TRENDS OF ENVIRONMENTAL TECHNOLOGY IN ART MUSEUMS: OBSERVATIONS ON HOW NATIONAL MUSEUM OF FINE ARTS IN TIRANA USES MICROCLIMATE TO CONSERVE DISTINCTIVE ARTIFACTS.

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Approval sheet of the Thesis

This is to certify that we have read this thesis entitled **"Trends of Environmental Technology in Art Museums: Observations on how National Museum of Fine Arts in Tirana uses microclimate to conserve distinctive artifacts"** and that in our opinion it is fully adequate, in scope and quality, as a thesis forthe degree of Master of Science.

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ABSTRACT

TRENDS OF ENVIRONMENTAL TECHNOLOGY IN ART MUSEUMS: OBSERVATIONS ON HOW NATIONAL MUSEUM OF FINE ARTS IN TIRANA USES MICROCLIMATE TO CONSERVE DISTINCTIVE ARTIFACTS.

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Using a series of data collected from the most recognizable museums of past and present, also illustrating some of the concerns of visitors and curators who have a non-fictional connection to art museums – as well as a preliminary bibliography – this research work, makes a prominent effort to distinguish an overview of the space occupied by the museum today in new environmental technologies. This researching aims a clear monitoring of natural parameters and the way these resources are used to conserve the values of the architecture of the twenty-first century that will resist different generations.

However, very important is a design estimation created after the monitoring of the National Museum of Fine Arts in Tirana, a model of today's technological and environmental development and the correct determination of the place that museum should occupy in the future of Albanian art and the conservation of its artifacts.

This research will testify how sustainable development is at the core of environmental technology by adopting practices that fuel economic development by avoiding the depletion of natural resources and further polluting always with the primer aim to save the artifacts.

In short, it must create a connection to artistic values and scientific control and make profit of both. In order to help the reader to understand the value of nature and its resources in tangible and intangible feelings and experiences like the one in a museum, this research and later the design estimation, will distinguish the importance of preservation of artistic values in modern times.

Keywords: *Museum Architecture; Environmental technology; Environmental monitoring; Renewability, Conservation; Natural resources; Microclimate; Temperature; Relative Humidity.*

ABSTRAKT

TRENDET E TEKNOLOGJISË MJEDISORE NË MUZETË E ARTIT: VËZHGIME SESI MUZEU KOMBËTAR I ARTEVE TË BUKURA NË TIRANË PËRDOR MIKROKLIMËN PËR TË RUAJTUR ARTIFAKTE TË VEÇANTA.

Avdyli, Servio

Master Shkencor, Departmenti i Arkitekturës

Udhëheqësi: M.Sc. Julian Beqiri

Duke përdorur një sërë të dhënash të mbledhura nga muzetë më të njohur të së kaluarës dhe të tashmes, duke ilustruar gjithashtu disa nga shqetësimet e vizitorëve dhe kuratorëve që kanë një lidhje jo-imagjinare me muzetë e artit – si dhe një bibliografi paraprake – kjo punë kërkimore, bën një përpjekje të spikatur për të pasqyruar hapësirën e zënë nga muzeu sot në teknologjitë e reja mjedisore. Ky hulumtim synon një monitorim të qartë të parametrave natyrorë dhe mënyrën se si këto burime përdoren për të ruajtur vlerat e arkitekturës së shekullit njëzet e një që do t'i rezistojë brezave të ndryshëm.

Sidoqoftë, shumë i rëndësishëm është një vlerësim i projektimit krijuar pas monitorimit të Muzeut Kombëtar të Arteve të Bukura në Tiranë, një model i zhvillimit të sotëm teknologjik dhe mjedisor dhe përcaktimit të saktë të vendit që muzeu duhet të zërë në të ardhmen e artit shqiptar dhe konservimit të objekteve të tij.

Ky hulumtim do të dëshmojë se sa i qëndrueshëm është zhvillimi në thelbin e teknologjisë mjedisore duke miratuar praktika që nxisin zhvillimin ekonomik duke shmangur shterimin e burimeve natyrore dhe ndotjen e mëtejshme, me synimin kryesor për të shpëtuar artefaktet.

Me pak fjalë, ajo duhet të krijojë një lidhje me vlerat artistike dhe kontrollin shkencor dhe të përfitojë nga të dyja. Për të ndihmuar lexuesin të kuptojë vlerën e natyrës dhe burimet e saj në ndjenja dhe përvoja të prekshme dhe jo-materiale si ajo në një muze, ky hulumtim dhe më vonë vlerësimi i projektimit, do të dallojë rëndësinë e ruajtjes së vlerave artistike në kohët moderne.

Fjalët kyçe: *Arkitektura e muzeut; Teknologji mjedisore; Monitorimi i mjedisit; Ripërtëritshmëria, Ruajtja; Burime natyrore; Mikroklima; Temperatura; Lageshtia relative.*

The way to become renewable.

H, S, E, B

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INTRODUCTION

1.1 Art Museums and the attempts towards conservation

Museums and galleries constantly monitor the environment that artworks are stored, displayed and transported in to ensure they maintain the most suitable conditions for their ongoing preservation. They must be maintained with specific levels of lighting, temperature, and humidity to preserve artwork's inherent qualities and prevent deterioration. The monumental importance of artwork preservation has influenced museums to take incredibly cautious approaches to their internal systems. But it's no longer enough for museums to simply serve as monuments to preservation — they must now focus on conservation, as well.

Climate control, lighting, and security are just a few of the aspects that influence a museum's effectiveness and success. They also serve as major contributions to its environmental impact. Based on these facts and data that are reflected in different periods of time, art museums are constantly evolving with the development of technology that maintains the optimal relationship between art and microclimate.

The museum, as we all know, is a structure that commands authority due to the 'authentic' fragments that it houses. Understanding museum architecture entails understanding how it is produced in the historical context of institutions as well as how it relates to larger social forces. Museum architecture not only provides the material-built contexts within which museums exist, but it also adds meaning to the objects and interactions that take place in these "spaces of encounter" (Boast, 1991). Therefore, there is a connection that we must conceive while exploring the history and the social context of museums and also while working and creating space for new ways of Museum architecture. In this case by adapting environmental or renewable technology, as the power of the future but also as a necessity for the acts of preservation and conservation of the past.

Museums are in a unique position to contribute to the environmental movement through actions and through their roles as educational institutions. Brophy and Wylie who gathered many materials and wrote “The Green Museum: A Primer on Environmental Practice (2008)” show the reader that no matter what type of museum, whether a natural history museum, a children’s museum, or an art museum, acting in an environmentally stressed way is central to each institution’s mission, if only for the fact that it can save the institution money and provide a clean and safe environment for objects and visitors.

What this brings to the past is just translation of the meaning in cohesiveness and practicality. History can be achieved through architectural tools as well as a documented old book. Having to explore art by being inside an architecture that speaks to the environment with soft tones is also what our century must try to achieve. Adapting these terms or just giving new approaches to architecture will only make an effort to bring individuals near their history and educate masses while the museums earn or save, money or energy, and why not both.

1.2 Problem Statement

The close connection of architecture with what it causes in the environment is one of the biggest challenges of policies in evolution. The massive museal buildings which usually stand in the city centers as attractions of cultural tourism – but also as very good landmarks of contemporary architecture – are more and more in the widespread attention for the innovations they bring in the technology that is used and the spaces they leave to the environment to recover what it has lost.

However, not all cultural spaces, such as Art Museums, are adapted to cost-efficiency policies and the optimal use of natural resources without damaging it. One of the basic concerns of these museums is to use these resources in order to be in optimal conditions to preserve and maintain the artworks they display.

What concerns all scholars today is the fact that the longevity of inherited objects of historical and cultural importance has a trend that goes towards their degradation or complete destruction. Currently, there is no way to stop this trend. But until now, science has only succeeded in slowing degradation rates to a bare minimum.

The longevity of artifacts is influenced by a variety of factors and issues, with the museum's conservation environment being one of the most important. Studying and comprehending the critical role of the conservation environment for artifacts in museums has been a complicated process that has resulted in significant material heritage losses.

The role of the environment, which was only recently understood and even more recently scientifically studied, encompasses a wide range of disciplines. Many environmental parameters are affected by the multitude of factors that affect the museum environment, the most important of which are the thermo-hygrometric parameters: Relative Humidity (RH) and Air Temperature (T). Deformations, cracks, discoloration, and rust of constituent materials of artifacts are caused by these factors.

Meanwhile, the two most important factors to improve these environmental parameters are indoor climate buildings and ancillary systems. But currently, the buildings of art museums in our country provide these parameters in an uncontrolled manner. Only a few of these structures were built in a controlled climate. Installing an HVAC system is expensive not only in terms of the initial investment, but also in terms of the ongoing costs, as the system must operate without interruption in order to maintain constant temperatures. For this reason, these systems were only installed in two museums. When radiator systems were used later on, they caused immediate deformation of works of art, as was the case at National Museum of Fine Arts in Tirana.

After 1990, the museum faced high operating costs for building air conditioning and maintenance systems. It did not have the funds to do the cyclic maintenance work on the building for almost a decade (until the early 2000s). This situation has not changed since then. As a result, the museum's building has an uncontrolled and unmonitored internal climate, posing a threat to our historical and cultural heritage. This is a hypothesis that has already been proven, but no specialist in our country can say: How are these values? What parameters does the museum building provide, and what role does it play in dampening the external climate? What is the risk level? What is going on with the artifacts on display in the museum, and how far away from fossilization are they?

Given this seemingly disturbing reality, the study aims to answer some questions which we set up at the beginning of the research process and which I am summarizing as follows:

– What are the contemporary architects proposing in order to create a bridge between technology and architecture for Art Museums to respect the special needs of artworks in order for them to be well preserved and represent their values at different times?

– How is the development of environmental technology affecting the “boldness” of Museum architecture and what is changing in respect of that?

– When and in what circumstances will the artists and curators be given the opportunity to show their works in environmentally “old” museums without fearing to destroy the content, distract the context and not being assured that their work will live forever?

– How are the climatic parameters presented in the museum buildings in our country? Do they meet the recommended scientific standards for the preservation of historical and cultural heritage?

1.3 Thesis Objectives

This study addresses the role of the conservation environment in museum buildings and the parameters of natural factors that affect this functioning. By evaluating the parameters of the indoor climate (T and RH) in the building of the Museum of Fine Arts, it is easier to analyze their impact on historical and cultural heritage sites and create the opportunity through other models from Europe, to identify the roads to be followed on improving these parameters.

The study also addresses the problem from the museum's point of view as a building with a specific architecture, its climate as a controllable and ever-evolving process, and the impact of climatic parameters on artifacts and their preservation throughout history.

In this way, since the beginning of this study, these objectives have been identified as indisputable and unchangeable in the process towards the finalization of this study;

– To bring to attention the museum, as the temple of history and culture, art and the genesis of contemporary art preserved in centuries.

– To emphasize the need of museums to preserve the work in new and more technological conditions, elaborating the growing trend from history to what modern architecture proposes today.

– To explore the best cases of renewable museums in architecture and to propose methods of how to remodel architecture that proposes new and environment-friendly ways to preserve the work of art and keep its values alive for centuries.

– To analyze the parameters of a museum in normal conditions and to adapt to them the new and renewable standards of making architecture under the pressure of natural resources and new technologies.

1.4 Methodology

In the twenty-first century, it is perhaps easier to understand that art museums are facing contextual difficulties in city centers that are regenerating new forms and policies of urban development. Such concerns stem from being unheard. Recent political leaderships are failing to manage decision-making by listening, so they go straight into action.

To give it an observable approach but also seeing it as a practical and fruitful human resource aid in my scientific study – trying to listen has been factorial.

The aim of this scientific work, in the researching is partly oriented towards practices in our country, but also a good part of the case studies, which are still helpful in conventional factors, will be taken mostly from what Europe proposes today.

A key role in the methods of the study have played the subversive reviews on how the museums of the past were and what should we do to include the much-talked-about ‘environmental technology’ control. In respect of that, the historical and contextual data collected from the National Museum of Fine Arts in Tirana, has been constituently analyzed.

All factual data obtained from The Museum have been confronted with the specific cases of this work, in the architecture of museums in different cultures. The evaluation of this data was processed to fit the adaptive recommendations that will accompany this research.

This strong collection of materials, also obtained from bibliography, will be put in use for this estimation of parameters which will exemplify The Museum as an object in ideal atmospheric conditions with all standard regulations that must create a connection to natural resources and be friendly to the environment without losing its meaning and the certainty in the architectural values.

What's more important is the strict monitoring conducted at the National Museum of Fine Arts in Tirana, which is the only building of arts that has proven itself through history. After the long process of measurements with a specific tool (model: testo 605i) and calculations – as well as graphical estimation of all data – they were later on compared with the normal parameters that a museum should have under specific climatic conditions.

A list of conclusions was formulated, and appropriate recommendations were put forward to correct any data that is not suitable for the museum environment or that can damage the artifacts and ways how microclimate is going to perform in terms of these changes.

CHAPTER 2

MUSEUM ARCHITECTURE AND THE IMPORTANCE OF HISTORY IN THE EVOLUTION OF TYPOLOGY

2.1 Art Museum and the unsolved definition

"…today there is apparently much confusion as to what a museum is or what it should be" (Colbert, 1961, p. 138).

Museums are not inclusive. They are places for preserving history, appreciating artistic icons, and recording the inventions of human science. As Salguero states: "Museums are political by their very nature and have always had an agenda. Because of the model they were founded on, they still reflect the dominant culture." (Saguero, 2020)

They are social spaces used by lots of different people in lots of different ways. Studying how use transforms or, to put it another way, produces museum architecture, is sometimes referred to as domestication. (Steets, 2015) Similarly, it has been found that the built, designed forms of museums and galleries are bound up in visitors' experiences in complex and significant ways; the evidence available suggest that as visitors move through museums, they map their experiences physically, as well as emotionally and imaginatively. (Bagnall, 2003)

The most influential 'put-in-practice' observation about museum as a concept is, arguably, Pierre Bourdieu and Alain Darbel's "The Love of Art" (1991). Bourdieu analyzed empirically the ways in which cultural institutions work to naturalize and legitimize the social order. It surveyed visitors to art museums across Europe and showed that museum attendance increased with higher levels of education and that museums were in fact "almost the exclusive domain of cultivated classes". (Bourdieu, Darbel, & Schnapper, 1991)

Museums' understanding of their role has shifted over the years: the traditional notion of a museum was as a center of scholarship and curatorial expertise but over time this has moved towards a more explicitly public-oriented role, helping people to learn about society, culture, history and science, and providing entertainment. (Travers, 2006) Bettina Messias Carbonell, in the introduction of her anthology of museums states that museums are both “(1) a literal gathering place for the reception of histories, memories, natures, nations, cultures, and audiences, and (2) a topos or more abstract mental gathering place for analytical and creative thinking about our encounters with such representations”. (Carbonell, 2012)

While for Luca Zevi the essence of the "museum" can be defined as collecting and preserving testimonies and displaying them to the public and scholars in order to increase knowledge of nature and the work of man (Zevi, 2003), other opinion comes from Glendinning who states: “Museum buildings are understood as a constitutive part of an active force in the ‘modern disease of individualism’, working against processes of community cohesion as a result of the ‘cult of individualism in architecture”. (Glendinning, 2010)

In the modern age, in addition to their original function as “cabinets of curiosities” demonstrating personal collections, the accepted meaning of architecture of museums can be regarded as an “artificial memory, a cultural archive” (Hein, 1998), which has to be created in the pursuit of “historical memories recording by books, pictures, and other historical documents” (Hein, 1998) for modern humans to define and better themselves and to appreciate the value of modern life.

2.2 Museum Architecture as a direct historical statement

“History consumed in museums is closer to what might be termed ‘public history’ than the history that circulates within the academy” (Alex Werner, 2008).

The word museum comes from the Greek “mouseion”, meaning shrine to the muses – the nine daughters of Mnemosyne and Zeus, each of whom rule over their own art or science: epic poetry, lyric poetry, sacred poetry, music, comedy, tragedy, dance, astronomy, and history.

In the ancient world was especially famous Mouseion of Alexandria, established by Ptolemaios Soter in the early 3rd century BC. It represented a "cultural institution" in which the material aspects of the heritage are preserved and culturally explained. (Lewis G. D., 2014) While the Latin meaning for this same notion is converted and has taken the meaning of a sacred temple of the muses, and gradually of a college or library (Lewis G. D., 2014).

During the Roman era, the word "museum" referred to "places of meditation and philosophical discourse." The word "Museum" was first used in Europe in the 15th century to describe Lorenzo de' Medici's works in Florence. (Manssour) He referred to a series of codes and works of art as “museums”, a term most evident in the 16th century (Alexander, 2007). From here, art was visible in all public places, but not in museums. In ancient Rome, the museum notion had the appearance of an open-air museum or a natural museum.

The concept of an institutional museum was formed in the 18th century with the purpose of preserving the collection and making it available to the public. During this period, the term "museum" is no longer related to content, but to the building itself. It refers to buildings that store and display cultural artifacts which are accessible to the public.

The first public museums, such as the Vatican Museum, the Louvre, the Hermitage, etc. were placed on the premises of luxury residences or royal palaces and are still admired as models of perfect museums. Our current concept for museum architecture is shaped by these models even though they were not designed to be such. In their beginnings, the galleries of the royal palaces were not built to exhibit collections, but to connect the extreme volumes of the complex.

2.2.1 Art Museums of 19th Century

The use of the exhibition rooms stems from the expansion of the collection and the need for new exhibition spaces. Gradually the connecting galleries of the royal palaces turned into spaces where artistic, cultural and historical heritage unfolded in a new form and concept (Giebelhausen, 2006).

A paradigm shift has occurred in the historical concept of museum, during the 19th and 20th century because of the revolutions took place around the world, in addition to the world wars. (Lewis G. , 2011) In this period, the terminology was further refined. As a result, the museum, as a dynamic concept, responds to societal changes and time constraints while maintaining its primary function: the preservation and conservation of cultural heritage objects displayed in these structures.

According to George E. Hein, the development of public museums in this period, can be divided into two stages. In the early stages of the 19th century, collections were focused on displays of “imperial conquests, exotic material, and treasures brought back to Europe by colonial administrations and private travelers or unearthed by increasingly popular excavations” (Hein, 1998, p. 3) and were only open to those who were “fortunate enough to be allowed to enter and observe the splendor of a nation's wealth” (Hein, 1998, p. 4).

Spatial organization of royal palaces with inner courtyards surrounded by colonnades, as well as their galleries with exhibition rooms, served as a model for the modern museum of the 19th century (Lewis G. D., 2014). The interpretation of the palace museum with a new social approach, created the forms of first of the typology of the museum, both in the architectural style and in the planimetric organization.

2.2.1.1 The British Museum

In the nineteenth century, museum construction in the United Kingdom was a direct result of war, colonialism, and missionary expeditions that returned with "exotic" objects.

Emily Duthie notes that: “In London, museums were built after successful colonial ventures with displays of empire and the hope that such displays, like the empire itself, would be a lasting achievement” (Duthie, 2011).

The museum was a powerful symbol of empire in the nineteenth century, and the world representations it offered were deeply imbued with British imperialism's culture. As many authors observe, it was an ‘imperial archive’ and ‘the most spectacular repository of the material culture of empire’ (Caygill, 1981, p. 66).

The British Museum considers itself first and foremost to be a global museum of material culture and art. It exhibits the types of collections that were acquired and donated during the 18th and early 19th centuries, as well as many of the key issues and objectives that shaped the early museum. As Duthie says: “The meaning of an object is inflected and even re-invented by the context in which it is displayed” (Duthie, 2011). In this way, the removal of objects by the British Museum from a ‘colonial periphery’ to an ‘imperial center’ changed the ways in which they were interpreted which also left a mark in history.

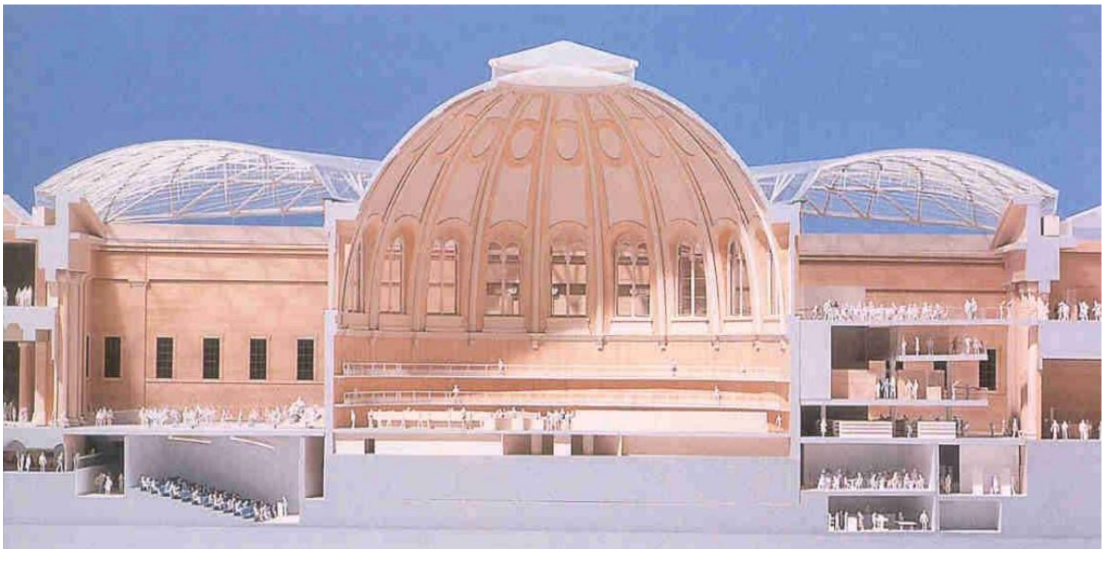

Figure 2. 1. The Great Court, The British Museum, Section (Foster, Sudjic, & De Grey, 2001)

A new generation of museums has been emphasized after this time by the architectural pioneers. Accordingly, designing a museum building has become a significant challenge for any architect who wishes to reflect the ideology of the time and be recognized as a step forward for any architectural school.

The "temple" museum and the "palace" established in 19th century were both condemned by the modernist avant-garde movement. The museum's architecture has to convey modernity's formal and ethical concepts, such as transparency, openness, space functionalism and universalism, technical accuracy, and the absence of conversation between the space and the artifacts on display.

2.2.2 The complexity of the modern museum

Museums designed by pioneers of modern architecture such as Le Corbusier, Frank Lloyd Wright, Mies van der Rohe and Louis Kahn showed that for the museum a new era had begun with radical changes. Corbusier proposed the museum of infinite growth (1923 and 1931) in the shape of a square spiral in which the movement took place around a continuous center, an idea which he implemented in 1951 at the Ahmedabad Museum in India. This typology of the museum designed by Corbusier is similarly elaborated through Wright withinside the Guggenheim Museum in New York in 1959. In this museum the motion of visitors, the exhibition and the perception of the complete museum changed into permeated through a specific approach. A spiral ramp descends the important atrium illuminated through a glass dome, thus turning into the middle of all motion and belief to exposure (Pfeiffer, 2001).

Vittorio M. Lampugnani defines the modern museum buildings of the late 20th century as "the seismograph of the architectural culture of the country they belong to" (Lampugnani & Sach, 1999). The medium of expressing architectural forms to adapt to the increasing functions and representative complexity of modern museums illustrates the evolution of architecture and the accelerating changes in the trends by using a specific architectural language to meet these requirements and determine the museum building and the art it contained as an aesthetic whole (Schneider, 1999).

The design of this new prototype is the result of two coexisting trends. The first trend follows the plan of Durand and his descendants, the most typical example is the Stirling State Gallery of James (1977-1983) (Francesco Dal Co, 1996), while the other trend is to bring solutions to the galleries in large-scale exhibitions. The most typical example is Neue Nationalgalerie designed by Mies van der Rohe (1962-1968), which inspired Renzo Piano and the Rogers Richard Pompidou Center in Paris (1971-77).

2.2.2.1 Mies’ Neue Nationalgalerie of Berlin

The history of the Neue Nationalgalerie is irrevocably linked to the political division of Germany and the city of Berlin as a result of World War II — and focusing on the early twentieth century, Neue Nationalgalerie became the house of modern art in Berlin. The collection includes a number of one-of-a-kind highlights of twentieth-century art. Cubism, Expressionism, the Bauhaus, and Surrealism are particularly well-represented and the museum's display space is almost entirely underground.

Figure 2. 2. Neue Nationalgalerie, Berlin. Main facade

Looking at the modern structure, which is made of glass and steel (except for the lower part), the connection to antique architecture is not obvious — yet it is. Mies' pavilion's functional elements, post and lintel, are closely related to ancient tradition, which was also used by 19th-century architects. The connection becomes clear when one considers Schinkel's Altes Museum as well as the Old National Gallery's neighboring structure (Staatliche Museen zu Berlin, 2016). The characteristics of the old temple, such as standing on a podium and columns supporting a roof, become clear.

2.2.3 The New Museum

The concept of the "new museum", first started in the year 1989 by Peter Eisenman and Frank Gehry, required that through a very articulated architecture to realize the presentation of the content as an integral part of the museum. While architects like Bernard Tschumi seek to realize the museum as an architectural sculpture (Lewis G. D., 2014). Museum buildings created by the architects mentioned above, have a powerful presence in the urban space where they are located, attract attention while often the exhibition curators emphasize that works of art have to struggle with the dominance of the building.

