OPTIMISING THERMAL INSULATION OF BUILDINGS BY INFLUENCE OF THE SERVICE LIFE BY HELP COMPUTERS

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Abstract

For building constructions, a new philosophy of their designing has been formulated. According to this, a building construction of optimal design should have the required standard and the minimum sum costs to make up construction and running cost during the anticipated service life of a building. The thermal insulation has an important part of running cost by external walls windows and other external constructions. In this article is described only optimizing of external walls, roofs and ground floor of buildings.

KEYWORDS: costs to make up construction, running costs, service life of the building and constructions, the optimal thickness of the thermal insulation, the minimum sum costs to make up construction and running cost during the anticipated service life of a building, the increasing energy costs.

1. Optimization of building structures

Optimization of building structures is important research in the last time, while increasing energy costs is very important for this solution. The service life of building constructions should be possibly equal to service life of the building. Its requirement cannot be fulfilled with some constructions on the present level of scientific development. For example, the service life of some types of facades, textile floors, additional thermal insulation, windows, etc. is usually shorter than the service life of the building. That's why is necessity of their replacement, maintenance, repair, etc. It has influence on the running costs of the building. At designing certain constructions it is necessary to take into account not only costs to make up construction, but also the running costs during the anticipated service life of the building. For that reason I have defined a new philosophy of the building construction designing. A building construction of optimal design should - during the service life of a building - be characterized by the possibly lowest sum of costs to make up construction and running costs whilst keeping the required standard. The sum of costs to make up construction and running cost has been defined by the term of "overall costs during the service life of a building". (Next in text only overall costs). For designing of building constructions the overall building costs was the most decisive criterion. The verification calculations have proven that the running costs during the service life of a building may be several times higher than the costs to make up construction. That is why the running costs play an important part at designing and dimensioning of building constructions against unfavorable influence during the service life of a building. In that case, the construction is being dimensioned also according to its corrosion-resistance, its resistance against the impacts of polluted air, etc., during the whole service life. [1]

The thermal insulation has an important part of running cost by external walls, windows and other external constructions. [2] In this article is described only optimizing of external walls. The running cost of the optimized layer, constituting between indoor air temperature and outdoor air temperature are:
The cost of energy leaking from the interior to the exterior, and next
The cost of cleaning and maintenance of the constructions,
The cost of replacement of constructions with shorter service life than the building itself,
The cost of repairs.

Several experts say that the costs of energies could rise in the next 10 years. During the input of the data (row n. 13) this factor should be taken into consideration. Other costs may rise at well, but not so significant.

2. Application in computer program ZAMUE

For operational practical use computer software called ZAMUE was designed. The software program is designed for optimizing the thickness or the additional thermal insulation of building, so as to achieve minimal overall costs during the service life of a building.

If you want to optimize the thermal insulation of your building, you can order the calculation by the author.

3. Input data to computer program

First step is to fill up input data for external walls roofs and ground floor. In this contribution is only input data for external walls. Similarly is possible fill up input data for roof end lower level.

TABLE 1 INPUT DATA FOR OPTIMIZATION OF THE THERMAL INSULATION FOR EXTERIOR WALL					
DECISION BLOCK					
CODE FOR EXTERIOR WALL	1	CODE FOR ROOF COVERING	1	CODE FOR THE LOWER LEVEL	1
IF THE CODE OF THE CORRESPONDING STRUCTURE = 1, THE STRUCTURE IS RANGED INTO THE CALCULATION. FOR THIS STRUCTURE A TABLE OF INPUT DATA HAS TO BE FILLED OUT AND THE DATA HAS TO BE COUNTED IN INTO THE CALCULATION. IF THE CODE = 0 THE CORRESPONDING STRUCTURE AND DATA IS NOT RANGED INTO THE CALCULATION.					

No.	*Data name*	Type	Length of input	Input text
1	Comment	Text	75	Thermal insulation by Polystyren
2	Comment	Text	75	text in red color is input data
3	Number of layers in the exterior wall without the optimal layer	Integer	I 2	3

4	Layer name existent construction	Thermal conductivity coefficient [W/(m•K)]	Type	Input	Layer thickness [m] source project or measured	Type	Input
4.1	Inside plaster	$\lambda_{(1)}$ 1)	R	0.8	$d_{o(1)}$ 2)	R	0.025
4.2	Bricks	$\lambda_{(2)}$ 1)	R	0.86	$d_{o(2)}$ 2)	R	0.45
4.3	Outside plaster	$\lambda_{(3)}$ 1)	R	0.93	$d_{o(3)}$ 2)	R	0.03

	Name of the input data	Type	Input
5	h_i– Surface coefficient of heat transfer at internal surface of the structure [W/(m^2•K)]	R	6.0
6	h_e– Surface coefficient of heat transfer at external surface of the structure [W/(m^2•K)]	R	23.
7	λ – Thermal conductivity coefficient for the optimized layer [W/(m•K)] 1)	R	0.039
8	F_k – Cooled (heated) surface of the optimized layer of the exterior wall [m^2]	R	213.
9	F_u – Wall surface under maintenance for the optimized layer [m^2]	R	213.
10	Z_j – Durability of the building [year]	R	100.
11	$\Delta\theta$- Average temperature difference between indoor air temperature and outdoor air temperature, during the heated (cooled) season [K] 5)	R	18.6
12	P_d – Number of heated (cooled) days during the year [day] 6)	R	212.
13	K_e– Energy costs [€ /GJ]	R	14.516
14	K_v –Costs for the built-up space of the given building [€/m^3]	R	322.58
15	K_u –Costs for maintenance of the optimized layer during one year [€/m^2•year]	R	0.

