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P.A.T.C.H. – Prevention, Analysis and Tools for Cultural Heritage

GUIDELINES

FOR PROTOCOLS AND PROCEDURES FOR THE RESCUE OF CULTURAL HERITAGE ITEMS DURING SEISMIC EVENTS

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1. Prefazione

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1. Introduction

Several major earthquakes have affected European countries intermittently over the centuries. Important parts of the Cultural Heritage (CH) of inestimable value have been lost such as those in Italy by only taking into consideration the last 15 earthquakes, which initially struck the city of Assisi and then the city of L'Aquila. Damage could be caused by indirect effects of the earthquake, such as fires, floods, emergency teams treading over the damaged area and robbery due to lack of security, and not just by the direct impact of the seismic event. However, compared to the past, the advancements in knowledge and the development of intervention technologies, together with the raise of awareness and increased ability to share experiences, allow mediating significantly on the consequences of these terrible events. As a consequence, in the scenario of an earthquake there is significant improvement of the interventions that should develop alongside the work of qualified operators in order not to cause further damage during the rescue of Cultural Heritage items.

The gained understanding in the specific field has shown that it is of paramount importance for the safeguard of works of art that correct pre-emptive measures are taken before an earthquake strikes. Furthermore, it has been made apparent that the absence of maintenance procedures during the prevention phase ("peace time") could amplify the destructive effects of earthquakes. The sharing of the experience of past interventions amongst operators facilitates turning lessons learnt, specialized techniques and innovations into best practice.

Past experience has shown that good communication between all the relevant actors is a key factor to efficiently prevent risks and manage safety, to attain well-timed response in order to avoid further damage caused by improper procedures and interventions over and above by the seismic event itself and to take immediate action if items are to be protected in their original location or have to be removed.

Thus, it is crucial, that all operations, methods of exchanging information and communication procedures are decided and set up. Acting on the spur of the moment with only aiming to "save the items" can cause further damage to the items and threaten the operators' lives.

Protection of human life remains the primary goal even when protection of works of art of universal value is involved. Thus, best practices applied and shared by all operators not only are a contribution to the safeguard of the national CH but are also a factor of diminished risk to human lives.

Cultural Heritage policies and Civil Protection have a major role in each European member state. In the case of a seismic event, all specialised operators (Civil Protection Operators: fire-fighters, army, emergency health assistants) are called to protect both people and Cultural Heritage items; and there are also experts in the field of the safeguard of works of art whose task is to enact the established procedures.

Identifying clear and simple rules, which may appear to be obvious but are often disregarded, is clearly considered a starting point for drawing up a European prevention plan for the safeguard of Cultural Heritage items in the case of earthquakes.

The Guidelines describe a set of "Golden rules" that imply a census of the items, their classification, routine maintenance and emergency planning. These rules refer to all organisations and museums and the relevant authorities as well as those improperly considered as "minor" actors.

The aim of these guidelines is to set up a series of procedures which the operators, working on prevention and in emergency situations, must carry out in order to act efficiently on protecting works of art, describing for the first time intervention procedures in master plans. The guidelines are based

on the assumption that interventions in emergency situations are effective only when all the necessary prevention activities and planning are carried out in the prevention and routine maintenance phases and they are supplying a good strategy on how to act.

Previous reactions to earthquakes have shown that the lack of pre-set procedures required extra conservation interventions, compromised timeliness and efficacy in carrying out operations during the emergency and, moreover, caused the loss of precious information of methods and practices adopted in preceding interventions. Common rules for behaviour and procedures would allow non-invasive actions and extreme efficiency in terms of results.

These guidelines take also into consideration the importance in the effective rescue of the works of arts that entails the presence of very skilled operators, familiar with good practices, who can support decisions taken at management level on conservative actions and who can also carry out basic and adequate interventions during the emergency phase.

The chapter 2 defines the area of applicability of the specific work specifying how it should be used. Then challenges the definition of the Cultural Heritage items and classifies them in accordance of their type and category. It also describes briefly the various scenarios in accordance with the severity of the event as well as the type and importance of the Cultural Heritage item affected. At last, states the chain of command and introduces the Cultural Heritage Designated team.

The chapter 3 advises on the safety measures: procedures, equipment, tools and technologies that should be adopted and used to ensure all actions are carried out considering risks and prioritising safety.

The chapter 4 describes the various common operations that emergency teams are called to fulfil and introduces the concept of the Cultural Heritage Defenders.

The chapter 5 is advising on technically simple and cost effective methods of assessing the vulnerability of the buildings

and containers of Cultural Heritage objects. Then it also evaluates the vulnerability of the Works of Arts and details a specific classification that should be adopted. On basis of that categorization, it suggests various intervention actions.

The chapter 6 initially defines the Protocols and procedures for the protection of Cultural Heritage items in general terms, advising on the "Golden Rules" that each member state should implement to prevent damage and further protect the Cultural Heritage objects. It specifically refers to Frescoes and wall paintings, Paintings on canvas, Icons, Natural science museums, Libraries and Archives.

The chapter 7 aims to define the Cultural Heritage Structures and Urban Fabric with historical/traditional interest and analyses methods for their protection. Various innovative procedures are suggested to identify and mitigate risks as well as to efficiently and successfully activate economical and social mechanisms to achieve better outcomes.

2. Area of applicability

The following chapter defines the term "Cultural Heritage" and suggests the Guidelines to enact measures for the protection of CH items in the case of an earthquake.

According to the Italian Legislation for the Cultural Heritage published on 22/01/2004, Cultural Heritage items are defined to be immovable and movable objects belonging to the State, Regions, other local governments, as well as any other public body and institution, and private non-profit, including legally recognized ecclesiastical authorities, who have artistic, historical, archaeological or ethno-anthropological interest. There are also other types of cultural documents and libraries, as well as property owned by individuals if declared as such by the local superintendent with a declaration. Common sense defines Cultural Works of Art as "Cultural Heritage" or "works of historical and artistic value". CH includes a huge variety of objects, places, areas, buildings of different nature and typology because of the materials used and their manufacture method adopted.

One could attempt to define this category in general terms as *all works of archaeological, historical, artistic, environmental, landscape, book and archival interest which are the product of human culture in each nation, as well as any other product which is the testimony of civilisation*. The traditional definition is "a set of economical, social, political, cultural forms peculiar to a certain nation in a given period".

However, this set of concepts sounds immediately inadequate since forms and objects considered important in a historical context which should be protected and passed on to future generations, such as the "tableaux vivants" of a science

museum, cannot be easily included according to the previously stated definitions.

Therefore, the guidelines apply to everything which should be passed on to the future generations being the testimony of our history, conveying also its significance along a potentially infinite timeline.

Considering the huge number of sites' categories and items as regards materials and risk scenarios with regards to the seismic events, the guidelines initially propose a classification of the CH items followed by an analysis of the type of intervention on certain items in relation to the various CH systems previously categorized.

The diversity and the width of the field of action stipulate the accurate determination of prevention, emergency and post emergency measures. The guidelines are applicable mainly to the emergency phase – a crisis caused by the seismic event – following which, measures are enacted for the safeguard of people and objects.

The principle expressed by the "Golden rules", detailed as guidelines in this document is that this phase's actions and procedures must be immediately available when the seismic event – by its not foreseeable nature – takes place.

The procedures, which the guidelines refer to, must be endorsed when the impact of the event hits an area, a place or a building where works of art are present.

Creating protocols and emergency procedures to be implemented during and after the event is deemed to be adequate but not the only requirement. It is understood that, although it is not possible to know the "if" and "when" an earthquake will take place, it is still mandatory to be prepared by putting in place procedures to prevent possible damage to happen and also by training of intervention teams. Therefore, the aforementioned protection activities that should be adopted during the prevention phase do not have a predefined time limit, but should be carried out constantly such as routine maintenance that responds to technical and organisational criteria defined by conservation managers should.

This phase known as "prevention" phase includes all that happens before the event, but which takes also into account

how the items or the sites must be protected to prevent possible earthquake damages.

The actions included in the prevention phase account to the general consensus that the CH objects could be damaged not only by the earthquake itself but also by events associated with and initiated due to the earthquake. As for instance, the mass of the fallen debris due to falling parts of the building could destroy works of art. In this specific example, an act of prevention would be to, place the works of art in such a position that the fall of debris would not damage them. More specifically, they could be put out of range or the rate of static vulnerability of the walls could be reduced. Another type of preventive measure is the creation and update of an inventory for the CH items present on the territory in order to be able to access all the necessary information in the shortest possible time and accordingly enact the most appropriate procedures.

This example shows that if an emergency team acts in a certain location with the precise notion of the value of the works of art kept in there, all decision regarding selective interventions (where first, what to retrieve first …) can be accessed and implemented rapidly and efficiently. It is obvious that in emergencies time is a risk factor and not wasting it is crucial for the human safety as well as preventing further damage to the CH items.

The guidelines cover the period of time since the first organisational and technical preparation phase should happen to when the item or the site is stabilised or moved to safe storing areas.

All restoration activities, which sometimes may even take years, aiming at restoring the items to their original conditions are carried out by methods and techniques which come under the heading “retrieval or restoration”.

In order to avoid any misunderstanding the post-emergency phase includes operations subsequent to the initial intervention such as removal (if necessary), packaging, transport and storage. This phase includes also protective measures in situ “first aid” whenever intervention is possible directly in the stricken areas.

The guidelines are for the use of all operators who under any type of responsibility take part in the conservation of the items during the emergency phase (owners, authorities responsible for the upkeep, curators and museum staff, restorers, Civil Protection operators, army units, art historians and cultural society volunteers).

The line of responsibility is defined by the chain of command of each European member state. For this reason, the setting up of this system in each country both under normal times and in emergency and the consequent responsibility areas precedes these guidelines that are only coming to add precaution measures. All operators must be familiar with a clear and detailed chain of command. Also, one and all must be entirely aware of the limits of his/her responsibilities across all relevant teams and disciplines.

2.1 *Classification of Cultural Heritage items*

Cultural Heritage items are classified according to their type and category. Type refers to locations, sites and buildings grouped together homogeneously or to the number of items present for example in museums, libraries, churches etc; to the relationship between natural and built up environment (historical cemeteries or gardens/parks); to the relationship between the site and the finding (prehistoric sites or military sites). Category instead refers to the grouping of items according to material and the method of creation and/or construction. The following table 2.1.1 shows the classification of Cultural Heritage items according to sites, buildings, works of art, level of risk during a calamity, materials and construction.

Table 2.1.1 – *Classification of Cultural Heritage Items*

CH items CLASSIFIED BY CALAMITY
Locations – buildings
- Exhibition sites: museums, picture galleries, art galleries These are large buildings with a large number of generally moveable CH items. **- Libraries and archives** Characterised by their size, these hold a large number of paper items. **- Buildings, churches, interiors of architectural value** Impact generally occurs on the buildings. Theatres and buildings of architectural value are also included. **- Historical centres and other built-up areas** Impact on individual buildings and on adjacent ones. **- Parks and landscaped areas, excavations and archaeological sites** These locations are either characterised by natural elements or by CH items spread over a wide area, by the geomorphology of the territory, as well as by specific features of the CH items and by their relationship with the environment. These areas include: historical sites and cemeteries, sites with modern installations, paleontologic, prehistoric and ethno-anthropological sites, as well as sites affected in the past by natural and non-natural catastrophes and turned into open-air museums.
Classification of works – movable items
- Books and documents Great concentration of paper items – books, manuscripts, paper and cardboard artefacts (archival items, bindings, papier-mâché sculptures, newspapers, stamps, photographs, designs, engravings, prints etc.). Materials such as: paper, magnetic tapes, vellum and leather, parchment, film (including slides). **- Paintings and art objects** Various types, dimensions and materials: ceramics, glass, metal, stone, wood, leather, vellum and parchment, paintings on canvas or wood; organic material such as bone, hair, horn, ivory, shell; textiles: cloth, garments and accessories. **- Voluminous moveable works of art** Voluminous works of art which can be difficult to move such as sculptures, bas-reliefs, paintings on canvas or wood. **- Fixed furnishings and works of art** These are practically impossible to move – frescoes, sculptures and architectural elements, mosaics, stained glass windows, valuable floorings, altars, choir stalls, organs, masonry heaters and voluminous furniture.

2.2 *CH items and earthquakes: possible scenarios*

A calamity creates a complex critical situation which must be thoroughly analysed to define risks and dangers to people and objects. An earthquake is described in simple terms as the result of a sudden release of energy in the Earth's crust that creates seismic waves. Its point of origin is called hypocentre which is an underground area located at anything between a few metres and some hundreds of kilometres. From this point the seismic waves spread in all directions until they reach the epicentre which is an area on the surface of the Earth's crust located vertically to the hypocentre. The effects can be: landslides, structural collapses or cracks, overturning of objects, etc. Earthquakes are classified according to the entity of the caused damage as severe, moderate and light and in relation with the diverse risk scenarios according to the typology and importance of CH items involved as follows:

1. Severe damage – total or partial collapse, subsidence of foundations

The total or partial collapse scenario presents structural damage, collapses (total or partial), beams sliding from walls, overturning of cabinets and bookshelves, collapse of ceilings, overhead lights and plaster, collapse of staircases, deformation of window and door frames, shattering of windows. The outdoor effects are objects falling from above such as roof tiles, façade decorations etc. Flooding is also caused by the breakage of radiators and water mains. Fires are caused by short circuits and a great amount of dust is generated. Seismic landslides or ground subsidence in built-up areas are compromising part of the urban fabric.