2.2.3.1 Frank Gehry and his Guggenhaim

The gleaming titanium-clad exterior is an intricate composition of daring curves, providing viewers with a new experience the moment they lay eyes on it. Despite the presence of a thirty-foot-high monumental sculpture of a spider right beside it on the riverbank, it is a vision that cannot be ignored. This work is a paradigm of the language used by Frank Gehry in his art: the free movement of forms, textures, experience, and humanity.

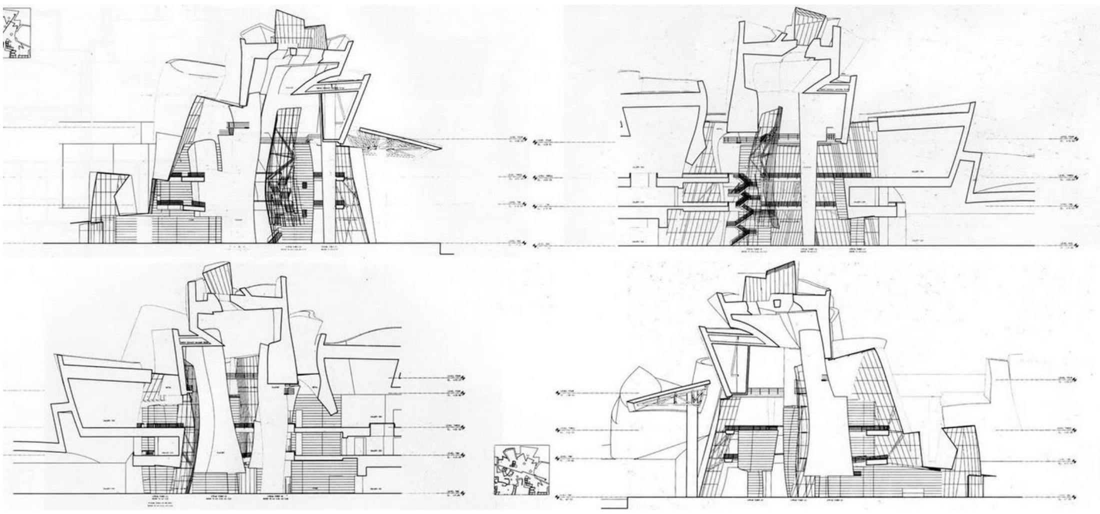

Figure 2. 3. Sections of Guggenheim Bilbao. Gehry Partners.

The Guggenheim Museum Bilbao building, designed by Canadian American architect Frank Gehry, is a stunning example of 20th-century architecture at its most innovative. With 24,000 m2, of which 9.000 are dedicated to exhibition space (Guggenheim Museum Bilbao by Frank Gehry: United the Critics, Academics, and the General public, n.d.), the Museum is an architectural landmark of bold arrangement and innovative design, creating a captivating backdrop for the art displayed in it.

This single work of art says a lot about the architect and his style. Frank Gehry's passion for treating architecture as a sculpture or a painting rather than fitting it into a box is evident in this project as well. Manifesting buildings that respond to time and the constantly changing world, and not allowing the past to burden the innovative ideas of the present, is accomplished by humanizing architecture and prioritizing people and their experiences. Building structures that are not faceless, but rather oozing with expression and character, challenging the sense of order, is a recurring theme in Frank Gehry's work. All of these characteristics are present at the Guggenheim Museum: asymmetry, exaggerated proportions, distorted organic forms, and unconventional materials.

2.3 Luca Zevi and the museal space

It is a peculiar feature of cultural heritage to manifest itself in space as a phenomenon of great diffusion and pervasiveness. Museum institutes that house collections from the surrounding area, regardless of legal affiliation or size, invariably serve as interpretation centers for the area itself.

Regardless of the value and rarity of the treasured heritage, these museums can provide critical support to any action modifying the structures and uses of the space, by providing elements of knowledge useful to support the pursuit or safeguard of the public interest for the protection of all the identity factors of the territory and the populations residing there, including the space (Zevi, 2003).

For extended safety reasons, the museum can also guarantee the carrying out of investigation, relief, research, documentation, prompt intervention, preventive conservation, and hospitalization activities in the presence of adequate human and instrumental resources, as well as any necessary authorizations.

As a result, it is clear that taking on space-related responsibilities is a choice rather than an obligation, even if it is strongly recommended that museums be adequately equipped to perform space-related functions suitable for locally facilitating the work of the bodies responsible for research, protection, enhancement, territorial planning, and teaching on the subject.

Each museum is required to declare its responsibilities and vocations in relation to the space to which it belongs and refers when indicating its purposes and characteristics (Zevi, 2003).

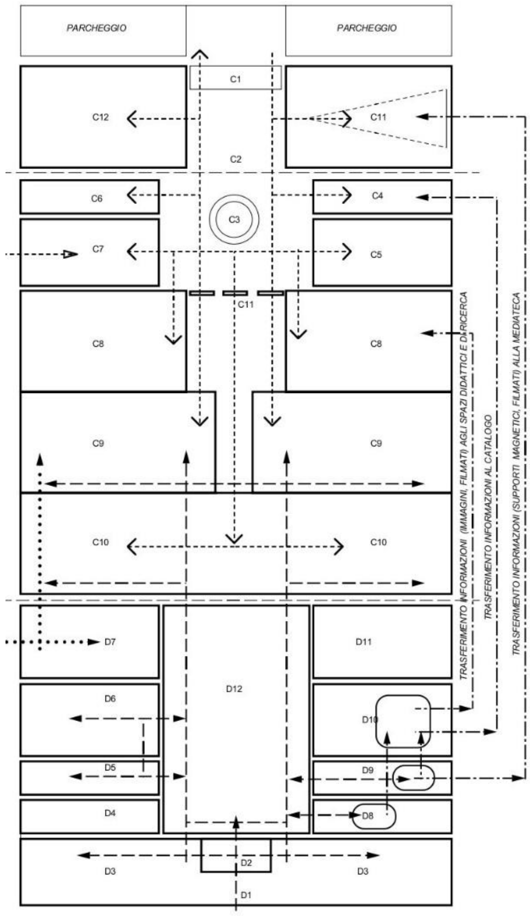

Figure 2. 4. Dimensional planimetric distribution scheme of a medium-large museum with the possible integration of complementary activities.

The development of an active space function must aim to implement and make accessible, in harmony with the museum regulations, documentary collections (if possessed) and databases relevant to the cultural heritage and landscape of the reference area (Zevi, 2003) and take place in a presentation aimed at providing the visitor with the most suitable reading keys for an understanding of the identity values of the space, also in a diachronic perspective and favoring development.

The exercise of an active role towards the space to which the museum belongs is configured as a subsidiary action towards the competent institutions, favoring the development of logics and system structures in the most appropriate ways and Zevi proposes some well-known schemes for the spatial organization of a universal museum that undergoes all the factorial needs of all the components.

Figure 2.4. shows the distribution of the activities of a medium-large museum and mutual relations, schematized in a dimensional graph. However, the different sectors of activities (deposit, exhibition spaces, activities optional complementary) not always are arranged on the same floor.

More often different functions *(each function for each space can be found at the Appendix 1, at the end of this research)* appear to be placed on different plans and, in the cases of larger dimensions, the same individual sectors may join on multiple floors. In such cases, for the transfer routes of the objects to be exhibited, they can use also lifting mechanisms (Zevi, 2003).

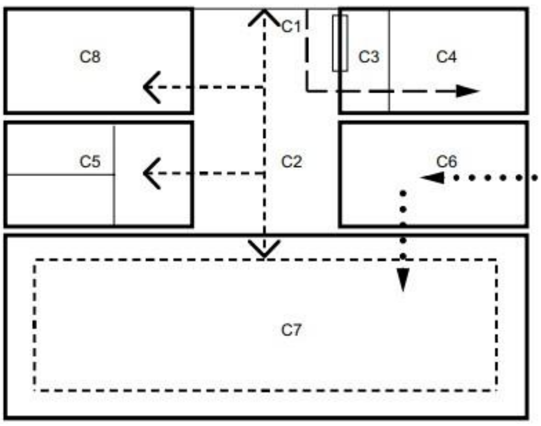

Figure 2. 5. Dimensional distribution scheme of a small museum.

In some cases, the restaurant services have a direct access also from outside the museum, in a way to allow the access outside the opening hours of the museum; In other cases, they are located inside the exhibition sector and are available only by visitors of the museum.

The exhibition spaces (palaces, galleries, etc.) are intended to set up and host temporary exhibitions of works of art from external collections (funds, collections, museums, etc.). Therefore, they do not involve the custody of reserves of works and related services (analysis and restoration laboratories). The presence of spaces for teaching and research is not even essential, given the absence of a resident collection of works. The spaces for complementary cultural activities - such as conference rooms, media room, library - can play a significant role in integration of cultural promotion driven by different "monsters" (Fig. 2.5) (Zevi, 2003).

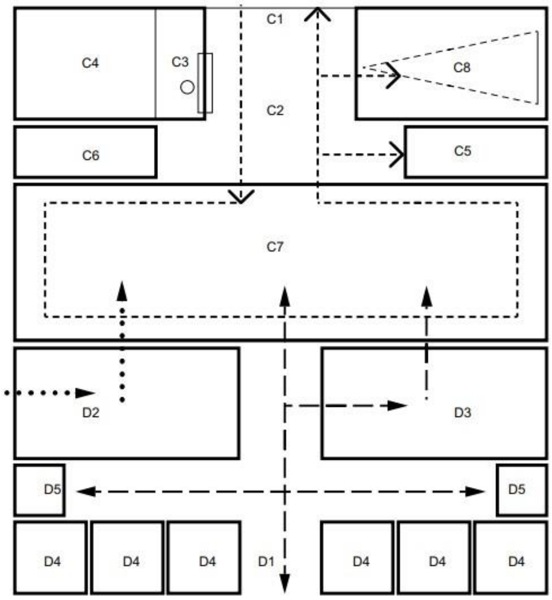

Figure 2. 6. Size distribution scheme of a scientific and educational museum with its own collection exhibited or kept in the warehouse – laboratory.

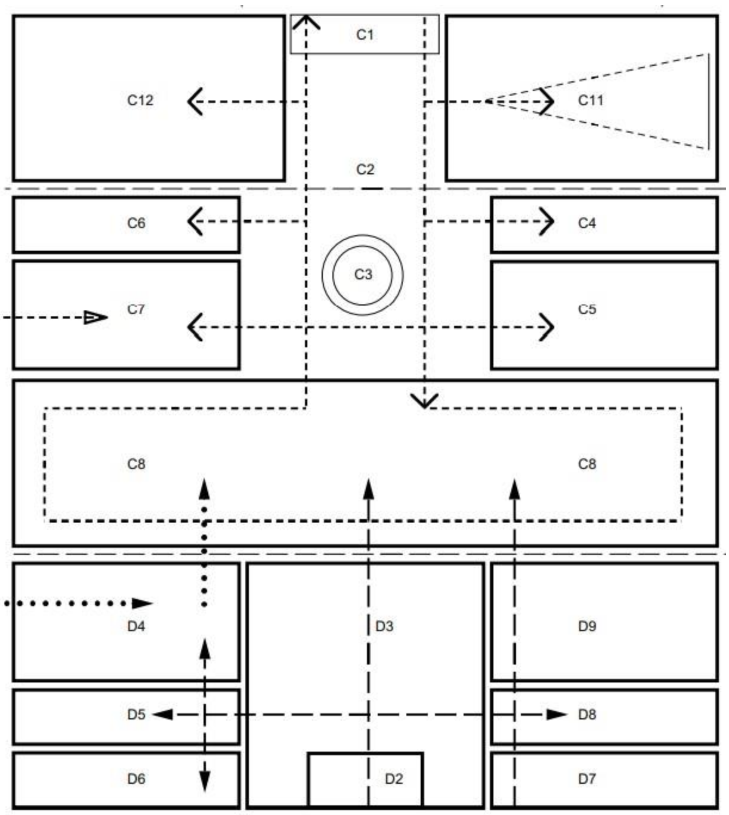

Figure 2. 7. Dimensional distribution scheme of an exhibition structure for art exhibitions without its collection.

What characterizes Zevi's practice in forming the standard scheme of the museum with clear exhibiting and research purposes is the linearity of the permeability of space. Naturalness and clean lines, with highly geometric interweaving are the most qualitative proposals of Zevi in the compositional aspect of the interior space.

Approved even institutionally, the minimization of panels and the creation of a transparent zoning for the access of an exhibition space, has created the success of the Zevi's museum that is exemplified in the following schemes:

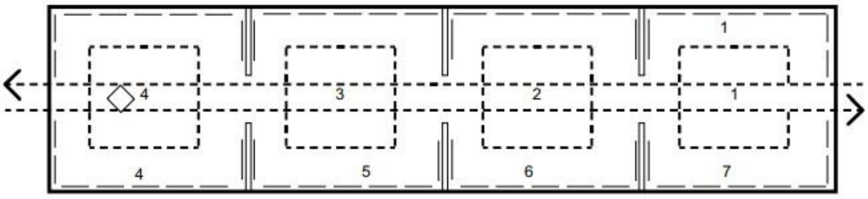

Figure 2. 8. Free path (with intersections); closed thematic areas or in sequence.

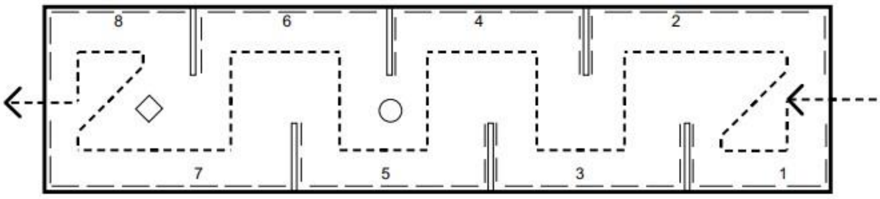

Figure 2. 9. Compulsory and unidirectional path (without intersections); thematic areas in open sequence.

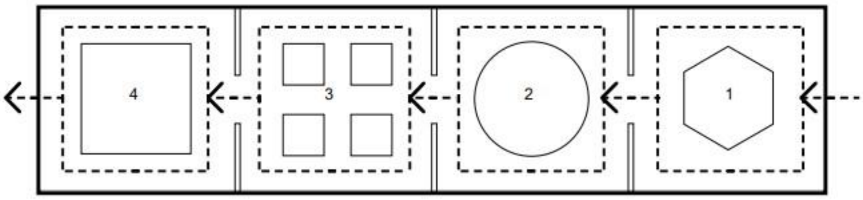

Figure 2. 10. Compulsory route for subsequent "rings"; closed thematic areas, with exposure to "islands".

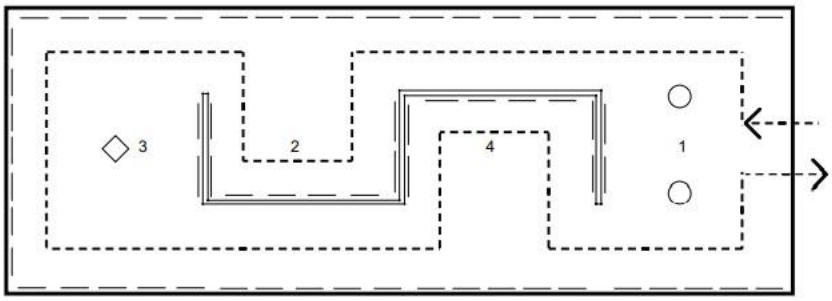

Figure 2. 11. Compulsory "anular" path (without intersections); open or closed thematic areas, in sequence

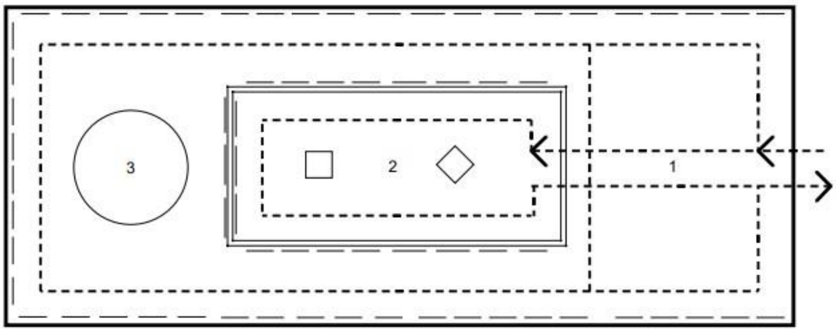

Figure 2. 12. Concentric "rings" path (with intersections); thematic areas in sequence.

2.4 Museum Architecture and its place today

Museums are now viewed in a multitude of settings. They are seen as businesses, storehouses of collections, exhibition and display venues, educational establishments, research organizations, communal spaces and places of memorialization (Werner, 2018). National and local government policy frequently push museums in new directions.

In his extract about London and museums, Werner confirms that “more recently, the British Museum has set out its stall for the 21st century as a ‘museum of the world’. Its collections are ‘worldwide in origin and intended for use by the citizens of the world’” (MacGregor, 2003).

This leads us to another direction in fact, because dismissing the historical context, even though in an historical body, is an approach that has origins, but also wants to spread new stems and embody a new mindset. For British Museum to be more open to what art proposes nowadays leaves space for architecture to be free and, as a consequence, propose new technics.

2.4.1 Stedelijk Museum Amsterdam: The Extension

At the turn of the 19th century, with the expansion of Amsterdam, city officials were planning not just the Rijksmuseum, a national museum, but a whole cultural district, which was organized around a large park. (Davidson, 2012)

Dutch architect Adriaan Willem Weissman designed the building for the Stedelijk in 1895 in this Museumplein. It has a look reminiscent of Dutch Neo-classicism of 16th century even though very flamboyant and distinctive for the use of red brick on the façade and white ones inside.

Figure 2. 13. Stedelijk Museum façade, by Jannes Linders, Benthem Crouwel Architects

In 2012, lead architect Mels Crouwel preserved the beloved white-brick interiors of the original, and at the same time ensured that old and new galleries flow together in a smoothly continuous sequence when he rethought the designing of the extension at Stedelijk. The seamless integration of the old and new interiors correlates with the seamless sheen of the new building's envelope. The defiant juxtaposition in architectural styles highlights the continuity of the artistic experience, “but this reasoning seems awfully gaseous when you're confronted with the way the building asserts itself on the city” (Davidson, 2012).

Benthem Crouwel Architects also wanted the addition to be a lightweight construction with a load bearing structure mainly made in steel and a highly innovative external cladding. This is constituted of panels made with a composite material, a para-aramidic fibre which is usually adopted in boat construction. This gives the extension the lightweight and elegant enveloping while also being comfort and adapted to stay next to the old Stedelijk, nevertheless the Museums' park. The use of a composite material also permitted the realization of a seamless, lightweight, fire-proof and durable building skin.

All these features are the very start to being efficient to the nature by also saving all what's inside. Because everything starts from creating the skin that endures all what ecosystems offer.

The Yellow Tube

There are three levels in the building, two above and one under the ground floor. There is a lobby, a library and a cafeteria; in the basement level is the Netherlands' largest open-air exhibition area and a small theater and entertainment

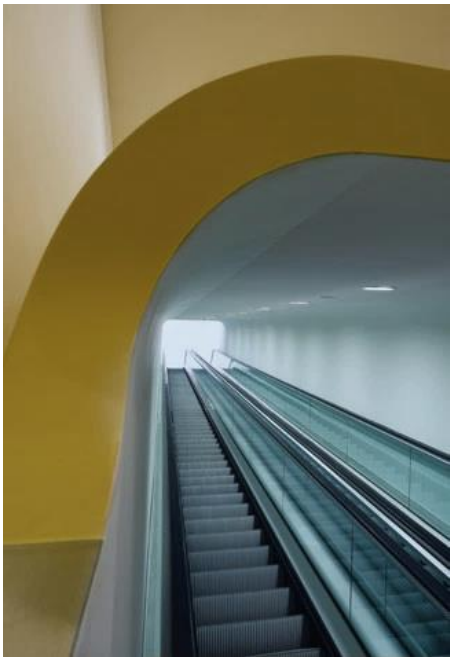

Figure 2. 14. The Yellow Tube, Stedelijk Museum.

area; other exhibition galleries and the links to the old structure are situated in the first floor (Davidson, 2012).

From underground levels guests can go through a "yellow tube" which contains two escalators directly to the first floor, thereby allowing interconnections between all exhibition sites on different levels without interruption and distraction (Davidson, 2012).

This physical solution is at the same time a process. It creates movement by also providing isolation and a prospect in the way of how to deal with ‘resources’ in limited architectural instances.

Similarly, as at The British museum where the public is gathered into an open space that provides enclosure and offers a Court that links every component using a parametric steel design on top of the building (to also cover it), this time at Stedelijk Museum, this happens with the tube. The most open spaces of the interior, and the most important ones actually, are linked through a physical experience of a renewable element.

CHAPTER 3

CLIMATE CONTROL AND THE INFLUENCE IN THE CONSERVATION OF ART COLLECTIONS

3.1 Art Museums under climate control

Art museums have been and continue to be an evidence of civilization and the history of emancipated societies that evoke free expression, human metamorphosis and the sources of life. Art today is made diligently, maybe more than it once was, with conditions and techniques aided by new technologies.

But as old techniques go and new trends are introduced, displaying the works of art present the curators with certain problems. And one of them is the ongoing preservation. Because some of the materials used in their creation are sensitive, the temperature, humidity, and lighting to which they are exposed must be kept within strict limits. And until now, these strict preservation (and conservation) conditions that certain collections require have prevented museums from meeting the needs of renewable development.

Climate control in museum premises intended for exhibition, preservation or restoration is a topic which is treated with special interest after the Second World War and is a still evolving issue to better understand the values of its parameters and how control. An improper and unstable indoor climate can lead to damage and destruction of artifacts over time.

Museum buildings, those designed as such, and historic buildings used as museums have undergone changes over the years in order to improve conditions. In the case of museums, their rehabilitation is often done to improve the climate efficiently or sustainably. Renovation of the museum building to improve the indoor climate requires a certain amount of energy. This has shifted the focus of research to more passive ways of controlling indoor climate. However, there is a lack of studies on passive museum buildings, as well as a lack of continuous monitoring of climate data (Toledo, 2007).

Control of environmental parameters, average values or their gradients, turns out to be essential for an optimal preservation of collections. Parameters such as temperature, relative humidity, solar radiation, lighting, pollution, etc. are considered as “risk factor” of environmental nature and the main problem in museum buildings is risk management. S. Michalski, focusing on environmental risk factors, in the book “Running A Museum”, underlines that *“the risk assessment of collections is not done for one year or for the next ten years, but by forecasting it for 100 years”* (Michalski, Care and Preservation of Collections. Running A Museum. A Practical Handbook, 2004).

The main objective of risk assessment in a museum building is to know the building system, which is a variable of many factors such as: the typology of the building (light, medium or massive, insulated or not, etc.), air permeability and the typology of installed plants or their absence.

Museum collections can be conceived as wrapped in several interfering layers, each of which plays its protective role. Assessment analysis of the impact of these layers has a trajectory with a direction from outside to inside starting with the analysis of location, building with all its features, interior of rooms, equipment, exhibitors and ending with the analysis of exhibited artifacts (Michalski, Care and Preservation of Collections. Running A Museum. A Practical Handbook, 2004). It is for this stratification and their interference that assessing the indoor climate of the museum, if it constitutes a risk factor, is a non-simple process.

To understand this, it is important to start with what is considered basic to the climate of art museums: the building (Michalski, Care and Preservation of Collections. Running A Museum. A Practical Handbook, 2004). The building is considered the main protective enclosure of the exhibited and preserved collections in the museum premises. The indoor climate is closely related to its performance. Problems which are caused as a result of non-maintenance or incorrect design of the building lead to increased climatic risks, not only for the collections, but also for the building itself. The presence of moisture in the building, lack of thermal insulation and water vapor barriers, improper ventilation, orientation and inadequate windows are key factors in creating an unstable climate in the museum. All these factors create what is characteristic of the indoor environment in the museum, the presence of microclimatic areas. For the reasons mentioned above, not the entire indoor environment in museums presents uniformity. It is characterized by local climate or microclimate, which differ from the average indoor climate. Unwanted temperature and relative humidity gradients create microclimates in the museum space unsuitable for conservation of artifacts because it is almost impossible to achieve complete uniform control of the whole building, as in museum buildings designed with the HVAC system as well as in historic buildings adapted for museums (Camuffo, Sturaro, & Bernardi, 2001) (Mecklenburg, Micro-Climates and moisture induced damage to paintings. Museum Microclimates, 2007).

Following the trajectory of the analysis we reach the exhibited artifact itself. They consist of one specific material or combinations of different materials. For many artifacts, their materials are organic, and their mechanical properties are extremely influenced by environmental factors, such as changes in temperature and relative humidity.

It is important to understand how each constituent material degrades as a result of different processes occurring. Numerous scientific researches have been done to understand and analyze the internal stresses that occur on paper, wood paintings, canvas paintings, ceramic materials, metal, etc. as a result of the values of the environment in which they are located.

