SINEKTIKA Jurnal Arsitektur

p-ISSN: 1411-8912
e-ISSN: 2714-6251
http://journals.ums.ac.id/index.php/sinektika

VISUAL COMFORT ANALYSIS OF OFFICE BUILDINGS IN THE *GEDHONG HINGGIL*, RECTORATE BUILDING OF WIDYA MATARAM UNIVERSITY

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Manuscript submitted: March 5, 2025
Manuscript accepted: June 13, 2025

ABSTRACT
Light will fall on an object and be reflected back to our eyes so we can see these objects. Visual comfort will be achieved when there is sufficient lighting in a room. If the light that comes in is less or more, it will disturb the comfort of human vision. The objective of this study is to delineate the area in the Gedhong Hinggil Dalem Mangkubumen Building to see whether it meets comfort standards for office buildings. The purpose of this study is to analyze whether the Gedhong Hinggil building is suitable to be used as a workplace, so that it can provide input to campus managers to be able to improve the condition of the workplace without eliminating the authentic hierarchy of the traditional Gedhong Hinggil building. On average, the intensity values for rooms in the rectorate do not meet SNI requirements. The west side and east side areas already have quite wide openings. This building is a cultural heritage building that cannot be changed, to comply with the established SNI standards for work spaces or offices, the light intensity in the room can be increased by adding artificial lighting (lamps). The final result of this study shows that the Gedhong Hinggil Dalem Mangkubumen building does not meet the standards if used as an office building. This is because the building originally functioned as the residence of the Crown Prince.

KEYWORDS: campus, Dalem Mangkubumen, Gedhong Hinggil, lightmeter, visual comfort

Cahaya akan jatuh pada suatu objek dan dipantulkan kembali ke mata kita sehingga kita dapat melihat objek-objek tersebut. Kenyamanan visual akan tercapai ketika pencahayaan di dalam ruangan mencukupi. Jika cahaya yang masuk kurang atau berlebihan, hal itu akan mengganggu kenyamanan penglihatan manusia. Tujuan penelitian ini adalah untuk menentukan area di Gedung Gedhong Hinggil Dalem Mangkubumen untuk melihat apakah area tersebut memenuhi standar kenyamanan untuk gedung perkantoran. Tujuan penelitian ini adalah menganalisis apakah Gedung Gedhong Hinggil cocok digunakan sebagai tempat kerja, sehingga dapat memberikan masukan kepada pengelola kampus untuk dapat meningkatkan kondisi tempat kerja tanpa menghilangkan hierarki autentik dari bangunan Gedhong Hinggil tradisional. Secara rata-rata, nilai intensitas cahaya di ruangan-ruangan di rektorat tidak memenuhi persyaratan SNI. Area sisi barat dan timur sudah memiliki lubang yang cukup lebar. Gedung ini merupakan gedung warisan budaya yang tidak dapat diubah, untuk memenuhi standar SNI yang telah ditetapkan untuk ruang kerja atau kantor, intensitas cahaya di ruangan dapat ditingkatkan dengan menambahkan pencahayaan buatan (lampu). Hasil akhir studi ini menunjukkan bahwa gedung Gedhong Hinggil Dalem Mangkubumen tidak memenuhi standar jika digunakan sebagai gedung kantor. Hal ini karena gedung tersebut semula berfungsi sebagai tempat tinggal Pangeran Mahkota.

KATA KUNCI: *kampus, Dalem Mangkubumen, Gedhong Hinggil, lightmeter, kenyamanan visual*

INTRODUCTION

Light is a type of energy that humans need to see objects visually. Light will fall on an object and be reflected back to our eyes so we can see these objects (Lechner, 2001). Visual comfort will be achieved when the lighting in a room is adequate. If the presence of light is too little or too much, this can harm human vision (Thojib & Adhitama, 2013). Good light will help humans in carrying out their daily activities. The level of light requirements for each human activity will vary. Fulfilling visual comfort in the work space is very necessary for users to carry out work activities productively and well. Visual comfort is obtained from natural or artificial lighting (ISO EN 7730, 2005). Natural lighting is obtained from sunlight, while artificial lighting is obtained from lamps used at night. The number and placement of openings/windows also influence the visual comfort of a room (Soekanto, 2017).

