

# Journal of Visualized Experiments

## Study on Moisture Absorption and Desorption Rate of Bamboo Scrimber by Hot-Humid Climatic Wind Tunnel --Manuscript Draft--

<b>Article Type:</b>	Invited Methods Article - JoVE Produced Video
<b>Manuscript Number:</b>	JoVE57504R3
<b>Full Title:</b>	Study on Moisture Absorption and Desorption Rate of Bamboo Scrimber by Hot-Humid Climatic Wind Tunnel
<b>Keywords:</b>	Bamboo scrimber; Hot-Humid climate wind tunnel; Moisture absorption and desorption rate
<b>Corresponding Author:</b>	Zujian Huang South China University of Technology Guangzhou, CHINA
<b>Corresponding Author's Institution:</b>	South China University of Technology
<b>Corresponding Author E-Mail:</b>	huangzuj@hotmail.com
<b>First Author:</b>	Zujian Huang
<b>Author Comments:</b>	
<b>Additional Information:</b>	
<b>Question</b>	<b>Response</b>
If this article needs to be "in-press" by a certain date, please indicate the date below and explain in your cover letter.	

## Cover Letter

Dear Dr. Jialan Zhang,

We submit our manuscript entitled 'Study on Moisture Absorption and Desorption Rate of Bamboo Scrimber by Hot-Humid Climatic Wind Tunnel' to Journal of Visualized Experiments for publication.

In this paper a wind tunnel test was carried out with complete climate data of a typical summer day in Guangzhou, a subtropical city located in south China. The climate data, including dynamic solar radiation, air temperature, relative humidity and constant wind speed was repeated for 72hr, of which the last 48hr were selected for analysis. The reference timber for comparison in this study was *Intsia.spp* (Caesalpiniaceae), a kind of antiseptic hardwood for outdoor flooring. The dynamic test result in wind tunnel showed that bamboo scrimber had lower moisture absorption and desorption rate than reference hardwood. The significant magnitude difference between the dynamic and static test results showed the necessity of a comprehensive evaluation approach that could take more practical climate conditions into consideration. The climatic wind tunnel enabled the control of complete climate conditions, therefore realized the repeatability and standardization of the climate-related experiment.

Thank you very much for your attention and consideration.

Sincerely yours,

Zujian Huang

SCUT-TUM Architecture PhD student  
School of architecture, State Key Laboratory of Subtropical Building Science, South China University of Technology, Guangzhou 510640, China;  
Chair of Building Construction and Material Science, Department of Architecture, Technical University of Munich, Munich 80333, Bayern, Germany  
Tel (DE): 49 151 4358 5282  
Tel (CN): 86 135 1276 7351  
Email: [huangzuj@hotmail.com](mailto:huangzuj@hotmail.com)

**TITLE:**

Study on the Moisture Absorption and Desorption Rate of Bamboo Scrimber in a Hot-Humid Climatic Wind Tunnel

**AUTHORS AND AFFILIATIONS:**

Zujian Huang<sup>1,2,3</sup>, Yimin Sun<sup>1,2</sup>, Florian Musso<sup>3</sup>

<sup>1</sup>School of Architecture, South China University of Technology, Guangzhou, China

<sup>2</sup>State Key Laboratory of Subtropical Building Science, Guangzhou, China

<sup>3</sup>Chair of Building Construction and Material Science, Department of Architecture, Technical University of Munich, Munich, Bayern, Germany

Corresponding Author:

Zujian Huang

Email: [huangzuj@hotmail.com](mailto:huangzuj@hotmail.com)

Email Addresses of Co-authors:

Yimin Sun (arymsun@scut.edu.cn)

Florian Musso ([musso@ebb.arch.tu-muenchen.de](mailto:musso@ebb.arch.tu-muenchen.de))

**KEYWORDS:**

Bamboo scrimber, hot-humid climate wind tunnel, moisture absorption, desorption rate, wind tunnel, dynamic, hygric behavior

**SHORT ABSTRACT:**

Here, we present a protocol to measure the moisture absorption and desorption rate of bamboo scrimber in an outdoor environment for a dynamic hot-humid climate wind tunnel test with complete meteorological conditions for 72 h.

**LONG ABSTRACT:**

The absorption and desorption rate  $U_{ab}$  is an important indicator to evaluate the hygric performance of hygroscopic building materials. However, standard methods to obtain this value are normally carried out in a static indoor environment, which cannot represent a dynamic outdoor environment. This protocol presents a Hot-Humid Climate Wind Tunnel (HHCWT) method to examine the hygric behavior of bamboo scrimber (BFB) in outdoor conditions, with the hourly solar radiation, air temperature, relative humidity, and constant wind speed of a typical summer day in the south of China. The complete meteorological parameters were repeated for 72 h, of which the last 48 h were selected for analysis. By comparison with the hardwood specimen (HW) in this test, BFB showed a more stable hygric performance. The BFB to HW ratio of the  $U_{ab}$  mean value and maximum value were, respectively, 64.35% and 66.02%. The maximum absorption rate  $U_{a,max}$  and desorption rate  $U_{d,max}$  from the dynamic test were correspondingly  $2.91E^{-05}$  kg/(m<sup>2</sup>/s) and  $4.45E^{-05}$  kg/(m<sup>2</sup>/s), far larger than the results of  $7.74E^{-07}$  -  $12.58E^{-07}$  kg/(m<sup>2</sup>/s) from the static test. The significant difference in magnitude shows the necessity of a dynamic evaluation approach that can take more practical climate conditions into

consideration. The HHCWT enables the reproducibility and standardization of climate-related experiments for building materials by creating climate conditions with complete meteorological parameters.

## INTRODUCTION:

Bamboo scrimber is considered to be an ideal product to achieve a high value-added utilization of the widely distributed bamboo forest resources, by decomposing raw bamboo and recombining it into bamboo panels that could be applied as outdoor flooring or a building facade. There already are studies on the hygrothermal properties of bamboo scrimber with static standard methods carried out in indoor environments<sup>1,2</sup>. However, the performance in more practical outdoor conditions needs further investigation. The hygric properties of bamboo scrimber obtained in our prior study are shown in **Table 1**.

The moisture absorption and desorption rate  $U_{ad}$  are an important indicator characterizing the hygric transport performance, and also closely affect the thermal performance of certain building materials, especially for those hygroscopic materials such as bamboo and timber. Normally, the  $U_{ad}$  value is measured by static standard methods in a laboratory environment, with constant ambient air temperature  $T$  and relative humidity  $RH$  (e.g.,  $T = 23\text{ }^{\circ}\text{C}$ ,  $RH = 50\%$ )<sup>3</sup>. However, the constant indoor testing conditions are very different from the practical application in an outdoor environment, where the meteorological conditions are more complex. The effect of solar radiation on the heat and moisture transfer cannot be ignored<sup>4,5</sup>. Other studies have investigated the dynamic performance by establishing dynamic models and transfer functions<sup>6,7</sup> and show different characteristics compared to the static standard tests<sup>8</sup>.

To test the material objects in real outdoor climate conditions is a more persuasive method to evaluate the targeted performance. However, outdoor climate conditions do not reappear, making the experiments difficult to standardize, let alone when done by different operators at different periods. For solving the above challenges, we studied reproducible meteorological conditions and developed them with a climate wind tunnel. A wind tunnel is a comprehensive concept to create different simulated conditions (e.g., wind resistance testing, evaporative cooling, or a microclimate on building envelope) to examine certain performances of the research objects<sup>9,10,11,12</sup>.

For this study, the HHCWT was created with a motivation to reproduce the outdoor climate conditions for examining the hygrothermal performance of building materials and building components closer to the practical application conditions<sup>13,14</sup>. The HHCWT consists of 18 elements: a protection room (**Figure 1.1**) with an air conditioner, a heater, a humidifier, a dehumidifier (**Figures 1.12 - 1.15**), a wind tunnel (**Figure 1.2**) with an entrance region, a stilling region, a test region, an auxiliary region, a diffusion region and a fan region in the order (**Figure 1.5 - 1.10**), a solar radiation chamber (**Figure 1.11**) overhead and an air conditioning chamber (**Figure 1.16**) below, the specimen slot (**Figure 1.4**) with a balance (**Figure 1.17**) on the boundary of the wind tunnel and the air conditioning chamber (**Figure 1.3**), and the operating condition control and data collection system (**Figure 1.18**) outside the protection room. An operating condition control and data collection system were set outside the protection room for the input

and output control of the whole system. The climatic wind tunnel enabled the complete control of climate conditions, therefore realizing the repeatability and standardization of the climate-related experiment (**Figure 1**).

