Monitoring and continuous maintenance of monuments and historic buildings

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Department of construction management and technology

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Monitoring and continuous maintenance of monuments and historic buildings

1. The traditional and modern structural system of the buildings
2. Use of the historic technologies
3. Existing maintenance systems
4. Development of maintenance systems
5. The work of maintenance systems

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The traditional and modern structural system of the buildings

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The modern structural system

- at least partially prefabricated/no carpenter structure
- pitched roof covering + PE-layer primer + secondary cover
- double insulation (under and above the structure)
- high-tech coverings
- reinforced concrete blocks
- no breathing, penetrable points
- cement plasters (not breathing)
- relative life load core + thermal insulation
- air/vapor high level electrical and building installation work

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### The structural system of the buildings

- **Heat insulation with the mass of material**
- **Insulation with coating**
- The system lets moisture (vapor) in the structure, and helps it to evaporate
- The system does not let moisture in the structures
- To be restored with traditional materials (+ technology)
- To be restored with modern materials (+ technology)

**traditional**

**modern**

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### Historic technologies

- ...technologies of historic trades, that not anymore used among the modern construction activities
  - e.g.
    - *tarring*
    - *traditional plasters*
    - *smithcraft*
    - *stone masonry*
    - *traditional carpentry*

- Time-consuming decoration techniques - appear as applied art
- Replaced by advanced techniques

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The application fields of historic technologies

- Restoration
- Conservation & maintenance
- Development of new technologies ("learning from the past")

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monitoring and continuous maintenance
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maintaining and restoring

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Maintenance:
Preservation of the proper state of buildings with continuous monitoring and correction of failures.

Restoration:
Construction process aiming the proper state of the building, after it has been more or less lost.

The importance of the maintenance systems

DEF.:
A service system for the regular control and continuous maintenance of the buildings

- performed by non-governmental, non-profit organizations
- voluntary to be joined
- specialized trade personnel are employed
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Organizations

Monumentenwacht Nederländen, Netherlands
- the first maintenance service
- founded in 1973 as a private initiative
- territorial organizations and a national umbrella organization
- 52 groups - 15,000 investigated buildings
- partially supported by the state – for a minimum amount of monitoring activity
- being a member of maintenance service is a necessary condition of the national grants for restoring buildings

Monumentenwacht Vlaanderen, Belgium
- founded in 1991
- follows the Dutch model
- today nearly 10,000 buildings are investigated

Maintain our Heritage + Bath Preservation Trust, United Kingdom
- operating since 1999 – a federative organization of some maintaining services
- pilot project in 2002-2003

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Organizations

BAUDID, Germany
- federative organization of different monument services

Byngingsbewarings, Denmark
- the total costs of the organization are paid from the fees of the owners exclusively

MAMÉG, Hungary
- since 2006
- independent foundation
- the Dutch Monumentenwacht was the model
- centre in Veszprém - representatives in many countries

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Organizations

**Historic Scotland, United Kingdom**
- governmental organization
- provide information and professional help to the owners for continuous maintenance

**NIKU, Norway**
- non-governmental foundation
- researches on monuments
- help the owners to maintain and restore the buildings properly

**Porta Speciosa, Hungary**
- since 1995
- non-profit organization
- federation of professional maintenance specialists
- focusing on the challenges of the monitoring

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What is the benefit of the maintenance service?

![Graph showing the benefit of maintenance services over time](image)

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What is the benefit of the maintenance service? - Validation

six historic buildings

- a treadmill,
- a cottage,
- two villas,
- a traditional apartment-house,
- a church

- different size
  - (more or less) different functions
  - no restoration in the last decades (15 years)

visual diagnostics (on the present state)

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What is the benefit of the maintenance service? - Validation

+ reference building

- regular inspected
- continuously maintained

listing the maintenance works of the last few years

calculation of the fictive annual cost of the maintenance for every six buildings

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What is the benefit of the maintenance service? - Validation

Comparison of costs in case of occasionally performed renovation and continuous maintenance

