Deterioration of building envelope of wooden apartment buildings built before 1940 based on external survey

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Wood was the main structural building material until WW II.

Many of the historic listed buildings and areas are in bad conditions and need thorough and ongoing renovation.

A lack of local guidelines aimed at increasing durability and energy-efficiency as well to longer the service life of monumental building or milieu valuable districts;
Introduction

- Wood was the main structural building material until WW II.
- Many of the historic listed buildings and areas are in bad conditions and need thorough and ongoing renovation.
- A lack of local guidelines aimed at increasing durability and energy-efficiency as well to longer the service life of monumental building or milieu valuable districts;
- This study concentrates on the:
  - investigation of technical conditions of the external side of the building envelope (roof, facades, windows, foundations etc.) of old wooden apartment buildings;
  - moisture-related problems mainly.
Studied buildings
- 4 towns
- private ownership
- 1-4 stories
- built <1940

external wall
- hor. log
- vert. log
- timber-frame

external surface:
- wooden gladding (73%)
- plastering (27%)
Methods

- **Studied buildings**
- **The survey**
  - External survey: 133 buildings;
  - External + internal survey: 29 buildings;
- **Special questionnaire**
  (in beginning two researchers, later more);
  - **Foundation wall**: dimensions, material, condition of the rendering, windows, causes of defects;
  - **Facade**: material, decorations, condition, windows, doors, maximum thickness of additional thermal insulation;
  - **Rainwater drainage systems**: existence of the components, condition;
  - **Roof**: material, leaks, condition;
  - **Chimney**: existence of the components, condition;
- **Recommendations**: required tasks to be attended and timeframe.
Methods

- **Studied buildings**
- **The survey**
  - External survey: 133 buildings;
  - External + internal survey: 29 buildings;
  - Special questionnaire (in beginning two researchers, later more);
  - Samples from possibly damaged areas;
Methods

- Studied buildings
- The survey
- Classification for technical condition
  0 – failure/dangerous situation, very severe damage: needs immediate renovation;
  1 – bad, severe damage: needs renovation during 1 year;
  2 – satisfactory, moderate damage: renovation recommended within 3-5 years;
  3 – good, slight damage: maintenance recommended within 5 years;
  4 – very good, very slight and small damage: may need maintenance within 10 years;
  5 – excellent, no visible damage, new structure in good condition, correct performance.
Typical problems:

- Leaking of roof:
  - corrosion of metal,
  - cracking of the roof-boards,
  - loose or missing roofing tiles.
- bushings;
- Flora on the roof (prevents water drainage; 50 % of stone and asbestos-cement roofs suffered from growth of moss or plants);
- Lack of maintenance;
Results: roof

- Typical problems:
  - Leaking of roof:
  - corrosion of metal,
  - cracking of the roof-boards,
  - loose or missing roofing tiles.
  - bushings;
- Flora on the roof (prevents water drainage; 50 % of stone and asbestos-cement roofs suffered from growth of moss or plants);
- Lack of maintenance;
- Low thermal resistance;

<table>
<thead>
<tr>
<th>Type of roofing material</th>
<th>Standing seam metal</th>
<th>Asbestos-cement board</th>
<th>Corrugated sheet metal</th>
<th>Stone roofing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Percentage of roofing materials</td>
<td>54 %</td>
<td>35%</td>
<td>15%</td>
<td>9%</td>
</tr>
<tr>
<td>(note: several materials could be present on a roof simultaneously)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average category of the technical condition</td>
<td>Good (cat. 3)</td>
<td>Satisfactory (cat. 2)</td>
<td>Very good (cat. 4)</td>
<td>Good (cat. 3)</td>
</tr>
<tr>
<td>Roofs in bad or dangerous condition, (cat. 0 and 1)</td>
<td>3 %</td>
<td>4 %</td>
<td>0 %</td>
<td>0 %</td>
</tr>
<tr>
<td>Roofs requiring replacement within 3 years (cat. 2)</td>
<td>13 %</td>
<td>35 %</td>
<td>0 %</td>
<td>25 %</td>
</tr>
<tr>
<td>Roofs requiring replacement within 10 years</td>
<td>33%</td>
<td>48%</td>
<td>0%</td>
<td>17%</td>
</tr>
</tbody>
</table>
Results: rainwater drainage systems

- 72% of rainwater drainage systems were defective:
  - non-vandal-proof lower sections of the drainage pipes
  - water reached foundation wall and external wall,
  - construction errors (pipes connected in the wrong order),
  - growth of flora and low maintenance.
Results: rainwater drainage systems

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  - water reached foundation wall and external wall,
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<table>
<thead>
<tr>
<th></th>
<th>Rainwater flow to the external wall or foundation wall</th>
<th>Defects and discontinuance of rainwater systems</th>
<th>Clogging of the rainwater systems</th>
</tr>
</thead>
<tbody>
<tr>
<td>Of all rainwater drainage systems</td>
<td>62 %</td>
<td>44 %</td>
<td>29 %</td>
</tr>
<tr>
<td>Of renovated rainwater drainage systems</td>
<td>40 %</td>
<td>21 %</td>
<td>14 %</td>
</tr>
</tbody>
</table>
Results: facades

- Main areas of damages:
  - above foundation wall: 48%
  - around eaves: 30%
  - near drainage system: 26%
  - near corners: 21%
  - around canopies: 11%
  - near trees and vegetation: 9%
  - around windows: 8%
  - near cables with wrong slope
Main damages:
- excess moisture (chipping of paint, destroyed mortar, bricks and limestone): 58%
- algae as an indicator of moist surface: 57%
- different settlement of foundation: 32%
- high level of the ground surface: 8%
Results: foundations

- **Main damages:**
  - excess moisture (chipping of paint, destroyed mortar, bricks and limestone): 58%
  - algae as an indicator of moist surface: 57%
  - different settlement of foundation: 32%
  - high level of the ground surface: 8%

- **Reasons for the wetting of the foundation:**
  - rainwater downpipe: 35%
  - vegetation: 22%
  - missing or broken gutter: 20%
  - water sprays from the street: 14%
  - flows down the wall: 14%
  - wrong street’s slope: 13%
Results: facade + foundations

- Typical area for damage: the rows first of the log of the external wall;
Results: facade + foundations

- Typical area for damage: the rows first of the log of the external wall;
- In renovation of buildings, the Heritage Board requires original solution (despite that was partly guilty on degradation);

Driving rain to wall flows down along the wall to foundation's board
Water sprays from foundation's board to wall

After degradation of foundation's board, water flows to the foundation
Water and excess moisture causes degradation of foundation and lower logs of the external wall
Results: rot damages

- 27% of wooden samples had rot damages:
  - brown rot: 20%,
  - soft rot: 5%,
  - white rot: 2%.

- Rot damage was determined in 63% of buildings (10/16).

- Main areas for rot damages:
  - the first log row of the external wall,
  - roofing construction,
  - floor beams in crawl space.
Conclusions

- Wood is not very moisture-tolerant and brings easily all mistakes out;
- The most critical factor in degradation of wooden buildings was free water;
- Nevertheless, in many cases designers still concentrate mainly on vapour diffusion;

**Required renovation within 10 years:**

<table>
<thead>
<tr>
<th>New cladding</th>
<th>New roofing</th>
<th>Foundation wall renovation</th>
<th>New windows</th>
<th>At least 3 of the previous combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>37%</td>
<td>52%</td>
<td>71%</td>
<td>17%</td>
<td>23%</td>
</tr>
</tbody>
</table>