Research on Heating Operation Mode of Near Zero Energy Consumption Building in Severe Cold Areas

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Abstract. Near zero energy building is a development direction of building energy saving, but it is difficult to meet the indoor heating demand simply by depending on passive design, according to the traditional mode, continuous heating will cause a lot of energy waste. In order to study the best operation mode of near zero energy consumption building heating in severe cold areas, this paper monitors a near zero-energy building in the northeast as a research object. This near zero energy consumption building adopts the concept of green building and passive design in the design, uses various building energy-saving technologies, compares and analyzes the energy consumption of conventional buildings, and finds that the heating load of near zero energy consumption buildings is lower than that of conventional buildings, which has great potential for energy saving.

1. Introduction

With the rapid development of social economy in our country, the construction industry is booming, building energy consumption will inevitably increase substantially, and near zero energy consumption building will become the development forefront of the construction industry. However, the near zero energy consumption building has small energy consumption and large heating storage quantity, if according to the common central heating mode, the continuous heating will generate a lot of heat waste, the actual energy consumption will be too large, and the energy-saving concept of near zero energy building will be deviated. Due to long winter heating period and colder climate in the severe cold areas of Northeast China, even the new buildings with better thermal insulation effect are often in the form of low-temperature continuous heating. As a future direction of building energy saving, near zero energy consumption building has strict control over energy consumption, and the extensive heating mode can no longer meet the demand.

2. The Design of Near Zero Energy Consumption Building

Energy saving analysis was carried out in a near zero energy consumption building in northeast China. This building has 1 floor underground and 2 floors above ground, this building area is 1600.7m2 and the total height of the building is 10.3m, the building design and construction process are strictly in accordance with the standard of green building, the principle of green design and green construction is upheld, the shape of the building adopts simple square shape, minimizes the shape factor of the building, avoids excessive heat loss in the building, and introduces various energy-saving technical measures such as PVT technology, tunnel wind, building heat recovery and so on. The renewable energy such as solar...
energy and geothermal energy are made full use of, which greatly reduce fossil energy consumption. The doors and windows of this building are advanced sealing technology; it ensures that the building's permeability coefficient is less than 0.6 times/h under 50 Pa pressure, which reaches the German passive house design standard. In addition, the near zero energy consumption building adopts a better thermal insulation technology of the external protective structure, which make its heat transfer coefficient reach 0.1 W/(m²·K); it is equipped with hydrophobic rock wool and PVT photovoltaic curtain wall facilities on the southwestern outer wall of the building, it can recover its own waste heat while photovoltaic panels generating electricity, realize the full utilization of solar energy, and combine the phase change energy storage technology to make more rational use of energy. The main indicators of the building envelope are shown in Table 1.

| Table 1. Basic parameters of enclosure structure of near zero energy consumption building and conventional building |
| --- | --- | --- |
| enclosure structure | heat transfer coefficient [W/(m²·K)] | |
| near zero energy consumption building | conventional building |
| photovoltaic curtain wall | 0.12 | 0.42 |
| outer wall | 0.10 | 0.42 |
| underground outer wall | 3.155 | 3.267 |
| roof skylight | 0.8 | 2.5 |
| external window | 0.8 | 2.5 |
| transparent outer door | 1.2 | 2.5 |
| non-transparent outer door | 1 | 2.5 |
| transparent curtain wall | 0.8 | 2.5 |

The building covers functional rooms such as offices, meeting rooms, showroom, guest rooms, tea break and toilet. According to the use characteristics of different functional rooms of the building, the working factors of different staff are formulated. The working hours of the office are mainly distributed in the daytime, while the guest rooms are mainly concentrated in the night; the staff in other rooms varies greatly (as shown in Fig.1).

![Fig. 1 staff schedules](image)

The staff density and daily schedule of different functional rooms are different, indoor personnel and equipment have a major impact on the building air conditioning load (as shown in Table 2). Different indoor functions, equipment thermal disturbance parameters and indoor temperature and humidity are set in the building by reference to the different functions of the rooms, the temperature at which people often stay is maintained at 20–25°C, and the duty temperature is maintained at 15–28°C for places where people are less likely to stay or no one is staying.
Table 2. Basic parameters of the thermal disturbance of room

