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The using feasibility Russian and European software products at thermal calculations

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Abstract. Modern software products for thermal calculations make possible to speed up the design process and to improve the energy efficiency of new and renovated buildings. This article provides a complex evaluation, comparison and analysis of the feasibility of using Russian and foreign programs in thermal calculations.

1 Introduction

One of the main buildings elements that are in contact with the environment is a facade. The primary task of the facade is to protect the building from weather, temperature extremes, drafts, heat loss [1-8]. The economy of energy resources is considered by the developed countries as the major national environmental and economic issue because of energy saving measures higher profitability and environmental safety than increasing energy resources [9-15].

The most effective use of energy resources of the country for the revival and subsequent recovery and provide a decent life for the population declared main goal of the energy strategy of Russia since 1995.

Thermal energy losses depend on the level of thermal protection of external envelope. In all countries there are regulatory requirements for the insulation level of enclosing structures. It depends on the climatic conditions of the country and its state energy saving policy. The norms of energy buildings consumption is constantly are decreasing and the requirements to the insulation level of external envelope are increasing because of constant growth of energy resource prices, the growth of thermal energy tariffs and reduction of stocks of non-renewable hydrocarbons (oil, gas). Thus, one of the most important ways of economy of energy resources is the reduction of heat losses through the building envelope of buildings [16-23]. One of the problems is low awareness of designers about the global experience of design of energy-efficient buildings. Using comprehensive software you can develop optimal conditions for the design of energy efficient buildings, because of engineering solutions are calculated to determine their contribution to the achievement of the overall reduction of energy consumption.

As discussed elsewhere [24-27] optimization of the energy performance of a building is similar to the solution of the equation with several unknowns. To help in its decision we can use a modern program of thermotechnical calculation. This allows you to visualize the wall structure of the building, to calculate various arrangements and to bring them into accordance with the norms and standards – and all this before construction starts.

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Thus, designers can choose the least expensive option for energy upgrading, optimize the energy consumption and other indicators of the building and use technologies that surpass in the speed and cost of traditional approaches for energy modeling and auditing [28, 30].

2 Input data

Design conditions and heat energy parameters of the buildings for the climatic conditions of St. Petersburg adopted according to SNiP 23-01-99*are presented at the table 1.

Table 1. The design conditions.

The characteristics	Symbol parameter	Unit of measure	Value
Design temperature of inside air	t_{int}	°C	20
Design temperature of outdoor air	t_{ext}	°C	-26
The duration of the heating period	z	day/years	220
Heating degree day	D_d	°C· day/years	4796
Mean temperature of outdoor air	t	°C	-1.8

We will consider three types of various exterior structures. Structures of walls and its characteristic are given at the table 2.

Table 2. Structures of walls and its characteristic.

Type of structure	Structures of walls	λ, W/mK	ρ, kg/m3	δ, mm
Type I	Concrete	2.0	2400	500
	Foam polystyrene URSA XPS	0.033	35	120
	Air (ventilated layer)	0.024	0,001	30
	Granite tile	1.5	2600	12
	Brick	0.960	2000	250
Type II	Rock wool facade insulation	0.035	100	150
	Air (ventilated layer)	0.024	0,001	30
	Granite tile	1.5	2600	12
	Light weight concrete	1.3	1800	300
Type III	Polyurethane foam MUSTOVO	0.022	50	200
	Air (ventilated layer)	0.024	0,001	30
	Granite tile	1.5	2600	12

3 Materials and Methods

Two programs, which make thermomechanical calculation of the multilayered enclosure structure, were chosen for the complex analysis.

The program TeReMOK 0.8.5 "Thermomechanical calculation of the multilayered enclosure structure " is based on the requirements and calculation procedures stated in Construction Norms and Regulations 23-02-2003 "Thermal protection of buildings", design and construction specifications 23-101-2004 "Design of thermal protection of buildings" and Construction Norms and Regulations 23-01-99 "Construction climatology".

