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ENERGY PERFORMANCE OF RENOVATED SOVIET TIME APARTMENT BUILDING

SILTINĀTAS PADOMJU LAIKU DAUDZDZĪVOKĻU ĒKAS ENERGOEFEKTIVITĀTE

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Introduction

This paper is written about energy efficiency of soviet time multi apartment buildings. Detailed study in one of soviet time building was done in Daugavpils. This building is special because practically all necessary energy efficiency measures were done in this building.
By using different measurement and calculation methods energy efficiency of this building was determined and compared to energy efficiency of two buildings of the same kind, but in these two buildings no energy efficiency measures have been done previously.

Fig. 1 shows the studied building and one of buildings with which the studied building was compared.

a b

Figure 1. The studied building (a) and building with which it was compared (b)

In order to compare all three buildings it is necessary that all of them are the same in shape, location and orientation to sun. All three buildings can bee seen in Fig. 2.

Figure 2. Studied building (Vienibas street 38a) in the upper circle and two buildings (Vienibas street 34a and 32a) used for comparing in two lower circles

Studied building, which is located in Daugavpils, Vienibas street 38a, was energy audited and afterwards renovated in the summer and autumn of year 2007. Following energy efficiency measures were done:

- Insulating of all outer walls (10cm polystyrene),
- Insulating of cellar roof (8cm rock wool),
- Insulating of roof (12cm rock wool),
- Replacement of staircase windows with insulation panels and plastic windows,
- Renovation of buildings heat substation.

Total costs of these energy efficiency measures was 161600 Ls or 54,45 Ls/m^2 (total heated area of building is 2968 m^2).

Methods and materials

In order to determine energy efficiency of studied building some measurements were done:

- Registration of consumed heat energy,
- Indoor and outdoor air temperature monitoring,
- Heat flux measurements trough insulated walls.

Besides these measurements different calculation methods were used. This helped to clearly determine the energy efficiency of this renovated building.

Consumed heat energy was measured with help of heat energy meter, which is installed in heat substation of building, and registered manually every week by the manager of this building. The consumption of all three buildings (the renovated building and two not-renovated buildings) was taken this way. Heat energy meters in these buildings are installed in such way that they count heat energy, which is needed for space heating, and heat energy, which is used for hot water preparation. This means that heat energy, which is used for hot water preparation, has to be separated from heat energy, which is used for space heating. This was done by measuring how much heat energy is used in building during summer period when space heating is turned off and assuming that the amount of heat energy for hot water preparation does not change during all year.

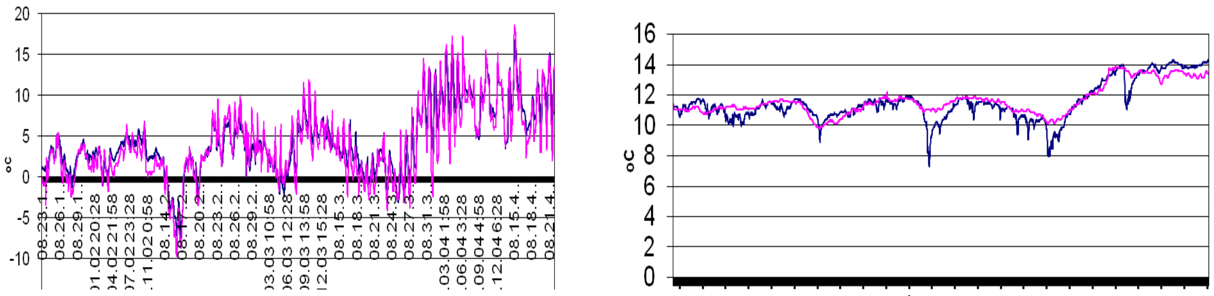
Since the amount of used heat energy for space heating depends from outdoor and indoor temperatures, these temperatures were measured for period of three months in heating season – from January 23rd till April 22nd. In total 9 temperature loggers were placed in such manner that 2 outdoor temperatures, 2 cellar temperatures and 6 indoor temperatures were measured (one of temperature loggers was registering two temperatures). Operations with temperature loggers can be seen in Fig. 3.

a b

Figure 3. Placing of temperature loggers (a) and data retrieving (b)

HOBO data loggers were used. These loggers were programmed in such way that they registered temperature with 30 minute intervals. Temperature loggers were put only in the renovated building, indoor temperatures of the two not-renovated buildings, which were used to compare energy efficiencies in renovated and not-renovated one type buildings, were measured by hand-held digital thermometer during a visit to these buildings.

