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Daylight intensity analysis of secondary school buildings for environmental development

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Irnawaty I[1,2], M. Ramli Rahim[1], Baharuddin Hamzah[1], Nurul Jamala[1]

[1]Department of Architecture, Hasanuddin University, Makassar Indonesia 90245
[2]Department of Architecture, University Muhammadiyah of Makassar, Indonesia

*Email: irnawatyidrus@unismuh.ac.id

Abstract. Environmental development can be achieved by implementing energy efficiency in buildings. According to International Energy Agency (IEA) data, the lighting sector consumes 20% of world electricity production, contributes 6% of global CO2 emissions and as much as 3% of world oil demand for the same purpose. Natural lighting is the best lighting source for buildings, including school buildings. By optimizing the lighting in the building, it will save energy use in the building. This study discusses the compatibility of natural lighting in junior high school classrooms and meets SNI 03-6197-2000 standards for building lighting. The method of this research is quantitative, data obtained through survey measurements directly at the study site. There are four junior high schools in the city of Makassar that were used as research samples. The sample was chosen by purposive sampling. In each school, morning measurements are carried out until noon. The results showed that most of the natural light in junior high school classrooms in Makassar City was below the average lighting standards of SNI classrooms. A total of 75.00% of the SNI standard is average for classrooms and only 25.00% exceeds the SNI standard value.

1. Introduction

The energy crisis is a topic that has been widely discussed this year to discuss the needs of non-renewable energy such as petroleum which is increasingly depleting. The world energy crisis encourages the development of new architectural concepts that are more energy conscious. Energy-saving architecture optimizes lighting and air conditioning systems, integration between natural, artificial lighting systems and natural, artificial air systems and synergies between passive and active methods with energy-efficient materials and instruments.

According to Jamala, one of the supporting factors in creating energy-efficient buildings is natural lighting that enters the room, by minimizing the number of lights that are lit and the selection of the type of anchor that serves to change the view that can save electricity consumption [1]. The concept of buildings with energy efficiency is fundamental because looking at global energy use, the building sector alone absorbs 45% of global energy needs. According to International Energy Agency (IEA) data, the lighting sector consumes 20% of world electricity production, contributes 6% of global CO_2 emissions and as much as 3% of world oil demand for the same purpose. Predictably, if the world does not switch to a more efficient lighting system, the need for artificial lighting will increase by more than 60% by 2030. The increasing use of energy resources for building services makes it very important to use energy resources to help Where is lighting optimization natural is something that needs to be done.

In Indonesia, the building requirements are regulated by Undang-Undang number 28 of 2002 and Minister of Public Works Regulation (Permen PU) number: 29/PRT/M/2006. The requirements for building lighting are one of the requirements related to the health and comfort of a building [2,3].

Rahim argues that the decision to use natural light during the day must be based on a deeper understanding of aspects of aesthetics and space because natural lighting can have an impact on the functional arrangement of space, occupant comfort (visual and thermal), structure and energy use in buildings. Therefore, there is no phase of the design process that will not be affected by natural lighting during the day [4]. In terms of lighting, the lack of natural lighting in buildings can be caused by various problems. This is stated in SNI-03-2396-2001 concerning the Design of Natural Lighting Systems in Buildings, where the entry of sunlight can be blocked by the building itself, other buildings and the environment around the building [5]. According to Kruger, the value of the intensity of natural lighting in a classroom must be adjusted to the age of the user of the classroom to get comfortable lighting [6]. Based on the Regulation of the Minister of Education of the Republic of Indonesia number 24 of 2007 concerning Standard Facilities and Infrastructures, classrooms as one part of the school infrastructure must have terms and conditions to support activities in the classroom. These conditions include a minimum area, circulation, and lighting [7]. Classroom lighting requirements based on SNI 03-6197-2000 on energy conservation in the lighting system, are having to meet the lighting intensity of 250 lux [8].