16	Z_f – Year in the beginning of the period for the output document (current year) [year]	R	1.
17	Z_l – Year in the end of the period for the output document (current year) [year]	R	100.
18	N_4 – Number of types of changes made in the optimized layer structure [-]	R	1.
19	$C_{4(i)}$ – Period for first renewal of the optimized layer structure [year]	R	40.
20	$C_{(i)}$ – Period between the first and the following renewals of the optimized layer structure [year]	R	40.
21	$K_{n(i)}$ – Costs of renewing i-type optimized layer [€/m^3] for the type of renewing from (i)= 1 to N_4	R	390.323
22	A – Factor used to round up to whole number, eventually a factor to round up the period of the last maintenance before Z_l [-]	R	0.2
23	N_4 – Number of types of surface maintenance for the optimized layer [-]	R	1.
24	$C_{5(i)}$ – Period of the first surface maintenance for the optimized layer [year]	R	20.
25	$C_{f(i)}$ – Period between the first and the following surface maintenance for the optimized layer [year]		20.
26	$K_{n(i)}$ – Costs of i-type surface maintenance [€/m^2]of the type of surface maintenance for the optimized layer (i)= 1 to N_5	R	10.323

Note:

1) λ – Thermal conductivity coefficient [W/(m•K)] . Source STN (Slovak Technical Standard) 730540 – 3.

2) d - Thickness of the layers [m] according to the project.
3) h_i - Heat transfer coefficient at the inner surface [W/(m^2•K)] . Source STN 730540 – 3, tab. 10.

4) h_e – Heat transfer coefficient at the outer surface [W/(m^2•K)] . Source STN 730540 – 3, tab. 10.

5) $\Delta\theta$- Average temperature difference between int. and ext. during the heated (cooled) season [K], source Tab. 1, Notification 625/2006 Slovak Republic. The rates change according to the clime zone and elevation about sea-level.

6) P_d – Number of heated (cooled) days during the heated (cooled) season [day], source tab. 1, Notification 625/2006 Slovak Republic. The rates change according to the clime zone and elevation about sea-level.

I have prepared an example of the output of the program for you to be more informed about how the program works.

4. Output data from computer program

EVALUATION OF OPTIMUM THICKNESS OF THERMAL INSULATION
AND CALCULATIONS IN OPTIMUM THICKNESS CASE

Input: K7.dat,Output K7out
Family house

EXTERNAL WALLS:

Optimum thickness of the optimized layer = 10.114 cm

Rounded up value for the next calculation = 10.00 cm

Estimated life of the building = 100. years

Saving of expenses in one year with the

Optimum thickness of the insulation= 773. Euro

Return of insulation expenses = 8.88 years

Layers of primary construction external walls:

Nr.	Material title	Thickness (m)	Lambda W/(m.K)
1	inside_plaster	.025	.800
2	Bricks	.450	.860
3	Outside_plaster	.030	.930

```
      Cost  (x1000 Euro)
               70                  98                 126
    |--------------------------------------------------------------------|
  0 |                                                           *
  1 |                                      *
  2 |                         *
  3 |                  *
  4 |            *
  5 |         *
  6 |       *
  7 |     *
  8 |    *
  9 |    *
 10 |    *
 11 |    *
 12 |    *
 13 |    *
 14 |     *
 15 |      *
 16 |      *
 17 |        *
 18 |         *
 19 |          *
 20 |           *
    |----------+---------+---------+---------+---------+---------+-------|

               70                  98                 126
```

PICTURE 1: GRAPH OF COSTS AT CONSTANT TIME APPLICATION THE BUILDING 100 YEARS BY VARIABLE THICKNESS OF THE THERMAL INSULATION.
In picture 1 optimal thickness thermal insulation is 10 cm

In picture 1 between 10 cm and 0 cm the most increase running costs, but between 10 cm and 20 cm most increase costs to make up construction.

RESULTS WITH OPTIMAL LAYER THICKNESS

	OPTIMAL THICK.(CM)	RETURN OF EXPENCES(Y)	SAVINGS OF EXPENCES(Euro)	ANNUAL SAVING OF ENERGY(kWh)	ANNUAL SAVING OF CO2 EMISSION(kg)
WALLS	10.	8.9	773.	19297.	4506.
ROOF	7.	11.7	406.	11087.	2589.
FLOOR	18.	18.5	345.	7833.	1829.
		TOTAL	1524.	38217.	8924.

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Conclusion

Optimization of building structures is very important, while increasing energy costs. Energy costs have important influence to the running costs. A building construction of optimal design should - during the service life of a building - be characterized by the possibly lowest sum of costs to make up construction and running cost whilst keeping the required standard. The sum of costs to make up construction and running cost has been defined by the term of "overall costs during the service life of a building". For designing of building constructions the overall building cost was the most decisive criterion. The verification calculations have proven that the running cost during the service life of a building may be several times higher than the costs to make up construction. That is why the running cost plays an important part at designing and dimensioning of building constructions. The thermal insulation has an important part of running cost by external walls, windows and other external constructions. The running cost of the optimized layer, constituting between indoor air temperature and outdoor air temperature are:

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