strategies. Due to insufficient funding and long-term planning or initiative, none of the management and tourism plans drafted for the PAP have been implemented in their totality and adopted officially, despite the recommendations stated in the UNESCO Operational Guidelines[2] (UNESCO 2011).

1.2 Risk mapping project in Petra

Given the range of problems previously described, the PAP requires a common strategy to be developed, in order to provide solutions for a defined threat. Risk identification and assessment, and research in the field of risk management in Petra have been identified as the most appropriate strategies for the mitigation of its risks and the protection of its values. This approach was welcomed by the local authorities recognizing the gap in the management of the site and the urgent need to develop a long-term progressive solution.

In February 2011, the UNESCO Amman Office partnered with the Raymond Lemaire International Centre for Conservation at the University of Leuven (KU Leuven), the Department of Antiquities of Jordan (DoA) and the Petra Development and Tourism Regional Authority (PDTRA), to carry out a Risk Mapping Project in Petra. The overall aim of the project was to strengthen the integrity of the site by way of identifying, assessing, mitigating, and managing risks. The project consisted of different phases with three main objectives: (1) field mapping of the boundaries of the World Heritage property, (2) outline of guidelines and usage regulations for a proposed buffer zone and (3) definition of risk criteria and risk categories and delineation of a proposal for a risk management strategy.

The focus of this paper is to develop and implement a methodology for risk assessment and management at the PAP. Outlining a risk management methodology for Petra intends to give the responsible authorities for the management of the site, a framework to identify, assess and record risks, and to respond to those risks based on the methodology. The vulnerability of a given monument, its significance and the level of risk could be prioritized by the site managers and concerned authorities. By further investigating a highlighted monument, it would be then best to plan a more in-depth assessment. Based on the results, prioritizing these action plans would result in a more efficient way of delivering the strategies set in place.

2 Risk management methodoloGy

Risk is defined as the probability that a certain kind of damage is realized (Ball and Watt 2001). Risks are results of natural or man-made threats. Natural risks could be catastrophic and sudden, such as a flood or an earthquake, and may be continuous, cumulative or slow, such as erosion. Anthropogenic risks are result of different human activities, from development to tourism, inappropriate management and lack of maintenance and neglect. Risks to the heritage sites are also dependent on the specific characteristics and inherent vulnerabilities of the site to the effect of threats.

2.1 The methodology

Following the compilation of an extensive literature review, a risk management methodology was developed by local authorities as well as national and international experts in the field of heritage conservation over several meetings and roundtable discussions. Comments and remarks were added to the methodology; the revised document was endorsed by the concerned authority at a final workshop.

The validated methodology was then applied to the pilot area in Petra during two weeks of fieldwork in Fall 2011 for the purpose of evaluating the efficacy and significance of the risk methodology plan. Prior to the fieldwork, a training course was conducted for the fieldwork team.

The risk management approach is mainly based on two theories developed for assessing and reducing risks to collections and artefacts, the 'Cultural property risk analysis model: development and application to preventive conservation at the Canadian Museum of Nature' (Waller 2003) and a similar approach proposed in the Risk Management Australian/New Zealand Standard (Standard Australia Standard and Standard New Zealand 2004) and adopted by the ICCROM and CCI – ICN for their courses in preventive conservation and risk reduction to collections. These approaches have been adapted and enhanced to be relevant to the sites at Petra and eventually to other similar sites.

The systematic application of the risk management process includes several steps [FIGURE 1]:

1. Defining the context and scope including documentation review,
2. Identifying risks,
3. Assessing the magnitude of each risk,
4. Identifying possible mitigation strategies,
5. Evaluating the cost and benefits of each strategy, and
6. Implementing strategies to treat and mitigate risks, preventively or actively.

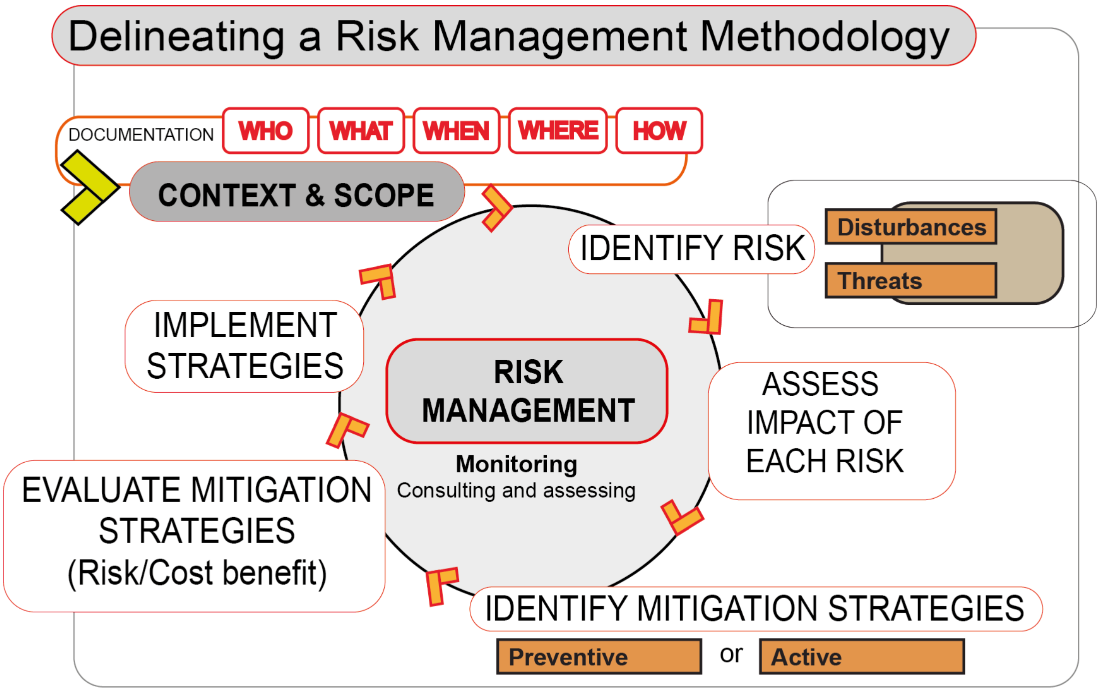

Figure 1. Risk Management Process

3 Application of the Risk Management Methodology at PAP

3.1 Defining the Context and Scope

Prior to carrying out any risk management assessment activity, an evaluation of available documentation on the site was conducted. This review was used to highlight pre-identified risks, and set up the scope for the new risk management process. These documents, which included maps, plans, and published and unpublished papers, were evaluated based on their historical relevance, legal and financial content. A comprehensive study and understanding of the existing site management context was needed to identify all relevant factors posing an immediate risk to the conservation and management of the site (Fischhoff and Kadvany 2011). It should be noted that, due to the project's time constraints, the developed approach was limited to the little research contained in the available documentation.

3.1.1 Required competences of the team

In order for the fieldwork team to implement an interdisciplinary approach, it was important that specialists of different academic and professional experiences be included in the team such as, but not limited to: archaeologists, historians, geologists, architects, landscape archaeologists and/or architects, conservators, engineers, and hydrologists. It was also important that a site manager or representative from the local authorities be part of the team. Important skills were considered in carefully selecting the members of the risk assessment team:

a. Understanding of the Outstanding Universal Values of the World Heritage Site or local heritage sites values and the statement of significance;

b. Understanding of the typologies of archaeological elements (e.g. standing structures, carved landscape, etc.);

c. Understanding of the risk methodology plan including, but to limited to, disturbances, threats and agents of deterioration, condition assessment and rating of degree of integrity affected;

d. Technical knowledge of the use of documentation systems, moderate knowledge of features of Geographic Information Systems (GIS) applications, moderate understanding of Global Network Positioning Satellite Systems (GNPSS) handheld devices as well as digital photography, especially panoramic photography (360 degrees georeferenced photo), and proficiency with Microsoft Office software.

3.1.2 Fieldwork approach

The risk management methodology was applied twice during the two-week fieldwork campaign. The fieldworks were preceded by an ad-hoc training for the team and PAP staff responsible for the management of the site. During the fieldwork, more than 100 site elements were mapped using the recording tools and saved in MEGA-J[3]. Due to the time and resource constraints, the application of the risk assessment in the field was carried out based on visual inspections and implemented in a limited period of time.

To ensure the consistent quality of the work, several consensus meetings were held between the fieldwork team and the authors of this paper as well as the PAP authorities. A comprehensive report on the risk assessment was compiled and later reviewed by the stakeholders and experts of the technical committee.

In brief, the fieldwork approach for the risk assessment involved the following phases:

1. Preparation:
   - Research of existing documentation
   - Research on period, topography, and typology of assessment area
   - Research of internationally used value assessment systems such as NARA grid (Van Balen 2008) or MEGA-J approach (Getty Conservation Institute)
   - Localization of assessment area on MEGA-J
   - Print out of MEGA-J site element and monitoring forms
   - Print out of satellite and/or aerial images covering the assessment area
2. Visual inspection:
   - Localization of the studied area
   - Identification of the topography and period and comparison with existing works
   - Sketch of site elements with GPS coordinates in plan and sketch of elevations
   - Photography of site elements noting the context and camera positions
   - Assessment of threats and disturbances using MEGA-J groups and agents of deterioration, detailed photography of threats and disturbances , and indication of location of disturbances on sketch with hatches and colours
   - Fill out risk assessment table
   - Draft report which includes preliminary assessment of severity of threat/disturbances

- Evaluate risk priority and propose mitigation strategies
- Consensus meetings with the expert team (local authority and authors of this paper)
- Input information on MEGA-J (mapping, completed forms and photographs)
- Archiving

3. Draft preliminary reports
4. Consensus meetings with the experienced and interdisciplinary experts and concerned authorities to provide feedback and advice
5. Finalize the report including the feedback received
6. Submit the final report to the PAP Technical Committee, consisting of interdisciplinary national and international experts and stakeholders. Their task was to review and validate the report, to make decisions, and carry out prioritized mitigation strategies and treatments

3.1.3 Pilot area

Given that the PAP covers a large zone, the pilot area comprised two archaeological monuments as well as two other areas, which were identified based on their OUV and as being faced with imminent risks and irreparable damage. The pilot area for the fieldwork included the following:

- 'The Temple of Winged Lions': an archaeological monument representative of standing structures at the site and of current disturbances, taking into consideration the impact of visitors, researchers and contractors.
- 'Turkmaniyya Tomb': an archaeological monument representative of carved structures located near a road, which is under possible threat due to the plan to widen this road.
- 'The Basin': a landscape at the site, which is under possible threat from touristic activities and other human impacts.
- 'The path to the Monastery': alongside both sides of the path leading from the Basin to the Monastery exists a variety of tombs and caves that are carved in the bedrock. Uncontrolled tourism activities and the over-use of animals to transport tourists to the Monastery are examples of threats to the path and tombs.

3.1.4 Recording tools

The assessment teams were equipped with a handheld GPS-device (GeoXH 2008) using DGPS with SBAS (EGNOS)-corrections (on WGS84 coordinates), with accuracy under 1m. This enabled to control the precision directly in the field.

Digital photography and spherical panoramic photography were used to capture disturbances and threats, and both were georeferenced using the handheld GPS device. Panoramic photos were taken using a Nikon D300 camera with Nikkor 10.5 lens (fish eye lens), processed and stitched using Autodesk Stitcher Unlimited.

Monuments with their location and information were recorded in the MEGA-J, a hybrid geographic and database system used to map monuments under assessment with their exact coordinates and to record specific information for each site element (period, type, ownership, condition, management recommendation, etc.). The six categories of threats and disturbances as defined in MEGA-J, namely, agricultural, development, human, natural, site management, and other impacts, were used to record conditions of the monuments.

For the elements of the pilot area, built structures were surveyed and measured using a Leica TC407 Total Station. The survey was combined with existing georeferenced CAD layers. For the purpose of the risk assessment project of the site, an open source GIS application was prepared using Quantum GIS version 1.7.2 to allow the integration and analysis of the data gathered during the fieldwork. [FIGURE 5]

3.1.5 Understanding values and integrity

Values attributed to monuments, places and landscapes are at the core of conservation plans and accordingly, risk management plans as well. Defining risk means specifying a value to make a decision based on the mitigations presented (Demas 2002). Consequently, a value-based study is the preliminary step for the assessment of the risk impact, identification of priorities, and application of mitigation strategies. Although Petra has been extensively researched, the property lacks an exhaustive values assessment study that provides specific information about what needs to be preserved (standing and carved structures, landscape, etc.). The outcome of such a study, using internationally recognized values assessment systems, may provide an indication of the required level of work required to preserve this important heritage site.

Due to the need of values assessment for the pilot area, a preliminary values assessment was carried out. A meeting with national and international experts in the field of archaeology, architecture, history and conservation was held prior to commencing the fieldwork. For the preliminary values assessment of the Basin area and the Turkamaniyya Tomb, the team chose to use the MEGA-J value approach where values are divided in five categories: scientific, historical, aesthetic, social and spiritual values. However, for the Temple of the Winged, the team opted to use the Nara-Grid approach which considers artistic, historic, social, and scientific values. These categories include sub-categories such as form and design, use and function, material and substance, tradition and techniques, location and setting, and spirits and feeling. Having the subcategories made it easier to define values of the Temple[4].

3.2 Identification of Threats and Disturbances

The Threats and Disturbances categories in MEGA-J were used to identify and record both conditions and risks. As it is defined in MEGA-J, disturbances are 'detectable, negative effects on the site or site element by natural forces or human activities' and threats are 'detectable phenomena, whether natural forces or human activities, that appear to predict a future disturbance to a site or element' (Getty Conservation Institute and World Monuments Fund 2010).

Threats and disturbances as defined in MEGA-J are classified into six main categories: agricultural, development, human, natural, site management, and other impacts. In the risk assessment process for the PAP the same categories of threats were used to identify risks. [FIGURE 2]

As disturbances and threats are detectable impacts, ten agents of deteriorations as used by Monuments Watch Flanders have been introduced and linked to the threats in MEGA-J[5]. Once a threat as the consequence of an agent is identified, and its probability and severity have been assessed, its magnitude of risk could then be defined. Once recorded, the agents which have been defined as a threat will help to identify methods of mitigation and treatment.

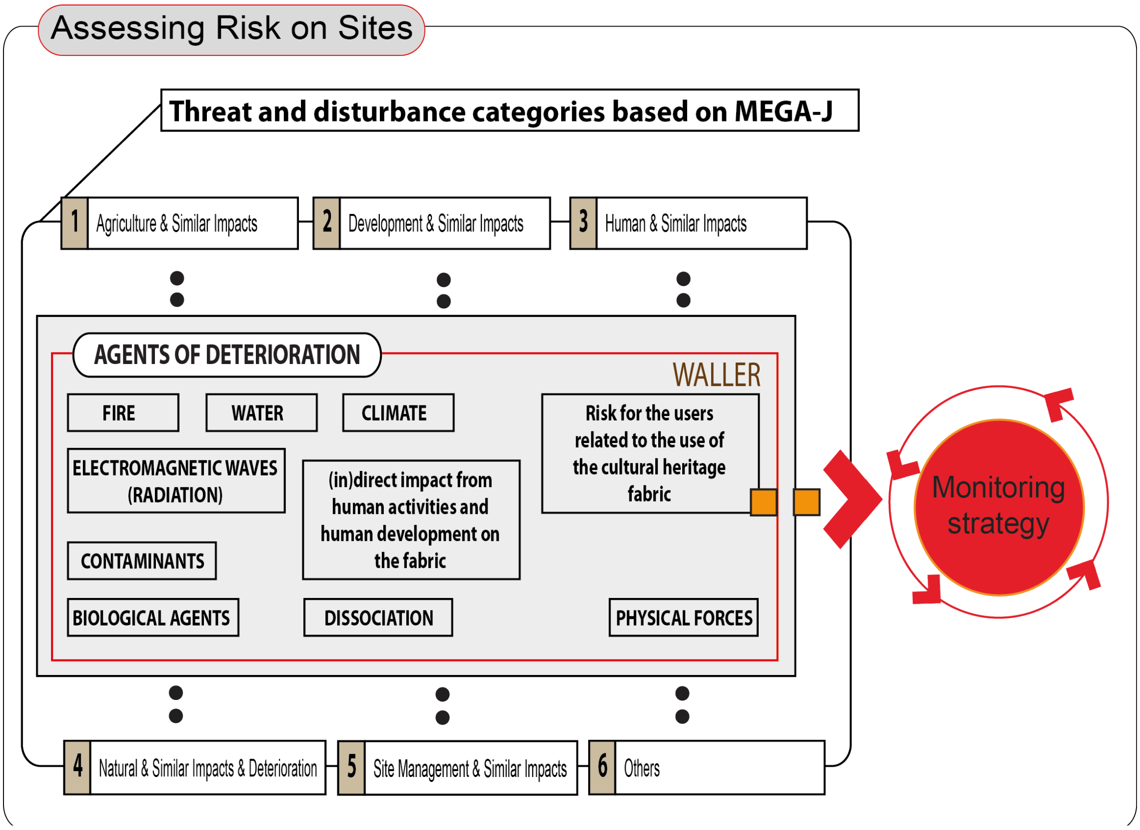

Figure 2. Threats and disturbances with the associated agents of deterioration

3.3 Condition and Risk Assessment

3.3.1 Condition assessment

As part of the risk assessment, the condition assessment focuses on identifying the existing disturbances and provides information about the actual condition and physical state of the conservation of elements, areas and sites. The assessment also helps identify the past causes and agents of deterioration. In some cases, future threats could not be identified easily without assessing the actual disturbance and condition of the site and its elements. In other words, the visible effect of risks may be viewed and assessed in terms of the current condition of the site or its elements.

During the fieldwork, the MEGA-J monitoring form was used to record the current condition of the site. The overall condition as defined in MEGA-J, was recorded using five categories: good, fair, poor, very bad, inundated and destroyed. The categories indicate to what degree a site element or site is physically stable or experiencing active deterioration.

3.3.2 Risk assessment

Risk assessment forecasts future threats from potential agents (Taylor 2005). Once threats and their agents are identified, the risk magnitude (level) could be assessed based on the probability of the identified threat to occur and the severity of its impact (Waller 2003).

The level of risk can be assessed using a qualitative and a quantitative approach, and a set of criteria. In this risk management methodology, both qualitative and quantitative approaches were used. The qualitative approach is based on qualitative data and analysis. A definition is used to describe the magnitude of severity (effect of damage) and the probability (likelihood) of a damage to happen. The quantitative approach is based on quantifiable indicators and uses numerical values to quantify the risk criteria. The magnitude of the risk is a result based on this numerical scoring system. The accuracy of the quantitative analysis depends on the correctness of the numerical values. Both methods are valid and may be used depending on the monument or site, and the targeted objectives of the team, amount of data, time, and resources available.

In the qualitative approach, level of risks are identified based on the severity of effect (mild, sever, catastrophic) and frequency and probability of the damage to happen (rare, sporadic, continuous). Three main types of risks could be defined choosing severity of effect and frequency: Type 1 - catastrophic and rare, Type 2 - medium and sporadic, and Type 3 - mild and constant. While mild, Type 3 usually has a continuous element and therefore, over a long period of time, would potentially have really serious consequences on a given monument or site. An example of Type 3 risk recorded as part of the first fieldwork analysis was erosion caused by the combined action of wind and water. Although mild, these elements affect the monument (the Monastery in Figure 3) continuously, by decreasing its aesthetical value, and probably its structural strength. This reduction in structural strength may eventually become a cause for serious concern, and immediate attention may be required. In case of a rare but potentially dangerous event such as an earthquakes or a flash flood, the monument or site may suffer irreparable damage (Type 1 risk).

The types of risk serve as indicators of the degree of impact and the frequency. The results are used to prioritize actions required in a specific site, monuments and/or areas that require immediate attention to mitigate and reduce risks of potential or further destruction.

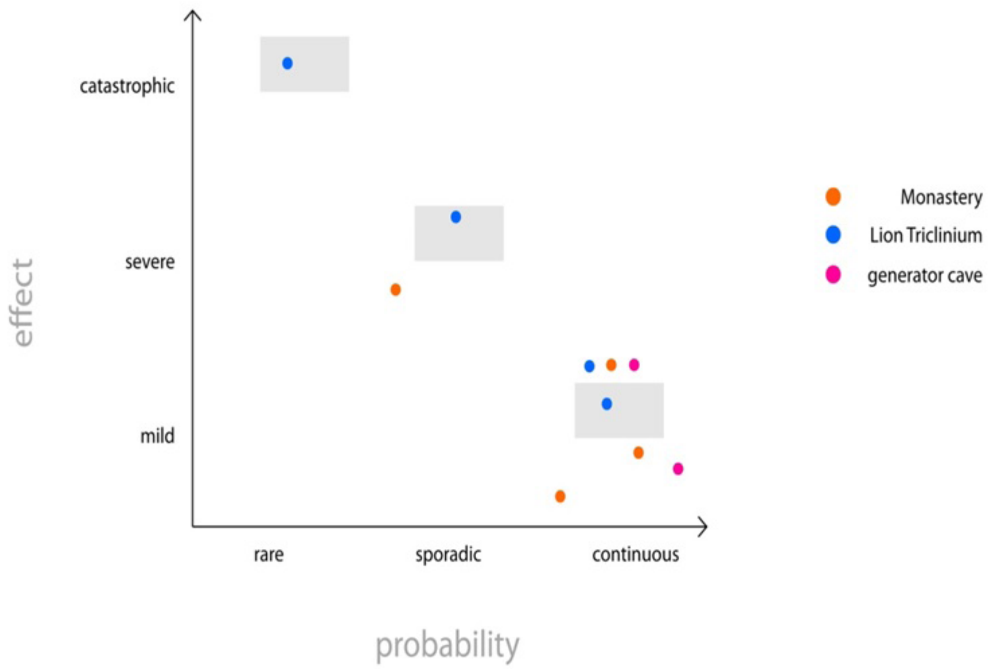

Figure 3. An example of use of probability and effect matrix at the Path to the Monastery Area of the PAP

In the quantitative approach, the level of risk can be calculated based on three criteria:

A) the probability of damage to happen,

B) the degree of loss of value and integrity as a result of impact, and

C) the fraction of the assessed area affected by the impact. [Figure 4]

Each of these criteria is evaluated based on the scoring system as shown in the graph below - from 0.5 to 5. The adding of scores of A), B) and C) will be a number representing the magnitude of risk of the specific threat.

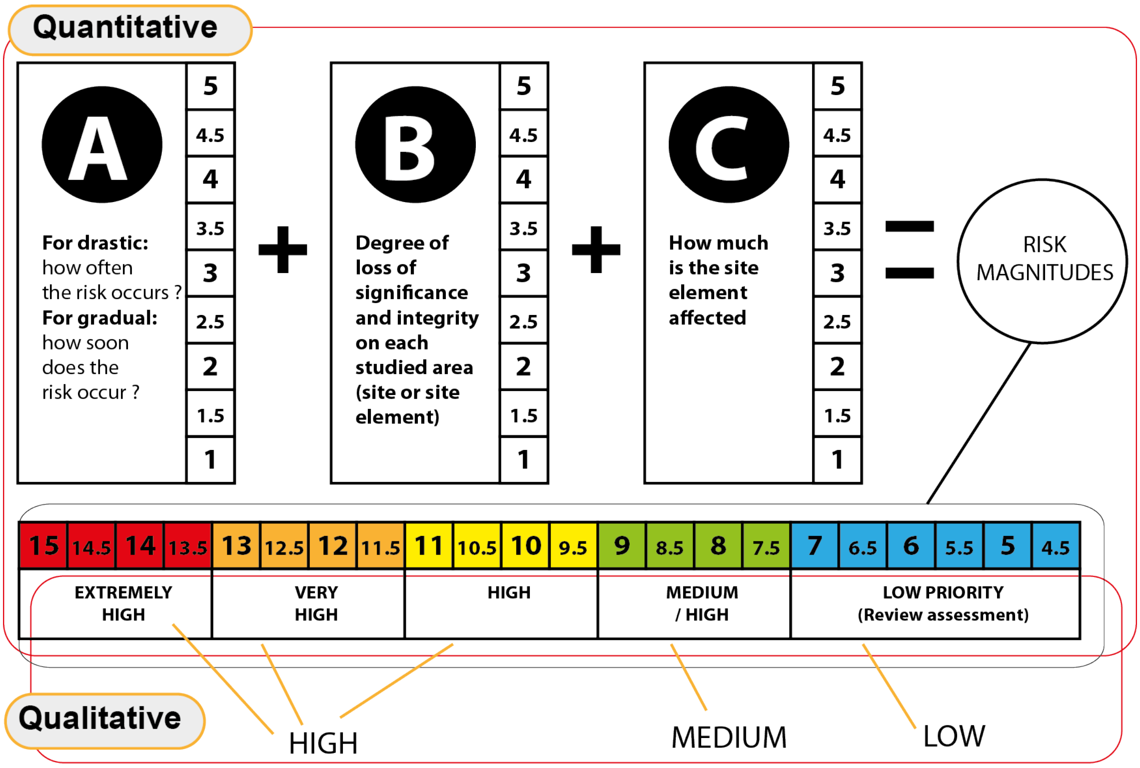

Figure 4. Risk magnitude assessment and quantitative approach

For example, an existing dirt road running through the precinct of the Temple of the Winged Lion may cause extensive damage to the archaeological materials that may be found beneath the surface of the road. As the road is utilized by animals and vehicles alike (physical forces on the surface of the structure), the road was recorded as being in danger, and as one of the threats to the overall site of the PAP. In this example, the probability of damage to the archaeological remains found beneath the road from the use of the road itself is relatively high (A), the degree of loss of significance is also high (B); however, the area affected by this damage is small in comparison to the whole site element (C). As a result of the ABC calculation table, the magnitude of this risk has been calculated 10.5 = high.

Another example of a potential threat is the likelihood of earthquakes. Given the poor condition of the temple, including many stability threats, an earthquake has destructive consequences for the Temple and may be fatal to visitors. The probability of it to happen is low, but the degree of loss of value and the affected areas are high. The risk magnitude of a potential earthquake is also high at 10.5. This method of scoring using numerical values while using the same scale for the criteria will provide site managers and decision-makers a means to compare the risk magnitude of different threats on individual monuments, specific areas and the site as a whole.

TABLE 1. Risk magnitude calculation and comparison table

Threat	Agents of deterioration	A	B	C	∑Risk Magnitude	Magnitude of Risk
2205: Road/ path running through precinct	Physical forces: AG04.1: On surface. Impact human activities: AG09.5: Physical developments.	4.5	4	1.5	10.5	High
2404: Earthquake	Physical forces: AG04.1: on body. AG04.2: dynamic. Dissociation: AG08.1: Physical dissociation. AG10: Risk for users.	1	4.5	5	10.5	High

3.4 Mitigation Strategies

Risk mitigation strategies may be identified once all risks have been recognized and their magnitudes assessed based on the described methods and processes. This section of the paper presents methods for the identification of possible mitigation strategies for a defined threat. The identification of the correct and effective mitigation strategy is directly related to the identified agents of deterioration, i.e. the cause of the risk.

This proposed framework intends to provide a tool for site managers to consider risk mitigation tactics and make decisions on suitable methods of control, whether preventive or active. Mitigation strategies are classified under two preventive conservation methods 1) avoid (eliminate) and 2) block (establish a barrier), and three active conservation strategies 3) detect, 4) respond (act on agent) and 5) recover (active conservation work).

The importance of adopting a risk management approach as part of the overall management of a site is critical. If risks are identified and monitored regularly, the possible damage resulting from these risks may be stopped or reduced by ways of less costly preventive measures. Taking the example of the dirt road running through the precinct of the Temple of the Winged Lion. The most favourable method of control would be to prevent traffic to pass through the precinct. This action may be implemented through a policy to decrease or stop the traffic in this area and another one would be to deviate it. In this way, the threat to the site will be avoided or reduced through a preventive measure with little to no cost impact. If no action is taken, the impact of damage would probably increase over time, and may be irreparable and/or costly to perform conservation or restoration works.

Based on identified mitigation measures, an ad-hoc strategy could be drafted on how the proposed mitigation measures will be implemented. The strategy would include a timeline, human resources required as well as their assigned responsibilities, along with the estimated budget needed for the implementation of each measure.

3.5 Risk Evaluation and Implementing Strategies

The goal of risk evaluation is to evaluate and manage the outcome of the risk assessment and to suggest which risks require immediate action, what would be the corresponding actions, and the priority of the works. Other factors listed below are equally as important in the risk evaluation process and in prioritizing the implementation of strategies:

a. Overall significance and value of the studied area (site, archaeological elements or features)

b. Level of impact and magnitude of risk (calculated based on the defined qualitative or quantitative method)

c. Level of uncertainty, which plays a very important role in the accuracy of the risk magnitude. Risk management decisions depend on the risk magnitude combined with its level of uncertainty. Uncertainty is related to the reliability of the information at risk. The more impact uncertainty has, the more important additional research is needed to reduce the uncertainty factor. The uncertainty factor may be a compilation of the impact of damage (risk magnitude), the reliability of information on the probability of damage, and the impact of possible solutions (methods of control). There are different ways in trying to reduce the uncertainty. Further information and higher level of knowledge may reduce the uncertainty. However, the amount of effort, time and resources needed to reduce the uncertainty may be balanced by the added value of the information to the risk assessment process and the decision-making process.

d. Cost-benefit assessment associated with each mitigation strategy, in order to be able to select the most appropriate options. This process is defined as balancing the cost of implementing each method against the benefits gained from it. The effect of each strategy on each and all agents of deterioration and threats should be taken into consideration. Cost-benefit should also be associated with the implementation and maintenance stages and the effect of the strategy on other factors at risk (aside from the heritage monuments or sites and their significance). Risks to visitors, researchers, stakeholders, and the. landscape should also be taken into consideration

e. Gain or loss to the local community

f. Economic benefits or losses, as well as other technical, social, legal, political, environmental criteria

Analysing all information gathered in the process of risk assessment was facilitated by a simple GIS platform prepared by the assessment team. [FIGURE 5] This helped to obtain a clear matrix of patterns and concentration or congestion areas of the risks inside the pilot area. Once risks, their attributes and their impact area are put into the GIS system, fast queries may be done according to the defined attributes. Now that the data gathered during the fieldwork is mapped and stored, further time and study is needed to analyse the data and obtain results that may be used in the decision making process.

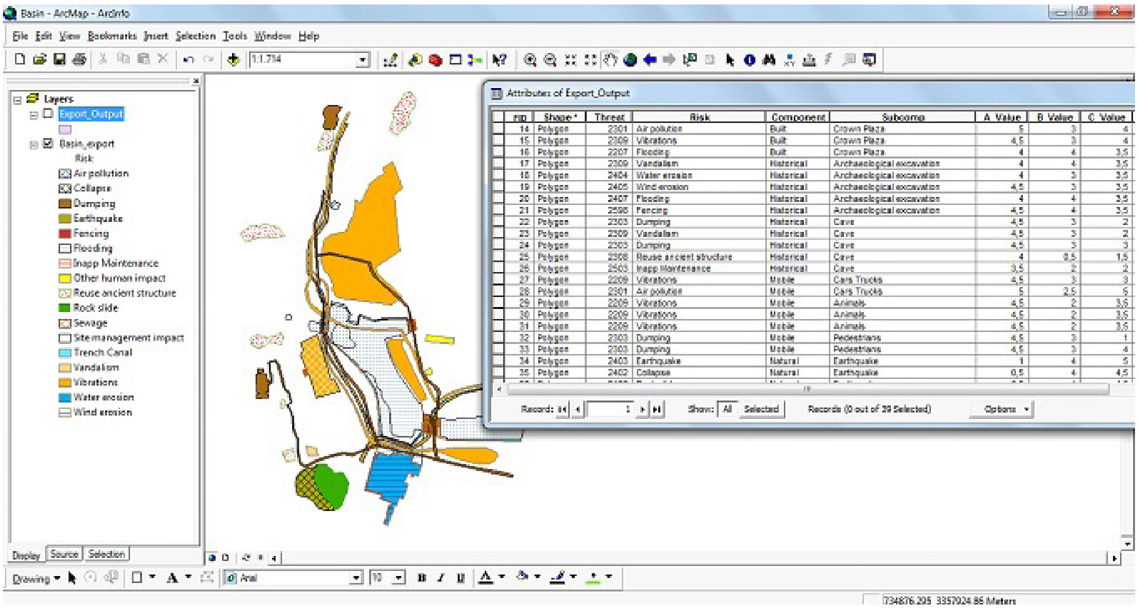

Figure 5. GIS image of PAP pilot area (Source: Aziliz Vandesande)

4 Closing Remarks

This methodology is aimed to be used as a base and guideline for the Jordan Department of Antiquities, as well as the Petra Development and Tourism Region Authority to carry out risk assessments and monitor the site's condition. The goal is to preserve the site's integrity, and develop the appropriate site conservation and management plans. During the time of the Risk Mapping Project in Petra (April 2011- June 2012), risk management strategies for the heritage sites were developed based on the risk assessment and management studies and used in other disciplines.

During the two site visits, risk assessment steps were used at the pilot area based on visual inspections; mitigation strategies were thus identified. Given the time and financial limitations of the Project, not all steps of the proposed risk management methodology were applied to the pilot area. Application of the risk assessment has provided a preliminary understanding of risks, their impact and pattern in the pilot area. It also helped to understand that the most appropriate mitigation strategies for most of the risks at the pilot area could be mitigated through preventive measures and at the level of policy and control.

This study does however need further development as the proposed methodology needs to be applied as a whole and conducted over a continuous period of fieldwork. More time and expertise are needed to analyse the data gathered from the fieldwork, as well as the risk assessments results. Only then, will strengths and limitations of the approach be clearly identified. This effort could be of benefit not only for the managers and authorities responsible for the PAP, but also other stakeholders involved in the management of heritage sites at the PAP and elsewhere.

The following are further remarks from the application of the risk management methodology at the pilot area in Petra:

- The delineation and further application of a risk management methodology combined with a documentation strategy enabled the team to collect a considerable amount of well-organized information. This same process could be developed as a ready-to-use tool for site managers and applied to other areas of the site and other sites in general.
- The importance of the cooperation with local stakeholders in implementing the phases of the project and in taking relevant decisions has to be identified as an integral part for the project's success. The Risk Mapping project and the application of the risk management methodology at the PAP showed how working closely with stakeholders, experts and the local community, can lead to positive results and more accurate strategies to document and manage a World Heritage Site. All stakeholders involved in the management of a World Heritage property are required to identify the changes and understand the site in its various layers of history including presently, and what should be done for the future. Eventually, this approach will lead to an appropriate selection of management and preservation strategies.
- Capacity building in the risk management methodology and its use are significant to the success of the project. The proposed methodology needs to be accompanied by structured and continuous training for the stakeholders involved in the management of World Heritage properties. Training of the staff and site managers at Petra in the application of the methodology was an integral part of this project
- Threats affecting the sites and the treatments and mitigations strategies are prone to change over time.

Risk assessment cycles should be carried out on a regular basis.

- The accuracy of the results needs to be monitored regularly. In order to have accurate results, the fieldwork team needs to be experienced, interdisciplinary, and trained on the risk management methodology. Moreover, it is important to have a multi-layer team of experts to review and verify the work and reports of fieldwork teams.
- Ultimately, the PAP Technical Committee needs to approve and validate the relevance of the threats and disturbances as well as their related agents, the proposed risk magnitude for each threat, and the suggested mitigation strategies. This committee decides and validates decisions on the implementation of each mitigation strategy. Site managers and decision makers are responsible for taking the final decision on what actions are to be taken.
- The choice between a qualitative and a quantitative assessment would depend of the level of expertise involved in the application of the assessment, as well as the amount of documentation and research available.

Endnotes

[1] Petra has been inscribed according to criteria i): the property represents a masterpiece of human creative genius; criterion , iii): the property bears a unique or at least exceptional testimony to a cultural tradition or to a civilization which is living or which has disappeared, and criterion iv): the property is an outstanding example of a type of building, architectural or technological ensemble or landscape which illustrates (a) significant stage(s) in human history (Operational Guidelines for the Implementation of the World Heritage Convention, 77).

[2] Four plans for the PAP are: US National Parks Services plan 1968 (USAID 1968), UNESCO Management Plan 1994 (UNESCO 1994), ICOMOS management plan 1996 (US/ICOMOS 1996), and the Operating Plan 2000 (United States, National Park Service 2000)

[3] Middle Eastern Geodatabase for Antiquities-Jordan (MEGA-J) is the national inventory and management system to record Jordan's archaeological sites, including information describing their location, extent, significance, boundary and buffer zone; also it s a tool to record and monitor condition of sites (www.megajordan.org).

[4.] The Nara-Grid is being developed by the Raymond Lemaire International Centre of Conservation (University of Leuven). It is based on the Nara Document on authenticity (1994).

[5] More information can be found at: http://www.monumentenwacht.be/

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Vulnerability Ranking and Damage Analysis of Historic Buildings Through Identifying and Valuing Vulnerability Indicators

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Abstract. Due to their diversity and lack of statistical data, vulnerability assessment of historic buildings appears to be painstaking and contentious. Nevertheless vulnerability can be assessed through identification of vulnerability indicators (UNESCO 2010). This paper will introduce two tiers of comparative measures to quantify the vulnerability of a historic building through valuing indicators. In the first tier, the loss or hazard exposure of a typical residential building is utilised as the basis to develop the risk index of a historic building under different hazards. The second tier will analyse the building's damage by disassembling it into key components and comparing them with a pre-selected prototype whose damage has been investigated. By rating the indictors, certain damage patterns that will occur in the examined building are predicted. The method is illustrated with a listed parish church. While Tier 1 is suitable for a quick evaluation of enormous historic buildings in a region to single out high-risk buildings and hazards, Tier 2 mainly intends to have an insight of the potential damage and loss of a specific building.

1 Issues in Assessing Vulnerability of Historic Buildings

Historic buildings are architectural heritage that have cultural, historic and aesthetic significance. They are vulnerable to natural hazards due to their age, deteriorated fabric and lost craftsmanship. Physical mitigation and other disaster preparedness interventions are effective ways to minimise future losses. However, physical mitigation and retrofitting may unavoidably jeopardise certain aspects of heritage significance when the original fabric or features are affected. Accordingly, prior to mitigation, understanding the vulnerability of a building and cost-effectiveness of the work is necessary (ICOMOS 2003).

The vulnerability of a building, or its resistance capacity to destructive hazards, relates to the robustness of its structure, construction materials, deteriorating condition, and existence of fragile elements or contents. Vulnerability is a rational property of a building and is not related to occurrence of hazardous events. However, vulnerability is generally interpreted by both hazard exposure and loss estimation. Unlike a risk assessment where only one scenario is presumed, vulnerability studies consider varied hazards and different scenarios (Coburn et al. 1994). Building vulnerability studies, motivated by the insurance industry and planning authority, are focused mainly on building typology and building-wide population. Studies on heritage-listed buildings, however, are aimed at individual buildings to address their uniqueness and diversity (Oliveira 2003; CIRIA 1986).

For a historic building, its vulnerability also comes from the embodied significance and reparability of its fabric and features. In the event of a disaster, a historic building may suffer from both economic loss and cultural-significance loss. [FIGURE 1]

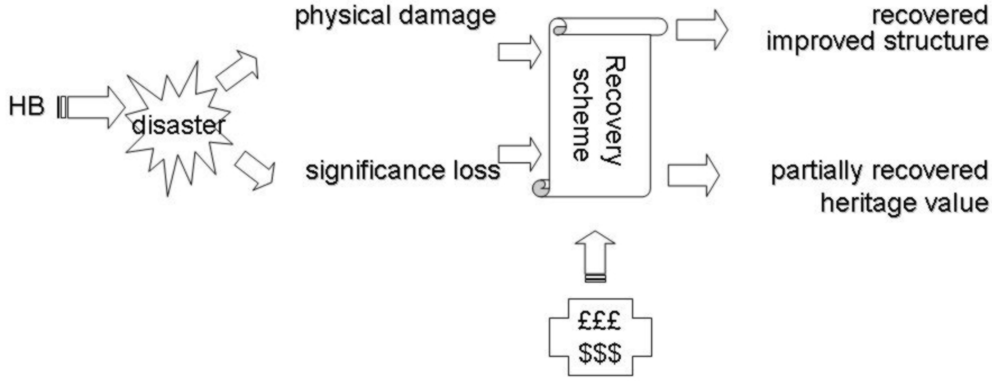

Figure 1. Consequences of hazards to a historic building (HB)

In vulnerability studies, it is difficult to directly apply available statistical casualty and loss data to historic buildings. This is because the restoration costs of some components of a historic building are not proportional to their physical damage, and the significance loss is difficult to value.

2 Vulnerability Ranking

Recent decades saw some quick-assessment tools being developed for the vulnerability of existing structures under threat of certain hazards, for example, the earthquakes risk-screening method by ASCE (2003) and ATC (2002). The main principle behind it is that vulnerability is valued by scoring indicators in a matrix by professional judgments (Thomas et al. 1996). This measure can be utilised to assess multi-hazards.

A historic building may be exposed to multiple hazards at varied times or simultaneously. The first step of disster planning for historic buildings is to find out which buildings are more vulnerable and which hazards impose the major risks. A quantitative ranking system, where the vulnerability index for each hazard and each building is developed, will achieve this target. The comparable indexes for different buildings will guide the establishment of the mitigation and disaster preparedness priorities in a region.

To develop the index, a benchmark has to be established (for comparative purposes) and associated modifiers developed (factors affecting the subject's performance deviating from the benchmark). The modifiers are equivalent to the vulnerability indictors in this paper. [TABLE 1]

TABLE 1: Hazard-risk indexing and ranking of a parish church

Name of building: *Bathampton Church* Code or registration number:

Location: *Parramatta, NSW, Australia*

Construction date:

Parameters \ Natural hazards	Earthquake	Flood	Tornado and gust	Hail storm	Weight of parameter w_i	Total index $\sum$
Loss index for residential buildings I_{resid}	7.3	42.7	22.6	22.1		94.7
Site hazard score F1	3	5	3	3	10	n/a
Structural system and building materials F2	4	2	2	2	5	n/a
Setting (terrain) condition F3	3	5	4	3	5	n/a
Historical performance in past Hazards F4	3	2	2	2	3	n/a
Building footage F5	4	4	4	4	2	n/a
Present condition F6	3	4	3	3	5	n/a
Effect of comparable indicators, $R(f_1, f_2, \dots, f_6)$	1.08	1.32	1.0	0.93		
Relevance index I_{hist}	85	593	234	216		1128
Hazard ranking	4	1	2	3		
Should the hazard enter next tier assessment?	no	yes	yes	yes		

C—coefficient of building typology C=1.2;

K1---coefficient of loss-sensitive components, K1=1.5 for presence of altars, organ, sculpture.

K2---coefficient of importance of the building, K2=3 for Grade II* listed churches;

K3---coefficient of function and use of the building, K3=2 for churches in service;

Note:

$$R(f_1, f_2, \dots, f_6) = \sum_{i=1}^{n} w_i f_i \Big/ 3 \sum_{j=1}^{n} w_j \;;$$

$$I_{hist} = I_{resid} C K_1 K_2 K_3 \sum_{i=1}^{n} w_i f_i \Big/ 3 \sum_{j=1}^{n} w_j$$

A common residential building is thought best suitable to be used as the benchmark building in the preliminary ranking. This is mainly because the loss data for common residences has been widely collected in a region, and the insurance industry is sophisticated in loss estimation (Walker 1999), in particular the loss of residential buildings. For instance, the NHC (National Hazards Centre in Australia) developed a program in evaluating the potential risks of residential buildings in a region under all kinds of potential natural perils (NHRC 2000). Recent research in Australia has enabled an internet-based assessment tool to predict the hazard exposure of every residence (Risk Frontiers 2012).

In order to transfer the benchmark building data (residential-building loss) to a historic building, the vulnerability indictors affecting both the examined building and the benchmark building need to be identified. They reflect the use, listing, physical and circumstantial differences of the historic building from the benchmark.

A 'Delphi process' (Turff and Linstone 2002), which is a structured communication method, may be adopted to work out the major indicators applicable to the majority of historic buildings in a region. Such a process allows a group of experienced experts, having knowledge both in heritage conservation and disasters, to brainstorm a list of indicators that attribute to the vulnerability of historic buildings. Then a vulnerability-indexing function or formula, along with associated coefficients and rules for indicator ranking, is developed. As the ranking system is only the preliminary assessment, both the process and number of indicators need to be simplified.

The example in Table 1 shows how the process works. It is an application of the 'linear additive weighted method' (Saaty 1988; Zeleny 1982) to develop the vulnerability index of a church under all potential natural hazards.Though the examined building is in Bath, England; the hazard exposure data (or normal residential-loss index) is from Parramatta, Australia. Such an application makes sense as many early parish churches in Australia have a similar configuration and construction detailing to their counterparts in England. The building is composed of a tower, nave, chancel, south-east Chapel, south and north aisle in the normal cross-shaped layout. It is built in masonry with timber trusses framing the roof. Dressed stones are used in the bell tower and exterior walls, but rubble stone at the interior. The main parts of the current building were built in 18th and 19th centuries. The church has a strong association with Australia. Arthur Phillip (1738-1814), the first governor of New South Wales Australia and the founder of the settlement of Sydney, was buried in the church, and the south-east chamber became the Australian Chapel in 1974. The church building is listed as Grade 2* by English Heritage.

The hazard-exposure data in the example is the loss index of a normal residential building, which is described as a one to two-storey brick-veneered, terra-cotta roofed and timber-framed independent house typical of Australia.

The formulas next to Table 1 reflect the 'linear additive weighted method'. The non-comparable indictors (Kj)represent the discrepancy of the use, listing status and presence of sensitive or vulnerable fabric, and their scores are designated to a group of building. These are pre-determined prior to the site survey. The comparable or building-specific indicators Fi, comprise the site hazard potential, structural system and building materials, setting and terrain conditions, historical performance at past events, present physical condition and building footage. They are scored by an evaluator during walk-by of a site. The score for Fi, ranges from 1 to 5. The weight of each comparable indictor (Wi) suggests the relative significance of the indicator. Similar to the non-comparable indicators, they are predetermined. The denominator 3 in the two formulas is the indicator's rating for the benchmark building. It is used to normalise the scores of the comparable indicators. In order to make the ranking consistent, basic ranking rules must be established, and certain training for the assessors is needed.

'Site Hazard' indicator F1 and 'Setting Condition' indicator F3 are designed to calibrate the hazard exposure or loss data to a specific site and building. If the further-refined loss index for a specific address is adopted, which is possible under available tools in Australia (Risk Frontiers 2012), these two parameters may be omitted. However, the exposure data for an area (suburb or postal-code area) is preferable, as such data reflect the source and accuracy of past statistical loss.

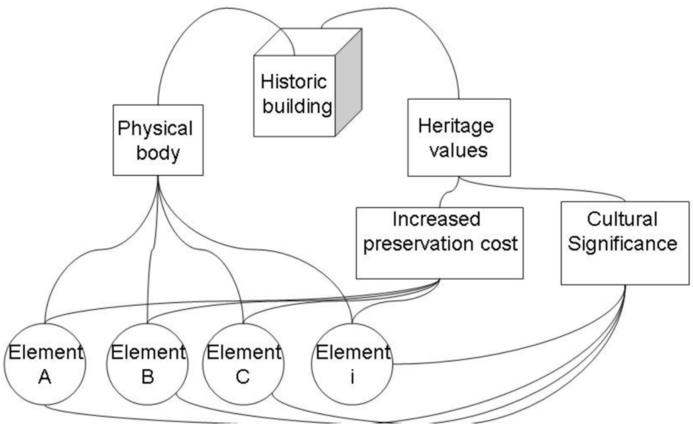

Figure 2. Disassembly of a historic building

3 Analysis of vulnerability through major building components

A historic building is considered to be the amalgamation of its physical body (fabric) and embodied significance. The physical body can be treated as a complex system, which may be divided into sub-systems or key components. Synthesizing results of the vulnerability of the components according to their relationship will generate the vulnerability of the whole system (the Royal Society 2002). The Tier 2 analysis on the vulnerability of a historic building is based on this concept.

