E3S Web of Conferences **376**, 03015 (2023) https://doi.org/10.1051/e3sconf/202337603015
ERSME-2023

Verification of compliance with the requirements of the norms for the internal microclimate of a corner room

Elena Malyavina[1*] and *Sergey* Landyrev[1]

[1]Moscow State University of Civil Engineering, 26, Yaroslavskoe Highway, Moscow, Russia

Abstract. The article considers the buildings of the transport infrastructure that provides services to transport workers, e.g. medical and preventive, children's educational and educative institutions. The resistance to heat transfer of the windows was not increased for such buildings at the last change in the norms of thermal protection in the Russian Federation in 2018. In this regard, it is important to check compliance with the requirements of regulatory documents for radiation temperature and asymmetry of the radiation temperature at the boundary of the serviced area of the premises of such buildings. A literary review has shown that much attention is paid to these parameters in the world. Since the heat transfer resistance of the windows is much less than that of the outer walls, the influence of the outside air temperature on the temperature of the inner surface of the window is much greater than that of the walls. The proposed article considers a corner room of an intermediate floor with windows in the outer walls, occupying 35% of the area of the external enclosing structures, in Belgorod. The building is serviced by air heating. A comparison of the radiation temperature and the asymmetry of the radiation temperature with the same indicators in the ordinary room considered earlier showed that with windows of the specified size, the influence of the second window significantly reduces the radiation temperature and increases the values of the local asymmetry of the radiation temperature. At the same time, during the estimated winter period, not only optimal, but also permissible requirements of the regulatory document are not met at the border of the serviced area of the premises. Keywords: ball thermometer, radiation temperature, local asymmetry of radiation temperature, resulting temperature, calculation, calculated winter conditions.

1 Introduction

The transport infrastructure buildings include the buildings housing the services that provide road users with various types of services necessary for normal working and recreation conditions. In particular, such buildings should include objects of medical care, secondary and vocational education, preschool educational institutions. Energy saving and

[*] Corresponding author: emal@list.ru

energy efficiency of the buildings should not be achieved due to non-compliance with the microclimate parameters required by the norms [1-4]. At the same time, maintaining the required microclimate without overheating in winter and overcooling in summer helps to save energy [5-7]. Radiation temperature and local asymmetry of radiation temperature play an important role in the feeling of comfort in the rooms [8-10], often the assessment of the comfort of people staying indoors is given using the PMV indicator [11-12], in which the radiation temperature is also taken into account. In some cases, as, for example, with intermittent heating, the assessment of radiation temperature plays an important role, especially after a break in heating [13] or in unheated Orthodox churches [14, 15]. It is necessary to pay attention to the state of the thermal radiation environment in the room, especially if provision is made of the air heating, when there are no heating devices in the room [16].

However, no attention is paid either during design or expert examination of the projects as to compliance with the requirements of GOST 30494 "Residential and public buildings. Indoor microclimate parameters" (hereinafter GOST) to the resulting temperature and local asymmetry of the resulting room temperature "in the center of the serviced area and at a distance of 0.5 m from the inner surface of the exterior walls and stationary heating devices".

The measurement of the normalized indicators in the premises in accordance with GOST should be carried out with a ball thermometer. In this paper, the values of the radiation temperature *tr* and the local asymmetry of the radiation temperature *dtr* were estimated by calculation with respect to the ball thermometer. In this calculation, the formula of the irradiance coefficient known from spherical geometry was used from a flat elementary platform to a sphere of known diameter [17]. The advantage of the calculation method is that the estimated calculation can be performed at any outdoor temperature. The greatest values of the asymmetry of the radiation temperature and the lowest values of the radiation temperature are observed at the lowest outdoor temperature, but the weather rarely provides calculated winter conditions for measurement. Therefore, the measured values of the parameters of the internal environment will still have to be recalculated according to the design conditions.

The difference between the results of the calculated method and the experimental one is the obtaining of the radiation temperature and the local asymmetry of the radiation temperature at each measurement point. The experimental measurement method determines the resulting temperature and the local asymmetry of the resulting temperature, since it simultaneously concentrates convective heat fluxes from the air and radiant fluxes from surfaces facing the room on its surface. Unfortunately, quite complex calculation methods are required to estimate changes in the air temperature by the room volume. Therefore, in the proposed work, the main efforts are aimed at determining the radiation temperature and the local asymmetry of the radiation temperature, which significantly depend on the location in relation to cold internal surfaces. When determining the resulting temperature, it is proposed to consider the room air temperature to be the same in volume or to calculate it using engineering methods for determining changes in the air temperature in convective (for example, from heating appliances) or supply (for example, ventilation or infiltration) jets. In the proposed work, the air temperature is assumed to be constant in volume, since there are no convective jets with air heating and in the absence of heat sources. The effect of the ventilation air is considered to be the introduction of a heat flow necessary to maintain the resulting temperature of 20 ° C in the room, with an accuracy of 0.001 ° C.

