THERMAL COMFORT MODELING OF A CHURCH HEATED WITH STATIC HEATERS

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ABSTRACT:

This paper evaluates a static heating system from a church. They are presented in almost every church. Temperature distribution in the church is done in 2d plane. The simulation is presented on a particular example, the Dormition of the Mother of God Church from Jassy, Romania. The heating system had been simulated in FLUENT and the consequences over the interior climate in the church are showed. An important issue is the impact of this system over the artwork, the church being rise in XVIII century.

1. INTRODUCTION

Churches are part of our country's heritage, to be preserved and cherished. Their construction meant the ritual Christian creator of sacred edifices in which man to glorify and honor the Divine. Over long as man has integrated these different construction techniques and technologies to increase comfort. They were translated both in new construction methods, materials and sustainable better in paintings and frescoes impressive, inspiring and increasing thermal comfort during the religious service by adopting heating systems (Camuffo, 2007, Camuffo, 2010, Liu et al, 2012).

Except for a few cases of cultural heritage, icons, frescoes, religious objects, etc., which for centuries were kept in unheated churches they are in good condition (Comuffo et all, 2014, Schellen and Lambertus, 2002). After installing one or more heating different there are signs of rapid degradation, which means that they should not be used randomly (Silva ,2014, Napp and Kalemees, 2015)) Churches preserve many types of valuable artwork, each with a specific vulnerabilities: paintings on canvas and wooden panels are subject to cracking, swelling, dirt; frescoes in bulk are blackening; wooden artifacts have cracked; metals were corroded; Textiles were discolored and dirty (Bratasz et al., 2007, Torres and Freitas, 2007)). Always for economic reasons warming is often designed for limited periods where people are present (Varas et al., 2014, Vuerich et al., 2008). Many churches are heated only once a week, to

Sunday Mass with inadequate systems. This practice causes severe changes of temperature and relative humidity of the indoor environment (Atkinson J., 2014, Serbanoiu et al., 2014). These cycles generate environmental stress, fatigue and degradation both buildings and works of art kept inside, the consequences are dramatic in most cases.

These mechanisms of damage often met in many cases studied and discussed in the literature and from this point of view the purpose paper is to identify weak aspects of the adoption of a heating system with radiators (Cirstolovean et al, 2018, Hornet et al, 2018).

Cathedral of Our Lady of Iasi, Romania is located in Iasi, Iasi Country. According SR 1907-1 / 1997, it is located in the wind III and III in the Romanian climate, with an outside temperature of -18°C (Figure 1).

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The building was built between 1782-1789 and since then has undergone multiple interventions for rehabilitation (Jung-Yoon K, 2010). The building, with height P has a usable space of 351.47 m². The resistance structure of the building is made of solid brick masonry. Exterior finishes are degraded, which are of cracks and falling plaster partial. Woodwork is metal with double glazing. The roof framing type, wrap sheet. In terms of facilities, building has electricity for interior lighting. Heating is performed with heaters, the heating is provided in a substation. The overall dimensions in plan of the building length are 40.61 m and 15.04 m wide (Fig. 2). Headroom in the narthex is 9.81 m above floor level. The thickness of the walls ranges between 110 cm and 85 cm. The construction foundations below the walls. The floor is brick and concrete. Type floor floor floor is made of marble cold.

2. HEATING RADIATORS MODELED WITH FLUENT 2015

Static body’s heater is used now in the Cathedral (Fig. 3).

Modeling Computational Fluid Dynamics (CFD) is done in a sectional plane where the radiator is located in the church. Section has a length of 31 meters and height of 12 meters. Thermo-technical characteristics of the tire are as follows: the roof of the heat transfer coefficient is λ = 0.9 W / m²K, floors have λ = 1.1 W / m²K wall λ = 1.1 W / m²K and the windows λ = 1.05 W / m²K. For each defined area of free convection. Radiatorele have been described having a temperature gradient of DT 800°C.

CFD analysis program is used to FLUENT was generated 2015. A fine mesh, having a step of at least 5 cm and 8 cm maximum. Model used in the construction of Cartesian coordinate system. The CFD model, were solved equations of flow, continuity and energy. How to implement these equations is standard, simple, one-order derivative, equation of time, momentum, and energy flow. The standard k-ε standard functions defined walls. Since heat was not introduced by forced ventilation by natural circulation but caused by radiators, Boussinesq approximation was used for the density. Transient analysis was performed with a time step of 1 minute and 100 iterations per minute.

Figure 1. Old Cathedral

Figure 2. Plan View

Figure 3. Thermographic image taken in the radiator of the cathedral

Figure 4 is the result of the analysis. It can easily be seen profiles with different temperatures of the air layers, their arrangement and how they influence the geometry of the church.
Hydronic heating system works on the basis of natural convection in large proportion (90%). The air enters the bottom, is heated due to the buoyancy phenomenon and it comes out at the top.

3. CONCLUSIONS

Although radiators look like inert objects placed in the church of their operation it is thus air around the radiator heats up, it becomes lighter and rises on pereteledin behind. In Figure 3 it can be seen clearly, drafts involving dust, with negative effects on paintings and frescoes. At the same time the Figure 4 we see a wide range of temperatures experienced within the church. The hot air rises to the ceiling, forming a layer at the top part.

Cold air, denser, accumulate at floor level. After a flow of air with different temperatures they tend to stabilize the site, forming a strong stratification of the air.

Other aspects of note are:

1. Air circulation adversely by the fact that generates a premature and rying of all objects in contact, paintings, frescoes, wooden objects of worship.

2. The volume of air that is moving trains dust, this rising is carried by air currents and deposited it in areas with thermal bridge cooler, where warm air condenses and dust is deposited.

3. Another negative aspect is that the heating radiator discontinuous operating mode of the system makes heating and cooling cycles of the air chamber to affect the interior and heritage objects occurs whenever religious service.

4. High air volume that it makes heating closing churches place of worship to be difficult to require a period of time, imposing a regime of continuous operation during cold season.

5. Heating radiator moisture combined with the recesses of the people favor the condensation on surfaces with low temperatures.

The method of analysis using the software Fluent CFD simulation demonstrates the need for the thermal comfort of the study. For a more precise and detailed analysis to be accurately in situ by placing the temperature sensors and humidity for a period of time.

All aspects must bring up note with discernamând uses heating systems and where appropriate their reassessment. Where warranted even change them with some new, more performant with less harmful effects on objects of worship. Because generally people pursue their own comfort rather than maintaining optimal parameters for preserving objects and buildings of worship requires a reconsideration prioritization and comfort needed for such property.

References:


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