<table>
<thead>
<tr>
<th>Building type</th>
<th>Annualized cost of the restoration after 15 years of negligence (EUR)</th>
<th>Annual average costs in case of regular maintenance (EUR)</th>
<th>Savings (EUR)</th>
<th>Savings (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>treadmill</td>
<td>335</td>
<td>163</td>
<td>152,03</td>
<td>45%</td>
</tr>
<tr>
<td>cottage</td>
<td>2,592</td>
<td>1,337</td>
<td>1,251,84</td>
<td>43%</td>
</tr>
<tr>
<td>smaller villa</td>
<td>2,518</td>
<td>2,095</td>
<td>423,72</td>
<td>16%</td>
</tr>
<tr>
<td>church</td>
<td>1,124</td>
<td>722</td>
<td>401,71</td>
<td>36%</td>
</tr>
<tr>
<td>larger villa</td>
<td>4,596</td>
<td>839</td>
<td>3,757,56</td>
<td>82%</td>
</tr>
<tr>
<td>apartment house</td>
<td>2,555</td>
<td>419</td>
<td>2,135,97</td>
<td>84%</td>
</tr>
</tbody>
</table>

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How can the optimal operation be ensured?

- adequate approach of the owners
- development of a maintenance / conservation system
- support of the state (legal, financial)
- support of the professionals
- standards, guidelines

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How were organizations established?

- **development** of the system of the services
  - non-profit (e.g. foundation) / profit oriented company
  - by location / by function
- **the characteristics** of the federative / umbrella organization
  - governmental / non-governmental

What are the main challenges?

- there is **no** received **standardized system**
- there is non-satisfying amount of standards, **guidelines**, regulations
- **limited** financial sources of the owners
- lack of specialists and experts (technician, engineers, skilled worker)
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**The possible solutions**

- establishing *umbrella organizations*, ensure cooperation of the existing initiatives, development of guidelines or standards
- training more *skilled workers* and technicians (governmental responsibility)
- governmental *support* system
- *informing* and supporting the owners

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**The work of maintenance systems**

- Diagnostics for monitoring historic buildings
- Indicators -> actions / treatment
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The possible procedures

Three different levels of diagnostics

- local monitoring (e.g. by caretaker/owners) (site-based diagnostics)
- start-up diagnostics (structure- and impact-based diagnostics)
- continuous – maintenance monitoring diagnostics (structure- and impact-based diagnostics)

Maintenance protocol for owners and caretakers

<table>
<thead>
<tr>
<th>Daily work</th>
<th>After storm, windstorm, earthquake</th>
</tr>
</thead>
<tbody>
<tr>
<td>handling of doors and windows (providing fresh air, closing windows before rain or in case of wind, etc.)</td>
<td>controlling the rainwater goods, the roof coverings, the soundness of the doors and windows (in case of storm, windstorm)</td>
</tr>
<tr>
<td>removal of the fallen leaves (at accessible places), take care of vegetation around the building</td>
<td>controlling soundness of load bearing structures, façades (in case of major storm, earthquake)</td>
</tr>
<tr>
<td>cleaning the windowstills, the terraces, and the sidewalks around the building</td>
<td>controlling the soundness of superstructures on roof (antenna, cable-pylon, chimneys) (in case of storm, windstorm, earthquake)</td>
</tr>
<tr>
<td>removal/handling of snow and ice (avoiding salt if possible)</td>
<td>removal of debris, bough, etc. from roof, sills, balconies, terraces (in case of storm, windstorm)</td>
</tr>
<tr>
<td>controlling, cleaning and treating the crackings, coverings and the furniture</td>
<td></td>
</tr>
<tr>
<td>controlling the installations (heating, water supply, etc.)</td>
<td></td>
</tr>
<tr>
<td>controlling the lamps, changing light bulbs in time</td>
<td>In case of need call for the monitoring service</td>
</tr>
</tbody>
</table>

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Types of diagnostics used for the service system

<table>
<thead>
<tr>
<th></th>
<th>visual</th>
<th>instrumental</th>
</tr>
</thead>
<tbody>
<tr>
<td>site-based</td>
<td>X</td>
<td></td>
</tr>
<tr>
<td>structure-based</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>impact-based</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Site-based diagnostics

The state of the building is recorded by the sections of it e.g.:

- facade sections
- rooms

In most of the cases

- monitoring is performed by the caretaker
- simple state recording

mainly visual diagnostics
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**Structure-based diagnostics**

The state of the building is recorded by each structural part e.g.:

- foundation
- wall structure
- slabs
- roof structure
- claddings
- etc.

