"Dynamic thermal and hygrometric simulation of historical buildings: Critical factors and possible solutions"

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Building dynamic simulation tools, traditionally used to study the hygrothermal performance of new buildings during the preliminary design steps, have been recently adopted also in historical buildings, as a tool to investigate possible strategies for their conservation and the suitability of energy retrofit scenarios, according to the boundary conditions. However, designers often face with the lack of reliable thermophysical input data for various envelope components as well as with some intrinsic limitations in the simulation models, especially to describe the geometric features and peculiarities of the heritage buildings. In such respect, the work carried out within the Task59 attempts to bridge this knowledge gap, providing critical factors and possible solutions to support hygrothermal simulations of historical buildings. The gathered information could be used by researchers, specialists and policy-makers involved in the conservation of building's heritage, who need to address a detailed study of the hygrothermal performance of historical buildings through dynamic simulation tools. The main guidelines can be briefly summarized hereafter:

- a simplified geometry is often unavoidable (e.g. curved surfaces can be represented as a series of flat surfaces) to meet the requirements of BES tools, but inaccuracies due to oversimplification in some geometrical features must be avoided;
- prolonged exposure to weathering processes, especially to wind, rain-water and air pollution, increases the natural process of ageing of historical materials, causing mechanical damage such as micro-cracks; this usually increases the porosity and thus the thermal conductivity, while also altering the reflection coefficient of the outermost material;
- the humidity content of the envelope materials may have a significant influence on heat transfer calculations, thus the assessment of the actual content of water is recommended;
- specific tools/interactive atlas must be used to properly assess thermal bridges and report corrected U-values in BES tools, also by adopting modelling expedients (e.g. introduce small sub-surfaces with no thermal mass, whose thermal resistance is assigned by the user so that the same heat transfer rate as in the thermal bridge occurs);
- modelling of transparent envelope requires attention in determining the correct U-value (with particular reference to the windows frame) and solar transmittance. Several reference values are provided in the paper to this aim;
- the infiltration rate of historical buildings is extremely variable (from 0.2 to 3 ACH), depending on many factors (poor airtightness of the envelope, openings necessary for the passage of visitors/churchgoers, etc.); thus, for a correct modelling, its quantification must preferably be performed according to experimental tests such as the tracer gas dilution method;
- if the height of the indoor environment is greater than 3 m, a vertical temperature gradient due to thermal stratification must be considered in the BES process;
- LTD such as endoscopic examinations and extraction of core samples, must be carried out when possible to have a complete knowledge about the technical features of building elements;
- HFM measurements and infrared thermography (IRT) are always suggested as means to correctly estimate the U-value and identify the thermal anomalies;

- EnergyPlus is currently the most used tool to simulate historical buildings, but other specific tools can be coupled for hygrothermal calculation or thermal bridges assessment. The combination of several tools is a key factor to obtain accurate results.

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