

Simulation and analysis of energy consumption of the energy-saving building in Shanghai

Jianmei Sun, Di Chen and Jiadong Hu

School of Economics and Management, Shanghai University of Electric Power, Yangpu District,
Shanghai, China

13472787768@139.com

283084929@qq.com

Keywords: residential building; energy-saving design; hot summer and cold winter area; energy simulation

Abstract. We use the building energy simulation software named Ecotect to carry out the simulation analysis of the overall thermal environment of residential buildings, to find the main factors of high energy consumption, to improve architectural design by analyzing several pieces of case. Firstly, we build 3D model according to the designing scheme and make material settings, schedule settings, area settings, etc; then understand the general characteristics of building energy consumption such as building condition, enclosure structure, air conditioning system, building indoor environment and so on, find the main factors of high energy consumption, explore energy conservation measures; Finally, the energy consumption analysis is carried out, and the design suggestions are given from the point of view of planning and design of the residential building based on the analysis results.

Preface

In emphasizing the harmony between man and nature, the sustainable development of human society, people pay more and more attention on the energy-saving emission reduction. Over the past five years, China's urban and rural residence added about 6.47 billion square meters, China's per person living area exceeded 21 square meters. Building energy consumption is huge, building energy saving has become the major initiative to achieve the basic national policy of sustainable development and implementation of energy conservation. According to the data of Shanghai Bureau of Statistics, Shanghai real estate investment in 2014 is 320.648 billion yuan totally, of which residential investment accounted for 172.465 billion yuan, more than the sum of investment in commercial and office buildings. Building energy consumption in the total social energy consumption accounted for a large proportion. At the same time, people's requirements of residence and residential building comfort are getting higher and higher, so the building energy efficiency planning and design has got more and more attention. Energy saving technology design is changing everyday such as wall materials, doors and windows, ground, roof, HVAC and so on. Energy saving research for building monolithic structure is also widely used. (Xuefang Bao, 2001) If we can considerate ventilation, lighting, air conditioning systems, comfort and other respects at design stage, optimizing the building design and reducing the energy consumption, it will play 70% energy saving effect and be conducive to the subsequent stages of energy-saving design. (Xiang Li, 2005)

Ecotect which based on BIM is widely used at home and abroad, a lot of Chinese design and research departments in architectural has applied the calculate results in practice and research. In 2013, according to "BIM model based on the construction of small high-rise office building energy efficiency research", Guan ChangSheng and several researchers, establishing 3D building information model about a small high-rise office building in Wuhan by BIM and then imported the files into Ecotect for Solar radiation analysis, enthalpy wet chart strategy analysis, occlusion projection analysis, air conditioning system energy consumption analysis. Shao YuLing's quantitative analysis of the impact of different factors and different forms of building on the thermal environment of urban settlements can also be used as a reference. (Lingli Shou, 2013) Ecotect has strong feasibility in building energy analysis and guiding on design of the building. (Yulin Shao, 2012) Ecotect uses

flexible and intuitive 3D model operation and has wide range of applications. Ecotect brings great convenient to the designer when designing more energy efficient building. We will use Ecotext to conduct energy analysis in this text, mainly for the building site, building and road layout, building orientation, building size, building spacing and building environment of Shanghai area.

Research on energy-saving Design of civil building in Shanghai

Because Shanghai is hot and humid in summer and cold and wet in winter, monthly radiation in certain areas are in higher levels. It becomes an important research direction that meeting the comfort and trying to achieve economic rationality and energy conservation supported by the energy-saving technology.

(1) Energy saving measures in residential area layout

Hot summer and cold winter areas in the past are non-heating areas, poor thermal performance of the maintenance structure. In the energy-saving design, the designers should combine body shape and residential lighting sunshine, select the reasonable rate of wall and window to improve residential sunshine and to promote natural ventilation. Furthermore, pay attention to summer sun shade, external walls and roof insulation; pay attention to use outside shade to cut down the sunshine in the main room. With the improvement of people's living standards, using air conditioning more frequently, the design of the house itself and layout orientation can also influence the energy consumption of air-conditioning.(Huiling Zhang, 2009)

In the planning and designing, it needs try to shade, promote outdoor ventilation, improve wind speed, reduce the building spacing and guide ventilation in summer. Winter need to use passive solar energy, increase the building spacing. So the designers should come up with a compromising method for the contradictory between winter and summer. It is necessary to let the north building higher than the south one in the building layout, south places using low-density residential arrangement (such as independent, semi-detached house) and north places using high-density residential arrangement.(Chao Zhao, 2005)

(2) Energy Saving Measures of Single Buildings

Planning the residential area well can improve the overall thermal environment, and be conducive to the lighting of each building, has a huge effect to building energy efficiency. Besides, designers should also take a series of energy-saving measures to the single building to meet the design specifications. This has the same important effect on building energy saving and also be the core to the energy analysis.

