минарета к высоте этой части, равно приблизительно 1:5. Это обстоятельство подтверждает вывод о том, что отношение ширины основания к высоте равное 1:5, считалось, по-видимому, предельным для свободно стоящих сооружений.

Из перечисленных соображений расчетную схему минаретов, возведенных в углах медресе, принимаем в виде гибкого сооружения с жесткой нижней частью. Цент тяжести этих сооружений лежит , как правило, за пределами диаметра минарета.

При определении динамических характеристик минаретов с жесткой нижней частью, в настоящей работе пользуется метод пробных постановок.

При исследования сейсмостойкости сооружений со сдвиговым характером деформация будем принимать расчетную схему в виде консольного стержня с сосредоточенными массами.

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УДК 620.91:697.1

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REDUCTION OF THERMAL TRANSMITTANCE THROUGH LIGHT STEEL FRAME WALLS

Metal stud wall systems for residential buildings are gaining in popularity. However, very strong thermal bridges caused by highly conductive metal studs worsen the thermal performance of such walls. So, various wall configurations have been developed to improve their thermal performance. In this paper the comparison of thermal performance of conventional steel framed wall (so called “cold construction”) and the construction with thermal breaks installed between stud flanges and exterior sheathing has been made. The results of computer modeling indicate that installing thermal breaking systems is an effective way to improve the thermal performance of metal stud walls.

Key words*: steel framed wall, thermal break, linear thermal transmittance, transmission heat losses.*

Системи стін із металевим каркасом для житлових будинків дедалі набувають популярності. Проте значний вплив містків холоду, викликаний високотеплопровідними елементами металевого каркасу, знижує теплову ефективність таких стін. Через це різноманітні конфігурації для таких стін були розроблені для підвищення їх теплової ефективності. У даній роботі було зроблено порівняння теплових характеристик звичайної стіни зі сталевим металевим каркасом (так званої "холодної конструкції") та конструкції з термовкладишами, встановленими у місті контакту металевих конструкцій каркасу та зовнішньою обшивкою. Результати комп'ютерного моделювання вказують на те, що встановлення систем термічних розривів є ефективним способом підвищення теплової ефективності стін із металевими каркасами.

Ключові слова: *стіна із металевим каркасом, тепловий розрив, лінійний коефіцієнт теплопередачі, втрати теплоти.*

1. Introduction

The building sector is characterized by its high impact on energy consumption.

To promote energy efficiency and sustainability in this sector, it is fundamental to reduce the energy consumption of buildings, especially in their operational stage, since this represents 80%–85% [1] of total energy consumed during their life cycle. For this large percentage, the main contributions come from cooling and heating, 55% to 74%, depending on the climatic region [2] and hot water production. Therefore, it is imperative to develop and/or optimize constructive solutions and methods that offer clear advantages in reducing the energy costs of buildings during this stage of their life cycle.

Over the last few years, alternatives to the traditional constructive methods have emerged and proliferated. Given the advantages of metallic structures along the entire life cycle of buildings, the use of steel as a structural and non-structural construction element has intensely increased in the construction sector. The lightweight steel framing (LSF) system, characterized by using cold-formed steel profiles and pre-fabricated non-structural panels, is an example of this new and growing trend.

The use LSF as a structural element in buildings has increased in recent years. Its various advantages [3, 4, 5] include high mechanical strength and lightweight, easy and rapid prefabrication and high potential for recycling and reuse.

Unfortunately, because the metal components in the walls can create significant thermal bridges, such walls, if not suitably designed, could lead to excessive heat transfer for building walls. Given this, in the recent years, efforts and methodologies have been gathered to evaluate and to improve this type of structures thermal behavior, attenuating the effect of thermal bridging in the exterior envelope.

In this paper the comparison of thermal performance of conventional steel framed wall and the construction with thermal breaks installed between stud flanges and exterior sheathing has been made.

2. Materials and methods

2.1. Description of simulated walls

Two configuration of steel framed walls are considered in this study: without and with thermal breaks separated steel stud flanges from exterior sheathing.

The model of the first case (without thermal breaks) is represented in Figure 1. The wall comprises a steel structure containing galvanized cold-formed steel studs with a “U” cross-sectional shape (150 mmx43 mm, 2 mm thick). The spacing between studs is 600 mm.

