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ENERGY AUDIT OF HISTORICAL MANOR „STUDZIENKA“

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Energy audit of historical manor „Studzienka

The building is described as a manor dated between XVII and XVIII century which belonged to Albrecht Bischoff as a summer residency with a garden. In 1973 the building was entered into the registry of monuments and has a status of a protected building

The purpose of energy audit for the building (Stage I):

- to examine existing energy efficiency for all elements of the building, including: walls, floor, doors, windows and roof
- To examine existing heating appliances, hot water and ventilation systems for the building
- To suggest methods and materials which gives satisfactory thermal performance of renovated building according to renovation project

	Building elements	**temperature conditions [□C]**	**U-value [W/m2K]**				**Difference [%]**			
			Present		**required WT2008, dwelling**	**required WT2008, public building**	**dwelling**		**public buildings**	
			moderate moisture conditions	**high moisture conditions**			**moderate moisture conditions**	**high moisture conditions**	**moderate moisture conditions**	**high moisture conditions**
	Walls (external):									
	ground floor 1 (thickness 47-50 cm)	>16□C	1,36	1.54	0.35	0.35	**289**	**340**	**289**	**340**
		≤16□C			0.92	0.75	**48**	**67**	**81**	**105**
	ground floor 2 (thickness 59-68 cm)	>16□C	1.12	1.27	0.35	0.35	**220**	**263**	**220**	**263**
		≤16□C			0.92	0.75	**22**	**38**	**49**	**69**
	first floor (thickness 30-35 cm)	>16□C	1,79	1,99	0,35	0.35	**411**	**469**	**411**	**469**
		≤16□C			0,92	0.75	**95**	**116**	**139**	**165**
	Floors									
	Floors over basement 1	basement not heated	1,12	1,28	0,52	0,52	**115**	**146**	**115**	**146**
	Floors over basement 2	basement not heated	1,04	1,2	0,52	0,52	**100**	**131**	**100**	**131**
	Floors over ground	Basement not heated	0,41	0,41	not required	not required	/	/	/	/
	Roof	>16□C	2,81	3,08	0,29	0,29	**869**	**962**	**869**	**962**
		8-16□C	2,81	3,08	0,58	0,58	**384**	**431**	**384**	**431**
	Windows	>16□C (climate zone I)	3,50	3,50	1,80	1,80	**94**	**94**	**94**	**94**
		8-16□C	3,50	3,50	N/A	2,60	N/A	N/A	**35**	**35**
	Doors		3,00	3,00	2,6	2,6	**15**	**15**	**15**	**15**

SUMMERY AND CONCLUSIONS

1. The analysis have proved that the technical solution proposed for the building (construction design from 2005) needs to be verified because it is unsatisfying from the perspective of energy saving and thermal insulation and, if used, the proposal will result in high costs of heating.
   According to the calculation, heating demand of the building (heating and hot water) and the heating energy costs for the building as designed shall be following:

1	*Calculated demand for thermal power*	*81,64 kW*
2	*Demand for thermal energy*	*769,47 GJ/year*
3	*Costs annually*	*54 752 PLN/year*

2. The proposed design hasn't sufficiently used all available opportunities for improvement of walls' thermal insulations and for receiving high efficiency of the heating system.
   Although the building is historical, it is highly recommended to seek (as far as possible) the best available energy quality and to minimize maintenance costs for the future user.

3. The technology of the additional thermal insulation of the external walls proposed in the construction design (insulation from the inside with YTONG PP2/0,4 blocks) doesn't protect the walls against condensation.
   Although the walls have been properly designed against mildew development (no surface condensation), there will still be condensation between the layers of insulation with the existing wall (the humidity is expected to evaporate during summer time).
   It is technically permissible for the steam to condensate inside the wall barrier during winter, provided that the wall's structure will enable evaporation during summer time with no resulting in deterioration of the building materials.
   Although it is technically permissible, this case is special because the building has historical value, it is old and the technical condition of the existing walls is not satisfying.
   The inter-layer condensation may give risk of further deterioration of the construction materials in the external walls on the first and second floor and in this case the risk should be eliminated by re-design of the wall.

