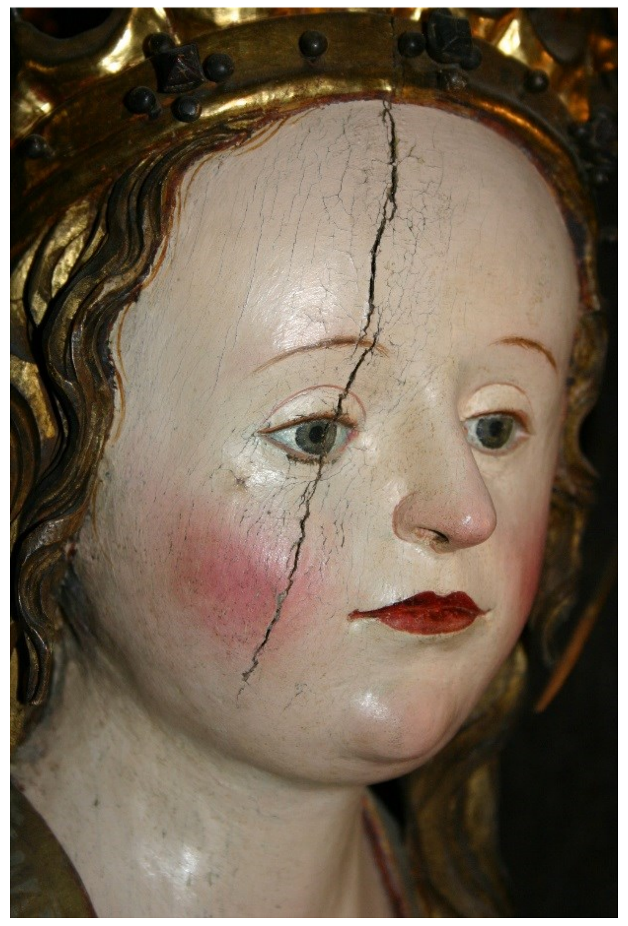
Development of evidence-based environmental specifications for short religious, cultural and commercial events in historic building

Magdalena Soboń[1], Łukasz Bratasz[1]
[1]Jerzy Haber Institute of Catalysis and Surface Chemistry,
Polish Academy of Sciences,
30-239 Kraków, Poland