Several studies on the intensity of natural lighting in classrooms have been carried out by several researchers in Indonesia, including Kurniawan, Illahi, Amin, et al., Prihatmanti, Budiman, Esa, and Atthaillah concluded that most of the intensity of natural lighting in the classrooms that have been studied is below the SNI (Indonesian National Standard) [9-15]. Similar studies have been conducted in several countries, by Abramson et al. in Brazil, Syaheeza et al. in Malaysia, Michael et al. in Southern Europe, and also by Chao in Beijing [16-19]. The study by Idrus, which was specified in several elementary school classrooms in Makassar stated that of the total classrooms studied, only 12.1% met the standards and 87.9% of the classrooms did not meet. To complete the data on Natural Lighting Intensity in Classrooms for Elementary and Middle School students, the authors researched Natural Lighting in Junior High School Classrooms [20].

From the description above, the researchers felt it was important to identify and reveal information about the intensity of natural light in the junior high school (SMP) classrooms, especially those in the city of Makassar as the study location. The information obtained will be a reference for developing optimization steps or as preliminary data to identify the level of visual comfort in the classroom.

2. Methods

To find out the intensity of natural light in a room, natural lighting testing is performed. Whether the lighting conditions in the room are in accordance with predetermined standards or not. This research is a preliminary study of daylight's optimization and visual comfort analysis of primary and secondary school buildings in Makassar city. Makassar is the capital of the province of South Sulawesi with a current population of around 1.5 million people who are faced with very limited electricity supply conditions. Some areas of the city of Makassar are still often found with rotating power cuts carried out by the National Electricity Company (PLN). This proves that the electricity available is still far below the maximum electricity demand. Real efforts are needed that can reduce energy consumption, one of which is through efforts to optimize natural lighting in buildings in order to create improved environmental quality.

This research is quantitative research. In this study, data obtained from observations and measurements will be compared with the provisions of national standards governing building lighting (SNI) in Indonesia. The steps taken in this study include:

- Record the condition of existing classrooms, sizes, and data openings.
- Existing data include class dimensions, wall color, floor and ceiling, class layout, class orientation, light intensity (lux), sky conditions, opening dimensions, and opening material, floor elevation, and measurement time.

- Data obtained in the field then inputted and analyzed using Excel and SPSS.

There are four schools which are the research samples. Sample selection through out purposive sampling method by considering the location of the school in the city of Makassar. The schools that became the study sample were SMP Negeri 8, SMP Negeri 20, SMP Negeri 30, and SMP Negeri 33. At each school, measurements were made in five or six classes. The measurement time is morning to noon. The intensity of the light is measured using the Luxmeter Data Logger and HOBO Data Logger tool which has functions such as measuring and storing data on air temperature, air humidity, light intensity, and wind speed in space.

3. Result and Discussion

3.1. The SMP Negeri 8 of Makassar case

The first case is in SMP Negeri 8 of Makassar. It is located on Batua Raya Street Number 1 in Makassar city. Administratively the location of SMP Negeri 8 is included in Batua Village, Manggala District, Makassar City. Research at SMP Negeri 8 was conducted on Wednesday, August 9, 2017. In general, the weather conditions on that day were cloudy. Measurement of the intensity of natural lighting in the class is carried out starting in the morning from 8:30 until 13:05. Measurements were made in six classes namely Class VII-2, VIII-7, VIII-2 located on the Ground Floor (G/F), and class IX-5, IX-2 located on the first floor (1st/F). The measurement results show that the overall data on the intensity of natural light in the overall space of the class is below the SNI standard for indoor lighting, which is 250 lux. The minimum average intensity level in the class is 52.12 lux; the maximum average intensity is 229.26 lux.

