Research principles and renovation demand of old brick apartment buildings in Estonia

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Situation of housing in Estonia

- 71% of population lives in apartment buildings, 20%: in detached- or in terraced house, 9%: in farmhouses;
- Brick is one of the main structural material;

Today the end of the *designed service life* of these older buildings is close;

Typically each occupant is owner of the apartment → building;

Milieu valuable areas (urban environment).
Service life of buildings / Performance criteria

**Service life**
- Quality and properties of components and building materials;
- Design level;
- Work execution level;
- Indoor environment;
- Outdoor environment;
- In-use conditions;
- Maintenance level;

**Performance criteria:**
6 essential requirements (CPD)
- Mechanical resistance and stability;
- Safety in case of fire;
- Hygiene, safe to health and environment;
- Safety in use;
- Protection against noise;
- Energy performance
The needs for renovation

- Typical aspects:
  1. safety of building, durability;
  2. healthy indoor climate;
  3. energy performance + living & visual quality

- Renovation and reducing energy consumption of historical buildings need to be done without losing their cultural value and identity.
The areas of research

Different areas of research

Values: historical, cultural, architectural (milieu valuable areas);

Structures: mechanical resistance and stability, durability, degradation of materials and components;

Building physics, energy performance, and indoor climate;

Technical systems: heating, ventilation, water, sewerage, electricity, etc.;

Background information of the building (actual drawings of the building; earlier damages, previous investigations, interviews, risk assessment);

Scale of the research

Case study (concerns one certain building or problem)

Large scale study (concerns certain type of buildings or problems)
The aim of investigation

- Investigation of the degradations
  - existents of the degradations
  - extent of the degradations
  - grade of the degradations

- Reasons of the degradations
  - detection of faults in design and construction
  - change of loading or alterations to a load-bearing member
  - change in thermal or moisture conditions

- Renovation solutions
  - Values;
  - Structures;
  - Building physics, energy performance, and indoor climate;
  - Technical systems.
Renovation demand of old brick apartment buildings in Estonia

- National research project: “Technical condition and service life of Estonian brick apartment buildings” 2009-2010

- The main objectives:
  - Survey of technical condition typical brick apartment buildings;
  - Investigate the indoor climate and energy performance of buildings;
  - Determine the main demands of renovations of old brick apartment buildings.

- Characterization of studied brick apartment buildings:
  - 30 buildings, constructed between 1940 and 1990, 4-9 storey;
  - From each building one to three apartments were selected to the indoor climate and building physics studies (50 apartments);
  - All the buildings and apartments studied were in private ownership.

- The research was financed by Credit and Export Guarantee Fund KredEx and Tallinn University of Technology
Research

- Investigation of building envelope
  - survey of technical conditions of the constructions (walls, floors, roofs, balconies)
Research

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  - frost resistance of the facades
Research

- **Investigation of building envelope**
  - survey of technical conditions of the constructions (walls, floors, roofs, balconies)
  - frost resistance of the facades
  - thermal transmittance and thermal bridges of building envelope
  - air tightness of building envelope
Research

- Investigation of building envelope;
- **Indoor climate, hygrothermal conditions**
  - indoor temperature and relative humidity over one year period, hour interval
  - indoor CO$_2$, performance of ventilation
  - microbiological contamination on surfaces of building, indoor air
Research

- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- Conditions of building technical systems
Research

- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- Conditions of HVAC systems
- Measurement and simulation of energy use
Research

- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- Conditions of HVAC systems
- Measurement and simulation of energy use
- Questionnaire for occupants
The main problems in general

- Mechanical resistance and stability are not the main problems.
- The main technical problems are in the field of:
  - indoor climate,
  - building physics,
  - HVAC systems,
  - energy efficiency.
- Old dwellings need improvement to meet today’s requirements in a:
  - healthy indoor climate, thermal comfort,
  - energy performance,
  - functional / architectural,
  - constructional / technical.
The main needs for renovation

- Improvement of indoor climate and energy performance of buildings in cold climate:
  - performance of building envelope;
  - performance of ventilation;
  - performance of heating systems.
Typical problems of existing systems:

