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Calculation of Heating Load for an Apartment Complex with Unit Building Method

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***Abstract*—**As a simple to method estimate the plant heating energy capacity of an apartment complex, a new load calculation method has been proposed. The method which can be called as unit building method, predicts the heating load of the entire complex instead of summing up that of each apartment belonging to complex. Comparison of the unit heating load for various floor sizes between the present method and conventional approach shows a close agreement with dynamic load calculation code. Some additional calculations are performed to demonstrate it's application examples.

***Keywords*—**Unit Building Method, Unit Heating Load, TFMLoad.

I. INTRODUCTION

CURRENTLY from ratio increase of the apartment complex and energy consumption increase of the building section, the heating energy consumption from the apartment complex is increasing. Therefore the energy consumption from the apartment complex is a matter of primary concern. In order to regulate the energy usage indiscreet, the government enforced 'the energy saving design criteria' issued in 2003. When urban development planning, the energy usage plan must establish. The energy usage plan include the result which predicts the energy amount used of the apartment complex.

In order to predict the energy amount used or to estimate the heating capacity of the apartment complex, it does a heating load calculation. This time is applied the load calculation method the unit generation method, that of each building is summed. When we calculate a heating load of one building which the apartment complex whose heating is provided by central heating method belongs to. Thermal loads of each house hold. We sum up as shown in Fig. 1.

This method based on each unit household could provide the correct data. However, this approach spends lots of calculation time. In this work to improve the efficiency of thermal load calculation, a building is regarded as a zone for thermal load calculation.

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II. CALCULATION MODEL OF HEATING LOAD

A. Apartment Complex

In this work, the apartment complex of typical type for thermal load calculation is shown in Fig. 2. The apartment complex model considered in this work has four buildings. The apartment complex is composed of four buildings, and floors put out. The areas of households are presented in Table I.

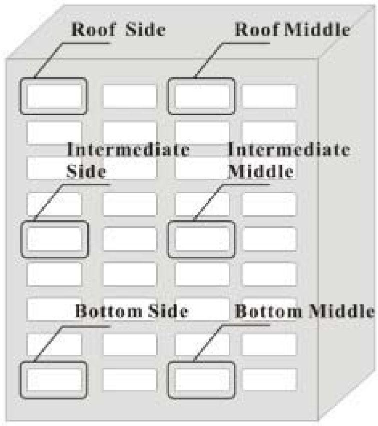


Fig. 1 Different apartment houses in a building

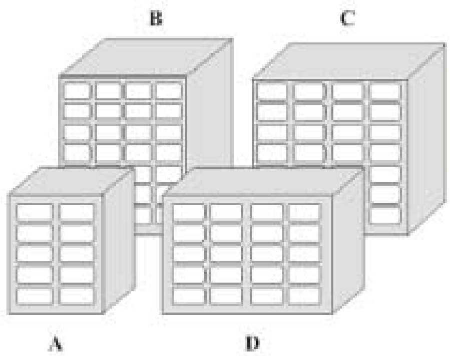
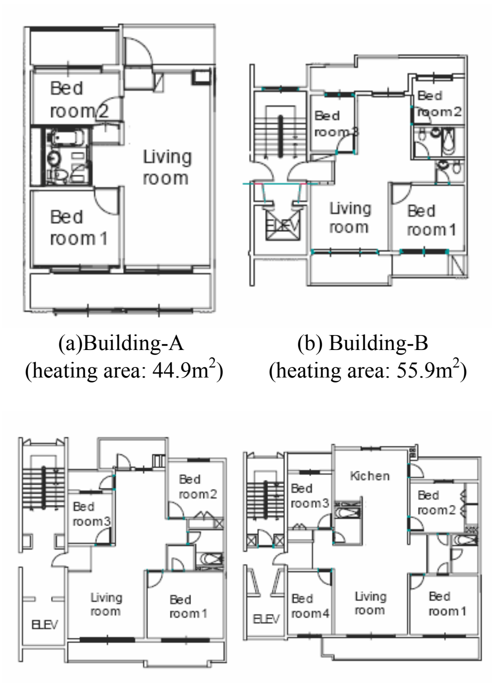