The case study that will be researched is the Widya Mataram University Dalem Mangkubumen Campus Rectorate building. Dalem Mangkubumen, located at Kadipaten, Keraton, Yogyakarta, was once a

building erected by Sultan HB VI which functioned as the residence of the crown prince. Currently the building has changed its function as the Widya Mataram University Campus. The rectorate building has a traditional Javanese building style but has undergone renovation with the addition of several rooms (Ashadi, 2017). While this building was used as a rectorate, users in this building felt a lack of visual comfort in carrying out their activities in several places (Brongtodiningrat, 1978). In the core area of this building, the walls are quite thick and there are very few openings/windows. The rector's room and meeting room areas do not have windows that lead directly to the outside of the building, as a result, natural light cannot reach the inside of the room (Yuniastuti & Murti, 2019). As a public building that facilitates the activities within it, lighting is required according to quality standards and quantity values in order to achieve visual comfort for its users.

This research aims to analyze work space comfort based on visual comfort standards using methods according to SNI 03-6572-2001 case study: Widya Mataram University Campus Rectorate Building, Dalem Mangkubumen, whether it meets visual comfort for room users who work in the rectorate room.

Definition of Light

In the study of physics, the definition of light is included in the wave energy category known as electromagnetic radiation (Istiawan, 2006). According to the KBBI (Big Indonesian Dictionary) the term light refers to the noun light or light produced by shining objects such as the moon, sun or lamp as well as shadows produced by objects around the object that can be caught by the eye. The presence of light acts as an essential factor for carrying out activities optimally and producing visual comfort. Until now, the main provider of light comes from sunlight and the curve of the sky (Widiyantoro, Muladi, & Vidiyanti, 2017). With accurate building design, natural lighting can meet the majority of our lighting needs to date. But when natural light is inaccessible or in a room closed to natural lighting, the use of artificial lighting using electricity becomes an inevitable solution (DKI Jakarta Provincial Government, 2012).

Definition of Lighting

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Natural Lighting

Natural lighting, as defined in various article sources, refers to light that comes from nature, especially from the sun (IFC, 2011). In everyday life, humans really need natural lighting. The presence of natural lighting also plays an important role in minimizing energy consumption in buildings, by saving energy through the use of electricity. Thus, it is important to implement and develop design concepts that optimize natural lighting. According to Riandito (2012), design strategies in an effort to utilize natural lighting include: increasing the number of areas that utilize natural lighting, optimizing the flow of natural lighting into the building, implementing an effective opening design for the entry of natural lighting, increasing light levels in the room through maximizing natural lighting reflections, avoiding direct exposure to sunlight in active work zones, and using the appropriate type of opening as a natural lighting filter (Jain, Garg, Jyotirmay, & Dhaka, 2011). In its use, sunlight has positive and negative sides. Here are some points that reflect both sides:

Positive :

1. Naturally
2. Present in abundant quantities.
3. Does not require costs for utilization.
4. Renewable (will continue to exist until the sun stops shining).
5. Contains heat and chemical elements that are essential for life on earth.
6. Due to the rotation of the earth and its movement around the sun, the direction of the sun's rays changes. Coupled with the obstruction of passing clouds, it creates variations in light intensity which gives a dark-light effect, thereby increasing the dynamic impression.

Negative :

1. In buildings with many floors and complex designs, utilizing natural light from the sun becomes difficult, even though there is fiberglass technology that can distribute light into the room.
2. Adjusting the light intensity is quite difficult, it can be too bright or too dim.
3. Incoming light often brings heat to the room.
4. May cause color to fade.

Artificial Lighting

According to Amin (2011), the term artificial lighting refers to light created from sources that do not come from natural light**.** The role of artificial lighting is essential when natural light is difficult to reach in a room, or when the available natural lighting is inadequate. Riandito (2012), provides a comprehensive explanation of the stages in realizing an effective artificial lighting design,

That is:

1. First stage: Determine the criteria for lighting design. There are several criteria in lighting design, including the quantity and quality of lighting. Both aim to ensure that the lighting being designed produces light in the appropriate amount.
   - Assess the Amount of Lighting
   - Lighting Quality
   - Energy code
2. Second stage: Record architectural conditions and existing limitations.
3. Third stage: Determine the role of visuals in the function of activity needs.Tahap
4. Fourth: Determine the system that will be applied as lighting.