| room          | staff/ (person/m²) | light thermal disturbance/(W/m²) | equipment thermal disturbance/(W/m²) | temperature upper limit/°C | temperature lower limit/°C | temperature upper limit/°C | temperature lower limit/°C | conditioning time |
|---------------|--------------------|---------------------------------|------------------------------------|---------------------------|---------------------------|--------------------------|--------------------------|------------------|
| office        | 0.1                | 13                              | 13                                 | 25                        | 20                        | 60                       | 50                       | 6:00-21:00       |
| guest room    | 2                  | 13                              | 13                                 | 25                        | 20                        | 60                       | 50                       | all day long      |
| toilet        | 0.02               | 5                               | 0                                  | 28                        | 20                        | 65                       | 50                       | all day long      |
| equipment room| 0.1                | 13                              | 0                                  | 28                        | 20                        | 55                       | 30                       | 6:00-21:00       |
| hall          | 0.1                | 18                              | 5                                  | 25                        | 20                        | 60                       | 50                       | 6:00-21:00       |
| showroom      | 0.2                | 11                              | 20                                 | 27                        | 18                        | 60                       | 50                       | all day long      |
| meeting room  | 0.3                | 11                              | 0                                  | 26                        | 20                        | 65                       | 35                       | 6:00-21:00       |
| lounge        | 0.1                | 11                              | 0                                  | 26                        | 20                        | 65                       | 35                       | 6:00-21:00       |

3. Load and Energy Analysis

DeST software is building energy analysis software developed by Tsinghua University, in order to understand the hourly building energy consumption and energy saving effect of the near zero energy consumption air conditioning system, DeST software is used to simulate near zero energy consumption buildings and conventional buildings, based on the meteorological data of the China Meteorological Parameters Database, the heating energy consumption and air-conditioning energy consumption of the two buildings were analyzed hour by hour, and detailed analysis was carried out for Great Cold Day (as shown in Fig. 2).

The winter in Northeast China is cold and long, and the outdoor temperature is -19 °C, the central heating starts from November 1 to March 31, which is 152 days, the building heat consumption index is 21.1 W/m², the indoor and outdoor temperature difference can sometimes be as high as 40 °C, taking the January 21st as an example, the relationship between heating energy consumption of building and outdoor environment is analyzed, the lowest outdoor temperature is -22 °C, the highest temperature is -4.2 °C, which is a full-load heating stage. The maximum heating load for conventional buildings occurs at 6:00 am, and it is 116 kW, and the maximum heating load of near zero energy consumption buildings is 22 kW, which is only 18.25% of conventional buildings. The cumulative load throughout the day is: the heating energy consumption of buildings in winter is basically inversely proportional to the outdoor temperature, and the time delay is not much, it shows that the good building thermal insulation technology can greatly reduce the building heating energy consumption, and has very good thermal insulation effect (as shown in Fig. 3).)

Through the results of simulation analysis, it can be found that the near zero energy consumption building has obvious energy-saving effect in winter, the heating energy consumption in the whole heating season is 24852.34 kW/h, while the conventional building is as high as 94603.3 kW/h, by adopting appropriate energy-saving measures, the heating energy consumption of the building has been reduced by 73.72%. Because the summer load factor is different from that in winter, indoor people,
equipment, lighting and other thermal disturbances account for a large proportion of summer air conditioning load, therefore, in summer, natural ventilation should be used to remove excess indoor heat. Compared with the summer, the energy-saving effect of building air-conditioning energy consumption is not as obvious as that in winter, which reduces about 15% energy consumption (as shown in Table 3).

![Fig. 3 comparison of outdoor temperature and heating energy consumption between near-zero energy building and conventional building in Great Cold Day](image)

### Table 3. Statistics and comparison of air conditioning and heating energy consumption of building throughout the year

| Project                                           | Near Zero Energy Building kW/h | Conventional Building kW/h | Energy Saving Rate % |
|--------------------------------------------------|--------------------------------|---------------------------|----------------------|
| Maximum heating load on winter solstice kW        | 22.9                           | 116.9                     | 19.58                |
| Total heating energy consumption on winter solstice kW | 364.4                         | 2004.7                    | 81.82                |
| Total heat consumption of building in winter kW/h | 24 852.3                      | 94 603.3                  | 73.72                |
| Total cooling consumption of building in summer kW/h | 37 063.5                    | 43 672.7                  | 15.13                |
| Total energy consumption of air conditioning all the year round kW/h | 61 915.8                        | 138 276.0                  | 55.22                |

4. Conclusion
The near zero energy consumption building physical model was established by DeST software, and the building energy consumption analysis was carried out, compared with the buildings with the same type and the same scale in the 1980s, it was found that advanced enclosure insulation technology and house sealing technology, authentic wind technology and building waste heat recovery technology can greatly reduce building energy consumption, among them, the energy consumption in winter can be saved by 73.7%, the comprehensive energy saving in the whole year is 55.2%, and the energy saving effect is remarkable, it is possible to promote the technology of near zero energy consumption buildings in the severe cold regions.

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