Research on Heat Loss Calculations Based on the Computer Simulation

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Abstract

This report will take an ordinary single-story villa as a typical case for heat loss calculations with the help of Hevacomp Design Software. Some evaluation of computed consequences and suggestions of specific energy saving measures will be provided then, as well as the assessment of the computer program (to what extent it is useful and user friendly) finally.

Keywords

Heat Loss; Computer Simulation; Energy Saving.

1. Introduction

Within thermal comfort, human can be allowed to do a range of activities and tasks cozily and enjoyably. Widely speaking, thermal comfort maybe defined as that “state of mind which express satisfaction with the thermal environment”. However, the degree of heat loss would significantly influence the heat balance in buildings and create thermal discomfort, which perhaps decreases working efficiency or leisure interest.

2. Objectives

To determine the heat loss of the following rooms i.e. bedrooms 1, 2, 3 & the lounge as shown on the attached drawing, using the Hevacomp computer program.

To examine the computed heat losses and make recommendations for energy saving.

To assess the computer program and express an opinion on its usefulness and degree of user friendliness.

3. Results (Given data & Printed Results)

3.1 Design data sheet (general)

Outside design temperature = -4˚C

“U” Value for external cavity walls = 0.35 W/m^{2}K

“U” Value for internal walls = 1 W/m^{2}K

“U” Value for exposed ceiling = 0.16 W/m^{2}K

“U” Value for exposed floor = 0.25 W/m^{2}K

“U” Value for external windows = 2 W/m^{2}K

Ignore all internal and external doors.

Table 1. Temperture and airchanges description

Room Number	Description	Internal Design Temperature (˚C)	Air Changes AC/HR
1	Bedroom 1	21	0.5
2	Bedroom 2	21	0.5
3	Bedroom 3	21	0.5
/	Study	21	0.5
4	Lounge	21	1.0
/	Dining room	21	1.0
/	Lobby	19	1.0
/	Toilet	19	1.5
/	Kitchen	18	3.0

3.2 Printed results of the calculation with a summary table

Table 2. Summary of results

Type of heat loss (w) \ Room	1	2	3	4
Fabric loss	351	318	194	554
Ventilation loss	120	94	71	351
Total loss of each room	471	411	265	905
Total loss	2053			

3.3 Examination for the Computed Heat Losses

For ventilation loss using $P_v = c_v NV\Delta t/3600$

Where

P_v = rate of ventilation heat loss = heat energy/time (W)

c_v = volumetric specific heat capacity of air = specific heat capacity (density J/m^{3}K). It is assumed 1300 J/m^{3}K in this situation.

N = air infiltration rate for the room (the number of complete air changes per hour, ach)

V = volume of the room (m^3)

Δt = difference between the inside and outside air temperature (˚C)

Table 3. Heat losses by calculations

Room	1						
wall	external 1	external 2	internal 1	internal 2	exposed floor	exposed ceiling	window
U value (W/m^{2}K)	0.35	0.35	1.00	1.00	0.25	0.16	2.00
Δt (˚C)	25	25	0	0	25	25	25
A (m^2)	6.86	7.68	9.02	7.68	12.03	12.03	2.16
Pf	60.03	67.20	0.00	0.00	75.19	48.12	108.00
							358.53
Room	2						
wall	external 1	external 2	internal 1	internal 2	exposed floor	exposed ceiling	window
U value (W/m^{2}K)	0.35	0.35	1.00	1.00	0.25	0.16	2.00
Δt (˚C)	25	25	0	2	25	25	25
A (m^2)	8.84	3.10	8.84	6.10	9.35	9.35	2.16
Pf	77.35	27.13	0.00	12.20	58.44	37.40	108.00
							320.51
Room	3						
wall	external 1	internal 1	internal 2	internal 3	exposed floor	exposed ceiling	window
U value (W/m^{2}K)	0.35	0.35	1.00	1.00	0.25	0.16	2.00
Δt (˚C)	25	0	2	0	25	25	25
A (m^2)	6.22	6.58	6.22	6.58	7.10	7.10	1.44
Pf	54.43	0.00	12.44	0.00	44.38	28.40	72.00
							211.64

For fabric heat loss, using $P_f = UA\Delta t$

Where

Pf = rate of fabric heat loss = heat energy lost/time (W)

U = U- value of the lement considered (W/m^2K)

A = area of that element (m^2)

Δt = difference between the temperatures assumed for the inside and outside environments (˚C).

The following Table 3 is the calculation results by formula above.

Table 3 heat losses by calculations and Table 4 summary of calculations are both attached as follows.

Compare Table 1 and Table 4, there are some variation between the individual heat losses. The total heat loss calculated is nearly 100 W more than that by program. In spite of this, the total is much larger than the difference, it can be generally considered that the program can be practical and appropriate for use to provide convenience when the formula calculation is relative complex.

