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ENERGY EFFICIENCY IMPROVEMENT POTENTIAL IN HISTORICAL BRICK BUILDING

Andra Blumberga, Gatis Zogla, Kristaps Zvaigznitis, Dagnija Blumberga
Riga Technical University
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Introduction

It is hard to increase energy efficiency level in historical brick buildings. These buildings usually are law-protected and no energy efficiency measures that can change the appearance of the building are allowed [LBN 002-01]. The biggest energy savings in buildings can be achieved by insulating outer walls and changing windows. If change of windows in historical buildings is allowed then wall insulation from outside is prohibited.

Since the low energy efficiency of historical brick buildings in Latvia basically is law-protected, there has not been practically any research to determine the existing energy consumption of these buildings. Some research has been done to determine the energy efficiency level, energy efficiency potential and measures in historical brick buildings outside Latvia. Fabrizio Ascione et.al. [1] have done research to investigate energy retrofit possibilities of historical buildings in Italy. This study suggested for insulation to use thermal plaster. Said M.N.A et. al. [2] have researched how internal wall insulation affects hygrothermal performance of a masonry wall. E. Grinzato et.al.[3] have used thermography for investigating historical buildings. This gives possibility to assess the moisture and the thermal diffusivity of walls in historical buildings. All previously mentioned research is concentrated on one building analysis, which does not show the existing energy efficiency level of historical buildings. The existing energy efficiency level in historical buildings has been investigated in research of Kristian Fabbri et.al. [4], where they are using EPC (energy performance certificates) to classify historical buildings. But no extensive research has been done to determine the existing energy consumption in historical buildings, which is the first step to understanding the energy efficiency potential of historical buildings.

Existing situation

The building is located in Riga city in *Spīķeri* complex, the industrial aesthetics of which is included into the UNESCO World Heritage List. The building has an area of 56, 3 m^2. The building is currently empty and is not being used, but the earliest goal was to provide facilities comprising functions.

Fig. 1. Building Maskavas Street 8, Riga, location and facade

Building envelope

Exterior wall of the building is made of colored silicate bricks with a thickness of 51 cm and it has an area of 129, 13 m^2. Building is not inhabited for several years and its constructions are significantly affected by weather and human factors.

It is is observed construction damage above the window, indicating a potential moisture penetration from the roof. Such damage reveals deeper bricks are not painted and which opposed to the bricks of the surface could not be formed surface layer over time, so they are more rapidly exposed to moisture damage. The wrong design contributed these defects, because there is no provided stitches lintel, or all the bricks are immured in parallel vertically and without complying with the required angle. Damage observed at the bottom, where the gutter is not required angle, as a result of rain water enters into the walls. At the bottom right be observed the moss, leading to intensify brick deterioration.

The final parts of building gutters can be stolen as a result the water is not drained 20 - 40 cm above the ground as recommended, but about 160 to 220 cm in height. One of the building windows have been replaced with plywood, which are not suitable fixed. At the bottom of figure CCC damage to the construction of the wall is visible, where the whole bricks are missing and the stitches crumbled away. Damages can be observed up to a height of 2 m on the annex joint.

The top and final leg of gutter is missing, as result moisture drains into the wall. At the bottom of the picture is observed moisture damage to building foundations and on the right of the picture part of the joint is crumbled away.

Estimated building energy consumption

Table 1

BUILDING ENVELOPE

Envelope	The area, m^2	Heat transfer coefficient, W/m^2K	HT (UA), W/K	MWh/year
External walls	129,13	1,50	191,1	16,76
Roof	80,12	1,00	80,12	7,03
Windows	16,20	2,80	45,36	3,98
Floor to the bottom	80,12	0,80	64,09	5,62
Total			**408,7**	**35,8**

The building is not the mechanical ventilation system, so the building has natural ventilation system with air flow through the building envelope not tight. The air exchange in building was set based on the type of building windows, and it was taken as a 0, 5 h^{-1} during the heating period.

Measurements of heat flow

During the measurements heat flows in brick walls are determined. Before the installation of heat flows density measuring equipment measurement sites were surveyed with the help of termocamera, to make sure that the measurement point does not contain thermal damage, which could reduce the measurement accuracy. Figure 2. displays instantaneous heat transfer coefficients of the walls of Maskavas Street 8.

