Microclimate analysis in Gheorghe Asachi auditorium: showcase for the indoor climate performance

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Abstract. The subject of this paper is to study the microclimate inside a heritage building. The Gheorghe Asachi Auditorium is one of most important buildings in the university and in the history of Jassy. Build in 1897, it was inaugurated by King Carol I. The auditorium serves as meeting place and manifestations for different occasions. Auditorium is built in baroque style with multiple paintings, artworks and wooden elements sensitive to moisture and temperature variations. CFD analysis is the proper tool for understanding the phenomena’s regarding the movement of large volume of warm and moisture air. The analysis allowed us to make some recommendations to the conservation of such historical place but with regard to main human comfort.

1. Introduction
The Auditorium of the Technical University Gheorghe Asachi from Jassy is found inside the Palace University and thought its classic baroque style is distinguished by its beauty and elegant architecture. On its inaugural stone - 22 October 1897, King Carol I make the inauguration. Since then it known a cruel history, it has suffered massive structural degradation during the war and then rebuilt. The sketches of the University Palace were drawn by Petru Poni, professor at the university and the final project were finished by the renowned architect Louis Blanc.

The purpose of all factors concerning heritage and historic building is to preserve them and their contents. If the external factors as ground humidity, roof seepage or earthquakes, can be excluded we can conclude that damage depends mainly on the internal factors strictly that are connected with the indoor microclimate or that are creating the interior climate. The main subject of the indoor climatic studies concerns only the relations between occupants and indoor microclimate, such as the physiological response, hygiene and thermal comfort of the humans to the microclimate. [1], [5]

2. Heritage building and microclimate: point of view
In the case of heritage building such as, auditorium of Technical University, figure 1, figure 2 and figure 3, our opinion is that the main important aspect is regarding to the historical heritage of the build so that the indoor microclimate evaluation and monitoring should be to preserve the building and artefacts and not the thermal comfort in the events that are hold in the auditorium.
In historic buildings, we need to change the view that has occurred until now so: the “object” such as – artefact, pictures, statues, artwork, building, are more essential than people are. Therefore, the microclimate for the indoor of the auditorium has to have the comfort range calibrated and adapted in order to privilege the “historical heritage artwork” instead of wellbeing. Historic heritage buildings are used for a very various purposes that put in the front the pure conservation tin instead of reuse for specific functions: this can be seen in religious building such as churches, museums or libraries. Indoor microclimate in historically heritage buildings is the centre of the paper research, so the comfort studies, that have high temperature and relative humidity (RH) could damage plaster, wall that have frescoes, wood objects, brick and other building materials and objects contained in the building: papers, canvas, old but even new manuscripts and other types of artworks. [2], [3], [4]
3. Aim of this research

In this paper we describe results of the indoor microclimate modelling, simulation CFD is used since there is a large volume, parameter studies must be performed in order to have a better computation domain. The software used is Autodesk CFD 2017 – capable of solving heat, air and water vapour simulation, the model has been made in Autodesk Inventor 2017 in 3d space in order to have a model closed to the investigation site. Modelling had been carried out in steady state regime, in a climatic zone is III-rd, with -18°C air temperature. Now, the heating system is a classical one with static heaters. The boundary conditions imposed for walls are:

- the film coefficient for exterior walls is $U=0.8 \text{ W/m}^2\text{K}$
- the film coefficient for interior walls is $U=0.6 \text{ W/m}^2\text{K}$
- the film coefficient for windows is $U=0.5 \text{ W/m}^2\text{K}$
- the film coefficient for floor is $U=1 \text{ W/m}^2\text{K}$

The boundary condition used for static heater are taken from the site, cast-iron material with an approximated temperature of 80°C. Model discretization has a step of 0,5 meter. (figure 5) in a volume of air of 2736 m³.
4. Results
The CFD modelling show the value of temperature that is create inside the Auditorium interior environment. It can be observed that near to the static heaters the air has a high temperature than the rest and that the walls behind the radiators are washed with warm air (figure 6) [6].

Figure 5. Auditorium 3d geometry and meshing.

Figure 6. Range of temperature and heat dissipation viewed in cross section of Auditorium.

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Standard thermal comfort developed by P.O. Fanger or predicted mean vote (PMV) is in good range despite the interior is heated with static heaters, meanwhile the temperature is uniform (figure 7).[5], [7]

**Figure 7.** Predicted mean vote inside de interior climate created in Auditorium.

The air distribution it can be observed in figure 8, where the pattern of air movement is the best way to see that elements are affected by the speed of air near the walls thus affecting the paint and artworks.

