

A Thermal Assessment of the Traditional House In Flores, Indonesia

Agung Murti Nugroho

Department of Architecture, Faculty of Engineering
University of Brawijaya, Malang Indonesia

ABSTRACT

This article engages thermal assessment to evaluate passive system of the Bena and Wogo traditional house in Flores Island, Nusa Tenggara Timur Province, Indonesia. By discovering the assessing the thermal performance of traditional houses, this research establishes certain advantages of vernacular building in light of a modern environmentally aware evaluation. Based on the field measurements of the thermal environment parameters and a short-term auto-recorder of the indoor and outdoor temperature and relative humidity at two typical traditional houses in summer and rainy season, some new viewpoints about Indonesian traditional house are clarified. Also, with the analysis of the fine structures design such as the wall, floor and roof by the measurements of temperature and relative humidity some design principles of the traditional house in Flores area are revealed, of which sun shading and insulation are of great importance while the natural ventilation is just considered as an auxiliary approach. So the strategy of passive system is to restrain the passive cooling at daytime and to boost it at night

Keywords: Thermal Assessment, Indonesian Traditional House

INTRODUCTION

The relationship between architecture and the climate is always a hotspot in the recent architecture studies. Indonesian traditional house, which perfectly show the principle of climate-oriented architecture, have become a very popular study project by more and more researchers. Unfortunately, these studies mainly focus on qualitative description of the relationship between the building types, materials, finite construction and the local climate, and lack of enough field tests and quantitative analysis [1][2][3][4][5]. According to Borong [6], it is difficult to evaluate accurately the thermal performance of the traditional buildings and some incorrect inclusions are easily to be drawn unconsciously. For example, it is stated in these literatures that the construction of the old houses can induce cool air around the building into the room in summer and bring a more desirable cooling effect than modern houses, and that the better daytime ventilation and higher ceiling height contribute to this effect. Generally, the wind speed is very low during the day and night time compared to accepted comfort in hot humid climate condition [7]. Aimed at a quantitatively study of the thermal performance of the traditional house as a detailed field study of two typical traditional house at Bena and Wogo village in Flores Island, Nusa Tenggara Timur Province, Indonesia has been done in the summer of 2010 by the researchers of the Department of Architecture, University of Brawijaya and Institute of Development of Technology of Traditional Housing. Many small villages in Flores collectively contain some of the best-preserved and aesthetically delightful traditional architecture in Indonesia.

The ecosystem of the Flores Island shows a prominent characteristic: diversity. The area is composed of independent, self-enclosed micro regions, due to the special mountain geography and climate. This diversity and independence has encouraged the development of unique and varied ethnic cultures and dwellings. Overall, the distribution of particular ethnic communities corresponds to the topographical character of the areas that they have chosen for settlement. The public space as the user carries out the proliferation space and activities from container [8]. The pattern of land use in the Indonesian traditional area is divided into two parts, based on the dominant functions and natural boundaries [9]. These reflect an evolved response to geography, climate, distribution of ethnic peoples, and vernacular architectural traditions. The Bena and Wogo traditional houses simply and admirably correspond to the hot, wet, and rainy surroundings. Typical Bena and Wogo traditional houses are empty on the ground floor for storing tools. The first floor is arranged with living room, bedrooms and kitchen. The roof sometimes has several layers and each layer has a large overhang protecting interior space from exposure to summer sunshine. In hot humid weather, the airflow is the main consideration in order to achieve comfort. At the same time the crevices in the floor, roof and walls enable hot air to rise up and cool air to sink down, which creates a mild and pleasing internal microclimate. The roof of a Bena and Wogo traditional houses is usually very steep, which helps rain to drain away quickly. High columns support the whole house and elevate it above moisture. Local people's houses are quite simple, humble and coarse. Some houses still utilize the most primitive colligation, instead of the more advanced rabbits technique. The Bena and Wogo traditional

*Corresponding Author: Agung Murti Nugroho, Department of Architecture, Faculty of Engineering, University of Brawijaya. Email: sasimurti@yahoo.co.id; sasimurti@ub.ac.id

houses also have some shining points from an ecological point of view, despite its primitiveness. First, its lifted floor minimizes the structural damage to the site, protects the original ecosystem on the earthen surface and potentially reduces land slides. Second, local mountain resources are used in building. Even the roof is made of a special kind of grass. Moreover, local material and simple construction endows it with a kind of purity and rustic beauty. The buildings have to be designed according to the nature of the building materials for reflecting the structural honesty [10].



