CENEAST

Reformation of the Curricula on Built Environment in the Eastern Neighbouring Area

Market Need Analysis for Built Environment Higher Education

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1 Introduction

Recent research carried out by the Civil Engineering Faculty of Tallinn University of Technology has shown that, in Estonia, the condition of buildings is generally inadequate and that there is a pressing need for renovation of the existing building stock.

This report explores the findings of research into the needs of the built environment market in particular with regard to the condition of the existing housing stock and the implications this has for the education of built environment professionals.

An overview of the existing study programmes offered at Estonian higher education institutions is provided and a short commentary is given on the extent to which these fulfil the identified needs.

Recommendations for appropriate themes for BSc, MSc and PhD study programmes conclude the report.

2 Evolving needs in the built environment market

2.1 An overview of the Estonian built environment

National built environment consists of very different buildings – built during different eras using different technologies and they have gone through very different life-times especially as to changes in usage. There have been also different owners – individual or institutional – of the buildings with different strategies and possibilities for maintenance and management to keep up these buildings. All these factors have affected the current status and condition of each building, but generally the quality level of the whole built environment.

Legally each owner of a building is fully responsible for his/her property, accordingly also for the quality of the building – its structures and suitability for purpose. There are the national standards and an 'army' of professionals that the owners can use to fulfil their major quality- and safety-related obligations. But still there may be different reasons why only a few of the buildings – not only in Estonia, but in most countries – satisfy all the official requirements.

In most countries there is the information on the buildings – their owners, age of buildings, volume of the building – but there is no overall overview about the condition of these buildings. Quite often only the housing sector has been the target for deeper surveys where we can describe in more detail the actual condition of these buildings. But the major findings from the housing sector may be used also for describing the whole built environment as the economic, legal and social environments have been the same ones for all the buildings.

2.2 General needs for renovation of the current housing stock

In Estonia, numerous surveys of technical quality in the housing sector have been carried out over the last twenty years, but the most exhaustive ones have been performed as part of research by the faculty of civil engineering of Tallinn University of Technology.

The overall living standards in older apartment buildings in Estonia need to be improved to meet today's requirements in functional, urban design, architectural and constructional-technical terms. Commonly, the first essential requirement "mechanical resistance and stability" is fulfilled in most cases but the main problems are related to building physics, indoor climate, HVAC systems, and energy efficiency.

Estonia's dwelling stock is relatively adequate in size. However, the main problems concern quality and energy-efficiency of most of the dwellings. In Estonia 71% of the population occupy multi-storey buildings, the remaining population live in detached or terraced houses (20%) and in farmhouses (9%). The majority (84%) of apartment buildings were built after World War II, mainly between 1961 and 1990. Today the first dwellings from this "constructional wave" are approaching the end of their design life (i.e. the service life intended by the designer).

Typical structural solutions for old apartment buildings in Estonia are:

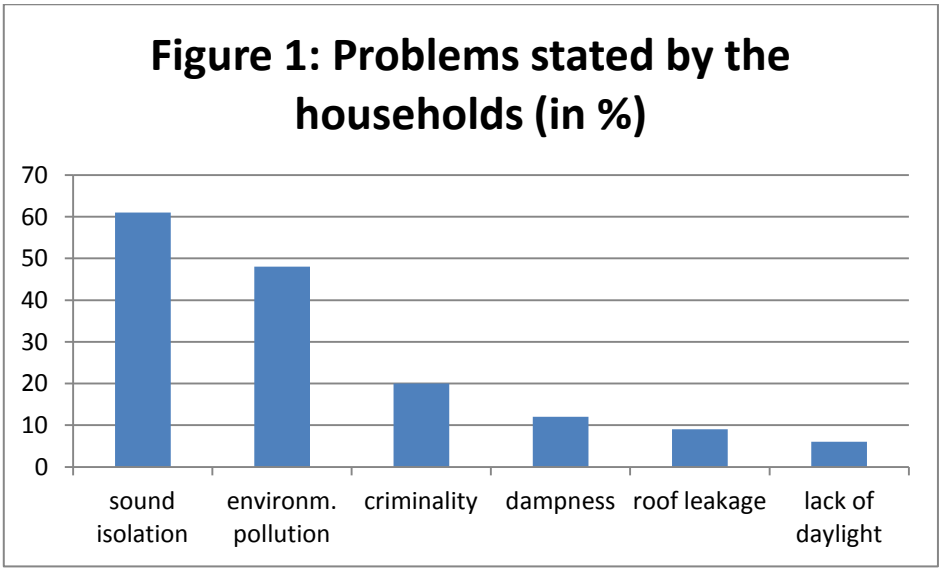
- prefabricated concrete large-panels
- brick (load bearing walls are typically silicate bricks, facades silicate bricks or ceramic bricks)
- large-blocks made of gas concrete (gas silicate or oil shale ash gas concrete)
- wood (timber frame, log): typically built before 1940

