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# Lighting Optimization of Karawo Production House

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**ABSTRACT**

Karawo embroidery processes are carried out without using machine technology. This research aims to optimize the lighting of the Gorontalo Karawo fabric production house. The method used is surveying, conducting direct measurements, and distributing questionnaires. A simulation is carried out using Dialux Evo 9.0 in existing conditions and after the addition of lights. Simulation measurement shows an average lighting value of 461.3 lux from 07.00 to 17.00. The result does not meet the SNI 16-7062-2004 for fine work, which is a minimum of 1000-2000 lux. Based on the measurements on the field, it was found that the lighting level only ranged from 22.19 lux to 30.78 lux. According to the Karawo craftsmen, 33% had headaches and eye pain during the production process, and 33% had eye pain. Moreover, based on the simulation with the light, the average intensity is 1107.4 lux and reached the specified standard.



Keywords: Karawo, Production house, Eyehealth, Lighting Intensity

## 1. Introduction

Karawo is a technique to shape ornaments in textiles by designing, slicing, and retracting certain parts of the textile fiber to create the primary field, then back embroidering the pulled-out fibers to produce various motives [1]. Karawo embroidery (Gorontalo's mother tongue) is a "unique and distinctive" handicraft art. Karawo comes from the root word "makarawo," which means slicing or punching holes. The process requires precision, patience, perseverance, foresight, and sensitivity because all the processes are carried out without using machine technology (handmade masterpieces). The process starts with design, slicing materials, pulling threads, fiddling, and embroidering [2].

Although the tools used today are more developed in the manufacturing process, the equipment used is still straightforward, such as razor blades, hand needles, handles made of plastic, and scissors. Compared to other craft industries that already use modern industrial equipment/machines, it takes quite a long time to complete one piece of Karawo cloth. The finer the fabric fiber and the larger the motif chosen, the longer the time used in its manufacture [2].

According to WHO, in 2010, as many as 285 million people, or 4.24% of the total population in the world, experienced visual impairment in the form of low vision / low visual acuity and blindness, with a distribution of 246 million people or 65% of the population experiencing low vision. In Indonesia, it is estimated that 3 million people have visual impairments [3].

Visual disturbances that can appear in Karawo artisans are eye fatigue. The leading cause of eye fatigue is a result of fatigue in the ciliary muscle due to eye accommodation that occurs continuously in using near vision. Symptoms of eye fatigue include eye strain, blurred/double

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vision, red and dry/watery eyes, the tension in the shoulders, and headaches.

Some of the problems are the Karawo craftsmen who do not have a special place to produce Karawo fabric. They only do Makarawo activities in their respective homes, so the lighting conditions are inadequate. The choice of working in poor lighting conditions is not in accordance with what is stated in the Regulation of the Minister of Labor No. 7 of 1964 concerning Requirements for Health, Cleanliness, and Lighting in the Workplace. The lighting standards set for Indonesia are roughly the same as the United States International standards (1968) for Interior Lighting lighting according to the type of worker nature in a nutshell. The intensity in question is lighting for workers who distinguish objects carefully and examine small, delicate items such as embroidering Karawo at least 300 lux. The field observations show that 90.01% of the lighting intensity of the Karawo craftsmen's workspace is below the KEPMENKES/NO.7/1404/2002 standard or less than 300 lux, and only 9.90% meets the standard or more of 300 Lux [4].

Several studies that have been done previously related to eye fatigue factors in Karawo artisans. Research conducted by Mohamad [4] on Karawo artisans in Gorontalo Regency showed that all Karawo craftsmen did not appear to cause symptoms that were felt before working due to eye fatigue. However, after working with inadequate lighting, all (100%) Karawo craftsmen felt headaches, eye irritation, double vision, and pain around the eyes. As many as 26% of the craftsmen who worked less than two weeks experienced acute fatigue, and 45% of the workers who worked more than two weeks experienced chronic eye fatigue.

Another study conducted by Lasabon [5] was obtained based on lighting measurements carried out in the morning, afternoon, evening, and night. Furthermore, 19 (54.3%) of them met the standard. For measurements, 28 (80.0%) did not meet the standard during the day, and 7 (20.0%) of them met the standard. Furthermore, for the measurement of daylighting, it is known that of the 35 measurement points, 26 (74.3%) do not meet the standards, and only 9 (25.7%) meet the standard. While the lighting measurement at night, 32 (91.4%) did not meet the standard, and 3 (8.6%) met the standard.

From table SNI 16-7062-2004 for fine work, namely with color selection activities, textile processing, fine machine work, and fine assembly, the minimum lighting level is 1000-2000 lux. From the data above, it was found that making Karawo requires careful eyes, while the process takes a long time, and on the other hand, the intensity of lighting in their room does not meet the standards. Further observations need to be made to determine field conditions and optimize lighting to overcome the eye fatigue factor of the Karawo craftsman. Artificial lighting will be the method to optimize it to achieve optimal lighting, as research conducted by Wijaya [6]. This article succeeded in developing a scenario so that the room achieved comfort. However, energy efficiency can be optimally reached, and the costs can be reduced as low as possible.

## 2. Material and Methods

This research was conducted by conducting a survey of lighting level measurements using a lux meter and distributing questionnaires to respondents. After that, a simulation was carried out using the Dialux Evo 9.0 application to determine the average lighting level at the respondent's work location and obtain the optimal lighting value according to the SNI 16-16 standard. 7062-2004, which is 1000 lux. Then the results will be compared with simulations that use artificial lighting to optimize the room's lighting.