In this study, a dynamic absorption and desorption pair-test was carried out for bamboo scrimber and hardwood specimens. The HHCWT was used to create complete climate conditions, including the solar radiation, air temperature, relative humidity, and wind speed of a TMD (Typical Meteorological Day) of Guangzhou, a typical subtropical city located in the south of China. The obtained values were compared with the results from the static standard method to show the progress of this experimental method.

Since factors such as bulk density, open porosity, and surface treatment had an impact on the hygric properties of the products<sup>15,16</sup>, typical samples were selected from the company that owned the core patent (**Table 2**).

## **PROTOCOL:**

### **1. Specimens Treatment**

#### **1.1. Specimens preparation**

1.1.1. Select the material: for the bamboo (BFB), a bamboo scrimber panel made of Moso (*Phyllostachys Pubescens*); for the timber (HW), a hardwood panel made of *Intsia* spp. (Caesalpiniaceae).

1.1.2. Ask the bamboo and wood factories to cut the specimens to a size of 30 x 30 cm (side length), while keeping the original thickness of 28 mm.

Note: The normal size of the bamboo panels used is 122 x 244 cm (width x length), and the thickness is 28 mm or 18 mm. The samples can best be cut at the factories because they have the suitable cutting machines. Chose the thickness of 28 mm instead of 18 mm, because the thicker sample generally ensures more stable results.

1.1.3. Prepare the specimens in duplicate.

#### **1.2. Vacuum saturation**

1.2.1. Arrange the equipment as follows: 1 vacuum chamber and pump (a sliding vane rotary vacuum pump, extreme pressure 600 Pa, speed 8 L/s); 1 independent and movable water sink of 35 x 35 x 20 cm (length x width x height); and 20 stainless-steel nut supports of equal size.

1.2.2. Plain lay the stainless-steel nut supports on the bottom of the water sink, and side stand the specimens on the supports.

1.2.3. Suppress it with a stainless-steel grid on the top.

Note: The weight of the grid should be enough to ensure that the specimens can be kept immersed in the water when the water is later injected into the water sink.

1.2.4. Move the specimens with the water sink into the vacuum chamber, then close the chamber and make sure that the water inlet valve has already been closed.

Note: The chamber is part of the vacuum pump, and the size of the chamber is 40 x 40 x 40 cm (length x width x height). If another type of machine is used, it can be a different size, as long as it is large enough to hold the water sink.

1.2.5. Connect the power plug of the vacuum pump to the 380 V electric source.

Note: The voltage of the power supply is decided by the requirement of the vacuum pump. We needed 380 V for the device we used, but it may also be 220 V or other values depending on the devices used.

1.2.6. Press the start switch to start the vacuum pump. Lower down the air pressure in the chamber to 20 mbar. Keep the vacuum pump running to hold the air pressure inside the chamber  $\leq 20$  mbar for 6 h.

Note: The purpose of this step is to make sure that the air inside the internal pores of the specimens is exhausted, so that water can fill in the pores in the following steps. Different materials might require different time lengths due to a difference in the transport resistance of the materials.

1.2.7. Keep the air pressure in the vacuum chamber  $\leq 20$  mbar, as mentioned above. Turn on the water inlet valve to slowly inject distilled water into the sink.

1.2.8. Keep the water level rise rate to be about 5 cm/h. Stop injecting water when the water level reaches about 5 cm over the top surface of the specimens, then turn off the vacuum pump.

1.2.9. Keep the specimens immersed in water for 3 days, until an initial moisture content of capillary saturation is reached.

1.2.10. One by one, take specimens out of the water and wipe off the attached water from the surface with a soft damp cloth.

Note: Due to the water surface tension, some water attached to the surface of the specimens will follow up when the specimens are taken out of the water.

### 1.3. Bottom and side sealing

1.3.1. Air-dry the specimens in an indoor environment (*ca.*  $T = 23\text{ }^{\circ}\text{C}$ ,  $\text{RH} = 50\%$ ) for 1 h, until the surface is dry.

Note: Make sure that the specimens are not covered by anything that might stop the surface from drying.

1.3.2. Seal the bottom and side surfaces with 1 - 2 mm petroleum jelly.

## 2. Wind Tunnel Operation

### 2.1. Equipment arrangement

2.1.1. Check the system components, as shown in **Figure 1** and **Table 3**.

2.1.2. Reset the computer time of the operating condition control and data collection system according to the climate data.

Note: In this step, each computer has different requirements. Click on the time in the lower right corner and input the condition time. It might be different at another computer system. In the following introduction, all the mentioned time is condition time that is synchronized with the climate data. The preheating of the wind tunnel is set to be at 4:00, the specimens' installation at 5:00, and the data recording starts at 6:00. The 24 h single-days are required to be repeated continuously at least 3x.

### 2.2. Wind tunnel preheating (at 4:00)

2.2.1. Start the wind tunnel system for preheating. Run it with the climate parameters as shown in **Table 2**.

Note: The TMD in this study is from Guangzhou and can be changed to other cities according to the experimental purposes (**Table 4**).

2.2.2. Observe the received data from the wind tunnel and ensure the hourly deviations of the real climate conditions in the test region are within the scope of the error requirements: the air temperature  $\leq 0.3\text{ }^{\circ}\text{C}$ , the relative humidity  $\leq 5\%$ , the solar radiation  $\leq 5\%$ , and the wind speed  $\leq 5\%$ . Extend the preheating time, if necessary.

Note: The scope of the error requirements is confined to the accuracy of the sub-systems of the HHCWT. A smaller or larger range might be also acceptable if the equipment is different.

2.2.3. Keep the air temperature in the air conditioning chamber at  $26\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$ , and the wind speed  $\leq 0.5\text{ m/s}$ .

### 2.3. Specimens installation (at 5:00)

2.3.1. Place the specimens into the test tanks and seal the gap between the edges of the specimens and the tanks with petroleum jelly.

2.3.2. Place the specimens in the test region in the test tanks of the wind tunnel and connect the bottom of the tanks to the balance below with prefabricated steel frames.

Note: The function of the steel frames here is to transfer the gravity of the specimens to the balances below. All specimens are tested together but the mass change rate for each specimen is recorded individually by each balance below.

2.3.3. Adjust the height of the balance to keep the top surface of the specimens' flush with the inner surface of the wind tunnel.

Note: In this operation, make sure that the test tanks do not come into contact with each other to avoid mass measurement errors.

## 2.4. Data recording (at 6:00)

2.4.1. Reset the balances to start the mass record at 0.

Note: Press the **Clear** of the balances to reset them to 0.

2.4.2. Use the computer (the operating condition control and data collection system) to record the data.

Note: During the data recording, pay attention to the data receiving ports for instantaneous mass values and climate conditions, and also to the alarm (which only happens when the real hourly deviations of the climate conditions run beyond the error tolerance).

2.4.3. Repeat the 24-h climate control for 3x, and continuously record for 72 h.

## 3. Post-operation

### 3.1. Dry the specimens

3.1.1. Arrange the following equipment: a drying oven (a digital stainless steel electric blast oven with an accuracy of  $\pm 1$  °C) and a balance (with an accuracy of 0.01 g). Keep the drying temperature of the oven at 70 °C.

3.1.2. Place the wet specimens in the drying oven and weigh 1 week later.

3.1.3. Continue to weigh the specimens each 24 h and measure the convergence until the difference between the two consecutive weighing results does not exceed 1%. Record the final



weighing result.

## 4. Data Processing

### 4.1. The values of the mass

4.1.1. Average all the instantaneous mass values within each h as the mass of time i ( $m_i$ ).

$$m_i = \frac{1}{n} \sum_{j=1}^n m_{i-1,j}$$

Where:

$m_i$  is the specimens' mass of time i in kg;

$i-1,j$  is the jth measured value within 1 h after time i-1 in kg;

$n$  is the number of measured value within 1 h (*e.g.*,  $n = 60$  when the recording interval is 1 min).

