ICRP 2018

PROCEEDING OF 3rd INTERNATIONAL CONFERENCE ON REBUILDING PLACE (ICRP) 2018

Towards Safe Cities & Resilient Communities

13 & 14 SEPTEMBER 2018

IMPIANA HOTEL, IPOH, PERAK

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EVALUATION OF NATURAL LIGHT LEVELS IN ARCHITECTURAL DESIGN STUDIO

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Abstract - Indonesia as a country with tropical climate has an abundant sun exposure. This high level of sun intensity should be able to be utilized as the main light during the day. One of the places that can take advantage of this sun exposure is classroom, where teaching and learning activities never stop, and the demand for visual comfort is very high. One example is the Faculty of Engineering in Universitas Syiah Kuala. In this building there are four architectural studios which is Studio A, B, C, and D. These four studios are mainly used by architecture students as a place to design and draw. This drawing activity requires a good level of lighting However, during the day where sunlight exposure is highly optimized, the use of lights as a lighting medium is still needed. If the lighting requirements cannot be met due to power shortage, drawing activities in this studio will be affected. Therefore, an evaluation of lighting designs for each studio is required. This study aims to evaluate the level of natural lighting in each studio by doing observation, surveys by questioners, and light measurement using Lux Meter. It is hoped this study will provide design recommendations to improve the natural lighting of the architectural studio.
Keywords - Natural Light Levels, Architecture Studios, Sunlight Exposure

1 BACKGROUND

Building is one of the largest energy users as stated by World Green Building Council. The construction sector absorbs as much as 30-40% of the world's total energy [1]. Therefore, the application of the concept of energy saving in buildings will be able to provide a significant effect on the sustainability of energy availability. One of the energy saving measures that can be applied to buildings is to optimize the design to accommodate the use of natural potentiallike lighting. Lighting that can be a major point in this energy saving process is natural lighting.

Natural lighting is a source of illumination that comes from sunlight. To obtain natural lighting in a room, large openings or glass walls are required to be at least 1/6 of the floor area. Each room with different functions has different levels of indoor lighting requirements [2]. Fulfilling the standard requirements of indoor lighting levels is important. This is because when humans do any activity in the room, one of the most needed factors is the availability of lights, both natural lighting and artificial lighting. Without any lighting, the room will tend to be dark and can hamper any activities to be performed. Thus, if the lighting standard is met well, the activity can also be done optimally.

In addition, standard lighting levels must also be met in a studio because the main activity undertaken in the studio is drawing. If the room had a poor level of light illumination this will interfere with the activities of drawing. Furthermore, this will lower the quality of the design

2 LITERATURE REFERENCES

Natural lighting is a source of illumination that comes from sunlight. Natural rays have many advantages. In addition to saving electrical energy, natural lights can also kill germs. To obtain natural lighting in a space, large windows or glass walls at least 1/6 of the floor area is required. Natural lighting is obtained by the entry of sunlight into the room through windows, cracks and open sections of the building. Thus, this ray should not be blocked by buildings, trees or high fence walls.

Soegijanto (1998) explains in his theory that natural lighting is meant to get the indoors lighting from natural light. In order to design natural lighting, the availability of natural light received at the site has to be known first. The availability of natural light is mainly influenced by two things, the first one is Geographical location, especially is the distance to the equator or degree of latitude, and the second one is Climate, which is the condition of the sky and type of clouds.

In optimizing the entry of natural light into a room, it takes some lighting designing strategy. These strategies will be helpful if appropriately applied to the design of the building. Below are the explanations of the strategy according to Lechner (2007):

1. Orientation, the best orientation is towards the south and north, and the worst orientation is towards the west and east.
2. The shape, shape of the building does not only determined by the combination of horizontal and vertical openings, but also by how many floor areas have access to natural light. Generally in many multi-storey buildings, the 15-foot perimeter zone will fully gets natural light, and 15 feet above it will only get natural light partially.
3. Use a separate opening for natural scenery and lighting. Use high windows, clerestory, or skylights for good natural lighting, and use low windows for scenery.
4. Color, interior with bright colors can reduce glare, dark shadows and the ratio of excess light levels, and also can reflect more light into space. The ceiling should have as much reflective factor as possible. The order of importance levels of the reflected surface is the ceiling, back wall, sidewall, floor, and small furniture.
5. Lighting through the roof, there are two advantages when using horizontal openings which are: first, they allow illumination that is not uniformly fair on a very wide interior area, while the natural light from the window is limited to a depth of 15 feet; secondly, horizontal openings also receive more light rather than vertical openings.
6. Space planning. It is very advantageous to bring light into the interior.

