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EXPERIMENTAL AND NUMERICAL STUDIES OF SOLAR CHIMNEY AND WETTED ROOF: AN APPLICATION IN THE HOT AND HUMID CLIMATE

Sudaporn Chungloo

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A Dissertation Presented

by

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Doctor of Philosophy
Energy Technology Program
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Approved as to style and content by the Thesis Committee:

Chair and Advisor ______________________
Assoc. Prof.Dr. Bundit Limeechokchai

Member ______________________
Assoc. Prof.Dr. Supachart Chungpaibulpatana

Member ______________________
Assoc. Prof.Dr. Kriengkrai Assawamartbunlue

Member ______________________
Prof.Dr. Vimolsiddhi Horayangkura

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The author also would like to express her appreciation to the Thailand Research Fund (TRF) for providing a research fund for this study.

Abstract

The thermal performance and benefits of two passive systems under hot and humid climate condition are experimentally and numerically investigated. The experimental results were obtained from a test cell and a controlled cell with identical walls but different roof configurations. The two passive systems applied to the test cell are passive ventilation by solar chimney and wetted roof by water spraying. The experimental results obtained from the test cell are compared with the closed, no passive system applied, controlled cell and are used for calculation of values of heat transfer coefficient of the wetted roof and evaluation of the mean cooling potential (MCP) of the combined passive systems. The effects of wetted roof on the temperature, velocity and air flow rate are also investigated through the validated two numerical models generated by the computational fluid dynamics (CFD) program.

The derived MCP values of the application of combined system are found two times higher than the application of the solar chimney. The derived coefficient of discharge of 0.4 is used to compute Air Changes rates per Hour (ACH). The ACHs with application of solar chimney solely are found to be in the range of 0.16-1.98. The experimental results show that application of the solar chimney in the test cell could maintain the room temperature at 31.0-36.5 °C, accounting for 1.0-3.5°C lower than the ambient air and 1.0-1.3°C lower than the controlled cell. However, to make the test cell's room temperature much lower than the ambient temperature, the application of water spraying on roof is recommended together with solar chimney. The application of the two systems in the hot and humid climate are discovered to sustain the room temperature of the test cell to be lower than the ambient air by 2.0-6.2°C and lower than the controlled cell by 1.4-3.0°C.

The effects of wetted north roof on the temperature, velocity and air flow rate in the controlled cell are investigated through the validated numerical model which the north ceiling temperature is reduced by 2-4°C from the measured values of 32.8-33.5°C. Good agreements between the predicted and experimental results are obtained from comparison of temperature and volume flow rate at the middle section of the controlled cell. The reduction of north ceiling temperature in the free-convection numerical model shows the decrease of air temperature in the upper region of the room by 0.5-0.7°C from the original value of 33.3°C, and the increase of volume flow rate by 12%.

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CHAPTER I

INTRODUCTION

1.1. Rationale for the Study

Nowadays Thai people have been widely adapted the modern houses, apartments, row houses, which are constructed from brick and concrete, in the cities and suburban area due to the modern aesthetic preferences, high costs of wood, labour and land. These modern houses need electrical energy for cooling machine to overcome the heat collected inside the building structures and to reduce the temperature of air in the building in order to provide comfort to the occupants. The applications of cool microclimate from plants and natural ventilation from wind are also difficult due to the limitation of area around the building and the high density of houses in the town, respectively.

Due to the high solar altitude and high solar intensity during the daytime in the tropical countries, the solar heat gain on roof is so high that it causes discomfort to occupants and high energy consumption for the cooling machine. Therefore, the reduction of the heat transferring from roof to the occupied space can bring thermal comfort to the occupants in low energy houses and reduce electricity consumption for the active/mechanical cooling houses. To reduce the heat transferring from the roof to the occupied space, temperature reduction of the roof tile and temperature reduction of air in the attic have been studied in many previous natural ventilation works. The passive system using roof and modifications of roof are: planted roof or green roof, pond roof or water spraying roof and roof solar chimney. However, the water spraying on roof and roof solar chimney are experimentally and numerically investigated in this study.

The modification of roof for utilizing passive system is an appropriate approach to reducing heat transferring from roof to the occupied space because of its effectiveness, no additional space requirement around the house, inexpensive materials, ease of installation and safe in operation. The planted roof, pond roof, water spraying roof and roof solar chimney have been experimentally and numerically studied for years. By using the existing roof structure and adding typical material like gypsum board, galvanized steel sheet, water, plants, soil etc., the passive cooling systems are inexpensively constructed. The passive cooling and passive ventilation system is safe and economical in operation because of no moving machine parts and no electricity requirements.

1.2. Objectives

(1) To design and apply passive ventilation systems, a solar chimney, together with wetted north roof (cool ceiling), in a test cell so that the combined passive system reduces air temperature and provides the natural ventilation in the room

(2) To experimentally study solar chimney in the south roof and cool ceiling on the north roof of the constructed test cell and the controlled cells

(3) Determine the values of MCP (W/m^2) in the passive systems: solar chimney, cool ceiling and combined cool ceiling with solar chimney.

(4) By using a computational fluid dynamics (CFD) program, the models of the test cell are derived and validated with the selected experimental results.

(5) By using the validated computational models, the detail study of solar chimney and the effect of cool ceiling on the air temperature and volume flow rate are determined

1.3. Scope of the Study

(1) All experiments are conducted in the test and controlled cells with interior dimensions of 2.8 m. (width) × 3.8 m. (length) × 2.4 m. (height)

(2) The test cell and the controlled cell have similar and specific interior configurations.

(3) The numerical study uses a CFD package called FLUENT. It is a two-dimensional model including low turbulence airflow and free convection characteristics but excludes the effect of thermal radiation.

CHAPTER II

LITERATURE REVIEWS

2.1. The Applications of Passive Cooling Strategies

The passive methodologies have been found as low energy cooling and ventilation strategies for buildings because they reduce indoor temperature and increase ventilation for non-air conditioning buildings and support the electric savings in mechanical cooling strategies. There are various kinds of passive strategies but the effectiveness and performance of each strategy principally depend on climates and designs. The temperate climate countries usually utilize night ventilation cooling and natural ventilation during daytime. The hot arid regions utilize nocturnal radiant cooling, soil cooling and evaporative cooling. The hot humid regions utilize radiant cooling, comfort ventilation and sun protection. With plenty of moisture in atmosphere in hot and humid regions, the direct evaporative cooling is not effective. Givoni [1] suggested ventilation for cooling, indirect evaporative cooling with roof pond, soil cooling, and shading for hot and humid climate. The researches on ventilation for cooling can be considered in two categories: the natural ventilation by wind and the solar induced ventilation. The natural ventilation can be achieved through the design of building's shape, windows, and the inlet and outlet in the building envelope. The solar induced ventilation can be achieved from Trombe wall, solar chimney and roof solar collector. In this study, only the passive systems by using indirect evaporative cooling and the solar induced ventilation are considered

2.2. Roof ponds

The utilization of a roof pond can be achieved by a shaded water pond over an uninsulated roof. In order to maximize the cooling of space by the pond, the water should be shaded during the daytime to eliminate the solar heat gain and uncovered during the night time for nocturnal radiative cooling of the water. By shading the pond, the only cooling process is by evaporation. For the floating insulation roof pond, the water is circulated at night over the floating insulation and thus is cooled by a combination of convection, evaporation, and long wave radiation. During the daytime, the water is insulated from the sun and the warmer ambient air by the tightly assembled floating insulation [1]. Givoni [1] showed that the two techniques, shading and floating insulation roof ponds, have similar results. The ponds temperatures follow the average wet-bulb temperature with a temperature elevation of 1°C the average of the ceiling temperature is 1.5-2.0°C above the pond temperature. In addition, the experiment conducted in the lightweight building shows higher temperature swing of 3°C than that of the high mass building which has a temperature swing of 1°C. The concept of floating insulation roof pond is similar to the "skytherm" invented and patented by Hay since 1978 [2] but the skytherm uses water in bags with a movable cover installed on the roof. The opened roof pond with long wave nocturnal radiation by Rincon [3] showed the average value of temperature reduction comparing to the adiabatic roof by 3 °C and the important parameter called Mean Cooling Potential (MCP) per unit area of the passive system indicated the cooling potential of 19-24 W/m^2K.

2.3. Green Roof

The experiments on cooling roof by growing plants and employing evaporation process via transpiration of plants are found in Greece [4] and Japan [5-8]. Plants can reduce the temperature of the surface by directly shade the surfaces and moderating solar heat through the evapotranspiration [4] . Niachou et al. [5] showed that the surface temperature of roof with plant is lower than that of the bare roof by 10°C for the case of non-insulated roof and the air temperature in the room under the planted roof is more stable than the room under the bare roof. Takakura et al. [6] showed a similar result of surface temperature reduction of 15 °C under the Japanese weather condition. Onmura et al. [7] replaced the heavy mass of soil by growing glass on a non-woven fabric with water pipelines and extensively analyzed the evaporation rate of water by using wind tunnel models. By comparing the results from difference models, Onmura found the evaporation rate and the surface temperature complicatedly depend on solar radiation, water supply, growing fabric, relative humidity, ambient temperature, and wind velocity. Zhou et al. [8] compared roof and room air temperatures between lawn on roof and water spraying roof and showed that the temperature of roof and room air during the daytime is lower than the case without lawn on roof by 4°C and 2°C but there is no significant difference between the bare roof and the water spraying roof because of the thick insulation under the roof.

2.4. Solar chimney

The utilization of solar chimney as a natural ventilation of buildings is widely investigated in the last few years. An appropriate design of a solar chimney for cooling includes providing an air gap in a south façade or in the roof of the building that causes stack effect between the solar chimney and the inlet of the building. The stack effect operates between the high temperature and high pressure developed in the solar chimney and the low pressure and low temperature at the inlet. If the openings are provided at the inlet of the building and at the outlet of the solar chimney, air will enter into the building due to the difference of air densities and pressure gradient and move through the building before exit from the outlet of the solar chimney. Many researches on using a solar chimney for natural ventilation can be found as modelling, experiment and field practices. One of the most recognized mathematical modelling is the classical energy balance equation of the solar-air heat collector and the air flow rate equations proposed by Bansal, et. al [9]. By using the proposed mathematical model, Bansal, et. al [10] calculate the performance of a solar assisted wind tower system and found that the solar chimney can increase mass flow rate of air by 50 % for the case of high solar intensity and low wind speed comparing to the case without the assisted solar chimney. By utilizing the similar mathematical models, Aboulnaga [11] presented parametric study of a specific design of residential building in the hot and arid climate. A simplified model and a computer program developed by Afonso and Oliveira [12] taking into account the effect of parameters varying along time showed that the developed model can predict the experimental results with a good accuracy.

In Thailand, the solar chimney attached to the south façade and/or roof is widely studied. However, this paper presents only those attached to the roof, recognized as roof solar collector. By fastening a gypsum board or a plywood plate to the lower part of the rafter, the air ducts with thickness of 14-16 cm are formed under the roof tile. Khedari et al [13] found that gypsum board is better than the plywood for resisting the heat loss. The measured results during September-November showed that the temperature, velocity and flow rate per area of solar chimney inside the air gap ranges from 30-36°C, 0.5-1.3 m/s and 0.08-0.15$m^3/s \cdot m^2$, respectively. Moreover, the inclined angle of the roof of 25-30° and the length of the air duct of less than 1 m were recommended by Khedari et al [13]. A large area of solar chimney of 6 m^2 consisted of roof solar collector and Trombe wall was also experimentally investigated by Khedari et al [14]. The measured results during the days in June-July showed that the temperature, velocity and flow rate per area of solar chimney inside the room ranges from 35-37°C, 0.02-0.08 m/s and 0.01-0.02 $m^3/s \cdot m^2$, respectively. The study of the effect of the air gap on the air flow rate was studied by Khedari et al [15]. The comparison of four types of roof solar collectors showed that the air gap of 14 cm derived a better volume of air flow rate by 15% comparing to that with the air gap of 8 cm. The results of measurement on a day in August showed that the highest temperature of the air in the solar chimney is 42°C at ambient air of 35°C, and specific air flow rate of 0.016 $m^3/s \cdot m^2$. Hirunlabh [16] analyzed four new configurations of roof solar collector by using a validated numerical model. The analysis showed that the highest volume flow rate of air by using the new configuration of roof solar collector is 0.072 m^3/s or 0.0206 m^3/s per 1 m^2 of solar chimney. The slope of roof solar collector of 20-60° to compromise the stack height and the absorbed solar intensity were also suggested.

2.5. Computational fluid dynamics in the study of thermal buoyancy for natural ventilation

From the computational point of view airflows in the room and in the channels such as solar chimney and Trombe wall can be simulated and demonstrated by using the computational fluid dynamics (CFD) programs. The characteristics of airflows can be fully turbulent, weakly turbulent, laminar recirculation, buoyancy driven in difference places in the room. Practically, the airflows are three-dimensional and unsteady but it is so complex that simplified boundary conditions and two-dimensional models are used for the airflow studies. Barrozzi et al. [17] reviewed that full description of the flow and heat transfer model by using three-dimensional formulation which taking into account turbulence phenomena, convection, and radiation is a formidable task. In addition, all of the existing turbulence model particularly when applied with the buoyancy-driven flow are under development and requires assessment. Typically, the studied domains generated by the CFD commercial package or created by other numerical models are compared with the experimental results before further analysis and utilization.

The numerical investigation deals with the velocity and temperature distribution in a room heated by warm air stream introduced at various opening levels were shown by Sinha et al. [18]. Sinha et al. studied the effect of thermal buoyancy force on the temperature and flow streamlines and pointed out many characteristics of the buoyancy driven airflow. Barozzi et al. [17] simulated the bioclimatic prototype buildings by using steady two-dimensional models without thermal radiation. The computational models are compared with the experimental results obtained from 1:12 prototype building with good agreements. Dobovsky et al. [19] studied the natural ventilation produced by heated downward-facing plate by applying three methods in parallel: temperature measurement at the middle section of the enclosure, flow visualization in the enclosure and the 3D-numerical simulation. The effect of positions of the inlet air and the temperature of the heated plate on the airflow rates and temperature distributions were discussed. According to Dobovsky et al [19], the position of inlet air at the bottom provided the highest rate of ventilation but the increasing of temperatures of the heated plate creates stagnation of hot air in the room next to the ceiling which can not be removed. Ziskind et al. [20] used similar experimental method of study to validated 2D-numerical model and applied the validated model to analyze the effects of hot horizontal attic, vertical heated wall and partitioned heated wall on the distribution of air temperature and streamlines in a real-size room. According to Ziskind, the exit of hot air should be located near the ceiling to avoid temperature gradient within the room. Gan [21] used the standard k-ε model for the study of solar chimney in the double facades. The optimum widths of 0.55-6.0 m for a solar chimney of 6 m height were found from the simulation and the integration of outer skin such as PV into the double facades could increase the ventilation in the double façade.

CHAPTER III

METHODOLOGY

3.1. Methodology of the study

Figure 3.1 shows the flow chart of experimental and numerical methodologies used in this study. There are two test buildings or cells called test cell and controlled cell located on the top roof of the SIIT laboratory building. The experimental studies started from the application of solar chimney, water spraying on roof and combination of solar chimney with water spraying on roof in the test cell. The results of air temperature in the room and in the solar chimney of the test cell are compared with the results of air temperature in the room of the closed controlled cell. After that, the experimental studies of solar chimney in the controlled cell are carried out and detailed measurements of temperature of walls, ceiling, roof, temperature and velocity of air are recorded. The experimental results in this latter study and the basic formulae of heat transfer processes are used to compute the values of heat transfer coefficient of the ceiling. The derived values of heat transfer coefficients is used to compute the values of mean cooling potential (MCP) of the passive cooling strategies applied in the preceding studies. The experimental results of solar chimney application in the controlled cell are used to construct and validate the numerical simulation, created by using FLUENT computer program, of the passive systems application in the test cell. According to the experimental results of solar chimney, water spraying roof and the combination of these systems, the air temperature near the ceiling of the test cell can be reduced by 2-4°C comparing to those in the controlled cell. Therefore, the ceiling temperatures of the validated numerical simulation are reduced by 2-4°C to study the effect of ceiling temperature on the temperature and velocity fields.

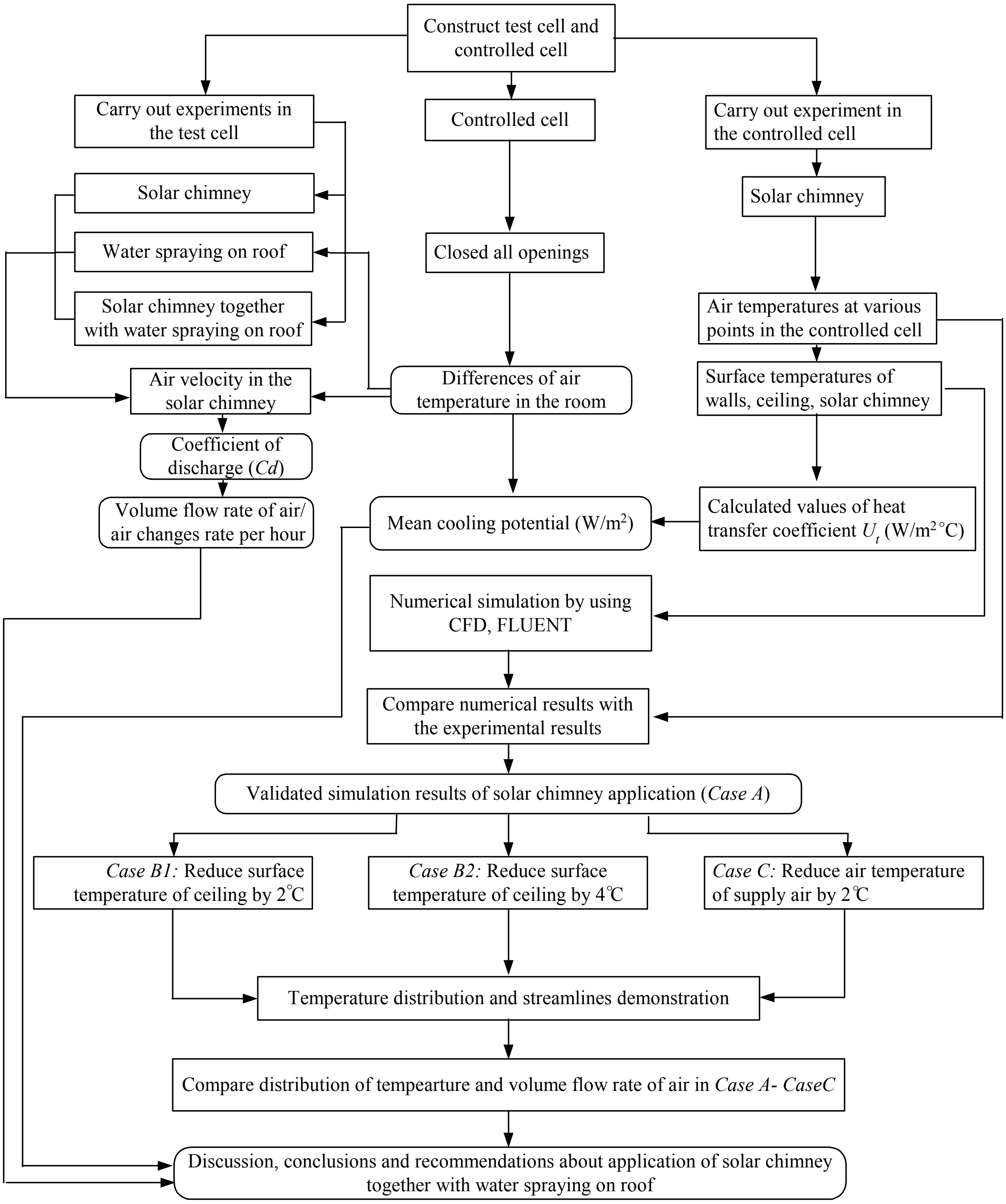


Figure 3.1. The flow chart of the study.

The numerical studies are reduction of ceiling temperature by 2°C (*Case B1*), reduction of ceiling temperature by 4°C (*Case B2*) and reduction of supply air at the window by 2°C (*Case C*). The numerical results of temperature distribution, streamline illustration and volume flow rate at the outflow of solar chimney obtained from the *Case B1*, *Case B2* and

Case C are compared with the numerical results of application of solar chimney, *Case A*. The advantages in terms of technical performance and economic in the applications of solar chimney, water spraying and the combination of these two system are discussed.

3.2. Testing buildings

There are two experimental cells in this study, the test cell and the controlled cell with equal interior dimensions of 3.8m × 2.8m × 2.4m and similar internal configurations. The south roof of controlled cell consists of solar chimney and the north roof is the typical fiber-cement roof tile and gypsum board. The test cell consists of solar chimney on the south roof and water spraying system on the north roof (see Fig. 3.2).

(a) (b)

Figure 3.2. Functions of the testing buildings (a) wall and water spraying roof of the test cell, (b) the roof solar chimney on the south roof of the controlled cell.

The detail drawings showing internal configurations of the controlled cell in Fig. 3.3 are

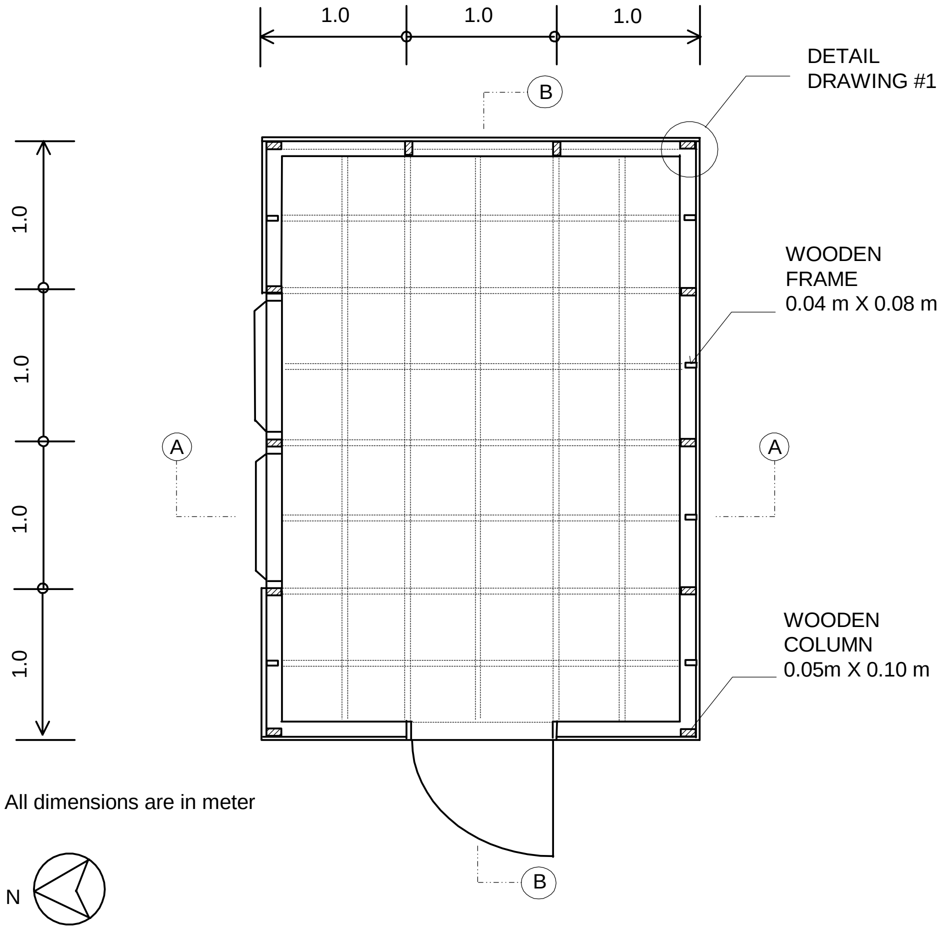
(a) the floor plan of test and controlled cells with two sectional views of the both cells, section A-A and section B-B.

(b) the sectional view A-A, structure of the controlled cell with solar chimney on the south roof

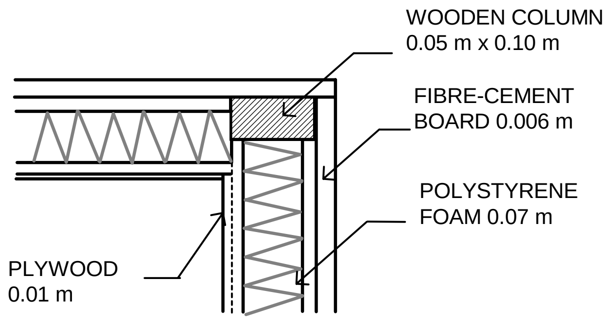
(c) materials for the walls arranging from the exterior to interior are white-painted fiber-cement board of 0.006 m, polystyrene foam of 0.076 m and the plywood board of 0.010 m, respectively and

(d) sectional view B-B of the cells showing structure of south wall and roof.

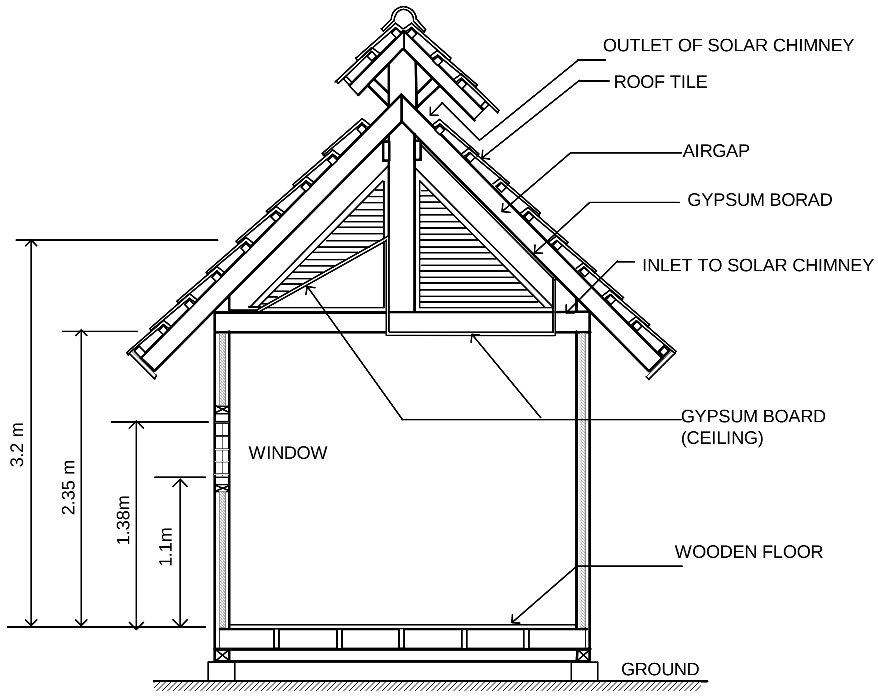
The south roofs of the test and controlled cell constitute of terracotta roof tile at the outer side, 0.12 m air gap and the gypsum board at the inner side (Fig. 3.3b). The air gap of 45° tilt angle under the south roof is the solar chimney where the outdoor air flowing through the window of the room reduces hot air storage in this gap. The total area of the roof tile of the solar chimney is 3.80 × 1.55 =5.89 m^2, composing of 4 channels of solar chimney with the average width × height of 0.94mm × 1.55mm. The north roof of the controlled cell consists of terracotta roof tile and gypsum board as a ceiling. The north roof of the test cell consists of two water spraying systems for the outer and the inner layers of the roof (Fig 3.4). The outer one made of zinc sheet arranged in an adjustable louver style with area of 6.08 m^2 and the inner one made of a galvanized zinc sheet with area of 4.56 m^2. The water pipelines mounted on both layers to ensure water spraying all over the area of zinc sheet and to reduce thermal radiation between the inner and the outer layers. The galvanized zinc sheet in the test cell used as north ceiling is arranged in the angle about 25° to let water draining out. Both cells are placed at the position that each of the four wall facing to east, west, north and south directions. The fixed louvers on the gables allow the ambient air entering the attic reduce temperature of the hot air above ceiling of the rooms.



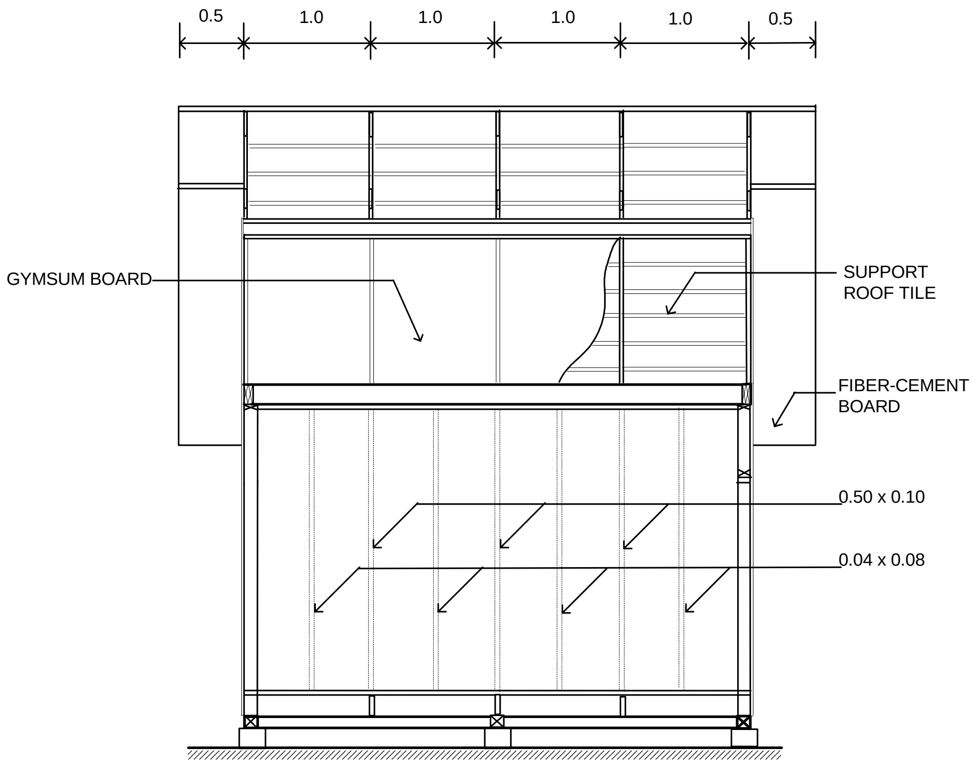
(a) **FLOOR PLAN 1:50**



(b) **DETAIL DRAWING #1**



(c) **SECTION A-A 1:50**



(d) **SECTION B-B 1:50**

Figure 3.3. Detail of test cell and controlled cell (a) floor plan (b) section view A-A (c) detail drawing shows wall materials (d) section view B-B shows south wall and roof.

The water used in water spraying experiments is supplied by a submersible pump placed in the water tank connected to the main water system of the laboratory building (see Fig. 3.5). During experiments, the water tank and the pipelines are covered with wetted plastic to reduce heat transfer from the sun. The pipeline is separated into two lines at the position near the test cell to supply water to the exterior surfaces of the galvanized metal louver and the galvanized flat metal sheet with total area of 5.18 m^2. Two ball valves are used to adjust the water quantity at this separated position. The drained-out water from both galvanized metal surfaces are collected in a plastic hose and re-circulated back to the tank (see Fig. 3.5). The wind protection device is built by combining PVC pipelines, cement molding bases and plastic nets to protect excess prevailing wind entering the window.

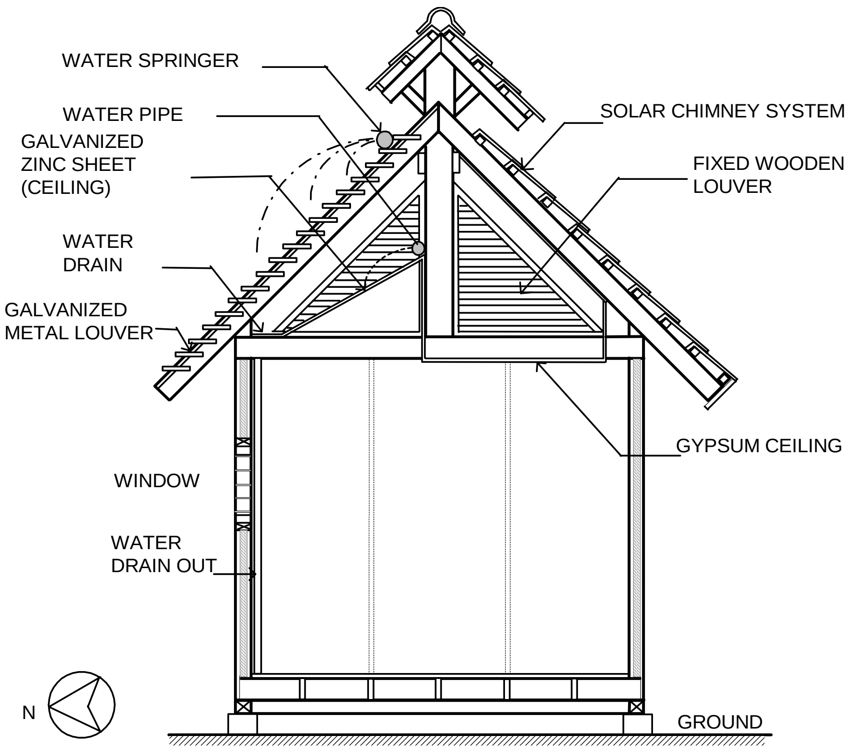


Figure 3.4. Test cell with water spraying on north roof.

3.3. Data collection

The application of solar chimney, water spraying on roof and the combination of solar chimney together with the water spraying roof in the test cell comparing to the closed controlled cell were conducted during June-July, September-October and February-March (2004-2005). The temperature, solar radiation, wind velocity data were recorded every 2 minutes during 24 hours. During the experiments on solar chimney, the window and the inlet to solar chimney are opened. The experiments on water spraying on the test cell's roof are conducted during the hot-air time, 12.00 a.m.-4.00 p.m., on the days during June-July. The results of temperature in the test cell are compared to the controlled cell, which is always closed.

The experiments on solar chimney in the controlled cell were conducted during May-June 2006. All data were recorded every 2 minutes from 9.00 until 18.00. Due to the high fluctuation of the solar radiation, walls/roof temperatures, ambient temperature and indoor air temperature, it is very difficult to obtain a steady condition in the test building. Hence, the 'quasi-steady' conditions are assumed when the solar radiation did not fluctuate more than 100 W/m^2 and the temperature of the roof surface did not change more than 0.5°C.

The experimental results of interior surface temperatures during the quasi steady state will be used for boundary condition of the numerical simulation and the experimental results of air temperature will be used for validation of the numerical model. By taking into account the surface temperature of ceiling, air temperature in the attic and the temperature of room air during the application of solar chimney, the values of steady state heat transfer coefficient (U_t), W/m^{2}K, are calculated. The derived heat transfer coefficient will be used to evaluate mean cooling potential of the experimental results of wetted roof in the previous study.

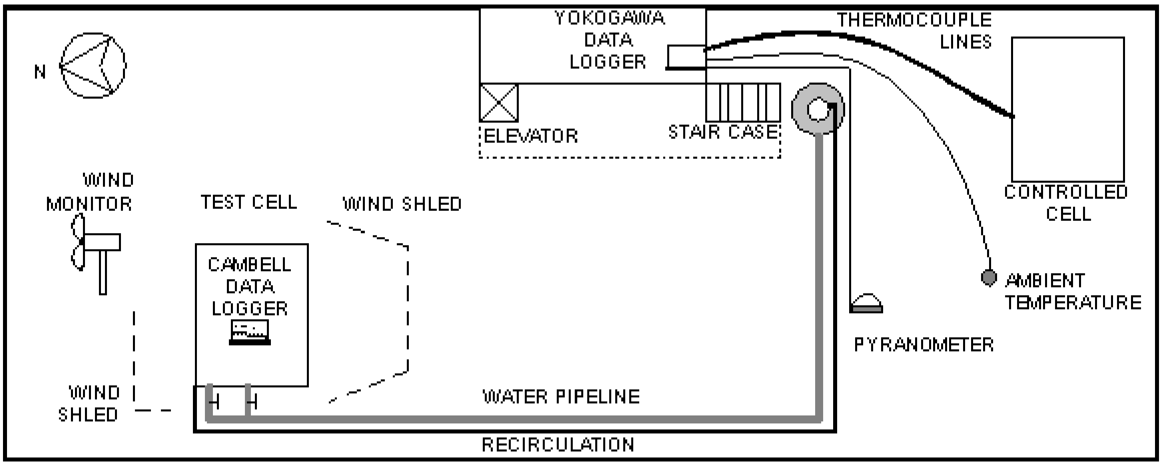
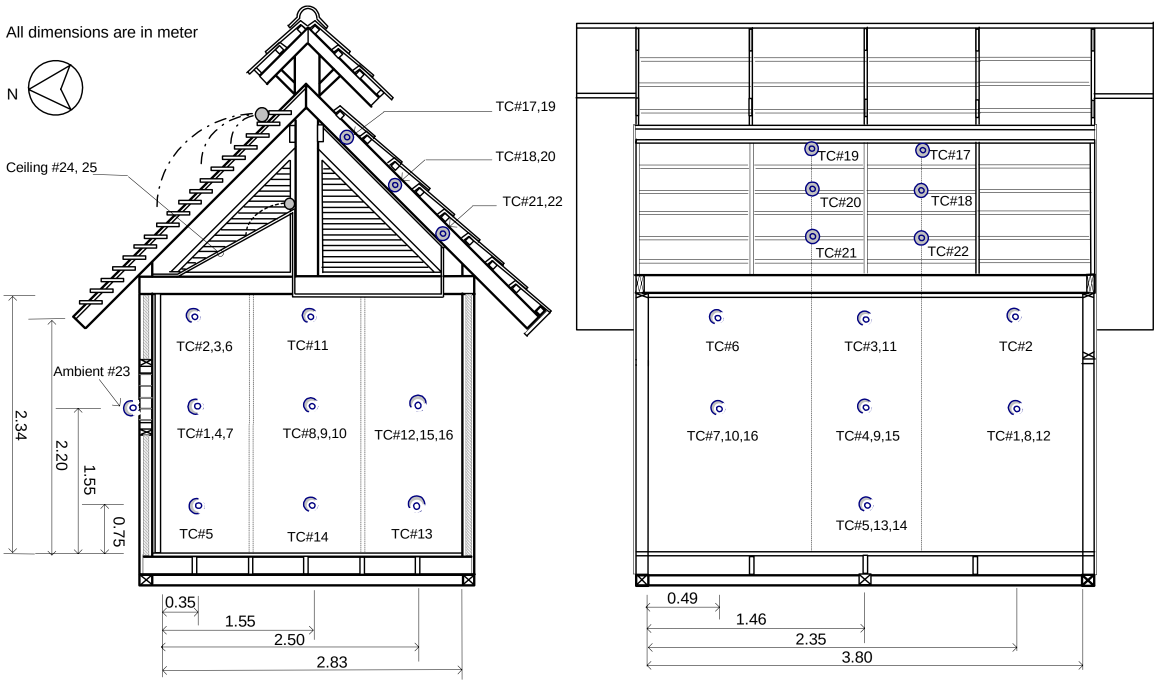


Figure 3.5. The schematic of the experimental field located on the deck of Sirindhorn International Institute of Technology.

3.4. Surfaces and air temperature, air velocity, wind speed and solar radiation

Figure 3.6 shows that total 24 thermocouples of type K connected to the Campbell-CR10X data logger (see Fig. 3.8a) were used for temperature measurement at various points in the test cell during September 2004-July 2005. There are 16 thermocouples measuring air temperatures inside the room. Six thermocouples measure air temperature inside the solar chimney, two thermocouples measure flat zinc inner surface temperature, and one thermocouple measures air temperature at the window. The total 16 thermocouples of type K connected to Yokogawa-DR130 data logger (see Fig. 3.8b) were used to record temperature in the controlled cell at the same point as in the test cell. One thermocouple was used for measuring ambient air temperature and another one was used for measuring water temperature in the tank. All data were recorded every 2 minutes for 24 hours. The relative humidity probes and hot-bulb velocity probes were connected to the

Testo-435 and Testo-454 data logger to record relative humidity and velocity at the inlet of the solar chimney (see Fig. 3.9).



(a) (b)

Figure 3.6. Position of measurement of air temperature in the experiment carried out during September 2004-July 2005.

The experiments carried out during May-June 2006 include the measurement of air and surface temperatures, velocity of air in solar chimney, solar intensity and wind speed. As shown in Fig. 3.7, there are 19 thermocouples of type K used for measuring air temperature in the controlled cell: 12 thermocouples (*A11-A43*) for measuring room air, 4 thermocouples (*Ah1-Ah4*) for measuring air in solar chimney, 2 thermocouples for measuring attic air and 1 thermocouple for measuring ambient air. The interior and exterior surface temperatures of walls and ceiling are measured by 14 thermocouples. The surface temperatures of the solar chimney are measured by 8 thermocouples: 2 for exterior roof tile, 2 for interior roof tile, 2 for interior gypsum surface and other 2 for exterior gypsum surface. These thermocouples are connected to Yokogawa-DR130 and Cambell data loggers. Two hot-bulb velocity probes are connected to the Testo-454 data logger to record velocity at the inlet and outlet of the solar chimney. All data were recorded every 2 minutes from 9.00 until 18.00.

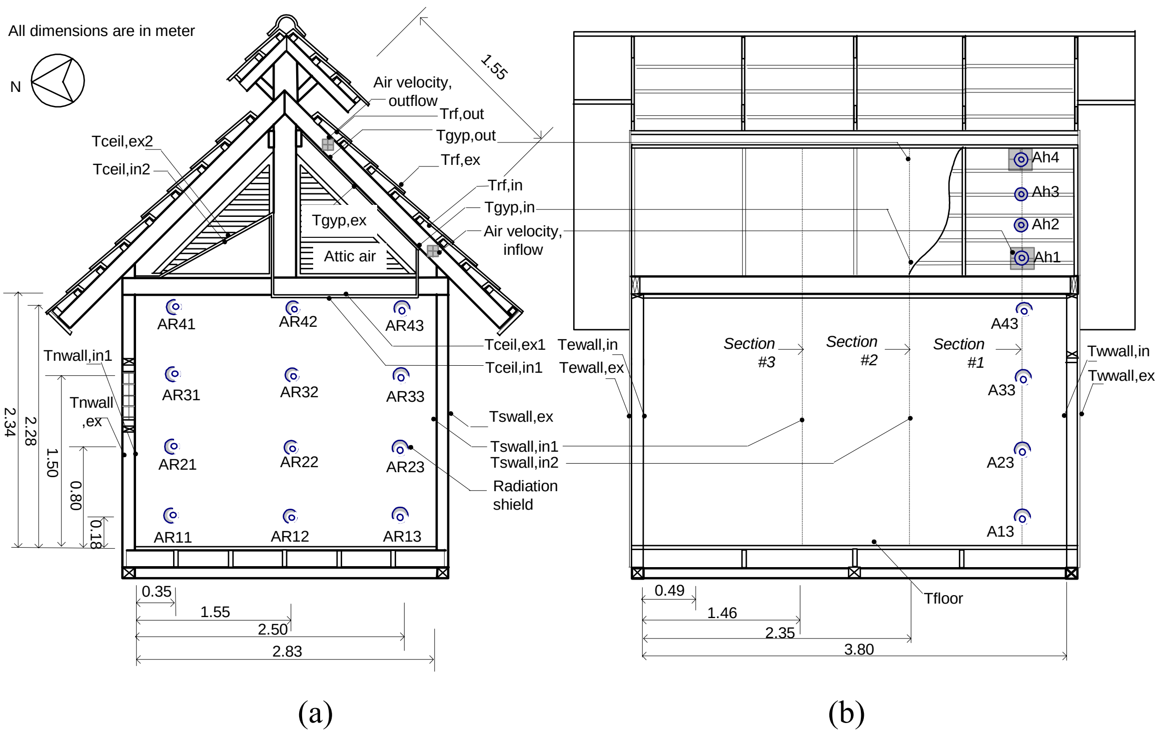
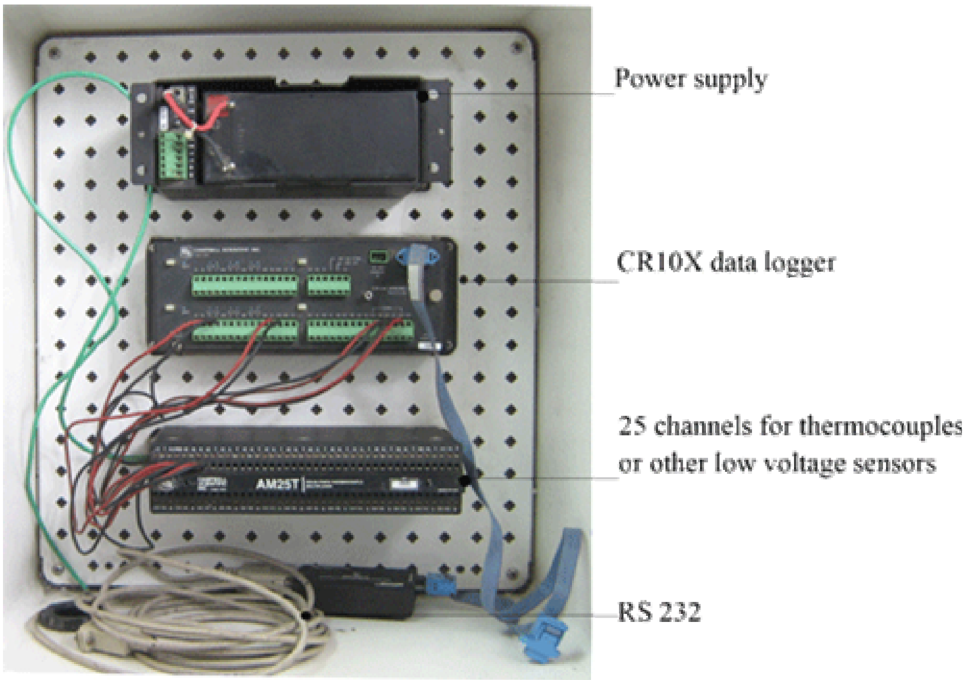
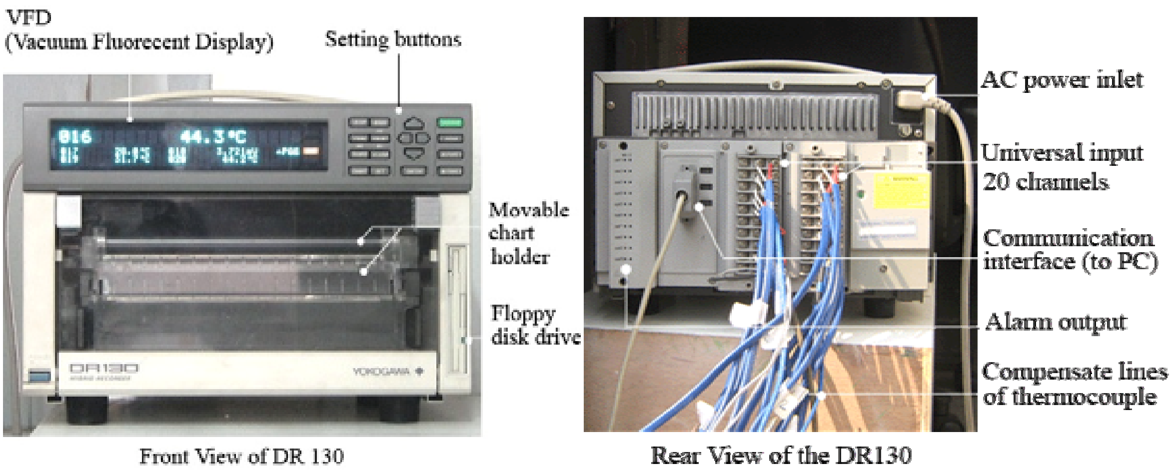


Figure 3.7. Position of measurement of air and surface temperature in the experiment carried out during May-June 2006.

For all experiments, all temperature probes were calibrated with a high accuracy and calibrated thermometer before using and each thermocouple is covered by a small screen made out of aluminum foil to reduce the radiation heat transfer from the window, walls, ceiling and the interior surface of roof tile. A pyranometer Kipp&Zonen-CM11 (Fig. 3.10) is connected to Yokogawa-DR130 and a wind monitoring device (Fig. 3.11) is connected to Campbell data logger and to collect global solar radiation in W/m^2 and wind velocity in m/s respectively.



(a)



(b)

Figure 3.8. (a) Campbell-CR10X data logger (b) Yokogawa-DR130 data logger.

(a) (b)

Figure 3.9. (a) Testo-435 with a multifunction probe (b) Testo-454 data logger with two hot-bulb air probes and one humidity and temperature probe.

Figure 3.10. Pyranometer Kipp&Zonen-CM11.

Figure 3.11. Wind monitoring device.

CHAPTER IV

THE RELATED MATHEMATICAL MODELS

4.1. The Volume Flow Rates of Air

The volume flow rates of air, $\dot{Q}$, obtained from utilizing a solar chimney are estimated from Eq.(1) [9]

$$\dot{Q} = C_D A \sqrt{\frac{2 \cdot g \cdot L \cdot \sin\theta \left(\frac{T_{outflow} - T_{tc}}{T_{tc}} \right)}{(1 + A_r^2)}} \tag{4.1}$$

where C_D is the coefficient of discharge, A is the cross-sectional area of the air gap, g is the gravitational acceleration (m/s^2), L is the length of the air gap (m), θ is the tilt angle of the solar chimney, A_r is the ratio between the cross-sectional area of outflow to inflow, $T_{outflow}$ is the temperature at the outflow of the solar chimney (°C) and T_{tc} is the average room temperature of the test cell (°C).

4.2. The Mean Cooling Potential

The value of mean cooling potential (*MCP*) was defined by Rincon et al. [3] as the simple evaluation of the passive cooling system. The calculation based on 1) the steady state coefficient, U_t (W/m^{2}K) obtained from the experimental results in the reference module, 2) the average daily temperature differences of the indoor air of the reference and experimental module (°C) and 3) the area of cooling surface (m^2), $A_{cool,ceil}$. It can be expressed as:

$$MCP = U_t \cdot (T_{air\ in\ room,\ ref} - T_{air\ in\ room,\ exp}) \tag{4.2}$$

The steady state heat transfer coefficient of the roof can be estimated from [22]

$$U_t = h_{conv} + h_r \tag{4.3}$$

where h_{conv} and h_r are the convection heat transfer coefficient and the radiation heat transfer coefficient (W/m^{2}K), respectively. Due to a steady and low air speed inside the attic, the free convection process is assumed for the exterior surface of the ceiling. Therefore, the average values of h_{conv} are calculated from [22]

$$\bar{h}_{conv} = \frac{Nu_L \cdot k}{L} \tag{4.4}$$

where k is the thermal conductivity of air (W/m·K), L is the characteristic length of the ceiling (m) computed from surface area divided by perimeter. For the upper surface of cool surface, the Nusselt number, Nu_L, is calculated from [22]

$$Nu_L = 0.27 Ra_L^{1/4} \qquad (10^5 \le Ra_L \le 10^{10}) \tag{4.5}$$

The Rayleigh number, Ra_L is computed from

$$Ra_L = \frac{g\beta\left(T_{ceil,ex} - T_{attic}\right) \cdot L^3}{\upsilon \cdot \alpha} \tag{4.6}$$

where

β = Volumetric coefficient of expansion (K^{-1}),

$T_{ceil,ex}$ = Surface temperature at the exterior of the ceiling (°C),

T_{attic} = Air temperature in the attic (°C),

υ = Kinematic viscosity of air (m^2/s),

α = Thermal diffusivity (m^2/s) of air.

By assuming the gypsum surface with the emissivity, ε, of 0.77, the values of h_r are calculated from [22]

$$h_r \equiv \varepsilon\sigma\left(T_{gyp,ex} + T_{ceil,ex}\right)\left(T_{gyp,ex}^2 + T_{ceil,ex}^2\right) \tag{4.7}$$

where

σ = Stefan-Boltzmann constant (σ = 5.67×10^{-8} W/m^{2}K^4),

$T_{gyp,ex}$ = Surface temperature at the exterior of the gypsum panel of the solar chimney (°C).

4.3. Computational Fluid Dynamics

4.3.1. The general transport equation

Computational Fluid Dynamics (CFD) performs the integration of the governing equations for each finite volume, discretization, and iteration for the solution. The governing equations involved in the CFD are the conservation of mass, momentum, energy and turbulence scale k and ε. The general form of all governing equations called the general transport equation is shown in Eq. 4.8. The dependent variable, ϕ with the related source terms, S_ϕ, are shown in Table 4.1.

$$\underbrace{\frac{\partial}{\partial t}(\rho\phi)}_{\text{transient}}+\underbrace{\frac{\partial}{\partial x}(\rho u\phi)+\frac{\partial}{\partial y}(\rho v\phi)+\frac{\partial}{\partial z}(\rho w\phi)}_{\text{convection}}=\underbrace{\frac{\partial}{\partial x}\left(\Gamma_\phi\frac{\partial\phi}{\partial x}\right)+\frac{\partial}{\partial y}\left(\Gamma_\phi\frac{\partial\phi}{\partial y}\right)+\frac{\partial}{\partial z}\left(\Gamma_\phi\frac{\partial\phi}{\partial z}\right)}_{\text{diffusion}}+\underbrace{S_\phi}_{\text{source}} \tag{4.8}$$

For Eq. 4.8 and Table 4.1,

Γ_ϕ = diffusion coefficient for scalar variables, i.e. conductivity *k* in the conduction heat transfer

μ_e = effective viscosity for vector variables, i.e. the velocities, respectively.