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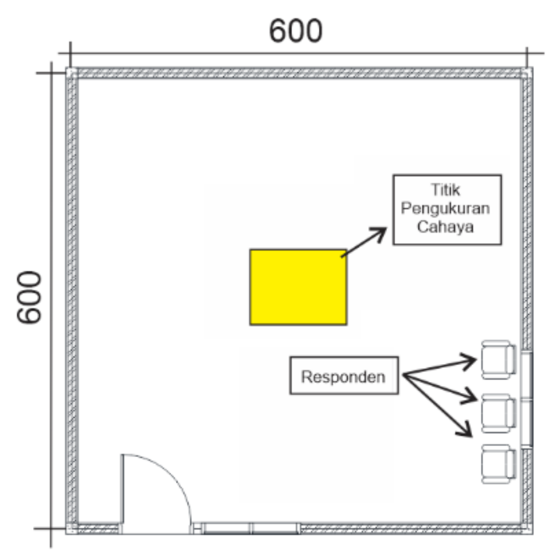
Table 1. SNI 16-7062-2004

| Activity Type | Minimum Lighting Intensity (Lux) | Explanation |
|---|---|---|
| Storage | 20-50 | Storage room and installation equipments which require continuous work |
| Rough work areas where visual tasks are only occasionally performed | 50-100 | |
| Rough work performed continuously | 100-200 | Working with machinery and rough assembling |
| Routine tasks | 200-500 | Administration room, control room, machinery tasks and assembling |
| Slightly fine work | 500-1000 | Drawing, machinery work, machine inspection |
| Fine work | 1000-2000 | Color selection, textile processing, fine machinery work and fine assembling |
| Very fine work | 5000-20000 | Hand carving, machinery work inspection, and very fine assembling |
| Detailed work | 10000-20000 | Work inspection, very fine assembling |

Several previous studies that used Dialux simulations were the Analysis of Lighting Performance in the Hall of the Faculty of Engineering, State University of Gorontalo, using the DIALux Evo 9.0 Simulation. This study uses a simulation method using Dialux Evo 9.0 [7]. Another research entitled Lighting Quality Analysis Using Numerical Modeling according to SNI Lighting, Direct Measurement Data (On-Site) and Simulation. This study uses three methods, namely numerical calculations based on the Indonesian National Standard (SNI) study on lighting, direct measurement methods, and computer simulation using DIALux [8].

The measurement location is at the Karawo craftsman's house in Telaga, Gorontalo Regency, with the work location in the living room with an area of 6 meters x 6 meters. The position of the measuring point is in the middle using a lux meter, as shown in Figure 1.

The DIALux Evo 9.0 simulation was carried out in the climatic conditions of Gorontalo on September 21, 2019. This date was chosen because the sun's position is in the middle of the equator. Meanwhile, the simulation is conducted in a sufficient work period, starting at 07.00 to 17.00 with clear sky conditions and a latitude of 0 ° 33 ' and longitude of 123 ° 8' (+8.0 DPL). The lighting level in a room is generally defined as the average lighting level in the workplane. What is meant by the work area is an imaginary horizontal plane located 0.75 meters above the floor in the entire room




Source: Author, 2021
Figure 1. Production room floorplan

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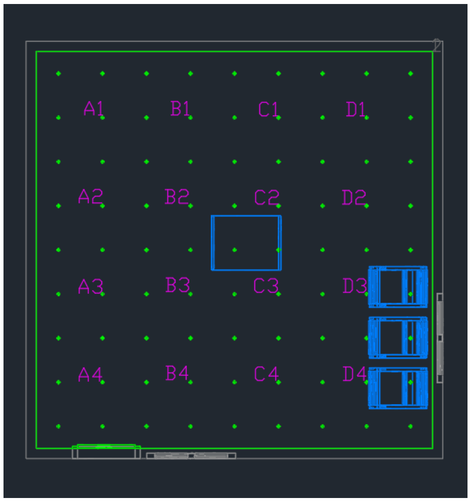
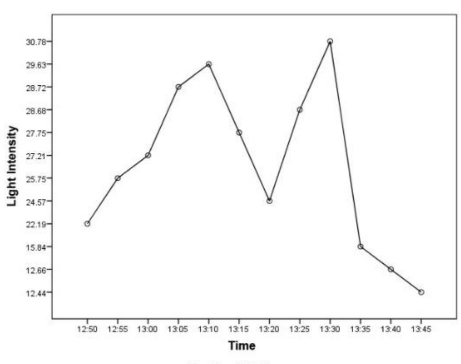