Office Lighting Requirements

Stated that interior solutions are related to material absorption and reflection in the context of lighting intensity (Febrianto, Susanti, & Istiqoma, 2018). According to Lippsmeier (1994), the high intensity and reflection of sunlight is a characteristic feature of a tropical climate. Therefore, it is important to design the materials and colors of the room's furnishing elements. The National Standardization Agency (2001), states that the aim of testing natural lighting in the middle of the day is to evaluate and review the existing lighting conditions. Based on SNI 16-7062-2004 released by the National Standardization Agency, work spaces require a lighting intensity of 350 lux.

Table 1. SNI 03-6197-2000 Lighting Standards

Office	
Directors Room	350
Workspace	350
Computer Room	350
Meeting room	300
Image Space	750
Archive Room	150
Active Archive Space	300

METHODS

This research method is a survey of the Widya Mataram University Rectorate building by measuring the intensity of incoming light using a light meter and then comparing it with the lighting standards required as visual comfort standards according to SNI 7062-2019.

RESULTS AND DISCUSSION

The Rectorate Building of Widya Mataram University previously functioned as the residence of the crown prince, which was built by Sri Sultan HB VI. However, currently this building has changed its function to become the Rector's office which has developments on each side.

The location of the Widya Mataram University Rectorate is located in the Kadipaten, Kapanewon Kraton, part of Yogyakarta City which is in the Special Region of Yogyakarta. The boundaries of the Widya Mataram University Rectorate building are as follows:
Northern boundary: Nehru Room
Eastern boundary: Residential areas
Southern boundary: Dalem Mangkubumen pavilion
Western boundary: Residential areas

Field Conditions

The spatial layout of the Widya Mataram University Rectorate Building is divided into 3 areas including the left wing, the core building directly connected to the front terrace and the right wing. A spatial layout designed in this way produces less than optimal results because the central room, which is the living room, the chancellor's room, the vice-chancellor's room and the meeting room cannot get direct access to natural lighting. This situation means that the amount of light in the room is still very low or below the visual comfort standards for office buildings.

Figure 1. Block Plan in Mangkubumen (source: https://docplayer.info/docs-images/73/69475546/images/3-3.jpg)

Building Orientation and Light Apertures

The orientation of the rectorate building is to the south and is directly connected to the Pendopo Dalem Mangkubumen. This building extends from east to west with the longest facade facing the north and south sides. The facade of the building is equipped with the most light openings in the east, south and west, while the north does not have light openings because it is directly connected to the Nehru room. The most light openings are located in the west, south and east, while the north has no light openings. With this orientation on the east and west sides and the openings on this side are quite optimal because the size of the light openings can be maximized to support the amount of light provided for the visual comfort of the users, especially in the computer room, bureau 1, bureau 2, bureau 3, warehouse.

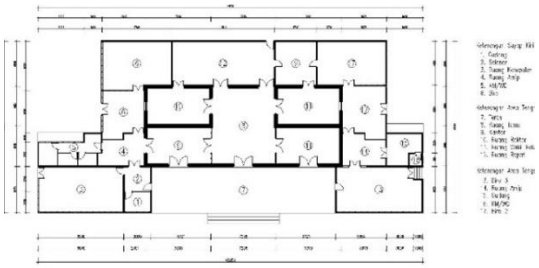

Figure 2. Plan of the rectorate
(source: Author's Document, 2022)

Figure 3. Front view of the rectorate
(source: Author's Document, 2022)

Figure 4. Rear view of the rectorate
(source: Author's Document, 2022)

Figure 5. Left side view of the rectorate
(source: Author's Document, 2022)

Figure 6. Right side view of the rectorate
(source: Author's Document, 2022)

Figure 7. Window opening layout
(source: Author's Document, 2022)

Research Object

The objects measured in this research are work spaces and offices. The Rectorate Building of Widya Mataram University is the object of observing visual comfort in the office. The scope taken is the entire work space within the rectorate. Some rectorate rooms have quite large open windows but still use artificial light (lamps) and also use cloth curtains. Meanwhile, the central room of the building does not have any windows at all, which can affect the visual comfort in the room.

