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ON THE DEPENDENCE OF THE TEMPERATURE INTENSITY OF HEAT TRANSFER IN MULTILAYER ENCLOSURE STRUCTURES IN THE CONDITIONS OF NORTHERN KAZAKHSTAN

The article presents studies on the intensity of the influence of temperature on the heat transfer inside the cement sandwich panel, taking into account the intensity of the influence of temperatures in the ranges of positive and negative values when determining the temperature distribution curve inside Protective construction for climatic conditions in Northern Kazakhstan. Three-layer cement sandwich wall panels, which contain basalt wool and foam polystyrene materials as insulation layer, are considered. The research was carried out using the computer program «Comsol Multiphysics» using the method of finite elements. The study of temperature change kinetics according to the thickness of the structures of two types of cement sandwich panels with the aim of revealing sharp temperature changes affecting the processes of material destruction. It has been shown that the temperature influence during the transmission of the heat flow under both decreasing and increasing temperature conditions flows under softer conditions during the passage of the heat flow through a structure comprising basalt wool as an insulating agent.

Keywords: temperature, heat transfer, intensity of action, enclosing structure, insulation.

Introduction

The tendency of rapid construction under conditions of shortening of its term requires conditions of use of lightweight constructions containing both loadbearing layers and layers of thermal insulation. In this development direction, multilayer fencing structures of full factory readiness are undoubtedly the most rational and acceptable solution for introduction into the practice of industrial and civil construction. The internal layer of such structures is usually effective thermal insulation materials, the performance of which depends on many factors, including the temperature factor.

Materials and methods

The thermal insulation capacity of the material is traditionally determined by temperature, humidity and material structure. This dependency is functionally represented by:

$$\lambda = f(T, W, P, Por, D, Struct......) \quad (1)$$

However, conditions of intensity of the temperature drop or rise in the presented dependency are not present. At the same time, the temperature intensity conditions determine the conditions of the heat transfer process in the structure and the operational reliability of its operation under different modes of operation. Methods of numerical simulation of heat transfer are the best solution for optimization of heat insulation in the construction layer Northern Kazakhstan is located in a harsh continental climate, with [1] the temperature of the coldest five-day period in average of 0.98, the region has an average temperature of – 37 °C and the absolute maximum temperature during the warm period of the year can reach 40 °C.

To date, increasing popularity as multilayer lightweight enclosure constructions receive sandwich panels due to the high properties of heat insulation, fire resistance, moisture resistance, ease and ability to create designs of various configurations. In the studies [2 – 5], it has been proved that the use of sandwich-panels meets all requirements for the development of construction production in the direction of creating energy-efficient and economical construction.

However, sandwich panels have a number of significant operational disadvantages that are directly related to the effect of temperature drops that affect the heat transfer disrupted by the formation of intermediate bridges of cold, due to sandwich bunching - construction and formation of destructive cracks and joints [6 – 10].

The materials used in these studies are those used as layers in cement sandwich panels. The temperature exposure study took into account the thermal characteristics presented in Table 1.

Table 1 – Characteristics of sandwich layers – panels

Material	Heat transfer [W/m K]	Heat capacity [kJ/kg K]	Density [kg /m^3]
Continuous basalt fibre	0,04	1,04	120 – 140
Foam polystyrene	0,042	1,28	0,25
Concrete 150 (two layers; internal and external)	1,49	0,08	2100
Mortar bed (two layers; internal and external)	0,93	0,075	1800

ccording to the climatic conditions of North Kazakhstan, the required heat transfer resistance is determined in accordance with [9] and should be conditional Ro cond not to be more than 1 m2 K/W. At the same time, according to [1] the average calculated indoor air temperature is tin = 21°C, the maximum air temperature during the warm period text= 40° C and the maximum temperature during the cold period text = – 37° C

Taking into account the influence of solar radiation factors, the heat transfer coefficient on the internal and external surface will be equal to α1= 4.8 W/m2 K and α2= 25 W/m2 K, respectively.

The studies used cement sandwich panels, which have an outer layer made of concrete 150. The compression resistance of such concrete is not more than 1.4 MPa.

The required heat transfer resistance for such a design is determined by:

$$R = \frac{1}{\alpha_1} + R_{sp} + \frac{1}{\alpha_2} \qquad (2)$$

R_{sp}- the thermal resistance of the sandwich panel, in which taking account the thermal resistance of all composite layers.