Measured outdoor and cellar temperatures can be seen in Fig.4.



a b

Figure 4. Outdoor temperatures (a) and cellar temperatures (b)

As can be seen in Fig. 4 outdoor temperatures during three months measuring period changed from -10 ^{o}C to +19 ^{o}C, but cellar temperature changed in smaller amplitudes – from 7 ^{o}C to 14 ^{o}C. As mentioned above indoor temperatures were measured in six different apartments and the results of these measurements are summarized in Fig. 5.

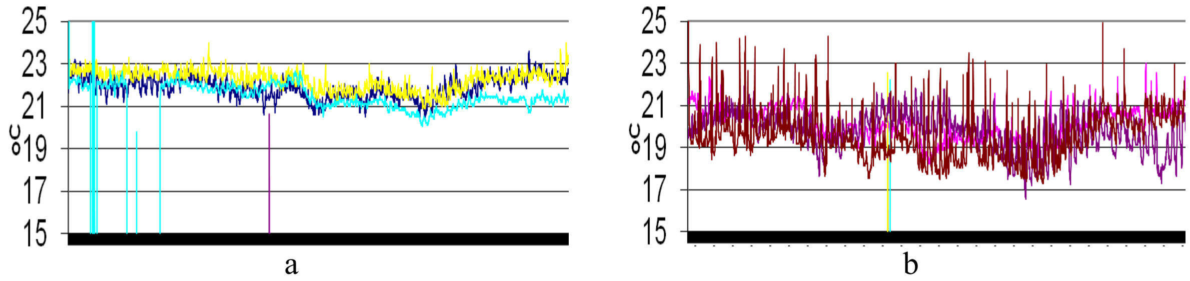


Figure 5. Steady indoor temperatures in three apartments (a) and alternating indoor temperatures in three apartments (b)

It can be clearly seen in Fig. 5 that in three apartments indoor temperatures were steady but in other three apartments indoor temperatures were alternating in quite big amplitude. This can be explained by the behaviour of inhabitants of these apartments. While the first three apartments were inhabited all the time or they were not inhabited at all, the other three apartments were inhabited periodically and this means that the inner heat gains were changing quite a lot, which results in alternating indoor temperature.

It is critical to know indoor temperatures because consumed heat energy for space heating in depended on indoor and outdoor temperature difference. Thanks to temperature measurements the average indoor temperatures for all three buildings were determined:

1. Vienibas 38a (renovated) – 21,02 ^{o}C,
2. Vienibas 32a (not-renovated) – 20 ^{o}C,
3. Vienibas 34a (not-renovated) – 21 ^{o}C.

In course of this study heat flux trough insulated brick walls was measured. This was done in order to see if insulation works have been done properly and what is the real heat conductivity of this wall. Heat flux measurements were done with measurement equipment from company Hukseflux – one of world's leading heat flux sensor producers. Measurement equipment can be seen in Fig. 6.

Figure 6. Heat flux measurement equipment from Hukseflux installed on wall in Vienibas street 38a

Measurements were done in accordance with international standard ISO 9869:1994 "Thermal insulation – Building elements – In-situ measurement of thermal resistance and thermal transmittance". The measurement was carried out for six full days. The results of heat flux measurements are shown in Fig 7.

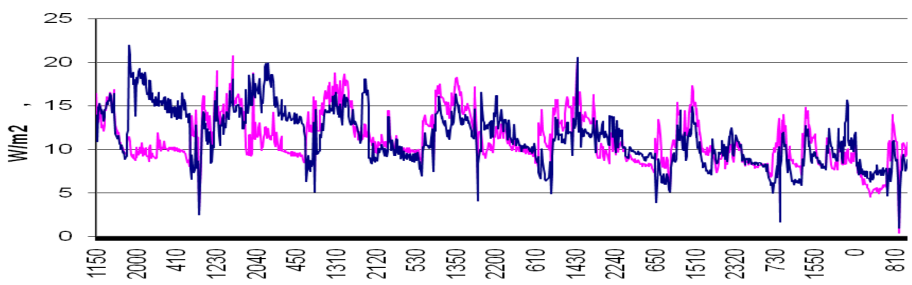


Figure 7. Heat flux through insulated brick wall

The device from Hukseflux contains two sets of heat flux measuring equipment that is why there can be seen two heat flux lines in the chart. S imultaneously outdoor temperature, indoor temperature and inner and outer temperatures of measured wall were measured.