The average annual specific heat energy consumption of old-type apartment buildings is 200…250 kWh/(m2•a) (for space heating 170 kWh/(m2•a) + for domestic hot water heating 50 kWh/(m2•a).

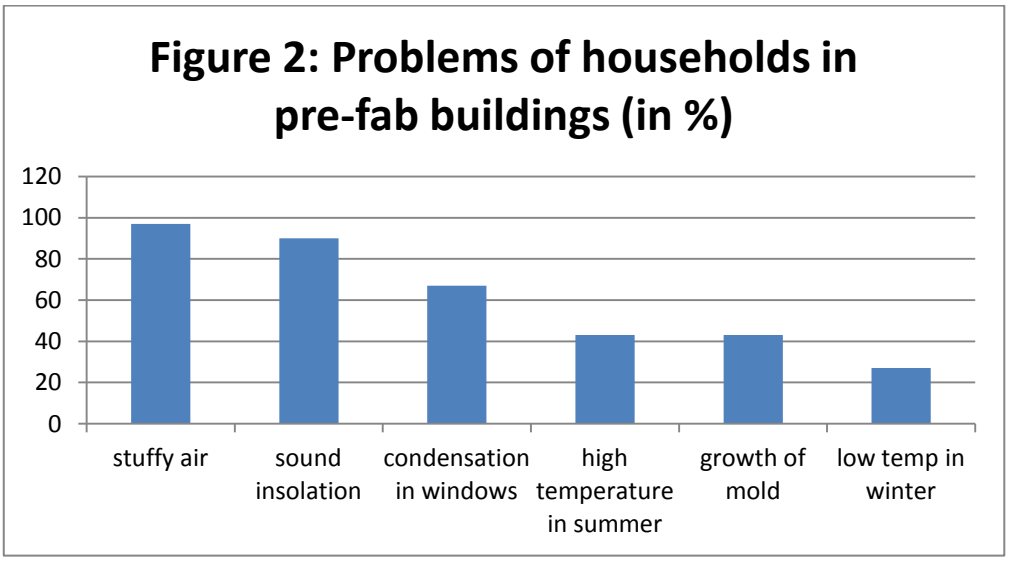
All these buildings need extensive renovation. As large investments are needed to improve and maintain the quality of dwellings, renovations should be executed in a cost-effective way. As most of the housing stock (96%) is privately owned (each apartment has an independent owner), it would be controversial and difficult to demolish these buildings.

The overall living standards in the older part of the housing stock need to be improved to meet today's requirements in functional, urban design, architectural (visual, planning) and constructional-technical terms. The buildings are in an inadequate condition due to low requirements for energy performance in old building standards, a historical lack of attention to quality in construction materials and practices, poor records of operation, maintenance and regular renovation.

Commonly, the first essential requirement "mechanical resistance and stability" is fulfilled in most cases. Figure 1 shows the main problems determined according to official statistics.



According to the survey carried out in the apartment buildings constructed of prefabricated concrete elements, the list of problems is slightly different. (Figure 2)



Based on this we can see that the main problems are related to building physics, indoor climate, HVAC systems, and energy efficiency.

Urgent repairs to guarantee safety of buildings (mechanical resistance and stability; safety in case of fire safety in use):

- improvement of indoor climate (hygiene and health aspects)
- improvement of energy performance of buildings and HVAC systems
- improvement of architectural planning, visual quality, overall living quality, and additional comfort

In the process of renovating the indoor climate and energy performance of buildings in cold climate these three components must be considered:

- performance of ventilation
- hygrothermal performance of building envelope
- performance of heating systems

Typically, older apartment buildings have natural passive stack ventilation. In some apartments kitchens are supplied with a hood. Typically in all of the dwellings, windows are also opened for airing purposes. Though mechanical exhaust ventilation has been the standard installation in the new dwellings in Estonia during the last decade, in old apartment buildings natural ventilation has preserved due to the complexity of renovating the ventilation.