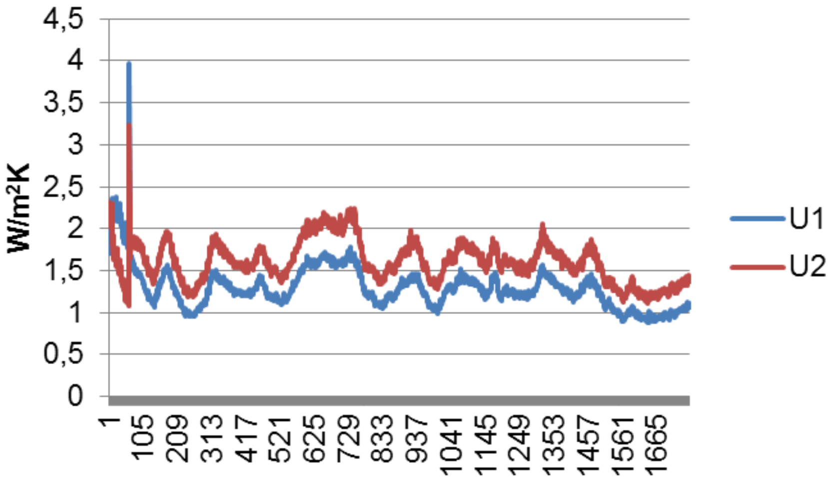

Fig. 1.10 Instantaneous heat transfer coefficients of the walls of Maskavas 8

Measurement of moisture content

Moisture measurements were made by the dielectric moisture indicators *Trotec 600* and *650*. Using these devices moisture content in the wall can be determined quantitatively in a scale from 0 to 200 sections. If the measured temperature is less than 40 sections the building material is dry, if between 40-80 sections then - humid, and if more than 80 sections then - wet.

Measurements were made on Maskavas Street 8 building interior walls in six different locations. Measurement data are collected in Table.2.

Table 2

MEASUREMENTS IN MASKAVAS STREET

	5 cm depth	30 cm depth
1.	57,5	35
2.	61,6	45
3.	64,3	50,9
4.	107	30,3
5.	139,4	37,6
6.	141,3	40,5

Determination of water-soluble salts

To determine water-soluble salts qualitative test method based on the methods developed in „A laboratory manual for architectural conservators” by International Centre for the Study of the Preservation and Restoration of Cultural Property (ICCROM) was used. Quantitative analysis of sulfate was carried out using the „determination of barium in a form of barium sulfate" methods. It was determined that the sample contains 2,5 mg/l NO_3^{-} and minimal amount of SO_4^{2-} that can be caused by acid rains, sulfates may also form in brick burning process. It was determined that sampling site building interior walls are wet in 30 cm depth, which is due to the fact that the building is not being heated.

Energy efficiency measures

Energy efficiency measures in the historical building in Maskavas street 8 present different possibilities for implementation of renovation by use of different insulation materials for exterior walls applied from inside.

Insulating materials, which are suitable for exterior walls insulation from the inside suggested in the Table 3.

Table 3

COMPARISON OF INSULATION MATERIALS

Insulation material	Thermal conductivity, λ W/(mK)	Insulation thickness, m	The new U-value W/(m²·K)	Savings of U-value W/(m²·K)	Reduction of heat consumption, MWh/year	Reduction of heat consumption, kWh/m² year
Eco wool	0,037	0,15	0,21	1,27	14,37	255,16
Flax	0,033	0,1	0,26	1,21	13,7	243,41
Hemp	0,055	0,1	0,39	1,08	12,22	217,03
Thermo wool	0,021	0,1	0,18	1,3	14,68	260,7
Aero gel	0,013	0,04	0,26	1,11	12,53	222,51
Vacuum insulation panels	0,004	0,06	0,06	1,42	16,07	284,86

Selection of insulation materials depend from two main criterias stated for energy efficiency improvement project.

- Level of energy saved. Calculations shows that the best results for reduction of heat consumption could be reached by use of vacuum insulation panels - 285 kWh/m^2year.
- Reduction of inside area. Calculations shows that the best results to reach minimum reduction of inside area by installation of inside insulation for reduction of heat consumption could be reached by use of aerogel insulation insulation – thickness only 0,04 m.

Conclusions

1. The estimated energy consumption for heating of the building is 35.8 MWh per year, or 633 kWh/ m^2 per year.
2. Measured thermal conductivity coefficient for bricks is different from the calculated values, which are based on the element structure and obtained using ISO 6946-1.
3. Calculated heat transfer coefficient is lower (1.32 W / mK) than measured (1, 48 W / mK).
4. Moisture and freeze - thaw cycles have done grate damage to external wall structures of Maskavas Street building. The main cause of damage is poor technical condition of roof gutters. While the main reasons for masonry cracking are three: the intense traffic and transport, poor foundations and groundwater fluctuations.
5. The sample, which was taken from the building in Maskavas Street 8 showed minimum concentrations of nitrate and sulfate content.
6. The building needs strengthening of wall constructions in places where cracks, loose joints and shifted bricks have developed. It is necessary to strengthen the window boxes, check the moisture barrier and prevent flaking of the joints.
7. Selection of insulation materials depend from two main criterias stated for energy efficiency improvement project.
   - Level of energy saved.
   - Reduction of inside area.

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