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Thermo technical calculation of enclosure structure of comprehensive school

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ABSTRACT

The paper presents the results and analysis of the calculation of the reduced total thermal resistance of the external building envelope (walls) for general education schools. The school, which the heater was picked up, is the student's project. This object is designed for 550 pupils, the school has three floors. Article is devoted to the solution of an actual problem — to energy saving and increase of energy efficiency of buildings. Also in the article there is a definition of optimal and profitable width of insulation in a system of hinged ventilated facade. The technical calculations are presented and optimal width of heat-insulating layer is given in this project. The company ISOVER offers ISOVER VENTI heat insulation for walls, which have a line of advantages: the ability to use both single-layer and double-layer insulation system (as the outer layer), is used in all types of buildings without height restrictions, the effective removal of the moisture from the structure due to the high vapor permeability, refers to a group of non-combustible materials, which is an important aspect for the educational institution.

Contents

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1. Introduction

Under the energy efficiency in the building should understand the complex of activities that aimed at reducing the consumption of buildings thermal energy required for maintenance in rooms of demanded parameters of a microclimate, at the corresponding feasibility study on introduced actions and safety. Thus, the concept of energy efficiency is inextricably linked to issues of energy-savings. But only in that case if the actions directed at reducing the energy consumption of buildings, is technically feasible, economically justified and safe.

At the surface approach, this problem is solved simply. The less building loses heat, the smaller quantity of energy is required to be brought to the building for completion of thermal losses. In this regard, at first sight, the most prime and rational way of economy of energy on heating the way of increase in heat-shielding properties of enclosure.

For the population — this considerable reduction of utility costs, for the country — economy of resources, increase of efficiency of the industry and competitiveness, for ecology — restriction of emission of greenhouse gases in the atmosphere, for the energy companies — decrease in expenses for fuel and unreasonable expenditure for construction [1-8].

2. Literature review

For energy efficiency assessment for production or technological process the index of power effectiveness which estimates consumption or losses of energy resources is used.

Russia takes the third place in the world on power consumption total volume (after the USA and China) and its economy differs a high level of power consumption (quantity of energy on gross domestic product unit). On power consumption volumes in the country the first place is taken by manufacturing industry, on the second place — the housing sector, about 25% at everyone[9-14].

About a half of all energy is spent for construction and operation in developed countries, in developing countries — about a third. It is explained by a great many in the developed countries of household appliances. In Russia about 40-45% of all developed energy are spent for a life. Costs of heating in residential buildings in the territory of Russia make 350–380 kW • h/m ^{2} in a year (is 5-7 times higher, than in EU countries), and in some types of buildings they reach 680 kW • h/m ^{2} in a year. Distances and wear of heating systems of networks lead to losses in 40–50% from all developed energy directed on heating of buildings [15-22]. Heat pumps, solar collectors and batteries, wind generators can be alternative energy sources in buildings.

The first national Russian standard STO NOSTROY 2.35.4-2011 "Green construction" is enacted in 2012. “Buildings inhabited and public. Rating system of an assessment of stability of habitat". The most known standards in the world such are: LEED, BREEAM and DGNB.

3. Purposes and tasks

1. Calculation of resistance to a heat transfer of a enclosure of general education school which is the student's project.
2. Analysis and choice of the most optimum heater of production of ISOVER.
3. Comparison of calculated resistance with the normative.
4. The offer of the measures, capable to reduce quantity of energy spent by consumers.

4. Necessity of carrying out power inspection

Educational institutions – from kindergartens to universities and postgraduate studies – represent potentially attractive area for investments into energy efficiency. Circumstance that educational institutions quite often belong to one organization, can simplify process of an investment of money in energy efficiency. In terms of subordination educational institutions are subdivided on local (preschool institutions and elementary school), regional (high schools) or national (state universities and average express educational institutions). In certain cases educational institutions can fall into specific state department (as, for example, military colleges and academies) [23]. Such direct measures as the instrument account and regulation, it is equal as engaging to work of the power manager in the sphere of consumption of thermal energy, can be very efficient regarding achievement of economy in view of possibility of minimizing of excessive giving of heat and (as in case of offices) temperature falls in night time and in the days off when buildings are empty. Where the regional or mini-network heat supply or where it already is absent, creation of "heat sources" is applied (or heat distributive points) can promote achievement of the considerable economy of energy. Use of efficient illuminants, thermal insulations, temperature-controlled valves and replacement of windows can provide essential reduction of power consumption also. As well as in case of offices, Construction Norms and Regulations and leading documents on MTO are also urged to promote indirect increase of effectiveness in educational institutions. Besides, educational institutions are perspective sector for taking a step in the field of energy efficiency increase in view of a number of other benefits, besides reduction of operational expenses. Increases of comfort and optimization of a temperature schedule of rooms which represent typical benefits from projects of modernization of buildings of educational institutions, promote improvement of conditions for knowledge acquisition [24-32]. Besides, projects carried out in educational institutions provide convenient opportunity for knowledge acquisition concerning a power engineering and awareness improvement at pupils, parents and teachers on visual materials (as one of examples see thematic research No. 2 on the Russian educational sector).

