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Assessment of Cooling Energy Performance for a Healthy Apartment Buildings in Korea

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ABSTRACT:

In general, balconies in apartment building connect the internal with the external environment as climate-filter that can minimize indoor environment changes with the changes of outdoor climate. Moreover, balcony can control thermal comfort, cold draft and the heating and cooling load in the buildings. However, as Korean government permitted balcony extension in apartment housing in 2006, many construction companies developed different apartment floor plans considering balcony expanding but not considering the energy issues. In this study, thermal performance comparison of 1 unexpended balcony and 3 expended balcony floor plans were investigated through the simulation methods to identify the energy efficient floor plans in apartment building. Based on the results of simulation, increasing rate and the area of cooling loads were analyzed.

Conference Topic: The Earth/Desert/Green and Sustainable Buildings
Keywords: Balcony, Cooling energy, Apartment buildings, IES VE

1. INTRODUCTION:

Balcony is an essential factor for controlling the indoor thermal environment by connecting the internal with the external environment as a climate-filter. Moreover, balcony can control thermal comfort, cold draft and the building energy loads. As Korean government permitted balcony extension of apartment buildings in 2006, most of the construction companies design apartment floor considering the balcony remodeling and the occupants prefer to live in the balcony extended houses.

However, as extended balcony increased in apartment buildings, some problems such as increase of heating and cooling load, surface condensation and the cold draft has been occurred. Therefore, occupants who want the balcony extension need to consider the cost, forms and energy efficiency. But building energy performance assessment is not compulsory in Korea so construction companies are not insufficient to give specific information of balcony extension relate to the energy issue.

As a first part of the building energy simulation, this paper outlines the cooling load of cooling period and the increasing rate of cooling load and cooling area under different extended balcony plans.

2. SIMULATION MEHOD:

2.1 Apartment floor plan:

The floor area of base case was $106m^2$ with 2.3m height which is most popular floor area in Korea [1]. The case plan consisted of 4 bedrooms, living room, kitchen and 2 bathrooms. The balcony was detached in each bedroom, living room and the kitchen. To simplify the simulation, only the zone boundary was simulated. The floor plan was classified as A, B, C, D and E as shown in figure 1. For the comparison analysis between the expended area and the cooling load, total of five cases were selected according to the expending balconies under different locations.

(a) Type A (a: 0 m^2, b: $106m^2$)

(b) Type B (a: 31 m^2, b: $137m^2$)

(c) Type C (a: 22 m^2, b: $128m^2$)

(d) Type D (a: $8m^2$, b: $114m^2$)

(e) Type E (a: $5m^2$, b: $111m^2$)

Fig.1 sustainability in underdeveloped
(a: expended floor area, b: total cooling area)

2.2 Simulation inputs:

To analyze building energy performance, IES Virtual Environment (VE) software was used. Simulation inputs for cooling energy load are shown in table 1. The cooling duration was assumed from May to September, and the indoor temperature was assumed as 24°C according to the previous study [1,2]. All the simulated cases were set to south orientation with no obstacles in surround area. For the wall and floor material, concrete was selected and the concrete material layer and properties were chosen as table 2. To minimize the conduction heat loss from floor, external and internal wall, upper and lower storey was simulated. To qualify the balcony expansion regulation, double glass window was used for the expended balcony. The infiltration coefficient was approximated from the previous study [1,2] and the air filtration flow rates were then calculated at 0.8~0.9 air changes/hour.

Table.1 Simulation conditions

	Conditions
Cooling month	May-Sep.
Indoor temp.	24°C
Infiltration coefficient	0.59 l/(s.m.pa)
Weather data	Seoul
location	Longitude: 35.8 Latitude: 128.6

Table.2 Material properties

	Specific heat (J/kg.k)	Thermal conductivity (W/mk)	Density (kg/m^2)
Concrete	1000	1.13	2000
Lightweight concrete	840	0.16	500
Plaster	840	0.16	950
Mortar	800	0.72	1860
Polystrene	1400	0.03	30
Tile	800	0.84	1900

3. Results:

Based on the simulation inputs, simulation model predicted annual, monthly cooling load as shown in figure 2 and 3. The result showed that the cooling load varied according to the extended cooling area. Type A (not extended) showed lowest cooling load and type B (fully extended) showed highest cooling load.