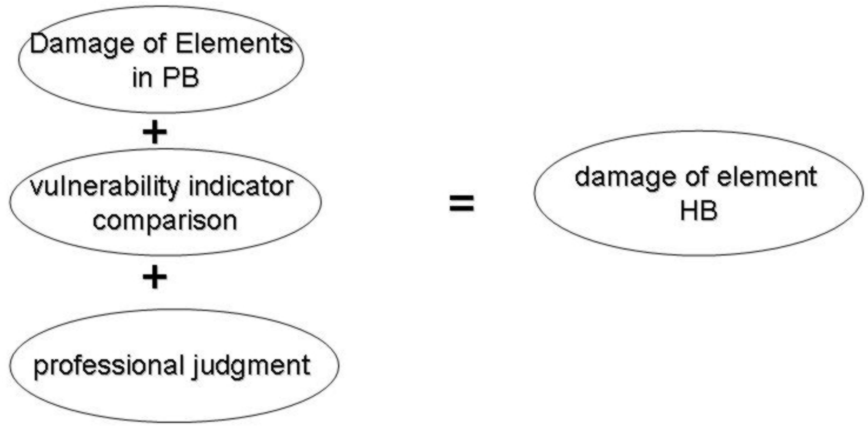

Figure 3. Damage judgement of major building elements (PB=prototype building, HB=historic building)

Disassembling a historic building into key elements has a number of merits. It is an effective way to handle diversity and uniqueness of each historic building through its elements. Comparison between building elements makes it much easier to use available investigative data, as both post-event surveys and analytical modelling focus on major building elements (Porter et al. 2001). Usually, building damage is described according to major elements, and most guidelines for post-event restoration are also based on building components. In addition, distributing significance of a building to its elements enables both its significance loss and economic loss to be properly assessed. [FIGURE 2]

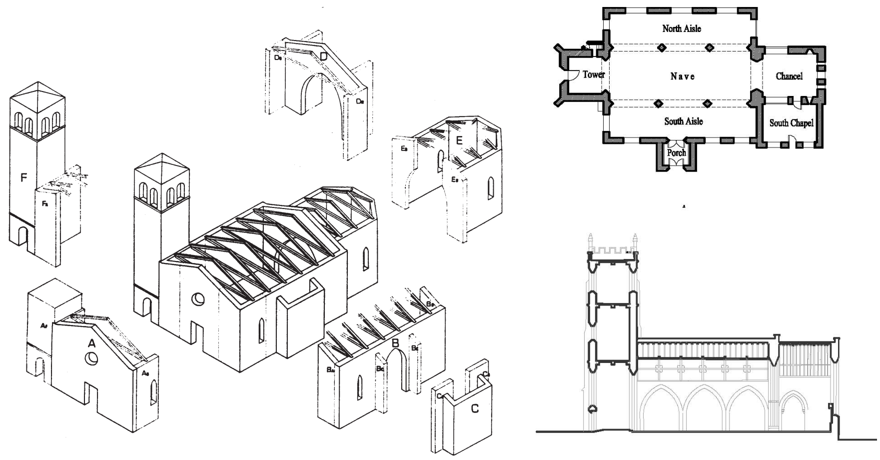

Figure 4. Configurations and macro-element of a typical Italian church (left, after Doglioni et al. 1994); plan and cross-section of the English church (right)

The damage of a building element is predicted by a comparative analysis, wherein the damage data of a similar building is employed as the benchmark. The first step is to select a prototype building (PB), which presents certain similarities to the examined building. It may be a tangible existing building, or a hybrid assembly of normalised components whose damage mechanisms are known. The second step is to disassemble the studied building (HB, a historic building) into key elements or components. The logic of damage judgement is illustrated in Figure 3.

The following is an application of this method to the church building examined in the previous chapter. The high-risk natural hazards are identified as earthquakes and floods in the Tier 1 vulnerability-ranking process. Here, we will only estimate the potential damage of one key building element, the chancel facade [FIGURE 5] of the church, at a given earthquake intensity. The performance of masonry churches in Italy are well studied, and adequate data is available (Lagomarsino 1998). A typical Italian village church is selected as the prototype (PB) for the examined English church.

The configuration of the Italian church includes a tower, a nave and a chancel (or apse) [FIGURE 4], which is similar to the English church. The damage mechanisms of main elements and the main causes are identified for churches in Italy (Langomarsino and Podesta 2004). The three potential damage mechanisms for the chancel façade are identified as overturning of the whole façade, overturning of the gable, and shear cracking. The damage function of the chancel has been established (D'Ayala 2000). [FIGURE 5]

TABLE 2: Indicator checklist and grading criteria

Indicator code	Indicators	Ranking criteria	values
V1.1	Connection details at corners	Enough connections applied at connections of transversal and longitudinal walls; Corners were enhanced in construction; No enhanced connection or week connection;	1; 0; -1;
V1.2	Presence of longitudinal tie rods or buttressed between roof truss or arches,	Not present; Present ;	0; 1;
V2.1V3.1	Opening size at walls	Big size openings, (>1/2 total wall size); Middle size openings (1/3 to ½ total size); Small or no openings (<1/3 total wall size);	-1; 0; 1;
V2.2	Roof covering connection with facade	Well connected or presence of connection ties; Lack of connection;	1; 0;
V3.2	Roof action on lateral walls, and presence of tie rods	No thrusting actions on the wall or presence of transversal ties or buttress; Thrusting actions exist on lateral walls, no presence of transversal ties or buttress;	1; -1;

Five indicators, relating to structural and construction details are listed to judge the potential damage mechanisms of the English church façade. A checklist for indicator rating (or ranking criteria) is developed, where all parameters for the benchmark are scored neutral (0) (Table 2). The feature of each indicator in the English church is matched to the criterion (highlighted) and scored, and the value of each indicator (*Vi.j*, the *j-th* indictor of the *i-th* damage mechanism) and damage mechanism (M) of each component are derived. A negative value (-1) of an indicator increases the probability of the occurrence of a damage mechanism in the examined component, and a positive value (+1) suggests otherwise. The combined value of all the indicators for a mechanism indicates their comprehensive effect, wherein a negative value will activate the damage mechanism.

In judging the extent of damage, other contextual indicators, including the soil type, terrain conditions and secondary hazards are considered as well. Using a similar scoring process, the combined value of the contextual indicators is obtained, which is - 2, suggesting the examined church is more vulnerable than its prototype. Thus the damaged state of the facade in the studied church will escalate.

The damage ratios under different earthquake intensities of the prototype are transferred to the examined church (Table 3). The damage ratio is the probability of occurrence of a damage mechanism or state. It may be understood as an average ratio of the repair cost versus the total reconstruction cost. Based on the damage ratio and building restoration guidelines (DiPasquale et al. 2005), the church façade's restoration cost is estimated.

Estimation of the loss of significance faces many challenges. It needs to have the significance of each building element quantified and the function of restorability established. As different cultures and communities may have different views and criteria on heritage significance, both quantitative measurements of significance and restorability tend to be controversial (Agnew and Demas 2002). However, there are some quantitative grading tools available, such as HIS1.0 by the National Park Service in the US (Lippiatt and Weber 1995). Similarly, a function-of-restorability ratio versus damage states for key building elements can be developed, and accordingly, the significance loss of the façade estimated.

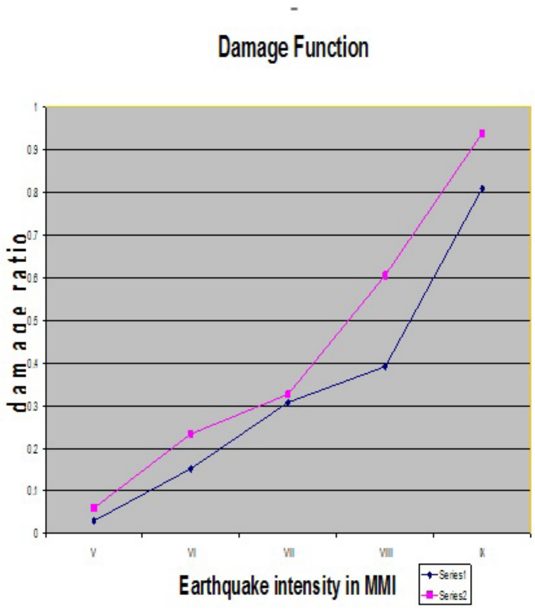

Figure 5. Chancel façade of the examined church (left) and damage function of the similar element in the prototype building (D'Ayala 2000) (right)

TABLE 3: Damage to the chancel façade of the examined church

Component	Contextual Indicator Score	Damage mechanisms and scores	Activated?	Damage ratio (higher ratio of all possible mechanisms)			
				V	VI	VII	VIII
Chancel facade	-2	Overturning of the whole facade - M1 (0)		0.182	0.243	0.368	0.542
		Overturning of the whole gable - M2 (-1)	√				
		Shear mechanism in the facade - M3 (-2)	√				

4 Summary

The purpose of the study introduced here is to bridge the gap between available data and studies of common buildings' loss and risk prediction for individual historic buildings. The specialities of historic buildings are considered through the introduction of relevant vulnerability indicators and separation of their physical bodies and their significance. The Tier 1 assessment, comparative vulnerability ranking, explores how to use the data of a normal residential building to foresee the hazard exposure of a historic building. The multi-attribute decision-making methodology is applied to establish an index for each building under each hazard. The Tier 2 assessment, comparative analysis of damage modes, employs the study result of a prototype to predict the damage and loss of a historic building. It also features dissembling a building into key elements in order to establish better comparability. In both tiers, major indicators are identified and scored so that consistent and informed judgements are made. The two tiers have very different demands on resources and expertise.

This model may be applied to different natural hazards, and both the index and damage loss are comparable between buildings. It has been tested for floods on the same church building (Wang 2007). The ranking or analysis result will assist to develop the disaster-preparedness priority, and guide the cost-effective study of retrofitting and mitigation strategies for historic buildings.

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Defining the Structural Risk at the Archaeological Site of Baalbek

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Abstract. The archaeological site of Baalbek is exposed to both natural hazards (mainly earthquakes) and human-induced hazards (armed conflicts, tourism...). Between March and July 2010, an international team prepared guidelines for the establishment of a 'Risk Preparedness Strategy (RPS)'; a work done in the framework of the UNESCO programme 'Capacity building of human resources for digital documentation of World Heritage Sites affected by the 2006 war in Lebanon'. This paper will discuss questions related to structural risks.

In an ideal situation, it would be possible to precisely quantify the hazards affecting the site, the vulnerability of its parts and the expected losses in case of disaster. The resulting knowledge about risks would form a sound base for the decisions of the managers. This is certainly a good target, but in reality, the process is not so straightforward. The data is incomplete and the process of gathering and improving knowledge requires time and resources. The RPS aims to address these requirements. The models used to estimate the vulnerability of the structures are far from perfect. Their use is not always innocent. It is always beneficial to multiply the points of view. Examples are given of the use of data from a laser scanner survey to better understand the effect of past earthquakes on the structure. The values to protect also require a better definition. Life is certainly of paramount importance, but what about the other values (heritage values, integrity of the buildings, costs of interventions). How can their often contradictory requirements be balanced?

1 Site

Situated in the centre of the fertile Beqaa valley, between the ranges of Mount Lebanon to the west and the anti-Lebanon to the east, Baalbek Temple complex was on the crossroad of two main historic trade routes, one between the Mediterranean coast and the Syrian interior and the other between northern Syria and northern Palestine. It lies around 90km northeast of Beirut. [FIGURE 2]

Figure 1. Great court from the platform of the Jupiter Temple

The site has been occupied since the Neolithic (Van Ess 2008). During the Roman era, Baalbek was the major construction project of Emperor Augustus – the founder of the Roman Empire – and his successors ever made in the East. It was then transformed into an important cultural and pilgrimage place in addition to an essential meeting point for all the caravans crossing the Beqaa from the interior to the south (Palestine) or to the Mediterranean coast. Consequently, Baalbek was transformed into a central place for the dissemination of the Roman civilization and to show the power of Rome to the inhabitants of the region.

The main construction campaign in the complex lasted from the first to the third century AD. The construction of the Jupiter Temple, the largest Roman temple of its time of which six huge columns are still standing [FIGURES 4 and 8], began around the year 15 AD and was almost completed around 55 AD; an inscription from this date was discovered on one of its columns. The building of the Bacchus Temple began around 60 AD and was completed around the mid-second century AD. The construction of the Great Courtyard [FIGURES 1 and 3] began around the end of the 1st century and the beginning of the 2nd century AD. As for the Venus Temple, its construction began during the middle of the 3rd century AD shortly before the Propylaea [FIGURE 7] and the Jupiter temple construction were completed under the reign of Emperor Philippus Arabs in 244-249 AD (Chéhab 1970).

This site was inscribed on the UNESCO World Heritage List in 1984 (ICOMOS 1984). This inscription was based on the site's outstanding universal value; therefore it belongs to all humanity and to future generations.

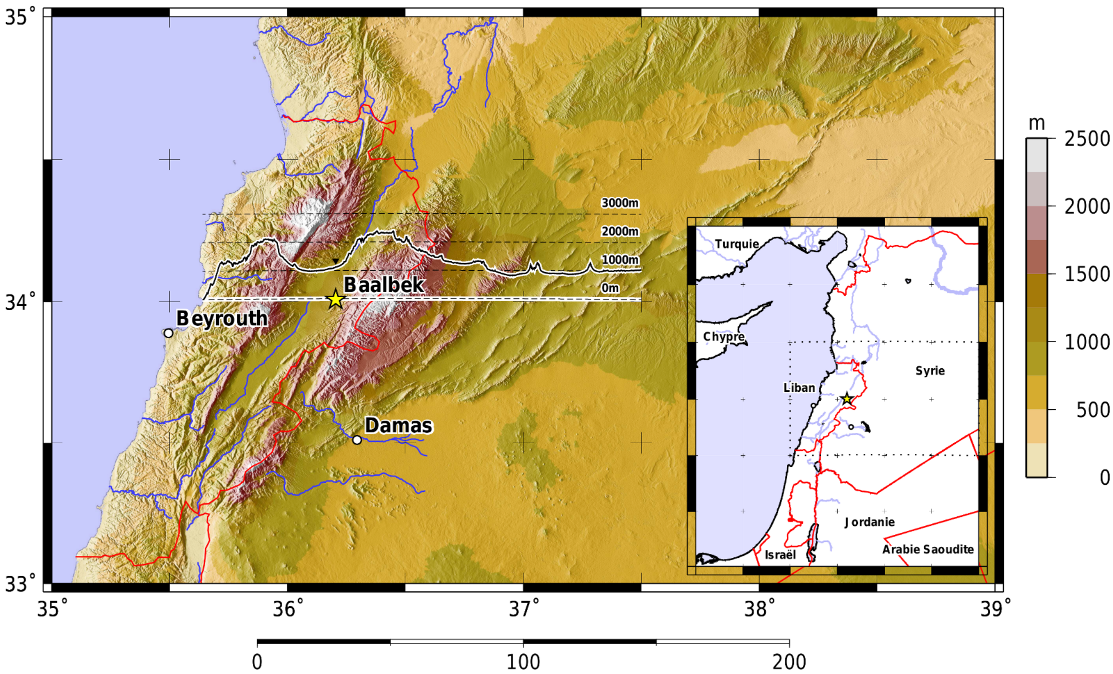

Figure 2. Situation of Baalbek, at the centre of the fertile Beqaa valley, between the chain of Mount Lebanon to the west and the anti-Lebanon to the east

2 Risk

To decide in the presence of uncertainty is perhaps the most fundamental act human agents have to perform. Knowledge is always imperfect (neither accurate nor complete, and perhaps not even adequate) and decisions have to be taken at heartbeat pace.

Intuitively, we may state that: 'A responsible line of action is to do what we believe is best'.

But who is the 'we' in the above statement? What makes us 'believe' and how do we assess that some course of action is the 'best'? When should actions take place and how will they influence the future? Are the actions chosen responsibly? Rationally? Answers to those questions will have a shaping influence on the definition of a strategy. Answering them is actually a key part of the whole process.

Decision making is intimately related to the question of risk, i.e. the 'effect of uncertainty on objectives' (ISO 31000: 2009). The awareness of risks influences our actions. A good knowledge of them hopefully leads to better decisions, taken on rational ground. The World Heritage Committee 'recommends that States Parties include risk preparedness as an element in their World Heritage site management plans and training strategies' (UNESCO 2011).

In a first attempt to clarify the situation, the problem can be approached from a partial 'engineering perspective' using a so-called 'risk-based' approach. PEER, the Pacific Earthquake Engineering Research Center has, for example, developed a very complete framework for a scientific evaluation of seismic performance of buildings: performance-based earthquake engineering (Porter 2003). A requirement of this approach is to be able to characterise precisely hazard (earthquake occurrence), vulnerability (physical effect of a given earthquake on the building) and expected losses (consequence of deterioration on the values).

If those parameters are known - most likely in a probabilistic sense - the risk of a loss can be evaluated. ISCARSAH, the International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage of ICOMOS, also sees this evaluation as a *prerequisite to any intervention*: 'No action should be undertaken without having ascertained the achievable benefit and harm to the architectural heritage, except in cases where urgent' (ICOMOS 2003). Uncertainty in the data will obviously propagate to the conclusions.

Apart from the inherent randomness (i.e. the statistical uncertainty present in the definition of seismic hazard for instance), there is another type of uncertainty not directly addressed in this approach: epistemic uncertainty, the kind of uncertainty related to things that we could theoretically know but that, in practice, we do not know.

A long-term strategy will try to reduce all kind of uncertainty and hopefully transform some epistemic uncertainty to statistical uncertainty. 'Turning uncertainty into opportunity is critical' (Vujicic-Lugassy 2010). At this stage, when the level of knowledge is low, it is arguably more efficient to work on reducing uncertainty before attempting to quantify risk (Klinke 2002, Smars 2010).

Clearly, it will be necessary to look outside the realm of civil engineering to define values and losses and a way to measure them. In the case of new constructions, it may be relatively straightforward to give them a monetary equivalent, but in the case of cultural heritage, it is clearly more complex. Those problems will be discussed in section 5.

3 Hazard

Figure 3. Great Court from the Northern side. The columns of the Temple of Jupiter and the Temple of Baachus are visible in the background

The values of the site of Baalbek are threatened by various hazards, natural and human-induced.

From the structural point of view, the seismic hazard is the most critical. The risk of flood and landslides are, for instance, low in the area (WHO 2011).

Lebanon is situated in a seismic zone. It is traversed by the Levant fault system separating the African and Arabian plates. At the level of Lebanon, the fault system is divided into three major branches. The first two are left-lateral strike-slip faults: the Yammouneh fault (the most active), bordering the Eastern flank of the range of Mount Lebanon, and the system of faults of Rachaya-Serghaya which crosses the Anti-Lebanon mountain range. The third is the East-dipping Mount Lebanon thrust, forming an arch offshore, between Tripoli and Saida.

Baalbek is situated in the Beeka valley, at approximately 7km away from the Serghaya fault and 25km from the Yammouneh fault.

In the past, various earthquakes affected the site (Daëron 2005): July 9th 551 (estimated Mw: 7.5), January 749, in 1170, May 20th 1202 (estimated Mw: 7.5), October 30th and November 25th 1759 (estimated Mw: 6.7 and 7.4) and more recently, September 29th 1918 (estimated Mw: 6.8) and March 16th 1956 (Mw: 6.3).

Earthquakes contributed to the progressive degradation of the site. Just considering the most emblematic of its monuments, the Temple of Jupiter, mention is made of two fallen columns in 565, one in 991, eleven in the 12th century, thirty one in 1202, and three in 1789 (last major earthquake) (Daëron 2005). Today, six columns are still standing. [FIGURE 8]

Hazard is probably the element of the risk-based approach which is best known. Seismic hazard maps of Lebanon exist. According to Huijer et al. (2011), the expected peak ground acceleration is 0.25g for a return period of 475 years and 0.35g for a return period of 950 years.

Improvements are nevertheless still possible. If site factors were studied (source mechanisms, local geology and topography, determination of the foundation levels), the local amplification factors of the Peak Ground Acceleration (pga) and the frequency content of potential earthquakes would be better known. Time-history representations of the earthquake motion (synthetic accelerograms) could then be prepared. A more accurate definition of the hazard would lead to better risk evaluations and a more effective intervention policy.

4 Vulnerability

The vulnerability of a structure is a measure of the effect of structural actions on its physical condition. As actions increase, new types of damage progressively appear: cracks, permanent deformations, local collapses, total collapse. Models should allow studying and quantifying this relation (many models commonly used by practitioners do not produce this kind of result/information, Smars et al. 2010).

A reliable assessment of the vulnerability requires a good knowledge of the solicitations (as discussed in Section 3), of the structures and suitable models.

In the present situation, structures are not yet sufficiently characterised. 'A full understanding of the structural and material characteristics is required in conservation practice. Information is essential on the structure in its original and earlier states, on the techniques that were used in the construction, on the alterations and their effects, on the phenomena that have occurred, and, finally, on its present state' (ICOMOS 2003).

The geometry is the aspect of the constructions which is best defined. The recent laser scanner documentation of the site provided accurate measurements of the buildings (Santana et al. 2010, Seif and Santana 2011). This is a clear and substantial asset, but before this data can be used for structural modelling, the geometrical models have to be completed. Most of the upper parts of the buildings were indeed not measured, as those areas are not visible from any potential laser scanner station. Finally, the data should be transformed to a form more suitable to structural analysis.

The construction techniques and material structure of the fabric (hidden inside the walls and below the ground) is not as well-known as the outside surface of the buildings (shapes). Most buildings on the site are built with large stone blocks. Metallic and concrete reinforcements are also common. Some are original (hooks, bolts) and some were placed during the various restoration campaigns (steel bars). Those reinforcements modify the connections between blocks and can significantly influence the behaviour of the structure. A precise documentation of past interventions and reinforcements is still missing. Reinforcements were, for instance, introduced in the architrave of the Temple of Jupiter. [FIGURE 4]

Figure 4. Temple of Jupiter. On the left: situation at the end of the 19th century (Source: Félix Bonfils (1831-1885), Service des collections de l'École Nationale Supérieure des Beaux-Arts). On the right, situation in March 2010

Past earthquakes destroyed many structures on the site and left numerous traces on the buildings left standing. This fact demonstrates well enough that future earthquakes could bring more destruction. An analysis of traces can help in understanding the potential effect of disasters (ICOMOS 2003). Laser scanner measurements can be used to study deformations and understand the damage [FIGURES 5 and 6] (Smars et al. 2010). Some caution is nevertheless necessary. All deformations are not the results of past earthquakes. Comparison of the current situation with ancient photographs demonstrates that some important deformations only appeared after anastylosis, probably to accommodate non-fitting elements.

Modelling such constructions is not easy. Even for a structure as simple as a column made of a single block, perfectly defined, studies have shown that similar dynamic solicitations (earthquakes with identical pga and frequency content) can lead to significantly different outcome (DeJong 2009). Behaviour is very sensitive to initial conditions. Ideally, vulnerability should also be expressed in probabilistic terms.

In practice, a progressive approach is necessary (ISO 31000: 2009, ICOMOS 2003). The site is very large. Priority should be given to a more detailed analysis of the structures of high value (see below) and structures identified on the basis of a qualitative assessment of the vulnerability.

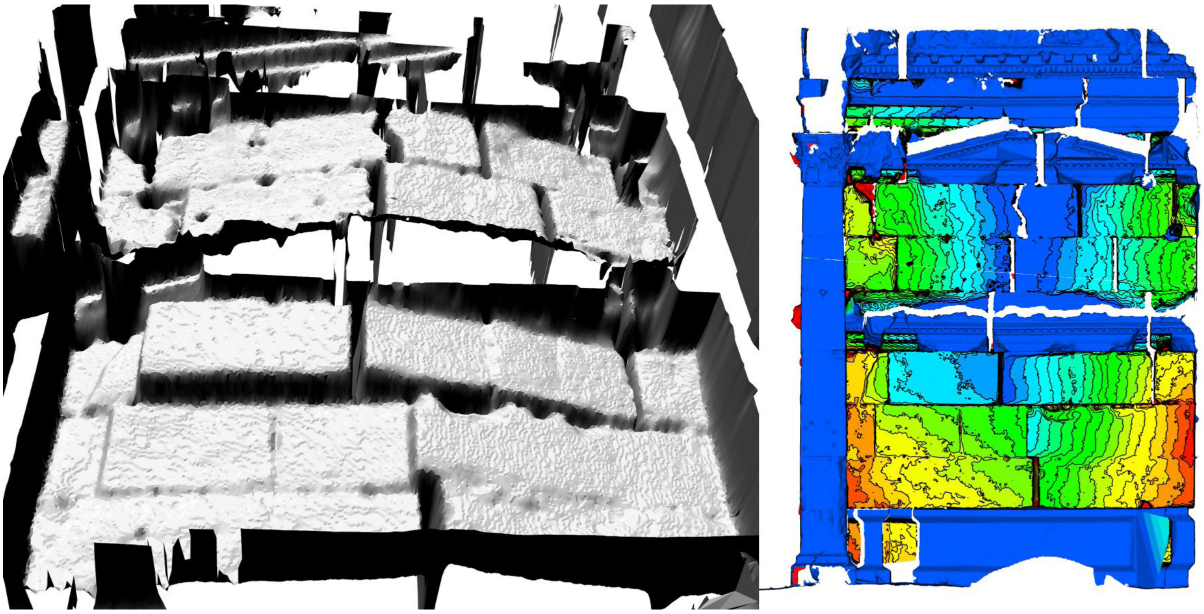

Figure 5. Eastern Wall of the northwestern semi-circular chamber of the Great Court.Left: exaggerated (10x) deformations of the wall. Right: elevation where colours indicate the distance to a vertical reference plane. The two figures were created with Points&Forces software using the data of the laser scanning documentation of the site

5 Values

The existence of risk is contingent on the existence of hazard. If nothing may vary, there is no risk. To reduce it, changes are necessary.

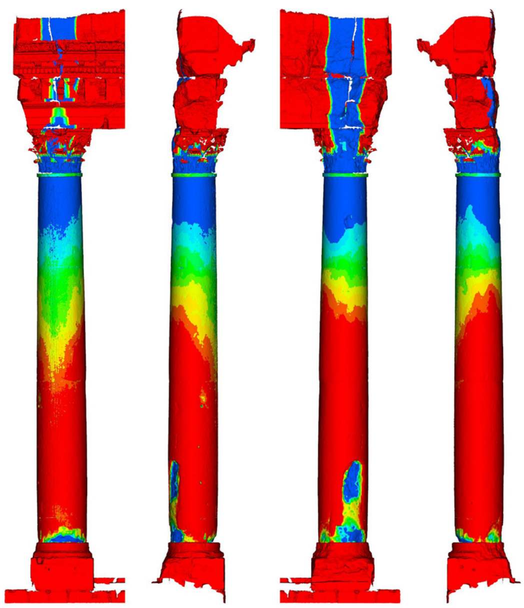

Figure 6. Analysis of the deformations on column of the Temple of Jupiter. Colours indicate the distance between the surface of the column and a vertical reference cylinder

Considering life value and safety of the visitors, the previous statement does not pose a conceptual hurdle. Structures can be reinforced, retrofitted and the risk on persons mitigated (within cost limitations).

Heritage values (under their various guises) introduce specific challenges. Professionals in the protection of architectural and archaeological heritage typically define their field using words like 'conservation' or 'preservation', which clearly do not fit with the idea of change. Those words may be misnomers but they certainly do not point obviously in the direction of retrofitting or structural reinforcement.

As already clear from the analysis of Riegl (1903), values are multiple; they often have contradictory protection requirements; they are not weighted equally by the stakeholders; and they will change with time and the evolution of society. Various cultures also see them in another light (Nara conference on Authenticity). Newer studies (like in Avrami et al. 2000) may have a different interpretation of Riegl but arguably do not alter fundamentally this vision.

But how can vulnerability actually be decreased? That can certainly be achieved by changing the object (structural mitigation), but also by changing its context (non-structural mitigation) and/or the perception of the problem by stakeholders. The question to answer will be: 'How much are we ready to change to be confident that what we value will be preserved?'

Structural mitigation reduces vulnerability by introducing new structural elements in the building: anchors, tie-rods, concrete beams, fibre-reinforced plastic reinforcements, injections, etc. If the intervention is properly designed, the object will be more resistant to disasters, and the chance to transmit some of its values to the future generations will be increased. As stated above, this is often the most straightforward and effective solution to protect life and 'use value'. Unfortunately, in the case of cultural heritage conservation, this type of mitigation may endanger other values.

Figure 7. Columns of the propylaea

Whatever the set of heritage values considered and their precise definition, some of them will nevertheless be negatively affected by changes to the fabric. For Riegl, it would probably be the 'historic value'. ISCARSAH (ICOMOS 2003) emphasise the importance of protecting buildings behind their surface: 'the value of architectural heritage is not only in its appearance, but also in the integrity of all its components as a unique product of the specific building technology of its time', 'the distinguishing qualities of the structure and its environment, in their original or earlier states, should not be destroyed' and 'each intervention should, as far as possible, respect the concept, techniques and historical value of the original or earlier states of the structure and leave evidence that can be recognised in the future'. The so-called 'principle of minimum intervention' is meant to protect those values. Finally, it may be argued that, in order to let to the future generations apply some new social-constructed values to the fabric, it is a good idea not to burn too much of its essence.

In past restorations, metallic bars were intensively used in Baalbek to give continuity to the block structures which were reconstructed (sometimes giving them a somewhat surrealist appearance) [FIGURE 7]. In that way, the 'integrity' of the structure was restored but without much consideration for 'the specific building technology of [the] time' and 'the concept, techniques and historical value of the original'. This is a case where values are conflicting – a typical problem with conservation issues. The major weight given to integrity may fit with a growing tendency towards reducing objects to the iconic value of their image (Adorno 1991) or towards seeing heritage solely as a means of economic development, a tendency well illustrated by the discussion surrounding the possibility of reconstruction of the statues of Buddha in Bamiyan. It is the opinion of the authors that it is important to have clear ideas about values and their relative weight before attempting to evaluate risks and certainly before deciding about future interventions. Those ideas should be developed, stated and publicised in dialogue with the representatives of the numerous stakeholders. Issues related transparency will be developed below. Furthermore, structural mitigation is not the only way.


Figure 8. Temple of Jupiter seen from the South

Non-structural mitigation decreases vulnerability indirectly, without changing the object or building. Smaller fragile objects may be moved to safer environments, like museums. Buildings and building elements, clearly, cannot receive the same treatment. But, for some of them, collapse may be anticipated and the environment prepared to limit damages and facilitate retreatability (Van Balen et al. 1999). Preventive measures can be taken to mitigate the effect of potential disasters: precise documentation of current condition, preparation of ground surfaces, and protocols of post-disaster intervention. This is not a solution to apply *indiscriminately,* but it is an option worth considering. Various factors may help deciding its suitability.

- A difference must be made between structures still standing in what we imagine was their original condition, structures still standing and retrofitted (like the columns of the Temple of Jupiter) [FIGURES 4 and 8] or modified (with some of their blocks moved); structures which collapsed and were rebuilt trying to keep the original structural concept; structures which collapsed, were rebuilt and retrofitted; and remains lying on the ground. Many blocks, often on the top of walls, are currently not exactly in their original position, some for many years.
- The expected damage in case of collapse and its impact on the other values, considering the possibility of a new anastylosis.
- The increased risk for the visitors must also to be taken into account. This risk may be decreased by controlling access and circulation. Some areas may become inaccessible.

Non-structural mitigation techniques have the clear advantage of keeping the historical document intact, but that does not mean that this approach does not affect other values: context and perception will be modified.

To improve the documentation of the site (photographs, surveys, analysis, scientific studies...) is also a non-structural mitigation technique. It reduces the risk to loose information, even if the risk of losing its material support is not changed.

To clarify the process of defining and measuring values, it is worth returning to the sentence ‘a responsible line of action is to do what we believe is best’ and discussing its parts.

‘Responsible’. Baalbek is inscribed on the UNESCO World Heritage List. As such, it is recognised that it has Outstanding Universal Value, i.e. that it is of ‘common importance for present and future generations of all humanity’ (UNESCO 2011). Decisions makers have therefore a huge responsibility. It is a truism to say that they should follow a responsible line of action.

‘We’. Who decides what course of actions should be followed? Who influences the decisions? Who should benefit from the action of the deciders? Those are classic questions related to governments and ethics. It is certainly beneficial to recognise this similitude and use it as an inspiration to state principles of good governance at the various levels (strategic and management).

The existence of a risk management strategy will improve the stakeholders’ confidence and trust (ISO 31000: 2009). In Baalbek, the stakeholder, i.e. ‘person or organization that can affect, be affected by, or perceive themselves to be affected by a decision or activity’ (ISO GUIDE 73:2009) is ‘humanity of today and of the future’ (UNESCO 2003): many people indeed!

Trust will also benefit from an understanding of the context. The formal as well as the practical or actual decision-making procedure should be studied, improved, laid out and publicised with deciders, influencers (technical, financial, political) and other stakeholders identified and their interaction clarified.

Participation and transparency contribute to the fulfilment of accountability to stakeholders. Questions of values should not be discussed in isolation at a decisional or at a technical level. They result from the manifold vision of the numerous stakeholders on the archaeological site. Stakeholder representatives could help raise awareness about values at stake. They may help define them or more likely help weighing the effect of practical decisions, 'courses of actions' or 'type of interaction' on values. Stakeholders should therefore have a place somewhere in the decision-making organization. Mechanisms should be implemented to let them exert influence both a-priori and a-posteriori. They should be given the possibility to complain and the assurance of getting responses. This is another guarantee of good governance; risk management benefits of negative feedback (ISO 31000:2009), it improves its robustness. This dialogue or 'participatory discourse' is part of the discourse-based management strategy discussed by Klinke and Rena (2002), a strategy which suits well situations combining low probability of occurrence, high stakes, and large uncertainty.

Another way to improve transparency is to give access to data (open data). Thanks to the implementation of this policy by many institutions, there is already a lot of information available on Baalbek. Numerous ancient photographs and documents are accessible in various open internet archives (E-corpus, Europeana, Gallica, INHA, Internet archives, Library of Congress (also stereoscopic images), etc.). Some UNESCO reports are also accessible online. It may be a good idea to investigate the possibility and conditions to go further and offer access to other types of data: results of measurements, monitoring, reports of experts, etc.

This policy would present various advantages:

- Improving transparency of the actions decided concerning a site 'important for all humanity', possibly mobilising new stakeholders.
- Facilitating 'peer review' of actions and studies.
- Facilitating new contributions to the understanding of a World Heritage Site, possibly offering new perspectives on complex issues. For instance, evaluation of the vulnerability can always be improved or done on the basis of other premises.
- Putting an organised repository in place (i.e. aggregating data coming from difference sources) to make it easier to identify gaps in the knowledge and in the strategy. A repository may become a tool of the risk-management strategy, facilitating monitoring (ISO 31000:2009).

Of course, the possibility of new threats has to be considered.

'believe'. Some epistemic uncertainty will always remain. This is particularly true when dealing with vulnerability assessment. Some assumptions cannot be verified without destroying the objects that are to be protected. Conservation is dealing with the unique; meaningful experiments are not reproducible ('einmal ist keinmal'). In such a context, it is beneficial to keep a critical eye on hypotheses, possibly test the sensibility of results to them, and multiply points of views which can, somehow, improve belief (ICOMOS 2003, Smars 2010).

'best'. What is the 'best' course of action? To answer this question, it is necessary to agree:

On the values to protect.

- To prepare a set of tentative options (possible course of actions). It is not possible to consider all options.
- To evaluate the influence of an option on the individual values. Some options will favour the protection of some values and be detrimental to others.
- On a measure to evaluate the options. This is certainly the most critical point. It requires compromises (Riegl 1903) and dialogue.

This agreement should be the result of a dialogue between deciders, influencers and stakeholders. Elements useful to this dialogue were presented above.

The preparation of a set of options is probably the point which will be left in the hands of technicians (a category of influencers). This may also be a critical point. Choices are made in the space defined by the options offered, but better solutions may lie outside this space. Structural engineers have bias. They are firstly trained to deal with new constructions, using a limited set of materials and techniques, and their ideas are influenced by the framework given by structural standards. They may also have the propensity to think only in terms of structural-mitigation.

For new constructions, the key values to protect are the safety of the occupants and the financial value of the construction. Their protection is guaranteed by requirements imposed by construction standards like the Eurocodes. Requirements are of two kinds: principles, which have to be followed in any circumstances, and application rules, which do not have necessarily to be followed if the designer can prove that the problem addressed can be solved using another approach, compatible with the relevant principle. This framework is interesting and its relevance extends beyond its legal limits. However, some principles are inappropriate for architectural heritage and even more for archaeological heritage. 'Often the application of the same safety levels as in the design of new buildings requires excessive, if not impossible, measures. In these cases, specific analyses and appropriate considerations may justify different approaches to safety' (ICOMOS 2003). One of the principles states that the structure should not collapse during its designed working life. But what is the designed working life of the archaeological site of Baalbek? And is it always necessary that structures will not collapse? For new buildings, it is certainly an effective way to protect the safety of occupants but for an archaeological site it is probably better to refer to higher principles: the life of the visitors and the protection of the heritage values and to let the designers find a suitable way to ensure their protection.

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A Reasonable Conservation Strategy Integrated with Value and Risk Assessments of Cultural Heritage:
An Exploration in Kuqa Cultural Relics Master Conservation Planning

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Abstract. Kuqa County in Xinjiang Province is the central historic site of the ancient city state Qiuci, with a large number of city ruins, beacon sites, Buddhist temples and other cultural relics. Due to a serious lack of financial support and professional conservators, it is very difficult to protect the cultural heritage from natural and human-caused disasters. Therefore, it is urgent to develop an effective conservation strategy to solve the problem. In this case, a comprehensive evaluation for each relic is made, and then a risk assessment of cultural heritage is developed. Taking into consideration the destructive environmental factors that may endanger the relics, we investigate and analyze the relics' materials, structures and damage, to estimate their anti-disaster resilience; and based on all of these factors, make a proper conservation strategy. It is our expectation to take significance and safety factors of cultural relics into comprehensive consideration, and generate a reasonable and effective conservation strategy with limited human labour and material resources.

1 Background

Kuqa, Kuche, or anciently named Qiuci, as transliterations of Chinese from Uygur كذ (Kuqa) and كر (Kuca or Kucar), which originates from ancient Qiuci language, meaning City (JI, 2000), is located in land-locked, northwest China at the Tarim Basin, which is in the south of Xinjiang Province (the historical 'Western Regions' in China). It used to be a very famous oasis city along the Silk Road, with a long history as well as distinctive culture, of more than 2,000 years. Now the city lies 448 kilometres, 753 kilometres in road mileage, away from the provincial capital Ürümqi.

Kuqa County is an expansive territory of 150,000 km² that originally belonged to the ancient Qiuci Kingdom. At present, it is occupied by multi-ethnic groups (mainly the Uygur). Abundant cultural heritage exist within its territory, 202 sites in total, including 68 sites newly added after the third national cultural relic/heritage exploration of 2009-2010. Among the 202 relics are 146 Cultural Relic Units separated into different classes, containing five National Key Cultural Relic Units, 27 autonomy-level Cultural Relic Units, and 114 county-level Cultural Relic Units. Of these, the Kizil Gaha Beacon Tower and Subashi Buddhist temples are included in programmes along the Silk Road as part of the World Cultural Heritage nomination.

Many city ruins, beacon tower sites and Buddhist temples remain in the county, mainly consisting of earthen constructions. These heritage sites have undergone damage to different degrees, due to natural and artificial factors. An appropriate and reasonable risk assessment of the heritages, therefore, lays the foundation for effective conservation measures.

During the process of developing the 'Kuqa Cultural Relics Master Conservation Plan', the research panel prepared risk assessments through minute field research on local heritage sites, adopting research approaches from various fields of study. Classification of the site surroundings was also conducted in order to give more specific assessment and appropriate conservation strategy. Our planning was closely connected to the concrete conditions in Kuqa, and a set of effective approaches in risk assessment, as well as administration methods took shape, articulated as follows.

2 Main content of the research

2.1 Current problems in heritage preservation

The abundance of heritage and relics in Kuqa, which are diversified in type and vast in quantity, in addition to being dispersed all over the region, made it impossible for us to scrutinize every site scattered over the 15,000 km² within limited time and under unfavourable circumstances. In the previous 'Conservation Plan of Kuqa as a National Celebrated City of History and Culture', our research panel proposed a structure for regional preservation, and as the following 'Kuqa 3S (RS, GPS and GIS)' concept went deeper, we conducted surveys on relics that were in better condition and of greater representativeness, following past routines and based on natural features of the distribution areas.

In order to be better informed about the current conditions of conservation for various types of relics, in different climatic and topographic conditions, we conducted several surveys at different times. We have surveyed 171 sites making up 85% of the total number; these sites represented all heritage types, as well as geographic surroundings. This laid a sound basis for the formulation of appropriate conservation planning. Moreover, our research panel cooperated with archaeological researchers and collected 286 samples without causing damage to the sites, including pottery fragments and C14 samples of bones and reed stems. These were taken from sections of archaeological exploration trenches.

Several issues can be explained as follows, based on our research and analysis, as well as conclusions derived from issues that exist in the preservation of sites in the county:

- Cultural relics are exposed to various kinds of natural and human-caused damage;
- Data for the heritage sites are inadequate within the region, and in-depth, quantified heritage evaluations are wanted;
- The conservation and usage of current Cultural Relic Units lack systematic consideration and transmission;
- The current conservation deployment is poor in operability;
- Most relics have unfavourable conditions for visiting, interpretation and presentation, leading to poor public recognition.

2.2 Multi-disciplinary cooperation and value assessment

Based on the problems articulated above, our conservation master planning engaged archaeology experts as advisors to the program. We also continued our cooperation with various institutions, including the Archaeological Chronology Research Base of the Chinese Archaeology Research Centre at Peking University, and the National Weather Bureau. These multi-disciplinary collaborations permitted us to conduct assessments of the values of and safety risks to the heritage sites. The key issues that emerged are as follows:

- Verifying the authenticity of sites newly discovered during the third national cultural relic/heritage survey;
- Dating scientifically significant relics in terms of archaeological chronology;
- Identifying the types and building methods of cultural heritage sites.

During our first-phase inquiries, we also investigated the current conditions of the Kuqa cultural-heritage study:

- As for research organizations, in addition to the Qiuci Research Institution, which falls under the auspices of the Department of Culture and Bureau of Heritage of the autonomy, an organization devoted to the study and conservation of grottoes, the only other relevant research organization is the Society of Qiuci Study. This organization was founded by the Propaganda Bureau of the CCP Prefectural Committee in Aksu, and the Xinjiang Economy and CCP County Committee in Kuqa. It is the only social institution of scholarship on local Qiuci studies. Moreover, areas of research achievements, both at home and abroad, are to be integrated.
- In terms of the research subjects, current study about Kuqa relics is concentrated on grottoes and mural paintings, while cultural sites, such as cities, beacon sites and constructed temples, are poorly understood.
- As far as the research faculty is concerned, there is a shortage of professional research staff, and communication with other relevant research institutions is absent, due to the lack of specific funds. In summary, local practice in conservation and research has remained at a relatively low level over a long period.

The purpose of cooperation between multiple disciplines is to acquire more accurate evaluations on the authenticity and continuity of the relics, and to highlight the connections between sites. This will lead to gaining a better interpretation of the holistic significance of Kuqa heritage, in order to provide a basis for scientific, systematic conservation.

2.3 Damage risk assessment of cultural heritage

Through solid basis of research, we have assessed the damage of different relics, and analyzed the heritage condition.

2.3.1 Assessment of the relics conditions by different types

By assessing different kinds of relics including ancient ruins, tombs, grottos, caved stones and architecture, we have made evaluation on the condition and quality of the relics.

The condition of ancient ruins: main problems are vegetation, surface washed out, powdering, spalling, surface deformation, cracking, collapsing and so on. Among all the ancient ruins, 16 relics have been well conserved; 78 are in average condition; 10 of them have been damaged seriously and are in need of protection desperately.

The condition of grottos and caved stones: this type of relics is mainly affected by water and weathering of rocks since it may take murals off easily. Artificial sabotage is also an important factor. Among all the grottos and caved stones, 1 grotto has been well conserved; 5 grottos have been affected by natural factors and are in average condition; 2 caved stones are in average condition.

2.3.2 Major damage risk factors

According to the assessment and analysis of different types of relics, the major damaging factors of cultural heritage are concluded below.

1. Artificial factors

The cultural relics located in or around the city have better environment for preservation, however human activities and urban development may create short-term huge damage.

a. Kuqa County has been constructed on the historic site: Buddhist Kingdom of Qiuci during the Tang Dynasty.

b. The construction of copper factory reservoir affects downstream area: the construction of copper factory reservoir may result in salinization of downstream area and have negative influence on the protection of earthen sites. Some units are below the reservoir storage line, which makes them in danger of annihilation.

c. Oil and gas industries development: physical exploration may do harm to cultural relics; site construction, oil drilling and oil transportation may also have unpleasant effects.

d. Farmland and water conservancy construction: the construction of irrigation canals and drainages; farming and reclamation.

e. Road construction may damage the relics.

f. Special departments and institutes: it is hard to protect and manage the relics within sheep farms, which belongs to Animal Husbandry Office of Xinjiang Uygur Autonomous Region.

g. Villagers build houses on the historic sites and use the soil of earthen sites for agriculture.

h. Some earthen relics have been stolen and destroyed.

2. Natural factors

It is hard to conduct the protection work of the relics on the field owing to the location and environmental conditions. For example, most of the ancient ruins and tombs are in the open air and not moveable, so they have long been damaged by various natural factors.

a. Natural factors

- Wind erosion: hard objects like gravel and rocks may be taken by the wind and damage the surface of the relics in open air.
- Rain erosion: rain, snow and melt water will wash out the relics, leading to surface cracking and collapsing.
- Freeze-thaw: since the differences of diurnal and annual temperature are high, the stress generated by water freezing and thawing may damage the relics exposed in the open air.
- Salinization: with the evaporation of water, the soluble salts in the soil may crystalize on the surface, generating stress that is harmful for the earthen sites.

b. Natural disaster

- Flooding threats to the relics: Weigan River and Kuqa River.

3. Biological factors

A considerable amount of grass, moss and fungus grow and cover the relics, which not only change the appearance but also accelerate the deterioration of the heritage site. There are also moss and fungus in the wet area of cave temples and stones, which affects the relics as well.

2.4 Assessment of protection facilities

After thorough research on the history and condition of the remaining relics, and in addition to the evaluation on historic, artistic, scientific and social values, we have also assessed the protection facilities and potential risks of cultural heritage.

2.4.1 Assessment of fire-fighting facilities

Based on heritage conservation level, relic type, material, location and supporting facilities, fire hazard and its level have been evaluated and identified.

- Fire hazard level 1: relics that are made of flammable material such as brick and wood, including ancient buildings and some modern architecture.
- Fire hazard level 2: relics that are made of flammable material but located in mountains or towns that are prone to fire.
- Fire hazard level 3: relics that are made of flammable material and at places that are not prone to fire.

Among 146 heritage units and 159 cultural relics, 17 of them are identified as fire hazard level 1, including Subashi Buddhist Temple, A'ai Ancient City, and Tangwang City. 21 of them are at fire hazard level 2, including Kuqa Temple, the Molana Eshiding Mazar, and Kizil Gaha Beacon Tower. 121 are at fire hazard level 3, including the Qiuci Ancient Kingdom site, Wuzita wooden garrison Fort, and Xiaolihanna Ancient City.

2.4.2 Assessment of security facilities

On the basis of heritage conservation level, relic type, location and supporting facilities, we have conducted a risk assessment and identified the levels.

- Risk level 1: national key units; grottos, tombs and other relics among regional key units that are in poor condition and facing serious damage.
- Risk level 2: regional key units (except those that are identified as risk level 1); grottos and tombs among county-level key units; and other relics among county-level key units and non-listed units that are in poor condition and facing serious damage.
- Risk level 3: county-level key units (except those that are identified as risk level 2); non-listed units (except those that are identified as risk level 2).