ρ = density of air (kg/m^3),

u, *v* and *w* = differential velocities in the Cartesian coordinate *x, y* and *z*,

p = pressure

T= temperature

$$\frac{q}{c_p}=\frac{\text{Energy production rate (W/m}^3)}{\text{specific heat (J/kg}\cdot\text{K)}}$$

c = concentration production rate (1/s)

$$G_s=\mu_t\left\{2\left[\left(\frac{\partial u}{\partial x}\right)^2+\left(\frac{\partial u}{\partial y}\right)^2+\left(\frac{\partial u}{\partial z}\right)^2\right]+\left(\frac{\partial u}{\partial y}+\frac{\partial v}{\partial x}\right)^2+\left(\frac{\partial u}{\partial z}+\frac{\partial w}{\partial x}\right)^2+\left(\frac{\partial v}{\partial z}+\frac{\partial w}{\partial y}\right)^2\right\}$$

= kinetic energy generation by shear

$G_B=\beta g\dfrac{\mu_t}{\sigma_t}\dfrac{\partial T}{\partial y}$ = kinetic energy generation by buoyancy.

This characteristic of the transport equations is very useful when the equations are discretized (reduced to algebraic equations) and solved numerically since only a solution of the general equation is required. Equation (4.8) also represents the continuity equation when $\phi = 0$ and $S_\phi = 0$.

The discretized form of Eq. (4.1) can be solved by one of the well-established numerical procedures such as finite volume method or the finite element method. The finite volume method is more popular than the finite element method in the CFD due to the more economical and computational time. The more detail about finite volume method in CFD can be found in the CFD texts such as Versteeg and Malalasekera [24].

Table 4.1. Source terms in the transport equations.

Equation	ϕ	Γ_ϕ	S_ϕ
Continuity	1	0	0
U momentum	U	μ_e	$-\frac{\partial p}{\partial x}+\frac{\partial}{\partial x}\left(\mu_e \frac{\partial u}{\partial x}\right)+\frac{\partial}{\partial y}\left(\mu_e \frac{\partial v}{\partial x}\right)+\frac{\partial}{\partial z}\left(\mu_e \frac{\partial w}{\partial x}\right)$
V momentum	V	μ_e	$-\frac{\partial p}{\partial y}+\frac{\partial}{\partial x}\left(\mu_e \frac{\partial u}{\partial y}\right)+\frac{\partial}{\partial y}\left(\mu_e \frac{\partial v}{\partial y}\right)+\frac{\partial}{\partial z}\left(\mu_e \frac{\partial w}{\partial y}\right)-g(\rho-\rho_o)$
W momentum	W	μ_e	$-\frac{\partial p}{\partial z}+\frac{\partial}{\partial x}\left(\mu_e \frac{\partial u}{\partial z}\right)+\frac{\partial}{\partial y}\left(\mu_e \frac{\partial v}{\partial z}\right)+\frac{\partial}{\partial z}\left(\mu_e \frac{\partial w}{\partial z}\right)$
Temperature	T	Γ_e	q/c_p
Concentration	c	Γ_e	ρc
Kinetic energy	k	Γ_e	$G_s - \rho\varepsilon + G_B$
Dissipation rate	ε	Γ_ϵ	$C_1 \frac{\varepsilon}{k}(G_s + G_B) - C_2 \rho \frac{\varepsilon^2}{k}$

4.3.2. Application of CFD in the thermal buoyancy airflow

Since the flow is the buoyancy-driven, the term $(\rho-\rho_0)g$ in Table 4.1 is carried out by the Boussinesq's model as follows:

Boussinesq's approximation: $$(\rho-\rho_0)g \cong -\rho_0\beta(T-T_0)g, \tag{4.9}$$

where ρ_0 is a constant density of the flow, T_0 is the operating temperature. This model sets the problem with fluid density as a function of temperature in the vertical-direction momentum and treats density as a constant value in other solved equations. According to FLUENT [23], the Boussinesq's approximation is accurate as long as changes in actual density are small.

CHAPTER V

EXPERIMENTAL RESULTS AND DISCUSSIONS

5.1. Experimental Results of Application of Solar Chimney and Wetted Roof

5.1.1. Temperatures in solar chimney during periods of the year

The volume flow rates of air, $\dot{Q}$, obtained from utilizing a solar chimney are estimated from Eq.(4.1). Figure 5.1 shows the ratios of measured temperature $\left(\frac{T_{outflow} - T_{tc}}{T_{tc}}\right)$ during (1) June-July (2) September-October and (3) February-March in the year 2004-2005 as a function of solar intensity (W/m^2).

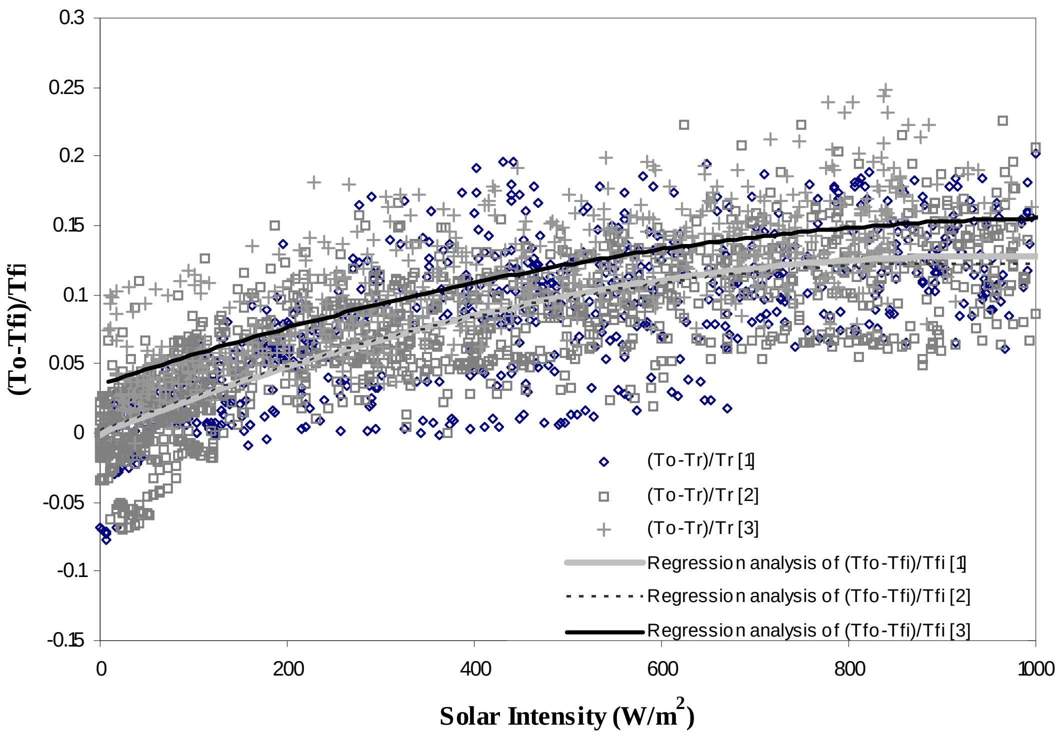


Figure 5.1. The relationships between solar intensity (W/m^2) and $\frac{T_{outflow} - T_{tc}}{T_{tc}}$ of the test cell during (1) June-July (2) September-October and (3) February-March.

It shows that application of solar chimney during different periods of the year provides different values of volume flow rate of the air and the airflow rate during February-March is higher than that during June-July and September-October. The difference of airflow rate during the different periods of the year can be explained from the relationships between the climatic data i.e. solar intensity, solar azimuth, ambient temperature (T_{amb}), and the changes in the temperatures of metal ceiling (T_{metal}), room air (T_{tc}), inflow air into the solar chimney (T_{inflow}) and outflow air from the solar chimney ($T_{outflow}$). In the morning, the ambient temperatures (T_{amb}), temperature at the outflow from the solar chimney ($T_{outflow}$), temperature at the inflow into the solar chimney (T_{inflow}), metal ceiling temperature (T_{metal}), and average temperature of test cell (T_{tc}) increase with the solar radiation until reaching the maximum values at 14.00 hrs (see Tables 5.1-5.4). As indicated in the Tables 5.1-5.4, the room temperature (T_{tc}) depends on both metal ceiling (T_{metal}) and ambient temperatures (T_{amb}), and the average temperature of metal ceiling closely follows the ambient temperature. During the cool period of February-March, the effect of direct radiation from the sun on the north roof and on the metal ceiling is less than those during June-July and September-October. As a result, the metal ceiling temperature (T_{metal}), average temperature of test cell (T_{tc}) and temperature at the inflow (T_{inflow}) into the solar chimney decreases with the ambient temperature (T_{amb}) after 14.00 hrs for the case of partly cloudy day (see Table 5.2.) and almost stable for the case of clear sky day (Table 5.1).

During the hot and humid periods of June-July and September-October, the average temperature of metal ceiling (T_{metal}) is slightly higher than the temperature of the ambient (T_{amb}) after 14.00 hrs because of the direct radiation on the north roof and high ambient temperature. After 12.00 hrs, the average temperature of the room (T_{tc}) increases rapidly with the metal ceiling temperature (T_{metal}) and ambient temperature (T_{amb}) until these three temperatures are almost equal at 18.00 hrs (see Table 5.4). This also occurs during the cloudy day but the ambient temperature, metal temperature and room temperature do not increase rapidly. After 14.00 hrs, the temperature at the inflow into the solar chimney (T_{inflow}) appears close to average room temperature (T_{tc}) and there is smaller difference between $T_{outflow}$ and T_{inflow}, and between $T_{outflow}$ and T_{tc} (see Tables 5.3 and 5.4), comparing to the cool period of February –March where the temperature differences between the $T_{outflow}$ and T_{tc} occur until 18.00 hrs and the temperature differences between the $T_{outflow}$ and T_{inflow} occur until 17.00 hrs (see Tables 5.1 and 5.2). Therefore, airflow rate during February-March is higher than that during June-July and September-October because of the low or almost stable temperature in the room comparing to the high temperature in the solar chimney, especially during the afternoon.

Table 5.1. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of the solar chimney in a clear sky day on March 3rd.

Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)
7:00	26.7	6.1	0.2	26.5	26.3	27.1	26.1	25.9
8:00	27.3	89.5	0.3	26.9	26.8	27.5	26.5	26.5
9:00	28.8	268.4	0.3	28	28	28.8	27.9	28.4
10:00	30.8	487.5	0.5	29.5	29.8	30.5	29.7	30.8
11:00	32.7	592.7	0.7	31.1	31.6	31.9	31.7	33.8
12:00	33.6	761.0	1	32.1	33	33.2	33	35.7
13:00	34.7	801.6	2.6	32.9	33.9	34.4	34.3	37.2
14:00	35.5	806.5	2.3	33.6	34.7	35.2	35.4	38.2
15:00	36.3	692.1	2.3	34.4	35.4	36.1	36	38.7
16:00	36.3	502.8	2.6	34.6	35.6	36.3	36	37.8
17:00	35.7	309.8	2.3	34.1	35.1	35.9	35	35.9
18:00	34.9	107.0	2	33.6	34.1	35.3	34.3	34.4

Table 5.2. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of the solar chimney in a partly cloudy day on March 2nd.

Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)
7:00	26.8	6.9	0	26.7	26.6	27.3	26.8	25.6
8:00	27.6	76.5	0	27.2	27.1	27.9	27.4	26.6
9:00	29.4	227.1	0.2	28.5	28.6	29.2	29	29.3
10:00	30.5	322.5	0.9	29.4	29.7	30.3	30.2	31.1
11:00	32.0	476.9	1.6	30.6	31.2	31.6	31.9	33.9
12:00	33.1	515.6	2.4	31.5	32.1	32.8	33.1	35.1
13:00	33.9	594.2	2.5	32.2	33	33.6	34	36.1
14:00	34.8	692.5	2.5	33	33.9	34.5	34.9	37.5
15:00	35.2	656.0	2.6	33.5	34.3	35.1	35.3	37.6
16:00	35.1	536.8	2.8	33.5	34.4	35.1	35.2	37
17:00	34.3	296.4	2.4	32.9	33.7	34.6	34.4	35.2
18:00	33.3	116.2	2.1	32.2	32.8	33.7	33.4	33.4

Table 5.3. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of the solar chimney in a cloudy day on July, 1st.

Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)
7:00	27.1	40.8	1.3	26.9	27.4	27	26.8	26.8
8:00	28.6	126.3	1.5	27.6	28.3	28.7	27.8	28.2
9:00	30.0	318.9	1.6	29	29.6	30.5	29.5	30.2
10:00	29.5	250.7	1.5	29.4	29.8	30.1	29.7	30.2
11:00	31.0	508.8	1.6	30.3	30.7	31.5	30.8	31.8
12:00	31.5	508.9	1.6	30.9	31.2	32.1	31.5	32.5
13:00	32.0	597.4	1.8	31.5	31.8	32.9	32.1	33.3
14:00	33.0	662.0	1.5	32	32.5	33	32.8	33.8
15:00	34.2	595.0	1.6	32.8	33.4	33.7	33.4	34
16:00	35.4	622.7	1.6	33.9	34.5	35.2	34	34.6
17:00	35.1	376.0	1.7	34.5	35.1	35.8	34.1	34.3
18:00	34.3	149.8	1.4	34.2	34.7	34.6	33.8	33.8

Table 5.4. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of the solar chimney in a partly cloudy day on July 4th.

Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)
7:00	26.5	37.9	1.1	26.6	27.1	26.6	26.5	26.3
8:00	27.5	118.7	1.4	27	27.5	27.8	27.1	27.4
9:00	29.2	416.5	1.4	28.2	28.7	29.7	28.7	29.5
10:00	30.4	406.9	1.9	29.5	29.9	31.1	30	31.2
11:00	32.7	767.8	1.4	30.6	31	32.3	31.4	33
12:00	34.3	935.1	1.6	31.8	32.3	33.8	32.8	34.4
13:00	34.8	793.8	1.7	32.7	33.2	34.5	33.6	35.5
14:00	35.4	725.3	1.7	33.5	34	35.5	34.1	35.7
15:00	36	740.4	2.2	34.6	35.2	36.2	35.1	36.4
16:00	36.3	469.0	2.1	35.2	35.9	36.7	35.5	36.6
17:00	37.5	480.6	2.5	36	37	37.6	36	36.5
18:00	36.1	227.6	2.2	36.1	36.9	36.8	35.9	35.7

The effect of high ambient temperature on the air flow rate is also shown when the temperature difference decreases beyond the solar radiation of 600 W/m^2 (see Fig. 5.1). Based on the preceding results and investigation of Tables 5.1 to 5.4, the high amount of solar radiation (W/m^2) results in the high value of $T_{outflow}$ and the high thermal buoyancy force that induce the air flow rate from outdoor into the room. However, the induced air with high temperature into the room makes the average temperature of the room increasing according to the increase of solar radiation and $T_{outflow}$. The temperature of air at the outflow from the solar chimney ($T_{outflow}$), which is continuously affected by the heat losses due to convection by the outdoor wind, decreases faster than the temperature of air accumulated in the room (T_{tc}) and temperature of air at the inflow (T_{inflow}) into the solar chimney (see Tables 5.1 to 5.3). During the hot day, the temperature of air accumulated in the room (T_{tc}) and temperature of air at the inflow (T_{inflow}) into the solar chimney increase consistently until reaching the temperature of air at the inflow (T_{inflow}) into the solar chimney (see Table 5.4). Therefore, the total effect of both high solar radiation above 600

W/m^2, high ambient temperature and high wind velocity after 14.00 hrs on the application of solar chimney is the decrease of temperature difference ($\frac{T_{outflow} - T_{tc}}{T_{tc}}$), the related thermal buoyancy force and the induced flow rate of air.

5.1.2. Air temperatures in the closed test and controlled cells

Before conducting the experiments on solar chimney and spraying water on roof, the windows and openings in the test and the controlled cells are closed and the temperatures in both rooms are collected. The rain during 0.00-10.00 hrs of June 21 causes temperature of the galvanized metal ceiling drops as well as the temperature of air in the test cell. After the rain stops, all temperatures increases and reach the peak value at 15.00 hrs. The metal ceiling of the test cell is sensitive to the cloud covering the direct sun and the shaded temperature at the test cell's window (T_{wd}). Figure 5.2 shows that the average temperature of air in the test cell (T_{tc}) is lower than that of controlled cell (T_{cc}) about 0-1.0°C because the temperature of the galvanized metal ceiling is lower than temperature of the outdoor. Therefore, the temperature of the test cell's room depends on temperature of the galvanized metal ceiling.

5.1.3. Utilization of solar chimney

Experimental results of utilization of the solar chimney for natural ventilation in the test cell are shown in Fig. 5.3. Table 5.3 and Table 5.4 indicate low solar intensity and high solar intensity of the cloudy day and partly cloudy on July 1 and 4, respectively. The average temperature in the test cell is lower than that in the controlled cell by 1.0-1.3 °C during the hot outdoor air 12.00-16.00 hrs. During 12.00-16.00 hrs, the outdoor air ranges from 32.0-36.5 °C and 33.0-39.0 °C on July 1 and 4, respectively. On the hot day, July 4, the temperatures of the metal ceiling, controlled cell's air (T_{cc}) and test cell's air (T_{tc}), gradually increase from 33.0 to 38.5 °C, 32.5 to 37.5 °C and 32.0 to 36.5 °C, respectively. The utilization of solar chimney only reveals that air temperature in the test cell is slightly different compared with the controlled cell. Therefore, comparing with the closed controlled cell, cooling effect by natural ventilation using solar chimney only is small.

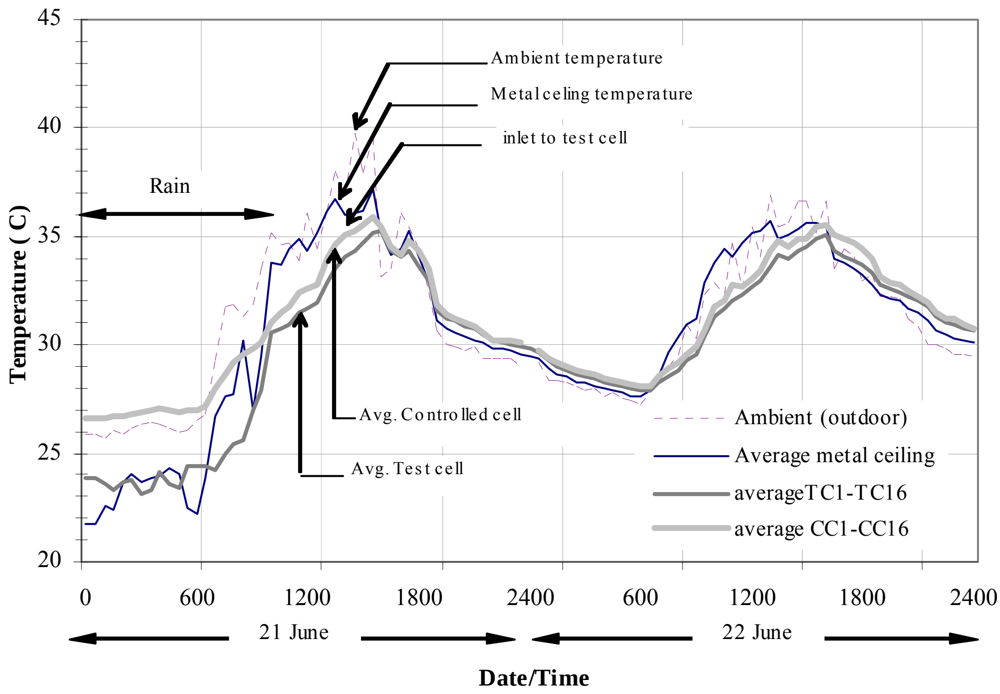


Figure 5.2. The experimental results during closing of the test and the controlled cell.

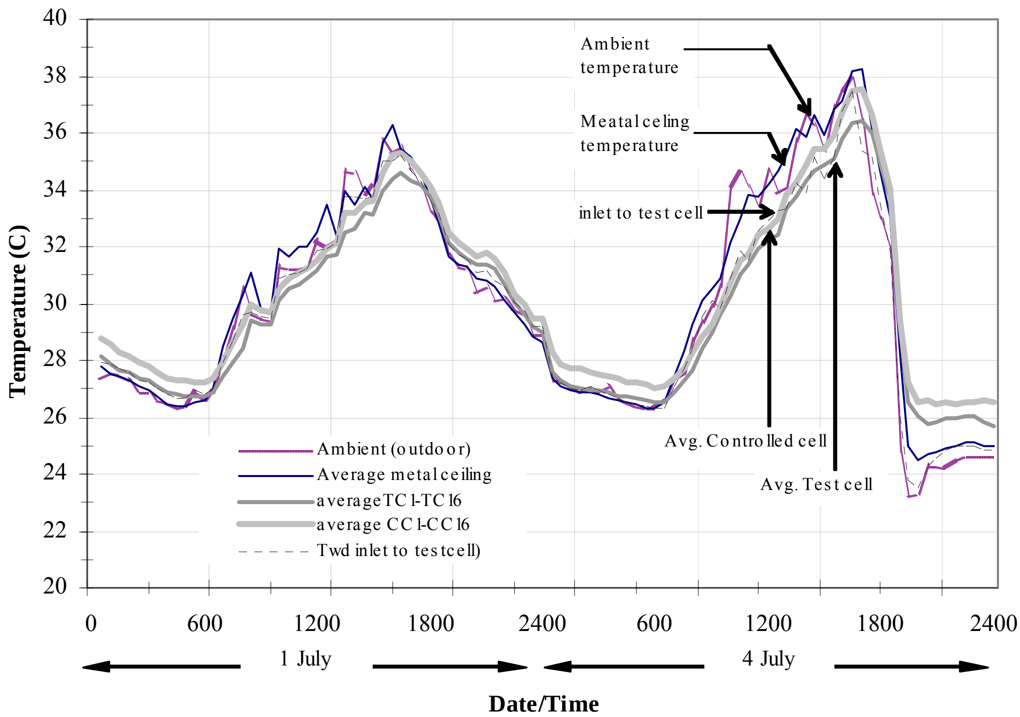
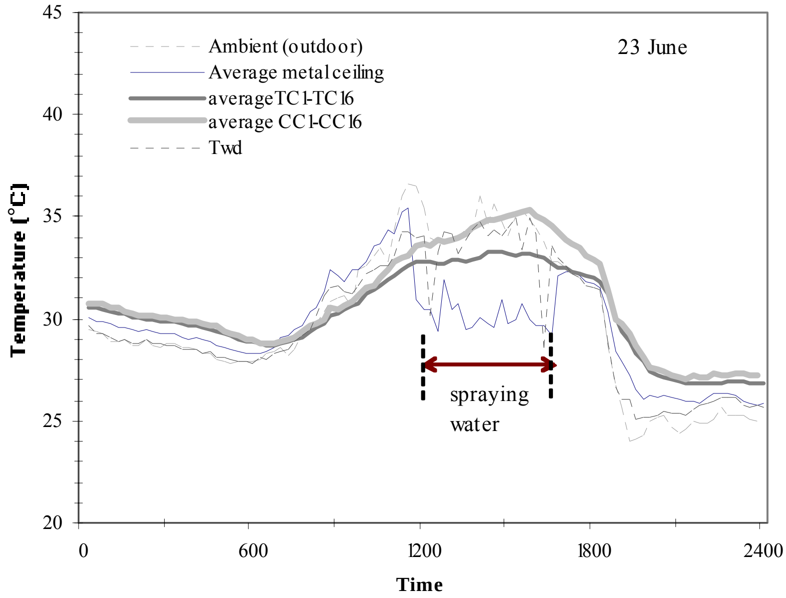


Figure 5.3. Comparison of temperatures in the room of both cells during experiment of utilizing the solar chimney.

5.1.4. Controlling the temperature of room air by the application of water spraying on the roof of the test cell

The hourly average of measured values of solar intensity, wind velocity, ambient temperature, average temperature of indoor air, temperature of metal ceiling, temperature at inflow and at outflow of the solar chimney and relative humidity during the application of water spraying on the north roof of the test cell during June 23-24 and allocations of solar chimney together with water spraying during July 10-11 are presented in Tables 5.5 to 5.8. During June 23-24, the sky condition alternates between clear and cloudy sky in the afternoon. The average solar intensity and ambient temperature during application of water spraying on June 23 and June 24 are 511 W/m^2 and 664.7 W/m^2 and 34.6°C and 35.0°C, respectively. In this experiment, the windows and openings of both cells are closed to keep the room temperature from the high temperature of the ambient and to manifest the effect of cooled metal ceiling on the temperature in the test cell's room.



(a)

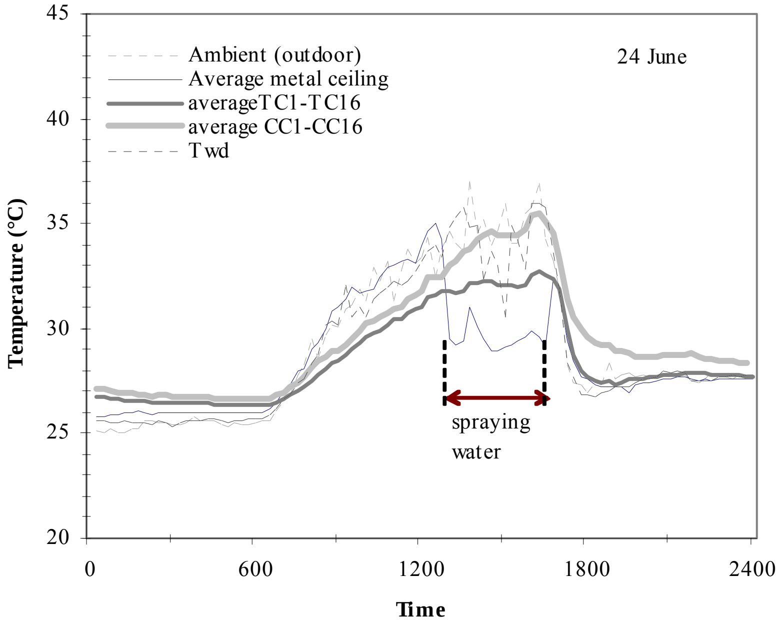


Figure 5.4. The experimental results during spraying water on test cell's north roof: comparison of average temperatures in the rooms on June 23 (a) and June 24 (b).

Experimental results of water spraying on the north roof of the test cell are shown in Fig. 5.4. Comparison of temperatures (see Fig. 5.4a and 5.4b) indicates that average temperatures in the test cell is 32-33°C which is lower than average temperatures in the controlled cell by 1.0-3.2°C, and lower than the ambient air temperature as much as 6°C at 16.00 hrs on June 24. The test cell's air temperature on June 24 is lower than that on the June 23 because the temperature of galvanized metal ceiling on June 24 is slightly lower than on June 23 (see Table 5.5 and 5.6 for comparison).

Table 5.5. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of the wetted roof in a cloudy day on June, 23rd (water spraying during 12.00-16.00 hrs).

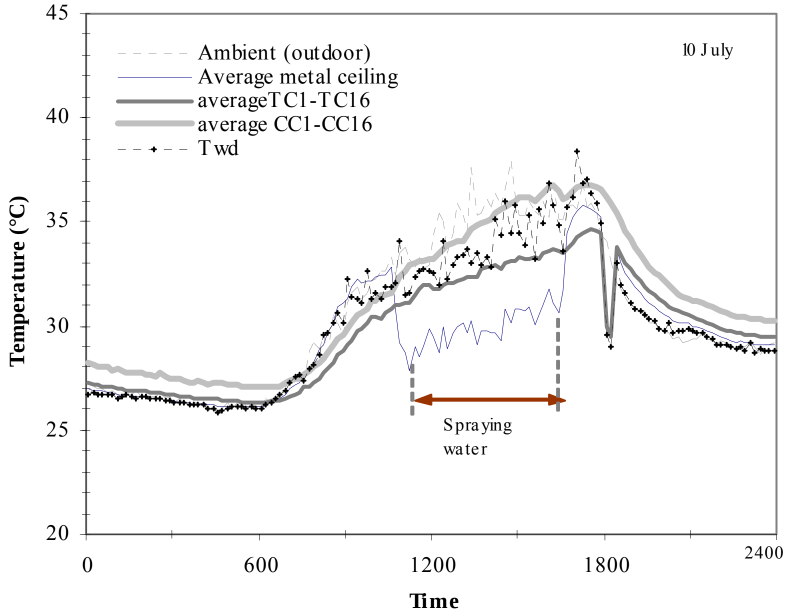
Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$	Relative humidity
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)	%
7:00	28.1	43.5	1.9	28.7	28.9	28.5	27.9	27.8	-
8:00	28.8	121.7	1.4	29	29.1	29.5	28.7	28.9	-
9:00	30.5	310	1.6	29.7	29.9	31.1	30.2	30.8	-
10:00	31.7	344	1.5	30.7	30.9	32.2	31.4	32.4	-
11:00	33	544.8	1.5	31.6	32	33.7	32.6	34	-
12:00	34.9	684.3	1.5	32.5	33	34.4	33.7	35.4	61
13:00	34.3	473.2	1.7	32.7	33.8	29.8	34.2	35.6	62.5
14:00	34.3	471	1.7	32.9	34.1	29.9	34.2	35.5	66.8
15:00	34.8	510.5	1.2	33.2	34.8	29.9	34.8	35.9	65.9
16:00	34.7	416.5	1.7	33.2	35.2	30.1	33.9	34.9	66.4
17:00	33.4	133.6	1.4	32.8	34.6	30.2	33.3	33.7	-
18:00	32.3	61.6	1.5	32.3	33.5	32.2	32.1	32.2	-

Table 5.6. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of the wetted roof in a partly cloudy day on June, 24th (water spraying during 13.00-16.00).

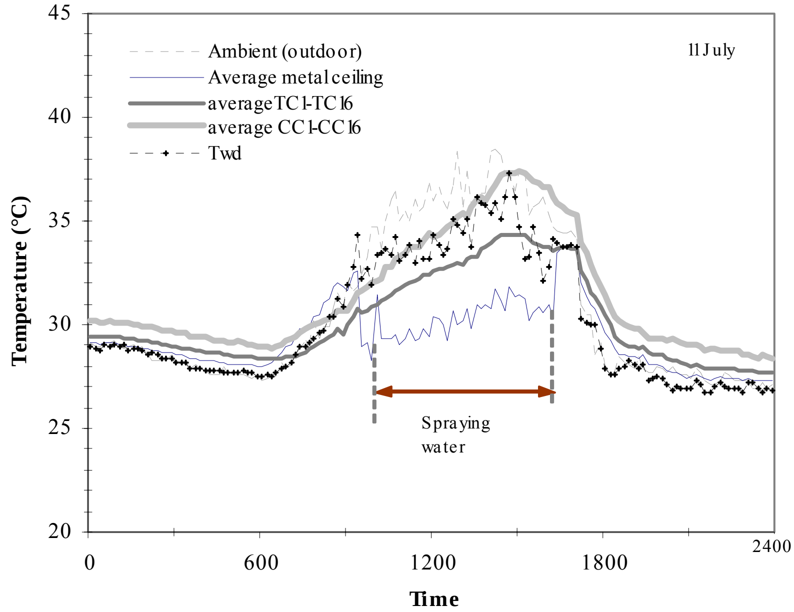
Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$	Relative humidity
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)	%
7:00	25.7	51.5	1.5	26.4	26.7	26.3	26.1	26.0	-
8:00	27.4	158.8	1.1	27.0	27.4	27.8	26.9	27.3	-
9:00	29.5	356.7	1.4	27.9	28.5	29.7	28.4	29.1	-
10:00	31.4	493.8	1.6	29.0	29.6	31.7	30.4	31.6	-
11:00	31.9	616.2	1.5	29.9	30.5	32.2	31.7	32.8	-
12:00	32.7	695.7	1.5	30.6	31.3	33.3	32.7	34.1	-
13:00	34.2	802.4	1.6	31.6	32.4	34.6	33.8	35.5	70.0
14:00	35.2	790.2	1.7	31.9	33.5	29.8	34.4	36.1	70.1
15:00	35.3	603.3	2.0	32.2	34.4	29.3	34.5	35.9	69.8
16:00	35.2	463.0	1.6	32.1	34.6	29.5	34.0	35.1	73.5
17:00	34.7	300.2	1.8	32.6	35.1	30.5	33.7	34.4	-
18:00	28.8	30.6	2.4	29.7	31.4	29.5	29.7	29.4	-

5.1.5. Application of solar chimney and water spraying on the north roof of the test cell

The experimental results of solar chimney application together with water spraying on the north roof show that the difference of room temperature between the test cell and the controlled cell is 1.4-3.0°C and between the test cell and the ambient is 2.0-6.2°C (Fig. 5.5). The experimental results shown in Fig. 5.4 and Fig. 5.5 are conducted during similar values of the solar radiation, solar azimuth and wind velocity. However, the room temperature of the test cell in Fig. 5.5 is higher than that shown in Fig. 5.4 because of the high ambient temperature in July. The low values of relative humidity suppress the water's saturated temperature which directly control the temperature of the galvanized flat metal sheet of the test cell and reduce the increasing of temperature in the test cell. Another consideration is the induced ambient air of high temperature by utilizing the solar chimney that causes high room temperature in the test cell.



(a)



(b)

Figure 5.5. The experimental results during application of solar chimney and spraying water on test cell's north roof: comparison of average temperatures in the rooms on July 10 (a) and July 11 (b).

Table 5.7. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of solar chimney and the wetted roof in a partly cloudy day on July, 10th (water spraying during 12.00-16.00 hrs).

Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$	Relative humidity
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)	%
7:00	26.4	28.1	1.4	26.4	27.1	26.3	26.3	26.1	-
8:00	27.7	119.5	2.4	26.9	27.6	27.5	27.2	27.5	-
9:00	29.6	292.2	1.8	28	28.8	29.8	28.7	30.1	-
10:00	31.6	441.8	1.6	29.7	30.4	32	30.3	32.3	-
11:00	32.4	488.3	1.6	30.7	31.6	31.5	31.5	33.4	-
12:00	33.4	600.5	1.6	31.5	33	31.3	32.7	34.9	51.3
13:00	34.4	644.8	2.1	31.9	33.6	29.6	33.2	35.5	49.2
14:00	35.6	832.7	2	32.4	34.6	29.8	34	36.2	48.8
15:00	36.3	757	1.6	32.9	35.6	30.1	34.5	36.2	48.2
16:00	35.8	432.8	1.3	33.3	36.2	30.6	34.4	35.9	47.5
17:00	35.6	338.5	1.4	33.7	36.4	32	34.5	35.4	-
18:00	36.2	201	1.5	34.5	36.7	35.6	34.6	35	-

Table 5.8. Hourly average of measured data of temperatures, solar intensity and wind velocity during application of solar chimney and the wetted roof in a partly cloudy day on July, 11th (water spraying during 11.00-16.00 hrs).

Time	Ambient	Solar	Wind velocity	T_{tc}	T_{cc}	T_{metal}	T_{inflow}	$T_{outflow}$	Relative humidity
hours	(°C)	(W/m^2)	(m/s)	(°C)	(°C)	(°C)	(°C)	(°C)	%
7:00	27.6	26.4	2.2	28.3	29.0	28.3	28.0	27.6	-
8:00	28.8	86.4	2.0	28.6	29.6	29.6	28.7	28.9	-
9:00	30.2	421.3	1.5	29.4	30.3	31.3	30.0	30.6	-
10:00	32.8	578.9	0.4	30.5	31.4	30.8	31.4	32.5	-
11:00	35.0	753.4	0.3	31.3	32.7	29.4	32.8	34.7	46.6
12:00	35.8	739.4	0.0	32.1	33.8	29.5	34.1	36.4	49.4
13:00	36.8	869.4	0.2	32.7	34.6	30.0	34.5	37.0	46.6
14:00	37.5	891.7	0.4	33.3	35.7	30.4	35.2	37.8	46.0
15:00	37.8	681.9	0.2	34.2	37.0	31.2	35.8	37.9	47.6
16:00	36.5	199.9	0.3	34.1	37.1	31.0	35.2	37.0	52.2
17:00	34.7	56.6	1.7	33.7	36.0	32.4	34.5	35.4	-
18:00	30.7	5.0	2.4	32.2	33.5	31.7	32.2	31.4	-

5.1.6. Coefficient of discharge and volume air flow rate during July and September

The total area of solar chimney is 0.945 m × 1.900 m × 4 (number of channels) = 7.182 m^2 and the volume of test cell's room is 25.54 m^3. A hot-bulb probe connected to a testo-454 data logger is used for collecting the velocity at the opening of the solar chimney with inlet cross-sectional area of 0.008 m × 0.945m = 0.00756 m^2. The values of coefficient of discharge, C_D, are derived from the temperature difference in Eq.(4.1) and the measured values of velocity during 12.00-18.00 in several days in June, July and September. By using Eq.(4.1), and the measured velocity and the corresponding temperature differences, the estimated value of C_D is derived. The actual flow rate on the left of Eq.(4.1) is computed from $\dot{Q} = V \cdot A_{inlet}$ where V (m/s) is the measured velocity and A_{inlet} is the inlet area (m^2). Figure 5.6 shows the relationship between Re_D and the C_D values in this study. The results of low value of the Reynold's number, Re_D, in this experiment corresponds to the low value of C_D ($C_D < 0.4$).

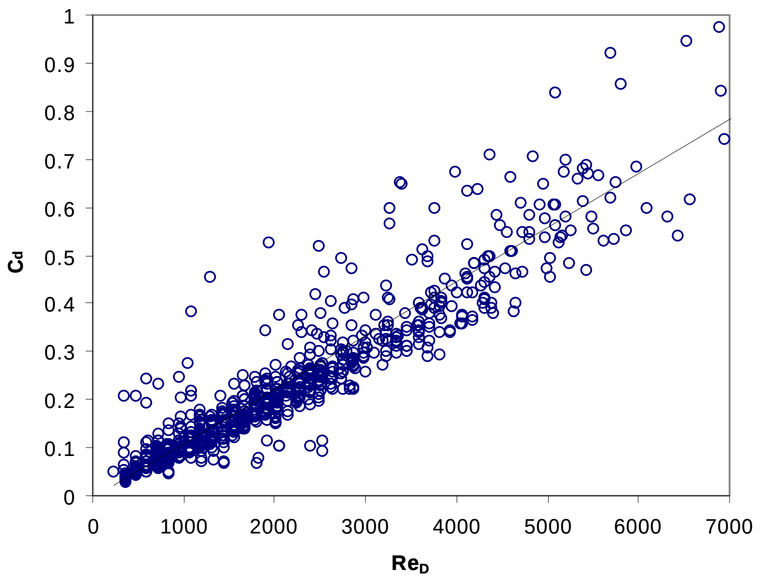


Figure 5.6. The Relationship between Re_D and the C_D values.

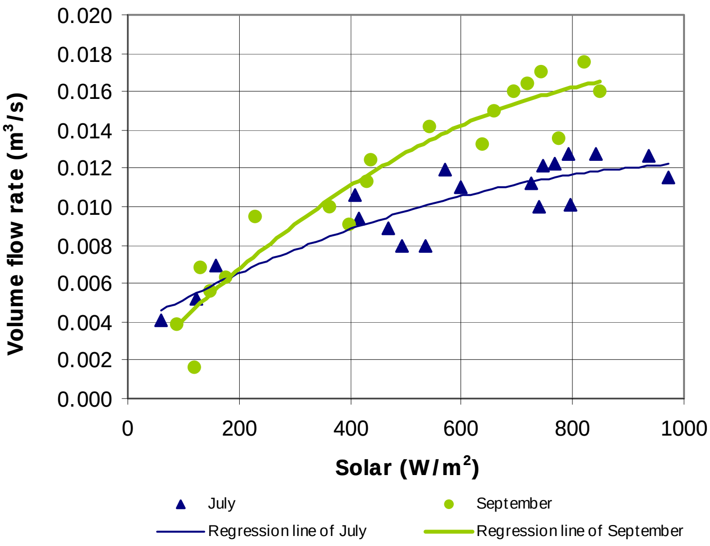


Figure 5.7. The hourly average of flow rate computed from estimated C_D value=0.4 and measured temperature $\frac{T_{outflow} - T_{tc}}{T_{tc}}$ in July and September.

By using the C_D values of 0.4, the volume flow rate of this system can be obtained from Eq.(1) with the result shown in Fig. 5.7. The computed volume flow rates through 4 channels of solar chimney for solar intensity of 400-1000W/m^2 are 0.008-0.012 m^3/s in July and 0.012-0.016 m^3/s in September, which are calculated for 0.0011-0.0017 and 0.0017-0.0022 m^3/s per m^2 of solar chimney, respectively. The air changes rate per hour (ACH) can be derived from volume flow rate (m^3/s) × 3600 (seconds/hour) / 25.54 (m^3). The computed values of ACH are 1.13-2.26 for the periods in June and September. Comparing to the previous studies of Khedari et al. [14 and 15] during June-August which experimentally found the values of velocity of 0.02-0.08 m/s and value of ACH of 4-15, the value of ACH in this study is much lower because it is the effect of solar chimney excluding the effect of wind, i.e. using the wind protection instrument.

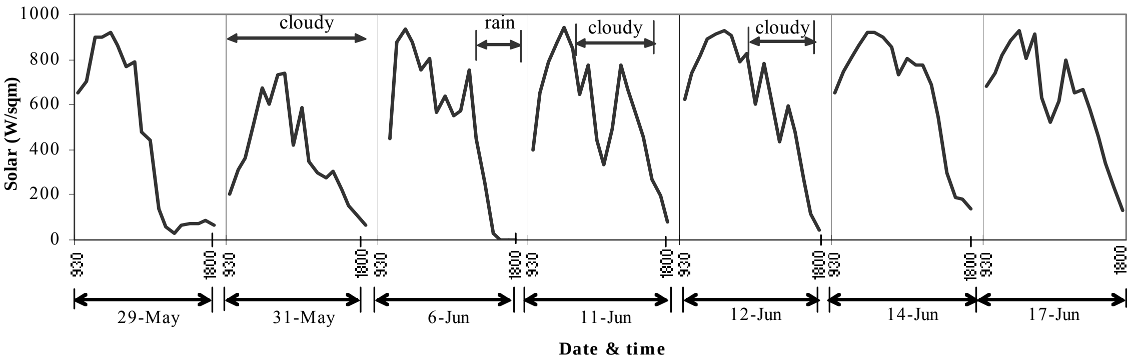
5.2. Experimental results of Utilization of Solar Chimney in the Controlled Cell and the Evaluation of MCP

5.2.1. Surface temperatures of the solar chimney

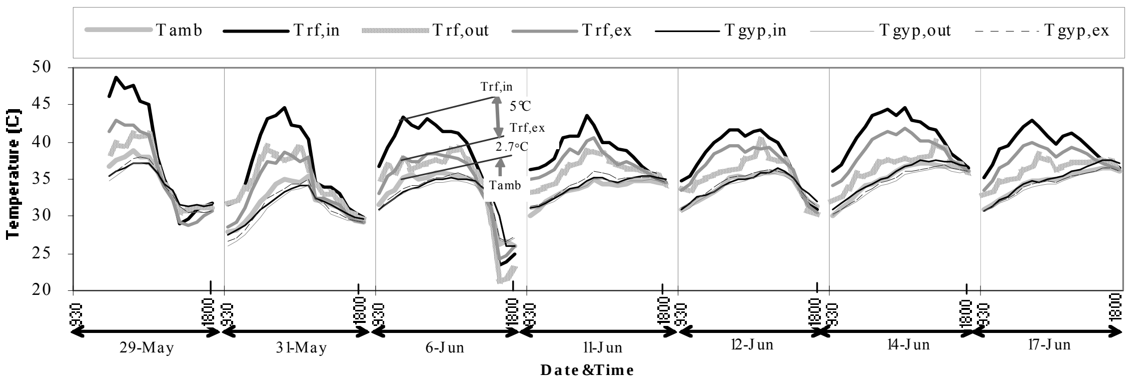
This study considers surface temperatures at the inflow, outflow, and exterior surfaces of the solar chimney for every 30 minutes interval. As shown in Fig. 5.8, the surface temperature of roof tile and gypsum follows the fluctuation of the solar radiation. Due to the temperature difference about 2.7°C between the exterior surface of roof tile ($T_{rf,ex}$) and the ambient (T_{amb}), the heat loss from the exterior surface are found from the temperature differences at the interior surface of roof tile. The experimental results show that the interior surface temperature of roof at the position of inflow ($T_{rf,in}$) to the solar chimney is higher than surface temperature at the outflow ($T_{rf,out}$) from the solar chimney by 2-5°C. The temperature of the exterior surface of gypsum ($T_{gyp,ex}$) is slightly higher than the temperature of interior surface ($T_{gyp,in}$ and $T_{gyp,out}$) and corresponding to the ambient temperature.

5.2.2. Air temperature in the solar chimney

The air temperatures at various positions in the solar chimney (*Ah1-Ah4*) are shown in Fig. 5.9a. Because of the heat loss from the exterior surface of roof tile to the ambient, the air temperature near the exit (*Ah3*) is higher than or equal to the temperature of air at the exit (*Ah4*). The comparison between the ambient air temperature (T_{amb}), air temperature in the solar chimney (*Ah1-Ah4*) and the average temperature of room air (*AR*) show that $Ah3 \geq Ah4 \geq T_{amb} \geq Ah2 \geq Ah1 \geq AR$. Therefore, the buoyancy induced ventilation in this system always exists due to the temperature difference between the room and the outflow of the solar chimney. By assuming the uniform air temperature in every channels, the volume flow rates of the solar chimney, calculated from the temperature difference between the average room air and the outflow air of 1-3.6 °C, chimney inflow area of 0.113 m^2 and the coefficient of discharge of 0.4 [2], are 0.01-0.04 m^3/s or air change rate per hour (ACH) of 0.60-5.38.

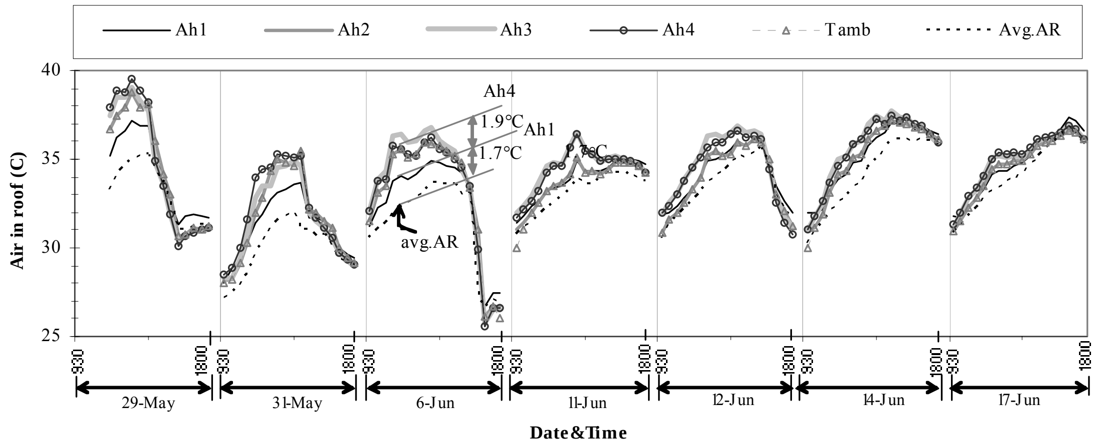


(a)



(b)

Figure 5.8. The average values of (a) global solar radiation W/m^2 and (b) surface temperatures of roof tile and gypsum of the solar chimney °C during the May-June 2006.



(a)

(b)

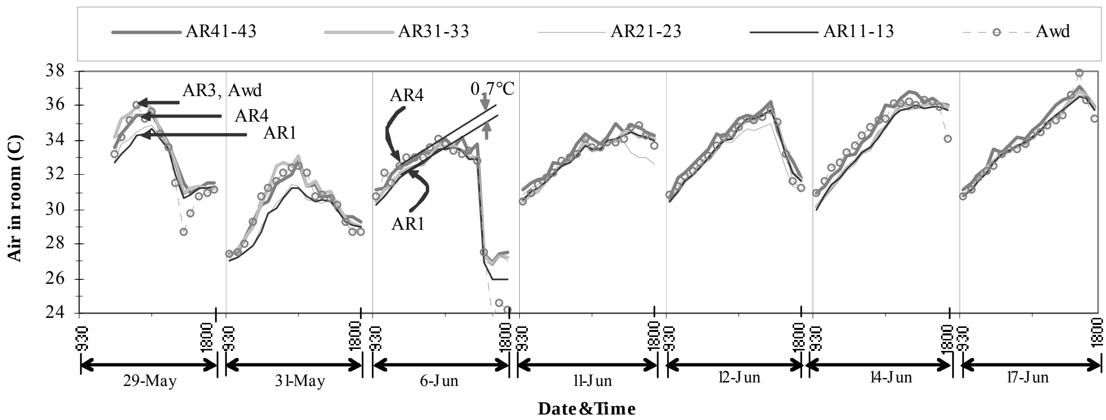


Figure 5.9. The average values of (a) Temperature of air in the solar chimney and (b) temperatures of air in the room°C during the May-June 2006.

5.2.3. Air temperature in the room

The experimental results show a small difference, 0.5-1.0°C, between air temperatures near the floor (*AR11-13*) and air temperature near the ceiling (*AR41-43*). Figure 5.9b displays that the values of air temperature at *AR41-43 AR31-33* and *Awd* are higher than the values at *AR21-23* and *AR11-13,* showing thermal stratification in the room. Therefore, it is necessary to provide an opening near the ceiling like an inflow to solar chimney to allow the hot air to flow out of the room.

5.2.4. The air temperature in the attic and the surface temperature of the ceiling

The comparison of surface temperatures i.e. $T_{gyp,ex}$, $T_{ceil,\ ex}$, $T_{ceil\ in}$, and air temperature i.e. T_{attic} and *AR41-43* show that $T_{gyp,ex} \geq T_{attic} \geq T_{ceil\ in} \geq AR41\text{-}43 \geq T_{ceil,\ ex}$. The surface temperature of gypsum of the solar chimney ($T_{gyp,ex}$) varies with the solar radiation and is higher than T_{attic}, $T_{ceil\ in}$, *AR41-43* and $T_{ceil,\ ex}$ about 3-9°C (see Fig. 5.10). The difference between $T_{gyp,ex}$ and $T_{ceil,\ ex}$ show the effective utilization of attic with fixed wooden louvers at the east and west gables to prevent excessive heat transfer from the exterior gypsum of the solar chimney to the exterior surface of the ceiling of the room. Due to the low value of thermal conductivity of the gypsum board used for ceiling, there is low heat transfer by conduction from the interior surface of the ceiling to the exterior surface of the ceiling. As a result, interior surface of the ceiling and air near the ceiling in the room are always kept warm due to the thermal stratification.

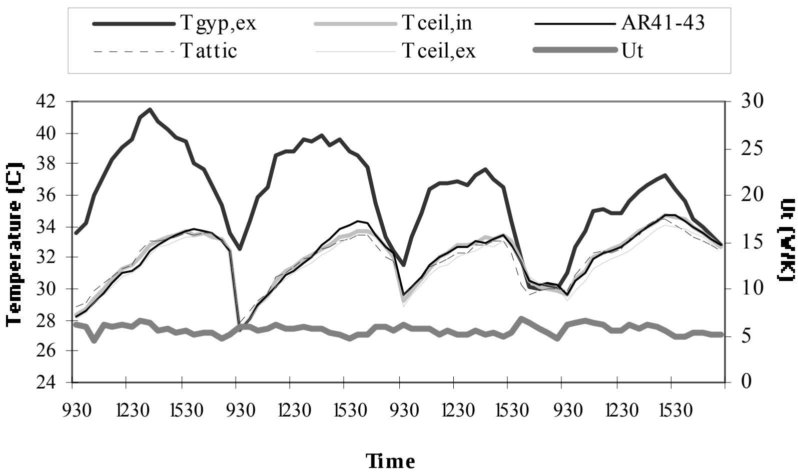


Figure 5.10. Experimental results of surface and air temperature with respect to the ceiling of the controlled cell on the selected day and the corresponding values of heat transfer coefficient.

5.3. Evaluation of mean cooling potential (MCP) of the solar chimney and the cool ceiling

The calculated values of Ra_L are in the range of 5×10^5 – 1.4×10^7 and the values of U_t are in the range of 4.6-6.8 W/ m^2K. The average value of U_t of 5.6 W/m^2K, shown in Fig. 5.10, is used to calculate the MCP of the cool ceiling and solar chimney operated during 12.00-16.00 hours on June, 23-24 and July, 10-11, 2005. The values of MCP are 2-8 W/m^2, 6-14 W/m^2 and 8-17 W/m^2, for the application of solar chimney, cool ceiling and solar chimney with cool ceiling, respectively (see Fig.5.11). It is clear that the combination of cool ceiling to the solar chimney can double the increase of the MCP.

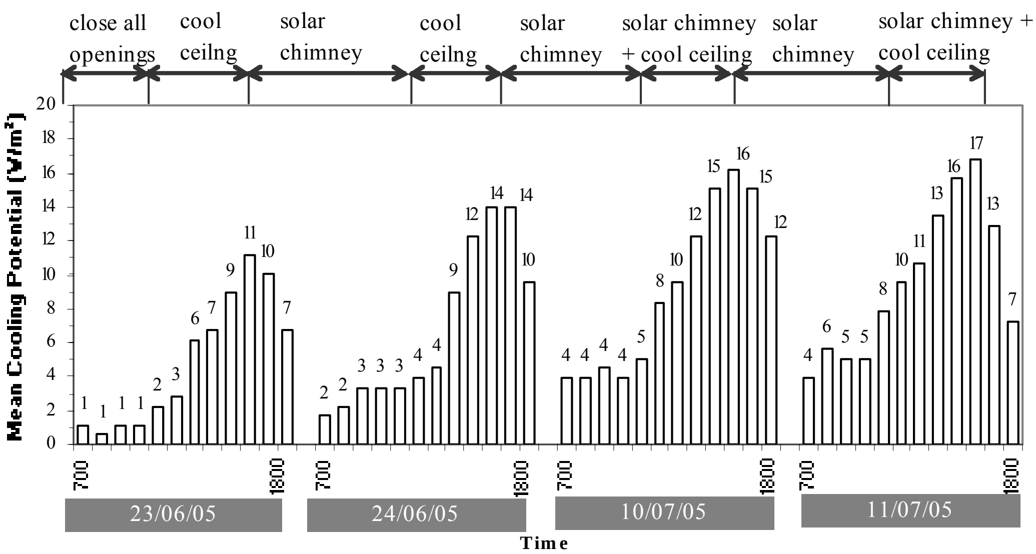


Figure 5.11. Mean cooling potential of application of solar chimney and cool ceiling.

