Solution of Air Conditioning Cooling Load Temperature for New Energy-Saving Walls

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Abstract: With the development of wall reforms, the production scale and engineering applications of energy savings are increasing daily. It is inevitable to aggressively extend production of new energy-saving walls. Based on the thermal instantaneous response factors method, this paper compiles calculation programs, analyzes the datasheets of air conditioning cooling load temperatures of new energy-saving walls that can be the same with engineering, and consequently promotes the application of wall reformation production in the calculation of air conditioning load. The study will provide a scientific foundation for further research on thermal particularity and general particularity evaluation for new energy-saving wall construction.

Key Words: building energy conservation，cooling load temperature，transfer function，response factors method

1 INTRODUCTION

With the development of walls reforms, the production, production scale and engineering applications of energy- saving are daily on the increase. Therefore it is inevitable that to extend production of new energy-saving walls energetically, which are energy-saving, soil-saving and environment- protecting.

Solution of walls cooling load in building is vital, which is closely bound up with indoor thermal environment and energy saving in building. In 1982, cooling load coefficient method was examined and commented; cooling load temperature tables used in cooling load calculating for traditional walls was provided by this method. But there is a lack of the data for new energy-saving walls in building, which led to Lacking data in load calculating for air conditioning. Aiming at a series of new energy-saving walls in China building[3] see also table1, according to thermal instantaneous response factors method, the paper compiles a program to calculate, and educes the datasheets of air conditioning cooling load temperature of new energy-saving walls in China building.

2 RESEARCH METHODS

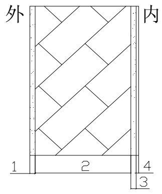
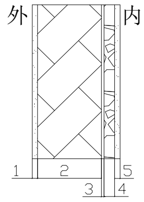
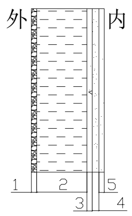
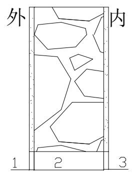
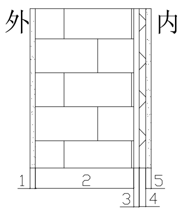
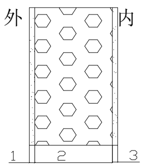
The study on the dynamic heat transfer of wall is the solving of temperature field and heat flowrate field which vary with time. On the part of air conditioning design, one of the most important outcomes is air conditioning cooling load temperature.

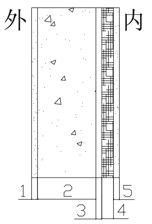
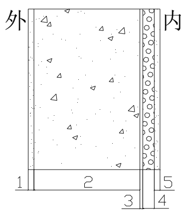
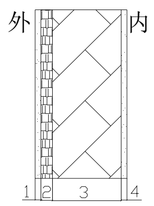
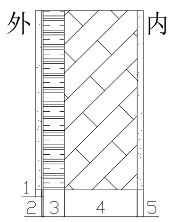
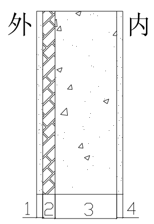
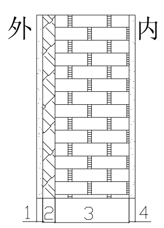
In the paper, thermal instantaneous response factors method is used for air conditioning cooling load temperature for new energy-saving[2], the process of which is: the disturbing quantity curve is dispersed in order of time of unit disturbing quantity; solve the response of wall thermal system to unit disturbing, which is response factors; worked out air conditioning cooling load temperature by superposing and integrating the response factors of wall.

The formula used to calculate the heat transfer thermal response factors $Y(j)$ are as follows:

$$j=0,\quad Y(0)=K+\sum_{i=1}^{\infty}\frac{B_i}{\Delta\tau}(1-e^{-\alpha_i\Delta\tau})$$

