International Journal of Architectural, Civil and Construction Sciences
ISSN: 2415-1734
Vol:5, No:4, 2011

Effects of Solar Absorption Coefficient of External Wall on Building Energy Consumption

Jian Yao, Chengwen Yan

***Abstract*—**The principle concern of this paper is to determine the impact of solar absorption coefficient of external wall on building energy consumption. Simulations were carried out on a typical residential building by using the simulation Toolkit DeST-h. Results show that reducing solar absorption coefficient leads to a great reduction in building energy consumption and thus light-colored materials are suitable.

***Keywords*—**Solar absorption coefficient, External wall, Building energy consumption.

I. Introduction

BUILDING energy consumption is one of the most important issues facing the building professions, researchers and energy policy makers worldwide. There is a growing concern about building energy consumption in China which accounts for 27.5% of the national total energy consumption [1-3]. And it is expected in the next 20 years, the community will be able to account for about 40% of the national total energy consumption. Therefore, a multitude of energy efficiency measures have been applied to aggressively reduce energy consumption in new and existing buildings, such as double glazing windows, insulated walls and roofs, and shading devices etc [4-7]. However the thermal property of the external surface of walls, which has a great impact on building energy consumption in subtropical climates, has not been studied in this region due to the complexity of determining all of influencing factors. Therefore this paper introduces solar absorption coefficient to determine the sol-air temperature, which combines the effect of radiation and transmission of heat, to study the impact of the thermal property of external wall surface on building energy consumption, and gives recommendations for energy efficient building design.

II. Methodology

A. Baseline

The baseline building modelled in simulation software DeST is a representative six-floor and three-unit building in Ningbo city with total area of 3544.56m^2. The height of each floor is 2.8m as well as the area of each household is 100m^2. The thermal design for envelop of this model is set to comply with the standard "hot summer and cold winter region residential building energy efficiency design standards" [8]. In this base model, the heat transfer coefficients are 1.5W/(m^2•K) and 1.0 W/(m^2•K) for exterior wall and roof, respectively. The area ration of window to wall is 0.5 in south, 0.45 in north, and 0.3 in east and west. In south and north orientations, the heat transfer coefficients of window are 2.5 W/(m^2•K), and their shading coefficients are 3.2 W/(m^2•K). In east and west directions, the heat transfer coefficients of window are 3.2 W/(m^2•K), and their shading coefficients are 0.8 W/(m^2•K). The HAVC systems for Baseline model are configured as continues system single zone heat pump, whose EER is 2.3 when cooling, and COP is 1.9 when heating with the air change rate of 1.0 times/h. The room temperature is set 26° for cooling and 18° for heating. The cooling and heating period is from the beginning of Jan. to the end of Dec. Fig. 1 shows the baseline building.

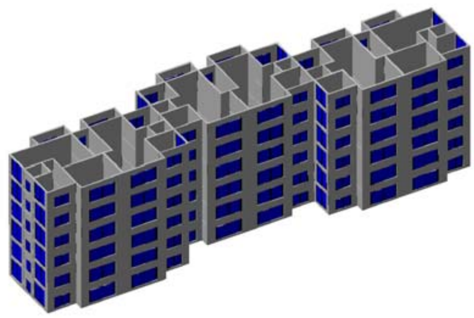

Fig. 1 The baseline building

B. Calculation method

Simulations of different solar absorption coefficients were conducted to study its influence on building energy consumption with other parameters remained unchanged. Since materials, colors and roughness etc are determinant factors in calculating solar absorption coefficient, all of different combinations of these factors are difficult to list. However commonly available solar absorption coefficients of wall surface are shown in table 1, thus this paper focused on the range of 0.45-0.85.

Jian Yao is with the Faculty of Architectural, Civil Engineering and Environment, Ningbo University, Ningbo, China, e-mail: yaojian@ nbu.edu.cn.

Chengwen Yan is with the Faculty of Architectural, Civil Engineering and Environment, Ningbo University, Ningbo, China, e-mail: yanchengwen@ nbu.edu.cn.

TABLE I SOLAR ABSORPTION COEFFICIENTS FOR VARIOUS MATERIALS

SURFACE MATERIALS	SURFACE CONDITION	COLOR	SOLAR ABSORPTION COEFFICIENT
Red tile	Old	Mahogany	0.70
Gray tile	Old	French grey	0.52
Asbestos cement tile		French grey	0.75
Treated felt	Old	Black	0.85
Cement		Steel grey	0.70
Red brick		Mahogany	0.75
Siliceous brick	Rough	Offwhite	0.50
Lime plaster	New	White	0.48
Light-colored coating		Reseda	0.50
Washed granitic plaster wall facing	Old, rough	Offwhite	0.70
Lawn		Green	0.80

III. RESULTS AND DISCUSSION

Figure 2 shows the relation between solar absorption coefficient and cooling and heating energy consumption. It can be seen that as solar absorption coefficient increases cooling energy consumption rises accordingly while heating energy consumption decreases, and they have strong positive and negative linear correlations, respectively, with R^2 higher than 0.99. Figure 3 further depicts the effect of solar absorption coefficient on total building energy consumption. Increasing solar absorption coefficient leads to an increase in total building energy consumption, with an rising rate of 1% per 0.1 solar absorption coefficient growth. This means light-colored materials can help reduce building energy requirements whereas dark-colored ones have the opposite effect. Figures 4-5 present heating and cooling consumption indexes vs solar absorption coefficient. For every 0.1 increase in solar absorption coefficient, heating consumption index reduce 2% whereas cooling consumption index increase 2%. Thus, the overall effect shows that light-colored materials are suitable and energy efficient for building surface in this climate zone.