Figure 1 Bena Traditional House (East-west orientation, single floors).



Fig. 2. Wogo Traditional House (East-west orientation, single floors).

MATERIALS AND METHODS

The field test includes a measurement of temperature and humidity. Table 1 shows the instruments for all corresponding parameters. And shading device was used at the beginning of the measurements of outdoor temperatures. The core area of Bena and Wogo traditional houses locates near the south latitude $8^{\circ}52'40.79''$ and belongs to the hot and humid tropical climate. The characteristics of such climate are hot in summer with humid air. The measured houses have most of the typical characteristics of traditional Bena and Wogo traditional houses. Two typical traditional vernacular dwellings with similar orientation, floor and space layout were

selected for the field measurement, among which two traditional have been selected to complete a short-term field study, shown in Table 2. The plan view and the section view of two traditional houses were shown as Fig. 3. The spots with a circle number show where the air temperature and humidity is measured. The shading part at the plan view indicates the dooryard.

Table 1: Measured parameters and instruments

Measured parameter	Instrument	Precision (°C)	Note
Air Temperature of indoor/outdoor	Lorton temperature, humidity/anemometer AM 4205 A	±0.05	Manual equation per 60 min
Relative Humidity of indoor/outdoor	Lorton temperature, humidity/anemometer AM 4205 A	±0.05	

Table 2: Information of the measured buildings

Building's name	Orientation	Floors	Short term measurement	Notes
Bena House	East-west	1	Yes	Built about 100 years ago
Wogo House	South-north	1	yes	Built about 100 years ago

