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THE USE OF SOLAR ENERGY FOR VENTILATION SYSTEM OF CULT BUILDINGS

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Ventilation system, heating system, air heating, solar energy, energy efficiency, reduced heat loss, religious buildings, Chapel, flat solar collector, solar air heating, ecohouse, energy-efficient House, Trombe wall, Edward Morse, Felix Thrombus, tilt attractive solar panel passive heating system, the building's façade, the building walls, ventilation of the cult buildings with shutters-grille, air duct.

In the last fifteen years, the construction of energy efficient and environmentally friendly houses has actively begun its development [1, 3]. The progress in the design of heating and building ventilation systems by using alternative energy sources is associated primarily with the deterioration of the ecological situation on the Earth, the increasing cost of energy, the shortage of primary energy and the development of energy efficiency policy in the world and the Republic of Belarus [2, 3].

The use of solar energy for heating civil, agricultural and residential buildings has long been known. The first mention in the world of the solar energy used in the house construction for heating the exterior walls of the building dates back to 1800. It was when Edward Morse described the heating effect of a brick exterior wall in the sun and its long cooling behind the glass partition at night. Later in 1960, this property of stone and brick walls heated up in the sun during the day and keeping (accumulating) the heat at night was used in the design projects of a French designer and architect Felix Trombe. His design proposal to place the outer wall of the building behind a glass frame in 1960 was called «Trombe wall». This method of heat storage of solar energy is used in the construction of houses, conservatories and greenhouses, but it was given a new name – passive solar air heating system of a house.

The scheme of a passive solar heating system of a residential building Fig. 1 is proposed in [4] Chapter 16, paragraph 16.1. Such schemes of air heating of residential areas are pictured on page 113 Fig. 5.6 [5].

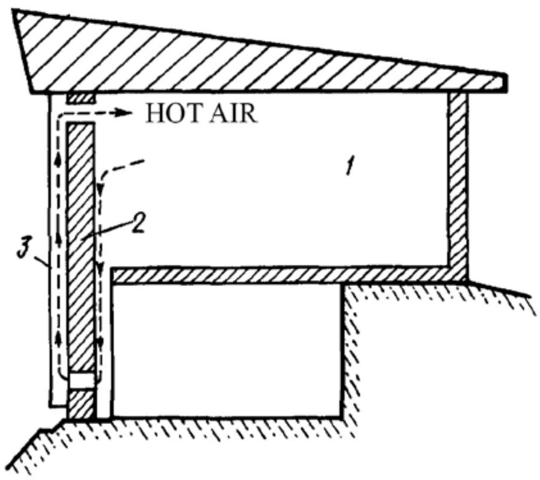

Fig. 1. Passive solar heating system of a building with natural convection
in the space between the glazing of the southern façade and a storage wall:
1 – building; 2 – thermal storage wall; 3 – cladding glass

It is important to place "layers" in the flat collector of solar energy (CSE) and consider their number. The scheme of CSE designs is not known fig. 2 [4, Fig. 16.10.].

One of the ways to use solar energy is an energy-efficient building "ECOHOUSE SOLAR-5" fig. 3 [6] containing walls, solid and vented, roof gabled window openings, solar collectors and solar water heating photovoltaic panels mounted on the roof of the building. The roof pitch facing the south is made double-part, where its lower level is fixed at an angle from 30° to the horizon up to the magnitude, which is calculated by the formula 90-f° where f is the latitude of the building area.

