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Comparison of Daylight and View's Openness According to Apartment Master Plans

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Abstract— Korean Apartment buildings have constructed since 1970s. The apartment became typical housing type in the present. It has changed the urban landscape. Resident's preference and the development project of many new towns have increased the number of apartment. An architectural design for apartment complex has been developed for finding an optimum among density of complex, quality of residential environment and profitability. Flat buildings have changed to various shaped buildings as L or Y shape ones. The latticed and parallel placement with flat buildings also has varied the arrangement of buildings depending on building shapes. In this study, daylight environment and visual comfort according to apartment master plans were analyzed based on the change of the building shape and mixed arrangement. Simulation by Daysim checked the proper amount of daylight with actual window area. The result was compared in terms of the location and the floor height of each unit. In addition, quantitative comparison of view's opened was conducted and the difference of the view from the window in the living room was examined by images created in ECOTECT. Therefore, this paper examined how the apartment building shapes make the indoor environment different from the flat buildings.

Keywords—Building shape, Building arrangement, Daylight performance, View's openness, Window Area

I. Introduction

The housing statistics in 2010 showed that apartment buildings account for 60% of houses in Korea. There are two reasons to increase the apartment construction: first, many new towns have been developed and many apartment buildings occupied the land. Second, the apartment is more preferable than other housing type (Lee, 2014). Construction firms also have preferred them on account of expected higher profit originated from higher floor area ratio than other housing types. Moreover, most households live in apartment buildings at the present, and they can choose the apartment building for the next house. According to the survey, more than 60% respondents selected the apartment as an ideal housing type (Lee; 2014). These master plans largely have changed the urban arrangement. Differences are found in plans for length and height of the building, way of arrangement, facade coverage ratio and central square or wide pedestrian passages(Yu-Mi,L.,1999). It became the major reason why residents prefer transformed arrangement more than flat type buildings and the parallel placement regardless of facing the south(Hyun-Jin,P.,2006; Lee, 2014).

Therefore, this research will show how the apartment building shapes influenced by the resident's preference and consideration of the cityscape affect the indoor environment such as daylight and view's openness by quantitative analysis. It will focus on the flat and L shaped building with 60 ㎡ of exclusive residential area.

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II. Preference of Apartment Master Plans

A. *Survey of the Preference*

According to the 2010 population and housing census, the ratio of households living in the apartment is about 60% in Korea. The total number of households is about 15million, i.e. 14,877,000. The number of apartment ones is about 8.9million. Households living in detached house occupy 27%, which was main housing type more than 30 years ago. The ratio of non-apartment type in multi-family housing is 14%. Therefore, most Koreans live in the multi-family house and the number of apartment buildings with more than 5 stories is the highest.

Lee(2014) surveyed the preference of housing type. All respondents lived in public apartment. In the ideal housing type, 63% of them wanted to live in the apartment buildings by private construction firm or public corporation. It is shown that more people(63%) selected the apartment as future housing than ones that they previously lived in the apartment(45%). In addition, preference towards lower density apartment complex which has less than 350peoples/hectare (86%) was tremendously high. Therefore, the building density of the apartment complex was changed from 400% to 250% in the apartment master plan like as Table Ⅰ.

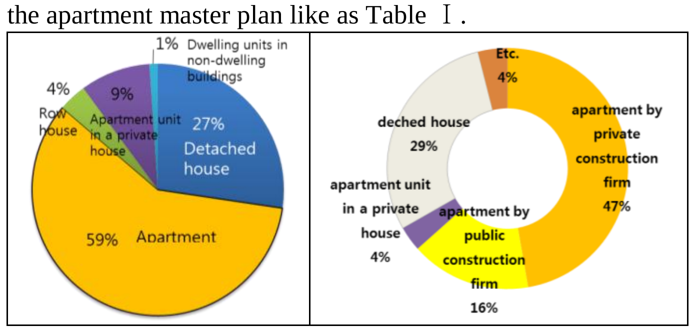


Figure 1. Households by type of living quarters in 2010(left) & Ideal housing type by Lee's survey in 2014(right)

Chan-Ho,K.(2011) reports that people mainly considered master plan, spatial organization, and size of apartments to buy a house in 2010 whereas safety, urban environment and size of the apartments were paramount in 2005. In 2010, direction, view and vertical location of units was essential to decide the housing location. However, direction and unit plan were regarded as more significant ones in 2005. This means that densification makes residents consider the proper density which ensures the daylight and view or the inconvenience of living in lower part or more than 20th stories.