Taking care of moisture-sensitive historic buildings requires a different approach than those designed as museum buildings. In historic buildings the object itself is as important as the exhibited collection, and perhaps sometimes even more important. Therefore, interventions to improve the climate in historic buildings are quite difficult, very costly and compromising for the building. The applied solutions aim at regulating the indoor climate in the most-friendly way in relation to the object.

According to this concept, heating systems work with different priorities depending on the standards set, the outdoor climate and the type of building. Heating systems can work with priority over relative humidity. This method creates better conditions for the protection of collections, less potential damage to the building and lower energy and maintenance costs compared to conventional control methods (Maekawa & Toledo, 2001). Passive climate control, using building materials to moderate the temperature and relative humidity is highly recommended for storage facilities of historical and cultural objects, which do not need frequent air change and may have lower parameters than those of human comfort (Padfield, Exploring the limits for passive indoor climate control, 2008).

In practice, achieving a suitable climate for artifact's conservation is difficult. In fact, it is almost impossible to provide to users, historical objects and the building the desired temperature and humidity, except in very rare cases. However, it is possible for all three groups to meet most of their needs for indoor climate conditions (Michalski, 1998). The level of risk acceptance is a compromise between the ideal theoretical and practical environment. It is possible to drastically slow down the degradation of objects, but by controlling the conflict between the functions of the museum; not only to preserve and conserve facilities, but also to create comfortable conditions for visitors and staff.

3.1.1 Temperature and its regulatory impact on museums

Temperature, unlike the physical pests of collections such as water, fire or other forces of nature which should be avoided, cannot be considered as such. When we talk about "temperature" as a risk factor, seen in the degrading perspective of the collection, we mean "incorrect temperature". (Michalski, Relative Humidity and Temperature Guidelines: What’s Happening?, 1994) In the conservation of historic buildings, the temperature values of the environment where they are exhibited or stored are important as they affect the acceleration of degradation processes. By treating this degradation-influencing factor, three temperature categories are defined towards which different collections have different sensitivities (Michalski, 1994) very high temperatures, very low temperatures and temperature fluctuations.

Very high temperatures: This category contains three phenomena: chemical, physical and biological. Some objects are made of materials that deform, weaken or even melt, above a certain temperature value. It is a universal truth for museums that rising temperatures affect the acceleration of chemical processes (aided also by moisture values), which lead to degradation. Accelerating degradation, temperatures weaken the structure of all materials (Mecklenburg, 2007).

Michalski considers as a very high temperature the value above 30°C. The higher the temperature, the faster the objects will age and be damaged. Most chemical reactions double with each increase of 5°C in temperature. The constituent materials of the collections present different chemical sensitivities grouped into four categories. (*Tab 3.1*).

Table 3. 1. The chemical sensitivity of materials to the Temperature in the museum. (Thomson, The museum environment, 1986)

Low sensitivity	Average sensitivity	High sensitivity	Very high sensitivity
Wood, organic adhesives, linen, cotton, leather, parchment, oil paints, watercolors, tempera and plaster.	Black and white negatives on glass tiles and black and white negatives on polyester film.	Paper and some types of films. Organic materials acidified by pollution such as: textiles and leather.	The so-called "unstable" materials are mainly media materials; video, audio, some elastic polymers and some acrylic paintings.

Very low temperatures: Low temperature values, in practice, do not cause damage to objects. In fact, they are considered desirable values as they reduce the problems related to bio-degradation (Thomson, The museum environment, 1986). However even low values should be within the recommended limits (Mecklenburg, Part 1, Structural Response to Relative Humidity, 2007). Michalski considers for the museum as very low temperature the values below 10ºC which have been proven to negatively affect only the paintings in acrylic (Michalski, 1994).

Temperature fluctuations: When we say "very high temperature" or "very low temperature" we mean damage caused, which are attributed only to these two extreme values. But the transition from one extreme temperature to another is a process of fluctuating values which occurs at a certain time interval. Due to these fluctuations, changes occur in the physical properties of materials. The essential mechanism of damage is the expansion and contraction of materials when the value of T increases or decreases. Two situations lead to damage: when the object is made up of two or more materials, which respond differently to temperature changes (destructive internal stresses can occur) and when an object is subject to fluctuations faster than his ability to respond to you just as quickly (Michalski, 1994). Such sudden changes can occur from direct exposure to sunlight or artificial lighting, as well as from a collapse of the air conditioning system.

Temperature fluctuations can be short-term fluctuations (day-night) and long-term fluctuations (seasonal fluctuations). The stresses that occur in the material, as a result of cyclical fluctuations, cause an increase of cracks in the material, the repetition of which leads to the final destruction of the heritage objects.

As mentioned above, temperature itself is not a problem for artifacts made of organic materials, which have low sensitivity to this factor, for all three categories (Tab 3.1). What's the primary role of temperature as a risk factor is its impact on Relative Humidity. Temperature is the main factor in determining relative humidity values, as it affects the ability of air to retain water. Must bring to attention that low temperature values lead to increase in relative humidity and it is impossible to control relative humidity without considering the values of temperature.

3.1.2 Relative Humidity and its regulatory impact on museums

Relative humidity is an essential component of the indoor environment in museum buildings. It expresses the relationship between the volume of air and the amount of water vapor it holds at a given temperature. Sources that increase the presence of moisture in the museum are numerous: climatic characteristics of the area where the building is located, the presence of rainfall, building technology, building maintenance, reconstruction interventions (improvements or deteriorations they bring), the influx of visitors, cycles of evaporation condensation and the selected air conditioning system and the parameters it enables.

Relative humidity - RH **-** is the ratio of the amount of water vapor found in the air at a given temperature to the maximum amount of water vapor that the air can hold at the same temperature. RH is expressed in percentage, so the value of this ratio is multiplied by 100% (Padfield, 2015).

We use the concept of relative humidity to show how saturated the air is with water vapor. "30% relative humidity" means that the measured air has 30% of the total amount of water vapor it can hold at a given temperature.

All organic and some inorganic materials absorb and release moisture depending on the RH of the surrounding environment and it is RH which determines the amount of moisture in the constituent materials of historic buildings. The extreme RH values of indoor air in museums significantly affect the conservation of artifacts, especially in objects with organic composition. But we must emphasize that many materials stabilize (reach equilibrium humidity) in climatic conditions where they are located even when conditions are extreme. Uncontrolled change of these conditions causes mechanical problems in artifacts as they seek to stabilize their state through a new equilibrium moisture value. The value of relative humidity is the primary factor in promoting the processes of chemical, biological and mechanical degradation of heritage objects.

Damage can occur when the LR is very high, variable, or very low (Michalski, 1994):

Very high RH: When RH is high, chemical reactions increase as the presence of moisture accelerates them. High levels of RH cause mechanical damage to organic materials. Very sensitive to these values is wood, as a result of the shrinkage-swelling cycle. The high value RH not only causes mechanical damage to the artifacts, but it is a stimulant of biological activity. Thus, the growth of mold and then of fungi is favored in humidity above 65%. Insect activity of historical objects (wooden, paper, textile, etc.) in the presence of high RH values increases (Blanchette, 1995).

Very low RH: Very low levels of RH cause shrinkage, bending, cracking of wood and ivory, shrinkage and splitting of photographic films and skin, drying of paper.

Variable RH: Changes of Relative Humidity in the indoor environment affect the water content of historic buildings, which results in dimensional changes and deformations in hygroscopic materials. They shrink or swell constantly adapting to the environment. When RH fluctuations are too large, object damage of the aforementioned natures occurs. Damage can be very invisible and therefore go unnoticed for a long time (e.g., cracks in the paint layers). Also, from an RH change immediate damage can occur (e.g., wood cracks). Such injuries are mainly manifested by immediate and extreme changes, for various reasons, of RH. In particular, materials at risk as a result of RH fluctuations are: wood, laminates, composite materials such as photographs, furniture, paintings, various varnishes and other similar objects.

RH levels defined as above in interaction with ambient temperature may cause three types of damage in historic buildings: biological, mechanical and chemical damages.

3.1.3 The relationship between T and RH

When studying the indoor climate in museums, we cannot analyze risk factors independently of each other. As explained in the two issues above, incorrect values of temperature and relative humidity affect the lifespan of artifacts, depending on the composition of the materials and their stratification. But in addition to the direct impact on artifacts, their interdependence on them causes a change in environmental balances. Certain temperature values may not have a direct impact on some of the artifact materials, but they do affect the relative humidity values. Therefore, we cannot simply talk about T or RH, separated from each other, but about thermohygrometric parameters of the museum environment. It is the temperature which affects the control of relative humidity values. Relative humidity is inversely related to air temperature. If the air temperature rises the relative humidity decreases and vice versa. The graph in Figure 3.1 clearly shows the relationship between T and RH.

As the air temperature increases, its capacity to hold water vapor increases. At 0°C air can hold 6g of water for every m^3 of air. If the temperature rises to 10°C the water vapor holding capacity increases to $10 g/m^3$, at 20°C increases to $17 g/m^3$ and at 30°C increases to $30 g/m^3$. Thus, the capacity of air to hold water vapor varies according to air temperature (Thomson, The museum environment, 1986).

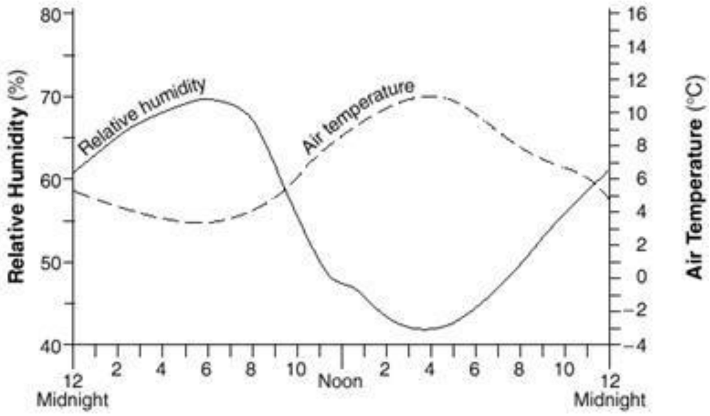

Figure 3. 1. The graphical relationship of T and RH (Thomson, 1986).

When T values are high and RH is low, water vapor evaporates rapidly causing the artifacts to shrink (in the case of this study of wooden ones). When T values are low and RH is high, the removal of water vapor is slow, and this causes the material to swell. And when the RH values reach 100% condensation appears on the surfaces of the artifacts and the building, which rapidly increases the degradation process to the destruction of the artifacts. Table 3.2 presents what unfavorable values of T and RH cause in artifacts when as a result dimensional changes, chemical reactions or biodegradation occur.

Table 3. 2. Damage caused to artifacts by the value of RH and T (Thomson, 1986).

Incorrect T and RH values.	Effects
Dimensional changes	Cracks, damage to joints, splitting, fiber breakage, loss of surface material.
Chemical reactions	Metal rusting, color fading, crystallization and movement of salts, yellowing of paper documents.
Biodegradation	Mold and bacterial developments

3.2 Garry Thomson and the museal environment

The topics discussed above in this chapter explain the role and importance of temperature and humidity parameters in museums, their development, the form of mechanical air-conditioning, and the damage caused to cultural relics due to insufficient values. We are talking about temperature and relative humidity. These values were originally determined by the performance of central heating. Later these values were aimed at human comfort, and only after World War II did they become targets for scientific investigations of temperature and humidity measurement.

Garry Thomson groups the constituent materials of artifacts into five clusters, according to sensitivity to the value of T and RH (*Table 3.2*). He classifies in "Group A" and "Group B" mainly wooden and paper artifacts, materials which are very sensitive to RH movements and present great sensitivity to high and very low values, as well as its fluctuations.

Table 3. 3. Material Sensitivities to Temperature (T) and Relative Humidity (RH) (Thomson, 1986).

Group A	Group B	Group C	Group D	Group E
Materials which require strict control of RH.	Materials which tolerate small fluctuations of RH.	Materials which tolerate big fluctuations of RH.	Materials which require a dry environment	Materials which require low temperature values
Lacquered furniture, wooden musical instruments, wooden	Textiles, oil paintings on canvas, paper and parchment, materials of	Stone, marble, ceramics, glass, gold and silver	Iron, Steel, Brass, Bronze, Copper, Silver, Gold, Archaeological Bronze, Glass,	Fur, leather.

paintings (icons), wooden sculptures, manuscripts on paper or parchment, plaster objects.	plant origin, lacquered wooden objects and furniture, objects of bone, ivory and horn	alloys.	Metallic Textiles, Mummies.

Following the recommendations of Plendrleith more in-depth studies raised some questions. At what levels do T and RH create a conservation environment for artifacts? What are the risk values that endanger their longevity? What causes fluctuations in T and RH values in artifacts? How much should the fluctuations be acceptable? In fact, these are not easy questions to answer.

The one who first sought to answer some of these questions is Garry Thomson with his book “The Museum Environment”, first published in 1978. On the issue of humidity the book was nothing more than a repetition of the values recommended by Plenderleith in 1960. The novelty of this treatment was the improvement of the understanding on how to realize climate and microclimate in museums. Particular attention was paid to measurement and control techniques, rather than reasoning for the recommended specifications.

In the section dealing with relative humidity specifications, Thomson refers to recent adjustments made to the Tate Gallery and the National Gallery in London (designed for RH 55 ± 4% and for T 20 ± 1.5 °C). His reasoning for the recommended value of RH starts from setting safety limits (upper RH limit of 65% and lower RH 45%) and then proposes the most appropriate RH value within these limits, that of 55%. In this publication Thomson insists that RH cannot exceed 50% - 55% and referring to Plenderleith he claims that RH below 40% is not appropriate when it comes to materials with thin and very delicate thickness. For these recommended values he gives no reference.

According to authors J. P. Brown and W. Rose, for these recommended values, he refers to mining storage during World War II and the installation of the air conditioning system at the National Gallery in London (Brown & Rose, 1996).

In addition to setting strict climate control values, as a very good connoisseur of air conditioning systems, he raised his concern about whether the equipment provided the values it claimed. To understand this, he attached importance to the climate monitoring process for the values of T and RH, raising also the inaccuracy of the thermo-hygrographs of that time which had an inaccuracy of ± 6% (Thomson, 1986).

His reflection on climate control issues at such a strict RH value led to the reprint of the book in 1986 in which Thomson recommended two classes on climate control in museums (*Table 3.3*):

– *Class 1* - has a strict RH control which includes museums built as such and all important museum buildings. For this class the recommended values for RH are 50-55%.

– *Class 2* - include museums in historic buildings in which major hazards should be avoided and RH values are recommended 40-70%. (Table 3.3).

Table 3. 4. Recommendations according to G. Thomson.

Year	Source	Temperature	Average	Short-term fluctuations	Comments
1978	Garry Thompson	19ºC (Winter) up to 24ºC (Summer)	50% or 55%	±5%	*Class 1* - suitable for national museums, young or old and also for all important museum buildings.
1986		Constant to stabilize RH	40% up to 70%		*Class 2* - avoids major risks by keeping costs and fluctuations to a minimum, e.g.

				historic dwellings or churches.

3.3 Three principles of the degradation of artifacts

Mechanisms of degradation caused by climatic factors are grouped into three types of mechanisms which lead to damaging of artifacts.

- Mechanisms of the physical type (which cause mechanical damage to artifacts such as changes in dimensions and shape of objects)

- Mechanisms of chemical type (e.g., chemical reactions)

- Biological type mechanisms (e.g., development of microorganisms)

All three of these mechanisms are called universal mechanisms of degradation of all artifacts as a result of the action of climatic parameters. These mechanisms, perhaps more than in all other materials, are more visible in wooden artifacts, due to the nature of the material and its sensitivity towards T and RH of the environment where it is stored or exhibited, but also in other solid materials.

3.3.1 Mechanical degradations

All hygroscopic materials and adhesives swell when RH increases and shrink when its values decrease, causing deformation, displacement of components, cracks, especially at low RH values. But where does this come from?

Such damage comes mainly from dimensional changes in material caused by movement. Mechanical damage to objects caused by RH is of two types and has to do with its hygroscopic and mechanical properties:

The first type of damage is caused by RH fluctuations over a long period of time (e.g., seasonal changes in RH values). In this case the whole building responds to gradual changes of RH causing dimensional changes depending on how the building is constructed.

The second type of damage is caused by short-term fluctuations in RH (e.g., day-night changes, frequent fluctuations in 24 hours or at intervals of several days). In this case, only a part of the object - usually the part closest to the surface - responds to the changes, while the deepest part fails to react. This creates differences in the equilibrium moisture of the surface layers with those at depth. The deepest part prevents the surface layers from moving creating stresses inside the material.

An object of larger volume will respond to the new RH value more slowly, in the outward direction inside the object. Thus, a sculpture, in real human dimensions, may take two or three months to complete its response (Uzielli L. , 1992). Changes in RH values cause internal stresses in the constituent materials of historic buildings, which lead to deformations of the constituent material and consequently the degradation of the artifact.

Wood paintings (icons) are the most typical examples where deformation from the influence of RH appears. These deformations are influenced by two factors; by the cutting direction and the moisture gradient in the wood. The wood has three cutting directions that are perpendicular to the annual rings (Radial cut, R), tangent to the annual rings (Tangential cut, T) and parallel to the vertical axis (Longitudinal cut, L) (Giordano, 1981). Its deformation of the RH impact is not the same in the three main cutting directions. This deformation is larger in the tangential direction of the cut, smaller in the radial one and less sensitive in the longitudinal direction of the cut (Mecklenburg, 2007).

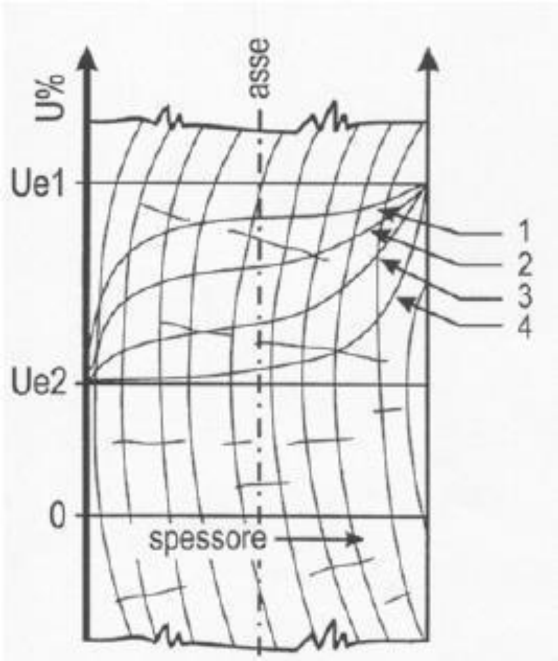

Figure 3. 2. Moisture gradient in the thickness of an icon.

When the RH value decreases the air starts to dry the panel. The moisture contained in the panel can be removed more easily from the back of the painting as the layers of painting (primer, painting and varnish) on the front act as a protective barrier against the relative humidity of the air. As a consequence, the back of the icon contracts more than the front of its moisture gradient in wood and the wooden base undergoes a convex deformation (*Fig. 3.2*) (Uzielli L. , 1992).

If environmental conditions change constantly, the wooden plinth seeks to restore a balance with the new RH values. It cannot pass immediately to the new equilibrium conditions: the moisture variations more or less slowly disperse into the depths and the absorption states overlap with the desorption ones. As a result of the above-mentioned moisture gradients, successive layers or parts of the material's tendon tend to shrink or swell in varying amounts (deformation gradient): this provokes internal stresses in the material and further tendency to deform. Researcher Luca Uzielli writes: *"Imagine dividing the icon's spacer into different layers, each with constant moisture and being free to deform independently of each other. At some point in the transition phase, the layers that are at a higher humidity tend to swell more than those with a lower humidity"* (Uzielli L. , 1992).

Given that different layers of material are not free to deform independently of neighboring ones, the thinnest layers can be molded less than they could if they were loose, and the less wet layers are forced to last longer. During the transition phase a state of internal tension is established: the thinner layers turn out to be compressed, the less moist ones turn out to be tense. If the internal stresses have produced only deformations of the elastic type, when the moisture of the material is completely balanced each layer tends to deform in the same amount and the internal stresses are canceled. If, during the transition phase, the internal stresses have produced permanent deformations in the material, when its humidity is balanced, the internal stresses are not canceled and thus the residual deformations are produced in the base of the icon. Adaptation of the painting layers to the deformation of the plinth (e.g., wood) causes it to crack. All the old icons have a characteristic appearance full of cracks not only of the painting layer, but also of the base, as from the latter the cracks in the painting are transmitted.

Relative humidity plays a complicated role in the mechanical degradation process. The main influence of RH is the dimensional change as a result of the change of equilibrium moisture, also some physical properties of the constituent materials change like, softening of adhesives and reduction of adhesive capacity in RH over 80% (Uzielli & Fioravanti, 1999).

3.3.2 Biological degradations

In all museum buildings, even those with air conditioning, the high RH value is the most important factor to keep under control. Degradations occur in almost all historic buildings of an organic nature when they are exposed to environments which favor the process of biological degradation.

High RH levels of air, the presence of moisture in the walls of the building, as well as favorable temperatures, accelerate the damage of historic buildings.

A variety of biotic agents, such as insects, fungi and bacteria interact causing considerable damage, which leads to the eventual destruction of the artifact. Wooden objects such as paintings, sculptures or icons are affected by xylophagic insects of the families Anobium, Lyctus, Cerambycid, etc. (Tampone, 2000). Characteristic of a large part of these insects is that they touch obsolete materials.

Insects lay their eggs in the cracks and crevices of objects. The eggs for a period of 3-5 weeks turn into larvae, which feed on wood (in the case of wooden material) opening galleries throughout the structure of the building. The open galleries have a dimension of 1-10 mm and vary according to the type of insect (Blanchette, 1995). Galleries damage the structure of the material and their holes appear on the painted or engraved surface of the artifact.

The period of action of pest insects is spring and summer. For some insect families (e.g., Anobium) the favorable environmental parameters are: temperature 22 - 23°C and RH 50-60% (Gambetta, 1992). Increasing RH to values higher than 60% increasingly favors the touch of wood by insects, not only at temperatures 22 - 23°C, but also at lower than 10ºC (Gambetta, 1992). High temperatures are favorable when we have increased humidity values. In cases where the RH is below 50% they become less dangerous. For RH values below 40% and T above 30ºC larvae cannot develop (Gambetta, 1992). It should be noted, however, that there are insects that act when T values are high and RHs are low (e.g., termites).

The amount of moisture is an important factor in the matter being touched by insects. Insects of the Anobium and Lyctus families to have a continuous activity require a relatively low wood moisture 8-20%. Some others require humidity higher than 30%. Many insects touch wood as it has been previously affected by the fungus (Blanchette, 1995). Insects and fungi are pests that cause biodegradation of cultural heritage sites as a result of non-optimal parameters of their preservation or exposure.

Fungal damage to objects manifests itself in the form of surface damage and depth of material. High RH values enable the growth of mold on the surface of objects and damage to its microscopic structure. Mold in museum facilities with unfavorable RH conditions first appears on dust-contaminated, oiled surfaces.

In all situations, humidity is an important factor for spore germination and successful fungal development. If the moisture content in the work material is 28% there is not enough water for the growth and development of the fungus (Blanchette, 1995). The ideal environment to protect the offense from fungal exposure is considered the environment with RH lower than 60%; while the temperature which favors their growth is 5-35°C, they withstand low temperatures (Tampone, 2000).

When historical objects are affected by fungi even though they can be placed in conditions with optimal environmental parameters the impact from the fungus lasts long and can cause visible damage in a short time, especially when the ambient temperature drops below 10°C and the RH is above 60% (Blanchette, 1995). The duration of action is determined by the type of fungus and the amount of moisture accumulated.

3.3.3 Chemical degradation

The most problematic parameter in the chemical degradation of artifacts is temperature. This for two reasons: first, when it reaches inappropriate values; and, secondly, for its impact on relative humidity values. It can be said that high temperature values promote the phenomenon, while low values tend to increase the chemical stability of the material, making it less reactive. As for the relative humidity, when it reaches the values above the recommended parameters, it plays the role of catalyst in chemical reactions which are constantly evolving.

A limited number of materials such as metals, paper and leather are sensitive to this degradation mechanism (Thomson, The museum environment, 1986), while wood materials present few problems in terms of chemical degradation. High T values cause the acceleration of chemical reactions that occur in the pigments of the painting layer. Damage also occurs at the base of icons or sculptures as a result of chemical processes occurring under the action of high values of T and RH.

3.3.4 Prevention of artifacts' degradation

Obviously, it is better to prevent damage than to make restorative interventions which cannot restore the work to its original integrity. And often the need for restoration of these objects comes from the lack of conservation rather than from their "natural aging". In what has been addressed and in the above Issues, it turns out that environmental climate change should always be considered as a potential risk factor, especially when they have high values and their fluctuations as they provoke deformations and stresses which can damage the material and layer of the painting. The main interventions undertaken to reduce such a risk factor can be grouped as follows:

- Intervention in the climate of the museum premises where the artifacts are exhibited.
- Interference in the microclimate, near the damaged artifact.
- Intervention in the material of the work, for its consolidation.
- Restoration of the painting layer.

