Daylight Quality Potency at Sarijadi Mass Public Housing in Bandung Indonesia

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Abstract
Apartment Sarijadi Bandung (ASB) is a first-generation mass public housing (1975) in Bandung Indonesia is intended as mass public housing for the lower middle income, and until now still inhabited. ASB is the only apartment in the city designed as cluster typology with one staircase lined to four dwelling units, so that the wall has openings on outer façade and inner court facade. One of its design approaches is to optimize natural lighting with wall openings on those two-façade. This study aims to determine the extent of a natural lighting at ASB that is designed with optimization approach of the natural lighting. This study used quantitative methods. Field surveys conducted to obtain data of (1) physical spatial configurations of architectural elements, and (2) illuminant of the residential units, which will be used for analyzing how much the natural lighting potential in the residential units at ASB. The finding is the innovations of disclosure of influence factors of the architectural physic-spatial configuration to day lighting potential in vertical residential building typology as in the ASB. It is a useful new finding to be applied in supporting the development of science and technology and procurement related to vertical housing that provide opportunities for better life quality and energy efficiency in urban areas.
Keywords: Daylight, physic-spatial configuration, apartment, Sarijadi Bandung Indonesia

1. Introduction

1.1 Background

Natural lighting in dwelling units of apartment for the lower-middle-income people is very important to be concerned, because it directly affects the visual comfort of the occupants in the day-to-day activities, and indirectly affect the use of energy for artificial lighting is to be financed.
More than a half of the total electricity consumption is used for building. Natural lighting can be used to reduce artificial lighting, so the design of building form plays an important role (Nikpour et al, 2011). Recent studies reveal that 50-60% for air conditioning and 20-30% for artificial lighting (Lam and Li, 1996).
Among the many parameters that can affect the energy consumption in buildings, especially tall buildings are window to wall ratio (WWR), coefficient of solar heat gain (SHGC) and light transmittance (LT) have an important role in the amount of solar heat and light into in the room and have a significant impact on energy consumption in buildings (Nikpour et al, 2011).
In Hong Kong, recently there has been an increasing interest to use natural lighting to save energy in buildings (Lam and Li, 1996). According to Zain-Ahmed et al (1998) in Malaysia, size of the window (the facade openings) is 25% WWR, for building without fin, while in Hong Kong, research shows that the optimal WWR for building with fin is 36%. (Nikpour et al, 2011).
Indonesia by Ministry of Human Settlement and Regional Infrastructure has regulations on window to floor ratio (WFR). The minimum skylight should be one-tenth of the floor area of the room. WFR is more related to the quantitative of space floor size and the figure of the building façade. The WWR is quantitatively also associated with the amount of wall area and direct impact on the building façade.
Apartment is a multi-story residential building, which always has a dilemmatic problem between shape and size of facade openings design, with thermal comfort and visual quality perceived by the occupants. Therefore, research on the ASB' WWR is very important to do. Additionally, architecturally the WWR is very important to be concerned, because it is closely related to the balance between the aesthetics of the building and building energy usage for lighting, especially for multi-story building that requires the use of energy in appropriate proportion.
Apartment Sarijadi Bandung (ASB) is a first-generation mass public housing (1975s) in Bandung city, and is still inhabited. It is one of the mass public housing in Bandung that is intended for lower middle-income people. ASB is a unique mass public housing in terms of as the only existing vertical residential in Bandung city, which has a series of cluster typology with one stair for every four dwelling units. ASB quite often become the research object, but less is discussed about natural lighting potential that is associated with the daylight simulation by DIALux software.

1.2 Research problems

From the phenomenon that was compiled above, research problems can be formulated that the correlation between the physic-spatial configurations of architectural elements with the potential of natural lighting in the units of ASB is need to be investigated.

1.3 Research questions

From the research problems, derived the following research questions. (1) How does the physic-spatial configurations of architectural elements (PSCAE) dwelling units on ASB? (2) To which extent the PSCAE affect potential natural lighting (PNL) in ASB?

It is important to know to get a better understanding of the link between PSCAE and PNL on vertical housing, considered that PSCAE is the important architectural realm in the realization of space in the dwelling unit especially on vertical housing.

1.4 Special purpose

To complete vocabulary of knowledge that can be used as suggestions for optimizing the better use of natural lighting, through physic-spatial configuration of architectural elements.

1.5 Research urgency

By knowing the PNL of the certain PSCAE, it is expected to obtain a better suggestion for a better PSCAE design. By knowing the extent to which PSCAE, can help to optimize the PNL, it is expected to obtain architectural intervention suggestions what can be put forward to be done by the relevant stakeholders.

Of scientific advice needed to complete vocabulary of architectural knowledge about management in urban vertical mass housing. The suggestions are very important for all those who take part related to initiators, planners, designers, developers, builders, managers, and supervisors of vertical housing in urban areas, which cannot be denied as important part for the future of cities in Indonesia.

1.6 Target of findings

The findings are the disclosure of PSCAE influence factors at ASB buildings that tend to provide opportunities to obtain optimal PNL. It was expected to be a useful new finding to be applied in supporting the science and technology development and procurement related to vertical housing that provide opportunities for better life quality and energy efficiency in urban areas.

