



Heritage buildings and historic microclimate without HVAC technology: Malatestiana Library in Cesena, Italy, UNESCO Memory of the World



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ABSTRACT

In the assessment of the indoor microclimate of heritage buildings, the general goal is to evaluate and improve users' comfort. In our opinion the comfort of users should not come first; the approach should be: "Heritage First", with priority given to the creation of the best microclimate conditions for the preservation of buildings, artefacts, etc. The case study described in this paper concerns an authentic exemplar: the Malatestiana Library in Cesena, Italy, listed in the UNESCO *Memory of the World Programme*. The indoor microclimatic conditions are exemplary because, since the year of its construction in 1454, its function as a library has remained unchanged: conserving the original book rests, same manuscripts and – most extraordinarily – the same indoor microclimatic conditions. The building does not have HVAC, never. Our hypothesis is that the lack of HVAC has allowed a perfect conservation of the book rests and of the manuscripts. In this paper we describe the results of the monitoring campaign; of how our research led to the discovery that microclimatic parameters change over a long period, as a result of simply opening windows to change the air, involving water vapour and CO₂ variation within the air volume of Library.

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1. Introduction

The aim of all disciplines concerning heritage and historic buildings is to preserve them and their contents, to study their decay and damage processes (chemical, physical, biological, mechanical, etc.) and relative causes, and to develop strategies in order to reduce or prevent them. If we exclude external damage factors, such as ground humidity, roof seepage or hydraulic system seepage, subsidence, statics or mechanical damage or earthquakes, we can affirm that damage depends only on internal factors strictly connected with indoor microclimatic conditions, functions and usage. The majority of indoor microclimatic literature studies concerns relations between human and indoor air microclimate, physiological response, hygiene and thermal comfort: from Fanger [1] to more recent studies of the subject, the aim is to verify user response or appreciation. Human sense of comfort depends on the physical indoor microclimate and the physiological and cultural response of those using the actual building. These studies, alongside Heating

Ventilation and Air-Conditioning (HVAC) technologies, allow the definition of the indoor parameter conditions of the building.

The above-mentioned analogy between heritage comfort and thermal comfort is also described in Corgnati et al. [2], where Indoor Microclimatic Quality (IMQ) and Indoor Environmental Quality (IEQ) are compared, following European Standard EN 15251 [3]; and also in La Gennusa et al. [4] where the conflict between user comfort and artefact wellbeing in museum buildings has been evidenced.

In this paper, the case study of the IMQ of the Malatestiana Library (building and artefacts) has priority to human comfort.

1.1. Heritage building and microclimate: point of view

In the case of heritage buildings, such as the Malatestiana Library, our opinion is that the goal of indoor microclimate evaluation and/or monitoring should be to preserve the building and the artefacts and not user comfort. We can consider user comfort and the building's function in order to allow visits.

In the present paper we adopt the term "heritage building" to define historic buildings which, for their immense value, are subject to legal preservation by Superintendence or by UNESCO. Historic buildings are not always considered heritage buildings, as the term

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“historic building” refers to all buildings of a certain period not necessarily under legal preservation.

In historic buildings we need to overturn the approach: the “*object*” (artefact, manuscript, artwork, building, etc.) is “*more essential*” than “*people*” (visitors, users, janitors, etc.). So the indoor comfort range must be *calibrated and adapted* in order to privilege the “*object*’s” range of wellbeing. Therefore in considering indoor microclimate control, visitors’ comfort is not a priority, in fact visitors can be considered a pollutant, and any HVAC system must be designed to defend the “*object*” comfort range against visitor “pollution.”

Our above postulates may appear obvious, but the approach to historic buildings depends on structural features and internal functions. In several heritage buildings, the introduction of HVAC, wiring and other systems was motivated by visitor or user presence, without considering the collateral effects on historic buildings. HVAC systems modify indoor microclimatic conditions and create “*microclimate stress*” for both artefact and building that often was not present in the original building. Several studies, such as Fabbri [5] and Pretelli et al. [6], discuss the role of technical systems (HVAC, wiring, elevators, etc.) in historical buildings. One of the aims of this paper is to continue along the same research lines referring to the specific case study of the Malatestiana Library because of its unique status as a “*representative sample*” of a building that has never implemented HVAC systems. If we exclude religious buildings, we have no knowledge of other heritage buildings without any HVAC or other systems, from their construction to the present day, with which to compare indoor microclimatic conditions.

Historic buildings are used for various purposes ranging from pure conservation to reuse for specific functions: this can be seen in religious structures, museums, libraries or in dwellings such as villas, etc. Indoor microclimate in heritage buildings is a specific aim of research, like comfort studies, because temperature and relative humidity (RH) could damage plaster, wood, brick and other building materials, and objects contained in the building: papers, manuscripts, artworks, etc. Heritage building microclimate is a specific field of research, evident in scientific literature such as Camuffo [7] or in museum studies, Camuffo et al. [8,9], Balocco [10], Cardinale [11], and other studies [20,21] and in the same way the “*historic climate*” concept as defined in Italian Standards UNI described in Del Curto [13].