The change of building codes as follows in Table Ⅰ make these changes possible. Allowable floor area ratio increased about two times for 12 years from 1979 to 1991. However, in 2009, the allowable floor area ratio was reduced again. In 1970's, site planning was focused on solar access and buildings are placed with same type and distance. Compared with the past, however, consideration of landscape became important element nowadays. Therefore, differentiated view is formed in recent apartment complex depending on the surroundings of a scene.

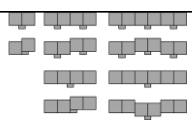
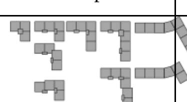
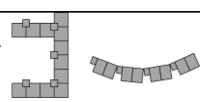
TABLE I. CHANGE OF BUILDING CODES(SEOUL)

Year of distribution	Standard			
	FAR	*BD to land ratio*	*pitch*	*references*
1979	200%	18%	1.25H	Mayor policy no.14
1985	250%	25%	1.25H	Mayor policyno.2016
1990	300%	30%	1H	Building ordinance
1991	400%	60%	1H	
2009	250%	50%	0.8H	

B. *Design Tendency Analysis of Apartment Complex in Competition*

In master plans selected by 140 housing competitions from 2012 to 2013, flat type buildings occupied 25% and L-shaped buildings did 75% in a total of 1021 buildings in the following table Ⅱ.

Table II. BUILDING SHAPES OF 2012-2013 LH SELECTED DESIGNS

Shapes	*2012*		*2013*		*Total*	
	Number of buildings	*Proportion (%)*	*Number of buildings*	*Proportion (%)*	*Number of buildings*	*Proportion (%)*
Flat type	184	24	73	29	257	24
L-shaped	584	75.9	175	69.4	759	75
Etc.	1	0.1	4	1.6	5	1
Total	769	100	252	100	1021	100
Details of shapes						
Flat type		L-shaped		Etc.		
						

Nowadays, certain conditions such as view, limit of length of the building, square and landscaping axis are reflected in law or guidelines of housing design competition for site planning (Young-Tae,K., 2010) Flat type and transformed type like L shaped type are mixed to place and the ratio of transformed type building increased gradually in the following table Ⅲ.

TABLE III. THE LATEST TENDENCY OF APARTMENT (N=140)

Characteristics		Number of buildings					
		1-4	*5-8*	*9-12*	*13-16*	*17-20*	*Total*
Number of cases		25	77	26	8	4	140
FAR(%)		151	170	165	168	178	166
Ratio of Building Shape(%)	*Flat*	19	23	28	25	34	24
	L	65	69	68	73	56	68
	Etc.	16	7	4	2	10	8
Number of Stories	*Min*	13	16	15	12	13	15
	Max	18	22	23	21	28	21

Table IV. THE RATIO OF BUILDINGS DEPENDING ON TOTAL FLOORS

Number of stories in a building	*Total buildings*	*Flat type*		*L-shaped*		*Etc.*	
		Number of buildings	*Proportion (%)*	*Number of buildings*	*Proportion (%)*	*Number of buildings*	*Proportion (%)*
1~5	2	0	0	1	0.1	1	20
6~10	29	12	4.7	17	2.2	0	0
11~15	162	52	20.2	106	14	4	80
16~20	522	136	52.9	386	50.9	0	0
21~25	278	54	21	224	29.5	0	0
26 ~	28	3	1.2	25	3.3	0	0
Total	1,021	257	100	759	100	5	100