U-value.net is the english translation of u-wert.net which is a very successful website in Germany. U-value.net is a private website that aims to support you on the planning of your insulation. After entering all layers of a building component into the U-value calculator you will receive information about the expected heat loss, eventual moisture problems and many other things.

3.1 Thermomechanical calculation of the multilayered enclosure structure TeReMOK 0.8.5

After creation of three types of an enclosure structure design, calculation in this program was executed on check on the normalized value of heat transmission resistance.

Let's consider the received results for all types of the construction (table 3):

Table 3. Value of heat transmission resistance for different type of the enclosure structure.

Type of structure	R, $(m^2 \cdot °C)/W$
Type I	5.213
Type II	6.012
Type III	10.787

By results of calculation, it is visible that the enclosure structure with insulation from polyurethane foam has the highest heat protection.

3.2 Thermomechanical calculation of the multilayered enclosure structure U-value.net

According to initial data, let's execute thermal calculation of the three types of multilayered enclosure structure. The following is a report on thermal calculations of the first type of the wall (figures 1-6).

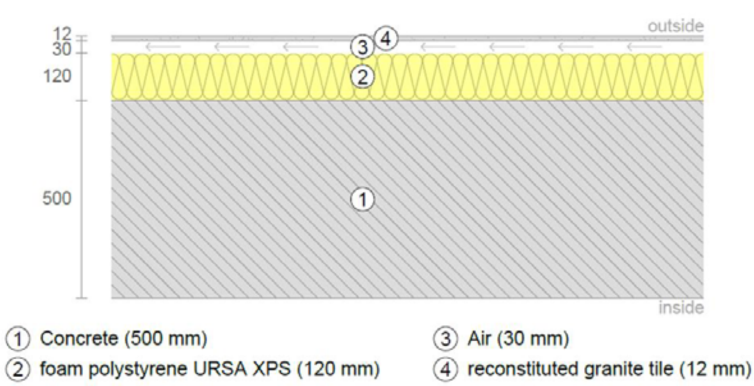

Figure 1. Cross-section of the enclosure structure.

By means of this program, we could receive contribution of different layers to the overall insulation, heat protection schedule, humidity schedule and temperature gradient schedule.

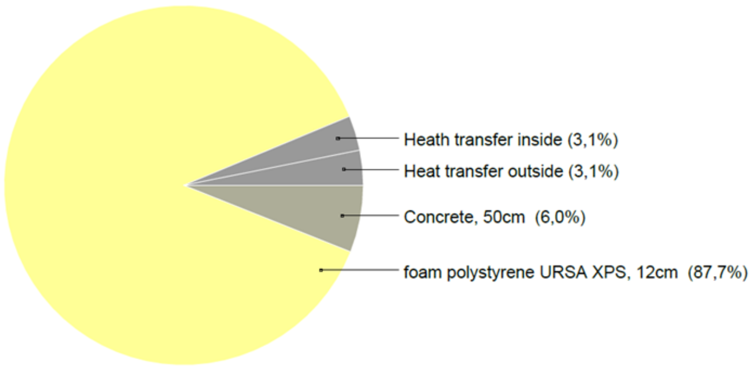

Figure 2. Contribution of different layers to the overall insulation.

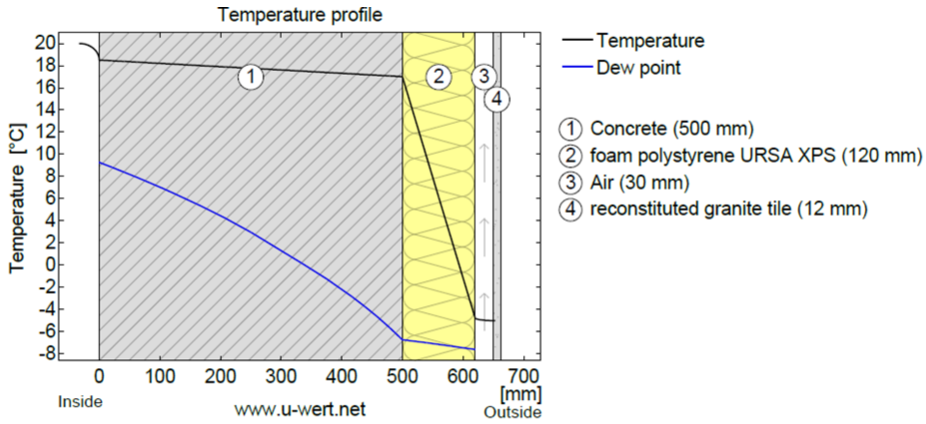

Figure 3. Temperature gradient. Condensing zone.

