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INDOOR ENVIRONMENT IN THE MUSEUM BUILDINGS: EXPERIMENTAL MEASUREMENTS IN THE NATIONAL HISTORICAL MUSEUM
MJEDISI I BRENDSHËM NË GODINAT E MUZEVE: MATJET EKSPERIMENTALE NË MUZEUN HISTORIK KOMBËTAR, TIRANË

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PERMBLEDHJE

Muzeu si ndërtesë quhet shpesh dhe "objekti më i rëndësishëm i koleksionit" meqenëse shërben si një mbështjellje amortizuese ndaj kushteve klimatike të jashtme. Godina e MHK në Tiranë është përfaqësuese e ndërtesave të reja të muzeve, prandaj është konsideruar si një rast i përshtatshëm për t'i studiuar kushtet mikroklimaterike. Ky punim prezanton rezultatet e një fushate monitoruese me fokus parametrat termo-higrometrikë të mjedisit të brendshëm të MHK. Qëllimi i këtij studimi është së pari të vlerësojë situatën ekzistuese, të krahasojë rezultatet me parametrat e rekomanduar dhe të analizojë arsyet e kësaj situate. Të dhënat e studimit do të shërbejnë për ndërhyrjet e mëvonshme rikonstruktuese në ndërtesë me qëllim përmirësimin e parametrave klimaterikë dhe të eficensës energjetike të ndërtesës. Studimi në MHK mund të shërbejë si model për të gjithë ndërtesat e muzeve në Shqipëri.
Fjalët kyçe: ndërtesa e muzeut, konservimi i veprave të artit, parametrat termo-higrometrikë, Data-logger.

SUMMARY

The museum as a building is often defined as "the most important collection object" since it serves as a buffering envelope to external climate conditions. The national historical museum (NHM) in Tirana is the representation of new museum buildings in Albania; therefore it is considered a proper case to observe and examine the indoor microclimatic conditions. This article presents the results of a monitoring campaign focused on the thermal and hygrometric features of the indoor air quality. The aim of this study is to evaluate the existing situation, to compare results with the recommended parameters and to analyze the reasons of these situations. The data of this study will serve for future reconstruction interventions of the building aiming to improve the indoor climacteric parameters and the building efficiency. The study carried out in NHM can serve as an example for the museum buildings in Albania.
Key words: Museum building, cultural heritage conservation, Thermo-hygrometric parameters, Data-logger

1.INTRODUCTION

Museums represent our cultural heritage and are buildings of great importance. Actually, they are very particular buildings, as they are supposed to preserve important and in many cases unique, cultural heritage objects from outdoor climatic conditions. The objects exposed in the museums are made of a variety materials, from stone to marble, wood, textiles and so on, and each of them require different microclimatic conditions to be preserved properly.

In our country there are two museum building typologies; building designed to be museums and old buildings used as museums (i.e. traditional houses, historical buildings, or previous churches). This article focuses on the first typology considering as a case study the building of National Historical Museum in Tirana (NHM). It is chosen as a sample because it is the most important building of this typology [Adhami 2001]. New museum buildings in our country are very rarely energy efficient and often provide dissatisfactory comfort conditions. Our new museum buildings are constructed after the 80's, and in some of them the indoor environment conditions were established only by heating or by HVAC (Heating, ventilation and air conditioning) systems. Actually all these systems are out of use and the indoor situation is not monitored anymore [Stamati 2004]. Since their construction very few interventions for maintaining the buildings of museums have been made. Considering this situation, the study aims to know and analyze the NHM building indoor conditions focused to the thermal and hygrometric parameters (Temperature and Air relative humidity). Both temperature (*T*) and relative humidity (*RH*) are key control variables to ensure the conservation of the objects of cultural heritage. The variations of *T* and *RH* produce dimensional changes which may lead to high levels of stress and mechanical damage. Furthermore, too high or too low RH levels represent rapidly growing risk of various types, such as a biological attack or low humidity desiccation and fracture of materials [Camuffo 1998]. The survey results will serve as a base for future building interventions in order to improve indoor hygrometric parameters and museum building efficiency according to recommended standards.

