Evaluation of The Pasar Rebo Sport Building Lighting Systems

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Abstract. This study aims to evaluate the indoor sports field lighting system in the Youth Center of Pasar Rebo District and its compliance with the BS EN 12193: 2007 standards. This study uses an experimental method. Data was collected through direct observation on the aspects of arena construction, field size, illumination, dimensions of light ventilation, and arena color schemes. The results showed that the indoor sports field consisting of badminton, volleyball court and basketball court did not meet the standards. Design recommendations are made by making three simulations by treating the independent variables. The first simulation by increasing the number of lights. The second simulation by changing the type and power of the lamp. The third simulation by changing the type of lamp, light point, and lamp layout. The most optimal design recommendation is in the second simulation, because the lighting strength has met the standard and is easy to apply as a design improvement because it only changes the type and power of the lamp, without changing the number of lamp points and the layout of the lamps.

1. Introduction

Humans need light to visually recognize an object. An object will be seen clearly if the lighting around the object is well received by the human sense of sight. Bad lighting can result in a lack of the ability of the human eye to see an object and also affect the productivity of the work done[1]. Good lighting must be proportional in its application both in quality and quantity, so that the activities carried out continue to run optimally[2].

Youth Center is a space or place that is usually used by teenagers to take advantage of their spare time by doing various activities that are useful for positive youth actualization, in general, namely indoor sports activities[3]–[5]. In the East Jakarta area, there are several youth centers representing the sub-district level, one of which are Youth Center, Pasar Rebo District Youth Center. These youth centers have a multi-functional field where on the field can be used for three sports at the same time, namely badminton, volleyball and basketball[3], [4].

The artificial lighting system in sports facility buildings has been regulated in the BS EN 12193: 2007 standard concerning "Light and lighting-Sports lighting" issued by the British Standard Institution (BSI)[6]. The standard contains minimum lighting requirements for indoor and outdoor sporting events as well as the design and control calculations of sports lighting installations in terms of lighting systems, uniformity of illumination, glare restriction and color properties of light sources. Sports facilities are generally divided into three types based on the criteria for using lighting according to BS EN 12193: 2007, namely class I for national and international competitions, class II for regional and city level matches, class III for local competitions between clubs[6].

The Youth Center in Pasar Rebo District are categorized as Class III arena according to their function, namely local or inter-club competitions. Class III indoor sports facilities for basketball and volleyball require an average lighting strength of 200 lux with a uniformity of 0.5, while badminton requires an average of 300 lux of light with a uniformity of 0.7.[4]
2. Research Methods

This research was conducted in the indoor field of a sub-district youth centers in the East Jakarta area. The location is Youth Center, Pasar Rebo District, which is located at Jalan Kalisari III, Kalisari Village, Pasar Rebo District, East Jakarta City.

This research was conducted in March 2020 with clear or cloudy skies. The time for conducting research measurements is divided into three sessions, namely morning (08.00-11.00 WIB), afternoon (12.00-14.00 WIB), and evening (19.00-22.00 WIB).

The method used in this study is an experimental method with quantitative analysis. This experiment was conducted using DIALux 4.13 software to simulate design recommendations[7].

![Diagram](image.png)

**Figure 1. Research Methods**

The point of measuring the strength of lighting was carried out on samples of indoor sports fields that were studied at the Youth Center, Pasar Rebo District. The point of measuring the strength of light refers to SNI 16-7062-2004 [8] regarding the measurement of the intensity of lighting in the workplace. Determination of the measurement point in public lighting is the intersection point of the horizontal line of the length and width of the room at any given distance as high as 0.75 meters from the floor. Determination of the main measuring point (TUU) is taken from the center of the room and then spaced according to the area of the room according to the conditions of the room.

Lighting simulation in general can use several types of software, namely Dialux, Ecotect, Sefaira, Radiance, etc. DIALux is engineering software originating from Germany. The advantage of this software is that it does not only rely on the engineer side, but also on visualization.