2. Literature review

2.1 State of the art

Though not entirely, a good architectural product is a form of the built environment that can make the better quality of life. Therefore, ongoing efforts to find physic-spatial configurations of architectural elements that offer an opportunity to make a better quality of life are a must (Suriansyah, 2012). One of them is to find the physical configuration of spatial architectural elements that give optimal natural lighting opportunities. Therefore this study used the theoretical foundation that includes the results of research related to the principle of natural lighting, as well as some earlier research that addresses similar issues in the study of different objects, as well as previous studies related to the ASB.

Several previous studies related to this research topic, among others: (1) Analysis of the Refurbishment Process in Lithuania in Terms of Sustainable Development, by Lina and Andrius Seduikyte Jurelionis; (2) Ventilation and Infiltration in High-Rise Apartment Buildings by Richard C. Diamond, Helmut E. Feustel and Darryl J. Dickerhoff, (3) Energy Conservation in Multifamily Housing: Review and Recommendations for Retrofit Programs by John DeCicco and Loretta Smith, Rick Diamond, Steve Morgan, Janice Debarros, Sandra Nolden, and Theo Lübke, Tom Wilson, (4) Comfort Analysis of a Passive House in Different Locations in Italy by Alessia Giovanardi, Alexandra Troi, Wolfram Sparber, Paolo Baggio; (5) Analysis of Thermal Comfort in Flats Sarijadi by Irena V. Gunawan; (6) Evaluation of Building Form and Massing in Gallery Ciumbuleuit Apartment Buildings, by Budi Harja; (7) Building Configuration Optimization in Housing Planning Project for Supporting Performance of Photovoltaic Modules with a case study: Flats Planning in Bandung City by Septana Bagus Pribadi; and (8) Effect of Psychological Comfort on Choosing Apartment Unit with Apartment Majesty as the object of study, by Desy Tri Handy. As far as tracking previous studies that have been done, such studies like this research have not found.

3. Methods

This research used descriptive and quantitative method, looking for correlations between the variable of physic-spatial configuration of architectural elements (PSCAE) with the potential for natural lighting (PNL) in dwelling units in the Apartment Sarijadi Bandung. The PSCAE variable consists of sub-variables are unit type, space lay-out, and window to wall ratio (WWR) of the dwelling units. The PNL variable consists of sub-variables illuminant and isolux on residential units in ASB.

3.1. Flow chart of the research

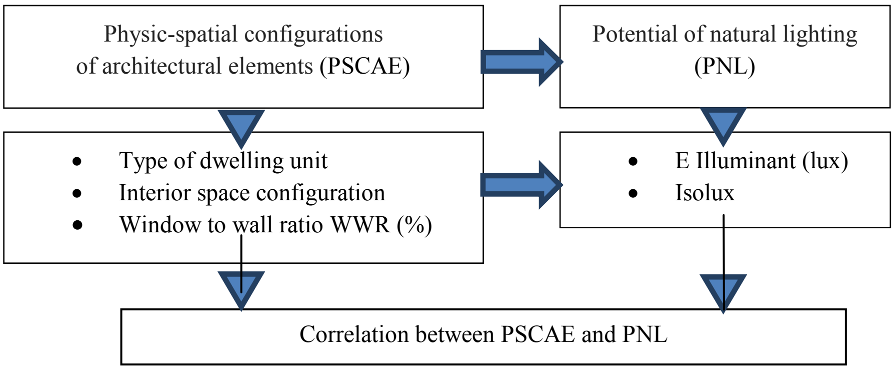


Figure 1 Flow chart of research

3.2 Stages of research

As seen in the diagram above, the study started with a field survey to collect data about the physic-spatial configurations of architectural elements at ASB, which consist of the type of unit, space lay-out, window to wall ratio (WWR) of dwelling units, and data on potential natural lighting consisting of illuminant (lux) and its contour line or isolux.

PSCAE data was collected by recording in the form of notes and drawings 2 and 3 dimensional of residential units in the study to show the three sub-variables mentioned above. The data of the three sub-variables is needed to determine to what extent the type of unit effects to the potential of natural lighting to come.

Data of the PNL was obtained through simulated measurement of the dwelling units are studied by using free-software DIALux version 4.9 to determine the base-line of natural lighting obtained in each type and lay-out, as well as a wide range of WWR of dwelling units. Potential of natural lighting was interpreted from illuminant scale and isolux distribution on residential unit space, and then compared with the natural lighting requirements based on the National Standards for Indonesians living space. The group of variables was then analyzed by using descriptive cross-correlation, so as obtained certain configurations trend descriptions that produce certain natural lighting.

3.3 Research outcomes

As seen in the research diagram, the expected outcome of this research is the description of the spatial correlation between the physical configurations of architectural elements with the potential natural lighting in residential units in mass public housing Sarijadi in Bandung Indonesia. Outcomes of this research can be used to construct hypothetical comparison between ASB with other mass public housings in terms of the correlation between PSCAE and PNL on each of its. The hypothesis can be put forward as part of a more complex research requiring greater funding.

4. Location and description of research object

Location of research object is in Jalan Sarijadi Bandung Indonesia, where ASB is located. Apartment Sarijadi Bandung (ASB) compound consists of 11 long type blocks (LB) and 5 short type blocks (SB). All long blocks facing west north-west and east north-east are row of 4 clusters consist of 4 units which are united by a stair, while the short type is a combination of the two clusters. See Figure 2.

