Solar Correction Factors of Building Envelope in Tebei

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Abstract: Tebei has very rich solar energy in China and needs heating in winter，but the present energy building design code has no solar correction factor for the overall heat transfer coefficient of building envelope for Tebei. Based on the typical year weather data, this paper compares the solar energy of a typical city, Lassa, in Tebei with that of another city that has the same degree-days of heating period, calculates the heating energy for the building, and proposes the solar correction factors for an overall heat transfer coefficient of building envelope in Tebei.

Key words： building envelope; solar energy; heat transfer coefficient; solar correction factor

1. INTRODUCTION

Energy sources are the base to develop economy. With the great Chinese west developing policy, the Tibet has having a rapid progress in city economy and the energy requirement is keeping increase. Tibet is poor in energy sources and be frail in environment sources. Energy efficient building has double significance for economic developing and environment protecting in Tibet.

In China, the present energy efficient building design standard has some blankness in Tibet. The most important one is lack of basic parameters for energy efficient building design, especially solar correct factor for overall heat transfer coefficient of building envelope [1]. Without the factor, we can not design the energy efficient building in Tibet based on the present energy efficient building design standard.

Tibet has very rich solar energy in China and even in the word. In China, Tibet is the only place that need heating in winter and need no air cooling in summer with the reason of the special highland climate in it. The rich solar energy is a very useful factor for building to save heating energy in winter.

With this paper, field test results are presented to understand the effect of solar radiation on the building envelope, and the climate characteristics of typical city Lassa in Tebei are analyzed. The solar correction factors for overall heat transfer coefficient of building envelope are proposed by dynamic calculation of heating energy

2. FIELD TEST RESULTS

In order to investigate the effect of solar radiation on building wall, a field test was curried out in the city of Zuogong, Tebei on 3 days in December 2004. Temperature and heat flow through insulated wall were measured, and some results are shown in figure 1～3. Figure 1 and figure 2 show the measured climate parameters. The maximum and average of solar radiation were 776 W/m^2 and 138 W/m^2 respectively. The maximum and average of outdoor air temperature were 7.4 and -5.8 respectively.

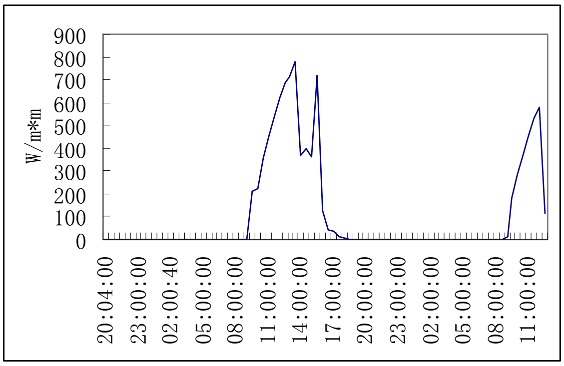

Fig.1 Horizontal solar radiation

Under these weather condition, the maximum of external surface temperature on south wall reached 48.6 at 13:00 and the daily average was 4 which were much higher than outdoor air temperature. Figure 3 shows the comparison of heat flow inside south wall and west wall. The average heat flows inside south wall and west wall were 12.2 W/m^2 and 16.9 W/m^2 respectively. It can be seen that heating energy lost through south wall was reduced by 28% because of solar radiation difference. So it is necessary to correct heat transfer coefficient of external wall for energy efficient building design in Tebei.

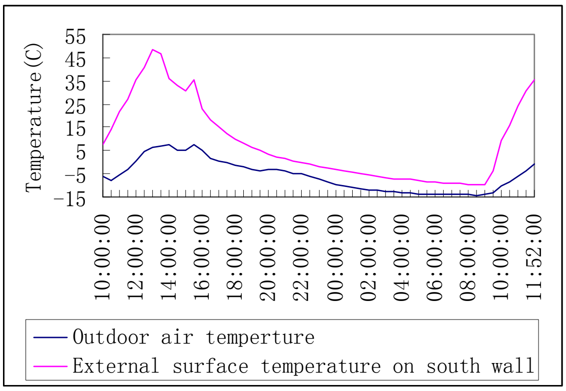

Fig.2 Surface temperature on south wall

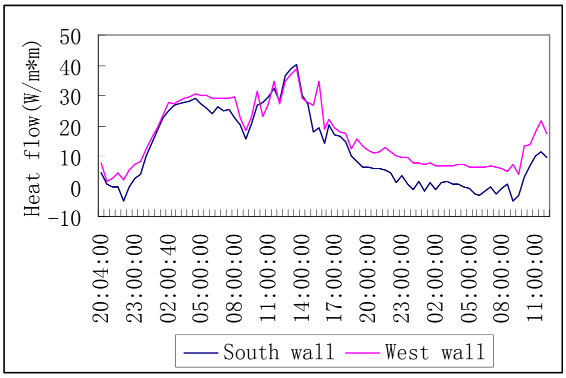

Fig.3 Heat flow into room

3. TYPICAL YEAR WEATHER ANALYSE

Analysis the typical year weather data [2] can help us to understand the climate characteristics in Tibet. Comparing the weather data of typical city, Lassa in Tibet with that of Xian and Beijing which are belong to the same cold climate zone, we can see the great differences between them

According to table 1, the heating period in Lassa is longer than that in Beijing, but the average air temperature during heating period in Lassa is higher than that in Beijing. So Lassa and Beijing have the almost same degree-days. From table 2, the solar radiation in Lassa is the most intensive. Solar radiations in the south, east and west in Lassa are 3.5, 4.0 and 2.5 times of that in Xian and 1.8, 3.0 and 1.7 times of that in Beijing.