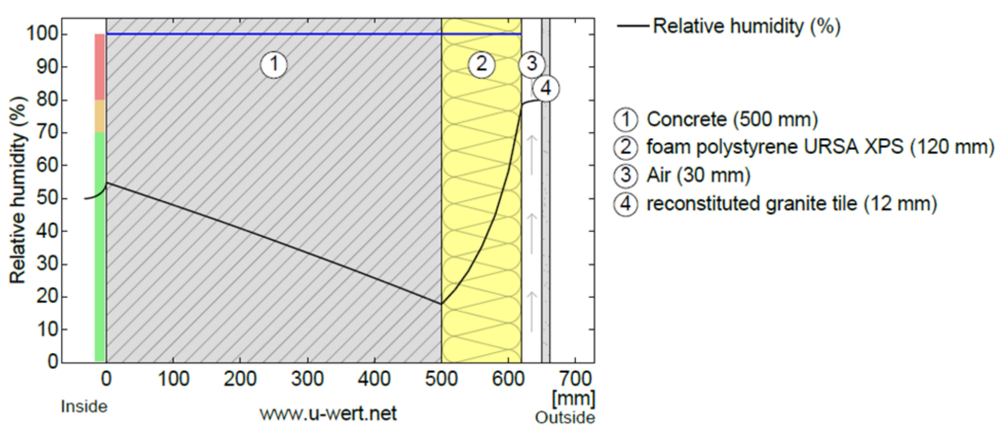

Figure 4. Humidity schedule.

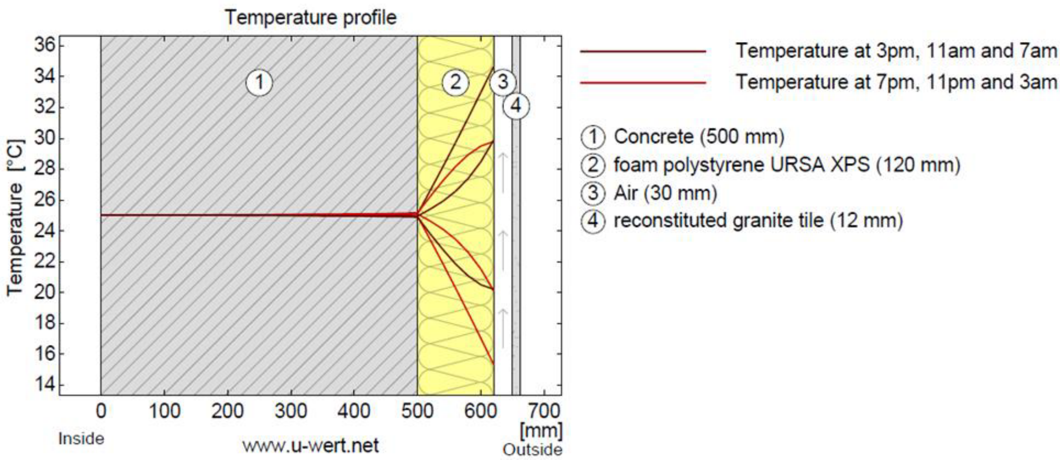

Figure 5. Temperature schedule.

