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CALCULATION OF THE THERMAL CONDUCTIVITY OF A THREE-LAYER REINFORCED CONCRETE WALL PANEL WITH AN INSULATING LAYER OF INSULATING ARBOLITE

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Abstract: The paper determines thermal and technical characteristics of fencing constructions made of three-layer reinforced concrete wall panels with a heat insulating layer made of lightweight concrete on porous cellulose aggregate from waste materials. The estimation of energy efficiency of such enclosures is given.

Key words: three-layer wall panel, brick wall, clayton panel, crushed cotton stalks, rice husk, wood chips and sawdust.

РАСЧЕТ ТЕПЛОПРОВОДНОСТИ ТРЕХСЛОЙНОЙ ЖЕЛЕЗОБЕТОННОЙ СТЕНОВОЙ ПАНЕЛИ С ТЕПЛОИЗОЛЯЦИОННЫМ СЛОЕМ ИЗ ИЗОЛЯЦИОННОГО АРБОЛИТА

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Аннотация: В работе определены теплотехнические характеристики ограждающих конструкций из трехслойной железобетонной стеновой панели с теплоизоляционным слоем из легкого бетона на пористом органическим заполнителе из отходов. Дана оценка энергоэффективности таких ограждений.

Ключевые слова: трехслойная стеновая панель, кирпичная стена, керамзитобетонная панель, измельченные стебли хлопка, рисовая шелуха, древесная стружка и опилки.

O'RTA QATLAMI IZOLYATSION ARBOLITDAN BO'LGAN UCH QATLAMLI TEMIR BETON DEVOR PANELLARINIING ISSIQLIK O'TKAZUVCHANLIGINI HISOBLASH

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Annotatsiya: Maqolada qishloq xo'jaligi chiqindilaridan tayyorlangan to`ldiruvchili o'ta yengil betondan tayyorlangan issiqlik izolyatsiyalovchi qatlamga ega, uch qatlamli temirbeton devor panelini issiqlik texnikasi bo`yicha xusisiyatlari aniqlanib, natijalar boshqa konstruksiyalar bilan taqqoslangan.

Kalit so'zlar: uch qatlamli devor panellari, g'isht devor, go'za poya, guruch qipig'i.

Energy and resource saving is the general direction of technical policy in the field of construction. In energy saving much attention is paid to increase of heat protection of building envelopes. According to statistical data, 90% of the total energy consumption in the building sector is spent on heating and air conditioning, 8% on production of building materials and products, and 2% on construction.

However, it should be noted that most of it goes to compensate for heat losses due to the following reasons [1]:

- Infiltration of heated air (up to 40%);
- Non-regulated operation of heating and hot water supply systems (up to 30%)
- Insufficient heat transfer resistance of envelop structures (up to 30%).

In order to reduce the unreasonably high energy consumption in the process of operation of construction objects, it is necessary to introduce new norms for thermal protection of buildings, providing a significant increase of requirements to their thermal insulation in cold and hot periods. Thus, it is necessary to transfer from sanitary-hygienic criteria of buildings thermal protection to economic criteria.

A special place in the solution of this problem is given to the reconstruction of the operating stock of residential and public buildings, the thermal technical characteristics of the fencing constructions of which do not meet the modern requirements.

The increase of heat-protective properties of fencing requires considerable consumption of material and labour resources. Therefore, thermal protection works should be carried out after elaboration of an appropriate project. Project decision must be made on the basis of preliminary calculations, taking into account experience of construction practice on increase of heat protection and technological peculiarities of works on each particular object.

International experience and scientific-practical developments in this field have received little coverage not only in educational, but also in engineering and special literature. The aim of this textbook is to summarise methodologically the experience of increase of heat protection of buildings in conditions of dry hot climate and by that allow students of construction and architectural specialities to obtain sufficient knowledge for successful practical work on reconstruction and capital repair as well as design of energy efficient civil buildings. By "energy-efficient building" we will understand a set of architectural and engineering solutions that meet the goals of minimizing energy consumption for providing a microclimate in the premises of the building.

Improvement of thermal-technical properties of enclosing structures is one of the perspective directions of increasing energy efficiency of buildings.

In recent years in Tashkent Architecture and Construction Institute staff of department "Technology of building materials, products and structures" conducts research on development of lightweight concrete compositions with porous cellulose aggregates obtained by using wastes of various industries and making modern building envelopes from them.

Particularly lightweight concretes produced with the use of porous aggregate from waste agricultural products (crushed cotton stalks, rice husk, wood chips and sawdust, etc.) in their physical and mechanical properties, durability in aggressive environments and deformational characteristics quite satisfy the requirements presented by the regulatory documents. The improved thermo-technical properties of these concretes, which allow them to be used as insulating layers of multilayer enclosing structures, are particularly noteworthy.

