1. Research activity

The aim of my research is contributing to the preventive conservation of paper collections through the development of innovative procedures based on an effective combination of microclimate assessment and refined hygrothermal modelling within library and archival storage facilities. To achieve this broad purpose, two specific objectives are pursued: 1) exploration of the capability of the whole-building simulation software IDA ICE coupled with the hygrothermal model HMWall in modelling the heat and moisture exchanges between the building environment and its hygroscopic content; 2) use of non-invasive spectroscopic techniques to enhance the comprehension of the interaction between the microclimate and the books.

Library collections are frequently affected by deterioration processes due to the environmental conditions (e.g. mechanical stress, acidification and of paper, colour changes and biological attacks). The conservation of paper collections is strongly interrelated with the air relative humidity (RH), as organic-hygroscopic materials act as buffers on RH fluctuations while being vulnerable to moisture-induced damage. In a library storage, the buffering impact on RH fluctuations produced by the hygroscopic materials should be adequately considered [1]. Microclimate monitoring over long-term periods combined with dynamic simulation provides a thorough characterisation of the indoor climate, thus allowing to investigate more deeply the interactions between the building and the outdoor climate as well as between the objects and their surrounding environment. The simulation of moisture transport through materials is complex as the properties of the materials are frequently not fully known. In paper objects, modelling the moisture uptake and release is usually simplified by adopting the effective moisture capacity (EMC) approach, which integrates the moisture buffering capacity of the indoor air with that of the books [2]. Alternatively, the hygrothermal response of cellulose-based objects can be modelled by means of the HAM-family (Heat, Air and Moisture) hygrothermal tools such as those used for the simulation of the simultaneous heat and mass transfer through porous

envelope materials [1,3]. In the specific application to a library environment, the effect of non-isothermal moisture buffering of paper collections was found to be more accurately simulated by using a complete HAM model than by the simplified EMC approach [3]. The HMWall model belongs to the HAM-family and can be coupled with the modular software IDA ICE (Indoor Climate and Energy), providing a reliable tool for the hygrothermal whole-building dynamic simulation in historic buildings [4]; so far, it has never been tested in modelling the hygrothermal conditions within library facilities. The degradation scenario linked to the microclimate conditions experienced by the library collections can then be estimated either using dose-response functions for paper or performing measurements directly on the artifacts. In addition, non-invasive spectroscopic techniques can be advantageously employed to investigate the material properties of the books affected by the microclimate.

The first year of research focussed on an intensive training on the whole-building simulation software IDA ICE in advanced mode, used for building the 3D model of a historic building and examining the retrofit solutions compatible with conservation being able to reduce energy consumption and thermal discomfort. An investigation of the thermo-hygrometric conditions inside microclimate frames used in preventive conservation for the passive control of relative humidity was useful to study, on a smaller scale, the thermo-hygrometric conditions established in environments holding large quantities of hygroscopic materials. Two library facilities located in Rome were chosen as case studies for the long-term microclimate monitoring campaigns: the Biblioteca Storica di Meteorologia at the historical complex of Collegio Romano and the vast storage facility of the Biblioteca Universitaria Alessandrina within the Sapienza University campus.

The research planned for the second year is directed to studying the use of the HMWall hygrothermal model in the IDA ICE simulation environment for the investigation of the influence of the moisture exchanges through paper collections on the indoor climate of a library. After the analysis of the preliminary microclimate datasets collected in the case studies, the capability of the coupled HMWall-IDA ICE model to simulate the hygroscopic behaviour of paper and books will be examined. The methodological approach can be synthetized as follows: 1) selection of the most common types of paper in library and archives and identification of their experimentally-measured hygrothermal properties available in literature; 2) derivation of the experimental curves describing their hygroscopic behaviour; 3) minimization of the discrepancy between the hygrothermal curves calculated

by HMWall and the ones measured in laboratory; 4) evaluation of the capability of HMWall to simulate the influence of paper collection in IDA ICE environment. A sensitivity analysis will be performed to identify the most influencing parameters in the simulation using the Elementary Effects method based on Morris random sampling. A comparison will then be conducted between the indoor climate simulated in a room where the collection is modelled either as an internal thermal mass or as an HMWall object with the hygrothermal properties of paper defined in steps 1-3. The development of this investigation will take advantage of the mobility period programmed from March to May 2020 to the Jerzy Haber Institute of Catalysis in Krakow (Poland). The obtained results will establish the basis of the application of the simulation model to the real case-studies, starting from the calibration and the validation of the model through the monitored data. The assessment of the performance of the validated model will unlock the possibility to pinpoint retrofit solutions and to suggest conservation strategies within the monitored library facilities. Finally, an experimental program on paper and books through non-invasive spectroscopic techniques will be set up and developed. Preliminary colorimetric measurements were used as proxies of material deterioration.

References

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