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CONCERNING THE FACTORS FORMING THE HUMIDITY MODE OF BUILDINGS

Abstract. *Climate change affects cities and settlements in the Russian Federation. In addition to the increase in outdoor air temperature, its relative humidity also changes. Increasing humidity in the internal environment of buildings leads to negative phenomena, such as dampness of the room, which has a negative impact on the well-being of people and the safety of buildings 'enclosing structures. In some cases, in addition to General exchange ventilation, it is possible to regulate the humidity state of the premises by using a sorbing material as a lining for the interior surface of the premises. In NIISF RAASN, analytical and mathematical studies of the humidity state of premises in the annual operation cycle were conducted, which showed that the relative humidity in the room can be regulated by using the correct selected sorbing material.*

Keywords: *climate change, external and internal sources of moisture, regulation of humidity, conditions of premises, dampness.*

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О ФАКТОРАХ, ФОРМИРУЮЩИХ ВЛАЖНОСТНЫЙ РЕЖИМ ЗДАНИЙ

Аннотация. *Изменение климата влияет на города и поселки в Российской Федерации. Помимо повышения температуры наружного воздуха изменяется и его относительная влажность. Повышение влажности внутренней среды зданий приводит к негативным явлениям, таким как сырость в помещении, что негативно сказывается на самочувствии людей и безопасности ограждающих конструкций зданий. В некоторых случаях, помимо общеобменной вентиляции, можно регулировать влажностное состояние помещения с помощью сорбирующего материала в качестве облицовки внутренней поверхности помещения. В НИИСФ РААСН были проведены аналитические и математические исследования влажностного состояния помещений в годовом цикле эксплуатации, которые показали, что относительную влажность в помещении можно регулировать с помощью правильно подобранного сорбирующего материала.*

Ключевые слова: *изменение климата, внешние и внутренние источники влаги, регулирование влажности, условия помещений, сырость.*

Introduction

The average surface temperature of the Earth over the past 100 years has increased by 0.74 °C, which has affected the nature of precipitation. By the anomaly of the surface temperature of the air (see figure 1) you can observe the trend of climate change. Extreme weather events have become more intense and frequent. Since the 1960 s, the number of registered weather-related disasters has more than tripled [1, 2]. Climate change in some cases has a devastating impact on buildings and construction objects. In recent decades, the intensity of heavy rains has increased, leading to an increase in the proportion of buildings with dampness problems, especially in flood-prone areas, river valleys and coastal areas. According to forecasts, the number of winter floods will continue to increase in the countries of North-Western Europe, and flood-in all countries of the European Region [3, 4].

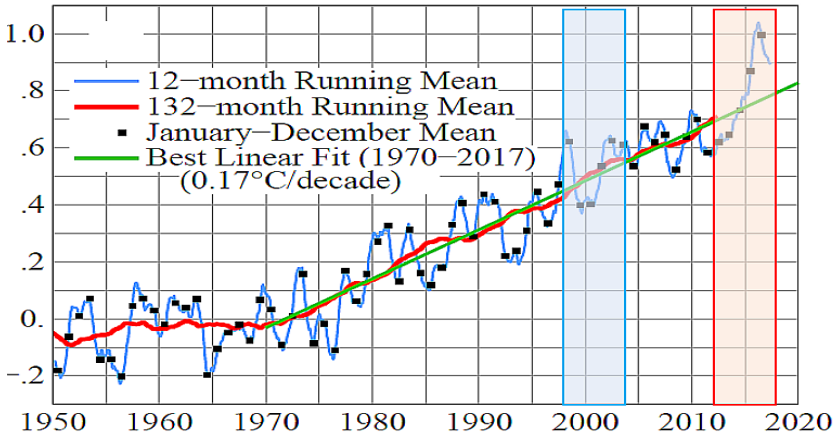

Figure 1 - Global anomalies in surface air temperature (until November 1917), according to NASA GISS. The author of the analysis is Igor Ezau, Ph.D., Ph.D., a senior researcher at the Center for Remote Sensing of the Earth and Environmental Studies. F. Nansen and the Climate Research Center. V. Björknes, Bergen, Norway

Construction objects and structures depend on external influences, the nature of which should be taken into account when designing and operating buildings. [5, 6]. The internal environment of the premises is largely affected by the external air [7]. Climate characteristics are widely used in the construction industry in the development of measures to ensure internal comfort, energy conservation of buildings and their safety. Specialists of the NIISF RAASN have been developing climate standards based on meteorological observations.