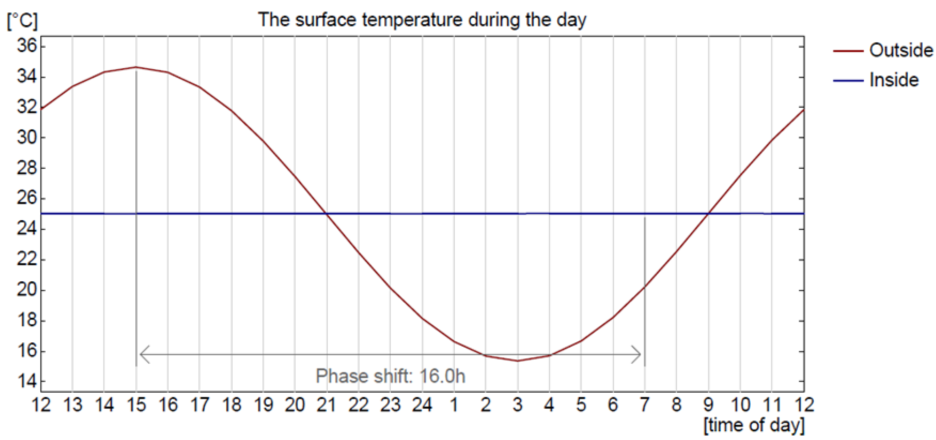

Figure 6. The surface temperature during the day.

The report on thermal calculations of the second type of the wall (figures 7-12).

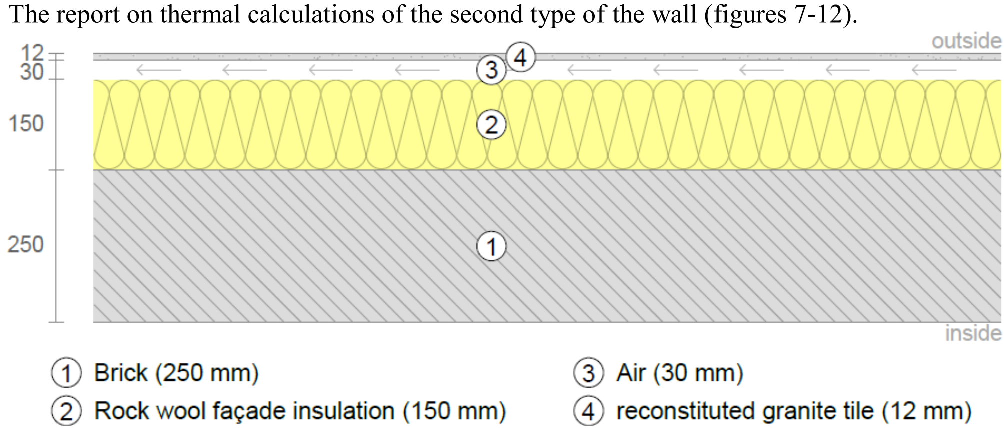

Figure 7. Cross-section of the enclosure structure.

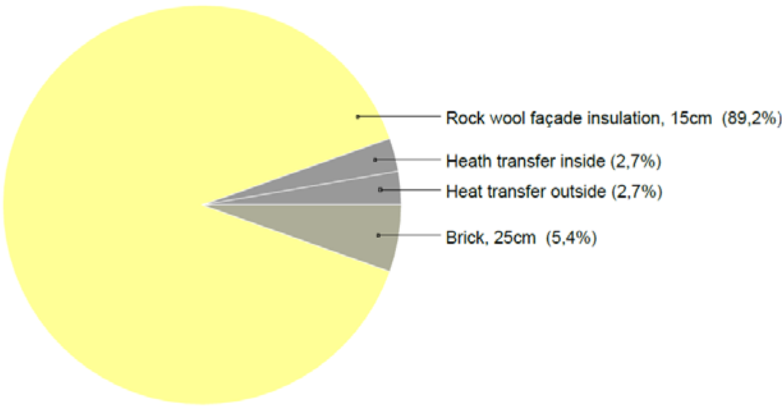

Figure 8. Contribution of different layers to the overall insulation.