2 Methods

GOST normalizes the t_r and dt_r checks at different heights from the floor, depending on the preferred position of people in the room (sitting or standing), and for preschool institutions, their heights from the floor are considered. Therefore, the distribution of these parameters across the room has been studied at different heights. Since the lowest values of the radiation temperature and the highest values of the asymmetry of the radiation temperature at the border of the serviced zone are always observed opposite the middle of the window and at the height closest to the center of the window, plans are provided here at a distance of 1.7 m from the floor. In addition, the distribution of t_r and dt_r along the vertical section of the room along the border of the serviced area is of interest.

It should be noted that GOST recommends to provide measuring of the radiation temperature with a completely blackened ball thermometer. Such a thermometer concentrates radiation fluxes from all surrounding surfaces on its surface. Therefore, to fix the radiation temperature readings at each point of the room, it is required to consider only one plan at each level of interest from the floor. At the same time, the asymmetry of the radiation temperature at each point should be measured by a ball thermometer, one half of which is blackened, and the other has a ray-reflecting coating. Therefore, the measurement at each point consists of two measurements. It is fundamentally important to outline where the blackened half of the meter is directed frontally. The difference of the measured temperatures at the point of the room, determined by a ball thermometer for two opposite directions, is a local asymmetry of the resulting or radiation temperature. Therefore, if the local asymmetry of the radiation temperature is determined in a corner room, then with the frontal direction of the blackened half of the ball thermometer on one window, the second window affects the ball thermometer from the side. To fix the *dtr* at the border of the serviced area at the second window, redirect the front orientation of the meter to this window. Therefore, the local asymmetry of the radiation temperature for a corner room with a window in the second outer wall should be represented at each level from the floor by two plans.

The city of Belgorod was chosen for the test, with the estimated temperature of the coldest five-days with 0.92 availability, equal to -24 ºC. For a large number of rooms of these buildings, the calculated resulting temperature is +20 ºC. The internal temperature is maintained by an air heating system. The geometry of the intermediate floors room for the study was adopted according to a real project. The length of one outer wall in the corner room is 6 m, and the other outer wall - 5.4 m. The height of the room in cleanliness is assumed to be 3.3 m. A window measuring 3.8 x 1.8 m is symmetrically located in a 6 m long wall with a height of the bottom of the window from the floor of 1 m. The second outer wall is shorter than the first one, but the window in it has the same size, is at the same height from the floor and the same distance of 1.1 m from the outer corner as in the first wall. The pier partition after the window in the second wall is shorter than in the first one and makes 0.5 m. The area of the windows is 35% of the total area of the vertical external enclosing structures of the room.

3 Results

It turned out to be interesting to assess the change in the radiation temperature and the local asymmetry of the radiation temperature when comparing the distribution of these indicators according to the room plan in an ordinary and corner room having a second window in the second outer wall.

Figures 1 and 2 convince us that *tr* and *dtr* at each point are influenced by all surrounding surfaces, but to a greater extent by both windows. Attention is drawn to the

 https://doi.org/10.1051/e3sconf/202337603015

distribution of isolines *tr* and *dtr* on the room plans near the windows. In the drawings, the isolines are drawn to the outer walls and partitions, and the boundaries of the serviced area are 0.5 m away from them. Therefore, some values of these parameters on the plans near the walls and partitions have values higher than the values shown on the cross sections along the border of the serviced area.

The arrangement of the *tr* isotherms is almost symmetrical with respect to the bisector of the outer corner formed by the two outer walls. The calculations were performed with the same resistance to heat transfer and the size of the windows in the two walls of the corner room. In a corner room at a height of 1.7 m opposite the window on the border of the serviced area, *tr* is 1.25 °C lower than in an ordinary one. It is also interesting that in the corner formed by the partitions, the radiation temperature isotherms have an asymmetric shape with respect to the mentioned bisector of the outer corner due to the different lengths of the outer wall piers near the inner partitions. These piers in the mentioned place have a significant influence on the formation of radiation temperature, although they are located relatively far away.