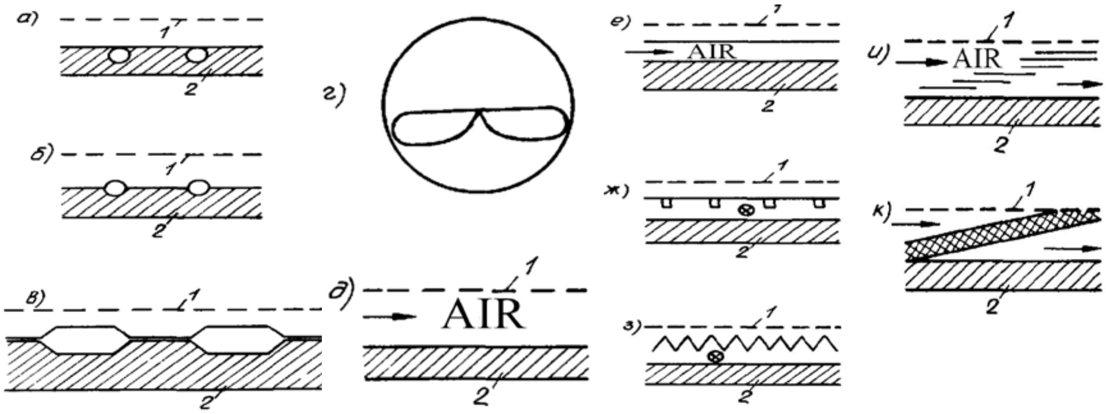

Fig. 2. Schematic designs of liquid (a–g) and air (d–k) solar collectors
1 – glass; 2 – adsorber (beam-absorbing panel)

In addition, the northern roof pitch is made double-part, where its lower level is fixed at an angle of 12 to 26.5° to the horizon and bulges out beyond the plane surface of the outer walls in form of a visor at no more than a quarter of their height.

This model of energy efficient buildings provides energy savings by the creation of a comfortable thermal mode due to the additional heat supply directly from solar heating and reduced heat losses in winter, wind effects and natural aeration and shading of residential premises in summer.

Described are domestic and foreign models of energy efficient buildings, accomplished for the temperate climatic zone of the Northern hemisphere [7, 8].

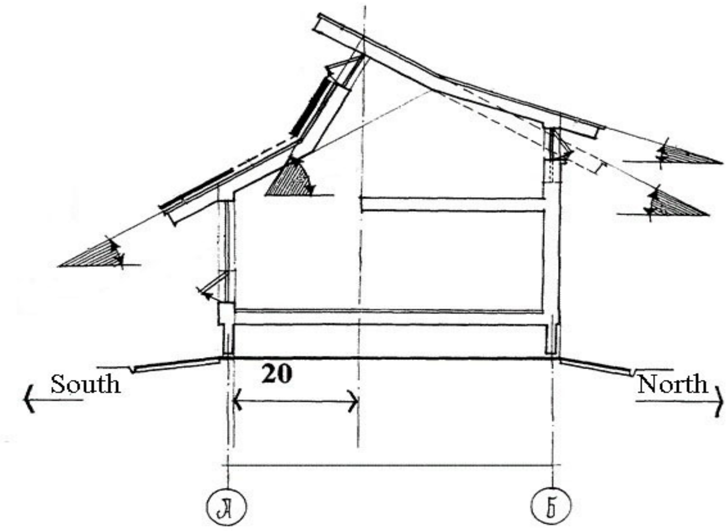

Fig. 3. Ecohouse solar-5

We calculated the sizes of the solar collector and the gap width for the passing of air. It makes 50 mm. The adopted design features of the collector of solar energy (CSE) for ventilation system of Russian Orthodox Church cult buildings are shown (fig. 4). CSE similar systems can be used for other civic buildings. To adopt the air velocity in the CSE 4 m/h is very important. The ventilation rate in the building of the church is not less than 30 m3/h and contains the outside air for 1 man [9]. 50 people can be simultaneously present in the square prayer hall of the church building.

The air intake will take place on the eastern side of the building through the exterior air intake grilles, which are installed on the duct fixed on the outer wall of the building at the height of not less than 2000 mm [11].