Table 3.5 sets out some general recommendations regarding climatic values in museum settings where artifacts are on display (Perucca, 1993). It would be highly preferable to maintain very strict climatic conditions in their conservation environments, but in practice they are difficult to achieve. And for this the table shows not only the optimal values but also acceptable conditions and safety limits, the exceeding of which risks accelerating the process of degradation of the work. It should be noted that the values of the table are not just figures on paper but they should be interpreted in the concrete terms of each case. They constitute recommendations which should be followed, but may not be considered valid in all cases; for example if the artifact has been stabilized for a long time at other RH values, similar climatic conditions can be maintained to avoid damage or degradation by ensuring that these values do not pose a problem for the artifacts (Uzielli & Fioravanti, 1999).

Table 3. 5. Recommendations of the values of thermo-hygrometric parameters for the preservation of paintings.

Risk Factors	Recommendations	Acceptable Values	Safety Limits
	55 ± 5% day- night	Winter: 45% ± 5%	40 – 70%

<table>
<tr><td rowspan="2">Relative Humidity (RH/%)</td><td>for the whole year</td><td>Summer: 60% ± 5%</td><td></td></tr>
<tr><td colspan="3">Avoid very frequent fluctuations
The distribution of air conditioning should be homogeneous, to avoid harmful gradients in the vicinity of the artifact.</td></tr>
<tr><td>Temperature (T/º C)</td><td>Winter: 19 ± 1º C
Summer: 24 ± 1º C</td><td colspan="2">It is recommended to be constant enough to stabilize the relative humidity of the air.</td></tr>
</table>

It is also not enough to maintain the average values of the recommended limits but care should be taken to avoid as much as possible fluctuations in the values of T and RH, such as those in the long period which cause shrinkage and swelling of the material. and as a consequence its deformations as well as those in the short period which cause in the material and mainly in its surface layers real stresses similar to an “accelerated aging” (Uzielli & Fioravanti, 1999). In the case of icons it is very important to control the fluctuations of RH as the moisture of the wood depends on this.

When it is impossible to maintain T and RH values within the recommended limits then to improve the stability and conservation of the artifacts more favorable microclimates can be created in the vicinity of the exposure or storage area, for example:

- Use of showcases, which may have installed air conditioning system;

- Removal from wall surfaces using backing panels which can help absorb RH and allow air circulation to the back of the artifact (this mainly for icons);

- Use of hygroscopic materials in the vicinity of the exhibited artifact.

Controlling the general climate and microclimates in both active and passive ways, always making proper observations and monitoring are the main measures which have to do with the conservation of the artifact before the restoration interventions are made. Understanding the causes of artifact damage is primary to restoration intervention, which should start with the material and then proceed to the restoration of the painting layer.

3.4 Microclimate and the new standards of today

After prolonged use of the Thomson values for preventive preservation of artifacts, problems were identified and strict values were recalled for review. Studies had shown that a variety of materials can withstand larger RH fluctuations without experiencing residual deformation. The determined values were shaken. The costs for installing and maintaining air conditioning systems to ensure strict values, not estimated everywhere and always necessary, were very high.

Proposals, based on scientific experiments, for a wider range of RH values and fluctuations are made by Stefan Michalski in 1993. In his paper "Relative Humidity: A Discussion of Correct / Incorrect Values" he proposes for rigid organic materials, the widest RH values from 25% -75%, beyond which a high risk of their damage begins. He also proposes the acceptance of RH fluctuations up to ± 20% during which a small mechanical damage may accumulate in brittle materials, but which is eliminated by normal fluctuations ± 10% of RH in wood and ± 5% in paint painting (Michalski, 1993).

In fact, this period of reviews and reflections on traditional standards coincides with the increasing of importance of the museum in terms of architecture, urban and socio-economic means. New museum buildings, conceived as giant cars with spaces now not only for display, presented increasing difficulties in controlling climatic parameters in buildings with lightweight materials and more transparent surfaces. In this context of study and controversy, two researchers, David Erhardt and Marion Mecklenberg, presented their perspective on the "optimal" values of RH and the difficulties of specifying it. According to them there may not be an ideal RH value for the museum, but rather a set of values and an extensional dimension which can be somewhere a little less and somewhere stricter. These values can be applied to specific materials or objects in which damage of various natures can stop, start, increase or decrease as a result of their specific reaction to RH values (Erhardt & Mecklenberg, Relative Humidity Re-Examined, 1994). They classified 12 classes of materials for which they recommended, based on mechanical damage, a safety zone from 45% to 70% (Michalski, 2016).

The proposal made by Michalski and Mecklenberg for a larger dimension of RH values can be found concretized and deepened in the recommendations of ASHRAE. In the ASHRAE Handbook of 1999, the chapter *"Museums, Galleries and Archives"* specifies five climate control classes from AA to D. Different RH and T values for each class are associated with the expected correspondent risks reflected in a summary table (Table 3.4). Class AA is the one with the strictest RH control throughout the year with fluctuations ± 5% while class C, prevents extreme risks and may have an RH fluctuation of 25% -75% and T values should be below 30ºC (*Table 3.6*) (ASHRAE Handbook: Heating, Ventilating and Air-Conditioning Applications, 1999, 2015).

Table 3. 6. Recommendations and control classes according to ASHRAE (2015).

Type	Annual Average	Maximum fluctuations and gradients in controlled spaces			Comments
		Class of control	Short-term fluctuations	Seasonal fluctuations	
Museums, Art Galleries, Libraries and	50% RH (annual average for permanent collections)	AA Precise control, without seasonal changes, with	RH ±5%, T ±2 ºC	RH without changes T to ± 5 ºC	This class does not pose a risk of mechanical damage to almost all

Archives		alternative emergency system.			objects and paintings.
	Temperature values between 15°C and 25°C	A Precise control, some seasonal fluctuations and some gradients, not both, with alternative emergency system.	RH ±5%, T ±2 ºC	RH ±10% T to +5 ºC T to -10 ºC	This class poses little risk of mechanical damage to very sensitive artifacts; there is no mechanical risk to most artifacts and paintings.
			RH ±10%, T ±2ºC	RH with no changes T to +5ºC T to -10ºC	
	Note: Halls designed for temporary exhibitions must have the parameters 50% RH and 21°C	B Precise control, presence of gradients and limit of T	RH ±10% T ±5ºC	RH ±10% T to +10ºC but not over 30°C	This class poses moderate risk of mechanical damage to highly sensitive artifacts, low risk to most paintings.

		C Prevents extreme risks	RH between 25% -75% throughout the year	T not above 30 °C usually below 25 °C	This class poses a high risk of mechanical damage to highly sensitive artifacts, as well as a moderate risk to most wood and canvas paintings.
		D Prevents moisture	RH under 75%		This class poses a high risk of sudden or accumulated mechanical damage to most objects and paintings due to damage from RH fluctuations.

ASHRAE divides buildings according to their characteristics, into five classes. Class V includes museums designed as such, and cultural and historical heritage buildings adapted for museums can be classified in class IV (*Table 3.7*) (ASHRAE Handbook: Heating, Ventilating and Air-Conditioning Applications, 1999, 2015). ASHRAE with its recommendations turned its attention to the building. Efforts today are made on improving the museum building to make it as quiet and stable as possible to ensure optimal storage conditions of the collections (Michalski, 2016).

Table 3. 7. Building classes according to ASHRAE and the corresponding climate classes.

Climate Control	Classes	Description of the building	Functions	Systems	Classes
Partial control	IV	Massive or layered and plastered walls, Compact construction, Double glazing.	Flat, church, warehouse, office	Heating Ventilation	B, C, D
Controlled climate	V	Insulated structure, Double glazing, Water vapor barrier, Double door.	Buildings designed for museums, libraries.	Controlled climate	AA, A, B
	VI	Constructions with steel structure, Very-well insulated walls.	Storage facilities, exhibitions.	Specific environments	AA, A

3.5 Conclusions

The history of the development of climate recommendations in museums shows that there has been little scientific research on the recommended values of T and RH. The values determined were simply findings or minimum of evidence which had to do with the durability of the constituent materials of the collection. The recommendations are also based on other considerations, such as mechanical limitations of the heating and air conditioning system, limitations imposed by the outdoor climate or the way the building is constructed, as well as the costs of implementing and maintaining the climate control systems.

Only after the 1990s could research provide a general scientific basis for determining suitable climate values for museums, especially T and RH values which may vary within a safety belt. The fact that the results of this research differ from what had become a "climate dogma" after World War II, were criticized by some representatives of this field. These achieved results do not face today any substantial challenges for the data or conclusions and are widely accepted (Erhardt, Tumosa, & Mecklenburg, 2014), they have been translated into international norms and standards.

Preservation of collections depends on understanding how the materials and objects of the collection behave towards the environment and how the impact of the environment can be controlled to maximize their longevity and possibly their survival. Some aspects of conservation are evident such as fire, flood, pollution and earthquakes, which eventually damage or destroy artifacts. It is clear that such threats need to be controlled, eliminated or minimized to the extent possible. Damage due to inadequate T and RH values is often slower but equally serious and dangerous problem which leads to degradation and eventual disappearance of artifacts.

Determining the values of T and RH is still today infinitely complex. A variety of factors need to be considered as different reactions of materials to these values, what is appropriate for one type of material may be harmful to others. Both the short-term and long-term effects of these parameters, which cause objects to age, must be considered. Maintaining a certain climate in a museum is a responsibility which is costly and time consuming. A suitable climate will contribute to the sustainability of a collection, but maintaining a selected climate based on inaccurate or incomplete information can be devastating for artifacts as well as loss of monetary and energy investment.

CHAPTER 4

ALBANIAN CONTEXT AND THE PERFORMANCE OF ALBANIAN MUSEUMS IN MEDITERRANEAN CLIMATE

4.1 Museums in the Albanian context

The history of the development of museums in Albania lays its foundations and has its origins in archaeological excavations. The first documented excavations date back to the 19th century. They were performed by Shtjefën Gjeçovi, ethnographer, archaeologist and researcher of Illyrian culture (Adhami, 2001) as well as by foreign archeological missions. At the end of the 19th century, foreign scholars and archaeologists became interested in conducting archeological excavations in Albania.

The first interests for archeological excavations emerge from Austria-Hungary in 1892, then the French Archaeological Mission led by Leon Raine and the Italian Archaeological Mission, led by Ugolini and followed by Pirro Marconi, Mustilli and Sestieri (Adhami, 2001).

The archeological findings of these expeditions were numerous and of great value for the history of our country. Preserving them in conditions suitable for the time, exposure to the public and the need to study them brought as a necessity the erection of museum buildings.

Since museums are a reflection of the time to which they belong, it is naturally concluded that historical, political, economic, urban and architectural, social and cultural developments turn into important factors, which influence the design and construction of museum buildings.

In order to analyze the climatic characteristics of museum buildings in Albania, it was first important to understand the development of typology and its characteristics from the point of view of both spatial and construction organization. Hence, to analyze the climate of a building you must first know its characteristics well and this chapter is the cognitive basis of the typology.

4.1.1 The pre-Museum of 19th Century and the beginning of 20th Century

The creation of public museums in the 18th century in Europe and the consolidation of the architectural typology of the 19th century museum could not help but influence the Albanian intellectual climate of the time. The first Albanian museums were formed as private collections, which resemble "curiosity cabinets" modestly following the history of the creation of European museums.

Even in our country the creation of the museum is associated with the existence of the first private collections. At the end of the XIX century in Shkodra there were three museums. In the years 1880 and 1890 two museums were established, which are the first two Albanian museums, known as the museum of the Jesuits and that of the Franciscans (Adhami, 2001). These museums were erected and enriched with objects discovered by archeological excavations carried out by Shtjefën Gjeçovi and Catholic priests. Also, without an exact date is mentioned the museum of Rozafa Castle part of the collection of the Bushati family (Gjipali, 1998). These museums represent two concepts of the private museum as well as the museum used for teaching purposes.

In these first museums the focus is on the contents of the museum rather than on the space where the objects would be placed. The interior and exterior architecture did not constitute any significant background for the exhibited objects. The museum building had not yet been formed as a typology and the name *"museum"* meant the collection and not the building.

The perception of the collections as private, later as educational and their transformation into collections accessible to the public led to the formation of the typology of the building, which would house, protect and exhibit Albanian collections.

The private collections were initially exhibited in the premises of the buildings, which had another function and were not open to the public. The buildings of the

Catholic colleges, their halls adapted for museums created an initial notion of the typology of the museum in our country. The subsequent development of the museum will also reflect in its synthesis these initial elements.

The collections which belonged to the Catholic priests, the later ones of the aristocratic families as well as the excavations of foreign archeological missions formed the basis of the collections of the Albanian museums and brought as a necessity the design of museum buildings with specific characteristics in different periods of social development.

4.1.2 The historical and typological evolution of museums in 1920-1944

The political situation of the country at the beginning of the twentieth century had changed. The country was separated from the Ottoman Empire, Independence was declared in 1912 and in 1920 the government elected by the Congress of Lushnja, made Tirana the capital. Highlighting the continuity of a nation's history and culture became part of the new government's policy, which influenced the intensification of archaeological excavations in the early twentieth century. Archaeological excavations by Albanian and foreign scholars revealed great values of our heritage. To support this situation, various writings of the time addressed the necessity of building a national museum in Tirana (Adhami, 2001). This period is characterized by numerous efforts to build museums, but the economic-political conditions and the many needs that the country had, did not enable the realization of these projects, as had already happened in Europe.

Tirana of the early '20s inherits a spontaneous urban structure stretched and fragmented, which included two areas: residential and economic, connected by a series of narrow streets and alleys which didn't lead to any node (Aliaj, Lulo, & Myftiu, 2003) (*Fig 4.1*). Attempts to build a building for the national museum materialized in 1922. The national museum building, a one-story building, with a compact roof-covered volume, with an unpretentious architecture had four exhibition rooms. It was a building with retaining walls consisting of an exhibition room and a corridor. The plan of the museum alluded to reflect the typology of the "palace" museum consisting of rooms and galleries, while the architecture of the building was a reflection of the urban and architectural context of the city of Tirana of 1920.

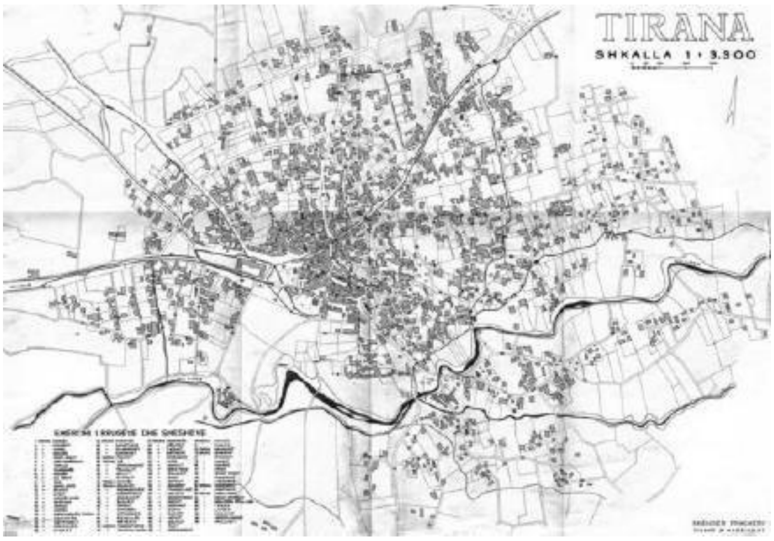

Figure 4. 1. Urban Plan of Tirana 1921.

In a poor style, often labeled as an undignified building for the national museum it collapsed in 1925 (Adhami, 2001). The reasons for the collapse of the building are given by two different authors. Stilian Adhami writes that the building collapsed due to an ownership conflict, while Ilir Gjipali cites as a reason the implementation of the first urban plan of Tirana drafted by A. Brasini in 1925-1926 (Gjipali, 1998).

It seems that the expectations of the intellectuals of the time for the building of the national museum and the transformation of the urban and architectural structure of Tirana justified the demolition of the building in the hope of building a new building. The National Museum was temporarily housed on the premises of the former National Library (Adhami, 2001).

Albanian cities from 1925 to 1943 entered a new phase of their urban development. The urban plans of these years sought to transform Albanian cities into

Figure 4. 2. The building of the National Museum, Tirana 1922.

European cities based on professional and planning concepts. Mostly foreign architects (such as A. Brasini, H. Köhler, F. Di Fausto, G. Bosio, G. Bertè, etc.) worked on the drafting of urban plans and the design of public buildings for several cities in Albania, among which we also find proposals for museum buildings positioned in the center, near important administrative buildings. In this time frame, the typology of the Albanian museum is shaped and developed influenced by the new urban and architectural situation as well as the typology of the European museum. The first projects of museum buildings were designed by the same foreign architects, who left traces in the urban and architectural formation of many Albanian cities.

Under the influence of foreign architects and archaeologists the typology of the museum building is developed according to two subtypes:

- buildings designed for museums;
- existing buildings reused as museums.

Attempts to set up museums according to one or the other subtype were made mainly in Tirana as well as near the archeological centers, which the study treats in chronological order.

4.1.3 Museums after World War II until the beginning of the ’90s

After World War II, the attention of architects and conservationists focused on the remodeling of existing museum buildings (mainly to ensure better climatic comfort) (Keeley, Ian, & Rawlins, 1951). The accommodation of museums in old buildings of historical, cultural and architectural value was rediscovered around the 1960s. Italian architects (Franco Albini, Ignazio Gardella, Carlo Scarpa, etc.) with their restoration interventions showed that they understood the old architecture, respected tradition and their successful reconstructions provided solutions which had a tremendous influence on the further development of the “museum architecture”. The "world masterpieces" broke away from their usual context to be placed in "neutral" spaces in terms of aesthetics and often making bold contemporary interpretations of the sharp divisions between the old and the new intervention (Moos, 1999).

Mainly after the 1970s in Europe, the construction of museum buildings designed as such resumes. The European architecture of the museum of this period is characterized by two tendencies: the architecture of the "white cube" a neutral aesthetic form seen everywhere and parallel to it the so-called "revolutionary intervention" with an innovative architecture (which begins with the Pompidou Center of Renzo Piano and Ernesto N. Rogers (1971-77). In this period museums are equipped with new functions. They are no longer just places of display and storage of heritage objects or works of art but play an important role in education and tourism. Conference halls, recreational facilities, souvenir shops, bars, restaurants, etc. become present in museums. Today's museum is a building where culture is used for new purposes. In these differently conceived, spacious, noisy, and crowded spaces, art is consumed in motion. And it is to this new dynamic of development that architecture has responded by becoming the visible and promotional part of this process. The architecture was adapted to the new functions of the museum. Architectural elements that previously belonged only to shopping malls, train stations, airports, etc. began to be present more and more often in large museums. In this way, the museum lost its unique identity to better respond to the new society.

The development of the typology of the museum in Albania, in this period, does not turn out to be in the same spirit and rhythms with its European developments. The Albanian Museum after the Second World War goes through a process of shaping, which is influenced, first, by the political and economic conditions of the country and the impact of the development of this typology mainly by the countries of the Eastern Bloc. The museum building more than any other building typology of the socialist period was used to serve the established political system and to trumpet the power of the people and the revolutionary efforts of the people in the war and in building socialism, characteristic of all the countries of the bloc communist until the late 1960s (Peeva, 1963). In this context the museum building acquires different typological features in accordance with the developments of the time. By studying the development of the museum after the Second World War in chronological order one can read the different phases and features of this typology, which is presented to us in the following forms:

1- Using the existing buildings as a museum, without making any adaptations or adaptations. Immediately after the end of the war, the best buildings of the time, with architectural and historical values, as well as the spaces of which somehow enabled the organization of the exhibition, were used as museums. This phase can be considered as a "transit phase" where attention was paid only to having a building of architectural value and a minimum of exposure.

2- Adaptation of buildings which had another function and their use as a museum. The typology takes on this feature mainly after the mid ’50s. The museums opened immediately after the war were transferred to other buildings, which had architectural value and after reconstruction adaptations offered opportunities for larger exhibition spaces. The museum begins and regains its importance not only in terms of museology, but also in terms of the studied space where it will take place, the itinerary of the movement, the way of exhibition and the whole architectural and aesthetic conception of the interior.

3- Restoration or adaptation of cultural and historical heritage buildings for museums. In the early 1960s until the end of the 1980s, buildings with important cultural heritage values were restored, some of which housed mainly archeology and ethnography, art and history collections, becoming museums. important of the country. This development consolidated a special typology of the museum, that of the restoration of cultural heritage buildings and their use as a museum.

4- Construction of new buildings designed for museums. This development is very important in shaping the typology of the museum building in Albania. The design and construction of museum buildings in Albania belongs mainly to the last period of the '70s until the end of the' 80s. Despite the ideological influence of this period, which was reflected in the new buildings designed for museums, we can say that this period is the "flourishing period" of the museum building in Albania.

The Albanian museums of these years are presented to us with two different paradigms of museum architecture. On one side the "palace" museum consisting of rooms and galleries, in which all the exhibition premises were interconnected, where the exhibition is treated in a continuous linearity and, on the other hand, the museum "open space" with central vertical opening. Both these museums, present different ways of organizing: one with consecutive closed spaces with defined movement and the other with open spaces and free movement, with fewer physical boundaries and wide visibility. Also, these two museums present different ways of exhibition, one with perimeter exposure along the walls and the other with free exposure and combined placement (perimeter and central) of transparent showcases. In addition to the different ways of functioning, these museums have their own climatic parameters influenced by the typology scheme, the way of design, construction, materials used and readjustments or adaptations performed. The study of these subtypes, the recognition of their characteristics serves as a basis for understanding and analyzing the conditions of the indoor climate in these buildings and its role in the conservation of exhibited objects.

4.1.4 Museum building after the ‘90s

As a result of the collapse of the centralized economy system and political changes in the country, after 1990 begins a period of change, which influences the architecture and urban development of Albanian cities, ending the period of socialist realism. The state of architecture and urbanism is the best visual expression of the difficult transition of the city (Aliaj, Lulo, & Myftiu, 2003). The transition from economics and centralized management to a free-market society created major problems in the country's economy, in the multitude of which architecture was not a priority. The difficult economic situation made impossible the existence of financing for the construction of new public facilities. The museum building as an already important part of the urban fabric of Albanian cities remains in oblivion, going through difficult moments of survival. The "blooming" period of the museum stops. Thus, in these years, the Albanian museum faces the loss of its identity, from a dominant building in the city squares, its presence is overshadowed, covered and surrounded by "informal architecture", which swallowed the museum squares. Some museums were closed, and not only the museums with ideological content, but also important historical and archeological ones (Adhami, 2001).

The architecture of these buildings, due to lack of funds and management policies, degraded daily. The museum did not function as such. The interiors of the museums were turned into warehouses for the preservation of artifacts, a function which they failed to fulfill either in terms of physical security or environmental safety. In this difficult confrontation the museum suffered a collapse, from which it did not recover even after the 2000s. On this difficult road, mainly after the 2000s, some maintenance of museum buildings was performed or any restoration intervention in museums located in architectural heritage sites (such as the Museum "Onufri" or the Archaeological Museum of Apollonia). The only museum, the Archaeological Museum of Durrës, which was completed in the late 1980s, was partially reopened in 2002 to be closed and reopened in 2015. During all these years, there is no new building designed for museum. However, after 2010, some museums were placed in existing buildings, which were redesigned for this function.

If the last museum of the '80s in Albania is in sync with the "boom" of the European museum, at least in quantitative terms, but for the level of architecture of socialist realism of the time we can also say in the architectural one, the museum after the 90s has failed to synchronize with the development of the 21st century museum. The beginning of this century for the world museum will be remembered as its "golden period". Today new museum buildings act as important urban catalysts in post-industrial cities and possess ambitious aesthetic mechanisms that influence how the architectural form harmonizes the functional and representative, increasingly complex, complexity of the contemporary museum. Today's museum architecture illustrates the evolution of architecture and gives an accelerating transformation to its trends (Greub & Greub, 2008). In reflection of this development and the current role of the museum, the deserved attention to museum buildings should be returned, both in the design of new museums and in the rehabilitation of existing buildings.

4.2 The internal climate of the Albanian museum and the presentation with its regulatory technology

Studying the history of the development of the museum typology in Albania aims at recognizing the archetypes and architectural features of this typology, the study of which has been a first opportunity to understand the efforts made to realize in these buildings what is very primary: creating an indoor climate suitable for both exhibited artifacts and visitors. The course of the typology of the museum building over the years somewhat clarifies the history of the indoor climate in these buildings, about which very little has been written. Familiarity with the methods of mechanical climate control and its historical monitoring has been the objective of this part of the study. This has been achieved without dwelling on the technical aspects of the operation of control systems, but paying attention to the ways of climate control, the impact of climate on conservation of artifacts and the values of thermos-hygrometric parameters achieved thanks to climate control methods.

The "historic climate" of the museum building, a concept already part of international museum standards is considered very important in determining the internal thermo-hygrometric parameters in museum buildings. Precisely for the importance of this climate, in this study is made a reflection of the "historical climate" and ways to control it in the buildings of the Albanian museum. The development of climatic comfort in museums correlates with the development of museum typology and can clearly be divided into three groups:

- Indoor climate in the period before World War II.
- Indoor climate after World War II.
- Indoor climate after the 1990s.

In all three groups, awareness of the conservation role of climate, economic factors and the level of technological development has also determined the ways to control it. Reflection on the climatic characteristics of the Albanian museum building will be valuable for the logical continuity of today's climate analysis in the monitored and analyzed case of this study.