2.MATERIAL AND METHODS

2.1The museum building (NHM)

The National Historical Museum building is situated in the center of the city. Constructed on the western part of "Skanderbeg" square it is one of most important architectonic buildings playing a special role on the city urban shape. The building was completed in 1981. It occupies a total construction area of 27,000 m2, a surface exposure of 18,000 m2 and a total construction volume of 81,000 m3 [Adhami 2001]. It is a three storey building, square shaped with an opened yard in the middle. Three parts of the volume are exhibition halls and one is used as museum administrative offices. NHM includes in his fund 3600 Albanian cultural heritage objects exposed in different exhibition areas according to the historical periods. A heating, ventilation and air-conditioning system was operational throughout the building but it is out of use since the 90's [Stamati 2004]. Today the microclimate of the building is influenced by outdoor weather conditions due to the exchange rate between indoor and outdoor.

2.2Environmental monitoring

2.2.1 Climate Characteristics of Tirana city

The climate of Tirana is part of the Mediterranean field –regional climate of Albania. It is characterized by mild and wet winters as well as hot and dry summers. The average annual temperature of the air goes from 15.2 ^{o}C (90 m height) up to 7^{o}C (1612 m height).

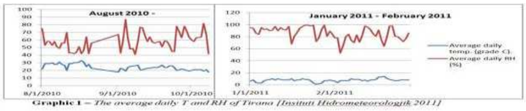
The hottest months of the year are July and August and the average temperature of these months is 24.9 ^{o}C, while the coldest one is January with an average of 4.7^{o}C. The average of the maximum temperatures in July is 30.7^{o}C while the minimum average is 1.8^{o}C in January. *RH* is relatively high in Tirana, with an annual average of 70% [Akademia e Shkencave 1975, Insituti Hidrometeorologjik 2011].

The values of T and RH of Tirana climate for the period of August 2010 to February 2011 are reflected in the graphic 1.

2.2.2 The indoor of NHM microclimate

The indoor microclimate is monitored from August 2010 to February 2011 within a campaign of 11 months. The parameters analyzed (during day and night) were air temperature (*T*) and air relative humidity (*RH*). The used device for measuring T and RH is a data-logger.

The Hobo U 12 T/RH/ 2 External Data-Logger is used. It is a four-channel logger with 12 –bit resolution and can record up to 43,000 measurements. The logger uses a direct USB interface for launching and data readout by a computer. The data reading is enabled by special software. Measurement of *T* and *RH* were sampled every 15 minutes.



Graphic 1 – *The average daily T and RH of Tirana [Instituti Hidrometeorologjik 2011]*

The museum building is quite large and such data-loggers were not enough to be placed in its all environments. Therefore, some criteria were fixed in collaboration with the staff of the NHM in order to select the data – logger positions. This place had to be:

-near the areas with high flux of movements
-in areas which are problematic regarding humidity
-situated not far from the windows
-where important objects were exposed
-the museum warehouses where heritage objects are preserved

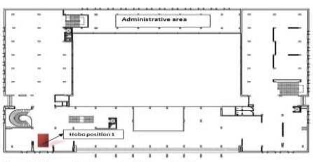


Figure 1: Museum first floor plan, Hobo position 1

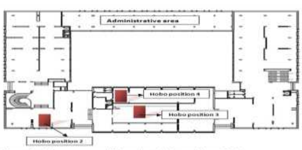
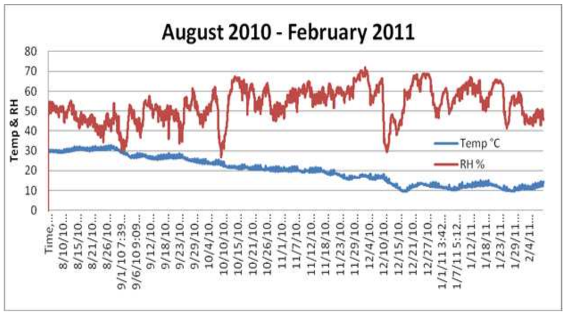


Figure 2: Museum second floor plan, Hobo position 2,3,4

According to these criteria four places were selected.