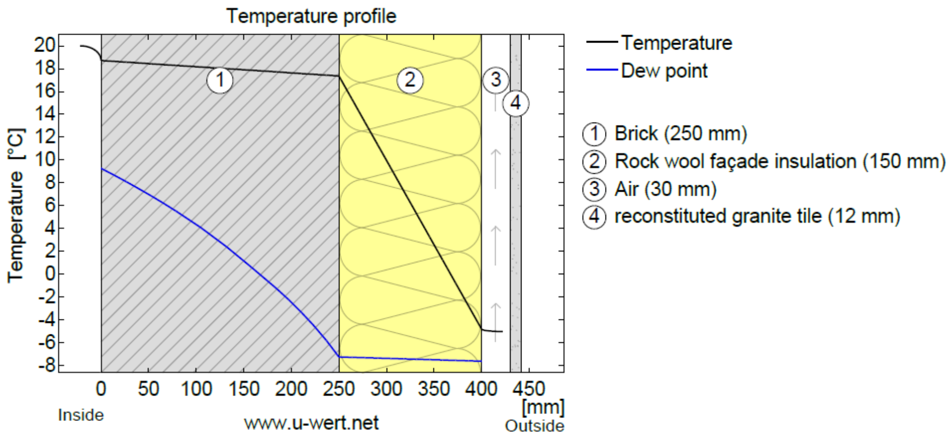

Figure 9. Temperature gradient. Condensing zone.

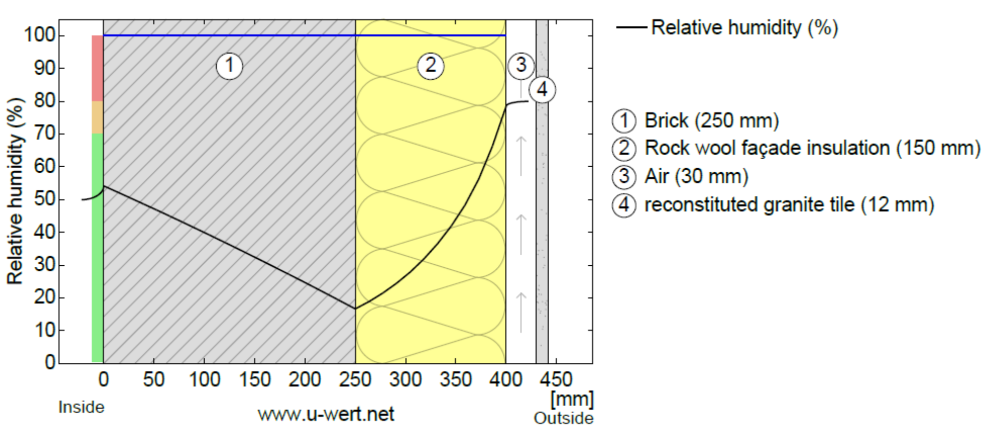

Figure 10. Humidity schedule.

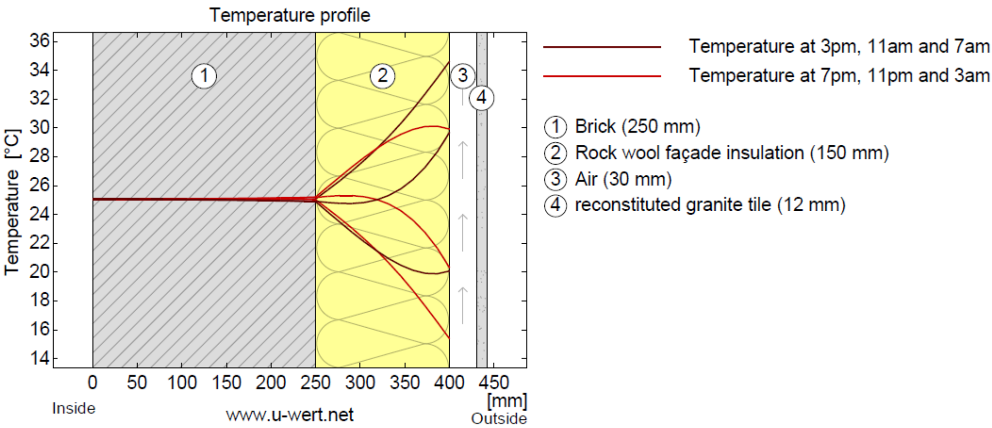

Figure 11. Temperature schedule.