In the Northern Kazakhstan:

$$R = \frac{1}{4,8} + \frac{0,05}{1,49} + \frac{x}{0,08} + \frac{0,05}{1,49} + \frac{1}{4,8} = R_{cond} = 1 m^2 K / W \rightarrow x \geq 0,07$$

Thus, the heat transfer resistance of the three-layer panel will meet the norm at an inner layer thickness of at least 0.11 m. At the same time, the most optimal sandwich panel size will be: 1200 x 6000 x 200.

Results and discussions

The following tasks can be accomplished by assessing the feasibility of using such panels with a given thermal resistance coefficient:

to compare the different types of insulation used in cement sandwich panels;

to analyze the possibilities of using such cement sandwich panels in various enclosing structures (wall panel, roof ceiling, basement ceiling, etc.);

to analyze the possibility of using cement sandwich panels as thermally insulated roof structures.

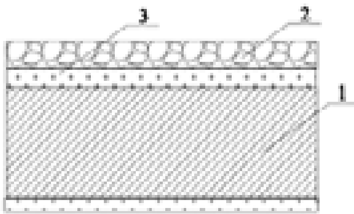
Research on the proposed analysis was carried out with the help of the computer program «Comsol Multiphysics», Module «Heat transfer», when determining the optimal thickness of the layers in accordance with the technical characteristics offered for the layers of materials in the cement sandwich panel, used as a wall.

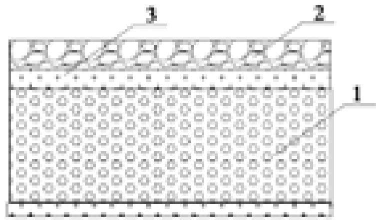
The simulation was carried out using the heat exchange equation in a multilayer concrete structure in the environment «Heat transfer in porous media» taking into account the physical model «Surface to radiation» in the climatic conditions of Northern Kazakhstan, taking into account the standard temperatures on the inside and outside surfaces of the sandwich structure:

$$\frac{\partial}{\partial x}\left(\lambda\frac{\partial t}{\partial x}\right)+\frac{\partial}{\partial y}\left(\lambda\frac{\partial t}{\partial y}\right)+\frac{\partial}{\partial z}\left(\lambda\frac{\partial t}{\partial z}\right)=\rho c\frac{\partial t}{\partial \tau} \quad (3)$$

The experiment involved decisions on the structure of the cement sandwich panels, KS – 1 and KS – 2 represented in table 2.

Table 2– Solutions for the structure of cement sandwiches – panels KS – 1 and KS – 2

Cement structure sandwich panels	Details of cement structure sandwich panels
1.Wall panel KS – 1 	1)Continuous basalt fibre (*Component 1)* thickness 0,07 m; 2) Concrete 150 (*Component 2*) thickness 0,05 m; 3) Mortar bed (*Component* 3) thickness 0,02 m.

2. Wall panel KS – 2 	1) Foam polystyrene (*Component 1*) thickness 0,07 м; 2) Concrete 150 (*Component 2*) thickness 0,03 м; 3) Mortar bed (*Component 3*) thickness 0,02 м.

The results of the studies are presented in figures 1 and 2

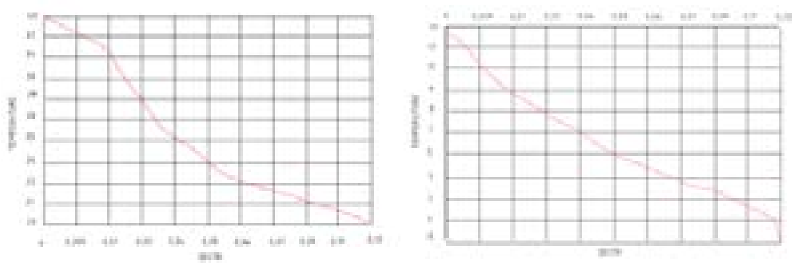


Figure 1 – Temperature kinetics inside KS-1 (in the left) and KS-2 (in the right) in the warm season

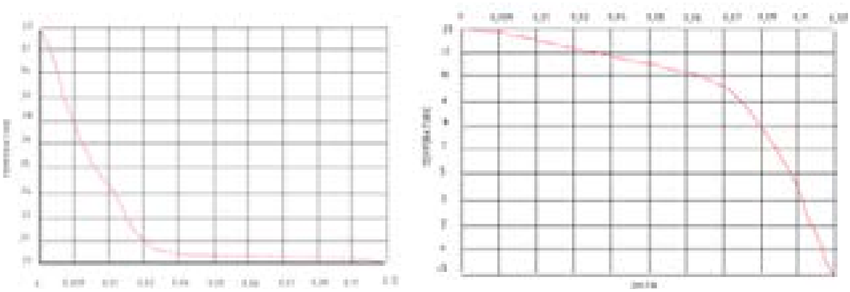


Figure 1 – Temperature kinetics inside KS-1 (in the left) and KS-2 (in the right) in the cold season

Conclusions

Studies have shown positive results of the using represented structures in the climatic conditions of northern Kazakhstan, taking into account the intensity of the temperature influence both in the cold and in the warm period of the year.

