Advanced Building Construction and Materials II

Edited by
Milan Palko

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Special topic volume with invited peer reviewed papers only.

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Trans Tech Publications Ltd
Churerstrasse 20
CH-8808 Pfaffikon
Switzerland
http://www.ttp.net

Volume 1057 of
Advanced Materials Research
ISSN print 1022-6680
ISSN cd 1022-6680
ISSN web 1662-8985

Full text available online at *http://www.scientific.net*

***Distributed** worldwide by*

Trans Tech Publications Ltd
Churerstrasse 20
CH-8808 Pfaffikon
Switzerland

Fax: +41 (44) 922 10 33
e-mail: sales@ttp.net

and in the Americas by

Trans Tech Publications Inc.
PO Box 699, May Street
Enfield, NH 03748
USA

Phone: +1 (603) 632-7377
Fax: +1 (603) 632-5611
e-mail: sales-usa@ttp.net

Preface

Development of the material-technological base in the field of construction is progressing faster than in the previous periods. Based on the potential of new materials and technologies, it is possible to create advanced engineering building systems. Integration of advanced materials, technologies and construction systems creates a high-quality construction with optimum performance in the presence as well as in the future. Nevertheless, improper application of high quality materials in the wrong environment may cause a defect.

Research in the field of building materials, technologies and construction is currently primarily driven by energy efficiency, ecology and quality of the human environment. The importance of energy efficiency is affected secondarily by limited resources of fossil fuels. Another significant moment in this part is the price of energy and forecasts of its growth. Ecology of environment enters the problem through the external environment and ecology of artificially produced human environment. An important factor in terms of ecology is a comprehensive view of the construction work and its segments in the context of the production of pollution produced in the manufacture, transport, installation, exploitation and recycling or removal (rated as for example: primary energy of the material). Construction is currently focusing on higher energy standards using environmentally friendly materials and energy based on renewable resources. The quality of the internal environment has a direct impact on the users, on their health, abilities, well-being and safety.

Saving energy and increasing energy standard applied to buildings entails numerous problems related to energy and economic efficiency, thermal and technical features of building materials and construction, built-in moisture with operational moisture regime, indoor air quality connected with aerodynamic characteristics of the construction. By using a high-performance insulation, which is often flammable, fire safety problems may arise. By changing the scope and material-design solutions form different acoustic parameters of the works. Energy optimization of proportionality, transparent and non-transparent container structures housing brings light and technical problems.

For solutions to these issues is important choosing the right methodology solutions whether in the form of experimental verification, surveillance or computer modeling.

The aim of this journal is to inform the general public with the results derived from research and practices related to the above-mentioned issues.

Topics:
• Energy Saving and Ecological Buildings
• Thermal Performance of Building Materials and Constructions
• Aerodynamic Characteristics of Buildings and Construction
• Fire Safety Materials, Spaces and Construction
• Noise Protection and Daylight Conditions

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Advanced Building Construction and Materials will be published annually (once per year).

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CHAPTER 1:

Energy Saving and Ecological Buildings

Advanced Materials Research Vol. 1057 (2014) pp 3-10
Submitted: 28.08.2014
Accepted: 12.09.2014

doi:10.4028/www.scientific.net/AMR.1057.3

Operation Energy Consumption after the Renewal of an Elementary School

Ivan Chmúrny

Technical University, Radlinského 11, Bratislava, Slovakia

ivan.chmurny@stuba.sk

Keywords: energy use, heating, ventilating, operational rating

Abstract. Analysis of energy consumption during the operation of the renewed elementary school in Lietavská Lúčka, which uses renewable energy sources. The results are based on the consumption of natural gas and electricity according to data from the meters of market suppliers of energy from 2006 to 2013.

Intoduction

The pilot project aimed at the elementary school Lietavská Lúčka [1] placed emphasis on the progressiveness of solutions, energy savings by improving the thermal protection of buildings as well as the use of renewable energy sources. The project was supported by the former Ministry of Construction and Regional Development of the Slovak Republic. The following were chosen as the basic principles of the solution:

- superior thermal insulation properties of building structures in comparison with STN 73 0540-2: 2002 valid at the time of the preparation of the project,
- the diversification of sources of energy (solar energy, electric energy, natural gas, energy from the environment)
- minimizing energy losses by ventilation (ventilation system with heat recovery).

The project also addressed the research and development tasks [2], which aimed to document and evaluate the measured data from operation after the renewal of the elementary school. Thus, to prove the results of the saving measures on the basis of the measurements of the real operation of the building. *Fig. 1* and *Fig. 2* show a view of the facade of the renewed elementary school.