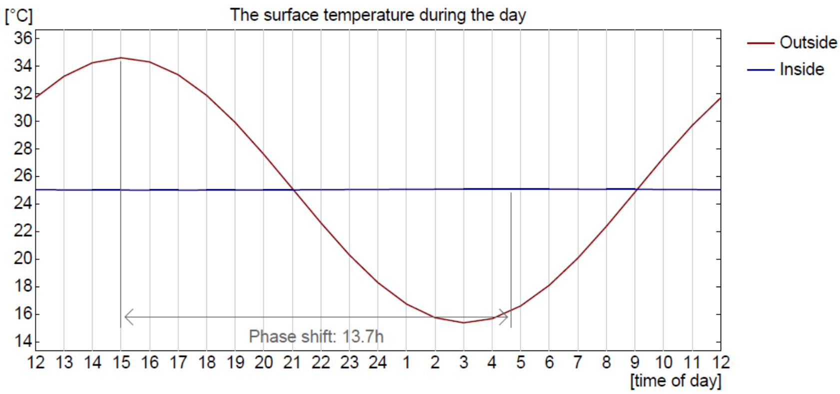

Figure 12. The surface temperature during the day.

The report on thermal calculations of the second type of the wall (figures 13-18).

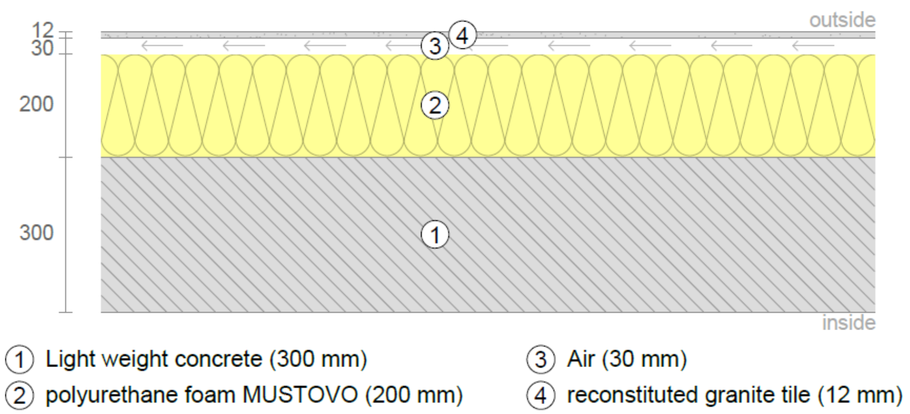

Figure 13. Cross-section of the enclosure structure.

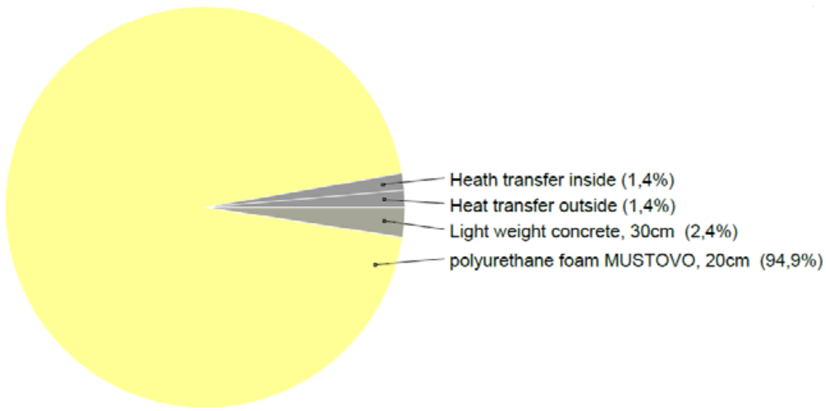

Figure 14. Contribution of different layers to the overall insulation.