This gives possibility to calculate the heat transmittance coefficient or so called U-value of insulated wall, that is done by using the following equation:

$$U = \frac{\sum_{j=1}^{n} q_j}{\sum_{j=1}^{n} (T_{indoor\_j} - T_{outdoor\_j})} \qquad (1)$$

where

U – heat transmittance, W/m^2K,
n – count of full days of measurement
q_j – the average heat flux, W/m^2,
T_{indoor_j} – the average indoor temperature, ^{o}C,
$T_{outdoor\_j}$ – the average outdoor temperature, ^{o}C.

After all measurements data on heat consumption of all three buildings were gathered and recalculated in such way that average heat consumption was calculated as if the average indoor temperature in all three buildings was 20 ^oC.

Results and discussion

Heat flux measurements showed that the real U-value of the insulated brick wall is 0,77 W/m^2K, which is much greater than the theoretical U-value of this wall, which was calculated to be 0,28 W/m^2K. This shows that wall insulation works have not been done properly and wall loses 2,75 times more heat energy than it should.

By using heat flux measurements in future it could be possible to bring under control the quality of buildings and to inspect the quality of energy efficiency measures, which have been done by builders.

Calculations showed that the renovated building in Vienibas street 38a uses 70 kWh/m^2 at 20 ^oC indoor temperature, while not-renovated buildings in Vienibas street 32a and 34a use respectively 127 and 148 kWh/m^2 at the same temperature, which means that the renovation of building in Vienibas 38a has given heat energy savings of 49%.
Also calculations on how indoor temperature affects heat energy consumption were carried out. Results of this calculation can be seen in Fig. 8.

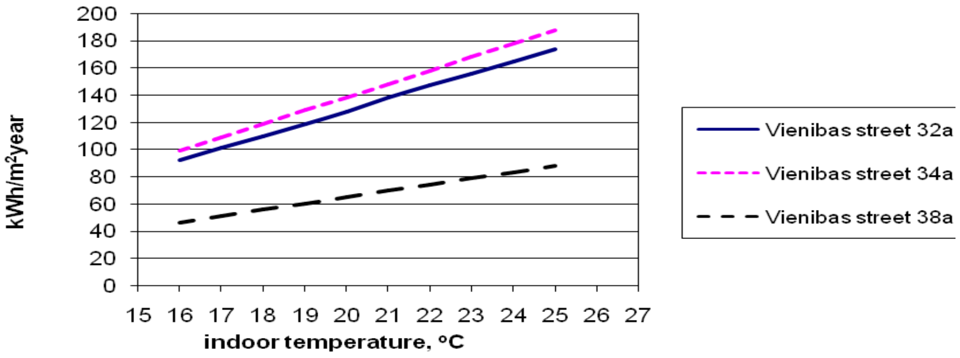


Figure 8. Heat energy consumption depending on indoor temperature

From Fig. 8 it can be seen that changes in indoor temperature leave big influence on heat energy consumption, which means that more attention should be paid not only on energy efficiency measures like wall insulation and changing of windows but also such energy efficiency measures as decreasing indoor temperature during night or while nobody is at home.
The amount of energy efficiency measures and the shape of studied building indicates that the reached heat energy consumption for space heating (70 kWh/m2 at 20 ^oC indoor temperature) in renovated soviet-time buildings in Latvia is the lowest heat energy consumption possible with these kind of measures. Lower heat energy consumption could be reached only by introducing higher quality energy efficiency measures like thicker insulation layers, ventilation with recuperation, etc.