In addition to technical questions, social/human questions also need to be solved: occupants have different possibilities and motivations to pay the cost of renovation. Typically occupants do not accept any additional ventilation channels in their apartment. Understanding about the importance of ventilation is very low. An example-renovation of old apartment building composed of prefabricated concrete large-panels was carried out two years ago in Estonia. As a result of the reconstruction project, the apartment building has a modern look, it is well insulated and has a heating system with individual calculation of heating expenses, where the estimated 40% energy saving can be expected. Even the building that was almost fully renovated, but had not renovated the ventilation system showed. Indoor climate measurements (CO2, relative humidity) showed poor indoor air quality and high humidity loads.

Thermal transmittance of solid walls of old apartment buildings is about 0.5…1.0 W/(m2•K), roofs 0.7…1.0 W/(m2•K), and windows 2.0…2.9 W/(m2•K). Serious thermal bridges are a big problem in old apartment buildings, especially in buildings composed of prefabricated concrete panels. Mould growth and surface condensation on the internal surfaces of thermal bridges is unavoidable without additional external insulation and/or lowering internal humidity loads. Due to low frost resistance and carbonization of facades, it is necessary to protect them. It is economically viable to make the additional thermal insulation for walls and roofs.

According to Estonian renovation practice, typically renovation works start in spring and finish in late autumn. The autumn is typically a rainy season in Estonia. The original wall may become wet before insulation works. Drying out moisture may cause much stronger hygrothermal loads than moisture diffusion (or convection). Drying out moisture can cause damage of finishing layer of external walls.

Measurements (with heat flow plate) of thermal transmittance of external walls show that calculated thermal transmittance is larger, than measured values. Complex renovation (ventilation + thermal envelope + heating systems) is not common in typical renovation practice. The main reasons for this are the lack of knowledge and higher momentary price. Not complex renovation may result in poor quality of indoor air and expected energy savings remain smaller.

As radiators were traditionally not equipped with thermostats, there was no possibility to control room temperature. Room temperature was regulated in the boiler room based on the outdoor temperature. Yet, if the slope and the level of the control curve of the temperature of the supply water are correct, room temperature does not depend strongly on the outdoor temperature.

Other problems concerned with heating systems are:

- incorrect water flow rate of the heating system or risers
- lack of direct room temperature control
- difficulties to balance the one-pipe heat distribution system
- lack of maintenance and improper modifications of the heating systems

2.3 Specific Issues to Consider when Educating Built Environment Professionals

The following are some serious issues and practical questions listed from design offices and building sites we have to tackle when educating our students and graduates:

- Air tightness of the building envelope strongly influences the indoor climate and energy efficiency of buildings. By what amount is it possible to lower the air leakage rate during renovation in different types on buildings?

- The renovation of ventilation in old apartment buildings is an important goal. How to implement the balanced ventilation with heat recovery to old apartments (noise problems, air channels in the room with height 2.5m)? Is the use of ventilation heat pumps the better solution? It should also be investigated as an opportunity to use room based ventilation with heat exchanger.

- Typical thickness of additional thermal insulation >10…15cm, makes windows like embrasure if windows stay in the original place. As some occupants have replaced their windows themselves, they do not want new renovation inside the apartment that follow with the change of windows again. Thinner insulation with smaller thermal conductivity or new architectural design could be the solution.

- What are real properties (and their distribution) of building envelopes and material properties, building services, equipment efficiency and service life?

- What is the long-term hygrothermal performance of different types of thermal insulation systems and insulating coatings in different types of apartment buildings?

- Problems that may be connected with "over-insulating" of thermal envelope (increase on convection inside the envelope, external condensation and ice on glazing, growth of algae on facades, influence on air tightness of air pressure conditions especially in case of unbalanced ventilation, hygrothermal performance of attics and crawlspaces, conditions in ventilated airspace in roofs and external walls, increase of cooling needs in buildings with higher internal heat loads).