Source: Author, 2021
Figure 2. Simulation Measurement Points

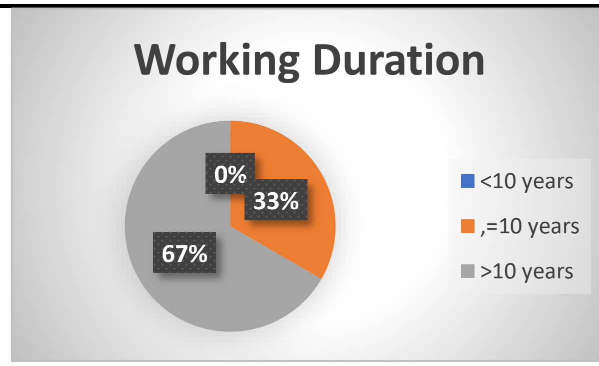
## 3. Results and Discussions

### *3.1 Measurement Results Using Luxmeter and Questionnaire*

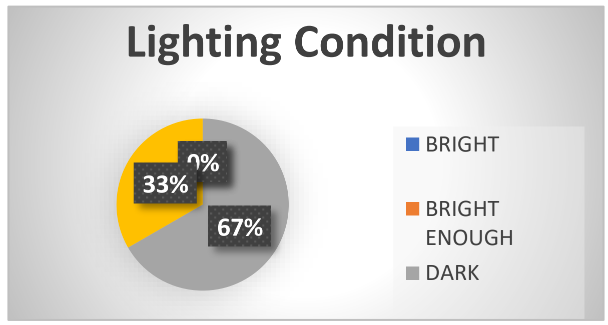
Based on the results of measurements made on November 4, 2021, it was found that the lighting at the research location only ranged from 22.19 lux to 30.78 lux (Figure 3). Meanwhile, about 67% of respondents totaling three people, worked as Karawo craftsmen for more than ten years and around 33% for ten years (Figure 4). According to the Karawo craftsmen, 67% of the lighting conditions in the room felt dark, and 33% felt very dark (Figure 5). While making Karawo, 33% had headaches and eye pain, and 33% had eye pain (Figure 6).



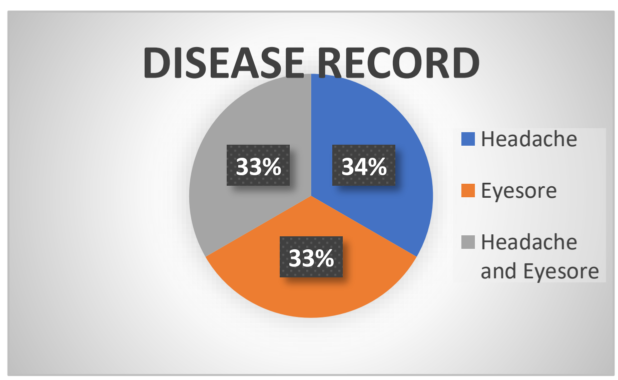

Source: Author, 2021
Figure 3. Measurements Result Using Luxmeter




Source: Author, 2021
Figure 4. Questionaire result on the working duration of Karawo craftsman




Source: Author, 2021
Figure 5. Questionaire result on lighting condition

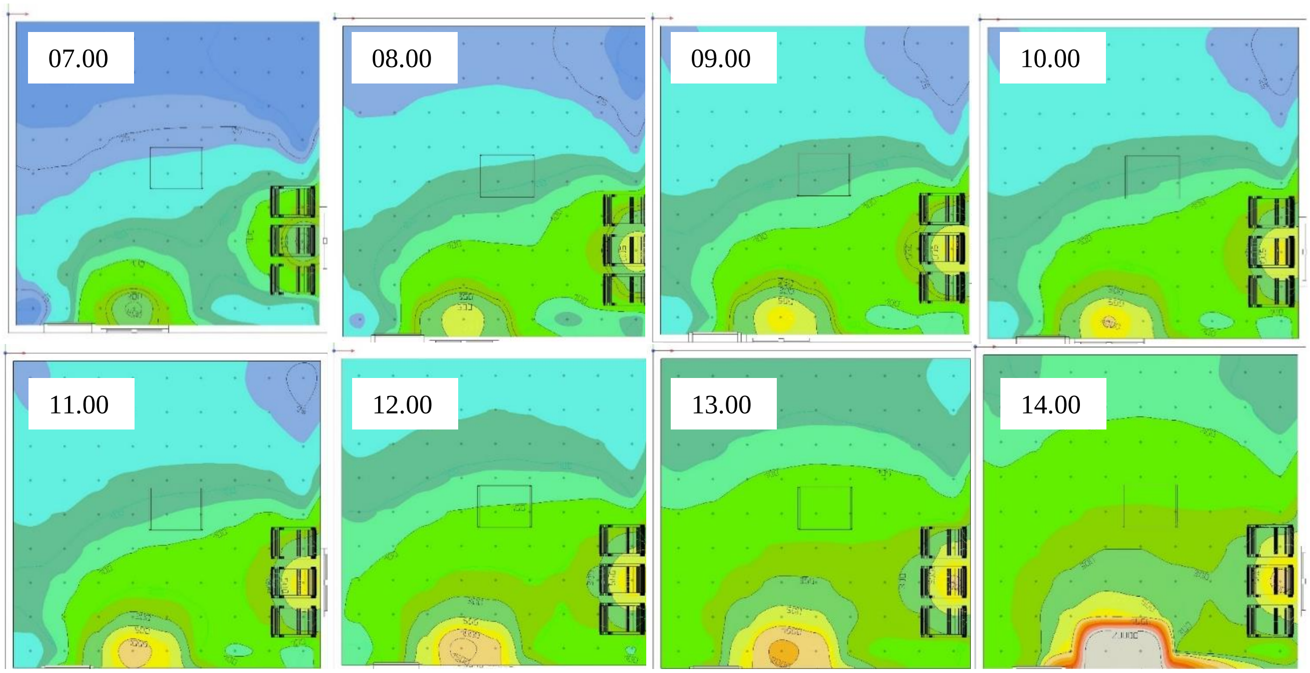



Source: Author, 2021
Figure 6. Questionaire result on disease suffered by the craftsman

