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Analysis of the Feasibility of Lighting System Installation in Classrooms with Reference to SNI 6197 – 2020 in Higher Education Buildings

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Abstract: This research was conducted to test the feasibility of a lighting application installed in a college classroom. The study involved several data collection stages: determining the lighting measurement space, determining each lighting measurement point, measuring using a lux meter, testing the standard formula for determining the number of lighting points, and testing the number of lighting points using lighting software.

Each lighting calculation result was based on SNI 6197-2020 to assess the suitability of the lighting in the classroom. Based on the data obtained from each data collection step, it can be concluded that the current lighting conditions in the classroom do not comply with SNI 6197-2020. Improvements were made by adding additional lights, referring to SNI 6197-2020, and testing using lighting software before implementation. Therefore, based on the lux standard in SNI 6197-2020, the room requires 350 lux with 12 lamps to achieve the standard lux level. Testing with lighting software revealed an even distribution of lux levels between 300 and 350 lux.

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I. INTRODUCTION

This research was conducted because of the importance of lighting standards in supporting room functions and creating a good workspace with adequate and sufficient lighting, so that work in the room can be done properly and reduce the occurrence of long-term damage to the senses due to poor lighting conditions.

Then to obtain a standard for planning and installing a lighting system in a classroom that is feasible by referring to the feasibility of the SNI 6197-2020 standard for artificial lighting. This standard includes measured and tested parameter values. Therefore, there is no need for repeated actual testing, and the process can begin by comparing the measured results with the SNI parameter values and formulating the measured results under room conditions to achieve good compliance.The study involved several data collection stages: determining the lighting measurement space, determining each lighting measurement point, measuring using a lux meter, testing the standard formula for determining the number of lighting points, and testing the number of lighting points using lighting software. [1] [2] [3] [4] [5] [6] [7].

- *Standard Values for Artificial Lighting in Rooms and Formulations in SNI 6197-2020*

- *Standard Lighting Values*

The minimum average lighting level and minimum color rendering index recommended must not be less than the lighting levels in Table 1. [1]

Tabel 1 Lighting Level and Color Rendering.

Room function	Minimum average illumination level (average E) (lux)	Minimum color rendering
Educational Institutions		
Classroom	350	80
Library reading room	350	80
Laboratory	500	90
Computer lab	500	80
Language laboratory room	300	80
Teachers' room	300	80

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Gym	300	80
Image space	750	80
Auditorium	300	80
Lobby	100	80
Stairs	100	80
Canteen	200	80

- *Formulation*

In artificial lighting, the lighting level in a room is generally defined as the average lighting level on the work surface. The work surface refers to an imaginary horizontal surface located 0.75 meters above the floor throughout the room. The average lighting level E_(average) (lux) can be calculated using the following equation:[1]

$$E_{average} = \frac{F_{total} \, x \, k_p \, x \, k_d}{A} \quad \text{.....(1)}$$

✓ *Description:*

F_{total} = Total luminous flux from all lamps illuminating the work area (lumen).

A = scope of work (m^2)

k_p = utilization coefficient

k_d = depreciation coefficient.

To calculate the number of luminaires, first calculate the total luminous flux using the equation:

$$F_{total} = \frac{ExA}{k_p \, x \, k_d} \quad \text{.....(2)}$$

Then the number of luminaires is calculated using the equation:

$$N_{total} = \frac{F_{total}}{F_1 \, x \, n} \quad \text{.....(3)}$$

✓ *Description:*

N_{total} = number of luminer.

F_{total} = *Luminous flux from all lamps illuminating the work area.*

F_1 = Luminous flux of a single lamp (Lumen).

N = number of lamps in a luminaire.

II. MEASUREMENT METHODS AND MEASUREMENT DATA

➢ *Measurement Method*

In this study, measurements were taken in one classroom in a university building. The data collection process is shown in Figure 1.

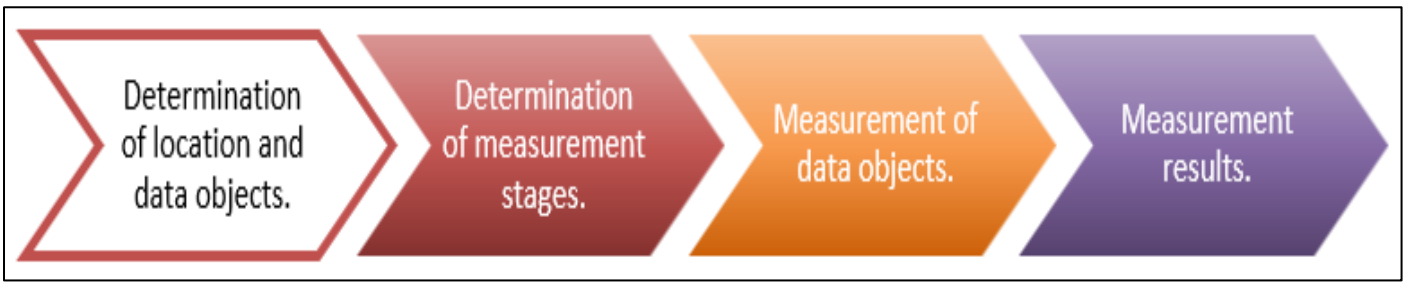

Fig 1 Measurement Stages

From the above stages, the measurement method is carried out by collecting data in the field, both in formulating problems, building hypotheses, and drawing research conclusions.