1.First floor (Fig. 1) – the measuring device was placed near the window (Hobo position 1) which is the most exposed part to the outdoor climate and located in front of the stairs.
2.Second floor (Fig. 2) – the measuring device was placed on the same position as in the first floor. (Hobo position 2).
3.Icon room (Fig. 2) - it is an important exhibition room where painted wood panels are exposed. They are very sensitive to thermo-hygrometric conditions. (Hobo position 3).
4.The museum warehouse (Fig. 2) – The device was placed according to staff suggestion. (Hobo position 4).



Graphic 2. Plots of indoor RH and T for the first floor

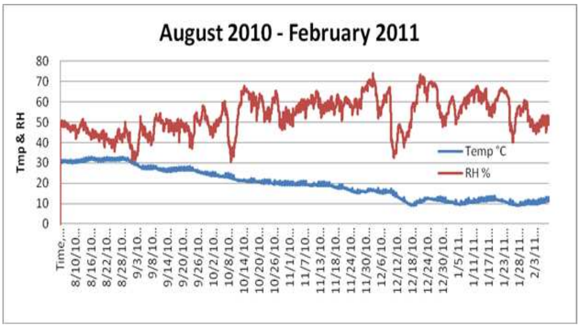
3.RESULTS AND DISCUSSIONS

The environment parameters *T* and *RH* were monitored during the period August 2010-February 2011. In order to understand variability of *RH* and *T*, the optimum *RH* set-point is specified within 50-60% range and optimal Temperature within 19-24 ^{o}C [Thomson 1986].

Graphic 2 **-** *shows plots of indoor RH (red line) and T (blue line) for the first floor.*

The average of *RH* measured from August 2010 to February 2011 is 53.6%. The graphic shows an increase of RH in winter up to 72% (max value) and a decrease in summer down to 26.9% (min value). The max and min temperature values recorded are T_{max} = 32.8 ^{o}C. T_{min} = 9.4 ^{o}C. The indoor short-term (day-night) RH fluctuations are more sensitive during the winter period. The literature recommended short-term fluctuation is ±5% [Thomson 1986].

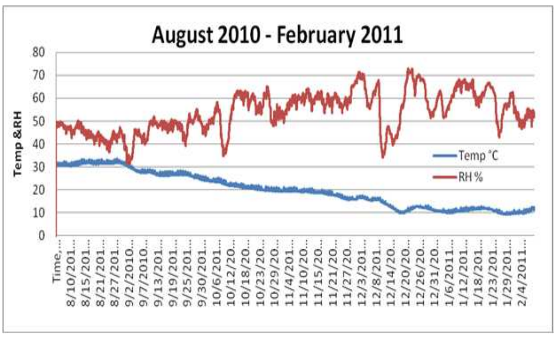
The measurements regularly show that these fluctuations are up to ±5%, the registered max. value is 30%.



Graphic 3. Plots of indoor RH and T for the second floor

Graphic 3 *- shows plots of indoor RH and T for the second floor.*

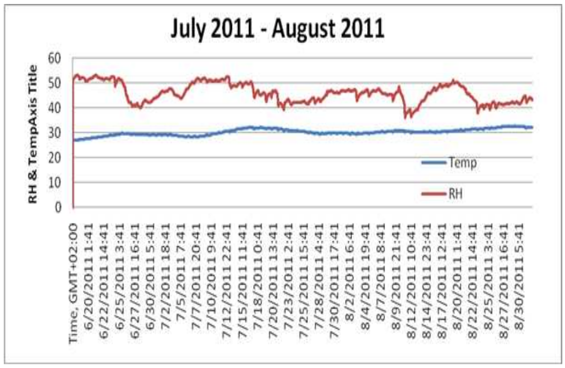
The RH average of the monitored period is 53.7%. The graphic shows an increase of RH in winter up to74% (max value) and a decrease in summer down to 30% (min value). The max and min temperature values recorded are T_{max} = 33 ^{o}C. T_{min} = 8.8 ^{o}C. The short-term *RH* fluctuations are more sensitive during the winter period. The measurements show short-term RH fluctuations up to 28%.



