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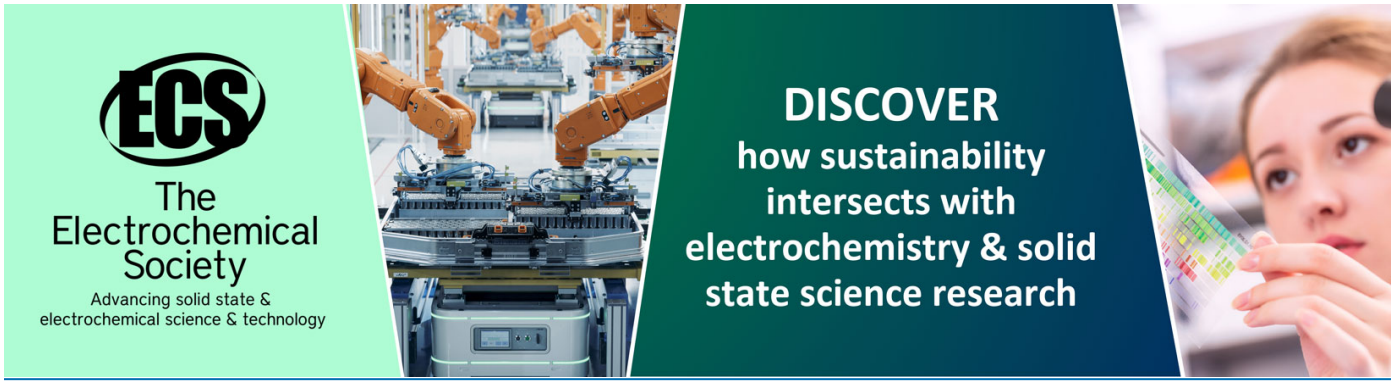

Natural Lighting Analysis in Plaza Senayan, Jakarta, Indonesia

Silvia Gunawan[1*], Naniek Widayati Priyomarsono[2], Rudy Trisno[3]

[1]Graduate Student, Department of Architecture, Tarumanagara University, Jakarta, Indonesia
E-mail: silviagoey@gmail.com
[2]Lecturer, Department of Architecture, Tarumanagara University, Jakarta, Indonesia
E-mail: naniekw@ft.untar.ac.id
[3]Lecturer, Department of Architecture, Tarumanagara University, Jakarta, Indonesia
E-mail: rudyt@ft.untar.ac.id

Abstract. As the development of malls went more advanced, there are malls in Jakarta that keeps up with the trend, while some others are left behind. A mall does not only function as a shopping center, while also catering for some other functions; to socialize, meeting place, hanging out, studying, and working. Visitors could experience something that couldn't be obtained elsewhere. Lighting is the most important aspect in the interior design of malls, to create an ambience in order to increase sales. This research is conducted to study on the effect of skylight shapes to natural lighting distribution in Plaza Senayan. Qualitative & quantitative methods are used with explorative approach, along with real measurements in the areas of the shopping mall covered by natural lighting. Building orientation, building shape, skylight shape, natural lighting distribution, and lighting intensity are the indicators used in this study. Field exploration was analyzed with current codes, and a simulation was conducted using Velux Daylight software to see the lighting distribution as well as the solution. Research results show that there are areas that hasn't fulfill the minimum lighting intensity requirement, areas with too much lighting, far from current standards. Results show that natural lighting distribution on square skylights are more evenly distributed than circular or hexagonal skylight shapes. This shows that skylight shapes does have an effect towards natural lighting distribution.

Keywords: Natural Lighting, Skylight, Mall Atrium, Light Distribution, Plaza Senayan

1. Introduction

The development of malls nowadays are following the modern urban lifestyle, therefore malls do not only function as shopping centers but also serves as a place for social interaction, hanging out, and meeting places. People, especially millennials go to malls to seek for an experience. Colliers saw that migrating patterns of our current society aren't actually a threat to mall operators. The migration of consumption patterns actually drives the mall operators to further develops their mall concept [1].

Design of a mall could shape an ambience and a visual presentation of commercial interior space that could affect effective evaluation of a consumer and their buying decision. Lighting is one of the aspects of interior design. Lighting could create an influence on consumer attention, ambience, shape

of an indoor space, and expose a product optimally. The use of natural lighting in a store dramatically increases the its sales [2].

Therefore, this research needs to be conducted to study on the natural lighting distribution and lighting intensity in Plaza Senayan, as well as its suitability with consumer's needs.