4.1.2. Consider the final value in step 3.1.3 as the dry mass of the specimens  $m_d$ .

4.2. Calculate the absorption and desorption rate  $U_{ad}$  value.

$$U_{ad,i} = \frac{m_i - m_{i-1}}{A}$$

Where:

$U_{ad,i}$  is the absorption and desorption rate of time i (when the  $U_{ad,i} > 0$ , it means absorption rate; when the  $U_{ad,i} < 0$ , it means desorption rate) in  $\text{kg}/(\text{m}^2/\text{s})$ ;

$m_i, m_{i-1}$  is the mass value of time i and the value at the previous time i-1 in kg;

$A$  is the measurement area of the specimens in  $\text{m}^2$ .

## REPRESENTATIVE RESULTS:

The recorded data of the last 48 h from the whole 72 h were selected and analyzed (**Figure 2, Table 5**).

The dynamic test in the wind tunnel was performed and the results showed that the bamboo scrimber (BFB) had a lower  $U_{ad}$  value than the reference hardwood (HW). Compared to HW, BFB showed a more stable hygric performance. The  $U_{ab}$  mean value  $U_{ab,mean}$  of BFB and HW were  $4.45\text{E-}05 \text{ kg}/(\text{m}^2/\text{s})$  and  $6.74\text{E-}05 \text{ kg}/(\text{m}^2/\text{s})$ , respectively and the max value  $U_{ab,max}$  were  $1.49\text{E-}05 \text{ kg}/(\text{m}^2/\text{s})$  and  $2.32\text{E-}05 \text{ kg}/(\text{m}^2/\text{s})$  respectively, of which the BFB to HW ratios were, respectively, 64.35% and 66.02%. The hourly  $U_{ad}$  values of BFB were up to  $33.69\text{E-}06 \text{ kg}/(\text{m}^2/\text{s})$  lower than that of the HW specimen, except in certain areas where the moisture process was in the absorption-desorption transition stage.

The maximum absorption rate  $U_a$  and desorption rate  $U_d$  of the dynamic test results of BFB were, correspondingly,  $2.91\text{E-}05 \text{ kg}/(\text{m}^2/\text{s})$  and  $4.45\text{E-}05 \text{ kg}/(\text{m}^2/\text{s})$ , far larger than the results of  $7.74\text{E-}07 - 12.58\text{E-}07 \text{ kg}/(\text{m}^2/\text{s})$  from the static test. The significant magnitude difference indicated that the indoor test results were far from being sufficient to describe the hygric performance in outdoor

conditions. Therefore, the evaluation approach with more practical climate conditions was necessary. Due to the changing climate conditions of solar radiation, temperature, relative humidity, and wind, the wind tunnel test showed much more mutative results that could describe the dynamic hygric behavior in practical conditions.

## FIGURE AND TABLE LEGENDS:

**Figure 1. Equipment and control system of the Hot-Humid Climatic Wind Tunnel (HHCWT).** The figure marks out the setup of the HHCWT. The HHCWT consists of 18 elements that are used to create climate conditions of solar radiation, air temperature, relative humidity, and wind. The balance and the operating condition control and data collection system work together to receive the mass change rate of the specimens within the wind tunnel.

**Figure 2. Absorption rate  $U_a$  and desorption rate  $U_d$  of bamboo scrimber and hardwood specimens.** The figure shows the actual climate conditions within the wind tunnel, including the solar radiation, air temperature, relative humidity, and wind speed, and the absorption rate  $U_a$  and desorption rate  $U_d$  test results of the bamboo scrimber and hardwood specimens. The  $U_{ab}$  mean value  $U_{ab.mean}$  of BFB and HW are  $4.45E^{-05}$  kg/(m<sup>2</sup>/s) and  $6.74E^{-05}$  kg/(m<sup>2</sup>/s) respectively, and the max value  $U_{ab.max}$  are  $1.49E^{-05}$  kg/(m<sup>2</sup>/s) and  $2.32E^{-05}$  kg/(m<sup>2</sup>/s) respectively, of which the BFB to HW ratios were, respectively, 64.35% and 66.02%. The hourly  $U_{ad}$  values of the BFB were up to  $33.69E^{-06}$  kg/(m<sup>2</sup>/s), lower than that of the HW specimen, except in certain areas where the moisture process was in the absorption-desorption transition stage. The maximum absorption rate  $U_a$  and desorption rate  $U_d$  dynamic test results of BFB were, correspondingly,  $2.91E^{-05}$  kg/(m<sup>2</sup>/s) and  $4.45E^{-05}$  kg/(m<sup>2</sup>/s).

**Figure 3. Photo of the bamboo scrimber sample.** The figure shows the cross-section and frontal photographs of the bamboo scrimber sample.

**Figure 4. The manufacturing process of the bamboo scrimber sample.** The figure shows a schematic diagram of the manufacturing process of the bamboo scrimber, including rolling, decomposing to a bamboo fiber bundle unit, and recombining to a bamboo scrimber board.

**Table 1. Bamboo scrimber hygric properties static test results.** The table shows the information of the bamboo scrimber hygric properties static test results, including the drying rate done in a static environment ( $T = 23$  °C,  $RH = 50\%$ ), showing that the drying rate of bamboo scrimber was between  $7.74E^{-07}$  -  $12.58E^{-07}$  kg/(m<sup>2</sup>/s).

**Table 2. Information on the bamboo scrimber sample.** The table shows the information on the bamboo scrimber sample, including the constituent unit, assembly method, thickness, main application, and the sample sources.

**Table 3. Equipment and control system of the Hot-Humid Climatic Wind Tunnel (HHCWT).** The table shows the equipment and control system of the HHCWT, including the sub-systems for the control of the solar radiation, air temperature, relative humidity, and wind within the wind tunnel.

**Table 4. Standard condition: Climate data of Guangzhou summer typical meteorological day.**

The table shows the information of the climate conditions, including the solar radiation, air temperature, relative humidity, and wind speed of a TMD (Typical Meteorological Day) of Guangzhou, a typical subtropical city located in the south of China.

**Table 5. Mass records and the calculated absorption and desorption rate  $U_{ad}$  value.** The table shows the information on the absorption rate  $U_a$  and desorption rate  $U_d$  test results of the bamboo scrimber and hardwood specimens. The  $U_{ab}$  mean value  $U_{ab,mean}$  of BFB and HW were  $4.45E^{-05}$  kg/(m<sup>2</sup>/s) and  $6.74E^{-05}$  kg/(m<sup>2</sup>/s) respectively, and the max value  $U_{ab,max}$  were  $1.49E^{-05}$  kg/(m<sup>2</sup>/s) and  $2.32E^{-05}$  kg/(m<sup>2</sup>/s) respectively.

**DISCUSSION:**

The protocol presented a Hot-Humid Climatic Wind Tunnel (HHCWT) test method to measure the moisture absorption and desorption rate of bamboo scrimber. The critical steps included the specimen's treatment, which in turn included the specimen's preparation, vacuum saturation, and bottom and side sealing; the wind tunnel operation, which in turn included the equipment arrangement, wind tunnel preheating, specimens installation, and data recording; the post-operation including drying the specimen; the data processing, which in turn included calculating the values of the hourly mass and the absorption and desorption rate  $U_{ad}$  value.

The problem of a climate-related experiment, especially in an outdoor environment, was that the climate conditions could not be reproduced, let alone that experiments done by different operators at different periods could be standardized. However, the HHCWT test method enables the complete control of climate conditions. With a TMD (Typical Meteorological Day) as the climate conditions, the HHCWT test method could help to realize the repeatability and standardization of outdoor experiments<sup>13,14</sup>.

Unlike disciplines such as chemistry, where the material samples, testing equipment, and operation processes are strictly standardized, the HHCWT is a combined system that consists of several different sub-systems, which is much more complicated. On the other hand, building materials are generally much more inhomogeneous and their properties are normally evaluated on more macroscopic perspectives. Therefore, the test method by wind tunnel shown in this protocol is, in a certain sense, a demonstration rather than a strict regulation.

