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SPECIAL ASPECTS OF ATTIC FLOOR WARMING IN HISTORIC BUILDINGS

***Abstract:** This article contains reasoning of the heat transfer performance uniformity factor determination for attic floors of historic residential buildings while energy effective modifying buildings. The numeral value of this heat transfer performance uniformity factor for the wooden attic floor structure was found during investigation. It was estimated that there was no moisture condensation in the wooden attic floor structure.*

Energy efficiency modifying of residential historical buildings should imply the principle of highest possible preserving historical engineering structures of a building.

The studied structure solution of the attic floor thermal insulation using modern efficient thermal insulation materials enables to exclude the risk of condensate formation in layers of a wooden floor being preserved.

***Key words:** historic building, attic floor, thermal insulation, heat transfer performance uniformity factor, reconstruction.*

Problem statement. Energy efficient reconstruction of historic buildings is a peculiar challenge because of being connected with the necessity of highest possible preserving of historical engineering structures and valuable historic interiors. Warming of enclosure structures of historic buildings became necessary on a regular basis only in the latest two decades because of standards tightening for building energy usage.

Analysis of the recent researches. It influenced on lots of scientific researches dedicated to this problem [1–10]. This scientific research is dedicated to special aspects of attic floor warming in historic buildings.

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Article purposes are special aspects of attic floor warming in historic buildings.

The main part. The reconstruction of wooden attic floor with historical ceiling preserving.

Warming of attic floors is a traditional measure being part of energy effective modifying of historic residential buildings. According to nature surveys, wooden beams being part of attic floor structure are often in satisfactory state and can be maintained.

The solution of wooden attic floor reconstruction with existing historical ceiling preserving and thermal insulation replacement are described below. Structure solution of the attic floor is shown on Figure 1.

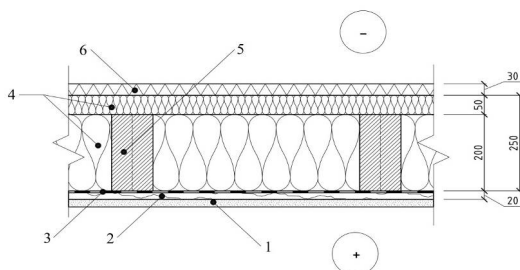


Fig.1. Structure solution of the wooden attic floor
1 – plastering; 2 – sheathing of boards; 3 – vapor insulation;
4 – thermal insulation PAROC eXtra; 5 – wooden floor beams
100x200 mm with 600 mm pitch; 6 – thermal insulation PAROC WAS 35t

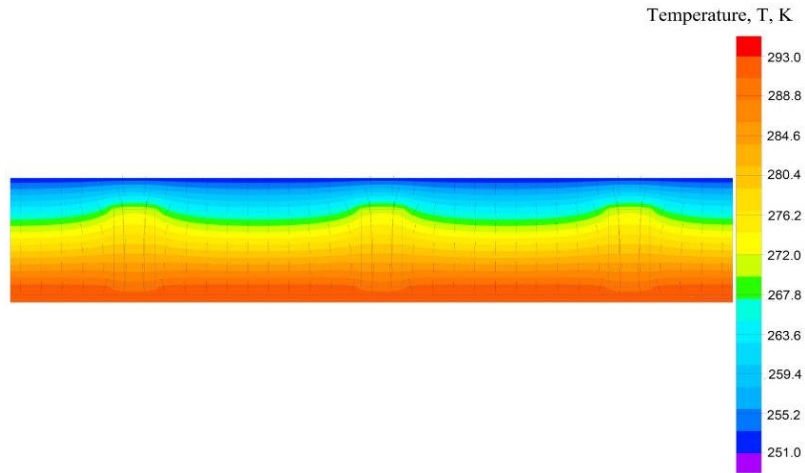
Determination of the heat transfer performance uniformity factor for attic floors of historic buildings.

The thermotechnical calculation of the determined structure was executed in Kiev climate conditions. Inside air temperature +20°C, outside air temperature -22 °C were taken into account for the calculation. Reduced thermal resistance required is 4.95 °C/W [11].