Figure 1. (a) Front View of Plaza Senayan (b) Building to Sun Orientation
(Source: Private Documentation, 2019)

2. Material and Methods

2.1 Material

Study cases are located inside Plaza Senayan in corridors and atriums that has sunlights and sidelights, which are the Rotunda, Oval Mall, Atrium Mall, Ruby Mall, and Emerald Mall with a total of 3 building levels. The study was conducted with well planned location points and time of day to study the light distribution. Plaza Senayan was opened in 1996, in Asia Afrika Road No. 8, Senayan, South Jakarta, developed by Kajima Corporation, and operated by PT Senayan Trikarya Sempana. This mall has a GFA of 130,500 sqm with 3 levels of retail and 1 level of basement.

Based on the mall area zoning, one skylight is taken in each zone to represent the shape and locations marked red in Figure 2 (b).

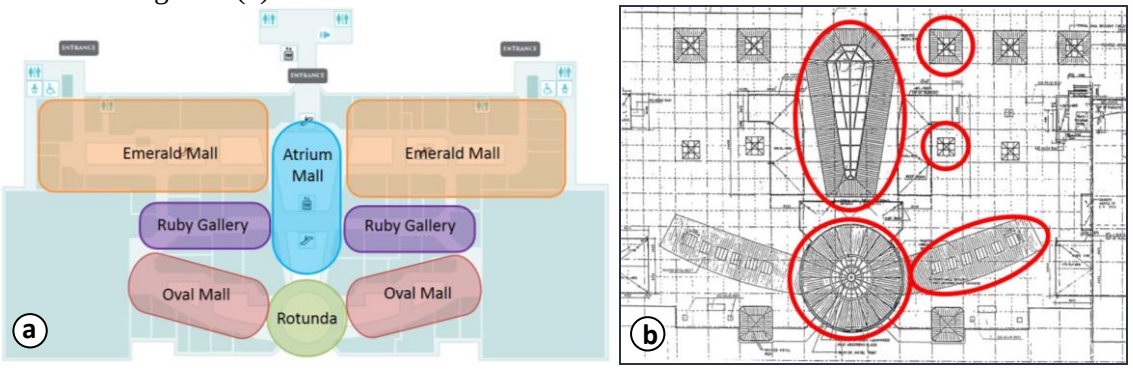

Figure 2. (a) Mall area zoning, (b) Studied skylights locations
(Source: Private Documentation, 2019)

2.2 Method

The big consideration of lighting design is how to point and refract a lighting towards the target design location. There are many ways to achieve this result, such as lowering or increasing lighting intensity, increasing lighting quality, reducing glares, and so on. One of the examples are refracting and distributing natural lighting using lighting pipes [3]. The goal in lighting distribution aside of creating various lighting patterns in design, is also to reduce visual inconvenience that was caused by glares [4]. Brightness and contrast in the design are results of lighting distribution from luminer and interaction of light in a room surface [5].

Natural lighting in a building is an expression of light filters. Darker lights provides a sacred ambience. The sacred ambience could be created silently and lightly with a certain ratio of natural lighting as a light filter to not be higher than the audio-visual buffer [6].

Intensity is a certain quantity of light coming from a source or on a surface. Intensity, or room brightness level, is an element that can be the easiest to control. Intensity is determined by the designer, to be achieved with certain fixture quantity and brightness, verified through calculations, and might be adjusted on the site using a control system as the part of the project [7].

Intensity is measured in lux, a measurement of light to determine the availability of natural lighting. It could be measured with luxmeter, or analyzed with acknowledged computer simulations [8].

The receptance of light in each building sides are variant, and could be used as and advantage towards certain requirement or function. North side of the building receives the most consistent light, and the south side receives a uniformly distributed light, east side in the morning would receive direct sunlight, while west side would receive direct sunlight in the afternoon [5].

Building shapes are matched with its climate. Slim buildings with long wings shaping towards east or west are used in tropical climates [9]. Slim shapes allow more natural lighting to enter its rooms, while buildings with a bigger volume could use an atrium concept to create the slimness effect by creating skylights or open space inside the interior of the building [10].

Skylights have various shapes and sizes, from simple rectangulars to complex polygons. Skylight shapes are matched with building length and come with different shapes and standard sizes. Flat glass surfaces can be used in single shapes, or layers of plastic glass are also available in dome and pyramid shapes [11].

Boyce dan Raynham (2009) stated that corridors need a lighting intensity of at least 100 lux, and enterance halls or receptions need at least 200 lux [12]. Poerbo (1995) stated that a circulation or a corridor needs at least 150 lux [13]. SNI 03-6197-2000 on energy conservation on lighting system states that retail spaces need at least 500 lux [14], while SNI 03-6575-2001 on artificial lighting design in buildings stated that minimum intensities in lobby and corridors are 100 lux [15].