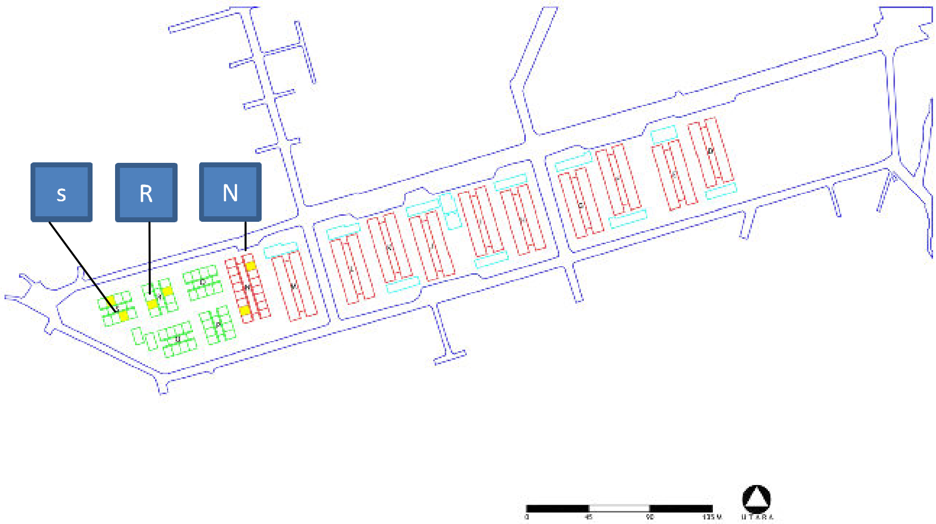
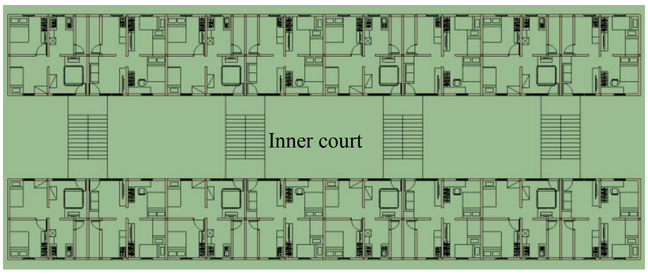


Figure 2. Apartment Sarijadi Bandung (ASB) compound in Bandung Indonesia

Dwelling unit as research object was taken as the unit of analysis, by purposive sample, taken at least one unit on each side of the block on each floor, as seen in the following pictures. Building blocks to be surveyed are Block S, R, and N. Those blocks were chosen because they represent every type of blocks in the ASB compound. Block S represents the type of short blocks with orientation to the north north-west and south south-east. Block R represents the type of short blocks facing west north-west and east north-east. Block N as representative of long blocks types, all facing towards the west southwest and east north-east. Both block types have similarities and differences in terms of the interior space composition. The similarity, both have size 36 m2, consist of two bedrooms, a sitting room (living room as well as a family room), a kitchen and a toilet. Bedrooms are on one side by side. See Figure 3, 4, 5, & 6.



Outer façade

Figure 3. Long block type (LB)

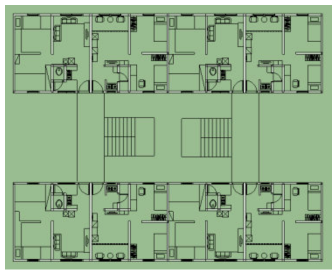


Figure 4. Short block type (SB)

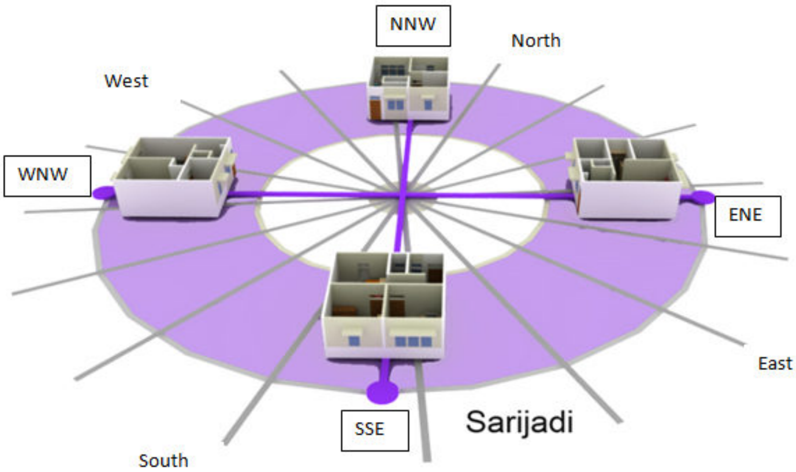


Figure 5. Residential unit name based on its façade direction

Figure 6. Façade deviation from North
(Source: GoogleEarth)

The difference is in the arrangement of these spaces. On LB, service zone (toilet and kitchen) is on outer façade side, while the SB, the service zone is on the inner court façade side. Thus contrary to the position of sitting room, at LB is located on inner court side, while at the SB is on the outer facade side, which is adjacent to the courtyard space. Both have a partition which is in the middle of the room, separates and located between two bedrooms, although not completely blocks the separated spaces, but partition has the potential to reduce the entry of light into the depths of space. See Figure 7 & 8.