CHAPTER VI

NUMERICAL STUDIES AND DISCUSSIONS

6.1. Numerical Simulation

The commercial CFD package, FLUENT [23], is used for simulation of the two dimensional model of the controlled cell. The room and the solar chimney are simulated simultaneously where it is divided into 4,284 rectangular meshes. In order to show the development of the airflow characteristics near the wall, the smaller grid size is used near the wall regions (see Fig. 6.1).

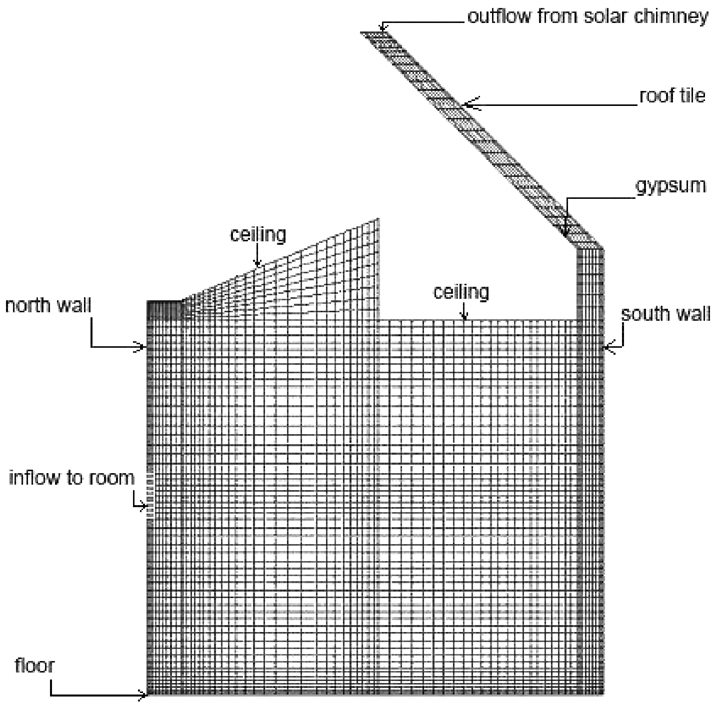


Figure 6.1. Division of the two dimensional model of the controlled cell into small meshes.

The two dimensional laminar and low Reynold's number turbulent flow modeling is an important study of airflow in the room [18]. The simulation of turbulent flow of low Reynold's number under the buoyancy effect in the controlled cell together with its solar chimney are carried out by using the Renormalisation Group (RNG) k-ε model and the Boussinesq's approximation provided by the FLUENT package.

6.2. Comparison of Numerical Results to Experimental Results

The experimental results of temperatures at the interior surfaces during the application of solar chimney in 4 selected periods are used for the boundary conditions of the computational models (see Table 6.1).

Table 6.1. The selected experimental results for boundary condition of CFD.

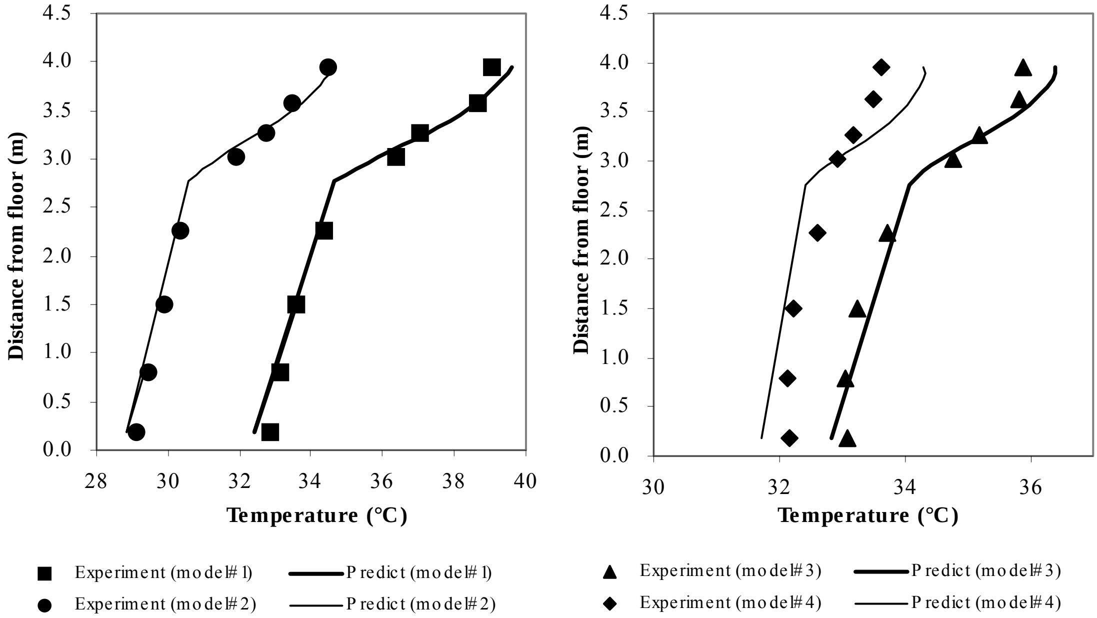
Model	#1	#2	#3	#4
Date	29-May	31-May	14-Jun	17-Jun
Time	11:38-11:52	11:34-11:48	12:10-12:30	10:56-11:10
Wind velocity (m/s)	0.07	0.62	0.77	0.93
Solar radiation (W/m^2)	874.4	578.0	905.5	896.2
$T_{rf,in}$	44.6	41.5	40.8	37.5
$T_{gyp,in}$	35.7	31.3	34.7	32.7
$T_{ceil,in}$	32.8	28.8	33.5	32.2
$T_{swall,in}$	32.7	29.2	33.5	32.0
$T_{nwall,in}$	32.3	28.7	32.5	31.6
T_{floor}	31.8	28.4	32.4	31.5
$T_{outflow}$	39.0	34.5	35.9	33.6
T_{room}	33.3	29.7	33.3	32.3
T_{inflow}	34.4	31.2	34.1	32.4
$V_{wd\ (m/s)}$	0.21	0.23	0.22	0.36
$V_{inflow\ (m/s)}$	0.20	0.25	0.50	0.51
$V_{outflow\ (m/s)}$	0.17	0.15	0.30	0.33

The highest and the lowest values of temperatures in the room are the ceiling and the floor, respectively. As shown in Table 6.1, the effects of excessive wind speed on the application of solar chimney are the high air velocity and the small temperature difference between $T_{outflow}$, T_{inflow} and T_{room} in case#3 and case#4.

6.2.1. Temperatures at various heights in the controlled cell

The comparison between the experimental and numerical results of temperature distribution along the height of the controlled cell is shown in Fig. 6.2. The computational model #1 and model #2 show the results of temperature distribution at the mid-section of the room and computational model #3 and model #4 show results at the near-wall section, see Fig. 4.6b for sections #3 and #1, respectively. All of the results obtained from the computation and the experiment show the thermal stratification in the controlled cell. In the model #1 and model #2, computational results found at the middle height of the room (the height of 0.8-1.5m from the floor), where the main stream flows from the window on the north wall to the solar chimney near the south wall, well agree with experimental results. However, the temperatures of air near the floor and near the ceiling tend to be under-predicted by the computational model. In the experimental field including three dimensions, the high temperature of air near the floor and near the ceiling can be the result of recirculation of the primary air stream of high temperature which is not expelled from the room through the solar chimney.

The computational model # 3 and model #4 show the effect of position of measurement and wind speed on the temperature distribution in the room. The intervention of wind in the air gap increases air velocity in the solar chimney so that values of air temperatures obtained from experiment are lower than values that obtained from the computation. Fig. 6.2b shows the temperature deviation of 0.2-0.7°C of experimental results from the computational results at the height of 0.8-1.5 m (position of window) in model #4 and at the height of 3.2-3.9 m (position of solar chimney) in model #3 and model #4. In the experiment room, the primary air stream from the window does not flow to this region of the room and because of the low temperature at surfaces of interior walls in the controlled cell comparing to the air entering through the window, the measured values of air temperatures in region of section #1 are lower than the predicted ones.



(a) (b)

Figure 6.2. Comparison between experimental and simulation results of air temperature in the test room and in the solar chimney (a) the experimental results at mid plane (b) the experimental results at plane near wall.

The point-by-point comparisons between the experimental and simulation results of air temperature in Fig. 6.3 show that the simulated air temperature is slightly different from those obtained from experimental ones. The simulated results of temperature in the steady state condition show a more uniform temperature (32.4-33.7°C) within the room and higher temperature range (35.9-39.3°C) in the solar chimney than those of the experimental results, i.e. 32.7-34.5°C and 36.4-39.0°C, respectively. This can imply that the simulation result shows higher thermal buoyancy force in the solar chimney and create the lower temperature gradient within the room than the experimental result. In the experimental field, the controlled cell exposed to the variations of environment and the three dimensional airflow in actual field is difficult to reach the steady state. However, the model #1 will be used for further analysis in this study.

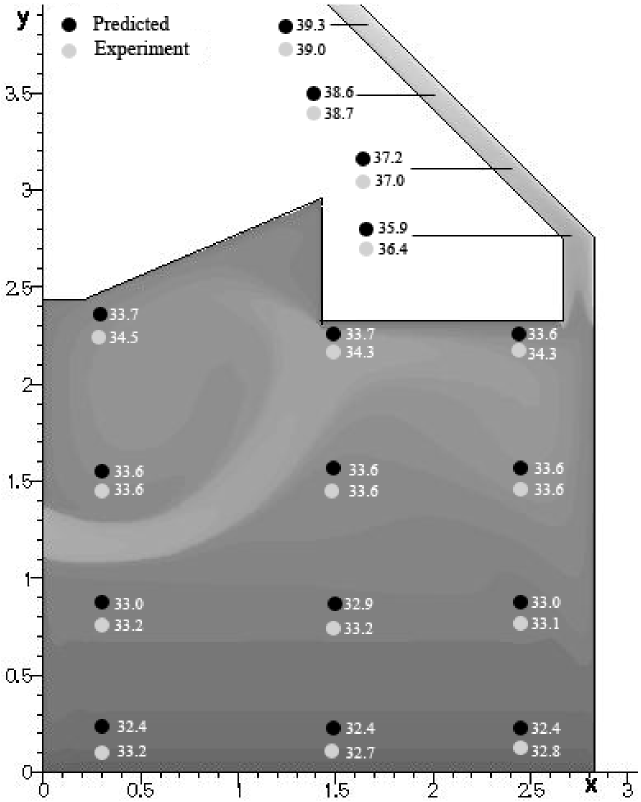


Figure 6.3. Comparison between experimental and simulation results of air temperatures in the steady state of model #1.

6.2.2. Volume flow rate per unit width of solar chimney

The average values of measured velocity and temperature differences as well as the calculated coefficient of discharge (C_d) are used for calculation of the total volume flow rate of the solar chimney. The derived values of total volume flow rate are divided by the total width of the solar chimney, before comparing with the volume flow rate computed from the CFD model. The values of temperature difference, the derived values of C_d and the comparisons between the experimental and numerical results of volume flow rate per unit width of the controlled cell are shown in Table 6.2. A certain agreement between the simulation results and experimental results are found in computational models #1 and #2 with differences in velocities of 5.6 and 19.1%, respectively. The high fluctuation of measured velocities during the experiment causes the difference between the experimental and the numerical results. For computational model #3 and model#4, the experimental results of air velocity is higher than that of the computed one with the relative errors about 26.0-44.1%.

Table 6.2. Comparison of experimental and computational results in the application of solar chimney in the controlled cell.

	unit	Model #1	Model #2	Model #3	Model #4
Calculated coefficient of discharge, $C_{d,avg.}$	-	0.14	0.21	0.51	0.80
$(T_{outflow} - T_{inflow})/T_{inflow}$	-	0.172	0.081	0.030	0.024
$\dot{Q}_{exp}$	(m^3/s·m)	0.0070	0.0072	0.011	0.012
$\dot{Q}_{predict}$	(m^3/s·m)	0.0074	0.0086	0.0082	0.0065
$(\dot{Q}_{predict} - \dot{Q}_{exp})/\dot{Q}_{exp}$	(%)	5.6	19.1	-26.0	-44.1

6.3. Numerical study of the solar chimney and the effect of cool ceiling on temperature and velocity distribution.

The computational model # 1 is used for the study of the effect of reduction of temperature on the north ceiling by 2-4 °C. The utilization of solar chimney in the computational model # 1 is the base case and here after is called *Case A*. In order to investigate the advantage of utilizing cool ceiling together with the solar chimney, the computational models of solar chimney together with cool ceiling, called *Case B* and the model of cool supply air from the window, called *Case C*, are compared to *Case A*. In this study, the transient simulations with the time step of 0.1 sec are performed. The transient processes of computational model #1 at 1 minute, 6 minutes, 12 minutes and 20 minutes are shown in Figs. 6.4-6.8. The computational results of temperature and streamlines of the *Cases A, B* and *C* are shown in Fig. 6.4, 6.5, 6.6 and 6.7, respectively. The values of non-dimensional air temperature shown in Fig. 6.4a and the non-dimensional values of the streamlines shown in Fig. 6.4b are used for the illustration of mixing air at various temperatures and for the comparison of each case. The non-dimensional air temperature T^* is defined as

$$T^* = (T - T_{\min})/(T_{\max} - T_{\min}) \tag{6.1}$$

where T, T_{min}, T_{max} are values of temperature at any position, minimum temperature and maximum temperature of air derived from computational results. The non-dimensional values of the streamline, ψ^*, are computed from

$$\psi^* = \psi / \psi_{\min,wd} \tag{6.2}$$

where ψ and $\psi_{min, wd}$ are the computational results of stream function at any position in the computational model and the minimum value of stream function at the window, respectively. A streamline is a line that tangents to the velocity vector of the flowing air and illustrates the flowing path of the air.

6.3.1. Case A: application of solar chimney

At the beginning, the warm ambient air entering the window on the left wall flows downward to the cold floor before colliding with the right wall. In Fig. 6.4 (a1), a certain part of air in this low right region rolls counterclockwise and starts mixing with the air initially situated inside the room and another part is expelled from the room through the opening at the ceiling. In Fig. 6.4 a (2), the air mixing proceeds in the upper region of the room and the stratification of air at various temperatures are generated in the lower region of the room, situated the cool air near the floor. The corresponding streamlines in Fig. 6.4(b1) and Fig. 6.4(b2) show that the primary streamlines entering from the window partly flows upward to the opening at the ceiling and the rest re-circulates in the regions above and below the primary stream. In the upper region of the primary stream, the air entrained by the warm primary streamlines gets heated and rises up to contact with the cool ceiling, where the air becomes cooler and heavier due to the increase of density and falls down along the left cool wall to complete the re-circulation pattern. In the low region where the cold floor is below the hot primary stream, two weak recirculation patterns are found (see Fig. 6.4b1 and Fig. 6.4b2).

At 12 minutes in Fig. 6.5(b1), two re-circulation zones in the upper left region are about to be completed and a re-circulation of air is developed in the upper right region because there are some air streams expelled through the window. Completed air mixing by re-circulation, the large region of uniform air temperature appears in the upper part of the room from 12 until 20 minutes. In the steady state condition, the re-circulation in the left upper region is pushed up and confined in the region shown in Fig 6.5(b2) because of the strong and well-defined re-circulation of air below it. In the solar chimney, the stable stratification of air temperatures are found along the air gap and the reverse flow appears near the exit of the solar chimney. The reverse flow indicates that the velocity boundary layer near the roof tile is less than the size of the air gap and the thermal buoyancy is developed due to the temperature difference between the air and the gypsum board as mentioned by Gan [10].

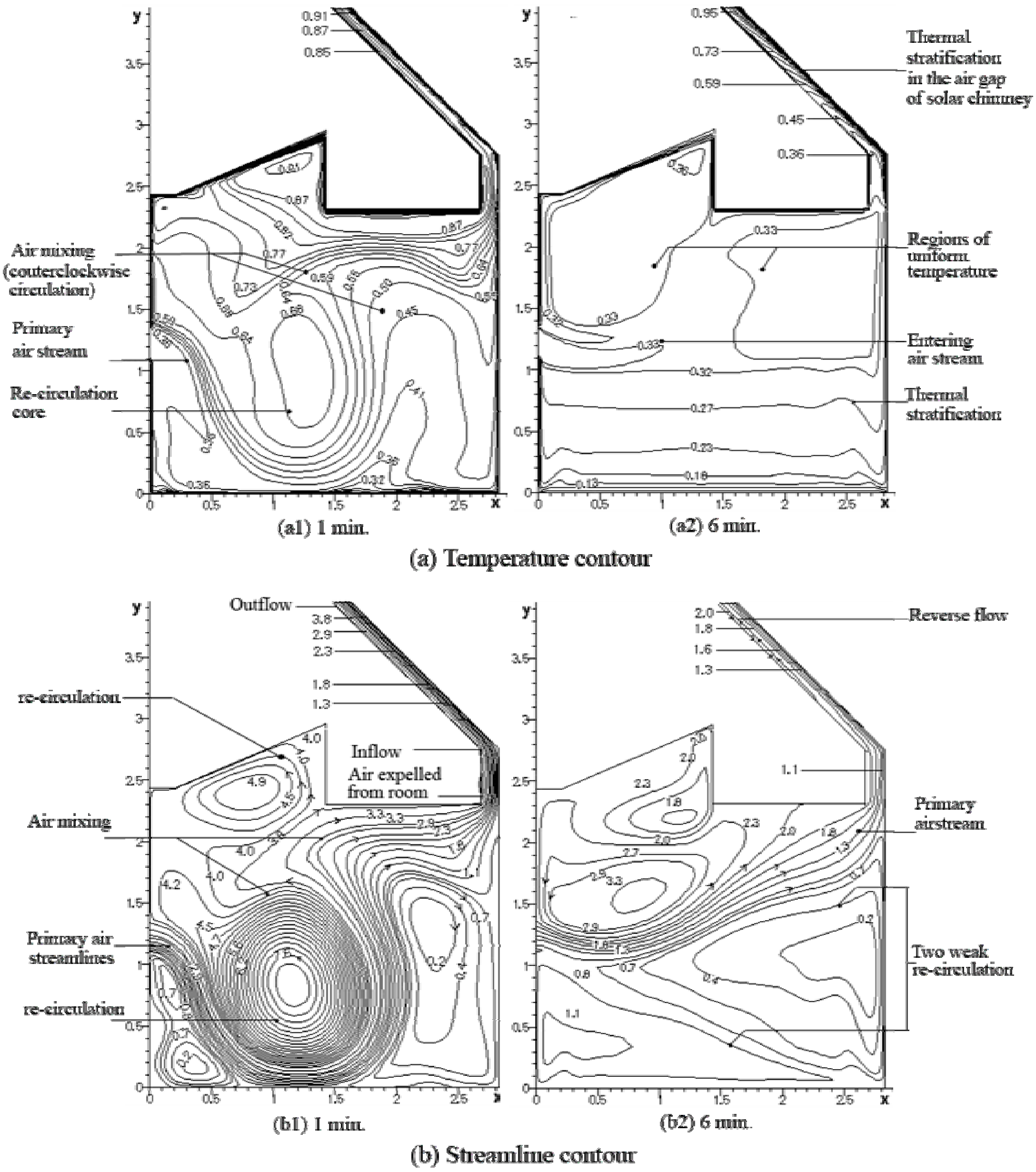


Figure 6.4. The computational results of (a) transient temperature distribution and (b) the corresponding streamline, during the application of solar chimney in *Case A* (simulation time of 1 and 6 minutes).

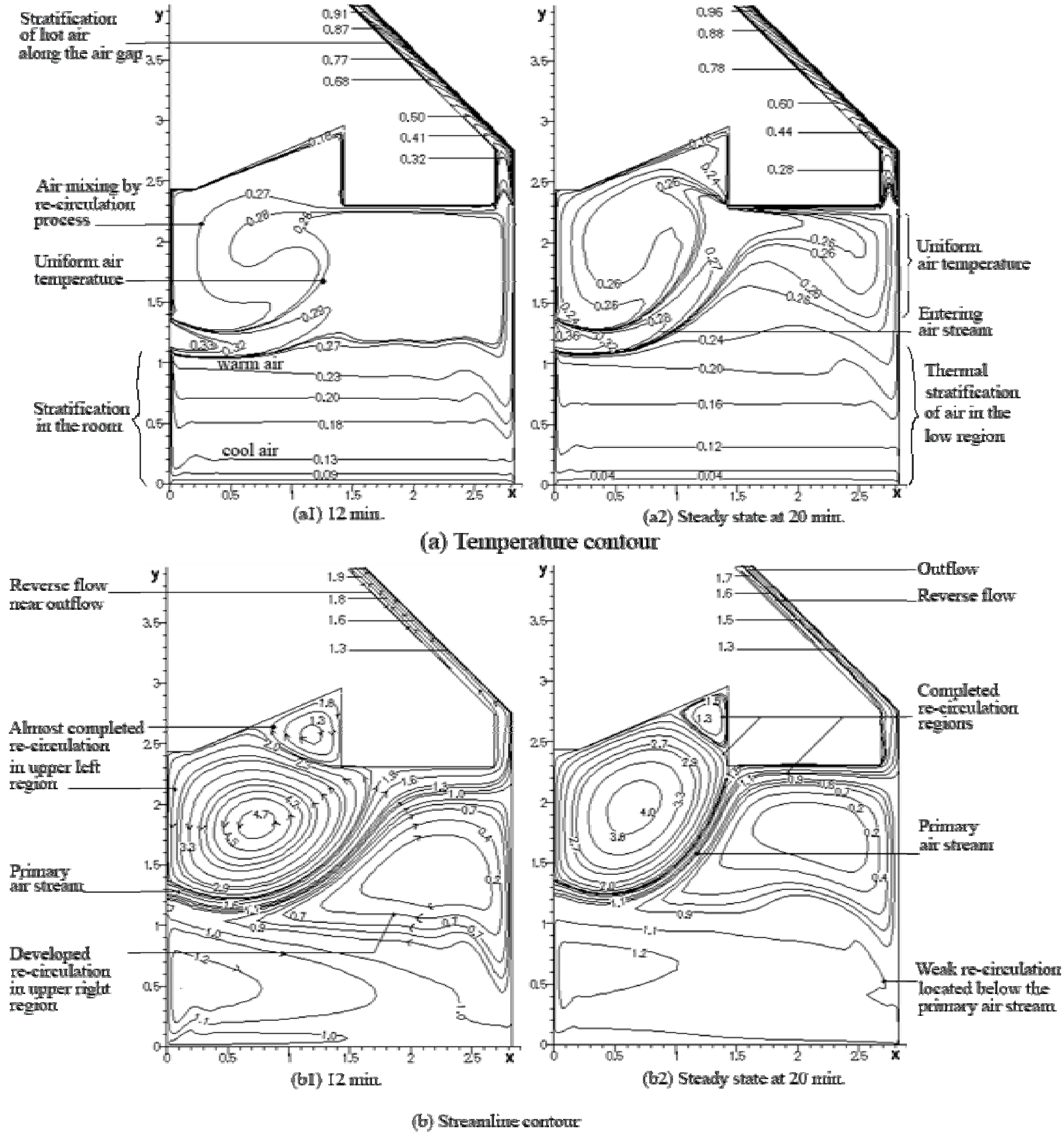


Figure 6.5. The computational results of (a) transient temperature distribution and (b) the corresponding streamline, during the application of solar chimney in *Case A* (simulation time of 12 and 20 minutes).

6.3.2. Case B: application of solar chimney with cool ceiling

As shown in Fig 6.6(b1)-(b4), the decrease of surface temperature of the ceiling by 2°C highly increases the re-circulation in the upper region of the room. In order to compare the results between *Case B* and *Case A*, the values of T^* shown in Fig. 6.6(a1)-(a4) are calculated from the computational results of temperature in *Case B*, the values of T_{min} and T_{max} from the *Case A*. It is shown in Fig. 6.6(a4) that the value of T^* in the upper region of the room decreases from 0.27 in *Case A* to 0.20 in *Case B* at steady state condition. Comparing to *Case A*, *Case B* shows the combination of cool ceiling to the application of the solar chimney reduces air temperature in the room by 0.5°C. The additional reduction of ceiling temperature of 4°C shows that air temperature in the upper region of the room is reduced by 0.7°C (see Fig. 6.7 (a4)) However, the CFD model in this study represents only the middle section of the room and excludes the effect of radiation heat transfer from the floors and walls on the reduction of surfaces and air temperatures during the application of cool ceiling. Hence, the computational results in this study are less than that in the experiments which show the reduction of 1.0-3.6°C in air temperature during the application of cool ceiling.

6.3.3. Case C: application of solar chimney with cool supply air at the window

In *Case C*, the value of supply air temperature at the window is decreased by 2°C from the original value. The computational results in Fig.6.8 (a2) shows that the primary air stream of cool supply air completely blends with the initial air inside the room within 6 minutes and the non-dimensional air temperature in the room decrease rapidly to 0.08-0.16 in the mid-region of the room. After 6 minutes, values of T^* vary in the range of 0.06 to

0.13 and the warm air of *T** of 0.13 enters to the opening of the solar chimney. The corresponding streamlines in Fig. 6.8(b2) at 6 minutes shows that one re-circulation of air occurs in front of the window and is trapped there due to the relative warm air above it. There are eight streamlines from the total of ten streamlines entering the room that are expelled from the room at 12 minutes but the number of the expelled streamlines decrease to 5 at 20 minutes because the increase of re-circulation in front of the window (see Fig. 6.8, b4). In the *Case C*, the air temperature in the room is lower than *Case A* and *B* because of a large amount of cool air entering the room. However, the settling heavy cool air is difficult to be removed by using a small opening and the existing thermal driven force. As a result, there is a large decrease of volume flow rate of air in the *Case C*.

6.3.4. The volume flow rate of Case A, B and C

The computational results of volume flow rate at the simulated time of 40 minutes in the *Cases A*, *B* and *C* are shown in Fig 6.10. The volume flow rate per unit width in the *Case A* and *Case B* are quite similar and consistent at 0.01 m^3/s after simulated time of 14 minutes. The further reduction of ceiling temperature by 4°C shows that the volume flow rate is increased by 12 %, comparing to the *Case A*. In the *Case C*, the value of air temperature at the window is reduced from the original value by 2°C. After reaching the steady state condition, the volume flow rates of *Case C* are less than those of *Case A* and *B* by 17-19%.

6.3.5. Air flowing from cool solar chimney into insulated room in the evening

Because of light weight material without insulation of the roof tile, the temperature of air in the solar chimney reduces faster comparing to the room air and the cool air flows from the solar chimney into the room after the sunset. In addition, the radiation during the night between the external roof surface and the sky keeps reducing of air temperature in the channel of solar chimney and maintaining the flowing of air into the room during the night time. Fig. 6.9 shows the computational results of (a) transient temperature distribution and (b) the corresponding streamline in the case that cool air in the solar chimney flow downward to the insulated hot room in the evening and night time. The boundary condition of the room remains identical to the case study A, B and C (about 32.5°C) but the temperature of the air at the inflow and outflow and the surface temperature of roof are less than the room boundary conditions by 2°C. Fig. 6.9 also shows that the air flows upward from the window to the solar chimney at the beginning of the process, however, the direction of flowing air switches after 6 minutes onwards (Fig. 6.9b1). The complete developments of temperature and streamline of air in the room are shown in Fig. 6.9 (a4) and (b4), respectively, where the cool air fills the room up, the primary streamlines locates above a large recirculation enclosing a uniform temperature.

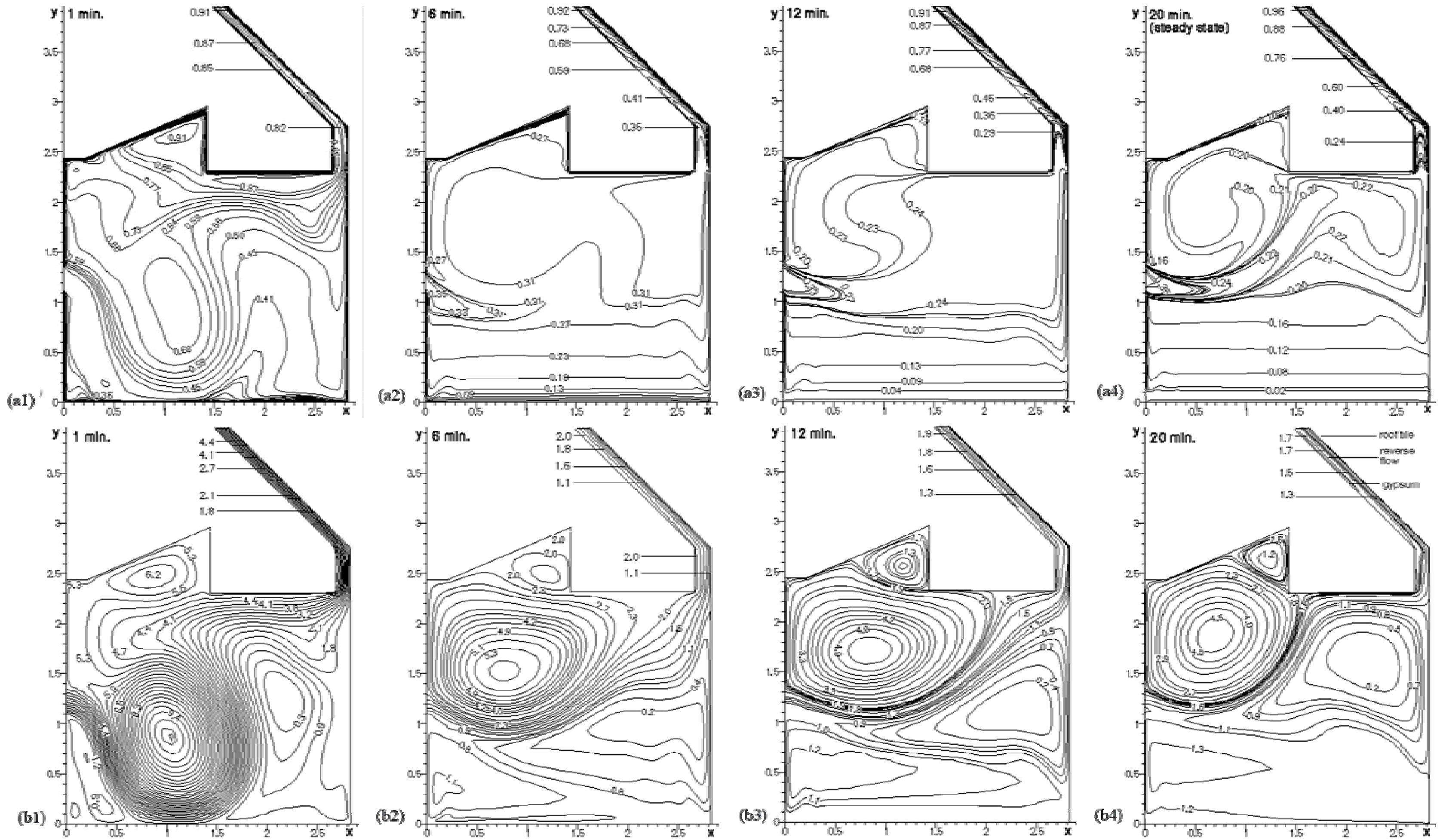


Figure 6.6. The computational results of (a) transient temperature distribution and (b) the corresponding streamline, during the application of solar chimney together with cool ceiling in *Case B1*.

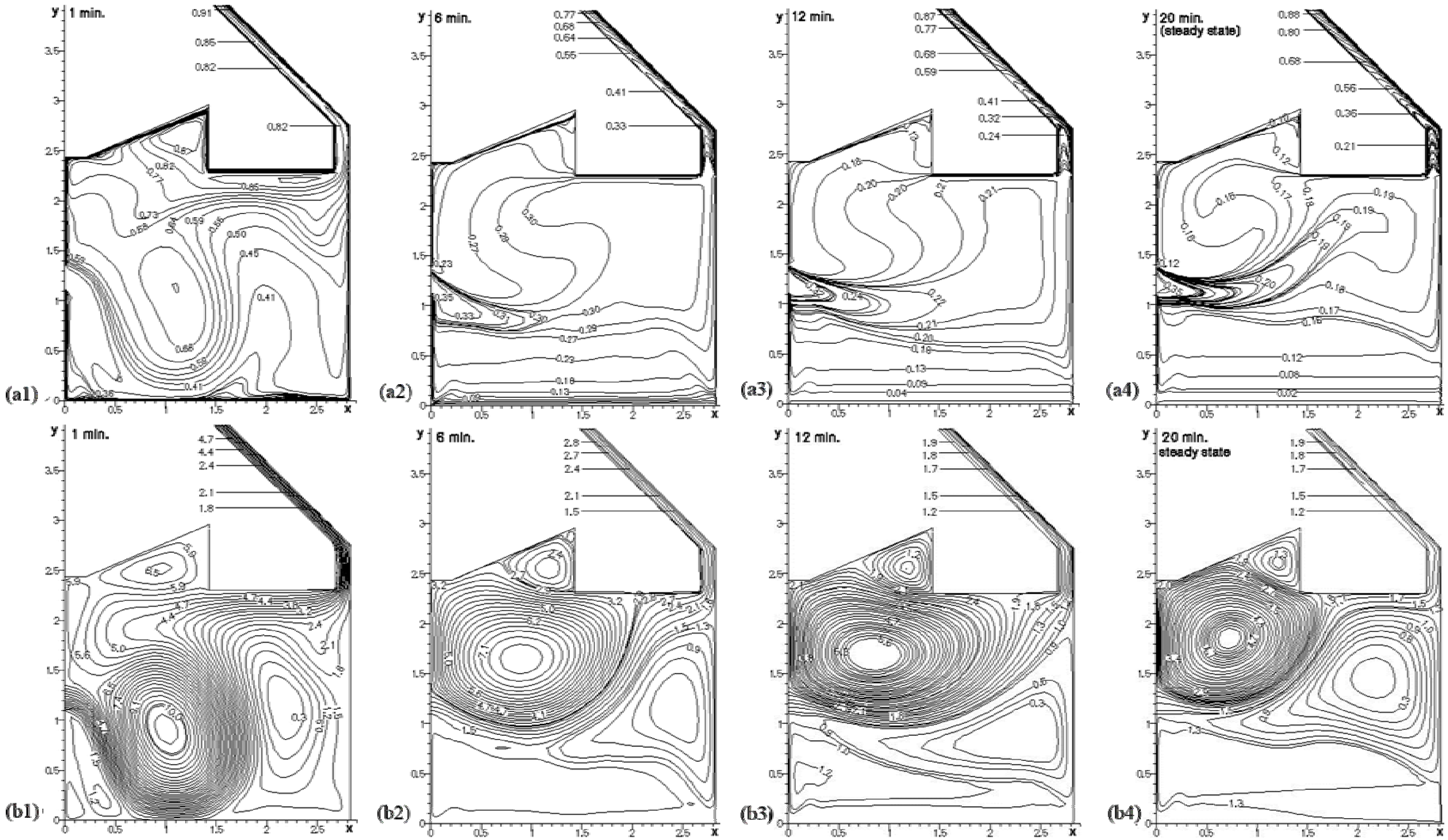


Figure 6.7. The computational results of (a) transient temperature distribution and (b) the corresponding streamline, during the application of solar chimney together with cool ceiling in *Case B*2.

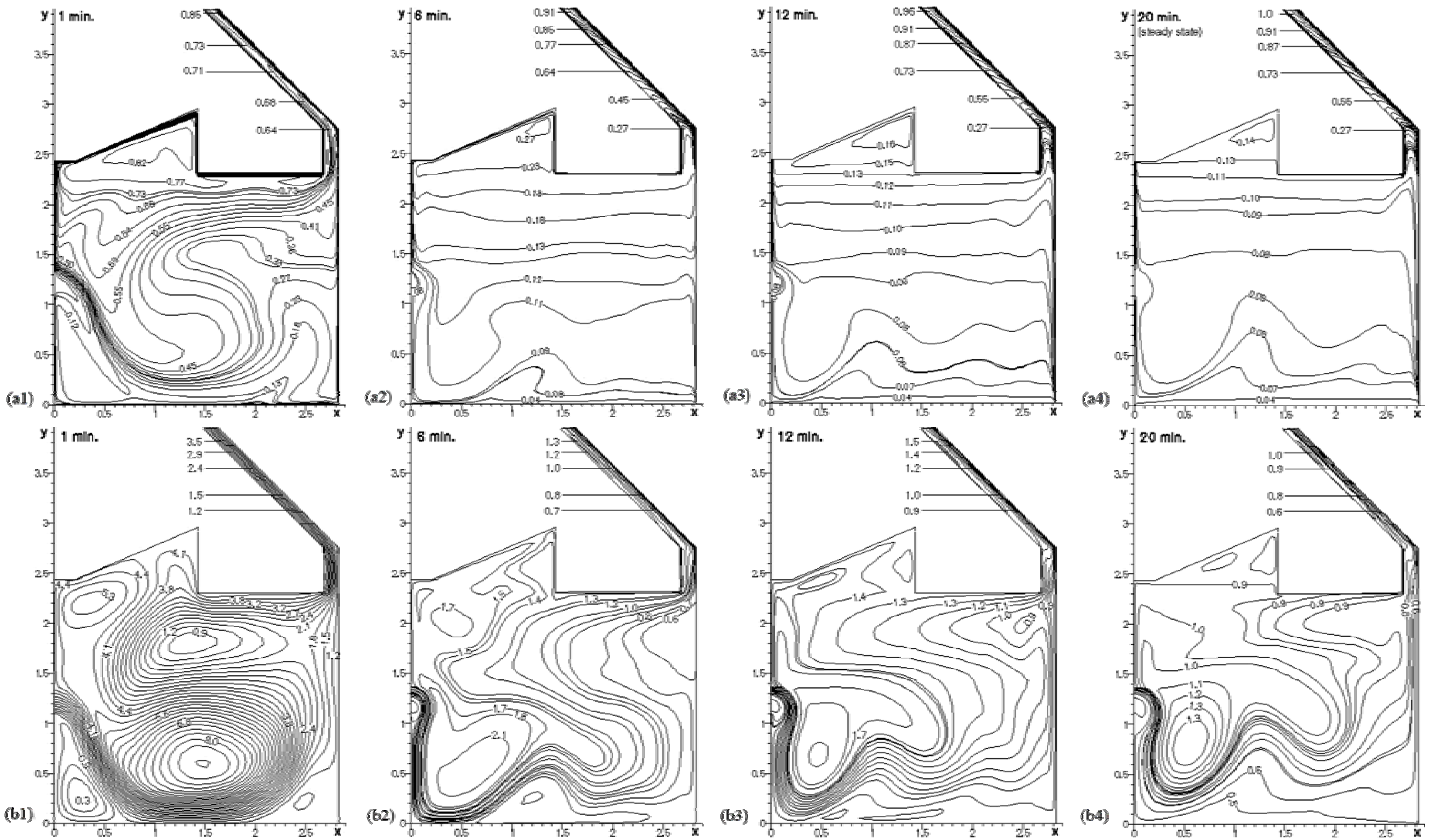


Figure 6.8. The computational results of (a) transient temperature distribution and (b) the corresponding streamline, during the application of solar chimney together with cool inlet air through window in *Case C*.

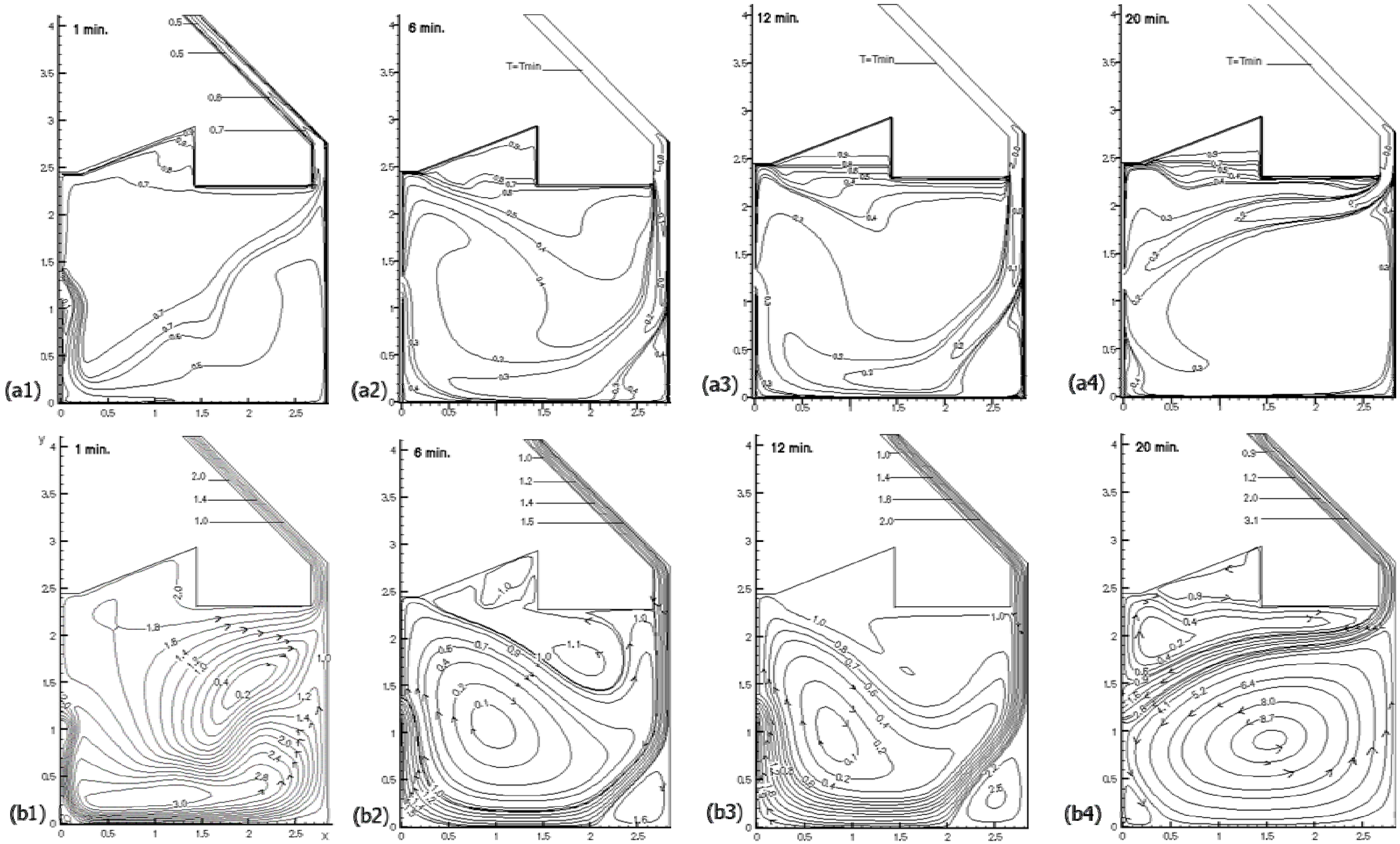


Figure 6.9. The computational results of (a) transient temperature distribution and (b) the corresponding streamline, in the case that cool air in the solar chimney flow downward to the insulated hot room in the evening.

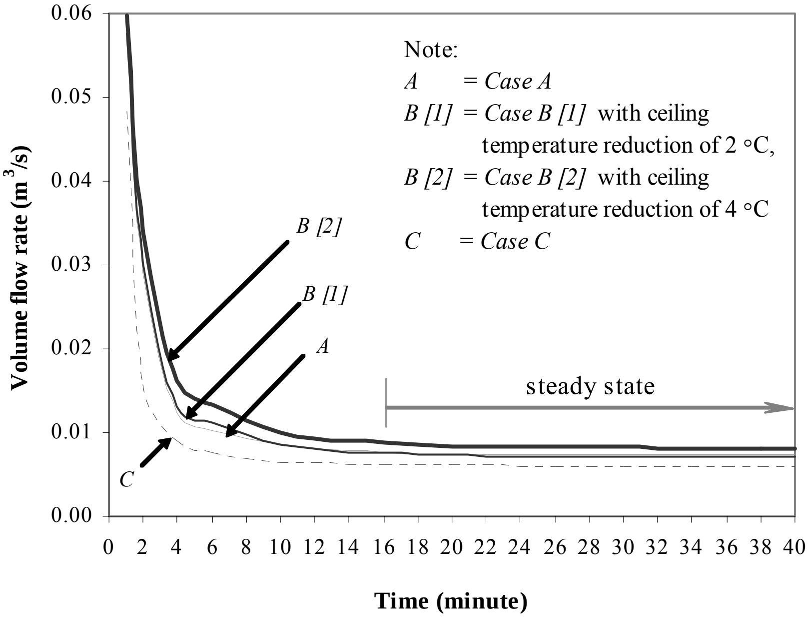


Figure 6.10. The transient computational results of volume flow rate at the exit of the solar chimney for *Cases A*, *B [1], B [2]* and *C*, respectively. All of the studied models approach steady state at 16 minutes.

CHAPTER VII

CONCLUSIONS AND RECOMMENDATION

7.1. Implementation of Solar Chimney in Hot and Humid Climate

7.1.1. The solar chimney provides high ventilation during the cool period of the year

The experimental study of solar chimney in the test cell and controlled cell shows the temperature gradient in the room and in the solar chimney. Therefore, the opening near the ceiling is an effective approach to expel the warm air from the room. The experiments on application of passive cooling techniques in a test cell comparing to those of a controlled cell conducted for several periods of the year show the temperature differences between the room and the solar chimney show higher temperature differences during February-March than during June-October. Therefore, the application of solar chimney during February-March can provide the more ventilation to the room than that during June-October due to the high ambient temperature.

7.1.2. Without the effect of prevailing wind, a solar chimney provides a significant ventilation

Utilization of wind shield can reduce the effect of the prevailing wind on the induced ventilation to the test cell, but increase the effect of solar chimney on the solar induced ventilation and help the investigation of the significance of a solar chimney. The experimental results show that without the wind effect, the solar chimney can provide a significant part of natural ventilation in the test cell by 1.13-2.26 of ACH [25] and in the controlled cell by 0.60-5.38 [26], depending on the temperature differences during the daytime. These derived values of ACH accounting for 7.5%-35.9% compared to the ACH value of 15 with wind effect by Khedari et al. [14 and 15]. The low values of ventilation rates show that by using the only solar chimney the ventilation is insufficient and the natural wind must be included in the natural ventilation application. However, the experimental results recommend further studies on stack effect or natural ventilation with low value of Reynolds number, Re_D.

7.1.3. Air temperature in the application of a solar chimney is slightly lower than that of a closed cell.

At high ambient temperature and high solar intensity in the daytime, the solar chimney can reduce the indoor temperature by 1.0-3.5°C compared with the ambient air of 32.0-40.0°C, and 1.0-1.3°C compared with that of the controlled cell of 32-38°C.

7.2. The Wetted Roof enhances the Thermal Comfort Opportunity to the Typical Roof Solar Chimney

The spraying of water on the roof and the combination of solar chimney with the spraying water on roof is recommended during the high temperature of ambient air. From the experimental results, water spraying on the roof together with those of the solar chimney can reduces indoor temperatures by 2.0-6.2°C compared with ambient air, and by 1.4-3.0°C compared with the controlled cell. By taking into account the steady-state heat transfer coefficient, surface temperature, and air temperature in the attic, the values of MCP of the passive cooling system are obtained. The derived MCP shows that the application of combined solar chimney with the cool ceiling increases the cooling potential by two times. From the experimental result of utilizing the solar chimney during the period of high solar radiation and high ambient temperature, the difference between temperature at the inflow into the solar chimney and temperature at the outflow from the solar chimney tends to decrease. Theoretically, water spraying on the metal ceiling does not only decreases temperature in the room but also increases the temperature difference and increases the related air flow rate from room to the solar chimney too.

7.3. Numerical Study of Solar Chimney with Cool Ceiling by Using the Computational Fluid Dynamics (CFD)

7.3.1. The results of CFD simulation corresponds to the experimental results

The detail investigations of the application of solar chimney together with cool ceiling are carried out by using CFD simulation. The comparisons of four computational results with the air temperature and volume flow rate of the experimental results found two computational models showing good agreement with the experimental results, the temperatures at various heights and the volume flow rates from both computational and experimental results are similar.

7.3.2. The CFD results show the characteristics of airflow in the application of solar chimney

The analysis by using computational models shows that the application of the solar chimney in the controlled cell in this study exhibits four airflow regions as followed (1) the main stream of the primary flow, (2) the recirculating in the upper regions of the room, (3) the weak recirculating in the lower region of the room and (4) the stable stratification of temperatures near the floor and in the air gap of solar chimney. The circulation process mixes the entering air stream with the initial room air, generating the uniform air temperature in the upper region of the room, which leaves the room through the opening in the ceiling.

7.3.3. The CFD results show the characteristics of airflow in the application of solar chimney with cool ceiling

The application of cool ceiling and solar chimney, which reduces the ceiling temperature by 2-4°C, does not only increase the circulation in the upper and lower regions of the room but also reduce the air temperature in the room by 0.5-0.7°C, which could increase the comfort opportunity.

7.3.4. The CFD results show the characteristics of airflow in the application of solar chimney with cool inlet air

In the evening, the solar chimney remains warm and the ambient air becomes cool. The cool ambient air enters the room through the window, flows into the inlet of the solar chimney, warmed by the chimney and left at the exit of the solar chimney. This process gradually reduces the temperature of the air inside the building until the night time.

7.3.5. The CFD results show the characteristics of airflow in the application of solar chimney during the night time

During the night time, the thermal radiation between roof tile and the sky keeps surface temperature of roof tile low and cools the air in the channel of solar chimney. The cool ambient air enters the room through the channel of the solar chimney and exits through the window. The room air and the building mass remains cool until the morning.

7.4. Recommendation

7.4.1. Application of solar chimney and wetted roof is appropriate for the low energy architecture

The cooling potential of the solar chimney and wetted roof shown in the study reveals that addition of passive technologies in the design of a building can provide a certain thermal comfort to the occupants with low expenditure (see Appendix C for costs of materials). To reach the satisfactory of thermal comfort to everybody in the low energy architecture, the hybrid system, i.e. passive cooling together with active cooling and ventilation, is usually utilized with careful and proper design.

7.4.2. The high thermal mass chimney maintains the night cooling effect until the daytime

Utilizing the high thermal mass for solar chimney such as clay tile and protecting the clay tile from the direct sun can store the cooling effect during the night ventilation until a certain time of the day. It is another way of using the chimney for allowing the cool air from the chimney to enter the room.

7.4.3. The energy conservation by passive cooling is highly recommended for large building with high cooling load

The closed residential building during the daytime, which has high cooling load during 16-17 hrs. of the day, can use solar chimney and wetted roof before the starting of active cooling machine to safe the energy. Spraying of water in one hour before the owner of the building arrived home can substantially reduce the cooling load accumulated during the daytime. The electric saving is higher for the increase of area of passive cooling and the number of hours of cooling. Therefore, the passive cooling is economical for the large building with large area of roof, high cooling load and utilizing cooling machine for many hours per day.

7.4.4. Recommendation of further studies

This study aims to detailed knowledge of application of solar chimney and wetted roof and the combination of them in the hot and humid climate. The experimental data are collected in a detached test cell of medium size for various seasons, days and times, those bring confidence for the real application of the passive systems all of the year under the hot and humid climate. The collected data showing in Appendix A and Appendix B can then be used as the base case for further studies such as.

- Studying the effect of positions and dimensions of the inlet and outlet on the air flow rate in the test cell
- Determining the optimum dimensions of room, windows, openings, inflow and outflow that bring lowest temperature and highest ventilation rate.
- For further study on the application of solar chimney, ones can change the material of the roof tile from corrugated light weight into the clay tile with high heat capacity.

- The study of the effect of wall material on the air temperature, ventilation rate and humidity prevention.
- During the experiments of wetted roof, not only the ceiling is cooled by water evaporation but also the wall and floor surfaces are cooled. The further study can be the effect of position and area of cool surfaces on the air temperature inside the room. It can help temperature reduction.