Among 146 heritage units and 159 cultural relics, 13 of them are identified as risk level 1, including Kuqa Temple, the Molana Eshiding Mazar, and Kizil Gaha Grotto. 90 of them are at risk level 2, including the Qiuci Ancient Kingdom site, Calaca ancient city site, and Niyaz-Aguilar dwellings. 56 are at risk level 3, including Kunasi ancient city site, Mazha Bage beacon, and Tangwang City.

2.4.3 Assessment of mine facilities

Most cultural relics are not installed with mine facilities. However many of them are earthen sites, mining sites and tombs that do not need mine facilities. Ancient and modern buildings without mine facilities are in danger of thunder and lightning.

2.4.4 Assessment of flooding

There are two rivers in Kuqa County, Kuqa River and Weigan River.

The southern part of the county is on a lower terrain, and most of the relics especially earthen sites are located on the banks of Weigan River, so flooding is a big threat to them.

Kuqa River runs from north to south and passes through the old town while a lot of relics stand beside it. If flooding happens, the relics along the river as well as the old town will suffer seriously.

2.5 Formulating a highly operable conservation plan

2.5.1 Comprehensive, systematic and scientific evaluations in all aspects

Besides the evaluations in terms of history, art, science and sociology, which are based on the combination of comprehensive, systematic research into both history and present facts, additional evaluations of current conditions took place. These were divided into five aspects, including the current conditions of faculty, environment, exhibition and usage, infrastructure, and management, along with 17 secondary aspects, to be precise. We concluded the following points:

1. Conservation lacks regional cooperation and integration, and the understanding of conservation is incomplete;
2. Relics abound, while scattered expansively, leading to the absence of systematic consideration and application of conservation, and development of the heritage;
3. Most Cultural Relic Units are currently applying conservation deployments that are poor in operability, and the basic recording of heritage sites remains to be accomplished;
4. There is a serious lack of conservation professionals and infrastructure;
5. Most cultural relics are vulnerable to damage and are non-conducive for visitation and appreciation, leading to poor public recognition;
6. The administrative system is defective, and funds for administration are insufficient.

2.5.2 Adopting pertinent and diversified preservation measures according to local conditions

Cultural heritage sites are classified into various types, and a single protection mechanism cannot be applied to all of them. Based on detailed evaluation of current conditions, our planning lays out regular explanations of natural factors as well as non-natural ones, and identifies those responsible for major damage. Protection methods are sequentially directed against these principal factors. More specific protection methods, aimed at different types of relics, are formulated according to the conditions of heritage damage.

Due to the great quantity of relics extant, we settled on the protection methods, while periodically implementing guidance according to economic factors, the current condition of relics, as well as the difficulty of application, thereby guaranteeing the usability of the master plan.

2.5.3 Proposing plans for archaeological excavation and the accomplishment of fundamental heritage evaluation pointed out the weaknesses in local heritage evaluation

As relic sites makes up the majority of heritages in Kuqa, and due to the underdeveloped archaeological research, information about the heritage sites' dating and types is still obscure, causing difficulty for the conservation and study of heritage. We developed schedules for archaeological excavations, along with conservation planning, in order to accomplish fundamental evaluation of local heritage sites. These were significant in permitting an in-depth and scientific understanding of the heritage, as well as for research in relevant study fields, and for future exhibition and display.

2.5.4 Formulating methods in fire-fighting and safeguarding, according to local conditions, the state of the relics and their surroundings

Over the 15,000 km² territory of Kuqa, heritage sites are dispersed sparsely, while staff for preservation and administration is scarce. As a result, most Cultural Relic Units may never meet the requirements for fire-fighting and safe-guarding facilities, were they to be provided by the same standard throughout.

For fire-fighting planning, the evaluation of security risks and the identification of risk levels are assigned according to the grade and type of heritage, as well as its building materials, its geographic surroundings and interior layout. Heritage sites, whose main structure consists of brick, timber, and other combustible materials, such as historic buildings and pre-modern buildings, are identified as heritage of first-degree fire risk. For heritage sites that contain no combustible materials in their main structure, but whose locations are places vulnerable to fire, such as forests and villages, thereby a potential risk to the safety of the relics, we identified as second-degree fire risk. Heritage sites, whose main structure has no combustible materials and whose surroundings are not likely to catch fire, were identified as third-degree fire risk. The plan matches the fire-fighting levels based on the security risks, and adopts appropriate deployment of fire-fighting facilities.

For planning related to safeguarding, evaluation of security risks and the identification of risk levels was also assigned according to the grade and type of heritage, its building materials, geographic surroundings and interior layouts. Important national cultural relics, and key provincial heritage of grottoes and tombs, as well as those located in harsh environments and exposed to severe damage, were identified as heritage sites of first-degree safety risk. Other key provincial cultural relics and significant county-level heritage sites of grottoes and tombs, as well as those located in harsh environments and exposed to severe damage, were identified as heritage sites of second-degree safety risk. The remaining county-level and other heritage sites were identified as heritages of third-degree safety risk. The levels of safeguarding were established according to the security risks, and appropriate safeguarding facilities were developed.

2.5.5 Taking into consideration current institutions and formulating an administrative system for cooperation within the region and integration between counties and villages

Combining the current separation of villages and counties, the distribution of cultural relics, and the present condition of conservation and administrative institutions, we advocated for a multipartite approach to conservation and administration, in order to carry out conservation as effectively as possible under the unfavourable conditions of the vast territory, limited faculty, sparse distribution of relics, and underdeveloped local economy.

We suggested formulating regional systems of administration and cooperation that goes beyond the limit of counties; making clear the vertical administrative system between higher administration departments of relic conservation and management (Cultural Relics Bureau of Xinjiang Uygur Autonomy, Cultural Relics Bureau of Aksu Region) and local heritage institutes.

Three levels of administration centres were set up within the county to construct the administration system. The administration centre of the first degree is the Department of Heritage Conservation and Management in Kuqa County, which is in charge of overall preservation and management of relics within the county. Administrative centres of the second degree, of which there are three in total, and whose allocation is determined by the current delineation of villages and density of site distribution, as well as the types of relics in that area, are conservation and administrative offices with research functions. These are in charge of survey and study, and visiting tours within the region. Each office has its area of research: the Office of Heritage Conservation and Administration in Age Village devotes itself to the study of smelting and casting sites; the Office of Heritage Conservation and Administration in Yakela Town focuses on the study of beacon sites; while the Office of Heritage Conservation and Administration in Tarim Village is in charge of the study of ancient city sites and castles in the Caohu District.

Administrative centres of the third degree exist as supplementary to those of the second degree. There are ten in total. These are in charge of daily touring and surveying within their administrative area.

3 Final Thoughts

This paper provides a description of the working methods, as well as concept behind our 'Kuqa Cultural Relics Master Conservation Plan', through which we try to discuss and articulate some of the principles that were applied in the formulation of the plan's conservation methodology. When faced with a county so rich in cultural relics as Kuqa, where many significant sites are distributed over a vast area, while limited time is available for research, the basic premise required is to apply a systematic and holistic approach, and to focus on the most representative relics during a survey. Such representatives, to be precise, is determined by the significant cultural customs of the Silk Road, intertwining the unique topography and landscape of the region, clues that lead to our selection of areas for further research.

As for the issue of how to enact the planning policy and deploy the general conservation practices through cooperation between multiple disciplines and effective integration of available resources, in districts that are behind in heritage research and primary materials, we explored a method of cooperation, leaving room for the reassessment of relics along with the implementation of planning. This method allows for sustainable and thorough conservation.

Adverse circumstances, such as vast lands with little population, inclement climate and underdeveloped economies, have resulted in massive damage from both nature and human beings, currently and over time, to heritage in the Kuqa District. Is it possible to provide favourable protection for these heritage sites by integrating available resources under the current circumstances of heritage management and basic government? The only solution is to increase investment, and to make full use of current resources, to eliminate the impact of harmful disasters as much as possible, and to deliberately prevent human-caused damage.

We believe that the practices applied in the protection of Kuqa heritage sites may inspire later planning, as an example of how to take both the values and safety factors of cultural heritage into consideration, and to formulate reasonable and effective methods for conservation.

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Theme 3: Protecting Cultural Heritage in Times of Conflict and Other Emergencies

Community Involvement in Emergency Operations for the Safeguarding of Borobudur from the Damage Caused by the Mount Merapi Eruption

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Abstract. In 2010, the Borobudur Temple Compounds faced a severe threat from the corrosive ash of the Mt. Merapi eruption as the ash started to penetrate deeply into the pores of the temple's stones and into the gaps between the stones. This threatened the stone itself and could potentially block the monument's drainage system. However, thanks to the strong commitment of some 600 local community members, the potential damage was mitigated. After the completion of the cleaning operations at the Borobudur Temple Compounds in February 2012, the UNESCO Jakarta Office surveyed each community member involved using a questionnaire written in Bahasa Indonesia, the official language of Indonesia. The questionnaire sought to ascertain the workers' view of the cleaning operations and to find out how the community-based conservation operation worked during the catastrophic natural disaster. The conclusion based on survey results was that a more holistic approach including community involvement was necessary to safeguard the Borobudur temple in disaster situations.

1 The Eruption of Mount Merapi, 2010

The end of 2010 saw new challenges for the Borobudur Temple Compounds. Mount Merapi, an active volcano located on the border between Central Java and Yogyakarta, erupted suddenly and catastrophically on 26 October in 2010; seriously threatening the thousands of people living on the volcano's fertile slopes. On 23 November 2010, the Indonesian National Disaster Management Agency officially reported 322 people dead, 776 injured and 136,585 displaced. The major eruption blanketed its surrounding areas in volcanic ash and posed a severe threat both to local people as well as to the Borobudur Temple Compounds and their surrounding areas.

Located only 25 kilometres away from Mt. Merapi, the Borobudur Temple Compounds were covered by a layer of volcanic ash (Figure 1). On 9 November 2010, site officials from the Indonesian Ministry of Culture and Tourism in the Magelang regency decided to close the Complex to the public. Although the volcano's final eruption was in November 2010, the resulting ash settled on the temple, and started to penetrate deeply into the pores of the temple's stones and into the gaps between the stones, which threatened the stone itself, and potentially block the monument's drainage system.

Figure 1. The ash-covered Borobudur temple (Source: Indonesian Ministry of Education and Culture)

The prolonged eruption of Mount Merapi also caused a problem for local tourism due to the closure of the Yogyakarta airport, and blocked roads and access routes to the temple. The local economy suffered seriously, especially in such sectors as tourism, handicraft manufacture and agriculture.

A joint operation was undertaken by UNESCO and the Indonesian authorities to ensure that the unique character of the Borobudur temple as well as the wider connected landscapes surrounding the temple, was maintained so it would remain a cultural and economic asset for future generations of local people. The following three-phase action plan was developed:

1. First Phase (December 2010 – December 2011)

Execution of an emergency cleaning operation with full participation of the local community, notably cleaning of the surface of the stone monuments and the drainage systems, related archaeological parks and surrounding natural resources;

2. Second Phase (February 2011 - December 2013)

Joint scientific damage assessment missions with the Indonesian government and UNESCO for the establishment of comprehensive remedial conservation measures;

3. Third Phase (July 2011 - December 2013)

Activities for the local community with respect to livelihood and income generation via tourism and creative industries, by re-vamping the cultural and eco-tourism potential of the region, and by creating greater involvement and opportunities for these affected communities.

Luckily, eighteen national and international donors provided UNESCO's emergency operation with more than USD 600,000 for the identified actions.

From January until December 2011, the UNESCO Office in Jakarta, in collaboration with the then Indonesian Ministry of Culture and Tourism and local NGOs, deployed some 570 workers from the local community to continue clearing ash from the monument. Local community members, coordinated by five local NGOs, worked tirelessly five days a week, using basic tools such as dustpans, vacuum cleaners and soft brushes to clear the ash. The workers had to remove the floor-stones of the temple to retrieve the ash that had penetrated beneath the temple's surface. [Figure 2] The floor-stones were lifted out of the floorboards, and painstakingly re-laid in the same location after the ash was removed. The workers also had to clean every corner and crevice of the temple, including within the temple's stupas.

Figure 2. Local community, between 18 to 60 years of age, have been cleaning the ash since early January 2011

In December 2011, after one-year of cleaning, the operation was successfully completed, and the entire temple was officially re-opened to the public. The upper tier of the temple had been closed since the eruptions, but thanks to the assiduous work of the local communities and the contributions from governments and private institutions, the potential disaster to the monument's stone reliefs was mitigated and the ash was successfully removed. [Figure 3]

In March 2011, while engaging in the cleaning operation with the local community members, UNESCO and the Indonesian government initiated a second phase activity to ensure long-term scientific protection of the damaged Borobudur Temple Compounds, and the establishment of comprehensive remedial conservation measures.

For this objective, UNESCO engaged three international experts for missions to Borobudur: Dr Costantino Meucci from 21 March to 4 April 2011 and Prof. Dr Leisen and Dr Von Plehwe-Leisen from 3 to 13 January 2012 and 10-17 June 2012. Dr Meucci's findings showed that the cleaning work carried out by the local community members effectively limited the ash's potential damage and that no changes to the condition of the temple were observed due to this immediate intervention. His reports state that 'the applied cleaning methodology worked successfully', which swiftly restored access to the temple by the visiting public. Meanwhile,

Figure 3. The ash collected from the temple after the cleaning operations

Dr. Leisen proposed a remedial conservation plan for the monument stones along with practical recommendations for training programmes to enhance national officials' knowledge of stone conservation techniques. These successes are not just limited to physical rejuvenation of Borobudur. The engagement of the local population in the project also proved to help strengthen the pride of local communities, giving them greater knowledge and respect for the site. This will strengthen future safeguarding capabilities and facilitate their ability to make a living through their acquired knowledge.

Needless to say, community participation in disaster situations is a key to mitigate the impact of disasters (Leask et al 2006). Hence, it is essential to integrate local community involvement into the overall framework of disaster management initiatives in the event of a natural disaster at the Borobudur Temple Compounds. This would, in turn, help the local community enhance their knowledge concerning protection, conservation and management of the cultural resources, and promote a sense of ownership in safeguarding and promoting cultural heritage resources, boosting their local pride.

After the completion of the cleaning operations at the Borobudur Temple Compounds in February 2012, the UNESCO Jakarta Office surveyed each community member involved using a questionnaire written in Bahasa Indonesia, the national language of Indonesia. The questionnaire sought to ascertain the workers' view of the cleaning operations and to find out how the community-based conservation operation worked during the catastrophic natural disaster. 254 community members who participated in the cleaning operation participated in the survey, providing an account of the workers' experience at the temple.

The results show that 86.3 percent of the participants were satisfied with the cleaning operation, whereas 67 percent of the participants had never been engaged in any preservation work at Borobudur before the cleaning operation in 2011. While 62.6 percent of the local community agrees that Borobudur needs to be more prepared for future disasters, 91.3 percent expressed their willingness to participate in such a future safeguarding operation if Mt. Merapi erupts again.

Obviously, community involvement in the protection at Borobudur in the event of a disaster was not strategically considered, nor have current disaster management strategies included participation of the local community who expressed their readiness to preserve the Temple from natural disaster. It is crucial to integrate community involvement into disaster management preparations (Pearce 2003). Even, article 98 of the Law of the Republic of Indonesia Number 11 of the Year 2010 Concerning Cultural Property stipulates that the preservation of Cultural Property shall be the responsibility shared between different levels of government and the community. When public participation is integrated into disaster management planning, a prompt mitigation measure could be implemented more effectively.

A radical improvement to the disaster risk management system to cultural heritage properties should be pursued. It is therefore essential to integrate community participation and disaster risk reduction initiatives into the national disaster mitigation strategy, and implement these plans at all levels of government. At the same time, it is important to promote advocacy and awareness among the community about the importance of the cultural heritage of Borobudur, and the protection of cultural resources. This will assist the wider population to develop an understanding of their own culture and history through the re-appropriation of their cultural heritage.

Due to its geographical condition and character, Indonesia is highly prone to natural disasters such as earthquakes, volcanic eruptions, tsunamis, landslides, floods and other catastrophes. Natural disasters are becoming increasingly frequent, particularly major earthquakes. These cause salient loss and damage, leading to a serious negative impact on numerous outstanding properties and on local and national communities.

While such devastating events have occurred, the Indonesian government has been organising a number of relevant complementary disaster risk mitigation/management activities for the cultural heritage of Indonesia.

Examples include the Seminar on Reconstruction and Rehabilitation of the Cultural Heritage Properties in Earthquake-affected Areas in Padang, West Sumatra in December 2010, the Disaster Risk Management Workshop for Borobudur and Prambanan in October 2008, and the Training-workshop for disaster risk-management in Prambanan in Yogyakarta in July 2007. These workshops used a risk-based approach based on the internal financial risk, control framework and the training module on cultural heritage risk management.

On Thursday 13 February 2014, Mount Kelud located in Kediri Regency, East Java Province erupted. The Government of Indonesia requested the Head of National Agency for Disaster Mitigation to handle the situation and help evacuate residents living in a 10 km radius of the volcano. The volcano affected over 200,000 people living in the Blitar, Kediri and Malang Regencies, with the volcanic ash also impacting millions more across the island of Java.

The volcanic eruption posed once again, a threat to the World Heritage Sites of Prambanan and Borobudur Temple Compounds located in the regions of Central Java, and the Special Region of Yogyakarta Region respectively. The Indonesian Ministry of Education and Culture swiftly undertook a preliminary assessment of the sites and found that a 3-5 mm layer of volcanic ash covering the Borobudur Temple with a 1cm layer blanketing the Prambanan Temple. The analysis from Borobudur Conservation Office on the composition of the Mount Kelud volcanic ash showed that it had a PH level of 5-6. While this is less acidic compared to the ash from the Mount Merapi eruption in 2010 it is much denser as it contains 70% of silica.

The Ministry of Education and Culture immediately responded to the disaster by closing the sites to the public and initiating their disaster emergency response procedures. The Borobudur temple was particularly well prepared as the authorities, in close cooperation with UNESCO, had previously responded to the 2010 Mount Merapi eruption that blanketed the temple in ash. Following this disaster the Borobudur Conservation Office refined their emergency response plan to include the use of custom made plastic covers to protect the temple. This plan was put in to action swiftly with all 72 stuppas of the temple covered along with the main corridors, minimizing the impact of the ash. The community groups who were involved in the cleaning effort after the 2010 eruption have also contacted the authorities to offer their assistance in cleaning the temple.

Cultural resources sustain their greatest losses during or after disasters. Disaster preparedness and planning, should therefore be required elements of our cultural resource management. Luckily, the cleaning efforts at Borobudur in 2011 and 2014 were completed with great success. The activities ensured that the whole Borobudur temple was fully accessible to the public, therefore bringing tourists back to a site whose revenue contributes greatly to the livelihoods in the area. The work undertaken at the Borobudur Temple Compounds has heightened the local community's sense of belonging, restoring pride and dignity while saving the world's history.

In terms of the disaster management at the Borobudur Temple Compounds, public participation is key in each phase of disaster preparedness, planning, and mitigation. To this end, a periodic in-situ drill on the adopted strategies together with participation from local community members is of utmost importance to ensure the sustainable preservation of the cultural and natural values of these sites.

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Suivi d'une situation de conflit, le cas du patrimoine culturel syrien
Monitoring a Conflict Situation, Taking Syrian Cultural Heritage as a Case Study

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Le suivi décrit ici n'est malheureusement pas encore achevé. Une mise à jour limitée a dû être partiellement ajoutée depuis le symposium de Beijing. Il est vivement à souhaiter que la paix reviendra le plus rapidement possible en Syrie et qu'il sera alors possible de passer à une vaste phase d'évaluation des dommages subis et à une intense campagne de restauration. Un large échange de réflexions sur les actions déjà menées ou restant encore à entreprendre reste de toute façon le bienvenu.

Abstract. The present conflict in Syria is first of all a terrible human tragedy. Hundreds of cultural heritage sites are also already damaged because of the war. Chaos and looting are spreading. This is a 'wound to the soul and identity' of its people to quote the Director General of UNESCO. The ongoing events are a challenge to international organisations, to their monitoring activities and risk preparedness. Someday, hopefully soon, international organisations, including ICOMOS will be invited on the ground.

The main purpose of monitoring mission is to collect information. As it is meant to be for a conflict zone, such as Syria at present, this mission had to be undertaken remotely, from abroad. We should therefore mention not only information available on World Heritage properties and others (based on reports on historic cities, monuments, excavations and museums,) but also the various types of information sources, which are typically from the beginning of the 21st century (videos, YouTube, etc.). Our proposals for a few lines of action had to be based on a neutral understanding of ongoing field activities and on knowledge and expertise of Syrian cultural heritage, its characteristics and its management. Finally, our present assessment would not be complete without recognizing national, foreign and international organisations and their actions during the crisis. Some of them have been long time partners like UNESCO, ICCROM, the Blue Shield or ICOM.

Our presentation will however be presented successively: Syrian cultural heritage and its organisation, the general evolution of the situation on the ground, damage to World Heritage properties, the nature of damage to other cultural heritage, cultural heritage stakeholders in Syria, sources of information, international action, ICOMOS action, preliminary conclusions and recommendations.

Since the ICOMOS symposium in Beijing, this paper has been updated in order not to disconnect this text from present realities. In spite of our shortcomings, this testimony may provide some basis for a more general discussion within the ICOMOS community about how to continue and extend the present monitoring activity, how to be prepared for the foreseeable future in Syria and what may be the lessons for future risk preparedness activities.

1 Introduction

Ayant une très ancienne connaissance à la fois personnelle et professionnelle de la Syrie, je me suis très vite intéressé, dès le début de l'été 2011, au sort du patrimoine culturel de ce pays quand celui-ci a commencé à s'enfoncer dans la crise et connaître de douloureuses pertes humaines, avant de basculer progressivement vers une atroce guerre civile.

J'allais rapidement me rendre compte que Paris était un lieu favorable aux contacts avec l'UNESCO, le secrétariat et les Comités scientifiques de l'ICOMOS, l'ICOM, mais aussi avec les représentants d'autres organisations internationales comme le Bouclier bleu, l'ICCROM ou Interpol.

La confiance accordée par les instances dirigeantes de l'ICOMOS, tant au niveau de leur représentation lors de réunions avec nos partenaires, que pour répondre à la presse m'a amené à assumer une mission de suivi. Celle-ci n'a pu être menée que qu'à temps très partiel, mais en collaboration avec le secrétariat et l'ICORP, ainsi qu'en contact avec nos partenaires syriens et internationaux. Il paraît utile de restituer cette expérience, de la transmettre, d'en tirer si possible de premiers enseignements et d'envisager les phases d'action encore à venir. A cet effet, il faudra commencer par présenter le patrimoine culturel syrien et ses spécificités.

Notre transcription des noms arabes reprendra les formes les plus courantes en France et à l'étranger et n'a pas de prétention scientifique.

2 Le patrimoine culturel syrien et son organisation

La République Arabe Syrienne est riche d'un patrimoine archéologique et bâti dense et très varié appartenant à une succession de civilisations relevant de toutes les époques historiques, ou même préhistoriques, comme celles de premières manifestations de l'agriculture et de la sédentarisation. Ses premières cités étaient aussi anciennes que celles d'Egypte et de Mésopotamie. Les civilisations hellénistiques, romaines, byzantines et arabes s'y sont succédé. Le califat omeyyade y a fleuri. L'Europe médiévale y a laissé des traces au temps des croisades. Elle a enfin fait partie de l'empire ottoman jusqu'au début du 20e siècle. La Syrie est étroitement liée à l'histoire des trois grandes religions monothéistes et elle a par ailleurs gagné le surnom touristique de ‘ berceau des civilisations ‘.

La Syrie comprend 7 sites inscrits sur la liste du Patrimoine mondial : les villages antiques de la Syrie du nord (inscrits en 2011), les villes antiques de Bosra (1980) et de Palmyre (1980), les citadelles médiévales du Krak des chevaliers et de Saladin (bien en série, 2006) et les villes historiques d'Alep (1986) et de Damas (1979). La plupart sont mondialement connus. Onze autres sites sont inclus sur la liste indicative : l'île d'Arwad, les norias de Hama, le village de Maaloula, les villes antiques d'Ebla (Tell Mardikh), de Mari (Tell Hariri), d'Ugarit (Ras Shamra), d'Apamée, de Doura Europos, la ville califale de Raqqa-Rafiqa, la cité-citadelle croisée de Tartous et le château de Qasr al-Hayr ach-Charqi.

Le pays compterait plus de 5 000 sites classés, dont des villages et des quartiers historiques. Depuis le milieu du siècle dernier, les découvertes archéologiques se multipliaient. L'une des particularités du pays est l'abondance de ‘ tells ‘, sortes de collines archéologiques produite par la succession et la superposition d'établissements humains au même endroit. Par ailleurs la fréquence des guerres, surtout au moyen-âge, a conduit à la construction de beaucoup de positions fortifiées sur les sites les mieux situés géographiquement. Le patrimoine architectural du 20e siècle, qu'il soit ottoman tardif, de l'époque du mandat ou encore de celle dite de ‘ l'indépendance ‘ est relativement méconnu.

Avant 2011, près de 180 missions archéologiques étaient en activité. Elles étaient syriennes ou mixtes, étrangères et syriennes. Des maisons de fouilles sont souvent présentes près des sites de fouilles, parfois accompagnées de dépôts. Le nombre de musées est de 38, certains comme le musée national de Damas et celui d'Alep sont situés dans les très grandes villes. Les autres, plus secondaires, peuvent être situés dans les quartiers anciens de ces mêmes villes. Beaucoup d'autres sont situés dans des villes secondaires, ce qui représentait un encouragement à parcourir le pays pour les touristes. Certains ont été construits en tant que tels, comme le musée national de Damas commencé en 1936 par l'architecte français Michel Ecochard. D'autres ont été aménagés dans des bâtiments historiques comme le Palais Azem à Damas ou la cathédrale croisée à Tartous. Les bâtiments qui les abritent ont souvent une haute valeur patrimoniale aussi.

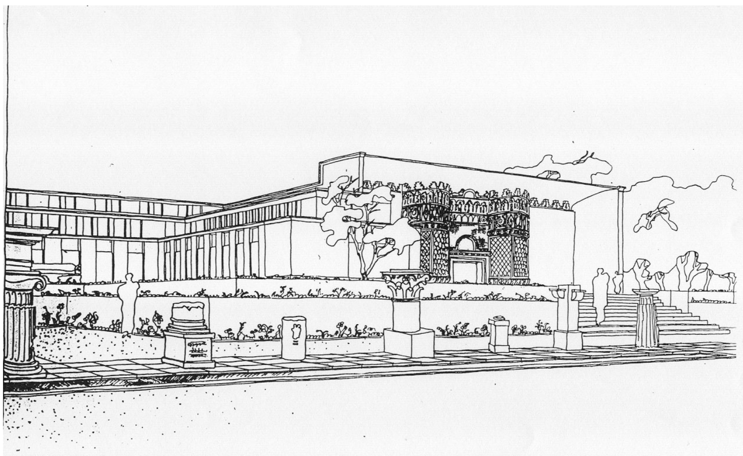

Figure 1. Damas. Le musée national, conçu par l'architecte Michel Ecochard en 1936 est un patrimoine du 20e siècle

La loi syrienne sur les antiquités date de 1963 et concerne les biens meubles et immeubles ; elle n'a subi que des modifications mineures depuis (la dernière étant en 1999). Quoiqu'un peu rigide, elle a permis le classement non seulement de monuments, mais aussi de quartiers historiques et donne à l'Etat des pouvoirs étendus. Elle interdit la présence d'installations militaires à moins de 0,5 km d'un site classé (article 26).

La Syrie est un état membre de l'UNESCO, signataire de la plupart des conventions internationales, dont celle de la Haye en 1954 (premier protocole) concernant la protection du patrimoine culturel en cas de conflit armé[1]. Le logo du Bouclier bleu est d'ailleurs apposé sur de nombreux édifices. Rappelons qu'en Afghanistan par contre, l'absence de reconnaissance du gouvernement Taliban par les Nations Unies avait considérablement compliqué l'action de l'UNESCO.

3 Evolution générale de la situation sur le terrain

Depuis mars 2011, la crise est passée par plusieurs étapes en Syrie. La répression des manifestations du début a progressivement cédé la place à des affrontements armés avec des insurgés à partir de l'été 2011. Ceux-ci ont d'abord pris place dans des villes petites et moyennes comme Deraa, Tartous, Hama, Idleb, Maarat al Nooman et dans des localités frontalières comme Tall Kalakh et Jisr el Shoughour. Il semble qu'à l'époque, seul un armement léger ait été utilisé.

Les combats ont changé de nature avec le siège de Baba Amro au début de l'hiver 2011-2012 quand un armement lourd a été utilisé par l'armée. A la chute de Baba Amro, les insurgés ont quand même pris le contrôle d'autres quartiers de Homs, notamment de la vieille ville ; leurs habitants ont fui et le pilonnage des quartiers rebelles s'est poursuit longtemps. Au printemps 2012, les combats avaient gagné des régions rurales autour d'Alep, de Damas et de Homs, notamment en bordure des frontières. En juillet de grandes offensives de la rébellion ont été lancées contre Damas puis Alep. La première a été assez vite écrasée, la seconde se poursuit encore. Désormais, l'armée régulière utilise ponctuellement des moyens aériens. Le terme de ' guerre civile ' est utilisé par le Comité international de la Croix-Rouge depuis le printemps 2012. La présence d'observateurs des Nations Unies d'avril à août 2012 n'a pas obtenu l'arrêt espéré des combats. Le bilan humain est terrible : le nombre de victimes aurait déjà dépassé les 20 000 à l'été 2012 et les réfugiés étaient de l'ordre d'un million dans le pays même et de 200 000 dans les pays limitrophes. Tristement, ces chiffres ont été largement multipliés depuis.

Nombre de concepts ont été évoqués par les chancelleries étrangères pour évoquer une intervention, telles que la création d'une ' zone tampon ' le long de la frontière turque, ou celle de ' couloirs humanitaires ' ou encore d'' exclusion aérienne '. Elles impliqueraient pourtant toutes, non seulement un aval du Conseil de sécurité de l'ONU, mais aussi des bombardements à grande échelle pour briser le dispositif de défense anti-aérienne du pays ainsi que des combats au sol. D'autres hypothèses évoquent un futur ' réduit alaouite ' le long de la côte, si les insurgés parvenaient à prendre les villes d'Alep et de Damas. Une région kurde prend déjà une autonomie de facto dans le nord-est et des groupes apparentés à Al Qaïda s'installent durablement, comme dans la région de Raqqa.

Le conflit qui ravage la Syrie s'est également accompagné d'une généralisation de l'insécurité à travers le pays, d'une paralysie des déplacements le long de la plupart des axes routiers, du développement du banditisme et des enlèvements, de pénuries d'approvisionnement et d'un effondrement des services de l'Etat. Ainsi, le patrimoine culturel ne souffre pas seulement des combats mais aussi du chaos et de l'insécurité qui se répandent dans le pays. Nous y reviendrons.

3.1 Les dommages subis par le patrimoine mondial

Il est encore impossible d'établir une évaluation complète et détaillée des dommages subis par le patrimoine archéologique, architectural et urbain.

Nous essaierons pourtant d'esquisser d'abord un premier panorama de la situation dans les sites inscrits au patrimoine mondial.

Figure 2. Les souks d'Alep ont brûlé au cours des furieux combats qui s'y sont déroulés (Source: APSA)

3.1.1 Alep

Malgré les combats en cours, peu de dégâts sont encore attestés. L'armée régulière occupe la citadelle, dont la valeur est à la fois stratégique et symbolique. Il semble que les insurgés aient lancé vers le 6 août 2012 un assaut contre elle par son entrée principale et qu'ils en aient pris la première tour-bastion sur laquelle ils auraient hissé le drapeau de la révolution. Un engin explosif improvisé aurait été utilisé contre la porte historique. Ils auraient ensuite été repoussés. La porte historique git à terre et des traces d'explosion circulent sur internet. La ligne de front passait dans la vieille ville. La mosquée des Omeyyades aurait plusieurs fois changé de main avant que ne s'écroule son minaret. Les souks ont été incendiés. Bombardements, explosions souterraines et voitures piégées ont pris un lourd tribut aux monuments de la ville et ce n'est probablement pas encore fini. [FIGURES 2 et 3]

Figure 3. Alep. Après de premiers combats, l'entrée de la citadelle est protégée par des sacs de sable (Source: APSA)

3.1.2 Damas

Figure 4. Damas. Les mosaïques de la façade sud de la mosquée des Omeyyades ont été atteintes par un tir. (Source: BBC, Avril 2013)

La ville est restée longtemps tranquille. Des constructions illégales élevées étaient signalées dans les quartiers périphériques faisant partie de la zone tampon comme Qanawat et Midan. Certains insurgés se sont retranchés à dans le faubourg historique de Midan lors de leur opération ‘ volcan de Damas ‘ en juillet 2012. Sa reconquête par l’armée régulière a occasionné de graves dommages à plusieurs constructions anciennes. Depuis, la vieille ville intra-muros reçoit épisodiquement des tirs de mortier en provenance de la périphérie. Ceux-ci ont notamment atteint la mosquée des Omeyyades, la citadelle médiévale et des établissements éducatifs. Le danger de graves incendies est toujours présent. [FIGURES 4 et 5]

Figure 5. Damas. La mosquée des Omeyyades.
Un chantier de restauration a été ouvert (DGAM)

3.1.3 Bosra

La citadelle médiévale est occupée par l’armée régulière. Des constructions illégales avaient été signalées dans l’enceinte archéologique. Des combats plus récents auraient endommagé des maisons anciennes.

3.1.4 Palmyre

L’armée semblait s’être retirée de la ville qui aurait alors été occupée par les insurgés. Elle serait revenue à partir de février 2012. Depuis, elle se serait établie sur les hauteurs de la citadelle médiévale dominant la ville antique et les tanks se seraient déployés dans une vallée funéraire. Des tirs à la mitrailleuse auraient été tirés à partir du château, puis des combats auraient eu lieu dans l’oasis. Le temple de Bêl porte des traces de roquettes. Des fouilles clandestines auraient été signalées (et même une fois filmées à une date indéterminée) avant et après le retour de l’armée. Des dégâts non précisés seraient signalés comme dans le ‘ camp de Dioclétien ‘. [FIGURE 6]

Figure 6. Palmyre. Un soldat au milieu des ruines
(Source: National Geographic)

Figure 7. Le Krak des Chevaliers. Une vue des destructions
(Source: DGAM 2014)

3.1.5 Krak des chevaliers

Il semble que celui-ci soit occupé depuis mars 2012 par des insurgés en armes qui auraient empêché les gardiens de revenir. La DGAM (Direction générale des antiquités et des musées de Syrie) les accuse de dégradations et de fouilles clandestines. Des affrontements avec l’armée régulière auraient suivi à proximité du château et un dommage non précisé se serait produit dans la mosquée (une ancienne chapelle) pourtant très enclavée. D’après des vidéos, l’armée régulière aurait lancé plus tard, en juillet 2012, quelques obus dont on a pu apercevoir une trace sur le glacis extérieur et une autre sur le créneau d'un chemin de ronde. La reprise du château fort par l'armée en mars 2014 se serait accompagné de sérieux dégâts autour de la cour centrale. [FIGURE 7]

3.1.6 Château de Saladin

Rien ne semble encore signalé. La forteresse est située dans un site éloigné de toute habitation.

3.1.7 Les villages antiques

Ceux-ci sont très mal situés, très près de la frontière turque par laquelle ne cessent de passer des insurgés et des armes. Des vidéos de juillet 2011 témoignent de traces de tirs dans les ruines d'al Bara où s'étaient peut-être réfugiés des rebelles. Elles témoignent aussi du curieux renversement, de l'intérieur vers la chaussée extérieure, de piliers de pierre bordant un champ. Pur vandalisme ou volonté de réduire la circulation sur une route secondaire ? Le célèbre site de Qalaat Samaan serait d'après la DGAM de temps à autre occupé par des rebelles. Une autre vidéo témoigne d'un bombardement le 31 mai 2012 à proximité immédiate, mais ses effets ne sont pas visibles. Le site y est à tort identifié comme étant Daret Izza, le chef-lieu. Des installations et des constructions illégales sont également signalées dans la région.

3.2 La nature des dommages subis par le patrimoine culturel

Il est encore loin d'être possible d'effectuer un recensement des dommages déjà subies par le patrimoine culturel, et la situation empire quotidiennement. Ils se compteraient déjà par centaines. Le collectif du Patrimoine archéologique syrien en danger (PASD) tient des archives et essaye de suivre l'actualité sur son site internet. Le Global Heritage Fund a publié le 16 mai 2012 une étude relativement détaillée d'Emma Cunliffe de l'université de Durham, elle-même largement basée sur les travaux de PASD. Mentionnons enfin l'utilisation d'une base de données informatique par Bijan Rouhani de l'ICORP, le Comité international sur la préparation aux risques. Même en l'absence d'accès au terrain, il faut désormais des équipes nombreuses ou une personne à plein temps pour collecter, documenter et organiser ces informations. Nous y reviendrons. Nous nous limiterons ici à présenter les dommages encourus et les risques encore à venir, en fonction de leur nature, sous une forme en quelque sorte typologique.

Il faudrait être expert militaire pour déduire la nature précise des armes qui ont provoqué un dommage donné. Les images disponibles nous permettent généralement tout au plus de distinguer l'action d'armes légères de celle d'armes lourdes. Ainsi, les vidéos disponibles semblent indiquer que l'église d'Um al Zennar (1852, bâtie sur une ancienne église du 4e s.) située dans le vieux quartier de Hamidiyeh à Homs n'avait subi que des tirs d'armes légères à la fin février 2012 (traces de balles, vitres cassées, etc.), alors qu'elle parait avoir été ultérieurement touchée par un bombardement sur des vidéos disponibles en août 2012 (effondrement de la toiture, chute du clocher, etc.). Entre ces vidéos, quelques autres ont une valeur significative : l'une d'elle de fin février 2012 avait enregistré la fuite des derniers habitants civils chrétiens du quartier. Dans une autre du printemps 2012, un commandant d'apparence islamiste faisait visiter les lieux. La reconstitution de scenarios peut s'effectuer. C'est pourquoi d'ailleurs le recueil, la datation et l'archivage des données visuelles sont si importants.

Beaucoup de photos ou même de vidéos disponibles témoignent de dommages sans qu'une documentation sur l'état précédent ne soit facilement disponible. Une notable exception est représentée par Qalaat al Madiq, une citadelle médiévale surplombant un village et contenant elle-même un village habité. Elle est proche de la ville hellénistique d'Apamée. Des rebelles armés s'y étant installés, plusieurs vidéos filmées à partir du village en contrebas ont enregistré ces images surréalistes d'une citadelle médiévale subissant les tirs directs d'une armée moderne. Plus tard, une voie d'accès a été réalisée au bulldozer afin de faciliter un retour éventuel de l'armée. Des chercheurs de l'Institut Français du Proche Orient (IFPO) ont mis en ligne des photos du chantier de restauration qu'ils venaient de terminer.

Figure 8. Serjilla (Villages Antiques). Construction illégale au milieu des ruines (Source: DGAM 2013)

La logique d'un conflit armé terrestre est que les combattants des deux bords essayent de s'assurer les premiers des points les plus stratégiques, de s'y retrancher et de s'y maintenir. Quelques-uns des exemples précédemment décrits illustrent ces situations. Aux citadelles d'Alep, du Krak des Chevaliers, de Qalaat al Madiq ou de Palmyre, on pourrait rajouter celles de Hama et de Homs. La présence d'équipements lourds de l'armée régulière sur (Khan Sheikhoun) ou sur le flanc (Tell Afis) des tells archéologiques peut signifier des travaux d'accès et de protection, très dommageables pour le site lui-même. A l'inverse, chaque site occupé par un parti devient lui-même un objectif militaire pour ses adversaires et la présence de stocks d'explosifs multiplie les dangers pour le patrimoine. Ainsi, un campement de l'armée régulière sur Tell Mardikh (Ebla) aurait été atteint par un tir rebelle.

Nous avons évoqué quelques exemples où les citadelles et les tells historiques étaient devenus un enjeu militaire. Dans une guerre civile, la disparité des forces amène par ailleurs les rebelles à se regrouper parfois dans des champs de ruines comme ceux des villages antiques de Jabal al Zawiyeh, ou encore à s'installer dans des quartiers aux rues étroites comme dans les vieilles villes d'Alep ou de Homs. Une guerre de rue étant coûteuse pour une armée régulière, celle-ci tend alors à assurer sa suprématie par sa puissance de feu. On pourrait se demander si dans un tel conflit quelle est l'importance des habitants et de leurs biens pour les uns et les autres dans les tactiques de combat utilisées.

Les exemples de destructions volontaires pour motifs idéologiques, comme en Afghanistan ou en ex-Yougoslavie sont rares. Dans l'Irak voisin, de nombreux sanctuaires chiites et même des églises ont été l'objet d'attentats sanglants. A ce titre, la présence de djihadistes en provenance d'Irak est inquiétante. Emma Cunliffe s'interroge en particulier sur le sort des monuments construits par les croisés. Evoquons encore la démolition de tombeaux de saints musulmans au Mali, en Libye et en Tunisie. En Syrie aussi des statues assyriennes et des mausolées de saint locaux ont été détruits et filmés. Des saccages apparemment volontaires d'églises restent inexpliqués. Quant aux mosquées, elles ne semblent pas plus épargnées que les églises en Europe lors des deux conflits mondiaux.

Enfin, le prolongement de la guerre, l'effondrement de l'Etat et le désastre économique génèrent une situation de chaos avec une multiplication des délits et le développement du banditisme et de la criminalité.

Les fouilles clandestines ont toujours plus ou moins existé à petite échelle dans le pays, mais elles se sont multipliées et systématisées. Un article publié en janvier 2012 dans un quotidien syrien dénonce déjà ' l'accroissement du vol des antiquités pendant la crise et le vandalisme les menace de disparition '. L'article explique que le vol et le vandalisme se commettent désormais quotidiennement et d'une manière croissante en plein jour, alors que les voleurs choisissaient autrefois la nuit pour effectuer leurs méfaits. L'interruption trop soudaine des fouilles fragilise de nombreux sites non sécurisés lors de leur abandon. Ceux-ci risquent ainsi d'être livrés à la fois aux intempéries et aux voleurs. Même les gardiens des sites sécurisés sont impuissants vis à vis d'homme armés. Des fouilles illicites sont signalées désormais dans les quatre coins du pays. Des vols de chapiteaux et de panneaux de mosaïque sont signalés même dans un site archéologique majeur comme Apamée. Celui-ci a désormais pris un aspect lunaire en raison de la quantité de fouilles effectuées. [FIGURE 9]

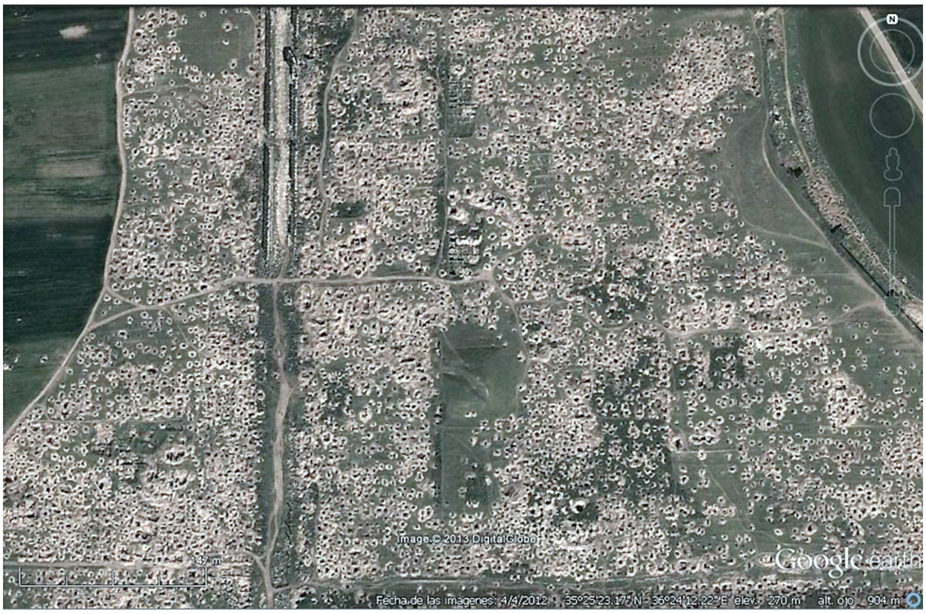

Figure 9. Apamée. Un pillage systématique s'y déroule depuis 2011. Sur cette vue satellitaire de 2013, chacun des trous indique une fouille illégale (Source: Google 2013)

Figure 10. Le musée national a été touché par des tirs et des explosions. Ses collections archéologiques avaient été évacuées auparavant (Source: DGAM)

Aucun des musées ne semble avoir été directement touché par le conflit armé. Le musée national d'Alep est toutefois trop proche de la ligne de front et le cas de Maaret al Nooman est devenu préoccupant. Des vols (Apamée, Deraa, Hama, Homs, Raqqa, etc.) et quelques pillages (Deir Ezzor, Jaaber, Raqqa, etc.) sont toutefois signalés dans des musées secondaires, même dans la presse internationale, sans qu'il ne soit possible de les confirmer. Les informations divergent sur le sort de collections volontairement évacuées comme à Homs ou Alep. Il est cependant compréhensible que les responsables de musées ne divulguent pas l'endroit où sont mises à l'abri les collections archéologiques et artistiques. On peut toutefois se demander dans quelle mesure le plan d'évacuation de la DGAM a pu être entièrement exécuté et dans quelles conditions.

Une contrebande d'antiquités existait déjà, surtout en direction du Liban. Les frontières avec la Jordanie et la Turquie sont devenues poreuses à leur tour. Les pouvoirs publics pourront d'autant moins l'empêcher qu'ils n'arrivent pas à contrôler eux-mêmes l'entrée d'armes, de combattants et même de journalistes sur le territoire national.

Enfin, signalons le paradoxal boom de la petite construction immobilière pendant les récents évènements (AFP 2012). Elle s'explique par l'accroissement des constructions illicites, surtout en périphérie urbaine alors que les agents de contrôle n'osent plus intervenir ou qu'ils reçoivent des consignes de tolérance. Il est cependant probable que les constructions illicites prennent également place aux abords des sites archéologiques et monumentaux (comme à Bosra) et même à l'intérieur des quartiers historiques. Dans ces derniers, des démolitions, des modifications ou des surélévations sont également à craindre. De telles situations avaient été signalées, rappelons-le dans certains faubourgs historiques de Damas. L'Egypte et la Tunisie n'ont pas non plus été récemment à l'abri de tels phénomènes.

4 Les acteurs du patrimoine culturel en Syrie

4.1 La Direction générale des antiquités et des musées de Syrie (DGAM)

La DGAM s'est beaucoup développée à partir du début des années 1950. Elle comprend des directions techniques centrales chargées des fouilles, des musées, de l'inscription des sites ou de la restauration des monuments. Des directions régionales sont implantées dans chaque gouvernorat (mohafazat). Les cadres élevés ne sont pas pléthoriques et leur continuité est parfois aléatoire. Le personnel de terrain est toutefois nombreux et le corps des cadres moyens s'est rajeuni, relativement féminisé et comprend de plus en plus d'architectes.

La DGAM avait réussi à établir et poursuivre de bons rapports avec les missions de fouilles étrangères (rappelons, Plus de 180 missions archéologiques y travaillaient, en provenance de France, d'Italie, d'Allemagne, d'Angleterre, de Belgique, de Hollande, du Danemark, du Japon et d'ailleurs). L'un de ses projets phares (avec la collaboration de l'Italie) était l'achèvement de l'étude et de la restauration de la citadelle de Damas qui aurait fait de celle-ci l'un des points focaux de la capitale. Une campagne internationale de fouilles de sauvetage avait dû être lancée dans la vallée de l'Euphrate en raison de la construction d'un projet de barrage controversé. Un projet très ambitieux devait, en partenariat avec le musée du Louvre, permettre la création d'un nouveau musée national à Damas en remplacement du bâtiment actuel avec la rénovation des autres musées de province.