4.3 Museums and the climate control after 1990s

The museum, as an increasingly complex building in constant transformation to better meet the demands of society, has a strong confrontation with the challenge of conserving artifacts. Today, even the largest museums, with an extraordinary number of visitors, do not find it easy to afford the high costs of operating air conditioning systems to achieve the strict parameters of T and RH as well as the costs of rehabilitating museum buildings with aimed at the continuous improvement of the conservation environment in the museum.

Buildings of the Albanian museums building after the 1990s also faced such a difficult situation, which still suffer today from two very existential problems:

Firstly, the climate control system in those few buildings where it existed ceased to function, creating a climate "shock" for the exhibited artifacts which were acclimatized to the historic climate of the building.

Secondly, for a very long time, until the early 2000s, the buildings did not have the funds to carry out cyclical maintenance work, which led to a deterioration in the museum's climatic parameters. Museum buildings suffer from the problems of humidity, uncontrolled infiltration of air from outside as a result of damage to the winding and windows of the building.

The storage conditions of the collections turn out to be deteriorating in all museums. Some museums were closed, for various reasons, and their collections were stored in warehouses, completely out of criteria. The deterioration of climatic conditions continues even today in these buildings leading the collection objects to accelerated degradation. Despite understanding the situation and the need to control the climatic conditions, it seems difficult to get out of this situation where Albanian museums are introduced today. Anyone can understand when visiting a museum in winter that you cannot stay long inside due to low temperature values or too high during the hot season.

But what are these values really, how dangerous they are for the artifacts no museum specialist can say, as forgetfulness has made the climate not be monitored and the values of the parameters not known. These values are understood in galleries and museums when employees find on the floor fragments of paintings or sawdust fallen from damage to wood by insects. And precisely to understand and analyze this situation, in its parametric values, I had to conduct short-term monitoring at National Museum of Fine Arts to really understand the situation to know better the concerns related to the building.

4.4 Conclusions

The typology of the Albanian museum building has its origins in the late nineteenth century. Like all European museums it took place inside buildings, which were not designed as museums, but had another function. The beginnings of the museum's shaping influenced the creation of an initial typological core of the public museum building. The first public museum built as such, in 1922 reflects in its planimetric and volumetric solution the beginnings of typology, architecture and urban fabric of the time. The presence of foreign archaeological expeditions and their work in discovering Albanian artifacts brought to light cultural heritage values which had nowhere to be exhibited.

The typology of the museum takes clear forms of development, in different subtypes, after the Second World War. According to the grouping into four subtypes, the Albanian museum of these years is presented with two different paradigms of museum architecture: on the one hand the "palace" museum consisting of rooms and galleries, in which all the exhibition premises were interconnected, where the exhibition treated in a continuous linearity with defined movement and on the other hand the museum "open space" with central vertical openings, without borders, with wide visibility and free movement. The architecture of the new museum buildings takes on due importance in this period in which modernist influence is felt, although it penetrated with great difficulty. However, the architecture did not escape the ideology, it covered the pure volumes of these mosaic buildings, the bas-relief paintings with ideological content, thus turning the museum into a servant of power both in content and form.

It can be said that the museum of the '80s coincides with the development of the European museum of this period in terms of the pace of design and construction of new museums as well as the restoration of architectural heritage buildings and their use as museums. Both of these typology developments appear with their own characteristics. The architectural heritage buildings restored for museums did not reflect the European tendency of the time where the sharp symbiosis between the new and the old brought a new conception of this subtype as well. They were simply restored and used as museums, and therefore constantly displayed problems of functioning and indoor climate necessary for the museum building.

In this view, summarizing the development of museum typology in our country, it has not been easy to group, study and illustrate with museum typology projects, as there are very few materials and studies in this field. I say this to understand perhaps another reason why today museum buildings are in a state of survival forgotten and covered by the rhythms of profitable constructions, without any role in the urban development of cities, without a dignified physiognomy and architecture.

The study of the process of shaping the museum building in Albania, identifying the characteristics of the typology, served as a basis for better understanding and analyzing the climatic conditions of the museum building in our country.

CHAPTER 5

NATIONAL MUSEUM OF FINE ARTS AND CLIMATE MONITORING

5.1 An overview of history

The National Museum of Fine Arts is a national central museum, a scientific institution, that to preserves, presents, promotes the national heritage of the Albanian state in the field of visual arts.

The gallery has its beginnings with the efforts of a group of Albanian artists and the Arts Committee of 1946. *Pinakoteka1* was the first institution of fine arts in Albania. After a genuine work and many efforts on January 11, 1954 it was officially opened to the public as the Art Gallery in Tirana. In 1956, as a result of the enrichment of the fund of works of art, from the flourishing of creativity and the purchases of the time, the Gallery was moved to the most suitable building, with three floors on "Fortuzi" street and with numerous exhibition spaces, both inside as well as outside it.

But the Museum has changed its body several times. The National Gallery of Arts was inaugurated on November 29, 1974 and was built from 1973 to 1974 by Architect and Urbanist Enver Faja. The fund of the new Gallery, up to this period had 4626 works and in its archive were registered more than 600 authors2.

In 1971, when the works started, the Gallery was built on the basis of a complete program for a genuine art gallery, with the function of exhibition, restoration and study of the fund, as well as the cultural function of organizing conferences, lectures, national, international and private meetings of people of art (Faja, 2008). The building was initially developed in the building near the "Dëshmoret e Kombit"

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[1] *Pinakoteka (eng. Pinacotecha) is a picture gallery in ancient Greece and ancient Rome. In Albania, it was opened in Tirana in 1952, where a number of works by Albanian and foreign painters and sculptors were collected from their own collections or from various state institutions, as well as from other works by contemporary authors.*

[2] Material retrieved from the archives of Ministry of Culture in Albania.

Boulevard and subsequently Faja designed additional spaces in the service of the National Gallery of Arts. In 1976, the part of the gallery that had mainly exhibition halls was inaugurated, other facilities remained at the minimum necessary to be realized in a second phase. On August 10, 1992, the Art Gallery was renamed the National Gallery of Arts with this motivation: "To better express the purpose and functioning of this institution as the only, national one that protects and promotes the interests of the Albanian fine arts" (Faja, 2008).

The cafe area on the ground floor was converted into a library and a new interior space was transformed during the period 1998-2002, when the Director of the Gallery was Gëzim Qëndro. This created a particular place for the Archive which had previously been extended and needed additional room.3

In 2009, a major investment and contribution was undertaken by the National Art Gallery, consisting of quality reconstruction and reintroduction of the interior space as closely as possible to their original building design and a new museum line designed to provide an opportunity to acknowledge, educate and inform the Albanian and foreign public.

The National Museum of Fine Arts has the mission of collecting, conserving, documenting, studying, restoring, exhibiting and developing cultural heritage values, promoting the best works of traditional Albanian visual art and national and international contemporary artworks.4

5.2 Architectural features of The Museum

The National Museum of Fine Arts (the building of the National Gallery of Arts) is located along the "Dëshmorët e Kombit" Boulevard in Tirana and consists of two buildings connected by each other; the main building, seen from the "Dëshmorët e Kombit" Boulevard, originally built in 1973, which consists of three floors and a partial technical floor below ground level, with a richer treatment of the facades, and

[3] Material retrieved from the archives of Ministry of Culture in Albania.
[4] Retrieved from: http://www.galeriakombetare.gov.al/mbi-galerine/historiku.shtml

the rear building with two floors that was added a few years later as an exhibition hall5 and does not have any special treatment in the cladding of the facades and is distinguished for the harsh choice of construction quality.

The National Gallery of Art is developed in 4 floors, of which one is underground and three are above ground. The functions performed on each floor are reflected below:

Basement floor (floor -1): Depo and warehouse**,** Technical Room

Ground floor (floor 0): Entrance**,** Main Hall**,** Administration Offices**,** Library**,** Restoration Laboratory**,** Education Space (atelier)**,** Temporary Exhibition

First floor (floor +1): Painting Exhibition**,** Fund

Second floor (floor +2): Exhibition

[5] Material retrieved from the archives of Ministry of Culture in Albania.

Figure 5. 2. Masterplan of the Museum.

5.2.1 Masterplan

Currently, the entrance area of the building appears arranged with greenery and stone tiles, while the back space of the building is occupied by car parking lots, kiosks, garbage dumps and improvised spaces for outdoor sculptures.

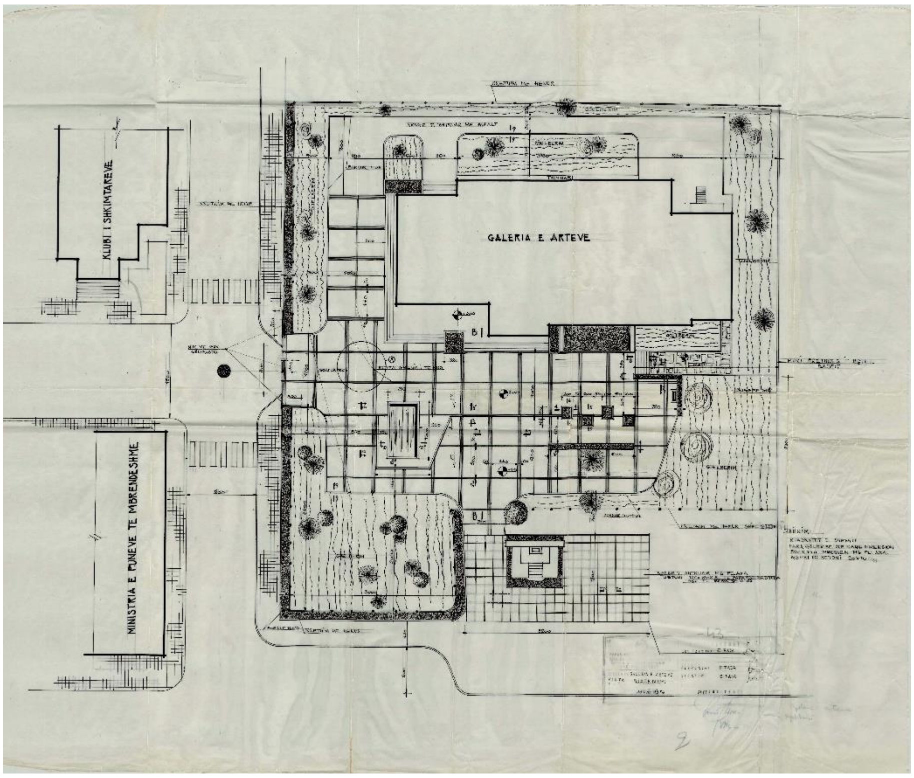


Figure 5. 3. The masterplan of Museum as it appears in the archives.

The terrain has significant quota disparity and different layouts. Parts of the paving slabs are broken, while a considerable area in the backyard is paved with fine gravel.

One of the important problems that is ascertained is the lack of drainage system which causes flooding of the spaces around the building and flooding in case of rain.

5.2.2 Basement floor

The partial basement floor is used as storage and electrical technical environment. Access to it is realized by internal stairs and some external stairs that come to the perimeter of the building. The floor is illuminated by windows on three sides of it.

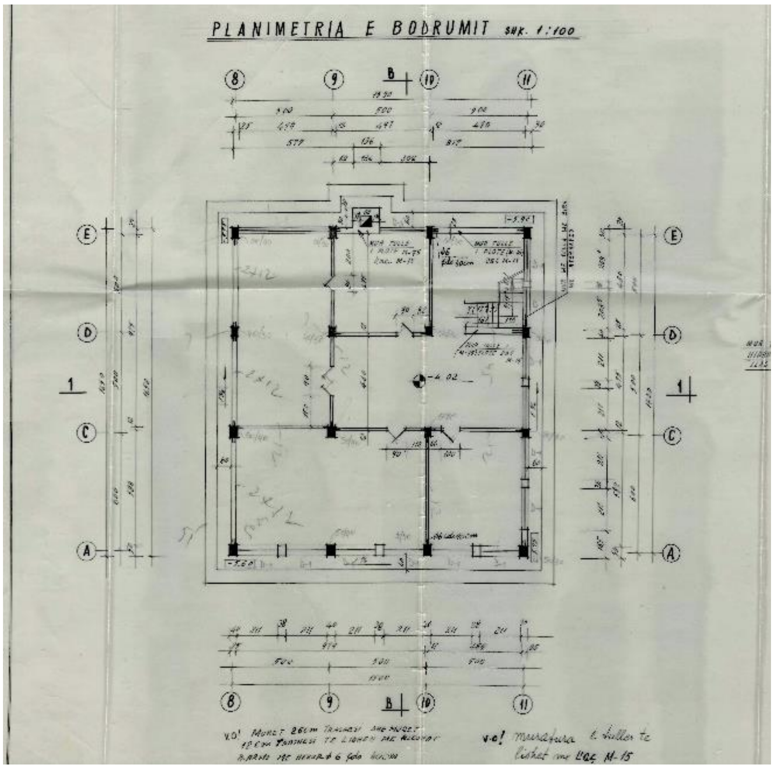


Figure 5. 4. Plan of the underground floor. Taken from the Museum's Archive.

Drainage problems have caused occasional flooding of this floor, which has made this space out of normal function. Some of the windows are closed and some are broken.

Humidity displayed on the walls, lack of plaster, paving slabs and lack of maintenance has led to severe degradation of this space. The following images show the current condition of the basement of the National Museum of Arts.

Figure 5. 5/a/b. Pictures from the basement.

5.2.3 Ground floor

The ground floor starts with the main lobby where the reception and the ticket office are located. Through the lobby the distribution takes place in the temporary showroom located in the rear aisle to the east, in the library which is located in the aisle to the north and in the administration.

The main public entrance is also used as an entrance for the administration and an entrance for the works, as the dedicated entrances for them are missing.

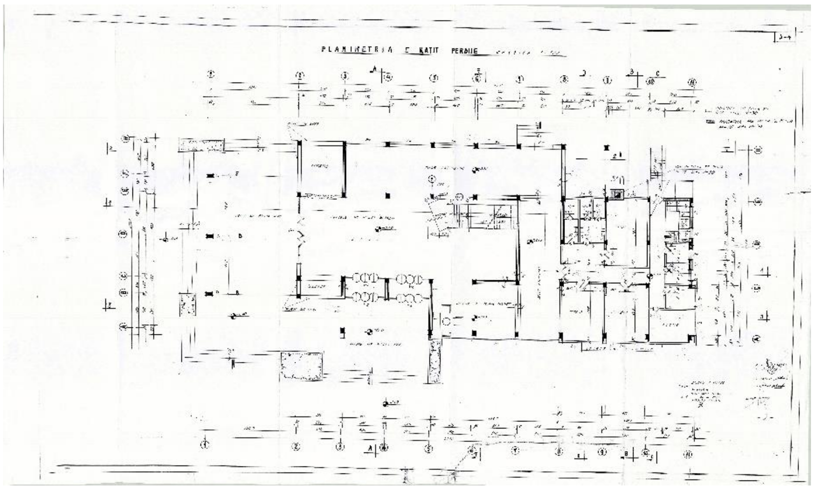


Figure 5. 6. Ground floor as it appears in the archives of The Museum (1973).

On the ground floor, in an improvised space between the main building and the additional one, are placed the fund of sculptures, outside any standard for the placement and storage of works.

The area dedicated to administration is very small compared to the capacity of staff and functions that an art museum should have.

There is currently no space dedicated to the temporary entry and storage of works brought to the gallery. There is also no real digitalization center for works, nor an elevator for transporting works to different floors.

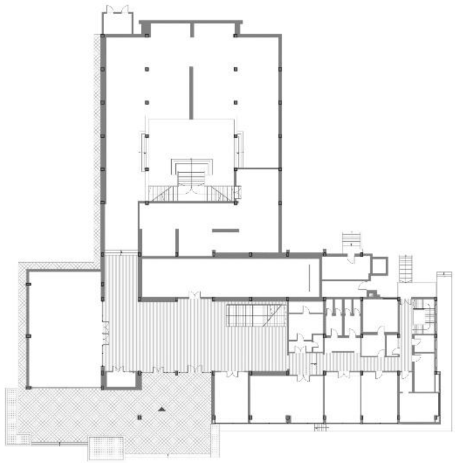


Figure 5. 7. Ground Floor as it appears in the update of 2019.

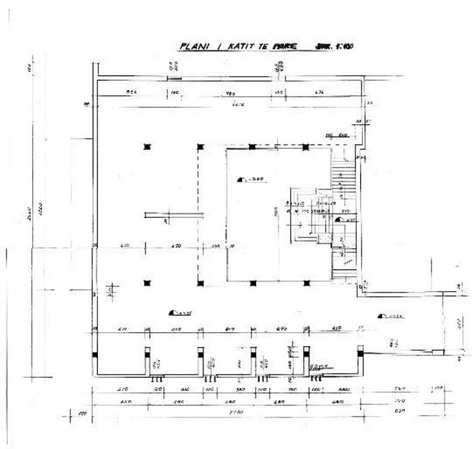
A minimum space of 50 m2 is improvised for the laboratory, which is used for both painting and sculpture. The laboratory has a glass facade in the west and is not shaded, which greatly complicates the working conditions and often damages the works. He also lacks the disinfection room, metal shelves, hood, etc. Within the space in question there are also two job positions.

Currently The Museum has a fund area of about 550 m2, of which about 200 m2 occupy sculptures and 350 m2 paintings and graphics. The spaces in which the fund is located are totally improvised, do not meet the physical conditions of storage of works and security conditions. The overlap of works without organizational structure has been forced due to insufficient space made available for the fund. The fund is located in four different areas of the building on the ground floor and the first floor.

The marble floor in the lobby has suffered significant cracking, while the 10x10 striped ceiling looks depreciated.

The Additional Volume

The building, which was built a few years after the initial project, is an addition that was built in response to requests for more exhibition space. This building, which was built next to the original building's eastern facade, has completely ruined the appearance of that facade by completely covering the architecture that it represents.



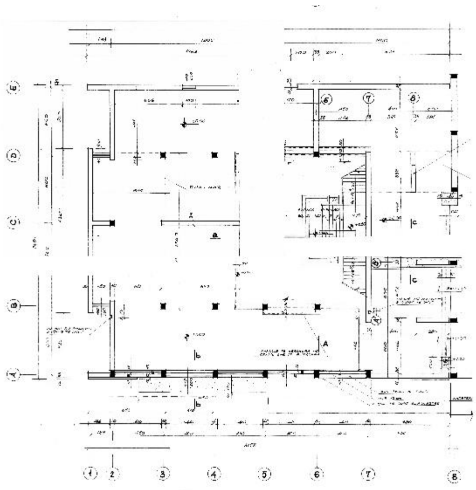


Figure 5. 9/a/b. Plans from the archive of the additional volume.

The majority of the surface of its perimeter is lined with mosaic, which is no longer visible, and the idea of having a glass window, as designed by the architects in the initial design, has been lost on the ground floor.

5.2.4 First and Second Floor

Permanent exhibition halls are located on the first and second floor of the main building. Exhibition halls do not have a controlled air and temperature system, which leads to serious damage to the exhibited works.

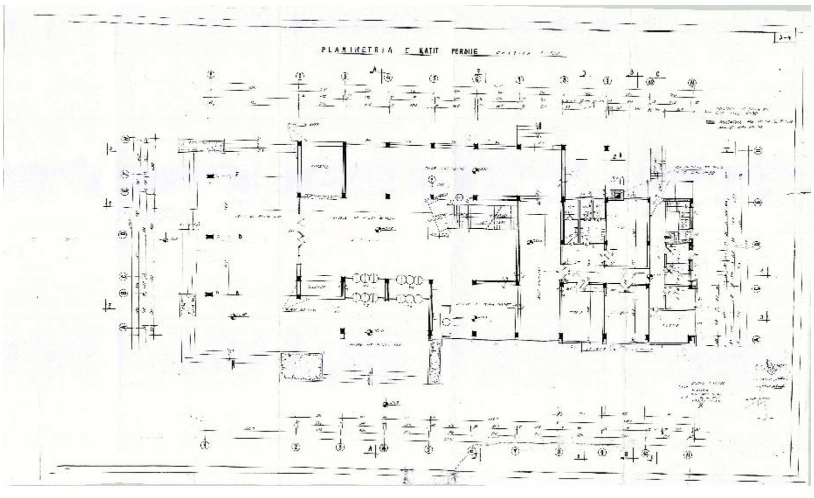


Figure 5. 10. Plan of First Floor as it appears in the archives of The Museum (1973).

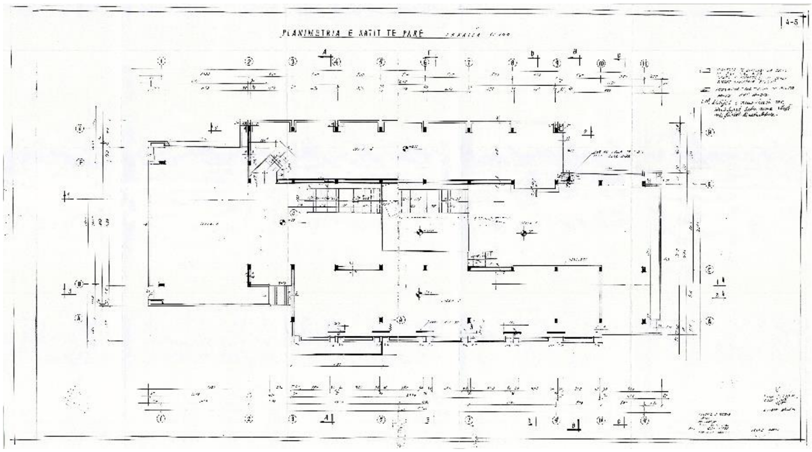


Figure 5. 11. Plan of Second Floor as it appears in the archives of The Museum (1973).

The windows of the building are made of wood or aluminum profiles with thermal bridges and single glazing, a system that brings problems in maintaining the internal temperature.

A space of about 200 m2, on the first floor of the additional building is improvised for the fund of paintings, a space that is improvised outside any standard for the placement and storage of works.

Figure 5. 12. The stairs at the additional volume that connect two floors from the East side.

5.3 Construction Features

The existing building project of the "National Museum of Fine Arts" or "National Gallery of Art" is dated 1974.

The level of in-depth knowledge of the structure is based on the graphic materials of the initial project, the visual evaluation during the visits to the building of Gallery of Arts and the evaluation of the issues raised in the reports of state institutions.

The evaluation of the structures of the existing building is based on the graphic material made available by the Central Technical Archive of Construction, the

Ministry of Culture, the National Institute of Cultural Heritage and the observations on the object of the issues raised.

Graphic materials are the constructive design and the initial geological relation used in the design of the existing building. The existing construction project is complete but the calculation relations are missing and the technical notes contain only the data on the strengths of concrete and steel. The plans of the foundations and ceilings are often very schematic incomplete with the dimensioning of the elements in the cut. This makes it difficult to read the dimensions of the structural elements. Below are the foundation plan and floor plans according to the existing project.*

The supporting structure of the existing building is with reinforced concrete skeleton. The brick walls are not retaining but simply serve for the division of the premises and the realization of the external facade.

From a structural point of view, the building is not regular in plan and height. The ceilings are made of reinforced concrete in some monolithic areas and most of the structure is covered with prefabricated slats.

The foundations of the building are conceived as separate plinth type foundations partially connected with foundation beams. The plinth slabs are positioned in several quotas.

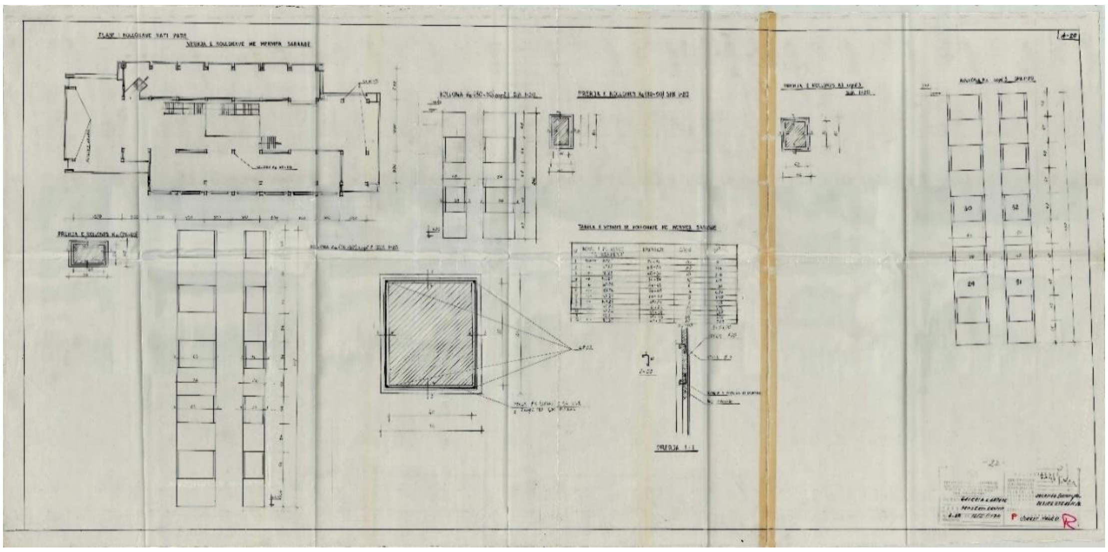


Figure 5. 13. Plan of the columns of First Floor. Details. (1973)

The building in one part of it has a basement. The perimeter walls of the basement are made of butobeton[6] concrete.