Table V. NUMBER OF HOUSEHOLDS DEPENDING EXCLUSIVE AREA

Exclusive area(㎡)	*Total households*	*Flat type*		*L-shaped*	
		Number of households	*Proportion (%)*	*Number of households*	*Proportion (%)*
21	176	0	0	176	0.4
26	1,152	0	0	1,152	2.8
29	4,015	156	18.9	3,859	9.4
33	258	0	0	258	0.6
36	4,207	234	28.3	3,973	9.6
46	4,972	198	23.9	4,774	11.6
49	795	0	0	795	1.9
51	1,461	0	0	1,461	3.5
56	209	0	0	209	0.5
59	6,004	0	0	6,004	14.5
67	66	0	0	66	0.2
70	40	40	4.8	0	0
74	6,133	99	12	6,034	14.6
84	12,612	100	12.1	12,512	30.3
119	4	0	0	4	0
Total	42,104	827	100	41,277	100

[Note] The result of 4 complexes with only flat type buildings and 58 ones with only L shaped ones in total 140 complexes.

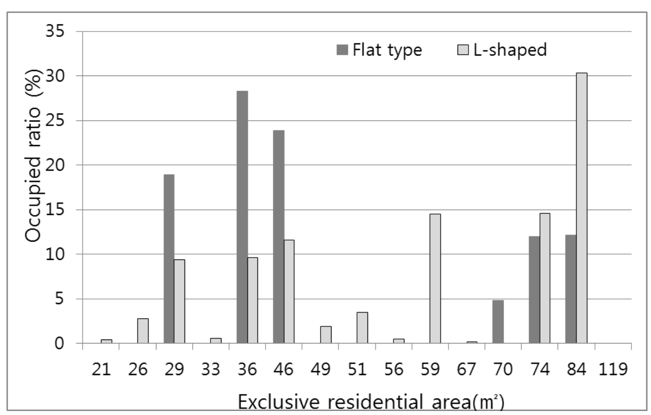


Figure 2. The percentage of exclusive area of households(N=140)

There is a difference how many stories were located in one building depending on the building shape. In the case of L-shaped building, the buildings have more stories than the flat type ones in the following table Ⅳ. In addition, in the floor area of each unit, L-shaped ones are mainly formed with 84 ㎡, which is mainly larger than 46 ㎡ of the flat ones in the following table Ⅴ and Figure 2. Flat ones are mainly comprised of 4 or 6 units. In the case of corridor access to housing, flat and L-shaped building have more than eight dwellings in one layer. By separating the core type as shown in the following table Ⅵ. The analyzed cases of this study have the core of direct access type and consist of 60 ㎡ floor area all houses.

Table VI. DISTRIBUTION OF CORE TYPE

Building Design		Building Shapes			
		Flat	*L-shape*	*Etc.*	*Total*
Component Ratio(%)		25	75	0	100
Total number of buildings		257	759	5	1021
Core type	***Direct access (buildings)***	200	600	2	802
	Corridor access (buildings)	57	159	3	219

III. Summary of Measurement

A. *Summary of analysis model*

This research was conducted from actual site planning by changing some of buildings to flat type. Difference of building shape makes two essential characteristics for comparison. First, the direction of each unit is either the same or the various. Second, L-shaped buildings have a special plan on the corner. The unit located on the corner has the different room arrangement and the area of building envelope.

Analysis model contained 11 apartment buildings. 3 buildings in the middle row were changed for comparison. 4 buildings on the left side which are placed in L shaped type have the same number of households and it is hard to plan as transforming to flat type to meet the condition of 1H. DA of the actual envelope was simulated and reducible area of the window area was examined through its result. Actual model for apartment complex modified one are shown as follows Figure 3.

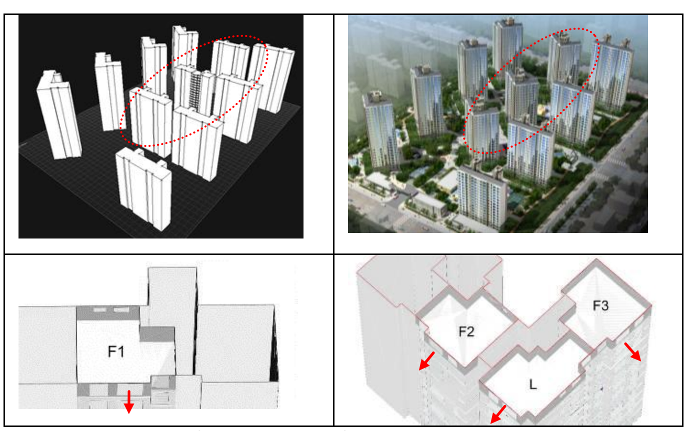


Figure 3. Modified model A(Left) and actual apartment complex plan B (Right). Arrows point the main direction.

TABLE VII. SUMMARY OF CASES ANALYSIS

Building Design		Master plan type			
		A	*B*		
Number of households		1050			
FAR(%)		191%			
Composition of buildings	*Flat*	7(64%)	4(36%)		
	L	4(36%)	7(64%)		
Units		**F1**	**F2**	**F3**	**L**
Floor area(㎡)		60	60	60	60
Window area(㎡)	*Main*	12.7	12.7	12.9	9
	Other	1.9	1.9	1.9	5.6
	Total	14.6	14.6	14.6	14.6
WFR(%)		24.3	24.3	24.3	24.3
Envelope area(㎡)		94.2	96.3	95.2	106.4
Window/envelope area(㎡)		15.5	15.2	15.3	14.7

B. *Material Planning for Exterior Walls and Windows*

In the case of window materials, thermal transmittance should be set more than adequate level of efficiency by 'Design standard for energy saving in building'. It is characterized that air-layer thickness of a window is 6~16mm and thermal transmittance is 1.8~4.0w/㎡ K according to composition of the window. Standard for a wall varies in different regions and 0.27~0.44w/㎡ K is shown when it reaches an outer wall directly. In other words, large area of a window enables to gain solar irradiance to utilize for heating but thermal loss is also severe. To conclude, unnecessarily wide area of a window is inefficient. Land and Housing corporation has own criteria that the window area of each unit is set with 20% of the envelope area. This case study took into account the window area as shown in the Table Ⅶ. However, it is necessary to adjust the size of windows by reflecting of this study depending on the floor level, the azimuth and the floor shape.

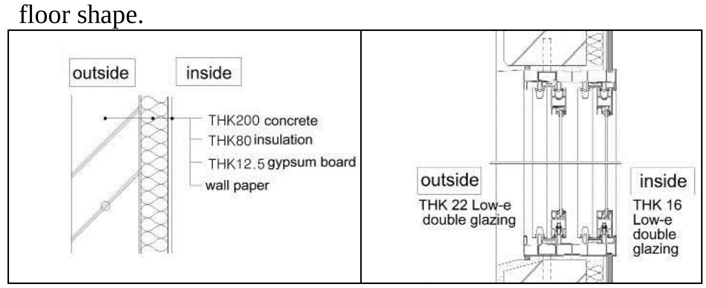


Figure 4. Sectional detail drawing of walls and windows

IV. Evaluation of Daylighting and View's Openness

A. *Comparison of Daylight Environment*

In the case of the apartment complex given as an example previously, unit plan in every type is set as approximately 60m^2 and composition of plan can be divided as two types. One is placed in flat type building which has windows in north and south and the other is located in corner of L shaped type building like Figure 3 as in the following. F1, F2, F3 were the same unit plan with the different azimuth angles; whereas, L unit are not in terms of fenestrated walls, location of rooms and ventilation performance. In general, windows are installed in different point to match with use of rooms while area of a window is similar. In this study, the difference of the daylight conditions by azimuth and shadow from other buildings found out. The required window area in the same building is different even on the same floor in the consideration of azimuth of each unit by referring to Table Ⅷ. Floors above 20th are not influenced by shadow from adjoining premises and have the same result, so same area could be set. To raise 1% of DA, the window size could be expanded up to 1% of window-to-floor ratio by referring to the result of L. Ji-Eun(2014).

