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ENERGY EFFICIENCY OF A PUBLIC BUILDING RENOVATION AND RECONSTRUCTION USING BASE MODEL PASSIVE HOUSE AND BIM TECHNOLOGY

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Abstract. Modern constructions, either private houses or public buildings, nowadays must be built meeting all the requirements of the European Union [EU] standards and must be highly energy efficient. Still, there are a lot of old inefficient buildings with high energy costs that require renovation. These buildings can be renovated applying a *passive house* model that helps to minimize buildings' heating and cooling energy expenses. Moreover, the decisions made in the stages of early design and preconstruction are essential for the sustainability in a building facility. It is possible to perform various analyses with Building Information Modeling (BIM) in order to have an optimized sustainable building design. BIM system can be used to evaluate and control the costs (e.g. renovation, efficiency) as well as to monitor the conditions during the life-cycle of the building.

Keywords: passive house, building, information, modeling, TOPSIS, SAW, COPRAS, SyMAD-3.

Introduction

Environmentally, economically and socially sustainable villages, towns and cities are the most urgent challenge of the 21st century (Jarrar, Al-Zoabi 2008).

Buildings have direct environmental impact, ranging from the use of raw materials for their construction and renovation to the consumption of natural resources and the emission of harmful substances (Balaras *et al.* 2005). Design of buildings should take long-term environmental and economic benefits into consideration (Wang *et al.* 2010).

Economical, social and environmental balance is promoted in sustainable construction practice implementing construction projects. Sustainable construction practice refers to various methods in the process of implementing construction projects that involve less harm to the environment. Energy performance of a building is an estimated energy content expressed as a building energy performance class required when using the building for its intended purpose (STR 2.01.09: 2012).

A Passive House is a building, for which thermal comfort (LST EN ISO 7730:2006) can be achieved solely by heating or cooling of the fresh air mass, which is required to achieve sufficient indoor air quality conditions – without the additional air recirculation (Bayir *et al.* 2013).

Energy efficiency has been attracting more society attention, because the expenses of the energy consumption for heating take a big part of the revenue. These costs can be reduced several ways: by lowering energy prices, increasing energy and constructing (renovating) buildings with less energy consumption (Volvačiovas *et al.* 2012).

Public building is a building intended to public needs taking into account provisions for STR

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1.01.09:2003 that covers hotels, administrative buildings, trade buildings, service buildings, catering buildings, transport buildings, culture buildings, education buildings and religious buildings (STR 2:02:02:2004). Most of the public indoor facilities climatic conditions do not meet the requirements of the Lithuanian hygiene standard, i.e. they do not fulfill the thermal comfort parameters, so they must be renovated in accordance to the hygiene standard of Lithuania (HN 42: 2009).

Under certain conditions, efficient energy demand can be achieved by selecting the building design changes. Technological advances and innovations of materials and construction techniques of the industry allow development of new solutions to be used in each element of the building (San-José Lombera, Cuadrado Rojo 2014).

The BIM technology (the future technology of the constructions (Harris 2013)) would help to solve the high costs, terms of construction process, life cycle and design model reconstructing public buildings of chosen alternative construction issues. It is a new industry term referring to parametric 3D visualization technology and processes in the AEC industry (Taylor, Bernstein 2009; Popov *et al.* 2010). BIM is one of the most promising recent developments in AEC industry (Azhar 2011). BIM includes more of life cycle phases, integrates program controls and standardizes information management so that meanings are clear and consistent (Talapov 2011). It is an additional model for project's engineering information database, storing all the architectural designs with geometric information and the corresponding technical information of all work (Ding *et al.* 2012).

The ability to import buildings' data from BIM reduces time and uncertainty in building energy modeling process. BIM technology requires significantly more labor resources than traditional design model. The workforce needs breakthrough for sections', elevations', specific parts' (heating, ventilation and electricity) preparation (Wong, Fan 2012).

The 4D technology use allows the construction planner to produce the more rigorous schedules (Heesom, Mahdjoubi 2004; Migilinskas *et al.* 2013).

1. Materials and problems

All the existing problems should be taken into consideration while renovating public and other buildings. Problems are individual in each case and unique to a particular building, however, the summarized data of the studies show often encountered ones:

1. Indoor temperature (°C) is too high or too low.
2. Great indoor temperature (°C) contrast at 0.10 and at 1.10 m above the floor.
3. Ground temperature (°C) is too low.
4. Humidity (%) is too low or too high.
5. Indoor airflow (m/s) is too high.
6. Carbon dioxide (CO_2) concentration (%) is too high.
7. High heating, hot water production and power supply (kWh) expenses.
8. High building physical depreciation (%): constructions, windows, doors, internal engineering systems.
9. Poor building external appearance.