Fig. 1 View of the entrance to the elementary school building

Fig. 2 View of the facade of the building

Thermal protection of building

The thermal performance of the building structure in its original condition is listed in *Table. 1* while the performance after restoration is listed in *Table 2.* During the restoration of the building by improving the thermal protection, EPS-Neopor gray foam polystyrene was used as additional thermal insulation. A thickness of 140 mm. was used on the walls. 300 mm. was used on the flat roof construction

Table 1 Thermal performance of the structure in its original condition

Building construction	U in W/(m^2 K)
Exterior wall thickness 270 mm	1.69
Exterior wall thickness 400 mm	1.4
Roof of the school	1.16
Roof of the dressing rooms	0.95
Floor on the ground	1.87
Wooden double windows	2.85
Double glazing	g = 0.75

Table 2 Thermal performance of building structure after renewal of the school building

Building construction	U in W/(m^2 K)
Exterior wall thickness 270 mm + ETICS with 140 mm EPS-Neopor	0.19
Exterior wall thickness 400 mm + ETICS with 140 mm EPS-Neopor	0.17
Roof of the school + 300 mm EPS	0.095
Roof of the dressing rooms + 300 mm EPS	0.093
Floor on the ground	0.33
Plastic windows with insulating double glazing	1.30
Double glazing	g = 0.63

This change in the thermal protection of the building means a significant reduction in the heat loss of the building. Computed, this represents a reduction of heat loss from the value of 242.6 kW to 92.4 kW, hence a reduction of heat loss by 61.6%. Theoretically, under standard conditions of evaluation and in the project energy evaluation, a theoretical energy savings in energy need for heating of 74.4% was achieved, as shown in *Fig. 3*.

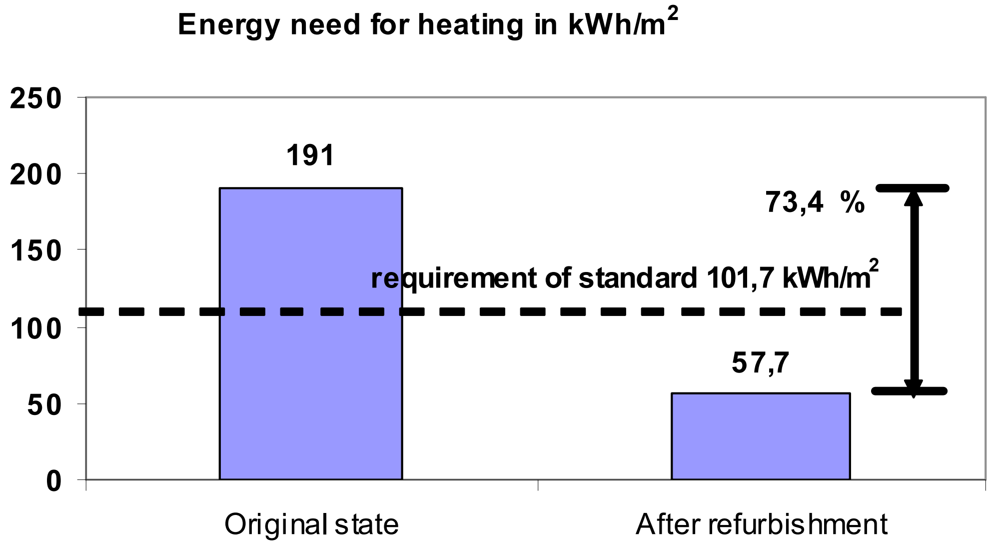

Fig. 3 Energy need for heating in project evaluation

Energy supply of the elementary school

After the renewal of the building structures and technical equipment of the building, it is provided with energy from market suppliers and renewables:

- 30 pieces of solar collectors with an absorption area of 69.6 m2
- heat pump water - water, total of 10 ground bores
- condensing gas boilers with a heat input of 3 x 49 kW
- controlled ventilation system

The installed air handling unit has a high efficiency heat recovery system, the declared value of the efficiency is 80%. The device enables:

- variable air flow,
- operation controlled by a time program,
- setback mode outside of operating hours,
- thus, savings of electricity and heat for heating the air is assumed.

The determining factor for the operation of the BTE equipment, which uses electricity, is its price and tariff. The fundamental attitude of the operator of the elementary school is to save fees for electricity. Thus, the starting point is that the technology systems be operated only during low tariff times. Low tariffs are during the periods:

Mo ...Fri 00:00...9:05; 10:05...12:15; 13:15...16:05; 17:05...19:35; 20:35...24:00;
Sat ...Su 00:00...2:45; 3:45...10:00; 11:30...15:20; 16:50... 24:00;

The operation of the heat pump is only during low tariff periods. Ventilation / without heater, only heat exchanger / operated only during low tariff periods and according to the time program, but only if the desired air quality is not achieved. Air quality is controlled by the built-in sensors for the concentration of carbon dioxide in the exhaust air. Time program for ventilation:

Mo ...Fri 7:00...9:00; 10:15...12:00; 13:30...15:05; 17:30...19:00; 20:45...22:00;

The air handling equipment is operated in an intermittent manner, which may affect the indoor air quality at the time of interruption.

