An Evaporative Cooling System for Hot and Arid Climates and Passive Cooling

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Abstract: The study provides experimental findings and a computer model of an evaporative cooling system with a sub-wet bulb temperature for space cooling in hot, dry conditions. Any long-term plan looking to increase sustainability should be centered around the low energy approach. Reducing the amount of energy used for heating and cooling residential structures is necessary given the climate in India. The performance of a passive cooling system was created as part of the low-cost residential construction project's design work. The sanitary section of the structure is used by the passive cooling systems to precool the air and include a solar chimney. The passage of fresh air within the sanitary area helps to cool it down, and the solar chimney improves natural ventilation. This system's implementation in the living rooms of a cheap housing complex was assessed and approved. This residential building's integrated cooling system is the third prototype the designers have created since 1998. To forecast the air temperature in the living room, a model was created.

Introduction: Thirty to forty percent of the world's principal energy use is consumed in buildings [1]. The main purpose of this is to give residents suitable interior climate conditions. For instance, more than 60% of the energy utilized in buildings in areas with hot weather is used for space cooling [2]. Worldwide demand for air conditioning systems is primarily being driven by rising living standards, increased affordability, population expansion, and the availability of inexpensive electricity in some areas, including the Middle East. In order to satisfy peak electrical loads, this has forced several nations to construct additional power plants and expand their grid infrastructure, which has a detrimental effect on the environment by increasing greenhouse gas emissions.

Thirty to forty percent of the world's principal energy use is consumed in buildings [3]. The main purpose of this is to give residents suitable interior climate conditions. For instance, more than 60% of the energy utilized in buildings in areas with hot weather is used for space cooling [4]. Worldwide demand for air conditioning systems is primarily being driven by rising living standards, increased affordability, population expansion, and the availability of inexpensive electricity in some areas, including the Middle East. In order to satisfy peak electrical loads, this has forced several nations to construct additional power plants and expand their grid infrastructure, which has a detrimental effect on the environment by increasing greenhouse gas emissions.

External air can be pre-cooled before entering the building. accomplished naturally, such as through the ventilation air's movement through the sanitary area. A few meter's down, the temperature of the soil is lower than the average daily outside air temperature and far lower than the typical outside daylight temperature. A solar chimney is used to increase natural ventilation through living rooms.

In the solar chimney air is heated up in contact with a surface, which absorbs solar radiation. Heating enhances the pressure difference between inlet and outlet of the chimney, thus increasing the rate of natural ventilation significantly.

3. Systems of Direct Evaporative Cooling

The process of evaporating liquid water into the surrounding air and lowering its temperature is known as direct evaporative cooling. As seen in Fig. 1, a conventional direct evaporative cooler circulates cold air throughout the building by using a fan to suck in outside air through a pad wetting media.

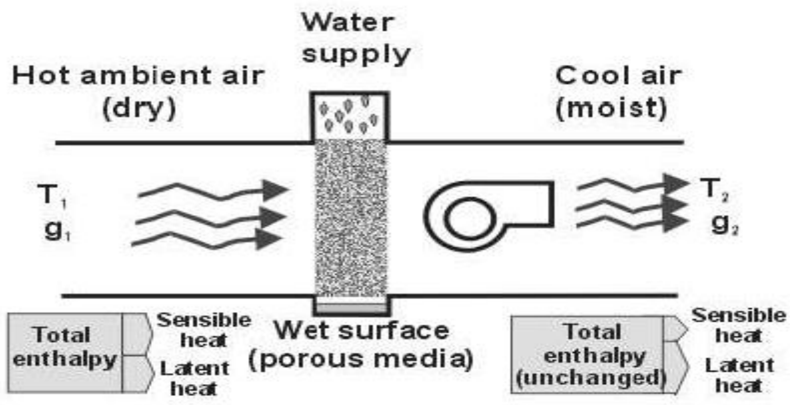

Figure 1. Schematic of a direct evaporative cooling system

The air provides the energy needed for water to evaporate, but doing so causes the air's temperature to drop and its moisture content to rise. Due to the process'sadiabatic nature, latent heat gain—which manifests as a rise in moisture content—balances out the sensible heat loss by the air.

4. Design strategy

In order to maximise solar gains through the windows on the south and east facing facades during the winter, the design strategy takes into account the conditions of the plot of land as well as the financial constraints imposed by the social housing project. It also makes use of external shadows cast by trees (Fig. 1) at the west facing facade and solar protection on the east and south facing windows. Summertime day ventilation in the building is accomplished by flowing pre-cooled outside air via the sanitary section, which is situated six metres below grade. During the day, a solar chimney drives air flow through the rooms when the outside air temperature is higher than the interior temperature. Additionally ensuring air movement at night when the outside temperature falls below the interior air temperature is the natural.

Figure 2: West Façade.

5. Conclusion

The application of passive cooling techniques enables maintaining thermal comfort while using less traditional energy. Utilizing a solar chimney is highly intriguing since it produces natural ventilation at a rate independent of wind speed. For areas with high solar radiation and typically low wind speeds, this arrangement is ideal. It was feasible to forecast a low energy consumption throughout operation by using this low cost approach on a building in India. Combined winter and summertime efforts can reduce it by more than 50%.

It was demonstrated that the evaporative cooler is capable of achieving great thermal performance with respect to efficacy and low air supply temperatures. Because of their structural stability and manufacturing controllability, ceramic materials are highly suited for integration into structures and for serving as air conditioning in areas with hot, dry weather.

References:

[1] A. Dodoo, L. Gustavsson, and R. Sathre, "Building energy-efficiency standards in a life cycle primary energy perspective," Energy and Buildings., vol. 43, no. 7, pp. 1589-1597, 2011.

[2] D. R.Vissers, "Study on Building integrated evaporative cooling of glass-covered spaces, in Building Physics and Systems," Eindhoven University of Technology, 2011.

[3] W. P. Jones, Air Conditioning Engineering, 5th Edition, Butterworth Heinemann, 2001. [

[4] S. T. Hsu, Z. Lavan, and W. M. Worek, "Optimization of wet-surface heat exchangers," Energy, vol. 14, pp. 757-770, 1989.

[5] European Union, Directive 2002/91/EC, Official Journal of the European Communities L1 46 (2003) 65.

[6] B. Givoni, Passive and Low Energy Cooling of Buildings, Van Nostrand Reinhold, New York, 1994.

[7] M.D. Santamouris, Asimakopolous, Passive Cooling of Buildings, James & James, London, 1996.

[8] ASHRAE, Handbook of Fundamentals, American Society of Heating Refrigeration and Air Conditioning Engineers, Atlanta, U.S.A., 2001. [5] C.A. Balaras, K. Droupsa, E. Dascalaki, S. Kontoyiannidis, Heating energy consumption and resulting environmental impact of European apartment, Energy and Buildings 31 (2005) 429–442.