2. Medium damage – overturned or fallen objects

In the medium damage scenario, the damage is similar to the total or partial collapse but it is less serious. There is great amount of dust, fallen architectural elements and furnishings; the ground is covered in debris. There could be possible damage to the water mains and flooding, power cuts and small fires caused by short circuits. Also, glass fragments, roof tiles, parts of façades, plaster and other debris scattered over a wide area; disrupt access to buildings creating further risks.

Additionally, there might be collateral damage to the nearby buildings.

3. Overturned or fallen objects, light damage

In the light damage scenario the damage is considered to be minimum. Nevertheless, a series of events as decribed for the medium damage scenario could happen.

The first action is to analyse the scenario and list the damages according to the entity of the earthquake (light, moderate, strong) and its effects on the structures (from light to total collapse). In parallel, there are suggested a number of scenarios that may occur due to an earthquake. These events are not always related to the intensity of the earthquake, as they may be realised in all or in any kind of earthquake, although they are more likely to worsen with the severity scale of the earthquake. It is advised that those events as they are stated in the following lines are considered simultaneously with the earthquake:

Flooding caused by inundation occurred during the earthquake or soon after, damage to pipes caused by the collapse of buildings or caving in of roofs.

Climate factors causing structural damage, changes in the environmental parameters and exposure of the CH items to adverse climate conditions.

Disruption of services (water, light, gas etc) which typically occur during a seismic event caused by collapses and ground subsidence which in turn damage the systems and alter controlled microclimate environments.

Biological infestation by organisms such as insects or rats; this phenomenon may precede the seismic event but becomes evident and is no longer contained after the collapse of structures. It can also occur in the case of destruction of the habitat of organisms which flee in search of food and shelter.

Fire can be caused by lightning, short circuits, damage to electric cables left exposed to the elements, heat, combustion.

Further damage can be caused by smoke, water and fire extinguishing products.

Explosions may be caused by gas cylinders, gas mains, fuel containers etc. present in locations where collapses or short circuits have occurred after a seismic event. These may in turn cause shockwaves, crashes and a shrapnel effect.

The subsequent tables act as reference summarising the main points of all the above possible scenarios following a seismic event on which each Member State should refer to create a more detailed scheme:

Table 2.2.1 – *Scenario of Strong earthquake – Severe collapses and subsidence of foundations*

Location	**Possible scenarios and effects**
Libraries and archives	Structural damage, collapses, damage of not bearing elements, beams coming out of walls, damage of finishes wardrobes and bookshelves overturned, ceilings collapsed according to the extent of the earthquake. Collapsed staircases, unhinged doors, shattered glass panes. Outside: fallen roof tiles, crack and detachment of plaster and external wall structures whose detritus accumulate in the streets. Damage to the water mains and risk of flooding. Great quantity of dust. Fires caused by short circuits.
Museums, galleries and picture galleries	See above
Palaces and churches	See above
Historical centres and urban fabric	As above plus complex damage caused to the urban fabric by the partial or total collapse of buildings. Access routes to individual buildings could be compromised. Collapse of towers, turrets, bell towers and other high buildings. Unstable urban fabric and need of building support and cordoning off operations.
Parks and landscaped areas Excavations and archaeological sites	Possible seismic-landslide events, subsidence and weakening of foundations, installations, archaeological remains etc. Damage to water courses and consequent possible flooding.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Overturned books from bookshelves in nearby corridors. Difficulty in keeping or re-establishing their order. This type of objects will unfortunately be covered in dust and detritus from the collapsed structures.
Paintings and object d'art	Paintings fallen from walls, objects on display not properly fixed to their base are overturned; broken objects.
Voluminous moveable works of art	Cracks propagation in voluminous objects such as statues etc. Major damage to objects violently hit and to "rigid" objects (non wood).
Furniture and furnishings	Cracks propagation to architectural elements. Cracks in vaults, frescoes, crushed and crumbled fragments of plaster.

Table 2.2.2 – *Scenario of Medium intensity earthquake – Small landslides with overturning of objects and structural collapses*

Location	**Possible scenario and effects**
Libraries and archives	Damage basically the same as described in the previous table. Great quantity of dust, fall of architectural elements and furniture, accumulation of detritus, damage to the water mains with risk of floodings, possible damage to the electric system and short circuits. Overturning of bookshelves.
Museums, galleries and picture galleries	Similar scenario plus fall of paintings from walls and consequent damage to paintings and frames. Objects overturning from the shelves and breaking.
Palaces and churches	Damage to vaults, floors, frescoes. Cracks in walls, detachment of plaster, staircases collapsed, furniture overturned.
Historical centres and urban fabric	Possible landslides or ground subsidence in urban areas. Compromised urban fabric. Roof tiles, glass shards, architectonic elements and detritus obstructs access to buildings. Collateral damage to nearby buildings.
Parks and landscaped areas Excavations and archaeological sites	Damage caused by landslides occurring even some days after the seismic event. Cracks and collapse of structures, walls and trenches.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Overturned books from bookshelves in nearby corridors. Difficulty in keeping or re-establishing their order. This type of objects will unfortunately be covered in dust and detritus from the collapsed structure.
Paintings and object d'art	Paintings fallen from walls, objects and shelves overturned; crushed objects.
Voluminous moveable works of art	Cracks propagation; damage caused by fallen objects.
Furniture and furnishings	Cracks propagation in walls and ceilings; unstable staircases and frames.

Table 2.2.3 – *Scenario of Light intensity earthquake – slight subsiding and light damage*

Location	**Possible scenario and effects**
Libraries and archives	Damage basically the same as described in the previous table but with a less strong impact. Cracks and detachment of plaster. Ordinary maintenance and assessment of hidden damage, support and strengthening needed.
Museums, galleries and picture galleries	Damage basically the same as described above but with a less strong impact. Cracks and detachment of plaster. Ordinary maintenance and assessment of hidden damage, support and strengthening needed.
Palaces and churches	Damage basically the same as described above but with a less strong impact. Cracks and detachment of plaster. Ordinary maintenance and assessment of hidden damage, support and strengthening needed.
Historical centres and urban fabric	Damage basically the same as described above but with a less strong impact. Cracks and detachment of plaster. Ordinary maintenance and assessment of hidden damage, support and strengthening needed.
Parks and landscaped areas Excavations and archaeological sites	Damage basically the same as described above in addition to that caused by small rocks falling.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Overturning of bookshelves, crates and cabinets. Damage caused by items rolling over or by small detachment of plaster
Paintings and object d'art	Overturning of bookshelves, crates and cabinets. Damage caused by the detachment of plaster.
Voluminous moveable works of art	Damage caused by the propagation of cracks and overturning of objects.
Furniture and furnishings	Propagation of cracks, detachment of plaster.

Table 2.2.4 – *Scenario of Flooding and effects*

Location	Possible scenario and effects
Libraries and archives	Flooding and water stagnation in lower ground rooms. Accumulation of detritus and mud. Mud and water traces on walls. Damp and crumbling plaster. Slippery surfaces difficult to walk on owing to mud and small detritus. Draining and reinforcement measures to be carried out.
Museums, galleries and picture galleries	Flooding and water stagnation in lower ground rooms. Accumulation of detritus and mud. Mud and water traces on walls. Damp and crumbling plaster. Slippery surfaces difficult to walk on owing to mud and small detritus. Draining and reinforcement measures to be carried out.
Palaces and churches	Flooding and water stagnation in lower ground rooms. Accumulation of detritus and mud. Mud and water traces on walls. Damp and crumbling plaster. Slippery surfaces difficult to walk on owing to mud and small detritus. Draining and reinforcement measures to be carried out.
Historical centres and urban fabric	Flooding and water stagnation, accumulation of detritus and mud including tree trunks and branches. Possible presence of vehicles swept away by the landslides and flooding obstructing roads. Structural damages. Damp and damaged plaster.
Parks and landscaped areas Excavations and archaeological sites	Flooding and water stagnation in lower ground or enclosed structures. Erosion of soil or sandstone surfaces. Problems to foundations damaged by floods. Disrupting the fauna habitat. Infestation by mosquitoes and other insects.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Damp or wet paper items and possible mould appearing after 48 hours. Books and documents bound in glossy covers, stuck together and difficult to separate. Weight of books and documents increased by water, possible collapse of shelves.
Paintings and object d'art	Wet and fragile canvases, particularly if old. Damaged frames. Shifted and possibly broken items.
Voluminous moveable works of art	Chipped statues. Wood made fragile by water.
Furniture and furnishings	Soaked textiles, stained and fragile. Plasterwork and frescoes stained and fragile: high risk of detachment from walls. Damage tends to increase with time due to the accumulation of mould or the salt precipitation during drying operations.

Table 2.2.5 – *Scenario of Climate change and effects*

Location	**Possible scenario and effects**
Libraries and archives	Wind and water can uncover roofs and damage buildings already weakened by the earthquake; possible damaged windows. This in turn could cause damage to the more delicate documents which need to be restored to a controlled climate.
Museums, galleries and picture galleries	See above. Damage to items can be caused by a fault in the air conditioning system with consequent change in temperature and humidity.
Palaces and churches	Possible damage caused by wind or hail. Lightening and possible fires. Long periods of drought can cause damage to walls and foundations subsiding.
Historical centres and urban fabric	Possible damage caused by wind or hail. Lightening and possible fires. Long periods of drought can cause damage to walls and foundations subsiding.
Parks and landscaped areas Excavations and archaeological sites	Damage caused by too much wind, rain, hail or sun.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Deterioration of objects caused by water, humidity, hail and change in the environmental parameters.
Paintings and object d'art	Deterioration of objects caused by water, humidity, hail and change in the environmental parameters.
Voluminous moveable works of art	Deterioration of objects caused by water, humidity, hail and change in the environmental parameters.
Furniture and furnishings	A prolonged exposition in the sun of frescoes and furniture can cause serious chromatic alterations. Possible damage caused also by wind and hail.

Table 2.2.6 – *Scenario of Service blackout (water, electricity, gas etc.) and effects*

Location	**Possible scenario and effects**
Libraries and archives	Risk of change in the structure of the objects, in particular of those that need a controlled environment temperature. Theft and looting after the malfunctioning of alarm systems and of the partial or total collapse of the building.
Museums, galleries and picture galleries	See above
Palaces and churches	See above
Historical centres and urban fabric	Areas of high cultural value should be cordoned off until normal conditions are restored. Security services should be organised when necessary.
Parks and landscaped areas Excavations and archaeological sites	See above
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Delicate objects needing a strictly controlled environment climate could become very fragile and be subject to severe alterations according to the length of time they have been exposed to unfavourable conditions.
Paintings and object d'art	See above. Environment parameters should be restored as quickly as possible by using generators and back up systems previously planned.
Voluminous moveable works of art	See above
Furniture and furnishings	Environment parameters should be restored as quickly as possible by using generators and back up systems previously planned.

Table 2.2.7 – *Scenario of Biological infestation and effects*

Location	**Possible scenario and effects**
Libraries and archives	Evident damage to stored or displayed objects, cavitation and damage to walls and nests, faeces, smell, carcasses of dead animals. The presence of insects, rodents and moulds can point to hidden pests. Damage may be widespread although not immediately visible. Insects, in particular, can quickly multiply in unfavourable weather conditions.
Museums, galleries and picture galleries	See above.
Palaces and churches	See above. There are no effects on the stability of the building save for woodworm in the supporting structures.
Historical centres and urban fabric	See above.
Parks and landscaped areas Excavations and archaeological sites	See above.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Books and documents may be gnawed at, torn, musty, stained or damaged according to the type of infestation.
Paintings and object d'art	Paintings and objects may be gnawed at, torn, musty, stained or damaged according to the material in which they are made of and the type of infestation.
Voluminous moveable works of art	Paintings and objects may be gnawed at, torn, musty, stained or damaged according to the material in which they are made of and the type of infestation.
Furniture and furnishings	The degree of infestation may be high in the most hidden and inaccessible areas: behind or inside walls, cellars, store rooms, pipes and conduits.

Table 2.2.8 – *Scenario of Fire and effects*

Location	Possible scenario and effects
Libraries and archives	Blackened walls, furniture and objects. Partial or total carbonisation of burnt objects. Possible structural collapse of floors, roofs or other support structures compromised by the fire. Decolourisation. Desiccation and deformation due to high temperatures caused by fire, water or fire extinguishing foam saturation.
Museums, galleries and picture galleries	See above.
Palaces and churches	See above.
Historical centres and urban fabric	Possible localised collapses.
Parks and landscaped areas Excavations and archaeological sites	Fire is a rare event unless it is a forest or brush fire caused by lightning or the propagation of other fires.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	Total destruction of documents. Serious damages to stored books caused by both fire and extinguishing products. High temperatures make paper dry, friable and therefore can easily disintegrate.
Paintings and object d'art	Destruction or serious damage to works of art due to fire or extinguishing products. High temperature may produce extremely serious and often irreversible damage.
Voluminous moveable works of art	Objects may undergo decolourisation, blackening and be covered in soot or by fire extinguishing powder or foam which will then have to be removed only by experts.
Furniture and furnishings	Carbonisation of organic elements in furniture. Partial or total carbonisation of the plaster, serious colour alteration of painted walls. Possible structural collapse and detachment of plaster. Decolourisation and desiccation caused by high temperature, fragility, loss of cohesion of wall paintings and supports. Damage caused by fire extinguishing products. Soot, dust and fire extinguishing foam should be removed only by experts.