These indicators show public buildings characteristics.

So as to find the solutions of the problems, a passive house principle model (Fig. 1) is applied to address the public building renovation issues.

The Vaidotai railway station of a 2168.00 m^2 building general area, built in 1980, is selected for a study. This is the five-story building with a local gas boiler located in the basement. The building outer walls

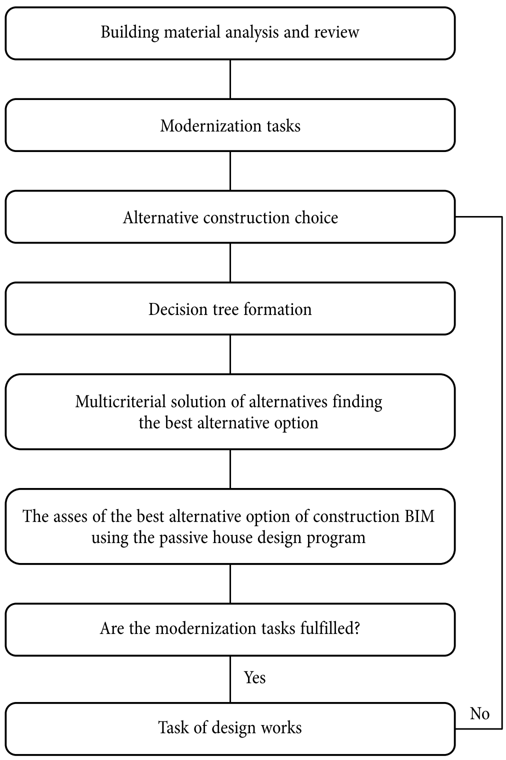

Fig. 1. Passive house model

are built of 510 mm thick silicate brick masonry and 400 mm thick reinforced concrete blocks plinth. Walls are not plastered from the outside but are plastered and painted from the inside. The roof is superposed, covered with the membrane roofing. The ventilation chimneys' tinning is worn out.

The decoration of the walls and ceilings are worn out. The facade plane has visible cracks of 1–1.4 mm.

The degree of the building isolation and non isolated spots of the building must be determined before starting the isolation works. The obtained results will show the necessity of the insulation and its degree.

The physical depreciation of 25% of the building was set during the examination using the BCH53 – 86 (p) method. The air temperature of the premises does not meet the requirements of Lithuanian hygiene norms, because the indoor temperature should range from 18 up to 22 °C during the cold season. Thermal conductivity measurements of the barrier zones showed that the heat transfer coefficient of the Vaidotai st. EC checkpoint external walls and roofs is too small and does not meet Lithuanian Construction Technical Regulation links.

The estimated building reconstruction areas:

1. Heat insulating layer and a deposited coating are recommended to install. During the repair works the parapet tinning must be restored. The tinning works of the worn out curbs must be performed, the masonry walls must be restored and caps replaced. It is recommended for the ceilings that are under the reinforced concrete roof flooring to be restored using the finishing tools – such as filler together with the glass fiber grids for the seams.
2. Examination of the building showed that the structural condition of the outer walls of the building is in satisfactory condition. It is proposed to insulate the walls of a building and to install the outside cladding layer.
3. The building examination showed that the plinth structure is in satisfactory condition. It is proposed to insulate the plinth construction and to install the outside cladding layer.
4. It is recommended to replace the windows and the doors.

Fig. 2. The heat flow laboratory equipment measuring the external partition

All the problems listed above are caused by low thermal resistance of the floor, walls, roof, windows, doors, including improper ventilation and uneconomic solutions in the building, and the other reasons.

2. The heat transfer coefficient indicator setting

All the audit parameters of the partition structures are set according to the actual measurements and using the following methods.

The parameters of the heat transfer coefficient, thermal conductivity of the partition structures, surface temperature, indoor and outdoor air temperature, and other microclimate parameters are measured using the measuring devices of the Ahlborn MESS- und Regelungstechnic GmbH (Germany) manufacturer (Fig. 2) that consist of:

– ALMEMO 2890-9 data logger with the measurement data memory;
– FQA018CSI (ALMEMO®) model for the heat flow measurements of the thermo plates' couples;
– FHA646-E1 (ALMEMO®) model sensors and probes for the temperature and relative humidity measurement;
– FHA646 (ALMEMO®) model of the air temperature probe;
– FVA605-TA10 (ALMEMO®) thermo manometer model;
– FY A600-CO 2 H (ALMEMO®) CO2 model for the gas measuring probe.