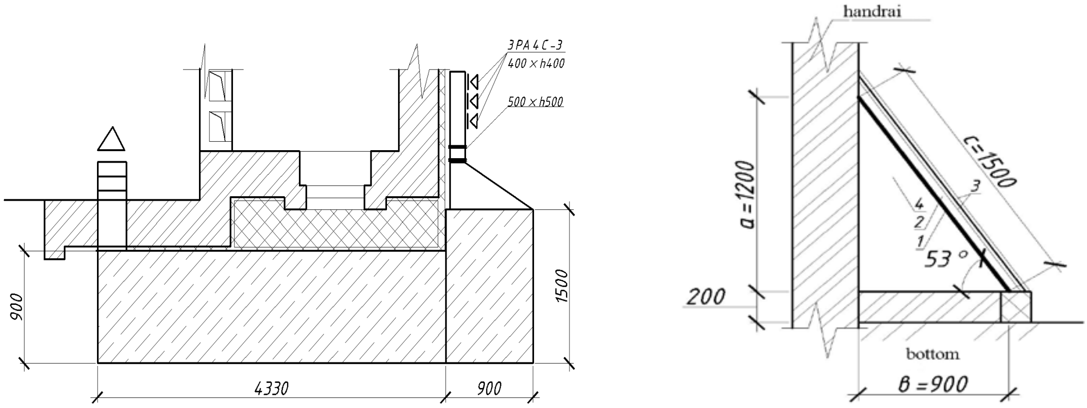

Fig. 4. Sectional view of a solar collector (CSE) the southern and eastern side of a church wall:
1 – copper plate, 2 – space for air, 3 – CSE, 4 – vacuum

Calculated dimensions design of air flat CSE and its placement fig. 5–6, which is a flat panel are located at an angle β with eastern and southern façade of the church. Angle β is equal to the latitude of area [4, paragraph 16.3]. The absorber is made of the plates of good conductive metal (copper). Non-selective glass that does not transmit light waves as well as heat and radiation is used. In contrast, there are no flat solar collector tubes, the air is heated directly in contact with the plate absorber. To increase the heat transfer the absorber has a ribbed form or perforation. The collector should be well isolated from the walls of the buildings to reduce the heat loss. Air circulation in such systems can be both natural and forced using fans and silencers. We propose to install a valve with an axial fan and a silencer on the inner side of the building after CSE.

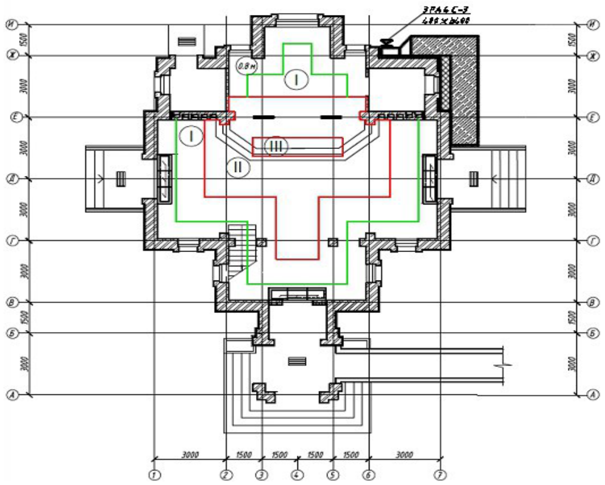

Fig. 5. Plan of the church and the placement of the flat solar collector (CSE)
on the eastern and southern facades

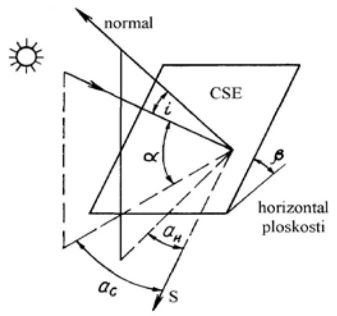

Fig. 6. The flat layout of the CSE

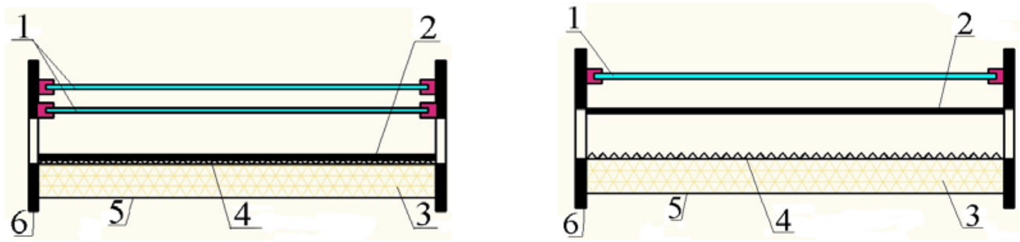

Fig. 7. The proposed design of the flat CSE:
1 – glass, 2 – solar panel, 3 – heat-insulation, 4 – heat-reflecting foil surface, 5 – bottom, 6 – flange

Both designs of the collectors are fairly simple from a technical standpoint (design, installation), as well as conveniently mounted from the available material fig. 7. The diameter of the duct and ventilation design of the transition is calculated [11]. The design standards for houses of worship in the Russian Federation differ from those adopted in the Republic of Belarus [10, 12].

