Building and Environment 46 (2011) 98–108

Contents lists available at ScienceDirect

Building and Environment

journal homepage: www.elsevier.com/locate/buildenv

Experimental study of practical applications of a passive evaporative cooling wall with high water soaking-up ability

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ARTICLE INFO

Article history:
Received 17 May 2010
Received in revised form
1 July 2010
Accepted 8 July 2010

Keywords:
Porous ceramics
Capillary attraction
Water soaking-up
Evaporative cooling
Passive cooling wall
Urban environment

ABSTRACT

Aimed at controlling the increase in urban surface temperature and creating comfortable urban environments in summer, the authors have developed a passive evaporative cooling wall (PECW) constructed of porous ceramics. These ceramics enable their vertical surfaces to be wet up to a level higher than 100 cm when their lower end is placed in water. Our previous study has demonstrated the cooling performance and applicability of a prototype PECW constructed of pipe-shaped ceramics (ceramic pipes). The present paper presents a PECW unit system which can be easily installed for practical applications. Experiments were conducted using experimental PECW units. Experimental results show that the ceramic pipe developed in this study possessed a higher water-holding and soaking-up ability than the previous one. Wet surfaces of the new ceramic pipe reached a height of over 130 cm at an outdoor location exposed to solar radiation on sunny summer days. Furthermore, the air passing through the PECW unit was cooled, and its temperature can be reduced by around 2 °C during summer daytime. These results indicate that the proposed PECW can be broadly applied to various urban locations.

1. Introduction

In order to create comfortable urban environments in summer, it would be an effective cooling strategy to apply the materials with evaporative cooling effect to urban vertical surfaces (such as building walls and fences) that surround the human activity spaces in outdoor or semi-outdoor locations. This cooling strategy not only can control the increase in urban surface temperature, but also can modify the microclimate in the urban environment from the surface temperature reduction, so that a mitigating effect on urban heat island formation would be provided. Generally, however, to cool urban vertical surfaces it requires a source of power such as a pump that can supply water for evaporation [1–6]. Thus, the current authors have developed a passive evaporative cooling wall (PECW) constructed of porous ceramics. These ceramics possess a capillary force to absorb water up to a level higher than 100 cm when their lower end is placed in water [7,8]. Our previous paper [7] has described the design concepts of a PECW and experiments for investigating the water soaking-up ability of the developed ceramics and cooling performance of a prototype PECW constructed of pipe-shaped ceramics (hereafter called the ceramic pipe). The cooling effects and applicability of the prototype PECW have been demonstrated through a long-term experiment conducted in an outdoor location. In order to enable the developed PECW to be installed easily and applicable to various urban locations, a practical PECW system was proposed and discussed in the present paper. Experiments have been conducted in outdoor locations for testing the water soaking-up ability and cooling effects of the newly-developed PECW, etc. Results of the experiments are also described in this paper.

2. Design of a practical PECW

A practical PECW should be designed to have the following features:

(1) It can cover a human outdoor activity space (at a height of 2 m or so).
(2) Rainwater can be reused as water for evaporation without the aid of a pump.
(3) The following passive cooling effects can be provided: 1) to shade solar radiation (shaded space formation), 2) to create

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doi:10.1016/j.buildenv.2010.07.004