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Independent Environmental Control for Relics Preservation and Visitors' Thermal Comfort in Archaeology Museums

Xilian Luo[a, b, *], Tian Wei [b, c], Penglong Song[a, b], Zangshe Wang[a,b] and Zhaolin Gu[a, b]

[a]*School of Human Settlements and Civil Engineerging, Xi'an Jiaotong University, Xi'an, 710049, China*
[b]*Shaanxi Energy environmental & Building Energy Conservation Engineering Technology Re-search Center, Xi'an,710049, China*
[c]*China United Northwest Institute for Engineering Design & Research Co., Ltd, No.81 Laodong Road, Xi'an, 710082, China*

Abstract

The environmental control in archaeology museum buildings should take into account the requirements of both visitors' thermal comfort and relics preservation. However, the environ-mental conditions for the thermal comfort of visitors are usually different to those for relics preservation, and the specialized needs of the latter are usually ignored due to financial and technological limitations. In this paper, an independent environmental control method employing a split air conditioning system for visitor comfort and a displacement ventilation system for relic preservation was proposed. An experimental study has been carried out to examine the feasibility and performance of the method. The results show that both air conditioning systems could be operated independently with different working parameters and operation models. Additionally, the different environmental needs of visitors and relics were simultaneously satisfied with this energy-saving method.

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Keywords: Displacement Ventilation; Environmental Control; Relics Preservation; Site Museum

1. Introduction

Currently, there are more than 770,000 unmovable cultural relics have been discovered and registered in China. Most of the relics are directly exposed to outside environment, such that a large percentage of them are suffering deteriorations, more than 2000 of them were destroyed completely and disappeared every year (Network 2017).

* Corresponding author. Tel:15991896859.
E-*mail address:* xlluo@xjtu.edu.cn

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Constructing archaeology museum to transfer the surroundings of those in situ relics from an open-air environment into an indoor environment is considered the most effective way to preserve them. Hundreds of archaeology museums have been built and opened in China [1]. The archaeology museums could prevent the natural weathering of the in situ relics caused by the sun, wind and rain; however, the relics preserved in archaeology museum are far from being well pre-served and many relics are still subjected to deterioration or even ruin due to improper preservation environments being adopted for relic maintenance [2].

In general, the in situ relics should be preserved in a stable and clean environment. The indoor environmental control is therefore of important significance for upgrading the conservation of the relics in an archaeology museum [3,4,5]. However, the thermal indoor microclimate conditions in museum buildings refer to two different requirements: the preservation of relics and the thermal comfort of visitors to these buildings and/or those working inside them [6] (see Fig.1). The recommended indoor temperature and RH for visitors in summer are 24°C-28 °C and 40%-70%, respectively [7], which are usually inconsistent with the standard for appropriate preservation of relics[9]. As described in the suitable preservation temperature for preserved earthen site in archaeology should be 20 °C, and the RH should be as high as possible[10]. It is therefore very difficult for the all-encompassing environmental management currently used in archaeology museums to simultaneously satisfy the different needs of both the relics and visitors.

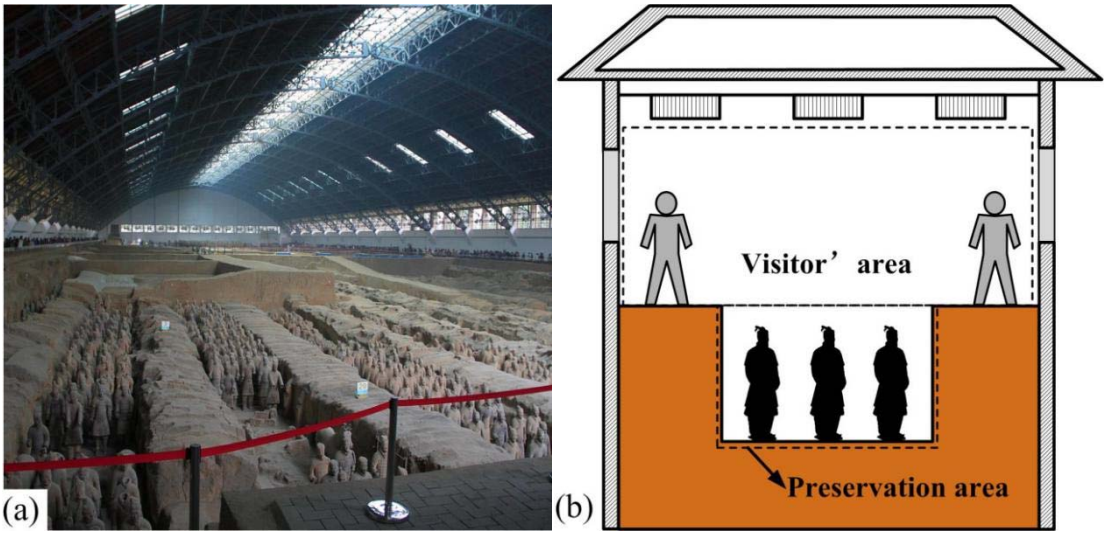

Fig. 1. (a) The No.1 exhibition hall (b) The schematic of visitors' area and relics preservation area.

Although the relics and visitors have different environmental requirements, it is encouraged that the recommended temperature of the preservation area is lower than that of the visitors' area. This thermal stratification enables the feasibility of the independent environmental control for relics and visitors in archaeology museum. Displacement ventilation is such an approach that utilizes thermal stratification in large space building to provide more efficient way in removing contaminants and heat load form the occupied area. It was initially developed in Scandinavian halls in the 1940s. In the 1980s this system started to be used in mechanical cooling of office buildings, with the goal of reducing room airflow velocities, ventilation induced noise, and HVAC energy consumption [11]. In this research, an independent environmental control strategy, by employing DV system and split air conditioner to control the preservation area and visitors' area, respectively, was proposed. An experimental system was built to validate the feasibility of the strategy.

2. Experimental system

A laboratory room with a total area of 100 m2 was constructed to simulate a large, open exhibition hall. The building is located in the campus of Xi'an Jiaotong University, which is only 31km and 24 km away from the