The detailed information for each step in this experiment is presented in the protocol, but that does not mean that everything must be followed strictly. There is flexible space to adjust. For example, the sub-systems like the heating fans, air conditioners, humidifiers, and dehumidifiers, etc., could be changed to other types. Secondly, the goal of the vacuum saturation treatment in step 1 is to reach an original state of moisture content for the specimens. When this is achieved, it is acceptable to change the vacuum pump and the chamber. Thirdly, different materials have a varying time length requirement to exhaust the inner air and reach the state of vacuum saturation. The bamboo scrimber in this study required a long time due to the high moisture transport resistance, but other materials will require a different time length.

The method has potential to be applied to climate-related experiments and as the verification of simulation results by a computer program.

#### **ACKNOWLEDGMENTS:**

The research was funded by The State Key Laboratory of Subtropical Building Science Project: 2017KC22 and The State Scholarship Fund by the Chinese Scholarship Council: 201506150017. The experiment was carried out with the Hot-Humid Climatic Wind Tunnel (HHCWT), which was developed by the Building Energy Conservation Research Center of South China University of Technology.

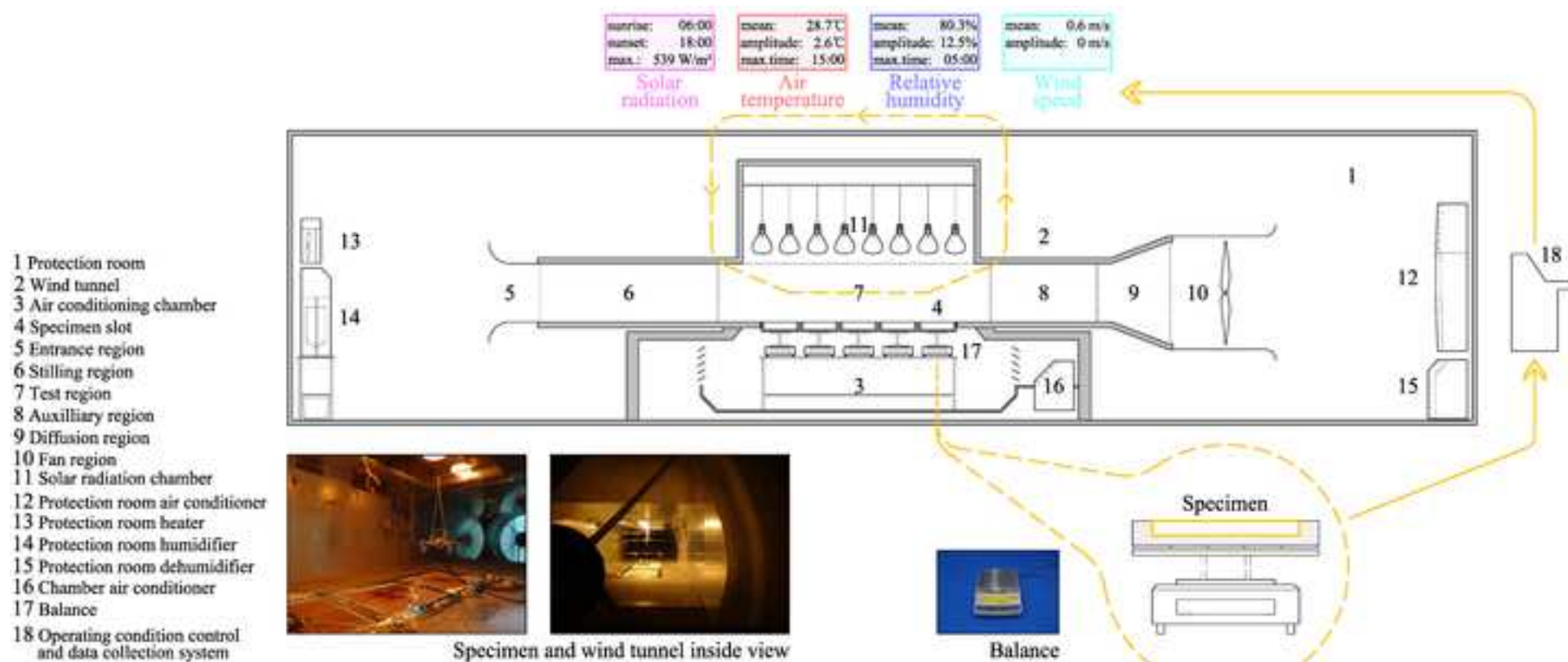
#### **DISCLOSURES:**

The authors have nothing to disclose.

