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RISK ASSESSMENT, MONITORING AND SIMULATION OF HISTORIC BUILDINGS

Muñoz González C.Mª [1], León Rodriguez A., Navarro Casas J., Teeling C., Joyanes Díaz Mª D.

[1] *Department of Construction, University of Malaga, carmenmgonzalez@uma.es*

Churches, chapels and other places of worship are a major **part of European cultural heritage** which modern society has decided should be preserved for future generations. The **indoor environment** of these buildings **crucial to conserving construction elements and movable artefacts**.

Originally, most of the religious historic buildings have been used for centuries as cold churches. Yet now, the increasing demand for thermal comfort and preservation of cultural heritage has made air-conditioning systems quite common.

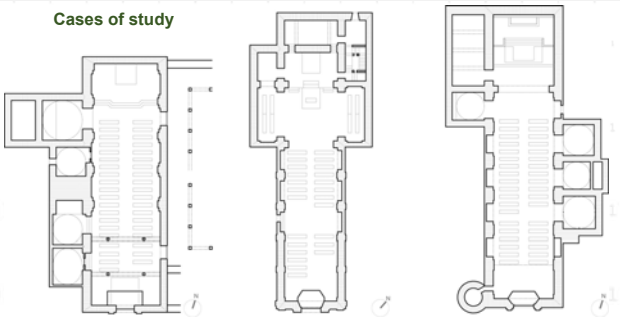
The main aim of this research is to describe different environmental techniques to improve the thermal comfort conditions of the faithful while preserving the cultural heritage. In the churches the indoor climate was monitored during a long period and the preservation conditions of the indoor climate in the collection and the monumental building and thermal comfort were evaluated. The methodology used assesses the application of passive and active environmental techniques in historic churches in Mediterranean climates and includes monitoring techniques and uses simulation tools.

Conclusions:

- ✓ The **measurements** of air temperature and RH were carried out in the different churches. The **hygrothermal conditioning** has been **characterized** and **evaluated**. The influence of the **thermal inertia** in delaying and thermal buffer the seasonal cycles was confirmed. Beside, the adjoining buildings decrease the direct solar radiation on the churches
- ✓ In relation to user comfort assessed through **PPD**, has been noted that the churches **are not comfortable** for the users in **winter** and during the **summer**, the percentage of comfortable users **is the highest**
- ✓ As regards the **risk of biological degradation**, in general all the churches prove that specially in **spring** and **summer** the risk of biological degradation is **the highest.**
- ✓ The proposals for retrofitting which exclusively **use passive environmental techniques** do **not** completely **eliminate mechanical risk** or the **bio-deterioration** of the materials that are part of the movable heritage.
- ✓ The proposals for the use of **active systems** and their **combination with passive techniques** operate 24 hours and 12 hours, **improve the initial preservation** of artworks and decrease the biological degradation risk
- ✓ The **initial situation** will **get worse**, when the proposals of **active systems do not control indoor humidity** (wetting or dehumidification), as in the case of the H7 (full air autonomous system), H8 (air handling unit (AHU) and H12 (ventilation).
- ✓ When **active and passive systems are combined** there is a **reduction in consumption** of **10-23%** for systems that **operate 24 hours** (the most efficient systems are AHU and radiators), **2-8%** for systems **operating 12 hours** and finally **1-3%** for systems **operation use.**

Morón de la Frontera (Seville), Spain

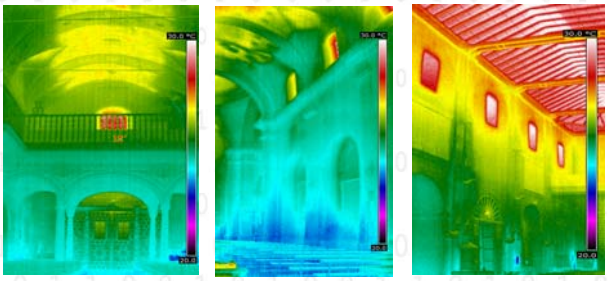
Cases of study



Church of S. Francisco Asís | Church of Merced | Church of Victoria

METHODOLOGY

- **Monitoring of churches**
- **Analysis and parameterization of hygrothermal behavior**
- **Validation of computer simulation models and generate a model similar to the real churches**
- **Implantation of pasive techniques with computer simulation models**