- Soviet-time apartment buildings have a lot of structural thermal bridges. Thermal transmittance through solid walls and joints can be in the same scale, causing remarkable heat loss.

- Extra value for inhabitants and real estate as well could be achieved by constructing common rooms in the basement. In case of a sauna, showers and pool hygrothermal performance of partitions should be investigated (high moisture excess, large temperature difference, basement wall in contact with soil etc). High rate of moisture must be eliminated in a short period of time if storage rooms locate close to common rooms. Also load bearing questions are risen in case of large pool and fire safety due to small windows and limited numbers of exits.

Based on these conclusions that require also deeper knowledge about the issues we come to the actual needs for renovation on our construction and property market.

The condition of buildings is generally inadequate due to low requirements for energy performance in old building standards, historical lack of attention to the quality of construction materials and practices, poor record of operational activities, maintenance, and regular renovation.

The needs for renovation can be viewed from the following aspects:

- urgent repairs to guarantee safety of buildings (mechanical resistance and stability, safety in use, safety in case of fire)

- improvement of indoor climate (hygiene and health aspects, fulfillment of requirements to ventilation air rates and room temperatures)

- improvement of energy performance of buildings and HVAC systems

- improvement of architectural planning, visual quality, overall living quality, and additional comfort

The condition of main load-bearing structures was found to be sufficient, allowing planning of renovation works instead of demolition. Similar results have also been obtained by other researchers. The main renovation areas to guarantee mechanical resistance and stability include balconies, canopies, and facades. Balconies as the most badly damaged structures may need also rebuilding solutions. Because of low frost resistance and carbonization of facades, it is necessary to protect them. Improving thermal insulation of the building envelope (roof and walls),

additional thermal insulation is unavoidable to remove serious thermal bridges. Therefore, additional thermal insulation is needed first of all to protect facades and to liquidate thermal bridges.

3 Need for energetically and ecologically sustainable, affordable and healthy built environment

3.1 Specific sustainability and affordability considerations

As additional thermal insulation improves also the energy efficiency, therefore renovation work becomes double advantageous.

In the process of renovation the indoor climate and energy performance of buildings in cold climate the following three components must be kept in mind:

- performance of ventilation
- hygrothermal performance of building envelope
- performance of heating systems

To improve the air change in old apartment buildings, it is necessary to use either central or more flexible individual mechanical ventilation. Typically mechanical exhaust ventilation is the easiest solution to implement. Challenges here are how to guarantee the thermal comfort during winter (one possibility is to combine fresh air inlets with radiators). Energy performance can be improved by help of the heat recovery system with heat pumps (heat from exhaust air to heat up the domestic hot water of the heating system). The mechanical exhaust ventilation solution is not suitable for all types of buildings (especially for buildings with combined stack). Balanced ventilation with room units is another possible solution to renovation of the ventilation in old apartment buildings. During the design process the following questions have to be solved: where to place room units (a little space); how to solve problems with sound pressure levels; where to place air channels (rooms height 2.5m); how to solve air flow in the apartment through existing doors.

To allow for the temperature regulation in the room level, radiators should be equipped with thermostats. Other aspects that should be kept in mind in the renovation of heating systems are: correct control curve of the temperature of the supply water of the heating system, correct water flow rate of the heating system or risers, balanced heat distribution system, and correct maintenance and proper modifications of the HVAC systems.

In addition to technical problems, also social/human questions need to be solved: possibilities and motivation of occupants to cover the cost of renovation vary.

As the buildings under study need extensive renovation, large investments are needed to improve and maintain the quality of dwellings, renovations should be conducted in a cost-effective way. Current economical calculations show that depending on the extent of required indoor climate- and energy renovation works, the price of the renovation is between 100…300€/m2 (plus renovations to guarantee structural safety of buildings). Under a standard condition, a bank can give a loan of up to 160€/m2.

Although complex renovation may be needed, but all renovations do not decrease energy consumption (structural renovation, improvement on ventilation air rates). Therefore, without external support and improved living quality and longer service life of building taken into account, renovations may not be rational in terms of cost-efficiency. During the design process it is possible to compare and analyze different renovation alternatives. This allows for dwelling renovation works to be realized in a cost effective way. The largest saving here is to make the investment once and in a correct way.