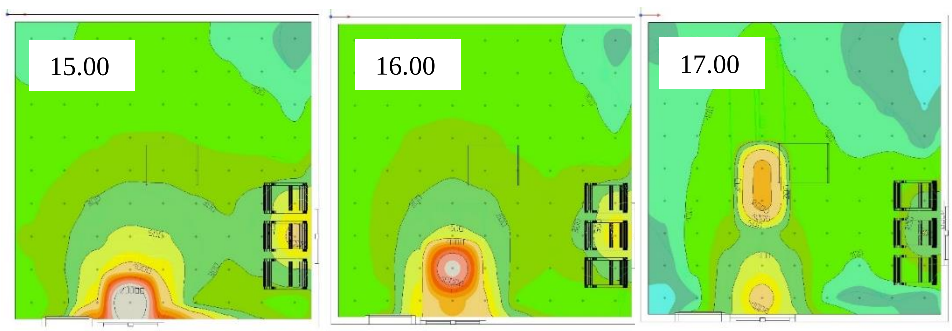
### *3.2 Simulation Results on the existing Karawo Production House using DIALux Evo 9.0*

Based on the simulation results conducted using the Dialux Evo 9.0 Simulation, on September 21, 2019, the measuring point D1 is the rear position with the lowest light intensity of 18 lux. Position B4 has the highest light intensity

28789 lux. The average lighting intensity from 07.00 to 17.00 is only about 491 lux.




Source: Author, 2021
Figure 7. Existing Condition Simulation Results from 07.00 to 14.00




Source: Author, 2021
Figure 8. Existing Condition Simulation Results from 15.00 to 17.00

Table 2. Simulation Result of The Existing Condition (Light off)

| Measuring points | Maximum | | Minimum | | Average intensity (07.00-17.00) |
|---|---|---|---|---|---|
| | Light intensity (lux) | Measured time | Light intensity (lux) | Measured time | |
| A1 | 171 | 16.00 | 25 | 07.00 | 83.7 |
| A2 | 225 | 16.00 | 34 | 07.00 | 113.6 |
| A3 | 305 | 15.00 | 55 | 07.00 | 167.6 |
| A4 | 391 | 15.00 | 86 | 07.00 | 227.9 |
| B1 | 1936 | 17.00 | 27 | 07.00 | 279.5 |
| B2 | 1989 | 17.00 | 41 | 07.00 | 331.8 |
| B3 | 1141 | 17.00 | 76 | 07.00 | 384.1 |
| B4 | 28789 | 15.00 | 219 | 07.00 | 4566.3 |
| C1 | 187 | 16.00 | 27 | 07.00 | 93.2 |
| C2 | 268 | 15.00 | 43 | 07.00 | 144 |
| C3 | 425 | 15.00 | 81 | 07.00 | 240.8 |
| C4 | 570 | 14.00 | 109 | 07.00 | 346.9 |
| D1 | 127 | 16.00 | 18 | 07.00 | 69.5 |
| D2 | 235 | 15.00 | 41 | 07.00 | 131.9 |
| D3 | 541 | 15.00 | 171 | 07.00 | 366.3 |
| D4 | 436 | 14.00 | 153 | 07.00 | 320.8 |

From table 1, it can be concluded that the average existing lighting from measuring points A1 to D4 from 07.00 to 17.00 has an average lighting intensity of 461.3 lux. The highest point is the B4 position, in front of the window with a maximum light intensity of 28789 Lux at 15.00. Meanwhile, the minimum intensity is 18 lux at the measuring point D1 at 07.00.

### *3.3 Simulation Results on the existing Karawo Production House using DIALux Evo 9.0*

Based on the measurement results in the initial conditions, which only have an average lighting intensity of about 491 lux, artificial lighting can be added to optimize lighting and utilize the space to maximize the work process. In this simulation, artificial lighting uses Philips brand lamps easily found in Indonesia with the type 4MX850 G3 491 1Xled55s/840 PSU A20.

The room also placed chairs and work desks to make it easier to do their work. The lamp's position is placed above each table so that the proper lighting falls on the work plane.