Thermal transmission coefficient of the external partitions identification methodology is: heat transfer coefficient U of the external partitions is defined by measuring the heat flow q; the indoor air temperature θ_i and the outside air temperature θ_e using formula:

$$U = q/(\theta_i - \theta_e), \text{ W/m}^2\text{K}, \quad (1)$$

where: q – is the average of the measured heat flows through the external walls; W / MC; θ_i – the average indoor air temperature; °C; θ_e – the average outside air temperature; °C.

Special laboratory devices with autonomous management software were originated for these investigations. For the accuracy of the study the heat flow was measured at 3 different spots of the same external partition at the same time. Heat flow and temperature were measured every 30 minutes around the clock. The ALMEMO® 2890-9 data memory results of measurements were computer scanned and the graphs drawn (Fig. 3), and the average heat transfer coefficient values calculated.

The Vaidotai st. EC post partition thermal transmission coefficient test results show that the 510 mm thick outer wall heat transfer coefficient U_s = 1.30 W / m^{2}K, (R = 0.77 m$^2 \cdot$ K/W). This factor was set of the north-west edge of the building room No.1-28 room measurements. This wall is on the high north-west side and it is mostly damaged. It follows, that the heat transfer coefficient of the Vaidotai st. EC external walls and roof is too small and does not meet the technical requirements of construction of regulations of Lithuania. It is recommended for the external walls and roof to be additionally insulate.

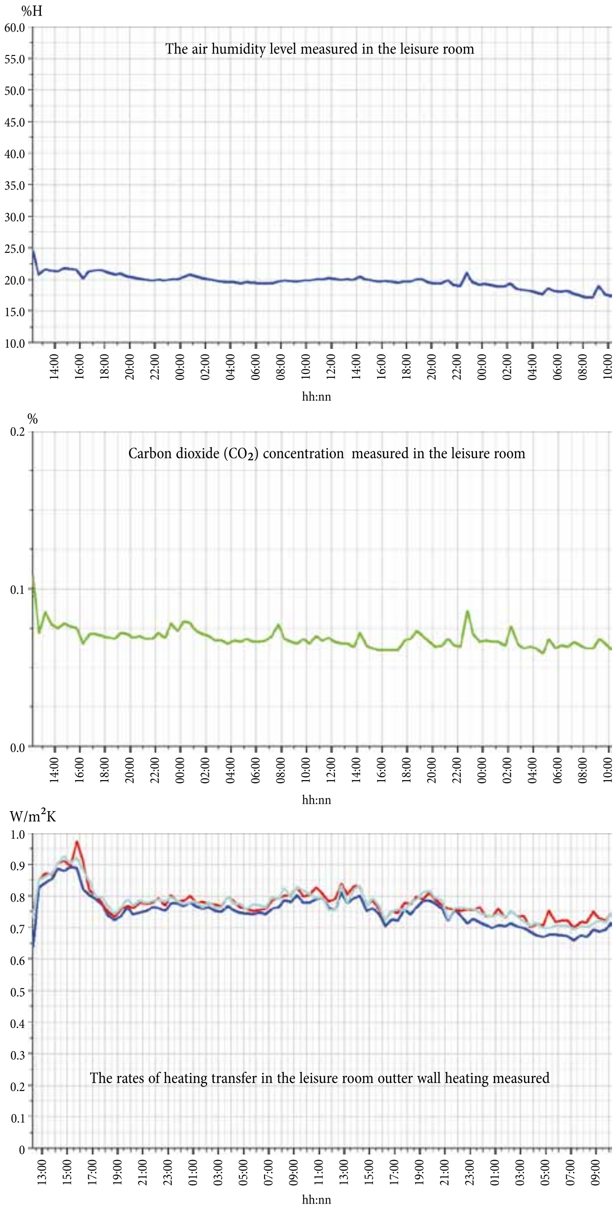

Fig. 3. Relative humidity, CO_2 concentration, external wall surface temperature measurements

3. The estimate of experimental research

Certain techniques must be applied and basic decision model (as it is shown in Fig. 4) must be created in order for the Vaidotai st. EC modernization benefit issue to be rationally formulated and solved and the best decisions made.

Foremost, the model identifies the options of insulation of plinths, walls and roof, and the combination variants.

The best modernization alternatives are selected out of all the chosen alternatives before resolving the Vaidotai st. EC checkpoint modernization task.