The ventilation system provides quantitative and qualitative criteria in supplying fresh air to the treated areas. Quantitative indicators are given for the planning and designing of this system, which considered these parameters. The designed ventilation system of the building is equipped with a highly efficient heat recovery capable of heating up the air supply through waste heat from exhaust air to a temperature of + 16 ° C without additional heating. The designer thought that reheating the air supply would not be needed, and that it would be offset by the increased output of the existing radiators. An additional power supply for heating the air is not installed. The required thermal power of the ventilation system was designed for 20 kW.

The electricity consumption for the operation of the air handling equipment is low compared to other electricity consumption. This is especially due to the time program, which ensures the operation of the ventilation equipment only at the time of low tariffs. In times of high tariffs, the ventilation equipment is not in operation. Thus, the operation of the ventilation without a heater, the heat exchanger is operated at the time of low tariffs and only if the desired air quality of 800 ppm is not achieved. In the operation of the classrooms, air quality varies from 600 to 1200 ppm, representing a class of air quality in the 2nd and 3rd category according to STN EN 15251. According to the records of the activities of ventilation, air quality did not fall to the 4th class, which is considered to be outside the parameters of acceptable quality and could be tolerated only for a limited part of the year. During such operation of the air handling equipment, ventilation by opening windows is also used, however, it is difficult to quantify. Air quality according to the records of the air handling equipment itself is acceptable and energy efficient. The subjective evaluation of students and teachers, however, reported up to 25 % dissatisfaction with the ventilation system on the basis of a questionnaire survey. They felt a slight discomfort due to the cold air falling on the heads of students and reported feeling a swirl of air and sometimes a draft of wind (breeze) through the hair. *Fig. 4* shows the concentration of carbon dioxide during teaching in three classes in the elementary school. Deductions are based on carbon dioxide sensors from the air handling control system, located at the diffuser of exhaust air.

Experience has shown and a questionnaire survey confirmed that even ventilation with a high efficiency of heat recovery heat can cause feelings of discomfort. Of particular concern is also the avoidance of the use of the ventilation system on the grounds of the tariff pricing policy of the market electricity supplier. It is therefore disadvantageous to run the ventilation system in times of high tariffs. However, intermittent operation of the ventilation system while saving energy can cause thermal discomfort in winter.

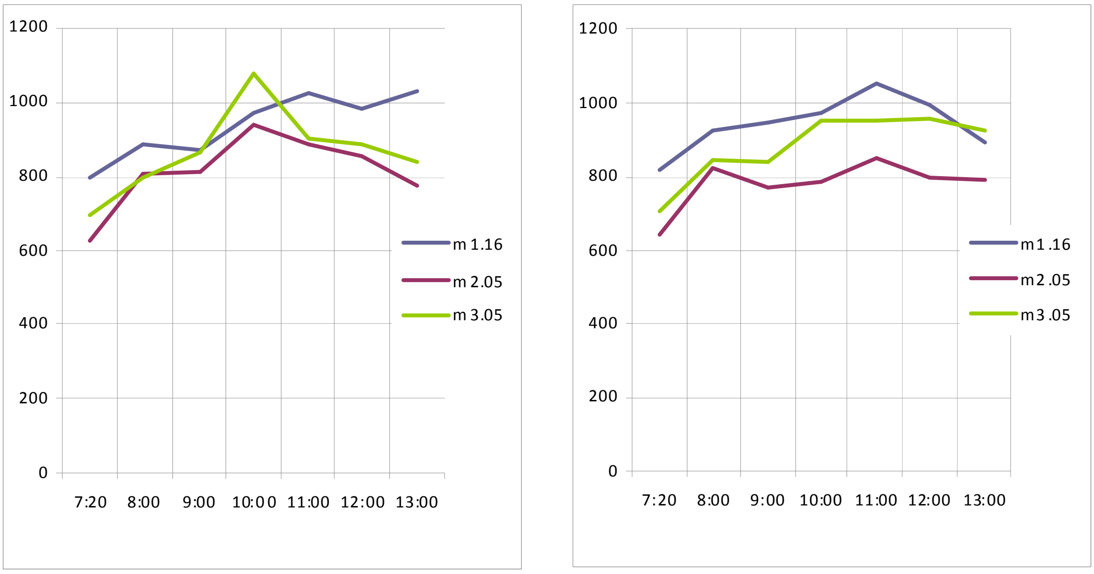

Fig. 4 Carbon dioxide concentration in ppm in three classrooms during class

Evaluation of energy consumption according to energy carriers

The documentation of data on energy consumption in this analysis is based on the measured data from operation. The reported energy consumption from different places is recorded on the meters of the market energy suppliers: