A STUDY ON AC LOAD IMPACT BY AC PATTERN AND HEAT INSULATION METHOD OF SUPER HIGH–RISE RESIDENCES

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ABSTRACT

This paper examines air-conditioning loads by several air-conditioning patterns and heat methods of a super high-rise residence by using the dynamic simulation software “THERB” (the simulation software of the thermal environment of residential buildings) which can estimate temperature, humidity, sensible temperature, and heating/cooling load for multiple zones of buildings. As high-rise residences, the ratio that the structural skeleton dominates a floor area is bigger than that of ordinary residences, and its skeleton is used concrete generally. Heat capacity has a considerable impact on air-conditioning load of high-rise residences. Meanwhile, aspects of air-conditioning style, heat insulation style, structural form and building direction affect to air-conditioning load of high-rise residences significantly.

Recently, high-rise residences are to be more and more important factor in our life with its rapid development. It is respected that most people will chose high-rise residences, because of its popularization. Therefore, we must reduce energy consumption for keeping environment load reduction in high-rise residences. Based on above mentioned, heat environment impact on high-rise residences will become an important issue in our society.

KEYWORDS

High-rise Residences, Heat Load, Heat Capacity, AC Pattern, Heat Insulation

1. INTRODUCTION

AC loads in two cases are compared to examine the influence of heat storage capacity of structural walls and slab floor with different AC styles (Intermittent AC two patterns and 24-hour operating AC one pattern). One of insulation method is a case that insulation is put on interior walls, ceilings and floors, and the other case of insulation method is no insulation except exterior walls. In Japan exterior walls are generally insulated, but neither are interior walls, nor ceilings and floors.

As super high-rise residences, a floor area ratio of the structural skeleton dominates is bigger than ordinary residences, and its skeleton is generally made of concrete. The concrete has high heat capacity which would have a considerably high impact on AC load of each unite of super high-rise residences. Then we examine the annual air-conditioning load of a typical super high-rise unit which has structural frame walls at both sides.

Table 1 is the outline of the high rise residence. We chose as a model of simulation.

Table 1 The outline of residence

Building Use	residences + hospital
Construction	RC
Stories	27 floors above ground
	1 floor under ground

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Height	96.7 m
Ground-round area	3991 ㎡
Building area	3179 ㎡
Gross Floor area	31779 ㎡
Building Coverage	79.7%
Bulk Ratio	607.4%

2. METHOD OF SIMULATION

We use THERB (Simulation software of the thermal environment of residential buildings), a dynamic simulation software which can estimate temperature, humidity, sensible temperature, and heating/cooling load for multiple zone buildings. THERB has the following features.

1) The successive transition method and the trapezoid hold function which can adjust itself to the time-discrete domain.

2) Dimensionless equations are used to calculate convective heat transfer coefficients for every part of.

3) The long-wave and short-wave absorption coefficients make it possible to simulate the net absorption of radiant heat and transmitted solar radiation.

4) A multi-layer window model, which defines the overall transmittance, absorptance and reflectance of solar radiation.

5) A network airflow model is used to calculate ventilation quantities.

2.1. Simulation Model

The objective of simulation model is a unit of the super high-rise residence above mantand.

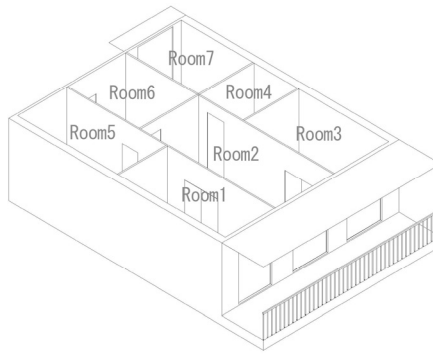


Fig. 2.1 The Image of Unite for Simulation

3. SIMULATION PATTERNS

The super high-rise units with different heat insulation types and different AC styles have been examined. The results that are from Jan.1st to Dec. 31st have been used.

3.1 Heat Insulation Cases

Super high-rise units with two cases have been examined. One is structural walls insulation on structural walls, ceilings and floors. The other one is no insulation except exterior walls. Table 2 shows the site of heat insulation.

Table 2 Site of heat insulation styles

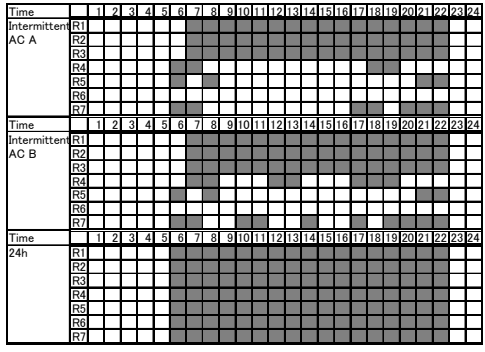
	Ceiling	Flooring	Structur Wal	ExteriorWall
No insulation				
All insulation				

※ Heat insulation
No heat insulation

3.2 Air-Conditioning Pattern

There are three patterns investigated. Two patterns as intermittent air-conditioning and one pattern as 24-hours operating AC. Intermittent A is a pattern as the AC is used for less time in a day. Intermittent B is a pattern as the AC is used for much time in a day. Moreover, three types of family as user of three patterns of AC are imaged. The temperature of heating AC is 17℃, the temperature of cooling AC is 28℃. Particular about AC is showed in Table 3.

Table 3 Particular about AC



※ AC ON
AC OFF

Intermittent A: corporate ranks husband, corporate ranks wife, three children
Intermittent B: corporate ranks husband, full-time housewife, three children
24-hours: the same as intermittent B.

4. RESULTS OF SIMULATION

4.1 Annual AC Load

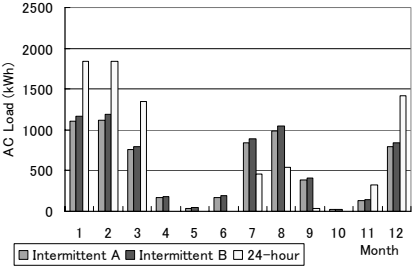


Fig.4.1.1 Monthly AC load of three AC patterns with insulation

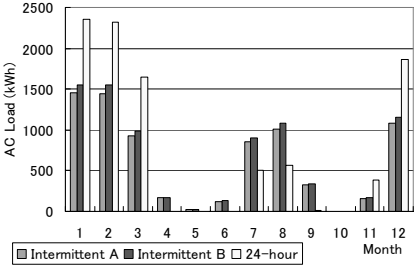


Fig.4.1.2 Monthly AC load of three AC patterns without insulation

Fig.4.1.1 shows monthly AC load of three AC patterns with insulation. The AC load with 24-hour AC is 1840.0kWh in Feb. It is the highest value in a year.

Fig.4.1.2 shows monthly AC load of three AC patterns without insulation. The AC load with 24-hour AC is 2355.4kWh in Jan. It is the highest value around one year.

As a result between Fig.4.1.1 and Fig.4.1.2, the biggest impact from insulation on AC load in winter is clearly. In February, AC load of the case with insulation is 20.8% lower than without insulation with 24-hour AC, and when using the intermittent AC B which is about 23.3% lower than the without insulation.

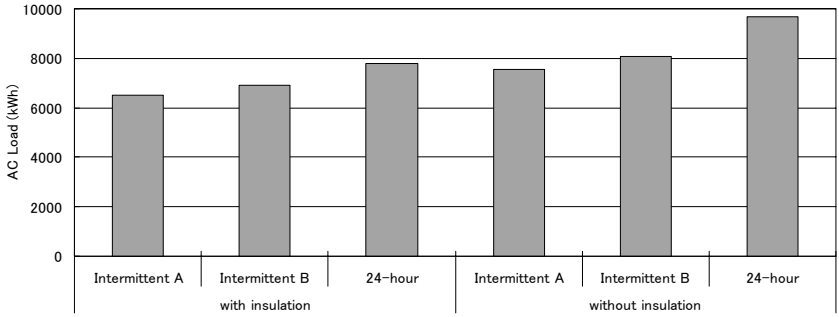


Fig.4.1.4 Annual AC load in three AC patterns with two heat insulation styles

Fig.4.1.4 shows annual AC load in three AC patterns with two heat insulation styles. The AC load with the case of insulation and intermittent AC A is 6499.0kWh in a year. Meanwhile, the AC load is the lowest. The AC load without insulation and 24-hour AC is 9661.1kWh in a year. AC load in all of the cases is the highest. The value of that is 3162.1kWh (32.7%) lower than what is highest one.

In the case of insulation, AC load with 24-hour AC is 16.6% (1292.5kWh) higher than the case of intermittent AC A. And also, It is 11.2% (868.8kWh) higher than the case of intermittent AC B. And when it is without insulation, AC load with 24-hour AC is 21.8% (2109.4kWh) what is higher than intermittent AC A. It is 16.5% (1594.5kWh) higher than the intermittent AC B. AC load with insulation is 13.9% (intermittent AC A) ~ 19.4% (24-hour AC) lower than without insulation in a year.

4.2. AC load in winter

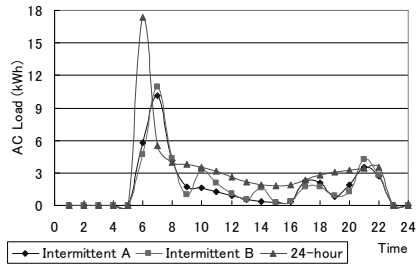


Fig.4.2.1 The results of AC load of three AC patterns with insulation on Feb. 8th

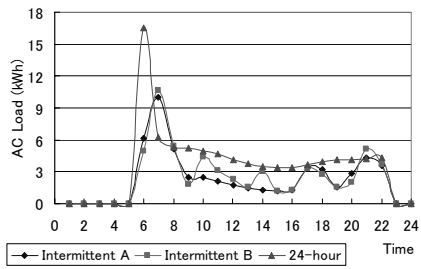


Fig.4.2.2 The results of AC load of three AC patterns without insulation on Feb. 8th

Fig.4.2.1 shows the results of AC load in three AC patterns with insulation on Feb. 8th. Fig.4.2.2 shows the results of AC load in three AC patterns without insulation on Feb. 8th. AC load with 24-hour AC is higher than the intermittent AC with tow insulation styles. On morning, AC load is the biggest in Feb. 8th at the time of turning on the AC.

In the case of insulation, AC load with 24-hour AC is 66.3kwh on Feb. 8th. AC load with intermittent A is 40.4kWh on Feb. 8th what is the lowest one among three AC patterns. AC load with intermittent A is 25.9kWh (39.1%) lower than the one with 24-hour AC. In the case of without insulation, AC load with 24-hour AC is 85.8kWh on Feb. 8th. AC load with intermittent A is 54.4kWh on Feb. 8th what is the lowest one among three AC patterns. AC load with intermittent A is 31.4kWh (36.6%) lower than the one with 24-hour AC.

Daily AC load on Feb. 8th is compared between insulation and without insulation. In the case with 24-hour AC, AC load with insulation is 19.5kWh (22.8%) lower than the without insulation. In the case with intermittent A, it is 14.0kWh (25.8%) lower than the without insulation. In the case with intermittent B, it is 15.3kWh (26.3%) lower than the without insulation. The reason is that the concrete have a high thermal capacity.

4.3. AC load in summer

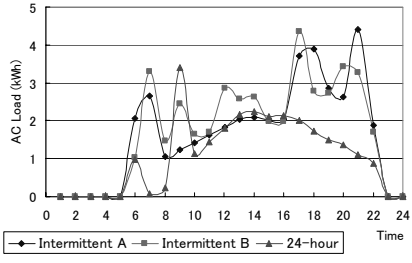


Fig.4.3.1 The results of AC load of three AC patterns with insulation on Jul. 20th

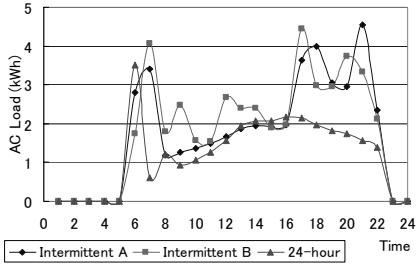


Fig.4.3.2 The results of AC load of three AC patterns without insulation on Jul. 20th

Fig.4.3.1 shows the results of AC load in three AC patterns with insulation on Jul. 20th. Fig.4.3.2 shows the results of AC load in three AC patterns without insulation on Jul. 20th. In the case of insulation, AC load with intermittent AC B is 41.9kWh on Jul. 20th. AC load with 24-hour AC is 26.3kWh on Jul. 20th, what is the lowest among three AC patterns. AC load with 24-hour AC is 15.6kWh (37.2%) lower than that with 24-hour AC. In the case without insulation, AC load with intermittent AC B is 44.1kwh on Jul. 20th. AC load with 24-hour AC is 29.0kWh on Jul. 20th. That is the lowest among three AC patterns. AC load with 24-hour AC is 15.1kWh (34.2%) lower than the one with intermittent AC B.

Daily AC load on Jul. 20th is compared with between insulation and without insulation. In the case with 24-hour AC, AC load with insulation is 2.7kWh (9.3%) lower than that without insulation. In the case with intermittent A, it is 2.0kWh (4.8%) lower than the one without insulation. In the case with intermittent B, it is 2.2kWh (5.0%) lower than the one without insulation.

AC load reduction by insulation in summer is not so lot as much as in winter. The reason is effect by insulation. In the case with insulation, heat can not through the wall during daytime. During night, air temperature of outside is lower than room's temperature. AC load also rate up in that case.

5. CONCLUSIONS

The impact of two insulation styles and three AC patterns on AC load of a high-rise residence have been verified. As the effect of high heat capacity of structural skeleton, the heating load and cooling load will be cut down by interior wall insulation. It is verified in different lifestyles by using different AC patterns. As the result of less impact from structural skeleton, the AC load has turned to be lower with interior wall insulation especially in winter than no interior wall insulation which is standard of today's Japanese high-rise units.

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