Tab.1 New energy-saving walls

serial number	Structure sketch	Thickness(mm)	arrangement name
1		20	1.cement mortar
		370	2.cellular clay bricks
		20	3.1.WE cement pearlite thermal insulating mortar
		20	3.2 JBS thermal insulating mortar
		10	4.cement mortar
2		20	1.cement mortar
		240	2.cellular clay bricks
		10	3.cement mortar
		40	4.1 hydrophobic resin expanded pearlite sheet
		25	4.2 expanded polystyrene sheet
		25	4.3 rigid rock wool sheet
		20	5. cement mortar
3		20	1.390mm×190mm×190mm three parallel orifice slag concrete cavity building blocks
		190	2.air space
		20	3.hydrophobic resin expanded pearlite sheet
		25	4.cement-lime mortar
		20	5.cement mortar
4		20	1.cement mortar
		290	2.390mm×190mm×190mm+390mm×90mm×190mm slag concrete cavity building blocks
		20	3.cement mortar
5		20	1.cement mortar
		370	2.solid Cellular clay bricks
		20	3.air space
		25	4.1 rigid rock wool sheet
		25	4.2 expanded polystyrene sheet
		40	4.3 hydrophobic resin expanded pearlite sheet
		20	5.cement-lime mortar
6		20	1.cement mortar
		200	2.high pressure steam cure solidify pulverized fuel ash cellular concrete building blocks
		20	3.mixed mortar

7		20 200 180 20 40 60 40 20	1.cement mortar 2.1 reinforced concrete wall 2.2 reinforced concrete wall 3. air space 4.1 rigid rock wool sheet 4.2 hydrophobic pearlite sheet 4.3 expanded polystyrene sheet 5.mixed mortar
8		20 370 10 40 60 40 20	1. cement mortar 2. reinforced concrete wall 3. air space 4.1 premoulded rock wool sheet 4.2 hydrophobic pearlite sheet 4.3 expanded polystyrene sheet 5.mixed mortar
9		20 40 240 20	1.cement mortar 2.hydrophobic resin expanded pearlite sheet 3.cellular clay bricks（23～26 orifice） 4.cement-lime mortar
10		20 5 70 240 20	1.special veneer mortar and coating 2.glass-fiber gauze cloth 3.thermal insulating layer 、 cement expanded polystyrene sheet 4.high pressure steam cure solidify pulverized fuel ash bricks 5.mixed mortar
11		20 40 200 20	1.cement mortar 2.expanded polystyrene sheet 3.reinforced concrete wall 4.mixed mortar
12		20 40 240 20	1.cement mortar 2.hydrophobic resin pearlite sheet 3.slag concrete cavity building blocks（two parallel orifice） 4.mixed mortar

$$j \geqslant 1, Y(j) = -\sum_{i=1}^{\infty} \frac{B_i}{\Delta\tau}(1-e^{-\alpha_i\Delta\tau})^2 e^{-(j-1)\alpha_i\Delta\tau}$$

Supplementary explanation in the above formulas must be pointed out: K is heat transfer coefficient of the wall ; $-\alpha_i$ is the root for the equation that is

$B(s)=0$,when $-\alpha_i$ greater（-40）, the program to solve the root will end, which satisfied precision requirements; $\Delta\tau$ is the discrete time that is one hour; As ASHRAE suggest, the range of the variable j is from 0 to 50, which satisfied precision requirements[2].

When we use thermal instantaneous response factors method, the first step in which is that the disturbing quantity curve is dispersed in order of time of unit disturbing quantity. It will be a long time before there is not thermal instantaneous response to a unit disturbing quantity at the calculation hour, so we must fall back on superposing and integrating the response factors to work out air conditioning cooling load temperature, the formula used to calculate air conditioning cooling load temperature $t_1(n,k)$ are as follows:

$$t_1(n,k)=\sum_{j=1}^{50} Y(j)\theta_Z(n-j,k)$$

Supplementary explanation in the above formulas must be pointed out: $\theta_Z(n-j,k)$ is solor-air temperature, k is the direction number of wall, n is the number n calculation hour. It is observed that the air conditioning cooling load at the number n calculation hour derive itself from not only the disturbing quantity at the number n calculation hour but also disturbing quantity at the number n calculation hour before, so we must multiply the heat transfer thermal response factors $Y(j)$ by the solor-air temperature $\theta_Z(n-j,k)$ at n-k calculation hour.