The variables in this study are divided into two, namely the independent variable and the dependent variable. The independent variables in this study were the type of lamp, the number of lamps, and the lamp layout. The dependent variable in this study, namely the strength of illumination and uniformity of illumination (uniformity).
3. Results and Discussion

3.1. Results

Validation of Simulation Model with Measurement

The simulation model validation is done by comparing the results of field measurements and the results of simulation software. Validation uses the calculation of the relative error percentage in indoor lighting. The simulation was carried out with DIALux 4.13 software. The comparison between field measurements and simulations should not be more than 15% so that the resulting data is more accurate.

Validation of Measurement of Youth Center in Pasar Rebo District

Table 1. Conclusion of the Validation Results Measurement of Indoor Sports Field Youth Center, Pasar Rebo District

| Fields      | Field Measurement | DIALux Simulation | Relative Error |
|-------------|-------------------|-------------------|----------------|
|             | Morning | Noon | Night | Morning | Noon | Night | Morning | Noon | Night |
| Badminton   |         |      |       |         |      |       |         |      |       |       |
| A           | 182     | 194  | 186   | 201     | 202  | 196   | 10%     | 8%   | 5%    |
| B           | 237     | 235  | 230   | 226     | 227  | 220   | 6%      | 6%   | 6%    |
| C           | 210     | 207  | 199   | 210     | 211  | 204   | 3%      | 4%   | 3%    |
| Volleyball  |         |      |       |         |      |       |         |      |       |       |
| A           | 182     | 189  | 186   | 195     | 196  | 189   | 8%      | 5%   | 6%    |
| B           | 211     | 211  | 203   | 203     | 195  | 195   | 5%      | 7%   | 8%    |
| Basketball  | 185     | 183  | 185   | 196     | 197  | 190   | 8%      | 10%  | 7%    |
| Average relative error | 6.7% | 6.7% | 5.8% |

Based on data in table 1, the overall validation results at the Youth Center in Pasar Rebo District have a relative error percentage of less than 15%, that is, it can be concluded that the simulation used is accurate (valid).

Recommended Artificial Lighting Design for Youth Center, Pasar Rebo District

Simulation by increasing the number of lights

Table 2. Data on the results of adding lights to the Youth Center in Pasar Rebo District

| Fields      | Existing (Night) | Simulation Adds Lights | Standard |
|-------------|------------------|------------------------|----------|
|             | Eavg | Uo   | Eavg | Uo   | Eavg | Uo   |
| Badminton A | 196  | 0.82 | 314  | 0.85 | 300  | 0.7  |
| Badminton B | 220  | 0.93 | 342  | 0.95 | 300  | 0.7  |
| Badminton C | 204  | 0.84 | 312  | 0.85 | 300  | 0.7  |
| Volleyball A| 189  | 0.79 | 299  | 0.81 | 200  | 0.5  |
| Volleyball B| 195  | 0.81 | 297  | 0.81 | 200  | 0.5  |
| Basketball  | 190  | 0.78 | 298  | 0.82 | 200  | 0.5  |

Based on table 2, the magnitude of the lighting strength in the first simulation by increasing the number of lamps with the DIALux 4.13 simulation, the results obtained reach the standard. This simulation produces an average lighting strength of up to 342 lux with a uniformity of 0.95 for a
badminton court, 299 lux with a uniformity of 0.81 for a volleyball court, and 298 lux with a uniformity of 0.82 for a basketball court. The following is a graph comparing the existing conditions with a simulation of the addition of existing lamps.

**Figure 2.** Comparison of Existing and Simulation I at the Pasar Rebo Subdistrict Arena

The graph in Figure 2 shows that in the first simulation it produces an average lighting strength that meets the BSEN 12193: 2007 standards. Volleyball and basketball courts produce light strength that far exceeds the standard.

