The thermal mode of the covered yard

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Abstract. The covered yards in the cities with big durations of the cold period of year are useful for people to stay in rather favorable conditions of a microclimate that increases ability of each person to carry out more useful work, study or other creative activity. The covered yards relieve the person of extra wind loading and children to spend time on the street more comfortably. Formation of the covered yards allows to have not freezing sandboxes in which children can play all the year. The research in this article is dedicated the thermal mode of the covered yards.

1. Introduction
The cities in Russian Federation, during the winter period, are covered with snow, roads in ice, playgrounds are difficult for use, streets round houses are filled with cars, snow on roadsides of roads has a black shade because of receipts of dangerous compounds from motor transport, so how to resolve this problem? Ten thousands of municipal services cars works to clean snow, to bring and melt it at special snow melting stations in cities in winter time [1].

There are many buildings in the center of St. Petersburg with courtyards on which perimeter are usually located low buildings where there are arches for pass of people As it is known the city of St. Petersburg is located on the Neva river and on the shore of the Finnish Gulf which the breeze as the movement of air from a surface of the water towards to the land. The strong wind during the cold period of year with a rain or wet snow causes unpleasant temperature feelings of the people moving on city streets. Existence of double-exit courtyards allows people to take cover from a wind that increases comfort of residence in the city. The wind flow of buildings with courtyards brings to reassignment of a wind stream on streets round the building and above the building with formation of vortex zones of an aerodynamic trace [2] that improves a wind situation in courtyards.

Existence of the courtyard covered with a translucent roof allows to receive, during the cold period of year, comfortable space to rest for adults and children where is not wind, the air temperature is above the external temperature, a minimum of snow, ice and also not freezing sandboxes for children. At desire, visitors from such yards can pass into parks which are actively formed on all districts of the cities such as Moscow and St. Petersburg.

In recent years there were many buildings with atriums and big spaces for people [3, 4] where it is possible to spend with convenience the time throughout the day. But it isn't enough of it for such megalopolises as Moscow and St. Petersburg.
2. Methods of calculating the thermal conditions

Let’s consider the building with the covered yard with a close to square form in the plan – its width is rather great from all directions and the wind flow for this kind of building has character as for the wide building when the windy vortex zone of an aerodynamic trace is formed partially on a roof of the building and on a back windy facade. A wind flow of various form buildings by air is connected with aerodynamics of city building [2, 5].

Figure 1. Picture of formation of vortex zones of an aerodynamic trace, where (+) – excessive pressure of air, (-) – small discharge of air

Vortex zones of an aerodynamic trace which are formed at a wind flow of building by air create adverse conditions for finding of the person in these zones that is shown in fig. 1, and the adverse wind situation in the Moscow and St. Petersburg is shown in fig. 2 and 3. It is possible to get rid of these zones at construction of buildings with conveniently streamline shape, or close areas with people by a translucent roof.

Figure 2. Change of wind’s speed in Moscow in November, 2017 (1) and February, 2018 (2)

During formation of the covered yard it is possible to carry out calculations of the thermal mode of internal air to understand the comfort level when the person is inside of this kind of space.

During the cold period of year the loss of warmth from the walls and windows to a courtyard and losses of warmth through translucent roof and ground allow to get the calculations of temperature
condition in the covered yard. It is desirable to warm passes through arches for people moving to a courtyard from abutting streets for reduction of warmth losses.

![Figure 3](image)

**Figure 3.** Change of wind’s speed in St. Petersburg in November, 2017 (1) and February, 2018 (2)

Management of a microclimate in the covered yard is defined by consideration of the air, thermal and gas modes [6, 7].

3. **Results of calculations**

Let’s consider the building with a square form courtyard, fig. 4, the section of this kind of building is presented in fig. 5.

![Figure 4](image)

**Figure 4.** The building plan with the covered yard, where tint – air temperature in the covered yard °C, Q1 и Q2 – thermal streams into the space of the covered yard, \( W, v \) – speed of wind, m/s
The covered yard size is $63 \times 63$. Its surrounded with the building with external sizes of $87$ m on each external facade. The building has 5 floors (with not heated attic). The area of the windows which are leaving in a courtyard is $840 \text{ m}^2$, the area of the walls turned into a courtyard is $3393.6 \text{ m}^2$, the area of a roof and the area of ground which are in the covered yard is $3960 \text{ m}^2$.

The thermal stream from walls and windows to the covered yard (Q1 and Q2), and the warmth losses of the covered yard through a translucent roof and ground (Q3 and Q4) that is shown in fig. 4 and fig. 5.

According of laws in the Russian Federation SP 50.13330.2012 "Thermal protection of buildings" and SP 131.13330.2012 "Construction climatology" resistance to a heat transfer of windows and walls of the building respectively are $0/49$ and $2/99 \left( \text{m}^2 \times ^\circ \text{C} \right)/\text{W}$ and a translucent roof of the covered yard is $0.36 \left( \text{m}^2 \times ^\circ \text{C} \right)/\text{W}$.