5.4 Museum's Climate Conditions

The period from the late '70s to the mid-'80s is the period of "blooming" of the typology of the museum building in Albania. During these years the typology develops into two main archetypes: that of the building designed for museums and the remodeling of architectural heritage buildings. Very few of these buildings were designed with climate control. Installing an air conditioning system is costly not only as an initial investment, but also the cost during its use is very high, as the system to maintain constant parameters must work without interruption. For this reason, these systems were installed in only two museums.

The mechanical control of the indoor climate in the Albanian museum is applied after the '50s, starting with the heating systems with radiators. The first moment in which we encounter such a system, where the indoor climate takes on due importance, is the building of the museum "Lenin-Stalin" (1954). The heating system project is carried out by Albanian engineers in cooperation with the Russian ones (P. Nishani and H. Mechuatal) (AQTN, 2021), which envisaged a central heating system with water radiator. The system boiler and all pipes were placed in the basement with an area of 6 m^2 so as not to affect the exhibition halls. The connection of the pipes to the radiators was done vertically by piercing only the floor (AQTN, 2021).

The project of The National Gallery pays attention to condensation problems. The building is considered to have sufficient ventilation as the premises were open and the positioning of the windows facing each other provided transverse ventilation of the exhibition halls. In case there would be condensation problems the project

[6] *Butobeton is a type of concrete mixed with stones usually used in base of walls or for perimetral walls especially in ground level.*
(**Description of the level of the information I could get about the construction and the explanation of the referential medias that has helped in this sub-chapter).*

recommended replacing part of the glass surfaces with glass shutters to enable better ventilation (AQTN, 2021).

The project notes indicate that: *"central heating and repairs of the changes are made in order to eliminate the internal humidity, which damages the exposed objects for which a temperature of 18 °C is calculated"* (AQTN, 2021).

In this museum, for the first time a project is designed with the aim to control the indoor climate in parameters favorable to the collection. Despite the recommendation for a "stable temperature value", no data is provided on the levels at which the relative humidity of the air could be controlled, which, as understood by the project, had to be controlled through temperature. From the studies of archival materials there is no data which show real values achieved by the system, but field workers show that they do not remember that there were problems in the exposed objects, although the placement of radiators with water heating was a way of controlling of climate already not highly recommended.

And in fact, the best example of where the radiator heating system failed to provide a comfortable climate for works of art is that of the National Gallery of Art. The heating system of the Gallery was realized with water radiators, which were supplied by a central boiler. The system worked during the hours when the gallery was open and disconnected during the night or days off (Stamati, 2004). Very soon with the commissioning of the system, within the first 2-3 days, damage to the wooden frames of the paintings was noticed. Damage initially appeared in the paintings on the radiator and a little later the situation was reflected in most of the paintings exhibited in their vicinity (AQTN, 2021). The damage came as a result of the immediate drying of the wooden frames. This situation was created by the fact that the set temperature level did not take into account works of art but human comfort and that such a system could not provide constant values of T and RH. The researcher Frederik Stamati in his book "Environment in the museums of Albania" writes:

"In order to understand and control the situation in the environment of the the National Gallery of Arts, several thermos-hygrographs were installed with weekly registration. It was found that temperature changes at peak heat and overnight temperature reached 12 °C, while relative humidity changes up to 26%. This 24-hour cycle, which was devastating, was immediately interrupted, making two interventions

within a week: the first by removing all the paintings placed on the wall surface above the radiators up to 2m right and left, where the impact of high temperature and the second intervention never putting into operation the wrongly designed heating system of the Gallery.”

The disconnection of the heating system brought improvements in the parameters of temperature and relative humidity of the air. Thermo-hygrographs showed a "calming" of the situation, which was considered better. However, the Gallery's indoor climate was out of control, depending on the "benevolent or malicious" weather (AQTN, 2021). The climatic situation was out of control; it depended on the weather and the depreciation that the buildings could do so out of any technical control.

The situation is the same today. Damage problems show not only the paintings on display, but also those stored in the fund. Storage facilities, in the basement, have no possibility of ventilation, the works on wood suffer from mold, a fact which proves that the relative humidity is over 70% (AQTN, 2021). The situation was assessed by analyzing the damage caused to the wooden artwork. This estimate is an argument which clearly states that we cannot estimate and analyze thermos-hygrometric parameters based on consequences which are often irreversible. Continuous monitoring and analysis of parameters is therefore a necessity to prevent degradation of artifacts.

The experience of the Albanian museum until the early 1980s confirmed what in Europe had long been scientifically and practically proven: the use of radiator heating systems caused damage to the organic materials of the artifacts. Damage came from high temperature values which caused air drying to levels below 30%, as well as RH fluctuations above 40% within the day-night interval (fluctuations more than 10%).

The National Gallery of Arts which was designed with controlled climate served as a negative example of a wrongful intervention in artificial climate control. The transition to an uncontrolled climate had two consequences: it created a climate "shock" within a period of 3 weeks and after that the climate continued to remain uncontrolled.

5.4.1 Museum ceilings as a lighting envelope

One of the added values of the project of the National Gallery – now the National Museum of Fine Arts – is the variety of ceilings for certain spaces within the building. Depending on the level where the exhibition surface is located but also under the possibilities conditioned by several policies, to have closer solutions to Modernism, architect Faja has created the opportunity to develop large ceiling surfaces with direct materials that integrate the necessary aspiration and lighting for the given function of space. What distinguishes it is the perforation of light materials, especially on the second floor, in which a direct relationship with nature is created, a filter with which, is a layer of plexiglass that transcends natural light.

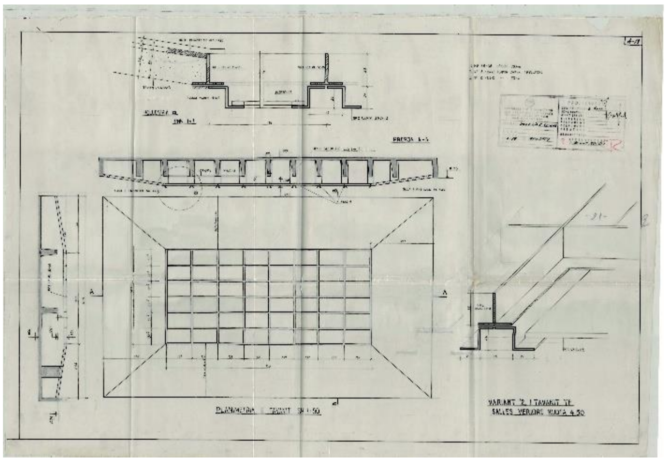


Figure 5. 12/a Ceiling plan of the exhibition space from the North.

Figure 5. 12/b The state of the ceiling now.

As shown in *Fig. 5.12/a/b* and *Fig. 5.13 a/b/c*, the initial ceiling plan contains quite simple engineering details and conditioned solutions, but they go very well with the rest of the building.

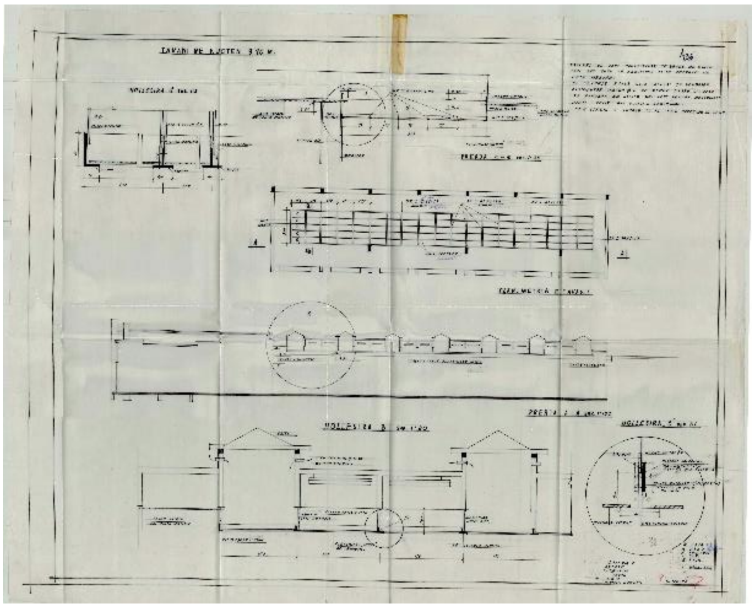


Figure 5. 13/a Ceiling plan of the exhibition space from the West.

Figure 5. 13/b The state of the ceiling now.

Figure 5. 13/c A detailed view of the covering.

5.4.2 Windows as a filter of air temperature

The object of the National Gallery is non-monolithic; the shape is irregular and the volumes of the various quotas remain self-contained. To maximize the exhibition spaces, the architect Faja, avoided openings in the perimeter walls, thus leading to the absence of windows in most of the Gallery. Although their lack is offset by illuminated ceilings, time has shown that lack of natural light is often inefficient in various areas.

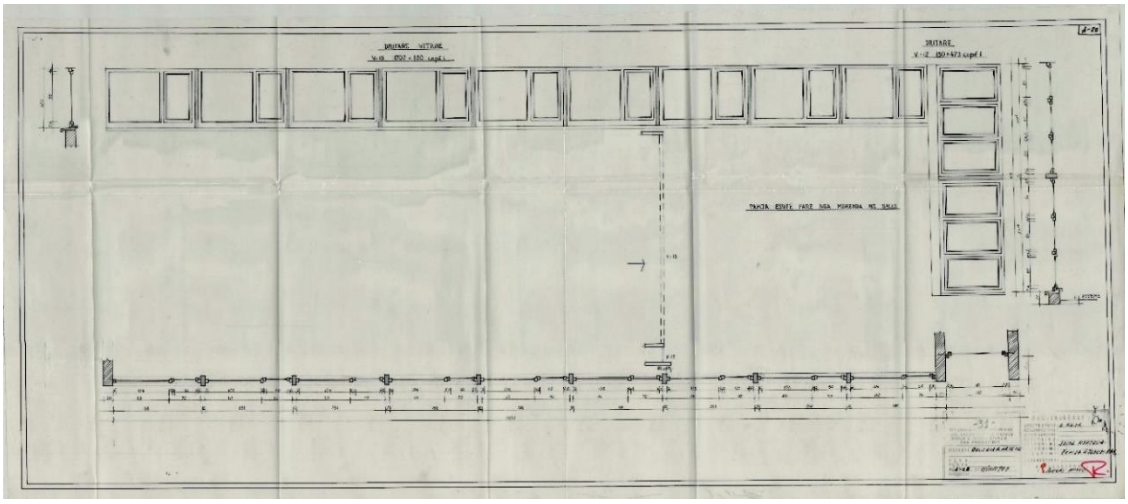


Figure 5. 14. Detail of the windows. (1973).

While in the later addition, from the presence of longitudinal windows is noticed on its upper floor. Although not so influential in the overall lighting, the presence of these openings creates more efficient ventilation in relation to the entire surface of the additional building, the ground floor of which stands gloomily under the artificial neon lighting under the plexiglass.

Figure 5. 15/a/b/c Openings on the West side of the added volume from the East.

What has really created the relationship with nature, but also with the urban context is undoubtedly the presence of windows on the first and second floor, while the transparent surfaces at the entrance, the library and the restoration area also play an important role. What is problematic is the lack of shading that normally brings a thermal shock to artifacts.

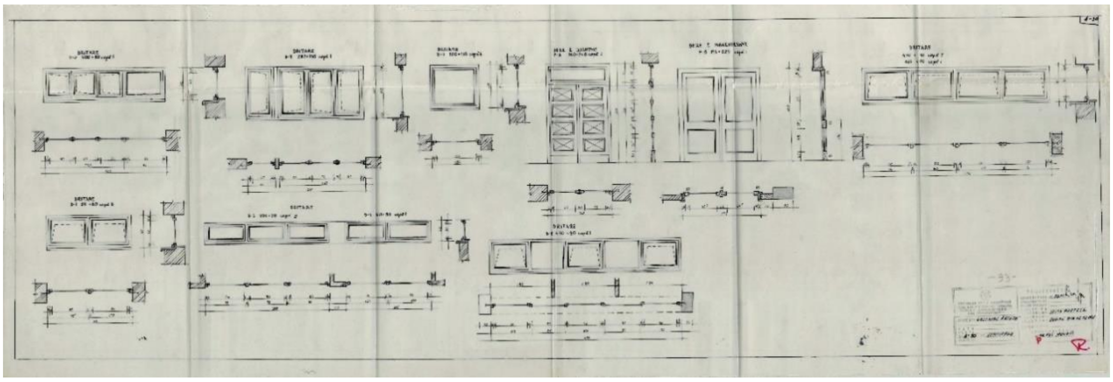


Figure 5. 16. Details from the windows and glass doors from the First Floor (1973).

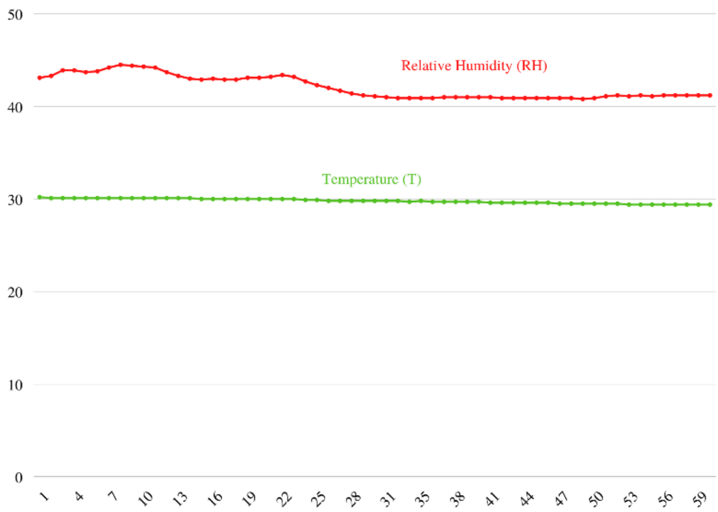
5.5 Measurements and results

At the National Museum of Fine Arts, measurements were made for each exhibition space. The measurement period aimed at a long period of time in order to have the most stable data, but in the case of this study the strategy of simultaneous measurement was followed. To measure the values of T and RH in the interior of the museum were followed the basic rules of thermo-hygrometric measurements with the "testo 605i" tool. 12 different points were monitored in the exhibition spaces of the museum (Fig. 5.16/a, Fig. 5.16/b).

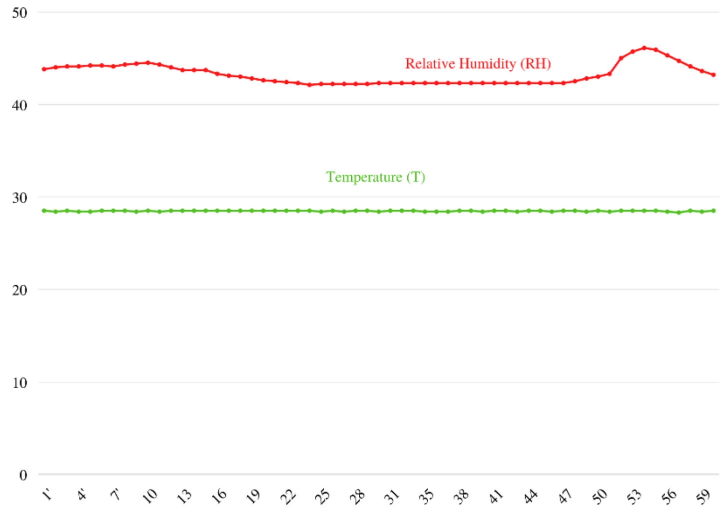
Figure 5. 17/a Points of Measurements for Ground Floor.

Figure 5. 14/b Points of Measurements for First Floor.

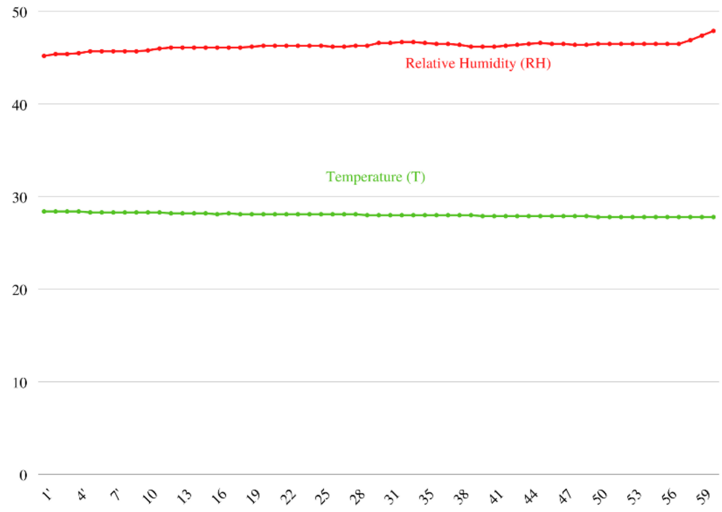
The values recorded and graphically processed are presented in detail for each position, according to the measurement schedule, in Appendix 2 of this study. This chapter presents the general graphs for each position as well as the total measurement graph for the whole museum.



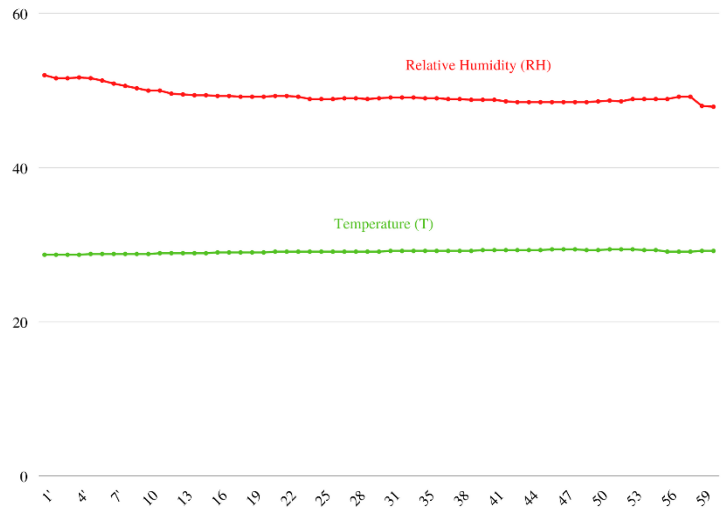
Graphic 5. 1. Values of T and RH for Point 1



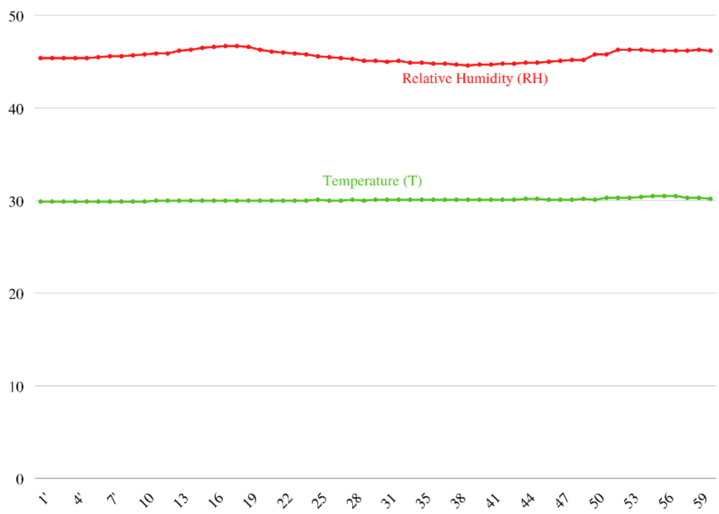
Graphic 5. 2. Values of T and RH for Point 2



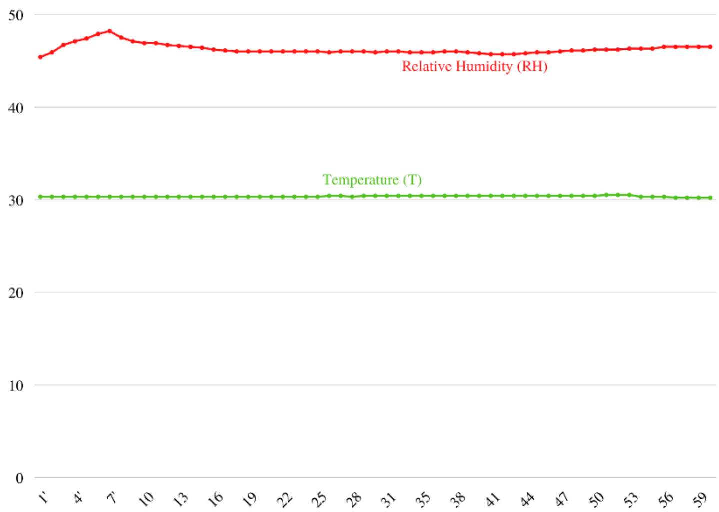
Graphic 5. 3. Values of T and RH for Point 3



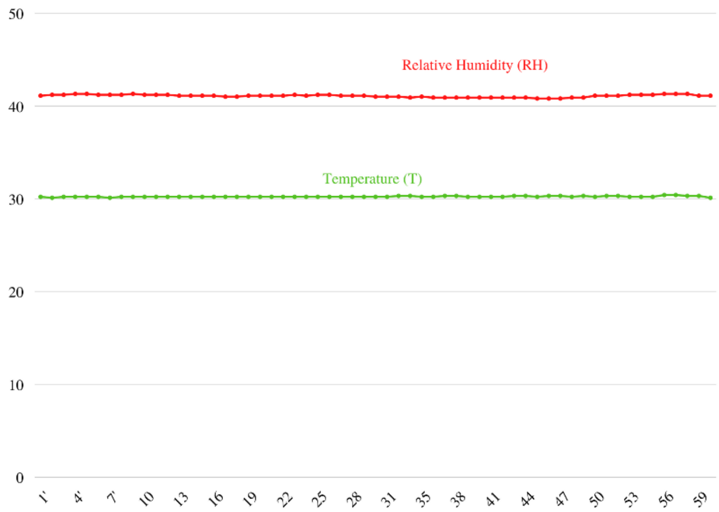
Graphic 5. 4. Values of T and RH for Point 4



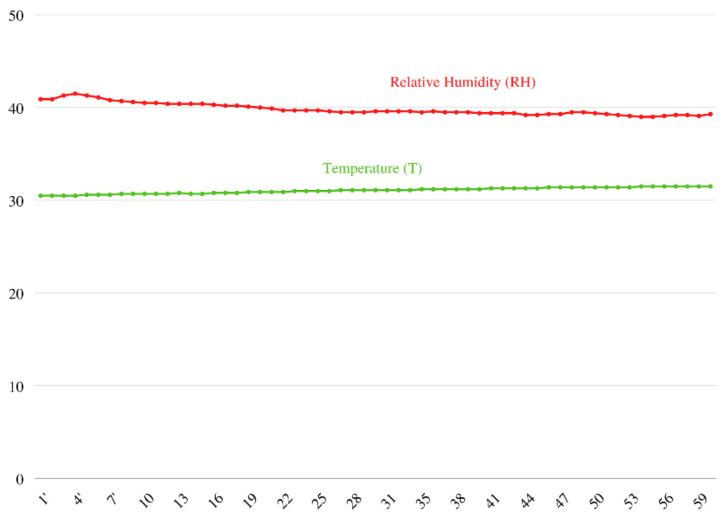
Graphic 5. 5. Values of T and RH for Point 5



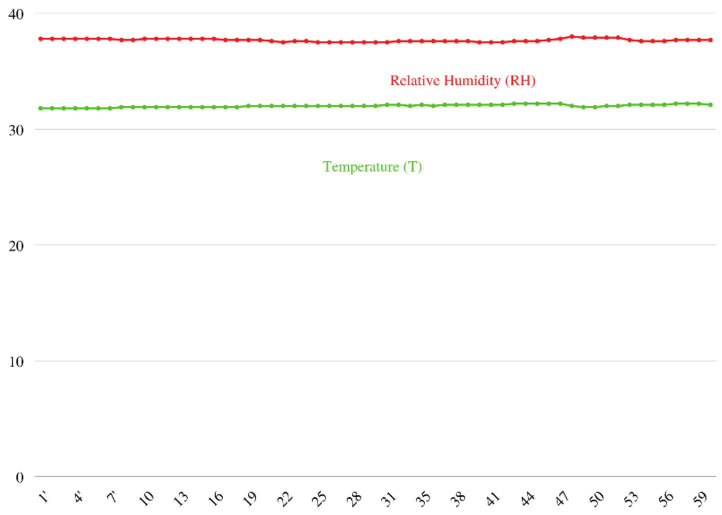
Graphic 5. 6. Values of T and RH for Point 6



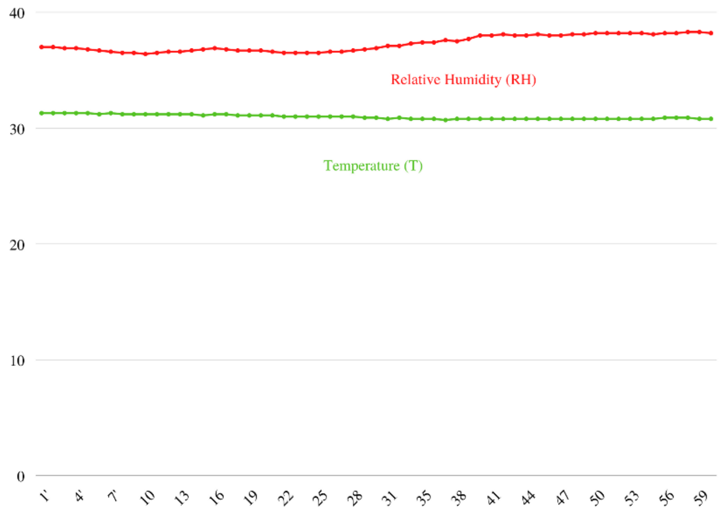
Graphic 5. 7. Values of T and RH for Point 7



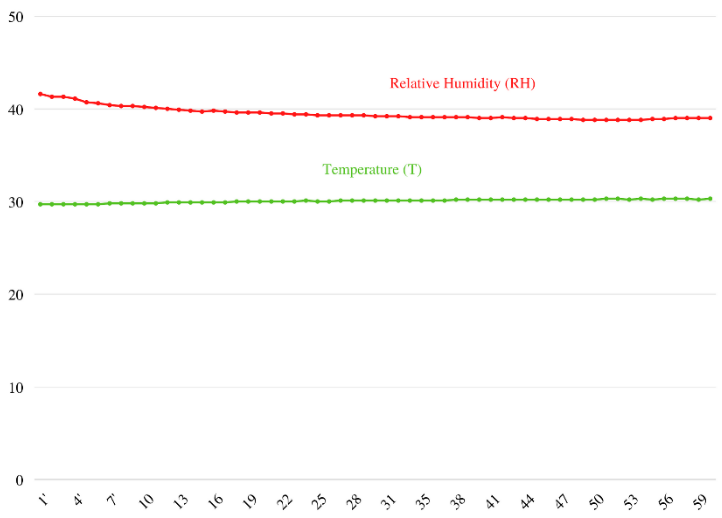
Graphic 5. 8. Values of T and RH for Point 8



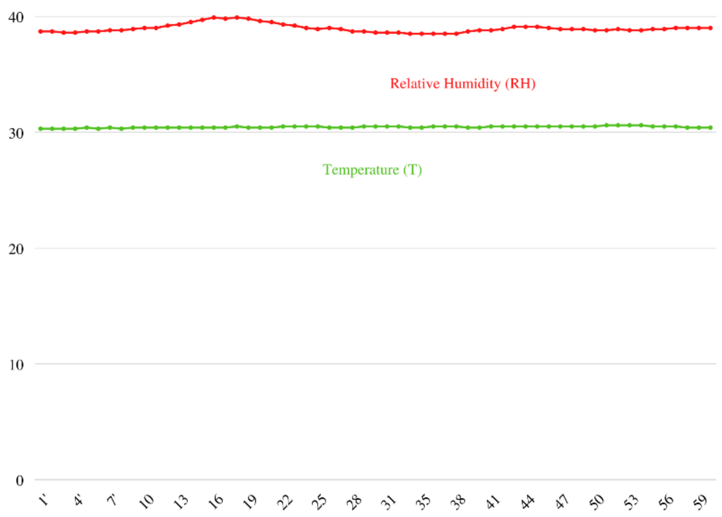
Graphic 5. 9. Values of T and RH for Point 9



Graphic 5. 10. Values of T and RH for Point 10



Graphic 5. 11. Values of T and RH for Point 11



Graphic 5. 12. Values of T and RH for Point 12

Table 5. 1. Table of the values for each measured point at The Museum.