On the abovementioned specifications on corridor or circulation in malls, 100 lux shall be used as a standard in this research.

In this research, the focus is on the field observation using luxmeters to study on the intensity of natural lighting in Plaza Senayan. The research starts from problem identification, literature study and determining indicators of measurements, which are: (1) building orientation, (2) building shape, (3) skylight shapes, (4) lighting distribution, and (5) lighting intensity.

After that, field observation was conducted by studying the atrium and 3 levels of corridor area of the mall which has some skylights, which are LG (lower ground) floor, Level 2, and Level 3. Intensity is measured using Luxmeter HS1000 device. Field observation data are organized and analyzed, and further simulation are conducted using Velux Daylight Visualizer 2.8.4 software to study on the natural lighting distribution from the skylight of the mall, and an experimental simulation was conducted to find the most optimum natural lighting distribution. The last step, is to provide conclusions and suggestions based on research results.

Information and data source in this research is categorized as two, which are primary data obtained from the field such as observation results, measurements, and documentation. The other category is secondary data, which is a supplementary data and information that was related to this research such as books, journals, and previous researches.

Figure 3. Location photo and skylight shapes in area: (a) Rotunda, (b) Oval Mall, (c) Ruby Gallery, (d) Atrium Mall, and (e) Emerald Mall
(Source: Private Documentation, 2019)

3. Results and Discussion

The measurement of lighting intensity uses Light Meter HS1010. Average intensity will be checked whether or not it already fulfills the minimum standard, as well as lighting distribution, based on skylight shapes. Measurements are conducted on 9th, 10th, and 22nd of April 2019 at 10 AM to 7 PM in the designated area and skylight in 3 floors. Since the natural lighting distribution varies during the day, the measurements are conducted at 10 AM, 12 PM, 2 PM, and 4 PM. The required measurement time for 1 session is approximately 1-1.5 hours. Outdoor daylight condition during the measurement

time was bright, in which that in 10 AM the outdoor sunlight is 60,000 lux, 12 PM is 40,000 lux, 2 PM is 40,000 lux, and 4 PM is 20,000 lux. Table 1 shows average results of mall lighting intensity measurements in lux.

Table 1. **Results of intensity measurement (lux)**

Rotunda											
Lantai GF				Lantai 2				Lantai 3			
10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00
619	**1031**	**653**	**461**	**223**	**293**	**229**	**205**	**347**	**290**	**243**	**201**
Oval Mall											
Lantai GF				Lantai 2				Lantai 3			
10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00
317	**319**	**248**	**190**	**219**	**511**	**197**	**153**	**346**	**365**	**296**	**420**
Atrium Mall											
Lantai GF				Lantai 2				Lantai 3			
10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00
863	**519**	**769**	**201**	**349**	**301**	**273**	**204**	**347**	**290**	**243**	**201**
Ruby Gallery											
Lantai GF				Lantai 2				Lantai 3			
10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00
134	**139**	**138**	**118**	**326**	**233**	**227**	**151**	**1977**	**742**	**2569**	**350**
Emerald Mall											
Lantai GF				Lantai 2				Lantai 3			
10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00	10.00	12.00	14.00	16.00
519	**355**	**303**	**282**	**350**	**311**	**236**	**223**	**624**	**553**	**407**	**567**

(Source: Private Documentation, 2019)

Table 1 shows that average lighting intensity was above the minimum corridor lighting intensity at 100 lux. In some certain time and area, the measured intensity was extremely high at 1,000 lux. However in corridors people do not tend to spend fewer time and would require higher accuracy. With the average of 100 to 500 lux, it is more than enough to light the whole corridor and atrium of the mall with consideration of adequate lighting to attract mall visitors and shine the sight to take a look inside the stores.

Indicator	Field Observation	Solution
Building Orientation	Building orientation faces west. Main lobby up to all levels of Rotunda uses glass materials facing the main boulevard. Negative effect of west orientation is glares and heat due to direct sunlight on the main lobby and atrium.	Glares in the lobby could be reduced with additional non-transparent shells on the façade. Long rectangular skylights should be placed in north-south direction for a more uniformly distributed lightings along the day.
Building Shape	Plaza Senayan's shape is a rectangle, that is slim and divided to 3 corridor lines, and Rotunda open area is located in the middle of the mall up to the atrium of the mall. Each corridors/open areas use natural lighting coming from the skylight, so that the indoor lighting doesn't only rely on artificial lighting and could conserve energy usage.	The matchingness of skylight shapes with interior plan of the building creates a more evenly distributed lighting in the corridor of the mall. With a building orientation facing west, the light opening should be decreased to reduce negative impacts from direct sunlight.
Skylight shape towards lighting distribution	Based on Figure 3, there are hexagonal, circular, square, and rectangular roof skylight. Simulation results (Figure 4) show that a major contrast of bright and dark areas was present in skylight of atrium & Rotunda and other areas. Circular skylights receives more intensity and	Skylight opening was too large, exceeding 5% of the roof area, receives excessive sunlight. Skylight shapes with more regular shapes, such as square shape shows more evenly distributed light.