In the case of housing, the criteria for LEED certification v.4 assigns a score of more than DA55% in the reference 300lx. This study set the 500lx reference of daylight and more than DA50% as the proper level of KS A 3011(2013). That is, in this study, the length of time that exceeds the 500lx between 8:00 and 17:00 has set four and a half hours or more as the lighting standards for each unit. The size of windows that do not meet the DA45~55% should be reduce or increase given the allowable range of 5%. Therefore, windows on the first floor were required the wider size and ones on the upper level need to reduce the size.

Table Ⅴ. DAYLIGHT AUTONOMY(DA) OF EACH OF UNIT

Type	F1	F2		F3		L	
Azimuth	*0°*	*-45°*		*45°*		*-45°*	
Stories	*DA*	*DA*	*F2-F1*	*DA*	*F3-F1*	*DA*	*L-F1*
1F	41[a]	39.8[a]	-1.2	44.0[a]	3	43.6[a]	2.6
3F	43.8[a]	41.4[a]	-2.4	45.9	2.1	45.1	1.3
7F	47.1	41.9[a]	-5.2	48.0	0.9	47.7	0.6
9F	48.4	44.0[a]	-4.4	49	0.6	50.3	1.9
11F	51.0	47.1	-3.9	51.0	0	52.3	1.3
14F	54.5	50.0	-4.5	55.1	0.6	56.6[b]	2.1
17F	59.8[b]	53.3	-6.5	58.4[b]	-1.4	60.8[b]	1
20F	66.9[b]	62.5[b]	-4.4	67.0[b]	0.1	66.7[b]	-0.2
Mean(%)	51.6	47.5	-4.1	52.3	0.7	52.9	1.3

a. The lack of sunligt
b. The oversupply of sunlight

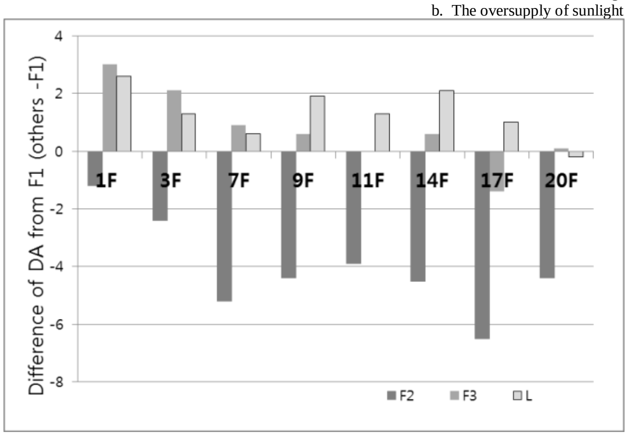
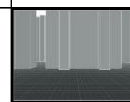
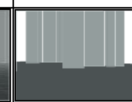
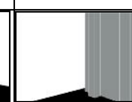
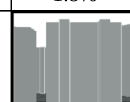
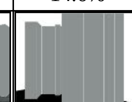
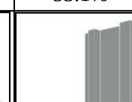
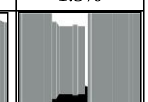
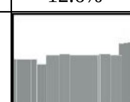
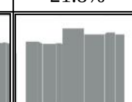
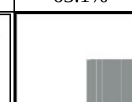
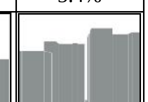


Figure 5. Difference of daylight autonomy(DA_{500}) depending on units

B. ***View's Openness***

The visual openness was estimated by the level that buildings do not block their views when the occupants view the outside in the living room. The images created in ECOTECT are related to view from the largest window at a right angle in the center of the living room. The area of the part that the view is blocked and opened was calculated by using Auto CAD. The four stories, i.e., 3th, 9th, 14th and 20th floor and four types of unit plans were analyzed for this comparison.