Table 2.2.9 – *Scenario of Explosion and effects*

Location	**Possible scenario and effects**
Libraries and archives	Possible serious structural damages and gutting of buildings and their contents in the areas affected by an explosion. The shockwave of the explosion causes direct shifting of the objects and pressure on the surfaces. Objects may be flung around damaging other objects nearby; they can be scratched or damaged by detritus or shuttered by the force of the explosion.
Museums, galleries and picture galleries	See above
Palaces and churches	See above. The shockwave can knock down walls or roofs already seriously weakened by the tremors or cause structural swelling.
Historical centres and urban fabric	See above
Parks and landscaped areas Excavations and archaeological sites	Fallen trees may damage vehicles which can be crushed, overturned, burnt and cause damage to the surrounding area.
ITEMS TO BE RESCUED	**Possible specific effects**
Books and documents	The force of the explosion can overturn containers and knock down walls and cabinets. Books and documents may be destroyed.
Paintings and object d'art	See above. Objects can be shuttered and scattered across a wide area.
Voluminous moveable works of art	See above with lesser fragmentation when less fragile and more voluminous objects are involved.
Furniture and furnishings	Damaged valuable surfaces, fragmented frescoes scattered around a widespread area. Mixture of sundry dust, detritus and fragments.

2.3 *The chain of command*

Operations during a calamity are very complex and involve collaboration and organisation at several levels which jointly enact all protection measures. It is therefore evident that the most immediate and direct intervention should be implemented to the areas that have suffered the most relevant damages to manage the protection of CH objects. The intervention should be guaranteed by the local institutions and only in the case of insufficient resources, institutions at a higher level should intervene. It is therefore necessary to define a clear chain of command, e.g. tasks, roles, coordination amongst people and structures involved, adopting prompt and simple methodologies to identify and subsequently execute the emergency procedures. To this purpose, it is recommended to set up operation centres at different levels so that all subjects involved could take cooperative decisions in real time.

Interventions in an emergency situation can be divided into three categories:

- events that require interventions by a specific team of operators
- events that, for their nature and extent, require a coordinated intervention by a multidisciplinary team of operators
- events that, for their intensity and extent, require extra measures and powers

When a calamity takes place a coordination team should be set up according to the existing national protocols. This action could be based on three closely connected elements as they are presented hereby:

1. *Joint management*

Capable of taking a holistic view of the situation defining univocal responsibilities at all levels of command. To this purpose, a series of criteria and instructions should be codified regardless of the extent and entity of the seismic event and independently of the number of items involved.

2. Good communication

A non-stop exchange of information and the use of unified

procedures and communication guarantee an immediate intervention and a better outcome in the emergency phase.

3. *Rational management of resources*

It requires the timely and efficient use of resources (people and equipment) available, easily traceable and fitted to the type of intervention.

3. Safety measures: procedures, equipment, tools and technologies

Operations in areas characterised by the persistence of calamities call for detailed planning preceded by analytic and thorough assessments of the operational risks and a survey of the itinerary that should be followed in emergency conditions in order to reach the areas in need.

This type of assessment as suggested will help to find the most suitable itineraries to reach the various areas and therefore the relevant buildings and structures; to determine the necessary equipment, procedures and actions in order to cut down to the minimum all the possible risks for the emergency teams.

Whenever any CH item is located in the area under survey, the procedures to guarantee proper protection for the operators are not very different from those enacted during any type of other emergency, however, there are some differences. In this case, having the correct equipment is not enough; it is also required to provide all the information in order to anticipate what type of situation the team might be called upon to solve.

In a diverse case, when such information is not available, a safety and protection plan setting up the procedures for intervention, decisions on the PPE – Personal Protection Equipment -, instruments and techniques should be developed during a preliminary survey carried out *in situ*.

The plan should be based on a number of preventive studies regarding the range of scenarios which the emergency teams might face. The most frequent scenario consists of instability problems of the structure where the CH items are housed or

of the nearby buildings and of the structures standing along the itinerary.

An immediate assessment should be carried out to weigh up whether inside the building of interest or in the surrounding area there are toxic substances harmful to humans caused by flammable gas leaks (pipe or container breakage), whether the level of oxygen and the presence of carbon monoxide or other harmful substances are causing breathing difficulties. This type of situation should be assessed by using instruments which can rule out any risk for the operators otherwise the procedures of accessing areas with possible dangerous conditions should be reconsidered. Anti-spark equipment should be used in the presence of combustible or flammable gases; the cause must be removed and the level of toxic gases reduced, rooms ventilated and the operators should be equipped with breathing apparatus (filter masks, re-breathers etc.)

Another risk factor is the presence of damaged electric systems which might cause electrocution. In this case, the power should be cut off.

In addition, an important parameter for a successful outcome is the personality of the emergency operator: physical ability and courage balanced by caution are qualities on which individual skills should be assessed.

Nevertheless, in emergencies, individual caution is not enough as it is highlighted throughout this document but a series of pre-defined procedures should be set up and operators should be made aware of those. They should also be supplied with appropriate equipment to ensure their own personal safety in order not to initiate additional problems to an already critical scenario. At last, they must be trained to correctly use the equipment, which must be properly kept, easily reachable and appropriate to the specific risk scenario.

The following lists (refer to lists 1, 2 and 3) provide more information with regards to the personal protection equipment, the equipment and tools and the available technologies to operate in safety:

1. Personal Protection Equipment (PPE)
   – Hand protection (gloves)
   – Feet and legs protection (boots, shoes)

– Head protection (helmet)
– Face and eye protection (safety glasses, goggles, visors)
– Protection from falls (harness, safety belts)
– Breathing apparatus (masks)
– Hearing protection (ear muffs, earplugs)
– Protective clothing (overalls, reflective safety clothing)

2. Equipment and tools to be used in unfavourable environmental conditions. These may be considered a kind of indirect protection e.g. instruments to assess the presence and level of toxic gases and lack of oxygen which might impair normal breathing. Also equipment to carry out the operations for the protection and/or removal of the CH items must be available; such as:
   – Pneumatic equipment
   – Hydraulic equipment
   – Saws, chainsaws etc.
   – Scaffolding and support equipment
   – Lighting equipment, e.g. flashlights, spotlights, rod tip chemical light
   – Search and detection systems
   – Computers
   – Diagnosis system

3. Technologies for Operating in safety
   – Speleological, Mountain and River operations techniques: When operators cannot use routine equipment (ladders, platforms etc.) the expertise and experience of special techniques should be put into practice. These innovative techniques come under the description of Speleological, Mountain and River operations and when properly learnt and applied, increase the safety of the rescuers.
   – Standard packaging: If CH items must be removed, it is absolutely necessary that the appropriate packaging is made available, i.e. modules which can be integrated with standard transport equipment for the removal of goods in emergency situations, rapidly guaranteeing correct protection. This technique is based on the assumption that the systems used for removal in normal conditions cannot be adapted to emergency cases since they have been de-

signed for one specific item and therefore cannot be used for other items.

- Labelling: Items should be labelled indicating evacuation priorities, type of container to be used and storage. All this should be done following a pre-defined labelling system. Labels show which item needs immediate retrieval and removal and which instead can be dealt with at a later stage.
- Mobile communication: Mobile communications allow high quality digital performance and a quick transfer of data.
- Wifi communication: The new information and communication technologies contribute to the experimentation of a communication method based on wireless technology in the case of a communication blackout.

4. The Emergency Team

Emergency interventions during a seismic event are defined in National protocols as those operations for the safeguard of people's health. This chain of command allows to identify the person (or group) in charge of deciding the interventions to be carried out and the measures to be adopted. However, in the case of damages to Cultural Heritage items caused by an earthquake, protocols are not always clear about the necessary competences to guarantee their safety and how to pre-organise the emergency teams in order not to waste precious time during the aftermath.

When Cultural Heritage items are damaged the current procedures are based on the coordination between the Protezione Civile and experts from the Conservation of Cultural Heritage.

It is clear that operators should be organized in intervention teams which here we are calling Cultural Heritage Defenders (CHDs). Their numbers can vary but they should have set roles and competences. The teams should be organized in mobile units and be coordinated.

This chapter gives an idea of the tasks and operational skills of a team i.e. the "operational skills" necessary to deal with two areas of impact which are additional to the normal emergency competences if mobile works of art and the sites where they are located are involved:

– assessment of damage and possible removal
– first intervention on location for the safeguard of the items, packaging and transportation

Therefore, the CHDs should have both general and specialized competences.

Competence here refers to "knowledge and skills directly and functionally linked to a performance, which can be defined and measured according to pre-set criteria".

Clearly, each task should be carried out by more than one profile according to how the Member states organise the teams. For this reason, it is important that these competences should be present in the team, regardless of the organisation given to the teams by each Member state and we have divided them into 4 areas:

Coordinator

Profiles who can manage and lead the team according to the terms set in the protocol. Leadership and team building are their main skills to "inspire, lead, direct and protect the team members; follow-up all decisions taken until the end of the operations". They will make and keep contact with the headquarters, acquire basic information on the building, site and item damaged by the earthquake, organise the transportation of tools and materials for the intervention, check the site, identify and cordon off the intervention area, set and coordinate operations by assigning the tasks to be carried out to each member of the team, assess operational safety, organise and chair assessment meetings.

The profile evaluation should also consider the ability to identify the type of risks threatening each artistic item, as well as those possibly affecting the site in order to determine the correct procedures for the protection, safeguard and removal of the items.

Such competences are often linked together since the concept of teambuilding lies in the interaction amongst its members in order to set priorities and implement all safety measures for the safeguard of the items once the underlying risk has been assessed.

The safety of the team lies in the correct assessment of the area in which the team will be operating, especially regarding the structural conditions of the site. Coordinating implies also being able to communicate in a dangerous situation: making quick decisions is a psychological trait that is paramount in

such a profile especially in a stressful environment and under the pressure from the media.

Action planning is essential – checking the outcome of the decisions taken until the end of operations and choosing the correct strategy to minimise damage to the site are different facets of one single profile – and can be carried out also with the help of other qualified operators. Action planning is also extended to the assessment of the materials needed and of the operation timetable.

The profile in question should also have an in-depth technical knowledge of all operational steps which, although supported by other team members on a strictly technical and scientific basis, are subject to his/her final decisions on the entire safeguard operations.

Technical-scientific profile specialised in Cultural Heritage

This is a fundamental role and concerns technical and scientific competences related to the type of item and its container.

It is important that the team has also an expert able to assess the nature and the degree of damage and the state of the item and to analyse the possible damages caused by the earthquake (visible or not immediately so).

As we have already said in the section about the classification of the works of art, Cultural and Historical heritage refers to single works of art and collections and their locations (buildings and sites). This said, it is clear that the organisation of actions to be carried out according to the law and to national procedures should guarantee the involvement of one or more experts able to operate specifically and immediately assess the state of the items, possible and foreseeable damage, and start removal procedures.

Therefore, there may not be only one profile but a group of experts in this matter and their tasks would be:

- Evaluation: assessing the state of the work of art and any damage occurred to it and possible variables (also if not immediately visible); assess the type of intervention for removal
- Operation: carry out the basic operations on location. This can be the case of restorers working on the protection of works on canvas with Japanese paper.

All operations imply the singling out of historical and artistic data and the conservational requirements related to Cultural Heritage items. This also in order to determine priorities when rescuing works of art.

This profile interacts with the team members and supplies all the correct information to avoid causing further damage to the items during operations.

However, criticalities could lie in the difficulty and stress of such operations and moreover in the possible inadequacies on the use of emergency equipment.

Operators should therefore attend specialized training courses on Cultural Heritage topics and on how to act in emergency situations. The latter should focus on:

- The use of self-protection devices and technology; use of the correct tools to guarantee the safeguard of the item/building
- Managing team work and stress in order to act rapidly and solve problems and unexpected situations. This is basically a way to *assess team competences and problem solving skills in a stress situation through specific psycho-aptitude training. Who does not act with the required clear mindedness in dangerous situations* could endanger the whole team.

Profile specialised in Statics and Structures

The initial assessment carried out soon after the earthquake is a very tricky phase of the emergency. This is the moment for the assessment of the site's accessibility under the danger that a so called earthquake swarm could cause additional damage to the site and the structures. Only after an expert on structural damage has give the green light, operations on the works of art can be started.

This preliminary phase calls for an ability to analyse the site, set up and adopt measures to guarantee site safety in order not to compromise the conditions of the CH items and not to cause any further damage.

The main skills required for this profile are the knowledge of structural characteristics of CH items, the ability to understand their physical composition which in turn calls for the use of appropriate techniques and instruments to ensure that the chosen procedures will safeguard, or at least minimise, damages to sites of high artistic or architectural value.

Assess the state of the walls in order to verify wall horizontation, the state of the floors and the connections.

This phase – operations and relevant competences – should last throughout the intervention until the items have been removed or protected on location. In fact, the analysis of the materials related to the statics of the structure and relevant procedures, the efficient deployment and use of materials, instruments and techniques to achieve the safety of the structure, the definition of the priorities based on clear and objective operational criteria are technical requirements which cannot be disregarded in order to guarantee the safety of both team and items.

Technical and logistic operational back-up

Profiles (such as volunteers) who, although without specialization, are trained to support the team in all useful operations in case of an emergency, such as the identification of the CH items, their removal, packaging and transport or surveillance in case the containers are damaged.

Although lacking specific training, this profile should have a certain degree of competence in this area as well as psychological traits which allow stress management and understanding of group dynamics. These operators should also be able to follow instructions given by the coordinator and take part in all first intervention procedures for the h ndling of the damaged items. This would require the necessary physical strength to lift and shift the works of art to be protected or rescued and transported to a safe location.