Method

The research method is based on calculations of normative values of climatic parameters. Currently, the normative document SP 131 13330 2018 is valid. “SNiP 23-01-99 * Building Climatology”, which was developed with the participation of specialists from the main geophysical observatory named after A.I. Voyeykova (FSBI GGO) Roshydromet.

An analysis of the standard values presented for the 50-year period of observations allowed us to note a significant excess of precipitation in the cold period of the year, with a relative humidity of 55 to 60 % (figure 2). During the warm season precipitation is decreasing, but the relative humidity exceeds 80% . Thus, in winter, ventilation can not be a full-fledged method of regulating humidity, since cold outdoor air has a very low moisture content, which can lead to a decrease in the humidity of the room relative to the standard values. In the summer, outdoor air may increase the humidity of the indoor environment when the room is ventilated. The parameters of the microclimate of premises are presented in the normative documents: GOST 30494-2011. "Residential and public buildings. Parameters of microclimate in buildings" and SanPiN 2.1.2.2645-10 "Sanitary and epidemiological requirements for living conditions in residential buildings and premises". In the cold period of the year, the optimal value of relative humidity should be in the range of 30-45%, and the permissible value - < 60%. In the warm season, the optimal and permissible relative humidity should be in the range of 30-60 % and not exceed 65 %.

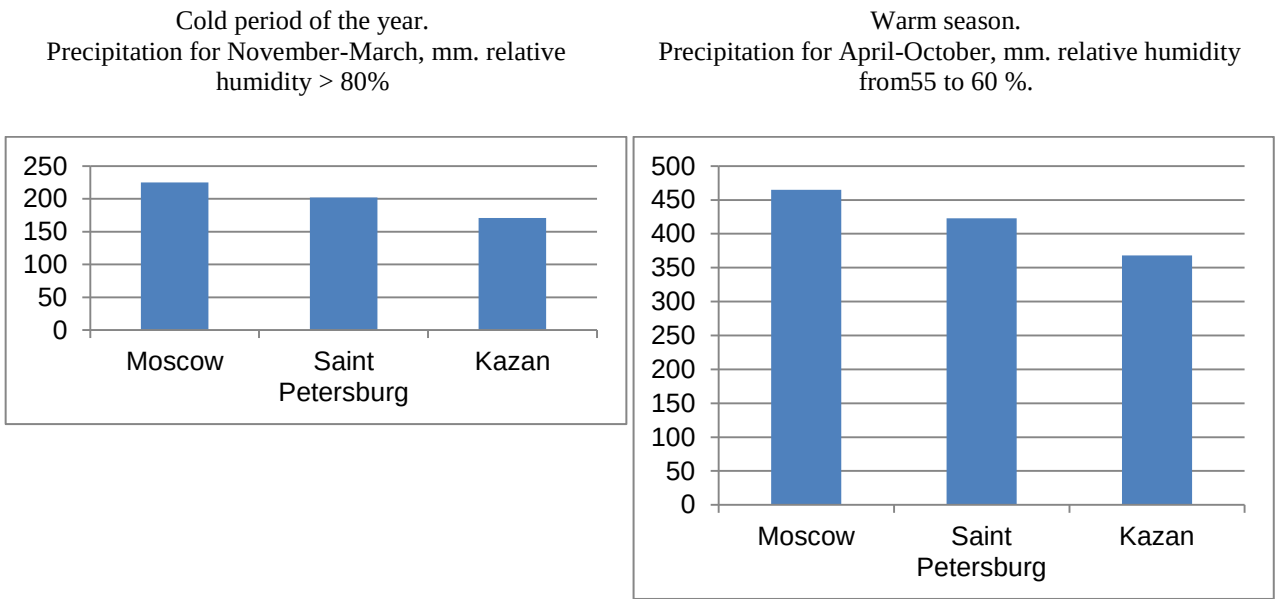

Figure 2 - The amount of precipitation cold and warm periods of the year in cities of the Russian Federation