- *And from the Measurement Stage, the Following Can be Determined:*

✓ Measurements were taken in one classroom in a college building.
✓ The data object is the lighting in the lighting installation system in classrooms in university buildings.
✓ Measurements will be taken from several distances in classroom lighting with a reading height of 0.75 meters horizontally.
✓ Data was collected and selected from several lighting measurement distances in classrooms.

➢ *Measurement Data*

Measurement data was collected under several measurement conditions, namely.

✓ Data on the area and height of classrooms.
✓ Measurement data for lighting in each distance condition.

- *Measure the Area and Height of the Classroom.*

The measurement data obtained for the area and height of the classroom was measured directly and can be seen in Figure 2, which shows the measurement process, and in Table 2, which shows the area and height of the classroom.

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Fig 2 Actual Measurement of Classroom Area and Height.

Tabel 2 Classroom Measurement Data.

Description	m1	Wide (m2)
Length	7,625	53,07
Width	6,96	
Heighti	3,6	-

- *Lighting Measurement Data for Each Distance Condition.*

Lighting measurements for each distance condition were taken at 19 measurement points. Measurements were taken both at the light source and outside the light source. This was done to observe the distribution of lighting on the horizontal plane in the classroom. The measurements taken can be seen in Figure 3, and the lighting measurement data can be seen in Table 3.

Fig 3 Actual Lighting Measurement with Hioki-3432 Measuring Device

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Tabel 3 Lighting Measurement Data.

No	Uraian	Lux	Field height (m')	Description
1	Point 1	45,5	2,85	Actual height from floor to roof = 3,6 meter, Measurement height = 0,75 meter, So the height measurement on the lighting field 3,6-0,75 = 2,85 Meter
2	Point 2	52,9	2,85	
3	Point 3	46,9	2,85	
4	Point 4	55,9	2,85	
5	Point 5	72,1	2,85	
6	Point 6	76,1	2,85	
7	Point 7	70,6	2,85	
8	Point 8	64,2	2,85	
9	Point 9	56	2,85	
10	Point 10	69,5	2,85	
11	Point 11	65	2,85	
12	Point 12	54,7	2,85	
13	Point 13	78,3	2,85	
14	Point 14	74,1	2,85	
15	Point 15	79	2,85	
16	Point 16	61,2	2,85	
17	Point 17	43,8	2,85	
18	Point 18	49,3	2,85	
19	Point 19	42,8	2,85	

The layout of the measurement points from Table 3 can be seen in Figure 4. Below is the condition of the room.