An important phase is the removal and packaging of the items. Being able to package the works of art to be removed or protected on location, calls for the ability to avoid any action which might endanger the items. It should be kept in mind that the items to be packaged are often of an immense historical and artistic value and any negative impact (even minimal) might entail costly restoration.

The psycho-aptitude aspect implies the ability to work in safety by quickly understanding the coordinator's instructions and operating with caution. It is recommended that training should deal – a part from self-protection and the work of the Protezione Civile- specifically with operations to be carried out

in the presence of CH items in order to make the trainee aware of what shouldn't be done.

This profile's psychological trait should also bear historical and artistic knowledge and sensitivity in order to pass on to future generations the full meaning of operating in a cultural environment.

5. Container and contents vulnerability: prevention criteria and base devices

5.1 *Introduction*

The objectives of the following paragraphs are firstly to analyse the constructions hosting Cultural Heritage objects, secondly to propose the evaluation methods of their vulnerability level and finally to provide a concise list of the main vulnerability elements with artistic and cultural relevance (e.g. painting, frescoes, sculptures).

The term "container" is used to describe both the building itself (e.g. museum, church, ordinary buildings) hosting the Cultural Heritage object and the case in which limited number of those objects are stored.

Among "containers/buildings" (c/b) only masonry buildings are examined, due to their diffusion and their artistic relevance. The preliminary phase refers to the containers/buildings' structural and typological assessment rather than the actual vulnerability analysis. This need is particularly evident in buildings hosting CH items, being often outdated and missing the original design drawings and documentation. The assessment is carried out by compiling a simple and concise form. The second phase of the methodology proposed is to undertake a vulnerability analysis of the c/b. In case of an earthquake this analysis, combined with the data of phase 1 previously described, may provide useful references for the teams that should assist to the recovery of the objects contained in the building. The aim of the procedure is to advise on the methodology that should be adopted to realise an initial and quick evaluation of the building safety level and identify the issues of large danger during the teams pres-

ence on-site to recover the art object. The vulnerability evaluation divided into specific items, can also suggest an appropriate degree of precision on which elements should be made safe to limit the risk accessing the c/b.

The term "content" means the specific artistically valuable item to be protected (e.g. sculptures, painting).

The term "Structural Unit" (SU) is the smallest cell, object of the vulnerability analysis: a building or a portion of it which shows a homogeneous structural behaviour with respect to vertical and horizontal actions. The "SU" term may often be synonymous with "building".

The term "agglomeration" or "aggregate" means a complex of several interacting buildings or SU This is a typical situation in historical urban centers.

Both containers' and content's vulnerability can be quickly estimated using a specific vulnerability form. In this Protocols and Procedures document, there are proposed prompt methods for estimating the c/b's vulnerability and a summary of main aspects of vulnerability of statues, paintings, etc. is presented.

The aim of this kind of vulnerability knowledge census with regards to these containers like museums, churches, and in general all sites hosting CH or being CH by their historical architectural nature may be several:

- creating a knowledge patrimony, a sort of a "register of museums." Every trustee or cultural institution manager could acquire the knowledge and vulnerability forms, related to the cultural property he administers and share them online to form a common database;
- creating priority lists in case of public funds allocation for maintenance or seismic prevention for possible vulnerability reduction campaign;
- defining a protocol for the preservation of cultural heritage through a better defined and consolidated intervention as it will be suggested by the prompt evaluation.

5.2 *Details of knowledge for the buildings/containers*

Prior to the b/c's vulnerability analysis, the only reference could be made to the collected data for the building and not

yet to its structural weaknesses. As it is particularly common in buildings hosting CH, the information is often dated and the original design papers are missing even in the Public Permission Agency.

In this section, it is proposed a brief and condensed form (shown in Appendix A), with the purpose to collect data related to all types of b/c. These forms could be kept in the local art museum and heritage management officies to create a structural database of buildings hosting art heritage.

The information summarized in the form, organized in two sections is referring to typological and structural description of the building and practically consists in a reconnaissance whose purpose is the recording of some macroscopic data of the building in examination.

The form is specifically designed so as to favor the usefulness, speed of use and possibility to be computerized especially if compared with detailed survey/structural analysis, which are more demanding in terms of time and numbers of staff involved.

It is fundamental that the form is compiled by technical staff, and it is recommended to form teams of at least two technicians for each building. The form must be compiled for the whole building, intending the structural unit (SU), which is identified by typological features and therefore distinguishable from adjacent buildings. The identification of SU in contexts of objective difficulties like buildings in agglomeration, will be discussed with more detail in the next section.

It is essential to collect the information during the actual inspection of the building site in question and by surveying the internal parts of the building except of the externals.

There are basically three compiling requirements: (i) filling in the boxes where the symbol O appears, (ii) writing in capital letters the required information where the spaces are marked with "_____"; (iii) ticking off with a cross the description that matches the situation in question. It is significant to highlight once more that the form is to be filled by an expert. The information that the sections of the form should contain is described in more details in the appendix A of this document.

5.3 *Isolated or in aggregate buildings*

5.3.1 *Vulnerability assessment for isolated or in aggregate buildings*

The following paragraph discusses a procedure to assess the masonry building's vulnerability level. The baseline can be either the single building block, called "structural unit" (SU) or the SU included in the historical agglomeration context.

This refers to buildings with a "building" configuration: masonry walls with reduced horizontal elements length. Churches and palaces with monumental rooms are excluded since they belong to a different category and special studies related to particular problems of these structural types are required. Later in this manual a prompt method for estimating churches vulnerability is presented.

The proposed procedure involves two phases: initially the SU identification and secondly the vulnerability evaluation. The SU identification is based on structural uniformity criteria.

Once the SU is defined, masonry quality is to be evaluated. This important parameter will be fundamental for the "own" vulnerability assessment (e.g. referred to the building as if it was isolated) and the "induced" vulnerability (e.g due to interaction with adjacent SU). "Induced" vulnerability is not assessed if the building is composed by a single SU.

The vulnerability should be estimated by a series of structural failures examinations which, if above certain limits (numerical or qualitative) will require a "vulnerability element" presence. Finally, a vulnerability synthetic index between 0 and 1 (from modest to severe vulnerability) should be elaborated.

5.3.2 *Structural Unit individuation method*

The next paragraphs present a methodological approach for the identification of factors aimed to define the SU when it is difficult to recognise, as for instance it happens for the SU in historical aggregates.

The following general criteria should be satisfied:

1. *historical and typological analysis*: aims to determine the age of the various block portions and their historical identification of aggregation mode. Portions built in different phases or periods or by different building types or structurally unrelated may define different SU;
2. *geometric survey*: defines the building and/or aggregate shape; floors, roof and foundations heights survey. Floors and roofs at different heights may define different SU;
3. *material analysis*: intends to determine the structural homogeneity of the vertical elements. In presence of wall portions with different construction types (e.g.: stone blocks and bricks) different SU could be defined;
4. *structural survey*: floors and roof plan analysis, identifying their ability to divide the horizontal actions (rigid diaphragms) and evaluating the methods and the degree of connection of the vertical structures; converging walls links analysis might be necessary, considering whether interconnected. In order to identify a SU, particular rigid and well connected to the masonry diaphragms elements should be considered.
   Another aspect that may help to define a single SU is the presence of an efficient chain of elements with high-quality wall connections, and effective connections walls (corner and hammers) even in absence of rigid diaphragms;
5. *structural behavior*: potential structural behavior in terms of response to static or seismic loads analysis. In particular, the SU must have a vertical continuity with respect to the vertical loads flow. Therefore, it isn't correct finding more SU on flats of the same vertical load.

Picture 5.3.2.1 – *SU (Structural Unit) aggregate identification*

Picture 5.3.2.2 – *Presence of combined SU in a single aggregate*

It becomes essential to assess interactions that the SU will provide to each other in case there is more than one SU as part of a single aggregate. These interactions are those initiating localized phenomena resulting from a single structural element but without generating strong repercussions on the whole complex, such as arches and vaults not counter pushing, adjacent SU floor plan offset presence, not-aligned portions of prospectuses, separation space insufficiency between building types with different behavior.

5.3.3 *Structural Unit vulnerability elements*

For the purposes of this paper two kinds of SU vulnerability may be identified: the own vulnerability and the induced vulnerability. The own vulnerability is given by all the SU vulnerability' situations as separate entity. It should be assessed both for isolated buildings and for aggregate buildings. The induced vulnerability instead considers the structural relations between the identified SU and the SU

adjacent, so it will be evaluated only for buildings aggregations SU.

The own vulnerability is divided into two classes:

- class *a*: includes those vulnerability elements whose resolution is considered fundamental for a prevention policy in relation to the best cost-effective ratio. The first and fundamental aspect to investigate is the masonry quality.
- class *b*: includes those vulnerability elements related to the specific structural context and is localized in specific SU areas.

Vulnerability elements

Class *a* vulnerability can be analyzed through the following elements:

a.0) insufficient walls quality;
a.1) widespread absence of links between confluent walls;
a.2) widespread absence of connections between walls and horizontal elements;
a.3) widespread absence of tying elements or equally effective protections;
a.4) insufficient shear area;
a.5) irregular plan configurations / critical torque;
a.6) static decay and failure.

Class *b* vulnerability can be analyzed through the following elements:

b.1) load-bearing walls critical slenderness;
b.2) irregular openings distribution;
b.3) pushing elements presence;
b.4) not resting on the ground addictions presence;
b.5) suspended without foundations walls presence;
b.6) large resistance variations from one floor to another one;
b.7) bad connections in secondary structural elements;
b.8) foundation settlement presence.

The induced vulnerability depends on the following factors:

c.1) not countered vaults and arches pushing;
c.2) boundary floors and roofs offsets;
c.3) front misalignments;
c.4) the SU head position;

c.5) insufficient seismic and/or structural joints size;
c.6) significant difference in stiffness between adjacent SU.

5.3.4 *Isolated or in aggregate SU vulnerability index determination*

In order to achieve a numerical indication of the maximum SU vulnerability level, vulnerability elements of SU are evaluated. **The total number of vulnerability elements to be considered** is equal to 14 (a.1 to a.6 and b.1 to b.8) for isolated buildings and is equal to 20 (c.1 to c.6 more) for aggregated buildings with induced vulnerability.

a.0 element, related to wall quality leads to an opinion expressed by A, B and C letters. Since walls quality is relevant for buildings seismic response, it plays a decisive role in vulnerability index, through the i_M coefficient.

Vulnerability index i_V is therefore defined as follows:
For an isolated SU:

$$i_V = i_M \times \frac{v_{a,b}}{28} \leq 1$$

(vulnerability elements class to consider: “a” and “b”);
For an aggregate SU:

$$i_V = i_M \times \frac{v_{a,b}}{28} + \frac{v_c}{12} \leq 1$$

(vulnerability elements class to consider: “a”, “b” and “c”);

where $v_{a,b}$ is the number of “a” and “b” vulnerability elements in analyzed SU; v_c is the number of “c” vulnerability elements in analyzed SU, and i_M is a parameter that considers the walls quality defined in a.0.

The values for the i_M are defined in the following table:

Masonry category (a.0 element)	i_M
A	1
B	1,5
C	2

5.3.5 *Interventions to reduce vulnerability*

Once the vulnerability analysis has been completed, it is possible to suggest the most appropriate interventions to eliminate the buildings' vulnerability. In the following table the numbers in the highlighted boxes correspond to the class intervention to eliminate or mitigate a particular vulnerability condition.

Blue boxes indicate the most appropriate intervention category to solve each single structural weakness. The table also indicates the most suitable consolidation interventions for the most dangerous situations as it is determined by the simultaneous presence of the two particular vulnerability elements.

These configurations correspond to the row-column intersections in the red highlighted boxes as they appear in the table. They put in evidence the simultaneous presence of the two structural weaknesses able to emphasize each other thereby producing a negative impact on the building.

