Business Building Energy Simulation and Energy Saving Design

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Abstract. According to the requirement of continuing to increase the proportion of the tertiary industry in the overall urban planning as well as the adjustment of industrial structure, office buildings, apartments, hotels, exhibition centers, large venues and other large commercial buildings will increase greatly in the next few years. At the same time, after a group of ordinary public buildings has been transformed because of the use of function change, energy demand has grown exponentially. And it has changed into large public buildings in energy use characteristics. When commercial buildings is compared to the other types, the annual power consumption is larger, and power consumption equipment is more, and the quantity of lighting equipment is more, and air conditioning system equipment has larger capacity and longer operation time. Business building energy simulation accords with the need of energy saving and emission reduction. So it has a strong research significance.

Introduction

With the execution of energy saving design standards about residential buildings in various regions, we need to calculate the annual energy consumption of the building to decide whether it meets energy saving standards, determine whether the building can be built, or whether a energy saving reconstruction technology is feasible. From the beginning of the 70's of the last century, the rapid development of information technology has provided a powerful tool for building saving analysis. Because building environmental change is a complex process which is decided by many factors, only with the computer simulation method can we effectively predict the possible conditions of the building environment without environmental control system and the existing environmental control system. Every country has developed many building energy consumption analysis softwares. Vigorous development of various kinds of models and simulation softwares makes the simulation technology be applied to a larger and more effective methods and steps of practical engineering, and makes it not just stay in the colleges and universities and research institutions.

Business Building Energy Simulation

In the analysis of energy consumption calculation the building energy analysis software can be used to simulate the all-year hourly load and energy consumption of the building and air conditioning system. It is helpful for architects and engineers to consider how to save energy from the whole architectural design process. Most of the building energy analysis softwares consist of four main modules: Loads, Systems, Plants and Economics, namely LSPE. These four modules are interconnected so as to form a building system model.

At present the building energy analysis softwares which are relatively popular in the world are mainly Energy-10, TRACE, DOE-2, BLAST, EnergyPlus, TRNSYS, DeST, Ecotect and so on. Here, combining the application in this paper, I will only introduce eQUEST and Ecotect.

The analysis of thermal environment in Ecotect is a kind of dynamic load calculation method based on the access method which is approved by the British Association of registered engineer(CIBSE). It is characterized by fast computation speed and its operation is simple, and its precision can satisfy the needs completely. Another characteristic of the access method is very

flexible. It has no limit for the building shape and the number of simulation analysis area. In Ecotect, the descriptions of the external disturbance mainly comes from the hourly meteorological data, which include the number of indoor people, calorific capacity and operation schedule of the equipment, etc. Another factor affecting indoor thermal environment is palisade structure and thermal properties. Different load calculation methods have different methods about calculation and description for palisade structure and thermal properties.Compared with other commonly used load calculation methods, CIBSE access method used in Ecotect is very different at this point.

The difference from other load calculation method is that the access method includes two calculation states, namely the average state and the state of fluctuation. As shown in Figure 1, two node network figures used here represent the average state and the state of fluctuation respectively.On the left there is the Average State Figure, and on the right there is the State of Fluctuation Figure.

The average part and the fluctuation part in the calculation process of the access method are handled separately, but the processing procedure is basically the same. We should calculate the internal heat gain and direct solar heat gain first. The average of these heat gains and the fluctuation part then will be divided into two types, namely convection and radiation. We can find that the heat gains mentioned above are assigned to the air temperature or the nodes of the environment temperature. The proportion of the heat gain which adds to the nodes of the environment temperature is fixed. It contains two-thirds of radiation heat gain,convection heat and a third of the convective heat gain.

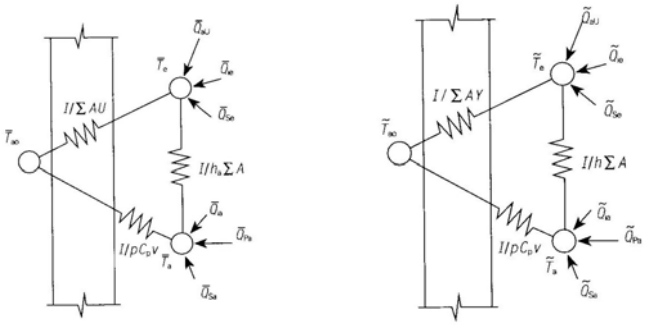

Fig. 1 The compute nodes Figure of the Access Method

The Establishment of Model

Due to the practical requirement of the engineering, the simulation of the buildings tends to be able to be maximally close to the prototype of the buildings. But it will increase the complexity of the model and the difficulty of modeling inevitably. How to accurately and quickly complete the establishment of the model becomes a problem that must be solved. The method which defines the surface by angular point in the process of Energy Plus's modeling gives the users a lot of freedom. That is to say, the model with any complex shape can be divided into squares or triangles with different shapes so that the model can be established.

Building Envelope. The input, Surface Construcion Elements, of the building envelope in Energyplus adopts the custom method. And the building envelope adopts the definition layer by layer. The parameters which need to input are the thickness of the material, thermal conductivity, density and specific heat. Then we can choose the materials of each layer in the keyword "CONSTRUCTION" and definite the sequence of each layer. For exterior wall and roof covering, the sequence of each layer must be arranged from outside to inside. For the floor and exterior wall which contact with the soil, the sequence of each layer should be arranged from the surface which contacts with the soil to inside. If we don't arrange according to this sequence, it will affect the calculated result of the building envelope with thermal and physical properties. After the definition layer by layer, the program will calculate the reaction coefficient of the structure. The reaction

coefficient will be used for the dynamic and delayed heat flux through the building envelope so as to do the hourly simulation.