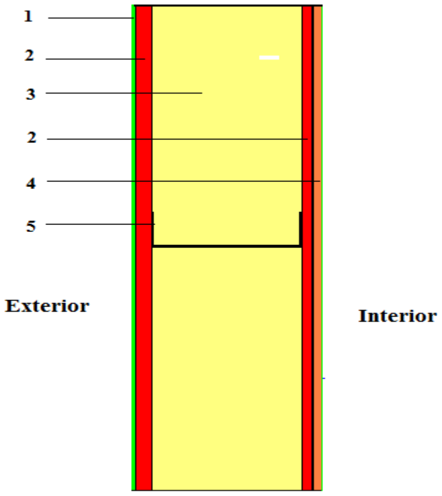

Figure 1. The scheme of a fragment of the steel framed wall without thermal breaks. Materials: 1 – exterior plaster; 2 – oriented strand board (OSB); 3 – thermal insulation; 4 – interior plaster board; 5 – steel stud.

The thermal characteristics of the façade wall materials are listed in Table 1.

Table 1. Thermal properties of wall materials

No	Wall material	Thickness, mm	Thermal conductivity, W/(m·K)
1	interior plaster board	10	0.25
2	OSB	15 (exterior), 10 (interior)	0.12
3	thermal insulation	150	0.035
4	steel stud	2	50
5	exterior plaster	5	0.45

To mitigate the influence of thermal bridges on thermal performance of the above wall construction it is proposed to use thermal insulation strips attached to the flanges of studs from the colder side. These strips (1 cm thick) separate metal studs from the exterior sheathing. The thermal conductivity of such strips is 0.015 W/(m K). It was assumed in computer modeling that air spacers were eliminated, as loose-filled insulation filled all cavities created by metal studs and thermal insulation strips. In this case the dimension of galvanized cold-formed steel studs with a “U” cross-sectional shape are 140 mmx43 mm, 2 mm thick.

The model of steel framed wall with thermal insulation strips is presented in Figure 2.

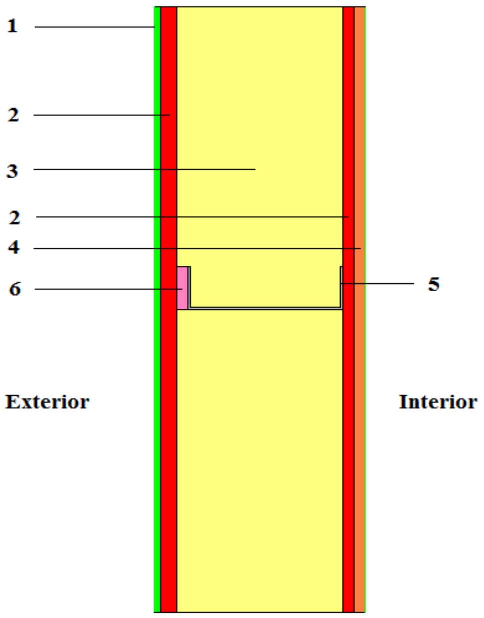

Figure 2. The scheme of a fragment of the steel framed wall with thermal breaks. Materials: 1 – exterior plaster; 2 – oriented strand board (OSB); 3 – thermal insulation; 4 – interior plaster board; 5 – steel stud; 6 – thermal insulation strip

2.2. Boundary Conditions

The following boundary conditions were set for external and internal environment: an external temperature equal to 0 ^{o}C and a convective surface heat transfer coefficient h_e =25 W/(m^2·K); the internal temperature was defined at 20 ^{o}C and a convective surface heat transfer coefficient h_i=7.69 W/(m^2·K). These convective surface heat transfer coefficients were established according to EN ISO 6946 [6] for a horizontal heat flow.

In order to calculate the U-value of the LSF facade walls, first it is necessary to identify a representative wall section to model. For a wall with a single layer of vertical steel studs and a frequency of 600 mm every two studs, standard ISO EN 10211 [7] suggest taking advantage of its symmetry to position the adiabatic plans (zero heat flow). Therefore, a cross-section of the wall measuring 600 mm, with a steel stud in the core, was considered as a geometric model.

2.3. Two-dimensional (2D) steady-state finite element heat-transfer simulation program

Thermal performance of steel framed walls was analyzed with heat-transfer simulation program THERM 7.6 [8].

THERM is a state-of-the-art computer program developed at Lawrence Berkeley National Laboratory (LBNL) for use by building component manufacturers, engineers, educators, students, architects, and others interested in heat transfer.

THERM's two-dimensional conduction heat-transfer analysis is based on the finite-element method, which can model the complicated geometries of building products.

3. Results and discussion

Temperature distribution maps obtained during computer modeling were used to estimate average surface heat flux for considered walls. A knowledge of heat flux values allowed U-value calculations.