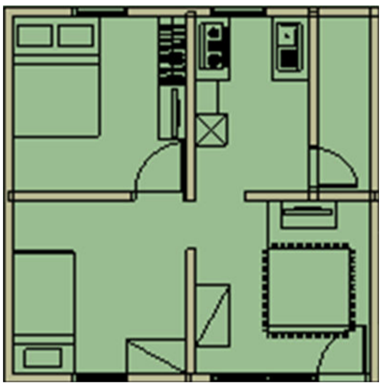


Figure 7. LB residential unit type

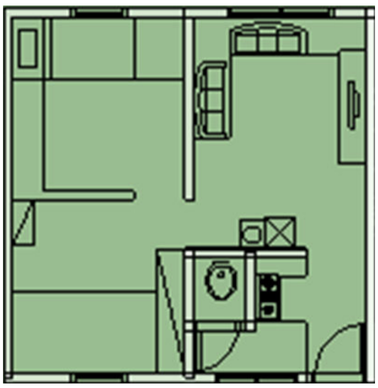
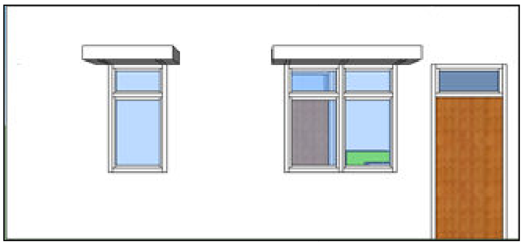
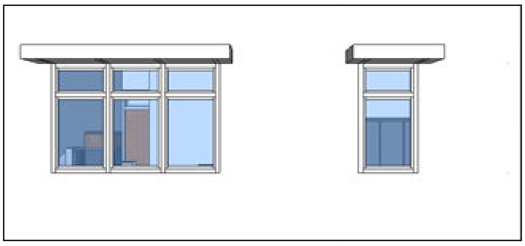


Figure 8. SB residential unit type

Window to wall ratio or openings on the inner court side of LB and SB unit are the same (9.53 %), although with different positions. In the LB unit, door and window openings is continued, while in the SB unit there is a distance between the door and window openings. At LB unit window openings illuminating bedroom, while the door-and-window openings illuminating the living room. At SB unit, window openings illuminating bedroom, while the door-and-window openings illuminating foyer into the kitchen and toilet. Openings on the outside facade of the LB unit (4.5 %) are less than the SB unit (6.02%). At LB unit window openings illuminating the bedroom and kitchen, and a hole for light illuminating toilet, while at SB unit, window openings illuminating the bedroom and sitting room.

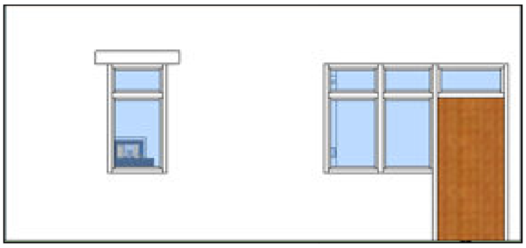


WWR 9.53 % on inner court facade

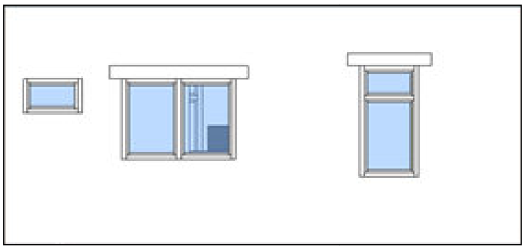


WWR 6.02 % on outer facade

Figure 9. WWR on SB type at unit NNW 1, SSE 2, WNW 3, and ENE 4.



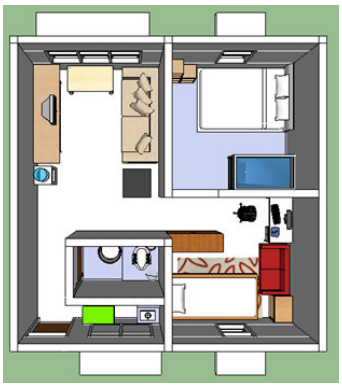
WWR 9.53 % on inner court facade



WWR 4.5 % on outer facade

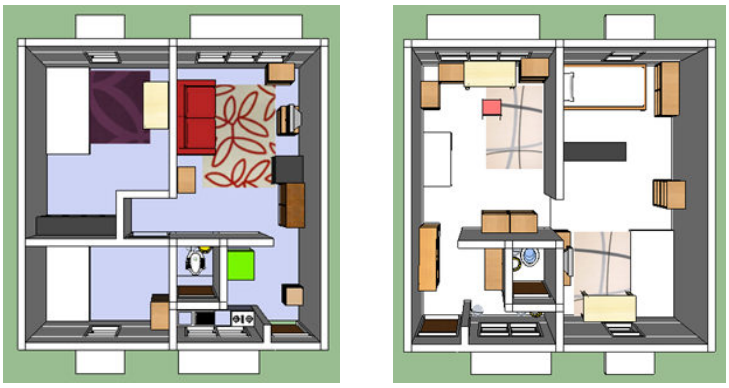
Figure 10. WWR on SB type at unit ENE 5 and WNW 6

Variety of partition and furniture layout is as seen in figure below. In this study a representative sample was taken for each façade direction. On each block were taken 2 façade directions and the opposites. Therefore there are 6 units each floors and simulated with different heights to represent the floor position that is on 1st to 4th floor. Twenty-four units are simulated at 4 extreme lighting moments, namely on December 21 at 8am and 4pm, and on June at 8am and 4pm.