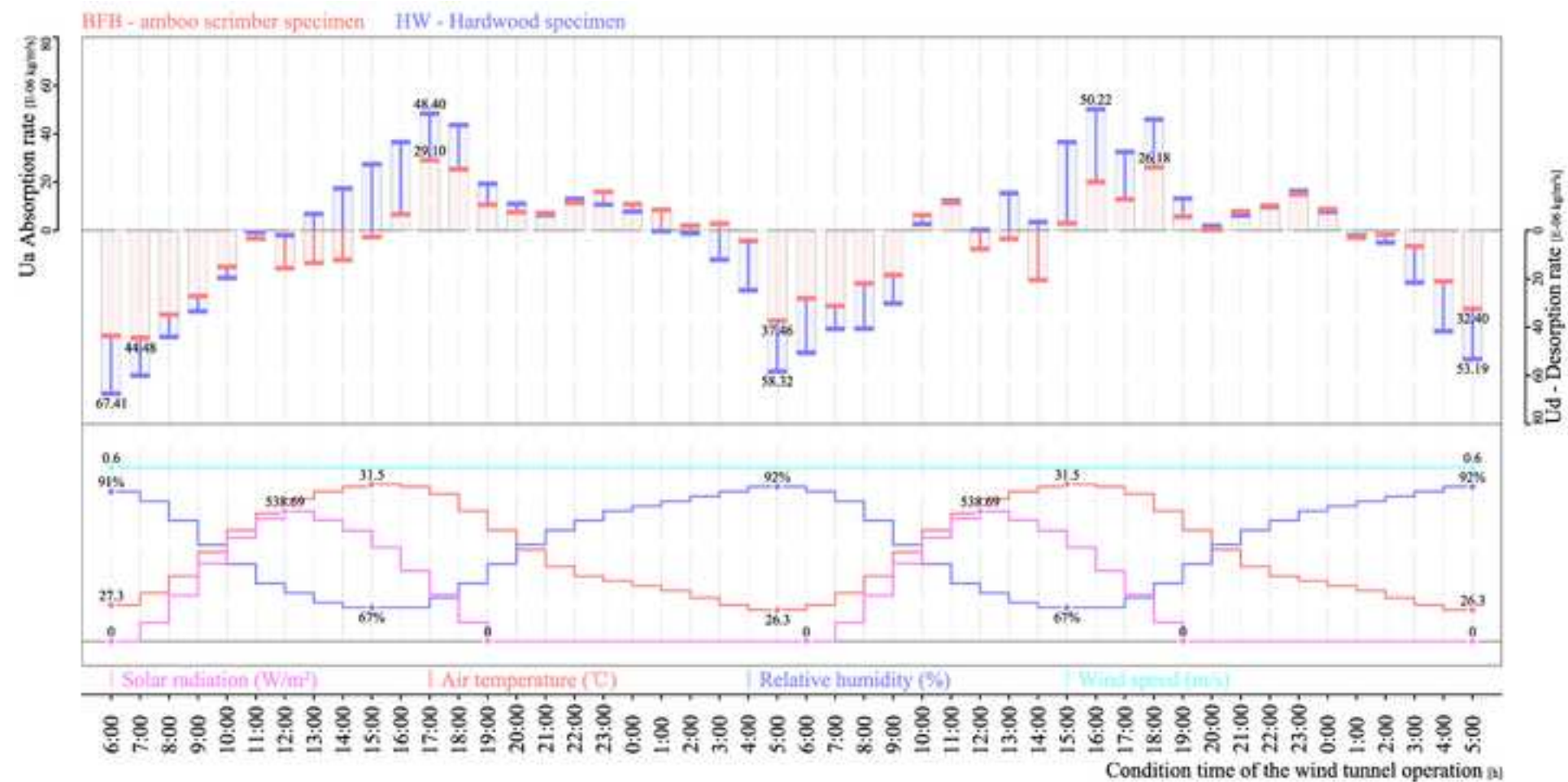
#### **REFERENCES:**

1. Huang, Z., Sun, Y., Musso, F. Assessment on bamboo scrimber as a substitute for timber in building envelope in tropical and humid subtropical climate zones - part 1: hygrothermal properties test. *ICBMM 2017 - International Conference on Building Materials and Materials Engineering*. Lyon, France (September 21-23, 2017).
2. Huang, Z., Sun, Y., Musso, F. Assessment of bamboo application in building envelope by comparison with reference timber. *Construction and Building Materials*. **156**, 844-860 (2017).
3. Fraunhofer Institute for Building Physics IBP. *Measuring and Testing Facilities*. Stuttgart: *Fraunhofer Institute for Building Physics*. 92, Fraunhofer IBP. Stuttgart, Germany (2015).
4. Chen, T., Chen, Y., Yik, F. W. H. Rational selection of near-extreme coincident weather data with solar irradiation for risk-based air-conditioning design. *Energy and Buildings*. **39** (12), 1193-1201 (2007).
5. Huang, S. *Solar-driven vapor flow in wood-frame walls with wetted cladding*. Concordia University. Montreal, Quebec, Canada (2005).
6. Diasty, R. E., Fazio, P., Budaiwi, I. Dynamic modelling of moisture absorption and desorption in buildings. *Building and Environment*. **28** (1), 21-32 (1993).
7. Chen, Y., Chen, Z. Transfer function method to calculate moisture absorption and desorption in buildings. *Building and Environment*. **33** (4), 201-207 (1998).
8. Yang, T., Ma, E. Comparison of dynamic sorption and hygroexpansion of wood by different cyclic hygrothermal changing effects. *Journal of the Korean Wood Science and Technology*. **44** (2), 191-203 (2016).

9. Montazeri, H., Blocken, B., Hensen, J. L. M. Evaporative cooling by water spray systems: CFD simulation, experimental validation and sensitivity analysis. *Building and Environment*. **83**, 129-141 (2015).
10. Liao, C.-M., Chiu, K.-H. Wind tunnel modeling the system performance of alternative evaporative cooling pads in Taiwan region. *Building and Environment*. **37**, 177-187 (2002).
11. Rong, L., Pedersen, P., Ladegaard Jensen, T., Morsing, S., Zhang, G. Dynamic performance of an evaporative cooling pad investigated in a wind tunnel for application in hot and arid climate. *Biosystems Engineering*. **156**, 173-182 (2017).
12. Hershovich, C. *et al.* Microclimate on building envelopes: wind tunnel and computational fluid dynamic analysis of basic and complex geometries. *The Symposium on Simulation for Architecture and Urban Design*. Toronto, Canada (2017).
13. Zhang, Y., Meng, Q., Chen, Y. Development of dynamic laboratory of hot-humid climatic wind tunnel. *Journal of South China University of Technology (Natural Science Edition)*. **36** (3), 99-103 (2008). [in Chinese]
14. Zhang, L., Feng, Y., Meng, Q., Zhang, Y. Experimental study on the building evaporative cooling by using the Climatic Wind Tunnel. *Energy and Buildings*. **104**, 360-368 (2015).
15. Kumar, A. *et al.* Engineered bamboo scrimber: influence of density on the mechanical and water absorption properties. *Construction and Building Materials*. **127**, 815-827 (2016).
16. Huang, Z., Sun, Y., Musso, F. Experimental study on bamboo hygrothermal properties and the impact of bamboo-based panel process. *Construction and Building Materials*. **155**, 1112-1125 (2017).
17. ASTM D7370. *Standard Test Method for Determination of Relative Density and Absorption of Fine, Coarse and Blended Aggregate Using Combined Vacuum Saturation and Rapid Submersion*. ASTM International. West Conshohocken, PA (2009).
18. DIN EN 1936. *Natural stone test method - Determination of real density and apparent density, and of total and open porosity*. European Committee for Standardization (CEN). Brussel, Belgium (2007).
19. GB/T 20313. *Hygrothermal performance of building materials and products - Determination of moisture content by drying at elevated temperature* (2006).



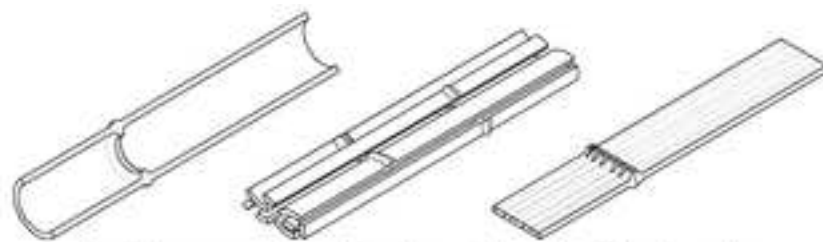
[Click here to download Figure Figure 2.jpg](#) 











Rolling processing: Bamboo tube-strip-fiber bundle



Bamboo fiber bundle unit



Bamboo scrimber board

**Table.1** Bamboo scrimber hygric properties static test results

Items		Unit	BFB -Bamboo scrimber	
Basic properties	Dry bulk density $\rho$	[kg/m <sup>3</sup> ]		1108.77
	Open porosity $\Phi$	[-]		17.36%
Hygric properties	Drying rate (T =23℃ , RH=50%)	[E-07kg/(m <sup>2</sup> ·s)]	U <sub>u12%</sub> ~u11%	12.58
			U <sub>u11%</sub> ~u10%	11.46
			U <sub>u10%</sub> ~u9%	10.38
			U <sub>u9%</sub> ~u8%	9.71
			U <sub>u8%</sub> ~7%	8.98
			U <sub>u7%</sub> ~u6%	7.74
	Capillary saturation moisture content			
	W <sub>cap</sub>	[kg/m <sup>3</sup> ]		165.93

**Table.2** Information of the bamboo scrimber sample

BFB (Bamboo scrimber)	Constituent unit	Assembly	Thickness	Main application
Photo of the bamboo scrimber sample (fig.3)	Bamboo bundle	Parallel	28.0 mm	Outdoor flooring
	Manufacturing process of the bamboo scrimber sample (fig.4)			

**Table.3** Equipment and control system of the HHCWT: Hot-Humid Climatic Wind Tunnel

HHCWT: Hot-Humid Climatic Wind Tunnel, including control systems for: Air temperature: 2 air conditioner (KFRd-60LW/VA-ZXF, 6kW, and KFR-72LW/08FZBPC-a, 7.2kW) and 2 electric heating fans (1.5kW and 5kW), range 20-40°C, accuracy 0.3°C; Relative humidity: 2 electrode humidifiers (BFD-01-04, 0.4kg/h) and 1 dehumidifier (DH-890C, 90L/d), range 40-90%, accuracy 3%; Solar radiation: 8 infrared lights (305-3000nm), range 0-1030W/m <sup>2</sup> , accuracy 10W/m <sup>2</sup> ; Wind: axial fan, range 0-5m/s, accuracy 0.2m/s.
The HHCWT (Hot-Humid Climatic Wind Tunnel) was developed by the Building Energy Conservation Research Center of South China University of Technology. The HHCWT consists of 18 elements: protection room with air conditioner, heater, humidifier, dehumidifier, wind tunnel with entrance region, stilling region, test region, auxiliary region, diffusion region and fan region in order, a solar radiation chamber overhead and an air conditioning chamber below, the specimen slot with balance on the boundary of the wind tunnel and the air conditioning chamber, and the operating condition control and data collection system outside the protection room.
The mass record was done by electronic balance (range 0-4kg, accuracy 0.01g; time step: 10s), together with the operating condition control and data collection system. The mass information from the electronic balance was transmitted to the computer through the USB data acquisition & control card. And the signal was received and converted by a software attached to the HHCWT system.