Standards define the range of microclimatic conditions for several kinds of artefacts (paper, drawings, wood, paintings, plasters, fresco, etc.), but they specify that in the case of preserved artefacts, from origin to present day, outside that range, we must guarantee the historic preservation climate. In order to allow the presence of visitors while preserving the microclimatic conditions in heritage buildings, different strategies may be implemented: specific HVAC technologies or visitors access control. Few relevant examples of the second approach might be found in the entrances management for Scrovegni Chapel in Padua [14,15] and in the Leonard’s Last Supper in Milan. In comfort studies a comfort-area is defined on psychometric charts, so we can similarly define a preservation area on psychometric charts for the indoor microclimate of heritage buildings, to allow perfect conservation.

2. Aim of this research

In this paper we describe results of the indoor microclimate monitoring of the Malatestiana Library in Cesena. The Library is “*a unicum*” (unicum is a Latin word to define a unique masterpiece), part of the historic building since its construction in 1454: it has been a library with same wooden *plutei* and original manuscripts, with no use of fireplaces, stoves or HVAC systems, resulting in an unchanged indoor microclimate. Pluteo, or plurals, plutei is

Latin name of wooden writing desk in wood of the Malatestiana Library. Since the XV century, indoor microclimate values, temperature and RH, have been regulated by opening windows and by regulating the flow of visitors. The windows are opened, usually once a day, without microclimate monitoring for indoor temperature and RH variables. Until our recent monitoring campaign, there was no awareness of the Malatestiana Library microclimate, whose variations depended on the officer and janitors’ “common sense” in opening windows. Malatestiana visitor rules limited the inflow: both in numbers and in the spaces open to visitors. The first monitoring results allowed a few methodological and scientific considerations to be developed, in order to promote new Malatestiana rules regarding visits and conservation.

We would like to clarify that the object of the present paper is the indoor air volume of the Malatestiana Library. We consider the air volume as a thermodynamic “open system” which changes mass and energy through its boundaries: window, door and visitors. In the present paper we do not consider the decay of wood, plaster or manuscript nor the effects of humidity, microbiology, artefact moisture absorption, etc. These aspects are described in several scientific studies: Zitek et al. [16] or the Equilibrium Moisture Content (EMC) [17], also Camuffo [18] and D’Agostino [19]. The above-mentioned factors of decay depend on changes of indoor microclimatic conditions following energy and mass flow. Our object of study is rather the microclimatic parameters and the control of their variations and monitoring their decay range.

3. The case study: the Malatestiana Library

The Malatestiana Library was built between 1450 and 1504 by Malatesta Novello, Lord of Cesena, on the design by Matteo Nuti, an architect from Fano and a pupil of Leon Battista Alberti.

The Library has the same original plutei and manuscripts dating back to 1454, and in 2005 it was listed in the UNESCO “Memory of the World Programme” [22]. “The Library of Malatesta Novello, the last ancient library dating from immediately before the invention of printing, embodies the very concept of a humanist library”.

Regarding indoor microclimatic conditions the UNESCO Nomination Form states: “Procedures and policies for control of the physical environment Manuscripts are kept in their original places, where optimal preservation conditions have been maintained for centuries (temperature 20 °C with a 3 °C variation; relative humidity between 45% and 65%). Intruder and fire alarm systems are in operation. There is continuous monitoring by CCTV with video recording”. [...] “Manuscripts are kept in their original places where optimal conservation conditions have been maintained for centuries. There are intruder and fire alarm systems. Continuous monitoring is carried out by CCTV with video recording.”

The Library has a rectangular floor with only one entrance, divided into 3 aisles with a centre aisle raised above the others; the space is divided by 20 columns, with capitals and shields, 22 windows per side and 1 rose window on the short wall opposite the entrance. The entrance is located on a short wall connected to the rest of the new library, in the same wall there are 2 windows that are always open (Figs. 1 and 2). Inside the Library 58 wood *plutei* are present (“pluteo” is a desk or backbench furniture to conserve and read manuscripts, “*plutei*” is a plural of “*pluteo*”) with book holders to consult manuscripts. The Library contains 343 Codex, about 150 from the XV century directly commissioned by Malatesta Novello, Lord of Cesena, while the other manuscripts were collected in the XVI and XVII centuries. Currently manuscripts are read in a separate room, with special equipment for reading, examining and restoring manuscripts.

The Malatestiana Library is accessed from an existing library (they called it “new library” although construction dates back to

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