Under effect of solar radiation the equivalent temperature composed of air temperature and solar radiation in Lassa is much higher than that in Xian and in Beijing according to table 3. Solar radiations transmit through double layer window in Lassa are 1.2～3.4 times of that in Xian and 1.3～2.8 times of that in Beijing from table 4.

Tab. 1 Data of heating heriod

City	Lassa	Xian	Beijing
Heating period（day）	130	93	108
Air temperature（ ）	0.67	0.70	-0.66
Degree-day（ .d）	2252	1609	2016

Tab. 2 Solar radiation（kW.h/m^2）

City	Lassa	Xian	Beijing
South	606.35	171.68	330.89
East	330.80	82.65	109.96
West	215.79	85.41	128.95
Horizontal	574.64	194.62	268.09

Tab. 3 Equivalent temperature

City	Lassa	Xian	Beijing
South（ ）	6.6	3.0	3.2
East（ ）	3.9	1.9	0.7
West（ ）	2.8	1.9	1.1
North（ ）	1.4	1.5	0.0
Horizontal（ ）	6.6	3.5	2.7

Tab. 4 Solar radiation through window

City	Lassa	Xian	Beijing
South（kW.h/m^2）	211.11	69.72	132.85
East（kW.h/m^2）	118.71	34.62	41.99
West（kW.h/m^2）	77.00	35.84	54.35
North（kW.h/m^2）	33.29	27.33	26.40

4. SOLAR CORRECTION FACTOR

Constructing a seven-story building model with volume 30×20×21 m^3, the heating energy with a full year is calculated by dynamic method under typical year weather condition. The thermal parameters for building energy calculation are supposed as following: heat transfer coefficients of roof, wall and window are 0.52, 0.61 and 2.3 W/m^{2}K respectively; solar radiation absorptions of roof and wall is 0.7; solar energy transmittance of window glass is 0.75; rates of window area to face area are 0.25～0.50. Heat load of the building includes that of roof, wall, window, air infiltration and indoor heat resource. Without solar radiation the heat load calculated by dynamic thermal transfer method is equal to that calculated by stable thermal transfer method during heating period.Obviously the heat load without solar radiation is greater than that with solar radiation during heating period. When the heat load with solar radiation is calculated by stable thermal transfer method, the effect of solar radiation on heat load of roof and wall can be corrected by solar correct factor for heat transfer coefficient

Based on the building energy calculation the solar correct factors for heat transfer coefficient are proposed [3], as shown in table 5. It can be seen that the solar correct factors on roof, south wall, east wall and west wall in Lassa are lower than that in Xian and Beijing. The solar correct factor on south window is variable with different rate of window area to face area, which is different from fixed solar correct factor method used in present energy efficient building design standard. In Xian and Beijing the solar correct factor on south window are positive values, while they are negative values in Lassa because of the strong solar radiation effect from south window in noon. The solar energy transmitted from south window not only balances the heat loss from south window but also balances part of heat losses from other envelope in Lassa. The solar effect to save energy in heating period is very important in Tebei.

4. CONCLUSION

Field test result shows that heating energy lost through south wall was reduced by 28% because of solar radiation.

Comparing the weather of typical city, Lassa in Tibet with that of Xian and Beijing which are belong to the same cold climate zone, Solar radiations in the south, east and west in Lassa are 3.5, 4.0 and 2.5 times of that in Xian and 1.8, 3.0 and 1.7 times of that in Beijing

Tab. 5 Recommended solar correction factors

Lassa				
South wall	0.66	South Window	Rate of window to face	Solar correction factor
East wall	0.81		0.25	-0.12
West wall	0.88		0.30	-0.10
North wall	0.96		0.35	-0.08
Roof	0.66		0.40	-0.06
East window	0.32		0.45	-0.03
West window	0.56		0.50	-0.01
North window	0.81			
Xian				
South wall	0.86	South window	Rate of window to face	Solar correction factors
East wall	0.93		0.25	0.46
West wall	0.93		0.30	0.46
North wall	0.95		0.35	0.47
Roof	0.83		0.40	0.48
East window	0.72		0.45	0.48
West window	0.71		0.50	0.49
North window	0.78			
Beijing				
South wall	0.79	South window	Rate of window to face	Solar correction factors
East wall	0.93		0.25	0.16
West wall	0.91		0.30	0.17
North wall	0.96		0.35	0.18
Roof	0.79		0.40	0.19
East window	0.73		0.45	0.21
West window	0.65		0.50	0.22
North window	0.83			

Based on the building energy calculated by dynamic method the solar correct factors for heat transfer coefficient are recommended for energy efficient building design in Lassa The solar correct factors on south window are variety with different rate of window area to face area and the values are negative.

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