**Table.4** Standard condition: Climate data of Guangzhou  
summer typical meteorological day

Hour	Air temperatur e	Relative humidity	Solar radiation	Wind speed	
	[°C]	[%]	[W/m <sup>2</sup> ]	[m/s]	
0:00:00	27.3	88	0	0.6	
1:00:00	27.1	89	0	0.6	
2:00:00	26.8	90	0	0.6	
3:00:00	26.5	91	0	0.6	
4:00:00	26.3	92	0	0.6	
5:00:00	26.3	92	0	0.6	
6:00:00	26.5	91	0	0.6	
7:00:00	27	89	77	0.6	
8:00:00	27.7	85	190	0.6	
9:00:00	28.7	80	322	0.6	
10:00:00	29.6	76	428	0.6	
11:00:00	30.3	72	508	0.6	
12:00:00	30.9	70	539	0.6	
13:00:00	31.2	68	501	0.6	
14:00:00	31.4	67	458	0.6	
15:00:00	31.5	67	389	0.6	
16:00:00	31.4	67	291	0.6	
17:00:00	31.1	69	194	0.6	
18:00:00	30.4	72	78	0.6	
19:00:00	29.6	76	0	0.6	
20:00:00	28.8	80	0	0.6	
21:00:00	28.1	83	0	0.6	
22:00:00	27.7	85	0	0.6	
23:00:00	27.5	87	0	0.6	
TMD (24hr repeated)	mean value:	mean value:	sunrise:		
	28.7°C	80.3%	06:00		
	amplitude:	amplitude:	sunset: 18:00	constant as 0.6m/s	
	2.6°C	12.5%			
	max. time:	max. time:	max. value:		
	15:00	05:00	539.0W/m <sup>2</sup>		

Note: the TMD (Typical Meteorological Day) in this study was from Guangzhou, and could be changed to other cities according to the experimental purposes

**Table.5** Mass records and the calculated absorption and desorption rate  $U_{ad}$  value

Assumed date	Time	Cumulative time [h]	Hourly mass change		Hourly mass change rate		Hourly mass change rate
			[g/h]		[g/(m <sup>2</sup> ·h)]		[kg/(m <sup>2</sup> ·h)]
			BFB	HW	BFB	HW	BFB
9/5/2016	6:00:00	0	0	0			
9/5/2016	7:00:00	1	-12.92	-19.66	-157.14	-242.67	-4.37E-05
9/5/2016	8:00:00	2	-13.16	-17.49	-160.12	-215.96	-4.45E-05
9/5/2016	9:00:00	3	-10.32	-12.83	-125.51	-158.38	-3.49E-05
9/5/2016	10:00:00	4	-8.05	-9.77	-97.94	-120.58	-2.72E-05
9/5/2016	11:00:00	5	-4.45	-5.74	-54.17	-70.89	-1.50E-05
9/5/2016	12:00:00	6	-1	-0.22	-12.12	-2.76	-3.37E-06
9/5/2016	13:00:00	7	-4.63	-0.57	-56.27	-7.04	-1.56E-05
9/5/2016	14:00:00	8	-3.97	2.02	-48.3	24.88	-1.34E-05
9/5/2016	15:00:00	9	-3.61	5.07	-43.95	62.59	-1.22E-05
9/5/2016	16:00:00	10	-0.79	8.01	-9.61	98.85	-2.67E-06
9/5/2016	17:00:00	11	1.96	10.66	23.83	131.58	6.62E-06
9/5/2016	18:00:00	12	8.61	14.11	104.75	174.24	2.91E-05
9/5/2016	19:00:00	13	7.52	12.73	91.42	157.11	2.54E-05
9/5/2016	20:00:00	14	3.17	5.64	38.55	69.64	1.07E-05
9/5/2016	21:00:00	15	2.23	3.25	27.14	40.08	7.54E-06
9/5/2016	22:00:00	16	2.15	1.9	26.16	23.44	7.27E-06
9/6/2016	23:00:00	17	3.37	3.81	41.02	47.07	1.14E-05
9/6/2016	0:00:00	18	4.73	3.14	57.5	38.7	1.60E-05
9/6/2016	1:00:00	19	3.24	2.28	39.36	28.14	1.09E-05
9/6/2016	2:00:00	20	2.54	-0.08	30.84	-0.95	8.57E-06
9/6/2016	3:00:00	21	0.59	-0.38	7.23	-4.64	2.01E-06
9/6/2016	4:00:00	22	0.85	-3.52	10.36	-43.46	2.88E-06
9/6/2016	5:00:00	23	-1.29	-7.22	-15.65	-89.11	-4.35E-06
9/6/2016	6:00:00	24	-11.08	-17.01	-134.84	-209.95	-3.75E-05
9/6/2016	7:00:00	25	-8.32	-14.74	-101.25	-181.96	-2.81E-05
9/6/2016	8:00:00	26	-9.24	-11.89	-112.44	-146.77	-3.12E-05
9/6/2016	9:00:00	27	-6.48	-11.87	-78.86	-146.57	-2.19E-05
9/6/2016	10:00:00	28	-5.44	-8.81	-66.17	-108.74	-1.84E-05
9/6/2016	11:00:00	29	1.89	0.77	23.01	9.5	6.39E-06
9/6/2016	12:00:00	30	3.39	3.6	41.25	44.5	1.15E-05
9/6/2016	13:00:00	31	-2.26	0.07	-27.52	0.89	-7.64E-06
9/6/2016	14:00:00	32	-1.01	4.51	-12.33	55.69	-3.43E-06
9/6/2016	15:00:00	33	-6.09	1.02	-74.06	12.53	-2.06E-05
9/6/2016	16:00:00	34	0.87	10.68	10.64	131.91	2.96E-06
9/6/2016	17:00:00	35	5.93	14.65	72.11	180.81	2.00E-05
9/6/2016	18:00:00	36	3.83	9.48	46.63	117.07	1.30E-05
9/6/2016	19:00:00	37	7.75	13.41	94.26	165.61	2.62E-05
9/6/2016	20:00:00	38	1.71	3.86	20.83	47.62	5.79E-06
9/6/2016	21:00:00	39	0.07	0.58	0.86	7.12	2.39E-07
9/6/2016	22:00:00	40	2.37	1.83	28.8	22.58	8.00E-06
9/7/2016	23:00:00	41	3.04	2.84	37.01	35	1.03E-05
9/7/2016	0:00:00	42	4.44	4.78	54.01	59.03	1.50E-05
9/7/2016	1:00:00	43	2.6	2.27	31.59	28.02	8.77E-06
9/7/2016	2:00:00	44	-0.89	-0.61	-10.8	-7.56	-3.00E-06
9/7/2016	3:00:00	45	-0.49	-1.46	-6.01	-18.08	-1.67E-06
9/7/2016	4:00:00	46	-1.92	-6.29	-23.37	-77.7	-6.49E-06
9/7/2016	5:00:00	47	-6.23	-12.16	-75.74	-150.09	-2.10E-05
9/7/2016	6:00:00	48	-9.59	-15.51	-116.65	-191.48	-3.24E-05
Max value			8.61	14.65	104.75	180.81	2.91E-05

Min value	-13.16	-19.66	-160.12	-242.67	-4.45E-05
Mean value	-1.13	-0.64	-13.78	-7.94	-3.83E-06

---

Note: BFB- bamboo scrimber; HW- hardwood

iss change rate [n <sup>2</sup> ·s)]	Hourly mass change rate [kg/(m <sup>2</sup> ·s)]	
HW	BFB	HW
-6.74E-05	4.37E-05	6.74E-05
-6.00E-05	4.45E-05	6.00E-05
-4.40E-05	3.49E-05	4.40E-05
-3.35E-05	2.72E-05	3.35E-05
-1.97E-05	1.50E-05	1.97E-05
-7.66E-07	3.37E-06	7.66E-07
-1.96E-06	1.56E-05	1.96E-06
6.91E-06	1.34E-05	6.91E-06
1.74E-05	1.22E-05	1.74E-05
2.75E-05	2.67E-06	2.75E-05
3.66E-05	6.62E-06	3.66E-05
4.84E-05	2.91E-05	4.84E-05
4.36E-05	2.54E-05	4.36E-05
1.93E-05	1.07E-05	1.93E-05
1.11E-05	7.54E-06	1.11E-05
6.51E-06	7.27E-06	6.51E-06
1.31E-05	1.14E-05	1.31E-05
1.08E-05	1.60E-05	1.08E-05
7.82E-06	1.09E-05	7.82E-06
-2.65E-07	8.57E-06	2.65E-07
-1.29E-06	2.01E-06	1.29E-06
-1.21E-05	2.88E-06	1.21E-05
-2.48E-05	4.35E-06	2.48E-05
-5.83E-05	3.75E-05	5.83E-05
-5.05E-05	2.81E-05	5.05E-05
-4.08E-05	3.12E-05	4.08E-05
-4.07E-05	2.19E-05	4.07E-05
-3.02E-05	1.84E-05	3.02E-05
2.64E-06	6.39E-06	2.64E-06
1.24E-05	1.15E-05	1.24E-05
2.48E-07	7.64E-06	2.48E-07
1.55E-05	3.43E-06	1.55E-05
3.48E-06	2.06E-05	3.48E-06
3.66E-05	2.96E-06	3.66E-05
5.02E-05	2.00E-05	5.02E-05
3.25E-05	1.30E-05	3.25E-05
4.60E-05	2.62E-05	4.60E-05
1.32E-05	5.79E-06	1.32E-05
1.98E-06	2.39E-07	1.98E-06
6.27E-06	8.00E-06	6.27E-06
9.72E-06	1.03E-05	9.72E-06
1.64E-05	1.50E-05	1.64E-05
7.78E-06	8.77E-06	7.78E-06
-2.10E-06	3.00E-06	2.10E-06
-5.02E-06	1.67E-06	5.02E-06
-2.16E-05	6.49E-06	2.16E-05
-4.17E-05	2.10E-05	4.17E-05
-5.32E-05	3.24E-05	5.32E-05
5.02E-05	4.45E-05	6.74E-05