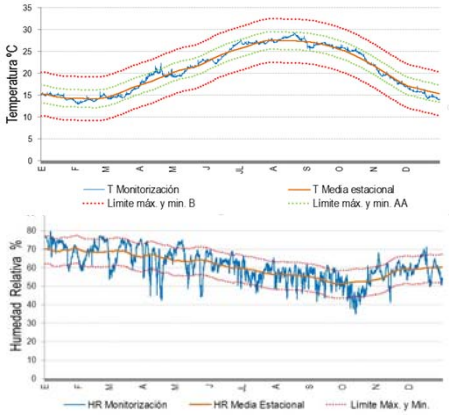
The most important **thermal fluxes** are found in the building elements with less thermal resistance: **windows** and **roof**. The **humidity by capillarity** activity is present in the **low areas** of the churches.

Monitoring of churches

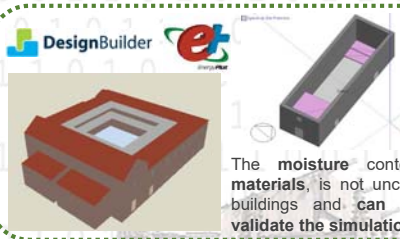
During the **cold months** and **spring**, the **indoor temperature** has a higher **impact** on the **absolute humidity**.

As regards the **risk of biological degradation**, in general all the churches prove that specially in **spring** and **summer** the risk of biological degradation is **the highest.**

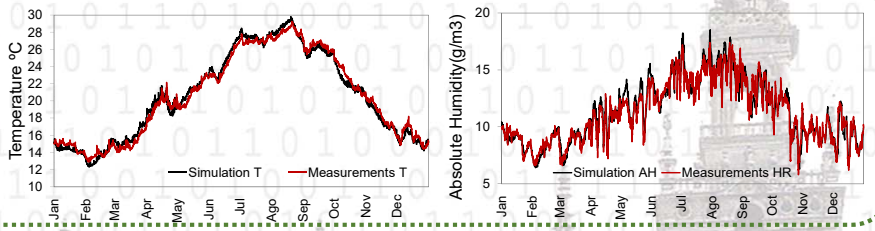
Autumn, winter and **spring** exhibit the **highest percentage of risk** due to the deviation of RH.



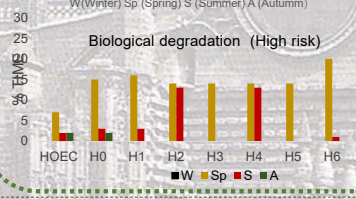
Validation of computer simulation models

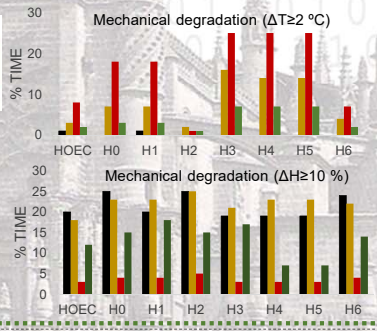


The **moisture** content in the **building materials**, is not uncommon in this type of buildings and **can make it difficult to validate the simulation models**.



Implantation of passive, active and combined environmental techniques





	CH	H7	H8	H9	H14	H16	H19	H10	H15	H17	H20	H11	H18	H21	H12	H13	H22
Op. 24h	SF	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	2%	20%	17%
	M	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	5%	23%	17%
	V	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	4%	30%	20%
Op. 12h	SF	15%	17%	15%	11%	12%	7%	15%	12%	12%	8%	10%	10%	7%	2%	12%	8%
	M	12%	12%	12%	10%	9%	6%	11%	10%	10%	6%	10%	10%	5%	5%	13%	7%
	V	15%	15%	15%	12%	11%	6%	12%	12%	10%	5%	12%	10%	5%	4%	23%	15%
Operating Use	SF	3%	3%	3%	6%	4%	4%	4%	7%	6%	5%	5%	6%	5%	1%	3%	2%
	M	5%	5%	5%	4%	4%	4%	5%	4%	4%	4%	4%	4%	3%	1%	3%	3%
	V	6%	6%	6%	7%	10%	6%	6%	7%	7%	4%	7%	6%	5%	2%	7%	5%

0% risk | 1-10% risk | +10% risk

There is not mechanical damage to the pieces of art if the active systems operate for 24 hours, except in the cases where the systems do not control the relative humidity or are ventilation systems.

Thermal comfort of users, when the systems are in **use for 24 hours or 12 hours** the churches are comfortable for 100% of the time.

Please, DO NOT use this box.