Indicator	Field Observation	Solution
	focused light hence creates a contrast effect with other areas.	
Lighting intensity	Lighting intensity measurements with luxmeters show that average lighting intenstity fulfills corridor standards at 100 lux. Rotunda and Atrium Mall have the highest lighting intensity compared to all other areas.	Skylight area and skylight distance to covered surface affects light intensity. A well matching plan and skylight should make a more evenly distributed lighting.

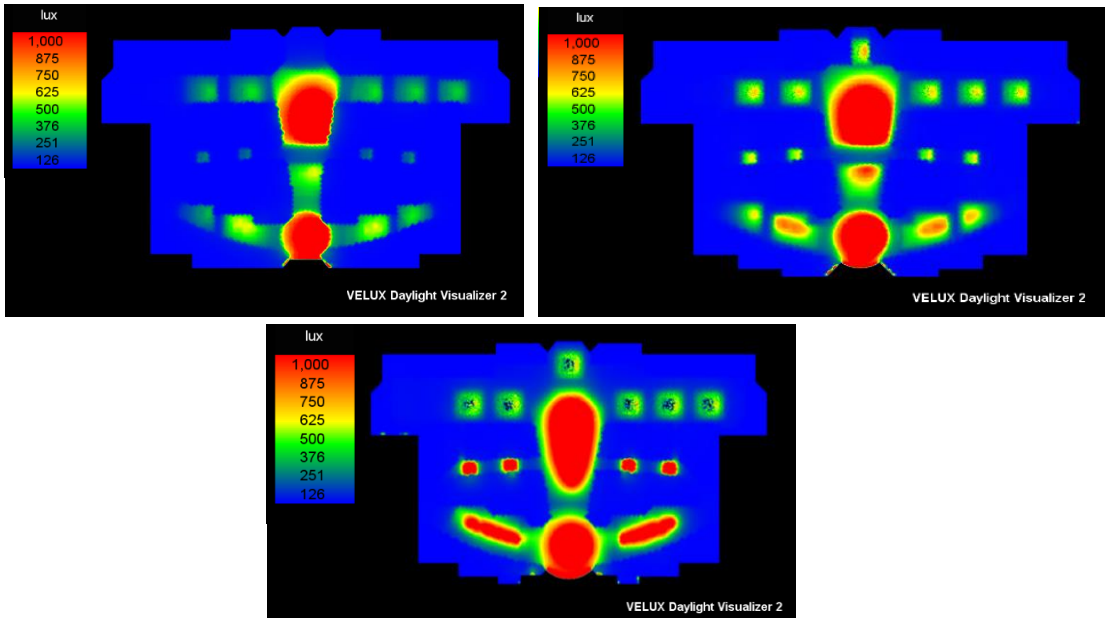

Figure 4. Simulation results of natural lighting on levels GF, 2, and 3
(Source: Private Documentation, 2019)

Simulation results on figure 4 uses Velux 2.8.4 software at 12.00 PM and is adjusted with site conditions to visually observe the lighting distribution based on the produced color contours. Red color contours show higher intensity while blue color contours show less intensity.

4. Conclusion

Research conducted in Plaza Senayan on the natural lighting distribution and intensity indicators show that:

1. Lighting intensity in the whole mall area fulfills corridor lighting intensity standard.
2. Matchingness of plan and skylight shapes create a more evenly distributed lighting.
3. Skylight sizes should not be more than 5% of roof area to avoid excessive glare.
4. Larger skylights receives larger light intensities.
5. Skylights with regular-shaped sides would create a more evenly distributed lighting compared to circular and hexagonal shapes.
6. Smaller skylight sizes and smaller distances from corridor doesn't create an optimum lighting distribution and would cause the mall to rely on more artificial lighting.

Research results show that skylights are placed on a north-south direction. For constructed buildings, efforts in material usage, reducing transparent areas that directly face with the sun, blocking some direct sunlight, and a comprehensive skylight area and lighting intensity calculation using softwares to obtain the best lighting design.

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