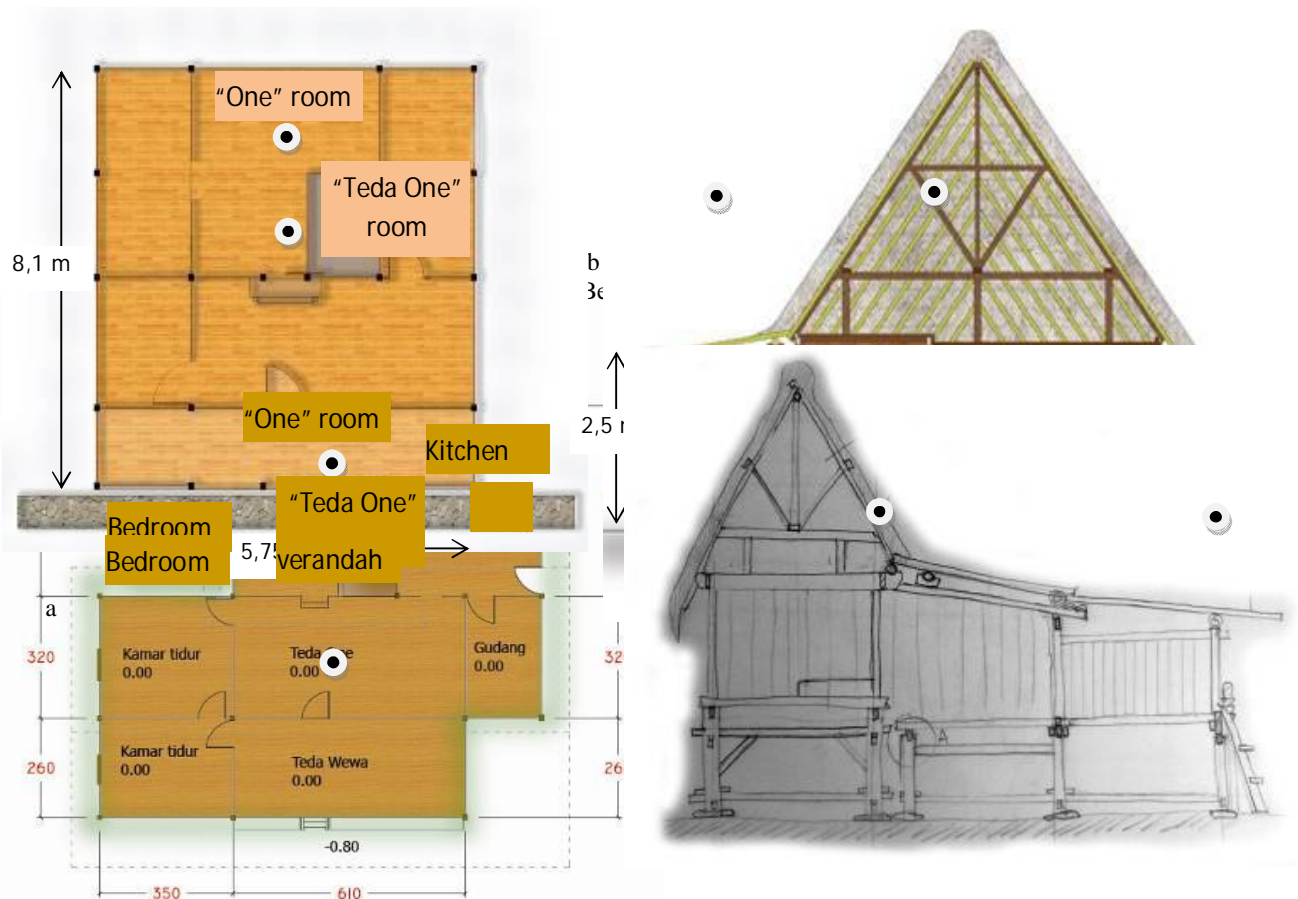


Fig. 3 the positions of thermal data logger in Wogo Traditional House (○) a is plan and b is section

RESULTS AND DISCUSSION

Wall and roof are important considerations in traditional house design to avoid and absorb solar radiation and it is easy to find various design elements in Flores area. For envelop design, the wall of traditional house at Flores area, which external wall is used with bamboo, is about 300mm thick and usually has a structure of “empletum” or general wall with local wood as walls. The first floor of the building is usually covered with wood and bamboo. For space layout, the traditionally important rooms such as the hall and the bedrooms with a large depth are often bounded by walls with wood-siding and the external walls are usually minimized. The master bedrooms are usually located beside to the hall and often have an overhead wood floor, which is about 30–40 cm higher than the floor of hall and can yield an effect of damp-proof and dehumidification with

ventilation outlet at the wall footing. Houses with two or more floors are common in Flores area, the primary function of the floors above two is for storage purpose. But obviously, they can also serve as an insulation layer for the building. It is very common that the roofs of the traditional houses are designed as a double-pitched raft and with an overhead double layer tiled structure.

1. Comparison of the thermal performance between the Indoor and Outdoor temperature in Bena and Wogo traditional houses

The measured temperature is shown in Fig. 4 and Fig. 5. Clearly, the diurnal air temperature of the outdoor is higher than the indoor temperature in summer. The temperature difference is above 2.5 °C with a maximum value of 4 °C. Furthermore, due to different kinds of shading and ventilation arrangement, there are temperature differences among different rooms at the same floor and the maximum difference can be above 2 °C. For example, if the dooryard is covered with a bamboo curtain, the temperature will be lower than without a bamboo curtain. Curve 6 represents the temperature of the entrance of south door and has no curtain shading and the curve 5 represents the temperature under the dooryard with a bamboo curtain (Their locations have been shown in Fig. 1). So the daytime temperature of Spot 6 is about 4–5 °C higher than that of Spot 5. During the night time, because of the long wave radiation to the sky from the ground, the temperatures of curve 5 are about 0.5 °C lower than those in curve 4.