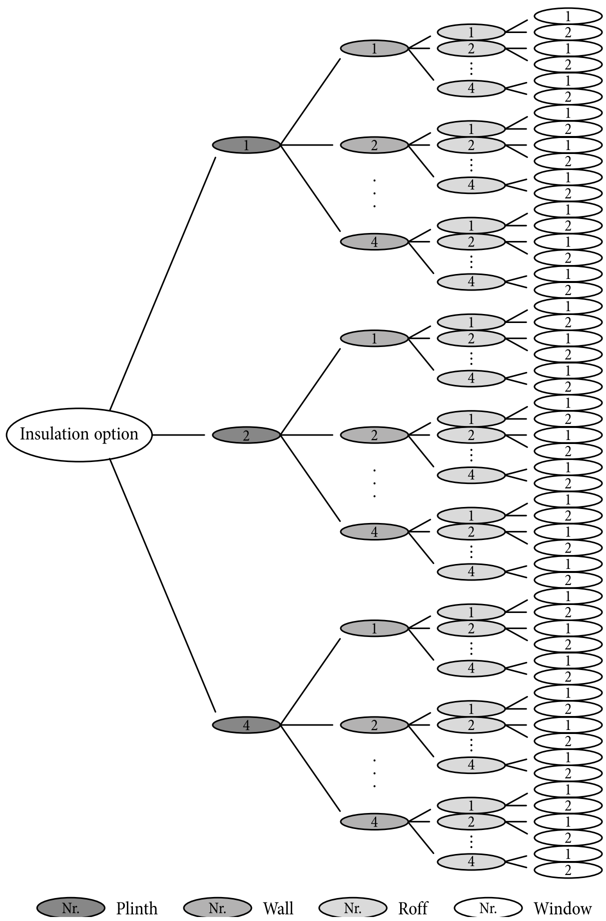

Fig. 4. Decision tree

Therefore, the following building parts are being analyzed: the plinth part, external walls, and roof. Required thermal conductivity *U* of the construction:

Walls $U = 0.10–0.15$ W/(m²K);
Roof $U = 0.09–0.12$ W/(m²K);

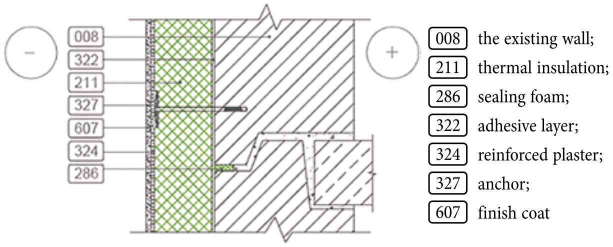

Fig. 5. Walls alternative details

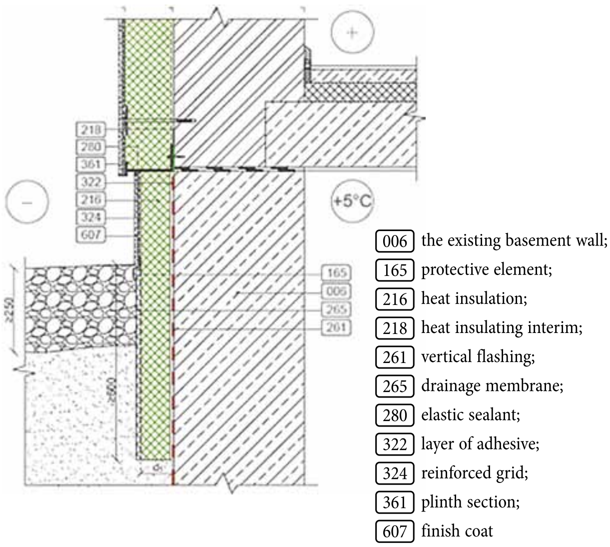

Fig. 6. Plinth alternative details

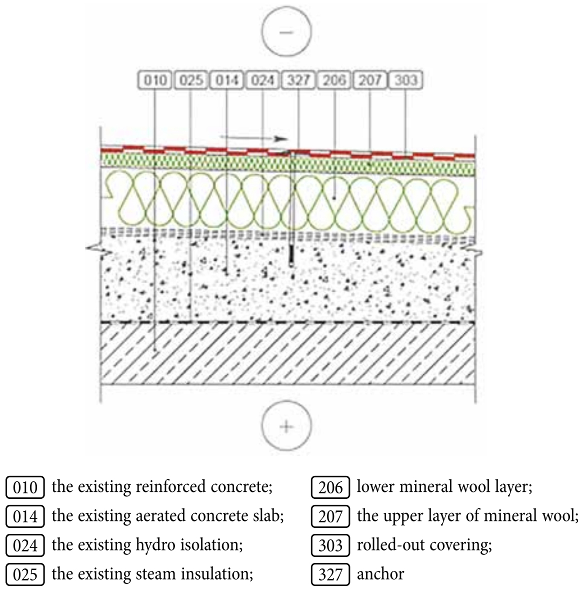

Fig. 7. Roof alternative details

Plinth $U = 0.12–0.18$ W/(m²K);
Windows $U = 0.70$ W/(m²K).