4. This paper presents suggestions for verification of the present proposal for design and shows opportunities how to significantly improve the thermal insulation of the walls and how to increase heating efficiency of the building.
   The calculation model developed for the building considers the proposed improvements of the building structure and of the thermal sources and installation.

   The detailed analysis and description of the proposed improvements have been covered in Chapters 3-6 of the paper.

Materials recommended for thermo modernization

External walls to be insulated with the following systems:

- Eurothane G (5-6 cm), or
- YTONG MULTIPOR blocks (10-12 cm)

Floor over basement to be insulated from the basement side with:

- Spray polyurethane foam IZOPIANOL 03/35 N

Roof insulation:

- Mineral wool

Windows:

- U-value 1.90 W/m^{2}K at wall level
- U-value 1.80 W/m^{2}K at roof level

Doors:

- U-value 2.60 W/m^{2}K

The proposed improvements will give significant reduction in thermal demand of the building and will result in cost savings.
According to the calculation, heating demand of the building (heating and hot water) and the heating energy costs for the building after the proposed improvements shall be following:

1	*Calculated demand for thermal power*	*73,97 kW*
2	*Demand for thermal energy*	*584,07 GJ/year*
3	*Costs annually*	*38 746 PLN/year*

The proposed improvements will give the following energy and economic results, compared to the solutions proposed in the current construction design:

1	*Savings of thermal energy*	*185,40 GJ/year*
		24,09 %
2	*Savings of heating costs and of hot water*	*16 005 PLN/year*
		29,23 %

5. The paper provides analysis of the currently used thermal insulation of external walls in historical buildings: climate boards, IQ-THERM, EUROTHANE and Ytong Multipor blocks. The analysis was made from the perspective of additional internal thermal insulation of the external walls on the first and second floor of the building.
The comprehensive analysis has covered both the opportunities for improvement of the walls' thermal insulation and specific limitations connected with the need to protect the walls against condensation (a detailed thermal and humidity analysis has been made for each calculation option).

The calculations have shown that the best recommended technical solution for the building is the EUROTHANE G technology which will significantly improve thermal insulation of the walls (very low heat transfer coefficient) and it also meets the thermal insulation requirements of the technical conditions and the energy audit criteria. The recommended technology protects against condensation inside the wall (provided the thickness of the insulation material shall be as required).

6. Calculations of the building's energy characteristic and the energy certificates issued for the test purposes have proved that the design made in 2005 doesn't meet the technical condition's requirements because the energy indicator of the received energy characteristic (EP) exceeds by ca 45% the limit and the heat transfer coefficient for the majority of walls exceeds the maximum limit U_{max}.
   If the design is verified and modified in line with the proposed thermal modernisation improvements for the walls and the heating system it will be possible to improve the building's total energy efficiency and to meet the technical requirements applicable for modernised buildings, because the value of the demand for primary energy (EP)will be lower than the limit.

   List of indicators of the building's energy characteristic for the analysed options:

			DESIGN 2005	VERIFICATION 2012
1	*Demand for non-renewable primary energy*	*EP*	*637,4 kWh/(m²year)*	*397,2 kWh/(m²year)*
2	*Comparative (limit) value of the energy characteristic indicator by WT2008*	EP_{WT}	*441,3 kWh/(m²year)*	*441,3 kWh/(m²year)*
3	*WT2008 requirements*			
	Indicator EP ($EP \leq EP_{WT}$)		*not met*	***met***
	Coefficient U for the walls ($U \leq U_{max}$)		*not met*	*not met*
	WT2008 requirements		*not met*	***met***

7. The additional analysis for the option which considered the conservation guidelines from 2010 has shown that a 6% increase of the building's heating demand should be expected and also that the heating annual costs will grow by ca 3100 PLN (5,7%).
   The actual increase of the heating demand and heating costs might be higher because the analysis was based on approximated data and covers only some of the changes covered in the appendix to the construction design from 2012.