5. Measures of increase energy efficiency

The most widespread measures of increase of energy efficiency include the following:

- efficient methods of construction and modernization of buildings for the purpose of reduction of requirements for area warm and, probably, cold supply [33-35];
- introduction of means of the instrument account and regulation;
- the efficient lighting engineering, urged to reduce power consumption;
- efficient purchases of devices and their marking in interests of decrease
- volume of power consumption by office equipment [36];
- measures of administrative and organizational character, such as programs of inducing of workers to switching off of not used inventory and irradiating [37].

6. Object of research

Comprehensive school

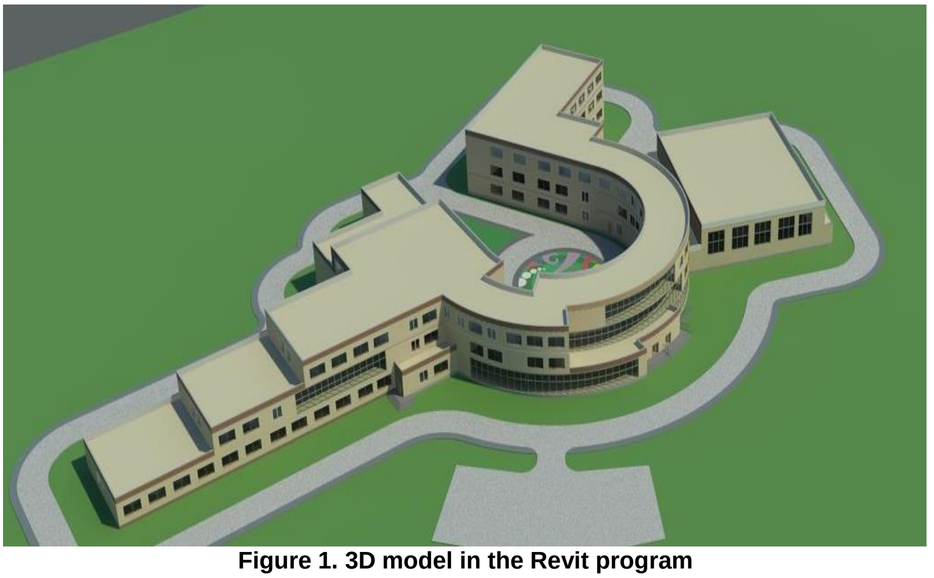

Figure 1. 3D model in the Revit program

- Quantity of pupils – 550;
- Quantity of floors – 3.

The design scheme of the building is accepted on system CDS (the combined design scheme). External walls – brick 300 mm thick, warmed outside by a heater ISOVER VENTI (see table 1) 100 mm thick, with a ventilated facade (figure 2) [38].

Table 1. Principal specifications of a heater

Type of a material	Plate
Thermal conductivity, W / (m*k), no more on GOST 7076-99, λ10 on SR 23-101-2004, λA on SR 23-101-2004, λБ	0.035 0.038 0.039
Compression strength at 10% of deformation, GOST REN 826-2008, kPa, not less	20
Tensile ultimate strength perpendicular to front faces, GOST REN 1607-2008, kPa, not less	4
Vapor permeability, GOST REN 25898, mg / m*h*Pa	0.3
Water absorption at partial immersion in 24 hours, GOST REN 1609, kg/sq.m, no more	1
Group of combustibility, GOST 30244-94	NC