Unit NNW 1

Unit SSE 2



Unit WNW 3 Unit ENE 4

Figure 11. Interior space configuration of dwelling unit at SB type

Unit ENE 5 Unit WNW 6

Figure 11. Interior space configuration of dwelling unit at LB type

5. Result and Discussion

Illuminant simulation results show that the lowest average inside room is 100 lux and the highest is 351 lux. Low illuminant was predominantly occurred on June 21 at 8 pm, while the high illuminant on December 21 at 4pm. Illuminant is lower in the morning than in the afternoon. Illuminant based on the position of the floor, in order from highest to lowest is, 2nd floor, 1st floor, 3rd floor and 4th floor. That's because the afternoon sun is relative frontal to the 2nd floor, compared to the 1st and 3rd floor, and the 4th floor.

The lowest of minimum illuminant is 1.27 at unit ENE 6 Block N (LB), while the highest maximum illuminant is at unit WNW 3 Block R (SB), followed by units ENE 4 Blocks R (SB), SSE 2 Block S (SB), NNW 1 Block S (SB), ENE 5 Block N (LB), and WNW 6 block N (LB). The highest maximum illuminant is contained in the block R. Block S has a medium average illuminant, and block N has the lowest average illuminant when compared with two other blocks. See the table 1, 2, 3, and 4.

Table 1. Illuminant (E) and daylight factor (DF) simulation result at Block S

		North north-west unit NNW 1 / BLOCK S (short block)				South south-east unit SSE 2 / BLOCK S (short block) \			
		21-Jun	21-Jun	21-Dec	21-Dec	21-Jun	21-Jun	21-Dec	21-Dec
Variables	Floor	8am	4pm	8am	4pm	8am	4pm	8am	4pm
E min (lux)	1	1.38	3.42	3.27	2.77	5.6	14	8.2	16
	2	4.13	10	6.04	12	5.01	12	7.33	14
	3	3.46	8.6	5.06	9.84	4.24	11	6.2	12
	4	3	7.46	4.39	8.54	3.58	8.91	5.24	10
E maks (lux)	1	857	2130	2033	1725	822	2043	1202	2339
	2	808	2009	1182	2300	816	2028	1193	2321
	3	804	1999	1176	2289	812	2019	1188	2311
	4	803	1995	1174	2284	810	2012	1184	2303
E avg (lux)	1	100	249	238	202	108	267	157	306
	2	107	267	157	305	106	262	154	300
	3	105	262	154	300	104	257	151	295
	4	104	259	152	296	102	253	149	290
u0	1	0.014	0.014	0.014	0.014	0.052	0.052	0.052	0.052
	2	0.038	0.038	0.038	0.038	0.048	0.048	0.048	0.047
	3	0.033	0.033	0.033	0.033	0.041	0.041	0.041	0.041
	4	0.029	0.029	0.029	0.029	0.035	0.035	0.035	0.035
D avg (%)	1	2.02	2.02	2.02	2.02	2.17	2.17	2.17	2.17
	2	2.17	2.17	2.17	2.17	2.13	2.13	2.13	2.13
	3	2.13	2.13	2.13	2.13	2.09	2.09	2.09	2.09
	4	2.1	2.1	2.1	2.1	2.06	2.06	2.06	2.06

Table 2. Illuminant (E) and daylight factor (DF) simulation result at Block R

		West north-west unit WNW 3 / BLOCK R (short block)				East north-east unit ENE 4 / BLOCK R (short block)			
		21-Jun	21-Jun	21-Dec	21-Dec	21-Jun	21-Jun	21-Dec	21-Dec
Variables	Floor	8am	4pm	8am	4pm	8am	4pm	8am	4pm
E min (lux)	1	9.96	25	15	28	2.03	5.05	2.97	5.78
	2	12	29	17	33	2.82	7.02	4.13	8.03
	3	10	25	15	29	3	7.46	4.39	8.54
	4	8.98	22	13	26	2.41	5.99	3.52	6.86
E maks (lux)	1	829	2061	1213	2359	821	2042	1201	2337
	2	821	2041	1201	2336	829	2062	1213	2360
	3	817	2031	1195	2325	825	2050	1206	2347
	4	814	2023	1190	2316	823	2045	1203	2340
E avg (lux)	1	123	307	181	351	118	293	172	335
	2	121	301	177	344	122	303	178	346
	3	118	294	173	337	120	297	175	340
	4	117	292	172	334	118	294	173	336
u0	1	0.081	0.081	0.081	0.081	0.017	0.017	0.017	0.017
	2	0.095	0.095	0.095	0.095	0.023	0.023	0.023	0.023
	3	0.085	0.085	0.085	0.085	0.025	0.025	0.025	0.025
	4	0.076	0.076	0.076	0.076	0.02	0.02	0.02	0.02
D avg (%)	1	2.49	2.49	2.49	2.49	2.38	2.38	2.38	2.38
	2	2.44	2.44	2.44	2.44	2.46	2.46	2.46	2.46
	3	2.39	2.39	2.39	2.39	2.41	2.41	2.41	2.41
	4	2.37	2.37	2.37	2.37	2.38	2.38	2.38	2.38