3 PROGRAMMING PROCESS

The processes of composing VB programme are as follows: input the physical property parameter of wall's material; calculate the root for the equation that is $B(s)=0$; calculate $B'(-\alpha_i)$, and input B_i , $B_i=-\dfrac{1}{\alpha_i^2 B'(-\alpha_i)}$; calculate the heat transfer thermal response factors $Y(j)$; input solar-air temperature $\theta_Z(n-j,k)$; calculate and output the air conditioning cooling load temperature of different direction walls $t_1(n,k)$ hour by hour.

4 PHYSICAL PROPERTY PARAMETER OF MATERIAL

Walls in building are multi layer structure those are built up of different material, the physical property parameter of which, involve density ρ , coefficient of thermal conductivity λ and specific heat c_p , derive from reference document [3].

5 THE COEFFICIENT OF CONVECTIVE HEAT TRANSFER OF AIR BOUNDARY LAYER AND THE THERMAL RESISTANCE OF AIR BLANKETING

According to reference document [4], the inner surface coefficient of convective heat transfer is 8.7 W/m^2℃, the outer surface coefficient of convective heat transfer is 19 W/m^2℃; The thermal resistance of air blanketing is can be derive from reference document [4].

6 THE RESULT OF COMPUTING

Aiming at a series of new energy-saving walls in table1, according to the above formulas, the paper compiles VB programs to calculate, and work out air conditioning cooling load temperature. Partial datasheet of 1st wall and 8th wall in table1 is given in the paper to fit an available space. The 3rd layer of 1th is WE cement pearlite thermal insulating mortar; the 4th layer of 8th wall is expanded polystyrene sheet.

The physical property parameter derive from reference document [3], ,involve density ρ , coefficient of thermal conductivity λ and specific heat c_p, are as follows table2， and the thermal resistance of air blanketing is 0.12K • m^2/W.

Tab.2 The physical property parameter

	ρ Kg/m3	λ W • m/K	Cp KJ/Kg • K
cement mortar	1800	0.93	1.05
cellular clay bricks	1400	0.58	1.05
WE cement pearlite thermal	400	0.078	1.05
reinforced concrete	2500	1.74	0.92
expanded polystyrene sheet	20	0.044	1.22
mixed mortar	1700	0.81	1.05

The air conditioning cooling load temperature for 1st and 8th wall are as follows table3, table4.

7 CONCLUSIONS

(1)Compared with the air conditioning cooling load temperature for traditional walls, the air conditioning cooling load temperature for new energy-saving walls drop off significantly, so that the air conditioning cooling load for new energy-saving walls drop off significantly too, and there are marked effect in energy saving in building .

(2)The research applies the result of the reform in new energy-saving walls to air conditioning cooling load calculation. the paper educes the datasheets of air conditioning cooling load temperature of new energy-saving walls are to be published by way of book, which will change the existing condition that there is a lack of the data for new energy-saving walls in air conditioning cooling load calculation., and which will be applied to the referable scientific foundation for air conditioning design.

(3)It must be point out that the result of the air conditioning cooling load temperature in table2 only for the area in and around Beijing, multiply the data in table2 by the coefficient of correction, we can work out the data for the other area by [5].

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[3] Energy conservation in building office of ministry of construction. Comprehensive collection of technique specification for energy saving in building. China Architecture and Building Press, 2003.5. (in Chinese)

[4] Ministry of construction P.R. of China, National standards of the People's Republic of China, Code of thermal technique design in civil architecture（GB 50176-93），China Architecture and Building Press, 1993. (in Chinese)

[5] Jiping Shan. Practical computational methods for air conditioning load. Beijing：China Architecture and Building Press, 1989. (in Chinese)

Tab.3 Air conditioning cooling load temperature for 1st wall ℃

the time of day	orientation								
	S	SW	W	NW	N	NE	E	SE	H
0:30	11.0	11.4	11.5	11.3	11.2	10.9	11.0	11.0	11.4
1:30	10.5	10.8	10.8	10.7	10.7	10.5	10.5	10.5	10.8
2:30	10.1	10.2	10.3	10.2	10.2	10.1	10.1	10.1	10.2
3:30	9.8	9.8	9.9	9.8	9.8	9.8	9.8	9.8	9.8
4:30	9.5	9.6	9.6	9.6	9.6	9.5	9.5	9.5	9.6
5:30	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
6:30	9.4	9.4	9.4	9.4	9.4	9.3	9.3	9.3	9.4
7:30	9.8	9.8	9.8	9.8	10.3	12.0	12.5	11.3	10.7
8:30	10.5	10.5	10.5	10.5	10.9	14.4	15.7	13.9	12.9
9:30	11.8	11.3	11.3	11.3	11.5	16.0	18.2	16.4	15.6
10:30	13.6	12.1	12.1	12.1	12.5	16.5	19.6	18.4	18.5