Figure 8. Photo of the rectorate opening
(source: Author's Document, 2022)

Measurement Results Using a Light Meter

Measurements were taken three times a day at different times. The hours used for measurement are 9.00 WIB, 12.00 WIB and 16.00 WIB. The measuring process uses a light meter with several points that have been determined as the location of the light

measurement point. Measurements were carried out during working hours when employees were still active in the office. Each room has different conditions, most of the lights when taking measurements are on. The measurement results inside the Widya Mataram University Rectorate building can be seen in the following Table 2:

Table 2. Measurement results using a light meter

Area/ Point	Lighting intensity (Lux)			Average	Exp
	09.00	12.00	16.00		
A1	21	32	8	20	
A2	92	101	25	73	
B1	15	22	6	14	
B2	56	68	41	55	
C1	46	76	17	46	
C2	77	101	71	83	
C3	179	175	85	146	
C4	106	120	95	107	
D1	75	66	56	66	
D4	66	35	77	59	
E1	105	173	53	110	
E2	66	72	72	70	
E3	158	150	148	152	
E4	67	65	66	66	
F1	237	299	110	215	
F2	50	51	29	43	
F3	80	85	78	81	
F4	94	104	90	96	
G1	175	220	69	155	
G2	56	56	49	54	
G3	25	59	27	37	
G4	90	97	89	92	
H1	106	170	41	106	
H2	80	46	45	57	
H3	28	29	38	32	
H4	82	94	80	85	
I1	200	195	37	144	
I2	33	37	30	33	
I3	46	48	40	45	
I4	81	86	78	82	
J1	290	230	60	193	
J2	51	55	48	51	
J3	73	75	70	73	
J4	51	72	50	58	
K1	93	84	33	70	
K2	29	30	27	29	
K3	35	38	32	35	
K4	138	45	124	102	
L1	128	148	78	118	
L2	111	110	84	102	
L3	165	225	145	178	
L4	104	118	128	117	
M1	118	140	105	121	
M2	17	20	7	15	
N1	120	165	70	118	
N2	57	102	38	66	
Average general lighting intensity				84	

From the findings obtained through field observations, it was concluded that the visual comfort in the Widya Mataram University Rectorate building did not meet visual comfort standards. The level of visual comfort in accordance with SNI standards for work spaces or offices is 300 – 350 LUX. When compared based on SNI 03-6197-2000 regarding Visual Comfort Standards in the work environment, the lighting in each rectorate room has an illumination level that is less than the visual comfort standard. The level of illumination for each rectorate room can be seen in the following plan:

1. Computer Room

From the results of measuring the light intensity in the computer room, the results obtained from measurements at 3 measurement points in the computer room with the condition of the computer room only using natural light, according to the measurements obtained, the results did not meet the requirements of SNI standards. The highest light intensity occurs at 12.00 where the room receives a greater average of light than at 9.00 and 16.00. Another factor that influences the lack of visual comfort in the computer room is the curtains being closed because the room is not being used.

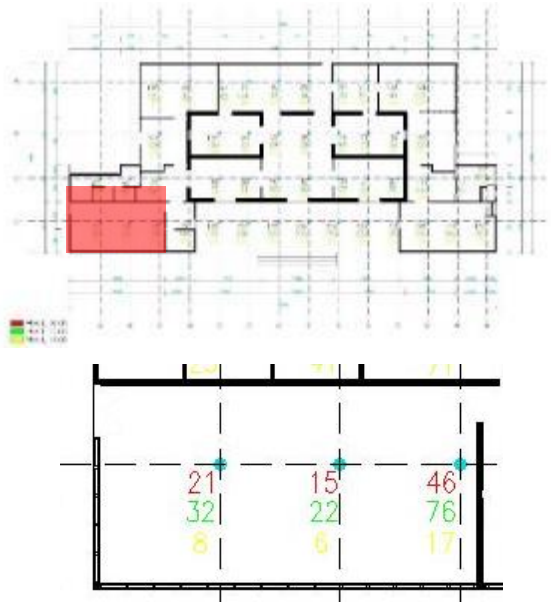

Figure 9. Computer room plan
(source: Author's Document, 2022)

2. Bureau Room 1

The results of measurements of light intensity in the Bureau 1 room were obtained from measurements at 3 measurement points with room conditions that used artificial light (lamps) and natural light. According to the measurements obtained the results did not meet the requirements of SNI standards. There are quite a lot of openings in the Bureau 1 room, but the results of measurements in the field of natural light entering the room are still very lacking.