### Simulation by Changing Lamp Type and Lamp Power

**Table 3.** Data on the results of changes in the types of lights for youth center in Pasar Rebo District

| Fields   | Existing (Night) | GentleSpace Gen3 84W | CoreLine 85W | Standard |
|----------|------------------|----------------------|--------------|----------|
|          | Eavg  | Uo      | Eavg | Uo      | Eavg | Uo      | Eavg | Uo |
| Badminton A | 196   | 0,82    | 452  | 0,77    | 359  | 0,78    | 300  | 0,7 |
| Badminton B | 220   | 0,93    | 563  | 0,94    | 445  | 0,96    | 300  | 0,7 |
| Badminton C | 204   | 0,84    | 452  | 0,77    | 359  | 0,78    | 300  | 0,7 |
| Volleyball A | 189   | 0,79    | 441  | 0,74    | 351  | 0,74    | 200  | 0,5 |
| Volleyball B | 195   | 0,81    | 441  | 0,75    | 351  | 0,74    | 200  | 0,5 |
| Basketball  | 190   | 0,78    | 436  | 0,67    | 349  | 0,70    | 200  | 0,5 |

Based on Table 3, the magnitude of the lighting strength in the second simulation by changing the type of lamp in the DIALux 4.13 simulation, results that far exceed the predetermined standards, namely for GentleSpace Gen3 lamps produce an average lighting strength of up to 563 lux with a uniformity of 0.94 for badminton court, 441 lux with a uniformity of 0.75 for a volleyball court, and 436 lux with a uniformity of 0.67 for a basketball court. Meanwhile, CoreLine lamps produce an average lighting strength of up to 445 lux with a uniformity of 0.96 for a badminton court, 351 lux with a uniformity of 0.74 for a volleyball court, and 349 lux with a uniformity of 0.70 for a basketball court. The following is a graph comparing the existing conditions with a simulation of changes in the types of existing lamps.
Figure 3. Comparison of Existing and Simulation Graph II at the Pasar Rebo District Gelanggang

The graph in Figure 3 shows that in the second simulation it produces an average lighting strength that exceeds the BSEN 12193: 2007 standard. In the second simulation the lights produce a significant increase in lighting strength to the existing conditions. By changing lamp type and lamp power with the same light point, GentleSpace lamps are superior to CoreLine lamps.

Simulation by Changing Lamp Types, Lamp Points, and Lamp Layouts

Table 4. Data on the results of changes in lamp types, light points, and lamp layouts at the Youth Center, Pasar Rebo District

| Fields     | Existing (Night) | GentleSpace Gen3 84W | CoreLine 85W |
|------------|------------------|----------------------|--------------|
| Eavg       | Uo               | Eavg     | Uo           |
| Badminton A| 196              | 0.82     | 307          | 0.81         | 300 | 0.7 |
| Badminton B| 220              | 0.93     | 331          | 0.90         | 300 | 0.7 |
| Badminton C| 204              | 0.84     | 308          | 0.81         | 300 | 0.7 |
| Volleyball A| 189             | 0.79     | 279          | 0.76         | 200 | 0.5 |
| Volleyball B| 195             | 0.81     | 279          | 0.76         | 200 | 0.5 |
| Basketball | 190              | 0.78     | 289          | 0.81         | 200 | 0.5 |

Based on table 4, the magnitude of the lighting strength in the third simulation by changing the type, number of points, and layout of the lamps in the DIALux 4.13 simulation, the results obtained reached the standard. This simulation produces an average lighting strength of up to 331 lux with a uniformity of 0.90 for a badminton court, 279 lux with a uniformity of 0.76 for a volleyball court, and 289 lux with a uniformity of 0.81 for a basketball court. The following is a graph comparing the existing conditions with simulation III.
Figure 4. Comparison of Existing and Simulation Graph III at the Pasar Rebo District Gelanggang

Graph in Figure 4 shows that the third simulation produces an average lighting strength that is sufficient to meet the standards of BSEN 12193: 2007. In this simulation the badminton court produces sufficient lighting strength to meet the standard, only exceeding a few lux. On the volleyball and basketball courts produce strong lighting that far exceeds the standard. By calculating the formula, the simulation can produce the lighting strength according to the calculation.