En fait, le poids et les moyens de la DGAM dépendaient beaucoup de la qualité de ses rapports avec ses ministres de tutelle. Les périodes des années 1950 et début 1960 puis des années 1990 et début 2000 avaient été particulièrement bénéfiques. Une convention signée entre les ministères du tourisme et de la culture il y a 5 ou 6 ans la soumettait malheureusement aux impératifs du tourisme. D'un point de vue légal, une nouvelle loi pour les Antiquités était sur le point d'être promulguée et le statut de la direction générale devait évoluer vers celui d'' établissement général ', ce qui devait lui garantir une bien meilleure autonomie.

Le ministre de la Culture avait très tôt réagi aux évènements du pays en adressant dès le 7 juillet 2011 une circulaire recommandant la vigilance aux gouverneurs. Le Conseil supérieur des antiquités n'aurait pas souhaité s'adresser à l'armée pour garder les sites archéologiques. Enfin, un plan d'évacuation avait été établi de manière à mettre en lieu sûr les collections de musées. Nous ne le connaissons pas et nous ignorons dans quelle mesure il a pu être appliqué. Des bribes d'informations signalent que les sous-sols du musée national de Damas avaient été aménagés et que des collections devaient être abritées dans les coffres de la Banque centrale. Un tel plan n'a en tout cas pas vocation à être rendu public.

Il est probable que le personnel de la DGAM n'ait pas, sauf exception, reçu de formation à la préparation aux risques. L'expérience des guerres avec Israël en 1967 puis en 1973 est maintenant lointaine. Toutefois, le voisinage de l'Irak a probablement fourni depuis 2003 et les années suivantes des enseignements aux responsables. L'état d'insécurité qui s'est très vite installé dès 2011 en Syrie a dû empêcher très tôt les visites d'inspection à partir de Damas et nous ignorons quel est resté l'état des télécommunications. Les directeurs régionaux des antiquités ont donc dû bénéficier d'une bien plus grande autonomie. Les plus astucieux se sont rapprochés des comités de quartier pour assurer la protection des musées comme à Hama ou encore à Maaret al Nooman. Ce dernier est présenté en bon état (sauf quelques traces de balles) et sous la ' protection ' d'insurgés depuis août 2012.

La DGAM tient à préserver l'unité du service sur l'ensemble du territoire national, sans aucune exclusive. Elle réalise une informatisation de ses inventaires et tient à jour un site internet bien documenté et illustré, mais dans lequel la majorité des informations est présentée en langue arabe.

4.2 La société civile

La société civile (architectes, universitaires, artistes, journalistes, commerçants, habitants,…) avait su dans les années 1990 empêcher la démolition du faubourg damascène de Sarouja, puis en 2007 se mobiliser efficacement pour empêcher, aux côtés de l'UNESCO, le passage d'une voie à circulation rapide (' élargissement ' de l'avenue du roi Faysal) et la destruction d'un vieux faubourg situé au nord de la ville historique intra-muros de Damas. L'opposition à un autre axe routier à travers les vestiges antiques de la ville de Soueida au début des années 1990 n'avait malheureusement pas eu le même succès. Il existe des ONG et des groupes citoyens de sauvegarde du patrimoine, mais leurs objectifs sont surtout d'ordre local. Un comité national syrien de l'ICOMOS était en 2011 en cours de formation. Celui-ci n'a pas encore pu se concrétiser faute de pouvoir réunir une assemblée générale pour voter ses statuts, mais une dizaine de ses futurs membres ont déjà individuellement adhéré à ICOMOS.

4.3 Les instituts étrangers

Des instituts étrangers établis dans le pays étaient actifs et accueillent des chercheurs comme l'Institut français du Proche-Orient. La coopération allemande (avec GIZ (précédemment GTZ)) a mené des actions de réhabilitation urbaine à Alep et Damas, et l'École de Chaillot avait établi depuis quelques années une antenne de formation à la restauration auprès de l'université de Damas. Même ICOMOS France a conduit une formation à la gestion des sites vers 2007. L'Union européenne finançait le programme de Modernisation de l'administration municipale (MAM). Ce dernier avait lancé une action sur la vieille ville de Damas et était intervenu pour sauvegarder le site de Palmyre. Le Trust Aga Khan pour la culture a entrepris depuis de nombreuses années des projets de restauration et de formation (comme à Alep et Masyaf). A mentionner aussi une présence du Global Heritage Fund et du World Monuments Fund.

4.4 Le collectif Patrimoine archéologique syrien en danger (PASD)

La PSAD réunit une trentaine de personnes, pour la plupart archéologues ou étudiants en archéologie. Ce sont des Français, des Espagnols et des Syriens, vivant pour la plupart en Europe. Ils ont l'avantage de disposer d'un réseau de correspondants en Syrie même, souvent des militants de comités de coordination locaux, qui leurs font parvenir des informations, des photos ou des vidéos. Ils disposent d'une page Facebook, accessible par internet sur laquelle ils publient en quatre langues (arabe, anglais, espagnol et français) des informations sur les sites en danger ou touchés en Syrie. Les informations recueillies ne sont pas toujours précises, mais les animateurs tentent au besoin d'expliquer l'importance archéologique de tel ou tel site et d'illustrer son contexte par des photos, des cartes ou des vues aériennes tirées d'archives. Leur intérêt s'est même porté récemment sur le patrimoine naturel d'îles situées au milieu de l'Euphrate. Le site a débuté le 20 juin 2011. Depuis, il s'est progressivement imposé comme une référence sur le sujet des atteintes subies par le patrimoine syrien. La réactivité du site est assez bonne, mais sa contenance étant limitée, les pages les plus anciennes cessent d'être accessibles. Il n'existe pas de moteur de recherche non plus. Les animateurs archivent bien néanmoins les données précédemment publiées. Ils ont successivement lancé quatre appels :

- Un appel de détresse : début février 2012
- Un appel en faveur des musées syriens : le 22 avril 2012
- Un appel en faveur aux archéologues étrangers : le 10 octobre 2012
- Un appel au peuple syrien : le 15 juillet 2012

Un atelier de formation a été réuni en février 2014 à Gaziantep, en Turquie méridionale, avec une quinzaine d'orateurs et de participants. Les informations du site proviennent souvent des zones insurgées

4.5 D'autres organisations

Heritage for Peace est une toute jeune association syro-néérlando-espagnole qui a organisé des sessions de formation en périphérie de la Syrie. Trois employés de la DGAM avaient assisté en 2013 à une session organisée à Beyrouth. Sa récente rencontre de Santander en Espagne réunissant des représentants de la DGAM avec ceux de l'opposition a permis la publication d'une déclaration commune.

Nous disposons d'une documentation insuffisante sur les déclarations éventuelles de l'opposition syrienne sur la question du patrimoine, à l'exception de la part du Courant du changement national syrien qui avait lancé un appel à l'UNESCO le 23 mars 2012.

5 Les sources d'information

Le bouche à oreille a été au commencement la seule source d'information sur la situation du patrimoine en Syrie. L'interruption graduelle des fouilles étrangères pendant l'été 2011, permettait encore des échanges entre scientifiques. Quelques-uns ont continué à recevoir des nouvelles de connaissances ou de collègues syriens. Depuis la fin de l'été 2012 la plupart des représentations diplomatiques ont fermé. La prudence au téléphone et la paralysie de la circulation intérieure maintiennent les habitants (et leurs correspondants) dans l'ignorance. Un blocus aérien rend de surcroît les déplacements, à l'étranger, difficiles. Nous procédons également à des échanges informels de nouvelles au sein de l'ICOMOS comme avec d'autres organisations internationales.

Beaucoup de nouvelles circulent grâce à la télévision et à internet, mais il s'agit essentiellement de nouvelles politiques ou militaires. Comme nous avions pu le constater dans le cas de Homs au début de mars 2012 des trésors d'information existent pourtant sur le net. Des cartes, des photos, des vidéos et des articles scientifiques sont disponibles. Il faut pourtant suivre le fil des nouvelles d'une page à l'autre et explorer les vidéos de You Tube par approches successives. Il convient néanmoins d'avoir dès le début d'une bonne vision d'ensemble, de lire de savoir lire et écouter plusieurs langues, avec l'arabe en premier. En ce début de 21e siècle, les internautes peuvent se constituer des dossiers fournis en quelques heures ou quelques jours. Il faut toutefois garder un esprit critique. En effet, une sorte de guerre de l'information a lieu sur internet aussi et l'on peut avoir la surprise de retrouver les même vidéos exactement, mais avec des commentaires tout à fait opposés quant à la responsabilité des faits. Relevons également que le référencement des images peut être compliqué par la fréquente disparition de vidéos de leur emplacement sur YouTube par exemple.

Je disposais d'une quarantaine d'articles publiés en 2012 sur la situation du patrimoine syrien. Ils proviennent de la presse écrite de Syrie, du Liban, de Turquie, de France et des États-Unis. Il y en avait certainement beaucoup plus et en provenance d'autres pays. Ils se comptent désormais par centaines. Leur publication augmentation est souvent en corrélation avec des appels lancés par la directrice générale de l'UNESCO. Il arrive qu'un célèbre reporter baroudeur comme Robert Fisk de l'Independant s'empare de ce sujet sur le terrain de sa propre initiative, mais la plupart des autres s'appuient sur le rassemblement de témoignages de sources crédibles (Fisk 2012a; Fisk 2012b). Assez étrangement, alors qu'à certains moments les journalistes étrangers se bousculent en Syrie pour couvrir les évènements, souvent en y pénétrant illégalement et au péril de leur vie, ceux-ci ne semblent pas avoir été intéressés par l'état des sites patrimoniaux par lesquels ils devaient pourtant nécessairement passer. Je ne connais en 2012 que deux exceptions dans la presse francophone, toutes les deux relativement naïves. Dans un premier cas une envoyée du Nouvel Observateur note dans les environs de Deraa des fouilles clandestines menées avec des excavatrices dans des cours de fermes. Un fermier lui explique alors qu'il s'agit de trouver de ‘ l'or des templiers ‘ pour ‘ financer le renversement du régime ‘ (Daniel 2012). Dans le cadre d'un autre reportage, Libération relate la rencontre d'un rebelle au Krak des Chevaliers qui explique qu'il entend ‘ protéger ‘ ce patrimoine historique ‘ propriété de tous les syriens ‘ avec sa kalachnikov[6] (AFP 2012) !

Une compréhension de la logique des situations permet dans une certaine mesure de suppléer à l'incohérence ou les lacunes de certaines informations et d'équilibrer des narrations trop contradictoires. Un maximum d'objectivité et de neutralité est en effet indispensable pour la crédibilité et l'efficacité de nos démarches.

6 Action internationale

6.1 Action de l'UNESCO

L'UNESCO, organisation intergouvernementale, n'a pas manqué de s'informer de près de l'évolution de la situation en Syrie et d'interroger les autorités syriennes. Celles-ci ont répondu le 7 mai 2012 par un courrier du ministre adjoint à la Culture et vers le 30 mai par un courrier du directeur de la DGAM à la Commission nationale syrienne pour l'UNESCO.

Le 30 mars 2012, la directrice générale, Irina Bukova, lançait un premier appel en faveur du patrimoine culturel syrien. Elle rappelait que ‘ l'histoire de la Syrie remonte à plusieurs milliers d'années. Les cultures qui s'y sont succédées ont laissé une richesse exceptionnelle en termes de sites archéologiques, de villes historiques, de paysages culturels, de monuments et d'œuvres d'art qui témoignent de l'évolution du génie humain ‘. Elle ‘ exhorte toutes les parties impliquées dans le conflit à assurer la protection de cet héritage culturel exceptionnel que la Syrie abrite sur son sol ‘. Elle ajoute que ‘ les dommages causés au patrimoine de ce pays sont autant de blessures infligées à l'âme de son peuple et à son identité ‘.

A la suite du déclenchement d'opérations militaires violentes à Alep, la directrice générale a renouvelé le 27 juillet 2012 son appel et exprimé la préoccupation de l'UNESCO au sujet de cette ville inscrite sur la Liste du patrimoine mondial. Elle a rappelé les risques de pillage et l'alerte donnée à Interpol. Elle explique avoir contacté le président du Conseil de sécurité en vue d'attirer l'attention de Kofi Annan, envoyé spécial des Nations Unies et de la Ligue Arabe de l'importance de s'assurer de l'application des dispositions de la Convention de La Haye sur la protection du patrimoine culturel en cas de conflit. Elle indique que l'UNESCO est en contact étroit avec le Coordinateur résident des Nations Unies à Damas. Elle presse encore ‘ toutes les parties concernées ‘ à respecter leurs obligations internationales.

Le Comité du patrimoine mondial a inscrit les sites syriens sur la liste des sites du patrimoine mondial en danger en juin 2013, tandis qu'Irina Bokova et Ban Ki-Moon allaient signer en mars 2014 un appel conjoint pour l'arrêt des destructions du patrimoine culturel syrien. Nous parlerons plus loin du projet qu'il entreprendra avec l'appui de l'Union Européenne.

Le Comité international du Bouclier Bleu a également publié deux déclarations sur la Syrie à ce jour :

- La première, le 11 mai 2011, mentionne les sites inscrits sur la liste du patrimoine mondial, cite la mosquée de Deraa et évoque le précédent à éviter de Hama en 1982. Elle rappelle la Convention de La Haye.
- La seconde, le 7 avril 2012, évoque les sites de Palmyre, Daraa, Hama, Homs et Idleb et en rappelant les conventions internationales appelle ‘ toutes les parties associées à la situation en Syrie à remplir leurs responsabilité ‘ en termes de protection du patrimoine culturel.

Il serait difficile de citer toutes les universités ou organisations qui ont affirmé par leurs communiqués ou leurs actions leur intérêt pour le patrimoine syrien. Parmi elles mentionnons :

- BANEA, British Associates for Near Eastern Archaeology, 16 mai 2012
- IFPO, l'Institut Français du Proche-Orient, 27 avril 2012
- SAVE, Save Antiquities for Everyone, juin 2012

- GHF, Global Heritage Fund, mars 2012
- WMF, World Monuments Fund, août 2012

Un rapport de Silvia Perini et d'Emma Cunliffe pour l'association Heritage for Peace en recensera 38 en mars 2014.

Des formations régionales à la protection du patrimoine culturel en temps de conflit ont été organisées au mois de juin 2012, l'une à Sharjah par l'ICCROM et l'autre à Beyrouth par l'IFPO à l'initiative de l'Ambassade de France. Un cours à Rome de l'ICCROM les avait précédées en octobre 2011. Nous ignorons si des participants syriens avaient pu y participer. D'autres encore s'y ajouteront en Syrie même ou dans des pays limitrophes.

6.2 Action de l'ICOMOS

L'ICOMOS a été invité par le sous-directeur général de l'UNESCO, Francesco Bandarin, à des réunions restreintes (et discrètes) auxquelles étaient associés différents services concernés de l'UNESCO, Interpol, l'ICOMOS, l'ICOM, l'ICCROM et le Bouclier bleu. Gaia Jungeblodt, directrice de l'ICOMOS, et moi-même y avons représenté l'ICOMOS.

Au cours de la première réunion, le 21 décembre 2011, l'objectif était d'échanger des informations, d'évoquer comment pourra évoluer la situation et de se concerter sur les suites à donner à la fois pour la Syrie et le Yémen. A l'époque, les exemples récents d'intervention dans les pays arabes, en Irak et en Libye étaient dans tous les esprits. Ceux d'Afghanistan et de l'ex-Yougoslavie aussi. Un appel à la communauté scientifique internationale pour la localisation de tous les sites historiques paraissait largement prématuré.

La seconde réunion s'est tenue le 4 avril 2012, juste après le premier appel de la directrice générale de l'UNESCO, à un moment où la mission de Kofi Annan et la présence d'observateurs internationaux sur le terrain pouvaient donner quelques espoirs.

J'ai également participé à une réunion d'information du personnel de la culture au cours duquel PASD présentait son action le 13 juin 2012.

A l'invitation de l'UNESCO, nous avons élaboré au titre de l'ICOMOS un premier rapport en début janvier 2012. Celui-ci portait sur :

- des aspects juridiques,
- une analyse de la DGAM et de sa politique,
- la détermination des sources de risque (chaos généralisé, guerre civile, invasion étrangère),
- les catégories de patrimoine culturel à protéger (sites archéologiques, monumentaux et urbains, et les musées),
- l'identification des risques (fouilles archéologiques clandestines, vols et pillage de musées, contrebande d'antiquités, démolitions et constructions illégales, occupations armées, tirs et bombardements,…)
- la localisation des régions à risque (notamment près de la frontière avec la Turquie)
- et enfin quelques recommandations sur les contacts à poursuivre et mener, la pédagogie de préparation aux risques pour les Syriens et les appels à lancer.

Un second rapport portant sur la situation à Homs après les combats de Baba Amro a été établi en date du 12 mars 2012. Ce travail illustrait les possibilités d'apport de contenu et d'illustration procurés par un travail à distance (' desktop work '). La vieille ville n'avait alors pas encore été si sérieusement touchée.

L'ICOMOS a été consulté par le Bouclier Bleu lors de la rédaction de ses deux communiqués et a pu y apporter quelques contributions. Notre préoccupation concernant les villages antiques du nord n'a toutefois pas été reprise. Nous avons transmis au Bouclier Bleu, à un moment où il en avait besoin la loi syrienne sur les antiquités en plusieurs langues, de même qu'une étude sur les musées de Syrie et une liste de leurs adresses. Par contre, nous n'avons pas pu répondre à une demande du Bouclier Bleu US qui, contacté par l'armée de son pays, lui avait fourni les coordonnées géographiques de 35 monuments et sites, parfois situés dans une même ville en mars 2012, puis 156 en août 2012. En effet, la Syrie comptant plus de 5 000 sites, cette tâche aurait nécessité l'intervention de nombreux collaborateurs ainsi qu'une mobilisation internationale. Une sélection plus restrictive entrainerait des choix scientifiques et moraux ardus.

Grâce aux rencontres tenues à l'UNESCO, nous avons également pu transmettre à Interpol des noms d'experts à contacter dans des cas de saisie d'objets archéologiques probablement syriens en Italie et aux Pays-Bas.

Grâce à la crédibilité de l'ICOMOS et aux renvois de la part de l'UNESCO, nous avons pu participer à l'alerte générale concernant le patrimoine culturel syrien, notamment par des interventions au micro de France Culture le 30 mars et le 8 août 2012[2] (Griessel 2012) Nous avons également été cités dans des revues françaises comme Le Figaro Histoire ou Les Cahiers de Science & Vie et même turque comme Today's Zaman (Collectif 2012 et Güzel 2012).

L'absence d'officialisation d'un Comité national syrien de l'ICOMOS ne nous a pas permis d'entreprendre des contacts officiels avec ses promoteurs. Une candidature est encore en attente au Conseil exécutif. Un appel individuel à témoignages pourrait encore être trop risqué pour nos membres syriens. Un projet de colloque du CIVVIH à Damas en juillet 2011 nous laisse également des contacts à réactiver.

A l'intérieur de l'ICOMOS, les contacts ont été essentiellement menés en coordination avec le secrétariat à Paris, le président Gustavo Araoz, le président du Comité consultatif John Hurd et l'ICORP avec notamment Rohit Jigyasu, son président, et Bijan Rouhani.

Nous avons été en contact avec l'ICORP pour le suivi de la crise syrienne, surtout à partir de 2012. Celui-ci a été représenté lors de plusieurs réunions internationales du Bouclier bleu, notamment à Vienne et Paris. Il essaie d'obtenir un financement de la Fondation du Prince Klaus et il avait essayé de prendre contact avec le directeur général de la DGAM pour proposer une session de formation à la préparation aux risques à Damas ainsi qu'à une future évaluation de la situation quand la situation le permettrait. Le reste du réseau pourra être mobilisé quand pourront lui être proposés des objectifs précis.

7 Conclusions provisoires

La nature des dommages subis par le patrimoine syrien ne représente pas une surprise. Ils avaient déjà été anticipés notamment dans notre rapport de début janvier 2012. Depuis, leur quantité a malheureusement dépassé nos prévisions les plus pessimistes. Les modèles des différentes phases du conflit irakien depuis 2003 (et même 1991) jusqu'à aujourd'hui paraissent les plus pertinentes. Certaines destructions font même penser à la seconde guerre mondiale.

La convention de La Haye n'est manifestement ni appliquée ni même évoquée par les parties adverses. Pourtant, son article 19 prévoit avec pragmatisme des ‘ conflits de caractère non international ‘. L'article 4 concernant le ‘ respect des biens culturels ‘ permet de couvrir l'ensemble des situations rencontrées, malgré l'énorme disparité des moyens militaires en présence sur le terrain.

Ce conflit est loin d'être encore terminé. Des interventions directes de puissances étrangères et le renforcement de groupes djihadistes pourraient augurer des développements suivant les modèles afghan, libyen, malien ou de l'ex-Yougoslavie.

Il n'est plus possible d'assurer une présence d'experts, surtout étrangers, sur le terrain, même dans la capitale Damas et même pour une durée limitée. Les projets d'évaluation des dommages sont encore prématurés.

Il reste difficile de planifier des interventions pour un idéal ‘ jour d'après ‘ une fin durable des combats. Trop d'hypothèses sont encore possibles. En tout cas l'instauration des conditions de sécurité et la remise en marche de l'appareil d'Etat risquent de prendre du temps. Il est probable que la prise en compte des problèmes humains soit longtemps prioritaire.

Reste le suivi pour le moment. Grâce aux réseaux sociaux, les conflits de ce début du 21e siècle ne peuvent plus être suivis d'une manière traditionnelle. Internet tient désormais une place majeure. Les techniques de documentation, d'archivage et de référencement doivent s'y adapter et s'appuyer sur l'informatique. De fortes ressources humaines sont néanmoins nécessaires pour assurer un bon suivi. Une attitude neutre et objective restera toujours nécessaire.

De nombreuses organisations nationales ou internationales, gouvernementales ou non, de nombreux experts individuels - Syriens ou étrangers - connaissent le patrimoine syrien dans toute sa diversité. Il serait possible de s'appuyer bien davantage sur eux encore. Pourtant, le soutien légitime et la ‘ capacitation ‘ des institutions et de la société civile syriennes doivent représenter une priorité.

8 Recommandations provisoires

L'appel au respect de la convention de La Haye doit être expliqué et inlassablement répété, tant auprès des parties prenantes actuelles qu'auprès des puissances qui seraient tentées par des opérations ‘ humanitaires ‘ ou de sécurisation. Une pression internationale devrait être dans la mesure du possible exercée autant sur le gouvernement que sur les insurgés pour les inciter à la préservation du patrimoine culturel de leur pays.

Poursuivre et même essayer d'amplifier les actuelles activités de suivi des dommages et d'information auprès de l'opinion publique.

Si une intervention militaire étrangère, similaires à celle d'Irak en 2003 ou de Libye en 2011, venait à se préciser, une campagne internationale devrait être lancée au plus vite afin de recueillir les coordonnées géographiques d'un maximum de sites culturels syriens et amplement compléter la liste préparée par le US Blue Shield.

La sécurisation des biens culturels, des musées et des sites devra être prioritaire de la part de toute autorité, dès le ‘ jour d'après ‘ la fin des hostilités. Elle devrait même être anticipée et sérieusement préparée.

Des évaluations de l'état du patrimoine seront urgentes, elles devront notamment s'appuyer sur une documentation de l'état avant le conflit, un inventaire des dommages (parfois successifs) subis pendant le conflit. Cette documentation pourrait être déjà assemblée, même partiellement.

De nombreuses compétences seront nécessaires pour le travail d'évaluation et de proposition de projets. Celles-ci pourraient être celles d'architectes, d'archéologues, d'urbanistes, de documentalistes, d'informaticiens, de muséologues, d'administrateurs, etc. Leur profil devra correspondre à la variété du patrimoine syrien. Leurs interventions viseront au diagnostic, à la réhabilitation, à la restauration, à l'établissement de stratégies d'action, etc.

L'exemple d'Haïti et de bien d'autres cas d'interventions souligne l'importance de s'appuyer sur une structure publique nationale compétente et aux pouvoirs étendus. La DGAM aurait avec son réseau régional vocation à jouer ce rôle. Une coordination générale et locale de tous les aspects de l'aide étrangère sera indispensable.

Des budgets importants seront nécessaires pour la remise en état du patrimoine culturel ; la Syrie étant un pays pauvre, toutes les ressources financières possibles, publiques ou privées, nationales ou internationales devront être mobilisées. D'ailleurs le patrimoine culturel serait l'un des atouts essentiels de la relance du tourisme.

Le patrimoine a par ailleurs vocation à symboliser l'identité nationale et une unité retrouvée. C'est pourquoi son rôle pourrait être si stratégiquement important dans la Syrie de demain.

Quelles pourraient être, dans ce cadre général et ' le jour d'après ' l'arrêt des combats, certaines des interventions spécifiques de l'ICOMOS ?

- D'abord, de contribuer à la création d'un comité national syrien et à la dynamisation du tissu professionnel syrien.
- Ensuite, s'appuyer sur son propre réseau de comités scientifiques internationaux, ses comités nationaux et ses experts individuels pour proposer des interventions techniques ou pédagogiques.
- D'élaborer une stratégie et une philosophie des interventions, notamment dans le cas des quartiers historiques bombardés.
- De tirer les enseignements de cette crise et de proposer notamment des améliorations éventuelles dans la préparation aux risques et dans l'application des instruments juridiques internationaux actuels.

Le symposium de l'ICOMOS à Beijing le 31 octobre 2012 pourrait être une occasion privilégiée pour discuter de ces conclusions et recommandations provisoires et de multiplier et d'approfondir l'implication d'autres comités scientifiques et nationaux ainsi que des membres experts ayant déjà travaillé en Syrie.

9 Prologue : les actions menées par ICOMOS depuis le Symposium de Beijing en 2012

Beaucoup d'événement s'étant produits depuis la rédaction de notre texte, j'ai essayé d'y ajouter ponctuellement quelques indispensables mises à jour factuelles sans porter atteinte à sa structure, mais l'essentiel d'entre elles est recensé ci-après pour ce qui est des actions de l'ICOMOS. Notre rencontre de Beijing en novembre 2012 aura permis le montage d'un groupe de travail interne actif et réactif.

9.1 Suivi de la situation

La situation est devenue malheureusement de plus en plus tragique avec l'utilisation d'un armement de plus en plus destructeur, des projectiles lancés au hasard sur les zones habitées, le creusement de tunnels bourrés d'explosifs, l'utilisation de véhicules piégés, les démolitions intentionnelles et idéologiques, ou la généralisation de pillages devenus systématiques. Le nombre des victimes du conflit approche désormais les 200 000.

9.2 Elaboration d'une réflexion interne

Celle-ci porte essentiellement sur l'appréciation de la situation actuelle, l'anticipation des risques à venir ainsi que la détermination des priorités d'aujourd'hui et de demain en termes d'actions et de stratégies.

9.3 Etablissement de liens et d'échanges

Le développement d'un réseau professionnel est une condition de travail indispensable. Au niveau international, il convient de souligner l'excellence des liens établis avec l'UNESCO ainsi qu'avec l'ICCROM. Mentionnons aussi les organisations internationales ou régionales comme le Bouclier bleu, l'ICOM, l'IRCICA, les universités de Durham et de Cambridge, les fondations comme l'Institute for Cultural Diplomacy ou Global Heritage Fund, des associations comme l'APSA ou Heritage for Peace. En Syrie même, nous avons établi des liens de confiance avec la DGAM et des rapports avec l'université de Damas, l'Union des ingénieurs et architectes, l'association Adiyat et des experts individuels.

9.4 Participation aux réflexions internationales

Il en est ainsi du colloque sur l'architecture de terre à l'UNESCO en décembre 2012, de l'atelier de lutte contre le trafic illicite du patrimoine culturel syrien, organisé par l'UNESCO à Amman en février 2013 ou de la rencontre restreinte d'experts avec Irina Bukova et Lakhdar Brahimi en août 2013.

9.5 Actions de sensibilisation

Contribution à de nombreux autres articles de la presse internationale, comme l'Aftenposten, le Figaro Histoire, le Gulf Times ou le New York Times ou Today's Zaman (Rubin 2012 et Güzel 2012).

9.6 Conseils et expertise

Une note urgente a été établie à la demande de la municipalité de Damas, établissement, en vue de prévenir les risques (incendies, destructions, etc.) pesant sur la vieille ville inscrite au patrimoine mondial, aux côtés de l'UNESCO, de l'ICCROM et d'Interpol, en décembre 2013.

Figure 11. Damas. Vue de la vieille ville intra-muros. ICOMOS a participé avec l' UNESCO et l' ICCROM à l'établissement de recommandations spécifiques pour sa protection des risques d'incendie en cas de combats rapprochés

A la demande du World Monuments Watch, des propositions concernant certains sites syriens comme la vieille ville d'Alep ont été examinées en juillet 2013.

9.7 Formation

Deux sessions de formation en Syrie même ont été organisées grâce à internet, en collaboration avec la DGAM et l'ICCROM et en coordination avec l'UNESCO. La session de Damas organisée en février 2013 regroupait 70 personnes. Celle d'Idleb, tenue en août 2013, regroupait une centaine de personnes. L'audience était composée de cadres de la DGAM, de professeurs d'université, de professionnels du patrimoine (dont des membres de l'ICOMOS), quelques étudiants ainsi que des secouristes du Croissant-Rouge. Les intervenants appartenaient à l'ICORP, l'ICOMOS, et l'ICCROM, s'exprimant à partir de l'Inde, de l'Italie, de France, d'Espagne, de Grande Bretagne et du Canada. Les exposés portaient sur les inventaires rapides, les évacuations d'urgence, l'accès aux sites touchés, l'évaluation des dommages, etc.

Figure 12. Idleb (Syrie). Annonce de la formation à la préparation aux risques sur le site de la DGAM (à gauche) et séance de formation par internet à la préparation aux risques par l' ICOMOS et l' ICCROM (à droite) (Source: DGAM)

9.8 Publication

Les cours ont été réunis et traduits en arabe. Un thème complémentaire, celui de la préservation des débris doit bientôt être publié.

9.9 Montage de projets

L'ICOMOS a essayé de tenir compte d'appels d'offres pour faire des propositions de travail s'appuyant sur son expertise. Il en est ainsi de sa réponse conjointe avec la DGAM à la fondation américaine CyArk pour réaliser une numérisation des plans de la vieille ville de Damas et leur restitution en 3D. La seconde étape vient d'être fournie en mai 2014.

Une réponse à l'appel d'offres du Département d'Etat américain concernant une planification de la sauvegarde du patrimoine syrien a été plus difficile à établir d'une manière indépendante en avril 2014, mais les contacts se poursuivent sous une autre forme.

Enfin, une soumission conjointe avec l'ICCROM et l'UNESCO à un important appel d'offres de l'Union Européenne en 2013 a dû être remaniée et c'est maintenant l'UNESCO qui en est le chef de file. Ce projet de sauvegarde d'urgence du patrimoine syrien a été ratifié au printemps 2014. Sa structure d'animation sera basée à Beyrouth. Un protocole d'accord (Framework of Cooperation) a été passé en septembre 2014 entre l'UNESCO et ses deux partenaires, l'ICOMOS et l'ICCROM.

Notes de fin

[1] La Syrie en a été l'un des tout premiers signataires, le 14 mai 1954.

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Preparation and Protection: Cultural Heritage in Times of Armed Conflict

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Abstract. The complicated nature of armed conflict and its multi-layered relationship with cultural heritage, necessitate a special risk preparedness plan for the protection of cultural heritage in times of war. The 1954 Hague Convention and its two protocols provide legal instruments and a general strategy for risk preparedness. The paper first overviews the historical background of the attempts for the protection of cultural heritage in times of conflict, and shows how the current legal instruments and preparedness measures have been developed on the basis of previous actions. The 1999 Second Protocol to The Hague Convention introduced the new regime of enhanced protection and also more explicit measures for the risk preparedness and peacetime activities. However, the protective capacity of this legal instrument is not fully used. While there are deficiencies and needs at all national, regional and international levels for the protection of cultural heritage in the event of armed conflict, ICOMOS International Committee on Risk Preparedness (ICORP) can play an important role for the promotion of the protection of cultural heritage by developing guidelines and collaborating with international organizations and assisting national committees to review their current protection system and preparedness policies.

1 Brief History of Risk Preparedness

The understanding of hazards and disaster has changed throughout history, but it is known that even in the ancient cultures, a notion of risk preparedness existed. When it comes to the protection of cultural heritage against the effects of war and armed conflict, intellectual, legal, and physical measures have been developed together, but with different paces.

The modern idea of the protection of cultural heritage in the event of armed conflict, embodied in the international legislation such as 'The 1954 Hague Convention,' is a part of a greater attempt to regulate war and limiting the extent and methods of warfare conducting. A historical perspective on the efforts to minimize the effects of war on cultural heritage, would help us to understand the path trekked, perceive our present position, and design the future way.

Many examples from ancient civilizations and cultures, including Indian, Greek, Roman, Mesopotamian and Persian, show that there have been war regulations, peace treaties, codes, and ethics for conducting of warfare and protection of certain properties, places and people during armed conflicts. In ancient India and Greece, a distinction existed between localities and places that should not be target and those that could be targeted for military action. The examples of the Cyrus Cylinder, in which the Persian emperor said that he had protected the temples in the conquered Babylon, or the concept of asylia in the Hellenic period in Greece, which meant giving immunity to specific places such as temples or even whole cities that should be spared from war (Rigsby 1997, 2) are the evidence of protective measures in ancient times. Such concept of immunity for certain places also existed in the Pre-Islamic Arab culture and then continued in the Islamic culture.

The question of just war, which was a subject of intellectual and philosophical debate in the Middle Ages, prepared the context for modern concerns about the protection and destruction of enemies' cultural properties. These concerns are reflected in the monumental works of Hugo Grotius and Emmerich de Vattel who, in his Le Droit des gens (The Law of Nations), directly condemned the wanton destruction of public monuments, temples, tombs, statues, and painting (1758, 369).

In 1863, the first code for a modern state with a clause for securing 'classical works of art, libraries, scientific collections, or precious instruments, such as astronomical telescopes, as well as hospitals' during a conflict, was drafted by Francis Liber in the 'Instructions for the Government of Armies of the United States in the Field'.

Since the distinction of properties that should be spared from hostility had an important priority for any preparedness measures, the 1874 Declaration of Brussels proposed that these properties become indicated by 'distinctive and visible signs to be communicated to the enemy beforehand' (Article 17).

After this, marking cultural properties by a distinctive emblem became one of the measures that international agreements and all the following conventions emphasized. The 1880 Oxford Manual, the Hague Conventions of 1899 and 1907, the Roerich Pact of 1935, and the 1954 Hague Convention have introduced this measure in a different way, and asked the States Parties to consider this as a tool in order to facilitate the recognition of cultural property. The necessity for using a distinctive emblem for marking cultural property was felt almost at the same time with the introduction of the emblem of the Red Cross in the 19th century. But the fact is that this measure could not become as worldwide as the Red Cross or Red Crescent.

1.1 Towards peacetime preparation

Marking of cultural property with a distinctive sign was a step toward designing preparedness measures that could envisage the intellectual and legal concerns for the distinction of cultural property, and thus providing immunity for them in the event of armed conflict. Marking cultural property together with providing inventory and list of the properties that deserve legal protection, formed a mechanism that was internationally introduced by The 1954 Hague Convention after the Second World War.

But before that time, further steps were developed by the Netherlands Archaeological Society (Nederlandsche Oudhheidkundige Bond or NOB) in 1918. The NOB in a report that was internationally circulated proposed an obligatory peacetime preparation measure and called it 'mobilization'. Providing a national inventory of monuments, and preparing a list of people who could undertake wartime control system, were proposed in the draft. It also proposed to create, where possible, demilitarized zones in the vicinity of important monuments (O'Keefe 2006, 41-43). The report was drafted in response to the hostility and destruction towards historic monuments in the First World War, especially in France and Belgium.

Even before this proposal, some countries had taken preparatory measures during the First World War. In Italy, for instance, the destruction of Reims cathedral and the other monuments in France and Belgium, raised the alarm for the protection of cultural heritage. In 1915, Venice was witness to a very delicate protection work, which was done for Basilica di San Marco. The bronze Quadriga (bronze horses) of the basilica based on the loggia or balcony was taken down and transported to a protected place, and also strong protection walls were constructed of sandbags along the main façade (Ricci 1917). The same measures were done in some other Italian cities.

In the UK, the underground railway tunnels and deep basements in the Museum were used for temporary storage of some parts of the British Museum collections in World War I. This policy was used once again during World War II. The British Museum had a master plan for the protection of its artefacts in wartime, chosen the objects that had to be moved first and assigned safe places to use in times of emergency (Caygill 1992, 34). In all these countries, taking these protective measures was a response to development in military technology, and especially aerial bombardment.

By World War II, the physical protection measures for both movable and immovable cultural heritage were improved and applied mainly in European countries and the United States. All these measures were aimed for the protection of cultural heritage against the possible effects of enemy attack. But in 1943, the United States took an important step towards protection of cultural heritage in the countries that could be attacked by the US Army.

The 'American Commission for the Protection and Salvage of Artistic and Historic Monuments in War Areas', known as the Roberts Commission, was established by President Roosevelt when it became clear that Allied armies would start war against Axis powers and invade Europe. The commission had protection plans during the war and post-conflict time. In Sicily and other Italian regions, for instance, although the special plans of the Commission and its activities could not prevent destruction of the monuments by aerial bombardments; it could provide first aid and necessary repairs to protect damaged buildings (United States American Commission for the Protection and Salvage of Artistic and Historic Monuments in War Areas 1946). The commission had a key role for the restitution of looted and stolen works of art after the end of the war. These activities in such scale, never repeated in the later conflicts after WWII. The prudence of the organizations and professionals, whose efforts led to establishing the Commission, proved how peacetime measures are effective in post-disaster response and recovery phase.

2 The Hague Convention and Protective Measures

In the aftermath of World War II and huge destruction and loss of cultural heritage in different cities, the Hague Convention for the Protection of Cultural Property in the Event of Armed Conflict was adopted by UNESCO in 1954. The Convention provides protection, based on respect and safeguarding, for both movable and immovable cultural property. In 1999, the Second Protocol to The Hague Convention was adopted in order to elaborate a new supplementary legal instrument and introduced the system of Enhanced Protection.

Besides introducing general protection, special protection, and enhanced protection, the Convention and its 1999 Second Protocol together, provide measures for risk preparedness and peacetime activities. The Convention in its Article 3 on safeguarding of cultural properties expresses that the States Parties undertake 'to prepare in time of peace for the safeguarding of cultural property situated within their own territory against the foreseeable effects of an armed conflict, by taking such measures as they consider appropriate'. Although it does not provide any details of these measures, but it gives three key elements for such safeguarding that are time, location and subject-matter, extracted from peace time, State Party's territory, and foreseeable effects (Hladik 2003, 93).

The Convention introduces the regime of special protection for a limited number of cultural properties, which gives immunity to them from any kind of hostility. The difficult conditions for registering in the International Register of Cultural Property under Special Protection prevented many cultural heritage sites and refuges from entering into this list. For instance, Article 8 of the Convention states that property should be situated at an adequate distance from large industrial centres or from any important military objective, aerodrome, broadcasting station, a port or railway station. In fact, many historic cities, urban centres or heritage sites inscribed on World Heritage List are faced with these obstacles. If a request for registering a cultural property by a State Party is faced by an objection of another State Party, based on the valid reasons mentioned in the Convention, that property cannot enter into this international register. Until 1978 only 5 State Parties could register their cultural properties under the special protection. This number was reduced when the Netherlands in 1998 and then Austria in 2000 asked the Director-General of UNESCO to cancel the entry of their properties in the Register (UNESCO 2010, 6). It is worth mentioning that among the few properties that are now placed under special protection, there is only one monumental complex, the whole of the Vatican City State, and the others are refuges for movable cultural property.

For this reason, the 1999 Second Protocol to the Hague Convention introduced the enhanced protection system. According to Article 10 of the Second Protocol, cultural property submitted for enhanced protection must be: of the greatest importance for humanity; protected by adequate domestic legal and administrative measures; and not used for military purposes or to shield military sites.

The enhanced protection is an easier regime than special protection. Unlike the latter, the enhanced protection does not need the agreement of all States Party for inscribing one cultural property in the register. The Second Protocol went into force in 2004, although it introduces an easier protection system; there still are not enough properties registered in its list. In 2010, eleven requests for the granting of enhanced protection were sent to the Committee for the Protection of Cultural Property in the Event of Armed Conflict by Azerbaijan, Cyprus, Italy and Lithuania.

The Second Protocol in its Article 3 has clear guidelines for safeguarding of cultural property which should be done in peacetime: 'the preparation of inventories, the planning of emergency measures for protection against fire or structural collapse, the preparation for the removal of movable cultural property or the provision for adequate in situ protection of such property, and the designation of competent authorities responsible for the safeguarding of cultural property'. The degree, quality and the technical methods for the implementation of these measures are left to each State Parties and the Protocol does not provide any more details. The limits of these measures depend on each country's financial resources, national or domestic laws, administrative structure, and technical and scientific capacities. Although the Convention and its protocols are not able to provide solutions for tackling these limits, they create a departure point for developing risk management and preparedness activities in peacetime.

Training military and establishing services or specialist personnel within armed forces are also emphasized by the Convention as peacetime activities.

Marking cultural property with the distinctive emblem of the Convention can be also seen as a preparedness measure. The Convention has two different policies for using its emblem. It is not compulsory to mark cultural property under the general protection, and it is left to the decision of each State Party. But the cultural property under the special protection, transport under special protection, and improvised refuges for cultural property should be marked by the emblem of the Convention.

The effectiveness of marking cultural property with the emblem of the Convention, that is usually a small plaque, has been the subject of many discussions, especially in the age of advanced military weapons, high-altitude military aircrafts, long-range missiles, and satellites. In some examples, like during the armed conflicts in the former Yugoslavia, the places marked with the emblem were intentionally attacked.

2.1 The link between The Hague Convention and The World Heritage Convention

The protection of immovable cultural properties is a common policy in The Hague Convention and its Second Protocol with The 1972 World Heritage Convention. The Hague Convention has a greater scope than The World Heritage Convention, since it also protects movable properties as well. Both the Second Protocol and The World Heritage Convention use intergovernmental committees and lists for certain types of cultural properties.

The efforts of the countries to inscribe their cultural heritage on the World Heritage List are not comparable with their intention and effort for obtaining enhanced protection for their cultural property. While as of July 2012, there are 745 cultural, 188 natural and 29 mixed (cultural and natural) properties inscribed on the World Heritage List, the efforts for inscribing cultural property on the list of enhanced protection has just started. UNESCO emphasizes that the organization does not intend to create a competition between World Heritage List and the List of Cultural Property under Enhanced Protection (UNESCO 2010, 2).

The mechanism that is predicted in the Second Protocol prevents automatic inclusion of cultural heritage inscribed on the World Heritage List into the list of enhanced protection. However, the conditions for cultural property to be considered with greatest importance for humanity are very similar to those with the Outstanding Universal Value, specified by the World Heritage Convention. For this purpose, the Guidelines for the Implementation of the Second Protocols confirms this link between the two conventions and asks the Committee to consider that 'immovable cultural property inscribed on the World Heritage List satisfies the condition of greatest importance for humanity' (UNESCO 2009, 14, Paragraph 36).

3 Risk Preparedness Measures; Natural and Human-made Disasters

The Hague convention is not the sole international document that insists on risk preparedness for the eventual threats to cultural heritage. Since 1954, this subject has been reflected in many national and international charters, recommendations and documents. By the 1980s, attention to risk preparedness became an important apprehension, especially after some terrible disasters in different countries, such as the 1966 Florence flood and the 1979 earthquake of Montenegro. Most attempts are focused on preparedness for cultural properties against natural disasters. The similarities between armed conflicts and natural disasters in many aspects make risk preparedness recommendations for natural disaster, applicable for cultural heritage even in the event of war. However attention should be paid to the differences that exist between them.

In any kind of disaster that threatens cultural heritage, at least one important element of cultural heritage is at risk. These elements are local communities or bearers, environment or ecology, and built heritage (Jigyasu 2003, 136). In time of conflict, the actors that have potential influence in the risk management cycle are more or less the same as the actors in times of natural disaster, but their role depends more-so on their socio-political position.

The role of army, media, social, religious, and ethnic groups and their leaders, local communities, international organizations and NGOs, governments, and experts is dynamic and might change during a conflict. While a natural hazard, which turns into a disaster, contains social, cultural, economic and even political outcomes, an armed conflict has a root in the incompatible goals of these different parties. This incompatibility might be over resources, power, identity or different values. In the hyper-politicized atmosphere of war, not only can cultural heritage become a target, but it can also have a role in forming a cause, triggering an event, or accelerating the violence. Therefore, the relationship between war and cultural heritage cannot be reduced to only damage and destruction.

Both natural and human-induced disasters can potentially create mechanical, physical, biological and bio-deterioration, and anthropogenic risks to a built heritage and its environment. But the duration, and sometimes the covered area, of a conflict are longer and broader than natural disasters. As conflicts move on the context of social ruptures, and can deepen them, attention should be paid to the social context in which a conflict occurs.

All these factors, including the duration of a conflict, its covered area, and its social and political context, necessitate a different approach for risk management in times of conflict. Emergency response also highly depends on these factors. A long term and ongoing conflict that covers a broad area with severe damage to cultural heritage may postpone or slow emergency response. The role of international organizations and NGOs, which may offer their help and expertise, are not viewed and interpreted in the same way as their role is usually comprehended in the aftermath of a natural disaster.

Ethical issues should also be added to all these complexities. The role of archaeologists and cultural heritage experts, their relationship with armies, and their neutrality have been the issues of many challenges in the recent decade, especially after the 2003 Iraq war. These challenges inside the experts' community would be escalated when the international community chooses to takes sides in a conflict. Considering cultural heritage and access to it as a human right, adds a new layer to the issues that should be dealt with in any risk management cycle for cultural heritage in times of conflict; as well as for first aider workers who would assist in emergency response.

These issues prove that guidelines for risk preparedness in times of natural disasters, are a departure point for armed conflict, but are not sufficient. This means that, while conflict and its risks to cultural heritage should be well incorporated into the framework of the risk management cycle, and not be considered as an individual factor, given its multi-layered relationship with heritage, it needs specific attention and a holistic approach, which may address all of these concerns.

4 Towards a Risk Preparedness Plan for Times of Conflict

To move towards a holistic and dynamic approach for risk preparedness planning for times of conflict, an understanding of cultural heritage and the various risks of a conflict is necessary. In recent decades, our understanding of the concept of cultural heritage has changed, and now its definition applies to a broader range of human's cultural manifestation. While the 1954 Hague Convention referred to cultural property, as the subject of its protection regime, the 1972 World Heritage Convention replaced 'property' with 'heritage' and accepted also the sites with aesthetic, ethnological, and anthropological values as a part of cultural heritage. In the later international documents, issued in 1990s and 2000s, intangible values of tangible heritage have been approached more and more. The 1994 Nara Document on Authenticity, 2003 Intangible Cultural Heritage Convention, and 2005 Convention on Diversity of Cultural Expressions show a conceptual shift in our understanding of cultural heritage, and now people, functionality, diversity and intangible values are also considered as our common human heritage.

Living heritage is as important as built heritage, as it gives meaning and significance to the built heritage, and is a guarantee for its continuity. Traditional skills and knowledge are needed in post-conflict emergency and recovery phases. Therefore, the protection of these aspects of heritage should be considered in risk management plans as well. The environment of cultural heritage and the relationship between heritage, nature and its surrounding environment should be regarded in this approach. The examples of many conflicts, including the First Persian Gulf War (1991) and the 2006 Lebanon War show how environmental damage can turn into a disaster for cultural heritage as well. By considering the extended concept of cultural heritage and its integrity with environment and nature, a new strategy for risk management in times of conflict has to assess the risks to all these elements.