However, the use of cement sandwich panels with insulation continuous basalt fibre will be more acceptable because the temperature curve in the wall thickness is less inclined, which means less temperature abrupt due to the absence of temperature changes and, according to the development of temperature gradients that cause the emergence of gradients of pressure and subsequently micro and macro degradation of materials.

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СОЛТҮСТІК ҚАЗАҚСТАН ЖАҒДАЙЛАРЫНДА КӨП ҚАБАТТЫ ҚОРШАУ КОНСТРУКЦИЯЛАРЫНДА ЖЫЛУ БЕРУГЕ ТЕМПЕРАТУРАЛЫҚ ӘСЕР ҚАРҚЫНДЫЛЫҒЫНЫҢ ТӘУЕЛДІЛІГІ ТУРАЛЫ МӘСЕЛЕГЕ

Мақалада Солтүстік Қазақстанның климаттық жағдайлары үшін қоршау конструкциясының ішіндегі температураның таралу қисығын анықтау кезінде оң және теріс мәндер диапазондарындағы температура әсерінің қарқындылығын ескере отырып, цемент сэндвич – панелінің ішіндегі жылу беруге температураның әсер ету қарқындылығы бойынша зерттеулер ұсынылған. Үш қабатты цемент қабырғалық сэндвич панельдері ұсынылады, олардың құрамында оқшаулау қабаты ретінде базальт жүні мен полистирол көбік материалдары бар. Зерттеулер соңғы элементтер әдісін қолдану кезінде «Comsol Multiphysics» компьютерлік бағдарламасының көмегімен жүргізілді. Материалдың бұзылу процестеріне әсер ететін температураның кенеттен өзгеруін анықтау мақсатында конструкциялары екі түрлі цемент сэндвич-панельдерінің қалыңдығына байланысты температураның өзгеру кинетикасын зерттеу. Температураның төмендеуі немесе жоғарылауы жағдайындағы жылу ағынының берілуі кезінде температуралық әсер ету жылу ағынының, жылу оқшаулағыш материал ретінде базальт жүні бар конструкция арқылы өткен кезде, жұмсақ жағдайларда жүретіндігі көрсетілген.

Кілтті сөздер: температура, жылу беру, әсер ету қарқындылығы, қоршау құрылымы, оқшаулау.

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К ВОПРОСУ О ЗАВИСИМОСТИ ИНТЕНСИВНОСТИ ТЕМПЕРАТУРНОГО ВОЗДЕЙСТВИЯ НА ТЕПЛОПЕРЕДАЧУ В МНОГОСЛОЙНЫХ ОГРАЖДАЮЩИХ КОНСТРУКЦИЯХ В УСЛОВИЯХ СЕВЕРНОГО КАЗАХСТАНА

В статье представлены исследования по интенсивности воздействия температуры на теплопередачу внутри цементной сэндвич – панели с учетом интенсивности воздействия температур в диапазонах положительных и отрицательных значений при определении кривой распределения температуры внутри ограждающей конструкции для климатических условий Северного Казахстана. На рассмотрение предлагаются трехслойные цементные стеновые сэндвич – панели, содержащие в качестве слоя утеплителя материалы из базальтовой ваты и пенополистирола. Исследования проведены с помощью компьютерной программы «Comsol Multiphysics» при использовании метода конечных элементов. Исследование кинетики изменения температуры в зависимости от толщины конструкций двух видов цементных сэндвич-панелей с целью выявления резких перепадов температуры, влияющих на процессы разрушения материала. Показано, что температурное воздействие при передаче теплового потока в условиях как понижения, так и повышения температуры протекает в более мягких условиях при прохождении теплового потока через конструкцию, содержащую базальтовую вату в качестве теплоизоляционного материала.

Ключевые слова: температура, теплопередача, интенсивность воздействия, ограждающая конструкция, утеплитель.

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