There are three energy saving measures should be paid attention. The first one is the saving measures of enclosure. To the outer wall, the designers should cut down the heat storage coefficient and heat transfer coefficient to improve the external wall thermal resistance through several measures such as out wall insulation and in wall insulation. The principle of roof energy-saving measures similar to the external walls one, to improve thermal resistance is one of the effective ways. In addition, we can grow some plants on the façade and roof. The second one is saving measures of doors and windows. The outer doors and windows must have excellent thermal resistance and shading performance to cut down external heat. In addition, the designers also should control the rate of doors and windows. Because the rate of doors and windows and integrated shading coefficient are inversely proportional, the smaller the rate of doors and windows is, the easier integrated shading coefficient is satisfied. The third one is the saving measures of air conditioning heating system, we have following measures. (1) Choice of air conditioning equipment reasonably and improve the utilization of equipment. (2) Use natural ventilation during the transition season. (3) Using heat recovery technology, it is also the development trend. (4) Use building function layout reasonably, rational use of lighting systems, natural lighting, natural ventilation, air conditioning end of the indoor control system, the use of light - heat, light - electricity, light - light and other renewable energy conversion, are advanced building energy - saving technology.

Engineering case

The research object of this paper is a residential area in Shanghai which located on the ground. Planning and design of residential buildings is six-story and long-shaped building, showing a patchwork layout, facing towards the south east 15 °, the north buildings are higher than the south ones on the whole. Each building has six floors, two household each floor. The total construction area is 2082.6 square meters, the total height is 21.4 meters. The body shape is close to 0.35. The roofs are slope roof.

(1) Thermal environment simulation analysis

Thermal environment simulation analysis is a part of whole district planning and design. The designers should make the model of single building firstly and use the Ecotect to carry out several analysis such as time-dependent temperature analysis, time-to-day heat analysis, monthly energy consumption analysis, temperature distribution analysis, month-by-month get hot analysis, passive component analysis, passive adaptation index analysis, temperature heat comparison analysis, to improve the model of the building thermal environment. (Tianzhu Liu, 2013) The designers should establish a 3D model before this and site the elements of the inspection, time control, regional attributes, system properties, analysis grid and other settings.

According to the data display, the model lost 8978.4Wh heat each month, 83.3% because of the enclosure and 10.2 because of ventilated heat. So the enclosure have some problem in holding heat, it need be improved. The designers can improve the enclosure by improving dining room, the outer windows of the main bedroom, the floor and the interior layout of the building.

(2) Transformation of energy saving

It has been found that the building energy consumption of the slanting layout is the smallest, followed by the crossed type, largest is the horizontal arrangement. Besides, the low-rise buildings should be put in the sun, high construction arranged in the subsequent. Try to add the floors to improve land use efficiency and to reduce building volume factor, it is conducive to energy conservation.

The enclosure has been improved, the improved parameters show in Table 1:

Table 1

Enclosure	Selected materials after the transformation	Heat transfer coefficient before transformation (W/m ² *K)	Heat transfer coefficient after transformation (W/m ² *K)
Outer wall	Cement mortar + 100mm polystyrene foam + seven rows of ceramic clay blocks + cement mortar	0.34	0.28
Inner wall	Coal gangue sintered brick, double-sided 10 thick plastering	2.51	2.51
Flooring	100mm concrete	0.88	0.88
Floor	Overhead pumice concrete floor	2.16	1.45
Glass	Ordinary double glass	2.68	2.68
	Double Low-E glass		2.26
Roof	220mm High steel purlin filled with glass wool	0.14	0.14

According to the data, the building thermal performance after the transformation is better than before, the losing heat of the enclosure has reduced 46.5%.

Conclusions

We simulated and analyzed the overall thermal environment of residential buildings by using Ecotect, identify the main factors that affect the high energy consumption of the building and make some suggestion about energy saving in building envelope and building space layout by the simulation analysis of building energy consumption. The whole building is set into a natural ventilation system, focusing on the properties of the building itself to conduct a comparative study. From this example, we can know that residential energy-saving design in the Shanghai area is meaningful.

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