Usually it is said that a risk management cycle consists of three phases, before, during, and after a disaster. But conflict, as much or more so than other types of hazards, has a dynamic and non-linear nature with no precise starting and ending point. For example, in Afghanistan, the country should overcome the damages inherited from the long decades of conflict on the one hand, but on the other, there are still ongoing conflicts and attacks that threaten its cultural heritage resources. Conflict situations and the related preparedness measures should be, therefore seen as a multidimensional matrix with numerous elements, which have interaction with each other and change by time factor (Rouhani 2010, 324). Thus, preparedness has to be taken at all local, national, regional and international levels, by undertaking legal, financial, administrative, scientific and technical measures.

5 Framework of Actions; Deficiencies and Necessities

Speaking about the necessity of a holistic approach to preparedness measures is not complete unless the actual deficiencies and needs in the protection system are addressed. First and in the legal framework, the 1999 Second Protocol and its enhanced protection regime should be ever more adopted on the international level. The scope of the protocol, which is both international and non-international armed conflict, its new protection regime, and almost explicit preparedness measures, make it the most effective legal instrument at the present time. However, by the end of March 2012, there are only 62 States' Parties that have ratified the Protocol. Comparing to 125 States Parties for The 1954 Hague Convention, and 189 States Parties to the 1972 World Heritage Convention; the Second Protocol still needs to be ratified by more states and introduced into domestic legislations. The capacity of the enhanced protection regime is not fully used as of yet. Establishing a more explicit link between the List of Cultural Property under the Enhanced Protection and the World Heritage List, as discussed above, may facilitate the implementation of the enhanced protection regime under the Second Protocol.

Training, as emphasized by The Hague Convention itself, is a necessary key to disseminate the Convention and its two protocols. Lack of training especially for military personnel has led to many risks to cultural heritage in recent conflicts, i.e. in Iraq. Training for military personnel, in cooperation with cultural heritage experts, would help to achieve a better understanding of both sides and build a common language.

Protection of cultural heritage has not yet found a fixed and secured position in peace monitoring and peacekeeping missions. Although in many cases, destruction of architectural and cultural symbols is a sign of an ethnic or sectarian conflict, monitoring cultural heritage, assessing its damages, and providing a protection for it, is not usually among the priorities of international peacekeeping missions; unless the destruction reaches an extreme degree with irreversible effects. It is understandable that during an armed conflict the operations for the protection of cultural heritage is not feasible, however we may question how a stronger link between peacekeeping missions and cultural heritage professionals can be established. Any issues reported or monitored by peacekeeping missions, would be helpful for professionals who undertake emergency response.

The Blue Shield can potentially undertake the responsibility of putting cultural heritage international NGOs and professionals in touch with army and peacekeeping missions. It can also coordinate the emergency response of its five different NGOs, or can organize joint missions for the scope of damage assessment and emergency response in conflict-affected areas. However, this network, including the International Committee of the Blue Shield (ICBS) and Association of National Committees of the Blue Shield (ANCBS), needs more political and financial support in order to be able to reach its primary goal, which is being the cultural equivalent of the Red Cross.

6 What Can ICOMOS-ICORP Do?

The goal of the International Committee on Risk Preparedness (ICORP), as one of the scientific committees of ICOMOS, is promoting the protection of cultural heritage places from the effects of both natural and human-induced hazards. Generally, this can be achieved by undertaking research, developing guidelines, promoting training, and collaborating with other partner organizations.

At the national level, ICOMOS-ICORP can assist ICOMOS national committees to establish their scientific committees for risk preparedness, and create and develop the network of experts. The network is essential in times of any disaster and conflict in order to exchange information and expertise, and foster scientific and international help and support. The ICORP's network still has to be more developed and extended.

Undertaking the training and dissemination of the 1999 Second Protocol to The Hague Convention, and its related legal and technical issues, especially its risk preparedness measures, should receive ICORP's attention. Knowing the technical and protective measures of the Second Protocol would be useful for the professionals of the non-Party States or the newly joined States.

The International Committee on Risk Preparedness can also help the Party States to the Second Protocol to nominate their cultural properties to be registered under the List of the Enhanced Protection. As ICOMOS is an advisory body to UNESCO, and especially to the World Heritage Committee on the implementation of the 1972 World Heritage Convention, ICORP can undertake the joining between the World Heritage Convention and the Second Protocol; in order to identify cultural heritage inscribed on the World Heritage List that has the condition to be protected by the Enhanced Protection. ICOMOS-ICORP can offer its advocacy to the Party States to these conventions, as well as to the Committee for the Protection of Cultural Property in the Event of Armed Conflict and UNESCO.

At the regional level, ICOMOS-ICORP can play an important role to identify weaknesses in the present system of protection and risk preparedness, especially in the regions that are mostly at the risks of conflicts and crises. For this purpose, ICORP can promote and support academic research on risk preparedness for cultural heritage in times of conflict.

By monitoring cultural heritage in conflict affected areas and undertaking post-conflict assessments and researches, ICOMOS-ICORP would offer its scientific support, assist in reviewing the applied measures and policies, and based on the lessons learned, propose new strategies for the protection of cultural heritage places in times of conflict.

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Theme 4: Planning for Post-Disaster Recovery of Cultural Heritage

Emergency Response to Natural Disasters
Experience Gained from Rescue Efforts for Cultural Properties Affected by the Great East Japan Earthquake

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Abstract. This paper reviews and examines the first year of activities of the salvage operations of cultural properties and other materials carried out in the aftermath of the Great East Japan Earthquake that occurred on March 11, 2011, from the standpoint of the ad hoc national Salvage Committee. This disaster and particularly the great tsunami that struck in its wake, wreaked havoc across a large part of the Tohoku region along Japan's Pacific coast, causing a great loss of life as well as the destruction of entire towns and villages. In the aftermath, the largest rescue operation for cultural properties in Japan's history was mounted and carried out by historians, and archaeologists from within the region, along with museum curators, cultural properties specialists, ordinary citizens and others from throughout Japan. While the Salvage Committee organized by the national government's Agency for Cultural Affairs (Bunkachô) formed the core of those operations, there had been no formal preparation for a response to disaster of this magnitude and the operations became a series of trial and error processes. Predictions today indicate that a massive earthquake and tsunami will strike again in the near future, likely somewhere along Japan's Pacific coastline, possibly near the Tokyo metropolitan region. This paper urges the quickest possible realization of the preparations essential for cultural properties rescue operations in time for the next natural disaster, based on the experience and lessons learned from the current operations.

1 Introduction

More than 18 months have passed since the Great East Japan Earthquake struck. The traces of the devastation caused by the unprecedented events that took place on that day still scar the disaster zone, and numerous and diverse challenges still hamper forward movement on the region's recovery.

Given its position as an island nation, located off the east coast of the Asian continent, since antiquity Japan has formed its own unique culture. As a result, the country is filled with countless historical sites and cultural properties. At the same time, Japan is a land beset by frequent earthquakes, typhoons and related natural disasters, and this means that all of its cultural properties are normally in danger of being affected by such calamities.

The events of March 11, 2011, particularly the massive tsunami that struck the Pacific shoreline of the Tohoku region, entailed great loss of human life as well as the complete destruction of many towns and villages. In the midst of this tragedy, Japan's largest ever rescue operation for cultural properties began. That rescue operation was initially carried out by the region's historians, archaeologists, museum curators, and cultural properties conservation specialists, as well as the general public and at times the members of the Japan Self-Defence Forces who were dispatched to the area on human rescue operations. And yet, this rescue operation was by no means either unified or coordinated. In terms of funding, there too, inadequate preparations were in place.

Soon after, the Agency for Cultural Affairs (Bunkachô) established the Committee for Salvaging Cultural Properties and other Materials Affected by the 2011 Great East Japan Earthquake and Related Disasters (Cultural Properties Rescue Operations). [FIGURE 1] The National Research Institute for Cultural Properties, Tokyo (Tobunken), where I am a staff member, was made the centre of the committee's operations and I was appointed to a leading role.

In Japan recent predictions indicate that a major earthquake and resulting tsunami will hit the Tokyo metropolitan area and the Pacific coast of Japan in the near future. This report is not simply a listing of the accomplishments of the current year-long rescue operation, but rather also an examination of the issues that have arisen during these ongoing rescue operations and a consideration of the preparations Japan must take for such future operations.

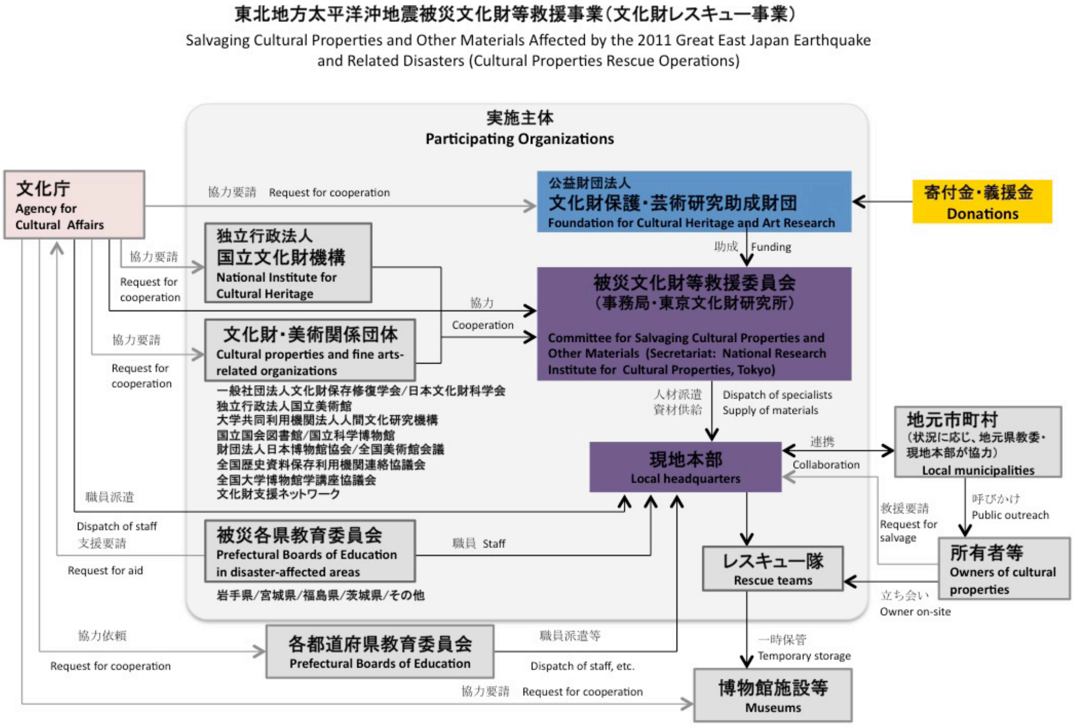

Figure 1. Rescue operations overview.

2 The Nature of the March 11th Disaster: The Destruction of Regional Society

The main earthquake struck on March 11, 2011 and was followed by a long period of aftershocks. But more destructive than the earthquake, it was the resultant giant tsunami that struck over a large area, destroying not only homes and businesses, but also in some places greatly damaging the very fabric of regional society through the destruction of prefectural, city and village government facilities. [FIGURE 2] The March 11th disaster was characterized by how this destruction of regional infrastructure meant that each region came up with a different means of restoring the necessary systems of government at the various levels for the relevant cultural properties rescue operations. Fukushima prefecture is in an even more difficult situation, due to the earthquake and tsunami effects on the Fukushima Daiichi Nuclear Plant and resulting explosions, and the fact that the entire populace has been evacuated and the usual local governance has been moved to other areas.

Figure 2. Six weeks later,
Ishinomaki City,Miyagi prefecture (April 29, 2011).

3 Objects of the Rescue Operation

The cultural properties subject to the rescue efforts of the rescue committee also had specific features. The Committee's Implementation Guidelines defined the goal of rescue efforts in these terms: 'Regardless of specific designation by national or regional authorities, efforts will focus on fine arts and moveable cultural properties, including paintings, sculptures, crafts, calligraphic works, classical books, ancient documents, archaeological artefacts, historical resources, tangible folk cultural properties and other items'.

First, the Guidelines clearly state that rescue of cultural properties will be 'regardless of designation status'. Compared to inland areas, the coastline area, damaged by a once-in-several-hundred-years historically huge tsunami, had only a few nationally designated cultural properties. Of course, there were also many cultural properties in the inland areas that also needed attention, but this time, the policy strongly advocated saving the items that had been damaged by the tsunami and within the greatly damaged coastal areas whose local governmental organizations were in dire straits. As a result, the cultural properties that we rescued included very few nationally designated items.[FIGURE 3]

In terms of the other type of cultural properties, namely in situ architectural structures, monuments and historic sites, those rescue operations were carried out by a different organization. Conversely, there are numerous archives and materials collections related to the fishing industry on the Tohoku coast, including gigantic models of whale skeletons and other such items [FIGURE 4]. So from the beginning, there was a consensus that such natural history materials and miscellaneous materials, indicated by the term '等tou' in the original Japanese, would also be made the subject of our rescue work.

Figure 3. Rescue work on folk materials,
Ishinomaki Culture Centre, Miyagi prefecture.

Figure 4. Rescue work on a stuffed whale,
Oshika Whale Land, Ishinomaki City.

4 The Preparations of the Salvage Committee and Activity Funding

This cultural properties salvage operation had as its goal the removal of affected cultural properties and their transport to a more stable location. This almost immediate triage work began on April 1, 2011, just half a month after the earthquake. An important element in the realization of the Salvage Committee's operations, was the funding arrangements necessary to retain participants, and to carry out activities.

Even though there are a great number of cultural properties, research specialists and conservation specialists in Japan; there is no specialist division for cultural properties conservation in either Tobunken itself or in the other research institute, and four national museums that combine to make up the Independent Administrative Institution known as the National Institutes for Cultural Heritage. Nationwide there is no standing rescue team that can be dispatched in an emergency. Regardless, the media and many of the Committee's participants called our rescue operations either: the Agency for Cultural Affairs or the national 'cultural properties rescue'.

In fact, the actual rescue operation process began with the Agency for Cultural Affairs calling for volunteers, and assembling a committee made up of a large number of organizations and groups involved with cultural properties: art, history and natural science, including museums, archives, research institutes, universities and academic societies. Of those groups the Tobunken was selected as the committee's administrative office to carry out the business of running the project. Tobunken, often assumed to be part of the Agency of Cultural Affairs as a national institution, is actually just one element of an Independent Administrative Institution. Similar to the other organizations who make up the Salvage Committee, responded to the Agency's request for participants. The individual specializations and regular jobs of the participants varied widely. In other words, Japan, as a country that does not have a standing cultural properties rescue organization, assembled specialists in various fields from organizations throughout the country, and it was this quickly assembled group that conducted the cultural properties rescue work in this instance.

Given that nature of the Salvage Committee, the activities of the committee were not funded at first by direct allocation of funds from the Agency. It depended on funds solicited from a wide range of donations, in addition to the large amount of money that many of the organizations who participated in the rescue operations provided from their own budgets. This is yet another special characteristic of this rescue operation.

Prior to beginning the cultural properties rescue operation, the Director General of the Agency for Cultural Affairs made an announcement to the people of Japan. He stated that numerous cultural properties were in danger of complete destruction due to the unprecedented degree of the disaster. He went on to explain how, as part of the Agency's rescue operations, first they wanted to plan an emergency relocation of cultural properties affected by the disaster, and then carry out conservation work and safe storage. In order to carry out these operations the Agency intended to plan for the allocation of standing budgetary items and the calculation of a supplementary budget, but in order to quickly provide the essential equipment needed for the dispatch of specialists, and ensure that damaged cultural properties have safe storage areas, he stated that there must be a national coming together to support this project. Thus he solicited donations and contributions for use in carrying out these activities.

As I noted earlier, when we began the rescue operation we had already realized that the great majority of cultural properties damaged by this disaster were not items formally designated as important by either the national or regional governments. Japan's cultural properties protection system broadly considers all cultural properties, both those designated and those undesignated, but there is special emphasis placed on those items designated as particularly important by the nation: items officially designated as National Treasures and Important Cultural Properties. Those in the next rank of importance: works that have been similarly designated by prefectures, followed by those designated by city and village governments. Essentially this system means that each of the levels of government is responsible for the cultural properties designated by their particular level, and thus the funding of the costs involved in their management, designation and conservation work is similarly the responsibility of their respective government level. Thus, naturally, in this system there is no allocation made for un-designated objects.

In this situation, the following became apparent:

1. No matter what level of designation or non-designation, there were no funds allocated for rescue operations in times of natural disaster
2. What were the measures the nation was going to take to provide the necessary funding for cultural properties rescue?

However, in the face of the great loss of human life and the destruction of regional social and governmental infrastructure across a wide geographical area, the funding needs of the Agency for Cultural Affairs for the rescue of cultural properties were extremely low priority amongst all the calls for funding in the immediate aftermath of the disaster. The Agency for Cultural Affairs Director General's call for donations to the cause not only indicated that cultural properties are a matter for the entire nation, but also that in fact, it was extremely difficult for the national government to provide funding, at least in the immediate period.

5 Actual Funding

The Foundation for Cultural Heritage and Art Research is the organization officially receiving the donations solicited by the Director General of the Agency for Cultural Affairs. The Foundation added the Agency-solicited funds to those accumulated through its own appeal and in further coordination with the World Monuments Fund; they assembled funds throughout a year-long period that amassed to more than 250,000,000 yen. The activities expenses of our rescue committee were provided from that amount in the form of a grant.

The rescue work on the cultural properties affected by the disaster, as mentioned in the Director General's message, was divided into two stages, namely emergency evacuation operations and later conservation and preservation work. Our rescue committee's mission was the emergency evacuation operations. The conservation work is also scheduled to utilize some of the funds assembled by the Foundation for Cultural Heritage and Art Research, but not all of those funds can be used solely on the activities of the Salvage Committee. Further, because there were no funds available when the rescue operations began in April 2011, the committee office set as a basic rule that foundation grant funds could not be used for dispatching personnel and told the participating groups the following:

1) Please dispatch specialists using your own funds to the greatest degree possible

2) Foundation grant funds can only be used to purchase materials and on contract labour for the transportation, cleaning and other specific work.

In other words, until the Agency for Cultural Affairs could prepare a budget using Supplemental Budget line items or such, it was left to those groups that could provide personnel to arrange their own funding. Thus, Tobunken as the committee's administrative office, was responsible for all expenses of that office. Given that there were limits to the amounts of money each participating organization could provide, there were some organizations that could not arrange personnel funds. Beginning with the arrangements meeting held in April 2011, the committee office continued to strongly request the provision of funds by the Agency for Cultural

Affairs.

In light of those requests, from August 2011 onwards the Agency provided funding to the Committee for the dispatch of specialists. Up until the end of the Japanese fiscal year, March 31 2012; this Agency funding amounted to a total of 29,000,000 yen, which covered the Salvage Committee's entire dispatch of specialists, totalling more than 350 specialists.

By the end of the fiscal year in March 2012, the Committee had received a total of 40,000,000 yen from the Foundation. These funds were used to purchase needed items, and to pay for specific work, such as fumigation and transportation. Thus the above amounts from the Agency for Cultural Affairs and from the Foundation, plus the amounts of their own funds used by each of the participating organizations, can be surmised to have totalled a mere 100 million yen from April 2011 to March 2012.

6 'Application-ism' and Rescue Operations

Regardless of the fact that the Agency for Cultural Affairs was not directly operating the Salvage Committee in terms of either organization and funding, the Agency defined the rescue activities as being carried out for the prefectures that 'applied for rescue'. This is also because of the fact that the system currently in place positions Japan's 'cultural properties' as the property of individuals, corporate bodies, local governmental bodies, or the nation. Because these cultural properties are assets, fundamentally the owner is responsible for the items, and in terms of a systematic structure, cultural property owners are responsible to/have recourse from either the immediately superior rank of local governmental body or the nation. As a result, this has led to a focus on application procedures. When a village or town wants to make an application for something, they have to work up through the governmental ranks, from prefecture to national. This was also the case for rescue operations, which could only begin after the requests were routed through the proper chain of administration. Rescue operations began on April 1, 2011, because Miyagi prefecture requested rescue on March 29th, and that was the 'form' in which the Agency for Cultural Affairs responded.

As a result, regardless of the fact that the affected prefectures on the Tohoku and Kanto coastline, and in the interior are quite numerous; the Committee's activities were only carried out in the four prefectures: Miyagi, Iwate, Ibaragi and Fukushima, namely those which submitted rescue requests.

7 The Position of Cultural Properties Rescue Operations

However, there is one thing we must remember. Even in Iwate, Ibaraki and Fukushima, where the Committee's work was delayed; from early on, independent rescue operations were being carried out by a collaborative effort between museums and universities within the affected prefectures. Even after the Committee's own work began, numerous independent bodies continued their own operations. At times the organizations that make up the Committee went on their own to affected museums in prefectures that had not submitted formal rescue requests. Naturally it was the same situation in the regions outside of the four prefectures that did not request rescues. As a result, it would be correct to say that the Agency for Cultural Affairs' 'cultural properties rescue operations', was only one part of the overall work by people who actually rescued cultural properties within Japan.

8 The Work Carried Out by the Member Organizations of the Salvage Committee

Because the Agency for Cultural Affairs issued a call for participation to organizations and groups over a wide spectrum, this meant that the participating groups had differing approaches and thoughts about cultural properties. For the Committee's administrative office, which was having to make do with limited funds and placing personnel with all of the related considerations, the passionate fervour of the people who participated in the operations seemed to be at odds with the business-like approach of the administrative office. Further, even though the operations title includes 'cultural properties and other materials (*tou*)', specifically stating '*tou*' the Japanese term for etcetera, and thus it is clear that in this instance the Agency for Cultural Affairs-led work targeted objects that are not normally considered 'cultural properties', it seems that the university researchers and museum curators who handle natural history items such as plant and animal specimens, still had questions about whether or not the rescue operations applied to their own materials. This questioning reveals the insufficient efforts of the Committee office regarding the distribution and sharing of information.

9 Results

Thus with these various complications included, the cultural properties rescue operations were carried out over a one-year period, and were able to rescue a large number of cultural properties materials through the efforts of the participating organizations and specialists.

When Miyagi prefecture submitted its rescue request, they made a list of 17 sites that needed rescue. In order for the work to proceed to plan, an on-site head office was established at the Sendai City Museum in accordance with Committee installation guidelines. A regular staffing system centring on Tobunken staff was established, and work was to be carried out through the cooperation of various committee member organizations. The first work conducted by the Committee was the removal of art works from the Ishinomaki Culture Centre in late April 2011. This work was carried out by specialist art conservators and numerous art historian specialist curators who were dispatched by the Japanese Council of Art Museums. [FIGURE 5]

Figure 5. Rescue work on fine arts,
Ishinomaki Culture Centre, Miyagi prefecture.

As surveys of the area progressed, the rescue subject list rapidly ballooned to around 40 sites by July. In spite of this expansion, work had advanced to the stage of the emergency evacuation of cultural properties for approximately 80 percent of those sites and by the end of July the regular staffing system was disbanded. At the same time, since work remained to be done, the Miyagi Network for Preserving Historical Materials was established among the various organizations within the prefecture. This remaining work includes the evacuation of remaining items and the temporary storage of items that could be anticipated to be in longer term storage until the items could be returned to their owners. As a result, at present, the cultural properties rescue operations being carried out in Miyagi prefecture are being conducted with this Network as the main operational group, and the Committee providing support when needed.

Figure 6. Rescue work on paintings,
Rikuzentakata City Museum, Iwate prefecture.

Figure 7. Emergency handling work
at an abandoned elementary school,
Rikuzentakata City, Iwate prefecture.

In Iwate prefecture, through the efforts of the various universities within the prefecture and the support of the Self-Defence Forces, a total of more than 400,000 collection items were evacuated from the Rikuzentakata City Museum and the Rikuzentakata City Sea and Shell Museum by around the beginning of May. The evacuated cultural properties were transferred to elementary school buildings that had fallen into disuse in the mountainous areas of Rikuzentakata and to the Iwate Prefectural Museum in Morioka. Their emergency handling was aided by the cooperation of the Sea and Shell Museum staff who survived the disaster. The rescue request was sent to the Agency for Cultural Affairs in mid-May, asking for material support for the emergency storage and disposition work that was being carried out at the prefectural museum with insufficient funds. As a result, the Committee's work in Iwate prefecture centred on the emergency storage and disposition handling of objects that had already been removed from the disaster zone. However, 120 paintings, including large-scale oil paintings, remained on the 2nd floor of the Rikuzentakata City Museum, whose entire staff of 6 was killed in the tsunami. The rescue of these paintings by the members of the Japanese Council of Art Museums began in mid-July 2011. [FIGURE 6] From late August to the end of September, fumigation, cleaning, media reinforcement and other emergency handling were carried out in prefectural facilities that had previously been vacant for the last ten years.

These abandoned schools and other such unused facilities were used because the great majority of the rescued cultural properties were so heavily soiled or damaged that they could not be taken as is into other museum settings. Given that there were problems assuring enough evacuation sites for all of the people displaced by the disaster, difficult problems also arose over finding enough secure places for all of the rescued materials. [FIGURE 7]

Ibaraki prefecture was also greatly damaged by the earthquake, and of the 744 nationally designated or registered cultural properties affected by the disaster overall in Japan, Ibaraki was home to 182 of the affected works. However, the rescue request from the prefecture was not sent until July 2011, and the Committee's work in the prefecture was limited to only four cases of evacuation and emergency handling. Along the coast, the tsunami damage to cultural properties was amazingly small. In both the coastal and inland areas of the prefecture, there were only a few moveable cultural properties the focus of the Committee's work that were damaged. The Committee was only minimally involved in the prefecture thanks to the fact that the universities and other related organizations in the prefecture carried out the majority of the rescue work for documents and other historical materials.

In Fukushima prefecture, the Fukushima Daiichi Nuclear Plant explosions meant the evacuation of all residents from the exclusion zone set up after the disaster, and as a result, the details of the damage to cultural properties within the exclusion zone are still not clear. This meant that the cultural properties rescue operation situation in Fukushima prefecture differed completely from those of other prefectures. In response to the rescue request sent to the Agency for Cultural Affairs in July 2011, the Committee evacuated materials from Sukagawa City's archaeological cultural properties storage facilities outside the exclusion zone. This facility was not damaged by the tsunami, but rather by floodwaters from the earthquake-damaged upstream water storage ponds. Given the fact that specialists from outside of Fukushima prefecture carry out the Committee's work, even though Sukagawa City is outside of the exclusion zone, there were fears about possible contamination from the Fukushima nuclear plant accident. Given the concerns about the radiation levels of the cultural properties and their surrounds, careful surveys were made prior to the operations to assure the safety of all involved personnel. [FIGURE 8]

Figure 8. The world's largest vacuum drying machine,
Research Institute for Cultural Properties, Nara.

The residents of the five towns within the exclusion zone have been completely evacuated and the residents and town officials hope that the cultural properties left behind in the municipal archives can be evacuated as soon as possible. Through ongoing consultation between the Fukushima prefectural government and the Salvage Committee office, rescue work has been carried out in the five towns in the exclusion zone since August 2012.

10 Issues

Thus, the situation in each of the affected prefectures differs and that means naturally that the actual rescue operations conducted in each also differ. And yet, the basic operations — namely the evacuation of affected cultural properties, their emergency handling, such as cleaning and reinforcement, and their placement in temporary storage — have produced considerable results over the course of a year. However, if we boast only of the numbers as results of the work, then it is clearly not a proper evaluation of this project in which we participated as 'cultural properties specialists'.

This work revealed a variety of issues. While I cannot go into all of those problems in this forum, in general, I can point out the following two issues:

1) The lack of a systematic rescue approach structure for use in the time of natural disasters

2) The lack of technical preparation for the rescue, handling, and storage of cultural properties subject to various disaster damage situations.

No matter how many participating organizations were gathered, the lack of a funding basis hampered the effective implementation of the Committee's work. In this regard, clearly the Agency for Cultural Affairs also worked hard on this problem. However, for those of us entrusted with frontline work, we had to carry out our work within the existing structural framework, experiencing frequent frustrations and a repeated trial-and-error process.

In general, the question kept coming up, since the Great Hanshin Earthquake, wasn't there supposed to have been some systematic preparation, some resolution of problems based on the experience of rescuing affected cultural properties in the recurring natural disasters that have struck Japan. And yet, the reality is that such preparation was not made after the 2005 events. When the predicted direct-hit, large-scale earthquake hits either Tokyo or the Tokai-Nankai coastline, naturally it can be imagined that the damage to society and cultural properties will differ from the types of damage experienced in the Tohoku area disaster. We cannot expect, like this time that people's sheer will and understanding will suffice. We must analyse our current experiences from various angles, and begin to go about actually resolving the various systematic problems that are revealed by such a consideration. And indeed, this will probably become an attempt at resolving the fundamental structural problems that exist within Japan's cultural properties protection administration.

On the other hand, on the technical front, there is an even more difficult problem for those of us who specialize in cultural properties preservation. Until the rescue operations can begin, what technologies should be used when there are different circumstances around the kind of damage experienced by the works, and the situation they are in? In particular, the work this time focused mainly on the area struck by the tsunami, so that in itself made the situation of the affected cultural properties unusual. Undoubtedly our techniques and experiences were inadequate for dealing with that situation. Soaked in seawater and then left in that condition for several months after the disaster meant that mould had started to grow, and other staining advanced. If an object was left where it was, the destruction of the form and state of the work would progress. At the same time, if it were moved, the new location would be polluted. Further, this disaster produced huge amounts of such materials.

For example, there was a sense of confusion regarding how to triage the paper materials soaked in the tsunami waters. Various methods were proposed, and the people involved worried how to select which method is best, what if the selected method were wrong? Of course, this time we learned that because circumstances differed, there really was no way to decide on which method was better than another. In spite of such issues, it is true that we need a response manual for use when disasters occur. For these kinds of issues, we must analyse our experiences during this current disaster from various angles and construct some countermeasures for future events.

11 In Conclusion

When the cultural properties rescue operations began in April 2011, the plan was for the operational period to last until March 2012, and as a result, the Salvage Committee was also established for that time period. However, the rescue work is by no means completed. The interior regions, which had watched the coastal areas given priority, continue to raise their voices, and asking for help in their regions too. Further, the system by which public funds are being used to pay for demolition work so that private housing can be rebuilt is beginning to be implemented, and that means that cultural properties in private homes are in further danger of being destroyed. Lastly, the cultural properties rescue work within the Fukushima exclusion zone has finally begun.

The majority of the cultural properties that have been evacuated have finished their immediate triage stage, and are being moved to temporary storage. However, it will take several more years before the damaged museum and archive facilities can be restored and we can get to the state where the materials can be both stored and displayed in these restored facilities. During that time, there are very few of the works that have been restored to a clean enough state to be safely deposited in other museums. Thus many of these works will face long periods of storage in less than ideal storage environments for cultural properties; namely those found in abandoned school classrooms and other such facilities.

Given these two factors, the cultural properties rescue operations have been extended until March 2013. During this time it is hoped that we can bring conditions to a better state.

At the same time, the Salvage Committee bears the responsibility of correctly compiling and analysing the experiences from this year's efforts, and on that basis proposing an appropriate form of rescue operations for cultural properties affected by disasters.

This is not only a case of learning from the March 2011 disaster. On the basis of the 1995 Great Hanshin

Earthquake, improvements were made in display and storage facilities in museums, other cultural facilities and seismic mitigation structures, and facilities became more common. As a result, damage from the March 2011 earthquake was quite minimal at a lot of museum facilities in the affected areas. This was even the case at the Ishinomaki Cultural Centre, Miyagi Prefecture, which was directly hit by the tsunami. Thanks to its sturdy construction and the effectiveness of the seismic isolation base holding the structure, the sculptures and other works in the second floor display galleries were largely undamaged. Thus in the face of disaster, the most important thing is technological improvement and planning for its dissemination.

At the same time, fundamental issues must be resolved in the organizational and systematic structures of such work. The following elements are essential as countermeasures for when a major natural disaster strikes, and when cultural properties are affected by that disaster:

1. Quick establishment of rescue countermeasures office
2. Establishment of countermeasures offices in the affected prefectures
3. Securing funding that does not depend solely on contributions, and outlay by the organizations participating in the rescue.

Then we might ask, what kind of system must we construct to make the realization of these three factors a natural progression? Our proposals must be linked to a reform of the national system.

On the other hand, regionally focused natural disasters occur regularly in Japan. It is not realistic to consider taking the major action of establishing a rescue committee or rescue countermeasures office for each of those situations. As mentioned at the beginning of my paper, this is why it is essential for a standing rescue team to be established. For example, establishing a centre specializing in cultural properties restoration in a national cultural properties facility, and making a system whereby the staff of that centre can immediately respond to cultural properties damage in a natural disaster.

That centre could have as its regular everyday duties:

1. Technical research on emergency evacuation and triage methods
2. Practice of technical procedures in conditions similar to an actual disaster area
3. Personnel development so that rescue can be conducted nationwide.

Japan's economic conditions are not as favourable as they once were. As a result, it is said that expenditures must be cut in order to recover from those economic conditions, and the national mood is such that it will not permit calling for the establishment of a new organization or the hiring of new staff. It is highly likely that this proposal will be met with a call for having the members of Tobunken or such facilities take on these added duties. However, that would just be a repetition of the situation we experienced in this disaster when we took on the rescue committee work.

Based on these conditions and our experience in this disaster, we must correctly analyse the situation and plan drastic measures for the improvement of the current situation. If we don't do it now, when will it get done? I would like to end my paper with a firm appeal for such action.

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A Research into Post-Earthquake Rescue, Maintenance, and Conservation Countermeasures of Taoping Qiang Village in Sichuan

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Abstract. Taoping Qiang village in Sichuan is an indigenous architectural heritage created based on the philosophy of harmony between mankind and nature, a practice of over 1,000 years in the region. After the 'Wenchuan Earthquake' on 12 May 2008, our institute undertook the rescue, maintenance, conservation, planning and restoration project of Taoping Qiang village. In practice, we hold to a rescue and restoration strategy based on the principles, which give priority to cultural values. According to these fundamental principles for maintenance of indigenous architectural heritage, we respect and maintain the traditional composition of villages, while using traditional structural styles, building materials, and building typologies of local Qiang Nationality dwelling houses as our technical principles. We applied a survey and design model. This involved individual surveys; organization of a design methodology; collection, analysis and investigation of traditional craftsmanship. At the earthquake-proof technical facilities of the Qiang Nationality, we built a five-level quality-control system including designers, craftsmen, supervisors, owners and residents, and implemented a self-recovery building model that provided employment as a form of relief for villagers of the Qiang Nationality.

1 Background

1.1 Introduction to Taoping Qiang Village

Located in a mountainous region, Qiang Village is the traditional village of the Qiang Nationality. The area developed over more than 2,000 years in deep mountain valleys on the southeast border of the Qinghai-Tibet Plateau in China. Taoping Qiang Village is located at a distance of 163 kilometres from Chengdu, and 41 kilometres from the county town of Lixian County, Taoping Town, in the Aba Tibetan and Qiang autonomous prefectures in Sichuan Province. The Qiang Nationality villages are located in high mountains and valleys, at an elevation of about 1,500 metres, facing water and hills in the upper reaches of the Minjiang River. The villages lie near Mount Dabao (4,521 m) and border on the Zagunao River, a tributary of the Minjiang. Zengtou Ditch, containing meltwaters from high mountains, lies in the western valley. It is located in a temperate climate zone with four distinct seasons. The average temperature during the year is 13 degrees Celsius, and the mean annual precipitation is 386.7 mm, mostly occurring from May to September.

According to historical records, Guangrou County was established as an ancient city in the sixth year of the Yuanding Era, during the reign of Emperor Wudi of the Western Han Dynasty (135 BCE). It was located 3 kilometres from the current Taoping Village. At that time, Taoping may have also existed, as a passageway to Guangrou County and a defensive fortified site of the suburbs. A county government was established in the ancient city during the Three Kingdom Periods, the Western and Eastern Jin Dynasties, and the Sui and Song Dynasties. During the Qing Dynasty, Taoping was under the jurisdiction of Guchengli Village, and the villages under the jurisdiction of Taoping were known as 'Housanku'. The current Taoping Town was established in the 19th year of the Republic of China (1930), named Taoziping; the site of the town government, was renamed Taoping.

These villages cover an area of about four hectares with an existing population of almost 100 families consisting of over 500 people. The villages are located in the strategic pass of official roads along the Zagunao River, where they are arranged compactly, forming architectural complexes with complete groundwater systems and distinct defensive characteristics. Each single dwelling is rectangular in plan, and mostly three to four storeys high. The outer walls are built of stone with an internal wooden framework. The exterior appearance of the dwellings are unpainted.

1.2 Earthquake damage

Taoping Qiang Village experienced severe damage during the Wenchuan Earthquake (May 12, 2008). Through primary field investigation, it was estimated that:

a. The old Taoping Village numbered 96 structures in total (including public buildings). As a result of the Wenchuan Earthquake, three structures were severely damaged, equivalent to 3.1% of the total; and 39 buildings were heavily damaged (40.6%); 37 structures were moderately damaged (38.5%); and 17 buildings suffered basically no damage (17.8%).

b. 53 structures have cultural value. Three of these were severely damaged (5.7% of the total); 19 structures were heavily damaged (35.8%); 21 buildings were moderately damaged (39.6%); and 10 structures suffered no damage (18.9%).

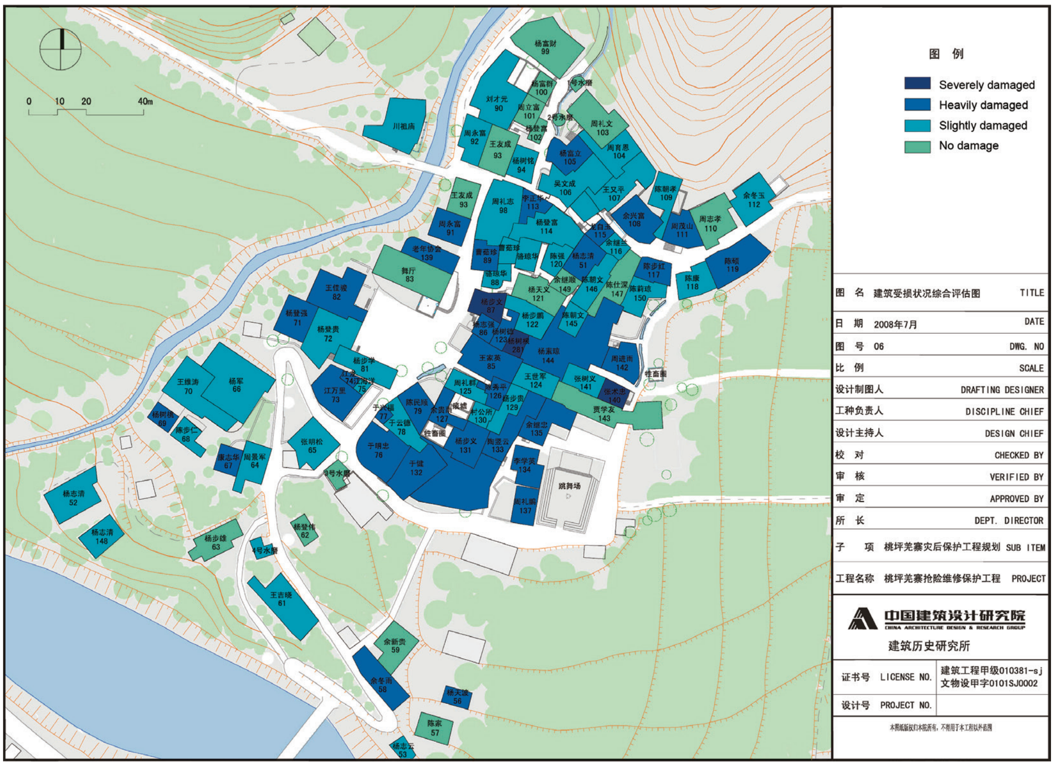

Figure 1. Damage assessment of buildings (Source: Institute of Architectural History)

2 Analysis of Characteristics of Properties and Protection of Cultural Value

2.1 Properties of Taoping Qiang Village

Taoping Qiang Village is one of the important examples of Tibetan and Qiang villages as well as of indigenous architectural heritage in China.

2.2 Characteristics of Taoping Qiang Village

Taoping is one of the main villages inhabited by the Qiang nationality. The vernacular buildings of Taoping Qiang Village give priority to a load-bearing system of stone walls; where there are large spatial spans, there are additional beam-to-central columns connections. All aspects of the buildings, such as architectural materials, technologies, and forms manifest themselves as building styles and building technologies indigenous to the Qiang Nationality, and characterised by the use local materials. The buildings also bear witness to the long history of the Qiang Nationality. The defensive system of the villages, as well as the distinct features of their surrounding landscape, are very unique for their elaborate and deep network developed as a result of the long history of fighting between Qiang people. The village and gabled water system are moulded into the landscape with strong regional characteristics and distinct aesthetic values.

2.3 Philosophy of the restoration project

The following philosophy was developed for the restoration project:

a. The rescue, restoration and conservation project takes heritage-value protection as the fundamental orientation.

b. The degree of rescue measures, maintenance and conservation project is differentiated based on the damage of heritage buildings.

c. The rescue, restoration and conservation project gives priority to local craftsmanship and traditional technologies, while modern technologies are taken as the auxiliary method.

2.4 Principles of the restoration project

a. The restoration should express the participation of multidisciplinary specialists through programmed organization and must fully respect cultural characteristics of local Qiang people.

b. Multidisciplinary technicians working in such fields as heritage planning, research of ancient buildings, conservation and restoration of ancient buildings, structural engineering, building rescue and reinforcement, construction, Qiang building craftsmanship, etc. should participate in the restoration project.

c. In view of the complexity of the project, the principle of phased construction is applied in the restoration of a building. The experience and data from expert assessment and evaluation obtained during the projects, throughout implementation, and based on ethnic beliefs, lifestyles and customs of local Qiang people are fully respected.

d. The restoration respects traditional characteristics of buildings and the community.

e. The restoration program applied the principle of preferential site conservation. A volume of *Analysis of Traditional Practice and Handicraft of Taoping Folk House of the Qiang Nationality* was compiled for Taoping Qiang village to deal with the particularities of the roofs of Qiang buildings. Building elements, such as walls, doors and windows, girders and steps, etc., as well as the aesthetic effects of traditional structural reinforcements, e.g. on the back wall of buildings ('fish back' technique), wooden ribs, and reinforced corners in wall construction were analysed and compared. As much as possible, these were conserved and stabilised, so as to be reused in the restoration, which guaranteed that styles and traditional features of Taoping Qiang village remained the same, reintegrating the buildings with the community.

f. The restoration projects did not apply to monolithic buildings, but rather integrated planning and assessment of Taoping Qiang Village as a living heritage site, thereby maintaining and preserving the significance of architectural complexes and settlements that are typical of the Qiang Nationality.

g. The restoration program applied individual surveys and combined these with a design guidelines. The individual survey results obtained were assessed as a whole, on the basis of full recognition by inhabitants, and the design guidelines for individual buildings were compiled according to preferential cultural value, traditional methods, and protection against and mitigation of earthquake-induced damage. During the program, design requirements for infrastructure improvement of Taoping Qiang Village were put forward as well, to further upgrade the quality of life of the inhabitants, thus guaranteeing not only post-disaster recovery, but also new vitality for Taoping Qiang Village.

h. The restoration fully preserves particular landscapes of Taoping Qiang Village and its environment.

i. For this project, restoration provided the opportunity to renovate the environment of old Taoping villages. In doing so, construction regulations for new Taoping villages were implemented with regard to building heights, mass and colour to avoid the negative effects of building new villages that may be incompatible with the existing cultural landscape. The earthquake risk in the surrounding mountains was fully assessed, and regulations were designed to accommodate these, while effectively maintaining a harmonious environmental relationship between old Taoping villages and Zagunao valley.

3 Survey and Design

Restoration was mainly carried out on 115 buildings in all of the old Taoping villages, once rescue and support work was completed.

3.1 According to the cultural value of each building, categories of structures were differentiated to clarify the degree of restoration intervention

Buildings in the whole village were prioritised into architectural heritage and non-architectural heritage according to their cultural values, including:

a. All architectural heritage with outstanding cultural value was regarded as the focal point of conservation projects without exception, and these took precedence over other projects in application of engineering materials, craftsmanship and allocation of skills, management and supervisory power.

b. All building components or elements with special value in indigenous traditional building skills should, without exception, be renovated according to the standards of 'Management Measures of Project on Protection of Heritage Sites' as issued by the Ministry of Culture in 2003.

c. For all non-heritage structures built in recent years that are not in accordance with cultural values nor well integrated into the environment of the villages, the corresponding measures were taken according to the requirements of management and planning, on the premise that the residents were properly notified and compensated for on the basis of consensus of interests.

d. Water systems and roads of old Taoping villages are an important component of the value of Taoping Qiang Village. During reconstruction, we emphasised protecting the historical water systems, as well as the early structures and dimensions of historical streets.

3.2 The method of the restoration was informed by an analysis of traditional practice and handicrafts

In accordance with the principle of giving preference to local traditions, renovation skills for conservation were classified into traditional methods and modern methods, and repairs were prioritised as follows:

a. The use of modern materials was not permitted, if traditional methods (including traditional materials, techniques, and forms) could be used to meet the restoration requirements.

b. For problems that could not be addressed using traditional methods, the use of modern methods was permitted only after adequate demonstration that they would be in compliance with the requirements of 'Principles for the Conservation of Heritage Sites in China' (Agnew and Demas 2002). In addition, modern methods had to be handled in accordance with 'Management Measures of Rescue, Maintenance, and Conservation Project of Heritage Sites after the May 12 Wenchuan Earthquake in Sichuan Province.'

c. According to analyses of traditional building techniques and building materials at Taoping Qiang Village, the main intervention methods for restoration were determined on the basis of the degree of damage from the earthquake.

Figure 2. Before (top) and after (bottom) the earthquake (Source: C. Tongbin; L. Jian)

Figure 3. After restoration (Source: W. Lijun)

3.3 Open design with local participation

Adequate cooperation and interaction between residents and local governmental branches was a prerequisite for success in the restoration of Taoping, as one of the indigenous architectural heritage sites. Effective conservation of heritage sites is successful only when heritage stakeholders fully reach a consensus.

For post-earthquake-damaged vernacular houses in Taoping, many of which are characterised by folk details, dispersed property rights, and varying degrees of damage, the design method of 'Construction Guidelines of Damage Survey and Restoration/Renovation of Buildings' was compiled creatively in combination with the characteristics of conservation project of heritage sites and the state post-earthquake reconstruction policy. Based on the individual surveys, the relevant rescue measures were formulated according to the conservation requirements of cultural heritage. We interacted reasonably with residents and local government, and lay a foundation for smooth implementation of the rescue work. In compiling the 'Construction Guidelines of Damage Survey and Restoration/Renovation of Buildings,' we fully interacted with residents while analysing the results of the surveys, which provided a sound foundation for the later compilation of the design guidelines. After the guidelines were finished, we consulted again with the residents to verify the restoration programme. The various branches of government participated as site managers in the overall process of construction, assisting in its coordination and promoting smooth implementation of the project.

4 Implementation Strategies

4.1 Government investment and administrative coordination

The project funds came from two sources:

a. The project involved the architectural heritage of Taoping Qiang Village; the rescue and restoration funds were dedicated funds for the protection of cultural relics.

b. About 45% of the houses in the area of old Taoping Village are not architectural heritage; therefore, restoration funds involved in their repair were from post-disaster reconstruction funds.

The government, as the provider of restoration funds and manager of heritage sites, was in charge of organising training for craftsmen of the traditional buildings in Qiang Village, before construction began, and of coordinating disputes in planning, design, construction, supervision, and amongst residents during the restoration.

4.2 Local participation in the overall process of construction

The project was carried out by a qualified company that managed and organised the local craftsmen. When traditional methods were applied during the restoration, the self-recovery housing model of Qiang villagers was discussed, which amounted to 'giving people work in place of relief subsidies.' By so doing, it also encouraged villagers to help themselves and preserve traditional building skills – an optimal method for effective conservation and maintaining the legacy of architectural heritage of the Qiang Nationality during the post-disaster reconstruction stage – as well as their traditional house-building skills.