Table 3. Illuminant (E) and daylight factor (DF) simulation result at Block N

		East north-east unit ENE 5 / BLOCK N (long block)				West north-west unit WNW 6 / BLOCK N (long block)			
		21-Jun	21-Jun	21-Dec	21-Dec	21-Jun	21-Jun	21-Dec	21-Dec
Variables	Floor	8am	4pm	8am	4pm	8am	4pm	8am	4pm
E min (lux)	1	4.52	11	6.62	13	1.38	3.42	3.27	2.77
	2	4.15	10	6.06	12	2.18	5.43	3.19	6.21
	3	3.4	8.44	4.97	9.66	1.58	3.92	2.31	4.49
	4	2.98	7.41	4.36	8.48	1.27	3.16	1.86	3.61
E maks (lux)	1	893	2220	1306	2542	857	2130	2033	1725
	2	887	2205	1297	2524	867	2156	1269	2468
	3	881	2191	1289	2508	862	2142	1261	2452
	4	877	2181	1283	2496	858	2133	1255	2442
E avg (lux)	1	105	262	154	300	100	249	238	202
	2	103	257	151	294	103	257	151	294
	3	101	252	148	288	102	253	149	290
	4	100	248	146	284	101	250	147	286
u0	1	0.043	0.043	0.043	0.043	0.014	0.014	0.014	0.014
	2	0.04	0.04	0.04	0.04	0.021	0.021	0.021	0.021
	3	0.034	0.034	0.034	0.034	0.016	0.016	0.016	0.016
	4	0.03	0.03	0.03	0.03	0.013	0.013	0.013	0.013
D avg (%)	1	2.13	2.13	2.13	2.13	2.02	2.02	2.02	2.02
	2	2.08	2.08	2.08	2.08	2.09	2.09	2.09	2.09
	3	2.04	2.04	2.04	2.04	2.06	2.06	2.06	2.06
	4	2.02	2.02	2.02	2.02	2.03	2.03	2.03	2.03

Table 4. The highest of illuminant average and the unit type

Block type	Block name	Unit Name	Orientation	E avg (lux)	Floor	Date	Time	DF (%)	Rank
Short block	R	WNW 3	West north-west	351	1st	21-Dec	4 pm	2,49	1
	R	ENE 4	East north-east	346	2nd	21-Dec	4 pm	2.46	2
	S	SSE 2	South south-east	306	1st	21-Dec	4 pm	2.17	3
	S	NNW 1	North north-west	306	2nd	21-Dec	4 pm	2.17	4
Long block	N	ENE 5	East north-east	300	1st	21-Dec	4 pm	2.13	5
	N	WNW 6	West north-west	294	2nd	21-Dec	4 pm	2.09	6

E avg = illuminant average; DF = daylight factor

Although average of DF on all units ranged from 2.06 to 2:49, but there is no lighting uniformity on the residential units. This was indicated by a low value of uniformity, only ranged from 0.013 up to 0.095. Unit WNW 3 has the highest illuminant, at once had highest uniformity. In opposite, the unit WNW 6 has the lowest illuminant at once has the lowest uniformity. It shows the effect of interior space configuration on the illuminant and natural lighting uniformity. See Table 5.

Table 5. The highest of illuminant average and the uniformity

Block type	Block name	Unit Name	Highest E avg (lux)	Minimum Uniformity	Maximum Uniformity
Short	R	WNW 3	351	0.076	0.095
	R	ENE 4	346	0.02	0.025
	S	SSE 2	306	0.035	0.052
	S	NNW 1	306	0.013	0.038
Long	N	ENE 5	300	0.03	0.043
	N	WNW 6	294	0.013	0.021

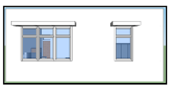
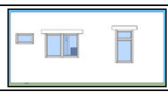
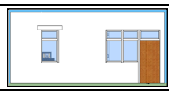
WWR of SB is greater than LB, correlated with its illuminant, the larger WWR, the greater of the illuminant average. In the SB type, the same types of dwelling units have a different illuminant at each orientation. The highest illuminant is in west north-west direction, followed by east north-east, south south-east, and north north-west direction. However, at the different configuration type and WWR, the units with BBD and TTL orientation are only the fifth and sixth rank. This indicates that the interior space configuration and WWR are more influential to the illuminant. See table 6.

Table 6. The highest of illuminant average and the interior space configuration

Block type	Block name	Unit Name	E avg (lux)	Interior space configuration			
				Bedroom position	Sitting room position	Kitchen position	Bathroom & toilet position
Short block	R	WNW 3	351	Inner court and outer façade	Outer façade	Inner court façade	Inner court façade
	R	ENE 4	346				
	S	SSE 2	306				
	S	NNW 1	306				
Long block	N	ENE 5	300	Inner court and outer façade	Inner court façade	Outer façade	Outer façade
	N	WNW 6	294				

In this case it takes the attention of the designers in particular, that in addition to attention on blocking building mass also noticed the interior space configuration and WWR in building facades.
With the same WWR on inner court façade, but with a different WWR on outer facade causes different illuminant. With the same façade orientation, the decrease of 1.52% WWR and different configurations causes the decrease average illuminant as much as 51-52 lux. See table 7.