Even after all the factors mentioned above have already been identified and used as the initial reference in the study, the main thing that has to be considered in the measurement of natural light is that each room has varied illumination needs that depend on the complexity of visual work. The more complicated and detailed the works, then the room will require a greater level of illumination.

Table 1 Illumination levels needed according to activity

Number	Visual Works	Illuminance (lux)	Glare Index
1	Regular vision	100	28
2	Rough work with great detail	200	25 -28
3	Public works with reasonable details	400	25
4	Fairly hard work with small details (drawing studio, sewing)	600	19-22
5	Hard work, long duration of works, small details (hand sewing)	900	16-22
6	Very rough work, very long duration of works, consistant, very detailed	1300-2000	13-16
7	Extraordinary hard work, very detailed, need constant duration of works (ex: instrument making)	2000-3000	10

(Sources: Satwiko, 2009)

From the table above, it can be concluded that the drawing studio has activities that are difficult and require a high level of detail. Thus, the minimum standard of illuminance level is at 600 lux.

3 METHODS

This research was conducted in Architectural Design Studio, Faculty of Engineering, Syiah Kuala University, located at Jl. Tgk. Syech Abdur Rauf No.7, Banda Aceh, Aceh, Indonesia.

(a) (b) (c)

Figure 1: Engineering Faculty of Universitas Syiah Kuala
(a) Exterior design, (b) Inside Studio A, (c) Inside Studio B

This research was conducted using three methods, which were observation, natural lighting level calculation and questionnaire. The results of the three research methods would be a reference in the creation of lighting design solutions that hopefully will help improve the natural lighting levels in each studio. In the process of making this design solution simulation using Autodesk Ecotect 2011 software was also used.

During observation method, a comparative study about the location of the object that had been selected was conducted. The result of this observation method is mainly about basic data about each studio, such as room size, number and type of openings, furniture used inside each studios, and solar orientation of the studios itself. Questionnaire method was conducted during the Architecture Design course. The researchers asked 20 potential respondents in each studio to fill out the questionnaireWhen potential respondents were willing to participate, the researcher provided a questionnaire containing questions that have been prepared previously. The questions in these questionnaire are related to the level of visual comfort felt by the respondent being the user of the room. Using this method, the researchers also measured the level of illumination on the research object by using lux meter.

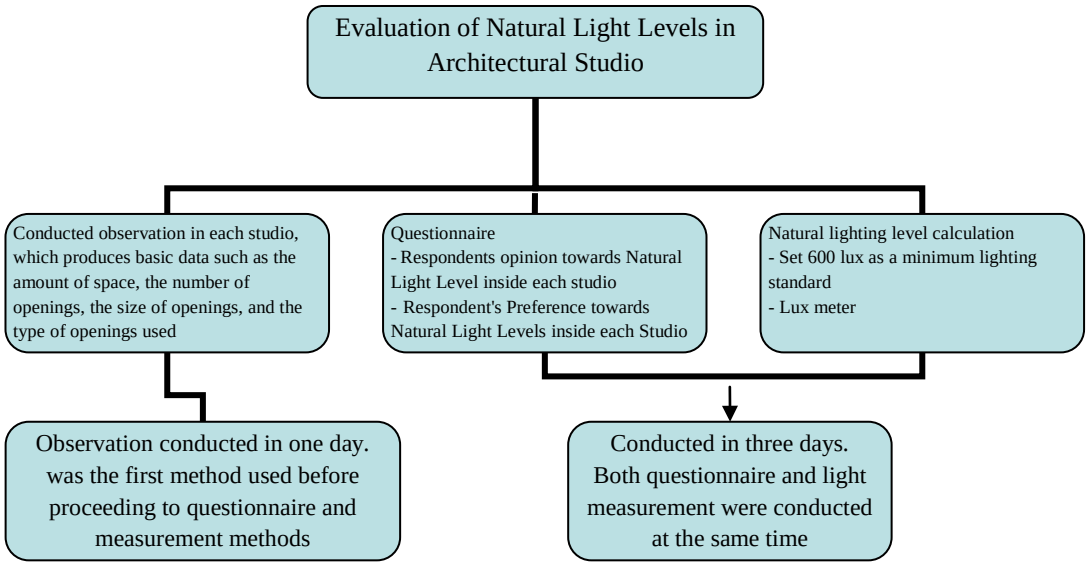


Figure 2 Flowchart of the research methodology

Figure 3 Lux Meter used during natural light measurement

4 RESULTS

In the early observation, there were some problems that might be the cause on why sunlight could not enter the room optimally. The first problem identified during the observation was that there were many windows in this room not being exposed towards open area where sunlight can enter the room freely. There were only two sides of the walls that has openings, and there is one side of the wall where the openings are exposed towards the building's corridors.. This preventsunlight to get into the room. Second problem that was identified is that three out of four studios observed are located right between two other two-storey buildings. This shows that even if all of the windows are facing towards open area, these studios will always be exposed to the shadow of the building next to it., Thus, this also prevent the studios to be able to get as much natural lights as possible.

