INDOOR AIR QUALITY IN MUSEUMS AND HISTORICAL BUILDINGS IN ST. PETERSBURG AND IN NORTH-WEST REGION OF RUSSIA

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ABSTRACT

This presentation deals with the problem of achieving stable microclimate in old buildings of St Petersburg - such as churches, museums and palaces. Characteristic traits of such buildings are rather thick envelops which as a rule accumulate large quantities of heat or cold. The majority of these buildings are equipped only with central water heating and are naturally ventilated.

Experimental study of microclimate in buildings of this kind proves that during cold season (with average temperature -10°C) the relative humidity there will be about 30-35% and less. In summer time temperature background does not rise above 22-24°C whereas the relative humidity sometimes can rise up to 75-80%. Eventually we should like to note that climate parameters of St Petersburg can be taken as a characteristic for entire Norten-West of Russia.

Inserting into such buildings air conditioning systems (provided with cooling plants and devices for automatic control) does not aways give positive results. With consideration of climate features of the region and pecularities of the buildings we worked out system which helps to maintain stable microclimate, special attention to thermal inertia of walls included. This decision will give an opportunity to reduce a load on heating system at any rate to 15-20%. It will also give the chance for adiabatic humidity control in winter which is nessessary for the humidity control. Besides, it will secure periodical air cooling (with dehumidification and natural cooling accumulators if nessessary).

Analysis proves this decision to be sufficiently reliable for the purposes of keeping microclimate parameters. Primary price of the system is about 1,5 times lower than of full air conditioning. Besides, this system while in operation, will give about 30 percent economy of energy resourses. Today such system works in the Russian Museum.

INTRODUCTION

North-West region of Russia occupies huge territory from Arhangelsk to Vologda, Pskov, Novgorod and St Petersburg. Great quantity of museums, churches, palaces, isolated houses, monasteries and fortresses are concentrated in this region. All these buildings were constructed from XII to XIX centuries. Outstanding architects of Russia and Western Europea took part in construction of these buildings. Overwhelming majority of them is of great historical and architectural value. Most part of these historical buildings house different kinds of museums. (Disposition of the museums, churches etc see on table 1).

Many museums are situated within St Petersburg and its suburbs. These are: picture galleries, museum appartments, historic-ethnographic, nature, theatrical, literary, military-historical etc. It is the place of disposition of the world-wide wellknown museums - State Hermitage, State Russian Museum, the palace-museums at Peterhoff, Pushkin, Pavlovsk. Museum's complexes at Novgorod and Pskov are unique as well. The buildings which house the museums at present were constructed for has been other purpeses, and their characteristics do not correspond with the disposition and conservation of museum collections.

Table 1. Museum, churches and old buildings of North-West region of Russia

A. Major centers		
Saint Petersburg	Sortavala	Valaam
Pskov	Viborg	Kondopoga
Novgorod	Petrozavodsk	Kem
Vologda	Kigi	Arhangelsk
Tihvin	Velikii Ustug	Izvara
Lodejnoe Pole	Poporojie	Kirillov
B. Suburbs of St.Petersurg		
Peterhoff	Koporjie	Ropsha
Strelna	Starajia Ladoga	Roshdestveno
Lomonosov	Hatchina	Oreshek
Zelenets	Pavlovsk	Ivangorod
		Priozersk

For this region cold climate is a common characteristic. Duration of winter time (heating season) here is 6,5-7,5 months. Besides, there is shortage of electric and heating energy in the central districts in St Petersburg, Pskov, Novgorod, Vologda. Electric and heat supply in the out-of-town palaces is not sufficient. It is the fundamental reason of insufficient engineering equipment of the museums. All these above mentioned factors stress the actuality of engineering equipment in museums of the North-West region of Russia.

Due to the works of G.Thomson, N.Stolow, T.Pedfild, N.Richard, etc [1-9] foundations for working out of the programme for long-term storage of exhibits of the museums' collections and buildings' interiors were laid. For these specialists the main object of investigation is temperature and relative humidity (RH) of the indoor air for the hygroscopic and nonhygroscopic materials in the museums. Different authors gave the safe and optimum conditions for conservation of the exhibits (temperature and RH). See tables 2 and 3. Temperature and RH for the hygroscopic exhibit must be: t = 18-25°C, RH = 45-55%. RH must be less than 40% for the numismatics, objects of metals and alloys.

Table 2. Conditions of indoor air in museums: recommendations in different countries

	Picture-galleries		Ethnographical museums	
Country	Temperature °C	RH %	Temperature °C	RH %
Russia	18-25	50-65	18-25	50-60
Japan	16-24	55-60	16-24	50-63
USA	16-24	40-55	16-24	40-60

Table 3. Requirements on relative humidity for safety of materials

Material	Russia	Japan	USA
Paper	50-60	50-63	30-50
Metals	50	40-63	15-40
Painting	40-60	55-60	40-55

METHOD

Investigations of specialists of the Russian Restoration Research Institute were concentrated on the studies of "dynamic" temperature and RH. The influence of a hysteresis for equilibrium moisture was studied. Safety range fluctuations of the temperture and RH during twenty-four hours or lesser time periods was determinated for the different hygroscopic materials (temperature = 4-6°C, RH = 5-12%). Majority of the specialists, working in this field, concentrate their attention especialy on individual behaviour of each collection, or , in many cases even of one of its items under the influence of the environmental conditions. Sometimes about creating individual conditions for the each art exhibit are discussed The process of adaptation to the environmental conditions influence the state of the exhibits. Material of the object, technology of its making and previous conditions of keeping determinate the choice of optimum temperature and RH.