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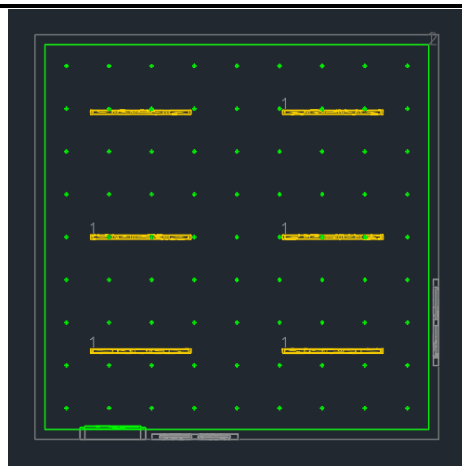
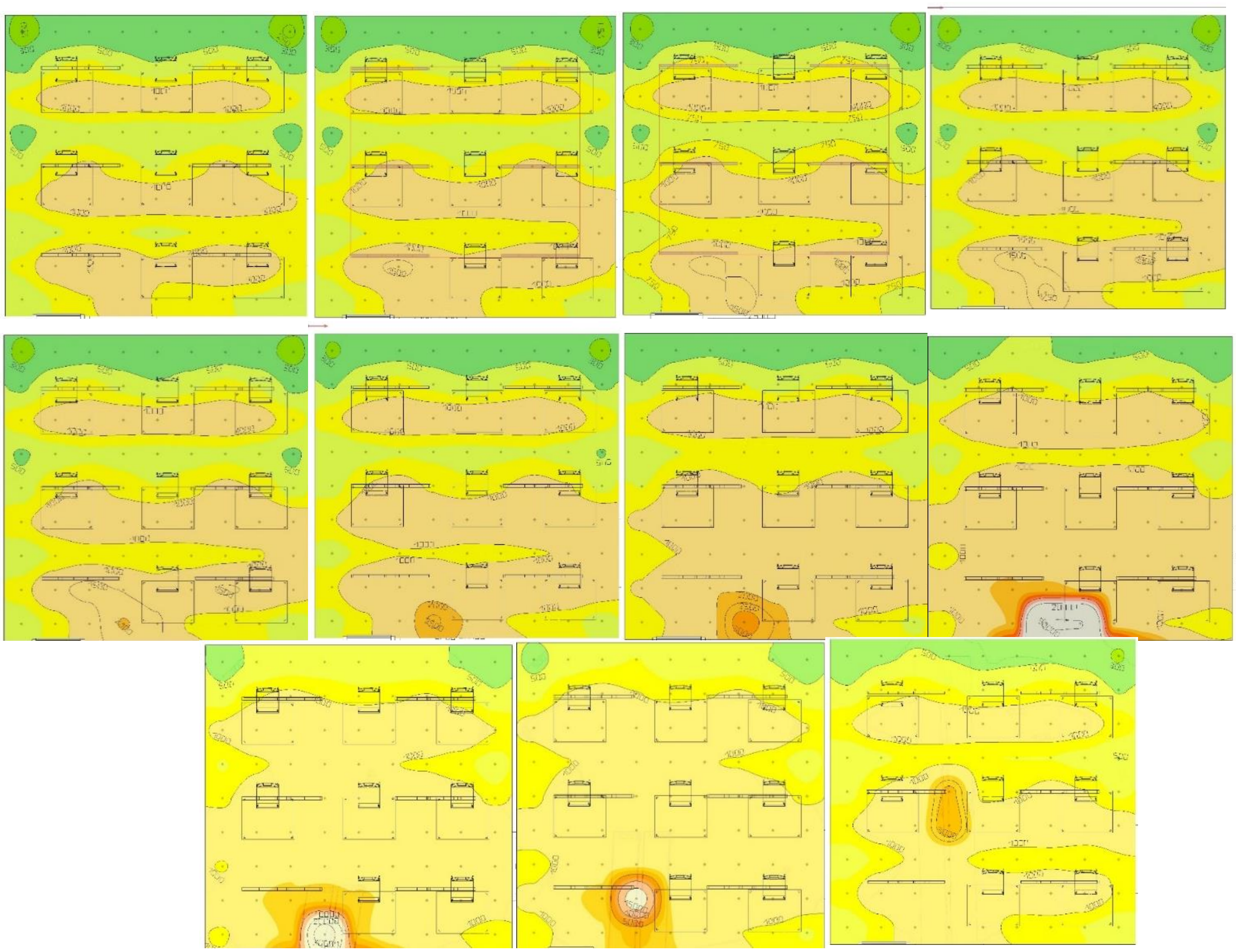


Source: Author, 2021

Figure 9. Location of luminaires in simulation with the light on



Source: Author, 2021

Figure 10. Condition of Simulation Results with the light on from 08.00 to 17.00

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Table 3. Simulation Result of the Room With the Light off

| Measuring points | Maximum | | Minimum | | Average intensity (07.00-17.00) |
|---|---|---|---|---|---|
| | Light intensity (lux) | Measured time | Light intensity (lux) | Measured time | |
| A1 | 854 | 16.00 | 549 | 07.00 | 649.9 |
| A2 | 1010 | 16.00 | 633 | 07.00 | 760.4 |
| A3 | 1583 | 15.00 | 1055 | 07.00 | 1249.7 |
| A4 | 1590 | 15.00 | 948 | 07.00 | 1183.1 |
| B1 | 2544 | 17.00 | 582 | 07.00 | 875.3 |
| B2 | 2754 | 17.00 | 751 | 07.00 | 1101.5 |
| B3 | 2357 | 17.00 | 1253 | 07.00 | 1644.0 |
| B4 | 3006 | 15.00 | 1118 | 07.00 | 1838.4 |
| C1 | 901 | 16.00 | 573 | 07.00 | 685.9 |
| C2 | 1193 | 16.00 | 762 | 07.00 | 924.4 |
| C3 | 1861 | 15.00 | 1259 | 07.00 | 1491.5 |
| C4 | 1731 | 15.00 | 895 | 07.00 | 1303.9 |
| D1 | 761 | 16.00 | 571 | 09.00 | 645.6 |
| D2 | 946 | 15.00 | 641 | 07.00 | 763.7 |
| D3 | 1688 | 15.00 | 1157 | 07.00 | 1399.4 |
| D4 | 1421 | 14.00 | 985 | 07.00 | 1202.4 |

From table 3, it can be concluded that the average lighting using lamps from measuring points A1 to D4 from 07.00 to 17.00 has an average lighting intensity of 1107.4 lux. The highest point is the B4 position, in front of the window with a maximum light intensity of 3006 lux at 15.00. Meanwhile, the minimum intensity is 549 lux at the measuring point A1 at 07.00.

### *3.4 Comparison of simulation result between the existing and Simulation Results Using Lights in Karawo Production House Using Dialux Evo 9.0*

The comparison between the existing simulation and using lights in the Karawo production house using Dialux Evo 9.0 can be seen in table 4.