The results of the work are as follows:

1. The application of CSE for hot air heating systems and ventilation systems in the houses of worship (fig. 4, 5, 8.)
2. The use of the flat solar energy collector to heat incoming air is an alternative way to support the work of the general ventilation aimed at dissipating dangerous substances emitting from people, burning candles and lamps in the cult church building accommodating 50 people.
3. For civil buildings, at the period of negative temperatures the hot air heating systems of the outside air is required in addition to CSE.
4. The flat CSE may be considered as an alternative to liquid heat solar components. However, the disadvantage will be the difficulty of implementing water heating and its connection to the traditional water heating systems because it is more convenient for air heating systems.

REFERENCES

1. Экономия и бережливость – главные факторы экономической безопасности государства. Директива Президента Республики Беларусь от 14.06.2007 г. № 3 / Национальный реестр правовых актов Республики Беларусь, 2007 г., № 146, 1/8668.
2. Республиканская программа энергосбережения на 2011 ÷ 2015 год. Утвержд. постановлением Совета Министров Республики Беларусь (СМ РБ) от 24.12.2010 г. № 1882 (Национальный реестр правовых актов Республики Беларусь, 2011 г. №1, 5/33067).
3. Государственная программа "Энергосбережение" на 2016 – 2020 годы : постановление СМ РБ от 28.03.2016 г. № 248, в редакции пост. СМ РБ от 30.12.2016 №1128.
4. Справочник проектировщика. Внутренние санитарно-технические устройства / под ред. И.Г. Староверова. – М. : Стройиздат, 1990. – Ч. 1. Отопление. – 344 с.
5. Er. Bharat Raj Pahari. Passive Building Concept s Design / Er. Bharat Raj Pahari. – Kantipur Engineering College: Dhapakhel, Lalitpur, Nepal. – P. 109–113.
6. Энергоэффективное здание "Экодом Solar-5": пат. 65926 RU, МПК51 U1 E04H14/00, E04H1/00 / П.А. Казанцев; заявитель П.А. Казанцев.- № 2007112278/22; заявл. 02.04.07; опубл. 27.08.07
7. Solararchitectur fur Europa/ Focus film. Astrid Schneider, Berlin, 1996., p.48-51:жилой дом «Nullenergiehaus – serienreif», Wettringen, Германия.
8. Энергоактивные здания. Одноквартирный жилой дом серии «П», полигон «Солнце» / под ред. Н.П. Селиванова. – М. : С/И. 1988. – С. 247–248.
9. Культовые здания и сооружения. Здания, сооружения и комплексы православных храмов. Правела проектирования : ТКП 45-3.02-83-2007. – Минск : Министерство архитектуры и строительства Республики Беларусь (Минстройархитектуры Республики Беларусь), 2008. – 46 с.
10. Стандарт АВОК-2-2004. Храмы православные. Отопление, вентиляция, кондиционирование воздуха. – М. : АВОК-ПРЕСС, 2004.
11. Внутренние санитарно-технические устройства: справочник проектировщика : в 3 ч. / В.Н. Богословский [и др.] ; под ред. Н.Н. Павлова и Ю.И. Шиллера. – Изд.4-е. перераб. и доп. – М. : Стройиздат, 1992. – Ч. 3. Вентиляция и кондиционирование воздуха, кн. 1. – 319 с. : ил.
12. Здания, сооружения и комплексы православных храмов : СП 31–103–99 : дата введения 27.12.1999 / Госстрой Россия. – Изд. офиц. – М. : ГУП ЦПП, 2000. – 34 с.