R.Thomson and N.Stolow [7,8] give recomendations as to the temperature and RH for objects of different materials (metals, wood, leather, fabrics etc). In our opinion, the regional codes for temperature and RH must be treated for different museums (art galleries, frescos and icon museums, ethnografical, military, natural-scientific museums, museums with paper exhibits, complex museums) on the data-analisis and generalization of the works of specialists from West Europe, USA, Canada and Russia on regional basis.

So far we considered only the temperature and RH. But museums' indoor air quality is created also by air rate and temperature and moisture regime of the buildings' envelopes. Today such kind of research practically is not being done. In several publications we can find that velocity of air in the rooms must be 0,2-0,3 m/s. But there is no data to prove the figures.

We tried to qualitatively estimate the influence of air velocity on an exhibits (This work can be done later). In process were examined the forms of the aerodynamic influence of the air jets upon the museums objects. Influence upon museum objects of the turbulent jets may lead to the mechanical stresses, shift and accumulation of dust, filtration; it can also pack with dust the pores of materials, abrazing action, when the room's air has hard particles; it can lead also to reinforsement of heat-mass exchange of the air with museum obects.

Picture of the distribution the air streams in the museum rooms is complicated. It conists of the inflowing jets of HVAC-systems, the ascenting covection streams in the zone of the heating units, the descenting air streams along the cold building envelops and in the zones the lighting fenestrations. In our opinion, working out of the recomendations about the air velocity in the museum rooms has to be intensified.

In series of the museums the location of art and grafic objects is on the exterior envelops of the buildings. Under the conclutions of the severe climate (an example outside calculating temperature may be from -25°C to -30°C, in North-West region of Russia), this results in extencive cooling of the inside surface of the outside walls. In series of the cases this cooling is

accompanied with condensation of the moisture on the interior surface of these envelopes. Tretjakov Gallery and Art Museum in Vienna are faced with such problem. Problems of the temperatural-moisture conditions of outside envelopes in museums also need additional investigation.

Almost all the museums of North-West region of Russia are equipped only with the heating systems of the different types. Water heating systems with radiator's and convector's units are used in the most cases. The air heating systems are used only in somes museum buildings. In all the region only some rooms of State Hermitage are equiped with the air conditioning systems. But these systems at present are not operating. System of winter air conditioning is tested in State Russian Museum. Designing of the air conditioning systems is carried out in several buildings of the State Russian Museum.

RESULTS AND DISCUSSION

The question may arise: what is the real state of indoor air quality in the museums of the region? We have done the analisys of the results of the natural observation in some museums and libraries of the St Petersburg in winter period. Air temperature in the most of these buildings is 14-23°C, which testifies as unsatisfactory work of the heating systems and to the absence of facilities for the individual or group control in the field of the heat output of the heating units.

Moisture content of indoor air must be more than 4 g/kg for maintanance; RH more than 40% when air temperature is 18°C. (Significants of moisture content in some of museum's buildings of St.Petersurg see in table 4.) Indoor air moisture content in the majority of the museum buildings is less than 4 g/kg and RH is 20-35 %.

In autumn and in spring when heating systems are not working, the temperature in the museums is rather low (14-16°C). However RH in spite of it is 65-75%. Absence of the heating does not allow to provide requered temperature and RH of the air in museum rooms. In summer outdoor air may have to be cooled. In addition heating-up of the indoor air to 28-32°C may also take place during summer days in rooms equiped with upper fenestrations. It is impossible therefore to maintain the nesessary parameters of indoor air through all the seasons with the help of heating systems only. Complex HVAC-systems are required for these purposes.

Table 4. Humidity in museums and libraries during heating period in St Petersburg

Name of Structure	Moisture content, January-February, g/kg
Benua Building (State Russian Museum)	2,4-3,5
Mihailovsky Palace (State Russian Museum)	3,5-5,5
Libraries	3,0-4,0
Winter Palace (State Hermitage)	3,0-6,5
Central Exhibition Hall	2,0-2,5
Kazanski Cathedral	4,5-6,0
Marble Palace	2,5-5,0

Air velocity has unsatisfactory values in the museum buildings. Often in exhibition zone of thesebuildings air velocity is about 0,7-1,5 m/s is when hot air heating and pressure airing are

used. Air velocity values are 0,3-1,2 m/s in the zones of the ascenting and descenting streams. Art and graphic exhibits are situated in these zones.

All requirements to indoor air of the museum rooms have to be relevant only within the limits of exhibit's zone. Demands to maintain the designing parameters of indoor air in all volume of the room at the height of 2 m has no ground. This requirement has been assumed when the air conditioning systems was designed for the Tretjakov Gallery in Moskow. In the zone of occupance must be maintained hygienic parameters of the air.

We summarized the experience of the engineering equipment in the museums at Munich, Dresden, Ottawa, Helsinki, Budapest, Cologne. Heating systems, ventilating systems with the partial treatment of the air, and air conditioning systems operate in these museums. Experience of these museums is very impotant for Russian practice.

Perfection of indoor air quality in the museums can progress by two routes. They are:
- modernization of the building itself and its elements;
- creation of the modern systems for maintainance of nesessary conditions of the indoor air throughout the year.

The certain route must be taken with due regard for historical, artistic and constructive featuries of the building, when it is reconstructed for new functional purposes. Possibilities for modern engineering equipment must be estimated along with the decision of these problems. It is necessary to keep in mind: building can live hundreds of years while life of engineering equipment is extremely short.

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