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Appendix A

Table A.1. Experimental results in the test cell on September 26th, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m2)
1:00	28.1	28.1	28.1	28.1	28.1	28.1	28.1	28.2	28.2	28.2	28.3	28.2	28.3	27.7	28.2	28.3	27.7	27.9	27.7	27.7	28.0	28.1	28.0	27.8	2.0	0.1
2:00	27.8	27.8	27.7	27.8	27.8	27.8	27.8	27.9	27.9	27.9	28.0	28.0	28.0	27.4	27.9	28.0	27.3	27.5	27.2	27.2	27.4	27.7	27.7	27.5	1.4	0.0
3:00	27.4	27.4	27.4	27.3	27.4	27.4	27.4	27.5	27.4	27.5	27.6	27.5	27.7	27.1	27.5	27.6	27.0	27.2	27.0	27.1	27.3	27.3	27.3	27.1	2.5	0.0
4:00	27.1	27.0	27.0	27.0	27.1	27.0	27.0	27.1	27.1	27.2	27.3	27.3	27.3	26.7	27.2	27.3	26.7	26.9	26.8	26.8	27.0	27.0	26.9	26.8	1.8	0.0
5:00	26.6	26.6	26.6	26.5	26.6	26.6	26.5	26.6	26.6	26.6	26.8	26.7	26.9	26.3	26.7	26.8	26.5	26.6	26.5	26.5	26.7	26.7	26.4	26.4	1.4	0.0
6:00	26.3	26.3	26.4	26.3	26.4	26.4	26.4	26.3	26.3	26.4	26.5	26.3	26.5	26.2	26.3	26.5	26.2	26.3	26.2	26.2	26.4	26.3	26.0	26.3	1.3	0.0
7:00	26.2	26.2	26.2	26.2	26.3	26.2	26.2	26.2	26.2	26.3	26.3	26.3	26.4	26.2	26.2	26.3	26.1	26.2	26.1	26.1	26.3	26.2	26.0	26.3	1.1	22.7
8:00	26.9	26.9	26.9	27.0	27.0	26.9	26.9	26.9	26.9	26.9	26.9	26.9	27.0	27.4	26.9	27.0	27.1	27.0	27.1	27.2	27.0	27.0	26.9	27.4	1.5	190.2
9:00	28.0	28.1	28.0	28.1	28.1	28.1	28.0	28.1	28.1	28.0	28.0	28.1	28.1	28.7	28.1	28.0	28.9	28.8	28.7	29.0	28.6	28.4	28.0	28.8	1.8	401.1
10:00	29.3	29.4	29.3	29.4	29.3	29.4	29.3	29.3	29.3	29.3	29.3	29.4	29.3	30.4	29.3	29.3	31.1	30.6	30.9	31.4	30.3	30.0	29.4	30.5	1.5	544.3
11:00	30.7	30.8	30.7	30.8	30.5	30.8	30.7	30.7	30.7	30.6	30.6	30.7	30.5	32.2	30.7	30.6	33.4	32.7	33.2	33.9	32.0	31.8	30.9	32.3	1.8	711.3
12:00	31.9	32.0	31.9	32.1	31.8	32.1	32.0	32.0	32.0	31.9	31.9	32.0	31.8	33.1	32.0	31.9	34.8	34.3	34.7	35.2	33.8	33.4	32.2	33.2	1.8	806.3
13:00	32.8	32.9	32.8	33.0	32.7	33.0	32.9	32.8	32.9	32.8	32.9	32.9	32.8	34.2	32.9	32.9	36.5	35.8	36.2	37.0	35.3	34.8	32.9	34.2	1.6	937.3
14:00	33.5	33.6	33.6	33.8	33.5	33.8	33.7	33.6	33.6	33.7	33.6	33.7	33.5	34.8	33.7	33.8	37.0	36.4	37.0	37.6	35.9	35.3	33.7	34.7	1.8	824.9
15:00	34.1	34.1	34.1	34.2	34.0	34.4	34.2	34.1	34.2	34.2	34.2	34.2	34.1	35.1	34.2	34.3	37.1	36.6	37.0	37.6	36.2	35.7	34.1	35.1	1.7	622.1
16:00	34.6	34.7	34.7	34.7	34.6	35.0	34.8	34.6	34.7	34.8	34.7	34.6	34.6	36.0	34.6	34.8	37.2	36.8	37.3	37.6	36.3	35.8	34.5	35.9	1.6	537.8
17:00	34.1	34.2	34.3	34.1	34.2	34.5	34.3	34.1	34.1	34.4	34.2	34.1	34.2	35.4	34.1	34.3	35.9	35.6	36.2	36.3	35.1	34.8	33.9	35.4	2.4	301.5
18:00	32.2	32.3	32.4	32.2	32.3	32.4	32.3	32.2	32.3	32.4	32.5	32.2	32.5	32.5	32.2	32.5	32.8	32.6	32.8	33.0	32.6	32.4	31.9	32.7	1.3	66.9
19:00	31.6	31.7	31.8	31.6	31.6	31.7	31.6	31.6	31.7	31.8	31.9	31.7	31.9	31.4	31.7	31.9	31.8	31.8	31.9	31.9	31.9	31.8	31.3	31.6	1.5	0.4
20:00	31.1	31.2	31.3	31.1	31.2	31.0	31.1	31.2	31.2	31.3	31.4	31.3	31.5	30.9	31.3	31.5	31.2	31.3	31.2	31.3	31.4	31.3	30.9	30.9	3.0	0.0
21:00	30.4	30.5	30.5	30.4	30.4	30.3	30.4	30.5	30.5	30.6	30.7	30.6	30.9	30.1	30.6	30.7	30.5	30.5	30.5	30.6	30.7	30.6	30.2	30.2	2.6	0.0
22:00	30.0	30.1	30.2	30.0	30.0	29.9	30.0	30.1	30.1	30.2	30.3	30.2	30.4	29.7	30.2	30.4	30.0	30.1	30.0	30.1	30.3	30.2	29.8	29.8	2.9	0.0
23:00	29.9	30.0	30.0	29.8	29.9	29.8	29.9	30.0	30.0	30.1	30.1	30.0	30.2	29.6	30.0	30.2	29.8	29.9	29.8	29.9	30.1	30.1	29.6	29.6	4.0	0.0
0:00	29.6	29.7	29.8	29.6	29.7	29.6	29.7	29.7	29.7	29.8	29.9	29.8	29.8	29.3	29.8	29.9	29.6	29.7	29.6	29.7	29.8	29.8	29.3	29.4	3.7	0.0

Table A.2. Experimental results in the test cell on September 27th, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m2)
1:00	29.4	29.5	29.5	29.3	29.4	29.4	29.4	29.4	29.5	29.6	29.7	29.5	29.7	29.1	29.5	29.7	29.3	29.4	29.2	29.3	29.5	29.5	29.1	29.1	2.6	0.0
2:00	28.6	28.6	28.7	28.6	28.7	28.8	28.8	28.6	28.7	28.8	28.8	28.7	29.0	28.3	28.7	28.9	28.6	28.6	28.6	28.6	28.8	28.7	28.3	28.4	1.1	0.0
3:00	28.5	28.6	28.7	28.5	28.5	28.7	28.7	28.6	28.6	28.8	28.8	28.7	28.8	28.1	28.7	28.8	28.3	28.4	28.3	28.3	28.6	28.5	28.1	28.2	1.6	0.0
4:00	28.2	28.2	28.3	28.2	28.3	28.4	28.4	28.3	28.3	28.5	28.5	28.4	28.6	27.8	28.4	28.5	28.0	28.1	28.0	28.0	28.3	28.2	27.8	27.9	1.4	0.0
5:00	28.0	28.0	28.1	28.0	28.1	28.1	28.2	28.1	28.1	28.2	28.3	28.2	28.3	27.6	28.2	28.3	27.6	27.7	27.6	27.6	27.9	27.9	27.7	27.7	1.2	0.0
6:00	27.9	27.9	28.0	27.8	27.9	27.9	27.9	27.9	27.9	28.0	28.0	28.0	28.1	27.5	27.9	28.1	27.4	27.5	27.4	27.4	27.7	27.7	27.6	27.6	1.4	0.0
7:00	27.3	27.4	27.5	27.4	27.5	27.5	27.5	27.4	27.5	27.6	27.5	27.4	27.6	27.3	27.4	27.6	27.2	27.3	27.2	27.2	27.4	27.3	27.1	27.4	1.5	17.8
8:00	27.7	27.7	27.8	27.8	27.9	27.8	27.8	27.7	27.8	27.8	27.8	27.8	27.9	28.1	27.8	27.8	27.9	27.8	27.8	27.9	27.9	27.8	27.6	28.2	1.4	129.2
9:00	28.6	28.7	28.6	28.7	28.7	28.7	28.6	28.6	28.7	28.6	28.6	28.6	28.7	29.4	28.6	28.7	29.3	29.2	29.2	29.4	29.1	29.0	28.6	29.4	1.9	363.4
10:00	29.5	29.5	29.5	29.6	29.6	29.6	29.5	29.5	29.6	29.5	29.5	29.5	29.6	30.3	29.5	29.5	30.4	30.1	30.4	30.6	29.8	29.8	29.5	30.4	2.8	576.4
11:00	30.7	30.7	30.7	30.8	30.8	30.7	30.7	30.7	30.7	30.7	30.6	30.7	30.7	31.8	30.7	30.7	32.2	31.9	32.0	32.4	31.5	31.4	30.7	31.8	2.2	634.9
12:00	32.0	32.1	31.9	32.2	32.0	32.2	32.0	32.0	32.0	31.9	31.9	32.0	32.0	33.2	32.0	32.1	34.5	34.1	34.3	34.9	33.8	33.3	32.1	33.3	1.5	720.1
13:00	32.9	33.0	32.6	33.1	33.0	33.1	33.0	32.9	33.0	-435.8	32.9	32.9	33.0	34.2	32.8	32.7	35.6	35.0	35.7	36.1	34.5	34.1	33.0	33.7	0.8	470.2
14:00	32.7	32.7	32.7	32.9	32.9	32.9	32.8	32.8	32.8	33.0	32.8	32.8	32.9	33.7	32.8	33.2	34.7	34.4	34.9	35.1	34.0	33.7	32.7	33.2	1.4	604.7
15:00	30.5	30.6	31.1	30.6	30.7	30.7	30.8	30.6	30.6	30.9	30.7	30.7	30.8	30.8	30.7	30.9	31.6	31.5	31.5	31.9	31.6	31.2	30.3	30.9	0.4	288.9
16:00	31.4	31.4	31.4	31.5	31.5	31.6	31.5	31.4	31.4	31.5	31.4	31.4	31.4	32.0	31.5	31.5	32.9	32.8	32.8	33.3	32.7	32.3	31.3	32.3	0.4	389.2
17:00	32.8	32.8	32.5	32.9	32.7	33.2	32.9	32.8	32.8	32.9	32.8	32.8	32.7	34.0	32.8	32.9	34.4	34.1	34.6	34.5	33.8	33.4	32.9	33.8	2.9	229.0
18:00	32.7	32.7	32.8	32.8	32.8	32.9	32.8	32.8	32.8	33.0	33.0	32.8	32.8	33.1	32.8	33.0	33.3	33.2	33.6	33.4	33.2	33.0	32.6	32.8	2.6	25.4
19:00	31.8	31.9	32.3	31.7	31.8	32.0	31.9	31.9	31.9	32.0	32.1	31.9	31.9	31.8	31.9	32.0	31.8	31.9	31.9	31.9	32.1	31.9	31.4	31.6	2.6	3.2
20:00	30.9	31.0	31.7	30.8	30.9	31.0	30.9	30.9	30.9	31.0	31.3	31.0	31.1	30.6	30.9	31.0	30.8	30.9	30.9	30.9	31.1	31.1	30.5	31.1	2.0	1.6
21:00	30.6	30.7	31.2	30.6	30.6	30.7	30.6	30.7	30.7	30.7	30.9	30.7	30.8	30.5	30.7	30.8	30.4	30.5	30.4	30.4	30.7	30.7	30.3	30.5	2.9	2.6
22:00	29.8	29.9	30.7	29.9	29.9	30.0	30.0	29.9	30.0	30.1	30.2	29.9	30.0	30.0	29.9	30.1	29.8	29.8	29.8	29.8	30.0	29.9	29.5	29.9	1.3	3.1
23:00	29.1	29.2	30.1	29.2	29.3	29.3	29.3	29.1	29.3	29.4	29.5	29.2	29.3	29.5	29.2	29.4	29.1	29.1	29.1	29.1	29.3	29.2	28.8	29.2	2.6	4.8
0:00	29.2	29.3	29.8	29.1	29.2	29.2	29.2	29.2	29.2	29.3	29.4	29.3	29.4	29.0	29.2	29.4	29.0	29.1	29.0	29.0	29.3	29.2	28.9	29.3	2.0	2.9

Table A.3. Experimental results in the test cell on September 28th, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m2)
1:00	28.9	29.0	29.6	28.8	28.9	28.8	28.9	28.9	29.0	29.1	29.2	29.1	29.2	28.7	29.0	29.2	28.8	28.9	28.8	28.8	29.1	29.1	28.4	29.0	2.0	2.8
2:00	28.9	28.9	29.3	28.8	28.8	28.7	28.9	28.9	28.9	29.0	29.0	29.0	29.2	28.8	28.9	29.0	28.5	28.7	28.4	28.5	28.8	28.9	28.5	28.5	2.9	3.9
3:00	28.5	28.5	28.9	28.4	28.5	28.4	28.4	28.5	28.5	28.6	28.7	28.6	28.8	28.4	28.5	28.7	28.0	28.2	27.9	28.0	28.4	28.5	28.2	28.5	2.0	3.8
4:00	27.5	27.5	28.4	27.5	27.6	27.7	27.6	27.4	27.5	27.6	27.8	27.5	27.7	28.1	27.3	27.8	27.4	27.5	27.4	27.4	27.6	27.6	27.1	27.6	1.0	7.8
5:00	27.5	27.6	28.1	27.4	27.5	27.6	27.5	27.4	27.4	27.5	27.6	27.5	27.6	27.6	27.2	27.6	27.2	27.4	27.2	27.2	27.6	27.6	27.1	27.4	2.3	4.4
6:00	27.3	27.4	27.9	27.1	27.2	27.4	27.4	27.0	27.0	27.1	27.2	27.1	27.3	27.6	26.9	27.5	27.0	27.1	27.0	27.0	27.4	27.3	26.8	27.2	3.3	6.4
7:00	26.9	26.9	27.4	26.8	26.9	27.0	27.0	26.6	26.7	26.8	26.8	26.7	26.9	26.9	26.5	27.0	26.6	26.7	26.6	26.6	27.0	26.8	26.6	27.2	2.6	19.6
8:00	27.1	27.1	27.1	27.1	27.2	27.1	27.1	27.0	27.0	27.1	27.0	27.0	27.1	27.3	26.9	27.2	27.2	27.2	27.1	27.3	27.3	27.2	27.0	27.7	2.0	160.3
9:00	28.2	28.3	27.8	28.2	28.2	28.2	28.2	28.2	28.2	28.1	28.1	28.2	28.2	28.8	28.1	28.2	29.3	28.9	29.1	29.4	28.7	28.5	28.3	29.0	2.3	365.2
10:00	30.2	30.5	29.3	30.3	30.0	30.6	30.3	30.2	30.2	30.1	30.2	30.2	29.8	31.2	30.2	30.1	32.6	31.9	32.6	32.9	31.5	31.1	30.6	31.4	2.3	555.1
11:00	31.6	31.9	30.7	31.8	31.3	32.0	31.6	31.6	31.6	31.5	31.6	31.6	31.2	33.0	31.6	31.5	34.9	34.0	35.1	35.3	33.2	32.7	31.9	33.4	3.9	746.9
12:00	31.7	31.8	31.5	31.8	31.8	31.9	31.7	31.7	31.8	31.7	31.7	31.7	31.7	33.0	31.7	31.8	34.0	33.4	34.2	34.5	32.7	32.5	31.8	33.3	1.6	590.0
13:00	32.2	32.3	32.1	32.4	32.4	32.4	32.3	32.3	32.3	32.3	32.3	32.3	32.3	33.6	32.3	32.3	34.6	34.0	34.4	35.1	33.4	33.2	32.4	33.6	1.3	814.6
14:00	32.2	32.3	32.4	32.4	32.4	32.4	32.3	32.2	32.3	32.4	32.3	32.2	32.3	33.2	32.3	32.4	34.0	33.6	34.0	34.4	33.0	32.8	32.2	33.6	2.6	734.5
15:00	33.0	33.0	32.9	33.2	33.0	33.2	33.1	33.0	33.1	33.1	33.0	33.0	33.0	34.1	33.0	33.1	35.3	34.9	35.2	35.7	34.3	34.0	33.0	34.0	0.4	616.6
16:00	33.4	33.4	33.3	33.6	33.5	33.7	33.6	33.5	33.5	33.6	33.5	33.5	33.5	34.1	33.6	33.7	35.4	35.2	35.3	35.8	35.0	34.6	33.4	34.1	0.1	439.1
17:00	33.4	33.3	33.3	33.4	33.4	33.6	33.5	33.4	33.4	33.6	33.3	33.4	33.4	33.3	33.4	-435.1	34.6	34.5	34.6	34.9	34.4	34.0	33.3	33.8	1.0	229.7
18:00	32.5	32.5	32.8	32.5	32.6	32.7	32.7	32.5	32.6	32.8	32.6	32.6	32.7	32.5	32.6	32.8	33.0	33.0	33.0	33.2	33.0	32.8	32.4	32.4	1.0	57.1
19:00	31.6	31.6	32.0	31.5	31.7	31.7	31.7	31.6	31.6	31.8	31.7	31.7	31.7	31.3	31.6	31.8	31.6	31.6	31.6	31.6	31.8	31.7	31.4	31.3	0.0	3.2
20:00	31.1	31.1	31.5	31.0	31.2	31.1	31.2	31.1	31.1	31.3	31.2	31.2	31.2	30.7	31.2	31.3	30.8	30.9	30.8	30.8	31.1	31.0	30.9	30.9	0.0	2.8
21:00	30.7	30.7	31.1	30.6	30.7	30.6	30.7	30.8	30.8	30.9	30.9	30.8	30.9	30.4	30.8	31.0	30.3	30.4	30.2	30.2	30.5	30.6	30.4	30.2	2.0	4.0
22:00	30.1	30.1	30.6	30.1	30.2	30.1	30.2	30.1	30.1	30.3	30.3	30.2	30.3	29.7	30.2	30.4	29.7	29.8	29.7	29.7	30.0	30.0	29.9	29.8	1.3	3.6
23:00	29.5	29.6	30.0	29.5	29.6	29.5	29.5	29.6	29.6	29.7	29.8	29.7	29.8	29.1	29.7	29.8	29.3	29.3	29.2	29.3	29.5	29.5	29.3	29.2	2.0	3.3
0:00	29.3	29.4	29.7	29.2	29.2	29.2	29.3	29.4	29.4	29.4	29.5	29.5	29.5	29.0	29.4	29.5	29.1	29.2	29.0	29.1	29.3	29.4	28.9	28.6	1.3	4.9

Table A.4. Experimental results in the test cell on September 28th, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m2)
1:00	28.9	29.0	29.6	28.8	28.9	28.8	28.9	28.9	29.0	29.1	29.2	29.1	29.2	28.7	29.0	29.2	28.8	28.9	28.8	28.8	29.1	29.1	28.4	29.0	2.0	2.8
2:00	28.9	28.9	29.3	28.8	28.8	28.7	28.9	28.9	28.9	29.0	29.0	29.0	29.2	28.8	28.9	29.0	28.5	28.7	28.4	28.5	28.8	28.9	28.5	28.5	2.9	3.9
3:00	28.5	28.5	28.9	28.4	28.5	28.4	28.4	28.5	28.5	28.6	28.7	28.6	28.8	28.4	28.5	28.7	28.0	28.2	27.9	28.0	28.4	28.5	28.2	28.5	2.0	3.8
4:00	27.5	27.5	28.4	27.5	27.6	27.7	27.6	27.4	27.5	27.6	27.8	27.5	27.7	28.1	27.3	27.8	27.4	27.5	27.4	27.4	27.6	27.6	27.1	27.6	1.0	7.8
5:00	27.5	27.6	28.1	27.4	27.5	27.6	27.5	27.4	27.4	27.5	27.6	27.5	27.6	27.6	27.2	27.6	27.2	27.4	27.2	27.2	27.6	27.6	27.1	27.4	2.3	4.4
6:00	27.3	27.4	27.9	27.1	27.2	27.4	27.4	27.0	27.0	27.1	27.2	27.1	27.3	27.6	26.9	27.5	27.0	27.1	27.0	27.0	27.4	27.3	26.8	27.2	3.3	6.4
7:00	26.9	26.9	27.4	26.8	26.9	27.0	27.0	26.6	26.7	26.8	26.8	26.7	26.9	26.9	26.5	27.0	26.6	26.7	26.6	26.6	27.0	26.8	26.6	27.2	2.6	19.6
8:00	27.1	27.1	27.1	27.1	27.2	27.1	27.1	27.0	27.0	27.1	27.0	27.0	27.1	27.3	26.9	27.2	27.2	27.2	27.1	27.3	27.3	27.2	27.0	27.7	2.0	160.3
9:00	28.2	28.3	27.8	28.2	28.2	28.2	28.2	28.2	28.2	28.1	28.1	28.2	28.2	28.8	28.1	28.2	29.3	28.9	29.1	29.4	28.7	28.5	28.3	29.0	2.3	365.2
10:00	30.2	30.5	29.3	30.3	30.0	30.6	30.3	30.2	30.2	30.1	30.2	30.2	29.8	31.2	30.2	30.1	32.6	31.9	32.6	32.9	31.5	31.1	30.6	31.4	2.3	555.1
11:00	31.6	31.9	30.7	31.8	31.3	32.0	31.6	31.6	31.6	31.5	31.6	31.6	31.2	33.0	31.6	31.5	34.9	34.0	35.1	35.3	33.2	32.7	31.9	33.4	3.9	746.9
12:00	31.7	31.8	31.5	31.8	31.8	31.9	31.7	31.7	31.8	31.7	31.7	31.7	31.7	33.0	31.7	31.8	34.0	33.4	34.2	34.5	32.7	32.5	31.8	33.3	1.6	590.0
13:00	32.2	32.3	32.1	32.4	32.4	32.4	32.3	32.3	32.3	32.3	32.3	32.3	32.3	33.6	32.3	32.3	34.6	34.0	34.4	35.1	33.4	33.2	32.4	33.6	1.3	814.6
14:00	32.2	32.3	32.4	32.4	32.4	32.4	32.3	32.2	32.3	32.4	32.3	32.2	32.3	33.2	32.3	32.4	34.0	33.6	34.0	34.4	33.0	32.8	32.2	33.6	2.6	734.5
15:00	33.0	33.0	32.9	33.2	33.0	33.2	33.1	33.0	33.1	33.1	33.0	33.0	33.0	34.1	33.0	33.1	35.3	34.9	35.2	35.7	34.3	34.0	33.0	34.0	0.4	616.6
16:00	33.4	33.4	33.3	33.6	33.5	33.7	33.6	33.5	33.5	33.6	33.5	33.5	33.5	34.1	33.6	33.7	35.4	35.2	35.3	35.8	35.0	34.6	33.4	34.1	0.1	439.1
17:00	33.4	33.3	33.3	33.4	33.4	33.6	33.5	33.4	33.4	33.6	33.3	33.4	33.4	33.3	33.4	-435.1	34.6	34.5	34.6	34.9	34.4	34.0	33.3	33.8	1.0	229.7
18:00	32.5	32.5	32.8	32.5	32.6	32.7	32.7	32.5	32.6	32.8	32.6	32.6	32.7	32.5	32.6	32.8	33.0	33.0	33.0	33.2	33.0	32.8	32.4	32.4	1.0	57.1
19:00	31.6	31.6	32.0	31.5	31.7	31.7	31.7	31.6	31.6	31.8	31.7	31.7	31.7	31.3	31.6	31.8	31.6	31.6	31.6	31.6	31.8	31.7	31.4	31.3	0.0	3.2
20:00	31.1	31.1	31.5	31.0	31.2	31.1	31.2	31.1	31.1	31.3	31.2	31.2	31.2	30.7	31.2	31.3	30.8	30.9	30.8	30.8	31.1	31.0	30.9	30.9	0.0	2.8
21:00	30.7	30.7	31.1	30.6	30.7	30.6	30.7	30.8	30.8	30.9	30.9	30.8	30.9	30.4	30.8	31.0	30.3	30.4	30.2	30.2	30.5	30.6	30.4	30.2	2.0	4.0
22:00	30.1	30.1	30.6	30.1	30.2	30.1	30.2	30.1	30.1	30.3	30.3	30.2	30.3	29.7	30.2	30.4	29.7	29.8	29.7	29.7	30.0	30.0	29.9	29.8	1.3	3.6
23:00	29.5	29.6	30.0	29.5	29.6	29.5	29.5	29.6	29.6	29.7	29.8	29.7	29.8	29.1	29.7	29.8	29.3	29.3	29.2	29.3	29.5	29.5	29.3	29.2	2.0	3.3
0:00	29.3	29.4	29.7	29.2	29.2	29.2	29.3	29.4	29.4	29.4	29.5	29.5	29.5	29.0	29.4	29.5	29.1	29.2	29.0	29.1	29.3	29.4	28.9	28.6	1.3	4.9

Table A.5. Experimental results in the test cell on September 29th, 2004 (application of solar chimney).

Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10	TC11	TC12	TC13	TC14	TC15	TC16	TC17	TC18	TC19	TC20	TC21	TC22	TC23	TC24	wind	solar
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)
1:00	29.1	29.2	29.4	29.0	29.0	28.9	28.9	29.1	29.1	29.1	29.3	29.2	29.3	28.6	29.1	29.2	28.6	28.8	28.5	28.6	28.9	29.1	28.8	28.5	2.3	2.7
2:00	28.5	28.5	28.9	28.4	28.4	28.3	28.3	28.5	28.5	28.5	28.7	28.6	28.7	27.8	28.5	28.6	28.0	28.2	27.9	28.0	28.3	28.5	28.1	28.1	2.0	2.2
3:00	27.8	27.9	28.3	27.7	27.7	27.7	27.8	27.8	27.8	27.9	28.0	27.9	28.0	27.0	27.9	28.0	27.2	27.4	27.1	27.2	27.6	27.7	27.4	27.4	2.6	1.6
4:00	27.3	27.4	27.9	27.2	27.2	27.2	27.3	-15.1	27.4	27.5	27.6	27.4	27.6	26.7	27.4	27.6	26.8	26.9	26.7	26.8	27.1	27.2	26.9	27.0	2.3	2.1
5:00	27.0	27.1	27.5	26.9	26.9	27.0	27.0	27.0	27.1	27.1	27.2	27.2	27.3	26.4	27.1	27.2	26.3	26.4	26.2	26.2	26.5	26.7	26.7	26.7	3.3	3.2
6:00	26.7	26.8	27.1	26.6	26.7	26.6	26.7	26.7	26.8	26.8	26.9	26.9	27.0	26.3	26.8	26.9	26.1	26.3	25.9	26.0	26.2	26.6	26.4	26.2	3.9	2.4
7:00	26.5	26.5	26.9	26.4	26.4	26.4	26.5	26.5	26.5	26.5	26.6	26.6	26.6	26.1	26.5	26.6	25.8	26.0	25.8	25.8	26.2	26.3	26.1	26.1	2.6	20.4
8:00	27.0	27.1	27.1	27.0	27.1	27.0	27.0	27.1	27.1	27.1	27.1	27.2	27.2	27.4	27.1	27.1	27.2	27.2	27.2	27.2	27.2	27.2	26.9	26.9	2.0	175.5
9:00	28.3	28.4	27.9	28.4	28.3	28.4	28.3	28.3	28.3	28.3	28.3	28.4	28.4	28.8	28.4	28.4	29.5	29.2	29.5	29.6	29.3	28.9	28.3	28.8	2.2	369.4
10:00	29.9	30.1	29.2	30.0	29.8	30.1	30.0	29.9	29.9	29.9	29.9	29.9	29.8	30.8	29.9	29.9	32.3	31.7	32.3	32.6	31.4	31.0	30.1	31.1	2.0	578.3
11:00	31.3	31.6	30.5	31.5	31.2	31.6	31.4	31.4	31.4	31.3	31.4	31.4	31.2	32.5	31.4	31.4	34.5	33.7	34.7	35.0	33.2	32.7	31.6	32.5	0.3	766.2
12:00	32.3	32.4	31.6	32.4	32.2	32.4	32.3	32.3	32.3	32.3	32.3	32.3	32.2	33.6	32.4	32.3	35.7	34.9	36.0	36.2	34.3	33.8	32.5	33.6	0.7	848.8
13:00	33.3	33.4	32.7	33.4	33.3	33.5	33.3	33.3	33.3	33.3	33.4	33.4	33.2	34.4	33.4	33.4	36.9	36.2	37.2	37.6	35.6	35.0	33.4	34.5	0.0	815.7
14:00	33.8	33.8	33.4	33.9	33.8	34.0	33.8	33.8	33.8	33.9	33.8	33.8	33.7	34.7	33.9	33.9	36.7	36.1	37.1	37.2	35.5	35.0	33.9	34.8	0.4	570.4
15:00	33.7	33.8	33.6	33.7	33.7	33.9	33.8	33.7	33.7	33.8	33.8	33.7	33.7	34.6	33.7	33.8	36.0	35.6	36.3	36.6	35.2	34.8	33.7	34.7	0.4	476.9
16:00	34.4	34.4	34.2	34.4	34.3	34.7	34.4	34.3	34.4	34.5	34.4	34.4	34.3	35.3	34.4	34.5	36.6	36.1	37.0	37.0	35.6	35.2	34.3	35.6	1.6	363.9
17:00	33.6	33.6	33.9	33.6	33.7	33.9	33.8	33.6	33.7	33.9	33.7	33.7	33.7	34.1	33.6	33.8	34.8	34.6	34.9	35.1	34.5	34.2	33.4	33.9	0.4	210.0
18:00	31.4	31.5	32.5	31.4	31.6	31.5	31.6	31.6	31.6	32.0	32.0	31.8	31.9	30.8	31.8	32.2	31.7	31.7	31.7	31.9	32.1	31.8	30.9	30.9	4.2	40.4
19:00	30.4	30.4	31.3	30.2	30.3	30.2	30.3	30.4	30.4	30.6	30.8	30.6	30.7	29.7	30.6	30.8	30.4	30.4	30.3	30.5	30.7	30.6	29.9	30.1	1.0	1.8
20:00	29.6	29.6	30.2	29.5	29.6	29.5	29.6	29.7	29.7	29.8	29.9	29.9	29.9	28.8	29.8	29.8	29.3	29.4	29.3	29.4	29.6	29.7	29.4	29.5	1.9	1.3
21:00	28.7	28.7	29.1	28.7	28.7	28.6	28.8	28.9	28.8	28.9	28.9	29.0	29.0	28.0	28.9	28.8	28.3	28.4	28.2	28.3	28.5	28.7	28.6	28.5	1.0	1.3
22:00	28.5	28.5	28.9	28.4	28.4	28.3	28.4	28.6	28.5	28.6	28.6	28.7	28.7	27.9	28.5	28.5	28.0	28.1	27.9	28.0	28.1	28.5	28.3	27.9	2.0	2.9
23:00	28.3	28.3	28.7	28.1	28.2	28.1	28.2	28.3	28.3	28.4	28.5	28.4	28.5	27.8	28.3	28.5	28.1	28.2	28.0	28.1	28.4	28.4	27.9	28.1	2.3	2.9
0:00	28.1	28.2	28.6	28.0	28.1	28.0	28.2	28.2	28.2	28.3	28.3	28.3	28.4	27.7	28.2	28.4	27.9	28.0	27.9	28.0	28.2	28.2	27.8	27.9	2.6	4.8

Table A.6. Experimental results in the test cell on October 1st, 2004 (application of solar chimney).

Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10	TC11	TC12	TC13	TC14	TC15	TC16	TC17	TC18	TC19	TC20	TC21	TC22	TC23	TC24	wind	solar
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)
1:00	25.5	25.4	25.6	25.5	25.5	25.5	25.5	25.5	25.5	25.6	25.6	25.6	25.6	25.5	25.6	25.7	25.1	25.3	25.1	25.2	25.4	25.4	25.4	25.4	1.9	5.2
2:00	25.2	25.2	25.4	25.2	25.3	25.2	25.3	25.3	25.3	25.4	25.4	25.4	25.4	25.3	25.4	25.5	25.0	25.1	25.1	25.1	25.3	25.2	25.0	25.0	1.6	1.8
3:00	25.2	25.1	25.4	25.2	25.3	25.2	25.2	25.2	25.2	25.3	25.3	25.3	25.3	25.3	25.3	25.4	25.0	25.1	25.1	25.0	25.3	25.3	24.9	25.1	1.2	3.9
4:00	25.4	25.3	25.4	25.4	25.4	25.3	25.4	25.3	25.4	25.5	25.4	25.4	25.4	25.5	25.4	25.5	25.2	25.2	25.2	25.2	25.3	25.3	25.1	25.3	1.3	4.4
5:00	25.6	25.5	25.6	25.6	25.6	25.5	25.5	25.5	25.5	25.6	25.6	25.6	25.6	25.6	25.6	25.7	25.3	25.3	25.3	25.3	25.4	25.4	25.3	25.5	1.4	6.2
6:00	25.4	25.3	25.4	25.4	25.4	25.3	25.4	25.3	25.3	25.5	25.4	25.4	25.4	25.4	25.4	25.5	25.1	25.2	25.1	25.1	25.3	25.3	25.1	25.3	1.4	2.3
7:00	25.2	25.2	25.2	25.2	25.3	25.2	25.2	25.2	25.2	25.3	25.3	25.2	25.3	25.3	25.2	25.4	25.1	25.1	25.0	25.0	25.2	25.2	25.0	25.2	1.5	12.7
8:00	25.4	25.4	25.4	25.4	25.5	25.4	25.4	25.4	25.4	25.5	25.4	25.4	25.5	25.5	25.4	25.5	25.4	25.4	25.3	25.4	25.5	25.4	25.3	25.7	1.6	82.8
9:00	26.1	26.2	26.0	26.2	26.1	26.2	26.1	26.2	26.2	26.1	26.1	26.2	26.2	26.2	26.2	26.2	26.7	26.8	26.5	26.7	26.8	26.6	26.2	26.7	2.0	309.6
10:00	27.6	27.8	27.2	27.6	27.4	27.7	27.6	27.6	27.6	27.5	27.5	27.6	27.5	27.5	27.7	27.6	29.3	29.4	28.9	29.4	29.4	29.0	27.7	28.6	1.8	604.1
11:00	28.9	29.1	28.5	29.0	28.7	29.1	28.9	29.0	29.0	28.9	28.9	29.0	28.9	28.8	29.0	28.9	31.4	31.5	30.9	31.5	31.4	30.8	29.1	29.9	2.0	796.8
12:00	30.2	30.5	29.8	30.3	29.9	30.5	30.2	30.3	30.3	30.2	30.2	30.2	30.1	30.0	30.3	30.1	33.6	33.0	33.3	34.0	32.4	32.0	30.5	31.6	1.8	730.6
13:00	30.9	31.0	30.6	30.9	30.7	31.0	30.8	30.9	30.9	30.8	30.8	30.8	30.8	30.7	30.8	30.8	33.6	32.8	33.3	33.7	32.1	32.1	31.0	32.1	1.7	582.1
14:00	30.5	30.4	30.3	30.4	30.4	30.3	30.3	30.5	30.4	30.5	30.4	30.5	30.5	30.4	30.4	30.5	32.0	31.8	31.9	32.2	31.5	31.3	30.2	30.9	2.6	437.9
15:00	26.2	26.2	27.1	26.0	26.1	25.8	26.0	26.2	26.1	26.4	26.5	26.4	26.2	26.2	26.3	26.6	26.2	26.2	26.0	26.2	26.6	26.4	25.6	25.3	1.7	27.4
16:00	26.3	26.3	26.6	26.2	26.2	26.1	26.2	26.3	26.2	26.3	26.4	26.4	26.3	26.3	26.3	26.4	26.3	26.3	26.2	26.4	26.6	26.4	26.0	26.6	2.0	44.0
17:00	26.9	27.0	26.9	26.9	26.9	27.0	26.9	26.9	26.9	26.9	26.9	27.0	26.9	26.9	27.0	27.0	27.6	27.5	27.5	27.7	27.5	27.3	26.9	27.8	2.6	105.7
18:00	27.1	27.2	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.2	27.1	27.2	27.1	27.1	27.2	27.2	27.5	27.5	27.5	27.6	27.4	27.3	27.1	27.7	3.5	25.0
19:00	27.0	27.1	27.1	27.0	27.0	27.0	27.0	27.0	27.0	27.1	27.1	27.1	27.1	27.0	27.1	27.1	27.0	27.0	27.0	27.0	27.1	27.1	26.9	27.2	2.7	0.3
20:00	27.0	27.0	27.1	26.9	26.9	26.9	26.9	26.9	26.9	27.0	27.0	27.0	26.9	26.9	27.0	27.0	26.8	26.8	26.8	26.8	27.0	26.9	26.8	27.2	1.8	0.0
21:00	26.9	26.8	27.0	26.8	26.8	26.8	26.8	26.9	26.8	26.9	26.9	26.9	26.9	26.9	26.9	27.0	26.7	26.8	26.8	26.7	26.8	26.9	26.6	26.8	2.1	0.4
22:00	26.1	26.1	26.4	26.1	26.1	25.9	26.1	26.2	26.1	26.2	26.2	26.2	26.2	26.2	26.2	26.3	26.0	26.1	26.0	26.0	26.2	26.2	25.4	25.3	1.4	0.2
23:00	24.5	24.5	24.9	24.3	24.4	24.1	24.3	24.5	24.4	24.5	24.7	24.6	24.5	24.5	24.6	24.7	24.5	24.5	24.5	24.6	24.6	24.6	23.6	23.9	1.4	0.0
0:00	24.1	24.2	24.5	24.0	24.1	23.9	24.0	24.2	24.1	24.2	24.3	24.3	24.2	24.2	24.2	24.3	24.1	24.2	24.1	24.1	24.3	24.2	23.7	23.6	2.6	0.4

Table A.7. Experimental results in the test cell on October 3rd, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m^2)
1:00	24.2	24.2	24.3	24.3	24.3	24.1	24.3	24.2	24.3	24.4	24.3	24.3	24.3	24.4	24.3	24.5	24.1	24.2	24.1	24.1	24.4	24.3	24.1	24.0	1.8	0.1
2:00	24.3	24.3	24.4	24.4	24.4	24.2	24.4	24.3	24.3	24.4	24.3	24.4	24.4	24.4	24.4	24.5	24.2	24.3	24.2	24.2	24.4	24.3	24.2	24.2	1.9	0.6
3:00	24.7	24.7	24.7	24.7	24.7	24.6	24.7	24.7	24.7	24.8	24.7	24.7	24.8	24.8	24.7	24.8	24.6	24.7	24.6	24.6	24.7	24.7	24.6	24.7	1.8	0.3
4:00	25.0	24.9	24.9	24.9	25.0	24.8	24.9	24.9	24.9	25.0	24.9	25.0	25.0	25.0	25.0	25.0	24.8	24.8	24.8	24.8	24.8	24.8	25.0	24.9	1.5	0.7
5:00	24.5	24.5	24.5	24.4	24.5	24.3	24.4	24.5	24.4	24.5	24.5	24.5	24.5	24.5	24.5	24.5	24.3	24.3	24.3	24.3	24.4	24.4	24.5	24.5	1.4	0.2
6:00	24.0	24.0	24.1	24.0	24.0	24.0	24.0	24.0	24.0	24.1	24.0	24.1	24.0	24.0	24.0	24.1	23.9	23.9	23.9	23.9	23.9	23.9	24.0	24.3	1.4	0.3
7:00	23.7	23.7	23.8	23.6	23.6	23.7	23.6	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.7	23.8	23.6	23.6	23.7	23.7	23.7	23.7	23.7	24.0	1.1	18.2
8:00	24.0	24.2	23.9	24.0	23.9	24.2	24.0	24.0	24.1	24.1	24.1	24.1	24.0	24.0	24.1	24.1	24.6	24.5	24.5	24.6	24.6	24.4	24.2	24.8	1.2	194.6
9:00	25.1	25.5	24.8	25.2	24.9	25.6	25.2	25.2	25.2	25.2	25.2	25.2	25.1	24.9	25.3	25.2	26.9	26.8	26.7	27.1	26.7	26.3	25.3	26.4	1.4	432.4
10:00	26.4	26.9	25.9	26.5	25.9	27.0	26.6	26.5	26.5	26.4	26.6	26.4	26.1	26.0	26.5	26.5	29.8	29.0	29.6	30.2	28.8	28.2	26.6	27.9	1.5	645.3
11:00	27.5	28.0	27.0	27.6	27.0	28.1	27.6	27.6	27.6	27.6	27.7	27.6	27.2	27.1	27.7	27.6	32.0	30.8	32.1	32.8	29.9	29.6	27.7	29.3	1.6	812.3
12:00	28.8	29.3	28.3	29.0	28.3	29.4	29.0	28.9	29.0	28.9	29.0	28.9	28.4	28.4	29.0	28.9	33.8	32.4	34.3	34.8	31.2	31.0	29.1	30.7	1.6	882.9
13:00	29.7	30.1	29.2	29.8	29.2	30.1	29.8	29.8	29.8	29.8	29.7	29.7	29.4	29.3	29.8	29.7	34.6	33.3	35.1	35.5	31.9	31.6	29.9	31.4	1.5	827.4
14:00	29.6	29.6	29.4	29.6	29.4	29.6	29.5	29.6	29.5	29.6	29.4	29.5	29.5	29.5	29.6	29.6	32.0	31.4	31.9	32.2	30.9	30.6	29.5	30.5	2.1	533.1
15:00	30.4	30.6	30.1	30.5	30.2	30.7	30.5	30.5	30.5	30.5	30.4	30.5	30.3	30.3	30.5	30.4	33.1	32.4	33.3	33.7	31.8	31.6	30.6	31.7	1.4	346.5
16:00	30.7	30.8	30.4	30.8	30.5	30.9	30.7	30.7	30.7	30.8	30.6	30.7	30.6	30.6	30.7	30.7	32.6	32.3	32.8	33.1	32.1	31.8	30.7	31.7	1.3	320.9
17:00	30.9	31.0	30.7	30.9	30.7	31.1	30.9	30.9	30.9	30.9	30.8	30.9	30.8	30.8	30.9	30.9	32.4	32.2	32.6	32.7	32.0	31.7	30.9	31.7	1.6	173.1
18:00	30.2	30.2	30.3	30.2	30.2	30.3	30.2	30.3	30.2	30.4	30.3	30.3	30.3	30.2	30.3	30.4	30.9	30.8	30.9	31.1	30.9	30.7	30.0	30.2	1.3	43.8
19:00	29.1	29.1	29.4	29.1	29.1	29.0	29.1	29.1	29.1	29.2	29.3	29.2	29.2	29.1	29.2	29.3	29.1	29.1	29.1	29.2	29.4	29.2	28.9	28.9	1.2	0.1
20:00	28.7	28.7	29.0	28.6	28.6	28.6	28.7	28.7	28.7	28.8	28.8	28.8	28.7	28.7	28.8	28.9	28.6	28.6	28.6	28.6	28.8	28.7	28.5	28.6	1.0	0.0
21:00	28.3	28.3	28.6	28.2	28.2	28.2	28.3	28.3	28.3	28.4	28.4	28.4	28.3	28.3	28.3	28.5	28.0	28.1	28.1	28.0	28.2	28.2	28.1	28.2	1.1	0.0
22:00	28.0	28.1	28.3	28.0	28.0	28.0	28.0	28.0	28.0	28.1	28.1	28.1	28.1	28.0	28.1	28.2	27.7	27.7	27.8	27.7	27.9	27.9	27.8	27.9	2.3	0.0
23:00	27.8	27.8	28.0	27.7	27.7	27.7	27.7	27.8	27.7	27.8	27.8	27.8	27.8	27.8	27.8	27.9	27.4	27.4	27.5	27.4	27.5	27.6	27.6	27.6	1.2	0.0
0:00	27.4	27.4	27.6	27.3	27.3	27.3	27.3	27.4	27.3	27.4	27.5	27.5	27.4	27.4	27.4	27.5	27.0	26.9	27.1	27.0	27.0	27.1	27.2	27.2	1.0	0.0

Table A.8. Experimental results in the test cell on October 7th, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m^2)
1:00	27.8	27.8	28.0	27.7	27.5	27.7	27.7	27.8	27.7	27.8	27.9	27.8	27.7	27.7	27.8	27.8	27.2	27.3	27.1	27.2	27.6	27.7	27.4	27.4	0.3	0.0
2:00	27.6	27.6	27.8	27.5	27.3	27.5	27.5	27.6	27.5	27.6	27.7	27.6	27.5	27.5	27.5	27.6	27.1	27.2	27.0	27.1	27.4	27.5	27.3	27.3	0.3	0.0
3:00	27.1	27.1	27.5	27.0	26.9	27.0	27.0	27.1	27.1	27.1	27.2	27.1	27.1	27.1	27.1	27.2	26.7	26.8	26.7	26.7	27.0	27.0	26.7	26.8	2.0	0.0
4:00	26.9	27.0	27.3	26.8	26.7	26.9	26.9	27.0	26.9	27.0	27.0	27.0	26.9	26.9	26.9	27.0	26.3	26.4	26.3	26.3	26.7	26.8	26.6	26.6	2.2	0.0
5:00	26.7	26.7	27.0	26.6	26.6	26.7	26.7	26.7	26.7	26.8	26.8	26.8	26.7	26.7	26.7	26.8	26.2	26.3	26.2	26.1	26.5	26.6	26.4	26.4	1.6	0.0
6:00	26.5	26.5	26.8	26.4	26.3	26.5	26.5	26.5	26.5	26.5	26.6	26.6	26.5	26.5	26.5	26.6	26.1	26.2	26.0	26.0	26.4	26.5	26.2	26.3	2.4	0.0
7:00	26.5	26.5	26.7	26.4	26.4	26.5	26.5	26.5	26.5	26.5	26.6	26.6	26.5	26.5	26.5	26.6	26.0	26.0	26.0	25.9	26.2	26.3	26.3	26.4	0.2	18.5
8:00	27.0	27.1	26.9	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.1	27.1	27.0	27.0	27.0	27.3	27.2	27.2	27.3	27.2	27.2	27.0	27.6	1.7	168.1
9:00	27.9	28.1	27.6	28.0	27.9	28.1	27.9	28.0	27.9	27.9	27.9	28.0	27.9	27.9	28.0	27.9	29.2	28.9	29.0	29.3	28.6	28.4	28.0	28.8	1.7	281.6
10:00	28.8	29.0	28.5	28.9	28.7	28.9	28.8	28.8	28.8	28.8	28.8	28.9	28.8	28.8	28.9	28.8	30.2	29.8	30.2	30.4	29.6	29.4	29.0	30.0	2.4	284.5
11:00	29.6	29.8	29.3	29.7	29.5	29.8	29.6	29.6	29.6	29.6	29.6	29.6	29.5	29.5	29.7	29.6	31.6	31.0	31.7	31.9	30.4	30.3	29.9	31.0	2.4	487.1
12:00	30.6	30.8	30.1	30.7	30.4	30.9	30.7	30.6	30.6	30.6	30.6	30.6	30.5	30.4	30.7	30.6	33.4	32.7	33.5	34.0	32.1	31.8	31.0	32.0	2.3	652.6
13:00	31.5	31.7	31.1	31.8	31.5	31.8	31.6	31.5	31.6	31.6	31.5	31.5	31.4	31.5	31.6	31.6	34.0	33.4	34.4	34.4	32.8	32.5	32.1	33.0	3.2	424.0
14:00	32.1	32.3	31.7	32.3	31.9	32.4	32.2	32.1	32.2	32.2	32.1	32.1	32.0	32.0	32.2	32.2	35.2	34.4	35.4	35.7	33.8	33.4	32.3	33.6	2.2	605.5
15:00	32.7	32.7	32.3	32.9	32.6	33.0	32.8	32.7	32.7	32.9	32.8	32.7	32.6	32.6	32.8	32.9	35.3	34.9	35.7	35.7	34.3	33.8	33.0	33.9	1.4	572.7
16:00	32.5	32.5	32.4	32.6	32.5	32.7	32.6	32.5	32.6	32.7	32.5	32.5	32.6	32.6	32.6	32.7	34.1	33.8	34.3	34.5	33.6	33.3	32.5	33.2	0.7	246.0
17:00	31.4	31.3	31.7	31.4	31.5	31.4	31.5	31.4	31.4	31.7	31.4	31.4	31.5	31.5	31.5	31.7	32.1	32.0	32.2	32.3	32.1	31.8	31.1	31.6	1.2	103.7
18:00	30.5	30.4	30.7	30.4	30.5	30.5	30.5	30.5	30.5	30.7	30.5	30.5	30.5	30.5	30.5	30.6	30.7	30.7	30.7	30.8	30.7	30.6	30.2	30.6	1.0	29.6
19:00	30.0	30.0	30.3	30.0	30.0	30.1	30.1	30.0	30.0	30.2	30.1	30.0	30.0	30.0	30.0	30.1	29.7	29.7	29.7	29.7	29.8	29.8	29.9	30.1	0.8	0.8
20:00	29.9	29.9	30.0	29.9	29.8	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	29.9	30.0	29.4	29.2	29.4	29.3	29.5	29.4	29.8	29.8	0.3	0.0
21:00	29.3	29.2	29.7	29.3	29.2	29.4	29.4	29.4	29.4	29.5	29.6	29.4	29.4	29.3	29.4	29.5	28.8	29.0	28.7	28.7	29.0	29.3	29.1	29.1	4.0	0.0
22:00	28.7	28.8	29.4	28.7	28.5	28.8	28.8	28.8	28.8	28.8	29.1	28.8	28.7	28.7	28.8	28.9	28.5	28.6	28.5	28.4	28.8	28.8	28.2	28.4	1.3	0.0
23:00	28.5	28.5	29.1	28.5	28.2	28.5	28.5	28.6	28.6	28.6	28.8	28.6	28.5	28.5	28.5	28.7	28.1	28.3	28.1	28.1	28.4	28.5	28.1	28.1	2.1	0.0
0:00	28.1	28.1	28.7	28.0	27.9	27.9	28.0	28.1	28.1	28.2	28.3	28.2	28.1	28.0	28.1	28.2	27.9	28.0	27.8	27.9	28.1	28.1	27.7	27.8	3.0	0.0

Table A.9. Experimental results in the test cell on October 9th, 2004 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m^2)
1:00	29.0	29.0	29.3	29.0	29.1	29.1	29.1	29.0	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.2	28.8	28.7	28.8	28.7	29.0	28.9	28.9	28.9	3.5	0.0
2:00	28.6	28.6	28.9	28.5	28.5	28.5	28.5	28.6	28.5	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.3	28.4	28.3	28.3	28.6	28.6	28.2	28.4	2.3	0.0
3:00	28.1	28.1	28.6	28.0	27.9	27.9	28.0	28.1	28.1	28.2	28.3	28.2	28.1	28.0	28.1	28.3	27.9	28.0	27.9	28.0	28.1	28.2	27.7	27.7	2.1	0.0
4:00	27.8	27.8	28.3	27.7	27.6	27.6	27.7	27.8	27.8	27.8	28.0	27.9	27.8	27.7	27.8	28.0	27.6	27.7	27.6	27.6	27.8	27.8	27.4	27.5	3.9	0.0
5:00	27.4	27.4	27.9	27.3	27.2	27.2	27.3	27.4	27.3	27.4	27.6	27.5	27.4	27.3	27.4	27.6	27.2	27.3	27.2	27.2	27.4	27.4	27.0	27.1	3.6	0.0
6:00	27.2	27.2	27.6	27.1	27.0	27.0	27.1	27.2	27.2	27.2	27.4	27.3	27.2	27.1	27.2	27.3	27.0	27.0	26.9	27.0	27.2	27.2	26.8	26.9	3.1	0.0
7:00	27.1	27.1	27.5	27.0	27.0	27.0	27.1	27.1	27.1	27.2	27.3	27.2	27.2	27.1	27.2	27.3	26.8	26.9	26.7	26.8	27.0	27.1	26.8	26.9	3.2	19.2
8:00	27.4	27.5	27.6	27.4	27.4	27.4	27.4	27.5	27.5	27.5	27.5	27.5	27.6	27.5	27.5	27.6	27.6	27.5	27.5	27.6	27.7	27.6	27.2	27.4	2.0	163.2
9:00	28.5	28.6	28.3	28.6	28.5	28.6	28.6	28.6	28.6	28.5	28.5	28.6	28.6	28.6	28.7	28.6	29.7	29.4	29.6	29.9	29.5	29.1	28.6	29.0	2.4	376.3
10:00	30.0	30.3	29.4	30.2	29.9	30.3	30.2	30.0	30.1	30.0	30.0	30.1	30.0	29.9	30.1	30.1	32.5	31.9	32.6	32.9	31.8	31.2	30.3	31.0	2.6	590.2
11:00	31.1	31.3	30.5	31.4	31.1	31.4	31.3	31.1	31.2	31.1	31.1	31.1	31.1	31.1	31.1	31.1	34.1	33.3	34.4	34.7	32.6	32.2	31.6	32.2	2.4	705.9
12:00	32.0	32.1	31.4	32.2	31.9	32.2	32.1	32.0	32.0	32.0	32.0	32.0	31.9	31.9	32.0	32.0	35.7	34.8	36.2	36.5	34.1	33.5	32.5	33.2	2.2	819.7
13:00	32.5	32.6	32.1	32.7	32.4	32.7	32.6	32.5	32.6	32.6	32.5	32.5	32.5	32.5	32.6	32.6	36.0	35.2	36.6	36.7	34.3	33.9	32.8	33.6	2.3	665.7
14:00	33.4	33.6	32.8	33.6	33.3	33.7	33.5	33.4	33.5	33.5	33.5	33.4	33.3	33.3	33.5	33.5	37.1	36.3	37.7	37.9	35.0	34.7	33.9	34.9	3.0	781.7
15:00	34.0	34.1	33.6	34.2	33.9	34.3	34.1	34.0	34.1	34.2	34.1	34.0	34.0	34.0	34.1	34.2	37.0	36.4	37.7	37.5	35.5	35.1	34.4	35.3	2.5	604.4
16:00	34.0	34.1	33.8	34.1	33.9	34.3	34.1	34.0	34.1	34.2	34.2	34.0	34.0	34.0	34.1	34.2	36.0	35.7	36.5	36.4	35.1	34.8	34.3	35.1	3.0	388.2
17:00	34.0	34.0	34.0	34.0	33.8	34.3	34.0	34.0	34.0	34.2	34.1	34.0	34.0	33.9	34.0	34.2	35.6	35.3	36.0	35.9	35.0	34.7	33.9	34.6	2.6	179.5
18:00	33.2	33.3	33.6	33.1	33.1	33.4	33.3	33.2	33.2	33.5	33.6	33.2	33.2	33.2	33.3	33.5	33.9	33.8	34.2	34.1	33.8	33.5	32.9	33.4	3.9	38.3
19:00	32.2	32.2	32.7	32.1	32.0	32.1	32.2	32.2	32.2	32.4	32.5	32.2	32.2	32.1	32.2	32.5	32.2	32.3	32.4	32.4	32.5	32.3	31.7	32.0	3.9	0.0
20:00	31.5	31.6	32.0	31.5	31.4	31.4	31.5	31.5	31.6	31.8	31.8	31.6	31.6	31.5	31.6	31.8	31.4	31.5	31.5	31.5	31.8	31.7	31.1	31.3	3.3	0.0
21:00	31.1	31.1	31.5	31.0	30.9	31.0	31.1	31.1	31.1	31.2	31.3	31.1	31.1	31.0	31.1	31.3	30.8	30.9	30.8	30.9	31.1	31.1	30.7	30.8	3.5	0.0
22:00	30.6	30.6	31.0	30.5	30.4	30.4	30.5	30.6	30.6	30.7	30.8	30.6	30.6	30.5	30.6	30.8	30.3	30.4	30.4	30.4	30.7	30.6	30.2	30.3	2.5	0.0
23:00	30.1	30.1	30.6	30.0	29.9	29.9	30.0	30.1	30.1	30.2	30.3	30.2	30.1	30.0	30.1	30.3	29.9	30.0	29.9	30.0	30.2	30.1	29.8	29.8	2.2	0.0
0:00	30.0	30.0	30.3	29.8	29.8	29.9	29.9	30.0	30.0	30.0	30.1	30.0	30.0	29.9	30.0	30.1	29.5	29.6	29.4	29.5	29.8	29.9	29.6	29.5	0.3	0.0

Table A.10. Experimental results in the test and controlled cells on February 27th, 2005 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m2)	CC average(°C)	Ambient (°C)
1:00	28.4	28.4	28.4	28.0	28.1	28.2	28.1	28.4	28.3	28.3	28.3	28.4	28.3	27.5	28.3	28.3	27.4	27.8	27.4	27.6	28.2	28.2	27.8	28.2	0.6	0.0	28.4	27.1
2:00	28.2	28.3	28.2	27.9	28.0	28.0	28.0	28.2	28.1	28.2	28.1	28.3	28.1	27.4	28.2	28.2	27.3	27.7	27.3	27.5	28.1	28.0	27.7	28.1	0.4	0.0	28.2	26.7
3:00	27.5	27.6	27.6	27.3	27.3	27.2	27.3	27.5	27.5	27.6	27.3	27.7	27.5	26.9	27.5	27.6	27.3	27.5	27.3	27.4	27.6	27.6	27.0	27.5	0.1	0.0	27.8	25.8
4:00	26.9	27.0	26.9	26.7	26.6	26.6	26.7	26.9	26.9	27.0	26.6	27.0	26.8	26.3	26.9	27.0	26.6	26.8	26.6	26.7	27.0	27.0	26.4	26.8	0.1	0.0	27.4	25.1
5:00	26.1	26.2	26.1	25.9	25.9	25.8	26.0	26.2	26.1	26.2	25.9	26.3	26.1	25.6	26.2	26.2	25.9	26.1	25.8	26.0	26.2	26.2	25.7	26.1	0.1	0.0	26.7	24.7
6:00	25.5	25.6	25.5	25.3	25.4	25.3	25.4	25.6	25.5	25.6	25.4	25.7	25.5	25.1	25.6	25.6	25.3	25.5	25.3	25.4	25.6	25.6	25.1	25.5	0.3	0.0	26.0	24.9
7:00	25.4	25.4	25.3	25.2	25.3	25.2	25.3	25.5	25.4	25.4	25.2	25.5	25.4	25.1	25.4	25.5	25.2	25.3	25.1	25.2	25.4	25.4	25.1	25.4	0.3	4.4	25.8	24.8
8:00	25.6	25.7	25.6	25.5	25.5	25.5	25.5	25.7	25.6	25.6	25.5	25.8	25.6	25.6	25.7	25.7	25.6	25.6	25.6	25.6	25.7	25.7	25.5	25.6	0.3	59.6	26.0	26.5
9:00	26.5	26.5	26.4	26.5	26.4	26.4	26.4	26.5	26.5	26.4	26.4	26.5	26.5	27.0	26.5	26.4	26.9	26.7	27.0	27.0	26.7	26.6	26.6	26.5	0.3	224.7	26.6	28.7
10:00	27.8	27.9	27.9	28.0	27.8	27.9	27.9	27.8	27.9	27.8	27.8	27.8	27.8	28.9	27.9	27.8	28.8	28.3	28.9	28.7	28.0	28.0	28.3	27.8	0.4	397.3	27.8	31.3
11:00	29.5	29.7	29.6	29.7	29.4	29.7	29.6	29.5	29.5	29.4	29.5	29.5	29.4	31.0	29.5	29.4	31.6	30.5	31.9	31.4	30.0	30.0	30.1	29.4	0.2	568.4	29.4	34.7
12:00	31.1	31.4	31.2	31.3	30.9	31.4	31.2	31.1	31.2	31.1	31.2	31.1	30.9	32.8	31.1	31.0	34.1	32.5	34.3	33.6	31.7	32.0	31.7	30.9	0.3	688.0	31.1	34.6
13:00	31.7	31.9	31.8	31.8	31.5	31.9	31.7	31.7	31.7	31.7	31.7	31.7	31.5	33.3	31.7	31.7	34.3	33.0	34.5	33.9	32.3	32.4	32.1	31.5	0.3	437.5	32.3	35.0
14:00	33.0	33.3	33.2	33.3	32.9	33.3	33.2	33.0	33.1	33.0	33.1	33.0	32.9	34.9	33.1	33.0	36.1	34.7	36.3	35.7	33.8	33.9	33.8	32.8	0.7	519.5	33.3	35.4
15:00	34.1	34.3	34.2	34.3	34.0	34.3	34.2	34.1	34.2	34.1	34.1	34.1	34.0	35.4	34.1	34.1	37.2	35.9	37.4	37.0	35.0	35.0	34.7	34.0	1.1	604.2	34.2	35.9
16:00	34.8	34.9	34.8	35.0	34.7	35.0	34.9	34.8	34.9	34.9	34.8	34.8	34.8	35.9	34.9	34.9	37.3	36.1	37.3	37.0	35.4	35.4	35.3	34.8	1.4	494.3	34.9	34.8
17:00	34.5	34.6	34.5	34.6	34.5	34.7	34.6	34.5	34.5	34.6	34.5	34.5	34.5	35.2	34.5	34.6	35.9	35.2	35.9	35.7	34.8	34.8	34.8	34.5	1.3	306.7	34.4	33.6
18:00	33.6	33.6	33.5	33.5	33.5	33.6	33.5	33.6	33.6	33.7	33.6	33.6	33.6	33.7	33.6	33.7	33.8	33.7	33.9	33.8	33.7	33.7	33.6	33.6	1.2	102.2	33.5	32.0
19:00	32.1	32.1	32.1	31.9	32.0	32.0	31.9	32.1	32.1	32.2	32.2	32.2	32.1	31.7	32.2	32.2	31.5	31.8	31.6	31.5	32.1	32.1	31.8	32.1	1.1	4.4	32.0	30.2
20:00	30.6	30.6	30.6	30.3	30.4	30.4	30.4	30.6	30.6	30.7	30.7	30.8	30.6	29.9	30.7	30.7	29.7	30.1	29.8	29.8	30.5	30.6	30.1	30.6	1.3	0.0	30.6	28.5
21:00	29.4	29.4	29.4	29.0	29.1	29.2	29.1	29.4	29.3	29.4	29.4	29.5	29.3	28.5	29.4	29.4	28.3	28.8	28.4	28.5	29.3	29.3	28.8	29.3	1.0	0.0	29.4	27.8
22:00	28.6	28.6	28.5	28.2	28.4	28.3	28.3	28.6	28.5	28.5	28.6	28.7	28.5	27.7	28.5	28.6	27.6	28.0	27.6	27.7	28.4	28.5	28.0	28.5	1.1	0.0	28.6	27.3
23:00	28.0	28.0	27.9	27.7	27.9	27.7	27.7	28.0	27.9	28.0	28.0	28.1	28.0	27.2	28.0	28.0	27.1	27.5	27.1	27.2	27.8	27.9	27.5	28.0	1.3	0.0	28.1	26.6
0:00	27.6	27.6	27.6	27.4	27.4	27.5	27.4	27.6	27.6	27.6	27.6	27.7	27.6	26.7	27.6	27.6	26.5	26.9	26.5	26.7	27.4	27.4	27.2	27.6	0.7	0.0	27.7	26.6

Table A.11. Experimental results in the test and controlled cells on February 28th, 2005 (application of solar chimney).

Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10	TC11	TC12	TC13	TC14	TC15	TC16	TC17	TC18	TC19	TC20	TC21	TC22	TC23	TC24	wind	solar	CC average	Ambient
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)	(°C)	(°C)
1:00	27.2	27.3	27.2	27.0	27.0	27.1	27.1	27.2	27.2	27.3	27.1	27.3	27.2	26.2	27.2	27.3	26.4	26.8	26.4	26.6	27.2	27.1	26.7	27.1	0.2	0.0	27.2	25.9
2:00	26.2	26.2	26.2	26.0	25.9	25.9	26.0	26.2	26.1	26.2	25.9	26.3	26.1	25.5	26.1	26.2	25.7	26.0	25.6	25.8	26.2	26.2	25.6	26.1	0.0	0.0	26.6	25.0
3:00	25.4	25.4	25.3	25.1	25.1	25.0	25.2	25.4	25.3	25.4	25.1	25.5	25.3	24.7	25.4	25.4	25.0	25.2	24.9	25.0	25.4	25.4	24.9	25.3	0.1	0.0	25.8	24.1
4:00	24.7	24.7	24.6	24.5	24.5	24.4	24.5	24.8	24.6	24.7	24.5	24.8	24.6	24.1	24.7	24.7	24.4	24.6	24.3	24.4	24.6	24.7	24.3	24.6	0.1	0.2	25.1	24.4
5:00	24.6	24.6	24.5	24.4	24.4	24.3	24.4	24.6	24.5	24.6	24.4	24.7	24.5	24.1	24.6	24.6	24.2	24.4	24.1	24.2	24.5	24.6	24.2	24.5	0.1	0.1	24.9	24.1
6:00	24.9	24.9	24.8	24.7	24.8	24.7	24.7	24.9	24.8	24.8	24.7	25.0	24.9	24.6	24.9	24.9	24.7	24.8	24.6	24.7	24.8	24.9	24.6	24.8	0.2	0.1	25.2	25.1
7:00	24.9	24.9	24.8	24.8	24.8	24.7	24.8	24.9	24.9	24.9	24.7	25.0	24.9	24.6	24.9	24.9	24.7	24.8	24.7	24.7	24.8	24.9	24.7	24.9	0.3	5.1	25.2	24.4
8:00	25.0	25.0	25.0	25.0	25.0	24.9	24.9	25.1	25.0	25.0	24.9	25.1	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.0	25.1	25.0	25.0	0.3	70.6	25.3	26.1
9:00	26.1	26.1	26.1	26.2	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.1	26.5	26.1	26.1	26.5	26.3	26.6	26.6	26.3	26.2	26.3	26.1	0.4	235.8	26.2	29.2
10:00	27.8	27.9	27.9	28.1	27.9	28.0	28.0	27.8	27.9	27.8	27.9	27.8	27.9	28.8	27.9	27.8	28.7	28.2	28.8	28.7	28.0	28.0	28.3	27.9	0.6	478.4	27.8	30.7
11:00	29.6	29.8	29.8	29.9	29.6	29.9	29.8	29.3	29.4	29.3	29.3	29.2	29.3	30.3	29.3	29.6	31.1	30.2	31.1	30.9	29.9	29.9	30.3	29.6	1.6	575.9	29.4	32.7
12:00	31.2	31.5	31.4	31.5	31.1	31.5	31.3	30.6	30.7	30.5	30.5	30.6	30.5	31.6	30.4	31.1	33.7	32.6	33.7	33.5	31.7	31.7	32.0	31.1	2.3	645.1	31.4	34.4
13:00	32.5	32.7	32.6	32.7	32.4	32.7	32.5	32.0	32.1	31.9	31.9	32.0	31.9	33.1	31.8	32.3	36.2	34.6	36.4	36.1	33.6	33.5	33.1	32.3	2.5	815.5	32.3	36.7
14:00	33.5	33.7	33.6	33.8	33.5	33.7	33.6	33.1	33.3	33.2	33.1	33.2	33.1	34.5	33.0	33.5	36.7	35.3	36.8	36.4	34.3	34.3	34.1	33.5	2.3	705.2	33.5	33.5
15:00	33.9	33.9	33.9	34.0	33.9	34.0	34.0	33.5	33.6	33.6	33.4	33.6	33.6	34.7	33.4	33.9	36.7	35.4	36.8	36.4	34.6	34.6	34.3	33.9	2.3	652.4	34.0	34.1
16:00	34.1	34.1	34.1	34.2	34.1	34.2	34.1	33.9	34.0	34.0	33.8	34.0	33.9	34.6	33.8	34.2	36.2	35.2	36.2	36.0	34.6	34.6	34.4	34.1	2.3	509.1	34.2	33.6
17:00	34.0	34.0	34.0	34.1	34.0	34.2	34.1	34.0	34.0	34.1	34.0	34.0	34.0	34.7	33.8	34.1	35.4	34.7	35.5	35.4	34.3	34.3	34.3	34.0	2.4	346.8	34.1	34.1
18:00	33.4	33.4	33.4	33.4	33.4	33.5	33.4	33.3	33.4	33.5	33.3	33.4	33.4	33.4	33.2	33.6	33.7	33.5	33.8	33.6	33.5	33.5	33.4	33.5	2.3	128.0	33.6	31.3
19:00	31.6	31.5	31.5	31.3	31.4	31.4	31.4	31.5	31.5	31.6	31.5	31.6	31.5	31.6	31.4	31.7	30.7	31.0	30.8	30.8	31.5	31.5	31.2	31.5	1.8	3.6	31.7	29.7
20:00	29.9	30.0	29.9	29.6	29.7	29.7	29.7	29.9	29.8	29.9	29.9	30.0	29.8	29.3	29.6	30.0	28.8	29.3	28.9	29.0	29.8	29.8	29.5	29.8	1.4	0.0	30.4	28.3
21:00	28.9	28.9	28.9	28.6	28.8	28.6	28.6	28.9	28.8	28.9	28.9	29.0	28.6	28.6	28.9	28.9	28.1	28.4	28.1	28.1	28.8	28.8	28.4	28.8	1.1	N/A	N/A	N/A
22:00	28.5	28.5	28.4	28.2	28.4	28.2	28.3	28.5	28.4	28.5	28.4	28.6	28.4	27.9	28.5	28.5	27.9	28.2	27.9	27.9	28.4	28.4	28.0	28.4	1.1	N/A	N/A	N/A
23:00	28.1	28.2	28.1	27.8	28.0	27.9	27.9	28.1	28.1	28.2	28.0	28.3	28.1	27.6	28.2	28.2	27.7	28.0	27.7	27.8	28.1	28.1	27.7	28.1	0.9	N/A	N/A	N/A
0:00	27.8	27.8	27.8	27.6	27.7	27.5	27.7	27.8	27.8	27.9	27.7	28.0	27.8	27.4	27.9	27.9	27.6	27.7	27.5	27.6	27.9	27.9	27.4	27.8	0.6	N/A	N/A	N/A

Table A.12. Experimental results in the test and controlled cells on March 8th, 2005 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	wind (m/s)	solar W/m2	CC average (°C)	Ambient (°C)
3:00	24.5	24.5	24.5	24.2	24.1	24.4	24.4	24.5	24.4	24.6	24.5	24.5	24.2	23.6	24.5	24.5	23.7	24.1	23.6	23.7	24.3	24.4	24.0	24.4	0.3	0.1	24.9	24.0
4:00	24.0	24.0	23.9	23.9	23.6	23.8	23.9	24.0	24.0	24.1	23.9	24.0	23.7	23.2	24.0	24.1	23.3	23.7	23.1	23.4	23.9	24.0	23.6	23.9	0.1	0.1	24.4	23.4
5:00	23.2	23.3	23.2	23.1	23.0	22.9	23.1	23.3	23.2	23.3	23.0	23.3	23.0	22.6	23.2	23.3	22.8	23.1	22.6	22.9	23.2	23.4	22.8	23.1	0.1	0.0	23.9	22.6
6:00	22.8	22.8	22.7	22.6	22.5	22.4	22.6	22.8	22.7	22.8	22.6	22.9	22.5	22.1	22.8	22.9	22.5	22.7	22.3	22.5	22.8	22.9	22.3	22.7	0.0	0.1	23.5	22.2
7:00	22.6	22.6	22.5	22.4	22.3	22.3	22.5	22.6	22.6	22.6	22.4	22.7	22.4	22.2	22.6	22.6	22.2	22.4	22.0	22.3	22.6	22.6	22.2	22.5	0.0	6.6	23.2	22.2
8:00	23.0	23.0	22.9	22.9	22.8	22.8	22.9	23.0	22.9	22.9	22.9	23.0	23.0	23.1	23.0	22.9	22.8	22.9	22.8	22.9	22.9	22.9	22.9	22.9	0.0	66.9	23.3	23.8
9:00	24.4	24.5	24.6	24.5	24.4	24.6	24.5	24.4	24.5	24.4	24.5	24.4	24.7	25.2	24.5	24.4	25.3	24.8	25.4	25.3	24.7	24.6	24.7	24.4	0.0	282.8	24.6	27.7
10:00	26.6	26.8	26.8	26.9	26.7	27.0	26.8	26.6	26.7	26.6	26.7	26.5	27.0	27.8	26.6	26.6	28.3	27.5	28.5	28.2	27.0	27.0	27.2	26.6	0.9	483.1	26.5	30.9
11:00	28.8	29.1	29.0	29.1	28.7	29.2	29.0	28.7	28.9	28.7	29.0	28.7	29.1	29.8	28.5	28.8	31.2	29.9	31.4	30.9	29.3	29.4	29.5	28.7	3.3	660.6	28.7	32.9
12:00	30.5	30.9	30.8	30.8	30.2	31.0	30.7	30.5	30.6	30.5	30.8	30.5	31.1	31.9	30.3	30.6	33.9	32.2	34.1	33.4	31.2	31.4	31.4	30.3	2.8	764.9	30.4	34.4
13:00	31.6	31.9	31.8	31.9	31.5	32.0	31.8	31.6	31.7	31.7	31.7	31.6	32.1	33.2	31.4	31.7	35.0	33.3	35.5	34.6	32.4	32.6	32.4	31.5	3.1	796.8	31.6	35.3
14:00	32.7	33.0	32.9	33.0	32.6	33.1	32.9	32.8	32.9	32.8	32.8	32.7	33.3	34.5	32.6	32.8	36.1	34.5	36.6	35.9	33.6	33.8	33.5	32.6	3.0	714.7	32.9	36.1
15:00	33.6	33.8	33.7	33.8	33.5	34.0	33.8	33.7	33.8	33.8	33.6	33.7	33.5	34.9	33.5	33.7	36.7	35.3	37.0	36.5	34.5	34.7	34.2	33.5	2.7	585.1	34.1	35.6
16:00	34.3	34.4	34.3	34.4	34.1	34.6	34.4	34.3	34.3	34.4	34.2	34.3	34.2	35.4	34.1	34.4	36.5	35.4	36.8	36.2	34.8	35.0	34.7	34.2	3.3	423.0	34.5	35.3
17:00	34.2	34.3	34.3	34.3	34.1	34.5	34.3	34.2	34.2	34.4	34.2	34.2	34.2	35.1	34.1	34.3	35.6	34.9	35.7	35.4	34.6	34.7	34.5	34.1	3.0	216.3	34.5	34.6
18:00	33.2	33.1	33.2	33.1	33.1	33.2	33.1	33.2	33.2	33.3	33.2	33.3	33.2	33.8	33.1	33.4	33.2	33.2	33.3	33.2	33.3	33.5	33.0	33.2	2.0	69.0	33.6	32.4
19:00	31.5	31.3	31.5	31.3	31.4	31.4	31.4	31.5	31.5	31.6	31.5	31.7	31.5	31.9	31.6	31.7	31.0	31.2	30.9	30.9	31.3	31.5	31.3	31.5	1.2	3.2	31.9	30.6
20:00	30.2	30.1	30.2	30.0	30.0	30.1	30.1	30.2	30.2	30.3	30.2	30.3	30.2	30.5	30.3	30.3	29.4	29.7	29.4	29.5	30.0	30.2	29.9	30.2	1.4	0.1	30.5	29.4
21:00	29.1	29.0	29.0	28.9	28.9	28.9	28.9	29.1	29.1	29.2	29.1	29.2	29.0	29.4	29.2	29.2	28.2	28.6	28.2	28.3	28.9	29.1	28.8	29.1	1.5	0.1	29.4	28.2
22:00	28.4	28.3	28.4	28.2	28.2	28.3	28.3	28.4	28.4	28.5	28.4	28.6	28.4	28.0	28.5	28.5	27.5	27.9	27.5	27.6	28.2	28.4	28.1	28.4	1.1	0.0	28.8	27.3
23:00	28.0	28.0	28.0	27.7	27.7	27.8	27.7	28.0	27.9	27.9	28.0	28.1	27.9	27.4	27.9	28.0	27.0	27.4	27.1	27.2	27.8	27.9	27.5	27.9	0.9	0.0	28.2	26.7
0:00	27.6	27.6	27.6	27.3	27.3	27.5	27.4	27.6	27.5	27.6	27.6	27.7	27.5	27.0	27.6	27.6	26.7	27.1	26.7	26.9	27.5	27.5	27.1	27.5	0.7	0.0	27.8	26.5

Table A.13. Experimental results in the test and controlled cells on March 9th, 2005 (application of solar chimney).

Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10	TC11	TC12	TC13	TC14	TC15	TC16	TC17	TC18	TC19	TC20	TC21	TC22	TC23	TC24	wind	solar	CC average	Ambient
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)	(°C)	(°C)
1:00	27.3	27.3	27.3	27.0	26.8	27.2	27.1	27.2	27.2	27.3	27.2	27.2	N/A	26.3	27.2	27.2	26.4	26.9	26.5	26.7	27.2	27.2	26.8	27.1	0.2	0.0	27.4	26.0
2:00	26.5	26.5	26.5	26.3	26.1	26.3	26.3	26.5	26.4	26.5	26.2	26.5	N/A	25.8	26.4	26.5	26.1	26.3	26.0	26.2	26.5	26.5	26.0	26.3	0.1	0.0	26.9	25.6
3:00	25.8	25.9	25.8	25.6	25.5	25.6	25.6	25.8	25.8	25.9	25.6	25.9	25.7	25.1	25.8	25.9	25.4	25.7	25.4	25.6	25.9	25.9	25.4	25.7	0.1	0.0	26.4	24.9
4:00	25.2	25.2	25.1	25.0	24.8	24.9	25.0	25.2	25.1	25.2	24.9	25.2	25.1	24.6	25.1	25.2	24.9	25.1	24.8	25.0	25.3	25.3	24.7	25.1	0.1	0.0	25.9	24.4
5:00	24.6	24.7	24.6	24.4	24.3	24.4	24.4	24.7	24.6	24.7	24.4	24.7	24.6	24.1	24.6	24.7	24.4	24.6	24.4	24.5	24.7	24.7	24.1	24.5	0.1	0.0	25.3	23.8
6:00	24.2	24.3	24.2	24.0	24.0	24.0	24.1	24.3	24.2	24.3	24.1	24.4	23.9	23.9	24.3	24.3	24.0	24.2	23.9	24.1	24.3	24.3	23.8	24.2	0.1	0.0	24.9	23.7
7:00	24.0	24.0	23.8	23.8	23.7	23.6	23.8	24.0	23.9	24.0	23.7	24.0	23.9	23.6	23.9	24.0	23.6	23.8	23.5	23.6	23.9	24.0	23.6	23.9	0.1	6.5	24.6	23.4
8:00	24.2	24.2	24.1	24.1	24.1	24.0	24.1	24.2	24.2	24.2	24.1	24.3	24.2	24.3	24.2	24.2	24.1	24.1	24.0	24.1	24.2	24.2	24.1	24.2	0.1	67.9	24.6	24.5
9:00	25.5	25.5	25.5	25.6	25.5	25.5	25.5	25.5	25.5	25.4	25.5	25.5	25.5	26.2	25.5	25.5	25.9	25.7	26.0	25.9	25.6	25.6	25.7	25.5	0.3	255.5	25.6	27.5
10:00	27.7	27.9	27.8	27.9	27.6	27.9	27.9	27.7	27.8	27.7	27.8	27.6	27.6	28.8	27.7	27.6	28.7	28.1	28.8	28.6	27.8	27.8	28.3	27.6	0.4	441.5	27.5	30.0
11:00	29.7	30.0	29.9	30.0	29.5	30.0	29.8	29.6	29.7	29.6	29.8	29.6	N/A	31.0	29.6	29.6	32.0	30.9	32.0	31.6	30.0	30.1	30.4	29.5	1.3	536.5	29.6	32.2
12:00	31.3	31.6	31.5	31.6	31.1	31.6	31.5	31.2	31.3	31.2	31.3	31.1	31.1	32.1	31.0	31.3	33.9	32.6	34.0	33.6	31.8	31.9	32.1	31.1	2.0	683.9	31.1	33.9
13:00	32.4	32.7	32.6	32.7	32.3	32.7	32.5	32.4	32.5	32.3	32.5	32.3	32.2	33.5	32.2	32.4	35.5	34.1	35.6	35.2	33.2	33.2	33.1	32.2	2.3	691.7	32.4	34.6
14:00	33.3	33.5	33.4	33.5	33.2	33.5	33.4	33.3	33.4	33.3	33.3	33.2	33.2	34.9	33.1	33.3	36.3	34.9	36.4	36.0	33.9	34.0	33.9	33.2	2.2	686.0	33.4	34.6
15:00	33.9	34.0	33.9	34.0	33.8	34.0	34.0	33.9	33.9	33.9	33.8	33.8	33.8	35.2	33.7	33.9	36.3	35.1	36.3	35.9	34.3	34.4	34.3	33.8	2.2	607.5	33.9	34.1
16:00	33.8	33.8	33.8	33.9	33.8	33.9	33.8	33.8	33.8	33.9	33.7	33.8	33.8	34.5	33.6	33.8	35.4	34.6	35.5	35.2	34.1	34.1	34.1	33.8	2.4	465.6	33.9	33.7
17:00	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.3	33.4	33.2	33.3	33.3	34.0	33.1	33.4	34.0	33.6	34.0	33.9	33.4	33.4	33.4	33.3	2.2	277.5	33.4	33.1
18:00	32.3	32.3	32.3	32.1	32.2	32.2	32.2	32.3	32.3	32.4	32.3	32.4	32.3	32.1	32.1	32.4	32.1	32.1	32.1	32.1	32.3	32.3	32.1	32.3	1.9	89.6	32.5	31.5
19:00	30.8	30.8	30.7	30.4	30.6	30.5	30.4	30.7	30.6	30.8	30.8	30.9	30.6	30.6	30.6	30.8	30.1	30.4	30.1	30.2	30.7	30.8	30.2	30.7	1.5	4.8	31.0	29.5
20:00	29.5	29.5	29.4	29.1	29.3	29.2	29.2	29.4	29.3	29.5	29.4	29.5	29.3	29.7	29.4	29.5	28.9	29.2	28.9	29.0	29.4	29.4	28.9	29.4	1.1	0.0	29.7	28.3
21:00	28.6	28.6	28.5	28.2	28.4	28.3	28.3	28.5	28.4	28.5	28.5	28.7	21.1	28.6	28.5	28.6	28.1	28.3	28.1	28.1	28.5	28.5	28.1	28.5	1.3	0.1	28.8	27.7
22:00	28.2	28.1	28.1	27.9	28.0	27.9	27.9	28.1	28.0	28.1	28.1	28.3	28.1	27.6	28.2	28.2	27.5	27.8	27.5	27.6	28.0	28.1	27.8	28.1	1.3	0.0	28.3	27.4
23:00	27.8	27.7	27.8	27.6	27.7	27.7	27.7	27.8	27.8	27.8	27.8	27.9	27.8	27.3	27.9	27.9	27.0	27.3	27.0	27.1	27.6	27.7	27.5	27.8	1.2	0.0	28.0	27.0
0:00	27.5	27.4	27.4	27.3	27.3	27.3	27.3	27.4	27.4	27.5	27.4	27.6	20.2	26.9	27.5	27.5	26.7	26.9	26.6	26.7	27.2	27.4	27.2	27.4	1.0	0.2	27.7	26.7

Table A.14. Experimental results in the test cell on June 15th, 2005 (application of solar chimney and wetted roof).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	27.9	28.0	27.9	27.7	27.9	27.8	27.9	28.0	28.0	28.0	28.1	28.1	28.0	28.0	28.0	28.2	27.9	28.0	27.7	27.9	28.2	28.1	27.5	27.6	27.1
2:00	27.5	27.6	27.5	27.3	27.5	27.4	27.5	27.6	27.5	27.6	27.6	27.7	27.6	27.6	27.6	27.6	27.3	27.4	27.2	27.3	27.6	27.6	27.1	27.3	26.8
3:00	27.5	27.6	27.5	27.4	27.5	27.4	27.5	27.5	27.5	27.6	27.6	27.6	27.6	27.5	27.6	27.6	27.3	27.3	27.2	27.2	27.5	27.6	27.3	27.3	26.9
4:00	27.7	27.8	27.7	27.7	27.6	27.6	27.6	27.7	27.7	27.7	27.7	27.8	27.7	27.7	27.7	27.7	27.3	27.4	27.2	27.3	27.7	27.7	27.4	27.5	27.1
5:00	27.9	27.9	27.9	27.8	27.8	27.7	27.8	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.3	27.4	27.2	27.3	27.7	27.8	27.6	27.6	26.8
6:00	27.9	27.9	27.9	27.8	27.8	27.8	27.8	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.5	27.6	27.3	27.5	27.8	27.8	27.5	27.6	26.9
7:00	28.2	28.2	28.2	28.1	28.2	28.1	28.1	28.2	28.2	28.1	28.2	28.2	28.2	28.1	28.2	28.1	28.0	28.0	28.0	28.0	28.2	28.2	28.2	28.3	28.6
8:00	28.9	29.0	28.9	29.0	29.0	28.9	28.9	28.9	28.9	28.9	28.9	29.0	28.9	29.0	29.0	28.9	29.5	29.3	29.6	29.4	29.2	29.0	29.5	29.4	31.0
9:00	30.0	30.2	30.0	30.1	29.9	30.0	29.9	30.0	30.0	29.9	29.9	30.0	29.9	29.9	29.9	29.9	30.8	30.6	30.9	30.6	30.2	30.1	30.9	30.6	32.2
10:00	31.1	31.2	31.1	31.2	31.1	31.1	31.0	31.1	31.1	31.0	31.0	31.0	31.0	31.0	31.0	30.9	32.5	32.2	32.8	32.2	31.6	31.4	32.0	31.8	36.3
11:00	31.5	31.5	31.5	31.6	31.6	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.5	31.6	31.5	31.5	33.1	32.8	33.1	32.6	32.1	32.0	32.2	32.0	32.2
12:00	31.5	31.6	31.5	31.6	31.6	31.5	31.5	31.5	31.5	31.5	31.5	31.6	31.5	31.5	31.6	31.5	32.7	32.4	32.7	32.3	32.0	32.0	32.1	32.0	32.4
13:00	31.4	31.4	31.3	31.5	31.5	31.4	31.5	31.5	31.5	31.5	31.6	31.7	31.5	31.5	31.6	31.5	33.0	32.8	33.0	32.6	32.2	32.2	31.9	29.5	29.5
14:00	32.1	32.0	31.9	32.2	32.2	32.1	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	32.2	34.2	33.7	34.5	33.7	33.0	32.8	33.0	29.7	29.8
15:00	32.3	32.2	32.1	32.4	32.4	32.3	32.3	32.3	32.4	32.4	32.4	32.4	32.4	32.5	32.4	32.5	34.4	34.0	34.5	33.8	33.2	33.1	33.1	29.9	30.6
16:00	32.4	32.3	32.2	32.5	32.4	32.3	32.4	32.4	32.4	32.4	32.5	32.5	32.4	32.5	32.4	32.4	33.8	33.5	34.0	33.5	33.1	32.9	33.2	30.0	30.3
17:00	32.4	32.4	32.3	32.5	32.4	32.4	32.5	32.4	32.4	32.5	32.4	32.5	32.4	32.3	32.4	32.4	33.2	32.9	33.3	32.9	32.7	32.7	33.1	32.5	32.6
18:00	32.1	32.1	32.1	32.1	32.1	32.0	32.1	32.1	32.1	32.2	32.2	32.2	32.1	32.1	32.1	32.2	32.6	32.5	32.7	32.4	32.4	32.4	32.6	32.3	33.3
19:00	31.3	31.3	31.4	31.3	31.3	31.3	31.4	31.4	31.4	31.6	31.5	31.5	31.4	31.3	31.4	31.4	31.2	31.2	31.2	31.2	31.3	31.5	31.3	30.6	31.4
20:00	30.7	30.7	30.7	30.6	30.6	30.6	30.5	30.7	30.6	30.5	30.8	30.8	30.6	30.6	30.7	30.7	30.4	30.4	30.4	30.4	30.7	30.8	30.5	30.0	30.5
21:00	30.1	30.1	30.1	30.0	30.0	30.0	30.0	30.1	30.1	30.0	30.2	30.3	30.1	30.2	30.2	30.3	29.9	29.9	29.9	30.0	30.2	30.2	30.0	29.5	29.6
22:00	29.7	29.8	29.8	29.7	29.7	29.7	29.7	29.8	29.7	29.7	29.9	29.9	29.8	29.7	29.8	29.8	29.4	29.4	29.3	29.4	29.6	29.7	29.6	29.0	29.3
23:00	29.5	29.5	29.5	29.4	29.4	29.4	29.4	29.5	29.4	29.3	29.6	29.7	29.5	29.5	29.5	29.5	29.1	29.1	29.1	29.2	29.4	29.5	29.3	28.7	28.9
0:00	29.3	29.3	29.3	29.2	29.2	29.2	29.2	29.3	29.3	29.3	29.4	29.5	29.4	29.4	29.4	29.4	29.0	29.0	28.9	29.0	29.2	29.3	29.1	28.4	28.4

Table A.15. Experimental results in controlled cell (closed openings) and ambient conditions on June 15th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	v_{inflow}	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m^2)	(m/s)	%
1:00	29.2	29.2	29.1	29.0	28.9	28.9	28.9	29.0	29.0	29.0	28.8	29.1	29.1	29.1	29.0	29.0	27.5	0.4	0.0	-	-
2:00	28.6	28.5	28.3	28.3	28.3	28.2	28.3	28.4	28.4	28.3	28.4	28.5	28.5	28.5	28.4	28.4	26.9	0.2	0.0	-	-
3:00	28.3	28.2	28.1	28.1	28.1	28.0	28.1	28.1	28.1	28.1	28.2	28.2	28.2	28.2	28.2	28.1	27.0	0.7	0.0	-	-
4:00	28.3	28.3	28.1	28.2	28.2	28.1	28.1	28.1	28.1	28.1	28.3	28.4	28.3	28.3	28.2	28.2	27.2	0.6	0.0	-	-
5:00	28.3	28.3	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.4	28.3	28.3	28.3	28.3	28.2	27.3	0.9	0.0	-	-
6:00	28.4	28.3	28.3	28.3	28.3	28.2	28.2	28.2	28.2	28.3	28.4	28.4	28.4	28.3	28.3	28.2	27.5	0.6	0.2	-	-
7:00	28.7	28.6	28.6	28.5	28.5	28.5	28.5	28.5	28.5	28.5	28.6	28.6	28.6	28.6	28.6	28.5	28.1	1.7	46.5	-	-
8:00	29.5	29.4	29.4	29.4	29.4	29.3	29.4	29.3	29.3	29.5	29.5	29.5	29.5	29.5	29.4	29.4	29.7	0.8	148.1	-	-
9:00	30.4	30.4	30.3	30.4	30.4	30.4	30.4	30.3	30.3	30.5	30.6	30.6	30.7	30.7	30.6	30.6	31.3	0.4	324.1	-	-
10:00	31.5	31.6	31.5	31.5	31.5	31.5	31.5	31.4	31.5	31.7	31.7	31.7	31.7	31.7	31.7	31.7	32.3	0.2	318.5	-	-
11:00	32.1	32.1	32.0	32.1	32.0	32.1	32.1	32.0	32.0	32.3	32.2	32.3	32.3	32.3	32.3	32.3	32.6	0.1	317.6	-	-
12:00	32.2	32.1	32.0	32.2	32.1	32.2	32.2	32.1	32.1	32.4	32.3	32.3	32.4	32.4	32.4	32.5	32.3	0.1	201.8	0.31	60
13:00	32.6	32.5	32.4	32.6	32.5	32.6	32.6	32.5	32.5	32.8	32.7	32.8	32.9	32.9	32.9	33.0	32.8	0.2	262.6	0.31	60
14:00	33.4	33.4	33.3	33.4	33.3	33.5	33.5	33.3	33.3	33.6	33.5	33.6	33.6	33.6	33.6	33.9	33.7	0.1	372.2	0.24	65
15:00	33.8	33.8	33.7	33.8	33.6	33.8	33.8	33.6	33.7	34.0	34.0	34.0	34.0	34.0	34.0	34.3	33.9	0.1	334.0	0.21	67
16:00	33.9	33.8	33.8	33.9	33.8	33.9	33.9	33.8	33.8	34.1	34.1	34.0	34.1	34.1	34.1	34.4	33.9	0.1	250.4	0.14	62
17:00	33.7	33.7	33.5	33.8	33.7	33.9	33.9	33.6	33.7	33.9	33.8	33.9	34.0	34.0	34.0	34.2	33.3	0.3	151.8	0.22	62
18:00	33.4	33.2	33.1	33.2	33.1	33.3	33.4	33.2	33.2	33.5	33.5	33.4	33.5	33.6	33.6	33.8	33.0	0.3	46.2	-	-
19:00	32.5	32.5	32.4	32.5	32.5	32.5	32.5	32.4	32.5	32.6	32.6	32.6	32.6	32.6	32.6	32.9	31.6	0.5	0.9	-	-
20:00	31.8	31.8	31.7	31.6	31.6	31.7	31.7	31.7	31.6	31.7	31.8	31.8	31.8	31.8	31.8	32.1	30.7	0.3	0.0	-	-
21:00	31.2	31.2	31.1	31.1	31.1	31.1	31.2	31.1	31.1	31.2	31.3	31.2	31.2	31.2	31.2	31.5	30.2	0.3	0.0	-	-
22:00	30.8	30.7	30.6	30.6	30.6	30.6	30.6	30.5	30.5	30.7	30.8	30.7	30.7	30.7	30.6	31.0	29.7	0.3	0.0	-	-
23:00	30.5	30.5	30.4	30.3	30.3	30.3	30.4	30.4	30.3	30.4	30.5	30.5	30.5	30.5	30.4	30.7	29.5	0.3	0.0	-	-
0:00	30.4	30.3	30.2	30.2	30.2	30.1	30.2	30.2	30.2	30.3	30.4	30.3	30.3	30.2	30.3	30.6	29.4	0.6	0.0	-	-

Table A.16. Experimental results in the test cell on June 16th, 2005 (application of solar chimney and wetted roof).

Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10	TC11	TC12	TC13	TC14	TC15	TC16	TC17	TC18	TC19	TC20	TC21	TC22	TC23	TC24	TC25
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)
1:00	29.2	29.3	29.3	29.2	29.2	29.2	29.2	29.3	29.3	29.3	29.4	29.4	29.3	29.3	29.3	29.3	28.8	28.9	28.8	28.9	29.1	29.2	29.1	28.4	28.9
2:00	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.2	29.1	29.2	29.2	29.3	29.2	29.2	29.2	29.2	28.9	28.9	28.8	28.9	29.0	29.1	29.0	28.3	28.7
3:00	29.1	29.1	29.1	29.0	29.0	29.0	29.0	29.1	29.1	29.2	29.2	29.3	29.2	29.2	29.2	29.2	28.9	28.9	28.8	28.9	29.0	29.1	28.9	28.2	28.4
4:00	28.8	28.9	28.8	28.7	28.7	28.7	28.7	28.8	28.8	28.9	28.9	28.9	28.8	28.8	28.9	28.9	28.8	28.8	28.8	28.9	29.1	29.0	28.4	28.1	28.7
5:00	28.6	28.7	28.7	28.5	28.5	28.6	28.6	28.7	28.6	28.7	28.8	28.8	28.7	28.6	28.7	28.7	28.2	28.2	28.2	28.3	28.5	28.6	28.1	27.7	28.0
6:00	28.5	28.5	28.6	28.5	28.5	28.4	28.4	28.5	28.5	28.5	28.5	28.6	28.5	28.5	28.5	28.5	28.2	28.3	28.3	28.5	28.6	28.6	28.5	28.0	28.5
7:00	28.5	28.6	28.6	28.6	28.5	28.5	28.5	28.5	28.5	28.6	28.5	28.6	28.5	28.5	28.5	28.6	28.6	28.6	28.6	28.7	28.7	28.6	28.7	28.3	29.0
8:00	29.3	29.6	29.5	29.5	29.2	29.6	29.4	29.3	29.4	29.2	29.4	29.4	29.3	29.1	29.3	29.2	29.7	29.6	29.7	29.6	29.4	29.4	29.8	30.1	31.1
9:00	30.8	31.0	31.0	30.9	30.5	31.1	30.8	30.8	30.8	30.8	30.7	30.7	30.6	30.7	30.8	30.8	31.6	31.4	31.6	31.4	30.9	30.9	31.4	32.1	32.4
10:00	31.8	32.0	32.0	32.0	31.7	32.0	31.9	31.8	31.8	31.7	31.7	31.7	31.7	31.6	31.7	31.7	33.0	32.7	33.2	32.7	32.1	32.0	32.9	33.3	35.5
11:00	32.8	33.0	32.9	33.0	32.7	33.0	32.9	32.7	32.8	32.7	32.7	32.7	32.6	32.6	32.7	32.7	34.5	34.0	34.6	33.9	33.2	33.1	34.0	34.4	37.6
12:00	33.3	33.4	33.3	33.4	33.2	33.3	33.3	33.2	33.3	33.2	33.2	33.2	33.2	33.2	33.2	33.2	34.8	34.4	35.0	34.4	33.9	33.6	34.4	34.6	37.9
13:00	33.1	33.2	33.1	33.3	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.2	33.1	33.1	33.2	33.2	34.7	34.3	34.8	34.2	33.6	33.5	34.2	31.1	37.9
14:00	33.4	33.4	33.2	33.6	33.5	33.4	33.5	33.4	33.4	33.4	33.5	33.5	33.4	33.3	33.5	33.4	35.7	35.2	35.9	35.2	34.4	34.3	34.7	31.2	40.0
15:00	34.0	34.0	33.8	34.2	34.1	34.1	34.2	34.0	34.1	34.0	34.1	34.1	34.0	34.1	34.0	34.0	36.5	36.0	36.8	35.9	34.9	34.8	35.3	31.0	40.7
16:00	33.5	33.5	33.5	33.6	33.5	33.5	33.6	33.6	33.6	33.7	33.7	33.7	33.5	33.5	33.6	33.7	34.7	34.5	34.8	34.3	33.9	34.0	34.1	30.1	36.8
17:00	30.1	29.8	30.0	29.9	30.1	30.0	30.1	30.0	30.1	30.6	30.4	30.3	30.2	30.5	30.2	30.6	30.6	30.5	30.7	30.5	30.6	30.4	29.7	28.7	30.8
18:00	25.9	25.8	26.0	25.7	26.0	25.9	26.0	25.9	25.9	26.1	26.1	26.1	26.1	26.1	26.0	26.1	25.6	25.5	25.6	25.7	26.0	25.9	25.4	24.7	26.6
19:00	27.0	27.1	27.1	26.9	27.0	26.9	27.0	27.1	27.0	27.1	27.1	27.1	27.1	27.0	27.1	27.1	26.8	26.8	26.7	26.9	27.1	27.1	26.7	25.9	26.8
20:00	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.5	27.4	27.5	27.4	27.5	27.4	27.5	27.5	27.5	27.3	27.4	27.2	27.3	27.3	27.4	27.4	26.2	27.2
21:00	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.4	27.3	27.3	27.3	27.4	27.5	27.4	26.5	27.3
22:00	27.7	27.7	27.7	27.7	27.6	27.6	27.6	27.7	27.6	27.6	27.8	27.9	27.8	27.6	27.7	27.6	27.4	27.3	27.3	27.4	27.6	27.7	27.6	26.7	27.5
23:00	27.6	27.7	27.7	27.6	27.6	27.6	27.6	27.7	27.6	27.8	27.7	27.8	27.7	27.7	27.7	27.8	27.6	27.6	27.5	27.6	27.7	27.7	27.6	26.8	27.2
0:00	27.3	27.4	27.3	27.2	27.3	27.3	27.3	27.4	27.3	27.5	27.4	27.5	27.4	27.4	27.4	27.5	27.4	27.4	27.3	27.5	27.5	27.5	27.1	26.6	27.2

Table A.17. Experimental results in controlled cell (closed openings) and ambient conditions on June 16th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	v_{inflow}	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	(W/m^2)	(m/s)	%
1:00	30.3	30.2	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.2	30.2	30.2	30.2	30.2	30.1	30.5	29.4	0.6	0.0	-	-
2:00	30.1	30.0	29.9	29.9	29.9	29.9	29.9	29.9	29.8	29.9	30.0	30.0	30.0	30.0	29.9	30.2	29.3	0.8	0.0	-	-
3:00	30.1	30.1	29.9	29.9	29.9	29.8	29.9	29.9	29.9	29.9	30.1	30.0	30.0	29.9	29.9	30.2	29.2	0.7	0.0	-	-
4:00	30.0	29.9	29.7	29.8	29.7	29.7	29.7	29.7	29.7	29.7	29.7	29.8	29.8	29.8	29.7	30.1	28.4	0.2	0.0	-	-
5:00	29.6	29.6	29.5	29.5	29.4	29.4	29.4	29.4	29.4	29.4	29.5	29.6	29.6	29.5	29.5	29.8	28.4	0.4	0.1	-	-
6:00	29.3	29.2	29.2	29.2	29.2	29.1	29.2	29.1	29.1	29.2	29.2	29.2	29.3	29.2	29.2	29.3	28.7	1.1	0.3	-	-
7:00	29.3	29.2	29.2	29.2	29.1	29.1	29.1	29.1	29.1	29.2	29.2	29.2	29.2	29.2	29.1	29.3	28.9	1.5	37.9	-	-
8:00	30.0	30.0	30.0	29.9	29.8	29.9	29.8	29.8	29.8	29.8	30.1	29.9	29.8	29.8	29.8	30.0	30.1	1.2	157.5	-	-
9:00	31.3	31.5	31.4	31.3	31.0	31.3	31.2	31.1	31.2	31.2	31.5	31.3	31.1	31.1	31.2	31.4	31.5	0.4	311.3	-	-
10:00	32.2	32.3	32.2	32.3	31.9	32.2	32.1	32.0	32.1	32.2	32.4	32.3	32.0	32.0	32.1	32.3	32.6	0.3	456.1	-	-
11:00	33.2	33.3	33.1	33.3	33.0	33.3	33.2	33.1	33.2	33.3	33.5	33.4	33.3	33.3	33.4	33.7	33.8	0.2	485.0	-	-
12:00	33.7	33.8	33.7	33.8	33.6	33.8	33.8	33.7	33.7	33.9	34.0	33.9	33.9	33.9	34.0	34.3	34.3	0.2	369.1	0.10	61.7
13:00	34.0	34.0	33.9	34.0	33.9	34.0	34.0	33.9	34.0	34.2	34.2	34.2	34.2	34.2	34.2	34.6	34.5	0.2	291.1	0.15	60.1
14:00	34.8	34.8	34.7	34.9	34.7	34.8	34.8	34.7	34.8	34.9	35.0	34.9	34.9	35.0	35.0	35.4	36.3	0.1	651.0	0.20	59.1
15:00	35.9	35.9	35.7	36.0	35.7	36.0	35.9	35.8	35.8	36.1	36.1	36.0	36.0	36.0	36.1	36.5	36.4	0.1	500.3	0.18	58.6
16:00	35.3	35.2	35.2	35.3	35.2	35.3	35.4	35.2	35.3	35.5	35.5	35.5	35.5	35.5	35.6	36.0	34.8	0.1	164.0	0.17	60.8
17:00	31.8	31.6	31.6	31.7	31.8	32.0	32.1	31.7	31.8	32.1	32.0	32.0	32.3	32.2	32.3	32.5	29.5	0.5	19.7	0.65	78.4
18:00	28.4	28.4	28.4	28.2	28.2	28.5	28.5	28.4	28.4	28.6	28.7	28.9	28.9	28.8	28.9	29.2	26.2	0.2	5.8	0.21	85.4
19:00	28.8	28.8	28.6	28.7	28.7	28.6	28.7	28.7	28.7	28.7	28.9	29.0	29.0	29.0	29.0	29.2	27.5	0.2	1.8	-	-
20:00	28.9	28.8	28.7	28.8	28.7	28.6	28.7	28.7	28.7	28.7	28.8	28.9	28.8	28.8	28.8	29.0	28.1	0.1	0.0	-	-
21:00	29.0	28.9	28.7	28.8	28.7	28.7	28.7	28.8	28.8	28.8	28.9	28.9	28.9	28.8	28.8	29.0	28.0	0.0	0.0	-	-
22:00	29.0	28.9	28.8	28.8	28.8	28.7	28.7	28.8	28.8	28.8	28.9	29.0	28.9	28.8	28.8	29.0	28.0	0.2	0.0	-	-
23:00	28.8	28.8	28.7	28.7	28.7	28.6	28.6	28.7	28.6	28.6	28.8	28.8	28.8	28.8	28.7	28.9	27.9	0.3	0.0	-	-
0:00	28.7	28.6	28.5	28.5	28.5	28.4	28.4	28.5	28.5	28.5	28.5	28.6	28.6	28.6	28.5	28.8	27.2	0.0	0.0	-	-

Table A.18. Experimental results in the test cell on June 21st, 2005 (closed openings).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	23.4	23.3	23.3	23.4	23.2	23.2	23.4	23.4	23.5	23.6	23.5	23.8	23.8	23.8	23.8	22.6	22.7	22.5	22.2	21.9	23.6	23.4	21.5	22.5	26.0
2:00	23.7	23.8	23.7	23.8	23.5	23.4	23.5	23.4	23.5	23.4	23.5	23.7	23.5	23.6	23.7	21.6	22.3	22.2	22.7	22.3	23.3	23.8	21.6	23.7	26.0
3:00	23.5	23.8	23.7	23.9	23.8	23.7	23.8	23.9	23.9	23.8	23.7	23.8	23.5	23.4	23.6	21.6	22.2	21.9	22.9	22.4	23.3	24.4	21.5	23.5	25.8
4:00	23.8	23.8	23.8	23.9	23.6	23.4	23.4	23.4	23.5	23.3	23.4	23.6	23.6	23.3	23.5	21.6	22.6	22.6	22.8	22.7	23.6	24.5	21.7	24.1	26.1
5:00	23.7	23.7	23.7	23.8	23.5	23.4	23.5	23.5	23.6	23.6	23.6	23.8	23.9	23.6	23.8	22.0	22.8	22.6	23.4	23.1	24.0	25.0	22.0	24.3	26.3
6:00	23.8	23.9	23.9	24.1	23.8	23.7	23.7	23.7	23.8	23.6	23.6	23.7	23.8	23.4	23.7	22.0	22.6	22.3	23.4	23.0	24.0	25.0	22.1	24.0	25.8
7:00	23.9	24.1	24.1	24.3	24.1	24.1	24.1	24.0	24.1	23.9	23.9	24.0	24.3	23.5	23.9	22.5	23.4	23.2	24.4	24.0	24.9	25.8	22.8	25.0	26.3
8:00	24.9	25.3	25.3	25.2	24.6	25.3	24.9	24.8	25.0	24.9	25.1	25.2	25.3	24.8	25.2	23.4	25.1	24.9	25.8	25.4	26.0	26.8	24.4	26.8	27.6
9:00	26.2	26.6	26.5	26.7	26.3	26.4	26.3	26.3	26.4	26.1	26.1	26.3	25.9	25.9	26.1	23.8	25.8	25.7	26.2	26.0	26.2	26.9	26.2	26.9	28.8
10:00	28.6	28.7	28.6	28.8	28.4	28.7	28.5	28.4	28.5	28.5	28.4	28.4	28.3	28.5	28.6	28.3	31.0	30.7	31.0	30.6	29.7	29.4	31.3	29.2	30.5
11:00	30.7	31.4	31.1	31.0	30.5	31.4	30.8	30.8	30.8	30.7	30.7	30.7	30.4	30.4	30.7	30.7	34.4	34.0	34.9	34.2	33.4	33.0	33.2	34.1	35.7
12:00	31.4	32.1	31.7	31.6	31.3	31.9	31.4	31.4	31.4	31.4	31.4	31.4	31.2	31.1	31.4	31.3	34.9	34.4	35.5	34.7	34.0	33.6	33.8	34.6	37.3
13:00	32.1	32.8	32.4	32.3	31.9	32.5	32.1	32.1	32.1	32.1	32.0	32.0	31.8	31.8	32.0	32.0	35.7	35.2	36.3	35.5	34.8	34.3	34.8	35.4	38.1
14:00	33.3	34.2	33.7	33.7	33.0	34.1	33.4	33.4	33.4	33.4	33.6	33.3	32.9	32.8	33.4	33.3	37.2	36.8	37.8	36.9	36.3	36.0	35.4	36.6	39.1
15:00	34.3	35.0	34.6	34.6	34.0	34.8	34.4	34.4	34.4	34.4	34.5	34.3	33.8	33.8	34.4	34.3	37.2	36.9	37.5	36.8	36.3	36.4	35.4	36.5	40.0
16:00	35.3	35.9	35.5	35.6	34.7	35.9	35.4	35.4	35.4	35.5	35.5	35.3	34.6	34.6	35.4	35.3	36.8	36.5	37.1	36.5	36.0	36.0	36.3	37.1	39.1
17:00	34.5	34.5	34.6	34.5	34.2	34.6	34.4	34.5	34.4	34.6	34.5	34.5	34.1	34.2	34.4	34.5	33.9	33.7	34.2	33.7	33.9	34.0	32.9	34.2	34.7
18:00	34.1	34.4	34.4	34.2	33.6	34.4	34.1	34.1	34.1	34.2	34.3	34.1	33.5	33.5	34.1	34.2	33.3	33.1	33.4	33.1	33.1	33.3	33.9	34.9	34.1
19:00	32.5	32.6	32.7	32.4	32.1	32.6	32.4	32.4	32.4	32.6	32.6	32.5	32.1	32.2	32.4	32.6	31.2	31.2	31.2	31.2	31.4	31.5	31.3	32.1	31.0
20:00	31.4	31.4	31.5	31.3	31.1	31.3	31.3	31.3	31.3	31.5	31.5	31.4	31.1	31.2	31.4	31.5	29.9	29.9	29.9	30.0	30.2	30.3	30.2	30.8	29.3
21:00	30.8	30.9	30.9	30.8	30.7	30.8	30.8	30.8	30.8	30.9	30.9	30.9	30.7	30.7	30.8	30.9	29.7	29.7	29.6	29.7	29.9	30.0	29.9	30.3	29.1
22:00	30.4	30.5	30.5	30.4	30.3	30.4	30.4	30.4	30.4	30.4	30.5	30.5	30.3	30.4	30.4	30.5	29.4	29.4	29.3	29.4	29.6	29.7	29.7	30.0	28.8
23:00	30.1	30.2	30.2	30.1	30.0	30.1	30.1	30.1	30.1	30.2	30.2	30.2	30.1	30.1	30.1	30.2	29.2	29.2	29.2	29.2	29.4	29.4	29.5	29.8	28.7
0:00	29.9	29.9	30.0	29.9	29.8	29.9	29.9	29.9	29.9	29.9	30.0	30.0	29.9	29.9	29.9	30.0	29.0	29.0	28.9	29.0	29.2	29.3	29.2	29.5	28.4

