ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

Artificial Lighting Design at the Lecture Theatre of the Faculty of Engineering, Hasanuddin University

Wasilah[1], Josef Prijotomo[2], Murni Rachmawati[3]
[1]Architecture/Lecture/Science of Technology of Faculty, Islamic State of Alauddin University
[2]Architecture/Professor/Doctoral Program of Architecture Department of Sepuluh November of Technology of Surabaya (ITS)
[3]Architecture/Head of Department/ Doctoral Program of Architecture of Sepuluh November of Technology of Surabaya (ITS)

Abstract— The study aims to describe the factors affecting the lack of illumination at lecture theatre of the Faculty of Engineering, Hasanuddin University and how to fix it. The artificial lighting were observed and measured with light meter indicates that the average illumination at the lecture theatre does not reach the minimal standard 500 lux for IES, CIBSE and DIN EN 12464. The data were analyzed by comparing the results of measurement with illumination and reflectance standards for lecture theatres, the luminary position with spacing criteria and the condition of lamps and luminaries. The alternatives solution to improve the lighting condition is to calculate with lumen method then draw the design with computer simulation, Auto CAD and 3 DS Max 6 program. The design recommended to add the number of lamps, increase the surface reflectance, and change the type and power of lamp. By fulfilling the spacing criteria and placing the luminaries in the right position, the uniformity of illumination standard can be met.

Keywords: **Illumination, artificial lighting, lighting design.**

I. INTRODUCTION

This research was conducted in the Lecture Theatre of the Faculty of Eengineering, University of Hasanuddin. Lecture Theatre were fully rely on artificial lighting and lighting design at the lecture hall should be noted so that the public can accommodate users room to read and write with comfortable.On the initial observation, the conditions that feels dark Lecture Theatre although the lights were turned on. Coupled with complaints from some users who found enlightenment in the public lecture spaces less bright. This condition can affect the read write activity the students in the room, even in the long term can lead to impaired vision [1].To achieve the visual comfort, IES, CIBSE and DIN EN 12464 recommends a minimum level of general illumination lighting for public lecture room of 500 lux and a demonstration desk area to 750 lux.B.With these symptoms, it should be examined further the causes of low level lighting and find a solution so that it reached the right level of information and support the visual comfort in a lecture in the Lecture Hall of the public.

II. RESEARCH OF OBJECTIVES

The research aims to find out the factors that cause low levels of artificial lighting on public lecture room HASANUDDIN UNIVERSITY Faculty of engineering and how the solution to fix it the level of artificial lighting (illumination) at the Lecture Hall of the Faculty of Engineering General UNHAS.

Lecture Theatre was fully rely on artificial lighting, daytime was considered blazing lights total. Research on artificial lighting, the influence of the Sun's light is not taken into account. This research is focused on the design of artificial lighting in terms of quantity of lighting spaces public lectures HASANUDDIN UNIVERSITY engineering faculty.

The research focused on the quantity of lighting with existing lighting and space conditions. The solution is limited to lighting system concerning the number and type of lights, colors and materials, the layout of the luminaries through calculation by the method of the lumen. An alternative design is then poured in the picture pre plan by using computer simulations Autodesk AutoCAD 2008 and 3 DS Max 6.

Public lecture room of the Faculty of engineering UNHAS rectangular with sizes 9 m x 9 m with a capacity of 150 people. Teaterikal space forms consisting of 10 lines with different heights. A demonstration Area located at the

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

elevation of 0.00 while the last line is at elevation of 4.00 m.