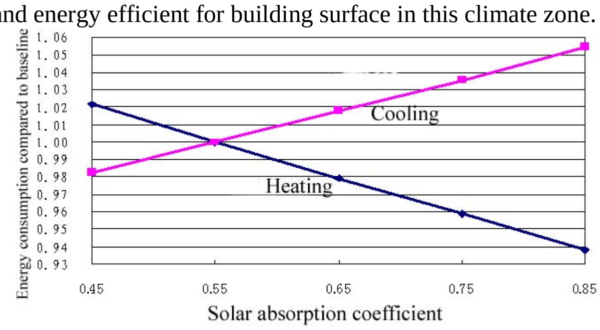

Fig. 2 Solar absorption coefficient vs heating and cooling energy consumption

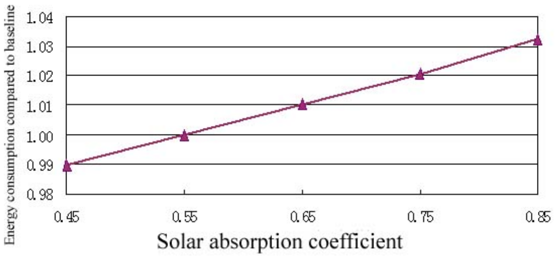

Fig. 3 Solar absorption coefficient vs total energy consumption

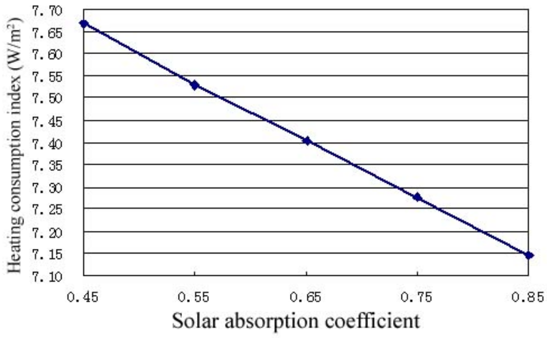

Fig. 4 Solar absorption coefficient vs heating consumption index

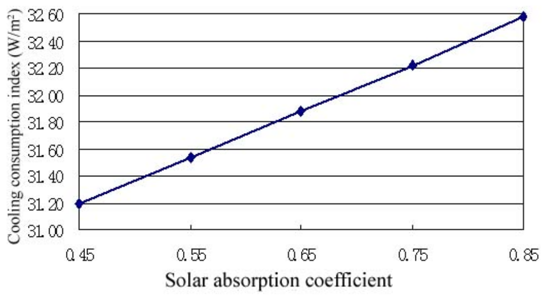

Fig. 5 Solar absorption coefficient vs cooling consumption index

IV. CONCLUSIONS

This paper carried out building simulations to study the effect of solar absorption coefficient on building energy consumption based on a typical residential building in hot summer and cold winter zone. Results show that as solar absorption coefficient increases cooling energy consumption rises accordingly while heating energy consumption decreases, and they have strong positive and negative linear correlations, respectively, with R^2 higher than 0.99. And For every 0.1 increase in solar absorption coefficient, heating consumption index reduce 2% whereas cooling consumption index increase 2%. Recommendations are given that light-colored materials are suitable and energy efficient for building surface in this climate zone.

References

[1] Y. Wu, "China Building Energy Efficiency: Current Status, Issues, and Policy Recommendations," *China Ministry of Construction*, 2003.

[2] N. Zhou, "Energy Use in Commercial Building in China: Current Situation and Future Scenarios," *8th ECEEE Summer Study, Lawrence Berkeley National Laboratory*, 2007.

[3] D.G. Fridley, N. Zheng, N. Zhou, "Estimating Total Energy Consumption and Emissions of China's Commercial and Office Buildings," *LBNL-248E, Lawrence Berkeley National Laboratory*, 2008.

[4] Zhou Yan, Ding Yong and Yao Jian, "Preferable Rebuilding Energy Efficiency Measures of Existing Residential Building in Ningbo," *Journal of Ningbo University(Natural science & engineering edition)*, vol. 22 pp. 285-287, 2009.

[5] Yao, J. and J. Xu, "Effects of different shading devices on building energy saving in hot summer and cold winter zone," *2010 International Conference on Mechanic Automation and Control Engineering*, Wuhan, China 2010, pp. 5017-5020.

[6] Florides GA, Kalogirou SA, Tassou SA, Wrobel LC, "Modeling of the modern houses of Cyprus and energy consumption analysis," *Energy*, vol. 25, pp. 915-937, 2000.

[7] Yao Jian and Yuan Zheng, "Study on Residential Buildings with Energy Saving by 65% in Ningbo". *Journal of Ningbo University(Natural science & engineering edition)*, vol. 23, pp. 84-87, 2010.

[8] China Architecture and Building Press, *The People's Republic of China National Standard JGJ 134-2001, Design standard for energy efficiecy of residential buildings in hot summer and warm winter zone*, Beijing, 2001.