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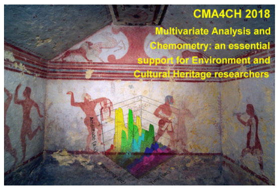

Evaluation of Wood Material Response to Relative Humidity: the Archaeological Museum of Priverno (Latina, Italy)

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Abstract

This work aims at providing a microclimate characterization of the Archaeological Museum of Priverno (Latina, Italy) using indoor environmental observations recorded over a 15-months monitoring period. A particular emphasis was given to the influence of relative humidity (RH) on physical damages in valuable wooden ceilings. For this purpose, RH values were calculated at the boundary layer between air and wooden surface at different time scale and, then, compared with the hourly evolution of crack width. It was found that a widening of cracks in wooden panels occurred mainly in summer, when low RH values related to high temperature were recorded. This means that an adequate control of indoor climate is necessary to reduce degradation phenomena.

Introduction

Indoor climate variables continuously interact with objects by means of direct and indirect hygro-thermal exchanges [1]. This means that the state of conservation of objects, especially those made of organic and hygroscopic materials, such as paper, wood, textile, etc., might be strongly affected by short and mid-term variability of indoor climate. In conservation science, wood is one of the most sensitive materials to the variations of relative humidity, which is the main responsible of physical damages induced by strain-stress cycles [2]. For such a reason, the adequate control of indoor climate plays a key role when sensitive artworks and/or historical component of building envelope are preserved in a building.

The aim of this study was to analyse how microclimate, especially relative humidity, affected the crack widths of historical wood. The analysis was performed in the Archaeological Museum of Priverno (Latina, Italy). The Museum, set in the three-storey historical building Valeriani-Guarini-Antonelli (12th -16th century), shows valuable and damaged wooden ceilings, decorated in the *Art Deco* style by the painters G.Sordoni and P. Campeggi in 1924-26. The study was funded by the University of Rome "Sapienza" in 2015 and belonged to the project *"Preservation, Conservation and valorisation of archaeological sites: the case of ancient site of Privernum"*.

Materials & Methods

The monitoring system consisted in sensors to measure indoor and outdoor temperature (T_{in} and T_{out}) and relative humidity (RH_{in} and RH_{out}) as shown in Fig. 1. Moreover, a sensor for surface temperature (T_s) and a crack width meter (C) were installed on a wooden panel in Room 9 as support to record the time evolution of crack width. The monitoring lasted from August 2016 till November 2017 with a recording time of 30 minutes.

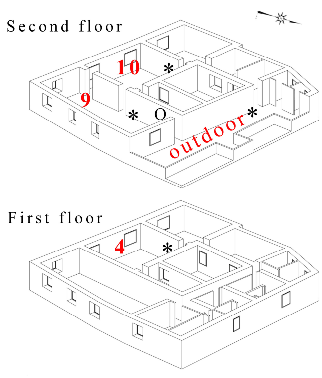

Fig. 1; The axonometric cross section of the museum and monitoring system.

First, the assessment of indoor climate was carried out by using statistical analyses. Then, RHS values were computed at the boundary level of air and wooden surface starting from the mixing ratio of air

(MR) and T_s. In this case, MR was assumed to be constant in the room volume. These RHS data were smoothed out to reproduce the propagation of RH in the wooden panel according to time scale of 3-hours, 24-hours and 1-week. The difference between RHS and the smoothed RHS were used to evaluate the material response according to C.

Results

The analysis by box plots has shown differences between the first and the second floor of the museum, especially in winter. This is mainly due to the position of Room 4 with respect to the building (only an external wall which is exposed to the south) and the capability of the heating system to supply warm air. As concerned the daily span, Room 10 showed the highest span in winter both for T (ΔT_{max}=8.0°C) and for RH (ΔRH_{max}=26.0%).

In Fig. 2, the crack width (upper panel) follows a daily cycle in coincidence with the heating period (from October till April), whereas it is stable when the difference between RHS and the smoothed RHS (mid panel) is close to zero. This can mean that, when no gradient is experimented by the material along the cross section, it keeps the width as possible as it is. However, from June 2017, a widening of the crack occurred. It seems that when an extensive difference between RHS and the 1-week smoothed RHS (black line in mid panel) and high temperatures (lower panel) occurred, the risk of physical damage increases.

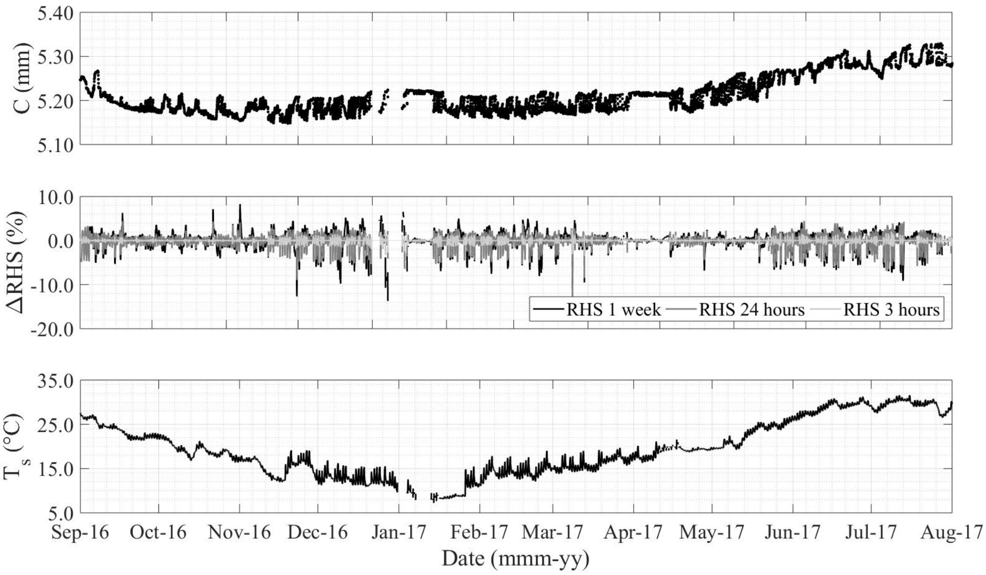

Fig. 2; Time evolution of C (upper panel), ΔRHS (mid panel) and T_s (lower panel) from September 2016 till August 2017. As for ΔRHS, each line is the difference between RHS and the smoothed RHS at 1-week (blackline), 24-hours (grey line) and 3-hours (light grey line).

Conclusions

This study revealed that a long-term monitoring campaign of indoor climate variables and crack width of a damaged wooden panel leads to a better and exhaustive comprehension of the relation between climate and degradation phenomena. This allows to prevent and/or reduce the occurrences of degradation, programming an adequate control of indoor climate.

References

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