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Assessment of Indoor Climate Environment Via Hygrothermal Simulation in Historical Churches

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Abstract

This paper studies how well the interior climate is naturally maintain. The church subjected to simulation is a Romano-Catholic one, Saint Archangel Michael in Sabaoani, Romania. Taking into account the construction, the exploitation during the years and the data from humidity and temperature sensors, some simulations are performed. In the simulations is used Ansys Fluent software. Historical churches, when they are unheated for hundreds of years, often face problems with moisture after a heating system is introduced. Because of the large number of persons attending to the liturgical service humidity in the air exceeds the limits and condenses on the walls and windows. High humidity can also damage the artworks and painting inside the churches. The conservation using heating control was tested in simulation model. Furthermore, are tested two different systems with and without ventilation in order to create in indoor climate for preservation of a monumental building and its monumental interior. Finally, is given a set of rules to create the interior climate proper for artworks conservation.

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Keywords: hygrothermal analysis; moisture modeling; heating system; artworks conservation; church interior climate.

1. Introduction

Churches are large volumes of air that are heated during winter. Apart of the high energy costs, there is another problem regarding the humidity that is created. The abrupt variations of temperature and humidity in a short period

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of time can cause damages to the artworks (such as paintings, frescoes, different liturgical object, wooden sculptures, organ). The best conservation strategy is to act in order to prevent damages and degradation rather than reacting afterwards. Climate control, when properly used, is an efficient and cost-effective method for preventive conservation. Too often the discussion on climate control is focused on the technical solutions whereas the real difficulty lies in establishing proper climate criteria.

The thermal indoor climate is defined by:

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

In order to control the indoor climate, we need a physical and quantitative understanding of the complex interaction in the building between air, the building structure, objects and interiors and people.

The proper indoor climate is determined with respect to:

- Comfort is a subjective parameter that describes to what extent humans find the indoor climate acceptable. People are very sensitive to temperatures, but not so sensitive to relative humidity. The comfort temperature range depends mainly on clothing, activity and duration of stay in the building; a typical range is 12–15ºC.
- Relative humidity matters to humans only when it is very high >80% or very low <30%. [1]
- Conservation of materials in the building require an indoor climate that minimizes ageing and degradation of the materials that are to be preserved. This depends on the materials and the type of degradation processes that are prevalent in the building.

  For materials, relative humidity is often the most important climate parameter.
- Costs are always a limiting factor and we must consider this from the beginning. A solution that is too expensive is useless.

Underfloor heating system is reasonable, comfortable and safety only if is operated continuously, if the building is well insulated and thermal power source is properly sized for a high inertia building. [2]

Underfloor heating system requires hours to heat the building and to reach the standards, so it must to be put into operation several hours ahead of the liturgical service. In order to reduce the costs of these systems are often combined with other faster systems. A great advantage of floor heating system consists that the air movement is greatly diminished. For tall buildings, underfloor heating can reduce cost maintenance costs by 50% compared to the other heating systems, ensuring a high level of comfort, with positive effects on the construction elements by reducing the inner streams of air, reducing air stratification. These advantages make the system to be used throughout the cold season, especially in churches where services had been several days of the week. [3]

Nomenclature

CFD	Computational Fluid Dynamics
RH	Relative Humidity

2. The Saint Archangel Michael Church in Sabaoani

The church is situated in the country village of Sabaoani, near city of Roman. Is situated in the IIIrd climate and wind zone with the external temperature during winter of -18^{0}C. In 1894-1902 the church has been raised. It is in Romano-Catholic church administration. In this time the church suffered multiple rehabilitation as for paints rehabilitation. The exterior of the church is simple, without any architectural elements (see Fig 1) put the interior of the church has numerous paints from the bible.

The monument with his historical value has the length of 53.7 meters and width of 22.7 meters. The height inside the church varies between 10 and 15 meters. The volume of air inside is 14700 m^3. The walls have the width of 80