Table 5.3.5.1 – *Vulnerability configurations and related intervention*

CONFIGURAZIONI CRITICHE E POSSIBILI INTERVENTI																				
	a0	a1	a2	a3	a4	a5	a6	b1	b2	b3	b4	b5	b6	b7	b8	c1	c2	c3	c4	c5	c6
a0	4/6																				
a1		1	1/2	1/3				1/4/5	1/5	1/3	1/4	1/5/6	1/5	1/6	1/9	1/3	1/3	1/5	1/5		
a2		1/2	2	2/3				2/4/5	2/5	2/3	2/4	2/5/6	2/6	2/6		2/3	2/3	2/5	2/5		
a3		1/3	2/3	3				3/4/5		3	3/4					3		3/5	3/5		
a4					4/5				4/5	3/4/5			4/5		4/5/9	3/4/5	3/4/5		4/5		
a5						4/5/7			4/5	3/4/5			4/5		4/5/9	3/4/5	3/4/5		4/5		
a6							4/6														
b1		1/4/5	2/4/5	3/4/5				2/4		3/4/5	4/5				4/5/9	3/4/5	3/4/5	4/5			
b2		1/5	2/5		4/5	4/5			5												
b3		1/3	2/3	3	3/4/5	3/4/5		3/4/5		3											
b4		1/4	2/4	3/4				4/5			4/5										
b5		1/5/6	2/5/6									5/6									
b6		1/5	2/6		4/5	4/5							5/6								3/7
b7		1/8	2/8											8							
b8		1/9			4/5/9	4/5/9		4/5/9							9						
c1		1/3	2/3	3	3/4/5	3/4/5		3/4/5								3					
c2		1/3	2/3		3/4/5	3/4/5		3/4/5									3				1/2/7
c3		1/5	2/5	3/5				4/5										1/2/3			3/4/7
c4		1/5	2/5	3/5	4/5	4/5													1/2/3		
c5																				7	
c6													3/7				1/2/7	3/4/5			7

The intervention classes proposed are:

1) Interventions aimed at improving or creating an effective connection between cross or hammer wall elements;

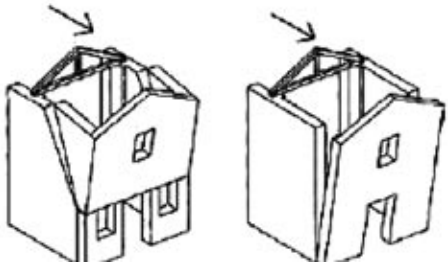
2) Interventions aimed at improving or creating an efficient connection between roof and floor's diaphragms with all the expertise masonry walls;
3) Interventions aimed at achieving or improving functional efficiency of tying elements or equally effective precautions, able to make a good connection between masonry walls;
4) Interventions aimed at increasing wall resistance, both for in-plan and out of plan action;
5) Interventions aimed at solving geometric masonry wall problems;
6) Devices to restore structural elements static efficacy for vertical loads of SU elements such as masonry walls, roofs and floors;
7) Devices to restore or insert "ex novo" structural seismic joints so that harmful hammering phenomena are avoided;
8) Devices to improve or restore structural/functional efficiency of non-structural elements;
9) Actions to improve foundation bearing capacity.

5.4 *Churches vulnerability*

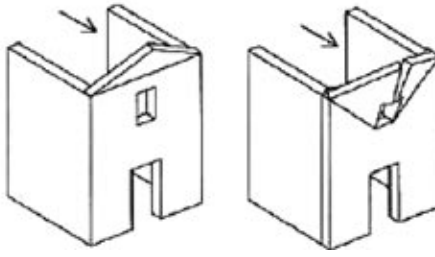
Among most interesting products on church vulnerability, there certainly is *Danno sismico e vulnerabilità delle chiese dell'Umbria*, by: Lagomarsino S., 1997, CNR – G.N.D.T. This is a fairly accurate survey of all churches' conditions after the 1997 earthquake in Umbria, reporting the calculation of two indexes, one referred to the damage and the other one to the vulnerability of the churches. This section focuses on how to calculate the vulnerability index. The vulnerability index is derived from a preliminary assessment of sixteen possible damage mechanisms. For each mechanism, it is necessary to evaluate the own vulnerability related to that mechanism through two specific indicators related to the structural deficiencies.

The sixteen damage mechanisms, each with two causes of vulnerability, are listed below (Pictures taken from LL.GG. BB. CC. of 2007):

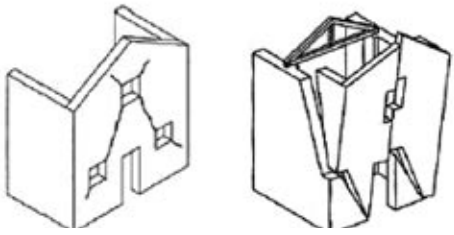
1) Front overturning
Vuln. a) Poor front-side walls connections
b) Chains or orthogonal spurs absence



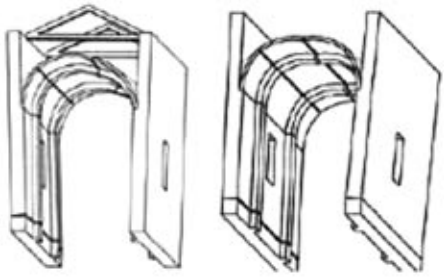
2) Top front hammering
Vuln. a) Large openings (canopy)
b) Poor front-roof connections



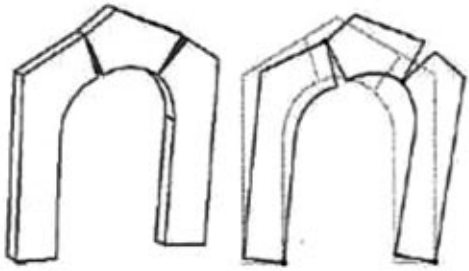
3) Front plane mechanisms
Vuln. a) Presence of many openings (also buffered)
b) Possible side walls rotation (no chains, pushing roof)



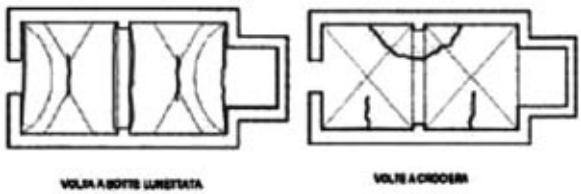
4) Room seismic response
Vuln. a) High slenderness sides
b) Cross-chains or spurs effective absence



5) Triumphal arch mechanisms
Vuln. a) Not thick arch or poor masonry made
b) Absent chaining or poorly positioned



6) Room vaults: lesions and disconnections from the arches
Vuln. a) Low and slender vaults
b) Concentrated loads from the roof



7) Roof hammering/head beams sliding/r.c. rings-underlying masonry disconnections

Vuln. a) Pushing coverage or rebuilt with increase weight

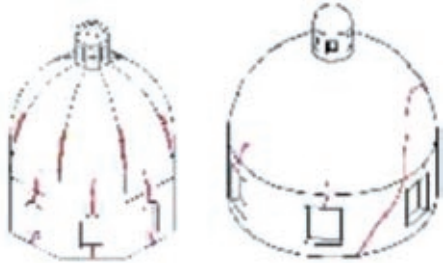
b) Masonry-beams link absence

Picture 5.4.1 – *Church of Bazzano (AQ) after the earthquake of 2009. Notice the hammering of the ridge beam of the roof with expulsion of the front top part and the roof portion collapse.*

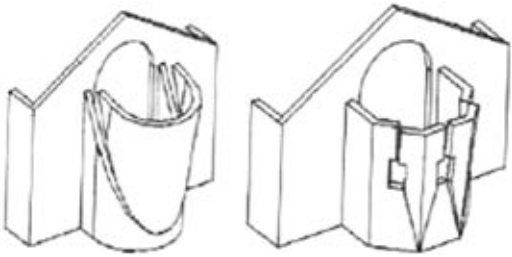
8) Dome, drum or lantern lesions

Vuln. a) Very high and with large openings drum

b) No hoops or exterior buttresses



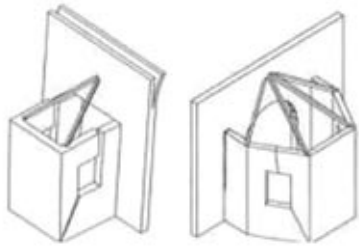
9) Apse or chancel overturning
Vuln. a) No hoop or longitudinal chains
b) Pushing coverage or wall openings



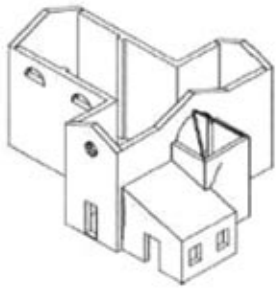
10) Chancel or apse vaults: injuries
Vuln. a) Lean or lowered vaults
b) Concentrated loads from roof

Picture 5.4.2 – *Lesions on the apse of the church of Santa Maria Assunta in Sellano after the 1997 earthquake.*

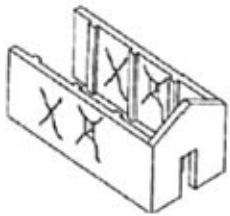
11) Walls overturning of adjacent buildings (chapels, transept)
Vuln. a) Poor detachable between those walls and orthogonal walls
b) No chains or spurs



12) Interactions in the proximity of discontinuity walls (adjacent buildings)
Vuln. a) Lack of connection between walls or different stiffness
b) Bad connections or no chains



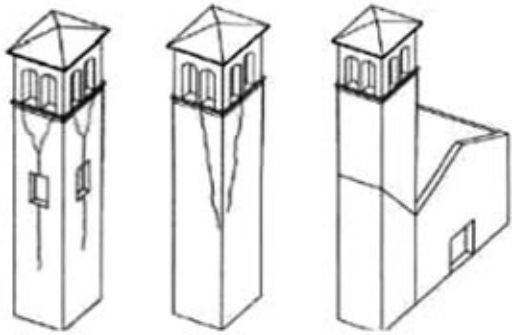
13) Walls shear failure
Vuln. a) Bad masonry or not much thick
b) Presence of openings (also buffered)



14) Lesions on the bell tower

Vuln. a) Lack of connection between masonry and the very lean tower

b) Bad or limited thickness masonry



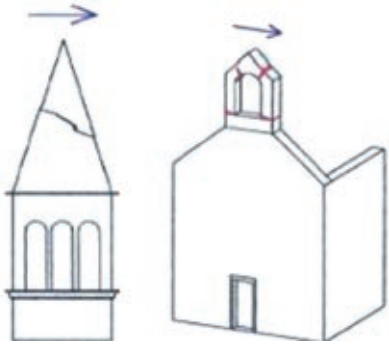
15) Injury, rotating or sliding of the belfry

Vuln. a) No chains or hoops; very slender piers

b) Heavy or pushing coverage

Picture 5.4.3 – *Collapse of the belfry of the town hall in Foligno during the seismic crisis of 1997-1998.*

16) Projections (sailing, pinnacles, statues)
Vuln. a) Lack of connections with the building
b) High slenderness of the projection



The vulnerability index, which is between 0 and 1, is defined with the following equation:

$$i_V = \frac{v}{2n}$$

n = number of mechanisms thought possible (e.g. if the church in examination hasn't the bell tower, you discard the bell tower mechanisms 14 and 15)

v = sum of all reported vulnerabilities (all of the same importance).

5.5 *Museum property vulnerability estimation and simplified interventions to reduce vulnerability*

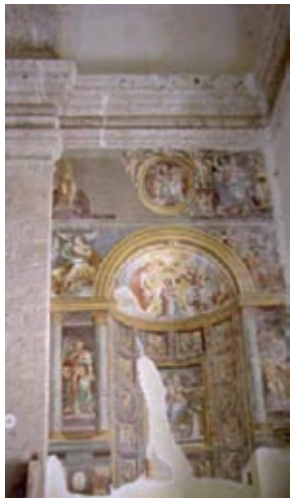
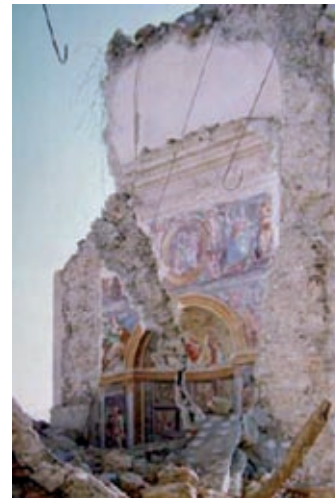
This section discusses concisely and in a not-exhaustive way some specific issues related to certain types of cultural or museum property. In particular, attention is focused on the seismic vulnerability of the contents and not on c/b's vulnerability, which has been already discussed in the previous sections. At this point is important to state that vulnerability of small objects is not given by the earthquake effect but rather by the earthquake effect on c/b that can collapse over them.

For each CH type is given an easily observable possible vulnerability elements checklist without having to recourse neither to trials (objectively difficult by the nature of uniqueness of the property to be protected) nor to extensive and costly analysis in terms of costs and time. The objective is to analyze each element's own vulnerability, putting aside the most general hosting building vulnerability's issues, which has been widely discussed in preceding paragraphs (refer to "container / building"). For each vulnerability element an action category is given, that could reduce the problem represented by that particular item or minimise the consequences. Each action or intervention class is indicated with a letter from A to L. Interventions or actions associated with a letter will be further described in section 5.6.

5.5.1 *Frescoes and wall paintings*

Following a frescoed walls and vaults vulnerability seismic elements summary is presented:

- Mild amplitude lesions presence due to time action on painting (F).
- Greater amplitude lesions presence which also affect underlying walls (F)
- Low painted walls masonry quality (when observable) (F)
- Vault fresco (which is a vulnerable condition itself, especially on thick vaults and high quote placed ones) (F)
- Perimetric wall or vault position or not countered one: e.g. on front or on church aisles, or on nave, where this is higher than aisles (that however "move" themselves more than church central portions) (F)
- Fresco ground quote e.g. if it is on a church top portion or on a building last level(F)
- Frescoed portion in collapsing tower trajectory (F)

Picture 5.5.1.1 – *"Santa Maria della Neve" (Norcia) church apse fresco, before and after 1979 Valnerina earthquake. We note frescoed walls masonry quality importance and an existing injury presence reopened by that earthquake in a serious way.*


Picture 5.5.1.2 – *"Santa Maria della Neve" (Norcia) church fresco before and after 1979 Valnerina earthquake. Note the lesion presence which has been a weakness during seismic activity.*

Picture 5.5.1.3 – *"Santa Maria ad Cryptas" (Abruzzo) church. Images before and after 2009 earthquake. Reopening of an existing crack.*

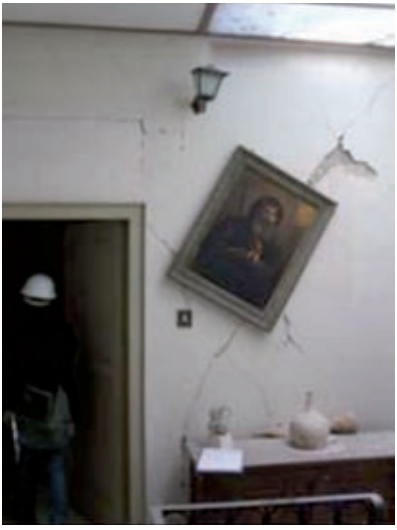
Picture 5.5.1.4 – *"Santa Maria ad Cryptas" (Abruzzo) church. Images before and after 2009 earthquake. Frescoed vault portion collapse.*

Picture 5.5.1.5 – *Basilica of "San Francesco in Assisi" ceiling frescoes collapse; September 26th, 1997 earthquake.*

5.5.2 *Mobile artworks: canvas paintings and icons case*

In this paragraph is proposed a possible seismic vulnerability elements list for canvas paintings and icons:

- Vulnerability to overturning (when the paintings and the icons are placed on supports). (A), (B)
- Hosting pictures or icons infill walls vulnerability (if they are disposed on infill walls or specially designed supports) (B).
- Canvas paintings or icons on not bound to the ceiling settings (A), (B).
- Paintings or icons on poor quality masonry infill walls settings (F), (G).
- Paintings or icons placed on a single nail (A), (B).
- Paintings or icons placed in vaults or ceilings likely to fall (F) (G).