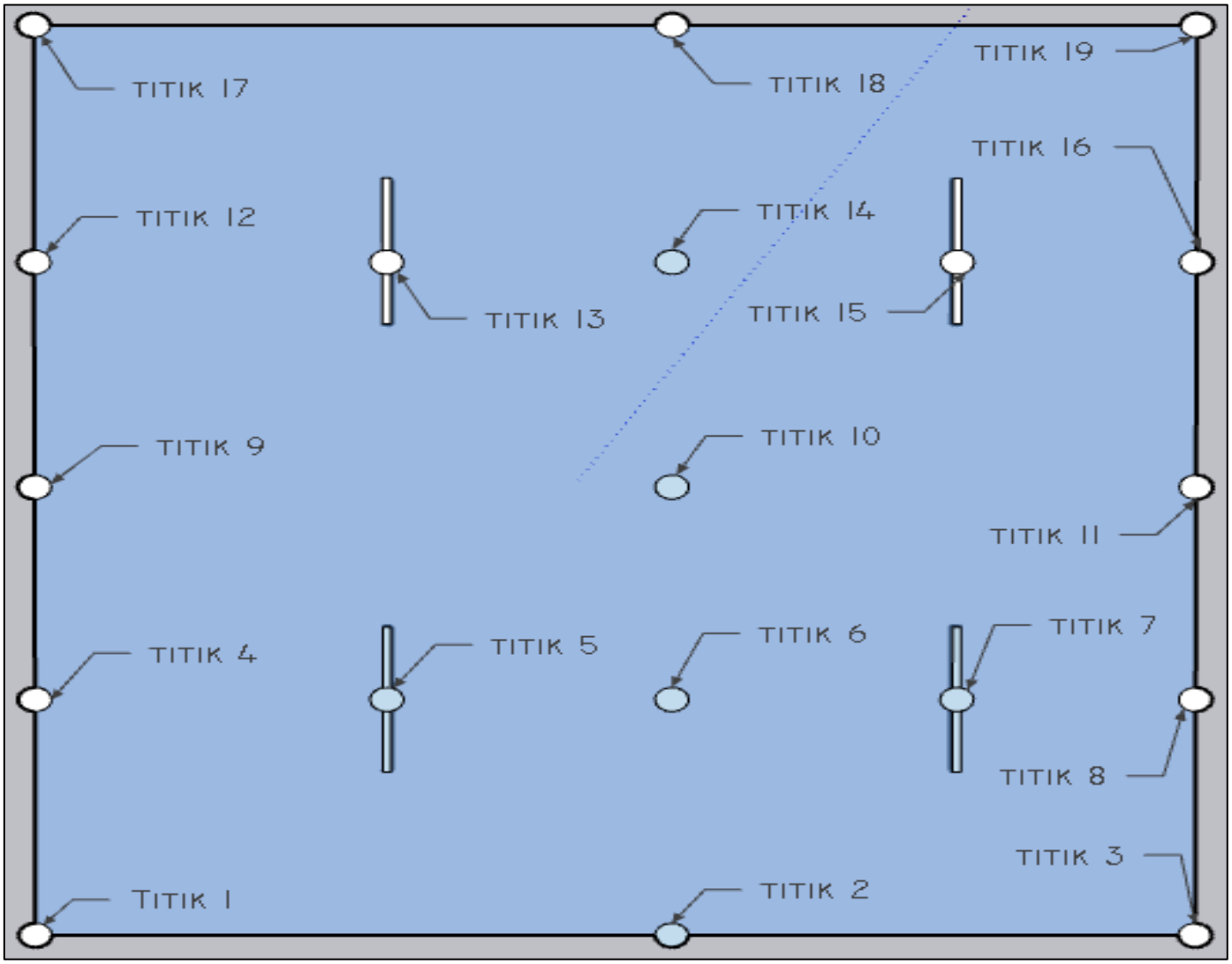

Fig 4 Lux Measurement Point Layout in the Classroom.

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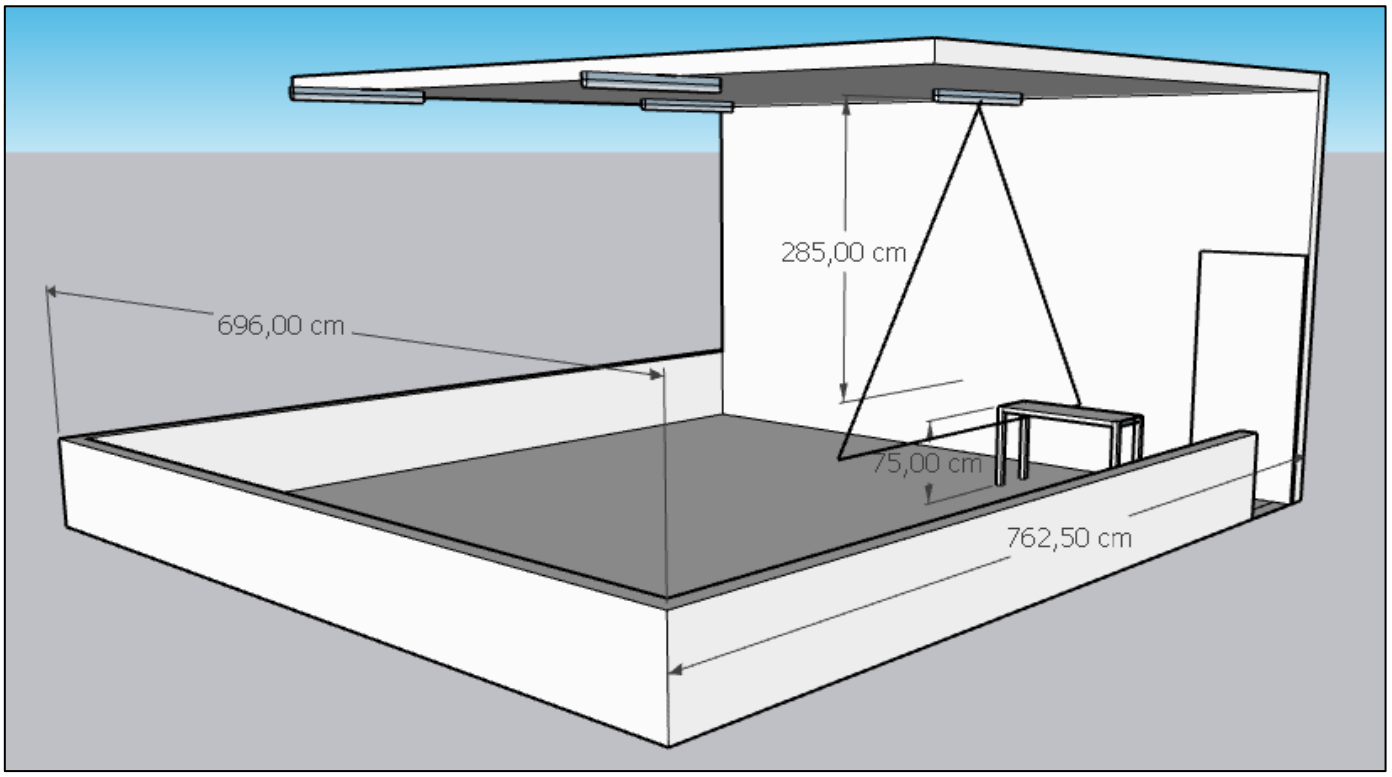