- natural ventilation (passive stack, window):
  - low air change,
  - low indoor air quality,
  - high moisture load,
- no heat recovery: large energy consumption,
- impossible to regulate air flows,
- air inflow from stack (wind),
- air tightness of old ventilation channels,
- the replacement of windows without renovation of ventilation:
  - smaller leakage rate,
  - more airtight building envelope.
Ventilation

- **Challenges for renovation:**
  - **mechanical exhaust ventilation with fresh air inlets:**
    - thermal comfort during winter (fresh air inlets with radiators)
    - energy performance (exhaust air heat pump → domestic hot water)
  - air tightness of old ventilation channels
  - not suitable for combined ventilation channels
Ventilation

- Challenges for renovation:
  - mechanical exhaust ventilation
  - balanced ventilation with room units:
    - where to put room units: a little space,
    - problems with sound pressure levels,
    - where to put air channels: rooms height 2.5m,
    - air flow in apartment through existing doors
Ventilation

- Challenges for renovation:
  - mechanical exhaust ventilation
  - balanced ventilation with room units

- acceptance of occupants:
  - how to motivate occupants for changes: “I do not want new tubes and noisy equipment in my apartment”
  - renovation works in apartments, change of internal doors?
  - cost-effective solutions are needed,
  - understanding about the importance of ventilation (customer, occupants): example-renovation without changes in ventilation: bad indoor climate
Thermal envelope

Existing problems:

- **high thermal transmittance:**
  - external walls: 0.5–1.2 W/(m²·K),
  - roof-ceilings: 0.7–1.0 W/(m²·K),
  - windows: 2–3 W/(m²·K).
Existing problems:
- high thermal transmittance
- serious thermal bridges: a large problem especially in old apartment buildings

mould growth and surface condensation on the internal surfaces of thermal bridges is unavoidable without:
  - lowering thermal transmittance,
  - lowering internal humidity loads.
Thermal envelope

Existing problems:

- **high thermal transmittance:**
  - also big problem in old apartment buildings already additionally insulated (windows)

- **serious thermal bridges:**
  - a need to protect facade,

- **low frost resistance:**
  - carbonization of concrete,

- it is economically reasonable to make the additional thermal insulation for walls and roofs (strong pressure).

- cultural value should be preserved
Thermal envelope

- Internal thermal insulation is risky solution in cold climate: mould growth and condensation in the wall on the old wall surface.
Typical problems with the additional insulation:

- **Windows**: old or new, on its original place
  - thermal bridge in connection of wall and window
  - visually bad solution
Typical problems with the additional insulation:

- **Windows**: old or new, on its original place
- **Low quality**: air space between old wall and new insulation;
Typical problems with the additional insulation:

- **Windows**: old or new, on its original place
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- **Loggias**: thermal bridges, mould

Thermal envelope
Typical problems with the additional insulation:

- **Windows**: old or new, on its original place
- **Low quality**: air space between old wall and new insulation;
- **Loggias**: thermal bridges, mould
- **Drying out of constructional moisture**
Typical problems with the additional insulation:

- **Windows**: old or new, on its original place
- **Low quality**: air space between old wall and new insulation;
- **Loggias**: thermal bridges, mould
- **Drying out of constructional moisture**
- **Complex renovation** (ventilation + building envelope + heating systems) is not common: mould after insulation (ventilation was not renovated)
Heating systems

Typical solution:
- one-pipe heat distribution system;
- no room thermostats on radiators;

Typical problems:
- incorrect control curve of the temperature of the supply water of the heating system,
- incorrect water flow rate of the risers of the heating system,
- lack of direct room temperature control,
- difficulties to balance the one-pipe heat distribution system,
- lack of maintenance and improper modifications of the heating and ventilation systems.
Conclusion

- There exists the need to renovate old brick buildings:
  - to lengthen the service life of building;
  - to provide healthy indoor climate;
  - to lower the energy consumption of buildings (pressure from occupants and from EU (20/20/20));
  - to ensure mechanical resistance and stability.

- During renovation of historical buildings we face different problems compared to new buildings;

- During renovation of historical buildings the identity should be preserved;

- There is a need for different renovation solutions where all presented aspects are taken into account;

- Example renovations with good practice, including monitoring and actual performance reports, are needed.