Fig. 2 Apartment complex

TABLE I
CONSTITUTION OF APARTMENT COMPLEX

Building	Apartment area [PY]	Floors	Households per Floors	Total Number of household
A	15	15	4	60
B	22	20	4	80
C	32	20	4	80
D	49	15	4	60



(a)Building-A (heating area: 44.9m^2) (b) Building-B (heating area: 55.9m^2)

(c) Building-C (heating area: 84.7m^2) (d) Building-D (heating area: 135m^2)

Fig. 3 Models of apartment house in present investigation

B. Unit generation method

The schematic diagrams of four types of each household are shown in Fig. 3. Heating area excluded stair case, elevator, balcony areas. The total height is 2.6m. The distance from the floor surface to the ceiling is 2.35m.

C. Details of households in buildings

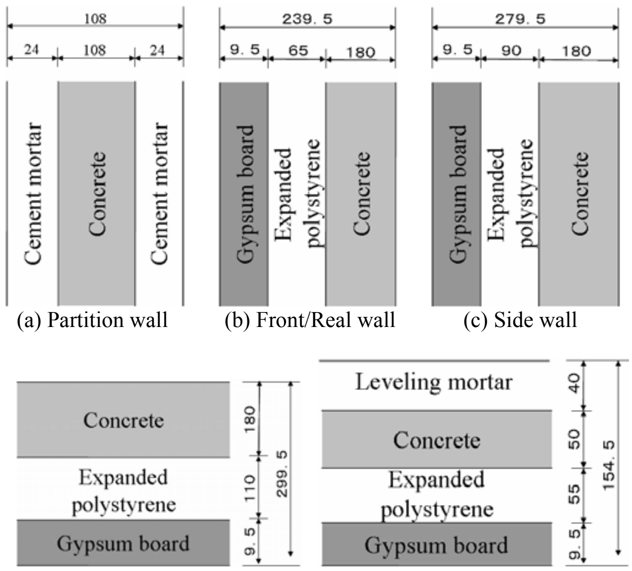
In the buildings, B, C, and D type, the staircase and elevator room are excluded from the heat area. The temperatures of the staircase and the elevator are assumed to be an average of outside temperature and room temperature. Since those spaces can be considered as buffering areas. The roof has a flat surface and the first floor is contacted to the ground. The window areas of front side and backside are 80% and 35%, respectively.

According to the energy saving design criteria of the building issued in 2003, the thickness of insulation wall and thermal conductivity is presented in Table II. The insulation criterion is bases on the standard of the central region of Korea. The thickness and compositions of the wall are shown in Fig. 4. The insulation is not applied to the partition walls of each household. Other walls except partition wall are made of gypsum boards. The bottom surfaces of the first floor has a floor heating type (Korean Ondol)

The other physical properties of the building materials are presented in Table III. The thermal conductivities of each material are found in the energy saving design criteria of 2003. Such as specific heat and density are obtained in the SAREK (The Society of Air-Conditioning and Refrigerating Engineers of Korea) ‘facility engineering handbooks’ [5].

TABLE II
REGULATIONS ON INSULATION MATERIALS FOR APARTMENT BUILDINGS IN CENTRAL KOREA

Wall type	Minimum thickness [mm]	Thermal conductivity [W/m · K]
Partition wall	-	-
Front/Rear wall	65	0.034 or less
Side wall	90	
Roof	110	
Lowermost floor	55	



(a) Partition wall (b) Front/Real wall (c) Side wall

(d) Roof (e) Floor

Fig. 4 Details of floors and walls (unit: mm)

TABLE III
THERMO PHYSICAL PROPERTIES OF WALL MATERIALS

Material	Thermal conductivity [W/m · K]	Specific heat [kJ/kg · K]	Density [kg/m^3]
Gypsum board	0.21	1.13	910
Expanded polystyrene	0.034	1.25	28
Concrete	1.62	0.79	2400
Autoclave lightweight concrete	0.17	1.09	600
Mortar	1.51	0.79	2000
Leveling mortar	0.37	0.79	2000
Double windows	Overall heat transfer coefficient 3.0W/m^2·K		

III. LOAD CALCULATION METHOD

For thermal load calculation method the TFM Load with the TFM algorithms are applied. The TFM algorithm has been known as the most accurate calculation method for thermal load calculation [6]. For the dynamic thermal load calculation dry bulb temperature is at each time step, absolute humidity and daily solar radiation are required. To obtain those data of SAREK (The Society of Air - Conditioning and Refrigerating Engineers of Korea) are converted for TFM Load input conditions. The used room temperature is 20°C, which is the suggested temperature 'Energy savings design criteria of 2003'. The ventilation rate is 0.85 ACH.

The general design criterion for ventilation is 1.5 ACH. However the measurement shows 0.4~0.82 ACH [2] or 0.28~0.583 ACH [3] at a Korean apartment household. The measurement results have a big difference with a design criterion of 1.5 ACH. This big difference caused by the fact that the newly built apartment is well-sealed and the opening of doors, windows and the operation of ventilation fans are neglected.

In this work, we selected 0.85 ACH, which satisfies 0.7 ACH of the Japanese standard. Shading factor of solar radiation is not included in the analysis by assuming that the next building does not interfere with the solar radiation. The temperature of underground is 15.57 °C which is an average of four years.

IV. APPLICATION RESULT AND INVESTIGATION OF UNIT BUILDING METHOD

A. Validity Investigation

Table IV presents thermal load of each of building. For convenient comparison unit heating load, which can be obtained by dividing total thermal load by total heating area. $q_{apartment}$ is a thermal load of each household. $q_{building}$ is a summation of $q_{apartment}$ in a building.

TABLE IV
RESULTS OF HEATING LOAD CALCULATION

Building	Total heating area [m^2]	Unit heating load [W/(h · m^2)]		ε [%]
		$q_{apartment}$	$q_{building}$	
A	2694	65.10	64.85	-0.39
B	3954	57.71	57.74	0.04
C	6776	51.26	51.23	-0.07
D	8100	47.57	47.03	-1.14

The errors of $q_{apartment}$ by unit household method and $q_{building}$ by unit building method are expressed by Eq. [1]. The errors are within ±2%.

$$\varepsilon = \frac{q_{building} - q_{apartment}}{q_{building}} \times 100[\%] \quad [1]$$

Since the safety factor is 10% in thermal load calculation, the error of 2% is allowable. The thermal load of the entire apartment complex can be calculated by the unit building method.

B. Effect of Orientation Buildings

The A, B, C and D buildings are assumed to be oriented the south. Since the orientation of the front side building affects the thermal load calculation, 8 directions are selected for thermal load calculation. The calculation result is provided in Table V. The orientation makes a 2% maximum error when the smallest south orientation is compared with the largest north orientation.

TABLE V
UNIT HEATING LOAD WITH BUILDING ORIENTATION

Orientation	Unit heating load [W/(h · m^2)]			
	Building			
	A	B	C	D
S*	60.08	57.99	51.23	47.03
SW	60.42	58.32	51.52	47.33
W	60.16	58.07	51.30	47.12
NW	61.08	58.96	52.08	47.85
N	61.41	59.27	52.36	48.10
NE	61.27	59.14	52.24	47.99
E	60.19	58.09	51.32	46.72
SE	60.59	58.49	51.67	47.46

V. CONCLUSION

This work, suggested the unit building method to improve the thermal load calculation. To verify the unit building method, the conventional unit household method and the unit building method are applied to the identical apartment complex. The results of each method agree well within ±2% of error. To find the effect of the orientation of each building, 8 orientations are selected for thermal load calculation. The thermal load of a north oriented building is larger than that of a south-oriented building by 2%.

The load calculation expense to the unit generation method application at the time of 102 times, to the unit building method application at the time of it appeared in case 4 times. When per load calculation once assuming the necessary time in 5 minutes, the unit generation method application at the time of 510 minutes, the unit building method application at the time of 20 minutes. This compared in unit generation method and the unit building method application at the time of load calculation expense was decreased about 96%. And the unit building method will be able to apply the load calculation for the heating device capacity estimate at the time of the large scale house for creation plan or the apartment complex for facility planning.

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