Fig 5 3-Dimensional Classroom Space and Height Measurements

From the data obtained, the distribution of lighting can be seen in the chart display in Figure 6.

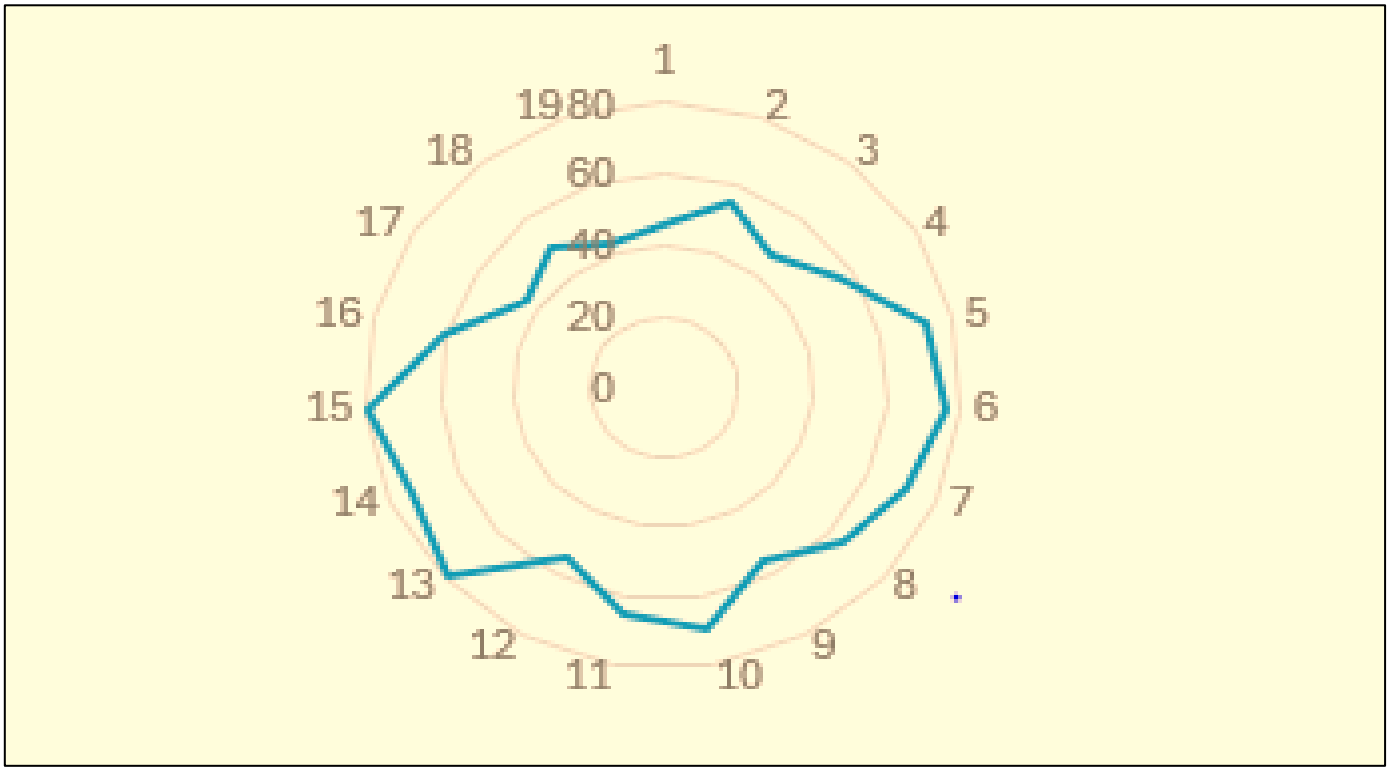

Fig 6 Current Lux Distribution Chart Display in the Room.

III. DATA TESTING, RESULTS, AND STANDARD CALCULATIONS

➢ *Data Testing*

Data testing can be done using data obtained from actual lighting measurements in classrooms and compared with the standard reference in SNI 6197-2020. Table 4 shows the measured lux values and standard values.

