International Conference

"Managing Cultural Heritage Protection In Changing Environment"

Prague, Czech Republic, 27 June 2019

Resilience supportingng tools for CH managers and owners

Prof. Ing. Miloš Drdácký, DrSc./Institute of Theoretical and Applied Mechanics (ITAM AV ČR

The **concept of resilience** indicates the **ability of a community or urban unit to withstand shocks to its survival and** to **absorb changes without a transition to a different state**

In other words resilience represents the capacity of a system or object to **absorb disturbances** and **reorganize** while undergoing change so as to **retain essentially the same function, structure, identity,** and **feedbacks**

Urban resilience – a complex issue

Resilience is quite often confused with related concepts which contribute substantially to it, such as:

sustainability, adaptability, transformability, resistance, equilibrium, stability, durability, robustness

Cities are **complex adaptive systems** with specific characteristics, therefore the **resilience of built heritage** as a substance or a **set of elements** of a **historic (smart) city** must take into account **resilience of individual cultural heritage objects** together with their interactive, dynamic, emergent and adaptive roles.

Complex adaptive systems have **histories** allowing to **learn from experience**

Resilience and disasters

Three aspects of resilience are involved in response to disasters (Vale et al. 2005) all are important for cultural heritage

Physical resilience – refers to the ability of a city or community to rebuild its physical structure

Emotional resilience – refers to the ability of individuals, families and communities to cope and heal from trauma

Cultural resilience – signifies the perseverance of cultural practices and norms through event of great cultural trauma (i.e. the ability of customs, traditions, languages or religions to survive and evolve).

Buildings are particularly vulnerable to natural disasters when **no / poor maintenance** has been carried out for years. This frequently happens in the case of vernacular or minor historic buildings. Some examples:

It contributed to the failure poor houses in Haiti or villages around L'Aquila, but also of San Francesco in Assisi, and in windstorms, floods, too.

IMMOVEABLE HERITAGE

INSPECTION OF STRUCTURAL HEALTH

- Regular inspection of structural health and loading conditions
- Discovering of structural weakness or critical problems
- Informing relevant stakeholders & decision makers - owners, managers, users, public, authorities – maps!
- Suggestion of protection strategies & measures
- Decision on adopting relevant measures:
  - maintenance
  - repair of various extent
  - retrofitting – “first aid” enhancement
  - retrofitting campaigns – systemic & standardized

REGULAR MAINTENANCE

- one of the **most important strategies** against damage
- lack of regular maintenance leads to material decay and loss of the structural properties
- maintenance is usually a result of a regular inspection, or
- regularly on a basis of a **maintenance plan**,
- maintenance actions in most cases do not require design work or even engineering supervision.
- they can be left to the skills of properly **trained craftsmen**
- this enables action to be taken **quickly**, and **prevents** a defect developing into **more serious damage**
- a **maintenance guide** is a useful tool, and should combine **tips for inspection** with **recommendations** on how to fix problems that are identified.
- work should focus on the state of the **joints**, **masonry integrity**, **material condition, resistance, overall integrity & stability**.

Disaster affects many buildings as well as a large amount of moveable family heritage – therefore, involvement of owners into resilience preparedness is necessary, which needs to provide them with adequate supporting information and advice sources – **manual for condition self-assessment and for adopting appropriate actions before, during and after any disaster**

EXAMPLE OF SUPPORTING MANUAL SHEETS

HAZARD:

Criticality

Presence of rendered masonries with clay mortars which are vulnerable in flood situations.

Typical damage

Washing out clay mortars from masonry joints after long duration of flooding or due to flow around the surface.

Resilience measures

Do-it-yourself PREVENTIVE	Do-it-yourself EMERGENCY	Do-it-yourself POST DISASTER
Repair all rendering discontinuities or detachments. Render the walls (if possible) with water less sensible mortar or close masonry joints with water resistant mortar.	Wrap the wall in plastic foil for temporary protection against water stream flow.	Support the walls against buckling or failure of outer wall leafs with temporary shoring. Perform deep repointing of the wall.

For selected criticalities short most important data are summarized, illustrated and the appropriate actions suggested and guided.