Table A.19. Experimental results in controlled cell (closed openings) and ambient conditions on June 21st, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	v_{inflow}	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	(W/m^2)	(m/s)	%
1:00	26.7	26.6	26.6	26.5	26.5	26.4	26.5	26.5	26.5	26.5	26.7	26.7	26.6	26.6	26.6	26.9	25.9	0.0	0.0	-	-
2:00	26.8	26.7	26.7	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.8	26.9	26.7	26.7	26.7	27.0	26.0	0.0	0.0	-	-
3:00	27.0	26.9	26.9	26.8	26.7	26.7	26.8	26.8	26.8	26.8	27.0	27.0	26.8	26.8	26.8	27.1	26.1	0.0	0.0	-	-
4:00	27.1	27.0	27.0	26.9	26.8	26.9	26.9	26.9	26.9	26.9	27.1	27.1	27.0	26.9	26.9	27.3	26.4	0.0	0.0	-	-
5:00	27.1	27.1	27.0	26.9	26.9	26.9	26.9	26.9	26.9	26.9	27.1	27.1	27.0	27.0	27.0	27.3	26.2	0.0	0.0	-	-
6:00	27.1	27.0	26.9	26.9	26.9	26.8	26.9	26.9	26.9	26.9	27.0	27.1	27.0	27.0	26.9	27.3	26.2	0.0	0.4	-	-
7:00	27.4	27.3	27.4	27.3	27.2	27.2	27.3	27.1	27.2	27.2	27.4	27.4	27.3	27.3	27.2	27.7	27.2	0.0	48.7	-	-
8:00	28.6	28.8	28.8	28.7	28.3	28.6	28.4	28.3	28.4	28.3	28.8	28.6	28.4	28.4	28.3	28.8	31.3	0.1	134.4	-	-
9:00	29.7	30.0	30.0	29.7	29.3	29.8	29.5	29.5	29.5	29.5	30.0	29.6	29.3	29.3	29.5	29.9	31.7	0.2	459.3	-	-
10:00	30.2	30.6	30.6	30.4	30.1	30.5	30.2	30.1	30.2	30.3	30.6	30.3	30.2	30.2	30.2	30.4	33.1	0.2	667.5	-	-
11:00	31.3	31.8	31.7	31.5	31.1	31.6	31.3	31.3	31.3	31.6	31.9	31.4	31.3	31.3	31.3	31.5	34.6	1.6	688.8	-	-
12:00	32.2	32.5	32.4	32.4	32.0	32.4	32.2	32.1	32.2	32.5	32.7	32.3	32.3	32.3	32.4	32.5	34.7	1.6	614.7	-	-
13:00	32.8	33.1	33.1	33.0	32.7	33.0	32.9	32.8	32.9	33.1	33.3	33.0	32.9	33.0	33.0	33.1	36.0	1.6	729.3	-	-
14:00	34.3	34.8	34.6	34.5	33.9	34.7	34.4	34.3	34.3	34.6	35.0	34.6	34.2	34.3	34.5	34.7	38.2	1.4	763.1	-	-
15:00	35.2	35.5	35.4	35.3	34.9	35.4	35.2	35.2	35.3	35.4	35.7	35.5	35.2	35.3	35.4	35.6	38.3	1.3	702.1	-	-
16:00	36.0	36.2	36.2	36.1	35.6	36.2	36.0	35.9	36.0	36.3	36.4	36.2	35.9	36.0	36.2	36.4	38.1	1.2	544.3	-	-
17:00	34.5	34.4	34.5	34.4	34.3	34.6	34.5	34.4	34.5	34.7	34.9	34.7	34.7	34.7	34.8	35.0	33.5	1.3	70.4	-	-
18:00	34.8	34.4	34.5	34.5	34.3	34.6	34.6	34.4	34.5	34.8	34.8	34.7	34.6	34.7	34.7	34.9	35.1	2.0	146.8	-	-
19:00	32.8	32.8	32.8	32.6	32.7	32.8	32.9	32.8	32.7	33.1	33.0	33.0	33.1	33.1	33.1	33.2	31.6	2.2	1.0	-	-
20:00	31.4	31.5	31.5	31.3	31.3	31.4	31.4	31.3	31.3	31.4	31.6	31.6	31.5	31.5	31.6	31.6	30.1	1.5	0.0	-	-
21:00	31.0	31.0	31.0	30.8	30.8	30.9	30.9	30.9	30.8	30.9	31.1	31.1	31.0	30.9	31.0	31.0	29.7	1.1	0.0	-	-
22:00	30.5	30.5	30.5	30.4	30.4	30.4	30.4	30.4	30.4	30.5	30.5	30.6	30.5	30.4	30.4	30.4	29.3	1.1	0.0	-	-
23:00	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.3	30.3	30.2	30.2	30.2	30.2	29.3	1.0	0.0	-	-
0:00	30.2	30.1	30.1	30.0	30.0	30.0	30.0	30.0	30.0	30.1	30.2	30.2	30.1	30.1	30.1	30.1	29.1	1.2	0.0	-	-

Table A.20. Experimental results in the test cell on June 22nd, 2005 (closed openings).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	29.5	29.5	29.6	29.5	29.4	29.5	29.5	29.5	29.5	29.5	29.5	29.7	29.4	29.5	29.5	29.6	28.7	28.7	28.6	28.7	28.9	28.9	29.0	29.2	28.1
2:00	29.0	29.1	29.1	29.0	29.0	29.0	29.0	29.0	29.0	29.1	29.1	29.2	29.0	29.0	29.0	29.1	28.3	28.3	28.2	28.3	28.4	28.5	28.5	28.7	27.8
3:00	28.6	28.6	28.7	28.6	28.6	28.6	28.6	28.6	28.6	28.6	28.7	28.8	28.6	28.6	28.6	28.7	27.8	27.9	27.7	27.8	27.9	28.1	28.1	28.3	27.3
4:00	28.3	28.3	28.4	28.3	28.3	28.3	28.3	28.3	28.3	28.4	28.4	28.4	28.3	28.4	28.4	28.4	27.5	27.6	27.5	27.5	27.7	27.8	27.9	28.0	27.0
5:00	28.2	28.2	28.2	28.2	28.2	28.1	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.2	28.3	27.5	27.6	27.4	27.5	27.6	27.8	27.8	27.9	27.1
6:00	28.0	28.0	28.0	28.0	28.0	27.9	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	27.1	27.1	27.1	27.1	27.3	27.4	27.5	27.6	26.5
7:00	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	28.0	27.7	27.7	27.7	27.7	27.8	27.8	27.9	28.2	28.0
8:00	28.4	28.6	28.5	28.5	28.5	28.5	28.4	28.4	28.4	28.4	28.5	28.6	28.4	28.5	28.5	28.4	28.9	28.8	29.0	28.9	28.8	28.7	28.9	29.4	30.3
9:00	29.3	29.7	29.4	29.4	29.3	29.5	29.3	29.3	29.3	29.3	29.4	29.4	29.2	29.2	29.3	29.3	30.5	30.3	30.7	30.4	30.1	29.9	30.3	30.9	32.7
10:00	30.5	31.2	30.8	30.8	30.5	31.0	30.6	30.6	30.6	30.5	30.7	30.6	30.4	30.4	30.6	30.5	32.8	32.4	33.1	32.6	32.1	31.7	32.0	33.2	34.8
11:00	31.5	32.2	31.9	31.8	31.4	32.0	31.5	31.6	31.5	31.5	31.7	31.5	31.3	31.3	31.6	31.5	33.9	33.5	34.3	33.8	33.2	32.9	32.8	34.1	36.2
12:00	32.2	33.0	32.7	32.5	32.2	32.7	32.3	32.3	32.3	32.2	32.5	32.3	32.1	32.1	32.3	32.2	35.0	34.5	35.4	34.7	34.1	33.9	33.8	34.9	37.1
13:00	33.0	33.7	33.4	33.3	33.0	33.5	33.1	33.1	33.1	33.0	33.3	33.1	32.8	32.8	33.1	33.0	35.7	35.3	35.9	35.3	34.8	34.7	34.1	35.3	38.3
14:00	34.0	34.4	34.2	34.3	33.9	34.2	34.0	34.0	34.0	34.0	34.1	34.0	33.7	33.7	34.0	34.0	36.1	36.1	36.2	36.0	35.6	35.7	34.1	35.4	39.4
15:00	34.3	34.7	34.5	34.6	34.3	34.5	34.4	34.4	34.4	34.4	34.5	34.4	34.1	34.2	34.4	34.4	35.9	35.8	36.0	35.7	35.3	35.4	34.6	35.7	38.3
16:00	34.9	35.0	35.0	35.2	34.9	35.1	35.0	35.0	35.0	35.1	35.0	34.9	34.7	34.8	35.0	34.9	34.9	35.3	34.9	35.1	35.1	35.2	34.8	35.3	37.0
17:00	34.5	34.5	34.6	34.6	34.5	34.5	34.5	34.5	34.5	34.6	34.5	34.6	34.4	34.5	34.5	34.5	34.0	34.1	34.0	34.0	34.2	34.3	33.3	34.1	35.8
18:00	33.8	33.8	33.9	33.9	33.8	33.8	33.8	33.8	33.8	33.9	33.9	33.9	33.8	33.9	33.8	33.9	33.4	33.5	33.5	33.5	33.7	33.8	32.5	33.4	34.3
19:00	33.2	33.2	33.2	33.1	33.1	33.1	33.1	33.2	33.1	33.2	33.3	33.3	33.1	33.2	33.2	33.2	32.3	32.3	32.3	32.3	32.6	32.7	32.1	32.6	31.7
20:00	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.6	32.7	32.7	32.7	32.6	32.6	32.6	32.7	31.6	31.6	31.6	31.5	31.8	32.0	32.0	32.2	30.8
21:00	32.2	32.2	32.2	32.2	32.1	32.2	32.2	32.2	32.2	32.2	32.3	32.3	32.2	32.2	32.2	32.3	31.0	30.9	30.9	31.0	31.2	31.4	31.0	31.6	30.4
22:00	31.6	31.6	31.7	31.6	31.5	31.6	31.6	31.6	31.6	31.7	31.7	31.8	31.5	31.6	31.6	31.7	30.2	30.2	30.1	30.2	30.4	30.7	30.2	30.9	29.7
23:00	31.1	31.1	31.1	31.0	31.0	31.0	31.0	31.1	31.0	31.1	31.1	31.2	31.0	31.1	31.1	31.2	29.7	29.8	29.7	29.7	30.0	30.1	29.9	30.5	29.2
0:00	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.7	30.8	30.8	30.8	30.7	30.7	30.7	30.8	29.5	29.6	29.4	29.5	29.7	29.9	29.7	30.2	29.0

Table A.21. Experimental results in controlled cell (closed openings) and ambient conditions on June 22nd, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Time	Ambient	wind	solar	vinflow
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(min)	(°C)	(m/s)	(W/m2)	(m/s)
1:00	29.7	29.7	29.7	29.6	29.5	29.5	29.6	29.5	29.6	29.6	29.7	29.8	29.7	29.7	29.6	29.6	1:00	29.0	1.4	0.0	-
2:00	29.2	29.2	29.2	29.1	29.1	29.1	29.1	29.1	29.1	29.2	29.2	29.2	29.2	29.2	29.2	29.2	2:00	28.4	1.3	0.0	-
3:00	28.9	28.8	28.8	28.7	28.7	28.7	28.7	28.7	28.7	28.8	28.9	28.9	28.8	28.8	28.8	28.8	3:00	28.0	1.1	0.0	-
4:00	28.6	28.6	28.6	28.4	28.4	28.4	28.4	28.4	28.5	28.5	28.7	28.6	28.6	28.6	28.5	28.5	4:00	27.8	1.6	0.0	-
5:00	28.5	28.4	28.4	28.3	28.3	28.3	28.3	28.3	28.3	28.4	28.5	28.5	28.4	28.4	28.4	28.3	5:00	27.7	1.0	0.0	-
6:00	28.3	28.2	28.2	28.1	28.0	28.0	28.0	28.0	28.1	28.1	28.3	28.3	28.2	28.2	28.2	28.1	6:00	27.3	1.8	0.4	-
7:00	28.4	28.3	28.3	28.2	28.2	28.1	28.1	28.1	28.1	28.2	28.4	28.4	28.3	28.3	28.2	28.2	7:00	27.9	1.9	60.8	-
8:00	29.0	28.9	28.9	28.9	28.8	28.7	28.7	28.7	28.7	28.7	29.0	28.9	28.8	28.8	28.7	28.7	8:00	29.2	1.5	152.7	-
9:00	29.8	29.8	29.8	29.8	29.7	29.6	29.7	29.6	29.6	29.7	29.8	29.7	29.6	29.6	29.6	29.5	9:00	30.3	1.4	258.2	-
10:00	31.0	31.2	31.1	31.1	30.9	31.0	30.9	30.9	30.9	30.9	31.2	30.9	30.8	30.8	30.8	30.8	10:00	32.5	1.5	621.3	-
11:00	32.0	32.2	32.1	32.0	31.8	32.1	32.0	31.9	32.0	32.3	32.4	32.1	32.1	32.1	32.1	32.2	11:00	33.6	1.5	689.3	-
12:00	32.6	32.9	32.8	32.8	32.5	32.8	32.8	32.6	32.7	33.1	33.2	32.9	32.9	33.0	33.0	33.1	12:00	34.7	1.7	815.5	-
13:00	33.4	33.5	33.5	33.5	33.3	33.6	33.5	33.4	33.5	33.8	33.8	33.6	33.6	33.7	33.7	33.9	13:00	35.0	1.5	841.0	-
14:00	34.4	34.5	34.4	34.5	34.3	34.6	34.6	34.4	34.5	34.8	34.8	34.7	34.7	34.8	34.9	35.0	14:00	36.0	1.5	683.0	-
15:00	34.7	34.8	34.6	34.7	34.6	34.9	34.8	34.7	34.8	35.1	35.0	34.9	34.9	35.0	35.0	35.2	15:00	36.8	1.4	672.4	-
16:00	35.4	35.5	35.4	35.4	35.2	35.6	35.5	35.4	35.4	35.7	35.7	35.6	35.6	35.6	35.7	35.9	16:00	37.1	1.7	514.9	-
17:00	35.0	35.1	35.0	34.9	34.9	35.2	35.2	35.0	35.1	35.4	35.4	35.3	35.4	35.4	35.4	35.6	17:00	34.2	1.8	158.6	-
18:00	34.3	34.4	34.3	34.3	34.3	34.5	34.5	34.4	34.4	34.8	34.8	34.7	34.8	34.8	34.8	34.9	18:00	33.5	2.6	57.9	-
19:00	33.5	33.5	33.5	33.5	33.5	33.6	33.6	33.5	33.5	33.7	33.9	33.9	33.9	33.9	33.9	34.0	19:00	32.6	2.7	0.2	-
20:00	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	32.9	33.0	33.1	33.1	33.1	33.0	33.0	33.1	20:00	32.2	2.4	0.0	-
21:00	32.4	32.4	32.4	32.3	32.3	32.4	32.4	32.3	32.4	32.4	32.5	32.5	32.4	32.4	32.4	32.4	21:00	31.0	1.2	0.0	-
22:00	31.8	31.8	31.8	31.7	31.7	31.7	31.8	31.7	31.7	31.8	31.9	31.8	31.7	31.7	31.7	31.7	22:00	30.1	1.3	0.0	-
23:00	31.3	31.3	31.3	31.2	31.2	31.2	31.2	31.2	31.2	31.3	31.3	31.3	31.2	31.2	31.2	31.2	23:00	29.8	1.4	0.0	-
0:00	31.0	31.0	30.9	30.8	30.8	30.8	30.8	30.8	30.8	30.9	31.0	31.0	30.9	30.9	30.9	30.8	0:00	29.6	1.2	0.0	-

Table A.22. Experimental results in the test cell on June 23rd, 2005 (closed openings and application of wetted roof).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.5	30.5	30.5	30.4	30.5	30.5	30.5	29.2	29.3	29.1	29.2	29.4	29.6	29.3	29.8	28.7
2:00	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.1	30.2	30.2	30.2	30.1	30.2	30.2	30.2	28.8	28.9	28.7	28.8	29.0	29.2	28.9	29.5	28.3
3:00	29.9	29.9	29.9	29.9	29.9	29.8	29.9	29.9	29.9	30.0	30.0	29.9	29.9	30.0	30.0	30.0	28.7	28.7	28.5	28.6	28.8	29.1	28.8	29.3	28.1
4:00	29.7	29.7	29.7	29.7	29.7	29.6	29.7	29.7	29.7	29.8	29.8	29.7	29.7	29.7	29.7	29.8	28.5	28.5	28.4	28.5	28.7	28.7	28.4	29.0	27.8
5:00	29.5	29.4	29.4	29.4	29.4	29.4	29.4	29.5	29.4	29.5	29.5	29.5	29.4	29.5	29.5	29.5	28.0	28.1	28.0	28.0	28.3	28.4	28.2	28.8	27.3
6:00	29.0	29.0	29.0	28.9	29.0	28.9	28.9	29.0	28.9	29.0	29.0	29.0	28.9	29.0	29.0	29.0	27.6	27.5	27.6	27.6	27.8	27.8	28.0	28.4	26.9
7:00	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.8	28.7	28.8	28.0	28.0	28.0	28.0	28.1	28.1	28.3	28.7	28.4
8:00	29.0	29.2	29.1	29.1	29.1	29.1	29.0	29.0	29.0	29.0	29.0	29.1	29.0	29.1	29.1	29.0	29.2	29.1	29.3	29.1	29.0	28.9	29.1	29.7	30.8
9:00	29.8	30.2	30.0	30.0	29.9	30.1	29.9	29.9	29.9	29.8	29.9	29.9	29.8	29.8	29.9	29.8	31.3	31.1	31.6	31.1	30.7	30.5	31.2	31.7	34.3
10:00	30.8	31.2	31.0	31.0	30.8	31.1	30.8	30.8	30.8	30.8	30.9	30.8	30.7	30.6	30.8	30.7	32.5	32.2	32.9	32.2	31.8	31.7	31.5	32.3	36.4
11:00	31.8	32.4	32.1	32.0	31.6	32.3	31.8	31.8	31.8	31.7	32.0	31.8	31.5	31.5	31.8	31.7	34.1	33.6	34.6	33.7	32.9	32.8	32.9	34.1	37.6
12:00	32.7	32.9	32.8	32.9	32.5	32.9	32.7	32.7	32.7	32.6	32.8	32.7	32.4	32.3	32.7	32.6	35.8	35.1	36.6	35.4	34.5	34.2	34.0	34.2	39.1
13:00	32.7	32.7	32.6	32.8	32.8	32.7	32.7	32.7	32.7	32.8	32.8	32.8	32.7	32.7	32.8	32.7	34.9	34.5	35.4	34.7	34.2	34.0	33.8	29.8	39.0
14:00	32.8	32.7	32.7	33.0	32.9	32.9	32.9	32.9	32.9	32.9	33.0	33.0	32.8	32.9	32.9	32.9	35.3	34.8	35.9	35.0	34.4	34.2	34.1	29.9	39.5
15:00	33.2	33.1	32.9	33.4	33.3	33.3	33.4	33.3	33.3	33.3	33.4	33.3	33.2	33.2	33.3	33.3	35.4	34.9	35.9	35.1	34.6	34.5	34.4	29.9	38.5
16:00	33.1	33.0	33.0	33.3	33.2	33.2	33.2	33.2	33.2	33.2	33.3	33.3	33.1	33.1	33.2	33.2	34.8	34.4	35.1	34.4	33.9	34.0	34.1	30.1	37.4
17:00	32.5	32.6	32.5	32.5	32.5	32.5	32.5	32.6	32.5	32.6	32.7	32.6	32.5	32.6	32.6	32.6	33.1	32.9	33.1	32.9	32.8	32.9	33.0	30.6	33.5
18:00	32.2	32.3	32.2	32.2	32.0	32.2	32.1	32.2	32.1	32.2	32.3	32.3	32.1	32.1	32.2	32.2	32.0	31.8	32.0	31.8	31.9	32.0	32.0	32.0	32.1
19:00	30.1	30.0	30.2	30.0	29.9	30.1	30.0	30.1	30.0	30.3	30.3	30.3	29.9	30.0	30.1	30.3	27.9	27.8	27.9	27.9	28.3	28.3	27.0	28.6	27.0
20:00	28.0	28.1	28.1	27.9	27.8	27.9	27.9	28.0	27.9	28.2	28.3	28.3	27.8	27.9	28.0	28.2	25.1	25.0	25.0	25.2	25.7	25.8	25.0	26.2	24.1
21:00	27.1	27.1	27.2	27.0	26.8	27.0	27.1	27.1	27.0	27.2	27.3	27.3	26.9	27.0	27.1	27.2	25.2	25.3	25.2	25.3	25.6	25.7	25.5	26.2	24.7
22:00	26.8	26.8	26.9	26.7	26.7	26.7	26.7	26.8	26.8	26.9	26.9	27.0	26.7	26.8	26.8	26.9	25.5	25.6	25.5	25.6	25.8	25.8	25.7	25.9	24.9
23:00	26.9	26.9	26.9	26.8	26.8	26.8	26.9	26.9	26.8	26.9	27.0	27.1	26.9	26.9	26.9	27.0	25.9	25.9	25.8	26.0	26.1	26.1	26.1	26.4	25.3
0:00	26.8	26.8	26.8	26.8	26.8	26.7	26.8	26.8	26.8	26.9	26.9	26.9	26.8	26.9	26.8	26.9	25.9	25.9	25.9	26.0	26.1	26.3	25.7	25.8	25.3

Table A.23. Experimental results in controlled cell (closed openings) and ambient conditions on June 23rd, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	vinflow	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)	(m/s)	%
1:00	30.7	30.7	30.7	30.6	30.6	30.6	30.6	30.6	30.6	30.7	30.8	30.8	30.7	30.7	30.7	30.6	29.2	1.2	0.0	-	-
2:00	30.4	30.4	30.3	30.2	30.2	30.2	30.3	30.2	30.3	30.3	30.4	30.4	30.3	30.3	30.3	30.3	28.8	1.2	0.0	-	-
3:00	30.2	30.2	30.1	30.0	30.0	30.0	30.0	30.0	30.0	30.1	30.2	30.2	30.2	30.1	30.1	30.1	28.7	1.0	0.0	-	-
4:00	30.0	29.9	29.9	29.8	29.8	29.8	29.8	29.8	29.8	29.9	30.1	30.0	29.9	29.9	29.8	29.8	28.5	2.2	0.0	-	-
5:00	29.7	29.6	29.6	29.5	29.5	29.5	29.5	29.5	29.5	29.5	29.7	29.7	29.7	29.6	29.6	29.6	28.1	1.7	0.0	-	-
6:00	29.2	29.2	29.1	29.0	29.0	29.0	29.0	29.0	29.0	29.1	29.3	29.3	29.2	29.2	29.1	29.1	28.0	2.1	0.3	-	-
7:00	29.0	28.9	28.9	28.8	28.8	28.7	28.7	28.8	28.8	28.8	29.0	29.0	28.9	28.9	28.8	28.8	28.3	1.6	63.7	-	-
8:00	29.4	29.3	29.3	29.3	29.2	29.1	29.2	29.1	29.2	29.2	29.4	29.4	29.3	29.3	29.2	29.2	29.2	1.4	150.0	-	-
9:00	30.3	30.3	30.3	30.3	30.1	30.1	30.1	30.0	30.1	30.2	30.3	30.2	30.1	30.1	30.0	30.0	31.2	1.4	399.4	-	-
10:00	31.2	31.3	31.3	31.3	31.1	31.1	31.1	31.0	31.1	31.1	31.3	31.1	31.0	31.0	31.0	31.0	32.2	1.6	381.5	-	-
11:00	32.3	32.5	32.5	32.4	32.1	32.4	32.2	32.1	32.2	32.3	32.5	32.2	32.1	32.1	32.1	32.1	33.4	1.5	592.7	-	-
12:00	33.2	33.5	33.4	33.3	33.1	33.4	33.2	33.1	33.2	33.4	33.7	33.3	33.2	33.2	33.3	33.3	35.6	1.4	753.2	-	-
13:00	33.7	33.8	33.8	33.8	33.7	33.8	33.8	33.7	33.8	34.0	34.0	33.9	33.8	33.8	33.9	34.1	33.9	1.7	476.4	-	-
14:00	34.2	34.3	34.2	34.3	34.0	34.3	34.3	34.1	34.2	34.5	34.5	34.3	34.3	34.3	34.3	34.6	34.4	1.7	518.7	-	-
15:00	34.8	34.9	34.9	34.9	34.7	34.9	34.8	34.7	34.8	35.1	35.0	34.9	34.8	34.8	34.8	35.0	34.6	1.5	462.4	-	-
16:00	35.2	35.2	35.2	35.2	35.0	35.3	35.2	35.1	35.2	35.4	35.4	35.3	35.2	35.2	35.3	35.6	34.7	1.6	347.4	-	-
17:00	34.2	34.2	34.2	34.1	34.2	34.3	34.3	34.2	34.2	34.6	34.5	34.5	34.5	34.5	34.5	34.8	33.0	1.4	95.5	-	-
18:00	33.2	33.2	33.1	33.0	33.1	33.2	33.2	33.2	33.2	33.5	33.4	33.4	33.5	33.4	33.5	33.7	32.2	1.5	45.5	-	-
19:00	30.2	30.3	30.3	30.0	30.0	30.2	30.2	30.1	30.1	30.2	30.5	30.4	30.3	30.3	30.4	30.5	26.8	1.6	0.0	-	-
20:00	28.4	28.4	28.5	28.0	28.0	28.3	28.2	28.2	28.2	28.3	28.6	28.5	28.2	28.2	28.3	28.5	24.1	1.7	0.0	-	-
21:00	27.5	27.5	27.5	27.2	27.2	27.3	27.2	27.2	27.2	27.3	27.5	27.6	27.3	27.3	27.4	27.5	25.0	1.9	0.0	-	-
22:00	27.3	27.3	27.2	26.9	27.0	27.1	27.1	27.1	27.1	27.1	27.3	27.3	27.2	27.1	27.2	27.3	24.9	1.3	0.0	-	-
23:00	27.4	27.3	27.3	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.4	27.5	27.3	27.2	27.2	27.4	25.4	1.2	0.0	-	-
0:00	27.3	27.2	27.3	27.2	27.2	27.2	27.2	27.1	27.2	27.2	27.3	27.4	27.3	27.2	27.2	27.4	25.1	1.8	0.0	-	-

Table A.24. Experimental results in the test cell on June 24th, 2005 (closed openings and application of wetted roof).

Time	TC1	TC2	TC3	TC4	TC5	TC6	TC7	TC8	TC9	TC10	TC11	TC12	TC13	TC14	TC15	TC16	TC17	TC18	TC19	TC20	TC21	TC22	TC23	TC24	TC25
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)
1:00	26.7	26.7	26.7	26.6	26.6	26.6	26.6	26.7	26.6	26.7	26.7	26.7	26.7	26.7	26.7	26.7	25.8	25.7	25.8	25.7	25.9	26.0	25.5	25.9	25.2
2:00	26.6	26.6	26.6	26.5	26.5	26.5	26.5	26.6	26.5	26.6	26.6	26.6	26.6	26.6	26.6	26.6	25.7	25.6	25.7	25.6	25.8	25.8	25.6	26.0	25.2
3:00	26.5	26.5	26.5	26.4	26.5	26.4	26.4	26.5	26.5	26.5	26.5	26.6	26.5	26.5	26.5	26.5	25.7	25.5	25.7	25.5	25.7	25.8	25.6	26.0	25.2
4:00	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.5	26.5	26.5	26.4	26.5	26.5	26.5	25.7	25.5	25.7	25.6	25.7	25.7	25.7	26.0	25.2
5:00	26.4	26.4	26.4	26.4	26.4	26.3	26.4	26.4	26.4	26.4	26.4	26.5	26.4	26.4	26.4	26.5	25.7	25.6	25.6	25.6	25.8	25.8	25.7	26.0	25.2
6:00	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.3	26.4	26.4	26.5	26.4	26.4	26.4	26.4	25.7	25.6	25.7	25.6	25.7	25.7	25.6	26.0	25.1
7:00	26.5	26.5	26.5	26.5	26.5	26.4	26.5	26.5	26.5	26.5	26.5	26.7	26.5	26.5	26.5	26.5	26.2	26.2	26.3	26.2	26.3	26.3	26.2	26.5	26.8
8:00	27.1	27.3	27.1	27.2	27.1	27.3	27.1	27.1	27.1	27.1	27.1	27.3	27.0	27.1	27.1	27.1	27.6	27.4	27.6	27.4	27.2	27.2	27.6	28.2	29.1
9:00	28.1	28.6	28.3	28.3	28.1	28.5	28.1	28.2	28.1	28.1	28.2	28.3	27.9	27.9	28.2	28.1	29.6	29.4	29.9	29.5	29.0	28.8	29.9	30.2	31.9
10:00	29.3	29.9	29.6	29.5	29.1	29.8	29.3	29.3	29.3	29.2	29.4	29.3	28.9	28.9	29.3	29.2	31.9	31.6	32.3	31.7	31.0	30.8	30.8	31.8	34.8
11:00	30.0	30.7	30.4	30.2	29.8	30.6	30.0	30.0	30.0	30.0	30.2	30.0	29.7	29.7	30.0	29.9	33.1	32.6	33.6	32.8	32.1	31.7	31.9	32.7	35.9
12:00	30.7	31.5	31.2	31.0	30.6	31.3	30.7	30.8	30.8	30.7	31.0	30.8	30.5	30.4	30.8	30.7	34.2	33.7	34.7	33.9	33.1	32.8	32.7	33.5	37.6
13:00	31.7	32.4	32.1	31.9	31.5	32.2	31.7	31.7	31.7	31.7	31.9	31.7	31.4	31.4	31.7	31.6	35.1	34.5	35.8	34.8	34.0	33.7	33.6	34.6	38.6
14:00	31.9	31.9	31.8	32.1	31.9	32.1	32.0	32.0	32.0	32.0	32.1	32.1	31.8	31.8	32.0	31.9	35.8	35.2	36.4	35.3	34.5	34.3	35.3	30.3	39.3
15:00	32.1	32.1	32.0	32.3	32.1	32.3	32.3	32.2	32.2	32.3	32.4	32.3	32.1	32.2	32.3	32.2	35.3	34.8	35.8	35.0	34.4	34.3	33.0	29.2	38.4
16:00	32.1	32.1	32.0	32.2	32.1	32.2	32.2	32.2	32.1	32.2	32.3	32.3	32.0	32.1	32.2	32.2	35.1	34.6	35.3	34.6	34.0	34.1	35.6	29.7	37.8
17:00	32.4	32.4	32.3	32.4	32.3	32.4	32.4	32.4	32.4	32.5	32.5	32.6	32.3	32.4	32.4	32.5	33.7	33.4	33.8	33.4	33.2	33.3	34.3	31.1	34.9
18:00	28.2	28.3	28.6	28.1	28.1	28.4	28.2	28.3	28.2	28.7	28.7	28.4	28.2	28.3	28.4	28.8	27.8	27.7	27.8	27.8	28.0	28.5	27.3	28.1	28.0
19:00	27.4	27.6	27.7	27.4	27.2	27.5	27.4	27.4	27.4	27.6	27.7	27.6	27.3	27.4	27.5	27.7	26.9	26.9	26.9	26.9	27.2	27.4	27.0	27.3	26.5
20:00	27.6	27.7	27.7	27.5	27.5	27.6	27.6	27.6	27.6	27.6	27.7	27.9	27.5	27.6	27.6	27.7	27.1	27.1	27.0	27.1	27.3	27.3	27.4	27.3	26.6
21:00	27.7	27.7	27.8	27.7	27.6	27.7	27.7	27.7	27.7	27.7	27.8	28.0	27.7	27.7	27.7	27.8	27.5	27.5	27.4	27.5	27.6	27.7	27.8	27.6	27.1
22:00	27.9	27.9	27.9	27.8	27.8	27.8	27.8	27.9	27.8	27.9	27.9	28.1	27.8	27.9	27.9	27.9	27.4	27.4	27.4	27.4	27.5	27.6	27.6	27.6	26.6
23:00	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.9	28.0	27.8	27.8	27.8	27.9	27.3	27.3	27.2	27.3	27.5	27.6	27.7	27.6	26.9
0:00	27.7	27.8	27.8	27.7	27.7	27.7	27.7	27.7	27.7	27.8	27.8	28.0	27.7	27.8	27.8	27.8	27.4	27.5	27.4	27.5	27.6	27.6	27.7	27.6	27.1

Table A.25. Experimental results in controlled cell (closed openings) and ambient conditions on June 24th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	vinflow	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)	(m/s)	%
1:00	27.1	27.1	27.1	27.0	26.9	27.0	27.0	26.9	27.0	27.0	27.1	27.1	27.0	27.0	27.0	27.2	25.1	1.4	0.0	-	-
2:00	27.0	26.9	26.9	26.9	26.8	26.8	26.8	26.8	26.8	26.9	27.0	27.1	26.9	26.9	26.9	27.0	25.2	0.5	0.0	-	-
3:00	26.9	26.8	26.8	26.7	26.7	26.7	26.7	26.6	26.7	26.7	26.9	27.0	26.9	26.9	26.8	27.0	25.5	1.5	0.0	-	-
4:00	26.9	26.8	26.8	26.7	26.6	26.7	26.6	26.6	26.7	26.7	26.9	26.9	26.8	26.8	26.7	26.9	25.7	1.1	0.0	-	-
5:00	26.8	26.7	26.7	26.7	26.6	26.6	26.6	26.6	26.6	26.7	26.9	26.9	26.8	26.7	26.7	26.9	25.5	2.2	0.0	-	-
6:00	26.8	26.7	26.6	26.6	26.6	26.6	26.6	26.5	26.6	26.6	26.8	26.8	26.6	26.6	26.6	26.8	25.5	3.1	0.1	-	-
7:00	26.9	26.7	26.7	26.8	26.7	26.7	26.7	26.6	26.7	26.7	26.9	26.9	26.8	26.8	26.7	27.0	26.0	1.4	77.3	-	-
8:00	27.6	27.6	27.7	27.6	27.5	27.6	27.6	27.5	27.5	27.5	27.8	27.6	27.5	27.6	27.5	27.8	28.0	1.2	195.1	-	-
9:00	28.8	28.9	28.9	28.8	28.6	28.8	28.7	28.5	28.6	28.6	29.0	28.7	28.6	28.6	28.6	28.8	30.1	1.4	406.0	-	-
10:00	30.0	30.3	30.2	30.1	29.6	30.1	29.8	29.7	29.8	29.8	30.2	29.9	29.6	29.7	29.7	29.8	31.7	1.8	474.9	-	-
11:00	30.8	31.0	31.0	30.9	30.5	30.8	30.6	30.6	30.7	30.7	30.9	30.6	30.5	30.5	30.5	30.6	32.2	1.4	658.0	-	-
12:00	31.6	31.8	31.8	31.7	31.4	31.7	31.5	31.4	31.5	31.5	31.8	31.4	31.3	31.3	31.3	31.3	32.9	1.4	698.7	-	-
13:00	32.6	32.8	32.9	32.7	32.4	32.6	32.5	32.4	32.5	32.6	32.8	32.5	32.3	32.4	32.4	32.4	33.9	1.8	796.5	-	-
14:00	33.7	33.9	34.0	33.8	33.4	33.9	33.7	33.6	33.7	34.0	34.0	33.7	33.5	33.6	33.7	33.7	35.5	1.8	855.1	-	-
15:00	34.3	34.4	34.5	34.5	34.2	34.6	34.4	34.3	34.4	34.7	34.7	34.5	34.4	34.4	34.5	34.5	34.7	1.9	444.6	-	-
16:00	34.7	34.8	34.8	34.8	34.4	34.9	34.6	34.6	34.7	34.9	35.0	34.9	34.6	34.6	34.8	34.9	35.9	1.4	574.0	-	-
17:00	34.6	34.7	34.7	34.7	34.5	34.8	34.7	34.6	34.7	35.0	34.9	34.9	34.8	34.8	34.9	35.0	33.5	2.1	151.8	-	-
18:00	30.2	30.2	30.4	30.1	30.0	30.3	30.3	30.1	30.3	30.5	30.6	30.4	30.4	30.4	30.5	30.6	27.3	2.4	31.8	-	-
19:00	29.0	29.1	29.0	28.9	28.9	29.0	29.1	29.0	29.1	29.3	29.3	29.3	29.3	29.3	29.3	29.4	27.4	1.4	0.0	-	-
20:00	28.7	28.7	28.8	28.6	28.7	28.7	28.7	28.7	28.6	28.6	28.8	28.9	28.9	28.9	28.9	28.8	27.7	1.2	0.0	-	-
21:00	28.7	28.7	28.7	28.6	28.6	28.6	28.6	28.6	28.6	28.7	28.8	28.8	28.7	28.7	28.7	28.6	27.7	1.0	0.0	-	-
22:00	28.8	28.8	28.8	28.7	28.7	28.7	28.7	28.7	28.7	28.7	28.9	28.9	28.8	28.8	28.8	28.7	27.5	1.0	0.0	-	-
23:00	28.6	28.5	28.6	28.4	28.4	28.4	28.4	28.4	28.4	28.5	28.6	28.7	28.5	28.5	28.5	28.4	27.6	1.0	0.0	-	-
0:00	28.5	28.4	28.4	28.3	28.3	28.3	28.3	28.3	28.3	28.4	28.5	28.5	28.4	28.4	28.4	28.3	27.7	1.1	0.0	-	-

Table A.26. Experimental results in the test cell on July 1st, 2005 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	28.2	28.2	28.2	28.1	28.1	28.1	28.1	28.1	28.1	28.2	28.2	28.2	28.1	28.1	28.2	28.2	27.5	27.6	27.4	27.5	27.7	28.1	26.5	27.8	25.3
2:00	27.8	27.8	27.8	27.8	27.7	27.7	27.7	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.8	27.3	27.4	27.2	27.3	27.5	27.7	26.4	27.5	24.9
3:00	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.4	27.5	27.5	27.5	27.4	27.4	27.5	27.5	27.0	27.1	26.9	27.0	27.1	27.4	26.0	27.2	24.6
4:00	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.1	27.2	27.2	27.2	27.1	27.1	27.1	27.2	26.5	26.6	26.3	26.5	26.7	27.0	25.4	26.7	24.3
5:00	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.9	26.9	26.9	26.8	26.8	26.8	26.9	26.2	26.2	26.0	26.1	26.4	26.7	25.2	26.5	24.2
6:00	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.8	26.8	26.7	26.7	26.7	26.8	26.3	26.4	26.2	26.3	26.5	26.7	25.4	26.5	24.2
7:00	26.9	26.9	26.9	26.9	26.9	26.8	26.8	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.9	26.8	26.8	26.7	26.8	26.8	26.9	25.9	27.0	24.4
8:00	27.6	27.7	27.6	27.7	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	28.1	28.0	28.2	28.1	27.9	27.7	27.5	28.7	25.0
9:00	28.9	29.3	29.0	29.1	28.9	29.1	28.9	29.0	29.0	28.9	29.0	28.9	28.9	28.9	29.0	28.9	30.2	30.0	30.3	29.9	29.5	29.5	28.8	30.5	26.1
10:00	29.3	29.5	29.4	29.5	29.4	29.4	29.3	29.4	29.4	29.3	29.4	29.4	29.3	29.4	29.4	29.4	30.2	30.0	30.3	29.9	29.6	29.7	28.3	30.1	26.7
11:00	30.1	30.5	30.3	30.4	30.3	30.3	30.2	30.2	30.2	30.2	30.2	30.2	30.2	30.3	30.3	30.2	31.7	31.5	31.9	31.3	30.7	30.9	29.8	31.5	27.6
12:00	30.8	31.1	31.0	31.0	30.9	30.9	30.8	30.8	30.9	30.8	30.8	30.8	30.8	30.9	30.9	30.8	32.4	32.1	32.6	32.0	31.4	31.5	30.3	32.1	27.6
13:00	31.4	31.8	31.6	31.7	31.5	31.6	31.5	31.5	31.5	31.5	31.5	31.5	31.4	31.6	31.5	31.5	33.1	32.7	33.5	32.7	32.1	32.0	30.8	32.9	28.3
14:00	31.9	32.2	32.1	32.2	32.0	32.1	32.0	32.0	32.0	32.0	32.1	31.9	31.9	32.1	32.1	32.0	33.8	33.6	33.9	33.1	32.5	33.1	31.9	33.0	28.7
15:00	32.8	33.0	32.9	33.1	32.8	32.9	32.8	32.8	32.8	32.8	32.8	32.8	32.7	32.9	32.9	32.8	33.9	34.0	34.0	33.6	33.2	33.6	33.0	33.7	29.4
16:00	33.8	34.1	33.9	34.1	33.8	34.0	33.9	33.9	33.8	33.9	33.8	33.8	33.7	33.9	33.9	33.8	34.5	34.5	34.6	34.3	34.0	34.1	34.2	35.2	30.9
17:00	34.4	34.8	34.5	34.7	34.3	34.6	34.5	34.4	34.4	34.5	34.5	34.3	34.3	34.5	34.4	34.3	34.3	34.1	34.4	34.2	34.1	34.2	33.9	35.8	31.3
18:00	34.2	34.3	34.3	34.3	34.0	34.3	34.2	34.2	34.2	34.3	34.2	34.1	34.1	34.2	34.2	34.2	33.7	33.7	33.8	33.7	33.8	33.9	33.1	34.6	30.5
19:00	33.1	33.1	33.2	33.1	33.0	33.1	33.1	33.1	33.1	33.2	33.1	33.1	33.0	33.1	33.1	33.1	32.6	32.6	32.6	32.7	32.9	32.8	31.7	32.8	29.0
20:00	32.0	32.0	32.0	32.0	31.9	32.0	32.0	32.0	32.0	32.1	32.1	32.1	32.0	32.0	32.0	32.1	31.3	31.3	31.3	31.5	31.8	31.6	30.5	31.6	27.8
21:00	31.5	31.4	31.5	31.4	31.4	31.4	31.4	31.5	31.4	31.5	31.5	31.5	31.5	31.5	31.5	31.5	30.7	30.7	30.6	30.7	31.1	31.3	29.7	31.0	27.3
22:00	31.2	31.2	31.2	31.2	31.2	31.2	31.1	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	31.2	30.1	30.2	30.2	30.4	31.0	30.6	29.1	30.5	27.5
23:00	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.4	30.5	30.5	30.5	30.4	30.4	30.4	30.5	29.5	29.5	29.5	29.7	30.1	29.8	28.9	29.9	27.2
0:00	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.3	29.4	29.4	29.4	29.3	29.4	29.3	29.4	28.6	28.7	28.7	28.8	29.2	28.8	28.0	29.0	25.9

Table A.27. Experimental results in controlled cell (application of solar chimney) and ambient conditions on July 1st, 2005.

Time (min)	CC1 (°C)	CC2 (°C)	CC3 (°C)	CC4 (°C)	CC5 (°C)	CC6 (°C)	CC7 (°C)	CC8 (°C)	CC9 (°C)	CC10 (°C)	CC11 (°C)	CC12 (°C)	CC13 (°C)	CC14 (°C)	CC15 (°C)	CC16 (°C)	Ambient (°C)	wind (m/s)	solar (W/m^2)	v_{inflow} (m/s)	RH %
1:00	29.0	28.9	28.9	28.8	28.8	28.8	28.8	28.7	28.7	28.8	29.1	29.1	28.9	28.9	28.9	28.9	27.7	1.2	0.0	-	-
2:00	28.5	28.5	28.5	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.6	28.6	28.5	28.5	28.4	28.4	27.6	1.4	0.0	-	-
3:00	28.1	28.1	28.0	27.9	27.9	27.9	27.9	27.8	27.8	27.9	28.2	28.2	28.1	28.1	28.0	28.0	27.2	1.5	0.0	-	-
4:00	27.8	27.7	27.7	27.5	27.5	27.5	27.5	27.4	27.4	27.5	27.8	27.8	27.7	27.7	27.7	27.6	26.6	1.3	0.0	-	-
5:00	27.5	27.4	27.4	27.3	27.2	27.2	27.2	27.2	27.2	27.2	27.5	27.5	27.4	27.4	27.4	27.4	26.4	1.3	0.0	-	-
6:00	27.4	27.3	27.3	27.2	27.2	27.1	27.1	27.1	27.1	27.1	27.4	27.4	27.3	27.3	27.3	27.2	26.6	1.4	0.6	-	-
7:00	27.5	27.4	27.4	27.4	27.3	27.3	27.3	27.2	27.2	27.2	27.5	27.6	27.5	27.5	27.4	27.3	27.1	1.3	40.8	-	-
8:00	28.4	28.4	28.4	28.3	28.2	28.2	28.2	28.2	28.2	28.2	28.4	28.4	28.3	28.3	28.2	28.2	28.7	1.5	126.3	-	-
9:00	29.7	29.8	29.8	29.6	29.5	29.6	29.5	29.4	29.5	29.5	29.8	29.7	29.5	29.5	29.5	29.4	30.0	1.6	318.9	-	-
10:00	30.0	29.9	29.9	29.9	29.8	29.8	29.8	29.7	29.7	29.8	29.9	29.9	29.8	29.8	29.8	29.7	29.5	1.5	250.7	-	-
11:00	30.8	30.8	30.8	30.8	30.6	30.6	30.6	30.6	30.6	30.6	30.8	30.7	30.6	30.6	30.6	30.6	31.0	1.6	508.8	-	-
12:00	31.3	31.3	31.4	31.3	31.2	31.2	31.2	31.1	31.2	31.2	31.4	31.3	31.2	31.2	31.2	31.1	31.5	1.6	508.9	-	-
13:00	31.9	31.9	32.0	31.9	31.8	31.8	31.8	31.7	31.8	31.8	31.9	31.9	31.7	31.7	31.7	31.7	32.0	1.8	597.4	-	-
14:00	32.6	32.5	32.5	32.5	32.3	32.5	32.5	32.4	32.5	32.7	32.7	32.6	32.5	32.5	32.5	32.6	33.1	1.5	662.0	-	-
15:00	33.3	33.3	33.3	33.3	33.2	33.4	33.4	33.3	33.4	33.7	33.5	33.5	33.5	33.5	33.6	33.7	34.2	1.6	595.0	-	-
16:00	34.4	34.4	34.4	34.4	34.2	34.6	34.5	34.3	34.4	34.8	34.7	34.6	34.5	34.5	34.6	34.8	35.4	1.6	622.7	-	-
17:00	35.0	35.0	35.1	35.0	34.9	35.2	35.2	35.0	35.1	35.5	35.3	35.2	35.1	35.2	35.3	35.4	35.1	1.7	376.0	-	-
18:00	34.5	34.5	34.6	34.5	34.4	34.7	34.8	34.5	34.7	35.0	34.8	34.8	34.8	34.8	34.9	35.1	34.3	1.4	149.8	-	-
19:00	33.2	33.3	33.2	33.2	33.2	33.3	33.4	33.3	33.4	33.7	33.6	33.6	33.7	33.7	33.7	33.8	32.9	1.4	13.3	-	-
20:00	32.1	32.2	32.2	32.1	32.1	32.2	32.3	32.2	32.2	32.5	32.5	32.5	32.6	32.6	32.6	32.8	31.7	1.5	0.0	-	-
21:00	31.5	31.6	31.6	31.5	31.5	31.7	31.7	31.6	31.7	32.0	31.9	31.9	32.0	32.0	32.0	32.2	30.9	1.5	0.0	-	-
22:00	31.3	31.4	31.3	31.3	31.3	31.4	31.4	31.4	31.4	31.7	31.7	31.8	31.8	31.8	31.8	32.0	30.3	2.0	0.0	-	-
23:00	30.5	30.6	30.5	30.5	30.5	30.6	30.7	30.6	30.6	30.9	30.8	31.0	31.0	31.0	31.0	31.1	30.1	1.5	0.0	-	-
0:00	29.5	29.5	29.5	29.4	29.4	29.5	29.6	29.5	29.5	29.8	29.7	29.9	29.9	29.9	29.9	30.0	29.2	1.5	0.0	-	-

Table A.28. Experimental results in the test cell on July 4th, 2005 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	27.6	27.6	27.6	27.5	27.5	27.5	27.5	27.5	27.5	27.6	27.6	27.6	27.5	27.6	27.6	27.6	27.3	27.3	27.2	27.3	27.5	27.6	27.4	27.4	25.3
2:00	27.2	27.2	27.3	27.2	27.2	27.2	27.2	27.2	27.2	27.2	27.3	27.3	27.2	27.2	27.2	27.3	26.9	27.0	26.9	27.0	27.1	27.2	27.1	27.0	25.0
3:00	27.0	27.0	27.0	27.0	26.9	26.9	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.0	26.8	26.9	26.7	26.8	26.9	27.0	27.0	26.9	24.7
4:00	26.8	26.9	26.9	26.8	26.8	26.8	26.8	26.8	26.8	26.9	26.9	26.9	26.8	26.9	26.9	26.9	26.6	26.6	26.5	26.6	26.8	26.9	26.8	26.7	24.6
5:00	26.7	26.7	26.8	26.7	26.7	26.7	26.7	26.7	26.7	26.7	26.8	26.8	26.7	26.8	26.8	26.8	26.4	26.5	26.4	26.5	26.6	26.7	26.6	26.6	24.5
6:00	26.6	26.6	26.6	26.6	26.6	26.5	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.2	26.2	26.1	26.2	26.4	26.5	26.4	26.4	24.5
7:00	26.6	26.6	26.6	26.6	26.6	26.5	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.3	26.3	26.3	26.3	26.4	26.5	26.4	26.6	24.5
8:00	27.0	27.1	27.1	27.1	27.0	27.0	27.0	27.0	27.0	27.0	27.0	27.1	27.0	27.0	27.0	27.0	27.4	27.3	27.4	27.3	27.2	27.1	27.3	27.8	24.9
9:00	28.1	28.6	28.3	28.3	28.1	28.4	28.3	28.2	28.2	28.1	28.2	28.2	28.1	28.1	28.2	28.1	29.5	29.2	29.6	29.2	28.8	28.6	29.0	29.7	25.9
10:00	29.4	29.9	29.6	29.6	29.4	29.7	29.5	29.5	29.5	29.4	29.5	29.5	29.3	29.3	29.5	29.4	31.0	30.6	31.5	30.8	30.2	29.8	30.1	31.1	27.9
11:00	30.5	31.0	30.7	30.7	30.4	30.8	30.5	30.6	30.5	30.5	30.6	30.5	30.4	30.3	30.6	30.5	32.8	32.3	33.2	32.3	31.5	31.3	31.0	32.3	29.6
12:00	31.7	32.4	32.0	31.9	31.6	32.1	31.7	31.8	31.7	31.7	31.9	31.7	31.5	31.5	31.8	31.7	34.3	33.8	34.6	33.7	32.9	32.7	32.3	33.8	32.6
13:00	32.6	33.2	33.0	32.8	32.5	33.0	32.6	32.7	32.6	32.6	32.8	32.6	32.4	32.3	32.7	32.6	35.2	34.7	35.7	34.7	33.7	33.5	33.1	34.5	33.7
14:00	33.4	34.1	33.8	33.6	33.3	33.9	33.5	33.5	33.5	33.5	33.7	33.4	33.2	33.1	33.6	33.4	35.5	34.9	36.0	35.1	34.3	33.9	33.9	35.5	34.6
15:00	34.5	35.0	34.8	34.7	34.3	34.8	34.6	34.6	34.5	34.6	34.7	34.5	34.2	34.1	34.6	34.5	36.2	35.9	36.6	35.8	35.2	35.0	34.5	36.2	35.6
16:00	35.1	35.6	35.4	35.3	34.9	35.5	35.2	35.2	35.1	35.2	35.3	35.1	34.7	34.7	35.2	35.1	36.4	36.0	36.9	36.1	35.6	35.4	35.5	36.7	35.4
17:00	35.9	36.6	36.3	36.1	35.5	36.5	36.0	36.0	35.9	36.1	36.3	35.9	35.4	35.3	36.0	35.9	36.3	36.1	36.7	36.2	36.1	36.0	36.8	37.6	35.5
18:00	36.1	36.3	36.3	36.1	35.7	36.5	36.1	36.1	36.0	36.3	36.2	36.0	35.7	35.6	36.1	36.0	35.6	35.4	35.8	35.5	35.8	36.0	35.5	36.8	35.3
19:00	33.6	33.5	33.7	33.4	33.5	33.5	33.5	33.7	33.5	33.7	33.6	33.7	33.5	33.6	33.5	33.6	32.2	32.2	32.2	32.3	33.1	33.5	31.7	33.0	32.6
20:00	28.5	28.0	28.0	28.1	28.4	28.0	28.0	28.4	28.2	28.6	28.3	28.3	28.1	28.5	28.3	28.6	26.5	26.5	26.3	26.7	27.8	27.9	25.5	27.2	27.7
21:00	26.0	25.6	25.8	25.7	25.9	25.7	25.6	25.9	25.8	26.0	25.8	25.9	25.8	26.0	25.9	26.0	24.7	24.7	24.6	24.9	25.6	25.7	24.0	24.6	24.4
22:00	26.0	25.9	26.0	25.8	25.9	25.8	25.8	25.9	25.9	26.0	25.9	25.9	25.9	26.0	25.9	26.0	25.1	25.1	25.0	25.3	25.7	25.7	24.8	24.9	24.6
23:00	26.0	26.0	26.0	25.9	26.0	25.8	25.9	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.0	26.1	25.2	25.3	25.2	25.5	25.9	25.6	25.0	25.0	24.8
0:00	26.0	25.9	25.9	25.8	25.9	25.7	25.8	26.0	25.9	25.9	25.9	26.0	25.9	25.9	25.9	26.0	25.2	25.3	25.3	25.5	25.8	25.8	24.9	25.1	24.9