-6.74E-05	2.39E-07	2.48E-07
-2.21E-06	1.49E-05	2.32E-05

---

Name of Material/ Equipment	Company	Catalog Number	Comments/Description
bamboo scrimber sample	Dasso Industrial Group Co. Ltd. Hangzhou, China	-	made of Phyllostachys Pubescens, mainly used for outdoor flooring
Hardwood sample	Shan Shang industry, Shanghai, China	-	made of Intsia.spp, Caesalpiniaceae, mainly used for outdoor flooring
Petroleum jelly	Guangzhou Suixin Chemical Co., Ltd.	-	White Vaseline
Balance	Shimadzu	UX 6200H	Range 0.5-6200 g, accuracy 0.01g
Vacuum pump	Dongguan Fopump Vacuum Equipment Co., Ltd., Dongguan, China	2X-8	Sliding vane rotary vacuum pump, extreme pressure 600Pa, speed 8L/s
HHCWT: Hot-Humid Climatic Wind Tunnel, including control systems for:	the Building Energy Conservation Research Center of South China University of Technology	-	The HHCWT consists of 18 elements (table 3)
Software attached to the HHCWT operating condition control and data collection system	the Building Energy Conservation Research Center of South China University of Technology	-	Created by visual programming language Visual Basic



1 Alewife Center #200  
Cambridge, MA 02140  
tel. 617.945.9051  
[www.jove.com](http://www.jove.com)

## ARTICLE AND VIDEO LICENSE AGREEMENT

Title of Article:

Study on Moisture Absorption and Desorption Rate of Bamboo Scrimber by Hot-Humid Climatic Wind Tunnel

Author(s):

Zujian Huang

Item 1 (check one box): The Author elects to have the Materials be made available (as described at

<http://www.jove.com/author>) via: ☒ Standard Access ☐ Open Access

Item 2 (check one box):

☒ The Author is NOT a United States government employee.

The Author is a United States government employee and the Materials were prepared in the course of his or her duties as a United States government employee.

The Author is a United States government employee but the Materials were NOT prepared in the course of his or her duties as a United States government employee.

### ARTICLE AND VIDEO LICENSE AGREEMENT

1. Defined Terms. As used in this Article and Video License Agreement, the following terms shall have the following meanings: “**Agreement**” means this Article and Video License Agreement; “**Article**” means the article specified on the last page of this Agreement, including any associated materials such as texts, figures, tables, artwork, abstracts, or summaries contained therein; “**Author**” means the author who is a signatory to this Agreement; “**Collective Work**” means a work, such as a periodical issue, anthology or encyclopedia, in which the Materials in their entirety in unmodified form, along with a number of other contributions, constituting separate and independent works in themselves, are assembled into a collective whole; “**CRC License**” means the Creative Commons Attribution-Non Commercial-No Derivs 3.0 Unported Agreement, the terms and conditions of which can be found at: <http://creativecommons.org/licenses/by-nc-nd/3.0/legalcode>; “**Derivative Work**” means a work based upon the Materials or upon the Materials and other pre-existing works, such as a translation, musical arrangement, dramatization, fictionalization, motion picture version, sound recording, art reproduction, abridgment, condensation, or any other form in which the Materials may be recast, transformed, or adapted; “**Institution**” means the institution, listed on the last page of this Agreement, by which the Author was employed at the time of the creation of the Materials; “**JoVE**” means MyJoVE Corporation, a Massachusetts corporation and the publisher of *The Journal of Visualized Experiments*; “**Materials**” means the Article and / or the Video; “**Parties**” means the Author and JoVE; “**Video**” means any video(s) made by the Author, alone or in conjunction with any other parties, or by JoVE or its affiliates or agents, individually or in collaboration with the Author or any other parties, incorporating all or any portion of the Article, and in which the Author may or may not appear.

2. Background. The Author, who is the author of the Article, in order to ensure the dissemination and protection of the Article, desires to have the JoVE publish the Article and create and transmit videos based on the Article. In furtherance of such goals, the Parties desire to memorialize in this Agreement the respective rights of each Party in and to the Article and the Video.

3. Grant of Rights in Article. In consideration of JoVE agreeing to publish the Article, the Author hereby grants to JoVE, subject to **Sections 4** and **7** below, the exclusive, royalty-free, perpetual (for the full term of copyright in the Article, including any extensions thereto) license (a) to publish, reproduce, distribute, display and store the Article in all forms, formats and media whether now known or hereafter developed (including without limitation in print, digital and electronic form) throughout the world, (b) to translate the Article into other languages, create adaptations, summaries or extracts of the Article or other Derivative Works (including, without limitation, the Video) or Collective Works based on all or any portion of the Article and exercise all of the rights set forth in (a) above in such translations, adaptations, summaries, extracts, Derivative Works or Collective Works and (c) to license others to do any or all of the above. The foregoing rights may be exercised in all media and formats, whether now known or hereafter devised, and include the right to make such modifications as are technically necessary to exercise the rights in other media and formats. If the “Open Access” box has been checked in **Item 1** above, JoVE and the Author hereby grant to the public all such rights in the Article as provided in, but subject to all limitations and requirements set forth in, the CRC License.



## ARTICLE AND VIDEO LICENSE AGREEMENT

4. Retention of Rights in Article. Notwithstanding the exclusive license granted to JoVE in **Section 3** above, the Author shall, with respect to the Article, retain the non-exclusive right to use all or part of the Article for the non-commercial purpose of giving lectures, presentations or teaching classes, and to post a copy of the Article on the Institution's website or the Author's personal website, in each case provided that a link to the Article on the JoVE website is provided and notice of JoVE's copyright in the Article is included. All non-copyright intellectual property rights in and to the Article, such as patent rights, shall remain with the Author.

5. Grant of Rights in Video – Standard Access. This **Section 5** applies if the "Standard Access" box has been checked in **Item 1** above or if no box has been checked in **Item 1** above. In consideration of JoVE agreeing to produce, display or otherwise assist with the Video, the Author hereby acknowledges and agrees that, Subject to **Section 7** below, JoVE is and shall be the sole and exclusive owner of all rights of any nature, including, without limitation, all copyrights, in and to the Video. To the extent that, by law, the Author is deemed, now or at any time in the future, to have any rights of any nature in or to the Video, the Author hereby disclaims all such rights and transfers all such rights to JoVE.

6. Grant of Rights in Video – Open Access. This **Section 6** applies only if the "Open Access" box has been checked in **Item 1** above. In consideration of JoVE agreeing to produce, display or otherwise assist with the Video, the Author hereby grants to JoVE, subject to **Section 7** below, the exclusive, royalty-free, perpetual (for the full term of copyright in the Article, including any extensions thereto) license (a) to publish, reproduce, distribute, display and store the Video in all forms, formats and media whether now known or hereafter developed (including without limitation in print, digital and electronic form) throughout the world, (b) to translate the Video into other languages, create adaptations, summaries or extracts of the Video or other Derivative Works or Collective Works based on all or any portion of the Video and exercise all of the rights set forth in (a) above in such translations, adaptations, summaries, extracts, Derivative Works or Collective Works and (c) to license others to do any or all of the above. The foregoing rights may be exercised in all media and formats, whether now known or hereafter devised, and include the right to make such modifications as are technically necessary to exercise the rights in other media and formats. For any Video to which this Section 6 is applicable, JoVE and the Author hereby grant to the public all such rights in the Video as provided in, but subject to all limitations and requirements set forth in, the CRC License.