Besides, some problems that were identified made it easier to identify resolution during the process of making natural lighting design solutions. All of these studios are located on the second floor of the building, and there are different from other rooms located in Engineering Faculty building. There is no other room right above all of these studios, meaning that the alteration of ceilings or roof is possible during the process of designing the new solution for each studios

The second method used in this study was a set of questionnaire, where in each studio, 20 participants were given two questions and they had to choose among the available answers. The first question asked participants' opinion about the natural light condition inside the studio they were in. During this question, lamps inside the studio were switched off, so that the participants can feel directly the condition of the room only with natural light without the help of other kind of lighting. Majority of respondents stated that the studio they were using the lighting is dim. The exact number of answers are shown in Figure 4.

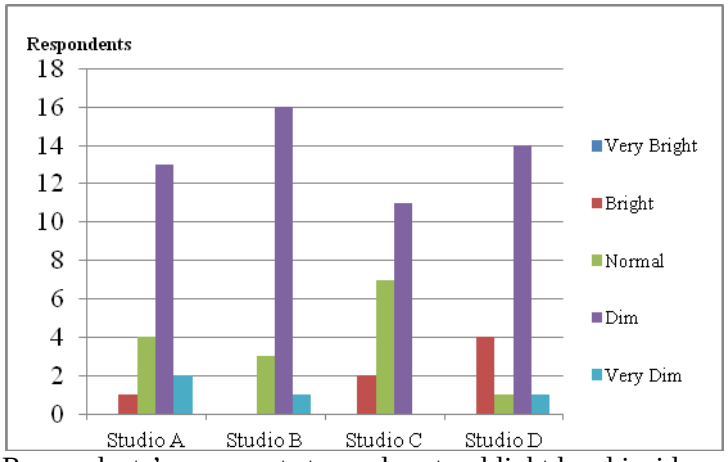


Figure 4 Respondents' assesments towards natural light level inside each studio

The second question was on the respondents' preference about the natural light level inside the studio. The respondents were asked if they want to have the studio brighter or want the studio to be dimmer. Majority of the respondents want the studio to be brighter. The exact number of answers are shown in Figure 5.

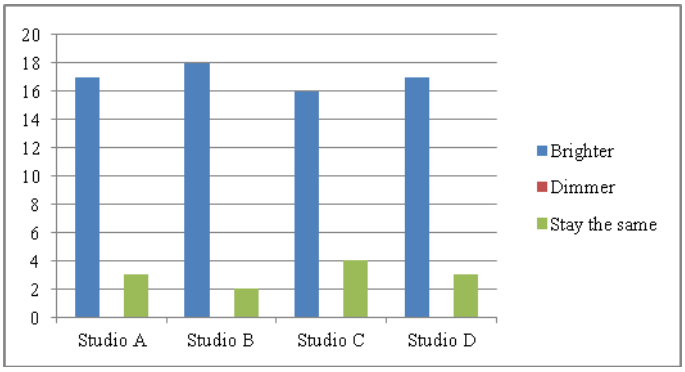
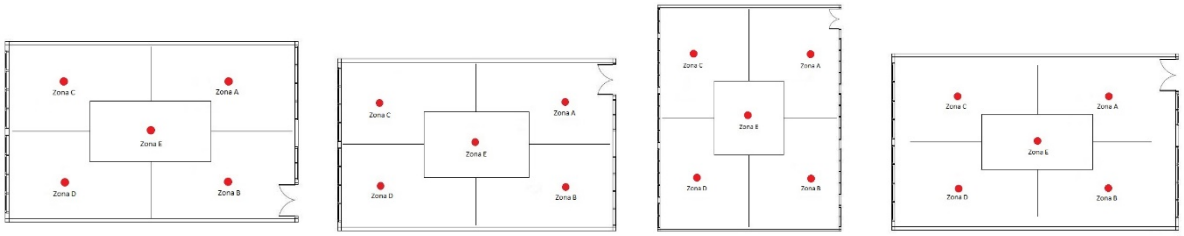


Figure 5 Respondents' preference towards studio's natural light level

The third method used in this study was the natural light measurement using Lux Meter. This method was done simultaneously with the questionnaire . The amount of lux meter used in this method is six pieces, where one lux meter is placed outside the room, which to not obstruct any object. This was done so that lux meter can measure the bright light of the sky more accurately. The other five lux meters will be placed on five specified measurement points within each studio. In the measurement process, lux meter will be placed on the drawing table. This was done to know the value of illumination of light that exists on student workstation or student work area that is a table.