Graphic 4. Plots of indoor RH and T for the icon room

Graphic 4 *- shows plots of indoor RH and T for the icon room.*

The RH average of monitored period is 53.9%. The graphic shows an increase of RH in winter up to72% (max value) and a decrease in summer down to 31% (min value). The max and min temperature values recorded are T_{max} = 33.5 ^{o}C. T_{min} = 9.2 ^{o}C. The short-term RH fluctuations are more sensitive during the winter period. The measurements show short-term fluctuations up to 26%.



Graphic 5. *Plots of indoor RH and T for the museum warehouse*

Graphic 5 *- shows plots of indoor RH and T for the museum warehouse.*

It is important to note that the period of measurements is different compared to the other ones. It is from July 2011 to August 2011. According to the graphic, there are fewer short-term fluctuations thus showing a stable situation but the thermo-hygrometric measurements show high values of T and low ones of RH. The data are: T_{max} = 32.6^{o}C; T_{min} = 26.9 ^{o}C; RH_{max} = 53.2%; RH_{min} = 35.9% and *RH* average 46%. The measurements show short-term fluctuations up to 10%. The min and max values of *T* and *RH* are reflected in the Tab.1 according to the measurements performed from August 2010 to February 2011; only the warehouse is monitored in a different period (July 2011 – August 2011) and it is still under monitoring.

The analysis of the graphics show that the three environments (First & second floor, icon room) demonstrate similar microclimatic conditions regarding thermo-hygrometric parameters. The study shows that the upper level of RH is not as dangerous as the lower level. The minimum RH values registered in all environments are lower (Tab. 1) than the safety limit 40-70% according to Michalski [Michalski 1993].

Areas	T_{max} [°C]	T_{min} [°C]	RH_{max} [%]	RH_{min} [%]	$RH_{average}$ [%]	Fluctuations max value [%]
First floor	32.8	9.4	72	26.9	53.6	30
Second floor	33	8.8	74	30	53.7	28
Icon room	33.5	9.2	72	31	53.9	26
Warehouse*	32.6*	26.9*	53.2*	35.9*	46*	10*

Tab. 1. Min & Max values for T and RH, RH Average and Fluctuations (* - values are not measured at the same period as the other areas in this table)

The measured temperatures (Tab.1) are considered as too cold and too hot for museum environments. The *RH* average for the monitoring period is around 53% for three facilities. It is considered that the fluctuations near the *RH* average (53%) assume fewer damages than the lower or higher ones. The graphics show that the short-term *RH* fluctuations are more than ±5% during most of all the days by reaching max. level of 30%. Several small differences are evident while comparing four environments. The values of *T* and *RH* registered show that the second floor is more influenced by the outdoor climate than the other ones. The icon room has no window; it is surrounded only by interior walls, thus less influenced by the outdoor climate but sensitive to the flux of the visitors since it is small, closed and unventilated. The data of the Tab. 1 show that the microclimate in this room is not satisfactory as well.

4.CONCLUSIONS

In the National Historical Museum the thermo - hygrometric parameters have not been measured since 1990. Before 90's the air conditioning system was functioning. The existing HVAC system is out of use because using it is costly. After the 90's objects exposed have been shifted from one controlled microclimate to another uncontrolled, and the influence is evident mostly to the wooden panel paintings (cracking, laceration, deformations). This article shows that today the indoor microclimate is mostly influenced by the outdoor climate (graphic 1) and the parameters are not satisfactory. The combined *RH* and temperature graphs show values which are over and under recommended ones. Changes of the indoor *RH* (seasonal and short-term fluctuations) induce changes in the equilibrium moisture content as the organic materials absorb and release moisture to adapt to the continually changing environmental thermo-hygrometric parameters. The low registered *RH* levels causes the desiccation and fracture of different materials (wood, paper, textiles, etc). The indoor parameters should continue to be monitored since 11 months is an insufficient period to draw long term conclusions. This will help to understand the ongoing situation and to have it under control.

The reported values shows clearly what the building itself can do and it is strongly recommended to take into account the existing buildings' efficiency even if it is not satisfactory. It is necessary to apply the thermal insulation to the surrounding walls, roof and placing thermal windows in order to reach better conservation standards. A combination of passive and mechanical system for HVAC is strongly advised. The building needs very prudent interventions because wrong ones might cause more damage than today situation.

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