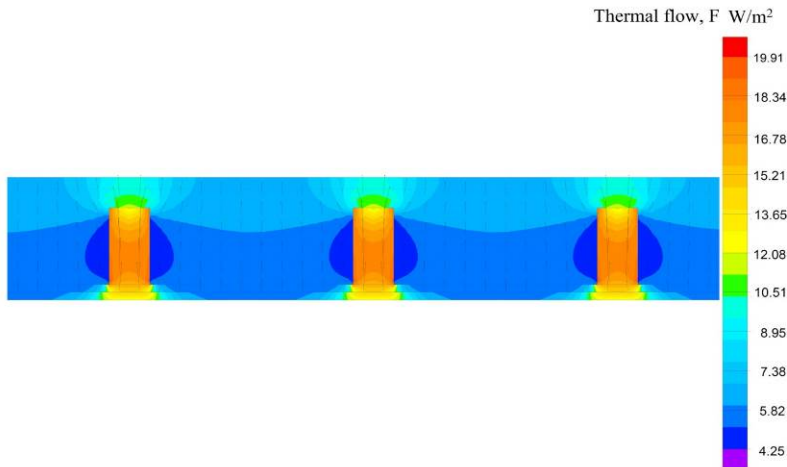
According to the calculations, thermal resistance of the thermal insulation over the sheathing is $R_0 = 6.984 \text{ m}^2 \cdot \text{°C/W}$ and in the cross-section in the middle of the beam is $R_0 = 3.333 \text{ m}^2 \cdot \text{°C/W}$.

The beams in the floor structure are a thermally conductive inclusion.

The temperature pattern was calculated in the software application “ELCUT” with the design outdoor temperature for the heat transfer performance uniformity factor determination (Fig.2).



a)



b)

Fig.2. Temperature pattern (a) and spread of thermal flows (b) in the attic floor structure

The heat transfer performance uniformity factor r_r is a non-dimension value equaling the ratio of the heat flow through the

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section of a heterogeneous enclosure structure to the heat flow through the conditional homogenous enclosure structure with the same surface area as the section. During the calculation a value of the heat transfer performance uniformity factor of the enclosure structure was found ($r=0.806$). The heat transfer performance uniformity factor included the beam influence.

Reduced thermal resistance of the attic floor

$$R_o^{np} = R_o \cdot r, \text{ m}^2 \cdot \text{°C/W}, \quad (1)$$

where R_o is thermal resistance of the homogeneous enclosure structure, $\text{m}^2 \cdot \text{°C/W}$

Thermal resistance of the homogeneous enclosure structure

$$R_o = \frac{1}{\alpha_g} + \sum \frac{\delta_i}{\lambda_i} + \frac{1}{\alpha_n}, \text{ m}^2 \cdot \text{°C/W}, \quad (2)$$

where α_g is a heat transfer coefficient of the inner surface of the enclosure structure, $\text{W}/(\text{m}^2 \cdot \text{°C})$;

$\sum \frac{\delta_i}{\lambda_i}$ is a sum of layer resistances of the enclosure structure $\text{W}/(\text{m}^2 \cdot \text{°C})$;

α_n is a heat transfer coefficient of the outer surface of the enclosure structure, $\text{W}/(\text{m}^2 \cdot \text{°C})$;

Reduced thermal resistance of the studied wooden attic floor $R_o^{np} = 6,984 \cdot 0,806 = 5,629 \text{ m}^2 \cdot \text{°C/W}$.

The risk of condensate formation. Following the calculation of the temperature pattern, the temperature change on the axis of the beam was determined and the scheme of the humidity conditions of the floor structure without vapor barrier was constructed (Fig.3).