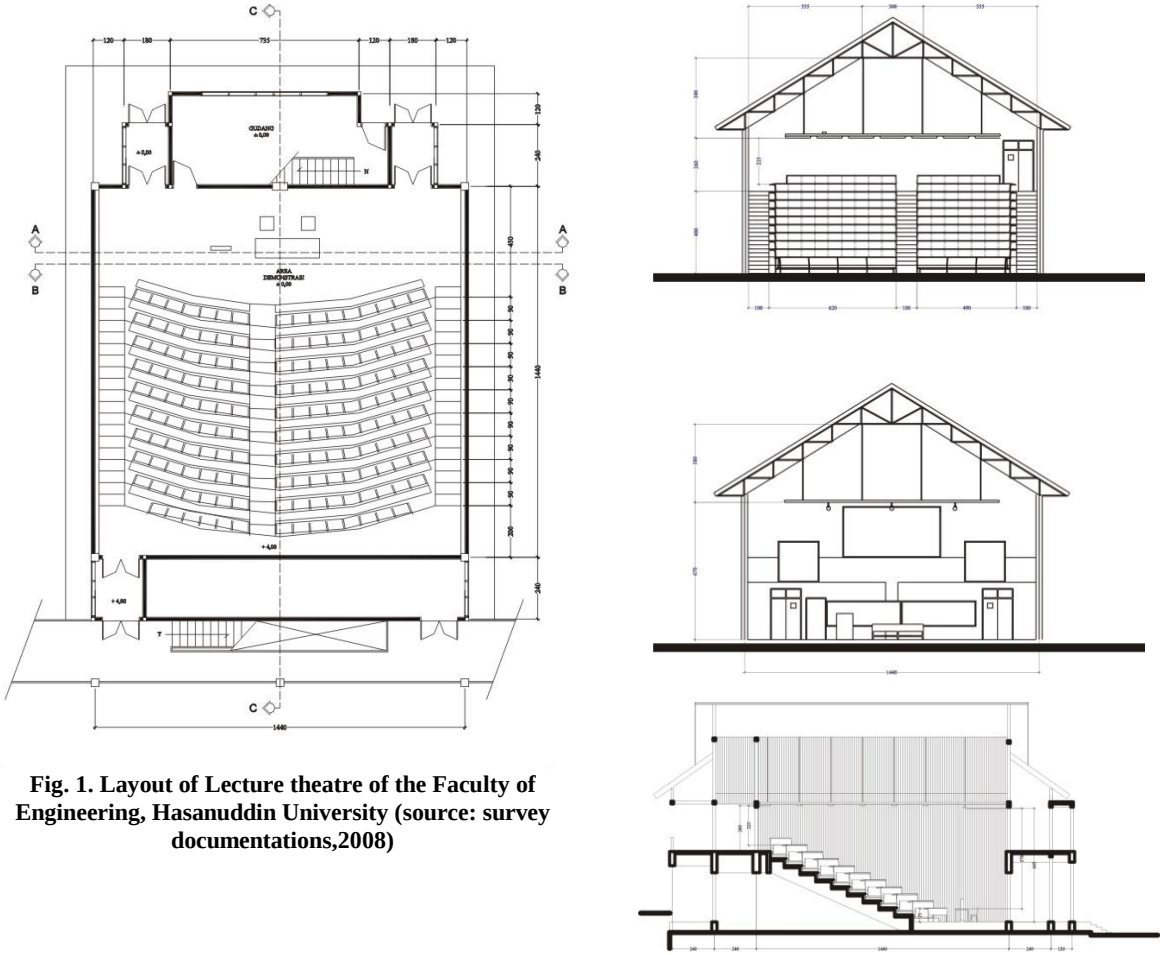

Fig. 1. Layout of Lecture theatre of the Faculty of Engineering, Hasanuddin University (source: survey documentations,2008)

Fig. 2. Interior of Lecture theatre of the Faculty of Engineering, Hasanuddin University (source: survey documentations, 2008)

Table I. Materials and Lighting installations of lecture theatre

Materials	Floor	40x40 cm ceramics, Color : cream
		40x40 cm ceramics, Color : pink
	Wall	Front wall and back wall , Color : white
		Acoustical wall Materials : white wood and pink busa
	Ceiling	Mengikuti Roof shape dengan kemiringan 35º finished by white wood

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

Lighting Instalations	General lighting (Installation II-VII)	42 luminaries TMS 011+GKH Philips TL-D 2x36 W/54 (2500 lumen) Philips *daylight*
	Demonstration area (Installation I)	3 flood lamps NP 50 + PAR 38 150 W
	Supplementary lighting	14 down lights + R-30 15 W

Source: Survey data, 2008

Iinstallation and lighting is left exposed. Ggeneral lighting semi-automatic system for direct general lighting installations where all hung on the ceiling in the exposed at a height of 6.6 m of elevation 0.00. Not all lights are functioning properly, the stairwell and the demonstration area all lights do not work anymore. The lighting is just rely on the light from fluorescent lamps in the audience area is not all work especially well on light installation band III and VII. Installation of the lamp is not functioning because VII luminaries are not equipped with flashing lights, while the TL installation band III due to the switch on the control panel does not work. On the installation VI and II there is each one lights that do not work any more. From 83 TL lights that can be accommodated by the luminaries, only 54% of fruit or 64, 29 lights are functioning.