Figure 10. Bureau room plan 1
(source: Author's Document, 2022)

3. Chancellor's Room

The results of measuring light intensity in the Rector's Room were obtained from 2 measurement points in the Rector's Room with room conditions that only used artificial light (lamps), the results obtained did not meet the requirements of SNI standards. The Chancellor's Room does not have any openings that directly face the outside of the room so this room only uses artificial light (lamps). This room is the original building of the prince's house whose layout has not been changed. The point of greatest intensity in the Chancellor's room is in the work desk area.

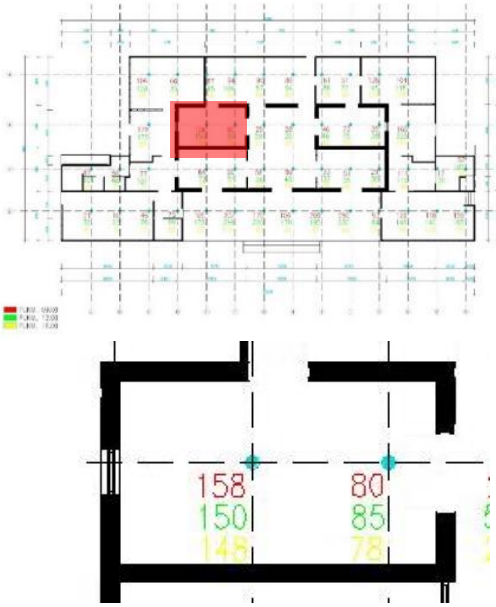

Figure 11. Rector's room plan
(source: Author's Document, 2022)

4. Front Office Space

The results of measuring the light intensity in the front office room were obtained from measurements at 2 measurement points in the rector's room with room conditions that used artificial light (lamps) and door openings that directly faced the front terrace. According to the measurements obtained the results did not meet the requirements of SNI standards. This front office room has a door opening that directly faces the front terrace. However, the terrace is too wide so not much light enters the room. The average measurement for each hour shows almost the same results and is not much different.

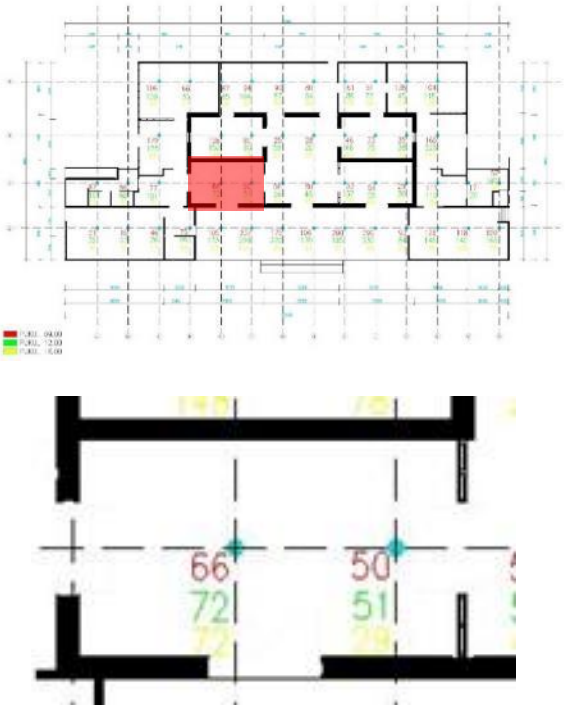

Figure 12. Front office space plan

(source: Author's Document, 2022)

5. Sitting room

The results of measuring light intensity in the living room were obtained from measurements at 4 measurement points in the living room with room conditions that used artificial light (lamps) and door openings that directly faced the front terrace. According to the measurements obtained the results did not meet the requirements of SNI standards. This living room has a door opening that directly faces the front terrace. However, openings cannot increase the level of light entering the room. The average measurement for each hour shows almost the same results and is not much different.