Table A.29. Experimental results in controlled cell (application of solar chimney) and ambient conditions on July 4th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	vinflow	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	(W/m2)	(m/s)	%
1:00	28.3	28.2	28.4	28.1	28.1	28.1	28.1	28.1	28.1	28.2	28.3	28.3	28.2	28.2	28.2	28.2	27.5	1.2	0.0	-	-
2:00	27.9	27.9	28.0	27.8	27.7	27.7	27.8	27.7	27.8	27.8	28.0	28.0	27.9	27.9	27.9	27.9	27.2	1.4	0.0	-	-
3:00	27.7	27.6	27.7	27.5	27.5	27.5	27.5	27.5	27.5	27.6	27.8	27.8	27.7	27.7	27.6	27.6	27.1	1.3	0.0	-	-
4:00	27.5	27.4	27.5	27.3	27.3	27.3	27.3	27.3	27.3	27.4	27.6	27.6	27.5	27.5	27.4	27.4	27.0	1.2	0.0	-	-
5:00	27.4	27.3	27.4	27.3	27.2	27.2	27.2	27.2	27.2	27.2	27.4	27.5	27.3	27.3	27.3	27.2	26.7	1.2	0.0	-	-
6:00	27.2	27.2	27.3	27.1	27.1	27.0	27.1	27.1	27.1	27.1	27.3	27.3	27.2	27.2	27.1	27.1	26.5	1.1	0.0	-	-
7:00	27.2	27.1	27.2	27.1	27.0	27.0	27.0	27.0	27.0	27.0	27.2	27.2	27.1	27.1	27.0	27.0	26.5	1.1	37.9	-	-
8:00	27.7	27.6	27.7	27.6	27.5	27.4	27.5	27.4	27.5	27.5	27.7	27.7	27.6	27.6	27.5	27.4	27.5	1.4	118.7	-	-
9:00	28.8	28.8	28.9	28.8	28.6	28.6	28.6	28.5	28.6	28.6	28.9	28.7	28.6	28.6	28.6	28.5	29.2	1.4	416.5	-	-
10:00	29.9	30.0	30.1	29.9	29.6	29.8	29.8	29.7	29.8	30.0	30.1	30.0	29.9	29.9	29.9	29.9	30.4	1.9	406.9	-	-
11:00	30.9	31.1	31.2	31.0	30.8	31.0	30.9	30.8	30.9	31.1	31.3	31.2	31.0	31.1	31.1	31.1	32.7	1.4	767.8	-	-
12:00	32.1	32.4	32.6	32.3	32.0	32.3	32.2	32.1	32.1	32.3	32.5	32.4	32.2	32.3	32.3	32.4	34.3	1.6	935.1	0.18	60.9
13:00	32.9	33.2	33.4	33.2	32.8	33.2	33.1	32.9	33.0	33.3	33.5	33.3	33.1	33.2	33.2	33.4	34.8	1.7	793.8	0.14	59.9
14:00	33.7	34.0	34.2	33.9	33.6	34.1	34.0	33.7	33.9	34.3	34.3	34.1	34.0	34.1	34.2	34.4	35.4	1.7	725.3	0.08	57.9
15:00	35.0	35.3	35.3	35.1	34.8	35.3	35.2	35.0	35.1	35.4	35.5	35.3	35.1	35.2	35.3	35.5	36.0	2.2	740.4	0.08	54.5
16:00	35.7	36.0	36.1	35.9	35.5	36.1	35.8	35.7	35.8	36.1	36.2	36.0	35.7	35.8	35.9	36.2	36.3	2.1	469.0	0.05	53.1
17:00	36.9	37.1	37.2	36.9	36.3	37.2	36.9	36.8	36.9	37.1	37.3	37.0	36.6	36.7	37.0	37.2	37.5	2.5	480.6	0.06	50.1
18:00	36.8	36.9	37.1	36.8	36.4	37.1	36.9	36.7	36.8	37.0	37.2	36.9	36.8	36.9	37.0	37.3	35.3	2.2	227.6	0.12	51.5
19:00	33.9	33.9	34.0	33.7	33.7	33.9	33.9	33.8	33.8	34.2	34.2	34.1	34.2	34.1	34.2	34.4	31.5	1.8	3.5	-	-
20:00	28.7	28.7	28.7	28.6	28.4	28.7	28.6	28.6	28.7	28.6	29.1	28.9	28.7	28.7	28.8	29.4	24.7	-2.0	0.0	-	-
21:00	26.4	26.5	26.3	26.3	26.1	26.4	26.3	26.2	26.3	26.4	26.7	26.6	26.4	26.4	26.5	27.2	23.7	0.2	0.0	-	-
22:00	26.6	26.6	26.5	26.5	26.3	26.4	26.4	26.4	26.4	26.4	26.8	26.8	26.6	26.6	26.6	27.0	24.2	1.8	0.0	-	-
23:00	26.6	26.6	26.5	26.5	26.4	26.4	26.5	26.4	26.4	26.5	26.8	26.8	26.6	26.6	26.6	26.9	24.6	2.0	0.0	-	-
0:00	26.6	26.6	26.5	26.5	26.4	26.4	26.5	26.4	26.4	26.4	26.7	26.7	26.6	26.6	26.6	26.8	24.7	1.8	0.0	-	-

Table A.30. Experimental results in the test cell on July 6th, 2005 (application of solar chimney).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	28.2	28.2	28.2	28.0	28.1	28.1	28.1	28.1	28.1	28.2	28.2	28.2	28.2	28.2	28.2	28.2	27.9	27.9	27.8	27.9	28.0	28.1	27.9	28.0	28.1
2:00	27.7	27.7	27.7	27.6	27.7	27.6	27.6	27.7	27.7	27.7	27.8	27.8	27.7	27.8	27.8	27.8	27.5	27.5	27.4	27.5	27.6	27.7	27.6	27.6	27.7
3:00	27.3	27.3	27.3	27.2	27.3	27.2	27.2	27.3	27.3	27.3	27.3	27.4	27.3	27.4	27.3	27.3	27.0	27.1	27.0	27.0	27.2	27.3	27.1	27.1	27.3
4:00	26.9	26.9	27.0	26.8	26.9	26.9	26.8	26.9	26.9	26.9	27.0	27.0	26.9	27.0	27.0	26.9	26.5	26.6	26.5	26.5	26.7	26.9	26.6	26.7	26.9
5:00	26.7	26.7	26.7	26.6	26.7	26.6	26.6	26.7	26.7	26.7	26.8	26.8	26.7	26.8	26.7	26.7	26.4	26.5	26.3	26.4	26.6	26.7	26.6	26.5	26.7
6:00	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.7	26.7	26.6	26.7	26.7	26.7	26.3	26.4	26.3	26.3	26.5	26.5	26.7	26.5	26.6
7:00	26.6	26.6	26.6	26.6	26.6	26.5	26.5	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.4	26.5	26.3	26.4	26.5	26.5	26.7	26.6	26.6
8:00	26.8	26.8	26.8	26.9	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.9	26.8	26.8	27.1	27.0	27.1	27.0	26.9	26.9	27.1	27.0	26.8
9:00	27.3	27.4	27.3	27.5	27.4	27.4	27.4	27.3	27.3	27.3	27.4	27.4	27.4	27.4	27.4	27.3	28.0	27.8	28.2	27.9	27.6	27.5	28.0	27.9	27.3
10:00	28.6	28.9	28.7	28.9	28.5	28.7	28.6	28.6	28.6	28.5	28.6	28.6	28.5	28.4	28.7	28.6	30.3	29.9	30.8	30.0	29.3	28.9	30.6	30.5	28.3
11:00	29.9	30.3	30.0	30.2	29.8	30.1	30.0	29.9	29.9	29.9	29.9	30.0	29.8	29.7	30.0	30.0	31.9	31.3	32.4	31.4	30.6	30.3	31.5	31.8	29.6
12:00	30.6	31.0	30.8	30.8	30.4	30.8	30.6	30.6	30.6	30.6	30.7	30.6	30.5	30.3	30.7	30.7	32.7	32.2	33.4	32.3	31.5	31.1	31.9	32.4	30.2
13:00	31.8	32.1	31.9	32.1	31.7	31.9	31.9	31.8	31.8	31.8	31.8	31.8	31.8	31.6	32.0	31.9	34.2	33.7	34.8	33.7	32.8	32.5	33.1	33.6	31.5
14:00	32.7	33.0	32.8	33.0	32.5	32.9	32.8	32.8	32.7	32.8	32.8	32.8	32.7	32.5	32.9	32.8	34.9	34.5	35.3	34.4	33.6	33.4	34.0	34.5	32.3
15:00	33.7	34.0	33.7	33.9	33.5	33.8	33.8	33.7	33.7	33.8	33.7	33.7	33.7	33.5	33.8	33.8	35.3	34.9	35.7	35.0	34.3	34.1	34.9	35.3	33.4
16:00	33.9	34.2	34.0	34.0	33.7	34.1	34.1	34.0	33.9	34.1	33.9	33.9	33.9	33.8	34.0	34.0	34.5	34.2	34.7	34.2	34.0	34.0	35.3	35.4	33.6
17:00	33.9	34.3	34.1	34.0	33.7	34.1	34.0	33.9	33.9	34.0	33.9	33.9	33.8	33.8	33.9	33.9	33.3	33.2	33.5	33.4	33.7	33.8	35.0	35.4	33.6
18:00	33.9	34.3	34.1	33.9	33.7	34.1	33.9	33.9	33.8	34.0	33.9	33.9	33.8	33.7	33.9	33.9	33.1	33.0	33.2	33.1	33.5	33.7	34.8	35.2	33.6
19:00	32.9	33.2	33.2	32.7	32.8	33.0	32.9	32.9	32.8	33.0	33.0	32.9	32.8	32.9	32.9	32.9	32.0	32.0	32.0	32.1	32.5	32.7	32.6	33.3	32.7
20:00	31.4	31.5	31.6	31.1	31.3	31.4	31.3	31.3	31.3	31.4	31.5	31.5	31.3	31.4	31.4	31.4	30.5	30.6	30.5	30.7	31.1	31.3	30.8	31.2	31.3
21:00	30.6	30.7	30.8	30.4	30.6	30.6	30.6	30.6	30.6	30.6	30.7	30.7	30.6	30.7	30.7	30.6	30.0	30.0	30.0	30.1	30.5	30.7	30.3	30.5	30.6
22:00	30.2	30.3	30.3	30.0	30.2	30.2	30.2	30.2	30.2	30.2	30.3	30.3	30.2	30.3	30.3	30.2	29.7	29.7	29.7	29.8	30.1	30.3	29.9	30.1	30.2
23:00	29.9	29.9	30.0	29.7	29.9	29.9	29.8	29.9	29.9	29.9	30.0	30.0	29.9	30.0	30.0	29.9	29.3	29.4	29.3	29.4	29.7	29.9	29.6	29.7	29.9
0:00	29.4	29.4	29.4	29.2	29.4	29.3	29.3	29.4	29.4	29.4	29.5	29.5	29.4	29.5	29.5	29.4	28.8	28.9	28.7	28.8	29.0	29.3	28.9	29.1	29.4

Table A.31. Experimental results in controlled cell (application of solar chimney) and ambient conditions on July 6th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	vinflow	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)	(m/s)	%
1:00	28.4	28.5	29.3	28.4	28.3	28.4	28.5	28.4	28.5	28.8	28.8	28.8	28.8	28.8	28.8	28.9	28.4	1.2	0.0	-	-
2:00	27.9	27.9	28.9	27.9	27.9	28.0	28.1	28.0	28.0	28.2	28.3	28.3	28.4	28.4	28.4	28.5	27.9	1.5	0.0	-	-
3:00	27.5	27.5	28.4	27.5	27.5	27.5	27.6	27.5	27.6	27.8	27.9	27.9	27.9	27.9	27.8	28.0	27.4	1.3	0.0	-	-
4:00	27.2	27.2	28.0	27.1	27.1	27.2	27.3	27.2	27.3	27.5	27.5	27.5	27.5	27.6	27.5	27.6	27.0	1.2	0.0	-	-
5:00	27.0	27.0	27.7	26.9	26.9	27.0	27.0	27.0	27.0	27.2	27.2	27.3	27.3	27.3	27.3	27.3	27.0	1.3	0.0	-	-
6:00	26.8	26.8	27.5	26.8	26.8	26.8	26.9	26.8	26.9	27.1	27.1	27.1	27.2	27.2	27.1	27.2	27.1	1.2	0.0	-	-
7:00	26.8	26.8	27.5	26.7	26.7	26.8	26.9	26.8	26.9	27.0	27.1	27.1	27.1	27.2	27.1	27.2	27.2	1.2	25.3	-	-
8:00	27.0	27.0	27.8	27.0	26.9	27.0	27.0	27.0	27.0	27.3	27.2	27.3	27.3	27.3	27.3	27.3	27.5	1.1	61.7	-	-
9:00	27.5	27.6	28.5	27.6	27.5	27.5	27.5	27.4	27.5	27.6	27.8	27.7	27.7	27.7	27.7	27.7	28.2	1.6	172.1	-	-
10:00	28.8	29.0	30.0	29.0	28.7	28.8	28.7	28.7	28.8	28.8	29.1	28.9	28.7	28.8	28.8	28.8	30.4	1.5	599.1	-	-
11:00	30.2	30.3	31.4	30.3	30.0	30.2	30.1	30.1	30.1	30.1	30.3	30.1	30.0	30.0	30.1	30.1	31.4	1.8	563.4	-	-
12:00	30.9	31.1	32.4	31.0	30.7	31.0	30.8	30.8	30.8	30.9	31.1	30.8	30.7	30.7	30.7	30.8	32.5	1.7	757.0	-	-
13:00	32.0	32.3	33.6	32.1	31.8	32.2	32.1	32.0	32.1	32.5	32.5	32.3	32.1	32.2	32.3	32.4	34.1	1.5	849.3	-	-
14:00	33.0	33.3	34.7	33.2	32.8	33.3	33.2	33.0	33.2	33.5	33.6	33.4	33.2	33.3	33.4	33.6	35.9	1.6	973.9	-	-
15:00	34.0	34.3	35.3	34.2	33.9	34.4	34.3	34.1	34.2	34.6	34.5	34.4	34.3	34.4	34.5	34.7	35.9	1.7	787.4	-	-
16:00	34.7	34.8	35.7	34.8	34.4	34.9	34.7	34.6	34.7	34.8	34.9	34.8	34.6	34.6	34.8	35.0	35.1	1.9	575.6	-	-
17:00	35.1	35.1	35.9	35.1	34.6	35.2	34.9	34.9	34.9	35.0	35.2	35.0	34.7	34.7	35.0	35.0	34.9	1.8	450.7	-	-
18:00	35.4	35.2	36.1	35.2	34.8	35.3	35.1	35.0	35.1	35.2	35.3	35.1	34.8	34.9	35.1	35.1	34.4	1.6	226.5	-	-
19:00	33.9	33.7	34.5	33.7	33.5	33.7	33.7	33.6	33.7	33.7	33.8	33.6	33.5	33.5	33.6	33.7	31.8	1.4	22.7	-	-
20:00	32.0	32.0	32.6	31.9	31.8	31.9	31.9	31.9	31.9	32.0	32.1	32.0	31.9	31.9	32.0	32.0	30.3	1.5	0.0	-	-
21:00	31.2	31.2	31.8	31.1	31.1	31.1	31.1	31.1	31.1	31.2	31.2	31.2	31.1	31.1	31.1	31.1	29.9	1.3	0.0	-	-
22:00	30.7	30.7	31.3	30.6	30.5	30.6	30.6	30.6	30.6	30.6	30.7	30.7	30.6	30.6	30.6	30.6	29.6	1.4	0.0	-	-
23:00	30.3	30.3	30.9	30.2	30.2	30.2	30.2	30.2	30.2	30.3	30.4	30.3	30.3	30.3	30.3	30.3	29.4	1.8	0.0	-	-
0:00	29.8	29.8	30.4	29.7	29.6	29.7	29.7	29.6	29.7	29.7	29.9	29.9	29.7	29.8	29.7	29.7	28.7	1.4	0.0	-	-

Table A.32. Experimental results in the test cell on July 9th, 2005 (application of solar chimney and wetted roof).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	28.0	28.0	28.1	28.0	28.0	28.0	28.0	28.0	28.0	28.1	28.1	28.1	28.0	28.1	28.1	28.1	27.6	27.6	27.4	27.5	27.7	28.0	27.7	27.8	27.8
2:00	27.9	27.9	27.9	27.8	27.8	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.9	27.3	27.4	27.2	27.3	27.6	27.8	27.6	27.6	27.7
3:00	27.7	27.8	27.8	27.7	27.7	27.7	27.7	27.7	27.7	27.8	27.8	27.8	27.7	27.8	27.8	27.8	27.1	27.2	27.0	27.1	27.3	27.6	27.4	27.4	27.5
4:00	27.6	27.6	27.6	27.6	27.5	27.5	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.0	27.1	26.9	27.0	27.3	27.4	27.3	27.3	27.4
5:00	27.6	27.6	27.6	27.5	27.5	27.5	27.5	27.6	27.5	27.6	27.6	27.6	27.6	27.6	27.6	27.6	26.8	26.9	26.8	26.8	27.2	27.2	27.2	27.3	27.3
6:00	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.5	27.6	27.5	27.5	27.6	27.5	27.5	26.9	27.0	26.8	26.9	27.2	27.3	27.2	27.2	27.3
7:00	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.6	27.7	27.7	27.6	27.7	27.6	27.6	27.3	27.4	27.2	27.3	27.5	27.6	27.5	27.7	27.7
8:00	28.1	28.2	28.1	28.2	28.2	28.2	28.1	28.1	28.2	28.1	28.2	28.2	28.2	28.2	28.2	28.1	28.5	28.4	28.6	28.5	28.3	28.2	28.5	28.7	28.7
9:00	29.1	29.2	29.0	29.2	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.1	29.9	29.7	30.1	29.6	29.3	29.2	29.7	29.6	29.9
10:00	30.1	30.1	30.0	30.3	30.1	30.1	30.1	30.1	30.1	30.3	30.1	30.1	30.1	30.1	30.2	30.2	31.3	31.1	31.5	30.9	30.5	30.3	31.6	31.2	30.9
11:00	31.1	31.1	31.1	31.3	31.2	31.1	31.2	31.1	31.1	31.3	31.1	31.1	31.1	31.1	31.2	31.2	32.5	32.3	32.7	32.0	31.5	31.3	32.9	32.7	32.5
12:00	31.6	31.7	31.7	31.9	31.7	31.7	31.7	31.6	31.7	31.9	31.6	31.7	31.7	31.7	31.7	31.7	33.0	32.7	33.2	32.4	32.0	31.9	33.0	33.2	32.9
13:00	32.3	32.2	32.1	32.5	32.5	32.4	32.3	32.3	32.4	32.5	32.4	32.4	32.4	32.4	32.4	32.4	34.1	33.7	34.3	33.6	33.0	33.0	32.3	30.6	29.9
14:00	32.5	32.4	32.2	32.7	32.7	32.5	32.6	32.5	32.6	32.6	32.6	32.6	32.5	32.6	32.6	32.6	34.6	34.1	35.2	34.3	33.6	33.2	32.4	29.8	29.1
15:00	32.5	32.4	32.1	32.5	32.6	32.6	32.5	32.5	32.6	32.7	32.7	32.6	32.6	32.6	32.7	32.7	34.6	34.3	34.8	34.1	33.5	33.7	32.8	29.1	28.3
16:00	30.5	30.2	30.4	30.2	30.4	30.7	30.6	30.6	30.6	30.9	30.8	30.7	30.6	30.7	30.8	30.8	31.9	32.0	32.0	31.6	31.2	31.6	29.6	27.0	26.5
17:00	30.1	30.0	30.2	30.0	30.1	30.2	30.2	30.1	30.2	30.4	30.3	30.3	30.2	30.3	30.3	30.3	31.4	31.5	31.5	31.1	30.7	31.1	30.2	28.4	28.4
18:00	30.1	30.2	30.1	30.1	30.0	30.1	30.1	30.1	30.1	30.2	30.2	30.2	30.1	30.2	30.2	30.2	30.7	30.8	30.8	30.6	30.4	30.6	30.0	30.1	30.1
19:00	29.5	29.6	29.6	29.3	29.3	29.5	29.4	29.5	29.5	29.6	29.6	29.5	29.4	29.5	29.5	29.6	29.5	29.6	29.5	29.6	29.6	29.7	29.1	29.3	29.3
20:00	29.0	29.0	29.1	28.8	28.8	28.9	28.9	28.9	28.9	29.0	29.1	29.0	28.9	29.0	29.0	29.0	28.6	28.7	28.6	28.7	29.0	29.1	28.6	28.6	28.7
21:00	28.8	28.8	28.9	28.7	28.7	28.7	28.7	28.7	28.8	28.8	28.8	28.8	28.7	28.8	28.8	28.9	28.5	28.5	28.4	28.5	28.7	28.9	28.6	28.5	28.6
22:00	28.5	28.5	28.6	28.4	28.4	28.4	28.4	28.4	28.5	28.5	28.5	28.5	28.4	28.5	28.5	28.6	28.1	28.1	28.0	28.1	28.3	28.5	28.3	28.2	28.3
23:00	28.0	28.1	28.1	27.9	27.9	28.0	28.0	28.0	28.0	28.1	28.1	28.1	28.0	28.0	28.0	28.1	27.5	27.6	27.5	27.6	27.8	27.9	27.7	27.7	27.8
0:00	27.6	27.7	27.7	27.5	27.5	27.5	27.6	27.6	27.6	27.6	27.7	27.6	27.6	27.6	27.6	27.7	26.9	27.0	26.9	27.0	27.4	27.4	27.1	27.2	27.3

Table A.33. Experimental results in controlled cell (closed openings) and ambient conditions on July 9th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	vinflow	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	W/m2)	(m/s)	%
1:00	28.6	28.6	28.9	28.5	28.4	28.4	28.5	28.4	28.5	28.6	28.8	28.7	28.7	28.6	28.6	28.5	27.8	1.5	0.0	-	-
2:00	28.5	28.4	28.8	28.3	28.3	28.3	28.3	28.3	28.3	28.3	28.6	28.5	28.4	28.4	28.4	28.3	27.6	1.1	0.0	-	-
3:00	28.3	28.2	28.5	28.1	28.0	28.0	28.0	28.0	28.1	28.1	28.3	28.3	28.3	28.3	28.2	28.1	27.3	1.1	0.0	-	-
4:00	28.1	28.0	28.4	27.9	27.9	27.8	27.9	27.9	27.9	27.9	28.1	28.2	28.0	28.0	28.0	27.9	27.3	1.1	0.0	-	-
5:00	28.0	27.9	28.4	27.8	27.8	27.8	27.8	27.8	27.8	27.8	28.0	28.0	27.9	27.9	27.9	27.8	27.1	1.1	0.0	-	-
6:00	27.9	27.9	28.3	27.8	27.7	27.7	27.7	27.7	27.8	27.8	28.0	28.0	27.9	27.9	27.8	27.7	27.1	1.0	0.4	-	-
7:00	28.0	28.0	28.4	27.9	27.9	27.8	27.8	27.8	27.8	27.8	28.0	28.1	28.0	28.0	27.9	27.8	27.3	0.8	37.1	-	-
8:00	28.6	28.6	29.0	28.6	28.5	28.4	28.4	28.4	28.5	28.5	28.7	28.6	28.5	28.5	28.5	28.4	28.3	1.5	120.2	-	-
9:00	29.7	29.7	30.1	29.7	29.5	29.6	29.5	29.4	29.5	29.6	29.8	29.6	29.5	29.5	29.5	29.5	30.0	1.3	279.7	-	-
10:00	30.9	31.0	31.5	30.9	30.6	30.8	30.7	30.7	30.7	30.7	31.0	30.7	30.6	30.7	30.6	30.8	32.1	1.6	561.6	-	-
11:00	31.8	32.0	32.6	31.8	31.6	31.8	31.7	31.6	31.6	31.7	31.9	31.7	31.6	31.6	31.6	31.7	33.3	1.8	697.1	-	-
12:00	32.5	32.7	33.4	32.6	32.3	32.5	32.4	32.3	32.4	32.4	32.7	32.5	32.3	32.3	32.3	32.3	33.9	1.7	773.3	0.5	51.0
13:00	33.2	33.3	33.9	33.3	33.0	33.2	33.2	33.1	33.2	33.4	33.3	33.2	33.1	33.2	33.2	33.2	33.5	1.8	523.9	0.3	49.6
14:00	33.6	33.7	33.8	33.7	33.5	33.7	33.7	33.6	33.7	33.9	33.8	33.7	33.7	33.7	33.7	34.0	34.1	2.3	647.4	0.2	53.3
15:00	33.9	33.9	33.9	34.0	33.9	33.9	34.0	33.9	34.0	34.2	34.1	34.1	34.1	34.1	34.1	34.4	33.9	2.1	453.3	0.3	52.8
16:00	32.4	32.3	32.3	32.4	32.3	32.4	32.4	32.4	32.4	32.7	32.6	32.7	32.8	32.7	32.7	33.0	31.6	2.4	294.5	0.4	52.1
17:00	32.1	32.0	32.0	32.1	32.0	32.0	32.1	32.0	32.2	32.4	32.4	32.4	32.4	32.4	32.4	32.6	31.7	2.1	253.6	0.3	51.7
18:00	31.5	31.5	31.5	31.5	31.4	31.5	31.6	31.5	31.6	31.9	31.8	31.9	31.9	31.9	31.9	32.1	30.9	2.4	99.8	0.3	54.1
19:00	30.8	30.9	30.9	30.8	30.8	30.9	30.9	30.8	30.8	31.0	31.2	31.2	31.2	31.2	31.1	31.3	29.6	1.6	17.0	-	-
20:00	30.3	30.3	30.3	30.2	30.1	30.1	30.2	30.1	30.2	30.2	30.5	30.4	30.4	30.3	30.3	30.4	28.8	1.5	0.0	-	-
21:00	30.0	30.0	30.0	29.8	29.8	29.8	29.8	29.8	29.8	29.9	30.1	30.1	30.0	30.0	30.0	30.0	28.9	1.4	0.0	-	-
22:00	29.6	29.6	29.6	29.4	29.4	29.4	29.4	29.4	29.4	29.5	29.7	29.7	29.6	29.6	29.6	29.5	28.5	1.6	0.0	-	-
23:00	29.0	29.0	29.0	28.8	28.8	28.8	28.8	28.8	28.9	28.9	29.2	29.2	29.1	29.0	29.0	29.0	27.8	1.6	0.0	-	-
0:00	28.6	28.6	28.6	28.4	28.4	28.4	28.4	28.4	28.4	28.4	28.7	28.7	28.6	28.6	28.6	28.5	27.2	1.6	0.0	-	-

Table A.34. Experimental results in the test cell on July 10th, 2005 (application of solar chimney and wetted roof).

Time (min)	TC1 (°C)	TC2 (°C)	TC3 (°C)	TC4 (°C)	TC5 (°C)	TC6 (°C)	TC7 (°C)	TC8 (°C)	TC9 (°C)	TC10 (°C)	TC11 (°C)	TC12 (°C)	TC13 (°C)	TC14 (°C)	TC15 (°C)	TC16 (°C)	TC17 (°C)	TC18 (°C)	TC19 (°C)	TC20 (°C)	TC21 (°C)	TC22 (°C)	TC23 (°C)	TC24 (°C)	TC25 (°C)
1:00	27.1	27.2	27.2	27.1	27.1	27.1	27.1	27.1	27.2	27.2	27.2	27.2	27.1	27.2	27.2	27.2	26.6	26.6	26.6	26.8	27.1	26.9	26.8	26.9	26.9
2:00	26.9	27.0	27.0	26.8	26.8	26.9	26.9	26.9	26.9	26.9	27.0	26.9	26.9	26.9	26.9	27.0	26.4	26.4	26.4	26.6	26.8	26.6	26.6	26.7	26.7
3:00	26.8	26.8	26.8	26.7	26.7	26.7	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.8	26.2	26.2	26.1	26.2	26.5	26.5	26.5	26.5	26.6
4:00	26.6	26.7	26.7	26.6	26.6	26.6	26.6	26.6	26.6	26.6	26.7	26.6	26.6	26.6	26.6	26.6	26.0	26.0	25.9	26.0	26.2	26.4	26.3	26.3	26.4
5:00	26.5	26.5	26.5	26.4	26.4	26.4	26.4	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	26.5	25.8	25.9	25.7	25.8	26.1	26.3	26.0	26.2	26.2
6:00	26.4	26.4	26.4	26.3	26.3	26.3	26.3	26.3	26.3	26.4	26.4	26.4	26.4	26.4	26.4	26.4	25.8	25.8	25.6	25.7	25.9	26.2	26.1	26.1	26.2
7:00	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.4	26.1	26.2	26.1	26.2	26.3	26.3	26.4	26.3	26.4
8:00	26.9	27.0	26.9	27.0	26.9	26.9	26.9	26.9	26.9	26.8	26.9	26.9	26.9	26.9	26.9	26.9	27.5	27.4	27.5	27.4	27.2	27.1	27.5	27.5	27.4
9:00	28.0	28.4	28.1	28.2	28.0	28.3	27.9	28.0	28.0	27.9	28.1	28.0	27.8	27.9	28.0	27.9	29.9	29.6	30.3	29.6	28.9	28.5	29.8	29.8	29.7
10:00	29.6	30.3	29.8	30.0	29.4	30.2	29.6	29.6	29.6	29.5	29.8	29.6	29.3	29.2	29.6	29.5	32.1	31.6	32.6	31.5	30.5	30.2	31.6	32.0	31.8
11:00	30.6	31.0	30.8	31.0	30.6	30.9	30.6	30.6	30.7	30.6	30.7	30.6	30.4	30.4	30.7	30.5	33.1	32.6	33.7	32.6	31.6	31.3	32.0	31.5	31.3
12:00	31.4	31.7	31.5	31.8	31.5	31.6	31.5	31.4	31.5	31.5	31.6	31.5	31.3	31.3	31.5	31.4	34.5	34.0	35.2	33.9	32.8	32.5	32.5	31.3	31.3
13:00	31.9	31.9	31.6	32.1	32.1	32.0	32.0	31.9	32.0	32.0	32.0	32.0	31.9	31.9	32.0	31.9	35.1	34.5	35.8	34.6	33.4	32.9	33.2	29.6	28.9
14:00	32.4	32.4	32.2	32.6	32.5	32.5	32.5	32.4	32.5	32.6	32.6	32.5	32.4	32.4	32.5	32.4	35.9	35.5	36.5	35.2	34.0	34.0	33.3	29.8	28.9
15:00	32.9	32.8	32.8	33.0	32.8	33.1	33.0	32.9	32.9	33.1	33.1	33.0	32.8	32.8	32.9	32.9	36.0	35.8	36.3	35.4	34.3	34.6	34.6	30.1	29.1
16:00	33.3	33.3	33.1	33.4	33.2	33.5	33.3	33.2	33.3	33.5	33.4	33.3	33.1	33.2	33.3	33.2	35.8	35.5	36.0	35.1	34.3	34.5	34.9	30.6	29.7
17:00	33.6	33.9	33.6	33.8	33.5	33.9	33.7	33.6	33.6	33.8	33.8	33.7	33.5	33.5	33.7	33.6	35.3	35.1	35.5	35.0	34.5	34.6	35.5	32.0	31.8
18:00	34.4	34.9	34.4	34.7	34.0	34.8	34.5	34.5	34.4	34.6	34.6	34.5	34.1	34.1	34.5	34.5	34.9	34.7	35.1	34.8	34.6	34.7	36.7	35.6	35.7
19:00	32.3	32.4	32.4	32.3	32.1	32.4	32.3	32.3	32.3	32.5	32.4	32.3	32.2	32.2	32.4	32.4	32.2	32.2	32.2	32.1	32.3	32.5	31.5	32.2	32.2
20:00	31.9	31.9	32.0	31.8	31.7	31.9	31.8	31.9	31.9	32.1	32.0	31.9	31.7	31.9	31.9	32.0	31.4	31.5	31.3	31.3	31.6	32.1	30.6	31.3	31.4
21:00	30.9	30.9	30.9	30.7	30.6	30.8	30.8	30.8	30.8	31.0	30.9	30.8	30.7	30.8	30.8	30.9	30.1	30.2	29.9	30.1	30.5	30.9	29.9	30.3	30.4
22:00	30.3	30.3	30.4	30.2	30.1	30.2	30.2	30.2	30.2	30.3	30.3	30.3	30.2	30.3	30.3	30.4	29.4	29.4	29.3	29.4	29.9	30.1	29.6	29.8	29.9
23:00	29.8	29.8	29.9	29.7	29.6	29.7	29.7	29.7	29.7	29.8	29.8	29.8	29.7	29.8	29.8	29.8	29.0	29.1	28.8	28.9	29.2	29.7	29.0	29.3	29.4
0:00	29.5	29.5	29.6	29.5	29.4	29.5	29.5	29.5	29.5	29.6	29.6	29.5	29.5	29.5	29.6	29.6	28.8	28.8	28.6	28.8	29.1	29.4	28.9	29.1	29.2

Table A.35. Experimental results in controlled cell (closed openings) and ambient conditions on July 10th, 2005.

Time	CC1	CC2	CC3	CC4	CC5	CC6	CC7	CC8	CC9	CC10	CC11	CC12	CC13	CC14	CC15	CC16	Ambient	wind	solar	v_{inflow}	RH
(min)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(°C)	(m/s)	(W/m^2)	(m/s)	%
1:00	28.1	28.1	29.2	27.9	27.9	27.9	27.9	27.9	27.8	27.9	28.2	28.2	28.1	28.1	28.1	28.0	26.9	1.4	0.0	-	-
2:00	27.8	27.8	28.9	27.6	27.6	27.5	27.6	27.6	27.5	27.6	27.9	27.9	27.8	27.8	27.8	27.7	26.8	1.5	0.0	-	-
3:00	27.7	27.6	28.7	27.5	27.4	27.4	27.4	27.4	27.5	27.5	27.7	27.8	27.6	27.6	27.6	27.5	26.6	2.1	0.0	-	-
4:00	27.4	27.4	28.4	27.3	27.2	27.2	27.2	27.2	27.2	27.3	27.6	27.6	27.4	27.4	27.3	27.3	26.3	1.4	0.0	-	-
5:00	27.3	27.3	28.3	27.2	27.1	27.1	27.1	27.1	27.1	27.2	27.4	27.4	27.3	27.2	27.2	27.1	26.0	1.2	0.0	-	-
6:00	27.1	27.1	28.2	27.0	26.9	26.9	26.9	27.0	27.0	27.0	27.2	27.2	27.1	27.1	27.1	27.0	26.1	1.3	0.0	-	-
7:00	27.1	27.1	28.2	27.0	27.0	26.9	26.9	26.9	26.9	26.9	27.2	27.2	27.1	27.1	27.1	26.9	26.4	1.4	28.1	-	-
8:00	27.7	27.6	28.9	27.6	27.5	27.4	27.4	27.4	27.4	27.4	27.7	27.6	27.5	27.5	27.5	27.4	27.7	2.4	119.5	-	-
9:00	28.8	28.9	30.4	28.8	28.6	28.8	28.6	28.5	28.6	28.6	28.9	28.7	28.6	28.6	28.6	28.5	29.6	1.8	292.2	-	-
10:00	30.4	30.7	32.3	30.5	30.1	30.5	30.3	30.2	30.3	30.2	30.6	30.3	30.1	30.2	30.2	30.2	31.6	1.6	441.8	-	-
11:00	31.5	31.7	33.6	31.6	31.3	31.6	31.4	31.3	31.5	31.6	31.8	31.5	31.3	31.4	31.4	31.4	32.4	1.6	488.3	0.1	50.7
12:00	32.7	33.0	35.0	32.9	32.5	32.9	32.7	32.6	32.8	33.0	33.1	32.9	32.7	32.8	32.8	32.9	33.4	1.6	600.5	0.1	50.9
13:00	33.4	33.6	34.5	33.6	33.3	33.6	33.5	33.3	33.5	33.7	33.8	33.6	33.5	33.5	33.6	33.7	34.4	2.3	644.8	0.1	49.1
14:00	34.4	34.6	34.7	34.6	34.2	34.6	34.5	34.4	34.5	34.7	34.8	34.6	34.5	34.5	34.7	34.9	35.6	2.0	832.7	0.1	48.8
15:00	35.4	35.6	35.7	35.5	35.2	35.6	35.5	35.4	35.5	35.8	35.8	35.6	35.5	35.5	35.7	35.9	36.3	1.6	757.0	0.1	48.1
16:00	36.0	36.2	36.2	36.1	35.7	36.2	36.1	36.0	36.1	36.4	36.4	36.2	36.1	36.1	36.3	36.6	35.8	1.3	432.8	0.1	47.5
17:00	36.3	36.4	36.5	36.3	36.0	36.5	36.3	36.2	36.3	36.6	36.7	36.5	36.4	36.4	36.5	36.9	35.6	1.4	338.5	0.1	48.2
18:00	36.6	36.7	36.8	36.6	36.1	36.9	36.6	36.4	36.5	36.9	37.1	36.8	36.6	36.7	36.8	37.2	36.2	1.5	201.0	0.1	46.7
19:00	35.4	35.3	35.5	35.4	35.1	35.4	35.3	35.2	35.3	35.4	35.5	35.5	35.3	35.3	35.4	35.7	32.5	1.2	26.2	-	-
20:00	33.1	33.1	33.2	33.1	33.0	33.1	33.1	33.0	33.1	33.1	33.2	33.2	33.2	33.2	33.2	33.3	30.4	1.0	0.0	-	-
21:00	31.8	31.8	31.9	31.7	31.6	31.7	31.7	31.6	31.7	31.8	31.9	31.9	31.8	31.7	31.7	31.8	29.5	1.0	0.0	-	-
22:00	31.1	31.1	31.1	31.0	31.0	31.0	31.0	30.9	31.0	31.0	31.2	31.2	31.1	31.1	31.1	31.1	29.4	1.2	0.0	-	-
23:00	30.7	30.6	30.6	30.5	30.4	30.4	30.5	30.4	30.5	30.5	30.7	30.7	30.6	30.6	30.6	30.6	29.1	1.1	0.0	-	-
0:00	30.4	30.4	30.4	30.3	30.2	30.2	30.2	30.2	30.2	30.3	30.5	30.5	30.4	30.3	30.3	30.2	29.0	1.4	0.0	-	-

Table A. 36. Experimental values of temperature and calculated values of Rayleigh number (Ra) Nusselt number (Nu) and heat transfer coefficient U_t (December 2nd and December 3rd).

December, 2nd 2005										December, 3rd 2005									
Time	Tattic	Tgyp,ex	Tceil,ex	Tceil,in	Solar	AR41-43	Ra	Nu	U_t	Time	Tattic	Tgyp,ex	Tceil,ex	Tceil,in	Solar	AR41-43	Ra	Nu	U_t
	(°C)	(°C)	(°C)	(°C)	(W/m^2)	(°C)			(W/K)		(°C)	(°C)	(°C)	(°C)	(W/m^2)	(°C)			(W/K)
930	29.9	31.1	29.2	29.6	508.9	29.6	5.15E+06	12.9	6.1	930	29.6	31.5	28.9	29.3	526.3	29.6	5.90E+06	13.2	6.1
1000	30.8	32.6	29.9	30.6	265.6	30.5	7.42E+06	14.0	6.4	1000	30.1	33.3	29.6	29.8	605.3	30.1	4.24E+06	12.0	5.8
1030	31.7	33.7	30.5	31.2	505.9	31.0	9.63E+06	15.0	6.7	1030	30.7	34.8	30.2	30.6	681.9	30.7	3.79E+06	11.6	5.7
1100	32.2	34.9	31.3	32.0	472.6	31.9	7.54E+06	13.7	6.4	1100	31.4	36.4	30.9	31.3	782.6	31.5	3.99E+06	11.7	5.8
1130	32.4	35.1	31.7	32.3	553.6	32.3	5.38E+06	12.9	6.1	1130	31.6	36.8	31.4	32.0	627.0	32.0	1.97E+06	9.5	5.2
1200	32.3	34.8	31.9	32.6	419.3	32.5	2.98E+06	11.0	5.6	1200	31.9	36.8	31.6	32.2	840.2	32.3	2.94E+06	10.3	5.4
1230	32.5	34.8	32.1	32.8	521.7	32.7	2.88E+06	10.8	5.6	1230	32.3	37.0	32.1	32.8	357.5	32.6	1.75E+06	9.2	5.1
1300	33.2	35.6	32.5	33.2	611.2	33.1	5.05E+06	12.6	6.1	1300	32.4	36.7	32.3	32.9	366.4	32.7	1.86E+06	8.9	5.1
1330	33.5	36.3	32.9	33.7	633.6	33.6	3.86E+06	11.4	5.8	1330	32.8	37.3	32.4	32.9	837.9	33.0	3.11E+06	10.3	5.5
1400	34.1	36.7	33.4	34.0	609.1	34.0	5.32E+06	12.4	6.1	1400	32.9	37.6	32.8	33.3	228.1	33.0	1.88E+06	9.1	5.2
1430	34.4	37.0	33.8	34.4	599.9	34.4	4.74E+06	11.9	6.0	1430	33.1	37.0	32.7	33.1	481.7	33.2	2.69E+06	9.9	5.4
1500	34.4	37.2	34.1	34.7	486.4	34.8	2.77E+06	10.3	5.5	1500	33.1	36.5	33.0	33.4	241.9	33.4	1.16E+06	7.9	4.8
1530	34.0	36.4	34.0	34.7	320.3	34.7	7.97E+05	7.8	4.8	1530	32.3	34.3	32.6	33.0	49.3	32.9	2.85E+06	9.8	5.3
1600	33.7	35.6	33.9	34.5	124.3	34.4	1.07E+06	8.4	4.9	1600	30.3	31.9	31.6	31.7	27.9	31.6	1.06E+07	15.4	6.8
1630	33.3	34.5	33.5	34.0	85.1	33.9	1.90E+06	9.9	5.3	1630	29.7	30.2	30.7	30.5	9.4	30.5	8.14E+06	14.3	6.4
1700	33.0	33.9	33.3	33.6	66.4	33.6	1.62E+06	9.6	5.2	1700	29.9	30.0	30.4	30.1	11.8	30.3	3.77E+06	11.9	5.7
1730	32.7	33.4	32.9	33.2	28.1	33.2	1.53E+06	9.3	5.2	1730	30.0	30.2	30.3	30.1	21.9	30.3	2.12E+06	10.2	5.3
1800	32.4	32.8	32.6	32.7	2.4	32.8	1.68E+06	9.6	5.2	1800	30.0	30.0	30.1	29.9	2.7	30.2	9.62E+05	8.3	4.7

Table A. 37. Experimental values of temperature and calculated values of Rayleigh number (Ra) Nusselt number (Nu) and heat transfer coefficient U_t (December 4th and December 5th).

December, 4th 2005										December, 5th 2005									
Time	Tattic	Tgyp,ex	Tceil,ex	Tceil,in	Solar	AR41-43	Ra	Nu	U_t	Time	Tattic	Tgyp,ex	Tceil,ex	Tceil,in	Solar	AR41-43	Ra	Nu	U_t
	(°C)	(°C)	(°C)	(°C)	(W/m²)	(°C)			(W/K)		(°C)	(°C)	(°C)	(°C)	(W/m²)	(°C)			(W/K)
930	28.9	33.6	28.1	28.4	527.1	28.3	6.10E+06	13.3	6.2	930	27.9	32.5	27.3	27.3	523.9	27.4	4.97E+06	12.6	5.9
1000	29.1	34.3	28.4	28.7	616.1	28.5	5.30E+06	12.7	6.0	1000	28.6	34.3	28.1	28.1	609.6	28.1	4.62E+06	12.3	5.9
1030	29.9	36.0	29.1	29.4	699.7	29.2	6.19E+06	13.4	6.2	1030	29.2	35.9	28.9	29.0	687.7	28.9	2.85E+06	10.8	5.5
1100	30.3	37.3	29.6	30.0	745.3	29.7	5.70E+06	13.1	6.2	1100	29.8	36.5	29.4	29.6	740.6	29.6	3.40E+06	11.3	5.7
1130	30.8	38.3	30.2	30.7	791.8	30.4	5.15E+06	12.5	6.0	1130	30.8	38.5	30.1	30.5	777.6	30.2	5.34E+06	12.9	6.2
1200	31.3	39.1	30.7	31.3	818.0	31.0	5.08E+06	12.7	6.1	1200	31.1	38.8	30.6	31.1	787.0	30.9	3.33E+06	11.0	5.7
1230	31.6	39.6	31.1	31.6	825.8	31.1	4.06E+06	11.9	5.9	1230	31.4	38.9	31.0	31.5	804.8	31.2	3.38E+06	11.3	5.7
1300	32.4	40.9	31.5	32.1	814.0	31.6	7.60E+06	14.1	6.6	1300	31.9	39.6	31.4	31.9	808.7	31.6	4.27E+06	12.1	6.0
1330	33.1	41.5	32.2	32.8	774.9	32.4	6.74E+06	13.6	6.5	1330	32.0	39.4	31.7	32.2	772.8	32.0	3.10E+06	11.0	5.7
1400	33.0	40.7	32.6	33.1	743.7	32.8	2.88E+06	10.6	5.6	1400	32.5	39.8	32.2	32.6	729.3	32.8	2.99E+06	11.1	5.7
1430	33.1	40.2	32.8	33.3	674.2	33.2	2.94E+06	10.7	5.6	1430	32.6	39.2	32.5	32.8	668.6	33.2	2.17E+06	9.8	5.4
1500	33.3	39.7	33.1	33.4	606.8	33.4	1.89E+06	9.5	5.3	1500	33.1	39.6	33.0	33.3	599.9	33.8	1.28E+06	8.5	5.0
1530	33.6	39.5	33.3	33.6	505.0	33.7	2.27E+06	10.0	5.4	1530	33.2	38.8	33.3	33.5	500.4	34.0	9.51E+05	7.5	4.7
1600	33.5	38.1	33.3	33.5	400.9	33.8	1.62E+06	8.7	5.1	1600	33.5	38.6	33.5	33.7	410.0	34.3	1.39E+06	8.8	5.1
1630	33.6	37.6	33.4	33.6	284.2	33.7	1.82E+06	9.3	5.2	1630	33.4	37.7	33.6	33.7	295.6	34.3	1.57E+06	8.9	5.1
1700	33.6	36.7	33.3	33.4	160.0	33.5	1.91E+06	9.6	5.3	1700	32.8	35.5	33.3	33.4	50.2	33.5	3.74E+06	11.8	5.9
1730	33.1	35.4	33.1	33.1	56.2	33.1	6.90E+05	7.3	4.6	1730	32.0	33.3	32.6	32.6	11.5	32.7	4.21E+06	12.2	5.9
1800	32.4	33.5	32.6	32.5	3.4	32.4	1.45E+06	9.1	5.1	1800	31.7	32.4	32.1	32.0	0.1	32.3	2.73E+06	10.9	5.6

Appendix B

Table B.1. Exterior and interior surface temperatures in the controlled cell on May 29th, 2006.

Time	Trf,ex1	Trf,ex2	Tgyp,ex	Tswall,ex1	Tswall,ex2	Tnwall,ex1	Tnwall,ex2	Twwall,ex	Tewall,ex	Trf,out	Trf,in	Tgyp,out	Tgyp,in	Tswall,in1	Tswall,in2	Tnwall,in1	Tnwall,in2	Twwall,in	Tewall,in	Tfloor	Tceil,in
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
9:30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10:00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11:00	41.1	42.0	35.5	35.2	36.0	34.4	35.1	35.0	39.5	38.7	46.4	34.8	35.5	32.2	32.6	32.0	32.3	32.1	33.1	31.7	32.5
11:30	41.2	41.8	35.4	35.2	35.8	34.3	35.0	34.8	39.8	38.4	46.1	34.7	35.5	32.1	32.5	32.0	32.3	32.0	33.1	31.7	32.4
12:00	42.4	43.4	36.2	35.5	36.6	34.8	35.5	35.6	37.9	39.8	48.7	35.4	36.0	32.6	33.0	32.2	32.5	32.4	33.4	31.9	32.9
12:30	41.6	43.0	37.0	35.4	36.4	35.4	36.4	36.3	36.9	39.6	47.2	36.3	36.5	33.4	33.7	32.9	33.1	33.2	33.8	32.3	33.9
13:00	41.6	42.9	37.8	35.8	36.8	36.2	37.4	37.5	37.1	40.9	47.7	37.2	37.2	34.0	34.1	33.5	33.8	33.9	34.2	32.7	34.7
13:30	40.8	42.1	38.0	36.5	37.6	36.1	37.1	38.2	37.3	40.7	45.5	37.1	37.1	34.4	34.6	34.0	34.3	34.4	34.4	33.1	35.1
14:00	40.7	41.4	37.8	36.5	37.6	36.1	37.0	39.7	36.7	40.9	45.0	37.0	37.2	34.7	34.9	34.2	34.5	34.7	34.6	33.3	35.2
14:30	36.1	37.1	36.3	34.4	35.0	34.8	35.5	37.2	34.5	36.5	37.9	35.7	35.8	34.8	34.8	34.4	34.6	34.9	34.9	33.2	35.1
15:00	33.8	34.1	34.1	33.4	34.0	33.6	33.9	35.5	33.0	34.2	34.9	33.8	34.4	34.2	34.1	34.2	34.3	34.4	34.6	32.8	34.2
15:30	31.9	32.4	32.9	32.8	33.3	32.7	32.8	33.6	32.4	32.7	32.6	32.8	33.5	33.6	33.5	33.8	33.8	33.8	34.1	32.5	33.4
16:00	28.9	29.3	31.4	30.9	31.6	29.3	28.5	28.3	30.7	30.6	28.9	31.3	31.5	32.1	32.3	32.7	32.7	32.3	32.9	31.2	32.2
16:30	28.7	28.9	30.6	30.3	31.2	29.2	29.1	29.6	30.1	31.1	29.5	30.5	31.3	31.7	31.7	32.1	31.8	31.5	32.4	31.0	31.4
17:00	29.0	29.5	30.7	30.5	31.1	30.3	30.2	31.2	30.4	31.4	31.0	30.6	31.6	31.7	31.6	31.9	31.6	31.7	32.0	31.0	31.3
17:30	29.8	30.2	30.6	30.5	31.0	30.7	30.6	31.7	30.3	31.3	31.3	30.5	31.4	31.7	31.6	31.7	31.5	31.7	31.8	30.9	31.1
18:00	30.8	30.7	30.8	30.8	31.2	31.1	31.1	32.2	30.7	31.6	31.7	30.7	31.6	31.6	31.5	31.6	31.5	31.7	31.6	30.9	31.0

Table B.2. Temperature and velocity of air in the controlled cell and ambient condition on May 29th, 2006.

Time	A_{wd}	AR11	AR21	AR31	AR41	AR12	AR22	AR32	AR42	AR13	AR23	AR33	AR43	Ah1	Ah2	Ah3	Ah4	v_{wd}	v_{Ah1}	v_{Ah4}	wind speed	solar	RH_{wd}	T_{amb}
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	(m/s)	(m/s)	(m/s)	(m/s)	(W/m^2)	%	°C
9:30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10:00	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10:30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
11:00	33.3	32.9	32.9	36.8	33.7	32.5	32.9	33.2	33.5	32.5	32.8	33.2	33.4	35.3	37.7	36.8	38.0	0.24	0.21	0.11	0.08	910.4	56.6	34.0
11:30	33.3	32.9	32.9	36.7	33.8	32.4	32.9	33.2	33.5	32.5	32.8	33.2	33.5	35.2	37.5	36.7	37.9	0.20	0.22	0.11	0.06	917.6	57.4	33.9
12:00	34.2	33.1	33.1	37.5	34.2	32.6	33.1	33.4	34.1	32.8	33.1	33.5	33.9	36.2	38.5	37.5	38.8	0.24	0.22	0.15	0.11	863.2	53.0	35.0
12:30	35.2	33.6	33.8	37.9	34.8	33.4	33.8	34.1	34.6	33.5	33.8	34.1	34.5	36.6	38.5	37.9	38.7	0.25	0.18	0.22	1.08	770.3	49.2	34.9
13:00	36.1	34.0	34.3	38.8	35.4	33.8	34.4	34.8	35.3	33.9	34.3	34.8	35.2	37.2	39.0	38.8	39.5	0.27	0.12	0.13	1.46	789.8	48.5	36.2
13:30	35.2	34.4	34.6	37.9	35.4	34.2	34.6	34.8	35.2	34.3	34.6	34.8	35.1	36.9	38.3	37.9	38.9	0.37	0.17	0.12	1.63	478.8	49.9	35.9
14:00	35.7	34.7	34.9	38.1	35.7	34.4	34.9	35.2	35.6	34.5	34.9	35.2	35.5	36.9	37.8	38.1	38.3	0.25	0.18	0.18	1.37	439.2	50.0	36.0
14:30	34.3	34.3	34.4	36.0	35.0	34.4	34.4	34.7	34.8	34.4	34.6	34.7	34.8	35.0	34.8	36.0	34.9	0.23	0.15	0.20	0.93	139.3	57.6	33.5
15:00	33.6	33.7	33.9	34.1	34.3	33.9	33.9	34.1	34.2	34.0	34.1	34.1	34.2	34.0	33.5	34.1	33.5	0.18	0.20	0.15	1.22	55.6	60.4	32.8
15:30	31.5	32.8	33.1	33.0	33.3	33.2	33.1	33.4	33.3	33.1	33.3	33.3	33.1	32.6	31.9	33.0	31.9	0.77	0.35	0.19	1.08	27.9	67.8	31.1
16:00	28.7	30.6	30.3	30.6	31.3	30.7	30.5	30.9	31.4	30.6	31.1	30.9	31.3	31.3	30.3	30.6	30.1	0.63	0.18	0.15	0.87	68.6	82.6	28.6
16:30	29.7	30.8	30.4	30.8	31.5	30.8	30.9	31.2	31.5	30.8	31.1	31.2	31.5	31.8	30.7	30.8	30.6	0.18	0.19	0.11	0.83	71.8	79.5	29.8
17:00	30.7	31.3	31.2	31.2	31.6	31.1	31.2	31.4	31.6	31.1	31.3	31.4	31.6	31.9	31.0	31.2	30.9	0.20	0.20	0.14	0.69	70.2	75.2	30.7
17:30	30.9	31.2	31.1	31.1	31.6	31.1	31.2	31.3	31.6	31.1	31.3	31.3	31.6	31.8	31.0	31.1	31.0	0.16	0.19	0.13	1.16	88.9	73.9	30.7
18:00	31.2	31.4	31.3	31.2	31.6	31.2	31.3	31.4	31.6	31.3	31.4	31.4	31.7	31.7	31.1	31.2	31.1	0.14	0.12	0.11	3.03	67.8	72.0	31.0

Table B.3. Exterior and interior surface temperatures in the controlled cell on May 31st, 2006.