@Cultural_Haber
@cultural_heritage_jhi
https://heritagescience.edu.pl

CULTURAL HERITAGE RESEARCH GROUP



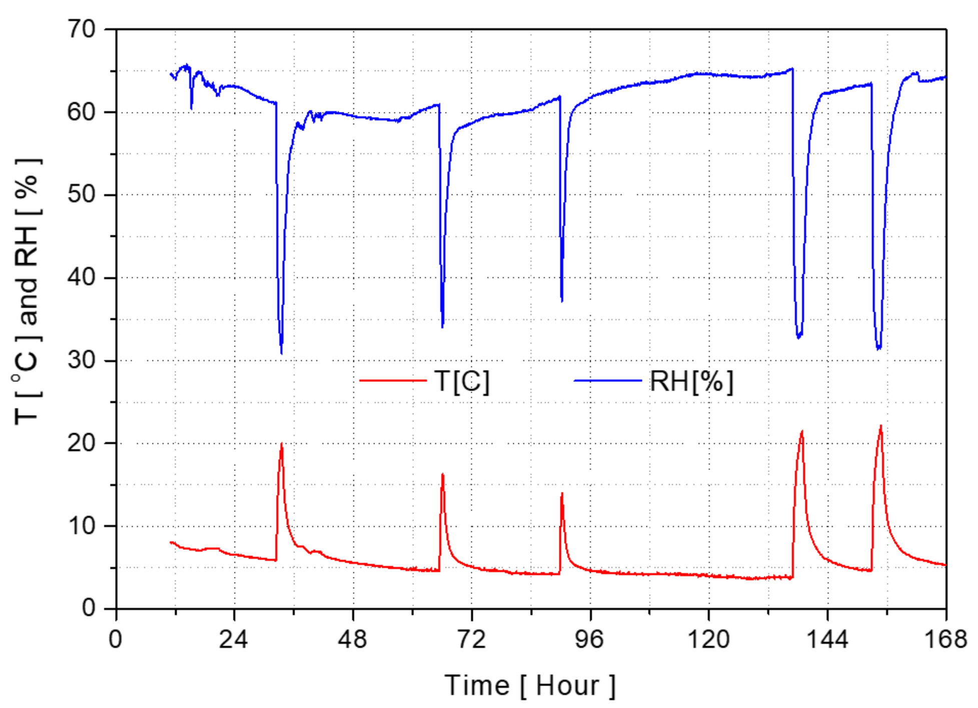
Introduction

Wooden sculptures or massive furnishing objects are the group of artifacts, among those usually found in historic interiors, most vulnerable to dynamic environmental variations. It results from their considerable dimensions contributing also to prolonged moisture diffusion time, causing stress field formation in their cross-section and therefore – **risk of cracking.**

Fig.1 Cracked sculpture of St. Mary from church in Rocca Pietore (Italy)

Dynamic environmental variations result from interior's heating – present requirement for visitors' comfort – causing dramatic drops of relative humidity (RH) in the historic interior.

Fig.2 Microclimate in the church in Rocca Pietore



Materials - lime wood
methods – fracture mechanics combined with Finite Element Analysis

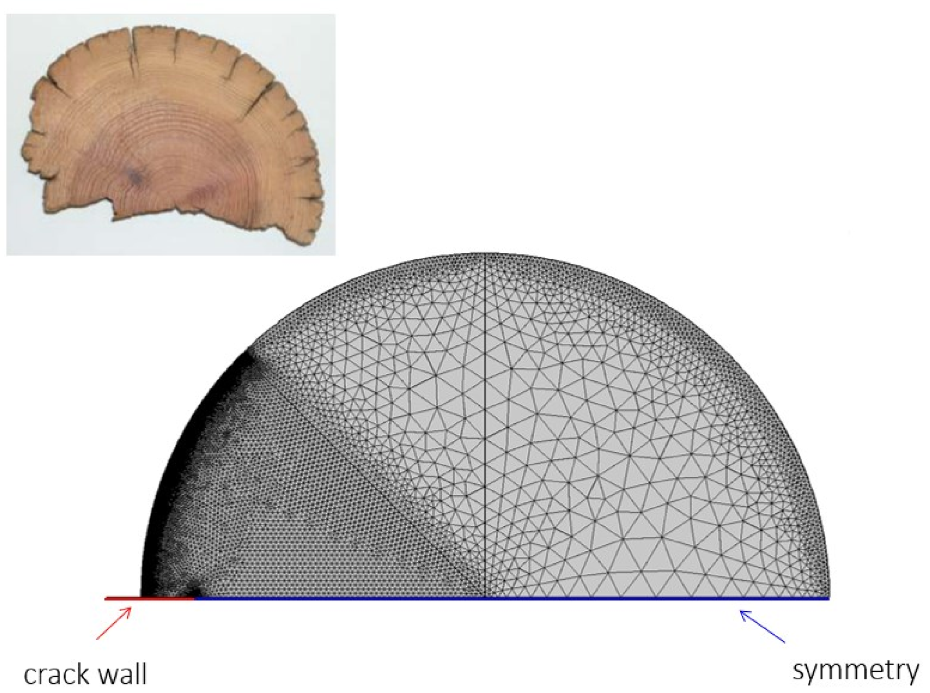


Fig.3 Finite Element model of a cylindrical massive wooden object with a pre-crack; wooden cross-section from *Mecklenburg M., „Determining the Acceptable Ranges of Relative Humidity And Temperature in Museums and Galleries"*

Objectives

I. Determining safe magnitudes and durations of RH changes

I. Developing guidelines for climate conditions in historic interiors

Results

Step change is suitable for the risk analysis from very **fast climatic events** typical of **weddings, concerts and any commercial meetings**.