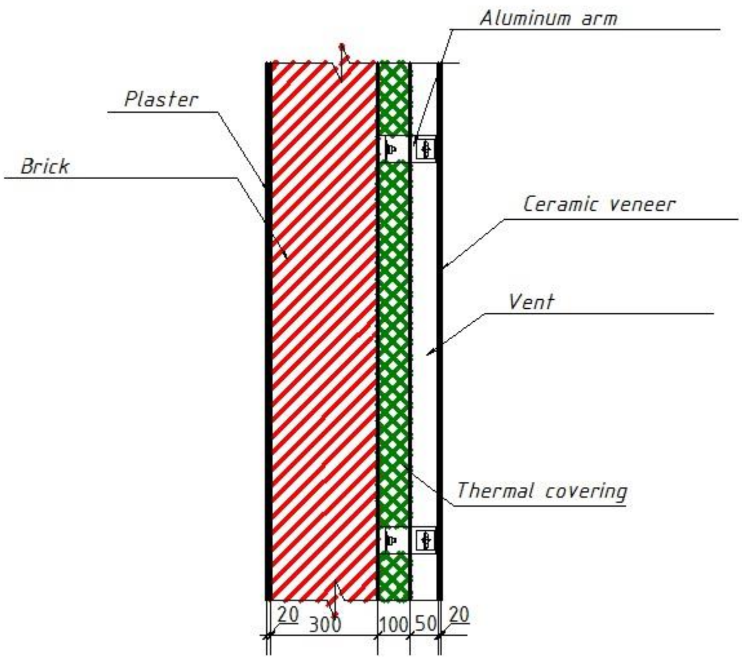

Figure 2. Pie of an External Wall

The bases – a monolithic ferroconcrete plate.

External walls – a ventilated facade.

Internal bearing columns – ferroconcrete.

Partitions – gas-concrete.

Overlappings – ferroconcrete monolithic.

Roof – combined, not operated.

Translucent fillings (windows, stained-glass windows): two-chamber double-glazed windows in unary PVC cover from glass with a soft selective covering are accepted to installation.

Heating system

The heat supply of systems of heating and ventilation is carried out according to the dependent scheme through the individual thermal point being on a mark: -2.7 .

The project provided three separate radiator systems of heating with heat carrier parameters 80/60ºC:

- T 1.2 and T 2.2;

The system of heating assumes laying of highways under a ceiling of technical underground both struts on staircases and mines.

Ventilation system

Ventilation of a cellar is carried out through pro-spirits in external walls. For each fire compartment from the opposite sides of the building.

Ventilation in premises of school is designed forced-air and exhaust with mechanical motivation.

The main objectives of activity of establishment are:

- providing the primary general, main general, secondary (full) general education established by the federal state educational standard for educational institutions;
- creation of an education system, adaptive to levels and features of development and preparation of the being trained;
- creation of the conditions guaranteeing protection and strengthening of health of the being trained
- ensuring education at the level answering to fast development of science and allowing the personality to be integrated into system of world and national cultures;
- realization of idea of the general, intellectual, moral development of the personality by means of a humanization of the content of education;
- formation of the personality with versatile intelligence, skills of research work, high lev-el of the culture ready to a conscious choice and development of professional educational programs;
- preparation of graduates for conscious choice of profession, independent creative training in establishments of the higher and secondary professional education;
- interaction with a family being trained for full development of the personality.

Working hours of institution with 7-00 till 20-00 daily except Saturday and Sunday forced-air and exhaust with mechanical motivation.

7. Climatic and heat power parameters

Climatic parameters according to Construction Norms and Regulations 23-02-2003 and GOST 30494-96 we accept the calculated average temperature of internal air equal:

$$t_{\text{int}} = 20°C;$$

We accept:

1) calculated temperature of external air during the cold period of year for city conditions

St. Petersburg:

$$t_{ext} = -26°C;$$

2) duration of the heating period:

$$z_h = 239 \ \ days;$$

3) average temperature of external air for the heating period:

$$t_h = -0{,}9°C.$$

Thermolysis coefficients. We accept values of coefficient of a thermolysis of an internal surface of protections : for walls, floors and smooth ceilings $\alpha_{\text{int}} = 8{,}7 \ \ \frac{W}{sq.m \cdot °C}$

We accept values of coefficient of a thermolysis of an external surface of protections: for walls and coverings $\alpha_{ext} = 10{,}6;$ building power consumption.

The normalized resistance to a heat transfer.

Degree day of the heating period of HSDD are determined by a formula:

$$HSDD = (t_{\text{int}} - t_h) \cdot z_h$$

$$HSDD = (20 + 0{,}9) \cdot 239 = 4995°C \cdot day$$

As value of HSDD differs from tabular values, standard R_{0req} value we determine by a formula:

$$R_{0req} = a \cdot HSDD + b \ ,$$

Where $a = 0{,}00035, b = 1{,}4.$

According to Construction Norms and Regulations 23-02-2003 for the received value of Degree days the normalized resistance to a heat transfer of $R_{req}, \frac{sq.m \cdot °C}{W}$, makes:

$$R_{req} = (0{,}00035 \cdot 4995) + 1{,}4 = 3{,}15 \ \ \frac{sq.m \cdot °C}{W}.$$

The actual resistance to a heat transfer of a wall of a protecting design is equal:

$$R_0 = \frac{1}{\alpha_{\text{int}}} + R_1 + R_2 + \frac{1}{\alpha_{ext}} \ ,$$

where $\alpha_{\text{int}} -$ coefficient of a thermolysis of an internal surface of a protecting design,

$\frac{W}{sq.m \cdot °C}$, accepted on Construction Norms and Regulations 23-02-2003 (see the appendix of the tab. 5 for walls).