Optional selected heating type is being selected for each building part alternative by identifying the construction type materials, specifying their technical data (shown in Figs 5, 6, 7).

The fallowing indicators are selected during the Vaidotai st. EC post examination of plinth, exterior walls, and roof:

- heat transfer factor *U*, W / m²K;
- modernization costs, Eur;
- projected lifetime, years;
- scores of possibility to carry out construction work, regardless of seasonality;
- annual savings MWh / m² / year;
- simple payback, years;
- operating care complexity, scores.

The description and the method determining the heat transfer coefficient are given in Chapter 3.

Lifetime indicator exercises description. This rate is determined by the projected warranty period of used instruments. This forecasted period depends on maintenance and use of the building for its intended purpose. This is a maximized quantitative indicator.

The feasibility indicator's description. This is a qualitative indicator measured on a scale from 1 to 6. Present construction work complexity depends on the season. The points of the capacity to carry out the construction work, regardless of the season, are:

- 1–2 points – work that cannot be carried out at the certain season of the year;
- 3–4 points – when the seasonality can be taken partially;
- 5–6 points – fully seasonal depending.

Annual savings rate. Some energy savings are expected after modernization when the thermal characteristics of the building improve. Heat loss through the partials, heating costs, and amount of required heat is reduced because of the outer envelope insulation. So the annual energy savings MWh / m² are set. This indicator is quantitative and maximized.

Simple payback time rate. Energy-savings, modernization measures and required investment ratings are presented. Comprehensive economic and technical efficiency analyses are carried out for each measure. Simple and real payback and savings of energy costs are calculated in order to evaluate the energy saving measures for economic efficiency.

Simple payback time (PAL – quantitative indicator and it is minimized) of the planned investment for energy saving measures is determined by the following formula:

$$PAL - I / S, \qquad (2)$$

where: *PAL* – years; *I* – planned investments, EUR; *S* – planned annual savings of installing energy conservation measures, Eur / year.

Operating care rate of complexity determination. This is a qualitative indicator that is measured on a scale from 1 to 6. Each alternative is assessed by the complexity of operation maintenance level as each modernization option has some complexity issues of the maintenance. Operating care difficulty scoring is classified as:

- 1–2 points – difficult to maintain;
- 3–4 points – less difficul to maintain;
- 5–6 points – easy to perform maintenance.

Purpose change indicator. This is a qualitative indicator measured on a scale from 1 to 6. Alternatives are evaluated in terms of how easy it is to replace the purpose of the building. Purpose change options points:

- 1–2 points – complicated purpose change;
- 3–4 points – less complicated purpose change;
- 5–6 points – simple purpose change.

The initial data tables are compiled for each of the building components after selecting the Vaidotai st. EC modernization indicators and alternatives (see Tables 1–3).

4. Materiality determination of indicators

Each purpose is expressed by indicators. Indicators show our objectives and are subject to change depending on the objectives pursued. Only the most efficient

Table 1. Plinth modernization versions

Plinth modernization alternatives	Plinth modernization indicators						
	Thermal conductivity ratio *U*, W/m²K	Modernization expenses, Eur	The forecasted life-cycle of the measure, years	Ability to carry out construction work, regardless of seasonality, points	Annual savings, MWh/m²/y.	Simple payback time, *y*.	Thickness of the construction, mm
Plinth 1 Plinth (95.3 m′) 800 mm depths and 130 mm thickness polystyrene foam EPS 100 insulation Finishing tiles Newly installed paving around the building	0.18	31611	30	2	3	12	600
Plinth 2 Plinth (95.3 m′) 800 mm depths and 160 mm thickness polystyrene foam EPS 100 insulation The foam is hydro insulating plastered Newly installed paving around the building	0.16	32485	25	2	3.66	12	630
Plinth 3 Plinth (95.3 m′) 800 mm depths and 200 mm thickness polystyrene foam EPS 100 insulation with a 600 mm injection into the ground The above ground foam covered with a decorative plate and the underground foam covered with a papillae membrane Newly installed paving around the building	0.14	33650	27	6	3.78	15	670
Plinth 4 Plinth (95.3 m′) 600 mm depths and 250 mm thickness extruded polystyrene foam EPS 80 insulation The above ground foam covered with a thin plaster and the underground foam covered with a papillae membrane Newly installed paving around the building	0.12	35106	25	2	3.89	14	720
Minimized/maximized	min	min	max	max	max	min	max
Significance, *q*	0.121	0.254	0.151	0.0461	0.173	0.175	0.0804