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Table 4 Table of Actual Results and Standard Values of SNI 6197 2020

No	Description	Lux	Standart lux SNI 6197-2020	Results	Explanation
1	Point 1	45,5	350	inappropriate	Actual height from floor to roof = 3,6 meter, Measurement height = 0,75 meter, So, the height measurement on the lighting field 3,6-0,75 = 2,85 Meter
2	Point 2	52,9	350	inappropriate	
3	Point 3	46,9	350	inappropriate	
4	Point 4	55,9	350	inappropriate	
5	Point 5	72,1	350	inappropriate	
6	Point 6	76,1	350	inappropriate	
7	Point 7	70,6	350	inappropriate	
8	Point 8	64,2	350	inappropriate	
9	Point 9	56	350	inappropriate	
10	Point 10	69,5	350	inappropriate	
11	Point 11	65	350	inappropriate	
12	Point 12	54,7	350	inappropriate	
13	Point 13	78,3	350	inappropriate	
14	Point 14	74,1	350	inappropriate	
15	Point 15	79	350	inappropriate	
16	Point 16	61,2	350	inappropriate	
17	Point 17	43,8	350	inappropriate	
18	Point 18	49,3	350	inappropriate	
19	Point 19	42,8	350	inappropriate	

And the results of lighting distribution using lighting software. The lighting distribution did not meet the standards with the following specifications and number of lamps:

Table 5 Light Specifications and Number of Lights

No	Equipment	Amount	Unit	Explanation
1	TL LED 19 Watt	4	Units	Lumen = 1950 lm. Series AN15MFSED LED 19W/840. Lighting area = 53,07 m^2

The measurement results from the lighting software can be seen in Figure 7.

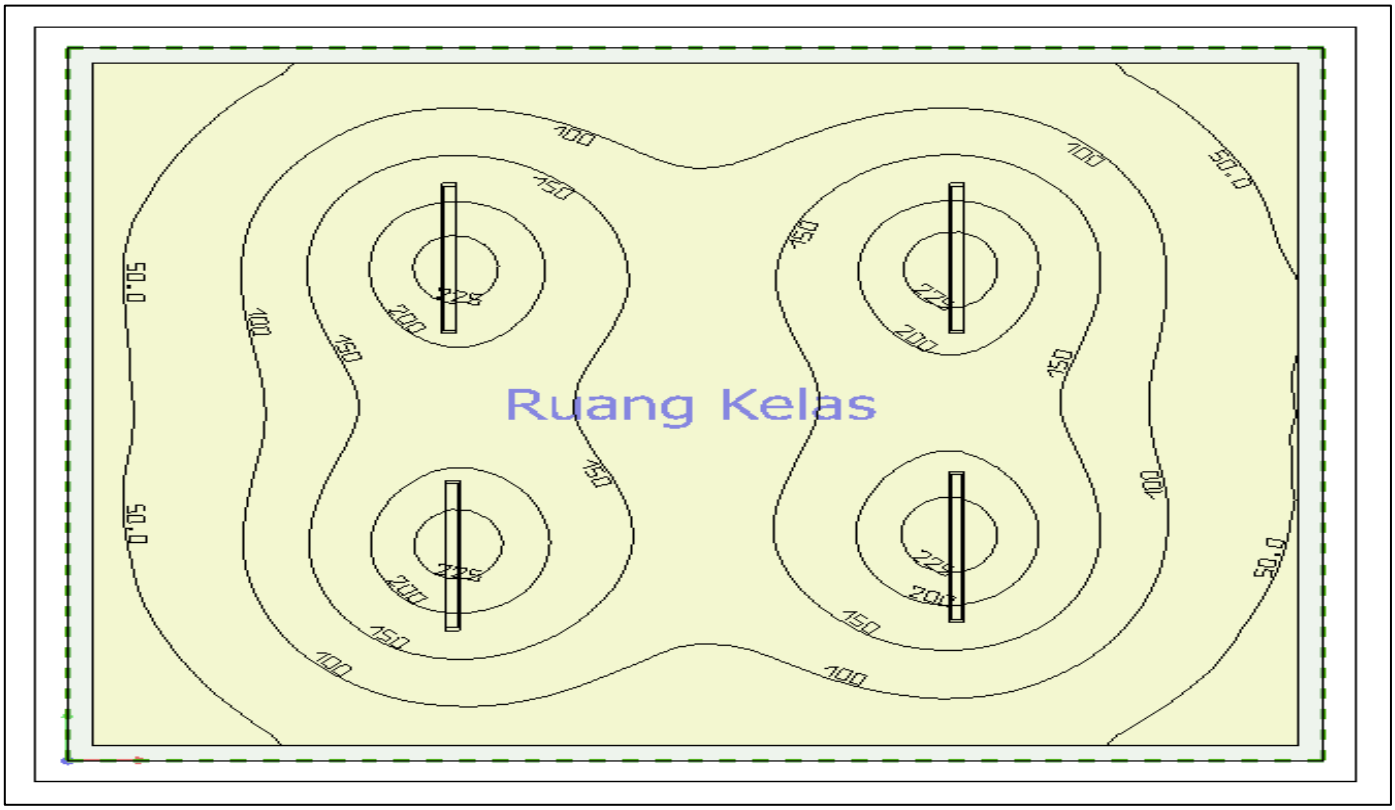

Fig 7 Measurement Results of Lighting Distribution Under Existing Conditions.