**Figure 8.** The model of trace for temperature and air movement in Auditorium.
It can be observed the difference in temperature distribution in the occupation zone. In case of classical solution with central heating and static heaters, the whole volume of air is heat figure 6. The warm air tends to rise to the upper part of church, which contain the art works. [8]

The air velocity of air is another important aspect. The system using static heats figure 6, figure 7 produce a high speed of air, that rises and in its move carry the dust, water vapor that has a strong destructive effect on paints and art works because is their condensing. In addition, the high speed of air causes a superficial drying of objects made from wood, painting of canvas, old book, etc. The movement of large mass of air has as result the movement of smoke from the candles that affect the paintings and fresco paintings.[9]

A building, and in particularly a historical heritage, can be viewed as a thermo-physical system that affects different scientific are of knowledge in the thermal comfort and archaeological artwork. The aim is in the knowledge to sustain the key factors conditions in the indoor microclimate: an important role is in this understanding the relationship between building and heating systems, also in the ventilation and air conditioning, this interaction being responsible for achieving ideal conditions for conservation of historically heritage buildings. [10]

5. Conclusion

The solution of heating with local heating elements can be effective for the occupants but for the interior artworks elements and paints it has a destroying effect. Also this system heats the whole volume of air after all, and because of that it isn’t too efficient. In order to maintain the artworks heritage from the Auditorium, it must be carry out a research the see, which is the proper heating system with the minimum effects on the art work.

The simulation software Autodesk CFD is a proper tool in thermal comfort modelling and indoor climate simulations with good results in understanding of fluid dynamics and heat transfer. Creating an indoor microclimate, different from the outdoor climate, is the inherent condition of most buildings. The indoor microclimate is meant to provide thermal comfort and wellbeing for people who live and work in climate created by the envelope of the building volume. Also, indoor microclimate induced degradation and this is one of the major hazards to our cultural heritage. The best conservation strategy is to act in order to prevent damages and degradation rather than reacting afterwards. Indoor microclimate control, when is properly used and design can act as an efficient and cost-effective method for heritage conservation. Often the discussion on indoor climate control has is focus on the technical solutions whereas the real difficulty lies in establishing proper climate criteria.

The thermal indoor microclimate is defined by:

- Air temperature
- Surface temperatures
- Relative humidity
- Air movements

The process of degradation, is basically described as a progressive and cumulative process of materials, that has different response to the values given by indoor microclimate and their changes, both in a temporal and spatial way. Rapid changes in a short period of time (or strong spatial gradients) in temperature and/or relative humidity, or exchanges of heat and mass in different direction in the area of the artwork (pictures, frescoes, wood, brick, stone), cause internal stress in materials with irreversible and cumulative effects that accelerate the deterioration process.

References

[1] Burlacu A et al 2014. Experimental study for data validation regarding the flow movement in natural convection in an asymmetrical heated vertical channel. Applied Mechanics and Materials, Volume 659, pp. 313-318
[2] Camuffo D 1998 Microclimate for Cultural Heritage. Amsterdam: Elsevier Science BV
[3] Camuffo D et al 2011 Humidity and environmental diagnostics in Palazzo Grimani, Venice. In: D. D. Curto, ed. Indoor environment and preservation – Climate control in museums and historic buildings. Florence: Kermes Quaderni, Nardini Florence, pp. 45-50
[4] Corgnati P S, Fabi V, Filippi M 2009 A methodology for microclimatic quality evaluation in museums: Application to a temporary exhibit. Building and Environment, pp. 1253-1260

[5] Fanger P O 1970 Thermal comfort. Analysis and applications in environmental engineering. Copenhagen: Copenhagen: Danish Technical Press

[6] Zuo W et al 2016 Coupling Indoor Airflow, HVAC, Control and Building Envelope Heat Transfer in the Modelica Buildings Library. Journal of Building Performance Simulation, 9(4), pp. 366-381

[7] Tian W, Xu H, Wangda Z, Sohn M D 2018 Building energy simulation coupled with CFD for indoor environment: a critical review and recent applications. Energy & Buildings, Volume 165, pp. 184-199

[8] Schellen H, Lambertus H 2002 Heating monumental churches - indoor climate and preservation of cultural heritage. Eindhoven(NL): Technische Universiteit Eindhoven

[9] Rohdin P, Moshfegh B 2011 Numerical modelling of industrial indoor environments: a comparison between different turbulence models and supply systems supported by field measurements. Building and Environment, Volume 46, pp. 2365-2374

[10] Marco P, Kristian F 2018 Indirect investigation: building simulation in Historic indoor microclimate of the heritage buildings. Bologna: Springer, pp. 100-102