Table 2. Walls modernization versions

Walls modernization alternatives	Walls modernization indicators						
	Thermal conductivity ratio U, W/m^{2}K	Modernization expenses, Eur	The forecasted life-cycle of the measure, years	Ability to carry out construction work, regardless of seasonality, points	Annual savings, MWh/m2/y.	Simple payback time, y.	Thickness of the construction, mm
Wall 1 Wall (1655 m^2) 180 mm thickness polystyrene foam EPS 70F insulation and thin plastering	0.15	361 508	25	3	58.8	12	690
Wall 2 Wall (1655 m^2) 200 mm thickness polystyrene foam EPS 70F (NEOPORAS)insulation and thin plastering	0.14	369 985	26	4	59.75	12	710
Wall 3 Wall (1655 m^2) 240 mm stone wool insulation, The windward stone wool of 30 mm 20 mm ventilation gap 10 mm font panel	0.11	424 520	27	6	62.59	15	780
Wall 4 Wall (1655 m^2) 310 mm stone wool insulation The stone wool fastened using glue and pins The reinforcing mesh is used Thin plaster layer is plastered	0.10	489 439	25	3	63.54	13	820
Minimized/maximized	min	min	max	max	max	min	max
Significance, *q*	0.140	0.245	0.136	0.0468	0.162	0.172	0.0976

Table 3. Roof modernization versions

Roof modernization alternatives	Roof modernization indicators						
	Thermal conductivity ratio *U*, W/m^{2}K	Modernization expenses, Eur	Thermal conductivity ratio *U*, W/m^{2}K	Ability to carry out construction work, regardless of seasonality, points	Thermal conductivity ratio *U*, W/m^{2}K	Simple payback time, *y*	Thermal conductivity ratio *U*, W/m^{2}K
1	2	3	4	5	6	7	8
Roof 1 The old roller coating is being removed and the existing heat-insulation materials are adjusted. The bottom layer of the 270 mm thick polystyrene foam EPS 80 is paved. The upper 30 mm thick hard mineral wool ROS 30 board is paved and the 2 layer roller waterproofing coating is fused (Area 424 m^2) The parapets are tinned, ventilation ducts insulated	0.12	108 802	25	6	33.05	17	520
Roof 2 The old roller coating is being removed and the existing heat-insulation materials are adjusted The bottom layer of the 300 mm thick polystyrene foam EPS 80 is paved The upper 30 mm thick hard mineral wool ROS 30 board is paved and the 2 layer roller waterproofing coating is fused (Area 424 m^2) The parapets are tinned, ventilation ducts insulated	0.11	113 971	25	5	33.3	17	540

End of Table 3

1	2	3	4	5	6	7	8
Roof 3 The old roller coating is being removed and the existing heat-insulation materials are adjusted The bottom layer of the 340 mm thick mineral foam ROS 30 is paved The upper 30 mm thick hard mineral wool ROS 50 board is paved and the 2 layer roller waterproofing coating is fused (Area 424 m^2) The parapets are tinned, ventilation ducts insulated	0.10	119193	25	4	33.54	22	590
Roof 4 The old roller coating is being removed and the existing heat-insulation materials are adjusted The bottom layer of the 380 mm thick polystyrene foam EPS 80 is paved The upper 20 mm thick hard mineral wool ROS 30 board is paved and the 2 layer roller waterproofing coating is fused (Area 424 m^2) The parapets are tinned, ventilation ducts insulated.	0.09	123417	25	6	33.78	20	620
Minimized/maximized	min	min	max	max	max	min	max
Significance, q	0.136	0.260	0.132	0.0485	0.155	0.216	0.052

variants which have a certain purpose are analysed. Every purpose is shown by indexes. They can be changed according to the objectives we seek.

Constructions are selected in the context of the experts' survey data. Significance of the scale is used to determine the priority. The table, formed in accordance to the completed questionnaires of experts' opinions, is being filled with average values of experts' indicators.

Group assessment may be considered to be quite reliable only when the opinions of surveyed experts are compatible.

Criteria ranks are set in accordance with each survey. The multipurpose decision-making methods TOPSIS, SAW, and COPRAS are applied.

The alternative selection issue, related to the various and contradictory indicators, emerges using the multipurpose decision method (Multiple Attribute Decision Making, MADM).

Subjective and objective analysis has many advantages and disadvantages. Significances, set in subjective point of view, indicate the subjective personal decisions that lead to the rankings of the problem alternatives. Objective decision rankings are determined by mathematical methods based on subjective information.

Technique for options' priority determination is used when the optimal alternative is at the minimum distance from ideal solution and at the greatest distance from worst solution. This method is called Technique for Order Preference by similarity to Ideal Solution (TOPSIS).

