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Study on the Influence of Window-wall Ratio on the Energy Consumption of Nearly Zero Energy Buildings

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Abstract

Window-wall ratio (WWR) is one of the key energy-saving design parameters affecting the energy consumption of nearly zero energy building (NZEB) in severe cold regions. The analysis and optimization of WWR is an important way to achieve nearly zero energy consumption. This paper takes one typical NZEB in severe cold area of Shenyang city as model. The influence of different orientations' WWR on energy consumption of NZEB was studied finally through the simulation method of dual energy consumption influence factors with a single variable, and the simulation software of EnergyPlus. The results showed that: the greater impact of different orientations' WWR on energy consumption order is east (west) > south > north; the most energy-efficient east (west) WWR for NZEB in severe cold area is between 10%-15%, south WWR is between 10%-22.5%, north WWR should be appropriately reduced when the lighting and ventilation conditions allowed it.

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Keywords: Nearly zero energy building; Window-wall ratio; Energy consumption simulation

1. Introduction

Actively respond to global warming, reducing carbon emissions and slowing down the burning of fossil fuels has become a global strategic choice. As the medium and long term development goal of Chinese architecture, nearly zero energy building (NZEB) has become a new international trend, and it is the fundamental way to achieve energy-saving and emission-reduction. Passive house, mini energy consumption house, climate house, ultra-low energy

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consumption building are different forms of NZEB. As shown in Figure 1, by the end of February 2016, China has one hundred nearly zero energy projects, but only 13% is located in the severe cold area, and there is no study on the energy-saving design parameters of window-wall ratio (WWR).

Based on the climatic characteristics of cold regions, there are many studies on the WWR. Martin Thalfeldt et al. studied the surface structure of NZEB in cold area Estonia, it was concluded that highly transparent triple low emissivity glazing with WWR is about 25% and external wall insulation thickness is 200mm($U = 0.16$), which could meet the demand of ultra-low energy consumption in Estonian. This is one of the few studies on the WWR of NZEB. Several other studies on the conventional buildings have been made. Susorova has simulated the office buildings in 6 different climate zones. The results showed that the optimal north WWR is between 20-30%, south WWR is between 50-80%. And the total energy consumption will increase with bigger WWR. Similarly, Motuziene studied one air conditioning office building in cold region Lithuania, and concluded that the most energy-saving south WWR is 20%, while the north is between 20-40%. Hu Songtao took one typical office building Qingdao as a model, and studied the impact of different orientations and the WWR on building load. The results showed that the greater impact of different orientations' WWR on load order is east (west) > south > north. The most energy-efficient east (west) WWR for NZEB in severe cold area is 36%, south is 38%, north is 23%. Poirazis made some office building energy consumption simulations in cold area Goteborg, studied WWR of 30% to 100%, different glasses, shading and orientations. The results showed that the office building with smaller WWR will be more energy-saving. Fang Tao analyzed the impact of key envelope energy-saving design parameters on passive residence energy consumption in cold area. And concluded that the energy-efficient transparent envelope heat transfer coefficient of south and north is $0.78\text{W}/(\text{m}^2\cdot\text{K})$, east and west $1.0\text{W}/(\text{m}^2\cdot\text{K})$. Solar heat gain coefficient SHGC values are not less than 0.474, south WWR is between 70%-80%, but this study didn't do enough study on the different orientations.

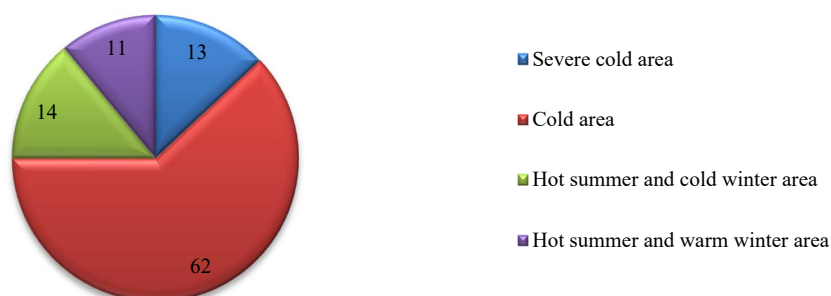


Figure. 1. Nearly zero energy demonstration buildings distributed in different climate areas

All in all, the above studies fully reflect that no matter which kind of buildings, determine the WWR reasonably is an important way for building energy-saving design. Today, although the NZEB has become a new international trend, most of the studies are not involved in WWR. And most studies of WWR were not based on severe cold area. Besides the NZEB is based on Climatic characteristics for guidance, energy consumption goal for performance design principle. So research the impact of different orientations' WWR in severe cold area on NZEB energy consumption is imperative.

2. Methods

In this paper, SketchUp is used to establish a model of typical demonstration NZEB in severe cold area. This NZEB is a rectangular building, whose shape coefficient is 0.54. The building size of length*width*height is $18\text{m}\times 8.4\text{m}\times 6.9\text{m}$, the total area is 302.4m^2 with two floors. The first floor height is 3.3m, which is used as a residential demonstration. The second floor height is 3.6m with open and closed office, which is used to do scientific research. Thermal performance of envelope is shown in Table 1.

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