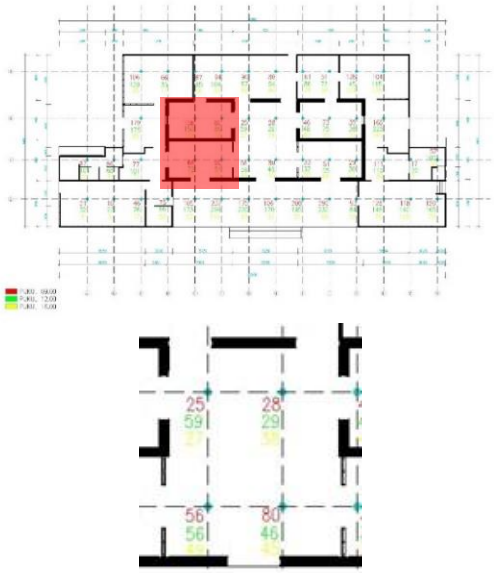

Figure 13. Living room plan
(source: Author's Document, 2022)

6. Deputy Chancellor I

The results of measurements of light intensity in the Vice Chancellor III room were obtained from measurements at 3 measurement points in the Vice Chancellor III room with room conditions that only used artificial light (lamps) according to the measurements obtained the results did not meet the requirements of SNI standards. The Vice Chancellor III's room does not have any openings that face directly outside the room so this room only uses artificial light (lamps). This room has a window that faces the living room, but this window does not affect the level of light intensity in the room. The average measurement for each hour shows almost the same results and is not much different.

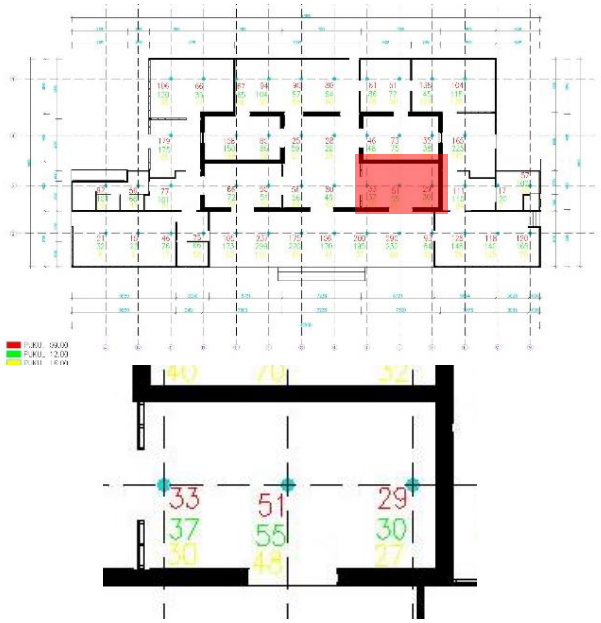

Figure 14. Vice chancellor I room plan
(source: Author's Document, 2022)

7. Vice Chancellor III Room

The results of measurements of light intensity in the Vice Chancellor I's room were obtained from measurements at 3 measurement points in the Vice Chancellor I's room with room conditions that only used artificial light (lamps), according to the measurements obtained the results did not meet the requirements of SNI standards. The Vice Chancellor I's room does not have an opening that faces directly outside the room so this room only uses artificial light (lamps). This room does not have windows that directly face the outside area of the building. The average measurement for each hour shows almost the same results and is not much different.

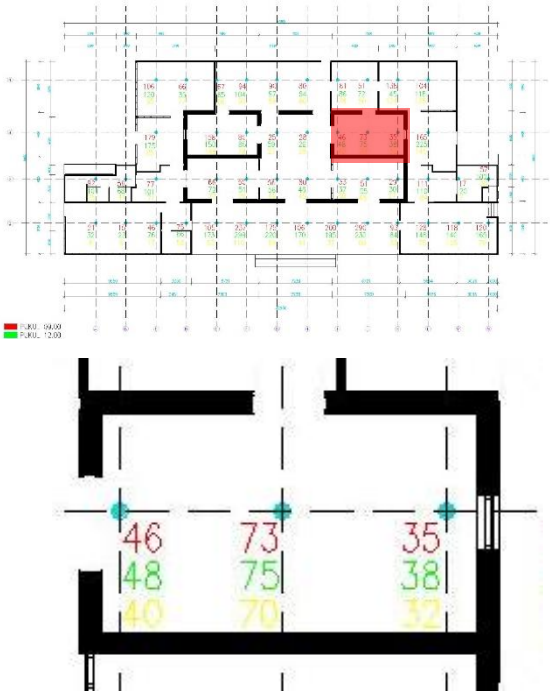

Figure 15. Vice chancellor III room plan

(source: Author's Document, 2022)