Best known Simple Additive Weighting method (SAW) is one of the simplest and most widely applied. Source data – decision matrix and significance sizes. Decision matrix cannot have non-numeric values.

The Synthesis of Multiple Attribute Decisions by three methods (SyMAD-3) is used based on previously described multi-level decision-analysis model. This method is designed to integrate multi-joint decision into a single solution. To increase the reliability of the decision three quantitative measurements based on decision support methods are applied. Following methods are used for the presented algorithm of the method: integrated materiality determination of efficiency and multipurpose solution making, SAW (MacCrimmon 1968), TOPSIS (Hwang, Yoon 1981), and COPRAS (Zavadskas *et al.* 2004; Kaklauskas *et al.* 2005) methods.

At the beginning of work decision stage setting is performed, efficiency indicators system for each step of the decision tree *k (k = 1, 2... c)* is formed. Each decision stage decision tabulation, here *mk - k* is a number of tables of each decision stage. Using these tables decision matrix is formed:

$$X_t = [x_{ij}^t], (t = \overline{1, m_k}; i = \overline{1, a_t}, j = \overline{1, n_k}); \quad (3)$$

where: t – decision table number, a_t – t – the number of alternatives of the certain table, n_k – k – the number of efficiency indicators of the certain stage.

Decision matrix x_{ij} is developed in such a shape:

$$[x_{ij}] = \begin{array}{c} \\ a_1 \\ a_2 \\ \dots \\ a_m \end{array} \begin{array}{c} \begin{matrix} X_1 & X_2 & \dots & X_n \end{matrix} \\ \begin{bmatrix} x_{11} & x_{21} & \dots & x_{1n} \\ x_{21} & x_{22} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots \\ x_{m1} & x_{m2} & \dots & x_{mn} \end{bmatrix} \end{array}, \quad (4)$$

where a_1–a_m – comparative options ($i = 1, m$);

X_1–X_n – performance indicators ($j = 1, n$);

x_{11}–x_{mn} – performance indicator values.

Purpose of the method is a synthesis of multi-purpose solutions using three multipurpose solving methods. Multistage solution tree model depicts the structure of solutions that belong to different tiers analysis.

Table 4. Table of alternative combinations

				Rankings by		
Alter-native combi-nations	Plinth	Wall	Roof	TOP-SIS	SAW	COP-RAS
B[1]	plinth 1	wall 1	roof 1	33	34	35
B[2]	plinth 1	wall 1	roof 2	27	29	28
B[3]	plinth l	wall 1	roof 3	61	61	61
B[4]	plinth 1	wall 1	roof 4	46	48	47
B[5]	plinth 1	wall 2	roof 1	28	24	24
B[6]	plinth 1	wall 2	roof 2	24	21	21
B[38]	plinth 3	wall 2	roof 2	1	1	1
B[39]	plinth 3	wall 2	roof 3	47	37	41
B[40]	plinth 3	wall 2	roof 4	15	8	7
B[41]	plinth 3	wall 3	roof 1	5	4	5
B[42]	plinth 3	wall 3	roof 2	3	3	3
B[43]	plinth 3	wall 3	roof 3	49	43	44
B[44]	plinth 3	wall 3	roof 4	20	12	13
B[45]	plinth 3	wall 4	roof 1	16	18	14
B[46]	plinth 3	wall 4	roof 2	12	13	10
B[47]	plinth 3	wall 4	roof 3	52	54	53
B[48]	plinth 3	wall 4	roof 4	34	33	32
B[49]	plinth 4	wall 1	roof 1	13	20	20
B[50]	plinth 4	wall 1	roof 2	10	16	15
B[51]	plinth 4	wall 1	roof 3	57	56	56

4.1. The addressing of the Vaidotai st. EC checkpoint modernization

Multilevel decision model is being established, taking into account the insulation options of plinth, walls, and roof. Four plinth, four walls and four roof insulation options are analyzed (Table 4).

Decision on which plinth, wall and roof insulation method would be most rational, assessing them in complex,

has to be made; decision tree model is formed by the evaluation of the complex alternative combinations to be carried out (see Fig. 8, which shows the rational alternative combination).

4.2. Decision search tree diagram of the insulation version

Equal set of modernization indicators is formed for each stage of modernization. Each plinth, wall and roof alternative was assessed according to 7 indicators of modernization.