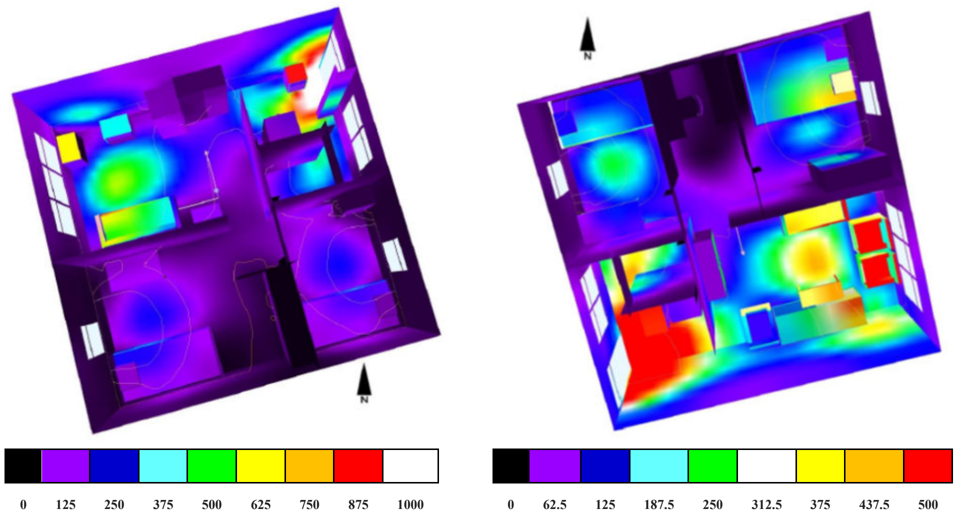
Table 7. The highest of illuminant average and the window to wall ratio (WWR)

Block type	Block name	Unit name	E avg (lux)	Outer facade	Inner court facade	Outer WWR (%)	Inner court WWR (%)
Short	R	WNW 3	351			6.02	9.53
	R	ENE 4	346				
	S	SSE 2	306				
	S	NNW 1	306				
Long	N	ENE 5	300			4.50	9.53
	N	WNW 6	294				

E avg = illuminant average; WWR = window to wall ratio.

Theoretically, the position differences of doors and windows should affect to the lighting distribution. Positions that have a distance between the openings, more evenly distributed, compared with the continuous one. But in the object of this study, the effect of the door and windows position is smaller than the effect of the interior space configuration. LB type has a door and a window, with continued position, while the SB type, there is a gap between the door and the window, but illuminant on the LB type is lower than on the SB type. All the sitting room has a high illuminant than the bedroom.
Shadowed areas on residential in the unit NNW 1 and WNW 3, are in bedroom and in between them itself, it is

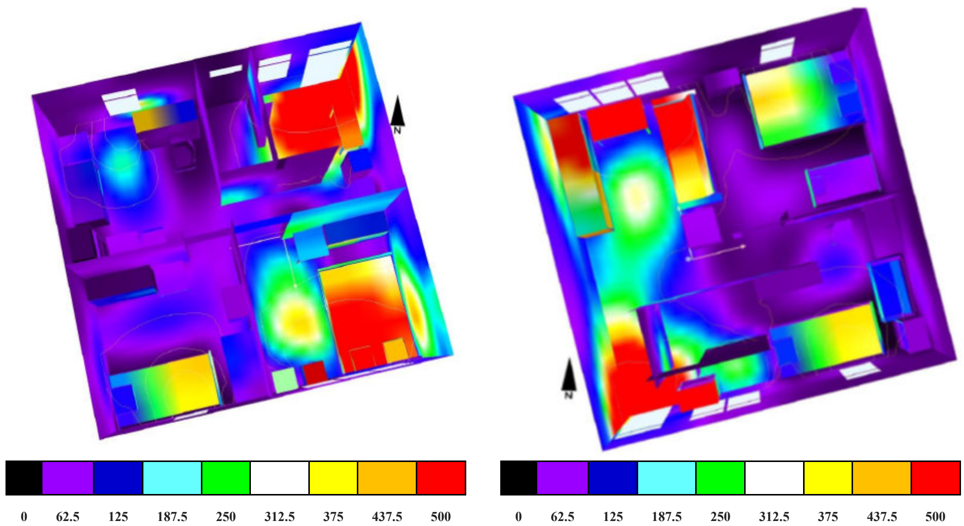
just getting a less natural light (only about 60 lux). Kitchen and sitting room has a pretty good lighting (up to> 500 lux). Unit SSE 2 has a dark room in the bathroom and toilet area. At unit ENE 4, there is a dark area due to the laying of the partition, which forms an extra space in between the two bedrooms. At unit ENE 5 and WNW 6 shadowed areas dominantly is in the toilet, because it has only a relatively small hole of light. See Figure 12, 13, and 14.