Today, improving the energy efficiency of building envelopes is a major challenge facing scientists and builders. In solving these problems an important role is played by increasing the thermal insulation qualities of these structures, through the use of new materials. Particularly lightweight concretes with porous cellulose aggregate are one of such materials.

The present work investigates the thermo-technical properties of a three-layer wall panel with thermal insulation layer (Fig. 1) and compares it with conventional brickwork.

A comparison of results of heat engineering calculations of building envelopes using these materials is conducted for cold and hot periods, in accordance with

QMQ 2.01.04. -18 Constructional heat engineering.

A three-layer wall panel with standard dimensions 6000x300x1200 mm is considered (Fig.1)

To evaluate the thermal properties of the enclosing structure in accordance with the requirements of [1], we determine the thermal resistance of each layer of the wall panel. Material of two external layers of wall panel, with thickness of each layer δ = 0.10 m, heavy concrete B20 with thermo-technical characteristics

λ = 1,92 Bt/(m ·^{0}C); s = 17,98 Bt/(m^{2} ·^{0}C).

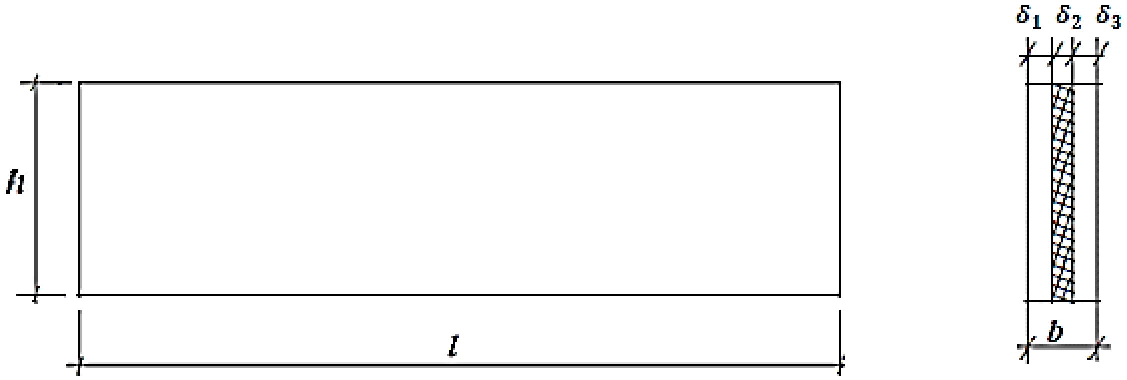

Fig.1

The middle, thermal insulation layer of the panel, with a thickness of δ = 0.10 m, is made of extra lightweight concrete, on porous cellulose aggregate, whose thermal characteristics have been determined by experimental studies and are equal: D 400, λ = 0,077 Bt/m ·^{0}C; s = 2,19 Bt/m ·^{0}C.

The thermal resistance of the building envelope of a three-layer panel with a thickness of δ = 0.30 m calculated according to [1] will be

$$R_{\text{с.п.}} = \frac{1}{\alpha_{\text{в}}} + \frac{\delta_1}{\lambda_1} + \frac{\delta_3}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \frac{1}{\alpha_{\text{н}}} = \frac{1}{8,7} + \frac{0,1}{1,92} + \frac{0,1}{0,077} + \frac{0,1}{1,92} + \frac{1}{23} = 1,5613.$$

The wall panel can be used as a curtain walling in framed public and industrial buildings. According to [1], to ensure the second level of thermal protection in public buildings and to ensure the third level of thermal protection in industrial buildings, on average, $R_0^{\text{тр}}$ = 1,8 (m^{2} ·^{0} C)/Bt). . Determine the missing reduced heat transfer resistance of the panel in question that is necessary to provide the required levels of thermal protection $R_{\text{с.п.}}^{\text{н}}$ = $R_0^{\text{тр}}$ - $R_{\text{с.п.}}$ = 0,2387 (m^{2} ·^{0} C)/Bt.

Determine the required thickness of mineral wool insulation to provide the required level of thermal protection.

$\lambda_{\text{м.в.}}$ = 0,06 Bt/m ·^{0}C;

$\delta_{\text{м.в}}^{\text{тр}} = \lambda_{\text{м.в.}} \cdot R_{\text{с.п.}}^{\text{н}}$ = 0,014 m=1,4 cm.