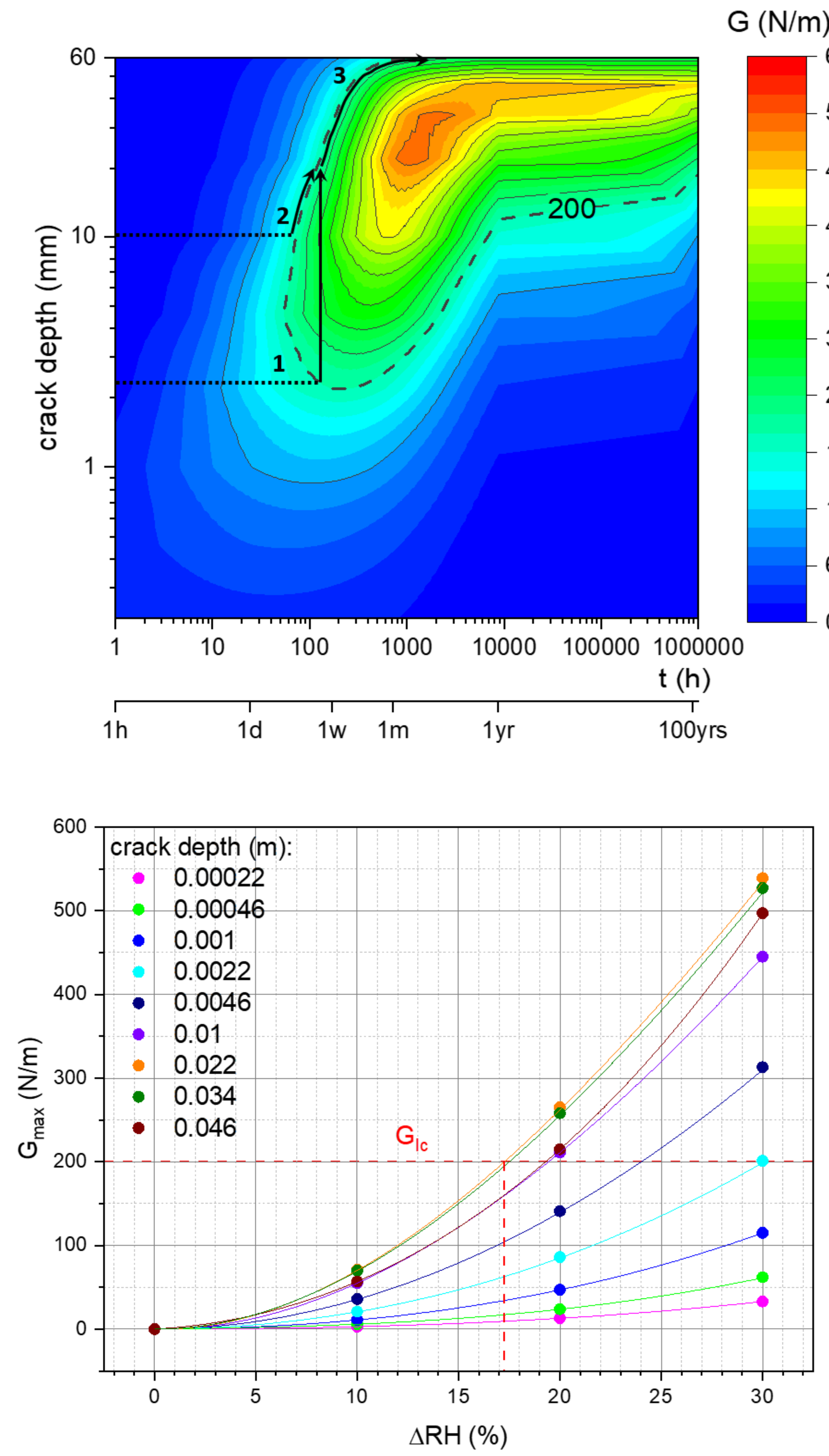


Fig.4 a Two-parameter risk map for an RH change 50 → 20% showing crack depth (y axis) as a function of time of drying (x axis) and corresponding G (isolines). G_{Ic} is represented by a dashed line, b maximum value of G as a function of ΔRH of step change.

