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Integrated design of museum's indoor climate in medieval Episcopal Castle of Haapsalu

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Abstract

The ruins of medieval Episcopal Castle of Haapsalu in Estonia are planned to be taken into use as a museum. Due to conservational, architectural or economic reasons, it is difficult or sometimes also impossible to install climate systems into historic buildings. Before the design process, indoor climate measurements have been carried out to get an overview of the current situation, the needs for changes, to get data for model calibration and to work out the design strategy. Combined heat, air, and moisture simulations were performed with IDA-ICE software together with different indoor climate control strategies and different outdoor climatic conditions (typical year, warm summer, cold winter, humid autumn). The interaction of indoor air and moisture performance of building envelope was taken into account. Simulation model was calibrated based on field measurements and the results of simulations showed reasonable agreement with field measurements. By simulations, different climate control systems were analyzed and their necessity and the extent of performance were determined. The main target is to find out capability of passive measures for climate conditions to avoid active drying and humidifying.

Results showed that: with only passive indoor climate measured the indoor climate is strongly dependent of the outdoor climate as well as the massive limestone walls with large thermal and moisture capacity. Without indoor climate systems there is extensive indoor temperature and relative humidity fluctuation throughout the year. To ensure suitable indoor climate, room heating, humidification during winter period, and dehumidification during summer and autumn periods is needed. It was difficult to provide strict required indoor climate conditions for museums through the year only with passive measures.

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1. Introduction

The design of indoor climate in museums is a complex, multidisciplinary problem. Integrated design is needed to guarantee the conservation of objects and architecture as well as to reach high performance in energy efficiency, indoor climate and moisture safety in building physics. The solution should fulfil the need for preservation of interior objects and the building itself as well provide appropriate climate conditions for human comfort. Indoor climate is strictly conditioned in modern museums [1,2].

It is attractive to house museums in monumental buildings that also have heritage value. Usually these heritage buildings were not originally built for the purpose of being a museum. While designing suitable indoor climate in monumental buildings, it is necessary to pay extra attention to using the space for building service systems. Building's massive walls with large thermal transmittance and large heat and moisture capacity are essential to take into account. Poor indoor climate design can cause damage to the artefacts in a museum. The deterioration of wooden objects [3–5], mould growth [6,5], and indoor air pollution [7] can occur. There have been many case studies on museums in monumental buildings. Schellen and Martens [8] conducted a case study in the Netherlands and investigated the indoor climate and HVAC systems in local monumental museums. In their study, Kramer et al. [9] showed how different ASHRAE's museum climate classes influence energy use and protect artefacts. Arumägi et al analysed the renovation possibilities of indoor climate in the Old Observatory in Tartu [10]. A RH-sensitive heating and ventilation system was developed to keep the RH and temperature at target level.

For the preservation of the artefacts in a museum, complex and large climate systems are needed. There are many possibilities to provide indoor climate in medieval buildings with valuable interior [11, 12]. Due to conservational, architectural or economic reasons, it is difficult or sometimes also impossible to install these systems into historic buildings.

In this study, indoor climate simulations for the museum in Episcopal Castle of Haapsalu are conducted to investigate the indoor climate and the necessity of different climate systems in monumental museum. The main target is to find out capability of passive measures for climate conditions to avoid active drying and humidifying.

2. Methods

2.1. Building and measurements

Episcopal Castle of Haapsalu was established in the 13th century and it is one of the oldest castles in Estonia (Fig. 1). It has massive walls typical of a medieval stronghold castle. The castle is located in the city centre of Haapsalu and today, it accommodates a museum and the dome church.

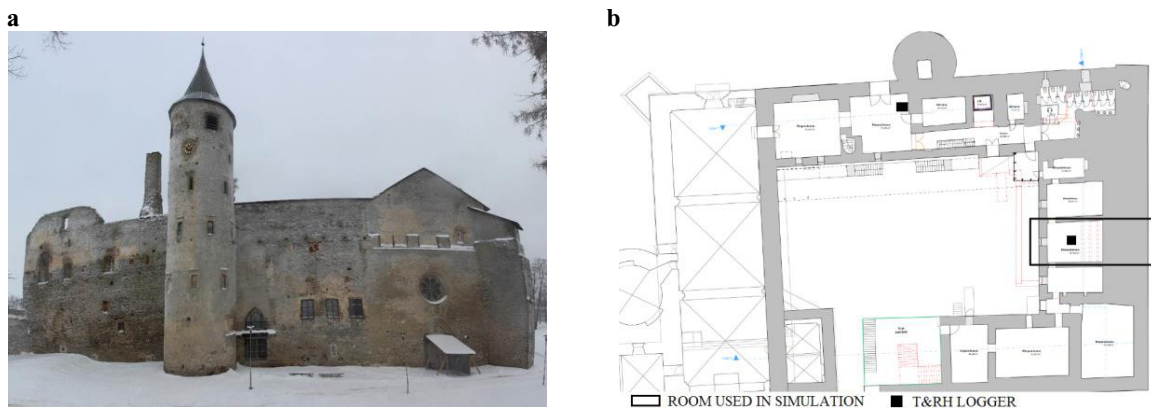


Fig. 1 (a) Episcopal Castle of Haapsalu; (b) first floor plan view of the castle

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