During the heating period, the relative humidity has low values that go beyond its standard value of 35%. External and internal sources of moisture supply contribute to an increase in the relative humidity of indoor air (table 1). Regulation of the air environment parameters of residential and public buildings, including its relative humidity, can improve the quality of the microclimate of premises.

Table 1 - External and internal sources of moisture

External	Anthropogenic		Other sources
Rain	Breath	Cooking	Animals
Snow	Sweat	Cleaning	Plants
Flow	Bath and shower	Clothes washing and drying	Aquariums
Subsoil waters	Dish Washing		

Results of observations

With the onset of the cold period up to January for residential premises humidity, as a rule, meets the standards, and then additional humidification of the room is required. During the warm period, humidity almost always exceeds the permissible standard value of 65%. The presence of additional sources of moisture release can lead to an increase in humidity up to 100 %. The use of ventilation can reduce humidity to 70-80 %. [8,9].

NIISF RAASN with the participation of the main geophysical Observatory. A. I Voey-Kova (GGO) of the Federal hydrometeorological service of the Russian Federation based on observation data for the period from 1980-2011 developed the climate parameters of Moscow. Based on the conducted research, the parameters of a typical year were obtained, with hourly values of meteorological elements that allow the use of energy-saving technologies in the design of buildings and structures [10,11]. However, the use of hourly values leads to an increase in the amount of information to complicate the calculations and increase the cost of machine time. In Russian practice, meteorological observations are made in three hours. This interval is also useful when forming a Bank of climate standards for a typical year. Table 2 shows the temperature and humidity characteristics of outdoor air during the coldest days of the heating season in Moscow. The analysis of the territory's climate parameters over several decades allows us to characterize the state of its climate system. Changes in the General circulation of air flows in the Northern hemisphere and the "greenhouse effect" led to a General warming of the climate in Moscow: the average annual temperature for this period was 4.1 oC, exceeding the average annual temperature of the previous 30-year period by 0.8 OC. There is a tendency to a significant repeatability in the cold period of a

combination of relatively high (above 0 ° C) air temperature with increased (more than 70 %) humidity, which leads to thaws that negatively affect the construction of buildings, structures, communications, and worsen health. The infiltration of outdoor air, when using window blocks made of "breathing" wood, is disturbed. Miscalculations in design and construction can lead to wet walls or corner parts of the building during rain, and in cold weather the wall can freeze. This is also true for damp basements, which are a source of mold that can spread throughout the premises through ventilation channels. The relative humidity at which some types of fungi germinate is 62-65%. Compliance with the standard values does not exclude the appearance of moisture on cold internal surfaces and in building structures. So, dust mites can exist at a relative humidity above 45-50%, in order to avoid their reproduction, the relative humidity in homes during the heating season should be lower than this value [12].

A changing climate, urbanisation and its associated environmental problems have an impact on the internal conditions of the premises. In this regard, there is a need to develop a new systematic approach to assessing the quality and formation of the internal environment of buildings. The data presented in tables 2 and 3 indicate some changes in the climate system of Moscow.

Table 2 - Temperature and humidity characteristics of the outdoor air on the coldest days of Moscow, presented in three-hour time intervals

Climate Characteristics	Three-hour intervals of the climatic parameters during the coldest times of the day							
	0-2	3-5	6-8	9-11	12-14	15-17	18-20	21-23
Temperature	-8,7	-9,4	-9,1	-7,7	-6,6	-6,9	-7,5	-7,6
Relative Humidity	82	84	83	78	78	75	78	83

Table 3 shows the temperature and humidity characteristics of the outdoor air on the warmest days of the summer period in Moscow.