Figure 3 shows temperature distribution through a steel framed wall without thermal breaks. It is seen that the lowest inner surface temperature reaches about 16 ^{o}C. Such low temperature may cause the phenomenon of surface condensation. The computed overall U-value of the construction is 0.416 (W/m^2·K).

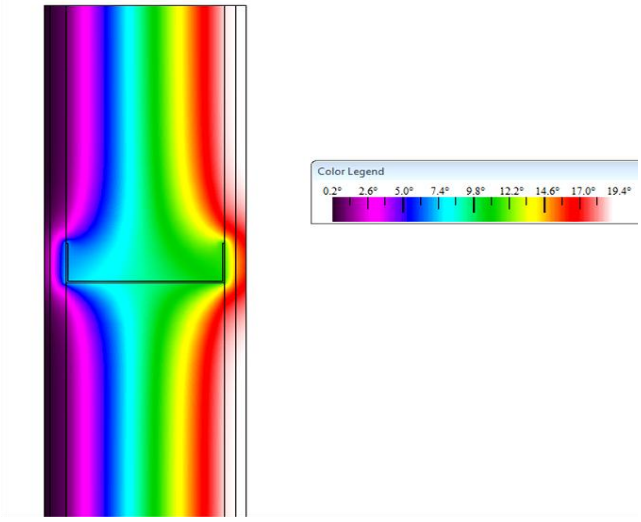

Figure 3. Temperature distribution through steel framed wall without thermal breaks

The results of computer modeling for the wall with insulation strips located between flanges of steel studs and exterior sheathing is presented in Figure 4. It can be seen that the lowest inner surface temperature reaches about 17,5 ^{o}C. So, the risk of surface condensation is prevented. The computed overall U-value of the construction is 0.316 (W/m^2·K).

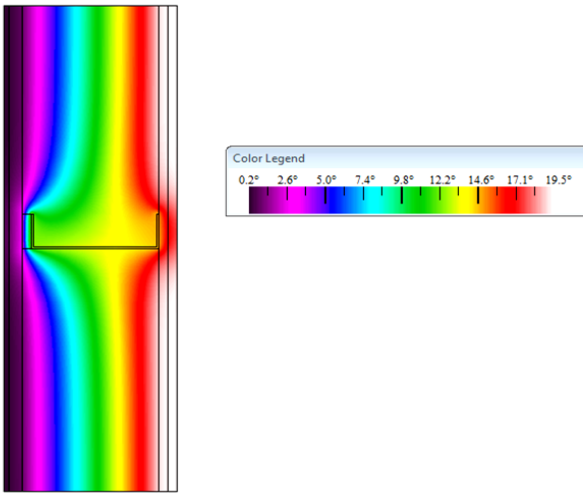

Figure 4. Temperature distribution through steel framed wall with insulation strips

Conclusions

In this study, the thermal performance of two steel framed walls (with and without thermal breaks) have been analyzed using computer modeling.

Simulation results show that the steel studs create a significant thermal bridges effect unless being mitigated.

Thus, the lowest inner surface temperature for the wall without thermal breaks is only 16 ^{o}C, and that may cause the phenomena of surface condensation. The overall U-value of the construction is 0.416 (W/m$^{2}\cdot$K).

In the case of installation of insulation strips between flanges of steel studs and exterior sheathing the lowest inner surface temperature increases to 17,5 ^{o}C. The overall U-value of the construction is lowed to 0.316 (W/m$^{2}\cdot$K). This indicates that installing a thermal breaking system is an effective way to improve the thermal performance of metal stud walls.

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УДК 624.04+01

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МЕТОДИКА И РЕЗУЛЬТАТЫ ПОСЛЕДОВАТЕЛЬНЫХ НАТУРНЫХ НАБЛЮДЕНИЙ И ОЦЕНКА ОСАДОК И КРЕНА КОНСТРУКЦИЙ ДВОРЦА ОКСАРОЙ ВЫСОКОТОЧНЫМИ ГЕОДЕЗИЧЕСКИМИ МЕТОДАМИ

В данной статье приведены основные результаты обследований технического состояния исторического дворца Оксарой в городе Шахрисабз. В конце статьи приведены и проанализированы динамические характеристики до и после усиления аварийного восточного пилона исторического дворца Оксарой на основе инструментальных исследований.

Ключевые слова: *арка, портал, пилон, кыровый раствор, ганчевый раствор, деформативность, усиление, консервация,* гидронивелир, микронивелир*, сейсмограф, ВЭГИК, осциллограф.*