Analysis of the economic insulation layer thickness of external-wall in North Henan

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Abstract: In this paper, the software of DeST-h was used to simulate the energy consumption of a residential building in Anyang,henan province, based on the comparison of external-wall with different insulation thickness.By analyzing the investment costs of exterior insulation material and the operation costs of the building, using net present value、dynamic investment recovery period and some other indexes to evaluate economic effects of building with different external wall insulation thickness.Finally, the economical insulation thickness was determined, providing a reference for building energy saving.

Introduction

In order to promote the energy conservation work and accelerate the development of green building, the development and Reform Commission,with Housing and Rural Construction Office of Henan province issued the bill of "Green building action plan of Henan province" in 2013.This billrequiredanamount of 15 million square metersfor heat metering and energy efficiency renovations of existing buildings.The bill also claims that we should pay more attention to energy conservation of enclosure structures. The northern area of Henan province located in the cold regions of china,most of the existing buildings are masonry structures.Generally speaking,these old buildings have poor thermal performance,this leads to a very high energy consumption. Previous researches in energy saving of Henan province usually focus on Zhengzhou and its surrounding areas,however, little researches have been done in small and medium-sized cities comparatively.As the regional central city of the northern area of Henan province,Anyang city is located in the cold regions[1],and it can represent the current situation of energy-saving reconstruction in most small and medium-sized cities of Henanprovince.This essay will provide a reference for the work of energy-saving reconstruction of this region bystudying the thickness of the economic insulation layer of external-walls[2].

Economic analysis method

Taking the research achievements of Xionghuan from Southwest Petroleum University[3] and Liyulong from Zhengzhou University[4]for reference,we can chose net present worth、dynamic investment reclaim time and economic benefits as evaluation indexes to make an analysis of the investment cost of insulating materials and the air-condition and heating cost.Based onthe analysis result,we can determine the most economical insulation layer thickness

When evaluating,mainly based on the net present worth index to determine the best scheme. Net present worth is a dynamic evaluation index which can reflect an investment program's profitability.it means the sum of the present values of incoming and outgoing cash flows over a period of time.Aanalysing different schemes equals to analyzing the increasd investment cost of insulating material and reduced money comes from operating period.By net present worth we can judge thefeasibility of the scheme directly,if the net present worth index is greater than 0,the scheme is feasible;if the net present worth index is less than 0,the scheme is not feasible;chosing the biggest one as the best scheme.

When calculating,the cost of exterior insulation material needed to be determined first.A residential building usually adopt external thermal insulation system.The cost in its life cycle can be simplified into the investment cost of insulating materials and the air-condition and heating cost[5]. The investment cost of insulating materials includes market purchase cost and construction cost,its computational expressions are as follows:

$$C_{in} = C_i + C_e \quad (1)$$

Among the expressions: C_{in} stands for investment cost of insulating materials per unit area(yuan/m^2);$C_i$stands for the cost of insulating materials per unit area(yuan/m^2);$C_e$stands for the cost of construction per unit area (including traffic expense,installation cost and cost of labor,yuan/m^2）.The air-condition and heating cost computational expressions are as follows:

$$C_0 = EC_f[1-(1+I^*)^{-N}]/I^* \quad (2)$$

When $g < I, I^* = (I-g)/(1+g)$;when $g > I, I^* = (g-I)/(1+I)$;

Among the expressions: C_0 stands for air-condition and heating cost in the life cycle (yuan/m^2);Estands for building energy consumption simulation per unit area $(kW \cdot h/m^2)$; $C_f$stands for local electricity price (yuan/$kW \cdot h$);Nstands for the number of years of insulation layer can be used(year);I^*stands for discount rate (%);Gstands for inflation rate (%);Istands for bank rate (%).

We can then get the total cost of insulation layer of life cycle by adding the investment cost of insulating materials to the air-condition and heating cost.The computational expressions for net present worth are as follows:

$$NPV = \Delta C_0 - \Delta C_{in} + R_{es} \quad (3)$$

Among the expressions:ΔC_0stands for present profits brought by incremental investment;ΔC_{in}

stands for the present value of incremental investment;R_{es}stands for the present remaining residual value of the materials.

When $NPV > 0$, means that the investment program can not only satisfy the earning requirement,but also gain excess earnings,the program is feasible; when$NPV = 0$,means that the program can basically satisfied the earning requirement,the plan leaves much to be desired;when $NPV < 0$,means that the program is negative.Making an analysis of different thickness of insulation layer based on net present worth index,we should eliminate the program whose NPV is less than 0 first,then make a comparison of the programs whose NPV is greater than 0,determine the biggest NPV as the best program.

In addition,dynamic investment reclaim time and economic benefits can also be determined by corresponding expressions,as a reference for determining the best plan.If the dynamic investment reclaim time is less than the materials' life,means that the investment plan can be returned during the service life and improve the indoor environmental quality. The less dynamic investment reclaim time is,the greater profits we can get.