(a) (b) (c) (d)

Figure 6 Zone divisions and measurement points in each studio

Based on the measurement of the natural lights, it can be concluded that no studio in each zone can achieve the lighting standard in a studio image that is 600 lux. Although it can not reach a minimum standard of 600 lux, it can be seen that among the four studios, studio C has the best lighting levels, while studio B has the worst lighting levels. Below is a graph of the average natural light in each studio measured previosly.

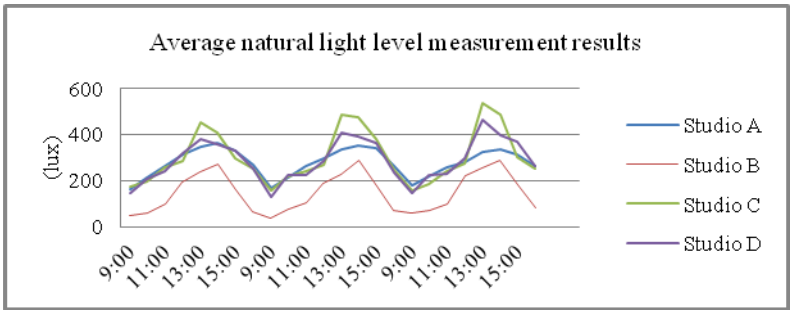


Figure 7 Graph of average lighting in each studio

5 SOLUTION

Based on the respondents' answers to the questionnaire, the majority of the respondents stated that a solution that makes it possible for more natural light to get into the studio is needed. The method used for the solution is by creating a simulation with Autodesk Ecotect Analysis software.

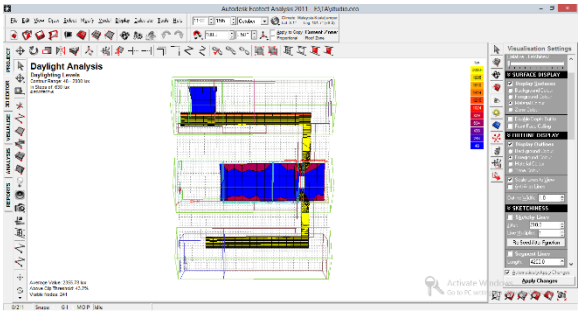


Figure 8 Result of current lighting level simulation

Figure 8 above shows the illumination calculation results in each of the drawing studios. In the simulation, the selected time is at 11.00, this hour is chosen because of the time consideration where the intensity level of sun light is very optimal. The simulation result from Autodesk Ecotect Analysis and the calculation result using lux meter is similar, where the average illumination level in each studio is able to reach 250-300 lux, and the zone that has the highest illumination level is the zone near the openings of the room.

One of the many things that can be done in using simulation method is improving the natural lighting level in the drawing studio that is by enlarging the opening. Referring back to the results of calculations and simulations, the openings that should be enlarged and improved are openings that face the hallway. The problem with this opening is that its position is too high and is overshadowed by the shading above the hall, so natural lights cannot enter the room optimally.

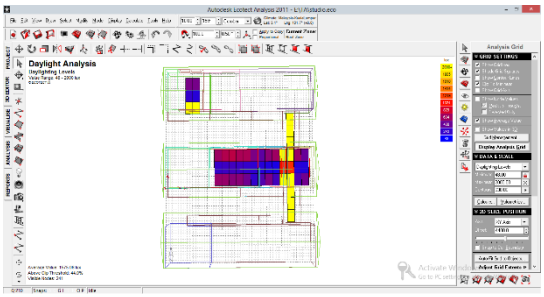


Figure 9 The simulation results after the size change of openings

Once the openings facing the hall in each studio are enlarged, the A and B zones which are originally the darkest zones, the illumination level changes and the A and B zones level of brightness will nearly match the C and D zones.

6 CONCLUSIONS

The results of evaluation with several methods of data retrieval is that the four studios do not have the minimum requirement of light intensity. The results of the questionnaires from the respondents also concluded that each image studio requires a design change to make the natural lighting level more effective. One of the easiest steps to take is to clean the opening glass of the studio. In addition, another important step is to change the size of the openings on the windows that lead to the hall of the building.

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