May showed significantly lower cooling load in all types compare to the other month and August cooling energy use was the highest. Monthly cooling load increased to 6.4times from May to June, 1.5times from June to July, and 1.1times from July to August and decreased about 2.2times from August to September.

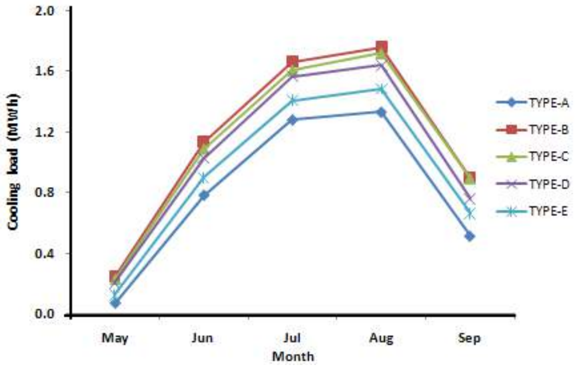

Fig.2 Monthly cooling load

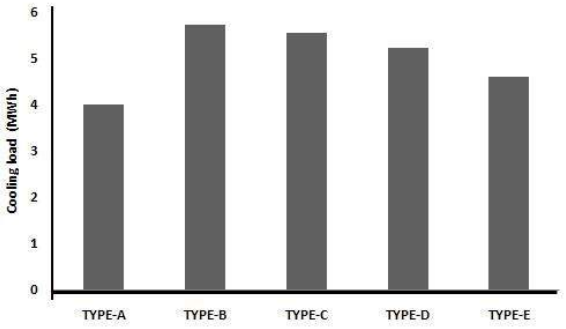

Fig.3 Annual cooling load

Increasing rate of cooling load and area in type B, C, D and E compared to type-A were analyzed to identify the relation between the cooling load and extended area (figure 4). The increasing gap between the cooling load and area showed different trend compare to the cooling energy use. The difference between the increasing rate of cooling load and area was 23% in type-D, 18% in type-C, 14% in type-B and 10% in type-E respectively.

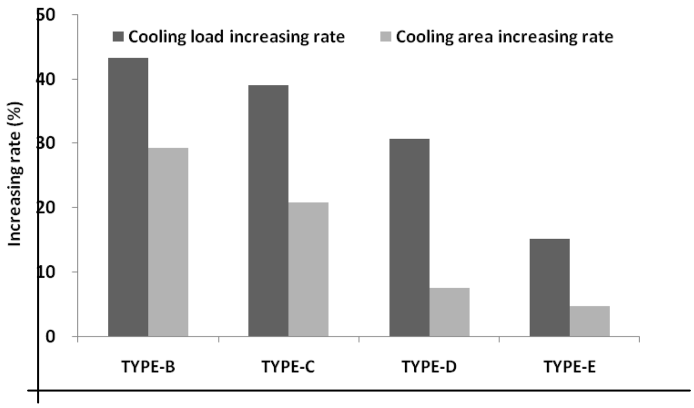

Fig.4 The bias of the increasing rate of cooling load and cooling area from type-A
(Type A: no expended balcony)

4. Conclusion

This paper investigated the cooling energy use of 5 different floor plans. The model was simulated by using VE software and the simulated data was analyzed by comparing monthly, annual cooling load and the increasing rate.

It was found that the cooling load increased with the increase of cooling area and identified that the balcony is a influential factor in indoor thermal environment. Keeping the balcony as a buffer zone will be the most effective way to improve healthy and energy efficient indoor environment. However, if extending, it should be carefully formed considering the energy usage and avoid fully extended balcony floor.

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