7. Government Employees. If the Author is a United States government employee and the Article was prepared in the course of his or her duties as a United States government employee, as indicated in **Item 2** above, and any of the licenses or grants granted by the Author hereunder exceed the scope of the 17 U.S.C. 403, then the rights granted hereunder shall be limited to the maximum rights permitted under such

statute. In such case, all provisions contained herein that are not in conflict with such statute shall remain in full force and effect, and all provisions contained herein that do so conflict shall be deemed to be amended so as to provide to JoVE the maximum rights permissible within such statute.

8. Likeness, Privacy, Personality. The Author hereby grants JoVE the right to use the Author's name, voice, likeness, picture, photograph, image, biography and performance in any way, commercial or otherwise, in connection with the Materials and the sale, promotion and distribution thereof. The Author hereby waives any and all rights he or she may have, relating to his or her appearance in the Video or otherwise relating to the Materials, under all applicable privacy, likeness, personality or similar laws.

9. Author Warranties. The Author represents and warrants that the Article is original, that it has not been published, that the copyright interest is owned by the Author (or, if more than one author is listed at the beginning of this Agreement, by such authors collectively) and has not been assigned, licensed, or otherwise transferred to any other party. The Author represents and warrants that the author(s) listed at the top of this Agreement are the only authors of the Materials. If more than one author is listed at the top of this Agreement and if any such author has not entered into a separate Article and Video License Agreement with JoVE relating to the Materials, the Author represents and warrants that the Author has been authorized by each of the other such authors to execute this Agreement on his or her behalf and to bind him or her with respect to the terms of this Agreement as if each of them had been a party hereto as an Author. The Author warrants that the use, reproduction, distribution, public or private performance or display, and/or modification of all or any portion of the Materials does not and will not violate, infringe and/or misappropriate the patent, trademark, intellectual property or other rights of any third party. The Author represents and warrants that it has and will continue to comply with all government, institutional and other regulations, including, without limitation all institutional, laboratory, hospital, ethical, human and animal treatment, privacy, and all other rules, regulations, laws, procedures or guidelines, applicable to the Materials, and that all research involving human and animal subjects has been approved by the Author's relevant institutional review board.

10. JoVE Discretion. If the Author requests the assistance of JoVE in producing the Video in the Author's facility, the Author shall ensure that the presence of JoVE employees, agents or independent contractors is in accordance with the relevant regulations of the Author's institution. If more than one author is listed at the beginning of this Agreement, JoVE may, in its sole discretion, elect not take any action with respect to the Article until such time as it has received complete, executed Article and Video License Agreements from each such author. JoVE reserves the right, in its absolute and sole discretion and without giving any reason therefore, to accept or decline any work submitted to JoVE. JoVE and its employees, agents and independent contractors shall have



## ARTICLE AND VIDEO LICENSE AGREEMENT

full, unfettered access to the facilities of the Author or of the Author's institution as necessary to make the Video, whether actually published or not. JoVE has sole discretion as to the method of making and publishing the Materials, including, without limitation, to all decisions regarding editing, lighting, filming, timing of publication, if any, length, quality, content and the like.

11. **Indemnification.** The Author agrees to indemnify JoVE and/or its successors and assigns from and against any and all claims, costs, and expenses, including attorney's fees, arising out of any breach of any warranty or other representations contained herein. The Author further agrees to indemnify and hold harmless JoVE from and against any and all claims, costs, and expenses, including attorney's fees, resulting from the breach by the Author of any representation or warranty contained herein or from allegations or instances of violation of intellectual property rights, damage to the Author's or the Author's institution's facilities, fraud, libel, defamation, research, equipment, experiments, property damage, personal injury, violations of institutional, laboratory, hospital, ethical, human and animal treatment, privacy or other rules, regulations, laws, procedures or guidelines, liabilities and other losses or damages related in any way to the submission of work to JoVE, making of videos by JoVE, or publication in JoVE or elsewhere by JoVE. The Author shall be responsible for, and shall hold JoVE harmless from, damages caused by lack of sterilization, lack of cleanliness or by contamination due to the making of a video by JoVE its employees, agents or independent contractors. All sterilization, cleanliness or decontamination procedures shall be solely the responsibility of the Author and shall be undertaken at the Author's


expense. All indemnifications provided herein shall include JoVE's attorney's fees and costs related to said losses or damages. Such indemnification and holding harmless shall include such losses or damages incurred by, or in connection with, acts or omissions of JoVE, its employees, agents or independent contractors.

12. **Fees.** To cover the cost incurred for publication, JoVE must receive payment before production and publication the Materials. Payment is due in 21 days of invoice. Should the Materials not be published due to an editorial or production decision, these funds will be returned to the Author. Withdrawal by the Author of any submitted Materials after final peer review approval will result in a US\$1,200 fee to cover pre-production expenses incurred by JoVE. If payment is not received by the completion of filming, production and publication of the Materials will be suspended until payment is received.

13. **Transfer, Governing Law.** This Agreement may be assigned by JoVE and shall inure to the benefits of any of JoVE's successors and assignees. This Agreement shall be governed and construed by the internal laws of the Commonwealth of Massachusetts without giving effect to any conflict of law provision thereunder. This Agreement may be executed in counterparts, each of which shall be deemed an original, but all of which together shall be deemed to be one and the same agreement. A signed copy of this Agreement delivered by facsimile, e-mail or other means of electronic transmission shall be deemed to have the same legal effect as delivery of an original signed copy of this Agreement.

A signed copy of this document must be sent with all new submissions. Only one Agreement required per submission.

### CORRESPONDING AUTHOR:

Name:	Zujian Huang	
Department:	School of Architecture	
Institution:	South China University of Technology	
Article Title:	Study on Moisture Absorption and Desorption Rate of Bamboo Scrimber by Hot-Humid Climatic Wind Tunnel	
Signature:		Date: 2017-10-26

Please submit a signed and dated copy of this license by one of the following three methods:

- 1) Upload a scanned copy of the document as a pdf on the JoVE submission site;
- 2) Fax the document to +1.866.381.2236;
- 3) Mail the document to JoVE / Attn: JoVE Editorial / 1 Alewife Center #200 / Cambridge, MA 02139

For questions, please email [submissions@jove.com](mailto:submissions@jove.com) or call +1.617.945.9051

**Dear Dr. Vineeta Bajaj,**

Thank you for the detailed comments for revision. Please see the following responses to each point.

**Editorial comments:**

1. Please thoroughly proofread the manuscript for any grammar or spelling issues.
2. Please do not upload tables 1-5 as Materials Tables. There is an option the "table" which can be used for uploading these tables in .xls/.xlsx file.
3. Table 2: We cannot have figures in the Table. Please upload the figures separately as third figure. However, please ensure that the figures are numbered in the order of their reference. Also, please remove the sample sources from this table and move it to the materials table. We cannot have commercial language in the manuscript. All commercial language should be sufficiently referenced in the materials table.
4. Table 3: Please remove Excel and Visual Basic and use a generic term. Please sufficiently reference it in the materials table.
5. Figure 2: Please provide an x-axis label (time of the day).
6. Please upload the table of the essential supplies, reagents, and equipment as Materials Table as well. The table should include the name, company, and catalog number of all relevant materials in separate columns in an xls/xlsx file.
7. Please address specific comments marked in the manuscript as well.

1. The manuscript has been revised, and the revised part has been marked as red text in the manuscript.
2. Table 1-5 have been uploaded in the 'table' in .xlsx file.
3. The figures in table 2 have been moved out, and numbered as 'figure 3' and 'figure 4', which are numbered in the order of their reference in table 2. The sample sources have been removed from table 2.
4. 'Excel' and 'Visual Basic' have been removed from table 3, and replaced with a generic state. 'Visual Basic' is stated in the 'Material table'.
5. An x-axis label (time of the day) has been added for figure 2.
6. An independent 'Material table' has been added and uploaded.
7. The answers to the comments have been added following each comment in the manuscript.