8. Vice Chancellor II Room

The results of measurements of light intensity in the Vice Chancellor IjusufI room were obtained from measurements at 2 measurement points in the Vice Chancellor II room with room conditions that only used artificial light (lamps) according to the measurements obtained the results did not meet the requirements of SNI standards. The Vice Chancellor II's room does not have any openings that face directly outside the room so this room only uses artificial light (lamps). This space is very closed and has no window openings at all. The average measurement for each hour shows almost the same results and is not much different.

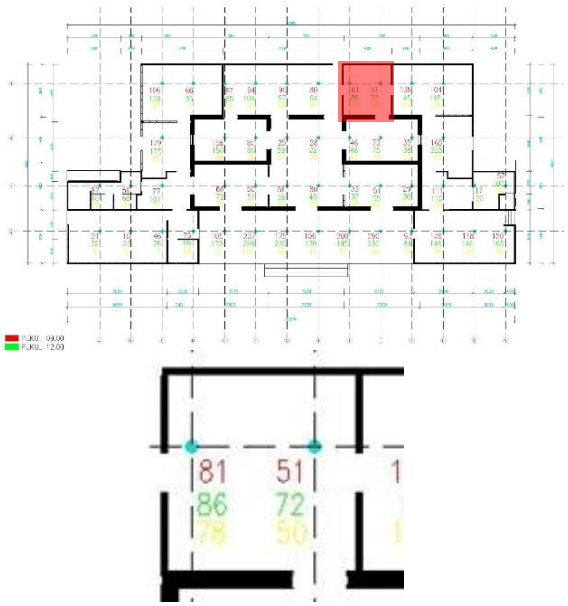

Figure 16. Vice chancellor II room plan
(source: Author's Document, 2022)

9. Meeting room

The results of measuring light intensity in the meeting room were obtained from measurements at 4 measurement points in the meeting room with room conditions that only used artificial light (lamps), according to the measurements obtained the results did not meet the requirements of SNI standards. The location of the meeting room which is at the very back of the building does not have any openings that face directly outside the room so this room only uses artificial light (lamps). This meeting room is directly adjacent to the Nehru room on the north side so there are no direct openings to the outside. The average measurement for each hour shows almost the same results and is not much different.

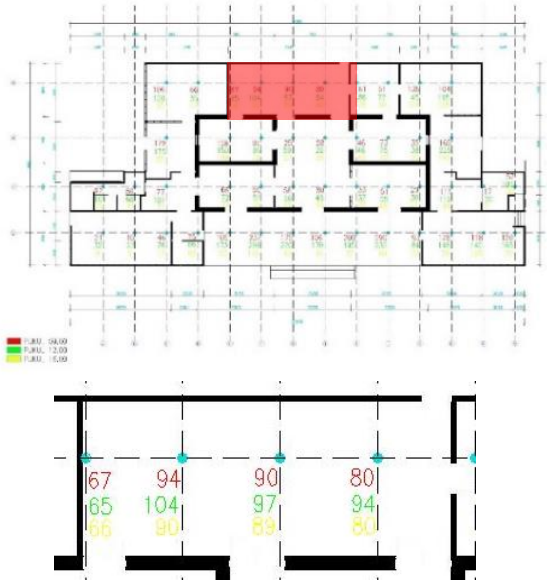

Figure 17. Meeting room plan
(source: Author's Document, 2022)

10. Bureau Room 2

The results of measurements of light intensity in the Bureau 2 room were obtained from measurements at 3 measurement points in the Bureau 2 room with room conditions that used artificial light (lamps) and natural light. According to measurements the results obtained on average did not meet the requirements of SNI standards. There are quite a lot of openings in the Bureau 2 room, but the results of measurements in the field of natural light entering the room are still very lacking. The canopy in front affects the entry of light into the room so that the light level cannot be maximized.