$\alpha_{ext} -$coefficient of a thermolysis of an external surface of a protecting design,

$\frac{W}{sq.m\cdot°C}$, accepted for winter conditions on Item 6 tab. for external walls;

R_{al} – the thermal resistance of the closed air layer accepted on the tab.7 taking notes into account. If the air layer is ventilated by external air, than at defining Ro, design layers, located between an air layer, and an external surface protecting design, aren't considered.

R_1, R_2, R_3, R_4 – thermal resistance of separate layers of a protecting design.

Thermal resistance of one layer is determined by a formula:

$$R = \frac{\delta}{\lambda}$$

where δ – thickness of a layer, m;

λ – coefficient of heat conductivity of a material of this layer

Actual resistance to a heat transfer of this design:

For the first layer (plaster in the building) it is considered so:

$$R_1 = \frac{0{,}02}{0{,}21} = 0{,}095 \quad \frac{sq.m\cdot°C}{W}$$

For the second layer (brick)

$$R_2 = \frac{0{,}30}{0{,}87} = 0{,}345 \quad \frac{sq.m\cdot°C}{W}$$

For the third layer (heater)

$$R_3 = \frac{0{,}10}{0{,}039} = 2{,}56 \quad \frac{sq.m\cdot°C}{W}$$

For the fourth layer (an air layer) you accept value

$R_4 = R_{al} = 0{,}160 \quad \frac{sq.m\cdot°C}{W}$ (the thermal resistance of an air layer accepted on the tab. of normative documents, Construction Norms and Regulations)

$$R_0 = \frac{1}{\alpha_{\text{int}}} + R_1 + R_2 + \ldots + R_n + R_{al} + \frac{1}{\alpha_{ext}},$$

Actual resistance to a wall heat transfer:

$$R_0 = \frac{1}{8{,}7} + 0{,}095 + 0{,}345 + 2{,}56 + 0{,}160 + \frac{1}{10{,}6} = 3{,}37 \quad \frac{sq.m\cdot°C}{W}$$

Table 2 Settlement conditions for comprehensive school

Index	Parameter label	Unit measure	Calculation value
Design ambient air temperature	t_{ext}	°C	-26
Average temperature of external air for heating period	t_h	°C	-0,9
Duration of the heating period	z_h	d/y	239
Heating degree day	HSDD	HSDD	4995
Settlement temperature of internal air	t_{int}	°C	20
Settlement temperature of a technical underground	t_{us}	°C	11

Table 3 Demanded and calculated values of the specified resistance to a heat transfer of external protecting designs of projected object

Type of enclosing parts	Demanded values of reduced total thermal resistance R_i^{tr}, m^2·°C/W	Calculated values of reduced total thermal resistance R_i^{pr}, m^2·°C/W
exposed wall	3,15	3,37

8.Conclusion

In this article an invoice thermal protection of elementary school was calculated, specificly values of the specified resistance of a heat transfer of external protecting designs were calculated.

External protecting designs of projected object conform to standard requirements for level of thermal protection. As a heater for an external wall the heater for professional construction on the basis of flinty fiber ISOVER VENTI was chosen. During calculation value of resistance to a heat transfer (R)was received 6,5% more than standard that is admissible. Thanks to reduction of heatlosses at the expense of application of:

- massive continuous heat-insulation layer on all external contour of the building,
- tight cover on an internal contour,
- highly effective window profiles and effective glazing,
- ventilation systems with heat recovery more than 80%.

Non-performing any of these four conditions is inadmissible and nullifies all efforts on reduction of power consumption of the building.

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Теплотехнический расчет ограждающей конструкции общеобразовательной школы

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дошкольные учреждения;

АННОТАЦИЯ

В статье представлен результат и анализ расчета приведенного сопротивления теплопередаче наружных ограждающих конструкций (стены) для общеобразовательной школы. Школа, для который был подобран утеплитель, является студенческим проектом. Данный объект рассчитан на 550 учащихся, школа имеет три этажа. Статья посвящена решению актуальной проблемы — энергосбережению и повышению энергоэффективности зданий. Также в статье определеляется оптимальная, экономически выгодная толщина утеплителя в системах навесных вентилируемых фасадов. Приводятся теплотехнические расчеты и предлагается оптимальная толщина теплоизолирующего слоя в дан-ном проекте. Компания ISOVER предлагает утеплители ISOVER ВЕНТИ для стен, которые имеют ряд преимуществ: возможность применения, как в однослойной, так и двухслойной системе утепления (в качестве наружного слоя), используется в зданиях всех типов без ограничения по высоте, эффективное удаление влаги из конструкции за счет высокой паропроницаемости, относится к группе негорючих материалов, что является важным аспектом для общеобразовательного учреждения.

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