Block R; Floor: 1st;; Unit: WNW 3
Outer façade orientation: West north-west
Date/time: 21-Dec/4 pm
E avg: 351; DF 2,49 %; Rank: 1

Block R; Floor: 2nd t;; Unit: ENE 4
Outer façade orientation: East north-east
Date/time: 21-Dec/4 pm
E avg: 346; DF 2.46 %; Rank: 2

Figure 12. Shadowed areas on residential in the unit NNW 1 and WNW 3



Block S; Floor: 1st;; Unit: SSE 2
Outer façade orientation: South south-east
Date/time: 21-Dec/4 pm
E avg: 306; DF 2.17 %; Rank: 3

Block R; Floor: 2nd t;; Unit: NNW 1
Outer façade orientation: North north-west
Date/time: 21-Dec/4 pm
E avg: 306; DF 2.17%; Rank: 4

Figure 13. Shadowed areas on residential in the unit SSE 2 and NNW 1

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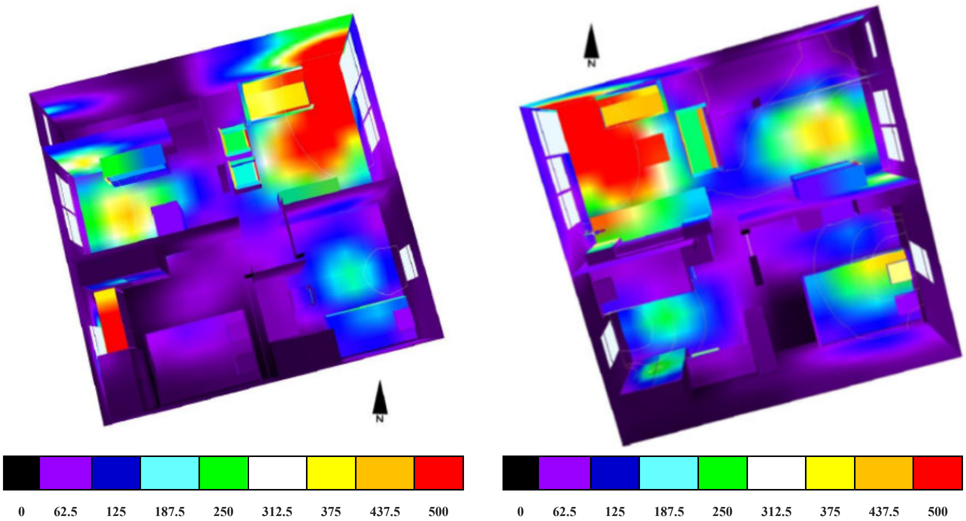

Block N; Floor: 1st;; Unit: ENE 5 Outer façade orientation: East north-east Date/time: 21-Dec/4 pm E avg: 300; DF 2.13 %; Rank: 5	Block N; Floor: 2nd t;; Unit: WNW 6 Outer façade orientation: West north-west Date/time: 21-Dec/4 pm E avg: 294; DF 2.09 %; Rank: 6

Figure 14. Shadowed areas on residential in the unit ENE 5 and WNW 6

Comparison between potential of natural daylight based on computation simulation with the Indonesian National Standard on day lighting shows that some parts of the rooms meet the requirement, some others have not enough daylight, and in some parts exceed the requirement. The illuminant of living room and dining room is met the requirement; in some parts exceed the requirement. In bedrooms the illuminant in some parts less and in some parts exceeds the requirement. Bathroom and toilet have not enough illuminant, only reach a half of standard. In the kitchen the illuminant in some parts meet the requirement, in some parts do not meet. The lack of daylight illuminant in their dwelling unit makes occupants using artificial light that means inefficiency on energy usage. See Table 8.

Table 8. Comparison between potential of natural daylight and standard

Function of Space	Requirement (lux)	Simulation results	Explanation
Living Room	120 - 150	>500	It meets the requirement; in some parts exceed the requirement.
Dining Room	120 - 250		
Working Room	120 - 250		
Bedroom	120 - 250	60-375	In some parts less, in some parts exceed the requirement
Bathroom & toilet	250	60-125	Not meets the requirement.
Kitchen	250	125-250	In some parts meet the requirement, in some parts do not meet.

6. Conclusion

Research result showed that physic-spatial configuration of architectural elements has influences to potential of natural lighting. Type of dwelling unit; interior space configuration; and window to wall ratio together have influence to illuminant and the distribution of it.

In this research case, dwelling unit in short block type is more recommended than the unit in long block type for a better daylight illuminant, with the important reason due to interior space configuration and the window to wall ratio.

Orientation and floor position also have influence to the illuminant in the dwelling unit, however less than interior space and window to wall ratio factors. On the same type of dwelling unit, orientation of outer façade that contributes the highest illuminant is west north-west direction. This study highlights that the greater size of window to wall ratio the higher potential of natural daylight. To optimize the size of window to wall ratio is very important to do.

Shadowed areas in residential unit are in the important apace, like bathroom and kitchen. It causes the occupant using the artificial light that means inefficiency on energy usage. To use prismatic light reflection is also very importance to consider, due to optimize the illuminant distribution and spread evenly.

The most important thing is to optimize the configuration of interior space. To design an appropriate and good configuration of interior space today will contribute on efficient energy usage in the future.

That consciousness related to this research is very important for every party that involved particularly in the vertical housing development for a better quality of life in urban area.

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