Table 4. Comparison of the result of simulation between lighting off and with the light on in the Karawo production house using Dialux Evo 9.0

| No | Time | A1 | | B1 | | C1 | | D1 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Light off | Light on | Light off | Light on | Light off | Light on | Light off | Light on |
| 1. | 07.00 | 25 | 549 | 27 | 582 | 27 | 573 | 18 | 648 |
| 2. | 08.00 | 42 | 570 | 46 | 604 | 43 | 596 | 32 | 664 |
| 3. | 09.00 | 45 | 575 | 52 | 614 | 50 | 603 | 38 | 571 |
| 4 | 10.00 | 45.5 | 576 | 53.5 | 614 | 52.5 | 605 | 40.5 | 575 |
| 5. | 11.00 | 46 | 578 | 55 | 618 | 55 | 611 | 43 | 578 |
| 6. | 12.00 | 60 | 599 | 70 | 644 | 71 | 636 | 56 | 599 |
| 7. | 13.00 | 81 | 648 | 96 | 704 | 93 | 687 | 77 | 638 |
| 8. | 14.00 | 107 | 714 | 130 | 788 | 129 | 765 | 103 | 695 |
| 9. | 15.00 | 143 | 801 | 170 | 921 | 162 | 867 | 123 | 742 |
| 10. | 16.00 | 171 | 854 | 213 | 995 | 187 | 901 | 127 | 761 |
| 11. | 17.00 | 117 | 685 | 1936 | 2544 | 115 | 701 | 78 | 631 |

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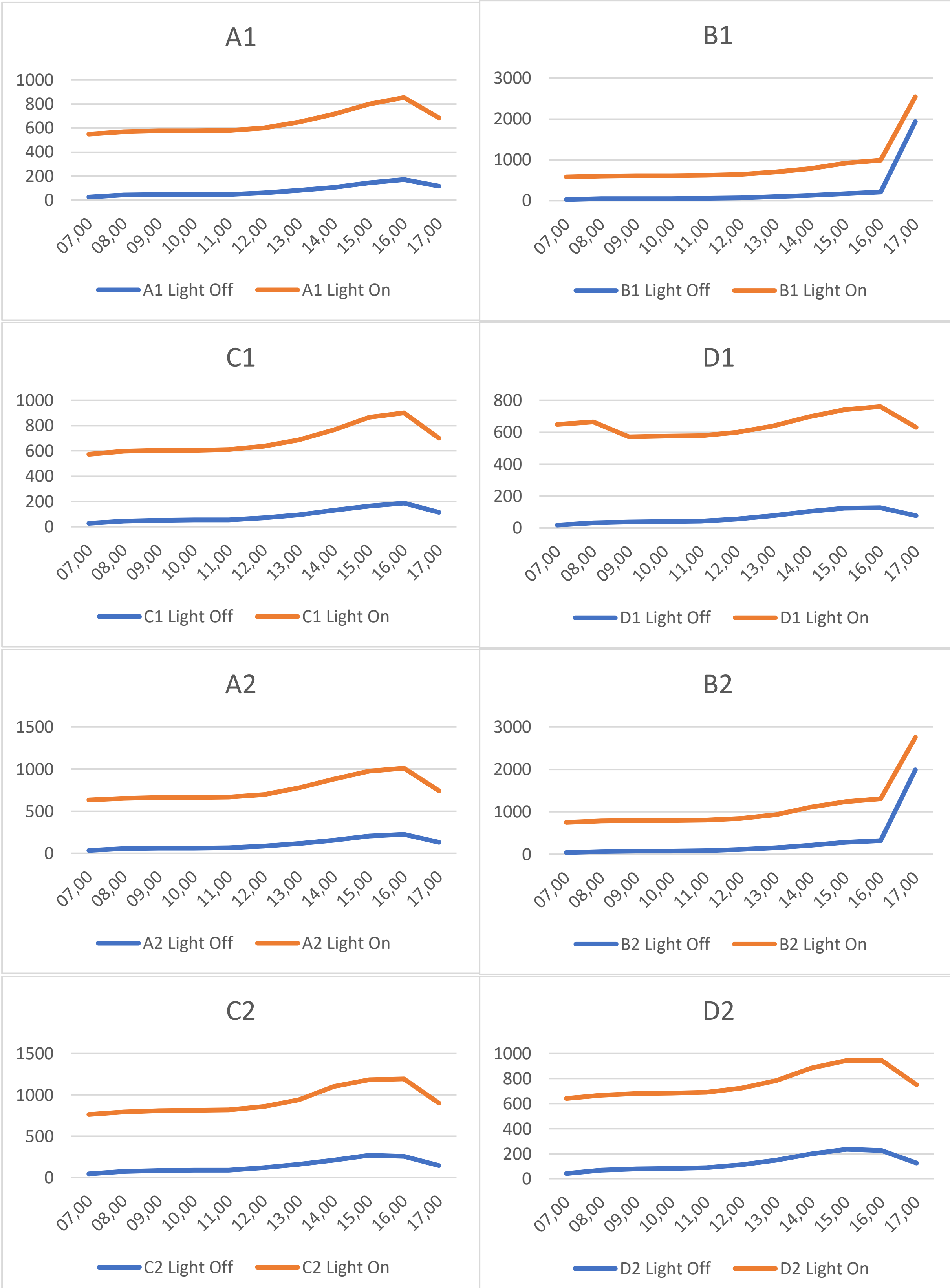
| No | Time | A2 | | B2 | | C2 | | D2 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Light off | Light on | Light off | Light on | Light off | Light on | Light off | Light on |
| 1. | 07.00 | 34 | 633 | 41 | 751 | 43 | 762 | 41 | 641 |
| 2. | 08.00 | 55 | 654 | 66 | 781 | 71 | 794 | 69 | 668 |
| 3. | 09.00 | 63 | 663 | 76 | 794 | 82 | 806 | 77 | 680 |
| 4 | 10.00 | 63.5 | 664 | 78.5 | 799 | 85.5 | 814 | 82.5 | 685 |
| 5. | 11.00 | 64 | 668 | 81 | 804 | 89 | 819 | 88 | 690 |
| 6. | 12.00 | 84 | 699 | 110 | 846 | 116 | 856 | 113 | 725 |
| 7. | 13.00 | 115 | 776 | 149 | 937 | 158 | 942 | 147 | 784 |
| 8. | 14.00 | 157 | 880 | 208 | 1106 | 211 | 1102 | 197 | 885 |
| 9. | 15.00 | 206 | 974 | 281 | 1240 | 268 | 1182 | 235 | 945 |
| 10. | 16.00 | 225 | 1010 | 317 | 1304 | 257 | 1193 | 226 | 946 |
| 11. | 17.00 | 133 | 743 | 1989 | 2754 | 145 | 898 | 126 | 752 |