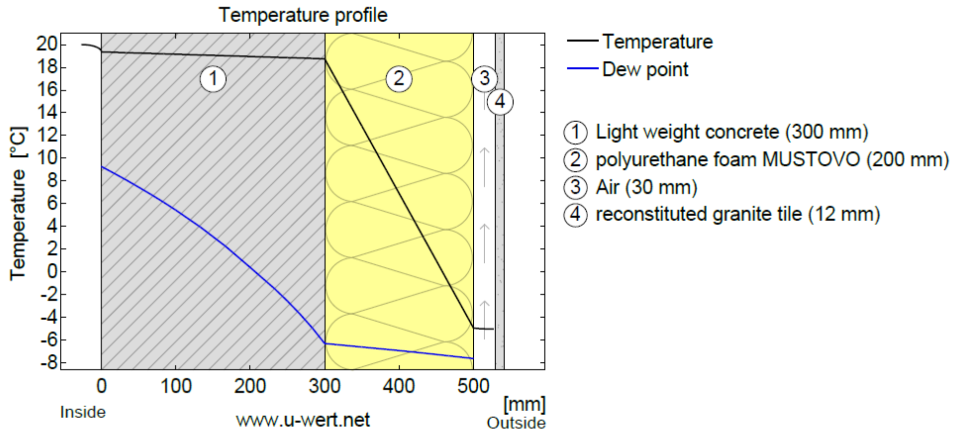

Figure 15. Temperature gradient. Condensing zone.

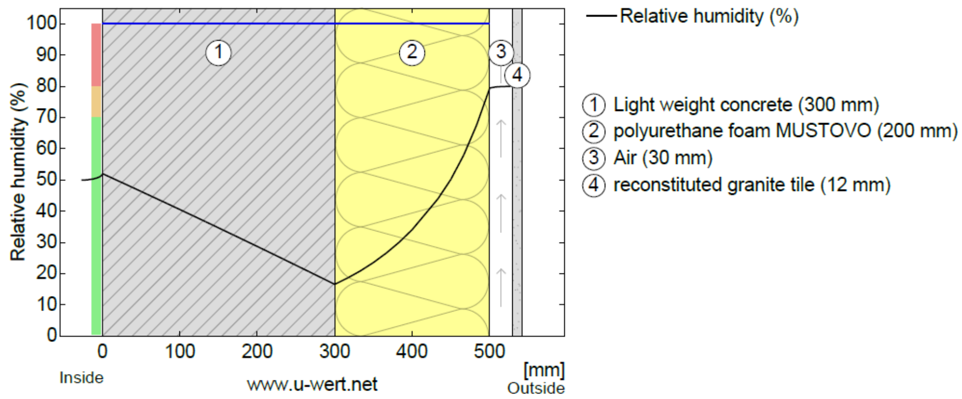

Figure 16. Humidity schedule.

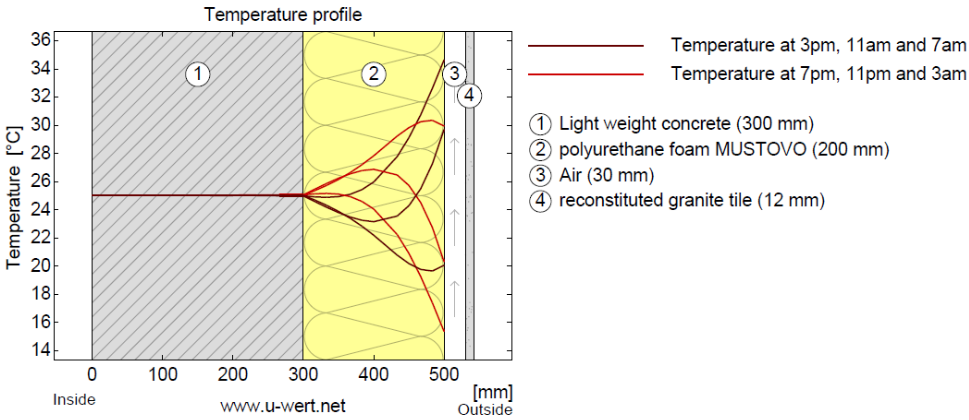

Figure 17. Temperature schedule.