4 Analysis of existing BSc, MSc and PhD study programmes in promoting energetically and ecologically sustainable, affordable and healthy built environment

Estonia has four higher education institutions which provide built environment-related study programmes. These are:

- Estonian Academy of Arts

- Estonian University of Life Sciences
- Tallinn University of Applied Sciences
- Tallinn University of Technology

In all of the built environment-related programmes, energy and ecological sustainability, affordability and health are central considerations which are incorporated to some extent into all study programmes.

4.1 Bachelors/specialists programmes

Name of Study Programme	Type of Programme	Institution	Nominal Duration
Geomatics	bachelors	Estonian University of Life Sciences	3 years
Construction	Specialist / Professional higher education course	University of Applied Sciences	4 years
Applied architecture		University of Applied Sciences	
Applied geodesy		University of Applied Sciences	
Road engineering		University of Applied Sciences	
Landscape architecture	bachelors	Tallinn University of Technology	3 years

4.2 Masters programmes

Name of Study Programme	Type of Programme	Institution	Nominal Duration
Architecture and Urban Design	Integrated bachelors & masters	Estonian Academy of Arts	5 years
Town landscapes	masters	Estonian Academy of Arts	2 years
Urban studies		Estonian Academy of Arts	
Civil Engineering (Rural Building)	Integrated bachelors & masters	Estonian University of Life Sciences	5 years
Water Management		Estonian University of Life Sciences	
Geodesy	masters	Estonian University of Life Sciences	2 years
Real estate planning		Estonian University of Life Sciences	
Land management		Estonian University of Life Sciences	
Landscape architecture		Estonian University of Life Sciences	
Environmental engineering	Integrated bachelors & masters	Tallinn University of Technology	5 years
Transportation engineering		Tallinn University of Technology	
Civil engineering		Tallinn University of Technology	
Environmental Engineering	masters	Tallinn University of Technology	2 years
Landscape Architecture		Tallinn University of Technology	

Name of Study Programme	Type of Programme	Institution	Nominal Duration
Transport Engineering		Tallinn University of Technology	
Civil and Building Engineering		Tallinn University of Technology	

4.3 PhD programmes

Name of Study Programme	Type of Programme	Institution	Nominal Duration
Architecture and Urban Planning	doctoral	Estonian Academy of Arts	4 years
Civil and Environmental engineering	doctoral	Tallinn University of Technology	4 years

5 Recommended themes for BSc, MSc and PhD modules

The current state of the built environment in Estonia is inadequate but this is indicative of numerous difficulties. Improving the education of built environment professionals offers a way to directly contribute to resolving some of these problems.

Rather than suggest specific (additional) modules which should be developed (or imported) in order to better equip Estonian built environment professionals to meet the challenges outlined above, it is recommended that the importance of renovating the existing building stock for stability and safety, energy efficiency, a healthy indoor environment and overall living quality is more effectively reflected in existing study programmes.

Consequently, the specific recommendation is to suggest the theme of "sustainable renovation of the existing housing stock" as an appropriate theme for joint, inter-university study programmes at BSc, MSc and PhD levels.

As a specific contribution to this, Tallinn University of Technology is able to offer to develop an existing MSc module entitled "Construction Investments" in order to refocus it towards supporting the sustainable renovation of the existing housing stock.

6 Conclusions

Recent research carried out by the Civil Engineering Faculty of Tallinn University of Technology has shown that, in Estonia, the condition of buildings is generally inadequate. This is variously due to low historical requirements for energy performance, an historical lack of attention to the quality of construction materials and practices, poor records of operational activities, maintenance, and irregular renovation.

The existing housing stock requires:

- urgent repairs to guarantee safety of buildings (mechanical resistance and stability, safety in use, safety in case of fire)
- improvement of indoor climate (hygiene and health aspects, fulfilment of requirements to ventilation air rates and room temperatures)
- improvement of energy performance of buildings and HVAC systems
- improvement of architectural planning, visual quality, overall living quality, and additional comfort

In recognition of this, it is recommended that the theme of "sustainable renovation of the existing housing stock" would make an appropriate them for joint, inter-university study programmes under the CENEAST project.

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