Analysis of the economic insulation layer thickness based on project example

Project profile. Taking the energy-saving renovation project of ShiYou residential quarter in Anyang as examples to do the studies. This residential quarter is located in the intersection of QingFeng road and YangChang road,and it was built in 1990.The energy-saving renovation project begins from august in 2013 to november in 2013,the energy-saving renovation proportion adds up to 114 thousand square meters.In this paper,we focus on the study of economic insulation layer thickness of the building envelope only.The method will be illustrated by the example of the building 8# of the residential quarter.

This building is a brick-concrete structure,6 floors,each floor is 3 meters high and the area of the building reaches 2479.3 square meters.It has two units,each unit has two houses each floor.A house contains three rooms,one hall,one kitchen and one washroom,can be used for 50 years.All the exterior walls have a thickness of 370 millimeters while all the inner walls is 240 millimeters.The external windows adopt single-pane window forms.Taking the building with no heat insulation measures as reference model,use the method above to analyze economical efficiency of different insulation layer thickness.

Determining the calculating index. Chosing the common material of EPS board as the insulation layer material,making an analysis of the influences of different thickness.

The survey found that the price of EPS board in Anyang area is about 55 yuan per square meter when the thickness is 40 millimeters,while the price is about 61 yuan per square meter when the thickness is 60 millimeters.Using the linear interpolation method,we can get the formula of the thickness and material price.The construction cost $\square_{\square}$ is about 23 yuan per square meter.The local electricity price C_f is 0.56 yuan/$(kw \cdot h)$,the life period of EPS board is 25 years.Taking the fact that the insulation material cannot recycle well into consideration,the present remaining residual value of the materials is settled as 0.The inflation rate is 4.5% and the bank rate is 6.7%.

Calculating of economical index. Using the calculating method above,we can get the expenses of exterior insulation with different thickness and the economic indexes.Using the energy simulation software Dest-h to simulate the building energy consumption.The building's residential unit figure is shown in Fig.1 and the building's structure model is shown in Fig.2.The result includes energy consumption with different thickness and we can get all the expenses and economic indexes by using the formulas above,the final results is shown in Table 1.

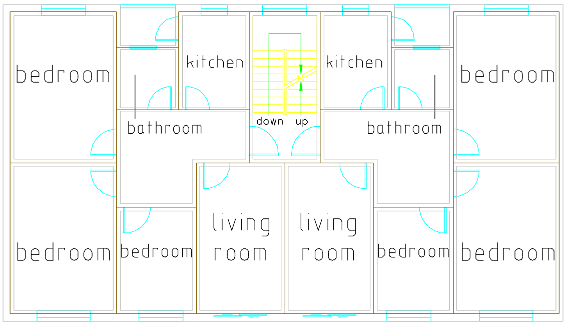

Fig.1.The building's residential unit figure

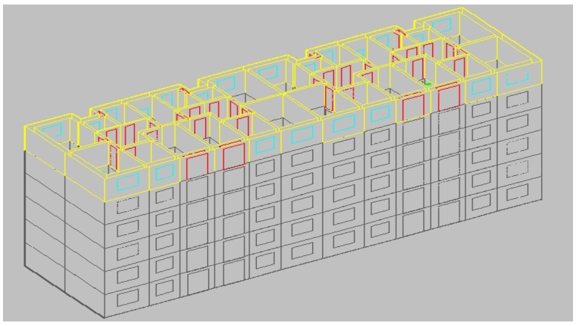

Fig.2.The structure model

Table1 Analysis of the economic insulation layer thickness of external-wall

Thickness (mm)	Material cost (yuan·m^{-2})	Energy consumption (kW·h·m^{-2})	Total expenses (yuan·m^{-2})	Energy consumption cost (yuan·m^{-2})	NPV (yuan·m^{-2})
0	0	41.33	446.36	23.14	0
20	72	33.72	436.17	18.88	10.19
30	75	31.56	415.84	17.67	30.52
40	78	29.9	400.92	16.74	45.44
50	81	28.59	389.77	16.01	56.59
60	84	28.12	380.78	15.38	58.67
70	87	28.26	373.95	14.88	54.16
80	90	28.45	368.64	14.45	49.11
90	93	28.93	364.29	14.07	40.92

The economic thickness. Making use of the data from the table above we can get the conclusion that when the insulation layer is added,the net present worth are all greater than 0,which means all the plans can get profit.In the mean time,the index of dynamic investment reclaim time is less than the material's life time.Chosing the plan which has the biggest NPV as the best plan,and the plan can get the most economic results .The corresponding thickness of the insulation layer is the most economic thickness.We can conclude from the table that when the insulation layer thickness is 60 millimeters,NPV reaches the biggest value,and the plan can get a good result.Thus,we can know that the most economical thickness is 60 millimeters.

Conclusions

Adopting heat preservation and heat insulation measures can reduce the energy consumption effectively in cold region.As the thickness of insulation layer increases,the energy consumption decreases.However,an the thickness of insulation layer increases,the expenses decreases frist,then begin to raise slowly.The reason is mainly because that as the thickness of insulation layer increases, the effect of insulation tend to begentle.However,the air-conditioning energy consumption increases accordingly.In this paper, we simulated the energy consumption and calculated the economic indexes of a building in Anyang,then determined the most economical insulation layer thickness.This study will provide a reference for the energy-saving reconstruction of this region.

Reference

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