Table 4. Summary of calculations

Room / Type of heat loss (w)	1	2	3	4
Fabric loss	359	321	212	566
Ventilation loss	130	101	77	380
Total loss of each room	489	422	289	946
Total loss	2145			

4. Analysis and Discussion of Results

There are usually two types of heat loss: fabric loss and ventilation loss. Analysis and discussion are based on the results by Hevacomp Program.

4.1 Fabric loss

To the respective of the building construction, the numbers of the internal walls and external walls often have an impact on the heat loss because the "U" values and the respective temperature differences vary. From the general data sheet, the "U" value for external cavity wall 0.35 W/m2K is much lower than it for internal wall 1 W/m2K, which only contains one layer and do not have cavity space which can add "U" value (lower "U" value means better insulation). Thus the designed external cavity wall has made a great contribution to the reduction of heat loss theoretically. However, in fact, larger temperature difference between the inside and outside could raise the heat loss via external wall on the other hand.

The size of the room also should be taken into consideration, since that which would be increased instantaneously and corresponding with the roof, ground and wall areas. From the printed data, it can be roughly estimated that the larger room size, the greater the heat loss would take place. It happens similarly in the ventilation loss section, which may be talked about later.

In addition, the four chosen rooms all have its own double glazing windows. In the ordinary course of events, the window loss accounts for a significant proportion in fabric heat loss. It can be also proofed again by dividing the window loss by fabric loss, which is 493/ (2053-636) = 44.9% in this specific condition. Depending on the quantity and size, from this printed outcome, the apparent evidence is that the fabric loss of the window becomes larger along the increasing of the number and area of the glass. For example, the lounge has two windows, whose sum of window area is 4.28 m2, leading to the largest fabric window heat loss 33+177 = 210w. However, the "U" value for double glazing window is 2 W/m^2K. By comparing to the normal "U" value of single glass window which is round 5 W/m^2K [3], it decreases the heat loss to a certain extent. In spite of this, further lessen can be achieved to save energy by changing the style of the window, which will be introduced in the suggestion part.

4.2 Ventilation loss

The ventilation heat loss is basically connected with the volume of the room and air infiltration rate for the room and the air temperature difference between the inside and outside [2]. By compare and contrast the data provided, the three values of lounge largest and bedroom 3 smallest, bringing out that the largest ventilation loss in lounge (351w) and smallest in bedroom 3 (71w).

4.3 Recommendations for energy saving

As McMullan, R (2015) stated that the main factors influence the rate of heat loss are insulation of shell, area of the shell, temperature difference, air change rate, exposure to climate, efficiency of services and patterns of use. In other words, the approaches for energy saving can be obtained by changing these values, which seems that there are plenty of ways can be chosen. But in practice, some data is fixed or not given, such as the configuration of the building (including the size and shape of each room), indoor and outdoor temperature, air infiltration rate, etc. Thus, the rest can be alternatives to alter.

First for wall shell insulation, it is difficulty and unfeasible to replace the current insulation with high-efficiency insulation materials in the external cavity walls. But at the exterior surface of cavity wall, a coating layer with micro-porous can prevent the moisture from penetration to keep the wall staying in relatively wet condition, since the water can have an adverse effect on both insulation materials and brickworks, i.e. drawdown of insulation level. Moreover, the coating also behaves as an insulator to some degree [1]. From the view of energy-saving, in real life, the exterior coating can minimum the effects on insulation of the walls caused by variation of the environmental surroundings (mainly the weather) and introduce to further its ability to lower the heat transfer rate.

The exact amount of saving in heat loss of the first proposal is quite hard to take due to the limited information. Nevertheless, changing the window type is another proposal which can be calculated by adopting the typical value. Here, triple-glazing with multiple low-emissivity or low-emittance coating and Argon filled can be an appropriate choice for reinstallation, which has the “U” value of approximately 0.65 W/m^2K [3], much lower than the present double glazing window.