Criticality	*Typical damage*	*Situation examples*
Presence of non-rendered masonries with clay mortars which are vulnerable in flood situations.	Washing out clay mortars from masonry joints after long duration of flooding or due to flow around the surface. *Situation presents destroyed retaining stone masonry wall constructed with clay mortar* →	
Resilience focused measures	**Skilled craftsmen help necessary**	
Preventive	*During disaster*	*After disaster*
Render the walls (if possible) with water less sensible mortar or close masonry joints with water resistant mortar.	Wrap the wall in plastic foil supported with formwork of stiffer plates for temporary protection against water stream flow.	Support the walls against buckling or failure of outer wall leafs with temporary shoring. Perform deep repointing of the wall.
Relevant hazards	**Floods – river, flash, tidal; Heavy rain**	

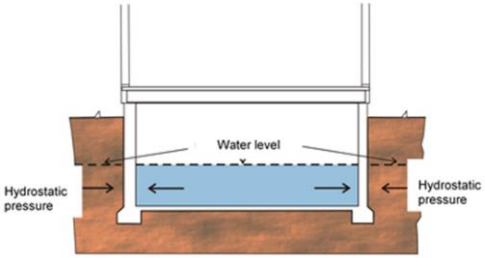
Criticality	*Typical damage*	*Situation examples*
Presence of materials which are vulnerable during intensive wetting – dried brick or adobe masonries.	Reduction of strength and load carrying capacity. Loss of material integrity, also during drying *Situation presents mixed dry brick /stone wall endangered with loss of integrity during drying after plaster removal.* →	
Resilience focused measures	**Do-it-yourself possible**	
Preventive	*During disaster*	*After disaster*
Repair all wall rendering discontinuities or defects. Protect the masonry against direct contact with water – sufficiently over-lapped roof eaves.	Wrap the wall in plastic foil for temporary protection against flooding water or heavy rain. Temporary shoring of walls, protective sheets on the both sides.	Drying without removal of render.
Relevant hazards	**Floods – river, flash, tidal; Heavy rain**	

Criticality	*Typical damage*	*Situation examples*
Foundation built on subsoil with fine particles vulnerable to washing out. Typical subsoils of this type are fillings and embankments.	Washing out of the fine particles from the subsoil layer and subsequent loss of load carrying capacity and collapse of supported walls. *Situation presents additional settlement of partition walls founded on collapsible soil due to washing internal erosion.* →	
Resilience focused measures	**Skilled craftsmen help necessary**	
Preventive	*During disaster*	*After disaster*
Subsoil strengthening with grouting. Deepen foundations.	Temporary support of endangered walls against failure due to additional settlement or creation of caverns.	Fill in caverns or replace unsuitable subsoil with more water flow resistant. Usually, the damaged walls need to be reconstructed.
Relevant hazards	**Floods – river, flash, tidal**	

Criticality	*Typical damage*	*Situation examples*
Presence of slender structures with materials which are vulnerable during intensive wetting – burnt brick or water sensitive stone masonries.	Reduction of strength and load carrying capacity for bricks up to 50%. Possible total collapse of a building. *Situation presents total failure of a house with ground floor brick pillars which lost their load carrying capacity during flood.* →	
Resilience focused measures	**Engineering assessment and design necessary**	
Preventive	*During disaster*	*After disaster*
Assessment of load carrying capacity of critical elements at water saturated condition. Proposal for strengthening measures.	Temporary shoring or strengthening of endangered parts.	Removal of debris with shoring of adjacent still standing structures and their stabilization based on a careful structural survey and design.
Relevant hazards	**Floods – river, flash, tidal; Heavy rain for façade elements**	

Criticality	*Typical damage*	*Situation examples*
Presence of timber structures damaged by biological agents, e.g. wood destroying insects or fungi.	Massive wetting and subsequent partial o total failures due to a decreased strength and increased dead load. *Situation presents partially failed timber ceiling biodegraded with insects and fungi during total inundation..* →	
Resilience focused measures	**Skilled craftsmen help necessary**	
Preventive	*During disaster*	*After disaster*
Replacement or strengthening of damaged structural elements. Repair of condition defects.	Temporary shoring of endangered parts.	Removal of shoring after complete drying of structural elements. In case of damage or failure subsequent repair of structural defects.
Relevant hazards	**Floods – river, flash, tidal; windstorms; earthquake**	

Criticality	*Typical damage*	*Situation examples*
Possibility that high water reaches levels above ceiling structures and causes water saturation of structural as well as stored materials and increases significantly the dead load of the structures.	Overloading and excessive deflection of ceiling structures, even failures of ceilings of floors may occur. *Situation presents destroyed light ceiling boards with water and mud saturated thermal insulation layer.* →	
Resilience focused measures	**Do-it-yourself possible**	
Preventive	*During disaster*	*After disaster*
Removal of stored materials with a high water absorptive capacity, temporary support of ceilings and floors.	Temporary shoring of endangered parts. Temporary removal of absorptive thermal insulation materials if possible.	Removal of shoring after complete drying of structural elements. Removal of damaged or restoration of removed water absorptive thermal insulation layers.
Relevant hazards	**Floods – river, flash**	