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In the image above, it can be seen that the maximum lighting is 228 lux and the minimum is 50 lux around the walls of the room.

It can be concluded from the lighting software measurement results that the lighting in the classroom currently does not meet the SNI 6197-2020 standard.

➢ *Results*

From Table 4 and Figure 7, the same result is obtained, namely that the lighting in classrooms measured in university buildings with reference to the SNI 6197-2020 standard is not adequate yet. Therefore, improvements can be made by recalculating with reference to the standardized formula and the specifications of the lamps used.

➢ *Standard Calculation*

From Table 5, formulas 2 and 3, it is possible to condition adequate lighting in the classroom and refer to the SNI 6197-2020 standard. The results can be seen in Table 6 below:

Table 6 Lighting Requirements According to the SNI 6197 2020 Standard

No	Lumen/ lampu	Banyak	Luas ruangan (m2)	Lux	$F_{total} = \frac{ExA}{k_p \, x \, k_d}$		$N_{total} = \frac{F_{total}}{F_1 \, x \, n}$	
1	1950	1	53,07	350	23.218	Lumen	11,91	Buah lampu

Note: Condition of k_p is 1 dan k_d is 0,8.

From the calculation results, it was found that ±12 lamps were needed, which could be rounded up to 12 lamps. From these results, the lighting distribution could also be tested using lighting software. The measurement results in the software can be seen in Figure 8 below. [8] [9] [10] [11] [12] [13] [14].