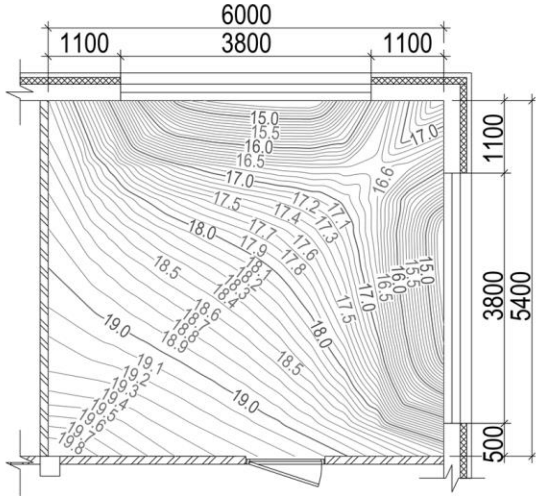
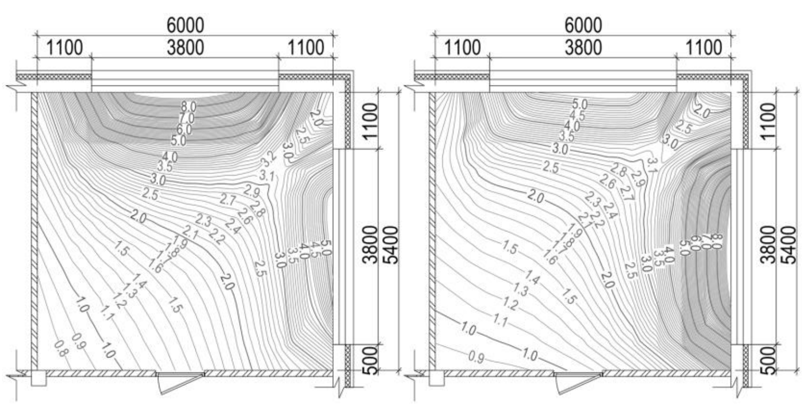


Fig. 1. Distribution of the radiation temperature according to the plan of the corner room at a height of 1.7 m from the floor.

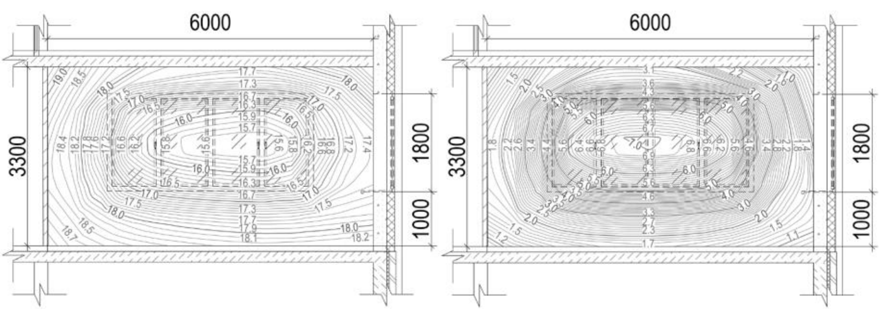


a) b)

Fig. 2. Distribution of the radiation temperature local asymmetry according to the plan of a corner room at a height of 1.7 m from the floor b) with a frontal orientation of the ball thermometer on a wall of 6 m long, c) with a frontal orientation of the ball thermometer on a wall of 5.4 m long.

At the same time, the *dtr* isolines are not symmetrical due to the above-mentioned need for the frontal orientation of the blackened half of the ball thermometer alternately to one and the other window. At the border of the serviced area opposite the center of the window at a height of 1.7 m from the floor, the *dtr* is 0.71 ºC higher than in an ordinary room. This excess arose due to the simultaneous influence on the local asymmetry of the radiation temperature of the windows in the two outer walls. If you move along the bisector of the outer angle, then next to the outer angle, the dt_r is lower and the tr is higher than with further progress. This is explained by the fact that at the beginning of this path, the radiation temperature is formed to a greater extent by the surface temperature of the piers near the outer corner, and later by the temperature of the inner surface of the windows. Near the corner formed by the partitions, there is a different influence of piers of different lengths in the outer walls. The difference is manifested in the fact that the values of the local asymmetry of the radiation temperature with the frontal orientation of the ball thermometer on a short wall are 0.1 ºC greater than with the orientation on a long outer wall.

Cross sections of the room along the border of the serviced area (Fig. 3), on the one hand, indicate the asymmetry of the isolines as well due to a decrease in the radiation temperature and an increase in the local asymmetry of the radiation temperature near the side window. On the other hand, they show that the values on closed ellipses *tr* increase and dt_r decrease with distance from the center of the window. At the same time, the radiation temperature of the room at the border of the serviced zone remains below the required value, so it is over its entire area below the resulting temperature of 20 ºC more than 1 ºC. The space of dissatisfaction with acceptable dt_r conditions at the border of the serviced zone is small. The zone of non-compliance with optimal requirements occupies almost the entire area of the window.



a) b)

Fig. 3. Distribution of the radiation temperature (Fig. 1 a) and the local asymmetry of radiation temperature (Fig. 1 b) along the cross section of the room at a distance of 0.5 m from the outer wall, 6 m long, in the design winter period.