Average values of each measured point at National Museum of Fine Arts			
Floor	Point	T (ºC)	RH (%)
Ground Floor	1	29.7	42
	2	28.5	43.1
	3	27.8	48
First Floor	4	29.1	49.5
	5	30	45.5
	6	30.3	46.2
	7	30.2	41.1
	8	31.1	39.8
	9	32	37.7
	10	31	37.2
	11	30	39.5
	12	30.4	39

5.6 Analysis of the results

The monitoring of the National Museum of Fine Arts has been a long and continuous process, which has not only coincided with the physical measurements, but also with research and observations of the thermal performance – as well as the architectural – of the museum object.

However, the values of the measurements for the summer period, are an important indicator, of a necessary process, for the continuity of this museum.

On the ground floor of the Museum, measurements have been made at three points in the Eastern area, where the exhibition hall of the fund works and from where the connection with the upper floor is made.

For the ground floor, the minimum value of T is **27.8ºC** and the maximum **29.7ºC**, while the average T of the single exhibiting area on the ground floor is **28.7ºC**. This value is considered ***high*** according to the standards for Temperature.

The minimum value calculated for RH is **42%**, the maximum **48%**, and the average value is **44.4%**. This value is considered ***not too high*** for the Relative Humidity standard.

These values, which do not show very large fluctuations towards the average standards, are conditioned by the position in which the exhibition spaces of works of art are located. For example, on this floor, thermal openings are missing, there is no presence of windows and the only aspiration function is the semi-functional aspiration system in the ceiling. Another aid, however small, is the bridge connecting the space with the central atrium.

For T the minimum value is that of point 3, 27.8ºC, below the stairs that lead to the upper floor, where currently are placed the most delicate and old sculptures of the fund of the Museum archive. The highest value of T is at point 2, where strangely, on which some of the aspiration tiles on the plexiglass ceiling operate normally.

For Relative Humidity, the lowest value of 42% is in the point 1, the one at the entrance of the additional building, while the highest value is 48% on point 3.

Measurements on the first floor were performed at 9 different strategic points. Although the thermal distribution is not attenuated and different environments make the transition process difficult, the values achieved for each point result as follows:

The minimum temperature has a value of **29.1ºC**, the maximum **32ºC**, while the average value of all measured points is **30.5ºC**. This value is considered ***high*** according to the standards of Temperature.

For Relative Humidity, unlike the floor below, this one is less stable, with less balanced values. The minimum value is **37.2%**, the maximum value **49.5%** and the overall average **41.7%**. This result is ***not too high*** for the RH standard, even though the maximum value is abnormal for a Mediterranean museum.

Such values are quite normal for Albanian museums in summer. The lack of a proper microclimate system, which helps the air temperature and humidity, creating conservation opportunities for artifacts, has led to the loss of technical values of the building.

On the first floor is the presence of portable air conditioners, located in the corner of the exhibition space, which apart from aesthetics is not even scientifically logical. Temperature values are high although there is external influence to regulate these values.

In total, the minimum value of exhibiting spaces for T is 27.8ºC and the maximum 32ºC; while for RH, the minimum is 37.2% and the maximum 49.5%.

CHAPTER 6

THE APPROVED RECONSTRUCTION PROJECT OF MUSEUM AND ITS APPROACH ON MICROCLIMA

The project of reconstruction and rehabilitation of the National Museum of Fine Arts, once the National Gallery, is one of the seemingly ambitious projects of the Albanian government and the Ministry of Culture in the field of culture and monumental buildings in the capital.

This project is conceived as an urban lounge, in the heart of museum life. According to the responsible architects, it will serve as an interface in the urban context for many public functions of the museum.

Figure 6. 1060. The proposed Ground Floor plan for the new Museum.

The project starts with intervention in the existing building of the Museum. Within the boundary of the development area this project proposes interventions in the external system. According to the reconstruction project, excavation and filling of the soil for the new leveling will be carried out. The new water drainage plan will be implemented. Green areas that will be eliminated due to new construction, will be replaced in an area 3-4 times larger.

On the ground floor, the initial project of the Museum has been re-proposed and the demolition of the additional building to the East, to make room for the building of new museum. The openings on the main façade will be restored and there will be fundamental changes in the floor laying and reinforcement of the supporting columns, which will happen for the entire volume (AQTN, 2021).

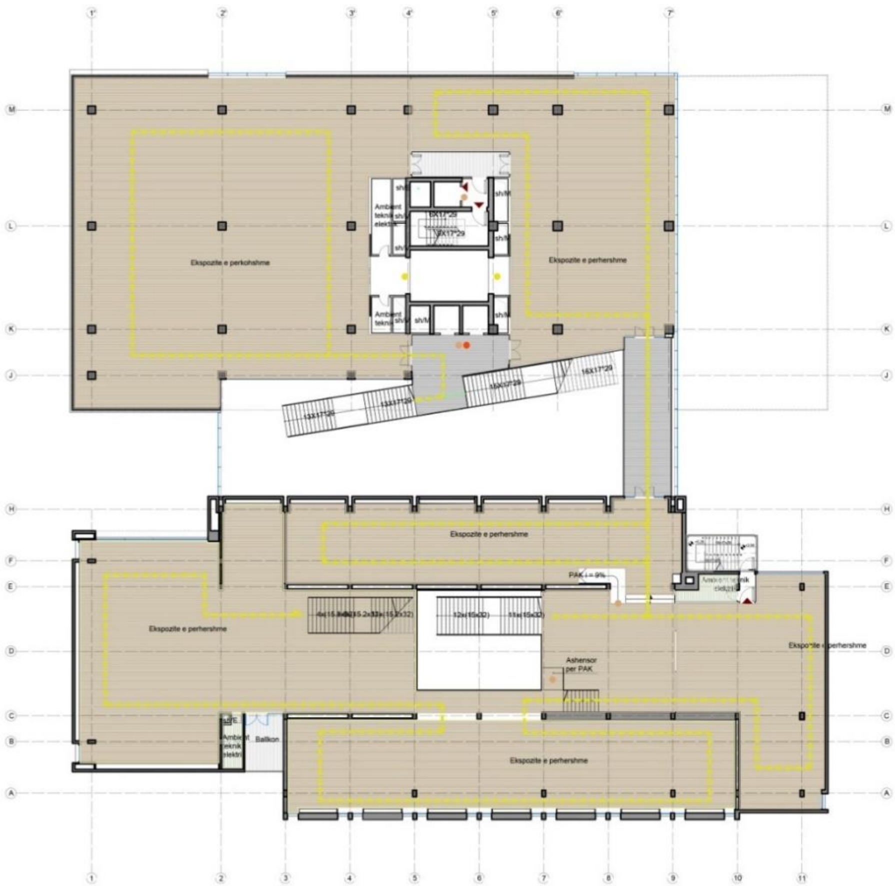


Figure 6. 1064. The proposed plan for the First Floor of the New Museum.

A new ventilation, heating-cooling system will be implemented and after that, on the first floor, there will be complete plaster coating for the ceilings. To reinforce the idea of a good microclimate shaping system, existing windows will be replaced, with others of the same size but of a more contemporary quality.

What appears in the concept is not always what is actually applied. It is a good idea to improve the climatic conditions in the Museum, as this is the main problem we raise in this research work, but a good museum does not only require air conditioning for its artifacts.

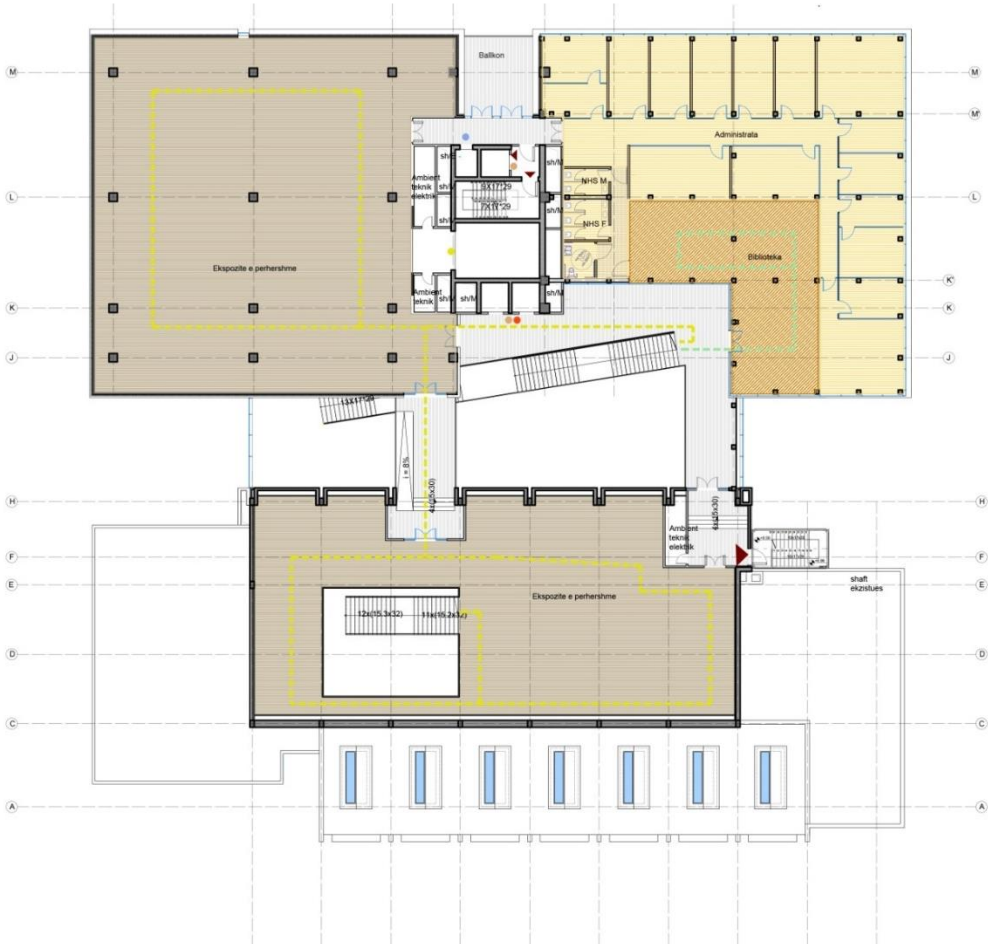


Figure 6. 1065. The communication of exhibiting areas on the Second Floor.

The lack of a proper microclimate system inside the Museum is the main problem that launches this project. The focus on a new structure and new spaces leaves little room for improving the climatic conditions of key areas such as exhibitions, archives and restoration laboratories. These shortcomings if not re-evaluated in the idea phase, will not be possible to develop in its implementation.

Contrary to what the existing building proposes, the majority of this project's components are centered on the construction of a new building from behind, in the eastern area, where the Museum's additional building will be demolished. This new object is wrapped in a rough metallic leather, a very mysterious look that does not draw attention to its exterior and lacks the aesthetic continuity of the existing Museum.

The movement in the museum is coordinated but also flexible. The staircase located in the main lobby looks like the largest conveyor of vertical movement for the distribution of the public in the exhibition halls as well as in the library. An attraction will also be the two public elevators located in the center of the building, a facility that was not in the existing building, and that is normally very crucial in a contemporary building.

The new project proposes to increase cultural, educational and recreational spaces for the public. Maximizing the surfaces of any space proposed by the existing facility. This is a good opportunity to create an urban cultural corridor that connects the Center, the theater square, already demolished, the pedestrian street, Dajti Hotel and the boulevard in a cultural axis inside the monumental axis that it already is.

However, this project proposes that in the existing building to remain only the open exhibition spaces and to move all administrative offices in the new building, respectively on the second floor. This makes you think that the new policies for the Museum may want to demolish the only national monument of visual art in Albania.

Figure 6. 1066. Render of the Southern facade. Atelier 4 Studio.

Although with its architectural problems under the pressure of a totalitarian regime, this object has lost much over the years, in addition to giving much to the art-loving public. Consequently, its preservation and conservation is an added value for all responsible entities, but above all for the Albanian culture.

It is worth mentioning that this project still does not respect the artifact as a good that needs specific care, but it continues to be a good effort to expand the mobility and give space to exhibition environments in Tirana, as they are in short supply.

CHAPTER 7

CONCLUSIONS AND RECOMMENDATIONS

The treatment of the problems posed for solution was done in a logical way, starting with a historical look at the evolution of the typology of the museum building in world history and in Albania, how it has changed and transformed from the beginning into types and subtypes with typological and constructional features. Museum buildings represent a very complex typology which in our country is unstudied. Therefore, in this research, initially it was necessary to know the typology of museum buildings in Albania and then, based on this, the way of controlling the indoor climate in Albanian museums was analyzed. The study reaches some conclusions regarding the typology and ways of controlling the indoor climate.

7.1 Conclusions

A listing of some *Conclusions* for this study:

– The beginnings of the formation of the Albanian museum influenced the creation of an initial typological nucleus of the public museum building, which took a relatively long time to appear in types and subtypes.

– The typology of the museum takes clear forms of development, in types and subtypes, after the Second World War. It is represented by two types: buildings designed for museums and buildings adapted for museums, the latter divided into four subtypes.

– The Albanian Museum after the Second World War is presented to us in two forms:

a) the "palace" museum consisting of rooms and galleries, where the exhibition is treated in a continuous linearity with defined movements;

b) open space museum with central vertical openings, without borders, with wide visibility and free movement.

– Architectural heritage buildings (representative of the sub-type buildings used for museums), no intervention was made to adapt or convert them into genuine museums according to European models, both in terms of functionality and climate.

–Very few museums were designed and built with climate control.

–After the ’90s the museum building is presented to us with deteriorating climatic parameters (T and RH). This is for two reasons: the mechanical control systems, even where they were installed, were no longer used due to the high costs of use, as well as the lack of necessary reconstructions for the rehabilitation of museums in accordance with the requirements of visitors and artifacts.

–Today, due to the high costs of mechanical climate control, almost all museums in the country have an uncontrolled climate.

–The indoor climate in museum buildings is not monitored and there are no standards set for its parameters in any museum.

This part of the study, in addition to highlighting the characteristics of typology and ways of climate control, showed that museum buildings today have an out-of-control and unmonitored climate. To create a realistic panorama of thermos-hygrometric values in Albanian museums, three museums were selected to be monitored. These museums represent three typologies of typology with different construction features.

From the monitoring conducted at the National Museum of Fine Arts we reach the following conclusions:

−T and RH monitoring showed analytically how these parameters are and enabled the creation of a climatic profile of the building. This museum results in climatic characteristics not atypical for museums and the conditions offered by Albania. The building is characterized by microclimate with differences of T and RH values according to the floors.

−Performs better in the warm season in terms of thermal ground floor being more stable and in which the extreme values of T are more moderate compared to other floors. The first floor is a floor with environments with different climates from each other and thus has no consistency and stability. While the second floor, although we could not have monitoring with facts, results in extremely high values of T. Regarding the values of RH, even in this parameter, the microclimatic zones are presented with fluctuating changes. During the warm season characteristic of indoor climate are very low RH values throughout the building which according to floors and microclimatic areas fluctuate by ± 5%. The most critical performance is the transition zone from the additional object to the object realized in 1971 with an average registered value of RH = 49.5% and T = 29.1ºC.

−The main problem of the Museum's indoor climate is the high temperature values up to 32ºC and the still high RH values above 45%. Compared to the ASHRAE table, this museum is classified in group B: This class poses moderate risk of mechanical damage to highly sensitive artifacts, low risk to most paintings.

7.2 Recommendations

As part of this contribution the study provides some *Recommendations* to improve the situation.

Short term / emergency recommendations:

–First, in this museum it is important to qualify the supervisory staff in the museum halls, in order to understand the importance of indoor climate control. The opening of windows in this building cannot be allowed due to the fact that the area where the museum is located is an area with very high pollution.

–Indoor climate monitoring equipment should be installed. Data logger devices must be on display, with alarm signal, as well as monitored in real time via computer.

–The number of appliances should be at least 4-5 on each floor. These metering devices will help to manage the climate as follows:

–After monitoring and controlling the thermos-hygrometric values and comparing them with the outside, it is recommended to turn on the ventilation system in the late hours in order to balance the very high temperature values and through it to reduce the very low RH values. Also putting the ventilation system into operation would clean the un circulated air during the day.

Long-term recommendations:

Recommendations described as long-term require considerable time and investment. The study recommends several interventions in the building to improve its performance:

–Solutions to moisture problems that come mainly from the drainage pipes of the terrace, reflecting on the first and second floor.

–Treatments should be made for filling the joints of cladding tiles, which absorb and transmit moisture by infiltration, in volumes with direct terraces.

–Replacement of windows in accordance with the standards recommended for the museum building in order to have as few foreign exchanges as possible.

–Improvement of the thermal insulation of the terrace.

–Improvements to the exterior walls of the building through thermal insulation. The facade should be redesigned from a technological point of view as infrared rays are not in our favor.

–Given the importance of this museum, I think that after the remodeling of the building, the heating, ventilation and air conditioning system should be redesigned in order to help the building as much as necessary to achieve the proper conservation parameters. This point is also considered in the approved project of the reconstruction of the museum.

At the end of this study, it should be emphasized that it is better to leave the microclimate in its natural historical condition than interfere in a wrong and not well-studied way on museums. This would be devastating for the artifacts as well as for the cultural heritage buildings, in this case a cultural monument like the National Museum of Fine Arts. Therefore, the study recommends careful steps for the museum, well thought out and constantly monitored, to make the right choices of conservation climate, investment and costs used in order to give the three groups – artifacts, building and visitors – most of the needs of to the conditions of the indoor climate.

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APPENDIX 1

This Appendix is the space dedicated to Luca Zevi schemes, to better understand the spatial division of different plans based on purpose and dimension.

Legend of Fig. 2.4

C1 – Public Access

C2 - Atrium

C3 – Information Office

C4 - Catalog

C5 - Bookstore

C6 - Hygienic services for the public

C7 - Restaurant service

C8 - Space for research

C9 - Temporary exhibition

C10 - Permanent exhibition

C11 – Accessory room (optional)

Complementary activities (optional):

C11 - media (optional) for video vision, projection, teleconferencing, ecc.

C12 - Conference room (optional) consisting of spare parts and relative service activity

D1 - Access to museal materials

D2 - Reception

D3 – Temporary Depo

D4 – Hygienic services for the personnel

D5 - Analysis laboratory

D6 - Restoration laboratory

D7 - Laboratory equipment

D8 - Catalog office

D9 - Photographic laboratory

D10 - Archive

D11 - Direction office

D12 - Deposits, reserves, collections

D13 – Transporting of exhibiting materials

Legend of Fig. 2.5

C1 - Public access

C2 - Atrium

C3 - Information desk

C4 - Direction

C5 - Public toilet services

C6 - Office toilet services

C7 - Exhibition spaces

C8 - Conference room

D1 - Equipment laboratory

D2 - Researching access

D3 - Research Laboratory

D4 - Research environments

D5 - Facilities

Legend of Fig. 2.6

C1 - Public access

C2 - Atrium

C3 - Information desk

C4 - Management, cataloging offices

C5 - Public toilets

C6 - Storage of objects

C7 - Exhibition spaces

C8 - Multipurpose room: catalogs, bookstore, meetings, etc.

Legend of Fig. 2.7

C1 - Public access

C2 - Atrium

C3 - Information desk

C4 - Catalog

C5 - Commercial activities (books, posters, media)

C6 - Toilet services for the public

C7 - Restaurant services (bar, self service)

C8 - Exhibition spaces

C11 - Media equipment for video visions, projections, films, teleconferences, etc.

C12 - Conference room

D1 - Access to the works to exhibit

D2 - Reception, acceptance, registration

D3 - Temporary storage of recent works

D4 – Equipment laboratory

D5 - Workshop reproduction works (photos, films)

D6 - Documentation archive of the exhibitions

D7 - Staff hygienic services

D8 - Catalog and information

D9 - Management office

APPENDIX 2

This Appendix is the space dedicated to the measurements performed at The National Museum of Fine Arts. For each of the measured points there is a table with all the detailed information about the values of T and RH in every exhibiting space of the museum.