Recapitulation of the Results of Improvements to the Indoor Sports Field Gelanggang, Pasar Rebo District

Table 5. Recapitulation of the Results of Improvement of the Indoor Sports Field at the Youth Center in Pasar Rebo District

| Fields     | Simulation I | Simulation II Lamp A | Simulation II Lamp B | Simulation III |
|------------|--------------|----------------------|----------------------|----------------|
|            | Eavg | u0  | Eavg | u0  | Eavg | u0  | Eavg | u0  | Eavg | u0  |
| Badminton A| 196  | 0,82 | 314  | 0,85 | 452  | 0,77 | 359  | 0,78 | 307  | 0,81 |
| Badminton B| 220  | 0,93 | 342  | 0,95 | 563  | 0,94 | 445  | 0,96 | 331  | 0,90 |
| Badminton C| 204  | 0,84 | 312  | 0,85 | 452  | 0,77 | 359  | 0,78 | 308  | 0,81 |
| Volleyball A| 188  | 0,79 | 299  | 0,81 | 441  | 0,74 | 351  | 0,74 | 279  | 0,76 |
| Volleyball B| 195  | 0,81 | 297  | 0,81 | 441  | 0,75 | 351  | 0,74 | 279  | 0,76 |
| Basketball | 190  | 0,78 | 298  | 0,82 | 436  | 0,67 | 349  | 0,70 | 289  | 0,81 |

The table above shows that the II A simulation with a GentleSpace Gen3 85W lamp produces the greatest light strength on each sports field. The uniformity of the resulting illumination meets the standards. The following is a graph of the recapitulation of the repair results at the Youth Center in Pasar Rebo District.

Figure 5. Graph of the Recapitulation of Repair Simulation in Youth Algae in Pasar Rebo District
3.2. Discussion

Making the first simulation is to increase the number of existing lights according to the existing light points at night conditions without natural light. The simulation shows that the average value of lighting strength throughout the field has met the BSEN 12193: 2007 Class III standards at the Youth Center, Pasar Rebo District[6].

Making the second simulation, namely replacing the type of lamp and lamp power with the same light point, showed that at the Pasar Rebo Youth Center, the entire field had met the BSEN 12193: 2007 Class III standards when it was not exposed to natural light.

Making the third simulation is changing the type of lamp, lamp power, lamp point and lamp layout. At the Youth Center for Pasar Rebo Subdistricts, it was shown that all fields had met the BSEN 12193: 2007 Class III Standard.

The most optimal simulation used for the Pasar Rebo District Youth Center is the second simulation, which is changing the type and power of the lamp. Taking into account the number of lamps and lamp power used, the second simulation is far superior to the first simulation. The lighting strength produced by the second simulation far exceeds the first simulation even though both simulations reach the BSEN 12193: 2007 Class III standard. The third simulation uses fewer lamps with a standard lamp layout but in terms of application it is difficult to do, changing the layout of the lights and the number of lights in this arena costs a lot of money and effort due to the permanent light points attached to the ceiling.

4. Conclusion

The results of measuring the average strength of lighting using Luxmeter and simulation modeling using Dialux 4.13 show that the badminton, volleyball and basketball courts at the Youth Center, Pasar Rebo Districts, have not met the class III standards of BSEN 121193: 2007.

Recommendations for improvement design are carried out by conducting three experimental simulations by giving treatment to the independent variables. The first simulation made improvements by increasing the number of existing lamps. In this simulation, it produces a strong light that reaches the standard for Youth Center in Pasar Rebo Subdistrict, while in the Youth Center, Kalisari District, the strength of the light produced is still far from the standard. The second simulation made improvements by changing the type and power of the lamp. While the arena received a significant increase in the strong quality of lighting. The third simulation made improvements by changing the type of lamp, lamp point, and lamp layout by calculating the armature requirement formula. In this simulation, it produces the correct lighting strength according to the standards of the two arena.

Recommendations The most optimal design is the second simulation, where in this simulation the lighting strength of the two arena has reached the standard. This simulation is easy to apply as a design improvement because it only changes the type and power of the lamp, without changing the number of lamp points and the layout of the lamps.

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