Criticality	*Typical damage*	*Situation examples*
Presence of elements endangered due to a high horizontal loads – typically water pressure on walls of underground spaces.	Heavy cracks and deformation in the walls, partial or total failure. *Situation presents possible protection of walls using counterbalance of water. →*	
Resilience focused measures	**Do-it-yourself possible**	
Preventive	*During disaster*	*After disaster*
Extrados water proof insulation of cellars to prevent wetting of walls – useful only in combination with intentional flooding of the cellar space during flood situation (see →).	Filling the cellar with water to create counter-balance against the outer forces. In buildings with extrados waterproof insulation a water tight foliating of the cellar space and filling with water can be adopted.	Controlled pumping of water from cellars keeping the water level inside and outside in equilibrium. Drying the walls.
Relevant hazards	**Floods – river, flash, tidal**	

Criticality	*Typical damage*	*Situation examples*
Presence of defects on roof envelopes causes water penetration into floors, accumulation in water traps, vulnerability to wind damage.	Wetting masonries and timber structures, material degradation, fungi colonization, subsoil defects. *Situation presents destroyed retaining stone masonry wall constructed with clay mortar* →	
Resilience focused measures	**Skilled craftsmen help necessary**	
Preventive	*During disaster*	*After disaster*
Repair the roof envelopes. Increase number of fastening elements fixing the roofing tiles or metal sheeting.	Use of fabric tops for covering unrepaired defects.	Repair roof damage as soon as possible.
Relevant hazards	**Heavy rain; Windstorm**	

Criticality	*Typical damage*	*Situation examples*
Roof framework joints and elements weakened by biodegradation (presence of fungi or wood destroying insects) or mechanical damage.	Partial or total destruction of roofs. *Situation presents a degraded / rotted roof frame joint →*	
Resilience focused measures	**Engineering assessment and design necessary**	
Preventive	*During disaster*	*After disaster*
Replace damage parts of the roof frameworks, repair small defects by a skilled carpenter..	Temporary support of the weakened structures with shoring based on stable walls or reinforced vaults or ceilings.	Repair the defects and maintain the roof structures in perfect conditions.
Relevant hazards	**Floods – river, flash; Heavy snow precipitation; Windstorms**	

Criticality	*Typical damage*	*Situation examples*
Long term draught on sensitive soils – namely clay. The effect may be increased by trees in the vicinity of buildings.	Shrinkage of clay subsoil creates additional settlement and cracks in masonry. *Situation presents a crack generated by shrinkage of clay subsoil intensely dried with roots of high trees. →*	 *Picture: Ivo Herle*
Resilience focused measures	**Do-it-yourself possible**	
Preventive	*During disaster*	*After disaster*
Drainage rain water in the clay subsoil in order to keep it wet even during draught periods.	Regular watering of the clay subsoil near buildings. Hewing trees with deep roots in the vicinity of buildings.	Watering subsoil. Stabilize foundations. Repair cracks in masonry.
Relevant hazards	**Draught**	

Massive damage and lost of cultural heritage assets is experienced in the category of „family heritage“. Written documents, photographs, pictures, furniture, china, musical instruments and similar artefacts are affected. They can mostly saved if the owners have appropriate knowledge or advice.

Criticality	*Typical damage*	*Situation examples*
Flooding of photographic pictures	Delamination of sensitive layer from the barium carrier during thawing after freezing and drying. *Situation presents an example of a photography after flooding.* *(Source I.Kopecká)* →	
Resilience focused measures	**Do-it-yourself possible**	
Preventive	*During disaster*	*After disaster*
Storing photography staff in dry spaces safe against water flooding. Evacuation of pictures from cellars and spaces endangered with floods or high moisture.	Gentle washing with clean water. Freezing of individual pictures separated with wax paper or PE/PPE/PES foil in packages properly marked, Photographic records of wet pictures useful.	Drying of individual pieces freely in the air. The frozen pictures should undergo thawing immersed in technical alcohol to prevent delamination of a sensitive layer and drying, which is possible even after years.
Relevant hazards	**Floods – river, flash, tidal; Heavy rain; Utility pipe failures**	

Concluding remarks – resilience supporting measures

Hazard maps – intimate knowledge of the territory and objects which are endangered with disaster, their coordinates, accessibility and vulnerability (GIS, inundation maps, criticalities) – duty of site and crisis managers, municipalities, owners

Regular health inspection (condition) of objects and early repair of defects or maintenance – duty of owners

Risk management and safeguarding plans, guidelines and recommendations for preventive measures, for management of crisis situations, for behavior after the event (all categories) – tools supporting effective management – e.g. manuals, etc.

Early warning & information service systems

THANK YOU FOR YOUR ATTENTION