11:30	15.5	12.8	12.8	12.8	13.1	16.0	19.9	19.6	21.2
12:30	17.2	14.4	13.5	13.5	13.7	15.7	19.0	20.0	23.5
13:30	18.6	16.4	14.7	14.1	14.3	15.6	17.9	19.4	25.3
14:30	19.3	18.6	16.8	14.7	14.7	15.5	17.1	18.2	26.2
15:30	19.3	20.3	19.0	16.0	14.9	15.4	16.4	17.3	26.2
16:30	18.6	21.6	21.2	17.7	15.0	15.3	16.0	16.5	25.9
17:30	17.3	21.8	22.6	19.1	14.9	15.1	15.5	15.8	24.2
18:30	16.2	21.0	22.7	19.8	15.0	14.7	14.9	15.1	21.8
19:30	14.8	18.2	19.5	17.5	14.1	13.9	14.0	14.1	18.6
20:30	13.8	16.1	17.0	15.7	13.4	13.2	13.3	13.3	16.3
21:30	12.9	14.5	15.1	14.2	12.7	12.5	12.6	12.6	14.5
22:30	12.2	13.2	13.6	13.0	12.1	12.0	12.0	12.0	13.2
23:30	11.6	12.2	12.4	12.1	11.5	11.4	11.5	11.5	12.2

Tab 4 Air conditioning cooling load temperature for 8th wall ℃

the time of day	orientation								
	S	SW	W	NW	N	NE	E	SE	H
0:30	18.4	18.4	18.5	18.4	19.1	18.3	18.3	18.3	18.4
1:30	17.6	17.7	17.7	17.7	17.9	17.6	17.6	17.6	17.6
2:30	17.0	17.0	17.0	17.0	17.1	17.0	17.0	17.0	17.0
3:30	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6	16.6
4:30	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
5:30	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3	16.3
6:30	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4	16.4
7:30	18.1	18.1	18.1	18.1	19.6	25.1	26.6	22.9	21.0
8:30	19.8	19.8	19.8	19.8	20.5	30.3	34.0	29.3	26.8
9:30	23.3	21.5	21.5	21.5	21.8	32.0	37.9	34.2	32.8
10:30	27.3	23.0	23.0	23.0	23.8	30.9	38.4	36.9	38.4
11:30	31.2	24.3	24.3	24.3	24.7	28.2	36.6	37.8	43.2
12:30	34.2	28.2	25.5	25.5	25.7	27.2	32.8	36.8	46.8
13:30	35.9	32.9	28.3	26.4	26.5	27.1	29.6	34.0	48.7
14:30	36.0	37.2	33.3	27.3	27.0	27.3	28.4	30.3	48.8
15:30	34.6	39.9	38.2	30.6	27.1	27.2	27.7	28.5	47.1
16:30	32.1	41.1	42.0	34.4	26.9	27.0	27.2	27.6	45.7
17:30	28.6	39.9	43.3	37.0	26.3	26.3	26.4	26.6	40.2
18:30	26.3	36.2	41.3	36.9	26.7	25.3	25.3	25.4	34.2
19:30	23.6	28.0	30.2	28.3	23.8	23.2	23.2	23.2	27.1
20:30	22.1	24.0	25.0	24.2	22.2	21.9	21.9	21.9	23.7
21:30	21.0	21.9	22.3	21.9	21.0	20.9	20.9	20.9	21.7
22:30	20.0	20.4	20.6	20.5	20.1	20.0	20.0	20.0	20.4
23:30	19.2	19.4	19.4	19.4	19.2	19.2	19.2	19.2	19.3