Picture 5.5.2.1 – *Painting detachment from a wall in a building protected by L'Aquila Superintendence after April 6th, 2009 earthquake.*

5.5.3 *Mobile artworks: sculptures and museum objects*

It is proposed the seismic vulnerability elements synthesis for sculptures and objects.

Statues main vulnerability compared to seismic phenomena affect their rigid overturning, sliding or failure due to excessive tension (in the case of so-called "big statues" in which weight is likely to create potential stress problems on the material).

- Mainly concentrated in upper part statue mass (B), (C), (E).
- Statue lesions (C).
- Slenderness (high ratio between height and support base along most unfavourable direction) (B), (C), (E).
- Under statue separate base presence (forming a two seismic masses oscillations system with difficult to predict consequent amplifications) (A), (C).
- Reduced statue foot section (this condition may cause injury to the sculpture foot) (C).
- Stone or marble statue (those materials are more fragile than the bronze and marble statue are also full and has a significant seismic mass) (C).
- Statue located under vaults or ceilings which could fall on it (F) (G).
- Statue located on high architectural elements top (columns, friezes of churches, cornices, etc ...) (A).
- Statue located on a building/multi-storey container high floor (this configuration produces seismic amplification effects) (G).
- No shatterproof protective glass case (D)
- Reduced attrition between object base and surface on which it leans (this condition makes it possible slippage) (A)
- Small items and handmade works with slender forms (D), (E)


Picture 5.5.3.1 – *Small size objects displayed in glass-cases and shelves.*

5.5.4 *Archival Assets*

The objective is the archive's analysis, putting aside whole building characteristics vulnerability issue. It is proposed a seismic vulnerability elements synthesis for shelves and cabinets containing archival heritage:

- Rack/cabinet excessive slenderness (A) (B).
- Excessive mass hosted in the rack/cabinet (A) (B), (E).
- Distributed mass mainly to high quote from the floor (E).
- Located archive on a multilevel building high floor (A) (B) (G).
- No constraints shelving/cabinet walls (A), (B).
- Configuration clearly weak, e.g. supports are too small or deformed decks under books weight (E).
- Shelves vulnerability because they are too thin or poorly bound to supports (A), (E).

Picture 5.5.4.1 – *Store shelves and cabinets damage in Nocera Umbra (PG) after 1997 Umbria earthquake.*

5.5.5 Archaeological Sites

Here we propose a non-exhaustive summary of some seismic vulnerability elements for archaeological sites. The focus is on ancient temples or their ruins (such as columns or colonnades), construction likely to overturn e.g. aqueducts or free walls and megalithic type works.

- Building excessive slenderness (H), (L).
- Large masses at the building top (H) (L).
- Bad state repair (L).
- One side against the ground walls (H) (L).
- Poor quality and poor state masonry walls repair (L).
- Any type protection absence from atmospheric agents, in particular rainwater accumulation that, in long term, can weaken materials structural performance (L).

a)

b)

c)

d)

Picture 5.5.5.1 – *Vulnerable structures on archaeological sites examples. Megalithic dolmens in Bisceglie, Puglia (a); masonry walls at Pompei (b) column and temple in Paestum (c), Roman aqueduct in Segovia (Spain).*

5.6 *Intervention strategies to reduce museum objects and their support own vulnerability*

5.6.1 *Active interventions*

A. Rigid constraints

It intends to bond the museum object through cables or tying elements in order to obtain a hyper static configuration for constraint redundancy. This solution is particularly suitable for shelves and bookcases that can be linked to each other or to walls room that host them. It requires designing the cables and their attachment to wall so that they are able to absorb seismic force due to design acceleration at the desired level. It is assumed that the wall, where the cables are anchored, will be able to bear any seismic action submitted by the same cable. By consequence, it might be appropriate to include devices that can share concentrated pulling action cables on larger surfaces.

Picture 5.6.1.1 – *Rigid constraint of an important painting on wood. Painting (1) is tied back with adjustable clamps on vertical guide (2) and in front to base with other terminals (3) nailed on fixed support.*

B. *Elastic constraints*

Except of the stabilising action of the elastic constraints, they may also act as dissipation and energy absorption elements by intervening only in case of earthquake when strain thresholds balance limits are exceeded.

The same consideration made for rigid constraint applies to this type of bond. It seems a particularly suitable strategy for paintings on walls. In particular it would be effective when

adequate length cables are used, rather than nails placed just above the frame. In fact, long cables are able to dampen the seismic action on the hung painting. However, the tying elements must be elastic in order to limit excessive displacement induced by the specific configuration.

This device should also provide a sliding surface with a low attrition coefficient between back side painting and wall.

Alternatively, a good anti-seismic set could consist of heavy mobile paintings hosted on suspended from ceiling supports by high length cables.

Picture 5.6.1.2 – *Painting suspension. Museum object is fixed on a suspended support with the stick (1) and strings (2). The ground constraint is simple support (3). In earthquake case, strings cables drastically dampen fluctuations reducing frequency and therefore force.*

C. *Base isolation*

This is to decouple museum object motion from ground seismic motion by inserting supports to control and dampen oscillations. Seismic isolation needs a sufficient mass to be decoupled and therefore, this intervention strategy is suitable for large statues in which mass is defined by the statue itself, especially recommended in case of marble statues.

To apply isolation to smaller items, you can create special protected by glass-case cabinets with platforms on which the objects are placed. The isolator is applied to whole glass-case and not to individual objects.

A further application mode refers to floors intact portions (floating floors) isolation in order to create some low seismic risk special environments where to place more vulnerable objects in museums, galleries and exhibition spaces.

Picture 5.6.1.3 – *Experiments on big statues isolation. Statue is bound rigidly to an upper base that is decoupled from lower base. Interposed between two bases are seismic isolators. In earthquake event the top block, that brings statue, oscillates with low frequency and large amplitude, reducing seismic stresses on the statue.*

D. *Protection guaranteed by glass-case strength*

Through this device c/b collapse is considered acceptable and the effort is concentrated to limit their consequences on the protected object and make it recoverable after the seismic event.

Picture 5.6.1.4 – *Transparent and unbreakable glass-cases.*

This is to protect objects with transparent and unbreakable glass-case by falling debris and other objects or prevent-

ing their collapse. In the building ceiling collapse event, the work of arts under rubble is protected and retrievable at a later time.

Platform supporting objects in glass-case could still be made of such material to absorb objects' shock in case they fall and could be characterised with a high friction coefficient to prevent slippage phenomena.

E. *Mass and centres of rotation redistribution*

This intervention, particularly suitable for small objects, aims to their protection by increasing their mass at the object's base by rigidly fixing it to an adequate weight and/or enlarged basis (e.g. little statues) support or, in case of vases and amphorae, by simply filling their bottom with sand or other suitable material. The lowering of the gravity centre helps to reduce overturning moment vertical wing and prevents the overturning of the object. At last, inserting a basic support of adequate width, the horizontal wing of the stabilizing moment increases so the object moves away in the opposite direction of the rotation axis.

Picture 5.6.1.6 – *Small ivory statue is protected by a transparent L-shaped support which back binds (2) and prevents it from slipping through a nail and from overturning by increasing the wing rotation (1).*

Picture 5.6.1.5 – *Painting disposition of a special support designed to minimize overturning possibility by an adequate width base (1).*

5.6.2 *Passive interventions*

F. *Consolidation and building interventions*

Building consolidation and building intervention for protection is advised in this case. In particular, appropriate structural interventions in relation to an optimal cost/benefit ratio for more traditional b/c types (churches, ancient buildings in masonry) is recommended which even if they appear conservative, they are minimally invasive: tying elements insertion using steel chains, coverage weight reduction, tying elements insertion pushing absorption, masonry walls consolidation (if compatible with involved works of art).

G. *Object location due to the local c/b vulnerability choosing*

Simple actions such as simple objects relocation translates and ensures a higher protection level.

H. *Object strength capacity analysis against overturning or sliding seismic actions and monitoring*

This action is principally aimed to determine risk level in archaeological sites containing handmade works likely to overturn. For example, here are mentioned: ancient frescoes at the top masonry walls, columns, colonnades, temples, statues in open air, dolmen, prehistoric megalithic age installations, etc...

Analysis concerns elementary collapse vulnerability mecha-

nisms for the objects that represent potential risk, which are essentially based on underpinning simple support constraints. Vulnerability analysis for elementary mechanisms can lead to identify the structures in greater risk and create a database that will be monitored to assess any cracked or static worsening and then to undertake consolidation if that is decided to be necessary

L. *Archaeological restoration*

It refers to simple surface archaeological restoration or protection of the elements that may have beneficial effects on materials strength and can arrest the deterioration. In particular, it emphasizes rainwater retention importance in the archaeological sites that will not stagnate or slide against the works of art to be protected.

References:

1. Lagomarsino, S., Podestà, S., 1997. *Metodologie per l'analisi di vulnerabilità delle chiese*. CNR-Gruppo Nazionale per la Difesa dai Terremoti - Roma.
2. Augusti, G., Ciampoli, M., 2000. *Vulnerabilità dei beni archeologici e degli oggetti esibiti nei musei* (a cura di D. Liberatore). CNR-Gruppo Nazionale per la Difesa dai Terremoti - Roma.
3. AA.VV. *Linee Guida per la salvaguardia dei beni culturali dai rischi naturali. Fascicolo III. Linee Guida per la protezione dei beni culturali dal rischio sismico*. Progetto ENEA-Murst.
4. Angeletti, P., Borri, A., Longhi, F., Nasini, U., Severi, A., 2004. *La legge 18/2002 della Regione dell'Umbria sulla prevenzione sismica. Atti del XI Convegno Nazionale L'ingegneria Sismica in Italia, 25-29.01.2004*, Genova, pp. 61-72.
5. Direttiva del Presidente del Consiglio dei Ministri, 12 ottobre 2007, G.U. n. 24 del 29 gennaio 2008. Valutazione e riduzione del rischio sismico del patrimonio culturale con riferimento alle norme tecniche per le costruzioni.
6. Regione dell'Umbria, Allegato tecnico al B.U.R., 30.07.2003. Norme tecniche per la progettazione degli interventi e la realizzazione delle opere di cui alla L.R. 23.10.2002 n°18 finalizzate alla riduzione della vulnerabilità sismica.

6. Protocols and procedures for the safeguard of CH items in the case of a seismic event: general outlines

The historical analysis of seismic events occurred in the past and the evaluation of the relevant experiences in emergency situations provide useful indications to set up easily repeatable procedures. There are have been identified three phases: prevention, emergency and post-emergency, for which explicit recommendations to be followed in order to act with efficiency on the various risk scenarios involving CH items.

In this chapter, there are initially identified guidelines in general lines, indicating activities common to all scenarios and categories of works of art and making up the three different phases of intervention. Then in the sub-chapters there are analyzed specific aspects of those three phases pointing out the "additional" features of the specific proposals for rescuing the mentioned works of art: frescoes and wall paintings, canvas paintings, icons and so on.

Phase 1: prevention

Efficient prevention measures – i.e. actions to safeguard CH items both in ordinary and emergency situations – should take in consideration a series of operations to be analytically assessed as regards works of art and locations and should be preparatory and functional to the subsequent actions. These actions should be finalised to the planning of targeted interventions in foreseeable scenarios.

Basic macro-activities are stated in the following paragraphs:

1. Mapping, cataloguing and documentation of CH items
   - Organisation of data according to the typology, materials, author and location
   - Drafting of a detailed chart of the building with architectural and historical details of its construction
   - Acquisition of the existing documentation and its integration through further historical, graphic, photographic data to be carried out with the most appropriate methods
   - Geo-reference of sites according to cataloguing methods accepted by the relevant Authority for the protection of the Cultural Heritage and current legislation in force in each European country.

2. Routine maintenance
   - Setting up a monitoring calendar for maintenance work and interventions to establish the correct safety measures for the environment and the works of art involved as well as assessing from time to time their efficacy
   - Routine maintenance operations and their documentation
   - Periodical maintenance and inspection of the basic services – water, electricity, gas etc.
   - Monitoring and maintenance of alarm systems

3. Protection measures
   - Control of the anchorage and display systems of the works of art and assessment of protection systems for moveable and non-moveable CH items such as earthquake proof systems (building and/or consolidation of the structures/containers to cover the area's seismic risk). Passive protections are deemed necessary to avoid the risk of collapse of structures or part of them on works of art and display cabinets; methods to avoid the overturning of display cabinets and other objects should be considered.