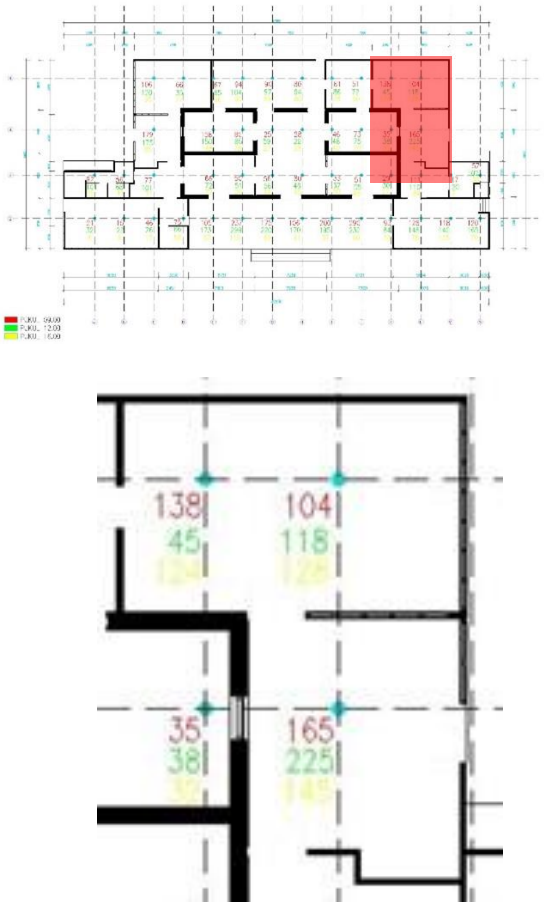

Figure 18. Plan of bureau room 2
(source: Author's Document,2022)

11. Bureau Room 3

In the Bureau 3 room, the results obtained from measurements at 3 measurement points in the Bureau 3 room with room conditions using artificial light (lamps) and natural light, according to the measurements obtained, the results on average did not meet the requirements of SNI standards. There are quite a lot of openings in the Bureau 3 room, but the results of measurements in the field of natural light entering the room are still very lacking.

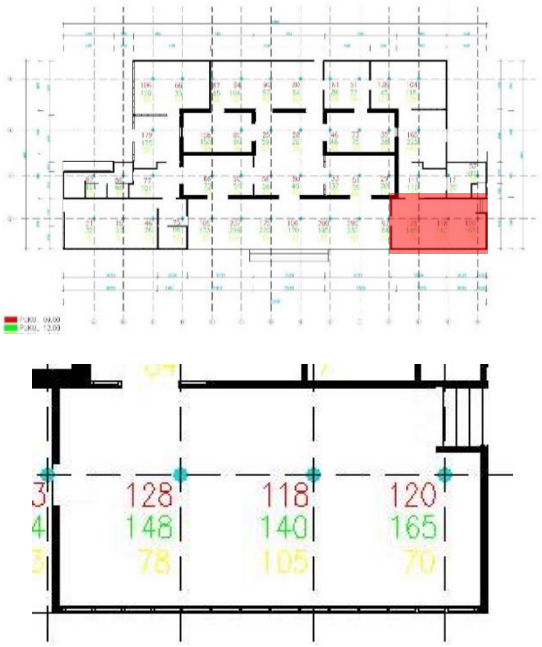

Figure 19. Plan of bureau room 3
(source: Author's Document,2022)

CONCLUSION

This study concluded that the final results indicate that the Gedhong Hinggil of Dalem Mangkubumen building does not meet the standards if used as an office building. This is because the building was originally used as a residence for the Crown Prince, not as an office building. The results showed that almost of the observations of visual lighting level was below 200lux, while the standard stated in SNI 16-7062-2004 for visual comfort for workspaces is 300 lux.

The results of this study which are below standard will have an impact on visual discomfort for users of the room during the work process. With these conditions, additional responses are needed to create visual comfort for users while working by increasing the light intensity in the room by adding artificial lighting (lamps).

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