Figure 4. During restoration (Source: W. Lijun)

4.3 Quality-control system composed of design company, construction company, supervisory company, local government and owners

An effective quality-control system is an important guarantee for a project to be smoothly completed. The design proposals took the conservation of heritage values as their starting point, and the degree of priority of each rescue project was decided on the basis of the amount of post-earthquake damage. We employed traditional skills and materials to protect the way of life of heritage sites of Taoping Qiang Village.

The rescue and construction companies followed gradual and orderly phased construction principles in organising the process, faithfully recording restoration processes and extracting restoration data. They assisted in the training of local specialised craftsmen, and lay the foundation for dissemination and implementation. The supervisory company controlled the degree and methods of intervention for the project during the construction process, while implementing the design proposal, and taking charge of supervisory responsibilities, such as inspections for landlords or acceptance of the quality of the restoration project. The purpose was to provide continuity for the architectural heritage under the principle of 'minimal intervention'.

The government controlled the proper use of funding – the government, in effect, became the 'landlord' of the project. This involved full coordination by the manager of heritage sites in the local Taoping Qiang Village, who coordinated and organised preliminary craftsmen training, assisted villagers in help themselves, and put forward effective policies by giving people work in place of relief subsidiaries.

Residents, as users of Taoping Qiang Village, became heavily involved with heritage conservation, keeping alive traditional building skills of the Qiang nationality, while simultaneously showing the methods of heritage conservation to the next generation of Qiang villagers. Therefore, five parties in the project - designers, contractors, supervisors, government, and house owners - jointly maintained the quality-control system for the overall conservation of heritage sites, thereby protecting Taoping Qiang Village and emphasising heritage conservation for vernacular buildings in the future.

5 Conclusion

The rules for maintenance of indigenous cultural heritage of cultural value demonstrated by this project are as follows. First, we must provide guidelines for renovation of heritage that are based on the principle of preferential value. Secondly, full use must be made of traditional skills and materials on the basis of giving preference to traditions so as to effectively maintain heritage, while paying attention to the legacy of traditional skills. Third, integrated conservation of all Taoping heritage sites, along with maintenance of their contextual traditional fabric, is more significant than restoration of individual buildings, which are the most outstanding in the Taoping Qiang Village. Fourth, effective maintenance and control of heritage sites and their environment is important for protection of integrated heritage values. Fifth, the interests of local residents should be emphasised. In accordance with the principles of cultural heritage protection and restoration, we should let local people join in the conservation process, thereby effectively improving their quality of life and living conditions, while providing an important opportunity to stimulate vernacular heritage. Sixth, a complete quality-control system is an important leverage to promote indigenous cultural heritage in the restoration process. Finally, during the operation, important models were extracted for recording heritage sites, building typologies and maintenance of landscape, training in traditional construction systems, appropriate use of substitution materials and components, all of which are key to any project's success.

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Comprehensive Assessment and Study on the Research Mode of Cultural Heritage Conservation in Post-Earthquake Restoration

Conservation work after the earthquake in Yushu

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Abstract. According to the statistics, a total of 84 cultural heritage sites were damaged to varying degrees as a result of the MS 7.1 earthquake that occurred on April 14, 2010 in Yushu. To coordinate the schedule of China's overall earthquake-relief programme, the strategies for post-earthquake restoration and reconstruction of different cultural heritage sites need to be determined within 20 days. For this process, work was based on consideration of the designated grade, the value and degree of threat to the cultural heritage site, as well as its relation to local religious beliefs and cultural activities. Moreover, the case study of Jiegu Temple is used as a prototype for its religious influence, public participation and other factors of post-earthquake reconstruction and protection.

China is an earthquake-prone country, and in particular, the south-western region linked to the Eurasian seismic zone, which is one of the three most active seismic zones in the world. The MS 7.1 earthquake in Yushu was the most powerful earthquake to occur in south-western China since the Wenchuan earthquake happened on May 12, 2008 (Chinese Earthquake Administration).

The Yushu earthquake was a strong but shallow earthquake with an epicentre depth of 14km. It impacted a total of six counties and 19 villages and towns, such as Yushu, Chenduo, Nangqian, Zaduo, Zhiduo, and Qumalai, all in the Yushu Tibetan Autonomous Prefecture of Qinghai Province (hereinafter referred to as Yushu Prefecture). In addition, eight villages and towns in Shiqu County in Ganzi Tibetan Autonomous Prefecture of Sichuan Province (hereinafter referred to as Ganzi Prefecture) were also affected, amongst which Yushu County was the worst hit area (Chinese Earthquake Administration). The earthquake happened in the early morning (7:49 AM, Beijing time), complicating disaster relief and risk aversion, and resulting in varying degrees of loss to cultural heritage sites.

In order to carry out the post-earthquake restoration of cultural heritage sites in a timely, orderly and efficient manner, comprehensive planning of reconstruction and protection on cultural heritages based on the sufficient data from field survey within the shortest timeframe (about 20 working days) was necessary. Furthermore, this work had to be coordinated with the national post-disaster reconstruction programme. The plan identifies what to protect, how to protect, how to allocate the resources for protection, etc.

Figure 1. Changu Temple after the earthquake

Figure 2. Xinzhai Gyana Marnyi stone mound after the earthquake

1 Comprehensive assessment and general policy decision on protected objects

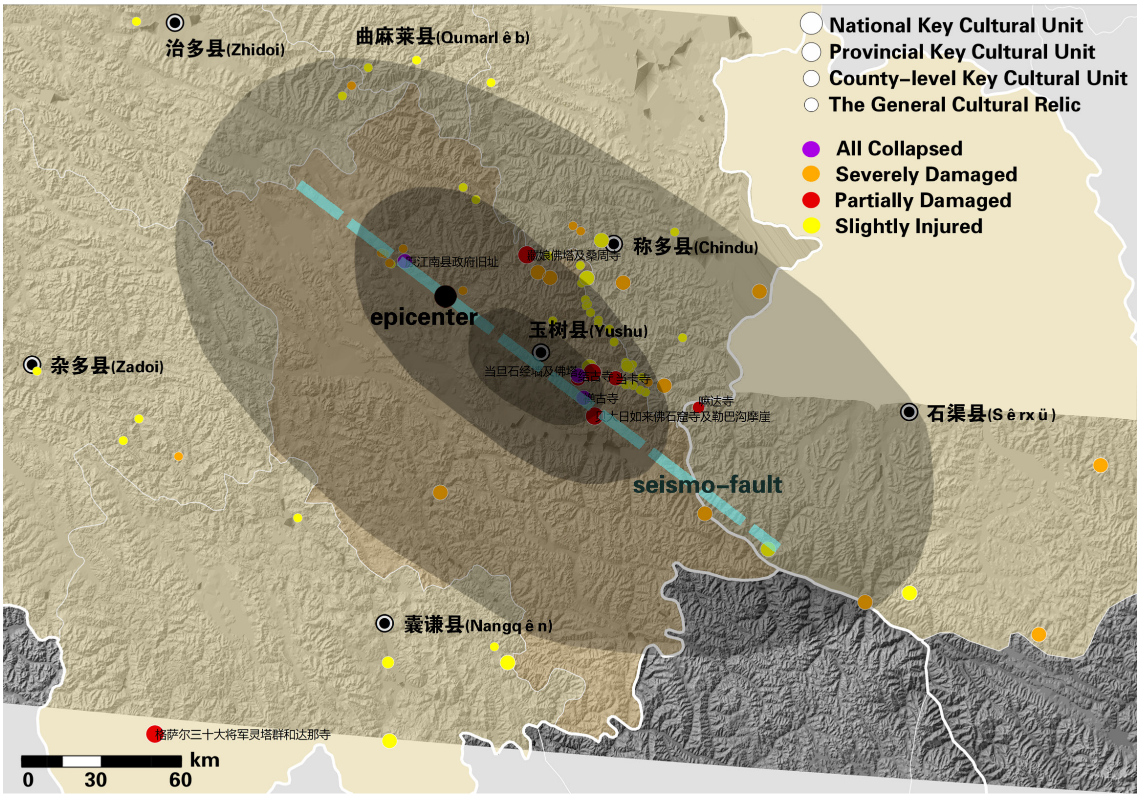

Figure 3. Devastated condition of the heritage

In the post-earthquake intervention to cultural heritage sites, how to identify the objects that need to be protected, how to classify these objects, and how to prepare appropriate protection standards was an important and complicated task, not only because of the widespread area and the number of cultural heritage sites that were affected by the earthquake, but also because Yushu is a less-developed region at a high altitude with a poor transportation system (the civil airport was only put into use shortly prior to the earthquake in 2010). Once a plan is established, it must remain flexible, because new information may surface that assigns previously unrecognized cultural values to a site.

A total of 84 cultural heritage sites were damaged in this earthquake, including categories such as ancient monuments, ancient ruins, ancient graves, grottoes, as well as stone carvings. In China, cultural heritage sites are divided into three levels of protection: from the high to low, these are national, provincial, and county levels of protection. There are also some cultural heritage sites already registered, but not classified into these three categories. It was possible to identify the damage level of the 84 cultural heritage sites through field investigation and data compilation. However, not all affected properties were able to obtain the sufficient financial and technical support initially because of the limited labour and financial resources.

Which types of cultural heritage sites should be protected and repaired first, in addition to the ones that had potential life-safety hazards? What should be the standard for the heritage assessment: the level of its value or the level of its class of protection? The recognition of heritage values and the understanding of the carriers of those values therefore determined the emphasis of our study. In other words, the effort and the prioritisation of restoration work are usually determined by the identification of the category of protection, and this seems to be the accepted practice. However, this changes in the face of a post-earthquake reconstruction; no longer a simple protection programme, the situation becomes far more complicated, because not only must an area be made physically safe, but also those populating the area need to return to a semblance of normal life. In Yushu, a region of both high altitude (the average altitude is over 4,200 m, and is over 5,000 m in the seismic zone) and relatively few resources, restoration of normal life following the earthquake was the primary mission.

In addition, compared with other regions, Yushu has its unique cultural and religious characteristics. Yushu Prefecture is the second Minority Autonomous Prefecture in China with the highest percentage of Minorities, among which 97% are Tibetan. Almost all local people believe in Tibetan Buddhism. Accordingly, in the process of restoration of the affected cultural heritage sites, we needed to identify whether these were interrelated with local religious activities and living heritage. In the process of planning, we found that 39 cultural heritage sites of the 84 are related to local religious activities. These religious activities include transmission of religious culture and religious knowledge, religious rites, festival celebrations, heritage of traditional handicraft skills, etc. Among these 39 heritage sites, 21 were not classified into the three categories of protection. Therefore, when we introduce the influence of local religious activities and living heritage into our assessment, we found that some unclassified cultural heritage sites should enjoy priority in the process of protection over those that were classified, since their usability determined when the local Tibetan could participate their daily religious activities.

As for the religious buildings that had completely collapsed, the restoration focused on clearance and protection of the ruins based on general practice in other Chinese regions. In Yushu, complexes of religious buildings such as Jiegu Temple and Changu Temple were identified as relics at the provincial level of protection; images and mapping data for these relics are incomplete because it was difficult to collect data at such high altitude. At any rate, the reconstruction of these relics would be in conflict with the requirements specified in 'Principles on the Conservation of Heritage Sites in China'[1] and might also be questioned for its authenticity[2] (Agnew and Demas 2002) Despite this, we chose to respect the beliefs of local Tibetan culture instead of complying with the relevant guidelines in the process of the work, particularly after further communication with the locals. Besides, the respect for what had become relics is also based on our understanding of the 'Hoi An Protocols'[3] and on insight gained from the local's attitude towards the importance of religious heritage sites to minority cultural heritages.

2 Controls implemented for the work in post-earthquake conservation based on a typical case study

Yushu is a region of cultural integration in history. Under the Sui and Tang Dynasties, during the Duomi Country period, the Tang-Bo Historical Corridor connecting ancient Changan and Lhasa was formed, passing through Riyue Mountain, Yushu and Changdu, as well as some other regions. From the Tang and Song Dynasties to Modern Times, Jiegu Town in Yushu region was developed into a critical node along the transport corridor for the tea and horse trade between Tibetan and Han nationals. Therefore, Tibetan Buddhism culture has had a deep influence on this region, as represented by Jiegu Town, and Yushu has been a unique autonomous prefecture where nearly the whole population has the same religious faith. There are a great number of temples in Yushu Region, and many of the cultural heritage sites damaged have a certain relationship with religious activities, more or less. Since only a short period of time was allowed for policy decisions, it is impossible to put forward a comprehensive and rigorous proposal for each cultural heritage property damaged. Therefore, we decided to take one of the most representative cultural heritage sites in this region as a typical case to study the relationship with its surrounding environment and with other cultural heritage sites, so as to

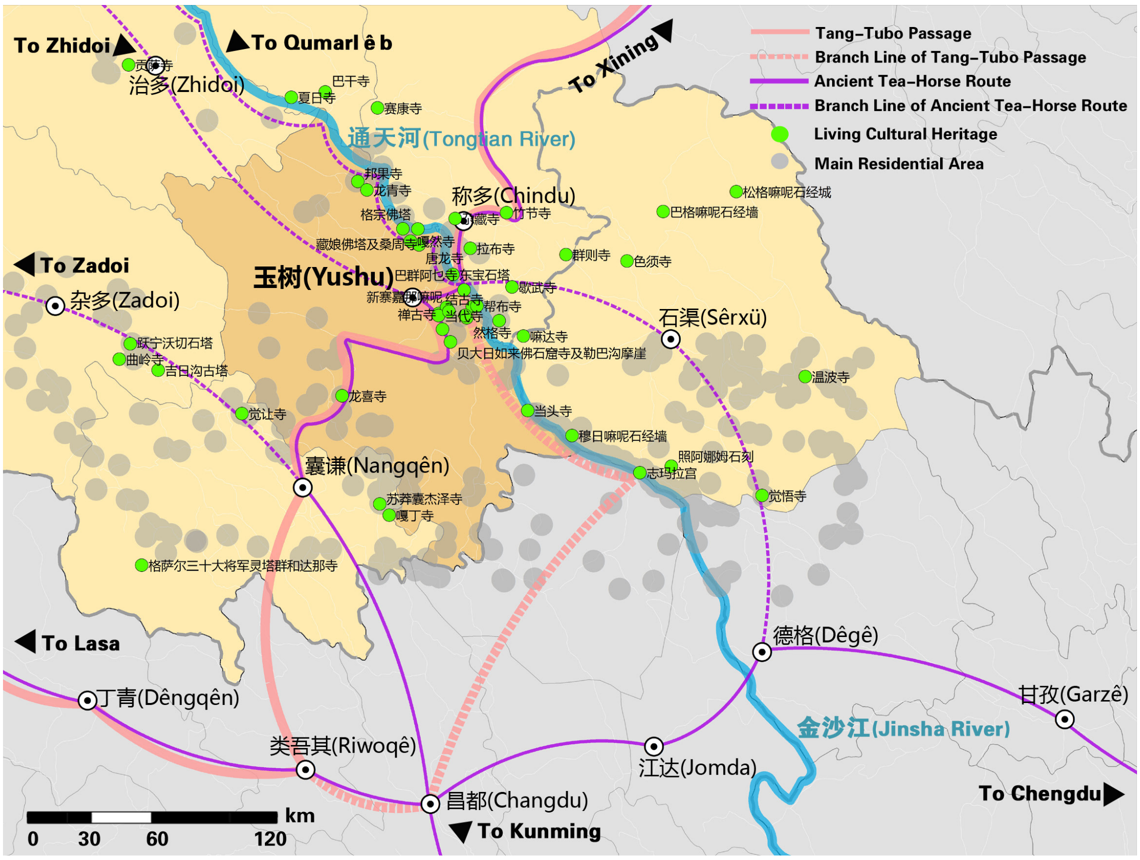

Figure 4. Stricken cultural heritage sites and cultural routes

establish a series of basic principles on post-earthquake restoration of cultural heritages sites and settings.

Jiegu Temple was selected because it is located in the seriously affected area of Jiegu Town, and it represented a religious relic that had totally collapsed, which had absolute priority in post-earthquake restoration.

Figure 5. Jiegu Temple after the earthquake

Study of the conservation of Jiegu Temple would not only ensure the advancement of recent restoration methods, but also provide guidelines for the conservation of other relics.

Jiegu Temple was built during the Ming Dynasty and is the main temple of Sakya Temple complex in northern Yushu. It is famous for its magnificent buildings, a lot of relics, and monks who are outstanding scholars. Jiegu Temple set up as many as 13 Mani Stones in neighbouring villages, especially in the vicinity of Jiegu Town. These Mani Stones and Buddhist halls were administrated by the monks assigned by Jiegu Temple, and were maintained by the respective villagers. They are important sites for small dharma assemblies, religious activities and daily communication among villagers. In addition, in the quiet valleys and cliffs near Jiegu Town, some retreats were set up for Contemplation, Reflection and Meditation. Besides the religious sites nearby, several sub-temples are distributed around Jiegu Town. Each temple or retreat was built at a location with a beautiful and peaceful natural view, reflecting the harmony between humankind and nature. Around these temples, Buddhist pagodas and holy mountains, many natural formations and circumambulations became the sites for religious rites, worship and other religious cultural activities.

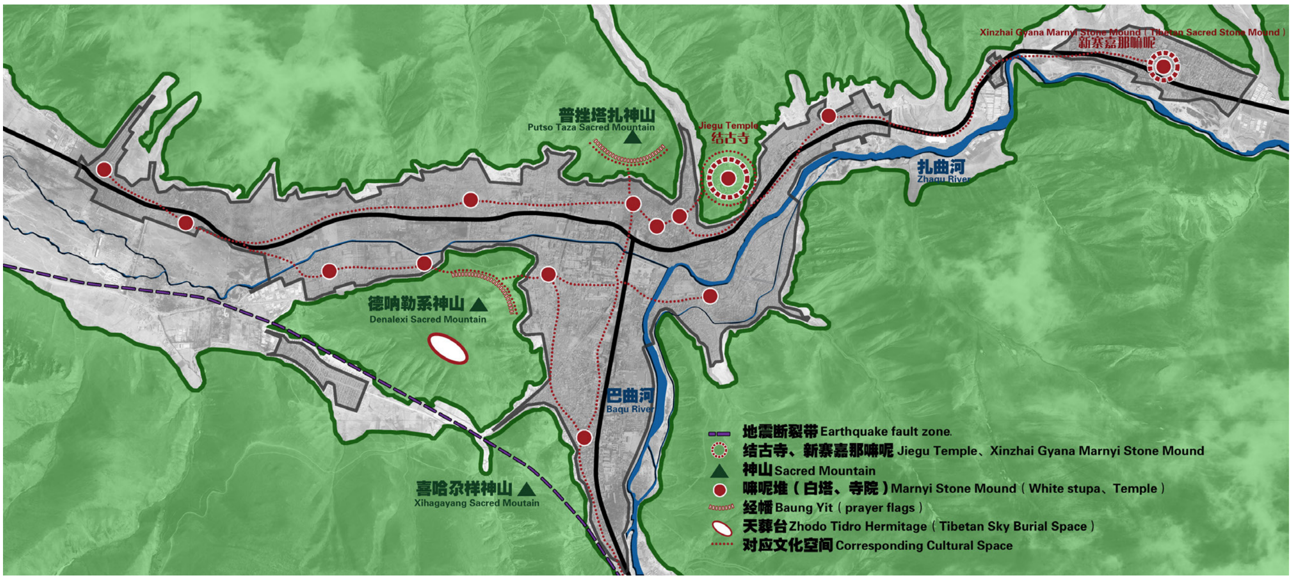

Figure 6. Jiegu Temple Complex and its components

Thus, for Jiegu Temple and other similar religious heritage properties, the most important sites that needed to be restored after the earthquake were temple complexes, relevant historical relics (such as Mani Stone carvings, Buddhist halls and pagodas, and prayer flags), and the related natural environment with its corresponding ‘cultural space’.

From this example, the attributes that required conservation at the Jiegu Temple were most of the constructed areas, and partially, some important natural environments of Jiegu Town. In combination with the planning principles we put forward earlier, the future conservation work will be mainly focused on the maintenance of the monastic buildings with potential life-safety hazards. The restoration of Mani Stones and prayer flags will be the next task, and the work on other relevant cultural relics will be carried out in the near future according to the progress of the post-earthquake conservation work. During this process, we insisted that the post-earthquake restoration not destroy the culture-related natural environments. The circumambulations connecting Jiegu Temple and its related cultural relics are an important clue for the following urban master plan.

3 Public participation, division of labour and cooperation of post-earthquake work

The particularities encountered in the Yushu Region are similar to the Asian problems described in the Hoi An Protocols. 'Staff attempts to preserve the heritage of the region with enthusiasm and good intentions but without adequate background and training' (UNESCO 2003). As for the regions where the religious beliefs of minorities prevail, the state and the heritage owner 'must ensure that it is interpreted in a way that provides minorities with a sense of their inclusion and the rest of the world with a full and correct understanding of its sources' (UNESCO 2003).

The stakeholders involved in the planning of post-earthquake cultural-relic conservation include managers, participants, and concerned organizations and individuals, who should participate in each phase of the conservation work, which becomes the basis for various types of intervention. The managers include the post-earthquake restoration leading team, cultural heritage administrative departments, as well as other administrative departments in charge. The participants include the users (monks and pilgrims), design firms or organizations, professional research institutions, etc. The concerned organizations include the funding sources or individuals, media, specialists and scholars, tourists, and relevant heritage conservation institutions, etc.

From the above-referenced groups, the monks and local community are the most important ones, as their inclusion is indispensable in terms of cultural-heritage conservation work, and they also represent the main group participating in intangible cultural-heritage activities. They are the heritage users and grassroots stewards, so it is necessary to actively guide them to participate in the planning, design, implementation and various other work processes required in a post-earthquake plan for rescue and restoration of cultural relics. The government and administrative departments in charge of cultural-relic rescue and restoration comprise the core of leadership of the entire work deployment responsible for decision-making and coordination. The technical research institutions, design firms and organizations provide the technical support for cultural-relic rescue and restoration of Jiegu Temple. Finally, the concerned organizations play a major role in monitoring and coordination.

Once the stakeholders involved in the restoration work were determined, we worked out the different implementation measures for each phase of every post-earthquake project, as well as the participation levels of various individuals. We especially emphasized the gradual participation and decision-making of the users in the project process. Thus, the heritage values and information recognized by them were integrated into the conservation work.

4 Conclusion

The Yushu earthquake occurred two years after the Wenchuan earthquake. The former was a strong and shallow earthquake that happened in the morning in the underdeveloped area of Yushu. As we observed on site, the cultural heritage in Yushu sustained critical damage. In the short period of 20 days, we found that the heritage-protection methodology developed from the Wenchuan earthquake could not be applied as a reference, because Yushu had its own particularities. The special geographical and climatic conditions in Yushu result in a shorter period suitable to engineering operations – only six months out of a year. Moreover, the high altitude accounts for a decrease in workers' efficiency.

Therefore, we had to carefully consider what to repair and how to repair it in a short timeframe. We made decisions quickly because of the religious nature of the culture heritage, so as to procure sources, materials and financial support, carry out the protection and restoration, in order to permit the Tibetan locals to begin their regular religious activities as soon as possible (although the believers' ritual activities never stopped, even over a heap of rubble). In this way, the confidence of the believers was rebuilt sooner rather than later.

Endnotes

[1]The 'Principles on the Conservation of Heritage Sites in China'are based on the Law of the People's Republic of China on the Protection of Cultural Relics, as well as interrelated laws and regulations. The 'Principles on the Conservation of Heritage Sites in China' have been specifically written with these laws and regulations as their basis, while drawing upon the 1964 'International Charter for the Conservation and Restoration of Monuments and Sites (the Venice Charter)'- the most representative document of international principles in this field. The 'Principles on the Conservation of Heritage Sites in China' are professional guidelines within the existing framework of laws and regulations relating to the conservation of heritage sites and provide guidance for conservation practice on those sites, as well as the main criteria

for evaluating the results of such work. These Principles also provide a professional explanation of the relevant articles of China's laws and regulations on protection of cultural heritage, as well as from a professional basis for dealing with matters related to heritage sites.

[2] In 'Principles on the Conservation of Heritage Sites in China,' ARTICLE 25: 'A building that no longer survives should not be reconstructed. Only in specially approved cases may a select few such former buildings be reconstructed in situ. This may occur only where there exists definite evidence that has been confirmed by experts. Reconstruction may only be undertaken after the approval process has been completed in compliance with the law and permission has been granted. Reconstructed buildings should be clearly marked as such.'

[3] The 'Hoi An Protocols for best conservation practice in Asia' are professional guidelines for assuring and preserving the authenticity of heritage sites in the context of the cultures of Asia within the framework of the 'Nara Document on Authenticity.

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Towards Reducing Risks to the Heritage of Ancient Theatres and Odea from Natural and Human-Caused Disasters

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Abstract. Ancient theatres and odea have not received the attention they deserve. However, many of their technical aspects have attracted interest in recent years. Their cultural significance can be defined in relation to their existence as ancient landmarks, as impressive architecture, their reuse in modern cultural performances and their acoustic qualities. However, since the cultural significance of many theatres and odea is not readily apparent, conservation, restoration and maintenance, interpretation and presentation, promotion and marketing, monitoring and re-assessment, and guidelines for the acoustic adaptation for modern performance can, and should enhance and preserve their integrity and their authentic scientific information. Therefore, besides historical, archaeological and architectural studies, special attention should be paid to the assessment of the monument relative to its present condition, and decisions about adaptive use. A complete physical evaluation of the present condition of the theatre is usually needed. However, higher priority should be put in the evaluation/mitigation of risks concerning the physical structure of theatres' sites and their 'modern use', based on a visual inspection and using the potential of digital technology. Generally, it is possible to classify the state of a theatre's decay, threats and risks under two main categories: 1- Natural Causes of Deterioration / Geo and Bio environmental Risks and Threats. 2- Anthropogenic Risks mainly due to improper modern uses. Elaborating on relevant recent studies, where the authors were involved in ERATO and ATHENA EU projects for ancient theatres and odea and general surveys, this paper discusses and assesses the main aspects related to definition, evaluation, assessment of accurate threats, and risks leading to a reliable framework in which mitigation and utilization hypothesis can be designed. Relevant case studies shall be also analysed in order to examine frameworks for risk assessment and related guidelines for the 'compatible use' of theatre sites.

1 Introduction

The heritage of Ancient theatres has become vulnerable because of rapid transformation processes resulting from many factors: urbanization and the increasing population density, development pressures, pollution, modern use, using insufficient maintenance of susceptible materials or inappropriate conservation, lack of awareness, and changing perceptions which tend to consider traditional knowledge systems as weak and outdated, and often neglected. On the other hand, many ancient theatres suffer from serious damage and deterioration due to natural and environmental factors: earthquakes, landslides, structural deterioration, fire, weathering, bio deterioration, flash floods and other such factors. Considerable decay is evident in many of limestone based theatres (limestone, and marble) as well as silica based types (sandstones) especially in aggressive urban polluted environments. Moreover, colour changes, patina, blackening of rock's surfaces in theatre and associated phenomena practically always have been related to other environmental factors of deterioration. All these factors put theatre cultural heritage at serious risk, especially in developing countries. Thus all places with theatre heritage value should be assessed as to their potential risk from any natural process or event.

However, where a significant risk is determined, appropriate action to minimize the risk should be undertaken, and a risk mitigation plan should be prepared (ICOMOS New Zealand 1993). The proposed 'ancient theatre' risk management approach, could inform and guide decision makers in other fields, and offers a sound methodology to incorporate the most recent knowledge into current practice. It allows an integrated vision of all expected damages and loss to the theatre cultural property, and of their mitigation; thus providing a useful tool for the design of more efficient conservation strategies. Finally, we need to define the effective methods, materials and preservation measurements for restoring and maintaining the theatres under study; which require a multi- disciplinary approach where cooperation of monument owners, archaeologists, scientists and restoration experts.

2 Approach and Methodology

Higher priority shall be put on the evaluation of risks concerning the physical structure of sites in relation to 'use'. A complete survey of the theatres should be carried out by using field observation, digital photography, a close visual inspection and other appropriate testing tools for: 1) Evaluation and investigation of theatre location, structure and materials, foundations, link to surrounding landscape in relation to the two main categories and factors of risk 'Natural and Anthropogenic'.

The evaluation and assessment of the physical and natural threats should cover risks in relation to Geo-environmental and Bio-environmental threats. 2) Evaluation and assessment of the risks within the urban fabric and landscape as a cultural cluster. 3) Assessment of implementing new ideas for the construction and installation of removable structures, with the aim of establishing general regulations on the use of each site with theatres and odea, while maintaining the acoustic qualities. 4) Establish a mechanism to produce a system of regular and permanent maintenance plans, calculated to ensure the preservation and conservation of theatres and odea.

2.1 Ancient Theatres Risk Mitigation Management

Addressing the reason(s) why a theatre building has reached such bad condition is an essential part of a repair scheme. Typically, proper maintenance of theatre buildings is the first important step in protecting them against the devastating effects of any natural or anthropogenic risks. For the risk mitigation management of ancient theatres it is anticipated that a database should be established for a core of cultural assets to include the following: a survey of all chosen theatres at risk gathering information about their condition and usage, catalogue their structural conditions and seismic vulnerability, and take practical measures to safeguard these assets.

The 'Theatre at Risk Survey' can form the basis of a proposed 'Theatre Buildings at Risk Register', with each entry being categorized according to the risk scale. This enables monitoring, recording, and prioritization on a case by case basis.

1. A classification in respect to their location, type, and construction is needed in order to estimate among other things, their vulnerability.
2. The conservation principles adopted should be appropriate to the original building technology, partly to preserve the integrity of the original design but also for practical reasons. A flexible approach and evaluation of the acoustic significance of the existing theatre fabric are required. However, the new target for those involved in digital acoustic technology should be to infuse ancient theatres and odea with their full role as places of cultural and artistic creation, shared enjoyment and emotion (Haddad 2007 and Haddad 2008). There are four recognized steps in using a risk management approach to preservation issues: identifying all risks to the ancient theatre, assessing the magnitude of each risk, identifying possible mitigation strategies, and evaluating the costs (where applicable) and benefits associated with each strategy.
3. Develop guidelines for planning of the mitigation measures and implementation of theatre mitigation technologies and products; for example the lighting systems, preparing evacuation plans and providing for community risk-volunteer training. Given the theatre site's vulnerability, regular monitoring plans of the physical fabric post conservation work or public events is essential. Such monitoring should be undertaken before, during and after performances.
4. Any rational policy and long-term plan of action for protecting theatre heritage requires co-ordination at the administrative level and relevant research and education, as well as public information and 'mobilization'. This is a rather difficult task; several legal, technical, social, organizational and financial aspects should be considered.
5. In terms of mitigating the damage to theatre heritage assets, there is a need to prepare an action plan that will mandate the development of a comprehensive inventory of cultural heritage assets, conduct/propose detailed studies to determine the different kinds of theatre vulnerability and recommend broad technical mitigation measures, and carry out the design/construction of a long term plan of the protection of these buildings now and in the future. For preventive conservation, theatre risk management can provide a framework for decision making.

3 Recommendations for Ancient Theatres Risk Planning, Response and Recovery

According to Herb Stovel (1998), the internationally accepted frameworks and procedures for Environmental Assessment can be applied in assessment and risk planning for any intervention. Eventually, the sharing of knowledge and promotion of the principles of risk theatre preparedness for cultural heritage is crucial in order to become more aware of the danger of the permanent loss of these resources to natural and anthropogenic deteriorations and risks. Ancient theatres risk mitigation planning should take into consideration the following:

1. Analysis of risks and assessment of theatre heritage should begin by building on national inventories which will serve as the key instrument necessary for effective planning. Such inventories should be up to date, easily accessible and spatially related by using geographic information systems (GIS) and digital documentation tools (3D laser scanning, Thermography, multispectral photography ...).
2. A strategy based on practical testing, continuous monitoring and preventive care should take place in order to develop a suitable methodology for each type of risk, i.e. small or large scale in-situ testing and medium (or even long) term monitoring and back feeding.
3. A successful working schedule should be considered and include scientific tools to prevent the harmful effects on theatre material, based on scientific diagnosis, and through the use of several methods and analytical techniques according to the deterioration nature and status.
4. In addition, theatre risk preparedness should not be conceived only in emergency situations but interwoven into the practical management of these theatre heritage resources. As defined by the Standards and Guidelines for the Conservation of Historic Places in Canada (2004), mitigation procedures should be put into place to ensure that modern performances have been adapted for the new use conditions even during seismic events.
5. Theatre buildings must be properly maintained to adequate conservation standards. Maintenance procedures should be taken into consideration for minimizing interventions in the future.
6. By maintaining theatre heritage sites; repairing, cleaning, or correcting defects, we are not only preventing deterioration of precious original materials, we are also ensuring that possible hazards are avoided.
7. A database should be created to provide the cataloguing of ancient and contemporary activities that contribute to the value and originality of every site.
8. Any management, intervention, or reconstruction plans should be mindful that local communities are dependent on tourism revenues, and that tourism facilities are planned with these communities in mind.
9. Establish margins of safety in relation to durability against all possible events, including natural disasters and adverse environmental conditions which may alter material and structural properties.
10. Considering the issues and challenges described above, there is an urgent need for awareness, education and training among local communities, visitors, audiences and key stakeholders to address the needs of theatre heritage threatened by the elements discussed and their associated risks.

4 Evaluation and Mitigation of Ancient Theatres' Risks: Towards defining and analysing these risk components

An attempt is made here to classify the type of ancient theatres' risks, disaster hazards and the likelihood of their occurrence, as a means of assessing the risk for theatre cluster. This includes disasters and major calamities due to natural phenomena whose origin and causes are beyond human control, such as environment, pollution, age and decay; in addition to disasters due to human activities.

However, emphasis is placed on synergy and interaction between the natural phenomena and the other causes of damage, particularly in theatre masonry structures.

4.1 Understanding How Ancient Theatres' Risks and Disasters Are Assessed

Actually, risks to ancient theatre heritage may stem from exposure to one or more hazards or factors. It is of importance to clarify that certain regions may be subject to greater danger due to earthquakes (which demonstrate the greatest power of massive destruction), while other dangers are more widespread (e.g. fires in urban nuclei, and historical centres with theatres). We therefore need to have a holistic understanding of risks to theatre heritage from various hazard sources and of vulnerability processes while incorporating specific actions and strategies for specific hazards. Though, theatre risk is assessed by a combination of condition and occupancy - an empty theatre building can be in relatively good condition but still be rated as vulnerable, simply due to the theatre building's lack of a viable use. In other words neglect is an important factor in this process. Conversely, a theatre that is in poor condition but has a viable use, may not necessarily be considered to be at risk, although will normally be monitored as a vulnerable building. We therefore need to link the physical and environmental vulnerability of theatre heritage to the vulnerability that comes from anthropogenic factors associated with social and economic development.

Risk preparedness for theatre heritage will therefore involve: 1) Geo and Bio-environmental management, including efforts to prevent the natural hazards, 2) Mitigating of risks to theatres which are caused by proposed physical interventions, and applying a minimum intervention approach, and 3) Community preparedness through awareness and training.

The degree of theatre risks can be classified as follows: 1) not at risk, and in excellent condition. 2) Not at risk, 3) in fair condition, 4) vulnerable to further decay and may become at risk if problems are not dealt with soon, 5) at risk of further decay, 6) severe risk of further decay, or 7) extreme risk of further decay or total loss.

5 Main Categories of Risk Mitigation of Ancient Theatres and Odea

As mentioned, there is no single reason why a theatre building becomes 'at risk', as each case has different circumstances which have led to the theatre building decay. There are complicated processes of destruction and distress that vary in theatre building materials' decay; eventually due to physical, environmental, anthropogenic, including political factors and forces, which lead to typical structural changes and different types of deterioration aspects.

There are three main causes to theatre material decay and deterioration patterns (cavea seats, orchestra, stage and walls): organic; mechanical; or chemical.

1. Causes that are classified as organic result from the direct impact of a living organism on the physical material of the theatre structure.
2. Deterioration from mechanical causes can often be recognized by breakage or crumbling of the theatre's materials. The source of the problem is either an object striking the building or of water forcing building materials apart through expansion - an especially harmful process during the winter freeze/thaw cycle. This is limited to the presence of other effects (wind, earthquakes, landslides, etc.).
3. Chemical deterioration results from localized contamination of the air or moisture, or from material incompatibility.

On the basis of relevant studies and general surveys, it is possible to consider the state of a theatre's risk, decay and deterioration under two main categories: natural (Geo-environmental and Bio-environmental); and anthropogenic.

6 Natural Causes of Deterioration and Threats, Geo and Bio-environmental Risks:

Damage and deterioration in this category is due to external factors and can result mainly from climatic and environmental factors. Generally, many of the theatre ruins and structures suffer from the effects of natural threats of earthquakes, rain water and inactive drainage system (flash floods), landslides, wind, sun, physical deformation such as microbiological patinas, superficial and calcareous sedimentation, scaling, efflorescence and cracking. Natural disasters cannot be prevented, but much of the damage to the theatre heritage can be prevented by proper construction design, technical, educational and planning measures. More analytically the Natural risks can be summarised as follows:

6.1 Earthquake Damages

Focusing on the protection of theatres from seismic hazards is essential. This could be done by consulting on risk assessment, risk mitigation, implementation of effective measures and decision making processes for the protection of theatre buildings, especially the stage and the portico columns which are able to withstand seismic activity due to the partially elastic and flexible movement of the drums with respect to each other. Pre-earthquake strategy may concern a four-fold action:

1. Completion of theoretical understanding of masonry, development of rational models, education and training of engineers and technicians
2. Development of specifications and guide-rules for assessment and upgrading, including quality assurance and effectiveness
3. Reconsideration of the whole framework of administrative and legislative measures
4. Evaluation of risks to theatre heritage, which entails estimating the hazard and assessing how vulnerable each particular theatre may be to that hazard

The criteria for earthquake hazard mitigation in relation to modern performances should be an essential undertaking. Geological data is needed. Investigation of mitigation methods for ancient theatres and identification of seismic risks is crucial; examples of mitigation approaches used in several countries with earthquakes need to be investigated (Guidoboni et al. 1994).

We need to gather information of past seismic activity and the geological condition of the theatres. A database of cultural assets including cataloguing of their location, structural conditions, construction technology, and landscape in relation to seismic vulnerability is to be evaluated and analysed. The following types of information could be taken into account:

1. Seismic history (frequency of tremors and their effects on theatre structures)
2. The geography of the city and geological and tectonic features, soil characteristics and its geotechnical behaviour, seismogenic sources
3. Assessment of the vulnerability of theatre building/cluster and the way this varies spatially and over time, impact of earthquakes on individual and cluster of theatres
4. The mapping of seismic risks in the different urban areas with theatres

Risks and problems arising from its topography/slope and landscape, (i.e. renewed settlement of the theatre foundations). Actually, the theatre can be identified in relation to topography, by three treatments for their structures, these are: on a hillside slope; on a purely flat site; and a combination of the two treatments (the lower cavea on a partially sloped hill site and the upper on a flat site) (Haddad 2004). For many ancient theatres, most of the settlement activities have ceased long ago. However, some changes to a theatre building's surroundings can bring about more differential movement. Changes are often gradual and not noticeable over a short period of time. Some of the common signs of settlement and shifting foundations are misalignments and gaps around doors and openings at the cavea sloping and the stage, cracks in the orchestra floor, cracks in the stone and cracks in the foundations.

However, there are several actions and events, natural or manmade that may lead to a renewed settling of the foundations. These include: 1) tree roots in clay soils, 2) change in the level and quantity of ground and surface water around the foundations, 3) humidification that may result in an increase or decrease of the normal moisture content in foundation or structural materials leading to shifting in the theatre foundation, 4) excessive traffic and human motion in the immediate vicinity, 5) new construction or excavation close to the theatre building, and 6) significant increase in the load due to the overloaded capacity and the introduction of new installation systems for modern use.

6.2 Flash floods and improper drainage systems

Sites within theatres are sometimes situated outside areas prone to floods (such considerations had a bearing on the choice of a site). The dangers of floods are therefore of minor importance if there are proper drainage systems. Floods should be mapped systematically in the theatre areas. The torrent and avalanche in danger zones have to be recorded in order to establish flood prevention measures.

6.3 Bio-deterioration Risks and Damages

Damages due to intense vegetation [FIGURE 1], overhanging branches or climbing plants, overgrowth of surrounding vegetation, biotic coverage (plants growing inside the stone) micro-organisms, animals, goats and bird droppings. Bio-deterioration of ancient theatre material is a complicated problem that needs an interdisciplinary approach by experienced conservators and specialized biologists. Micro-organisms, plants and animals cause serious decay to the theatre building stones. Decay due to animals is principally from goats and bird droppings and their acidic metabolic products can severely damage stone. Recent research results indicate that Epilithic micro-organisms presence is correlated with orientation and humidity: most lichen and bryophyte mats can be observed on the northern surfaces of the monuments or on ancient inorganic mortars. Mats become more intense where water retention is higher due to the inclination of a surface or because of the limited exposure to the sun (Papida et al. 2010).

Trees and gigantic bushes, grown on theatre ruins particularly in the walls can cause severe damage to the theatre's stone structures and construction materials. For example the ancient theatre of Thasos, North of Greece, has suffered serious damages due to the intense vegetation in the region; 72 trees have grown in the cavea and have transferred diseases and fungus to the material of the theatre. The roots of these trees have also broken many seats. The seasonal manual elimination of plants needs to become a regular part of the annual schedule for the management of a theatre site. A key issue is whether biocide application should be performed before or after consolidation, cleaning, joining of fragments, filling of discontinuities and sealing. Microbiologists suggested that biocide application should follow conservation procedures, and that biocides should not be removed after application. In contrast, the manufacturers' guidelines regarding both issues are variable. An additional concern is that biocides may gradually be converted to nutrients and enhance recolonization (Warscheid and Braams, 2000, Papida et al 2010). However, cleaning before biocide application resulted in effective removal of epilithic mats. On the other hand, biocide application on unconsolidated surfaces inevitably causes greater material loss. Raw microbiological data up to now suggests that the action of biocides, applied after the treatments, was limited since the recolonization time was shorter (Papida et al. 2010).

Assessments need to be performed on the direct and indirect impact and damages due to intense vegetation and biotic coverage on the theatre to control bio-deterioration caused by micro-organisms and plants using biocides. The control strategy should involve careful in vitro and in situ examination of the stone substrates, (micro) flora, fauna and biocides. This should include the identification of plants and microorganisms that adversely affect the monuments. Constraints that inevitably affect choices and treatment potential has also to be identified, and include the varying condition of the stone; co-existing and synergistic deterioration mechanisms, and the scale of the monuments and their exposure to the natural environment (Warscheid et al. 2000). A strategy based on practical testing, ceaseless monitoring and preventive care should take place in order to develop a suitable methodology for each type of substrate, and each bio-deterioration pattern.

New approaches should increasingly be part of a protective strategy against both biological growth and loss of material. This strategy for bio-deterioration of theatres should be designed to consider the scale of the theatre, as well as the complications encountered in situ because of numerous environmental and logistical parameters. This bio-deterioration control strategy should illustrate a mechanism for controlling bio-deterioration from plants and microbes: 1) to describe the most characteristic bio-deterioration patterns in stone theatre in order to investigate their control parameters, and 2) to identify the main plants and microbes with bio-deterioration potential in order to select an efficient method for controlling the damage of the stone surfaces of the agreed case studies.

Figure 1. Example of vegetation in cavea of the Southern theatre in Jordan

6.4 Climate weathering and erosion risks (temperature and relative humidity)

There is a relation between the pollutant levels and meteorological parameters, especially wind speed and relative humidity (RH), that are usually elevated in winter as well as the level of exposure to weather and air temperature. Such parameters remarkably accelerate the degradation processes: erosion, pulverizations and disintegration, scaling, gaps, exfoliation, separation, biological patina, and efflorescence. Some of the weathering aspects dominating the urban environment are exfoliation and scaling that are mostly due to the action of freeze-thaw with the presence of acidic pollutants. Weathering morphologies could be mapped by visual inspection. This is an important step, since these morphologies are considered an effect of rock alteration and weathering processes. Visual inspection should be carried out in relationship with rock foliation and the different orientations.

Regarding temperature and relative humidity, we need to monitor the temperature air and building material temperature (Date, time, location in also relation to orientation). A data of average temperature for each month of the year will help to determine when the highest and the lowest average of temperatures occur. Data of average temperature, maximum temperature (°C), average minimum temperature (°C), and average thermal amplitude (°C) are important. Decay due to freezing is a serious consequence of the wetting of masonry. Experiments have shown that damage to masonry materials by freezing depends in large measure on their moisture content when the materials are frozen (Ritchie 1976). The deterioration of masonry materials because of frost action is more rapid and intensive, therefore, in those wall areas where excessive wetting of masonry occurs (for example at the top of a wall). High Frequency and low magnitude agents (particle disaggregation, human induced moisture) are another factor to be monitored.

6.5 Rain: wetting damage effect (direct impact and indirect impact (moisture)

Differences in wetting are attributable to the wind-flow patterns over the wall surface, which direct the paths of the falling raindrops (Ritchie 1976). The water flow patterns may also produce stains and streaks by eroding the masonry material, the resulting differences in texture and colour giving an appearance of vertical streaks on the wall surface (Lewin 1982). The main problem and risk at the theatre building is to keep water/snow out of the building, which is the single most damaging element to stone. Precipitation results in effective removal of chasmoendolithotrophs on bio-deteriorated stone surfaces. However, in an urban setting with ancient theatres, there exist some deterioration features such as dissolution and erosion of stone surfaces because of some chemical effects resulting from acidity spots composed as direct results of interaction with 'acid rain' (Wei and Wang 2005). This mainly appears in the urban and industrial areas as it is very clear in the upper parts of the Roman Theatre of Amman. This phenomenon leads to the increase of the theatre stone's porosity, and thus water will penetrate more deeply and react with internal cement materials and Calcite grains. It also, increases the ratio of damage and decreases the cohesive index of structure, and eventually the failure of the structure after the production of so called sugaring (Rands et al. 1986). Meanwhile, due to direct synergetic effects between rain water and soiling by particles, some layers of un-noble patina and coloured surface crusts are often observed. Due to dissolution processes from acid rain, severe etching and loss of calcite grains on theatre stone surface occurs.

In winter, the air within the theatre building has a higher moisture content than the outside air and the resulting difference in water vapour pressure causes a diffusion of vapour outward through the theatre enclosure. At some point in the course of its passage through a material, the dew point temperature may be reached and condensation takes place, thus increasing the moisture content of the material. For example, we can see algae growth from moisture in the stone very clearly in the Roman theatre of Amman. Though, it is important to ask: are there any signs of excessive moisture, musty smells and corrosion? Is there any condensation forming? Are there water stains or rotted stone near the orchestra and the stage floor?

6.6 Salt Damage in relation to wetting and drying cycles accelerated deterioration

Efflorescence frequently reflects the direction of rain-wetting of walls. Efflorescence also reflects differences in the amount of wetting received by a wall; it often appears at the top of the wall but not at the bottom (Ritchie 1976).There are several aspects of salt efflorescence and sub-efflorescence covering both theatre stone surfaces and mortar layers due to the crystallization and re-crystallization cycles of salts coming from acid rain especially after drying cycles, either by air temperature or by air current. Disappearance of some parts of stone surfaces can also occur as a direct result of salt crystal growth due to alternating processes between wet and dry cycles daily, seasonally or annually. Efflorescence or Sub-efflorescence aspects affect our theatre's materials and permits the migration of different materials from inside to outside such as calcium carbonate salt. This phenomenon depends essentially on the amount of salt present, its nature and number of dry-wet cycles (Binda and Baronio 1985).