Table of measurements for Point 1

Date/Time	**315 [°C]**	**315 [%RH]**
25/06/2021 11:47:46	30.2	43.1
25/06/2021 11:47:47	30.1	43.3
25/06/2021 11:47:48	30.1	43.9
25/06/2021 11:47:49	30.1	43.9
25/06/2021 11:47:50	30.1	43.7
25/06/2021 11:47:51	30.1	43.8
25/06/2021 11:47:52	30.1	44.2
25/06/2021 11:47:53	30.1	44.5
25/06/2021 11:47:54	30.1	44.4
25/06/2021 11:47:55	30.1	44.3
25/06/2021 11:47:56	30.1	44.2
25/06/2021 11:47:57	30.1	43.7
25/06/2021 11:47:58	30.1	43.3
25/06/2021 11:47:59	30.1	43.0
25/06/2021 11:48:00	30.0	42.9
25/06/2021	30.0	43.0

11:48:01		
25/06/2021 11:48:02	30.0	42.9
25/06/2021 11:48:03	30.0	42.9
25/06/2021 11:48:04	30.0	43.1
25/06/2021 11:48:05	30.0	43.1
25/06/2021 11:48:06	30.0	43.2
25/06/2021 11:48:07	30.0	43.4
25/06/2021 11:48:08	30.0	43.2
25/06/2021 11:48:09	29.9	42.7
25/06/2021 11:48:10	29.9	42.3
25/06/2021 11:48:11	29.9	42.0
25/06/2021 11:48:12	29.8	41.7
25/06/2021 11:48:13	29.8	41.4
25/06/2021 11:48:14	29.8	41.2
25/06/2021 11:48:15	29.8	41.1
25/06/2021 11:48:16	29.8	41.0
25/06/2021 11:48:17	29.8	40.8
25/06/2021 11:48:18	29.8	40.9
25/06/2021 11:48:19	29.7	40.9
25/06/2021 11:48:20	29.8	40.9
25/06/2021 11:48:21	29.7	41.0
25/06/2021 11:48:22	29.7	41.0
25/06/2021 11:48:23	29.7	41.0
25/06/2021	29.7	41.0

11:48:24		
25/06/2021 11:48:25	29.7	41.0
25/06/2021 11:48:26	29.6	40.9
Overall Average	**29.7**	**42**
Minimum Total	**29.7**	**40.8**
Maximum total	**30.2**	**44.5**

Table of measurements for Point 2

Date/Time	**315 [°C]**	**315 [%RH]**
25/06/2021 11:51:24	28.5	43.8
25/06/2021 11:51:25	28.4	44.0
25/06/2021 11:51:26	28.5	44.1
25/06/2021 11:51:27	28.4	44.1
25/06/2021 11:51:28	28.4	44.2
25/06/2021 11:51:29	28.5	44.2
25/06/2021 11:51:30	28.5	44.1
25/06/2021 11:51:31	28.5	44.3
25/06/2021 11:51:32	28.5	44.4
25/06/2021 11:51:33	28.5	44.5
25/06/2021 11:51:34	28.4	44.3
25/06/2021 11:51:35	28.5	44.0
25/06/2021 11:51:36	28.5	43.7
25/06/2021 11:51:37	28.5	43.7
25/06/2021 11:51:38	28.5	43.7
25/06/2021	28.5	43.3

11:51:39		
25/06/2021 11:51:40	28.5	43.1
25/06/2021 11:51:41	28.5	43.0
25/06/2021 11:51:42	28.5	42.8
25/06/2021 11:51:43	28.5	42.6
25/06/2021 11:51:44	28.5	42.5
25/06/2021 11:51:45	28.5	42.4
25/06/2021 11:51:46	28.5	42.3
25/06/2021 11:51:47	28.5	42.0
25/06/2021 11:51:48	28.4	42.2
25/06/2021 11:51:49	28.5	42.2
25/06/2021 11:51:50	28.4	42.2
25/06/2021 11:51:51	28.5	42.2
25/06/2021 11:51:52	28.4	42.2
25/06/2021 11:51:53	28.4	42.3
25/06/2021 11:51:54	28.5	42.3
25/06/2021 11:51:55	28.5	42.3
25/06/2021 11:51:56	28.4	42.3
25/06/2021 11:51:57	28.4	42.3
25/06/2021 11:51:58	28.5	42.3
25/06/2021 11:51:59	28.4	42.3
25/06/2021 11:52:00	28.4	42.3
25/06/2021 11:52:01	28.4	42.3
25/06/2021	28.4	42.3

11:52:02		
25/06/2021 11:52:03	28.5	42.3
25/06/2021 11:52:04	28.5	42.3
Overall Average	**28.5**	**43.1**
Minimum Total	**28.4**	**42**
Maximum total	**28.5**	**46.1**

Table of measurements for Point 3

Date/Time	**315 [°C]**	**315 [%RH]**
25/06/2021 11:54:49	28.4	45.2
25/06/2021 11:54:50	28.4	45.4
25/06/2021 11:54:51	28.4	45.4
25/06/2021 11:54:52	28.4	45.5
25/06/2021 11:54:53	28.3	45.7
25/06/2021 11:54:54	28.3	45.7
25/06/2021 11:54:55	28.3	45.7
25/06/2021 11:54:56	28.3	45.7
25/06/2021 11:54:57	28.3	45.7
25/06/2021 11:54:58	28.3	45.8
25/06/2021 11:54:59	28.3	46.0
25/06/2021 11:55:00	28.2	46.1
25/06/2021 11:55:01	28.2	46.1
25/06/2021 11:55:02	28.2	46.1
25/06/2021 11:55:03	28.2	46.1
25/06/2021	28.1	46.1

11:55:04		
25/06/2021 11:55:05	28.2	46.1
25/06/2021 11:55:06	28.1	46.1
25/06/2021 11:55:07	28.1	46.2
25/06/2021 11:55:08	28.1	46.3
25/06/2021 11:55:09	28.1	46.3
25/06/2021 11:55:10	28.1	46.3
25/06/2021 11:55:11	28.1	46.3
25/06/2021 11:55:12	28.1	46.3
25/06/2021 11:55:13	28.1	46.3
25/06/2021 11:55:14	28.1	46.2
25/06/2021 11:55:15	28.1	46.2
25/06/2021 11:55:16	28.1	46.3
25/06/2021 11:55:17	28.0	46.3
25/06/2021 11:55:18	28.0	46.6
25/06/2021 11:55:19	28.0	46.6
25/06/2021 11:55:20	28.0	46.7
25/06/2021 11:55:21	28.0	46.7
25/06/2021 11:55:22	28.0	46.6
25/06/2021 11:55:23	28.0	46.5
25/06/2021 11:55:24	28.0	46.5
25/06/2021 11:55:25	28.0	46.4
25/06/2021 11:55:26	28.0	46.2
25/06/2021	27.9	46.2

11:55:27		
25/06/2021 11:55:28	27.9	46.2
25/06/2021 11:55:29	27.5	46.3
Overall Average	**27.8**	**48.0**
Minimum Total	**27.5**	**45.2**
Maximum total	**28.4**	**50.6**

Table of measurements for Point 4

Date/Time	**315 [°C]**	**315 [%RH]**
25/06/2021 11:58:55	28.7	52.0
25/06/2021 11:58:56	28.7	51.6
25/06/2021 11:58:57	28.7	51.6
25/06/2021 11:58:58	28.7	51.7
25/06/2021 11:58:59	28.8	51.6
25/06/2021 11:59:00	28.8	51.3
25/06/2021 11:59:01	28.8	50.9
25/06/2021 11:59:02	28.8	50.6
25/06/2021 11:59:03	28.8	50.3
25/06/2021 11:59:04	28.8	50.0
25/06/2021 11:59:05	28.9	50.0
25/06/2021 11:59:06	28.9	49.6
25/06/2021 11:59:07	28.9	49.5
25/06/2021 11:59:08	28.9	49.4
25/06/2021 11:59:09	28.9	49.4
25/06/2021	29.0	49.3

11:59:10		
25/06/2021 11:59:11	29.0	49.3
25/06/2021 11:59:12	29.0	49.2
25/06/2021 11:59:13	29.0	49.2
25/06/2021 11:59:14	29.0	49.2
25/06/2021 11:59:15	29.1	49.3
25/06/2021 11:59:16	29.1	49.3
25/06/2021 11:59:17	29.1	49.2
25/06/2021 11:59:18	29.1	48.9
25/06/2021 11:59:19	29.1	48.9
25/06/2021 11:59:20	29.1	48.9
25/06/2021 11:59:21	29.1	49.0
25/06/2021 11:59:22	29.1	49.0
25/06/2021 11:59:23	29.1	48.9
25/06/2021 11:59:24	29.1	49.0
25/06/2021 11:59:25	29.2	49.1
25/06/2021 11:59:26	29.2	49.1
25/06/2021 11:59:27	29.2	49.1
25/06/2021 11:59:28	29.2	49.0
25/06/2021 11:59:29	29.2	49.0
25/06/2021 11:59:30	29.2	48.9
25/06/2021 11:59:31	29.2	48.9
25/06/2021 11:59:32	29.2	48.8
25/06/2021	29.3	48.8

11:59:33		
25/06/2021 11:59:34	29.3	48.8
25/06/2021 11:59:35	29.3	48.6
Overall Average	**29.1**	**49.5**
Minimum Total	**28.7**	**48.5**
Maximum total	**29.4**	**52.0**

Table of measurements for Point 5

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:01:23	29.9	45.4
25/06/2021 12:01:24	29.9	45.4
25/06/2021 12:01:25	29.9	45.4
25/06/2021 12:01:26	29.9	45.4
25/06/2021 12:01:27	29.9	45.4
25/06/2021 12:01:28	29.9	45.5
25/06/2021 12:01:29	29.9	45.6
25/06/2021 12:01:30	29.9	45.6
25/06/2021 12:01:31	29.9	45.7
25/06/2021 12:01:32	29.9	45.8
25/06/2021 12:01:33	30.0	45.9
25/06/2021 12:01:34	30.0	45.9
25/06/2021 12:01:35	30.0	46.2
25/06/2021 12:01:36	30.0	46.3
25/06/2021 12:01:37	30.0	46.5
25/06/2021	30.0	46.6

12:01:38		
25/06/2021 12:01:39	30.0	46.7
25/06/2021 12:01:40	30.0	46.7
25/06/2021 12:01:41	30.0	46.6
25/06/2021 12:01:42	30.0	46.3
25/06/2021 12:01:43	30.0	46.1
25/06/2021 12:01:44	30.0	46.0
25/06/2021 12:01:45	30.0	45.9
25/06/2021 12:01:46	30.0	45.8
25/06/2021 12:01:47	30.1	45.6
25/06/2021 12:01:48	30.0	45.5
25/06/2021 12:01:49	30.0	45.4
25/06/2021 12:01:50	30.1	45.3
25/06/2021 12:01:51	30.0	45.1
25/06/2021 12:01:52	30.1	45.1
25/06/2021 12:01:53	30.1	45.0
25/06/2021 12:01:54	30.1	45.1
25/06/2021 12:01:55	30.1	44.9
25/06/2021 12:01:56	30.2	44.9
25/06/2021 12:01:57	30.1	44.8
25/06/2021 12:01:58	30.1	44.8
25/06/2021 12:01:59	30.1	44.7
25/06/2021 12:02:00	30.1	44.6
25/06/2021	30.1	44.7

12:02:01		
25/06/2021 12:02:02	30.1	44.7
25/06/2021 12:02:03	30.1	44.8
Overall Average	**30.0**	**45.5**
Minimum Total	**29.9**	**44.6**
Maximum total	**30.2**	**46.7**

Table of measurements for Point 6

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:03:07	30.3	45.4
25/06/2021 12:03:08	30.3	45.9
25/06/2021 12:03:09	30.3	46.7
25/06/2021 12:03:10	30.3	47.1
25/06/2021 12:03:11	30.3	47.4
25/06/2021 12:03:12	30.3	47.9
25/06/2021 12:03:13	30.3	48.2
25/06/2021 12:03:14	30.3	47.5
25/06/2021 12:03:15	30.3	47.1
25/06/2021 12:03:16	30.3	46.9
25/06/2021 12:03:17	30.3	46.9
25/06/2021 12:03:18	30.3	46.7
25/06/2021 12:03:19	30.3	46.6
25/06/2021 12:03:20	30.3	46.5
25/06/2021 12:03:21	30.3	46.4
25/06/2021	30.3	46.2

12:03:22		
25/06/2021 12:03:23	30.3	46.1
25/06/2021 12:03:24	30.3	46.0
25/06/2021 12:03:25	30.3	46.0
25/06/2021 12:03:26	30.3	46.0
25/06/2021 12:03:27	30.3	46.0
25/06/2021 12:03:28	30.3	46.0
25/06/2021 12:03:29	30.3	46.0
25/06/2021 12:03:30	30.3	46.0
25/06/2021 12:03:31	30.3	46.0
25/06/2021 12:03:32	30.4	45.9
25/06/2021 12:03:33	30.4	46.0
25/06/2021 12:03:34	30.3	46.0
25/06/2021 12:03:35	30.4	46.0
25/06/2021 12:03:36	30.4	45.9
25/06/2021 12:03:37	30.4	46.0
25/06/2021 12:03:38	30.4	46.0
25/06/2021 12:03:39	30.4	45.9
25/06/2021 12:03:40	30.4	45.9
25/06/2021 12:03:41	30.4	45.9
25/06/2021 12:03:42	30.4	45.9
25/06/2021 12:03:43	30.4	46.0
25/06/2021 12:03:44	30.4	46.0
25/06/2021	30.4	45.9

12:03:45		
25/06/2021 12:03:46	30.4	45.8
25/06/2021 12:03:47	30.4	45.7
Overall Average	**30.3**	**46.2**
Minimum Total	**30.3**	**45.4**
Maximum total	**30.4**	**48.2**

Table of measurements for Point 7

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:05:29	30.2	41.1
25/06/2021 12:05:30	30.1	41.2
25/06/2021 12:05:31	30.2	41.2
25/06/2021 12:05:32	30.2	41.3
25/06/2021 12:05:33	30.2	41.3
25/06/2021 12:05:34	30.2	41.2
25/06/2021 12:05:35	30.2	41.2
25/06/2021 12:05:36	30.1	41.2
25/06/2021 12:05:37	30.2	41.3
25/06/2021 12:05:38	30.2	41.2
25/06/2021 12:05:39	30.2	41.2
25/06/2021 12:05:40	30.2	41.2
25/06/2021 12:05:41	30.2	41.1
25/06/2021 12:05:42	30.2	41.1
25/06/2021 12:05:43	30.2	41.1

25/06/2021 12:05:44	30.2	41.1
25/06/2021 12:05:45	30.2	41.0
25/06/2021 12:05:46	30.2	41.0
25/06/2021 12:05:47	30.2	41.1
25/06/2021 12:05:48	30.2	41.1
25/06/2021 12:05:49	30.2	41.1
25/06/2021 12:05:50	30.2	41.1
25/06/2021 12:05:51	30.2	41.2
25/06/2021 12:05:52	30.2	41.1
25/06/2021 12:05:53	30.2	41.2
25/06/2021 12:05:54	30.2	41.2
25/06/2021 12:05:55	30.3	41.1
25/06/2021 12:05:56	30.3	41.1
25/06/2021 12:05:57	30.2	41.1
25/06/2021 12:05:58	30.2	41.0
25/06/2021 12:05:59	30.3	41.0
25/06/2021 12:06:00	30.2	41.0
25/06/2021 12:06:01	30.2	40.9
25/06/2021 12:06:02	30.2	41.0
25/06/2021 12:06:03	30.2	40.9
25/06/2021 12:06:04	30.3	40.9
25/06/2021 12:06:05	30.3	40.9
25/06/2021 12:06:06	30.2	40.9

25/06/2021 12:06:07	30.3	40.9
25/06/2021 12:06:08	30.3	40.9
25/06/2021 12:06:09	30.2	40.9
Overall Average	**30.2**	**41.1**
Minimum Total	**30.1**	**40.9**
Maximum total	**30.3**	**41.3**

Table of measurements for Point 8

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:08:01	30.5	40.9
25/06/2021 12:08:02	30.5	40.9
25/06/2021 12:08:03	30.5	41.3
25/06/2021 12:08:04	30.5	41.5
25/06/2021 12:08:05	30.6	41.3
25/06/2021 12:08:06	30.6	41.1
25/06/2021 12:08:07	30.6	40.8
25/06/2021 12:08:08	30.7	40.7
25/06/2021 12:08:09	30.7	40.6
25/06/2021 12:08:10	30.7	40.5
25/06/2021 12:08:11	30.7	40.5
25/06/2021 12:08:12	30.7	40.4
25/06/2021 12:08:13	30.8	40.4
25/06/2021 12:08:14	30.7	40.4
25/06/2021 12:08:15	30.7	40.4

25/06/2021 12:08:16	30.8	40.3
25/06/2021 12:08:17	30.8	40.2
25/06/2021 12:08:18	30.8	40.2
25/06/2021 12:08:19	30.9	40.1
25/06/2021 12:08:20	30.9	40.0
25/06/2021 12:08:21	30.9	39.9
25/06/2021 12:08:22	30.9	39.7
25/06/2021 12:08:23	31.0	39.7
25/06/2021 12:08:24	31.0	39.7
25/06/2021 12:08:25	31.0	39.7
25/06/2021 12:08:26	31.0	39.6
25/06/2021 12:08:27	31.1	39.5
25/06/2021 12:08:28	31.1	39.5
25/06/2021 12:08:29	31.1	39.5
25/06/2021 12:08:30	31.1	39.6
25/06/2021 12:08:31	31.1	39.6
25/06/2021 12:08:32	31.1	39.6
25/06/2021 12:08:33	31.1	39.6
25/06/2021 12:08:34	31.2	39.5
25/06/2021 12:08:35	31.2	39.6
25/06/2021 12:08:36	31.2	39.5
25/06/2021 12:08:37	31.2	39.5
25/06/2021 12:08:38	31.2	39.5

25/06/2021 12:08:39	31.2	39.4
25/06/2021 12:08:40	31.3	39.4
25/06/2021 12:08:41	31.3	39.4
Overall Average	**31.1**	**39.8**
Minimum Total	**30.5**	**39.0**
Maximum total	**31.5**	**41.5**

Table of measurements for Point 9

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:09:54	31.8	37.8
25/06/2021 12:09:55	31.8	37.8
25/06/2021 12:09:56	31.8	37.8
25/06/2021 12:09:57	31.8	37.8
25/06/2021 12:09:58	31.8	37.8
25/06/2021 12:09:59	31.8	37.8
25/06/2021 12:10:00	31.8	37.8
25/06/2021 12:10:01	31.9	37.7
25/06/2021 12:10:02	31.9	37.7
25/06/2021 12:10:03	31.9	37.8
25/06/2021 12:10:04	31.9	37.8
25/06/2021 12:10:05	31.9	37.8
25/06/2021 12:10:06	31.9	37.8
25/06/2021 12:10:07	31.9	37.8
25/06/2021 12:10:08	31.9	37.8

25/06/2021 12:10:09	31.9	37.8
25/06/2021 12:10:10	31.9	37.7
25/06/2021 12:10:11	31.9	37.7
25/06/2021 12:10:12	32.0	37.7
25/06/2021 12:10:13	32.0	37.7
25/06/2021 12:10:14	32.0	37.6
25/06/2021 12:10:15	32.0	37.5
25/06/2021 12:10:16	32.0	37.6
25/06/2021 12:10:17	32.0	37.6
25/06/2021 12:10:18	32.0	37.5
25/06/2021 12:10:19	32.0	37.5
25/06/2021 12:10:20	32.0	37.5
25/06/2021 12:10:21	32.0	37.5
25/06/2021 12:10:22	32.0	37.5
25/06/2021 12:10:23	32.0	37.5
25/06/2021 12:10:24	32.1	37.5
25/06/2021 12:10:25	32.1	37.6
25/06/2021 12:10:26	32.0	37.6
25/06/2021 12:10:27	32.1	37.6
25/06/2021 12:10:28	32.0	37.6
25/06/2021 12:10:29	32.1	37.6
25/06/2021 12:10:30	32.1	37.6
25/06/2021 12:10:31	32.1	37.6

25/06/2021 12:10:32	32.1	37.5
25/06/2021 12:10:33	32.1	37.5
25/06/2021 12:10:34	32.1	37.5
Overall Average	**32.0**	**37.7**
Minimum Total	**31.8**	**37.5**
Maximum total	**32.1**	**37.8**

Table of measurements for Point 10

Date/Time	**315 [°C]**	**315 [%RH]**
25/06/2021 12:12:04	31.3	37.0
25/06/2021 12:12:05	31.3	37.0
25/06/2021 12:12:06	31.3	36.9
25/06/2021 12:12:07	31.3	36.9
25/06/2021 12:12:08	31.3	36.8
25/06/2021 12:12:09	31.2	36.7
25/06/2021 12:12:10	31.3	36.6
25/06/2021 12:12:11	31.2	36.5
25/06/2021 12:12:12	31.2	36.5
25/06/2021 12:12:13	31.2	36.4
25/06/2021 12:12:14	31.2	36.5
25/06/2021 12:12:15	31.2	36.6
25/06/2021 12:12:16	31.2	36.6
25/06/2021 12:12:17	31.2	36.7

25/06/2021 12:12:18	31.1	36.8
25/06/2021 12:12:19	31.2	36.9
25/06/2021 12:12:20	31.2	36.8
25/06/2021 12:12:21	31.1	36.7
25/06/2021 12:12:22	31.1	36.7
25/06/2021 12:12:23	31.1	36.7
25/06/2021 12:12:24	31.1	36.6
25/06/2021 12:12:25	31.0	36.5
25/06/2021 12:12:26	31.0	36.5
25/06/2021 12:12:27	31.0	36.5
25/06/2021 12:12:28	31.0	36.5
25/06/2021 12:12:29	31.0	36.6
25/06/2021 12:12:30	31.0	36.6
25/06/2021 12:12:31	31.0	36.7
25/06/2021 12:12:32	30.9	36.8
25/06/2021 12:12:33	30.9	36.9
25/06/2021 12:12:34	30.8	37.1
25/06/2021 12:12:35	30.9	37.1
25/06/2021 12:12:36	30.8	37.3
25/06/2021 12:12:37	30.8	37.4
25/06/2021 12:12:38	30.8	37.4
25/06/2021 12:12:39	30.7	37.6
25/06/2021 12:12:40	30.8	37.5

25/06/2021 12:12:41	30.8	37.7
25/06/2021 12:12:42	30.8	38.0
25/06/2021 12:12:43	30.8	38.0
25/06/2021 12:12:44	30.8	38.1
Overall Average	**31.0**	**37.2**
Minimum Total	**30.7**	**36.4**
Maximum total	**31.3**	**38.2**

Table of measurements for Point 11

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:15:59	29.7	41.6
25/06/2021 12:16:00	29.7	41.3
25/06/2021 12:16:01	29.7	41.3
25/06/2021 12:16:02	29.7	41.1
25/06/2021 12:16:03	29.7	40.7
25/06/2021 12:16:04	29.7	40.6
25/06/2021 12:16:05	29.8	40.4
25/06/2021 12:16:06	29.8	40.3
25/06/2021 12:16:07	29.8	40.3
25/06/2021 12:16:08	29.8	40.2
25/06/2021 12:16:09	29.8	40.1
25/06/2021 12:16:10	29.9	40.0
25/06/2021 12:16:11	29.9	39.9
25/06/2021 12:16:12	29.9	39.8

25/06/2021 12:16:13	29.9	39.7
25/06/2021 12:16:14	29.9	39.8
25/06/2021 12:16:15	29.9	39.7
25/06/2021 12:16:16	30.0	39.6
25/06/2021 12:16:17	30.0	39.6
25/06/2021 12:16:18	30.0	39.6
25/06/2021 12:16:19	30.0	39.5
25/06/2021 12:16:20	30.0	39.5
25/06/2021 12:16:21	30.0	39.4
25/06/2021 12:16:22	30.1	39.4
25/06/2021 12:16:23	30.0	39.3
25/06/2021 12:16:24	30.0	39.3
25/06/2021 12:16:25	30.1	39.3
25/06/2021 12:16:26	30.1	39.3
25/06/2021 12:16:27	30.1	39.3
25/06/2021 12:16:28	30.1	39.2
25/06/2021 12:16:29	30.1	39.2
25/06/2021 12:16:30	30.1	39.2
25/06/2021 12:16:31	30.1	39.1
25/06/2021 12:16:32	30.1	39.1
25/06/2021 12:16:33	30.1	39.1
25/06/2021 12:16:34	30.1	39.1
25/06/2021 12:16:35	30.2	39.1

25/06/2021 12:16:36	30.2	39.1
25/06/2021 12:16:37	30.2	39.0
25/06/2021 12:16:38	30.2	39.0
25/06/2021 12:16:39	30.2	39.1
Overall Average	**30.0**	**39.5**
Minimum Total	**29.7**	**38.8**
Maximum total	**30.3**	**41.6**

Table of measurements for Point 12

Date/Time	315 [°C]	315 [%RH]
25/06/2021 12:18:19	30.3	38.7
25/06/2021 12:18:20	30.3	38.7
25/06/2021 12:18:21	30.3	38.6
25/06/2021 12:18:22	30.3	38.6
25/06/2021 12:18:23	30.4	38.7
25/06/2021 12:18:24	30.3	38.7
25/06/2021 12:18:25	30.4	38.8
25/06/2021 12:18:26	30.3	38.8
25/06/2021 12:18:27	30.4	38.9
25/06/2021 12:18:28	30.4	39.0
25/06/2021 12:18:29	30.4	39.0
25/06/2021 12:18:30	30.4	39.2
25/06/2021 12:18:31	30.4	39.3
25/06/2021 12:18:32	30.4	39.5

25/06/2021 12:18:33	30.4	39.7
25/06/2021 12:18:34	30.4	39.9
25/06/2021 12:18:35	30.4	39.8
25/06/2021 12:18:36	30.5	39.9
25/06/2021 12:18:37	30.4	39.8
25/06/2021 12:18:38	30.4	39.6
25/06/2021 12:18:39	30.4	39.5
25/06/2021 12:18:40	30.5	39.3
25/06/2021 12:18:41	30.5	39.2
25/06/2021 12:18:42	30.5	39.0
25/06/2021 12:18:43	30.5	38.9
25/06/2021 12:18:44	30.4	39.0
25/06/2021 12:18:45	30.4	38.9
25/06/2021 12:18:46	30.5	38.7
25/06/2021 12:18:47	30.5	38.7
25/06/2021 12:18:48	30.5	38.6
25/06/2021 12:18:49	30.5	38.6
25/06/2021 12:18:50	30.5	38.6
25/06/2021 12:18:51	30.5	38.5
25/06/2021 12:18:52	30.5	38.5
25/06/2021 12:18:53	30.5	38.5
25/06/2021 12:18:54	30.5	38.5
25/06/2021 12:18:55	30.5	38.5

Overall Average	**30.4**	**39.0**
Minimum Total	**30.3**	**38.5**
Maximum total	**30.5**	**39.9**