Table 1. results of measurement of natural lighting intensity at SMPN 8

Classroom Code	Floor	Statistic	*Daylight Intensity* (lux)	SNI Standart (lux)
8-I	G/F	Average	229.26	250.00
8-II	1st/F	Average	56.45	250.00
8-III	1st/F	Average	90.02	250.00
8-IV	G/F	Average	68.91	250.00
8-V	G/F	Average	52.12	250.00
8-VI	G/F	Average	75.66	250.00

3.2. The SMP Negeri 20 Makasar case

The second case is SMP Negeri 20 Makasar. It is located at Inspeksi Pam Street Number 20, Makassar. The central location of this school is located in Nipa-Nipa Sub-District, Manggala District, Makassar City. This school is in a residential area, and the environment is very calm. SMP Negeri 20 is one of the favorites and excellent schools in Makassar City. The classrooms in this school have several buildings and are junior high schools that have a land area of ± 2 hectares with a fairly large playing and sports yard. The research at SMPN 20 was conducted on Monday, August 7, 2017. Generally, the weather conditions on that day were clear. Measurements in class are carried out starting in the morning at 08:20 until 12.00. Measurements were made in six classes namely Class VII-B, VII-G, VIII-A, VIII-I, IX-A and IX-G.

Classes have varying sizes, on average they have an area of between 60 m^2 and 62.35 m^2. The number of students per class is 30 people on average. The ceiling height of the classroom starts from 3 m to 3.5 m. Openings in the class are located on the left and right sides of the class with the average window area on the right side of 13.42 m^2 and the average area of openings on the left side is 6.26 m^2. The average openings model uses *jalusi* at the top, and glass windows at the bottom. The measurement

results show that there are three classes with natural lighting that are above the minimum standard value of classroom lighting, the other three classes are far below the minimum lighting standards. The lowest illumination of natural lighting in SMP Negeri 20 Makassar is 51.50 Lux and the highest is 309.51 Lux.

Table 2. results of measurement of natural lighting intensity at SMPN 20

Classroom Code	Floor	Statistic	*Daylight Intensity* (lux)	SNI Standart (lux)
20-I	G/F	Average	266.40	250.00
20-II	G/F	Average	51.50	250.00
20-III	G/F	Average	57.20	250.00
20-IV	G/F	Average	309.51	250.00
20-V	G/F	Average	85.07	250.00
20-VI	G/F	Average	268.31	250.00

3.3. The SMP Negeri 30 of Makassar case

The third case is in SMP Negeri 30 of Makassar. This school is located on Tamalanrea Raya street. The school is located in the Bumi Tamalanrea Permai (BTP) housing complex; the school is bordered by Jalan Tamalanrea Raya in the North, on the south bordering the Mosque and on the West and East in a residential street. At the site, there are several class buildings; the ceremony grounds are at the front of the site. Entrance to this school building, facing the Northeast.

The research at *SMP Negeri 30* was conducted on Tuesday 08 August 2017, starting in the morning at 8:15 until noon at 2:40 a.m. Measurements were made on six classes consisting of 3 (three) Southeast-Northwest oriented classes and 3 (three) Southwest-Northeast-oriented classes. Two classes on the 1st floor (1^{st}/F) and four classes on the ground floor (G / F). The area of each class is 7m x 9m ($63 m^2$); the type of building is permanent with brick walls in plaster; the roof uses tiles, asbestos, and zinc. In general, the weather conditions on that day are sunny. The classes used as research objects are: 1) class VIII-2 (1stF) at 08.15-08.45; 2) Class VIII-3 (1stF) at 08.50-09.20; 3) Class IX-5 (G / F), at 09.25-09.55; 4) Class IX-6 (G / F), at 10:00 to 10:30; 5) Class VII-9 (G / F) at 13.35-14.05; and 6) Class VII-8 (G / F) at 14.10-14.40. The measurement results show that there are two classes whose natural light intensity is above the SNI standard, in classes with Code 30-II, the illumination is far above the standard. While the other four classes are still below under the Minimum Lighting Average standard (250 Lux). The minimum level of intensity in the class is 64.59 lux, the maximum average intensity of which is 423.06 lux.