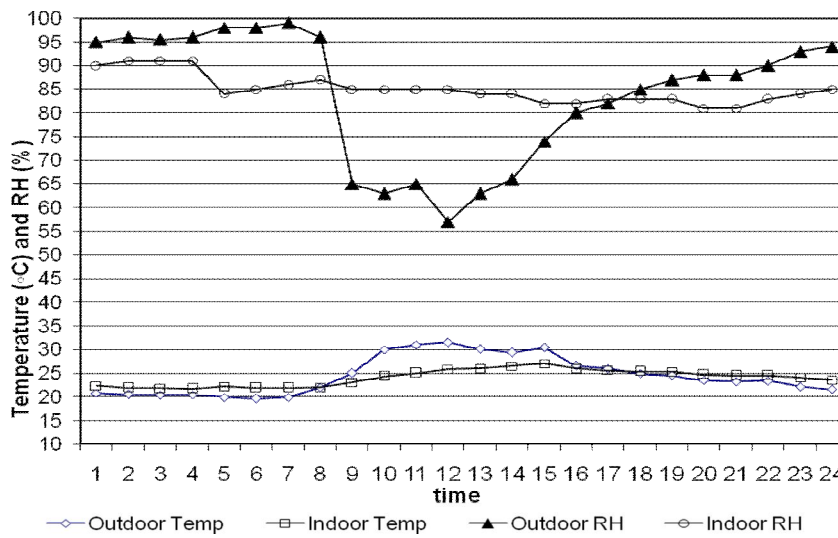


Fig. 4 Comparison of internal-external temperature and relative humidity at 0.9 m height from floor level – 14 to 15 April 2009 at Bena Traditional House

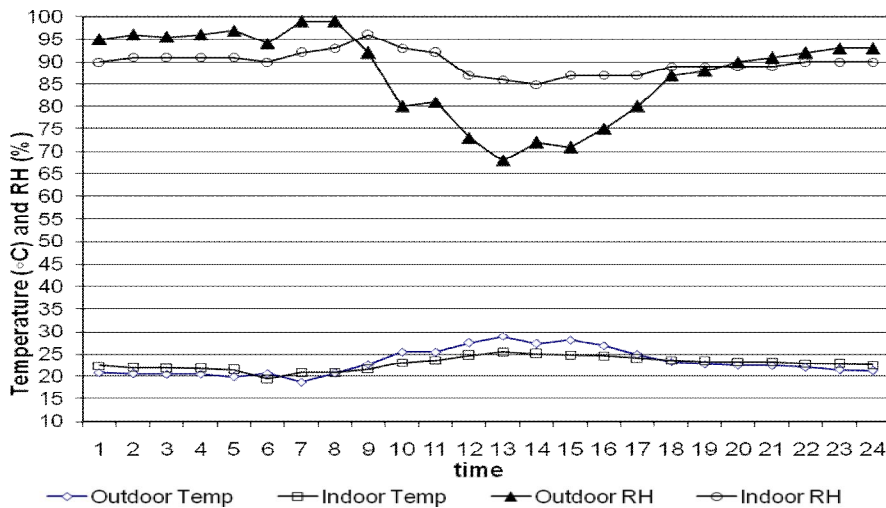


Fig.5. Comparison of internal-external temperature and relative humidity at 0.9 m height from floor level – 14 to 15 April 2009 at Bena Traditional House

3.2. Comparison of the thermal performance between the Bena and Wogo traditional houses

For nearly the same indoor heat source, comparison can be done for about 1 day temperature and relative humidity results measured of the Bena and Wogo Traditional Houses, shown in Fig. 6. From the results, the whole day mean temperatures of the indoor of the Wogo traditional house are 1.19°C lower than the Bena traditional house. But for the mean temperature at daytime, especially during the several hours near midday, the Wogo traditional house is about 1–2 °C lower than the Bena traditional house and for the mean temperatures at night the indoor temperatures of the both houses are similar, which is higher than the outdoor ambient temperature. The whole day temperature fluctuating breadths of the Bena and Wogo traditional houses are 2 °C, respectively. So it clearly shows that during the daytime the temperatures of the Wogo traditional house are lower than the Bena traditional house.