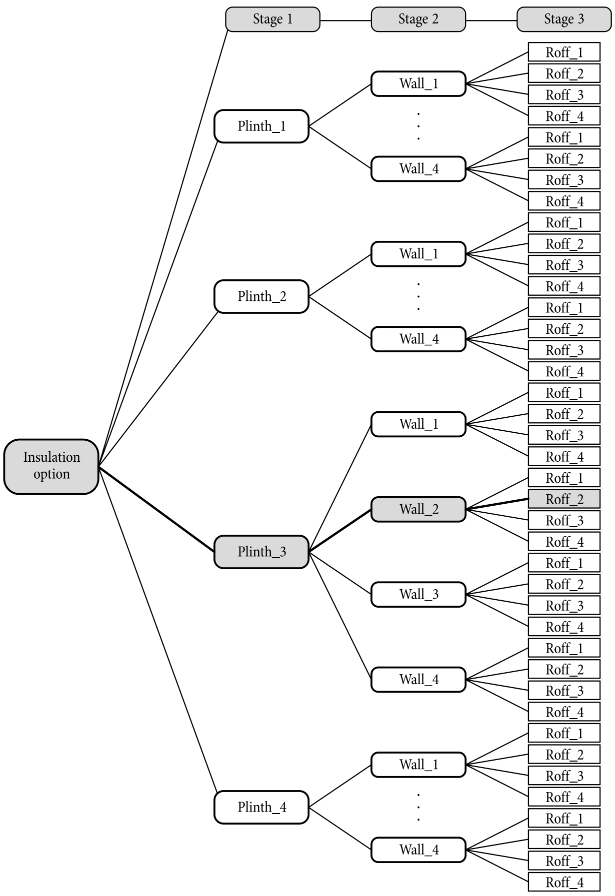

Fig. 8. Alternative combinations decision tree

5. BIM technology

Benefits identified during the construction phase include less rework, reduction in requests for information and change orders, customer satisfaction through visualization, improved productivity in phasing and scheduling, faster and more effective construction management with easier information exchange, accurate cost estimation, and visualizing safety analysis (Hardin 2009; Elbeltagi, Dawood 2010; Eastman *et al.* 2011; Azhar 2011; Hartmann *et al.* 2012; Migilinskas *et al.* 2013). During operation phase this technology includes control of facilities management progress, integrated life-cycle data, rapid and accurate information of updating and changing activities, and more effective facility management with easier information exchange (Popov *et al.* 2010; Eastman *et al.* 2011; Hardin 2009; Klein *et al.* 2012).

This system gives ability to model changes in the structure of the building, re-design building engineering equipment, to renew the information which then satisfies the exploitation requirements, monitor the current status of the building and take timely action for the restoration, competently operate existing facilities. Both technologically and economically BIM is an additional model for a project's engineering information database, storing all the architectural designs with geometric information and the corresponding technical information for all the works (Ding *et al.* 2012).

BIM construction standardization contains not only geometry of walls, columns, beams, doors, windows, and other building components, but also contains specific attributes for each object, such as material type, material properties and vendor.

BIM methodology can be used to make project simulations like Virtual Project Development (VPD). This helps to evaluate an effectiveness of Project Management implementation in the 5D environment (Popov *et al.* 2010). Updating the as-built schedule during the construction phase is generally recognized as the most critical strategy for successful Schedule (Tserng *et al.* 2014) and cash flow management.

With selected types of structures the design works task can be formulated.

The benefits that people can gain from BIM are based on the energy analysis which offers better data and possibility to reuse the existing data more efficiently. It also suggests the ability to use dynamic energy simulation instead of static methods and use the whole building spatial simulation instead of zone based approach. Although, the major benefit that BIM offers is that it gives the possibility to get the approval of energy performance in the whole building life cycle. From the project experiences it is obvious that BIM also is needed to revise management by comparing different revisions, making visualisations of thermal performances and getting architect model validations so as to analyse their development.

Conclusions

- The examination and comprehensive analysis of the object found that: relative humidity of the air is low, which in accordance with HN42: 2012 does not meet public indoor comfort conditions requirements and increases the costs of building heating. The high heat loss through the walls, roof, plinth, and other constructions is detected, high heating costs, too low room temperature, too low relative humidity, poor ventilation, and other problems are indicated.
- Significances of selected alternative were determined by the pair comparison method interviewing 12 experts. The results were systematized and used for further calculations.
- Studies and calculations were made using the methods of SAW, TOPSIS, COPRAS and SyMAD-3. The best combination of building modernization alternatives were set and the rest were aligned in accordance of their beneficence.
- The best combination of the alternatives was set in accordance with the calculations made: Plinth 3 – Wall 2 – Roof – 2.
- It is proposed to use the best combination of the alternatives based on the calculations as in that way the best thermal results, lowest cost, and most cost savings for heating during the cold season can be achieved.
- BIM model which describes the components is prepared for building modernization.
- BIM technology allows to use simulation of visualization and energy calculation in building model.

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