4 Discussion

In the opinion of the authors, non-compliance with permissible and especially optimal norms of the radiation temperature and the local asymmetry of the radiation temperature occurs due to a rationing approach to the choice of resistance to heat transfer of windows with the same principles as rationing of the resistance to the heat transfer of walls and coatings. The principles of rationing are aimed at saving energy to maintain a thermal microclimate during the heating period, characterized by the number of degree periods of the heating period (DPHP). At the same time, the possibility of forming a low temperature on the inner surface of the window during the coldest estimated winter period is not considered. And such a situation is possible, since the window has the least heat transfer resistance of all external enclosing structures. In addition, the window has the least heat resistance. Therefore, it cannot maintain a higher temperature, even if the weather was relatively warm before the cold snap.

5 Conclusion

In a corner room with windows in each outer wall, with the ball thermometer facing one window, the radiation temperature values decrease, and the local asymmetry of the radiation temperature increases compared to the same indicators in a room with one window due to lateral irradiation from the second window. The length of the pier partition near the window also affects the distribution of these parameters over the volume of the room.

It is proposed to take into account not only the degree-day of the heating period, as is now customary, but also the calculated outdoor temperature for the cold period of the year when forming the required resistance to heat transfer of windows.

References

1. Iu.N. Sankina, A.B. Sulin, T.V. Ryabova et al, Vestnik mezhdunarodnoi akademii kholoda **1**, 28-33 (2021) DOI: 10.17586|1606-4313.2021-20-1-28-33
2. E. Teitelbaum, F. Meggers, Energy Procedia **122**, 1129-1134 (2017) https://doi.org/10.1016/j.egypro.2017.07.436
3. S. Malz, P. Steininger, O. Steffens, Energy and buildings **236**, 110779 (2021) https://doi.org/10.1016/j.enbuild.2021.110779
4. M. Musy, L. Malys, C. Inard, Procedia environmental sciences **38**, 562-570 (2017) https://doi.org/10.1016/j.proenv.2017.03.126
5. M. Musy, L. Malys, B. Morille, C. Inard, Urban climate **14(2)**, 213-223 (2015) https://doi.org/10.1016/j.uclim.2015.07.004
6. T. Datsyuk, Y. Ivlev, V. Pukhkal, Magazine of Civil Engineering **6**, 12-21 (2013) DOI:10.5862/MCE.41.2
7. E. Malyavina, A. Zdoronok, D. Ozerchuk, E3S Web of Conferences **244**, 05028 (2021) https://doi.org/10.1051/e3sconf/202124405028
8. Al-hafiz. Bisam, M. Musy, H.Turki, Procedia environmental sciences **38**, 562-570 (2017) https://doi.org/10.1016/j.proenv.2017.03.126
9. Yu.N. Sladkova, V. Smirnov, E. Zaritskaya, Russian Journal of Occupational Health and Industrial Ecology **5**, 35-39 (2018) http://dx.doi.org/10.31089/1026-9428-2018-5-35-39
10. T.V. Ryabova, A.B. Sulin, Yu.N. Sankina, Vestnik mezhdunarodnoi akademii kholoda **2**, 78-84 (2018) DOI: 10.17586/1606-4313-2018-17-2-78-84
11. A. Karpenko, I.Yu. Petrova, IFAC-Papers **51(30)**, 636-640 (2018) https://doi.org/10.1016/j.ifacol.2018.11.229
12. N. Puangmaleea, K. Hussaroa, V. Boonyayothinc, J. Khedaria, Energy procedia **79**, 480-485 (2015) https://doi.org/10.1016/j.egypro.2015.11.522
13. W. Hua, Q. Liu, J. Niea, M. Chang, Y. Gaob, Q. Zhang, Procedia engineering **205**, 2545-2552 (2017) https://doi.org/10.1016/j.proeng.2017.10.230

14. A.G. Kochev, M.M. Sokolov, E.A. Kocheva, A.A. Fedotov, Construction **7**, 78-85 (2019) DOI 10.32683/0536-1052-2019-727-7-78-85
15. L.G. Starkova, Yu.A. Moreva, Yu.N. Novoselova, Bulletin of the South Ural State University. The series "Construction and Architecture" **18(3)**, 53-59 (2018) DOI: 10.14529/build180308
16. A. Frolova, E. Malyavina, E3S Web of Conferences **263**, 04017 (2021) DOI: 10.1051 / e3sconf / 202126304017
17. E.G. Malyavina, A.A. Frolova, S.S. Landyrev, Light & Engineering **29(5)**, 61-67 (2021) https://doi.org/10.33383/2021-078