Fig. 3. Lighting installation of lecture theatre (source: survey documentations, 2008)

III. BASIC OF THEORY

A. Illumination

One of the most obvious measures of the adequacy of a lighting installation is the amount of illumination its provides. This is define in term of the amount of light falling on the working plane or the object of attention. The seeing task may be located on a horizontal plane at the desk or a machine, on a vertical or sloping surface. There is no definite work area; it is assumed that the illumination measured on a horizontal plane 30 inches above the floor. The quantitative requirement for good illumination varies greatly with the nature of the activity, and its primarily a function of the difficulty of the visual task [2]. To get *visual comfort*, IES, CIBSE and DIN EN 12464 recommended minimum *general lighting* illumination 500 lux for lecture theatre 500 lux and 750 lux for demonstration area.

B. The Uniformity of Illumination

The practice in design of lighting objectives is to get uniform general illumination on the working plan. The uniformity of illumination is impossible in the practice, but minimum illumination standard 80% of average of illumination. It means that if the average of illumination is 100 lux, so the illumination on the entire working plan must be $\geq$ 80 lux [3].

The distribution of illumination, as well as its average foot candle level, should be determined by the purpose of installation. In light for seeing or light for production it is usually desirable to position the luminaries so as to provide reasonably uniform general illumination over the entire area. The ratio of maximum foot-candles under the luminaries to the minimum between them should never be greater than two to one, and for best results should be nearer unity. Units with wide distribution characteristics can be spaced farther apart, for the same mounting-height, than those with more concentrated distribution. Maximum spacing-to-mounting-height or ceiling height ratios for various type of equipment are supplied by the manufacturers. It should be noted that these figures are maximum values from the standpoint of reasonable uniformity alone, and that closer spacing are often necessary to desired illumination levels [4].

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

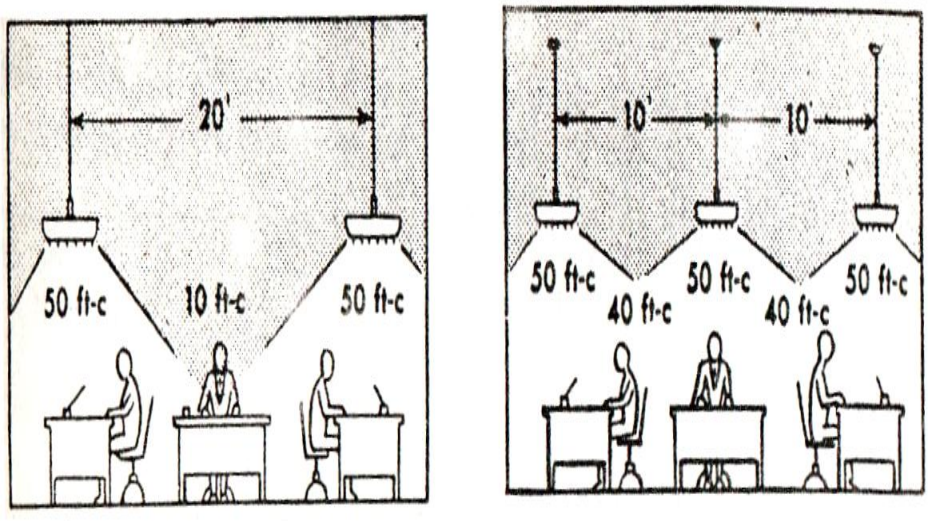

Fig. 4. Relation between spacing and illumination distribution, (source: Westinghouse, 1963)

The uniformity of illumination fulfilled by the spacing criterion (SC) of luminaires that is ratio between the centers of luminaires to mounting height. SC depend on the type of luminaires used, SC 1,5 means maximum distance between luminair to luminair is 1,5 x *mounting height*. [5].

C. Surface reflectances

The reflectances of walls, ceilings and floors have a marked effect on the utilization of light within a room. The inherent lighting qualities of luminaries can be modified, accentuated, or nullified by the reflections from surrounding. For maximum lighting efficiency, major surface reflectances within a space should be high, that is, Light colours should be used whenever possible, but excessively bright surface are to be avoided because they could cause glare or help create a "*sterile*" and "*environment*".

To get Visual comfort in the classroom of the school, recommended:[6]

a. Walls reflectance : 50 – 70 %
b. Floors reflectance : 20 – 40 %
c. Ceilings reflectance : 70 – 90 %

Coefficient of utilization (CU) are the most dominant, depend on surface reflectances; so that, higher surface reflectances can result higher CU. So, if surface reflectances dan CU are high, the illumination is become higher too [7].