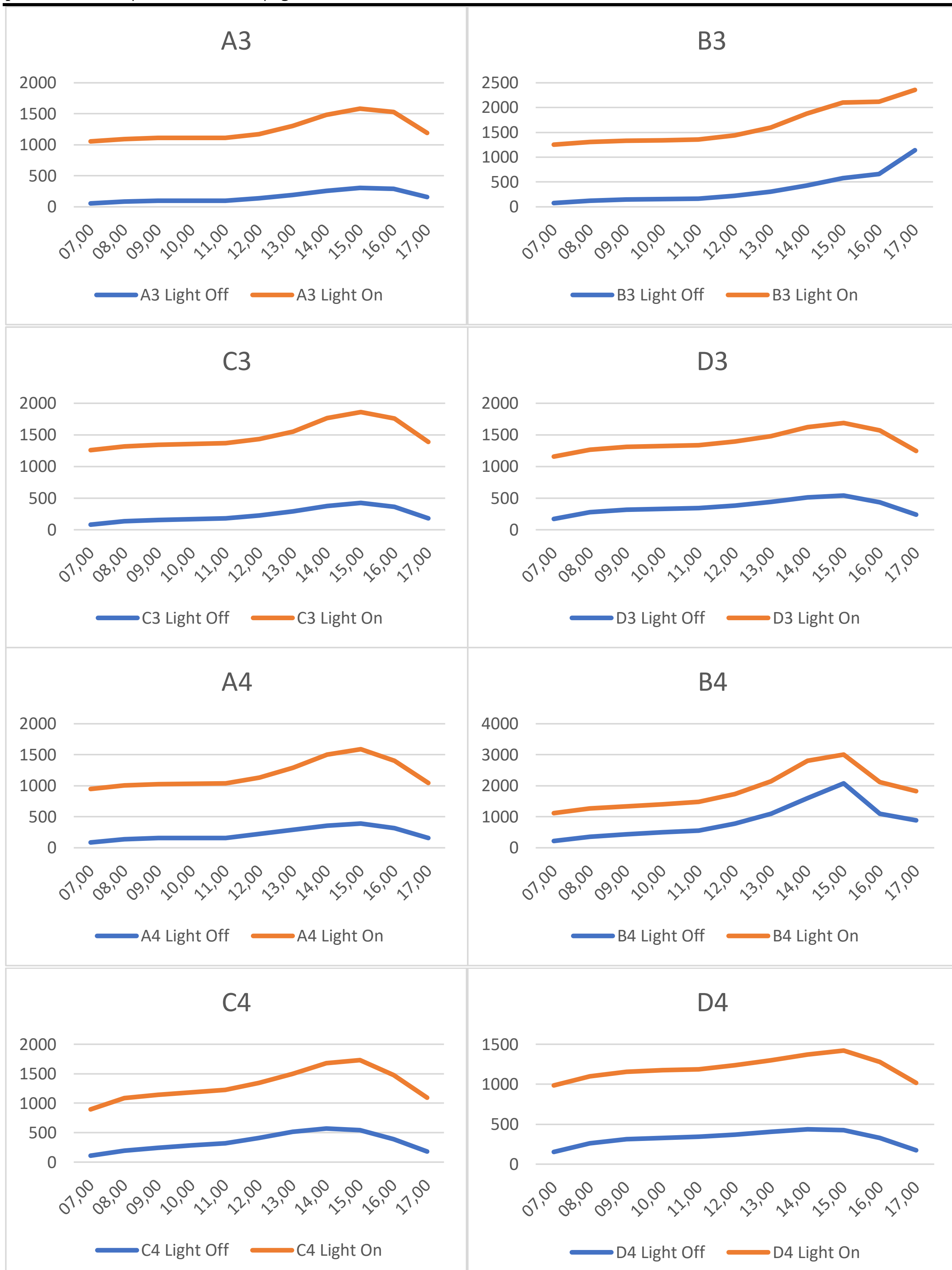
| No | Time | A3 | | B3 | | C3 | | D3 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Light off | Light on | Light off | Light on | Light off | Light on | Light off | Light on |
| 1. | 07.00 | 55 | 1055 | 76 | 1253 | 81 | 1259 | 171 | 1157 |
| 2. | 08.00 | 87 | 1094 | 124 | 1310 | 134 | 1317 | 278 | 1267 |
| 3. | 09.00 | 99 | 1110 | 145 | 1331 | 157 | 1345 | 319 | 1311 |
| 4 | 10.00 | 100 | 1111 | 153.5 | 1344 | 168.5 | 1358 | 329.5 | 1325 |
| 5. | 11.00 | 101 | 1115 | 162 | 1355 | 180 | 1369 | 340 | 1336 |
| 6. | 12.00 | 139 | 1174 | 219 | 1436 | 228 | 1435 | 380 | 1393 |
| 7. | 13.00 | 188 | 1305 | 306 | 1598 | 292 | 1550 | 443 | 1480 |
| 8. | 14.00 | 254 | 1481 | 433 | 1879 | 373 | 1769 | 515 | 1620 |
| 9. | 15.00 | 305 | 1583 | 575 | 2100 | 425 | 1861 | 541 | 1688 |
| 10. | 16.00 | 293 | 1531 | 660 | 2121 | 360 | 1757 | 436 | 1570 |
| 11. | 17.00 | 155 | 1188 | 1141 | 2357 | 178 | 1386 | 240 | 1246 |