As can be seen, the consumption of mineral wool insulation is low. But the arrangement of a mineral wool insulation layer requires additional costs, both in terms of materials and technology. Therefore, in our opinion, it is better to increase the thermal protection layer of the wall panel to ensure the required level of thermal protection together with the use of mineral wool insulation. Let us calculate the required thickness of the thermal insulation layer of the panel

$\delta_2^{\text{тр}}$ =0,1+$\delta_{\text{т.с}}^{\text{тр}}$ = 0,1+$\delta_{\text{т.с}}^{\text{тр}}$ =0,1+$\lambda_2 \cdot R_{\text{с.п.}}^{\text{н}}$=0,1+0.077 · 0,2387=0,118 m=11,8 cm.

So in order to ensure the required level of thermal protection, it is sufficient to increase the thickness of the thermal insulation layer to 12 centimetres in the wall panel. To maintain the total panel thickness of 30 cm, the outer layers of heavy concrete can be reduced by one centimetre, i.e. 9 cm.

Then

$$R_{\text{с.п.}} = \frac{1}{\alpha_{\text{в}}} + \frac{\delta_1}{\lambda_1} + \frac{\delta_3}{\lambda_2} + \frac{\delta_3}{\lambda_3} + \frac{1}{\alpha_{\text{н}}} = \frac{1}{8{,}7} + \frac{0{,}09}{1{,}92} + \frac{0{,}12}{0{,}077} + \frac{0{,}09}{1{,}92} + \frac{1}{23} = 1{,}81,$$

which is more $R_0^{\text{тр}}$ = 1,8 $(\text{m}^{2\cdot 0}\text{C})/\text{Bt}$.

As can be seen from the calculation results, a three-layer wall panel with a thermal insulation layer of especially lightweight concrete on porous cellulose aggregate can fully provide the second level of thermal protection required for the external walls of public buildings and the third level for the external walls of industrial buildings.

If one compares the panel in question with walls made of other materials the following can be seen.

At a brick wall with 1.5 brick thickness $\delta_{\text{к}}$ = 0,38 m and $\lambda_{\text{к}}$ =0,7 Bt/m $\cdot^{0}$C, to provide the required levels of thermal protection, an additional layer of mineral wool with thickness $\delta_{\text{м.в}}^{\text{тр}}$ = 7,5 cm is required.

When using expanded clay aggregate panels of corresponding thickness, with a density equal to the given density of the three-layer panel

γ_0=1400 кг/м^2 and thermal characteristics $\lambda_{\text{к}}$ =0,56 Bt/m $\cdot^{0}$C, s = 7,75 Bt/m $\cdot^{0}$C, the necessary additional mineral wool layer is $\delta_{\text{м.в}}^{\text{тр}}$ = 7,6 cm.

Compare the thermal inertia of the building envelope.

Brick wall: s_k = 9,2; $s_{\text{м.в.}}$ = 0,64,

$$D = \frac{\delta_{\text{к}}}{\lambda_{\text{к}}} \cdot s_k + \frac{\delta_{\text{м.в.}}}{\lambda_{\text{м.в.}}} \cdot s_{\text{м.в.}} = 5{,}8.$$

Clayton panel

$$D = \frac{\delta_{\text{к.б.}}}{\lambda_{\text{к.б.}}} \cdot s_k + \frac{\delta_{\text{м.в.}}}{\lambda_{\text{м.в.}}} \cdot s_{\text{м.в.}} = 4{,}96.$$

Three-layer wall panel

$$D = R_{1.} \cdot s_{\text{т.б.}} + R_2 \cdot s_{\text{л.б.}} + R_3 \cdot s_{\text{т.б.}} = \frac{0{,}09}{1{,}92} \cdot 17{,}98 + \frac{0{,}12}{0{,}077} \cdot 2{,}19 + \frac{0{,}09}{1{,}92} \cdot 17{,}98 = 5{,}1.$$

The above calculations show that with almost similar thickness of enclosing structures and equal thermal inertia, only a three-layer wall panel with a thermal insulation layer of especially light concrete on porous cellulose aggregate, without additional insulation layers, provides the required level of thermal protection for walls of public and industrial buildings. At the same time the empty weight of the wall panel is 1.4 times lighter than that of a brick panel, which is very important in seismic areas.

If we consider that a large proportion of heat loss in buildings occurs through external walls (about 35-40%), the use of three-layer wall panels with a thermal insulating layer of especially lightweight concrete with porous cellulosic filler, as curtain walls in frame-type public and industrial buildings significantly increases their energy efficiency. In addition, the production and installation of three-layer wall panels with a thermal insulation layer is more technologically feasible than the construction of brick walls.

All this shows that the use of three-layer wall panels with a thermal insulation layer of especially lightweight concrete on porous cellulose aggregate as envelope structures of frame buildings increases the energy efficiency of buildings and promises a large economic benefit.

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