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Žogla G., Kamenders A., Blumberga A. Siltinātas padomju laiku daudzdzīvokļu ēkas energoefektivitāte
Aptuveni 40% no Latvijā patērētās enerģijas tiek izmantota mājokļu sektorā, tas ir, telpu apkurei un karstā ūdens sagatavošanai. Vidējais īpatnējais siltumenerģijas patēriņš Latvijā ir 220–250 kWh/m²gadā. Uzstādītais mērķis, kas būtu sasniedzams tuvākajā nākotnē, ir 150 kWh/m²gadā. Lai šo mērķi sasniegtu, ir jāveic daudz dažādi pasākumi. Viens no efektīvākajiem pasākumiem ir padomju laiku ēku energoefektivitātes paaugstināšana, ēkas siltinot .
Šajā pētījumā tika analizēta siltināta padomju laiku ēka, kas atrodas Daugavpilī. Tika apskatīta pirmā apkures sezona pēc energoefektivitātes pasākumu veikšanas. Tika uzskaitīts siltumenerģijas patēriņš, mērītas telpu un āra gaisa temperatūras, noteiktas sienu termiskās īpašības. Iegūtie mērījumu dati tika salīdzināti ar divām atskaites ēkām, kas atrodas blakus analizētajai ēkai. Pateicoties mērījumiem, iespējams izdarīt secinājumus par termālā komforta līmeni ēkās pēc energoefektivitātes pasākumu veikšanas un par iedzīvotāju uzvedības ēkā ietekmi uz komfortu.
Pētījuma rezultātā tika noteikta siltinātās ēkas energoefektivitāte, kas dod ieskatu, cik reāls ir Latvijā uzstādītais mērķis samazināt vidējo ēku siltumenerģijas patēriņu līdz 150 kWh/m² gadā.

Žogla G., Kamenders A., Blumberga A. Energy performance of renovated soviet time apartment building
Approximately 40% of heat energy used in Latvia is used for domestic purposes, i.e., space heating and hot water preparation. The average specific heat energy consumption in Latvia is 220 – 250 kWh/m² per year, a goal has been set, which should be reached in the nearest future, this goal is 150 kWh/m² per year. In order to achieve this goal there are many measures that could be taken. Some of the most effective measures are energy efficiency measures that are taken in Soviet time apartment buildings.
In this research a renovated Soviet time apartment building in Daugavpils was monitored for one heating season, this was the first heating season after implementation of energy efficiency measures. Heat energy consumption, indoor and outdoor temperatures were monitored, thermal properties of insulated walls were also measured. The obtained data were compared with two reference buildings located near by the monitored building. Thanks to measured data it is also possible to make some conclusions about thermal comfort in buildings after implementation of energy efficiency measures and how this comfort is influenced by the behaviour of its inhabitants.
The results of this research show the energy performance of renovated building and give insight how realistic it is to reach the goal set by Latvia, i.e., specific heat energy demand – 150 kWh/m² per year.

Жогла Г., Камендерс А., Блумберга А. Энергоэффективность утепленных многоквартирных домов советского времени
Приблизительно 40% из энергии потребленной в Латвии использовано в секторе домашних хозяйств, т.е. для отопления помещений и для подготовки горячей воды. Среднее удельное потребление тепла в Латвии 220-250 кВт/м² в год. Установленная цель, которая могла бы быть достигнута в ближайшем будущем 150 кВт/м². Чтобы достичь этой цели, необходимо проводить много различных мероприятий. Одной из наиболее эффективных мероприятий повышение энергоэффективности зданий советского времени реализуя мероприятия по утеплению зданий.
В данном исследовании было утепленное здание советского времени, которое находится в Даугавпилсе, было проанализировано, был рассмотрен первый отопительный сезон после проведения энергоэффективных мероприятий. Было замерено потребление тепловой энергии, температуры в помещениях и температура на улице, были определены термические особенности стен. Полученные измерения были сравнены с двумя отчетных зданий, которые находятся рядом с анализируемым зданием. Благодаря измерениям, возможно сделать выводы об уровне термального комфорта в зданиях после проведения энергоэффективных мероприятий и как на этот комфорт влияние жителей в здании.
В результате исследования была определена энергоэффективность утепленного здания, которая дает обзор, насколько реальная для Латвии установленная цель уменьшить среднее потребление тепловой энергии до 150 кВт/м².