**Typical at the specialist (e.g. static) investigation**

- before restoration
- at case of sale
- after disaster

Visual and instrumental diagnostics

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**Impact-based diagnostics**

Recording the state of the building by the impact on the building

- state
- revealing the problems
- restoration proposal
- investigation of the impact/canceling the impact/consideration of the problem
- investigation the adjoining structures

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**Typical impacts / groups of impacts**

- **rain**
  - windblown rain
  - failure of the rainwater goods
  - failure of the roof
- **humidity**
  - broken pipes
  - vapor
  - moisture from the soil
- **biological impacts**
  - plants around the building
  - biological pests (fungi, insects)
- **movement of the building**
  - sinking
  - vibration
- **air**
  - wind (erosion)
  - air pollution (corrosion)
- **material incompatibility**
  - alteration of the climatic conditions
- **new function (vapor, lack of ventilation)**
- **construction failures**

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<table>
<thead>
<tr>
<th>Material</th>
<th>Structure</th>
<th>Testing methods</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>concrete</strong></td>
<td>Foundation walls, slabs, floors</td>
<td>Sampling, porosity</td>
</tr>
<tr>
<td><strong>metals</strong></td>
<td>Grills, welds, pipes, radiators,</td>
<td>Hardness test, microanalysis,</td>
</tr>
<tr>
<td><strong>ceramics</strong></td>
<td>(ceramic, tile, marble)</td>
<td>3-day test, penetration test,</td>
</tr>
<tr>
<td><strong>stone</strong></td>
<td>Walls, floor</td>
<td>Sampling, microscopy</td>
</tr>
<tr>
<td><strong>masonry</strong></td>
<td>Bricks, stones</td>
<td></td>
</tr>
<tr>
<td><strong>paint</strong></td>
<td>Walls, exterior</td>
<td>Sampling, microscopy</td>
</tr>
<tr>
<td><strong>wood</strong></td>
<td>Walls, interior</td>
<td></td>
</tr>
<tr>
<td><strong>textiles</strong></td>
<td>Curtains, textiles</td>
<td>Sampling, microscopy</td>
</tr>
<tr>
<td><strong>glass</strong></td>
<td>Windows, glazing</td>
<td></td>
</tr>
</tbody>
</table>

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### Indicators

**DEF.**
The indicator helps us to evaluate a procedure:

- Where are we standing?
- Which direction we have to follow?
- How far are we form the aimed goals?

Proper indicators indicate the problems in proper time, and help to recognize the duties to be done.

*Indicators*

Which case do we need intervention for?
Which case have to be a contractor involved in the restoration works?
Which case have to be specialists involved in?
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Indicators

1. When do we need intervention?

If the failure of a structure likely
• to cause the further damage of the structure
• or to jeopardize the soundness of another structure.

<table>
<thead>
<tr>
<th>Structure</th>
<th>State Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitched roof</td>
<td>- covering: missing, dislodged, broken elements</td>
</tr>
<tr>
<td></td>
<td>- carpenter structure: disconnection</td>
</tr>
<tr>
<td></td>
<td>- fastenings: corrosion spot, fracture, hole</td>
</tr>
<tr>
<td></td>
<td>- rainwater goods: silt, dislodging elements</td>
</tr>
<tr>
<td></td>
<td>- eaves: lack of paint, (moisture) staining</td>
</tr>
<tr>
<td>Flat roof</td>
<td>- surface: lumpy surface, puddles, optical mutation of the insulation material, oblation of dampness</td>
</tr>
<tr>
<td></td>
<td>- fastenings: corrosion spot, minor holes, cracks</td>
</tr>
<tr>
<td>Walls</td>
<td>- plaster: staining, planar growth, missing spot</td>
</tr>
<tr>
<td></td>
<td>- wall: minor cracks, staining, damp</td>
</tr>
<tr>
<td>Slabs</td>
<td>- wood: staining, failure of the surface</td>
</tr>
<tr>
<td></td>
<td>- stone, brick: minor cracks</td>
</tr>
<tr>
<td>Inner coverings</td>
<td>- wood: staining, wearing of coating (paint, lacquer), deformation</td>
</tr>
<tr>
<td></td>
<td>- ceramic, stone: cracks, falling elements, deterioration</td>
</tr>
<tr>
<td>Footing</td>
<td>- staining, cracks, dislodging</td>
</tr>
<tr>
<td>Doors, windows</td>
<td>- metal: distortion, failure of the painting, broken glass, missing paint</td>
</tr>
<tr>
<td></td>
<td>- wood: distortion, failure of the painting, broken glass, missing paint</td>
</tr>
<tr>
<td>Railings, grills</td>
<td>- metal: missing paint, corrosion spot, missing long elements</td>
</tr>
<tr>
<td></td>
<td>- wood: damaged coating, abrasion, missing long elements</td>
</tr>
<tr>
<td>Surroundings of the building</td>
<td>- pavement: cracks</td>
</tr>
<tr>
<td></td>
<td>- plants: plants, vegetation in the direct surrounding of the building</td>
</tr>
</tbody>
</table>