4. Setting up and updating emergency plans

Emergency plans, based on those set up for the safety of individuals should be drawn up by CH category and type of risk. They should cover both priorities and ways of intervention making clear which would be the operations to be carried out when accessing for first time the site of interest (this responsibility should be assigned to specialised teams – e.g. fire-fighters, decontamination teams etc.) and the subsequent operations assigned to the CH expert intervention teams.

This means planning and organising all measures to be enacted in case of emergency with special reference to the study of the CH items transfer systems and identification of storage sites.

The emergency plan should cover the following main points:

– Seismic vulnerability:
  Analysis of the buildings and their contents and assessment of the impact of the seismic event and its possible consequences.
  - System vulnerability

  Assessment of risk of fire, safety and prevention systems (electricity, heat, air conditioning, anti-theft, CCTV and fire). Furthermore, analysis of possible consequences in the case of a seismic event should be carried out.
  - Assessment and updating of instrumental and human resources in the territory.
  - Analysis of the availability of adequate transport vehicles, drawing up and updating lists of materials and equipment according to the type of calamity, specific characteristics of the site or buildings and of the works of art.
– Listing and updating the roster of CH and conservation experts to be periodically contacted in order to acquire fresh information on their competences and availability in emergency cases.

– Operational planning and updating in emergency cases.

Setting up a series of operational plans, with reference to the specific site and CH items of interest and possible risk scenarios is also required. These plans should cover retrieval measures,

disinfestations – if needed – packaging, transport and storing, systems for CH item identification and monitoring until they are properly stored, equipment and devices for emergency cases and a system for identification of storage sites. Assessment of authorised storage facilities for moveable items at short, medium and long term and/or possible alternative sites.

– Full time cooperation with the Civil Protection is deemed mandatory.

Establish and maintain a full time link with the chain of command of the Civil Protection for prevention, forecasting and monitoring purposes.

5. Organising and training intervention teams

- Organising and training CH intervention teams in the case of a seismic event, planning and executing periodic exercises.
- Drawing up a protocol of intent amongst all institutions involved indicating all team operations of coordination.

Phase 2: emergency

The emergency phase is characterised by a series of procedures and measures set up by the Command Headquarters and carried out during the occurring calamity. The emergency is also marked by an uncertain and ever developing risk scenario. This could be even worse in the case where there are CH items affected since their typology is extremely diversified.

Hence, there are five basic macro activities to be considered during a seismic emergency and during the aftershock period closely linked with Phase 1 and with staff specifically trained for this purpose.

1. Alarm and briefing

The accountable authorities should alert and call up the first intervention teams supplying them with detailed information on the seismic event and on the CH items of interest. All the data and guidance explicitly stated in the emergency plan should be implemented and clearly communicated to the teams. The authorities should also supply the teams with PPE (Personal Protection

Equipment) as well as appropriate instruments in accordance to the type of the intervention that will be carried out.

2. Site safety measures

Safety plans should be drawn up after the survey of the site affected by the emergency. A thorough analysis of the safety and protection measures to be enacted for the safeguard of individuals and sites should be undertaken to decide appropriately and without compromising the CH items by causing any further damages.

3. Direct assessment of the conditions of CH items and planning of necessary interventions

Where immediate assessment is possible, the following actions are required:

- assessment of historical, documental aspects and conditions of the CH items and forecasting possible further deterioration based on data on hand
- definition of the type and priority of intervention according to type, material and conservation of the CH items at risk
- forecasting operations for the safeguard and conservation of CH items once the emergency is over should be considered. It is advisable to appoint people responsible for the operations and for the implementation of the relevant procedures (assessment and improvement of the protection measures already enacted, restoration and conservation *in situ*, packaging and transport to safe storage areas).

4. Safety operations

- implementation of protection measures (which may include also the use of specific techniques such as supports, scaffolding, frames, roofing or materials such as waterproof or fireproof tarpaulin, paper; removal to outdoors or indoors safe areas or to storehouses previously identified). First conservation operations to stop deterioration and/or prepare the CH items for packaging and transfer (e.g. contain the risk of detachment and carry out collection of fragments)

– labelling CH items in order to ensure their traceability should only fragments be retrieved or if the CH item has to be removed and transferred from natural locations for safety reasons or for further conservation operations.

5. Photo and video documentation and logs
   – documentation of the conditions of the CH item as a whole and in detail in order to assess the damage, as well as the rescue and the first intervention procedures to be carried out. The documentation should be prepared during the operations using digital cameras, thus ensuring the immediate transfer of the relevant data
   – daily updating of the log indicating the state of the emergency situation, the interventions carried out on the various sites and the items under survey (to be listed) as well as the protection measures needed to ensure conservation.

Phase 3: post-emergency

This phase includes operations to be carried out immediately after the earthquake at the end of the emergency phase. It defines and enacts the conservation operations needed to stabilise the works of art and therefore contain the deterioration and further damage for a correct storage of CH items awaiting restoration.

6.1 *Frescoes and wall paintings*

A wall painting is any piece of artwork painted or applied directly on the wall. The outer layer of the plaster is an integral part of the frescoes support; in fact while for the painting on canvas, the support of the paint layer is the canvas and for the painting on wood panel is the wood frame, the wall is meant here as the outermost layer of the wall which is also the support of the painting. The colour is bind with the plaster to a different degree according to the painting technique used – fresco, distemper, oil.

In frescoes the paint is embedded in the plaster, becoming part of it and resulting in a cohesive bond between the pigment and the plaster, while in the other techniques it only adheres to it.

The phases listed in the foreword are valid in general terms. However, wall paintings will be treated as follows:

Phase 1: prevention

1. Mapping, cataloguing and documentation of CH items
   - Mapping and cataloguing of wall paintings under protection with geo-reference indicating data, such as title, author and date, will be based on the cataloguing systems established by the relevant Authority for the protection of the Cultural Heritage as per current regulations.
   - Detailed documentation should be drawn up by experts to create a digital image archive showing the size of the paintings and thus be able to faithfully reproduce them in any scale up to 1:1. (image 6.1.1)

Image 6.1.1 – *Digital image of a frescoe*

This documentation will include HD photographs and photogrammetries taken *in situ* of both the wall paintings and surrounding structures to geo-reference them, to reproduce CAD

designs and then mosaic, scan, retouch and print the original images in scale 1:1

2. Routine maintenance
   - Conservative interventions to avoid damage spreading and worsening.
   - Routine maintenance operations such as dry cleaning, dusting with soft brushes and consolidation work to re-establish the adhesion and cohesion of both the painted surfaces and the underlying layers, if damaged.

The calendar of interventions as well as the specific operations should be set up according to specific needs and state of conservation of the item. However, it is clear that if maintenance operations are punctual and frequent there will be less need of interventions and better results in terms of safeguard.

- Paper documentation (including subject, technique, author, period and location) listing: maintenance date, type of intervention, materials, name of operator. Each card will include digital photographs on CD and should be sent to the relevant Authority for the protection of the CH.

3. Protection

Adequate support measures should be taken, when the paintings stand near structures or containers (display cabinets, cabinets and shelves), which in the case of a seismic event could collapse or overturn damaging the works of art. Frequent checks to ensure that the structures supporting the paintings are stable and solid and that walls, floors and roofs are built or have been reinforced to meet earthquake proof regulations are recommended.

4. Emergency planning

Special care should be taken for:

- Finding a site (working station) to "stabilise" and store the works of art. Rooms where to store the fragments in cabinets should be identified. Storage and work sites can be separate and should be large enough to contain frescoes of any size. The working station where the frescoes could be 'stabilized' should be not less than 50 sqm and should have an area for storing the boxes containing the

materials, tables for working on the fragments, a storage area for materials and tools and cabinets for storing the stabilised fragments prepared for transportation. The cabinets containing the fragments already saved should have sliding racks with 'sheets of paper' placed on them so that the fragments do not touch one another and thus cause an accidental trauma, or any other appropriate method using spacers. The working station should also be equipped with fire extinguishers, dust suction and alarm systems.
- Acquiring crates (with handles) in which the retrieved fragments will be packaged. Maps of the locations of the frescos should travel with them in order to complete the cataloguing and restore the fragments to their original places.
- Obtain and organise all material needed to work on the stabilization of the fragments as in the post-emergency phase.

5. The emergency teams – Organisation and training
   - Specific training of first intervention teams on how to reach and work in disaster areas without further damaging the works of art or the sites should be organised. This will allow locating, collecting and removing the works of art or their fragments for further reassembly and restoration.
   - Specific training in removal and transportation of the fragmented works of art is also advisable.

Phase 2: emergency

1. Alarm and initial briefing
   - Supply the teams with the necessary equipment for the recovery of the works of art. Items that should be included in the equipment are:
     - Maps of the sites, description with full data and photographs before the earthquake;
     - Multiple copies of the maps on which the grid and all data regarding the collection of the fragments will be added;

- Paper, different size indelible ink marking pens and rigid plastic panels.
- Flashlights, string, nails, hammers for the grid;
- Crates for the collection and transport of fragments;
- Self-adhesive and waterproof labels;
- Paint brushes for removing dust from the fragments;
- Alert laboratories and storing locations to wait for the results of a first analysis and details of safety measures and first interventions.

2. Safety measures - Sites
   - Clearing and cordoning off intervention areas. Protection from debris near collapsed walls or painted plaster avoiding trampling over it and removal of any fragments before the arrival of restoration experts.
   - Clearing sites, under experts' supervision, using the utmost caution in order to avoid causing any further damage.

3. Assessment of the condition of the works of art and intervention planning
   - Assess conditions, damage, imminent risks, photographic documentation; define immediate interventions.
   - Make weakened structures safe (from subsidence, shifting, collapsing, fire and flooding) by using temporary supports e.g. scaffolding.
   - In the case of fragmented painted walls, set up a variable dimension grid (image 6.1.2). The grid should be set up to mark the depth of the debris with coordinates x, y and z. Create a reference plan including the said grid (image 6.1.3) and determine a safe location for first treatment and preparation to transport the fragments.

Image 6.1.2 – *Setting up a dimension grid.*

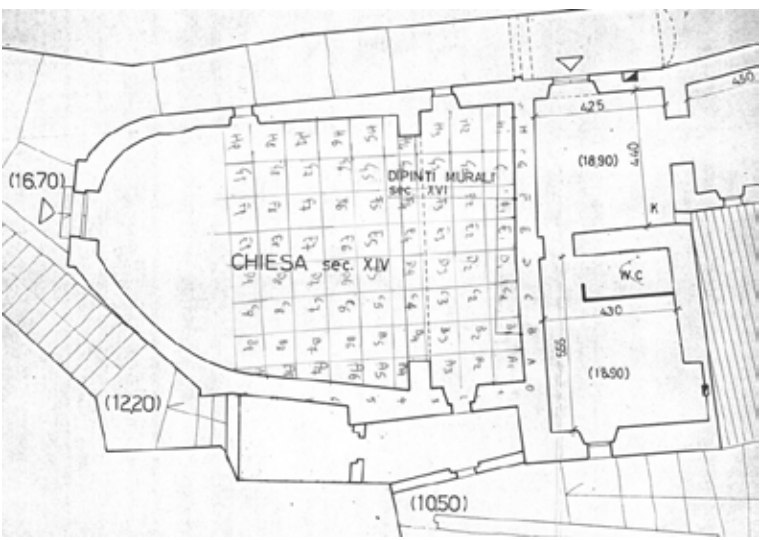


Image 6.1.3 – *Creation of reference plan with accordance to the set grid.*

– Securing the paintings through use of props and protections panels interposed, cloths and bandages with special glues and/or resins (by selecting materials that can be easily removed, so as not to affect the conservation status of the works) and in cases limit, if environmental conditions permit, detachment of painted plaster. However if the paintings have experienced flooding and murals are soaked in water, the painted surfaces should not be touched, since they are further weakened by the presence of water and may crumble. They should not undergo conservation work, or forced ventilation and abrupt changes to their environmental parameters.

4. Interventions

– Removal of detritus containing wall paintings. Initial careful cleaning and cataloguing according to where the item was found as per grid ref. x, y, z coordinates (image 6.1.4);

Image 6.1.4 – *Grid reference of the item.*

– Packaging items in crates of solvent resistant plastic, stackable, with handles, dimensions ca. 50x30x10, with holes for the drainage of the consolidating liquids. These crates will then be numbered and marked with the coordinates of the retrieval point in the grid;
– Transport to pre-arranged handling/storing site.

5. Photo and video documentation and log
   - Digital documentation of all interventions and written report of all phases including date, name of writer and of all operators involved.

Phase 3: post-emergency

Murals damaged but not off the walls, which could not be immediately protected *in situ* will be subject to conservation measures in order to stabilise them until proper restoration takes place. These measures can be carried out only after stabilisation of the structures and when the walls have been dried. Fragmented paintings instead will be handled, catalogued and stored in special containers in order to allow manual or computerised assembly. It is recommended to set up a laboratory equipped with shelves to store the restored fragments.