There are the balance equations (1, 2) of losses and receipts of warmth in the covered yard which allowing to determine temperature in the covered yard.

$$\sum Q_1 + \sum Q_2 = Q_3 + Q_4$$  
$$f(t) = f(Q_1, Q_2, Q_3, Q_4)$$

Figure 6. Change of temperature of external air and air in the covered yard in Moscow in November, 2017, where 1 – external air, 2 – air in the covered yard and 3 – air in the covered yard 2

Calculations are carried out for temperature conditions of Moscow and St. Petersburg for the real values of temperature of external air in November, 2017 and February, 2018 has taken from the
existing meteorological data. The air temperature in the rooms of the building is accepted +20 °C. As the yard is blocked by a translucent covering and this additional resistance to a heat transfer, the protecting designs turned into a courtyard, can have the lowered resistance to a heat transfer that will allow to increase still temperature of internal air in a courtyard during the cold period of year.

Results of calculations are presented on schedules figures 6–10 where "The covered yard" and "The covered yard 2" is the temperature of internal air in the covered yard at the specified values of resistance to a heat transfer and the lowered resistance to a heat transfer respectively.

**Figure 7.** Change of temperature of external air and air in the covered yard in Moscow in February, 2018, where 1 – air in the covered yard, 2 – external air and 3 – air in the covered yard 2

**Figure 8.** Change of temperature of external air and air in the covered yard in St. Petersburg in November, 2017, where 1 – air in the covered yard, 2 – external air and 3 – air in the covered yard 2
Figure 9. Change of temperature of external air and air in the covered yard in St. Petersburg in February, 2018, where 1 – air in the covered yard, 2 – external air and 3 – air in the covered yard 2

Figure 10. Change of air temperature in the covered yard depending on temperature of external air, where 1 – change of temperature in the covered yard at standard values of resistance to a heat transfer of the protecting designs of the building leaving to the yard and 2 – change of temperature in a courtyard at the lowered values of resistance to a heat transfer of the external protections of the building leaving to a courtyard

The differences in heat physical characteristics of the external protecting designs for Moscow and St. Petersburg have insignificant character therefore fig. 9 is suitable for the considered two cities.
4. Conclusion
According figure 10 (the line 2) it is visible that already at -12 °C, the external air in the covered yard has positive value of temperature of internal air. The increased air temperature in the covered yard allows to receive space, more convenient for rest. The translucent covering shades yard space that can demand additional lighting [8]. Heat losses from the walls and windows to courtyard will be reduced during the cold period of year which will allow to reduce thermal data security of the protecting building designs. The snow which dropped out on a roof should be cleaned up by mechanics or melted away with removal of thawed snow in the sewerage. During the warm period of year in space of the covered yard can be hot that can demands possibility to open the shutters of translucent overlapping for natural airing or it is necessary to provide additional engineering systems for cooling [9]. The big square of a glazing in a translucent covering of the covered yard will lead to formation of the descending streams of cold air which are compensated by the ascending streams of the heated air rising along walls with windows in the form of convective streams. In the covered space of the yard air circulation by means of the ascending and descending convective streams is formed. The microclimate of the covered yard in winter time has cold character, and when cooling air its moisture content aspires to a minimum, and it results in dryness of sand in sandboxes for children as moisture from sand will evaporate and will disappear together with air exchange of the covered yard. To understand all concept of the thermal mode in the covered yard we should carrying out more detailed modelling of the microclimate parameters changing in time is necessary. And the roads which are filled up with snow how to be with them? They can be covered with translucent arches with heating for transformation of snow into water and branch it in the sewerage too. Of course, cars with the electric engine are not fast translation process of huge park of cars on such type of fuel as electricity that improves ecology and allows to solve many infrastructure problems of set.

References
[1] Gogina E S and Derusheva N L 2016 Bases of a method of design of snow of melting constructions taking into account criteria of ecological safety Water and ecology: problems and decisions 2 (66) 58–64
[2] Retter A I 1984 Architectural and construction aerodynamics (Moskow)
[3] Kim A N 2015 Passages and atriums as elements of formation of public spaces in a modern urban environment Innovations in sociocultural space Materials VIII of the international scientific and practical conference (Amur state university) 38–42
[4] Kupriyanov V N and Smetanin D V 2010 History of development and classification of atriums News of the Kazan state architectural and construction university 2 (14) 32–39
[5] Egorychev O O and Dunichkin I V 2013 Questions of forecasting of a microclimate of an urban environment for an assessment of wind power potential of building Vestnik MGSU 6 123–31
[6] Rymarov A G 2012 Gas mode of the building Natural and technical science 6 (62) 595–9
[7] Rymarov A G 2013 Characteristics of heat-mass exchange modes of mutual influence buildings Natural and technical science 1 (63) 380–2
[8] Gorgots S E and Solovyov A K 2006 Calculation of natural lighting in the rooms fronting in an atrium Lighting engineering 2 51–2
[9] Brodach M M and Efremov M N 2014 Systems Ventilation, heating, air conditioning of atriums AVOK: Ventilation, heating, air conditioning, heat supply and construction thermophysics 3 16–24

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