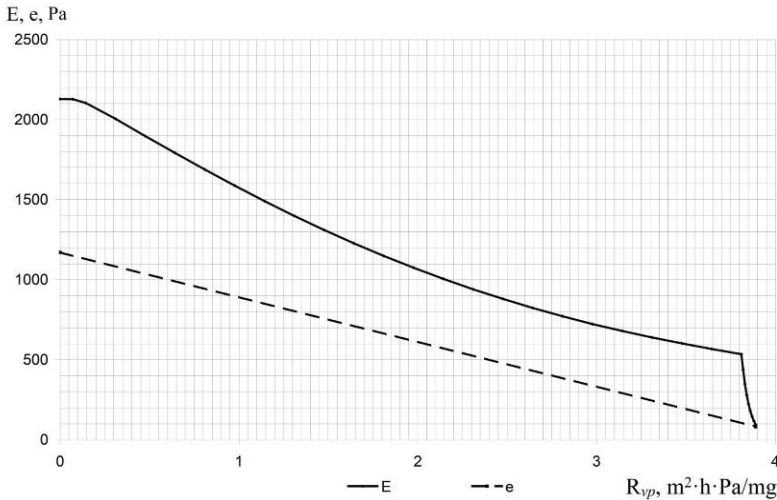


Fig.3. Scheme of attic floor humidity conditions at the design temperature of outside air -22°C (from left to right – from the inside surface to the outside surface of the floor)

Lines e (the line of partial pressure of saturated steam, Pa) and E (the line of saturated steam pressure change, Pa) do not cross at the design temperature of 22°C , which means that there is no moisture condensation in the attic floor in this case [12]. The floor is drawn on a scale of vapor transmission resistances (R_{vp} , $\text{m}^2 \cdot \text{h} \cdot \text{Pa} / \text{mg}$).

Conclusions.

1. Energy efficiency modifying of residential historical buildings should imply the principle of highest possible preserving historical engineering structures of a building.

2. The studied structure solution of the attic floor thermal insulation using modern efficient thermal insulation materials enables to exclude the risk of condensate formation in layers of a wooden floor being preserved.

3. The calculation of the temperature pattern and thermal flows of the floor structure in the software application “ECULT” evidenced the necessity of the heat transfer performance uniformity factor consideration while executing thermotechnical

calculations. The value of the heat transfer performance uniformity factor for the wooden attic floor including beam influence was determined, $r = 0,806$.

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Аннотация:

Мургул В. Специальные аспекты утепления мансардного этажа в исторических домах. Эта статья содержит обоснование определения коэффициента однородности теплопередачи для мансардных этажей исторических жилых зданий, в процессе энергоэффективной модификации зданий. Во время исследования было определено числовое значение коэффициента однородности характеристик теплопередачи для деревянного чердачного перекрытия. Было подсчитано, что в деревянной мансардной конструкции не возникает конденсат.

Изменение энергоэффективности жилых исторических зданий должно подразумевать принцип максимально возможного сохранения исторического инженерного оборудования здания.

Изучение приемов решения теплоизоляции мансардного этажа с использованием современных эффективных теплоизоляционных материалов позволяет исключить риск образования конденсата в сохранившихся слоях деревянного пола.

Ключевые слова: историческое здание, мансардный этаж, теплоизоляция, коэффициент равномерности теплопередачи, реконструкция.

Анотація:

Мургул В. Спеціальні аспекти утеплення мансардного поверху в історичних будинках

Ця стаття містить зауваги щодо визначення коефіцієнта рівномірності теплопередачі для горищ історичних житлових будинків в процесі енергоефективної модифікації будівель. Чисельне значення цього коефіцієнта теплопередачі однорідності для конструкції підлоги дерев'яного мансардного поверху було виявлено в ході дослідження. Було підраховано, що не виникає конденсації вологи в конструкції підлоги.

Енергоефективна модифікація житлових історичних будівель повинна мати на увазі принцип максимально можливого збереження історичного інженерного обладнання будівлі.

Вивчення прийомів вирішення структури теплоізоляції перекриття мансарди з використанням сучасних ефективних теплоізоляційних матеріалів дозволяє виключити ризик утворення конденсату в шарах дерев'яної підлоги, що зберігається.

Ключові слова: історична будівля, мансардний поверх, теплоізоляція, коефіцієнт ефективності теплопередачі, реконструкція.

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