Treatment of fragments of painted plaster still attached to fallen quoins
   - retrieval of fallen quoins (image 6.1.5) with painted plaster still on them (image 6.1.6); cleaning of fragments

Image 6.1.5 – *Fallen quoins.*

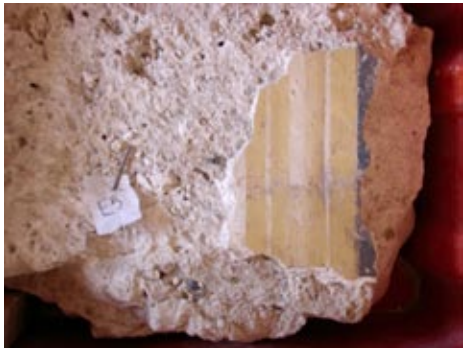


Image 6.1.6 – *Fallen quoins with plaster.*

- place the quoins on sand in order to position them together and analyse them
- removal of paintings from each quoin after cleaning and protecting them with a layer of washi (Japanese paper) paper, gauze and linen cloth applied with an acrylic resin solution or emulsion. The plaster have to be removed with attention and minimum 5mm thick plaster should be left (image 6.1.7).

Image 6.1.7 – *Removal of plaster.*

- thinning, smoothing down and strengthening the back of the murals, applying additional support of gauze and linen cloth soaked in lime followed by the removal of pictures and preparation for the application at the back of the fragments of a polyethylene sheet.

Treatment of fragments of crumbled painted plaster (not attached to structural elements) (image 6.1.8)

Image 6.1.8 – *Fragments of crumbled painted plaster.*

- 24 hours immersion of each crate containing only fragments of plaster in a "tub" filled with ethil silicate; the fragments will then be put in another crate to drain the excess liquid;
- Fragments are cleaned with soft paintbrushes and then glued on a flat cardboard surface (A3 size)
- This is then applied to a thick polystyrene support and secured with stainless steel nails
- The polystyrene supports should be labelled with the number of the relevant crate and in a progressive number. (image 6.1.9)

Image 6.1.9 – *Items labelled and placed on polystyrene supports.*

- Fragments are then thinned down to 10 mm with a non vibrating tool equipped with an abrasive disk and a vacuum dust collector
- The thickness of each carton will be reduced to 5 mm (average thickness of the original plaster) by 0.5 mm for each passage of the calibrating machine
- Fragments less than 5mm thick will be brought up to the thickness required using special mortar and smoothing them down with the calibrating machine

Final treatment of the two types of crumbled fragments:

- A 2 mm thick polyethylene sheet will be applied to the back of the fragments using a water and heat resistant glue. Removal of the special glue (gum Arabic and thickeners) previously applied to the front of the fragments with warm water (images 6.1.10 – 6.1.13).

Image 6.1.10 – *Removal of the special glue, step 1.*

Image 6.1.11 – *Removal of the special glue, step 2.*

Image 6.1.12 – *Removal of the special glue, step 3.*

– Storage of the sheets containing the fragments on shelves or cabinets (images 6.1.14, 6.1.15).

Image 6.1.13 – *Storage of the sheets containing the fragments.*

6.2 *Paintings on canvas*

Paintings on canvas contain different mediums (pigments and bindings) according to the period they were painted and the techniques used. Pigments range from oil, distemper, acrylic and other mixed media, while supports can be made of linen, cotton, hemp cloth, silk etc of various weave and thickness, single or multilayer, sewn according to the size of the painting and the period.

Canvases are usually covered with a layer of mixed glue and chalk, and then colour is applied on top of them. The composition and the thickness of this mixture vary according to the period and school of art.

All these specific characteristics are important in relation to possible damage, conservation and restoration.

Paintings on canvas applied to ceilings often painted on paper glued on the canvas are considered a category apart. This is a separate category that requires different treatment and therefore not included in this study. As with all categories of works not specifically covered in the examples in Chapter 6,

similar studies which relate to those categories should be carried out, according to the guidelines.

As regards the protection of paintings on canvas during an earthquake, prevention, emergency and post-emergency measures listed in the introduction are to be considered valid in general terms but these works of art are to be treated according to their individual characteristics defined in the following paragraphs:

Phase 1: Prevention

1. Mapping, listing and documentation of H
   - Census of listed paintings on canvas, geo-reference and listings with main data (including title, author and creation date) according to the official cataloguing system as per regulations in force.
   - Drawing up of a detailed file, according to the said cataloguing indicating the conditions of the painting and including the documentation of any repairs and/or restorations.
   - Professional photographs of each painting should be made: whole picture and detail pictures especially of those parts which are not serial and are reproducible such as hands, faces, scrolls and inscriptions and signatures.

   Photographs of the back of the canvas: frame, any front and/or back frames and/or the structure of the canvas that has been stretched on, supports, hooks or any other supports that connect the frame to other structures. Photographs will have to be in high definition.

2. Routine maintenance

   Main maintenance should include the following actions:
   - periodical assessment of the tension of the frames and their conservation. If needed, wooden frames should be strengthened and disinfected.
   - dry-cleaning of the back of the canvas with soft paintbrushes and vacuum cleaners; dry-cleaning of the paint-

ed surface with soft paintbrushes provided the coloured surface is in good conditions.
- strengthening the degree of adhesion and cohesion of both the painted surface and the underlying layer, if damaged.
- in case of wooden frames, dusting, strengthening and disinfection should be carried out.

All the above interventions should be carried out according to the state of the item and its conservation. They shall be documented on individual cards showing date of interventions, data of painting (subject, technique, author, period), location, type of intervention and materials used, names of the restorers. All interventions should be documented by digital photographs.

3. Protection

Particular care should be given to:
- structures (stable, solid and earthquake proof)
- hooks on the walls and stability of the cabinets
- stability of the structures, furniture and objects located in the surrounding area should be also taken in consideration since should they fall could damage the painting.

4. Intervention planning

Much care should be taken in finding the right storage locations. These should be big enough to contain the items and have enough space for the operators to move around when bringing items and materials in and out, for work tables, to store materials and equipment and for shelving.

Locations should also be equipped with fire extinguishers, alarm systems and a controlled air conditioning system to ensure a correct thermal-hygrometric environment.

Storage areas should be equipped with three types of racks:
- moveable racks for the transport of framed canvases. Frames as those indicated on the image 6.2.1

Image 6.2.1 – *Various types of frames.*

- moveable racks with special 'suspended' supports for rolled-up canvases
- racks with metal grid shelves (one for each painting to be positioned flat)

The following materials should be ready and at hand:

Fireproof crates for transport of framed canvases, wooden panels, nails, tools and ropes, as well as PVC tubes (Ø 50 cm) to contain rolled-up canvases or fibreglass panels on a wooden structure; all first intervention and transport materials such as gauzes, washi paper, resins, solvents, vaporizers, paintbrushes, waterproof materials such as Goretex and all packaging material for transport.

Maps should always be updated and clear indications should be on them with regard to the location of the works of art and

their detailed description along with photographs in order to be able to easily identify, document and catalogue them.

Transport should be organised.

5. Intervention teams and training
   - Specific training for operators on how to access "critical areas" without causing further damage. Teams should be trained on recognising, documenting and cataloguing works of art.
   - Training on first intervention measures: moving, packaging and transport of works of art.

Phase 2: Emergency

1. Alert emergency teams and initial briefing
   - List of equipment for the retrieval of works of art:
     - Maps with location, data and photographs of each painting prior to the earthquake
     - Copies of maps, data and photographs of each painting prior to the earthquake
     - Paper, different sizes indelible ink marking pens and rigid plastic panels used as note boards when there is nothing else to write on
     - Flashlights, pliers, clench cutters, nails and hammers for taking the canvases off their frames and for packaging as necessary
     - Waterproof adhesive labels
     - Paintbrushes for initial dust removal
     - Same material as in Phase 1 First intervention (gauzes, washi paper, resins, solvents)
   - Alerting labs, storage areas and transport vehicles while awaiting results from initial assessment of damaged areas and items.

2. Location safety measures
   - Clearing out and cordoning off intervention areas safeguarding debris which might contain fragments of canvases, frames and decorations in order to avoid treading on them and moving out them before the arrival of specialised restorers

– Carefully cleaning areas in order not to cause further damage. This operation must be carried out under the supervision of restoration and conservation experts.

3. Direct assessment of the conditions of the items and intervention planning
   – Assessment of the state of the paintings
   – Transport of paintings in danger of being damaged to safe areas
   – List of immediate intervention to be carried out and equipment required
   – Locate a safe area as clear as possible from dust where to start initial restoring operations and preparation for transport

4. Interventions
   (*This section does not describe retrieval of frames*)
   – Organising transport to remove the work of art without causing any further damage: removal of dust, spraying painted surfaces with a mixture of thermoplastic resin or removable adhesive or gauzes according to the degree of damage
   – Packaging, cataloguing and labelling of small paintings which can be transported without removing the frame. Painted surfaces will be protected by sheets of washi paper, bubble wrap, other shockproof material or fireproof wood
   – Removal of big canvases from their frames (photographing each passage), cataloguing and transport
   – Roll canvases around tubes (Ø 50cm) without stretching them and putting a layer of washi paper in between the tube and the painted surface
   – Cover the tubes with a transpiring and waterproof material such as Goretex. Frames and stretchers must be labelled and travel with their relevant tube
   – Thorough search of the premises where the paintings have been found in case there should be any missing fragments. Initial cleaning of fragments, strengthening, cataloguing and transport together with the painting
   – Transport to the established storage area

5. Photo/video documentation and log
   - Digital photos of the intervention phases and the written description of each passage with the date carried out, the name of operators and the interventions should be referred.

Phase 3: post-emergency

Storage areas must be thermal-hygronometrically stable. When paintings are involved the following measures should be taken:

A) Paintings transported in crates (paintings stored *in situ* and transported without taking the canvas off the stretcher) will be stabilised and put vertically on the racks (pictures 016-017-018) until proper restoration is carried out.
B) Rolled-up canvases will be suspended on the racks in order to avoid distortion caused by their own weight.
   - Canvases should be disinfected on the tubes. This operation can be carried out also on the wrapping.
   - Whenever possible, the canvases should be unrolled and stabilised in order to move and store them until proper restoration begins.
   - The canvases will then be placed horizontally on the racks on top of a sheet of washi paper with the painted side facing up. Canvases must be placed separately on the racks to avoid contact.

6.3 *Icons*

The term "icon", deriving from the Greek word *eikon*, is originally meaning any image or representation. In the History of Art "icons" are the holy images used in the Orthodox World and most precisely the portable ones painted on wood panels. In very rare cases Byzantine portable icons were made of mosaic or enamel (see for instance the Pala d'oro in St Mark's Cathedral in Venice brought from Constantinople in/or slightly after 1204). In some cases the icons are covered with metallic covers reproducing the same or similar iconographic subject.

These metallic covers are frequently of gold, silver or various gold-plated metals. In the icon's world could also be included the painted with egg-tempera wood panels of the Medieval Primitives painters in the Catholic World (13th-15th century) before the introduction of the oil painting on canvas during the Renaissance, common in the East and West Europe until the 12th-13th centuries.

The wood timbers used were those commonly available in every country. For example among the frequent kinds of timber are the pine (*pinus nigra* or *pinus bruttia*), the cypress (*cupressus sempervirens*), the walnut (*juglans regia*) and rarely the cedar (*cedrus brevifolia*). The wood panel can be one piece or several ones, assembled together by means of wood and metal elements. Most frequently on the wood panel is glued a linen or cotton cloth which is covered with several very fine and thin layers of gesso. Rarely the gesso is directly applied on the wood panel. On the well-smoothed surface of the gesso the painter was producing the drawing of the icon, then he was gilding the background and/or other areas and finally he was painting the icon with egg-tempera. After the pictorial layer of the icon was dried, a final protective varnish layer was applied. Initially the icons were painted with the encaustic technique with wax medium instead of the egg. The egg-tempera technique and the gilded background were gradually abandoned in the Catholic World since the 15th century during the Renaissance Period together with the traditional dogmatic and standardised iconographic tradition. On the opposite, in the Orthodox World the egg-tempera and the gildings with foil are still in use together with the traditional dogmatic and standardised iconographic tradition as established with the end of the iconoclasm in 843.

Phase 1: preventive measures

1. Mapping and recording with written and photographic documentation
   - Mapping of the old icons, giving the priority to those endangered, as far as their geographical distribution is concerned, mentioning mainly the place of provenance such as monasteries, churches, chapels, museums.

- Digital recording of the icons following the system established by the relevant Autority
- Digital photographic documentation classified in four main categories as follows:
  1. State of preservation before any treatment.
  2. First aid treatment *in situ* where the destruction took place.
  3. Carry out interventions during treatment for conservation/restoration.
  4. State of preservation after treatment.
- Digital drawings of technological or other features of important icons, such as the wooden structure or the areas of special destructions.

After the recording by the Art Historian, digital recording of the diagnosis of the state of conservation of the icons must be done by the Conservator-Restorer of the icons following the system established by the local or national Centres of Cultural Heritage by completing the related form. These forms are to be completed at a first stage and submitted as a proposal for approval and after completion of the works it will be re-adapted as the final documentation.

2. Preventive conservation and maintenance

- Guidelines and instructions should be given to the users or supervisors of the icon heritage so that they always apply measures for preventive conservation of this heritage. These guidelines and instructions concern the keeping of favourable climatic conditions, conditions of light and measures for security. Also instructions of how to use and clean old icons, which are still in use within religious buildings.
- Conservative interventions to avoid damage spreading and worsening:
  - In cases where icons have been broken into pieces, they must be carefully collected and be kept on horizontal shelves. The pieces must be numbered separately for every icon so that their reunion during conservation is facilitated.
  - In cases where there is pealing of the colours, a preventive facing with Japanese paper must be applied