In the case of bricks they are susceptible to acid rain through the selective dissolution of their glassy skin. Repeated dissolution and recrystallization of these salts leads to the mechanical disruption of the masonry structure (Charola and Lazzarini 1986). Dry, powdery, white substance that appears at various locations on the brick exterior appears both on the brick, and sometimes in the mortar is probably efflorescence, and is evidence that moisture is transpiring through the wall.

As an example, in the ancient theatre of Taormina in Sicily (Brai et al. 2010), results on the degradation phenomena of the structural materials (stone, brick and mortar) showed that deterioration is due to the aggressive action of environment agents. Soluble salts, such as chlorides, sulphates and nitrates, were found in efflorescence samples. Mortars were affected by a decomposition process induced by sulphate attack. In the theatre of Taormina artificial stone materials in different conservation conditions were investigated. Samples of salt efflorescence from brick walls and degraded setting mortars were taken from the open gallery in 'summa cavea'. The chemical, physical and structural characterization was performed by means of X-Ray Photoelectron Spectroscopy (XPS), X-Ray Diffraction (XRD) and X-Ray Fluorescence (XRF), both in situ and ex situ (Brai et al. 2010).

6.7 Orientation/sunlight and wind erosion (insolation) sun rays: negative impact, positive impact (reduce the rate of moisture, shadow in some locations)

Before evaluating a theatre's orientation in relation to risk mitigation, it is of importance to understand how different orientations affect the amount and intensity of the sunlight, and daily sun heating received at different times of day and at different times of the year. However, varying degrees of orientation may lead to different periods of theatrical events, since the theatres had seats made of stone or marble; the trapped heat would transfer to the stone, making it bearable to sit for an entire performance, meanwhile the audience could avoid direct sun-light.

In general we can assume that structures that are exposed to wind provoke disintegration and pulverization of materials, while those exposed to less sun, suffer with the growth of moss and layers of lichens of whitish colour; responsible of the chromatic alteration, and de-cohesion for chemical dissolution of the superficial layers.

Practically all of the rain striking the surface of a highly porous material is absorbed, whereas much of the rain runs off the surface of less porous materials without being absorbed. An index of the wind-driven rain for a particular location, which takes in to account the amount of rain and the wind speed (summer wind, winter wind), may be calculated by taking the product of the annual rainfall and the mean wind speed.

6.8 Fire Damages

Fire can be considered a natural catastrophe and a man-made disaster as well. The sources of fire can be due to human error, naked flames such as candles, lighting and dangers resulting from old fireplaces near ancient theatres.

Many historic theatres were destroyed by fire. Each theatre has its own degree of risk of a fire, and of resultant damage. The concept of fire precautions may be broken down into two distinct subsections: fire prevention (measures to prevent fires from starting or indeed from being started); and firefighting (measures to control the spread of a fire and to extinguish it). Many fires could be prevented by technical or educational measures. A wide range of different fire detection senors are available and can be blended in with lighting systems in a variety of ways, thus ensuring a solution which is entirely satisfactory from the aesthetic point of view. On events and visiting days the number of visitors can be very large. This gives rise to the following protection objectives: 1) It must be possible to evacuate all visitors in time and in complete safety, 2) Damage to theatre from fire and smoke must be avoided or at least limited to one area. For example, vacuum cleaning reduces the risk of dust being ignited by lightning. 3) It is necessary to consider the fire safety of the theatre as a cluster. Such a strategy needs to meet the following criteria: to ensure that the fire is discovered in time, and to enable the fire to be tackled quickly and in a well-organized manner.

Fire policing provisions generally require a fire protection strategy to be studied and adopted on a case by case basis in such a way as to meet the protection objectives agreed in advance between owners, managers, the authorities, the insurers and fire protection experts. In order to prevent grass fires from spreading to theatre building, all vegetation should be removed at least 1 meter away from the structure to create a zone buffer around the building. Emphasis should be placed on the aesthetic appearance of this zone in order to retain the relationship between the theatre building and its surroundings. To reduce the risk of fire, all stores should be cleared, taking care of course not to discard any valuable material which might be there.

6.9 Risks Arising of Structural Problems and Ageing of Materials

The majority of theatres buildings are constructed mainly of limestone. In some cases they are built of marble, brick masonry and/or sand stone. Typically, masonry structures have problems and damage associated with one or more of the following: foundation displacement (also known as settling over time); water penetrating into structural walls; shoddy construction; poor materials; stresses on the masonry walls due to fluctuations in temperature; and aging of mortar in masonry joints. The combination of many structural peculiarities such as age/decay creates a challenging scientific and technological problem, as well as the acute social-economic consequences. In this respect, engineering procedures for the assessment and upgrading of theatre buildings are not yet well developed and have not yet reached an adequate degree of refinement. There are various reasons for this, not to mention the need for unconventional analytical models, and for a more general and complex reliable philosophy. In view of this, it is not surprising that previous solutions offered to specific problems may hardly be considered as satisfactory; such an unsatisfactory situation is however successfully faced in some cases by experts and specialists by means of rough but reliable rules based on the available experience, and by repetition. Therefore, certain measures should be taken at international levels, aiming at the: 1) completion of theoretical and experimental knowledge (models on analysis and resistance of masonry), 2) development of methods on in-situ testing and monitoring, 3) development of methods on overall testing for global verification and validation.

These methods, besides their obvious usefulness for assessment procedures, should be applied as feed-back in order to correct analytical models, and as a means to face unpredictable consequences of accidents (earthquakes, floods, fires, abnormal environmental influences, etc.). Thus, rational estimations and predictions can be made regarding the safety and performance of the monuments, and a logical framework for decision-making can be secured with possible operations in mind. Special attention should pay to two aspects: 1) assessment of the monument in its present condition, and decision making regarding alternative types of operation, 2) assessment of the broader sense; besides the historical, archaeological and architectural evaluation of the theatre, a complete structural evaluation of the present condition of the theatre, is needed, such as interaction between soil structure and building, characteristics and structural typology of the buildings, topography of buildings, interpreting the cracks in the theatre building within particular blocks; an examination of cracks helps us to understand what has happened. We also have to know whether the cracks are dangerous or not.

However, monitoring the movement of the theatre structure normally takes an extended period of time. Foundations should be inspected, with additional checks following any severe rainstorm, nearby construction, excavation or maximum capacity for modern use. In addition it is necessary to gather information and to look for: What is the condition of the orchestra floor? Is rainwater lodging in the orchestra and around the base of the theatre building? Are the rainwater gullies draining properly? What is the condition of the pointing? Has earth banked up against the base of theatre walls? Are any serious cracks visible in the stage structure? Are columns, posts vertical and stable? Are beams, columns, posts and joints sound. Is there any sign of decay of theatre stonework? Is there any plant growth on or against the theatre walls? Do the walls need to be cleaned?

7 Anthropogenic Risks: Causes of Deterioration and Threats to Ancient Theatres and Odea

Anthropogenic causes of deterioration and threats to ancient theatres and odea have many risks that can result in the loss of authentic technical, scientific information and their acoustic characteristics. In addition to these, it is also essential to note damage caused by humans (human foot-tread).

Generally the human (anthropogenic) risks are due to:

1. Growth of uncontrolled tourism and the lack of management plans with proposed visitors capacity and

compatible criterion for reuse. Visitors may stray into uncontrolled areas. Visitors often wear inappropriate dress and shoes.

2. Economic constraints and lack of funding that can be seen in the maintenance and public services at the sites of ancient theatres and odea
3. Lack of cultural heritage education and limited public awareness about the values of ancient theatres and odea
4. Limited archaeological and historical research of ancient theatres and odea leading to inappropriate development; the thematic patterns that could emerge from the research may be useful for the planners and interpreters
5. Absence of a holistic and integrated conservation plan, lack of maintenance, poor application of conservation principles, and lack of skilled people can cause further decay to the infrastructure of the historic theatres and odea
6. There is a gradual disappearance of traditional stone crafts and skills.
7. Limited scientific approach and methodology in the diagnosis and conservation of stone. Limited detailed documentation of theatres and odea, in addition to a lack of documentation of environmental conditions (i.e. temperature variations, air pollutant levels, salinity of soil, wind, etc.)
8. Poor legislation and related management programs to protect the historic ancient theatres and odea, including special technical regulations
9. Conflict and war areas; as an example, the United States military turned the site of ancient Babylon into Camp Alpha in 2003 and 2004, inflicting serious damage according to an exhaustive damage assessment recently released by UNESCO. Bulldozers levelled many of Babylon's artefact-laden hills. Helicopters caused structural damage to an ancient theatre. More analytically the anthropogenic risks can be extended and summarised as follows.

7.1 Air pollution

From an environmental point of view, we can classify the different sources of air pollution dominated in affected theatres in an urban setting into two main sources; stationary (industrial activities like petroleum refineries, calorific stations, factories, waste water stations, and quarries) and mobile (vehicular traffic (cars, buses, etc.) and planes in different stations and civil or military airports), inside and around the theatre area (Rosval 1988). Pollution and pollutants from traffic, like tourist buses especially where the theatres and odea exist in a congested urban context. In particular due to many sources of air pollution many theatres suffered and still suffering from many deterioration, and risk theatre aspects resulting from several deterioration factors and mechanisms either physical or chemical. Urban development in the buffer zone of the theatres causes visual as well as air pollution.

Evaluation of the direct and indirect impacts for of the different components and chemical characteristics of ambient air in a theatre area, according to National and International Standards need to be registered. Evaluation and investigation of the different deterioration factors affecting the theatre building either chemically, physically or biologically and resulting from the different effects of air pollution should use scientific techniques such as XRD, Stereo microscope, ICP-OES techniques and others, (Elgohary 2008); especially with the presence of other synergic deterioration factors such as air temperature, relative humidity and wind erosion. The following issues need to be determined:

1. Sources of air pollution in the theatre study area. One can say that the different values of air pollution in the urban development of the buffer zone of the theatres were increased as a direct result of great development, and the wide usage of energy which lead to presences of negative effects on air quality
2. Relation between air quality and rain water in the theatre study area. Through scientific studies we have to define the relation between air pollutants and the chemical nature of precipitation
3. In order to distinguish the different environmental parameters and quantitative description of stone's deterioration, samples should be taken and investigated to get a proper understanding of the harmful effect of air pollution.

7.2 Deterioration due to previous restorations

Many interventions, like the reconfiguration of seating, have not always been respectful of technical correctness. In the theatre of Taormina, as an example, the stairs have been reconstructed in concrete that do not fit well with the rest of the koílon (Ruggirello 2007). There were many restorations that promoted reconstruction of theatres but their general valuation is rather critical: they can be catalogued as stylistic restoration and reconfiguration, which are different from intervention of 'anastylosis'. A clear example is the theatre of Solunto, whose reconstruction occurred through stylistic references from other theatres, without favouring the reading of the archaeological finds. Furthermore, improper introduction of materials without regard to conservation principles can cause more damage and irrevocable harm to historic theatre structures.

On the other hand, the decision, rather unpropitious, to cover the koílon of the theatre of Morgantina with a cover in Perspex (Ruggirello 2007 and Lampropoulos et al. 2004), is considered the worse intervention of restoration in Sicily; as the successive interventions could not cancel possible damages caused by such cover. The archaeological excavations specially the trenches opened at the foundations of a theatre, even if refilled, may change the compactness of the soil. This could allow more water to go under the foundation. Moreover, staining and efflorescence can be observed due to the use of cement-containing mortar which was used to in-fill losses in the stone blocks. Those mortars were not compatible with the original colour and texture, thus staining the stone surfaces. Poor quality and misguided attempts at restoration have also led to certain deformations.

For example, in the theatre of Eraclea Minoa, the entity and the causes of degradations are various: in the exposed part degradations were caused from chemical and physical effect of the aeolian and meteoric action; in the covered part they were caused both by the oxidation and corrosion of the metallic structure, with the consequent fissure of the stone, and by the infesting vegetation that is favoured by the greenhouse effect. In the Morgantina's theatre some trials on filling material executed behind the right frontal analémmata that had serious structural failure. They have recorded an argillaceous ground water saturation, which provoked an excessive thrust on the structures of the analémmata. The intervention constituted in dismounting partially the wall, replacing it with barren material in the lower surface; a tube for the water-drainage has been placed at the base of the digging, and the walls have been waterproofed with reinforced geo-membrane, coupled to geo-composite in order to facilitate the water-drainage of infiltrating waters (Lampropoulos and Karampotsos 2004).

Additionally, the functional properties of some of the theatre spaces were disregarded during these restorations and many original traces providing information about some parts were lost. On the other hand, poor ventilation of the theatre structural parts like vaults is evident, especially where some of them are being reused nowadays for exhibitions, offices or museums, such as in the case of the Roman theatre in Amman.

Therefore there is a need of knowledge of construction techniques and of materials which must be at the base of programming of conservation activities and of the management of ancient theatres. That knowledge must consider the dynamics of the degradation processes relating to the natural, ambient, anthropogenic attack and of past operations to evaluate mistakes but even effective intervention which have allowed correct preservation of the resource.

7.3 Deterioration due to poor maintenance and related conservation programmes

Regarding human impact and stone wall decay and degradation, many damages occur due to the removal of structural material from its solid walls. Many theatres have taken on some damage from stone-robbers who want to have a piece of the many famous theatres auditoria (later quarrying and stone-robbing activity). Collecting information on the restoration, maintenance and repair programmes executed on the theatre is essential. State of conservation, consolidation works, structural reinforcement and restoration of the theatre need to be addressed.

To identify the treatment adopted by the restorers and to highlight the material integration at a theatre, documents, like photos and detailed architectural sections that indicate material and construction techniques are needed. In addition photographic survey and assessment of the areas under excavation are needed near to the theatre, and to the main sites under study.

7.4 Decay and deterioration due to improper modern uses of ancient theatres and odea

Since all ancient theatres have their own unique set of conditions, and reuse cannot be separated from the whole ancient/modern context that surrounds them, it is important to make clear that modern use is altogether different from ancient use. Their use in modern cultural performances and actualities causes much of the risks concerning the physical structure and authenticity of theatre sites. For example the use of heavy machinery such as bulldozers, cranes, water tanks etc., lead to vibrations on the structure of the theatres (as in the case during Jerash Festival). However, heavy machinery is also used in restoration works to transport materials and lift the stones.

According to the 'Verona Charter on the Use of Ancient Places of Performance' (1997), proper use of the sites should reduce the risks of material damage to ancient structures by performances and prohibit non-removable staging or modifications for the public. Today, ancient performance places are a vulnerable resource threatened by erosion of time and improper uses to which they are sometimes put, in addition to natural threats.

The human threats and risks can be summarised as follows:

1. Risk of overloaded capacity in modern use. Capacity can be too great with special regard to problems related to capacity and emergency exits, especially when they are used for festivals, conferences and receptions, exhibitions/museums and tourism purposes. The other important issue of degradation at the site concerns the lack of proper sanitation facilities at these events. Overloaded capacity can also create human-induced changes in relative humidity rates, with direct effects from humans on small-space humidity. Information on the activities held in the theatre should also inform contemporary scientific studies about the capacity and risks facing the theatre structure, calculate capacity of the theatre and define unsafe places due to crowding. [FIGURE 2]
2. Risks to authenticity due to new additions. Construction of new structures such as partitions, additional seats in the orchestra for the audience, doors, shelters, footbridge etc. are practiced to accommodate

new uses and services. Recommendations for executing new ideas for the construction and installation of removable structures, with the aim of establishing general regulations for the use of each site with theatres and odea need to be aesthetically and architectonically acceptable, while providing enhancements for acoustics.

Figure 2. The International Jerash festival in the southern theatre in Jordan launched in 1981 with a wide range of activities from all around the world. The arrows show some unsafe places for the crowded audience.

3. Thermal risks of lighting systems, especially when they are used at night; what is important to note is that the lighting system should not harm ancient materials and should adhere to environmentally safe standards. Due to some damage caused by fitting modern theatrical equipment during the festival events, the Turkish authorities have suspended further shows in Aspendos theatre. A new modern facility known as Aspendos arena has been constructed nearby to continue the tradition of open air theatre in Aspendos. In addition to these solutions, we have to establish a set of aesthetic rules concerning the best types, distance between parallel sources of lighting, and the way the lighting should follow the architectonic details, and so on. By following these guide-lines, and by employing skilled staff, it is possible to have lighting exposed in the sensitive places without affecting the general appearance of the theatre. [FIGURE 3]

Figure 3. Examples of risks of lighting systems that caused damages from due to the fitting of modern theatrical equipment during the festival events, in addition deterioration due to previous wrong restorations in the southern theatre in Jerash in Jordan.

4. Noise pollution risk, especially of modern sound equipment, fixing these equipment onto the original material of the theatre structure, including the position of loudspeakers and amplifiers in poorly conceived positions which can harm the ancient materials of the monument and its acoustic qualities.
5. Visual pollution risk arising from some supplementary lighting and sound system buildings and signage system in the theatre cluster. Signage and panels, in terms of documents and photos are needed for

exhibition/museum areas in addition to signage for services provided, in terms of ticket office, on site signs, bookshop, etc.). Hence, photographic survey and visual assessments are needed to understand where to install these the technical devices for the services provided, especially during drama performance.

6. Deterioration of Acoustics Quality. In fact, the acoustic characteristics of ancient theatres and Odea are at risk. In most ancient theatres, the stages and the upper parts had been damaged. If we use ancient theatres for modern performances with modern technology, we have to ensure that no harm is done to the original acoustics of the building (Haddad 2007). It is necessary that a system for describing and rating ancient theatre acoustics is in place before any intervention is carried out on these monuments. [FIGURE 4]. On the other hand, the distinguishing qualities of the theatre structure (especially the acoustical), and its environment in their original or earlier settings can be restored and revived. The European Commission's ERATO (identification, evaluation and revival of the acoustical heritage of ancient theatres and odea) project makes it possible for the first time to hear these significant structures as they sounded in the past and to feel their sense of space (Haddad 2008). It was found that, restoration (including anastylosis) of the stage wall can improve the source loudness and speech intelligibility by reflecting the sound towards the audience and reinforcing the direct sound. The stage colonnade has a scattering effect, improving sound distribution, and the colonnade around the cavea improves strength of sound in remote seats. Meanwhile, the portico is not only architectonic: it has an acoustic function (as mentioned by Vitruvius), providing acceptable voice strength to the upper levels.

The conservation and restoration of acoustical characteristics is important, also as important is to take advantage of the acoustical design of ancient theatres and Odea; this should be considered as one of the most important support for the conservation process. In order to promote human comfort and take advantage of the acoustical design of ancient theatres and odea, the conservation and restoration of acoustical characteristics should be considered as a priority. Conservation and restoration of ancient theatres and odea can enhance and preserve their authentic scientific information, since the cultural significance of many theatres and odea is not readily apparent (Haddad 2007, 2008, 2010). A dialogue is needed between those specialized in acoustics, and those involved in the process of theatre conservation to discuss some new aspects concerning the approach for conservation and restoration of these monuments, including new ideas for the construction and installation of removable structures. They should concentrate not only on the artistic and structural requirements of the building but also on achieving high acoustic standards by means of modern technology. It is now possible to determine if such investments are effective and can really increase and diffuse knowledge of theatre heritage while also satisfying the requirements of users (Haddad 2007, 2008, 2010).

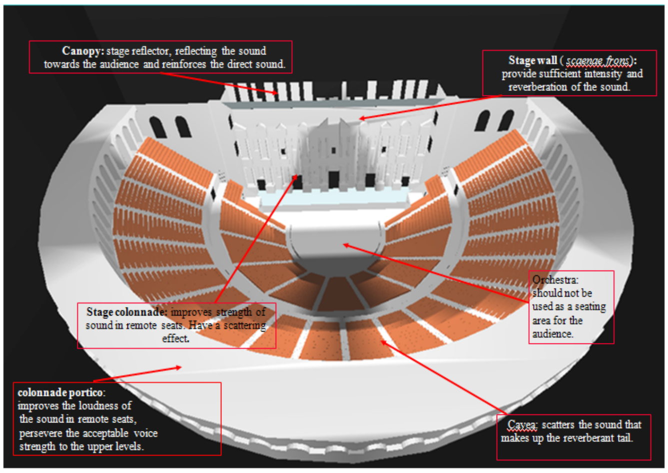

Figure 4. The main architectural and acoustical elements of a typical open-air Roman theatre.

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Technical Experience in Post-Earthquake Rescue and Conservation Planning for Cultural Relics at the National Level

The case study of the Rescue and Conservation Plan for Cultural Relics after the May 12th Wenchuan Earthquake of China

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Abstract. After the 2008 Wenchuan Earthquake disaster, the total affected administrative area of cultural relics reached 422.8 thousand square kilometres; including 1302 cultural landmarks at all levels, 4109 collections of cultural relics, and 170 conservation facilities for various types of heritage properties have been damaged. At the national level, Rescue and Conservation Plan for Cultural Relics after the May 12th Wenchuan Earthquake is a specialized standard for the overall planning and rapid implementation of rescue and protection of cultural relics following the disaster. This paper introduces three planning principles for giving priority to the rescue and strengthening work, heritage values and community needs according to the characteristics of disasters. Some evaluation indicators and methods for special disasters, together with corresponding protection measures and projects, will be given in this paper. The implementation process and cost estimation methods of the protection projects will also be provided. This plan has played a prominent role in planning and coordinating rescue and conservation work of cultural relics at a national level after large-scale disasters.

1 Survey of the damage of cultural relics in the May 12, 2008 Wenchuan Earthquake disaster area of China

The Wenchuan Earthquake of China was a world-shaking disaster, which caused heavy casualties in the Sichuan, Gansu, and Shaanxi Provinces, as well as tremendous property losses to the country and its people, and wrought unprecedented catastrophe to cultural relics of the aforesaid three provinces.

The Wenchuan Earthquake induced substantial losses of cultural relics and their protection, management and exhibition facilities in the three provinces, including 430 major historical and cultural sites (including 145 major historical and cultural sites protected at the national level, and 285 historical and cultural sites protected at the province level), 872 historical and cultural sites protected at the city or county levels; 4109 collections of cultural relics (including 372 precious collections of cultural relics); and 170 buildings (150,653 square metres) for protection of various cultural relics and some facilities. It has become an especially serious disaster in China's history of cultural relics protection.

Aiming at the various after-effects caused by the earthquake, China established at the national level the State Planning Group of Post-Wenchuan Earthquake Restoration and Reconstruction ('National Planning Group') to develop a series of post-disaster reconstruction or rescue and conservation plans in disaster areas, such as urban and rural housing, urban construction, rural construction, public service, infrastructure, industrial reconstruction, disaster prevention and alleviation, and ecological environment, etc., and to provide guidance for disaster relief in a timely, orderly and effective way. The Rescue and Conservation Plan for Cultural Relics after the May 12 Wenchuan Earthquake of China was developed as an important part of the special planning for post-disaster reconstruction of public facilities, aiming at providing technical guidance for post-disaster rescue, conservation, and renovation of cultural relics, and for building up the spiritual homestead of people in disaster areas actively.

2 Overall thought of planning

2.1 Guiding ideology

Combining the principles outlined in the National Post-Earthquake Reconstruction Working Plan with the objectives of cultural relics rescue and conservation, the guiding methodology for planning is to:

a. Comprehensively carry out a scientific review on development and persist in people foremost;

b. Stick to the working guideline of 'giving priority to protection, placing rescue first, strengthening management, and making reasonable utilization' for cultural relics

c. Adhere to making overall plans and taking all factors into consideration, distinguish the relative importance or urgency of protection work, and give priority to implementing the rescue, reinforcement, maintenance and conservation of major cultural relics

d. Pay attention to the rescue, conservation and traditional techniques of vernacular built heritage in disaster areas

e. Give overall consideration and make sound planning by identifying heritage typologies, the level of required protection, the extent of damage, the regional distribution, and breakdown of steps for implementation

f. Persevere in taking local authorities as a major stakeholder, and rebuild the spiritual homestead of the people in disaster areas with the powerful supports of the country, its society, and relevant stakeholders and organisations

2.2 Basic principle

The basic principle for planning is to carry out a scientific appraisal and classified protection, distribute responsibility evenly, develop an overall planning mechanisms and highlight its key points by distinguishing the order of priorities through clear step-by-step actions.

3 Technical planning scheme

The 'Rescue and Conservation Plan for Cultural Relics after the May 12 Wenchuan Earthquake of China' covers 203 counties (cities) in 37 cities (autonomous prefectures) of Sichuan, Gansu and Shaanxi Provinces, and the total affected administrative area of cultural relics is 422,800 square kilometres. The cultural relics in 51 counties and cities of Sichuan, Gansu and Shaanxi Provinces (covering an area of 132,500 square kilometres), which were publicized as the 'extremely' harder-hit area in the country, were considered priorities in the rescue, conservation and repair work.

3.1 Main planning problems and challenges

This plan is the first one developed especially for earthquakes in China. A series of special challenges were faced during the compilation of this plan due to the following five issues:

3.1.1 Extremely big scope and insufficient time.

In order to avoid secondary disasters and the predicament of people living in disaster areas, the country required completion of the plan in an extremely tight timeframe of three months. Within this period, great changes occurred several times while compiling the requirements and scope of the plan, and the originally tight timeframe seemed to be even shorter. The amounting pressure was quite uncommon.

3.1.2 Difficulty in data acquisition and quantitative statistics.

Traffic and communication systems in disaster-stricken areas were severely damaged, and the acquisition of data on the extent of damage to cultural relics was often unverified. Providing a sufficient understanding of the loss to cultural relics caused by the earthquake and avoiding any omission is necessary to define the projects in the post-disaster reconstruction stage. It is therefore necessary to strengthen the quantitative analysis and appraisal of the damage. This will inform post-disaster conservation interventions for cultural relics.

3.1.3 Extremely large scale and complicated situations.

The cultural relics damaged this time not only included buildings, but also collections of cultural relics and material vernacular heritage. Furthermore, the level damage was also unprecedented. The planning addressed 1,302 historical and cultural sites at all levels, more than 4,000 collections of cultural relics, and 150,000 square metres of buildings and facilities.

3.1.4 Lack of experience for criteria and relevant standards.

In the face of such large-scale damage and the challenging locations of cultural relics affected by the earthquake, there was no benchmark either in China or abroad for achieving the planning objectives, which were to rescue and conserve scientifically, practically and effectively damaged cultural relics, within a limited timeframe and with limited manpower, technique and resources. It was therefore necessary to pursue the biggest possibility of post-disaster rescue and conservation of cultural relics by aiming for the most practical conditions, combining previous work experiences, and exploring step by step.

3.1.5 It is extremely difficult to give consideration to different working objectives of the country, local authorities, and departments.

The country, local authorities, and departments have different post-disaster reconstruction tasks, plans and objectives. Meanwhile, in the three affected provinces, the cities and counties suffering from serious damage to their cultural relics were different than the cities and counties where people were affected by the earthquake. Towns and buildings were severely damaged; and there are still 152 counties suffering from damage to cultural relics which are not within the national planning scope. Therefore, the biggest challenge in preparing this plan is to ensure that consideration of the overall post-disaster rescue of more cultural relics is better integrated and prioritized into the national planning scope.

3.2 Technical route

The plan adopts the following technical methodology:

- Collect data on the damage to cultural relics and relevant facilities in the three affected provinces.
- Classify the cultural relics according to characteristics of their conservation and management.
- Classify and appraise the degree of damage to cultural relics to inform the objectives of rescue and conservation.
- Execute statistical and quantitative analysis of disaster condition.
- Set up a clear planning scope and formulate the overall objectives of special planning according to national disaster relief objectives.
- Formulate the objectives of post-disaster rescue and conservation within the planning scope by classification.
- Determine the main tasks in rescue and conservation of various cultural relics.
- Formulate special technical measures and requirements for rescue and conservation of cultural relics stimulating community involvement.
- Divide the stages and estimate the resources required for each project.
- Design each project's implementation programme.
- Supplement the rescue and conservation plans for damaged cultural relics not within the planning scope according to industrial disaster relief objectives.

3.3 Content Compilation

With the 51 counties and cities within China marked as key points, and the other 152 counties and cities marked as secondary points, the degree of damage to cultural relics in the three provinces caused by the Wenchuan Earthquake was comprehensively appraised. Plans and projects for the rescue, conservation and repair of cultural relics during the post-disaster reconstruction stage were developed for immovable cultural relics, moveable cultural relics, relevant building facilities, and vernacular cultural heritage at the national layer. This allowed to understand the resources available and identify those required at the local and community levels. The main contents include:

a. Assess the damage to cultural relics and relevant facilities and equipment in Sichuan, Gansu and Shaanxi Provinces, including the scope of disaster, the disaster condition, the reasons for damage, and the economic losses, etc. [FIGURES 1, 2, and 3]

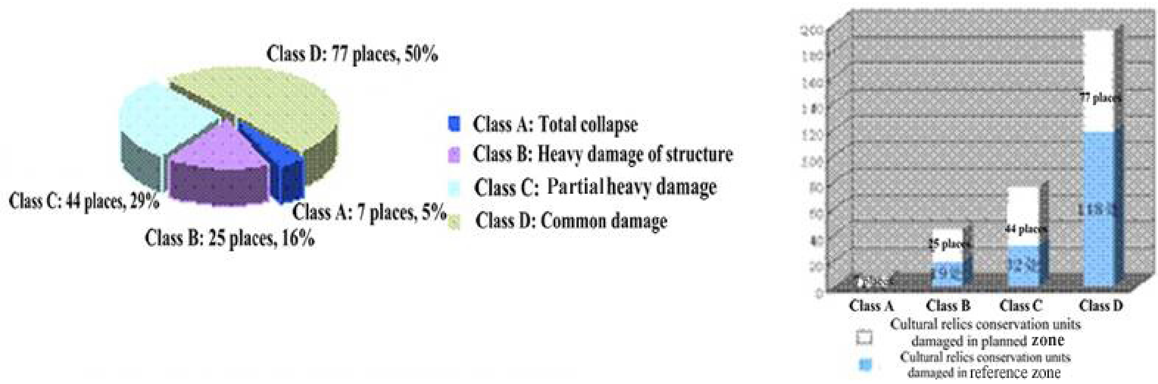

Figure 1. Assessment of the degree of damage to conservation units for cultural relics in the planning zone of Sichuan Province

b. Prepare a spatial distribution map and an earthquake-induced damage grade assessment chart for important conservation units in the three provinces according to the assessment results [FIGURE 4]

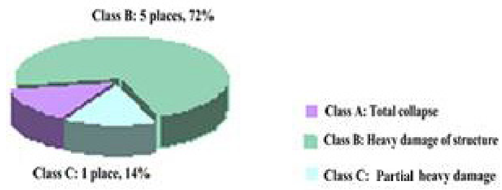

Figure 2. Assessment of the degree of damage to conservation units for cultural relics in the planning zone of Gansu Province (Left)

Figure 3. Assessment of the degree of damage to conservation units for cultural relics in the planning zone of Shanxi Province (Right)

c. Divide the severely stricken area (planning zone) and the lightly stricken area where damaged cultural relics are distributed in the three provinces according to national requirements, in order to guide the implementation steps, the extent and scope of the overall rescue and conservation measures for cultural relics;

d. Establish (1) the main tasks and planning requirements for the rescue, conservation and repair of immoveable cultural relics; (2) the main tasks and planning requirements for the rescue, conservation and repair of moveable cultural relics; (3) the repair and planning requirements for the conservation of museums and buildings, as well as relevant facilities and equipment; and (4) the main tasks and planning requirements for the vernacular cultural heritage of ethnic minorities;

e. Determine to preferentially rescue World Heritage sites, national historical and cultural sites, major historical and cultural sites protected at the provincial level, and precious collections of cultural relics according to different conservation grades and damage degrees;

f. Set up planning projects for the systematic rescue and conservation of cultural heritage of ethnic minorities such as the Tibetan Nationality and Qiang Nationality, etc. in earthquake disaster areas;

g. Plan around 709 rescue and repair projects of various cultural relics and estimate the required resources for each project accurately.

4 Innovation in Planning

The Rescue and Conservation Plan for Cultural Relics after the May 12 Wenchuan Earthquake of China is the first special plan, developed at the national level, for the rescue, conservation and repair of cultural relics which were seriously damaged by the earthquake. It shows the following innovation in terms of planning concept and method.

4.1 According to the demand for rescue of cultural relics and the characteristics of earthquake damages, and based on a scientific assessment of disaster damage, this plan distinguishes the process and level of rescue required, establishes a corresponding relation between the assessment of the damage to cultural relics and the rescue measures possible, and has direct relevance and operability.

The plan sets up the following four grades of damage for immoveable cultural relics and relevant facilities in the three provinces: A) Total collapse; B) Heavy damage; C) Moderate damage; D) Ordinary damage. Based on a comprehensive assessment, the plan provides parameters to assist in identifying the order of priority for rescuing and for the level of conservation interventions. The assessment allowed to correlate the level of rescue and conservation intervention with the grade of damage: repair and reconstruction (for A); rescue and reinforcement (for B); rescue and maintenance (for C); and maintenance and reinforcement (for D).

4.2 According to the actual disaster condition and the characteristics of the intervention required, the plan highlighted three fundamental principles: give priority to rescue and reinforcement work, prioritize heritage value and the level of significance of the cultural relics, and pay attention to the community's needs. These principles are not only relevant for planning the rescue, conservation and repair of cultural relics damaged in the Wenchuan Earthquake, but can also be applied to any relief, rescue, conservation and repair efforts for cultural relics affected by any future earthquake.

Three guiding principles were identified:

1. Prevent further post-earthquake damage to cultural relics in the case of secondary effects such as aftershocks, rainstorms, etc. and prevent further damage to the non-regenerable value of cultural relics through large-scale remedy;

2. Consider level of significance by prioritizing important heritage like World Heritage or rare heritage like vernacular heritage;
3. Guarantee the rescue in the field of cultural heritage and address the demand of communities for rebuilding spiritual homesteads in disaster areas.

Giving prominence to these key points can ensure the systematic and orderly implementation of heritage rescue. These three principles are not only applicable to the rescue of cultural relics post-Wenchuan earthquake, but can also guide rescue and conservation efforts of China’s cultural relics after any severe disasters.

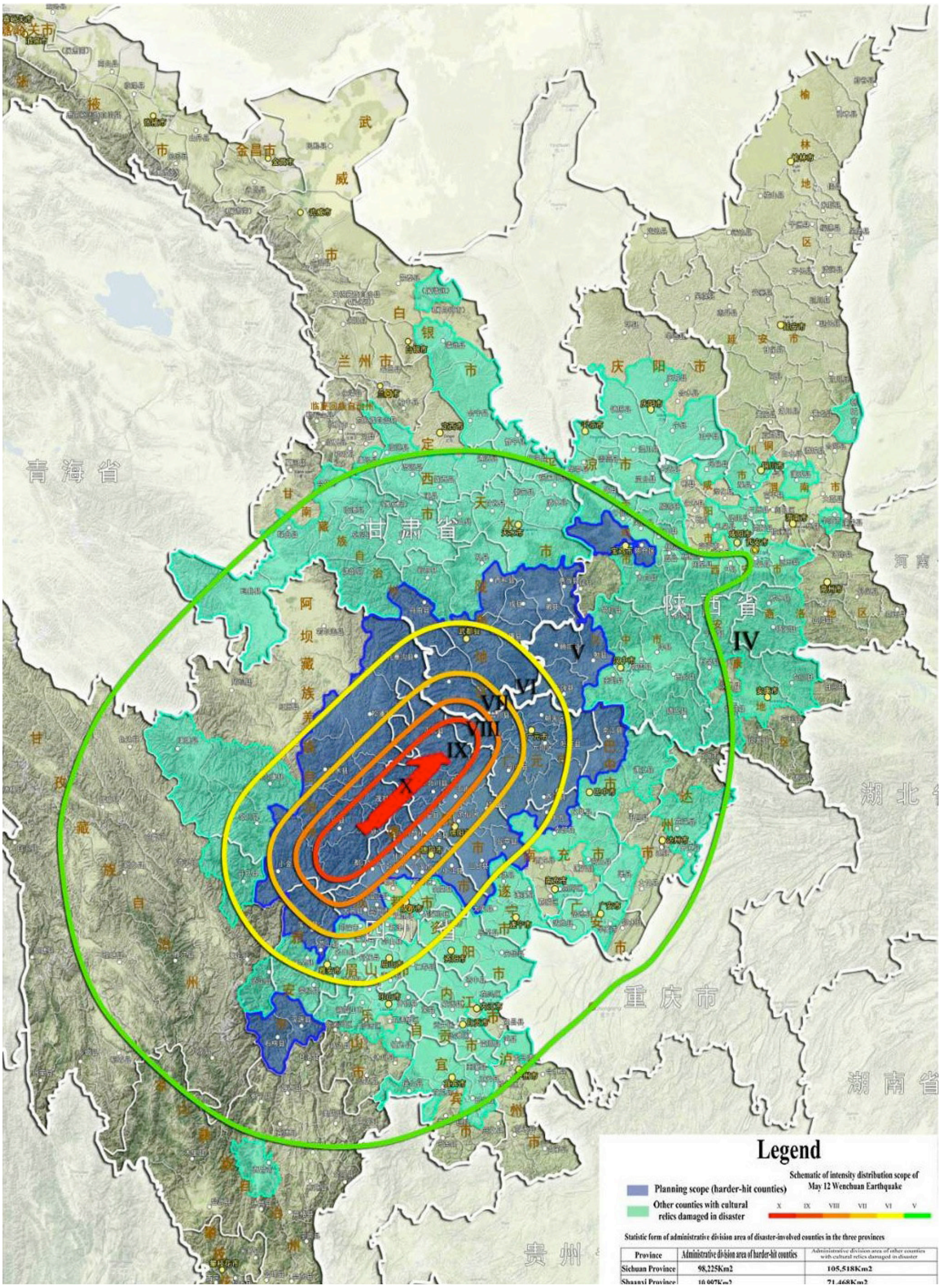

Figure 4. Planning scope

4.3 Based on the principles for cultural heritage conservation and according to the values and functions of cultural heritage, the plan classifies rescue and conservation measures for various damaged cultural relics and associated cultural facilities. The plan is not only meant to link to the national overall plan for post-disaster reconstruction, but can also be integrated into the operations of administrative department for cultural relics at all levels as well as guide the community-based interventions. The plan is meant to be highly pragmatic.

Due to the wide variety of types of cultural relics and their various associated facilities for protection, conservation, exhibition, use, services and research, etc., the plan classifies cultural relics according to their values and functions, and based on their typologies (immoveable cultural relics, moveable cultural relics, museum and buildings for conservation, or other relevant facilities and infrastructure associated with cultural relics, and material cultural heritage of ethnic minorities). Based on this classification, the plan assesses and identifies the corresponding tasks and action plan for rescue, conservation and repair for each category, and formulates different rescue measures and requirements.

4.4 The plan explains how to prioritize projects and highlights past projects as useful examples.

According to the state of conservation and the level of significance, the plan has prioritized conservation and repair of cultural relics in the following decreasing order : first, to World Heritage; second, to major historical and cultural sites at the national level (including representatives of vernacular cultural heritage); third, to major historical and cultural sites at the provincial level; fourth, to some historical and cultural sites at the city and county levels; fifth, to precious collections of cultural relics; and sixth, to regional central storerooms. The plan emphasizes to develop key projects on the sites that are severely damaged, have great social value, and hold outstanding significance. The plan also discusses the emergency repairs and provides examples of post-disaster rescue and conservation efforts which may encourage communities to carry out post-disaster reconstruction.

The plan not only addresses the most severely damaged areas (planning zones), but also proposes planning measures for cultural relics in less damaged areas. This not only concurs with the national planning scope but also takes into consideration national demand, departmental demand, and local demand. The plan therefore provides a systematic approach for the rescue, conservation and repair of cultural relics damaged in earthquake disaster in consideration other priorities.

The conservation of cultural relics is greatly different from urban post-disaster reconstruction. All damaged cultural relics must be listed as rescue and conservation objects, and cannot be rebuilt in another location. The plan is not only aligned with the national planning scope by covering severely damaged areas, but also proposes planning measures for cultural relics in less damaged areas. The plan therefore not only meets the requirements of national overall planning, but also the requirements of the national uniform disaster relief plan and the overall rescue requirements for cultural relics.

5 Epilogue

This plan, examined and approved by the country in September 2008, has been publicized for implementation in the National Post-earthquake Recovery and Reconstruction Plan. It puts forth a methodology and action plans to rescue, conserve and repair cultural relics during the national reconstruction stage after the May 12 Wenchuan Earthquake. The plan formulates standards and requirements to ensure efficient implementation at the community level and is highly efficient, pragmatic, and resourceful. This plan is a pertinent reference and can play an outstanding role in guiding coordinated rescue and conservation efforts for cultural relics at the national level after large-scale disasters.

Theme 5: Awareness-Raising and Capacity-Building for Managing Disaster Risks to Cultural Heritage

Australian Responses to Natural Disasters, 2009-2012
Lessons Learned

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Abstract. Australia is a land of climate extremes and the last three years have been fraught with disasters almost over the whole of the continent.

On Saturday, 7 February 2009 as many as 400 individual bushfires were burning across the state of Victoria during extreme weather conditions. Almost a year later, on 3 February 2011, Cyclone Yasi rolled over Queensland devastating coastal and outback communities. Barely having recovered from Yasi, a year later most of Queensland was flooded, including the capital Brisbane, where the city centre came to a standstill.

This paper examines the states of preparedness for these disasters, discusses the effective use of legislation as part of overall disaster planning and sets out lessons to be learned.

Australia's climate is one of extremes, immortalized in a famous poem as 'a land of drought and flooding rains'. Since 2009, almost the entire eastern third of the continent has been the subject of bushfires and floods, and furthermore the north was affected by cyclones. These events caused significant loss of life of people and animals, massive disruption to businesses, farming and mining, and resulted in severe economic impacts.

1 Black Saturday Bushfires 2009

South-eastern Australia is one of the most fire-prone areas of the world. After 11 years of drought Victoria was already tinder dry and after two months of little or no rain and weeks of a continued heatwave, what was to be a catastrophic disaster of unimaginable proportions unfolded on a fiercely hot Saturday, later named 'Black Saturday'. On 7 February 2009, temperatures went over 46 °C (115 °F), in Melbourne temperatures rose to 46.4 °C (115.5 °F), 'the hottest temperature ever recorded in an Australian capital city'. Many localities recorded their highest temperatures since records began in 1859 (Wikipedia). Hot north-westerly winds were in excess of 100 km/h (62 mph) and later changed direction and increased their speed to in excess of 120 km/h (75 mph). Bushfires had already been burning and more erupted as the day progressed. Up to 400 individual fires were recorded, eventually affecting 4,500 km² (450,000 hectares, 1.1 million acres). One hundred and seventy three people died, 414 were injured, and over a million animals including wildlife, farm animals and pets were lost. Seventy-eight towns were affected, and some were all but completely destroyed. Over 2,030 houses and more than 3,500 structures were irretrievably ruined, 7,562 people became homeless. Fires continued to burn into mid-March and a conservative estimate of the cost was A$4.4 billion.

Figure 1. Remnants of a house at Kinglake

One description of the fire was 'that the amount of energy released during the firestorm in the Kinglake-Marysville area was equivalent to the amount of energy that would be released by 1,500 Hiroshima-sized atomic bombs' (Hughes 2009). Another account stated 'the energy produced by the fires in just a few hours on February 7 was enough to provide Victoria's industrial and domestic energy needs for a year' (Hughes 2009). Eyewitness accounts included: a sound like a jumbo jet or a steam train; 'the wind [was] pulling the trees right out of the ground…'; 'My wife went from preparing the dinner … to survival mode in virtually an instant'; 'like being in torrential rain but it was burning' and 'a monsoon of fire' (2009 Victorian Bushfires Royal Commission 2010, Vol 1, 18).

The eyewitness's words echo the experiences and highlight the severity of the situations that confronted many of the people who faced the bushfires that burned in Victoria in late January and February 2009:

> 'I knew the front was coming. You could hear it, you could smell it, you could feel the heat coming up out of the valley … I could hear rushing, not a wind, it was a white noise you could call it almost … like a pressure. If pressure could make a noise that is what it would sound like.
>
> The flames were right there. They would have been about 50 metres away. The flames were so high. They were the height of the trees and that again … 300 feet high plus. There were big, swirling vortexes, just big, swirling masses of flames that would just burst and explode out of … tree tops' (2009 Victorian Bushfires Royal Commission 2010, Vol 1, xxiii).

After such an event it is usual to hold an enquiry, the most significant being conducted as a Royal Commission. The 2009 Victorian Bushfires Royal Commission report opens with the words:

> 'Black Saturday wrote itself into Victoria's history with record-breaking weather conditions and bushfires of a scale and ferocity that tested human endurance' (2009 Victorian Bushfires Royal Commission 2010, Vol 1, v)

The four-volume report containing over 1,000 pages, records the scope and results of the investigation: preparation and planning for future bushfire threats and risk, particularly the prevention of loss of life; land use planning and management including urban and regional planning; fireproofing of houses and other buildings, including specification of construction materials; emergency response; public communication and community advice systems and strategies, and training, infrastructure and resourcing (2009 Victorian Bushfires Royal Commission 2010, Vol 1, viii). Only some of these findings can be discussed here.

Human activity and failings were definitely major contributors; arson was a factor in some cases; failure to maintain electricity infrastructure in rural areas; settlement in fire-prone bushland; instances of inadequate planning and advice; insufficient warnings for firefighters and communities; lack of adequate preparedness by emergency response agencies and the community.

One of the fundamentals of emergency response is management of roles and responsibilities and clear communication according to prepared and rehearsed emergency management plans. Notwithstanding a belief that they were well-prepared, there were several significant systemic failures in the official emergency response which failed the test in circumstances so extreme, that they were not predicted or even expected.

Firefighters in rural Victoria are mostly volunteers drawn from the State Emergency Services and the Country Fire Authority, who work together with staff from the Department of Sustainability and the Environment, and the police during an emergency response.

The Australasian Inter-Service Incident Management System (AIIMS) protocols were established to provide an effective command, control and co-ordination of emergency response agencies, and are used by all firefighters except the police. At a general level the system worked well, however there were critical deficiencies ((2009 Victorian Bushfires Royal Commission 2010, Vol 1, 227). Some incident management teams were not pre-positioned in assigned areas, notwithstanding training and a high level of understanding that the threat of a conflagration was extreme. In areas where personnel and equipment were on the ground, the response had a greater degree of success but in other areas an inadequate chain of communication meant that the state of preparedness was not understood in some regional areas and, as a result, there were consequent often extensive delays in establishing effective incident management (2009 Victorian Bushfires Royal Commission 2010, Vol 1, 226-232). When fires were being spotted up to 40 Kms away, this had turned to a significant and catastrophic event. Firefighters and incident management teams were caught by surprise when the wind changed earlier than expected. Standard operating procedures were sometimes not followed, resulting in delays in communicating 'time-critical information to firefighters and in several cases inaccurate or inconsistent warnings, or no warnings at all were sent to firefighters on the ground', thus breaching safety procedures.(2009 Victorian Bushfires Royal Commission 2010, Vol 1, 227). This information was crucial as the wind change injected new severity into the fires. Calls to 000, the emergency telephone number, caused a backlog which resulted in difficulties for people reporting fires. In an emergency, warnings are provided by ABC (Australian Broadcasting Corporation) local radio, community radio and emergency response websites. On Black Saturday the Standard Emergency Warning Signal was never activated and many communities were alerted only through the personal efforts of various response crews. One fire station activated its warning siren.

While many aspects of the response were effective and in accord with established protocols, management of individual fires varied, sometimes with catastrophic consequences. Where the response failed, management and communications were not clear and some fires continued to be managed by the wrong personnel or there was confusion as to who actually had management responsibility. Information gathering about some fires was not effectively undertaken and ultimately proved unreliable for planning and decision-making. Record-keeping was sometimes inadequate and lead to confusion about warnings and the location of firefighters on the ground. This was exacerbated by an intense volume of radio traffic blocking systems and the state of facilities in individual incident control centres. Communication by mobile phone and landlines was also problematic. To add to the problem, the police communication system was hampered by the 'incompatibility of the digital metropolitan and analogue rural police radio networks' (2009 Victorian Bushfires Royal Commission 2010, Vol 1, 230). Years of discussions at all levels of government about privacy issues meant that individuals did not receive any warning by mobile phone, however after Black Saturday this was resolved by the state government, and when another serious outbreak occurred a few weeks later everyone received a text message warning.