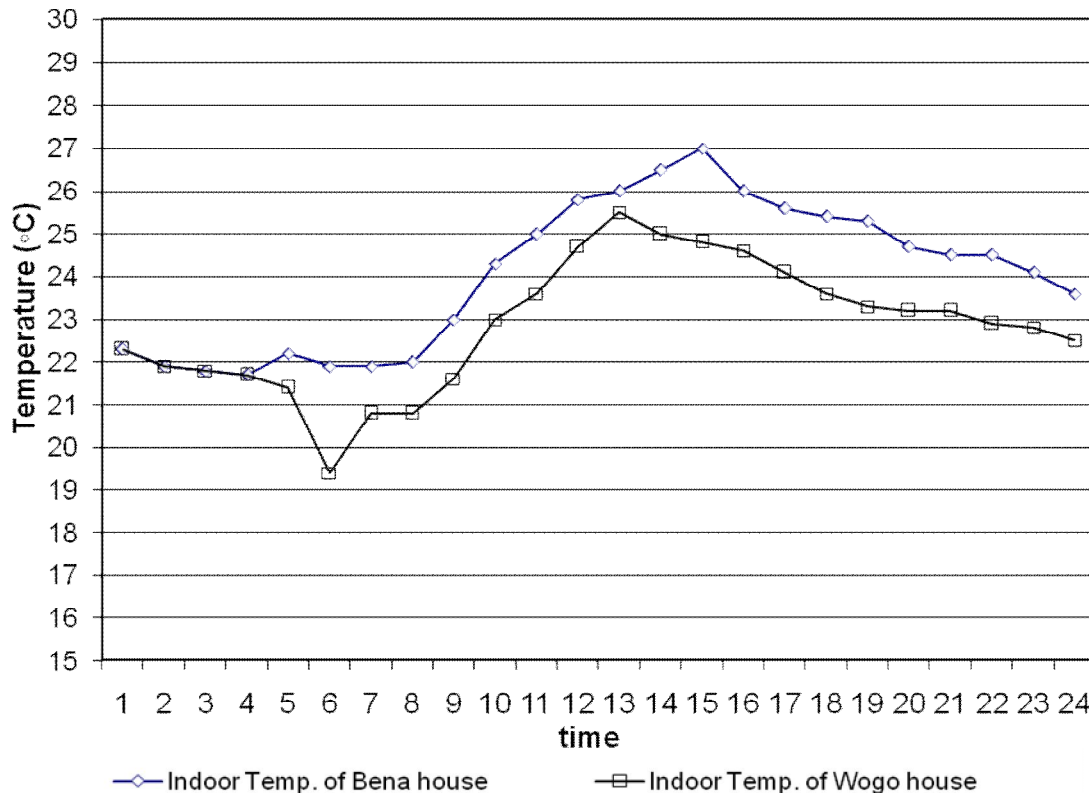


Fig. 6 Comparison of internal temperature at 0.9 m height from floor level between Bena Traditional House and Wogo Traditional House