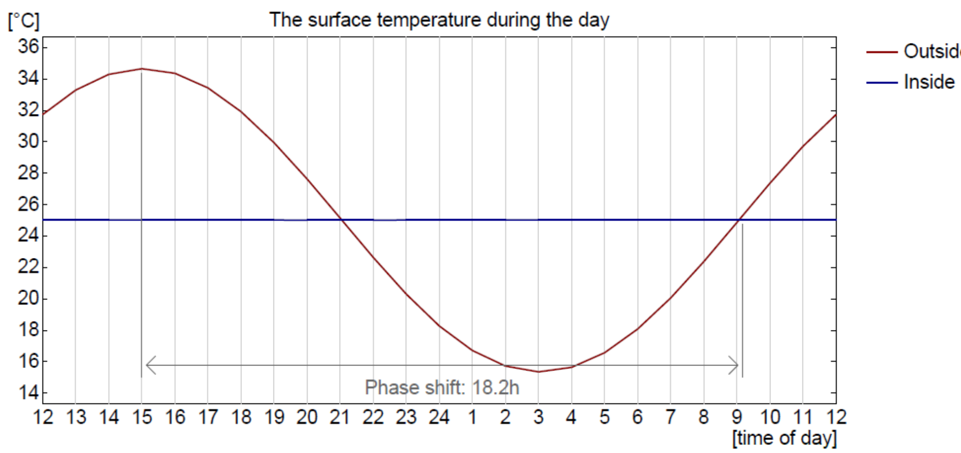

Figure 18. The surface temperature during the day.

4 Results and Discussion

The analyses and estimation of quality attributes for software is presented at table 4-7.

Table 4. Estimation of functionality of software.

TeReMOK	U-wert
Calculation of the demanded thickness of a required layer (a layer with not set thickness)	U-value calculator (graphical
Check on rated value of reduced resistance heat transmission	U-value calculator (tabular)
	Heat demand calculator
	Cross-section of exterior structure
	Diagram of contribution of different layers to the overall insulation
	Temperature gradient / Condensing zone Schedule

	Humidity schedule
	Heat protection schedule
	Possibility of creation of multy-layer cross-section of exterior structure
	Heat losses calculation

Table 5. Estimation of character of the user interface of software.

TeReMOK	**U-wert**
Simple interface	Difficult various interface
Possibility of a choice of the normative document	Without possibility of a choice of the normative document
The minimum quantity of the carried-out functions	A large number of the carried-out functions
The minimum percent of information entered in the on-line mode	A large number of information entered in the on-line mode
Ease of data processing	Ease of data processing
Without possibility of a choice of language (only one)	Possibilities of a choice of language (five languages)
	The minimum efforts on modification for elimination of mistakes
	Possibility of obtaining the report in the PDF-format
	Fast data processing

Table 6. Estimation of complexity of software online use.

TeReMOK	**U-wert**
Registration isn't obligatory	Registration is necessary for obtaining the individual report
Free in use	Free in use

Table 7. Estimation of the correctness of software.

TeReMOK	**U-wert**
There are no failures and mistakes in the program	There are no failures and mistakes in the program
Correctness of results, compliance to the Russian norms of construction	Correctness of results, compliance to the European norms of construction

5 Conclusion

Merits and demerits of each program were revealed according to the carried-out analysis. These modern software products for thermal calculations undoubtedly accelerate process of design and are additional check for the designers. By means of such programs it is possible to choose and calculate very quickly and reliably a energy-efficient construction of the enclosure structure. According to calculations in both programs the third type of a construction of the enclosure structure is the most energy-efficien. Having executed calculations by means of these programs, it is possible to draw a conclusion that on the Russian standards of the requirement to a building thermal protecting very low. Thus the Russian standard documentation requires modernization of regulatory base, development of new normative documents on a thermal protecting of buildings.

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