A risk map developed for a step change 50 → 20% helps to analyse and interpret crack propagation process by selecting crack depth and duration of an RH variation. When the chosen combination of those parameters results in reaching the critical value of energy release rate G_{Ic}=200N/m, a flaw in material starts to propagate.

Sinusoidal variations better reflect risks from **natural climate variability: daily variations, weather and seasonal changes.**

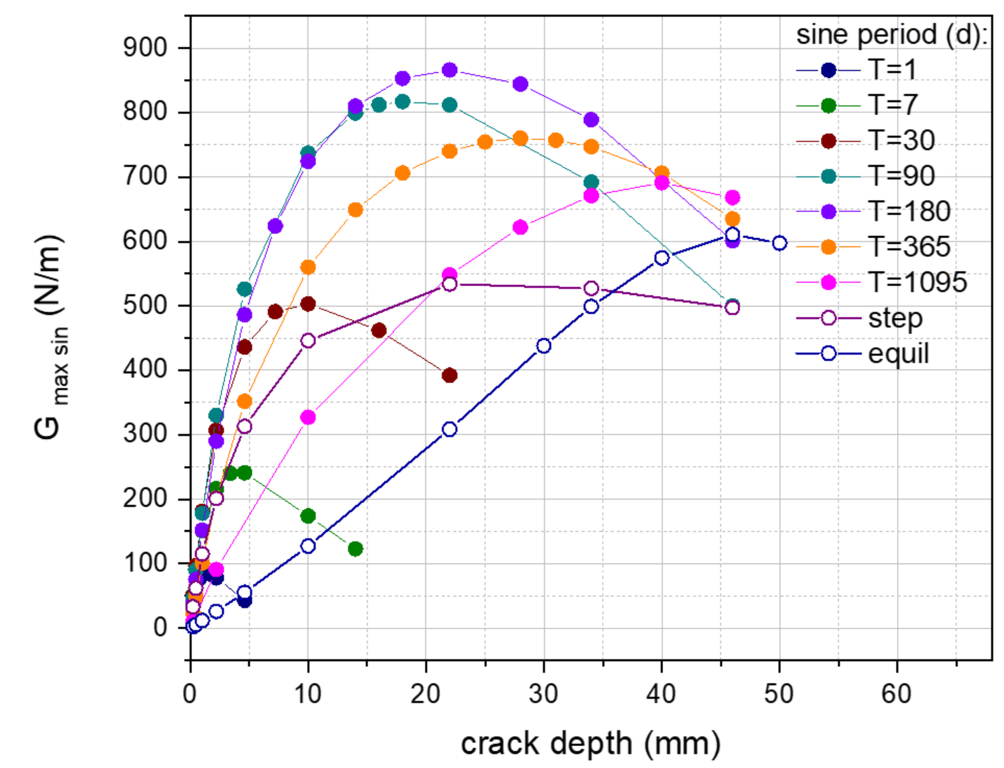


Fig.5 Maximum value of *G* reached during the full sine cycle as a function of crack depth

Conclusions

The allowable RH variations, below which crack will not propagate towards the centre of a sculpture, were derived as a function of the amplitude and duration of the variation.

Crack in lime wood remains stable if the amplitude of RH drop is smaller than 17% from 50% RH level.

The maxima of G values are about 30% higher in the case of an RH sine variation than a step change of the same amplitude. Therefore, **sinusoidal variations represent the worst case in analysis of risk of fracture in massive wooden cultural heritage object.**

Acknowledgements and Funding

PRELUDIUM 19 project funded by National Science Center, Poland, no. 2020/37/N/HS2/01727

Polish National Academy of Academic Exchange [Grant PPN/PPO/2018/1/00004/U/00001]

The statutory research fund of the Jerzy Haber Institute of Catalysis and Surface Chemistry PAS

FRH Future for Religious Heritage

FRH Conference 2023 – European Sustainable Religious Heritage