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Indicators

2. Which case have to be a contractor involved in the restoration works?

If the volume of the work is too large or the technical preparedness of the monitoring personnel is not enough for the on-site repair.

<table>
<thead>
<tr>
<th>Structure</th>
<th>State indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pitched roof</td>
<td>covering: remarkable amount of damaged elements</td>
</tr>
<tr>
<td></td>
<td>carpenter structure: damaged structural element</td>
</tr>
<tr>
<td></td>
<td>flashings: remarkable amount of corrosion, sparse</td>
</tr>
<tr>
<td></td>
<td>retraction goods: falling parts, fatal damage to concrete</td>
</tr>
<tr>
<td>Flat roof</td>
<td>surface: flooding</td>
</tr>
<tr>
<td></td>
<td>flashings: remarkable amount of erosion, holes, etc.</td>
</tr>
<tr>
<td>Walls</td>
<td>plaster: large scale crumbling</td>
</tr>
<tr>
<td></td>
<td>wall: damaged wall sections</td>
</tr>
<tr>
<td>Stairs</td>
<td>wood: damaged beams</td>
</tr>
<tr>
<td></td>
<td>stone, brick: breakthrough</td>
</tr>
<tr>
<td></td>
<td>inner coverings: irreparable breaking, material decay</td>
</tr>
<tr>
<td></td>
<td>ceramic, stone: material decay</td>
</tr>
<tr>
<td>Pitched roof</td>
<td>covering: remarkable amount of weaved, cracked, missing elements</td>
</tr>
<tr>
<td>Footing</td>
<td>major crumbling and disengagement</td>
</tr>
<tr>
<td>Doors, windows</td>
<td>metal: major corrosion</td>
</tr>
<tr>
<td></td>
<td>wood: material failure</td>
</tr>
<tr>
<td>Glazing, windows</td>
<td>wood, metal: remarkable decay of material</td>
</tr>
<tr>
<td>Building installation</td>
<td>brick chimney, stove: cracking, failure of the elements</td>
</tr>
<tr>
<td></td>
<td>metal, ceramic, ceramic pipes: leakage</td>
</tr>
<tr>
<td>Surroundings</td>
<td>pavements: sinking, chiseling</td>
</tr>
<tr>
<td></td>
<td>plants: structural damage caused by plants</td>
</tr>
</tbody>
</table>
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Indicators

3. Which case have to be specialists involved in?

• If the state of the structure can not be detected by visual diagnostics (e.g. instrumental diagnostics)
• If the monitoring personnel are not competent in the required (special) fields of knowledge (e.g. statics, fungiology)

The studies of specialist experts have to be done before the restoration works starts!

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*Treatments*

1. diagnostics of the state
2. decision about the fact, whether treatment is required
3. analyses (getting information on the building and on the technologies)
4. decision about the treatment (material and technology)

*Influencing factors (choosing technology and material)*

1. Protection of the building (legal)
2. The original structure (material, technology)
3. The use of the building (function)
4. The aim of the restoration
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Thank you for your attention!

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References