| No | Time | A4 | | B4 | | C4 | | D4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | Light off | Light on | Light off | Light on | Light off | Light on | Light off | Light on |
| 1. | 07.00 | 86 | 948 | 219 | 1118 | 109 | 895 | 153 | 985 |
| 2. | 08.00 | 139 | 1006 | 361 | 1267 | 191 | 1084 | 261 | 1098 |
| 3. | 09.00 | 157 | 1027 | 431 | 1342 | 244 | 1140 | 313 | 1154 |
| 4 | 10.00 | 158 | 1033 | 495 | 1396 | 282 | 1183 | 327 | 1176 |
| 5. | 11.00 | 159 | 1037 | 559 | 1477 | 320 | 1224 | 341 | 1186 |
| 6. | 12.00 | 223 | 1129 | 779 | 1730 | 409 | 1342 | 368 | 1237 |
| 7. | 13.00 | 289 | 1294 | 1096 | 2144 | 512 | 1499 | 407 | 1300 |
| 8. | 14.00 | 357 | 1501 | 1604 | 2801 | 570 | 1677 | 436 | 1370 |
| 9. | 15.00 | 391 | 1590 | 2078 | 3006 | 544 | 1731 | 428 | 1421 |
| 10. | 16.00 | 319 | 1404 | 1093 | 2114 | 390 | 1476 | 328 | 1280 |
| 11. | 17.00 | 159 | 1045 | 891 | 1827 | 180 | 1092 | 173 | 1019 |




Source: Author, 2021

Figure 11. Comparison of simulation result between the light off and on condition using Dialux Evo 9.0 in spot A1 to D2




Source: Author, 2021

Figure 11. Comparison of simulation result between the light off and on condition using Dialux Evo 9.0 in spot A3 to D4

From the results of the simulation comparison between existing and appropriate lamps that look good in table 3 and graphs 1 and 2, the results obtained are pretty significant for the change, namely from an average of 461.3 lux increasing to an average of 1107.4 lux. The minimum intensity of existing lighting is 18 lux in the D1 position at 07.00. In contrast, the artificial lighting produces a minimum of 549 lux in the A1 position at 07.00.

Based on the data presented in the previous section, compared with the SNI 16-7062-2004 table for fine work, the minimum lighting level is 1000-2000 lux, so the existing condition has an average lighting value from 07.00 17.00, which is 461.3 lux does not meet the standard. However, the highest intensity is the B4, which is in front of the window, with a value of 2078 lux at 15.00. This value is also not included in the SNI standard because it is too high, causing glare. Meanwhile, the minimum intensity is 18 lux at the measuring point D1 at 07.00. This value is very low for fine work. Based on the measurements made on November 4, 2021, it was found that the lighting at the research location only ranged from 22.19 lux to 30.78 lux. According to the questionnaire results obtained, about 67% of respondents totaling three people, worked as Karawo craftsmen for more than ten years, and about 33% for ten years (Figure 4). According to the Karawo craftsmen, 67% of the lighting conditions in the room felt dark, and 33% felt very dark (Figure 5). Moreover, while making Karawo, 33% felt headaches and eye pain, 33% had eye pain, and 33% felt eye pain (Figure 6).

Therefore, to optimize lighting, a simulation using lamps is made. The average lighting using lamps from measuring points A1 to D4 from 07.00 to 17.00 has an average lighting intensity of 1107.4 lux. This condition has reached the specified standard. The highest point is the B4 position, in front of the window, with a maximum light intensity of 3006 lux at 15.00. Moreover, the measuring point A1 at 07.00 has a minimum intensity of 549 lux. LED lights are one of the most efficient alternatives that meet the expected intensity [9].

LED lamps are the new type of lamp with a very long life with low power consumption. Among the advantages of LED lamps besides this is that they have a high level of efficiency, 80-90 lm/watt, and reach a lifespan of 20,000-60,000 hours, available in various colors and energy-efficient lamps [10].

## Conclusion

Based on exposure who has done in the previous chapter, the conclusion obtained is that when compared with the SNI 16-7062-2004 table for fine work, the minimum lighting level is 1000-2000 lux, and the existing condition has an average luminance value of 07.00 to 17.00, i.e., 461.3 lux is not up to standard. Based on the measurements made on November 4, 2021, it was found that the lighting at the research location only ranged from 22.19 lux to 30.78 lux. According to the Karawo craftsmen, 67% of the lighting conditions in the room felt dark, and 33% felt very dark. Moreover, as long as they make Karawo, 33% feel headaches and eye pain, 33% eye pain, and 33% feel eye pain.

Moreover, based on the simulation using lamps, the average lighting from measuring points A1 to D4 from 07.00 to 17.00 has an average lighting intensity of 1107.4 lux. The condition has reached the specified standard. The highest point is the B4 position, in front of the window, with a maximum light intensity of 3006 lux at 15.00. Furthermore, A1 at 07.00 has a minimum intensity of 549 lux at the measuring point. LED lights are one of the most efficient alternatives that meet the expected intensity [9].

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