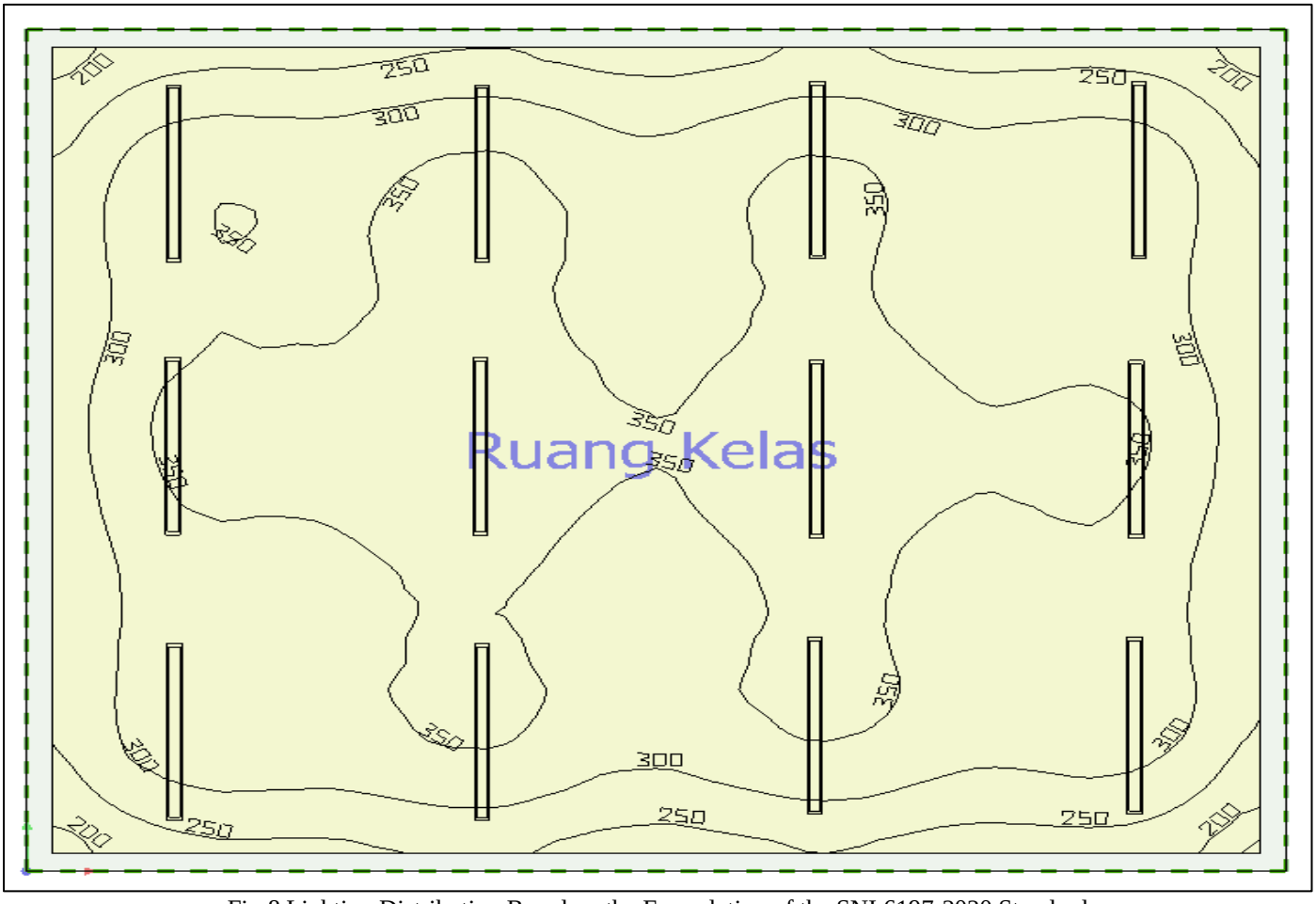

Fig 8 Lighting Distribution Based on the Formulation of the SNI 6197-2020 Standard

The 3D conditions of the light distribution can be seen in Figures 9 and 10 below.

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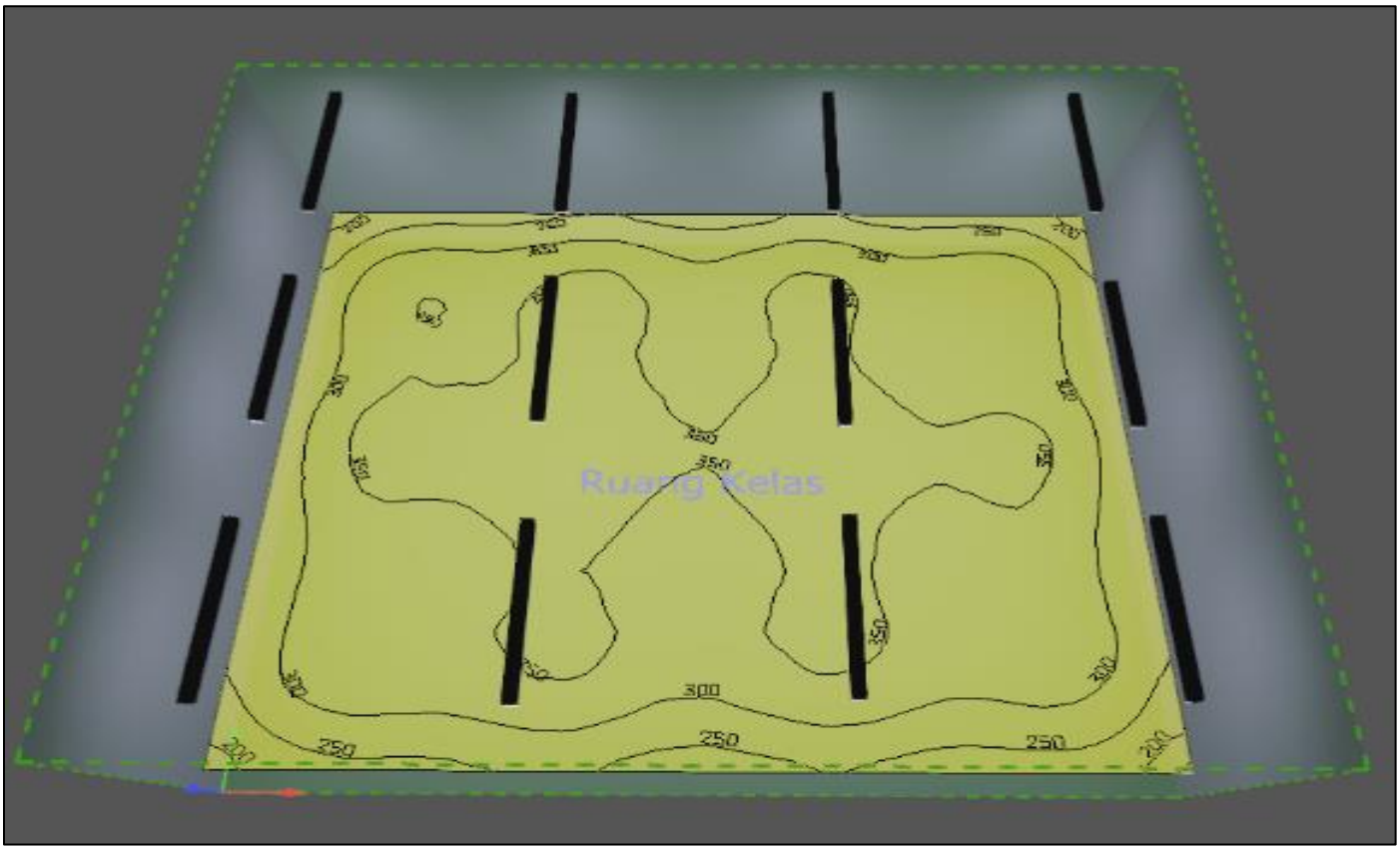

Fig 9 3D View of Light Distribution.