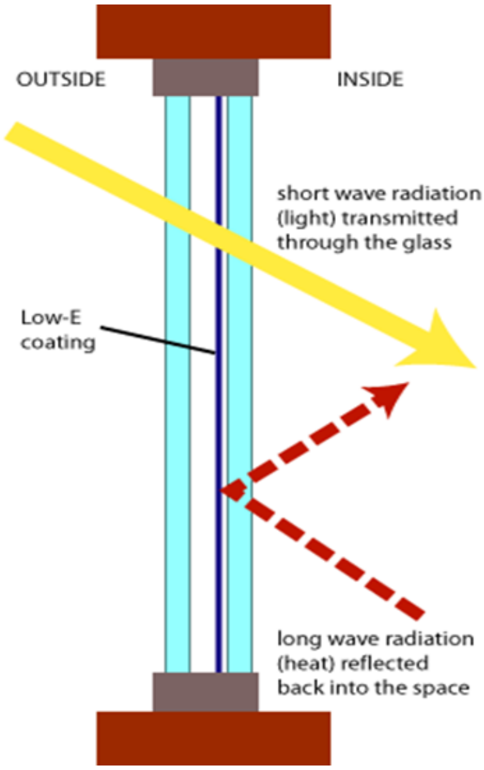

Fig. 1 Low-E coating

As defined by Efficient Windows Collaborative (2018) and National Green Specification (2018), Low-E coating is extremely thin and made by metal, metallic oxide or semiconductor film mostly covered the inner side of the glass to block the long-wave radiation and meanwhile is transparent to the short-wave radiation as Figure 1 shows. Since temperature outside is - 4℃ (cold climate), the solar radiation gain in daytime, which contains large quantity of short-wave radiation, plays a vital role in total heat gain of the building. The suitable window technology of low-E coating is rather proper in this building.

Another feature of the new window is triple glazing, which has a higher insulation value due to its added glass layer without question. Displayed in the heat maps blow, a triple glazed window is warmer over its entire glazed surface, including its edges.

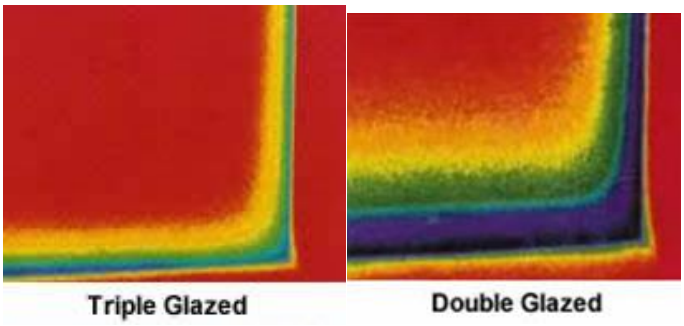

Fig. 2 The heat map of triple glazed and double glazed.

The argon filled in the space between glass layers is also effective to benefit a lot from reduction of heat transfer by conduction and convection [5].

To qualification, take the "U" value of 0.65 W/m^2K as mentioned previously to calculate the fabric heat loss of all windows in these four rooms.

$P_f = UA\Delta t$

Where

P_f = rate of fabric heat loss = heat energy loss/time (W)

U = U value of the element considered (W/m^2K)

A = area of that element (m^2)

Δt = difference between the temperatures assumed for the inside and outside environments (℃)

Put the data correspondingly into Table 5 below and do the calculations using the formula.

Table 5. Data infomation

Window (room)	1	2	3	4	
Area (length * width, m^2)	1.8*1.2	1.8*1.2	1.2*1.2	1.5*0.45	2.4*1.5
U value (W/m^2K)	0.65	0.65	0.65	0.65	0.65
Temperature difference (℃)	25	25	25	25	25
Fabric loss for each window (w)	35.100	35.100	23.400	16.875	58.500
Total heat loss (w)	35.100				

Compare to the current total window loss 493w, 35.1w is much smaller, indicating outperform in the building of this window style.

Apart from the structure modification proposals, an easier way is to improve the human sense of energy saving concept. As a single-story dwelling house, the thermal comfort is normally required for whole day. The heat is mostly gained by solar (achieved by first method), only a little is gained from occupants and equipment due to its house type offered for a few of people, not like the office building whose majority heat gain is from people's activities inside. Therefore people living inside can share rooms and do things together if they are not for privacy, for instance, studying and having meals. All these would obtain heat by not only human activities but also emission of the equipment, like radiators or artificial lights. Additionally, dwellers can do different things in different period of time. For example, in the daytime, occupants can withdraw the curtains and let more solar radiation penetrate into the room and do the opposite at night to preserve heat energy.

4.4 Assessment of the computer program

The computer program Hevacomp software is easy to use following the steps and printed results are clear and concrete to read. In addition, if users want to change the data input, the system will inform the users to correct other relevant statistics to make the process smoothly taken place. Accordingly to a certain extent, the heat loss program is useful and user friendly.

However, sometimes the process of data input cannot finish once if the user has to do other things urgently. When stopping in the middle of the progress, the program cannot save it and force the user to finish putting the information in surface tab with a warning window. It seems not so flexible and convenient.

5. Conclusion

Within the printed results of heat loss, in conclusion, the higher levels, such as areas, U value, and air discharge rate, the larger heat loss it will be. By printing insulation at the outside wall skin, reinstalling triple low-e window filled with Argon, and improvement of human sense, the current building can perform better and much energy can be saved.

For the computer program, the steps are easy to follow but the property of flexibility should be improved further.

References

[1] Efficient Windows Collaborative (2018). Window Technologies: Low-E Coatings.

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[3] National Green Specification (2018). Glass and Glazing.

[4] Passive House Institute (2016). Windows for Passive Houses – Superior Quality of Transparent Components.

[5] Wethertex UK (2019). Wall Coating Insulation Properties.