Table 1 The U Value Table of Effective Heat Transfer Coefficient in the Buildings about the Malls

Name	Methods	U Value
Exterior Wall	cement mortar plaster+370mm brick wall +internal surface plaster	1.50
Interior Wall	240 mm brick wall with the plaster of two surfaces	1.97
Floor	cement mortar layer with 20 mm thickness +reinforced concrete structure plate with 120mm thickness + polystyrene insulation layer with 40mm thickness	1.16
Roof Coverin g	SBS the waterproof roll+cement mortar screeding with 20 mm thickness+hydrophobic perlite board with 100 mm thickness +cement mortar screeding with 20 mm thickness	0.66
external window	Single glass tempered	4.7
Curtain Wall	hollow glass with 16 mm thickness	3.2

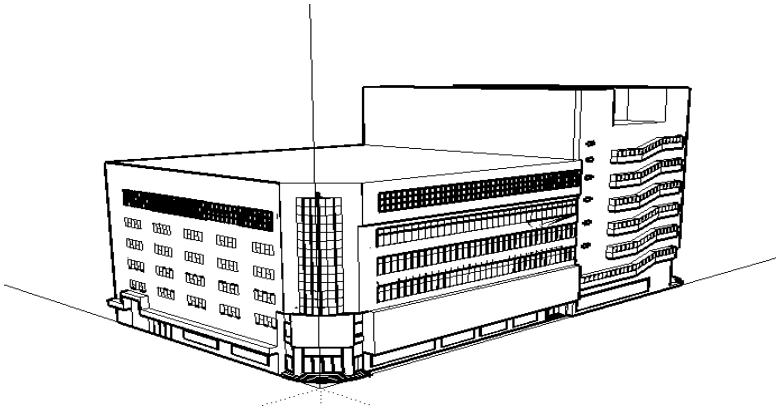

Figure 2 The Periphery Structure of the Store Building

Indoor Load. Indoor load includes PEOPLE, LIGHT and ELECTRIC EQUIPMENT.

In the calculation of Energyplus, indoor load value for each hour equals to the product of the maximum of the personnel set by the users, lighting and equipment heat dissipating capacity and corresponding time schedule (the SCHEDULE). After the completion of the air conditioning partition, Energyplus will call the maximum of heat dissipating with indoor heat source in the database according to the type of partition.

HVAC Equipment and System. HAVC system is divided into water system and air system. Each system needs to define the demand loop and the supply loop. Loop is composed of a number of serial-parallel branches, and the branches are parallelly connected with the tuples surrounded by the node. The system is composed of several general demand loop and supply loop. The loop is formed by one or many branches. Each demand loop or supply loop is semi-closed, but after both of them are correspondingly connected a closed loop is formed. The loop has a clear demand side and supply side. The cold and hot demand of the room, and the cold heat supply of equipment system transfer through the loop layer by layer. And the equipment operating parameters and the energy consumption of the system, etc will be ultimately determined.

The linking relationship of HVAC requires that the users must give the names of the unique program which can be identified to each loop, branch, separator, collector and node. When an equipment is defined every time, besides the equipment parameter, all equipment connected nodes should be given. What's more, these nodes need to be repeatedly cited many times in different modules. Figure 3 is the connection diagram of air conditioning system with full air in the mall.Main equipments are shown in the table:

Table 2 The Main Equipment Parameters of the Water System in the Mall

Name	Model	Number of Units	Equipment Parameters
centrifugal water-cooled chiller	Y7K4C5F25CPH	3	The rated refrigerating capacity is 2549.8kW.
chilled water circulating pump	SB-X type single-stage double-suction centrifugal pump	4(3 need to be used and 1 are used as backup)	The rated flow is 625m^3/h，and the rated head is 33mH_2O.
cooling water circulating pump	SB-X type single-stage double-suction centrifugal pump	4(3 need to be used and 1 are used as backup)	The rated flow is 625m^3/h，and the rated head is 33mH_2O.
cooling tower	CBTNI3—700	3	The blast capacity is 40m^3/h，and the cooling water flow is 700m^3/h.

The Hourly Report. Energyplus adopts user-defined hourly report method. The hourly report in Report can make the calculated results be output in specified period of arbitrary variable, such as load, air system, water system, economic nmodel and so on, or during the whole year. Each output report can be selected according to the needs of the user's calculation.

The Influence of Improving Building Envelope on Energy Consumption. The heat transfer and energy consumption in different regions account for 57% ~ 57% of total energy consumption among the buildings. Hether he north or the south, the heat transfer loss 0f building envelope is he key consideration nenergy saving design of the building. In the building envelop, the heat transfer of window and the heat consumption of air permeation are maximum. Each region accounts for about 50％～60％ of total eat consumption of the building.So this part is the key of the building energy saving. Next, the proportion of heat transfer and heat consumption of exterior wall is lager too, and it is about 30％～45％. As a result, it is also the position which needs to be taken of technical measures mainly. Therefore, the energy saving transformation of existing buildings needs to choose suitable technical methods to do energy saving for the doors and windows, walls and roof covering according to the different constructions and conditions of usage. Under the condition of the same outdoor temperature, thermal whether insulation performance of building envelope is good or bad directly affects the heat exchange indoors and outdoors. If the performance about heat preservation and heat insulation of building envelope is good, the energy consumption of heating and air-conditioning and other equipments is less. On the contrary, if the performance about heat preservation and heat insulation of building envelope is bad, the energy consumption of heating and air-conditioning and other equipments is more.

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