Theory that light walls and ceilings are much more efficient than dark walls in conserving energy and distributing light uniformly. In her research, Kristanto found that the use of bright colours with add white colours in ratio 1:5 (*terracotta*: white) could increasing the surface (wall) reflectance. The average of illumination standard can be fulfilled with increasing the surface (wall) reflectance only; whereas the uniformity of illumination standard should be fulfilled both with increasing the surface reflectance and fulfill the spacing criterion of luminaires [8].

IV. RESEARCH OF METHODOLOGY

For the initial measurement was carried out on a Lecture Theatre University of Hasanuddin. Initial measurements include measurements of strong light, the value of vitrinite and surface layout of the luminaires. Measurement of strong lighting and vitrinite using the luxmeter brand Krisbow KW06-288, menukur for light intensity with specifications range 0-50,000 lux/fc on confined space conditions and not used. The measurement is done in three ranges of time, i.e. in the morning (9: 00 am-11: 00: 00), lunch (12.00-14.00: 30) and afternoon (15.00-17.00 :).

The number of measuring points as much as 57 points, measuring point vertically divided into three zones, namely the demonstration area, a zone of audience and back area. As for the measurements the measuring point of the vitrinite taken each wall material (walls and wood), flooring (ceramic beige and red) and the ceiling. Initial measurement result is then compared to the strong lighting and standard values of vitrinite and spacing surfaces criteria. Further research is the search for alternative methods of calculation of repairing lumen and computer simulations Autodesk AutoCAD 2008 and 3 DS Max 6.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

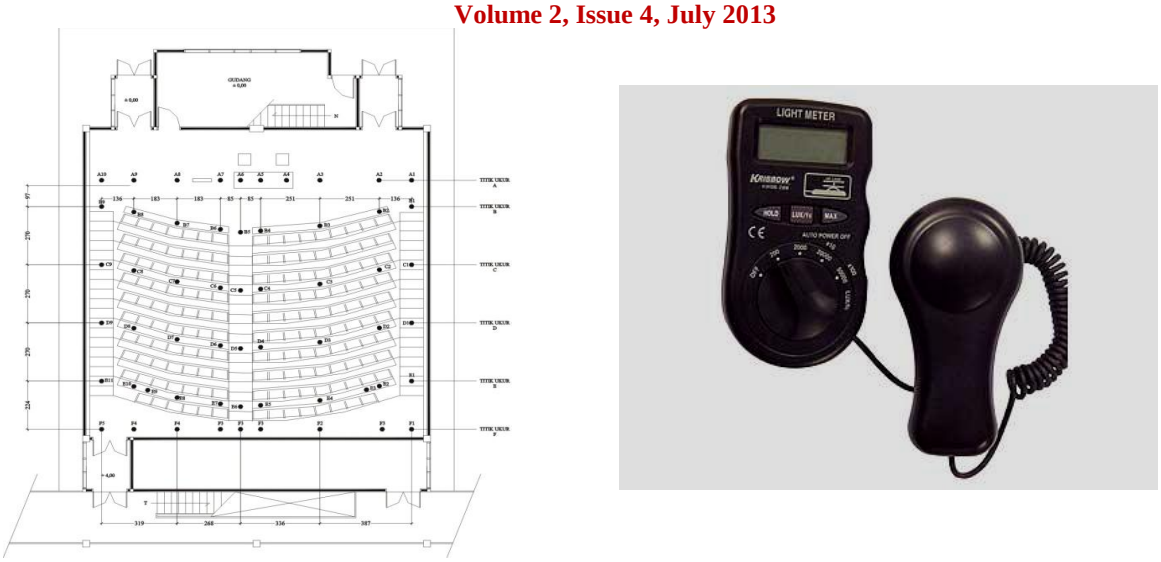

Fig. 5. Measurement Titik ukur and dan alat ukur *Light Meter* Krisbow KW06-288 (www.krisbow.com, accessed 30th January 2008)

V. RESULT AND DISCUSSION

A. Illumination and Reflectances Measurement Results

Table II. Comparison between Illumination and reflectance measurement results with standards

	Standards	Measurement results
E rata-rata a. General lighting area b. Demonstration area	 500 lux 750 lux	 217,39 lux 125,42 lux
Pencahayaan merata a. General lighting area b. Demonstration area	Emin ≥ 80 % Erata-rata 400 lux 600 lux	 Hanya 1 titik ≥ 400 lux Tidak ada titik ≥ 600 lux
Reflectance a. Wall b. Floor c. Ceiling	 50 – 70 % 20 – 40 % 70 – 90 %	 Brick wall = 59,60 % Wooden wall = 29,42 % Room's floor = 49,19 % Stair's floor = 23,11 % 59,93 %

From the results of the measurements obtained are right that public lecture room HASANUDDIN UNIVERSITY engineering faculty does not meet the standards of the average illumination strength, standard uniformity checked and recommendations a number of wooden walls and vitrinite ceiling.