TABLE VI. VIEWS FROM THE LARGEST WINDOW IN THE LIVING ROOM

Building Shape		Flat	L-shaped		
Units		*F1*	*F2*	*F3*	*L*
3 F	*View[a]*				
	Ratio[b]	0.5%	11.3%	35.7%	1.2%
9 F	*View*				
	Ratio	1.8%	14.6%	53.1%	1.5%
14 F	*View*				
	Ratio	12.6%	21.8%	63.1%	5.4%
20 F	*View*				
	Ratio	44.4%	38.4%	78.1%	28.7%

a. White : sky, openness; Grey : buildings ; Black : the ground
b. Ratio = area of openness(white) / the largest window area X 100

The window size of the cases that the openness area is less than 40% should be determined by the view by referring to the result of K.Kwang-Ho(2005). In the 20th floor, the view's openness is relatively better. Thus, reducing the size of windows could be favorably considered. The possible area is different depending on the location of each unit in Table Ⅶ.

TABLE Ⅶ. COMPARISON OF DAYLIGHT AND OPENNESS FOR THE VIEW

Building Shape		Flat		L-shaped					
Location		F1		F2		F3		L	
		Value	*Suit (㎡)*	*Value*	*Suit (㎡)*	*Value*	*Suit (㎡)*	*Value*	*Suit (㎡)*
3 F	*Daylight*	43.8	↑[a] 0.6	41.4	↑ 2.1	45.9	-[b]	45.1	-
	Openness	0.5		11.3		35.7	-	1.2	-
9 F	*Daylight*	48.4	-	44	↑ 0.6	49	-	50.3	-
	Openness	1.8	-	14.6		53.1	-	1.5	-
14 F	*Daylight*	54.5	-	50.0	-	55.1	-	56.6	↓ 0.9
	Openness	12.6	-	21.8	-	63.1	-	5.4	
20 F	*Daylight*	66.9	↓[c] 7.0	62.5	↓ 4.4	67.0	↓ 7.0	66.7	↓ 6.9
	Openness	44.4		38.4		78.1		28.7	

a. The meaning : 0.6 ㎡ of total window area is more needed for more than DA45%.
b. - : properness
c. The meaning :7.0 ㎡ of total window area can be reduced for more than DA55%

V. Conclusion

The environmental characteristic and performance, especially daylight and view's openness were identified through case analysis of the plan for apartment complex which was selected by recent housing design competition. To examine the difference of the indoor environment of each unit depending on the building shape, the result of daylight autonomy by DAYSIM and the view images by ECOTECT were simulated. The results are summarized as follows.

First, the selected master plan in LH 2012 and 2013 competition contained 68% of L shaped type and 24% of flat type in the rate of mixed type buildings in average. 5~8 buildings in one block is the most common. In addition, most complex plans have various apartment building shapes. The analyzed result is shown that L shaped building is taller and has larger floor area of each unit. In total, buildings of 16~25stories occupied more that 50% of all buildings. More than 29% of L-shaped buildings have 21~25stories; while, more than 20% of flat buildings do 11~15 stories.

Second, DA of each unit in L-shaped apartment buildings is different depending on the azimuth or the floor level. The unit(F3) facing on the South-East have the similar to the unit(F1) facing on the South in the flat building. The unit facing on the South-West has the 4% lower DA. The unit(L) locating on the corner in the L-shaped building is the highest daylight performance due to the fact that sunlight can be provided from the directions of South-East and South-West. On the whole, higher than 17^{th} floors exposure to excessive sunlight and the unit on the ground level lack the sunlight.

Finally, the dwellings in the flat buildings paralled to each other take the poor view due to the fact that it faces other building's front or back squarely. In this study, the calculation result of view's openness show that units on the corner of L-shaped buildings have the worse condition. However, the living rooms of the corner units have bigger windows on both sides of the corner. Thus, the visible window area can be expanded and the views from various directions are possible. Actually, there is high possibility to make up for the weakness.

This study implied that if not-flat buildings mixed with the flat buildings in an apartment complex, it probably could cause increase of preference and construction cost. L-shaped buildings are flawed in terms of orientation and construction cost than the flat building. That is to say, the buildings had poorer orientation while spaced out buildings, and raised the quality of view from windows. In addition, construction cost could go up because of envelopes and the underground work for parking space. To conclude, L shaped apartment buildings in a complex should be mixed with proper ratio and compatible design. If not units with the poorer orientation and unnecessary spending for construction would increase.

Acknowledgment

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