Table 3 - Temperature and humidity characteristics of the outdoor air of the warmest days of the summer period of the year in Moscow, presented in three-hour intervals

Climate Characteristics	Three-hour Intervals of the climatic parameters during t warmest the times of the day							
	0-2	3-5	6-8	9-11	12-14	15-17	18-20	21-23
Temperature	16,3	17,3	20.2	22,9	23,9	23,2	20,6	17,7
Relative Humidity	87	85	72	65	59	63	66	85

Along with the increase in outdoor air temperature, its relative humidity also increased . The process of moisture formation in the room is not constant, the humidity level changes periodically. The ability of building and finishing materials to absorb and release moisture affects fluctuations in the humidity level in the room [13, 14]. Dampness control in order to avoid the formation of excessive humidity in structures requires proper temperature control and ventilation. To combat dampness, it is necessary to avoid the formation of stagnant air zones when ventilating premises.

Excess moisture on almost any surface contributes to the growth of micro-organisms such as mycelial fungi (mold) and other types of fungi, as well as bacteria, which then become a source of air pollution by spores, cells, parts, and volatile organic compounds. In addition, dampness causes biological decomposition of materials. Humidification of building materials contributes to their chemical destruction, which increases the level of emission of volatile organic compounds (including formaldehyde), leading to the destruction of building structures. The incidence increases in geographical areas with high air temperature and high humidity. When the temperature increased to 40°C and humidity to 60%, the release of formaldehyde from building materials and furniture was recorded at levels 1.5–2.5 times higher than normal [15]. Compliance with the rules of design, construction and operation of building envelope structures is key to preventing and controlling

excessive humidity that leads to the growth of microorganisms. It should also be noted poorly ventilated areas with moisture sources such as kitchens, bathrooms, swimming pools.

When waterproofing of enclosing structures is violated, when using porous building materials, capillary absorption of rain and ground water moisture occurs . The contact area of the building with the ground base is often larger than the surface of the shell in contact with the outside air [16]. The layout of modern apartments does not involve Windows in bathrooms and bathrooms and sufficient effective ventilation. Meanwhile, as a result of drying clothes or water treatments, humidity increases.

During warm and humid weather, outside air that penetrates through cracks and holes in the building envelope can cause condensation to form on cold surfaces of engineering systems. In cold weather, the ex-filtration of warm humid air from the premises into the enclosing structures leads to condensation of moisture in cracks in walls and ceilings, as well as in attics. Experiments on the behavior of materials have shown the destructive effect of microorganisms on building structures, leading to a decrease in strength indicators, the destruction of concrete products and brickwork. The calculation of the cost of restoring structures may be commensurate with the size of the damage from biological damage [17].

Indoor air pollution by micro-organisms is caused by hundreds of species of bacteria and fungi that grow in rooms with a sufficient level of humidity. The elimination of dampness in the premises can be considered as a measure to combat their adverse effects. Health disorders include an increase in the frequency of respiratory symptoms, allergies, asthma, and other pathological immune responses. Scientists have proved that the constant presence of fungal spores in the body increases the risk of cancer, the most dangerous fungi include black mold.

In NIISF RAASN, work was performed to Refine the parameters of the micro-climate of residential and public buildings, within which search studies were conducted to study and evaluate the comfort and safety of the internal environment of premises. It was found that the annual dynamics of changes in relative humidity, formed by non-stationary changes in the temperature and humidity state of outdoor air, can range from 10% to 90% and significantly exceed the limits set by regulatory documents. Studies of external influences were conducted for the external atmosphere corresponding to the Moscow region. To regulate the humidity regime of buildings ' premises, wall cladding was considered as a sorbing material. The change in outdoor humidity is shown in figure 3. Atmospheric air data is obtained from the revised archive data (Moscow VVC) (for the beginning of the countdown at 00.00 hours on January 1, 2013) with details within each day [18].