3. Relationship Room Position and the Indoor Thermal Environment

From the measured results of the indoor temperature for overall room in Wogo Traditional house shown in Fig. 7. The outdoor air temperature begins to increase more rapidly after 7 a.m. and to decrease after 3 p.m.; and as a result of that, the temperatures of the indoor room of the raft also began to decrease quickly. About 6 p.m. the temperatures of the indoor of all the room are almost equal to the outdoor air temperature. The result shows that the lowest temperature is in the bedroom under the overhead period. The next is at the deepest spot in the “teda one” room and “one” room. Generally, the temperature of the “one” room and kitchen room of the north side and the “teda one” room and bedroom is both lower than the air temperature in most of the daytime and then can produce a cool thermal sensation in summer. The results show that at the daytime the temperature at the south room (bedroom and “teda one” room as in Fig. 4) is always more than 1 °C lower than the temperature at the north room (“one” room and kitchen room), while the situation is similar in the early morning. The reason for this is the compact layout of the Wogo traditional house. The compact laneway shades the direct solar radiation and produces a cool thermal sensation in the daytime of summer. From the statistics of the indoor temperature distribution as time, it shows that about 70% of the time the indoor air temperature of Wogo traditional house is lower than 25°C while the maximum temperature of outdoor air is about 29°C.

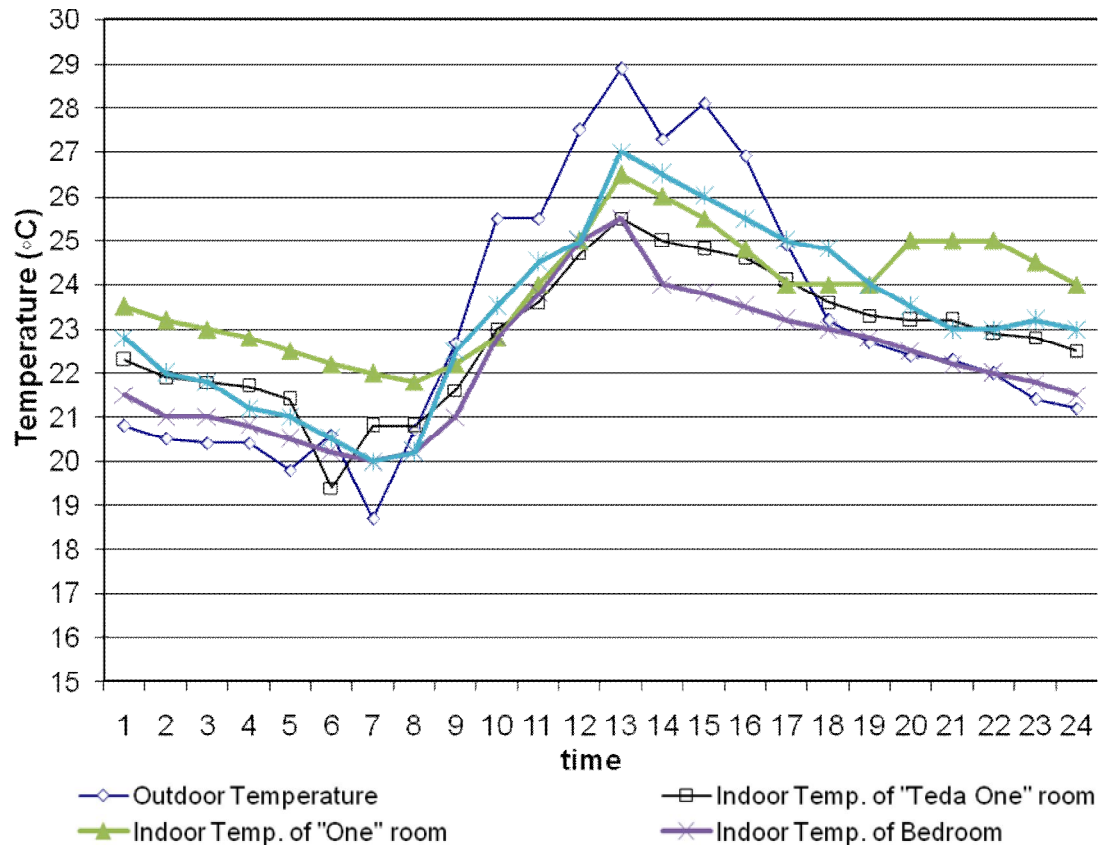


Fig.7. Comparison of internal at 0.9 m height from floor level – 14 to 15 April 2009 each room at Wogo Traditional House