Table 3. results of measurement of natural lighting intensity at SMPN 30

Classroom Code	Floor	Statistic	*Daylight Intensity* (lux)	SNI Standart (lux)
30-I	1^{st}F	Average	269.45	250.00
30-II	1^{st}F	Average	423.06	250.00
30-III	G/F	Average	108.46	250.00
30-IV	G/F	Average	64.59	250.00
30-V	G/F	Average	107.31	250.00
30-VI	G/F	Average	188.96	250.00

3.4. The SMP Negeri 33 of Makassar case

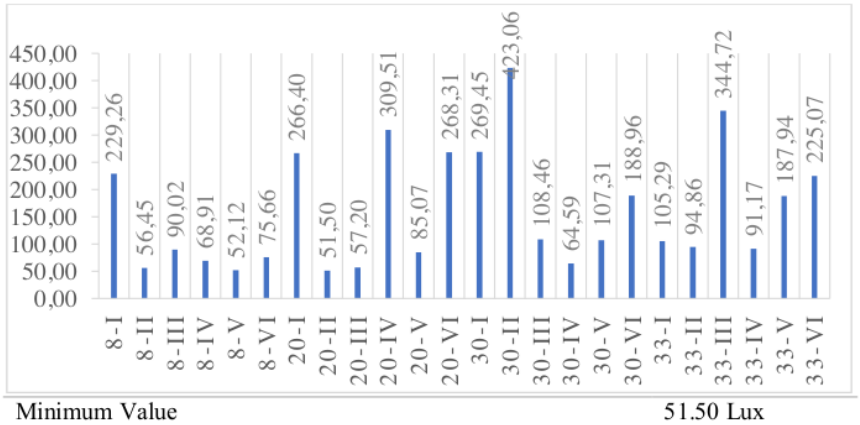
The fourth case is SMP Negeri 33 of Makassar. It is located in Jalan Tamalate 8 Number 1. The administrative location of this school is at Kassi-Kassi Sub-District, Rappocini Sub-District. The area of this school is ± 5000 m^2. In the north, east and south of SMP 33 Makassar is a residential area and on the west is bordered by SMPN 13. The research at SMPN 33 is conducted on Tuesday 01 August 2017. In general, the weather conditions on that day are clear. Measurements in class are carried out starting in the morning from 8:20 until 13:50. Measurements were made in six classes, namely Class IX-C, IX-A, VIII-C, VIII smart 2, VII smart 2, and VII smart 1. Class IX-C and IX-A are located on the ground floor (G/F) while class VIII C, VIII smart 2, VII smart 2 and VII smart one are located on the first floor (1st/F). The measurement results show that only one class has an average natural light intensity above the SNI Standard; the other five classes are below the SNI standard in indoor lighting, which is 250 lux. The minimum average intensity level in the classroom is 91.17 lux; the maximum average intensity is 344.72 lux.

Table 4. results of measurement of natural lighting intensity at SMPN 33

Classroom Code	Floor	Statistic	*Daylight Intensity* (lux)	SNI Standart (lux)
33-I	G/F	Average	105.29	250.00
33-II	G/F	Average	94.86	250.00
33-III	1stF	Average	344.72	250.00
33-IV	1stF	Average	91.17	250.00
33-V	1stF	Average	187.94	250.00
33-VI	1stF	Average	225.07	250.00

4. Conclusion

From the results of the Junior High School classroom measurements, it can be concluded that most of the natural light intensity of the classrooms in Makassar City is below the average lighting standards of the SNI classrooms. A total of 75.00% is below the average SNI lighting standard for classrooms, and only 25.00% is above the SNI standard value (Figure 1). For further research, the natural lighting of classrooms will be examined for further education students, Senior High Schools in Makassar City. Further research is needed on efforts to optimize natural light in school buildings for environmental development.



Minimum Value 51.50 Lux

Maximum Value	423.06 Lux
Average Illumination above the SNI 250 Lux Standard	75.00 %
Average Illumination Under Standard SNI 250 Lux	25.00 %

Figure 1. *Descriptive Graphic* of SMP Classroom's Daylight Intensity in Makassar City

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