Leadership of incident management teams varied from effective to inadequate 'to manage the ferocious fires'. Some Incident Controllers lacked 'the necessary experience, training and competence' and poor preparation ensued (2009 Victorian Bushfires Royal Commission 2010, Vol 1, 228) .Some incident action plans were delayed, underdeveloped or only began to be prepared hours after the fire had been reported and some considerable time after the fire had swept through the local area. In one case an entire town was destroyed and resulted in the death of 34 people and the loss of the entire local history collection and museum at Marysville.

While there were failures on behalf of the emergency responders, there were also failures on the part of communities and individuals. In Victoria the evacuation policy is one of 'stay or go'. Evacuation is not compulsory. Despite consistent advice from emergency responders to individuals and householders to develop their own fire preparedness plans, many people did not have one nor did they tune in to the radio to hear warnings. By way of contrast, others were well-prepared. Many people did not realize the danger and left it too late to evacuate; by the time they did try to evacuate, smoke and fire disoriented and trapped them and rendered this a catastrophe.

Figure 2. People leaving late became disoriented in the smoke or were overtaken by radiant heat and fire

Each municipality is responsible for an emergency management plan. These plans are tested and rehearsed regularly. While many plans were effective, in at least one case, the municipal emergency management plan technically complied with the Emergency Management Act 1986, but when tested by the fires, it was found to lack 'substance, detail and precision, and in particular, did not accommodate planning for responding to bushfire [and that] there was insufficient detail to enable responses to be actioned if an emergency were to occur' (2009 Victorian Bushfires Royal Commission 2010, Vol 1, 231).

Part of the emergency plan also involves setting up emergency co-ordination and relief centres. These variously support emergency evacuation provide food clothing, personal items, shelter and welfare for evacuees; food for farm animals, machinery and equipment, assistance with road closures and transport. In providing welfare, these centres facilitated identity re-establishment via photo ID on drivers' licences which then provided evacuees with immediate access to bank accounts, insurance claims and the like. Initially there were calls for people to donate unwanted items but this resulted in an avalanche of goods, and many donations were unsuitable for the purpose, and then had to be disposed of, increasing the burden on already stretched resources. Nevertheless, on the whole these relief centres provided valuable support for affected communities, and several of these centres remained operational numerous months later.

In Victoria, settlement and building construction is controlled by a range of laws and regulations. While ember attack is a significant cause of ignition, in these fires a high proportion of buildings were destroyed by direct flame. Not surprisingly, brick structures performed better compared to timber, cellulose cement and mud brick construction. Likewise, concrete and steel water tanks survived better than polyethylene or fibreglass. Buildings which did not have clear buffer areas around them and no active water defence suffered the most damage. Gravity fed water systems were the most consistent as mains and pumps often failed. In relation to buffer zones, in excess of 20% of destroyed houses were located more than 100 metres (328 ft) from forests, hitherto this had been the accepted standard for safety (2009 Victorian Bushfires Royal Commission 2010, Vol 2, 217).

Figure 3. Destruction caused by the Kinglake fire

The Victorian Planning Provisions are an important tool to regulate development in bushfire prone areas, the other important tool is building regulation. Both have been examined as a consequence of the fires, and numerous changes have been made. This has not only given rise to consideration of specific building materials and design for bushfire-prone areas, but also to a consideration that in areas at risk, new subdivisions should not be permitted; given the attraction of living in the bush environment this is significant for many outer-urban dwellers. Equally significant is that until the fires, there were no zones relating to bushfire risk in contradistinction to flood zones. Opinions vary on both zones i.e. the use of such zones to prohibit most land uses, including dwellings, renders the land useless for many purposes including legitimate development. Flexibility of control is preferred because as the Royal Commission observed:

> 'The level of bushfire risk in a municipality, and the location of bushfire hazards will vary ... in a municipality where the bushfire hazard is primarily on public land on which little or no development is likely to occur, a much less detailed policy would be required than for a municipality in which entire towns are deemed to be at high risk of bushfire. The model local bushfire policy should be flexible enough to accommodate a range of local circumstances.' (2009 Victorian Bushfires Royal Commission 2010, Vol 2, 231)

Figure 4. It was of some interest that exotic vegetation survived the fires while the native vegetation did not

In municipalities in Victoria where there is a risk of bushfires, Councils can include a Wildfire Management Overlay in their planning scheme. These Overlays address strengthening community resilience to bushfires, identify areas where the bushfire hazard requires specified bushfire protection measures for subdivision, buildings and works. Ensures the location, design and construction of development takes into consideration the need to implement bushfire protection measures, and ensure that development does not proceed unless the risk to life and property from bushfire can be reduced to an acceptable level. A separate clause sets out standards which address such things as water supply, safe access for emergency vehicles and residents, design and siting of buildings and works, management of ground fuel, vegetation, landscaping and defendable space. In the mix is also the need to achieve a balance between the conservation of native vegetation, biodiversity, native flora and fauna with human life and the built environment, which is often the subject of debate.

The Australian Standard, AS 3959, describes construction of Buildings in Fire-Prone Areas where the initial construction regulated but do not address ongoing maintenance, as this is impractical despite the risk. There are also regulations for flood-prone areas and areas subject to cyclonic activity.

One apt observation made by the Royal Commission was 'The level of water in a 100-year flood is a known, quantifiable and discretely defined area and that can be easily mapped and put into a planning scheme. The challenge of mapping a much more dynamic response to a hazard [i.e. a bushfire] in a bushland sense is much harder' (2009 Victorian Bushfires Royal Commission 2010, Vol 2, 228).

This is an interesting point of comparison with the experiences of the floods in Queensland.

2 Queensland Floods, 2010-2011

Communities had barely recovered from the ravages of Cyclone Yasi when they were hit by disaster again. Following considerable rainfall over a long period of time which affected large parts of Queensland in December 2010 through to January 2011, floods of historic proportions inundated the City of Brisbane, which came to a standstill. At least 70 towns and over 200,000 people were affected and thousands more were evacuated; 35 people died. Three-quarters of the state of Queensland was declared a disaster zone. Initial estimates of damage were about A$1 billion while reduction in Australia's GDP was estimated at about A$30 billion.

Like the Bushfire Royal Commission, the Queensland Floods Commission of Enquiry was held to examine what had occurred and how future events could be mitigated. The ensuing two volume report contains over 650 pages, and this section necessarily focuses only on some of the recommendations.

Figure 5. The flooded Brisbane River inundated the central business district causing the city to come to a standstill
(Courtesy: Australian geographic)

Two large urban centres which were inundated in the 2012 floods are Brisbane, the Queensland state capital which is located on the Brisbane River and Ipswich, located on the Bremer River.

> 'Years of drought did not promote rigour in flood planning, whether in relation to disaster response, dam management or land use. Complacency about flood prevailed, at least in parts of the state, over many years' and Brisbane, Ipswich and other centres bore the brunt' (Queensland Floods Commission of Enquiry 2012, 31).

'Most cities and town in Queensland are located on floodplains' (Queensland Floods Commission of Enquiry 2012, 38) which are subject to flooding and there is an expectation that floods of varying magnitudes will occur during the wet season. However, equal with that expectation is also that the various levels of government will be prepared and will 'protect its citizens from disaster' and 'that all available science should be applied so that the nature and extent of the risk is known and appropriate action taken to ameliorate it'(Queensland Floods Commission of Enquiry 2012). Appropriate floodplain management strategies should include 'a combination of land planning and building controls, emergency management procedures, and structural mitigation measures such as levees and dams'(Queensland Floods Commission of Enquiry 2012).

Current Australian best practice floodplain management principles are:

- land use planning controls (zoning requirements to ensure compatibility between land use and flood risk)
- building controls (minimum flood levels and flood-proofing)
- structural measures (flood mitigation works such as the construction of levees)
- flood emergency measures (flood warning, evacuation and recovery plans' (Flood Plain Management Plan in (Queensland Floods Commission of Enquiry 2012, 40)

The starting point for floodplain management should be a management study and associated mapping.

Previous actual practice ranged from ad hoc decision making to comprehensive planning and emergency response strategies (Queensland Floods Commission of Enquiry 2012, 40). Some estimates of the 1 in 100 year flood line (i.e. flood of exceedance probability) had been based on the modelling of a single rainfall event instead of a wider range of factors including topography, stream flow behaviours and the size of the area likely to be affected by inundation and their variations between events. Over the years urban development has changed the landscape and reduced the amount of permeable surfaces, and run-off patterns have changed as a consequence. The flood studies for Brisbane and Ipswich were not comprehensive, and planning controls between 1976 and 2011 in Brisbane remained static, envisaging a flood level of 3.7 metres at the Post Office gauge (Queensland Floods Commission of Enquiry 2012, 23).

A comprehensive flood study commissioned by the Brisbane City Council, completed in 1998 had estimated a flood level of 5.34 metres. Subsequently, various other studies and reviews were undertaken and it was only in 2003 that any other reasonably reliable data became available. In follow-up reviews it was noted also, that for various reasons, the studies which had been completed were not comprehensive, and as a consequence there was a degree of uncertainty about the findings (Queensland Floods Commission of Enquiry 2012, 49-51). Nevertheless, due to political expediency generated by public interest to come to a resolution quickly, the flawed study data was adopted as a ‘best estimate’. Sadly, in the event, this estimate was inadequate and one of the recommendations of the Commission of Enquiry is that a comprehensive flood study of the Brisbane River catchment, including ‘suitable hydrological models run in a Monte Carlo framework’ be undertaken ‘as soon as practicable’ (Queensland Floods Commission of Enquiry 2012, 46-47). The Monte Carlo framework allows mathematical modelling to be undertaken with thousands of different values including a comparison with the actual records of floods over the past 150 years taken at the Brisbane Post office gauge, and also with hydraulic modelling. Climate change could also be factored, preferably after modelling the observed flood behaviour and natural variability outcomes data. It was also recommended that ‘a recent flood study should be available for use in floodplain management for every urban area in Queensland’ and that if on did not exist, it should be initiated (Queensland Floods Commission of Enquiry 2012, 54).

Figure 6. Flood in Limestone Street, Ipswich’s central business district
Courtesy: goodnaflood.blogspot.com)

Ipswich was also inundated by the floods. The flood studies which had been undertaken followed the work for Brisbane, because Ipswich can be affected by flooding in both the Bremer and Brisbane Rivers due to the proximity of their headwaters. These studies were also inadequate for similar reasons to the Brisbane studies, and also partly due to various additional constraints imposed on the scope of the Ipswich flood study. Nevertheless they were relied upon.

Simply put, both councils were not adequately prepared as a result of procrastination in finalizing their existing flood studies, and as a consequence when the floods came and caused extensive and unprecedented damage in the Brisbane Central Business District, suburban and nearby areas; people were taken by surprise and considerable disruption and damage occurred.

As a result of these failings it is now proposed that ‘all urban areas [in Queensland] should have access to the results of a recent flood study’ (Queensland Floods Commission of Enquiry 2012, 54). The studies should not be restricted by municipal boundaries, rather they should ‘be completed over a whole catchment to encompass the hydrology and hydraulics of relevant waterways’ (Queensland Floods Commission of Enquiry 2012, 54). Importantly, in the case of Ipswich, a comprehensive analysis of the joint probability of flooding from both rivers should be included in any broader study. Flood maps should be made available to the public in a manner that they can be readily understood by the average person so as to understand their risk in the event of an emergency and to inform any decision to stay or evacuate. Matters to be included are the likelihood of flooding at a particular place, the extent of flooding, the depth, and 'the level of hazard to persons and property posed by it' (Queensland Floods Commission of Enquiry 2012, 69). Councils should also include an assessment of flood risk when assessing development applications in identified areas.

Further, federal, state and local governments should co-operate to ensure that appropriate flood studies are prioritized and completed in a timely manner, and that the necessary funds should be allocated. The results then should be translated into appropriate planning controls. In this regard the planning system in the state of Victoria has been held up as an appropriate model in which all aspects of areas subject to the risk of flooding have been identified and are covered by a special zone. In these zones there are controls over land use,

Figure 7. Damage to property was both shocking and extensive
(Source: http://www.b105.com.au/)

including prohibition and special building requirements.

Building controls were also examined. In Australia these operate at the national and state levels, and also through municipal planning schemes. Critical in flood risk areas are minimum floor heights which are assessed differently in different localities. Some councils set 'freeboard' below-floor buffer levels differently for habitable and non-habitable rooms, all rooms or none at all. The 'flatboard' allows for wave action and unforeseen variations in local flood behaviour (Queensland Floods Commission of Enquiry 2012, 210). It is proposed to introduce a mandatory standard minimum height of 300 mm throughout Queensland, and with discretion for Councils to increase this as considered necessary such as for the protection of heritage buildings (Queensland Floods Commission of Enquiry 2012, 211). The prescription of aspects of building design and materials is still under consideration by statutory authorities. However, various strategies employed by individual building owners included construction from concrete blocks or fibrous cement sheet, elevating power outlets, open-able louvered windows to allow floodwaters to flow through, appropriate also for ventilation in a hot and tropical climate, water resistant materials for lower walls and doors, acrylic water based paint, flood resistant floor materials, mobile furniture and equipment on wheels at the ground level and only built-in fixtures above, and construction in a manner which would enable easy dismantling in advance of floodwaters. Many of these strategies enabled a quick recovery after the floods; however, if regulated prior to construction, the cost could compromise affordability, alternatively, this could reduce insurance costs. In any event, some of the requirements are likely to be incorporated into the Queensland Development Code and local planning instruments. A new section of the Code relating Construction of Buildings in Flood Hazard Areas commenced on 26 October 2012.

The location of lifts and electrical equipment, the protection of sanitary drainage backflow, the failure of electrical pumps due to submersion and impact damage, is also being considered for the building design stage (Queensland Floods Commission of Enquiry 2012, 210-211, 213, 225). The other strategy which became evident was to have an efficient evacuation procedure so as to also enable a fast recovery, particularly for commercial premises.

The floods also created havoc with Brisbane's transport system and river architecture. Brisbane's 'River City' image derives from 'its impressive river architecture' which includes docks for ferries and catamarans, bridges (Queensland Floods Commission of Enquiry 2012, 159); over 400 private pontoons, and a floating walkway. This infrastructure was severely damaged, and detached elements became waterborne missiles endangering navigation and bridges.

The aftermath of the January 2011 floods revealed the extent of pollution and debris, much of it hazardous, which littered the industrial and commercial areas in Brisbane's south. While industry is often located on land subject to the risk of flood, it also poses a significant risk for the wider surrounding area. Agricultural runoff and mining sites also pose similar risks as do carcasses and snakes. Legislation controls the storage of dangerous

Figure 8. Carried to safety (Source: sewprimkhris.blogspot.com)

goods, and it has been recommended that the relevant sections of the 'Environmental Protection Act 1994' be amended to require the risk of flooding to be considered in relation to development applications and change of use for sites potentially at risk.

Needless to say, other recommendations have been sent to be reviewed by municipal emergency management plans, and flood evacuation plans. Councils are responsible for municipal emergency plans, and it is of interest that some individual businesses had prepared their own evacuation plans which minimized damage to stock and enabled a speedy recovery; these efforts were commended by the Commission as common sense measures(Queensland Floods Commission of Enquiry 2012, 395-396). Co-operative efforts between councils and businesses have been encouraged as has the establishment of local disaster management sub-groups and evacuation sub-plans, to include information for potential hazard-affected areas including 'safe evacuation routes, estimated evacuation timelines, transport requirements and traffic management strategies'(Queensland Floods Commission of Enquiry 2012, 396)

3 Cyclone Yasi

Severe Tropical Cyclone Yasi reached northern Queensland in the early hours of Thursday, 3rd February 2011 by which time it was a Category 5 Cyclone. Hundreds of homes were damaged and 170,000 people were left without power. The damage bill was estimated at A$3.6 billion, making it the costliest tropical cyclone on record to hit Australia.

There is an annual cyclone season in northern Australia, and the level of preparedness is high. Various monitoring bodies issued frequent warnings and prediction models proved to be accurate. Having been through such an event before, residents were well-rehearsed and prepared; and the emergency response unrolled as intended. Only one unrelated death occurred; this is in stark contrast to the Victorian bushfires and the Queensland floods. Through familiarity with a real experience, terrifying nonetheless, people knew what to expect and what to do. They survived even though in the event, Yasi was more severe than anyone had imagined.

4 Conclusions

While the bushfires and floods were on a catastrophic scale, subsequent enquiries highlighted that despite a belief that disaster preparedness was of a sufficiently high degree so as to be able to cope with future emergencies; deficiencies, often serious, were revealed in the emergency response plans and in the failure of individuals to properly prepare themselves. However, the fires and floods were unprecedented in living memory and beyond imagination. It is often human nature and capacity which causes preparedness to fail when put to the test. Lack of real-life emergency experience and competing priorities can lead to complacency which can undermine even the best level of risk preparedness, particularly if a previous occurrence of an emergency has faded from living memory.

In closing, the Queensland Floods Commission of Enquiry opined:

> 'And there is a risk that the recommendations made here will be enthusiastically taken up in the short term, but, absent another flood disaster in the next few years, priorities will drift and the lessons will be forgotten' (Queensland Floods Commission of Enquiry 2012, 396).

A final strong message from the 2009 Victorian Bushfires Royal Commission is:

> 'The simple message is that everyone who lives in (or visits) bushfire-prone areas in Victoria

needs to understand that fires can occur regularly in those places during summer. When bushfires – particularly fast-moving fires of extreme intensity – occur in populated areas, there is potential for tragedy.

Sound preparation and effective responses on the part of the State, municipal councils, the community and individuals will collectively help to minimise harm' (2009 Victorian Bushfires Royal Commission 2010, Vol. 2 (2) 356).

and

'The State's bushfire campaign should bluntly deliver the message that ultimate responsibility for health and safety lies with individuals, that tragedy can come suddenly, and that bushfire can kill or have lifelong consequences' (2009 Victorian Bushfires Royal Commission 2010, Vol. 2 (2) 356).

These lessons have similar parallels, and may be applied internationally.

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Promoting a Culture of Prevention versus Recovery

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Abstract. A culture of disaster prevention over recovery needs to be further developed, promoted and implemented, including for the protection of our cultural heritage. Globally, the number and severity of disasters are increasing. Adverse impacts continue to rise in terms of cost, loss of life and persons impacted. We have surpassed the USD 1 trillion mark in disaster costs since the turn of the 21st century. Approximately 225 million people are adversely impacted each year (CRED 2011), within these numbers are losses to our cultural heritage. A number of hazards are not preventable, however pre-planning, preventative and mitigation measures can greatly help reduce their impact. While some hazards may be more challenging to mitigate, there are significant methods of low cost/high impact prevention and mitigation measures that can be implemented and have positive implications. Resources and further attention therefore need to be focused on creating awareness, building capacity, developing legislation, codes and guidelines, engaging stakeholders; including governments, emergency responders, communities, insurers, global heritage organizations, craftspeople and designers in disaster prevention/mitigation efforts, rather than waiting and spending valuable resources on disaster recovery efforts that can amount to one to two orders of magnitude more. This paper provides an overview of these challenges and the need to further strengthen and support the movement to a culture of disaster prevention versus recovery given the significant beneficial impacts, and better investment from a cost-benefit perspective than through disaster response and recovery, and help better protect our cultural heritage.

1 Background

Disasters continue to impact lives and cause significant damage each year. The impacts of climate change and future trends indicate that this will continue to increase in the coming years. Efforts are underway to address disasters in all phases including prevention/mitigation, response and recovery. Greater movements are being made towards prevention given the benefits of addressing hazards beforehand. The impact to cultural heritage is a subset of these disasters being significantly impacted, and the role cultural heritage structures and sites play in society. There are numerous actions that can be undertaken and initiatives one can support to limit the impact of disasters on cultural heritage related structures and sites. An overview of these actions are provided herein.

2 The Impact of Disasters

2.1 Losses to life

The year 2011 saw a significant loss of life and numerous injuries related to disasters. In this year alone, there were approximately 325 total catastrophic events (175 natural disasters versus 150 man-made) that in total claimed 35,000 lives. Over 19,000 of these lives were lost in the Japan earthquake and tsunami while Tropical Storm Washi in the Philippines, and the floods in Brazil and Thailand claimed 3,000 more lives.

While these numbers are significant, they were less than the 2001-2010 annual average of over 100,000 disaster related deaths per year. This was primarily due to the lower number of deaths from geophysical disasters in 2011 (CRED 2011).

2.2 Impact to people and livelihoods

There were over 244 million people affected by disasters worldwide just in 2011 (1 in 30 people globally) (CRED 2011). This is an increase over the annual average number of people affected from 2001 to 2010 of 232 million (CRED 2011). This increase is in part due to the larger impact from hydrological disasters. Hydrological disasters affected 140 million people in 2011 compared to an annual average of approximately 107 million from 2001 to 2010. It also needs to be remembered that these figures, like the other statistics, are cumulative and that from year to year there are still millions of people previously affected from prior years that are still trying to recover from these disasters, in addition to those exposed in the current year (Swiss Re 2012).

2.3 Losses to property

Total economic losses due to disasters in 2011 reached approximately USD 370 billion. This was a substantial increase compared to 2010 losses at USD 226 billion. The earthquake in Japan was the highest magnitude earthquake to have ever hit the country. This represented approximately 57% of the losses in 2011. Earthquakes in New Zealand, Turkey and other areas; and the floods in Thailand and Australia contributed significantly to these economic losses.

Natural disaster related insured losses exceeded USD 100 billion, while losses from man-made disasters were approximately USD 6 billion. This made 2011 the second-highest catastrophe loss year ever for the insurance industry. Meanwhile, two-thirds of the USD 370 billion in economic damage resides on the shoulders of corporations, governments, relief organisations, and ultimately individuals (Swiss Re 2012).

The losses to cultural heritage structures, sites, collections, artefacts, etc. are a subset of these losses. Quantifying these financially is extremely difficult particularly when a lot are one of a kind and irreplaceable. Additional discussions on losses to cultural heritage and the need to protect this better are provided in latter sections of this report.

2.4 Climate change and what lies ahead

In reviewing scientific reports and statistics regarding climate change, the trending is an increasing loss to life, property and impact on people in regions susceptible to these changes. Additionally, climate change appears to be placing more people at risk from climate induced disasters. In the past, the majority of natural disasters were caused by climate related events: tornadoes, hurricanes, typhoons, heavy rains, high winds, wildfires, avalanches, rock slides and drought. With changes to the climate there will likely be a greater frequency and intensity of these events. Given the locations of people, as well as historic structures in these areas impacted by these disasters, the risks to both will likely continue to increase.

3 Promoting Disaster Prevention Over Recovery

3.1 Overview

There is a growing understanding of hazards; that they are increasing and exposing larger populations, and having severe adverse impacts to lives, livelihoods, property and cultural heritage. This is driving the need to focus more on developing and implementing a culture based more on prevention than recovery.

3.2 Cost benefit of prevention over recovery

As noted by UNISDR, disaster mitigation and prevention are an investment. The World Bank has estimated that for every dollar invested in disaster risk reduction, between four and seven dollars are saved in the long run. In Peru, incorporating risk reduction into development investments led to a cost/benefit ratio of 1:37 (UNISDR 2009).

3.3 Prevention pays

Due to effective building codes and other disaster risk reduction measures that were implemented, the 8.8-magnitude earthquake in 2010 in Chile killed less than one person out of every 595 affected. On the other hand, Haiti's earthquake was 500 times less powerful but killed one in every 15 persons affected. No lives were lost in the 7.2-magnitude earthquake that hit Christchurch, New Zealand in 2010. In looking at the 2011 earthquake and tsunami in Japan, despite the great loss of life, more lives may likely have been lost and damage would have increased had the Japanese government not invested 5 per cent of their annual budget in disaster risk reduction measures since the last earthquake in 1995. Investments made in building codes and preparedness measures after the Japan Earthquake saved lives in 2011 (UNISDR 2011).

3.4 Alignment with global and national efforts

3.4.1 Overview

There are several different global, national and regional efforts underway to help limit the impact of disasters on a very broad scale. A few are mentioned herein. As seen the emphasis is moving towards prevention and mitigation of disasters rather than response and recovery, though the latter are important components as well. Aligning with these efforts underway can increase the synergies and reduce redundant efforts in helping to reduce hazards and the impact of disasters.

3.4.2 Alignment with Hyogo framework

Three weeks after the tsunami in the Indian Ocean killed approximately 250,000 people in January 2005, over 150 governments convened at the second World Conference on Disaster Reduction, in Kobe, (Hyogo). There, they agreed to a 10-year plan to reduce disaster losses by 2015. This plan is called the 'Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters (HFA).' The HFA Plan is specifically aimed at reducing disaster risk and disaster losses, and furthering integration of risk considerations into sustainable development. The HFA sets out strategies for reducing disaster risks through five priorities for action amongst government signatories and development agencies. These priorities include:

- Ensuring disaster risk reduction is a national and local priority and has a strong institutional basis for implementation
- Identifying, assessing and monitoring disaster risks and enhancing early warning
- Using knowledge, innovation and education to build a culture of safety and resilience at all levels
- Reducing underlying risk factors
- Strengthening disaster preparedness for an effective response

3.4.3 Alignment with Millennium Development Goals

A large proportion of populations that are impacted by natural disasters live in countries with low to medium human economic development. Disasters are one of the biggest obstacles to achieving the millennium development goals (MDG). These disasters can often reverse development gains. As the frequency and severity of disasters increase in the world, achieving the MDG will be very challenging without integrating disaster risk management approaches in different national policies and development interventions. Addressing disaster risk and vulnerability, and limiting these hazards from becoming disasters can assist in furthering achievement of the MDG (UNDP 2010).

As noted in the 'Parliamentarians Plan of Action for Making Millennium Development Goal Programmes Disaster Resilient', adopted at the Consultative Meeting for West African Parliamentarians, Dakar, 2 June 2010 (UNISDR 2010)

> 'We cannot achieve the Millennium Development Goals without addressing disaster vulnerability, risk and the impact of climate change. Disaster Risk Reduction should be an integral and essential part of our strategies and programmes, aiming to avoid the creation of additional risks of disasters and climate changes' effects in the development process'.

3.4.4 Alignment with UNISDR

The United Nation's office vision is: 'To enable all communities to become resilient to the effects of natural, technological and environmental hazards, reducing the compound risks they pose to social and economic vulnerabilities within modern societies', as well as to 'proceed from protection against hazards to the management of risk through the integration of risk prevention into sustainable development'. as defined on their website. They have numerous programmes underway serving the needs of numerous stakeholders in a myriad of ways. These cover all phases of disaster management and have a strong focus on prevention and mitigation. They produce documentation related to disaster management and facilitate international conferences on the subject as well.

4 The Need to Change How We Protect Cultural Heritage

4.1 Drivers of change 1: we continue to lose our heritage to disasters

Included in all of these losses is the subset of losses related to the impacts and irreparable damage caused to cultural heritage. These are felt locally, regionally and globally. Historic towns and cities, archaeological sites, monuments, landscapes and structures are being severely damaged and/or lost forever. This includes physical property and artefacts, spirit of place, as well as the significance and function to local communities that they represent. This also includes sacred sites, places of worship, museums, libraries, education facilities, and archival centers, as well as artefacts and records, whether they be of artistic, historic, educational or of social importance (Jigyasu and Marrion 2011).

On a broad scale, there have been recent losses to numerous cultural heritage sites due to earthquakes in Iran (2012), Italy (2012), Turkey (2012), Japan (2011), New Zealand (2011) which included the Christchurch Cathedral and numerous other historic structures there, and Haiti (2010) with significant damage to the historic colonial town of Jacmel. Floods have adversely impacted numerous historic structures as well, including those at the Ayutthaya World Heritage Site in Thailand (2011). Fires continue to devastate numerous structures including those recently at the Wangduephodrang Dzon in Bhutan (June 2012), Krasna Horka Castle in Slovakia (2012), and Srinagar's Dastgeer Sahib Shrine (2012) (Jigyasu, Douglas and Marrion 2012).

Cultural heritage sites and structures have also been extensively damaged due to armed conflict and civil unrest. Examples include damage to museums and heritage sites during civil unrest in Egypt and Libya last year; the ongoing conflict in Syria; and destruction of the Sidi Mahmoud, Sidi Moctar and Alpha Moya Mausoleums in Mali, three of the 16 mausoleums that form part of the World Heritage property of Timbuktu.

It is challenging to compile information as to the full extent of damage to sites, buildings and contents, let alone trying to put a monetary value on these one of a kind, unique structures, collections and artefacts so it is difficult to exactly quantify the losses and their specific monetary value. Various reports have been developed to give an idea of the impact that disasters have had on our cultural heritage. These includes reports from Japan following the Kobe Earthquake. For example, Murakami reports that in the Hyogo Prefecture, 46 national cultural properties, 54 prefecture-designated cultural properties, and 43 municipal-designated cultural properties were damaged, corresponding to a total damage worth more than 8 billion yen. The report also discusses the impact to the 'brewing tools of Nada' which are designated as important tangible folklore cultural assets. Sake brewing in the Kobe area dates back to the 1300's, and brewing facilities were severely damaged. Approximately 300 Japanese sake brewing houses which accounts for 95% of brewing houses collapsed (Murakami 2011).

These losses and damage resulting from various hazards do not just impact the structure and contents. They also have an impact on lives, livelihoods, local economies, cultural traditions, education activities, and the role and 'spirit of place' that these structures and sites represent to the local communities, as well as the world.

4.2 Drivers of change 2: we need to protect our collective cultural heritage

There are a number of reasons we need to protect our cultural heritage from disasters.

4.2.1 Role of Cultural Heritage

Cultural heritage plays a significant role in society globally, nationally and locally (Jigyasu, Douglas, Marrion 2012). This includes for instance the reliance local communities place on cultural heritage including:

- To act as a local meeting place and strengthen relationships with their community, region and their country;
- Assist in shaping residents' and visitors' sense of identity and place, and maintain community pride and a sense of belonging;
- Serve as physical anchors within a community;
- Provide a sense of identity and a link to the past and contribute to creating a unique local and regional identity; and
- Provide an area of refuge for people who are searching for a known source of comfort and identity after a disaster.

These sentiments are echoed by Yasumichi Murakami, Director of Cultural Assets Office, Hyogo Prefecture Board of Education siting the impacts of the Kobe Earthquake in Japan 10 years later, 'Under this situation, there has emerged a growing awareness that the loss of cultural properties and their values as society-related capital is essentially the loss of a common catalyst that creates a 'sense of place' for all generations of people' (Murakami 2011).

4.2.2 One-of-a-kind

Cultural heritage structures, collections, artifacts and other elements are typically one of a kind. Once they are damaged, destroyed, or lost, replicas can be made obviously, but the original is gone. It is therefore important to protect these elements given the rarity and the significance that each represents.

4.2.3 Cultural tourism

Cultural tourism has been defined by the ICOMOS Charter for Cultural Tourism (ICOMOS 1997) in part 'as that activity which enables people to experience the different ways of life of other people, thereby gaining at first hand an understanding of their customs, traditions, the physical environment, the intellectual ideas and those places of architectural, historic, archaeological or other cultural significance which remain from earlier times. Cultural tourism differs from recreational tourism in that it seeks to gain an understanding or appreciation of the nature of the place being visited.'

Throughout the world, cultural resources facilitate heritage tourism and contribute billions of dollars annually to local and regional economies. This includes increasing local jobs, increasing local real estate values, supporting local businesses, and providing additional tax money. It is important therefore from both a communities' emotional as well as economic interest, to plan to appropriately protect these resources and to prevent or at least limit their loss due to disasters.

4.2.4 Cultural Heritage Educational Facilities

Places where tangible and intangible aspects of cultural heritage are taught and learned are extremely important to society as well. These places allow people and younger generations to learn of local traditions, spiritual practices and culturally significant experiences so that they may continue on for generations to come. Without these places, there may be challenges in readily facilitating and continuing on with these practices, traditions and experiences which contribute to the strengthening of one's cultural heritage. As one example, the 2010 Earthquake in Haiti killed about 1,300 teachers and 38,000 school children, and destroyed or damaged more than 4,000 school buildings. This damage represents 80% of the schools in Port-au-Prince (UNISDR 2012). Therefore, educational related facilities, which at times may also be historic buildings and sites themselves, should also be protected from various hazards.

4.3 Driver of change 3: the need for a culture of prevention versus recovery

4.3.1 Recovery is not the only answer

As noted above, addressing hazards while they are happening, or after the fact during the recovery period is not the most effective way to go about saving lives, limiting the impact to people and livelihoods, reducing damage to property or protecting our valuable cultural heritage. There is a genuine need to continue to develop and support the change to a culture of prevention versus one of recovery, as well as significant benefits in saving lives, property and our cultural heritage from irreparable damage and loss.

4.3.2 Alignment with UNESCO and others

UNESCO's 'Operational guidelines for the implementation of the world heritage convention' (UNESCO 2011) includes requirements for developing Management Plans for World Heritage Sites. Within this as well, are the following recommendations by UNESCO with regards to developing and integrating not just disaster management plans, but those focused on risk preparedness into their Management Plans.

> 118. The Committee recommends that States Parties include risk preparedness as an element in their World Heritage site management plans and training strategies.

4.3.3 Contributing to local economies

As previously indicated, heritage tourism is a multi-billion dollar industry and needs to be maintained. Failure to protect this can have significant impacts to local economies not only for the specific site, but also for the surrounding community; this includes supporting restaurants, lodging, transportation, local shops and artisans. Adverse impacts to these sites that require them to be shut down for some time can therefore not only impact the cultural heritage aspect of the site, but also economically impact the site and local community.

4.3.4 Financial impact to local community - a brief case study

As an example of the potential financial impact a disaster may have, one could look at the theoretical losses from the fire aboard the Cutty Sark. During restoration work back in May 2007, a fire started aboard the Cutty Sark that caused an extensive amount of damage and delayed its opening to April 2012.

The financial costs related to the fire damage alone were indicated to be on the order of USD 7-15 million (Heritage Daily 2012). In addition, there was considerable lost revenue during this time not only to those involved with tourism related directly to the Cutty Sark, but also those businesses and livelihoods in the area depending on tourists and visitors coming to Greenwich to visit the ship. As a first order approximation of losses, it is indicated that the Royal Museums Greenwich welcomes over 1.8 million British and international visitors a year. With tickets ranging from USD 9 to USD 15 for adults, this potentially represents USD 25 million per year of direct revenue for entrance just to see the Cutty Sark. It does not account for all other expenditures locally spent on food, souvenirs, transportation, etc. while visitors and tourists are enjoying their stay, that figure may be in the same order of magnitude as the ticket sales.

5 Promoting Prevention Over Recovery in Protecting Cultural Heritage

5.1 Objectives/goals

In promoting an environment of prevention over recovery, it is important to understand some of the issues/challenges, identifying which prevention measures need to be done and which can be done, defining the drivers of change to be implemented, and then developing plans for how this can all be accomplished.

The following provides some initial recommendations and opportunities for international organizations including ICOMOS that encompass recommendations across the various drivers of change.

5.2 Creating awareness

One of the first elements is creating awareness with regard to the need, importance and benefit of prevention over recovery.

There are numerous entities/stakeholders that need to be made aware. Each has their own perspective and potential to impact these efforts. These range from policy makers/government, enforcers, owners/managers, designers/engineers, funders and banking institutions, insurers, crafts/tradespeople, international and local organizations involved in preservation and cultural heritage, as well as the general public.

There are also numerous modes of communicating the need of promoting the concept of prevention over recovery to help develop further awareness. These can be through news services, conferences, training/workshops, articles and papers, as well as working with associations and organizations on committees.

Part of the success of being able to communicate the need to focus more on prevention is also to understand local cultures, challenges, traditions, customs and methodologies in order to help develop sustainable solutions.

As an example of creating awareness and building capacity, based on prior experience of disaster response, the Hyogo Prefecture Board of Education developed an initiative to develop human resources who would participate in community development efforts. They have offered 'Hyogo Prefecture heritage manager training seminars' since 2001 in collaboration with the Hyogo Association of Architect Building Engineers (Murakami 2011). The seminars enroll applicants from various occupational backgrounds, from people engaged in design and construction, to members of government offices and artisans. In addition to the cultural properties, fine arts and crafts, natural monuments, and sites and places of scenic beauty are part of this successful program and engages numerous people in the community to help further develop a culture of prevention.

5.3 Engaging governments

Governments play a significant role in promoting a philosophy of prevention over recovery, including local, regional and national governments. In part, they are responsible for developing and strengthening legislation and supporting the developing of codes, standards and guidelines necessary to provide safe environment, as well as institutional frameworks. This needs to include not only new buildings and construction, but how to handle the buildings that exist already, including cultural heritage structures and sites.

Along with the codes and standards, are means that are needed to support the implementation, design oversight, reviews, implementation and enforcement. These means should be developed and coordinated as much as possible across national, regional and local levels, and technical experts could help lead these efforts and their implementation.

5.4 Enhancing the role of media

Media can have a substantial impact on creating awareness as well as helping influence movements to a more prevention/disaster risk reduction based society.

For instance, just by asking more probing questions such as: Why are disasters happening? How can we prevent disasters? Who is responsible for these hazards turning into disasters? The media can help influence political decisions, change public attitudes and, of course, save lives.

UNISDR developed a valuable resource for the media with regard to their covering disasters (UNISDR 2011). It was developed strictly for journalists and the media to learn more about disaster risk reduction issues, and the important roles that they play.

The media needs to play a role in disaster risk reduction and do more than just inform and raise awareness about disasters. They need to explore and investigate further the root causes behind disasters and their social dimensions. They also need to cover disaster risk reduction stories that can help communities and countries understand what it is that makes them vulnerable, and what they can do to increase their capacities to prevent and mitigate disasters, and cope with disasters. As noted by Margareta Wahlström, UN Special Representative of the Secretary-General for Disaster Risk Reduction, in the Foreword to this work:

> 'You are much more than a simple mirror of society. You are a powerful force that can change the minds of people. You can influence policy change and, together with other development stakeholders, bridge the information gap between communities and governments. You can help make populations safer and change the world from a culture of reaction to a culture of prevention'.

5.5 Supporting capacity building/training

Capacity building and training efforts are needed for stakeholders involved with cultural heritage, with content developed on a variety of subject areas and the depth to reach the necessary levels required for the target audience. This includes government, emergency responders, designers, craftspeople, insurers, owners/operators, etc. that are involved with cultural heritage sites. Depending on the role of the specific stakeholder, there is a significant amount of information and level of detail in policy making and development of codes, general disaster management approaches, developing tailored strategies, and assisting local craftspeople and tradespeople in reducing disasters such as fire during their restoration work.

Developing supporting information that is accurate, easy to read, easy to understand and relatively easy to implement are key. A lot of times this information can be developed and passed along to others for further distribution and communication such as the training that is being implemented with school children in Japan with regard to disaster awareness, early warning and proper response procedures.

5.6 Implementtion and Demonstration Through Project Work

One of the best ways to teach prevention is through demonstration and hands-on experience with actual projects rather than through reading or theoretical analyses. We should look to train and develop the technical capacity of those involved with training, as well as documenting for instance what training decisions were made, and why they were important for the subject site. It is also of equal importance when involved on these projects to listen, understand and incorporate as appropriate local knowledge, skills, materials and techniques, as a lot of times local builders have developed building systems that can withstand local hazards. It is also important that systems that are developed and implemented are sustainable, and that there are local people that have the knowledge, experience and tools to maintain/service these systems. Recent training efforts involving close interaction with local people and training the trainer have shown the benefits of how this information is passed forward (UNESCO/ICCROM 2011).

5.7 Finding each other

5.7.1 Finding stakeholders

It is important to identify the various stakeholders that are in need of expertise, and having technical experts engaging with them. This includes directly engaging these stakeholders, writing articles and editorials for newspapers, speaking at various venues outside one's normal area (i.e. museums), and even engaging in conferences attended by other stakeholders (i.e. media experts) in addition to conferences talking with peers. It is important to reach out and provide input as at times, stakeholders may be uninformed or misinformed as to hazards and specific risks.

The Iceland volcanic eruption of 2010 was not a disaster in terms of life lost, but had significant impact on flights and global travel, and an interesting story that reveals what we do not know. The volcanic eruption resulted in the biggest shut down of European airspace since World War II. In terms of experts and risk assessments, Prof. Beddington stated: 'We didn't expect volcanic ash - that wasn't on our risk assessment. It probably should have been when you look at the relative frequency of volcanic events in Iceland. We should have had that on the risk register'. When asked whether the government had gotten it wrong regarding volcanic ash, Prof Beddington replied: 'We failed to predict it was a likely event - absolutely' (BBC 2011). Engaging experts in volcanoes and studying past volcanoes, wind directions, modeling of movement of smoke/ash, etc. could have helped limit the impact from the Iceland volcanic eruption.

5.7.2 Finding and engaging technical experts

It is important that the various stakeholders are aware of the importance of integrating technical experts in disaster risk reduction and cultural preservation. It is just as important that they are able to find technical experts. These experts not only need to be technically competent, but open to understanding local cultures, methods, materials and resources; establishing sustainable solutions, limiting the impact of these solutions on the aesthetics of the site and structures, and develop solutions that are cost-effective and provide low cost/ high impact solutions. Means should be available to help identify these experts such as websites for various technical committees.

5.7.3 Engaging other stakeholders – top down

It is important to create awareness, as well as engage stakeholders involved with protecting cultural heritage at different levels. Stakeholders include governments, emergency responders, funding/grant agencies, cultural heritage organizations and associations, insurers, designers, preservationists, crafts/tradespeople, owners/ residents/managers, and numerous others. Supporting a top down approach can have significant benefits and can help expedite the provision of technical assistance when and where needed. Through engaging these entities at high levels early on, creating awareness that there are measures that can be taken to reduce risks and vulnerabilities, providing technical support as to approaches to disaster risk management, identification of hazards, developing alternatives to address vulnerabilities, assisting in implementing these, training local contractors and crafts/tradespeople, etc. and training the trainer, one can have a large impact on how quickly disaster risk management can filter down through the various levels, and gain support and finances.

In summary, a culture of prevention over recovery has numerous benefits, including saving lives and protecting our cultural heritage. Technical experts play key roles in numerous ways and should seek to help support this ideology whereever and whenever possible.

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Rapporteur Notes

Roundtable Discussion Report

Rapporteurs: Amel Chabbi and Sheridan Burke

The symposium audience was organized into roundtable discussion groups according to the themes of the symposium. An author from each theme was assigned to lead the discussion and report back after the discussion session. Each group identified challenges and opportunities for their particular theme, proposing relevant actions and suggestions as to how ICOMOS could play a role in implementing such actions.

Group 1: Mitigating risks (Randolph Langenbach)

The following challenges and opportunities were identified:

- Education is key. ICOMOS needs to expand its influence so that children at an early age know about ICOMOS and its work, about material culture, cultural heritage, how to build, and learn handy crafts in order to restore the dignity of working with one's hands.
- Peer-to-peer education is important. It is essential to become active at university levels in architecture, engineering, architectural history, etc., in order for conventional professions to know more from preservation professionals.

Actions proposed included:

- ICOMOS International Scientific Committees (such as ICORP – International Committee on Risk Preparedness, and ISCARSAH – International Scientific Committee on the Analysis and Restoration of Structures of Architectural Heritage) should collaborate more together, analyze building construction methods, document traditional techniques and the structure of buildings. Understanding these is key to building stronger buildings.

It is crucial to raise awareness and educate the general public that traditional buildings are not inherently dangerous, as well as educate insurance companies about how traditional buildings are more resistant.

Group 2: Methodology and tools (Koen van Balen)

The following challenges and opportunities were identified:

- Understand heritage value, and explicitly, consistently and transparently assess heritage value.
- Identify the impact of events that have a certain probability.
- Perform more risk-assessment studies and adapt the existing knowledge of insurance companies on heritage by connecting their evaluation to quality rather than quantity.
- Stress the importance of monitoring to assess what the risks are and their impact.

Actions proposed included:

- Short-term: Exchange good practices (for example, Chinese villages), and set up activities to respond to the challenges listed above.
- Mid-term: Develop tools, such as geomatics, and more handbooks.
- Long-term: Implement pilot projects, evaluate these and propose recommendations.

Sharing the outcome of this symposium with International Scientific Committees and National Committees would be a first step by ICOMOS to ensure better coordination. For instance, a draft document was prepared in Paris on risk preparedness, but it should be revised and discussed within the ICOMOS forum.

Group 3: Protection during conflict (Samir Abdulac)

The following challenges and opportunities were identified:

- The conflicts in Mali, Libya, Syria and Tunisia are a result of ideological conflicts.
- Properly leveraging the media can help raise awareness and educate.

Actions proposed included:

- In the short term, inventories should be systematic and properly safeguarded.
- Public-awareness campaigns on the threats of armed conflict to heritage and on the Hague Convention need to continue.

ICORP and other International Scientific Committees should share ideas on how to develop standards for rapid inventories and create educational kits to raise awareness. Web-based training should be provided for professionals who are living in areas affected by disasters. Standards and approaches for reconstruction of destroyed heritage should be studied by the relevant International Scientific Committees.

Group 4: Post-disaster recovery (Luigi Petti)

The following challenges and opportunities were identified:

- Recovery plans should take into consideration the landscape, urban and rural areas, as well as local traditions.Measures have to respond to immediate needs and should not affect the identity of place and the integrity of the cultural heritage and landscape.
- There is a need to consider tangible and intangible values of the environment and landscape as a whole, without defining hierarchies of value between different components: cultural heritage, housing, production, facilities and territory, etc.
- A multi-disciplinary approach should guide the rationale.

Proposed actions include:

- Document the resource preferably before, but as an absolute necessity immediately after a disaster.
- Develop knowledge of the place, cultural heritage and traditions.
- Implement training courses for management of post recovery.
- Develop protocols and guidelines for post recovery.
- Improve the perception and knowledge about the value of cultural heritage.

The role ICOMOS could play includes providing an interface between private institutions and the public; creating stronger relationships between international organizations for post recovery (like UNESCO, Blue Shield, Red Cross); providing direct support in the disaster zone through deployment of experts; and transferring experience and knowledge through networking.

Group 5: Capacity building and awareness raising (Christopher Marrion)

The following challenges and opportunities were identified:

- There is a lack of procedures and proper channels for communications.
- Identify the right people to build capacity and raise awareness. Involve experts.
- The press and media are not focused or interested. Train media to provide targeted information.
- Training is not a priority until a disaster happens. Train and educate owners and stakeholders.
- Heritage is not on the agenda in regional/national disaster planning. Raise awareness and build capacity.
- Very few heritage disaster-management plans exist.
- There is a need to remember history.
- Disaster relief funds are not properly channeled. There is no money for risk preparedness, particularly for heritage.
- Turn a disaster into an opportunity for community building.

Proposed actions include:

- Identify the stakeholders among policymakers, media, scientists, public, heritage professionals, and first responders.
- Short-term: Identify knowledge gaps; build awareness among young professionals, scientists, media, emergency responders; build capacity; engage the general public (for example, as was done in Japan); cross-pollinate within various groups (government, ministries); develop national strategies on managing disasters, which address cultural heritage; create awareness that disasters can happen.
- Mid-term: Develop a standard structure for disaster-management plans and prepare plans.
- Long-term: Implement, monitor regularly, and maintain buildings and heritage resources properly.

ICOMOS can play an important role by providing a common voice for disaster prevention and risk preparedness for cultural heritage. ICOMOS could assist in building capacity and developing training programs, where ICOMOS could award an ICOMOS-endorsed certificate. A handbook of best practices should be developed in collaboration with CIF (International Committee on Training). Awareness can be raised by establishing 'risk preparedness' as a theme for an upcoming 18 April celebration (International Day for Monuments and Sites). ICOMOS needs to engage more fully with other institutions such as Blue Shield. A means of communication should be established (webpage, targeted information, database for experts, etc.). ICOMOS should conduct a gap analysis regarding risk preparedness and disaster recovery. ICOMOS should encourage UNESCO to require disaster-management plans for World Heritage sites.