Different from the Bena traditional house, the wall of the Wogo traditional house has a structure of Wogo wall type and its width is about 2.5–3 m. Clearly, it is so called Wogo wall type because the wall is like a double layer wall located at the north and west of the prime room about 2.5m away. Apparently, its main function is to shade the solar radiation, just like the bamboo curtain installed at the wall. On the other hand, day lighting should also be considered besides sun shading. Thus, the shading of Wogo traditional house is selected for a proper length about 2m with the compromise between sun shading and day lighting. So, it seems that the indoor temperature of the traditional house is satisfactory with the combined effects of sun shading and insulation. In a word, the room with double layer wall has a considerable desirable effect both on good insulation and quick cooling.

CONCLUSION

The field measurement and analysis gives us more accurate understanding of the thermal environment of the Indonesian traditional houses at Flores island area. Some wrong or one-sided views about these traditional houses, such as the temperature distribution in the high rooms and its cooling effect on the indoor room, and the relationship between room position and indoor air temperature, are also clarified. In summary, there are two main conclusions from this study. First, the strategy of the design is to consider the sun shading and insulation in the indoor temperature and there are various methods of shading and insulation including the materials and structure of building envelopes and the layout of the room. Second, passive system is just an auxiliary facility for a better indoor thermal environment. The design strategy is to restrain the ventilation during the daytime and to boost it at night with used double layers wall (wood and bamboo). Clearly, it is more important and worthwhile to apply its idea to modern building design.

ACKNOWLEDGEMENT

The authors would like to give their best acknowledgement to the Institute of Development of Technology of Traditional Housing and University of Brawijaya for their great support. We also wish to thank

the residents at Bena and Wogo village. Without their kind help, we could not finish our field measurement and the short-term record of the thermal environment parameters.

REFERENCES

1. Fan (1994), Simulation study on the indoor and outdoor summer environment of two kinds Fujian traditional residential buildings [J], *Journal of HV&AC* 4 (1994) 45–48 (in Chinese).
2. Guohua (1996), *The thermal, light and sound environment of Xiguan buildings at Guangzhou, South Architecture* 1 54–57.
3. Ming (1996), A study of the thermal environment of Qing dynasty residential buildings at Foushan Dong Huali, in: *Proceedings of the 6th National Symposium on the Thermal Performance of Building* 428–432.
4. Qigao (1996), A discussion of Chinese traditional healthy architecture, *Journal of Chongqing Architecture University* 18 (4) 20–25
5. Xingfa (1996), The environment of “Yi Keyin” building, in: *Proceedings of the 6th National Symposium on the Thermal Performance of Building* 474–481
6. Borong Lin, Tan Ganga, Wang Peng, Song Ling, Zhu Yingxin, Zhai Guangkui, (2004), Study on the thermal performance of the Chinese traditional vernacular dwellings in Summer, *Energy and Buildings* 36 (2004) 73–79
7. Nugroho, Agung Murti (2011), Research and Design of Green Tropical Architecture, *Journal of Applied Environmental and Biological Sciences*, 1(11)492-499, 2011
8. Wulandari, Lisa Dwi (2010), Space-Metaphor Concept in Urban Open Space, A Case Study of Malang City Square, *International Journal of Academic Research*, Vol. 2. No. 6. November, 2010, Part II
9. Sudikno, Antariksa; Usman Fadly; Puspitasari, Perwitasari H,(2012), Conservation of Chinatown Area in Pasuruan, *Journal of Applied Environmental and Biological Sciences* 2(1)1-8
10. Nugroho, Agung Murti (2011), A Preliminary Study of Thermal Environment in Malaysia’s Terraced Houses, *Journal of Economics and Engineering*, ISSN: 2078-0346, Vol. 2. No. 1