Technical condition, indoor climate and renovation demand of 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:**
  - 7 essential requirements
    - Mechanical resistance and stability;
    - Safety in case of fire;
    - Hygiene, safe to health and environment;
    - Safety in use;
    - Protection against noise;
    - Energy performance
    - Sustainable use of natural resources
The demand 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, indoor climate;**
  - **Building services:** 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, indoor climate;
  - Building services.
Renovation demand of 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 of typical brick apartment buildings;
  - Investigate the indoor climate and energy performance of buildings;
  - Determine the main demands of renovations of 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 condition of the structures (walls, floors, roofs, balconies)
Research

- **Investigation of building envelope**
  - survey of technical condition of the structures (walls, floors, roofs, balconies)
  - frost resistance of the facades
Research

- Investigation of building envelope
  - survey of technical condition of the structures (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 RH over one year period at one hour interval
  - indoor CO₂, performance of ventilation
  - microbiological contamination on surfaces of building fabric and indoor air
Research

- Investigation of building envelope;
- Indoor climate, hygrothermal conditions
- Conditions of building services

Sp1: temp 37.1
Sp2: temp 11.8
Sp3: temp 22.8

FLIR 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,
  - structural / 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.
Ventilation

- 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 and heating)
  - 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).
Thermal envelope

- 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:**
  - **Serious thermal bridges:**
    - Also big problem in old apartment buildings already additionally insulated (windows)
  - **Low frost resistance:**
    - A need to protect facade,
  - **Carbonization of mortar,**
  - It is economically reasonable to make the additional thermal insulation for walls and roofs (strong pressure).
  - Cultural value should be preserved
- Internal thermal insulation is risky solution in cold climate: mould growth and condensation in the wall on the old wall surface.

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**Diagram:**

- Temperature $t_w$, °C
- Relative humidity, RH%
- Risk for mould growth
- t&RH in the wall

**Graph:**

- Data points showing risk for mould growth and t&RH in the wall.
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
- **Low quality**: air space between old wall and new insulation;
- **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 **structural moisture**
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 **structural 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 a demand to renovate brick apartment 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.