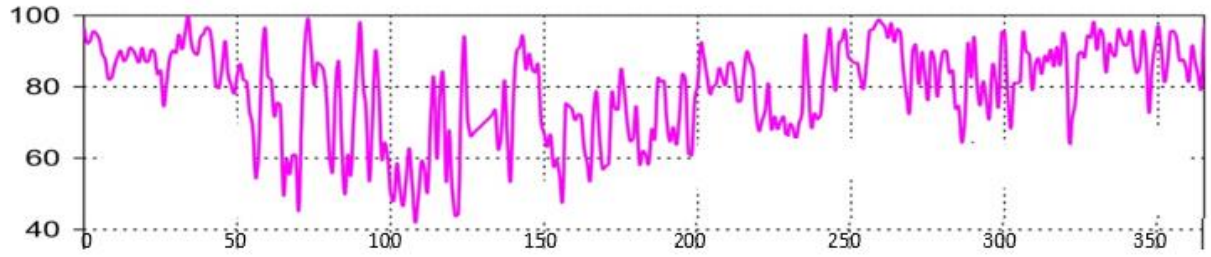

Figure 3 - Relative humidity of outdoor air

During the research, the requirements for the lining of internal surfaces of fences were evaluated. Figure 4 shows the calculated data of relative humidity in the room depending on the sorption properties of the material used for finishing the interior surfaces of the room.

In construction practice, it is customary to take into account the influence of the sorption effect on the moisture content of the material itself. The influence of sorption as a means of regulating humidity during long-term operation of premises has not been practically studied. The use of indoor sorbing material may be sufficient to ensure a standard humidity regime for most of the year. During the cold period, the average indoor humidity is about 30% for January-March and

more than 40% for November-December. During the warm period, humidity does not rise more than 75% and can exceed the standard value of 65% in fact only in summer. Calculations have shown that the damping properties of the sorbent in the form of wood are so effective that they can reduce humidity fluctuations several times within a single day. The results obtained allow to smooth out humidity fluctuations in premises by using water vapor-absorbing materials and efficient operation of ventilation systems.

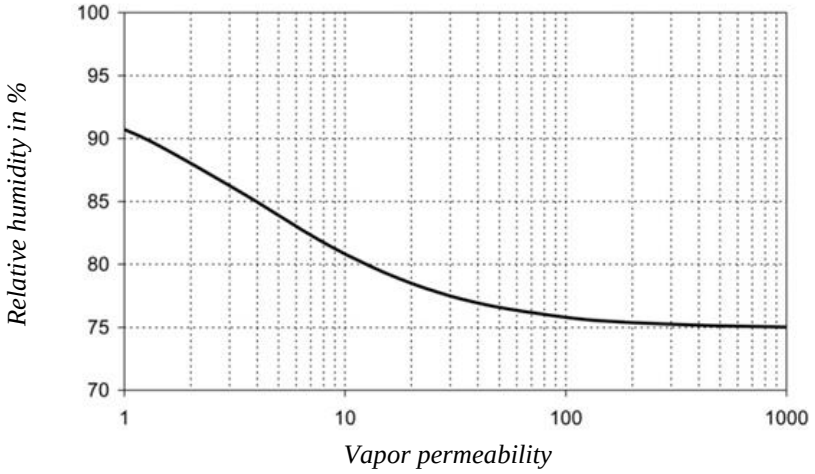

Figure 4-relative humidity in the room on one of the most unfavorable days, depending on the vapor permeability of the coating of wood veneer N•1010 kg/PA/m2/s

Conclusion

The development of a new ecostrategy is aimed at improving the quality of life and health of the population of the Russian Federation by ensuring the quality of the indoor environment and its safety. Public policy should be based on a scientific approach that is common to hygienists, physicians, ecologists, architects, designers and builders, including: the impact of the outdoor environment, assessment of microclimatic parameters of the environment; determination of air exchange and effective ventilation; selection of environmentally friendly types of construction and finishing materials; assessment of fungal and bacterial contamination.

Assessment of the humidity regime of premises is one of the most important tasks stated in the social project "Housing and urban environment", aimed at ensuring the health and longevity of the population of our country by improving the quality of the internal environment of buildings. Preserving the health of the people , reducing the death rate , and increasing the life expectancy of people largely depends on the microclimate of the room.

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