Time	Trf,ex1	Trf,ex2	Tgyp,ex	Tswall,ex1	Tswall,ex2	Tnwall,ex1	Tnwall,ex2	Twwall,ex	Tewall,ex	Trf,out	Trf,in	Tgyp,out	Tgyp,in	Tswall,in1	Tswall,in2	Tnwall,in1	Tnwall,in2	Twwall,in	Tewall,in	Tfloor	Tceil,in
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
9:30	29.3	28.6	27.1	27.4	28.1	27.1	27.9	29.2	26.7	31.9	31.5	26.8	27.9	26.6	26.6	26.4	26.4	26.7	26.7	26.5	26.4
10:00	29.7	28.8	27.2	27.7	28.3	27.2	27.9	29.5	27.0	32.4	32.2	26.6	28.1	26.9	27.0	26.6	26.8	27.0	26.9	26.7	26.6
10:30	31.6	30.5	28.1	28.6	29.2	28.0	28.8	30.3	28.0	33.8	34.2	27.5	28.7	27.3	27.4	26.9	27.0	27.4	26.7	26.9	27.0
11:00	34.0	32.8	29.3	29.4	30.2	29.3	30.2	31.3	30.1	34.5	37.3	28.6	29.6	27.9	27.9	27.4	27.5	28.0	27.1	27.4	27.7
11:30	36.1	35.5	30.8	30.7	31.7	30.7	31.7	32.2	32.0	37.7	41.1	29.9	30.8	28.6	28.6	28.0	28.2	28.7	27.7	27.9	28.4
12:00	37.2	37.5	32.5	32.1	33.2	64.1	32.3	32.9	32.7	39.3	43.1	31.2	31.6	29.4	29.3	28.6	28.9	29.2	28.4	28.4	28.8
12:30	36.8	37.6	33.0	32.7	33.7	31.4	32.7	33.5	32.9	38.4	43.6	32.0	32.5	29.9	29.8	29.2	29.4	29.6	29.0	28.9	29.4
13:00	38.3	38.8	33.7	33.1	34.1	32.0	33.2	34.1	33.1	37.6	44.6	32.8	33.3	30.4	30.5	29.7	30.0	30.2	29.6	29.5	30.2
13:30	37.8	38.5	34.3	33.5	34.5	32.5	33.7	35.1	33.2	38.0	42.3	33.5	33.8	30.7	30.9	30.2	30.6	30.7	30.1	29.9	31.0
14:00	37.0	37.5	34.4	34.0	35.1	32.6	33.7	36.2	33.3	39.0	42.0	33.7	34.1	31.1	31.3	30.6	31.0	31.1	30.5	30.2	31.6
14:30	37.4	38.6	35.0	32.8	33.8	32.8	33.9	36.6	32.8	36.1	40.4	34.2	34.1	31.6	31.8	31.1	31.4	31.8	30.9	30.5	32.2
15:00	32.2	32.8	32.5	30.6	31.3	31.2	31.9	33.3	30.9	34.2	34.7	32.2	32.3	30.7	30.7	30.8	31.1	30.9	30.9	29.5	31.5
15:30	32.4	32.5	31.8	30.5	31.1	30.9	31.7	34.1	30.2	33.1	33.9	31.4	32.0	30.4	30.5	30.6	30.8	30.7	30.8	29.5	31.1
16:00	32.2	31.7	30.7	30.2	31.0	30.6	31.4	34.8	29.7	33.1	33.9	30.2	31.5	30.3	30.4	30.6	30.7	30.8	30.7	29.2	30.6
16:30	31.7	31.5	30.3	29.8	30.4	30.2	31.0	34.1	29.3	32.0	33.0	29.9	31.0	30.3	30.3	30.4	30.6	30.8	30.4	29.1	30.2
17:00	30.0	30.2	29.6	29.1	29.5	29.5	29.9	31.8	28.9	31.0	31.2	29.3	30.3	29.8	29.8	30.1	30.2	30.3	30.1	28.8	29.7
17:30	29.2	29.7	29.5	28.7	29.0	29.2	29.5	30.3	28.8	30.3	30.4	29.4	30.0	29.5	29.4	29.8	29.8	29.7	29.7	28.6	29.5
18:00	28.9	29.3	29.2	28.6	29.0	29.0	29.3	30.0	28.6	29.6	29.8	29.1	29.7	29.2	29.2	29.5	29.5	29.4	29.4	28.5	29.3

Table B.4. Temperature and velocity of air in the controlled cell and ambient condition on May 31st, 2006.

Time	A_{wd}	AR11	AR21	AR31	AR41	AR12	AR22	AR32	AR42	AR13	AR23	AR33	AR43	Ah1	Ah2	Ah3	Ah4	v_{wd}	v_{Ah1}	v_{Ah4}	wind speed	solar	RH_{wd}	T_{amb}
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	(m/s)	(m/s)	(m/s)	(m/s)	(W/m^2)	%	°C
9:30	27.5	27.4	26.8	28.1	27.5	26.7	26.9	26.8	27.3	26.8	26.9	26.9	27.3	28.7	27.9	28.1	28.6	0.20	0.22	0.17	0.03	301.2	84.4	28.7
10:00	27.5	27.4	27.2	28.3	27.5	27.1	27.2	27.1	27.6	27.3	27.2	27.2	27.5	28.9	28.4	28.3	28.9	0.17	0.12	0.11	0.30	315.1	84.8	29.1
10:30	28.1	27.5	27.3	29.2	27.9	27.1	27.2	27.3	27.9	27.1	27.3	27.5	27.8	29.4	29.4	29.2	30.0	0.15	0.11	0.11	0.22	359.4	83.6	30.1
11:00	29.3	28.0	27.8	30.3	28.9	27.5	27.8	28.0	28.7	27.5	27.8	28.2	28.7	30.2	30.8	30.3	31.6	0.16	0.10	0.11	0.28	517.0	79.4	31.3
11:30	30.7	28.7	28.6	32.0	29.9	28.1	28.6	29.0	29.7	28.1	28.5	29.1	29.6	31.4	32.8	32.0	34.0	0.21	0.11	0.13	0.55	671.0	72.5	32.6
12:00	31.2	29.6	29.5	32.8	30.4	29.0	29.5	30.0	30.4	29.1	29.5	29.9	30.3	31.9	33.4	32.8	34.4	0.29	0.26	0.15	0.86	604.0	66.0	33.5
12:30	31.6	30.3	30.2	34.4	31.1	29.8	30.0	30.5	31.0	30.0	30.2	30.5	31.0	32.7	33.5	34.4	34.5	0.34	0.30	0.16	0.89	731.1	64.0	33.6
13:00	32.1	30.8	30.8	35.0	31.7	30.3	30.4	31.2	31.6	30.5	30.8	31.2	31.6	33.1	34.5	35.0	35.3	0.46	0.39	0.20	0.86	738.9	60.0	33.6
13:30	32.5	31.3	31.3	34.9	32.0	30.6	30.6	31.6	31.9	30.9	31.2	31.5	31.8	33.3	34.6	34.9	35.2	0.27	0.34	0.15	0.70	418.7	59.4	33.7
14:00	32.5	31.4	31.5	34.7	32.3	31.0	31.0	31.8	32.2	31.2	31.5	31.7	32.1	33.6	34.9	34.7	35.1	0.34	0.19	0.13	0.43	583.8	60.2	34.2
14:30	32.2	31.5	31.8	35.5	32.4	31.3	31.2	32.1	32.3	31.4	31.8	32.2	32.2	33.7	34.6	35.5	35.2	0.27	0.29	0.29	1.20	345.6	61.5	32.2
15:00	30.8	30.6	30.6	32.1	31.2	30.4	30.0	30.8	31.1	30.4	30.7	30.8	31.1	31.7	32.0	32.1	32.3	0.17	0.18	0.20	1.13	296.6	62.7	31.0
15:30	30.8	30.6	30.7	31.9	31.1	30.5	30.1	30.8	31.0	30.6	30.8	30.9	31.0	31.7	31.5	31.9	31.7	0.25	0.13	0.19	0.49	272.0	65.9	30.7
16:00	30.7	30.6	30.5	31.5	31.0	30.3	30.1	30.6	30.8	30.4	30.6	30.6	30.8	31.5	31.2	31.5	31.1	0.20	0.11	0.11	0.27	307.9	68.9	30.7
16:30	30.2	30.3	30.3	31.2	30.5	30.2	30.0	30.4	30.5	30.3	30.4	30.4	30.4	31.0	30.5	31.2	30.5	0.32	0.16	0.19	0.53	226.5	69.9	30.0
17:00	29.3	29.7	29.6	30.0	29.9	29.6	29.4	29.8	29.9	29.6	29.8	29.7	29.9	30.0	29.7	30.0	29.8	0.23	0.22	0.26	0.92	154.9	73.8	29.2
17:30	28.7	29.3	29.1	29.5	29.5	29.1	28.7	29.3	29.5	29.0	29.3	29.3	29.5	29.6	29.2	29.5	29.4	0.31	0.18	0.27	1.04	107.3	76.9	28.6
18:00	28.7	29.2	29.0	29.2	29.4	29.0	28.6	29.1	29.4	29.0	29.2	29.2	29.4	29.4	29.0	29.2	29.1	0.19	0.13	0.16	0.85	68.4	76.0	28.6

Table B.5. Exterior and interior surface temperatures in the controlled cell on June 14th, 2006.

Time	Trf,ex1	Trf,ex2	Tgyp,ex	Tswall,ex1	Tswall,ex2	Tnwall,ex1	Tnwall,ex2	Twwall,ex	Tewall,ex	Trf,out	Trf,in	Tgyp,out	Tgyp,in	Tswall,in1	Tswall,in2	Tnwall,in1	Tnwall,in2	Twwall,in	Tewall,in	Tfloor	Tceil,in
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
9:30	34.2	34.6	30.8	32.3	32.9	31.6	31.5	31.5	40.4	33.0	37.1	30.7	31.8	30.4	30.2	30.1	29.8	30.0	31.1	30.1	30.5
10:00	34.7	35.1	31.0	32.2	32.9	31.7	31.6	31.5	40.3	32.9	36.9	30.9	31.8	30.4	30.4	30.3	30.0	30.1	31.3	30.3	30.7
10:30	35.7	36.2	31.4	32.8	33.4	32.1	32.2	32.1	40.1	33.6	38.2	31.2	32.3	30.8	30.8	30.5	30.4	30.5	31.6	30.5	31.0
11:00	37.3	37.9	32.2	33.5	34.0	32.8	32.9	32.8	40.0	35.2	40.2	31.9	33.0	31.3	31.3	31.0	30.9	31.0	32.1	30.9	31.6
11:30	38.6	39.5	33.1	34.1	34.8	33.6	33.7	33.5	39.4	35.4	41.9	32.7	33.9	31.9	31.9	31.4	31.4	31.5	32.6	31.4	32.2
12:00	39.9	41.0	33.7	35.1	35.7	33.8	34.1	34.2	37.3	36.1	43.2	33.3	34.3	32.3	32.3	31.8	31.9	31.9	32.9	31.7	32.7
12:30	40.4	41.8	34.4	35.7	36.4	34.3	34.7	35.1	36.3	36.9	43.9	34.1	35.0	32.9	32.9	32.3	32.3	32.5	33.1	32.2	33.3
13:00	40.6	42.2	34.8	36.3	37.1	34.6	35.0	35.7	36.5	38.0	44.3	34.4	35.2	33.2	33.4	32.7	32.8	32.9	33.3	32.5	33.8
13:30	40.6	41.6	35.1	36.1	37.1	35.2	35.7	38.4	36.4	37.2	43.6	34.7	35.8	33.7	33.9	33.1	33.3	33.5	33.6	32.8	34.2
14:00	41.4	42.2	35.8	36.9	37.8	36.0	36.6	41.4	36.8	37.9	44.5	35.4	36.6	34.2	34.4	33.5	33.8	34.2	33.9	33.2	34.6
14:30	40.8	41.6	36.1	37.0	37.9	36.3	36.8	41.8	36.8	37.8	43.3	35.8	36.8	34.6	34.8	34.0	34.3	34.9	34.3	33.6	35.2
15:00	39.9	40.4	36.1	36.8	37.8	36.4	37.0	42.8	36.6	37.8	42.4	35.9	37.4	35.0	35.2	34.4	34.7	35.4	34.5	33.9	35.5
15:30	39.9	40.3	36.5	37.1	38.2	36.9	37.5	44.0	36.7	38.2	42.1	36.2	37.5	35.4	35.6	34.8	35.2	36.0	34.9	34.2	35.8
16:00	39.4	39.8	36.6	37.7	38.8	37.0	37.5	43.8	36.9	39.5	41.5	36.4	37.6	35.6	35.8	35.0	35.5	36.3	35.1	34.4	36.0
16:30	39.1	39.1	36.9	37.7	38.8	37.2	37.9	41.9	36.9	39.4	40.4	36.6	37.4	35.7	35.9	35.2	35.7	36.4	35.2	34.6	36.2
17:00	37.4	37.7	36.5	36.7	37.7	36.9	37.3	39.6	36.4	37.9	38.6	36.2	37.3	35.7	35.9	35.3	35.7	36.2	35.3	34.5	36.0
17:30	36.6	37.1	36.3	36.1	37.0	37.0	37.3	39.0	36.0	37.1	37.7	36.1	37.1	35.7	35.8	35.4	35.7	36.1	35.4	34.4	36.0
18:00	35.9	36.3	36.1	35.6	36.2	37.0	37.5	39.1	35.7	36.0	36.7	36.0	36.9	35.7	35.6	35.5	35.7	36.0	35.4	34.4	35.9

Table B.6. Temperature and velocity of air in the controlled cell and ambient condition on June 14th, 2006.

Time	A_{wd}	AR11	AR21	AR31	AR41	AR12	AR22	AR32	AR42	AR13	AR23	AR33	AR43	Ah1	Ah2	Ah3	Ah4	v_{wd}	v_{Ah1}	v_{Ah4}	wind speed	solar	RH_{wd}	T_{amb}
	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	℃	(m/s)	(m/s)	(m/s)	(m/s)	(W/m^2)	%	℃
9:30	31.7	31.2	30.4	30.7	31.2	30.5	30.5	30.5	31.1	30.4	30.4	30.7	31.0	31.1	31.4	31.1	31.4	0.42	0.28	0.28	0.44	724.7	59.5	32.5
10:00	31.7	31.3	30.6	30.8	31.2	30.6	30.8	30.8	31.2	30.6	30.6	30.7	31.2	32.1	31.7	31.2	31.9	0.26	0.46	0.28	0.93	751.9	58.9	31.9
10:30	32.3	31.6	31.1	31.1	31.5	31.1	31.1	31.1	31.5	31.0	31.0	31.0	31.5	32.1	32.4	31.8	32.4	0.23	0.47	0.29	0.79	804.2	57.8	32.6
11:00	32.7	32.0	31.5	31.6	32.1	31.4	31.5	31.6	32.1	31.4	31.3	31.7	32.1	33.0	33.6	32.8	33.4	0.26	0.32	0.22	0.94	851.9	55.0	32.8
11:30	33.1	32.6	32.1	32.2	32.7	31.9	32.1	32.2	32.8	31.9	31.9	32.3	32.8	33.9	35.1	34.0	34.6	0.25	0.31	0.19	0.72	910.7	54.1	33.4
12:00	33.6	32.9	32.4	32.5	33.0	32.3	32.4	32.5	33.1	32.3	32.2	32.5	33.1	34.0	35.0	34.3	35.0	0.31	0.49	0.29	0.68	924.8	51.9	34.2
12:30	34.0	33.4	33.0	33.1	33.6	32.8	33.0	33.1	33.6	32.8	32.8	33.2	33.7	34.7	35.9	35.1	35.8	0.25	0.47	0.29	0.71	901.3	51.8	34.9
13:00	34.6	33.6	33.3	33.4	33.9	33.2	33.3	33.4	33.9	33.2	33.2	33.5	33.9	34.8	36.0	35.3	36.0	0.37	0.44	0.29	0.73	861.0	50.1	35.2
13:30	35.1	34.3	33.9	34.1	34.5	33.7	33.9	34.0	34.6	33.7	33.8	34.1	34.6	35.7	36.9	36.2	36.5	0.40	0.26	0.20	0.85	692.3	47.2	34.9
14:00	35.3	34.9	34.4	34.7	35.3	34.2	34.5	34.7	35.3	34.2	34.4	34.8	35.2	36.2	37.6	36.7	37.3	0.34	0.38	0.24	0.74	810.1	46.6	35.9
14:30	36.0	35.4	35.0	35.2	35.6	34.9	35.1	35.2	35.6	34.8	35.0	35.2	35.5	36.5	37.2	36.8	37.1	0.34	0.49	0.33	0.95	799.6	45.4	35.6
15:00	36.1	35.8	35.3	35.6	36.1	35.2	35.4	35.6	36.1	35.2	35.3	35.6	36.0	36.7	37.5	37.0	37.2	0.26	0.27	0.20	0.91	784.9	44.2	35.6
15:30	36.2	36.3	35.8	36.0	36.5	35.7	35.9	36.0	36.4	35.7	35.8	36.0	36.3	37.0	37.4	37.2	37.3	0.29	0.38	0.27	0.67	707.0	44.5	35.6
16:00	35.9	36.3	35.9	36.1	36.4	35.8	36.0	36.1	36.4	35.8	35.9	36.1	36.4	37.0	37.3	37.0	37.3	0.23	0.39	0.25	0.64	579.8	45.6	36.2
16:30	36.3	36.2	35.8	35.9	36.3	35.8	35.9	36.0	36.2	35.8	35.9	35.9	36.2	36.8	37.0	36.8	37.1	0.25	0.37	0.26	0.60	344.2	45.6	36.3
17:00	36.2	36.2	35.9	36.0	36.4	35.7	35.9	36.0	36.3	35.8	35.9	36.0	36.3	36.9	36.9	36.7	36.9	0.15	0.19	0.14	0.62	190.4	45.5	35.0
17:30	36.0	36.2	35.9	36.1	36.3	35.8	36.0	36.1	36.3	35.8	35.9	36.1	36.2	36.6	36.5	36.5	36.5	0.16	0.13	0.12	0.77	183.3	46.2	34.7
18:00	34.5	36.1	35.8	36.0	36.2	35.7	35.9	36.0	36.2	35.7	35.9	36.0	36.2	36.5	36.0	36.2	36.1	0.40	0.16	0.16	0.68	143.5	54.0	34.4

Table B.7. Exterior and interior surface temperatures in the controlled cell on June 17th, 2006.

Time	Trf,ex1	Trf,ex2	Tgyp,ex	Tswall,ex1	Tswall,ex2	Tnwall,ex1	Tnwall,ex2	Twwall,ex	Tewall,ex	Trf,out	Trf,in	Tgyp,out	Tgyp,in	Tswall,in1	Tswall,in2	Tnwall,in1	Tnwall,in2	Twwall,in	Tewall,in	Tfloor	Tceil,in
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C
9:30	34.6	34.9	31.2	32.4	32.8	31.7	31.6	31.7	40.2	33.3	36.6	31.1	31.4	30.8	30.7	30.7	30.6	30.5	31.4	30.6	30.8
10:00	34.9	35.5	31.4	32.6	33.0	31.6	31.9	31.8	39.9	33.5	37.1	31.3	31.4	30.9	30.8	30.6	30.5	30.6	31.5	30.7	31.0
10:30	36.1	37.0	31.9	33.4	33.8	32.3	32.4	32.4	40.4	34.4	38.7	31.7	32.0	31.3	31.2	30.9	30.8	31.0	31.9	31.0	31.4
11:00	36.5	37.7	32.5	33.8	34.2	32.8	33.0	32.9	39.6	34.8	39.3	32.2	32.6	31.8	31.8	31.4	31.3	31.4	32.4	31.4	31.9
11:30	37.7	39.0	33.0	34.5	35.2	33.2	33.5	33.6	39.5	35.2	40.7	32.8	33.5	32.2	32.1	31.7	31.7	31.8	32.6	31.7	32.4
12:00	38.8	40.1	33.7	35.0	35.9	33.9	34.3	34.6	37.1	36.0	41.9	33.4	34.3	32.7	32.7	32.1	32.1	32.3	33.0	32.1	32.9
12:30	39.1	40.5	34.3	35.7	36.6	34.2	34.6	35.3	36.4	36.9	42.5	33.9	34.6	33.1	33.2	32.5	32.6	32.8	33.3	32.5	33.4
13:00	38.7	40.2	34.5	36.3	37.1	34.2	34.6	35.5	36.6	37.8	42.1	34.1	34.7	33.4	33.5	32.8	33.0	33.2	33.4	32.7	33.7
13:30	38.3	39.6	34.8	36.5	37.4	34.5	35.0	36.6	36.9	37.9	41.1	34.3	35.0	33.7	33.9	33.1	33.3	33.5	33.6	32.9	33.9
14:00	37.5	38.6	34.6	35.9	36.9	34.9	35.2	37.3	36.5	36.5	39.8	34.3	35.1	33.9	34.0	33.4	33.6	33.8	33.8	33.1	34.0
14:30	38.2	39.2	34.9	36.2	37.0	35.2	35.6	39.1	36.4	36.7	40.6	34.7	35.4	34.1	34.2	33.7	33.9	34.2	34.0	33.5	34.3
15:00	38.7	39.7	35.4	36.7	37.6	35.5	36.1	40.7	36.5	37.3	41.2	35.2	36.0	34.5	34.6	34.0	34.2	34.9	34.2	33.8	34.7
15:30	38.4	39.3	35.7	36.9	37.8	35.9	36.4	41.5	36.4	37.4	40.6	35.6	36.2	34.9	35.0	34.4	34.6	35.4	34.6	34.1	35.1
16:00	38.0	38.7	35.8	36.9	37.9	35.8	36.5	42.4	36.3	37.3	39.7	35.8	36.6	35.1	35.3	34.7	35.0	35.8	34.8	34.4	35.4
16:30	37.8	37.3	36.1	37.1	38.1	38.1	38.8	43.3	36.3	37.5	38.6	36.1	37.1	35.5	35.7	35.0	35.5	36.3	35.1	34.6	35.7
17:00	37.3	36.8	36.5	37.1	38.1	40.9	40.1	44.7	36.5	37.7	37.6	36.5	37.6	35.9	36.1	35.5	36.0	36.9	35.5	34.8	36.1
17:30	36.8	36.7	36.6	37.1	38.0	40.5	39.8	44.0	36.5	37.4	37.4	36.7	37.7	36.1	36.3	35.8	36.4	37.1	35.7	34.9	36.3
18:00	36.2	36.2	36.1	36.5	37.3	37.4	37.9	40.3	35.8	36.4	36.7	36.1	37.2	35.9	36.0	35.8	36.3	36.7	35.6	34.9	36.1

Table B.8. Temperature and velocity of in the controlled cell and ambient condition on June 17th, 2006.

Time	A_{wd}	AR11	AR21	AR31	AR41	AR12	AR22	AR32	AR42	AR13	AR23	AR33	AR43	Ah1	Ah2	Ah3	Ah4	v_{wd}	v_{Ah1}	v_{Ah4}	wind speed	solar	RH_{wd}	T_{amb}
	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	°C	(m/s)	(m/s)	(m/s)	(m/s)	(W/m^2)	%	°C
9:30	31.2	31.2	30.8	30.9	31.3	30.7	30.9	30.9	31.3	30.8	30.8	31.0	31.3	31.6	31.7	31.3	31.9	0.67	0.36	0.34	0.60	727.0	62.1	30.7
10:00	31.2	31.2	31.0	31.1	31.3	31.0	31.1	31.1	31.3	31.0	31.0	31.1	31.6	31.7	31.9	31.5	32.0	0.24	0.53	0.35	0.90	742.2	61.9	30.9
10:30	31.7	31.5	31.4	31.5	31.9	31.4	31.5	31.5	31.8	31.4	31.4	31.5	32.0	32.3	32.7	32.1	32.7	0.33	0.56	0.33	0.69	802.5	60.9	31.4
11:00	32.2	32.0	31.9	32.0	32.4	32.0	32.0	32.0	32.3	31.9	31.9	32.0	32.4	32.8	33.3	32.8	33.3	0.30	0.44	0.30	1.07	871.7	58.6	31.9
11:30	32.4	32.6	32.2	32.4	32.7	32.3	32.3	32.4	32.8	32.2	32.3	32.4	32.9	33.2	33.9	33.4	33.9	0.37	0.49	0.33	1.04	916.6	56.4	32.3
12:00	33.1	33.2	32.8	33.0	33.4	32.8	32.9	32.9	33.4	32.8	32.8	33.0	33.3	34.1	34.9	34.3	34.8	0.34	0.46	0.30	1.01	850.3	55.4	33.0
12:30	33.3	33.5	33.2	33.3	33.6	33.2	33.2	33.3	33.7	33.1	33.2	33.3	33.6	34.2	35.0	34.6	35.2	0.59	0.56	0.34	0.94	933.8	54.6	33.4
13:00	33.6	33.7	33.4	33.5	33.8	33.5	33.5	33.6	33.9	33.4	33.4	33.5	33.8	34.4	35.2	34.8	35.4	0.39	0.52	0.33	0.94	692.8	54.0	34.0
13:30	33.8	34.0	33.7	33.8	34.0	33.7	33.8	33.8	34.1	33.7	33.7	33.8	34.0	34.6	35.2	34.9	35.5	0.42	0.47	0.31	0.84	486.5	53.2	34.9
14:00	34.2	34.3	34.0	34.0	34.3	33.9	34.0	34.1	34.5	33.9	33.9	34.1	34.3	34.8	35.1	34.9	35.3	0.28	0.45	0.32	0.79	583.5	52.2	35.2
14:30	34.4	34.6	34.3	34.4	34.7	34.4	34.5	34.5	34.8	34.3	34.4	34.5	34.8	35.1	35.5	35.2	35.6	0.36	0.46	0.33	0.83	762.8	50.8	36.0
15:00	34.7	35.1	34.7	34.8	35.1	34.8	34.9	34.9	35.3	34.7	34.8	34.9	35.2	35.6	35.9	35.6	36.0	0.34	0.47	0.34	0.90	708.1	49.9	35.9
15:30	35.2	35.4	35.1	35.2	35.5	35.1	35.3	35.4	35.7	35.1	35.2	35.3	35.7	36.0	36.1	36.0	36.2	0.28	0.50	0.34	0.76	665.8	49.1	36.1
16:00	35.3	35.7	35.4	35.4	35.8	35.5	35.6	35.8	36.1	35.5	35.5	35.6	36.0	36.3	36.2	36.0	36.3	0.57	0.56	0.36	0.92	600.8	48.6	35.8
16:30	36.5	36.2	35.8	36.0	36.4	35.8	36.0	36.1	36.6	35.8	35.9	36.0	36.4	36.7	36.5	36.3	36.5	0.29	0.40	0.23	0.57	480.9	46.7	35.7
17:00	37.9	36.8	36.4	36.6	37.2	36.3	36.6	36.6	37.3	36.3	36.4	36.6	37.0	37.2	36.8	36.6	36.8	0.29	0.32	0.22	0.76	359.4	43.1	35.2
17:30	36.7	36.8	36.5	36.6	37.0	36.4	36.6	36.7	37.2	36.5	36.5	36.7	36.9	37.2	36.8	36.6	36.8	0.30	0.38	0.25	0.59	250.8	45.2	35.1
18:00	35.2	36.2	36.0	36.0	36.2	35.9	36.1	36.2	36.4	36.0	36.0	36.1	36.2	36.6	36.2	36.2	36.2	0.34	0.41	0.26	0.69	141.1	49.3	33.2

Appendix C

Table C.1. Constant values of a, b for the linear regression of thermocouples calibrated with the accurate thermometer.

Thermocouple number	a	b	Thermocouple number	a	b
TC1	0.76	7.79	CC1	0.80	6.63
TC2	0.79	7.20	CC2	0.78	7.26
TC3	0.88	4.30	CC3	0.80	6.66
TC4	0.78	7.20	CC4	0.80	6.59
TC5	0.78	7.30	CC5	0.83	5.84
TC6	0.79	7.00	CC6	0.89	3.86
TC7	0.83	5.77	CC7	0.82	6.23
TC8	0.78	7.13	CC8	0.81	6.27
TC9	0.72	8.87	CC9	0.78	7.17
TC10	0.79	6.74	CC10	0.80	6.69
TC11	0.82	6.24	CC11	0.76	7.58
TC12	0.80	6.78	CC12	0.78	7.28
TC13	0.87	4.49	CC13	0.79	7.10
TC14	0.99	0.30	CC14	0.80	7.00
TC15	0.83	5.77	CC15	0.70	6.66
TC16	0.78	7.20	CC16	0.90	3.52
TC17	1.15	-4.18			
TC18	1.02	0.07			
TC19	1.16	-4.61			
TC20	1.09	-2.14			
TC21	0.97	1.41			
TC22	1.09	-1.95			
TC23	0.99	0.93			
TC24	1.00	0.81			
TC25	1.01	0.91			

Note: TCxx = temperature measurement in test cell
CCxx = temperature measurement in controlled cell

Table C.2. Measuring ranges and accuracy of the measuring devices.

Measuring device	Connected Probe	Measuring range	Accuracy
Testo 110	Efficient, robust NTC air probe 	-50 to +150 °C	±0.2 °C (-20 to +80 °C) ±0.3 °C (remaining range) Resolution 0.1 °C
Testo 435-1	Thermal velocity probe with built-in temperature and humidity measurement, Ø 12 mm, with telescopic handle (max. 745 mm) 	-20 to +70 °C 0 to +100%RH 0 to +120 m/s	±0.3°C ± 2% RH ± 0.03 m/s
Testo 454	Humidity/ temperature probe 	-20 to +70 °C 0... +100 %RH	±0.4 °C (+0.1 to +50 °C) ±0.5 °C (-20 to +0 °C) ±0.5 °C (+50.1 to +80 °C) ± 2% RH
Testo 454	Robust hot bulb probe, Ø 3 mm, with handle and telescopic handle for measurements in the lower velocity range (hot bulb NTC) 	0 to +10 m/s -20 to +70 °C	±(0.03m/s ± 5% of mV)
Kipp& Zonen Pyranometer CM11		Irradiance: 0-1400 W/m^2	5.07 µV/ (W/m^2)
Yong wind monitor model 05103		0 to 60 m/s	1.0 m/s

Appendix D

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BUILDING AND ENVIRONMENT

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Application of passive cooling systems in the hot and humid climate: The case study of solar chimney and wetted roof in Thailand

Sudaporn Chungloo, Bundit Limmeechokchai*

Sirindhorn International Institute of Technology, Thammasat University, P.O. Box 22 Thammasat Rangsit Post Office 12120, Pathumthai, Thailand

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Abstract

The thermal performance of two passive cooling systems under hot and humid climate condition is experimentally investigated. The experimental results were obtained from a test cell and a controlled cell with identical walls but different roof configurations. The passive cooling systems applied to the test cell are solar chimney and water spraying on roof. The experimental results obtained from the test cell are compared with the closed and no passive cooling controlled cell. In addition, the significant of solar-induced ventilation by using a solar chimney is realized by utilizing a wind shield to reduce the effect of wind-induced ventilation resulting in low measured air velocities to the solar chimney and low computed value of coefficient of discharge. The derived coefficient of discharge of 0.4 is used to compute Air Changes rates per Hour (ACH). The ACHs with application of solar chimney solely are found to be in the range of 0.16–1.98. The studies of air temperature differences between the room and the solar chimney suggest amount of air flow rates for different periods in a year. The derived relationships show that the air flow rate during February–March is higher than during June–October by 16.7–53.7%. The experimental results show that application of the solar chimney in the test cell could maintain the room temperature at 31.0–36.5 °C, accounting for 1.0–3.5 °C lower than the ambient air and 1.0–1.3 °C lower than the controlled cell. However, to make the test cell's room temperature much lower than the ambient temperature and increase the flow rate of air due to the buoyancy, the application of water spraying on roof is recommended together with solar chimney. The application of the two systems in the hot and humid climate are discovered to sustain the room temperature of the test cell to be lower than the ambient air by 2.0–6.2 °C and lower than the controlled cell by 1.4–3.0 °C.

Keywords: Passive cooling in building; Natural ventilation; Solar chimney; Water spraying; Coefficient of discharge

1. Introduction

The utilizations of solar chimney as a natural ventilation of buildings are widely investigated in the last few years. An appropriate design of a solar chimney for cooling includes providing an air gap in a south façade or in the roof of the building that causes stack effect exists between the solar chimney and the inlet of the building. The stack effect operates between the high temperature and high pressure developed in the solar chimney and the low pressure and low temperature at the inlet. If the openings are provided at the inlet of the building and at the outlet of the solar chimney, air will enter into the building due to the difference of air densities and pressure gradient and move through the building before exit from the outlet of the solar chimney. Many researches on using a solar chimney for natural ventilation can be found as modeling, experiment and field practice. One of the most recognized mathematical modeling is the classical energy balance equation of the solar-air heat collector and the air flow rate equations proposed by Bansal et al. [1]. By using the proposed mathematical model, Bansal et al. [2] calculate the performance of a solar assisted wind tower system and found that the solar chimney can increase mass flow rate of air by 50% for the case of high solar intensity and low wind speed comparing to the case with out the assisted solar chimney. By utilizing the similar mathematical models, Aboulnaga [3] presented parametric study of a specific

*Corresponding author. Tel.: +66 2 986 9009x2206; fax: +66 2 986 9009x2201.
E-mail address: bundit@siit.tu.ac.th (B. Limmeechokchai).

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The Field Investigation On The Application of Solar Chimney and Wetted Roof in the Hot and Humid Climate

Sudaporn Chungloo and Bundit Limmeechokchai

Sirindhorn International Institute of Technology, Thammasat University
P.O. Box 22 Thammasat Rangsit Post Office 12120, Pathumthai, Thailand
Email: bundit@siit.tu.ac.th

ABSTRACT

This paper reports on the field thermal performance of two passive cooling systems; namely the solar chimney and water spraying on roof, under hot and humid climate condition. The experimental results were obtained from a controlled cell without applications of passive cooling systems and a test cell with identical walls but different configurations. The natural ventilation from using a solar chimney is realized by utilizing a wind shield to reduce the effect of prevailing wind resulting in low measured air velocities to the solar chimney. The experimental results show that application of the solar chimney in the test cell could maintain the room temperature at 31.0-36.5 °C, accounting for 1.0-3.5°C lower than the ambient air and 1.0-1.3°C lower than the controlled cell. However, to make the test cell's room temperature much more lower than the ambient temperature the application of water spraying on roof is recommended together with solar chimney. The application of the two systems in the hot and humid climate are discovered to sustain the room temperature of the test cell to be lower than the ambient air by 2.0-6.2°C and lower than the controlled cell by 1.4-3.0°C.

Keywords: Passive cooling in building; natural ventilation; solar chimney; water spraying; coefficient of discharge.

1. INTRODUCTION

The utilizations of solar chimney as a natural ventilation of buildings are widely investigated in the last few years. An appropriate design of a solar chimney for cooling includes providing an air gap in a south façade or in the roof of the building that causes stack effect exists between the solar chimney and the inlet of the building. The stack effect operates between the high temperature and high pressure developed in the solar chimney and the low pressure and low temperature at the inlet. If the openings are provided at the inlet of the building and at the outlet of the solar chimney, air will enter into the building due to the difference of air densities and pressure gradient and move through the building before exit from the outlet of the solar chimney.

In Thailand, the solar chimney attached to the south façade and/or roof is widely studied. However, this paper presents only those attached to the roof, recognized as roof solar collector. By fastening a gypsum board or a plywood plate to the lower part of the rafter, the air gap with height of 14-16 cm are formed under the roof tile and utilized as the roof solar chimney. Khedari et al [1,2,3] found that gypsum board is better than the plywood for resisting the

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A Numerical Study of Natural Ventilation in Buildings - Utilized Solar Chimney and Cool Ceiling

Sudaporn Chungloo and Bundit Limmeechokchai*

Sirindhorn International Institute of Technology, Thammasat University, P.O. Box 22 Thammasat Rangsit Post Office 12120, Pathumthai, Thailand

Abstract: *The objective of this paper is to investigate the benefit of application of solar chimney on the south roof and water spraying on the north metal ceiling of a test building through a numerical model constructed from a computational fluid dynamics (CFD) program. The two dimensional numerical model are generated by the CFD model using the experimental data of walls and air temperatures during application of solor chimney in a test building as the boundary conditions. The predicted results are compared with the selected experimental results before the temperature of 2 ℃ and 4 ℃ of the cool ceiling are applied to the validated model in order to study the effect of cool ceiling on the temperature, velocity and air flow rate in the test building. The simulation results show a satisfactory agreement with the experimental results for the temperature distribution in the test building. The differences between numerical results and the experimental results of volume flow rate are 13-18%. According to the numerical simulation, the reduction of temperature of the north ceiling by 2 ℃ and 4 ℃ increases the volume flow rate at the exit of the solar chimney by 6%and 17%, respectively.*

Keywords: Passive Cooling in Building, Natural Ventilation, Solar Chimney, Water Spraying, Simulation

1. INTRODUCTION

As a device for natural ventilation, a solar chimney has been found as an effective passive cooling design in the hot and humid climate [1-3]. An appropriate design of a solar chimney for natural ventilation includes providing an air gap in a south façade or in the roof of the building that causes stack effect between the solar chimney and the inlet of the building. The stack effect operates between the high temperature and high pressure developed in the solar chimney and the low pressure and low temperature at the inlet. If the openings are provided at the inlet of the building and at the outlet of the solar chimney, air will enter into the building due to the difference of air densities and pressure gradient and move through the building before leaving the outlet of the solar chimney. Therefore, the performance to produce a certain ventilation flow rate of a solar chimney depends on the temperature difference between the inlet and the outlet. In addition, the high ambient temperature, high wind velocity and highly fluctuating of solar radiation in hot and humid climate can effect the ventilation flow rate of a solar chimney.

There are some modifications of the solar chimney for increasing the air flow rate through buildings [4-7], and utilizing daylighting [8]. The recent study of reduction of temperature by water spraying on the ceiling of a test building for increasing the temperature difference between the inlet of the building and outlet of the solar chimney found that the temperature of the air in the test building was reduced by 1.4-3.0 °C comparing to the building without water spraying [9]. The purpose of this paper is to numerically investigate the effect of application of solar chimney and water spraying on roof on the temperature field, velocity field, and volume flow rate of the test building.

2. METHODOLOGY

2.1 Test building

The test building is a detached one-story room located on the roof of Sirindhorn International Institute of Technology (SIIT)'s laboratory building, Thammasat University. The interior dimensions are 3.8m × 2.8m × 2.4m. Its walls are constituted by wood frame externally covered with white-painted asbestos-cement board and internally covered with plywood board. A layer of polystyrene foam of 0.076 m is located in the wood frame between the asbestos-cement board and the plywood. The pitch roof with tilt angle of 45°, composes of terracotta roof tile at the outer side, 0.12 m air gap and the gypsum board at the inner side. The air gap under the south roof is the solar chimney where the outdoor air flowing through the window of the room reduces hot air storage in this gap (Fig 1 and 2). The test building is placed at the position that each of the four wall facing to east, west, north and south directions.

2.2 Testing methodology

The experiments were carried out on selected days during May-June 2006. Figure 2 shows that total 16 thermocouples of type K connected to the Yokogawa-DR130 data logger were used for temperature measurement at various points in the test building. A wind monitoring device is connected to the Yokogawa-DR130 data logger to collect wind velocity. A pyranometer, Kipp&Zonen-CMII, was connected to Yokogawa data logger to collect global solar radiation in W/m^2. Two hot-bulb velocity probes were connected to the Testo-454 data logger to record velocity at the inlet and outlet of the solar chimney. All data were recorded every 2 minutes for 24 hours. Due to the high fluctuation of the solar radiation, walls/roof temperatures, ambient temperature and indoor air temperature, it is very difficult to obtain a steady condition in the test building. Hence, the 'quasi-steady' conditions are assumed when the solar radiation did not fluctuate more than 100 W/m^2 and the temperature of the roof surface did not change more than 0.5°C. Before experimental startup all temperature probes were calibrated with a high accuracy and calibrated thermometer. Fig. 2 and Table I show the positions of measurement and the average values of the four selected experimental results, respectively. These experimental results are used for boundaries and the validation of the result from simulation.

Corresponding author: bundit@siit.tu.ac.th

การประชุมเชิงวิชาการเครือข่ายพลังงานแห่งประเทศไทยครั้งที่ 3
23-25 พฤษภาคม 2550 โรงแรมใบหยกสกาย กรุงเทพฯ

การประยุกต์ใช้ปล่องรังสีอาทิตย์ร่วมกับการพ่นละอองน้ำบนหลังคา เพื่อการระบายอากาศและลดความร้อนภายในห้องทดสอบในภูมิอากาศร้อนชื้น

Application of Solar Chimney and Wetted Roof in the Test Cell for Natural Ventilation and Heat Reduction in the Hot and Humid Climate

บัณฑิต ลิ้มมีโชคชัย สุดาภรณ์ ฉุ่งกู้
ภาควิชาวิศวกรรมเครื่องกล สถาบันเทคโนโลยีนานาชาติสิรินธร มหาวิทยาลัยธรรมศาสตร์ (ศูนย์รังสิต)
ตู้ ปณ. 22 อำเภอคลองหลวง จ. ปทุมธานี 12120 โทร 0-2986-9009 โทรสาร 0-2986-9121 E-mail: bundit@siit.tu.ac.th

Buncit Limmeechokchai Sudapom Chungloo
Department of Mechanical Engineering, Sirinchom International Institute of Technology, Thammasat University
P.O. Box 22 Klongluang, Pathumtani 12121 Thailand Tel: 0-2986-9009 Fax: 0-2986-9121 E-mail: bundit@siit.tu.ac.th

Abstract

The thermal performance of two passive cooling systems under hot and humid climate condition is experimentally investigated. The experimental results were obtained from a test cell and a controlled cell with identical walls but different roof configurations. The passive cooling systems applied to the test cell are solar chimney and water spraying on roof. The experimental results obtained from the test cell are compared with the closed and no passive cooling controlled cell and are used to calculate values of heat transfer coefficient of the cool ceiling and evaluation of the mean cooling potential (MCP) of the combined passive cooling system. The experimental results show that application of the solar chimney in the test cell could maintain the room temperature at 31.0-36.5 °C, accounting for 1.0-3.5°C lower than the ambient air and 1.0-1.3°C lower than the controlled cell. However, to make the test cell's room temperature much lower than the ambient temperature, the application of water spraying on roof is recommended together with solar chimney. The application of the two systems in the hot and humid climate are discovered to sustain the room temperature of the test cell to be lower than the ambient air by 2.0-6.2°C and lower than the controlled cell by 1.4-3.0°C. The derived mean cooling potential of the application of combined system are found two times higher than the application of the solar chimney.

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Utilization of Cool Ceiling with Roof Solar Chimney in Thailand: The Experimental and Numerical Analysis

Sudaporn Chungloo and Bundit Limmeechokchai *

Sirindhorn International Institute of Technology, Thammasat University
P.O. Box 22 Thammasat Rangsit Post Office 12120, Pathumthani, Thailand

Abstract

The objective of this paper is to study the benefits of application of solar chimney on the south roof and cool metal ceiling on the north roof through the experiment in a detached building called a controlled cell, and the related numerical model constructed from a computational fluid dynamics (CFD) program. The experimental results are used for calculation of values of heat transfer coefficient of the cool ceiling and evaluation of the mean cooling potential of the combined passive cooling system. The two dimensional numerical models generated by the CFD program use the mean values of wall temperatures in the application of solar chimney in the controlled cell as the boundary conditions. The effects of cool ceiling on the temperature, velocity and air flow rate in the controlled cell are investigated through the numerical model which the north ceiling temperature is reduced by 2-4°C from the measured value of 32.8°C. The mean cooling potential of the application of combined system are found two times higher than the application of the solar chimney. Good agreements between the predicted and experimental results are obtained from the comparison of temperature and volume flow rate at the middle section of the controlled cell. The reduction of north ceiling temperature in the free-convection numerical model shows the decrease of air temperature in the upper region of the room by 0.5-0.7°C from the original value of 33.3°C, and the increase of volume flow rate by 12%.

Keywords: Passive cooling in building, natural ventilation, solar chimney, CFD.

* Corresponding author: Dr. Bundit Limmeechokchai. Tel.: +66-2-986-9009 ext.2206; fax: +66-2-986-9009 ext.2201.
E-mail address: bundit@siit.tu.ac.th.

Appendix E

Reference No. SIIT 10/07 201

Form: G11.2
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SIRINDHORN INTERNATIONAL INSTITUTE OF TECHNOLOGY

THAMMASAT UNIVERSITY

EXTERNAL EXAMINER COMMENT FORM

Title of thesis: *Experimental And Numerical Studies Of Passive Cooling Technologies In The Hot And Humid Climate: The Case Study Of Solar Chimney And Wetted Roof*

Name of external examiner: *Prof. Dr. Ursula Eicker*

Signature: Date: 19.6.2007

Overall Recommendation

- ☐ Approve without any revision.
- ☒ Approve if revisions are made according to the following comments.
- ☐ Disapprove because of the reasons shown in the following comments.

Detailed Comments

Please substantiate your overall recommendation with written comments. (Continue on additional sheets if necessary.)

see attached sheet

(Attached to Form G11)

A copy has been received by the School Secretary __________ Date ________

FACHHOCHSCHULE STUTTGART HOCHSCHULE FÜR TECHNIK

STUTTGART UNIVERSITY OF APPLIED SCIENCES

Hochschule für Technik · Postfach 10 14 52 · 70013 Stuttgart

Schellingstrasse 24
70174 Stuttgart
www.hft-stuttgart.de

Fachbereich
Bauingenieurwesen,
Bauphysik
& Wirtschaft
Forschungszentrum
nachhaltige Energietechnik
www.zafh.net

Prof. Dr.
Ursula Eicker
Tel.: (0711) 8926-2831
Fax: (0711) 8926-2366
ursula.eicker@hft-stuttgart.de

20.6.2007

The work of Sudaporn Chungloo contains a detailed experimental and numerical analysis of natural ventilation driven by a solar chimney and evaporative cooling in the hot and humid climate of Thailand.
The methodology of the study is well described and both experiments and CFD simulations are carried out with accuracy. The monitoring results of the built test and control cells are used to validate the CFD models and there is certainly a scientific value in this work.

A major problem with the approach is the mix-up of passive cooling (by water evaporation) and "cooling" by natural ventilation using the solar chimney. Ms Chungloo often describes the natural ventilation as a cooling method, although during the daytime very hot ambient air is drawn into the room and increases the room cooling loads! Only night ventilation could provide some cooling effect, but during the night the solar chimney as constructed would not work.

My recommendation is to clearly separate the issue of natural ventilation from cooling. Only if the ambient temperature is lower than room temperature, a cooling effect can be obtained. It would be interesting for Ms Chungloo to investigate possibilities of using the chimney at night with thermal storage (phase change materials or high thermal mass chimneys might store the day's heat).

Concerning the evaporative cooling, I also see a problem of using a roof construction with basically no thermal separation between the hot ambient air and the room. This means that heat is transmitted through the roof most of the time and even when water is sprayed, the temperature levels of the roof are still about 30°C. If the room would be at a comfortable temperature level (i.e. below 30°C) no cooling effect would be obtained. A possibility would be to use a movable insulation and evaporate water during the night with insulation removed and shield the room from the heat during the day.
Different options and their effect on cooling performance should be discussed by Ms Chungloo.

The CFD work is good and the models are well validated. I would recommend to use the CFD models to do further parameter studies to explore other options than the experimentally chosen ones. For example, a situation could be studied, where the chimney maintains higher temperatures during the night and cooler ambient air could be drawn into the room.

In summary, I would approve the thesis, if revisions are made concerning the issue of natural ventilation and if some alternatives to the chosen experimental configuration with Pros and Contras would be discussed.

The revisions are made according to the comments from the external examiner as follows

Comments:

#1. The major problem with the approach is the mix-up of passive cooling (by water evaporation) and "cooling" by natural ventilation using the solar chimney. Ms. Chungloo often describes the natural ventilation as a cooling method, although during the daytime very hot ambient air is drawn into the room and increases the room cooling loads, only night ventilation could provide some cooling effect, but during the night the solar chimney as constructed would not work.

#2. My recommendation is to clearly separate the issue of natural ventilation from cooling. Only if the ambient temperature is lower than room temperature, a cooling effect can be obtained. It would be interesting for Ms. Chungloo to investigate possibility of using the chimney at night with thermal storage (phase change materials or high thermal mass chimneys might store the day's heat).

Answers:

The author agrees on the separation of the natural ventilation from the cooling and it has already been replaced the words, for example, "two passive cooling systems" with the words "passive systems".

The replacements of the words are inserted in pages and paragraphs as shown in the flowing attachments

chapter	Attachment
Abstract	ii
Abstract	iii
I	iv
I	v
II	vi
III	vii

In addition, the dissertation topic is revised from

" Experimental and Numerical Studies of Passive Cooling Technologies in The Hot and Humid Climate: The Case Study of Solar Chimney and Wetted Roof"

to

"Experimental and Numerical Studies of Solar Chimney and Wetted Roof: An Application in The Hot And Humid Climate". (see Attachment i)

In addition to the numerical studies of utilizing solar chimney, wetted roof and cool supply air, the application of the existing lightweight roof for ventilation during the night was studied and discussed in Chapter 6 (see Attachments viii, and ix). The recommendation of using high thermal mass chimney is added to Chapter 7 (see Attachment xii).

Comments:

#3. Concerning the evaporative cooling, I also see a problem of using a roof construction with basically no thermal separation between the hot ambient air and the room. This means that heat is transmitted through the roof most of the time and even when water is sprayed, the temperature levels of the roof are still about 30°C. If the room would be at a comfortable temperature level (i.e. below 30°C) no cooling effect would be obtained. A possibility would be to use a movable insulation and evaporate water during the night with insulation removed and shield the room from the heat during the day. Different options and their effect on cooling performance should be discussed by Ms. Chungloo.

Answers:

The author agrees that the removed insulation of water during the night and covered insulation and using water to shield the room from the heat during the day can reduce the temperature of the roof and possible to achieve the comfort level. The movable insulation roof pond is easy to install in the building with flat roof and strong structure, however houses in the hot and humid climate utilize the gable roof to receive the heavy rain and allow the rain water left the roof rapidly. The test cell constructed with the lightweight structure and inclined gable roof to imitate the construction of typical houses in the hot and humid climate can not be safely installed the heavy water bags or water pond on it. The roof of the test cell does not directly contact with the sun because of the protection of the shading so that the temperature of the roof is lower than the typical roof without shading.

According to the experimental results, the water spraying on the roof can reduce temperature of air in the room to be lower than the do-nothing option. However, it is difficult to reduce the temperature of the water-spray roof to be lower than 30°C because the temperature of the water in the tank exposing to the ambient always varies in the range of 28-30°C during summer. If it is possible to reduce the temperature of the water to 28°C, i.e. shading protection and full evaporation of water in the tank, the author believes that the temperature of the roof can be lower than 30°C. In addition, the increase of the area of water sprayed roof to the entire area of the floor, the lower room temperature and the comfortable temperature can be achieved.

Comments:

#4 The CFD work is good and the models are well validated. I would recommend to use the CFD models to do further parameter studies to explore other options that the experimental chosen ones. For example, a situation could be studied, where the chimney maintains higher temperatures during the night and cooler ambient could be drawn into the room.

Answers:

The author has shown the situation that the chimney remains higher temperature and the cooler ambient was drawn into the room by CFD simulation in Chapter 6 in Case Study C: application of solar chimney with cool supply air at the window. The CFD work of Case Study C was conducted in addition to the options that the experimental chosen, i.e. Case Study A (solar chimney) and B (solar chimney with water spraying). It has shown that allowing cool air to enter the room in Case C retards the application of natural ventilation but it can reduce temperature of air in the room more than just application of cool ceiling.

The option of night ventilation was added in the CFD study of application of solar chimney. The cool roof tile producing cool air flowing from solar chimney and entering into the room during the nighttime is shown in Chapter 6 (see Attachments viii, and ix), as a case study of air flowing from cool solar chimney into insulated room in the evening.

The conclusions about the application of solar chimney for cool air entering the window and the cool air entering the solar chimney in the evening and night time, respectively are shown in Attachment x and xi.

Note: The modification and revision of the dissertation contents includes the corrections of the page numbers and the figure numbers in the Table of contents and List of Figures. Please kindly see the improved versions of the final draft of dissertation in the .pdf electronic file.