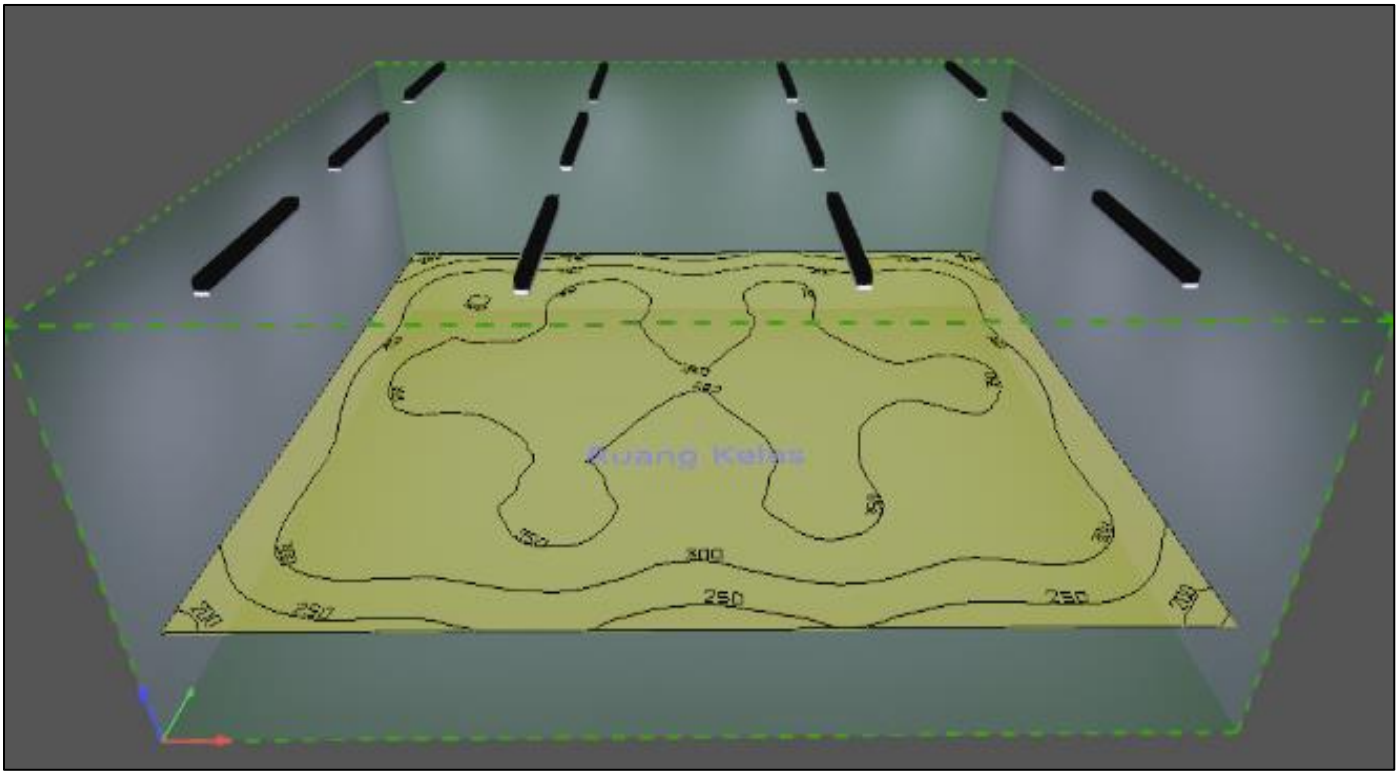

Fig 10 3D View of Light Distribution and Horizontal Light Height.

Based on the lighting design and distribution results from the lighting software, the outcomes are satisfactory, with a maximum lighting level of 350 lux and a minimum lighting level of 200 lux on each side of the classroom partition walls. Therefore, referring to the classroom standard of 350 lux, the calculated lighting requirements and the extent of lighting distribution obtained can be deemed suitable and compliant with SNI 6197-2020 standards.

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IV. CONCLUSION

Based on the results obtained, it can be concluded that there are still some planning and implementation issues in the installation of lighting in classrooms that do not comply with SNI 6197-2020.

This can have adverse long-term effects on users of the space, particularly on their eyes or vision during routine activities within the space.

All of this can be addressed by implementing standardized improvements that adhere to established standards. This applies to lighting systems as well as other systems across all areas. The goal is to achieve optimal functionality of the space and ensure the health and well-being of its users.

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