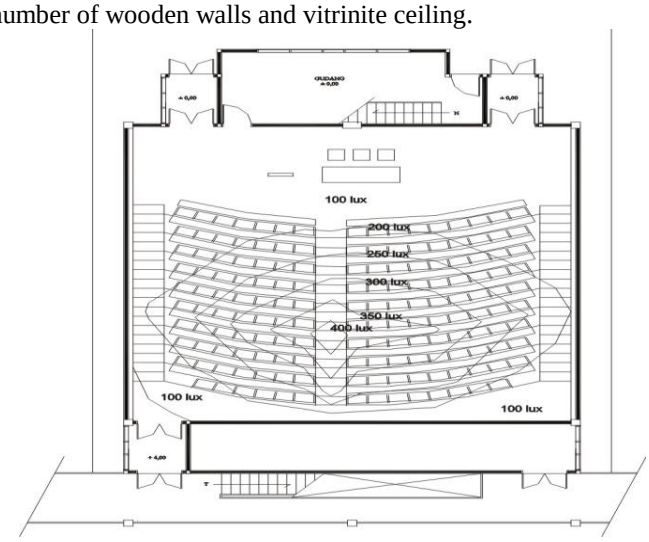

Fig. 6. Isolux graphic of illumination (Source: measurement results, 2008)

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

Public lecture room illumination engineering faculty can be reasonable if UNHAS low and did not reach the standard that exists because of the many lights that do not work. In addition, the lamp has reached the age of 15 months with the use of 10 hours a day (Monday-Friday) and are often used on Saturday-Sunday for Student Affairs also affects the depreciation or the reduction of the luminous flux.

B. The Condition of Luminaires Installation

From the results of checking the layout of the luminaires, for TMS011 and downlight have reached the standard spacing criteria as for spotlights needed fixes the layout of the luminaires with walls.

Table 3. Comparison between measurement result and spacing criteria standard

luminaries and lamps specification	standard		existing condition
TMS011 + GKH TL-D 2 x 36 W/54 (Philips)	Luminair to luminair	SC ≤ 1,3 MH SC max =1,3 x 3,85 = 5,01 m	Horizontal = 1,77 m
			Vertical = 1,80 m
	Luminair to wall	Distance = 0,5 x SC = 0,5 x 5,01 = 2,51 m	Horizontal = 1,75 m
			Vertical = 0,65 m
Flood NP 50 PAR 38 Halogen A 100 W (Philips)	Luminair to luminair	SC ≤ 0,7 MH SC max = 0,7 x 5,7 = 3,99 m	3 m
	Luminair to wall	Distance = 0,5 x SC = 0,5 x 3,99 = 1,995 m	Horizontal = 4,06 m
			Vertical = 2,5 m
Downlight s + R-40 15 W	Luminair to luminair	SC ≤ 0,6 MH SC max =0,6 x 3,85 = 2,31 m	1,8 m
	Luminair to wall	Distance = 0,5 x SC = 0,5 x 2,31 = 1,16 m	On wall (Distance = 0 m)

Source: Measurement result, 2008

C. The Alternative Solutions

On the outcome of measurement, obtained symptoms as follows:

a. Ddecrease in illumination Occurs on average at the point of measurement which are not directly under the lights, so that the further the distance point measurement with the layout of the lamps illuminated will decrease, especially on the bench most tip and stairwell side.

b. Decrease in illumination occurs due to the difference in the distance between the working areas with luminaires to each point measure even though both are right under the lights that light up. Thus increasing the distance between the working areas with luminaires will reduce the value of illumination falling on areas of work. The installation of lights II and III that exceeds the average height (3.85 m) using the type and strength of the light is the same on all installations and areas within the field of work with the greater need of luminaires the light more.

c. The placement of the light installation which is a VII 65 cm from the rear wall will cause a light more acceptable to back alleys, to consider and prioritize student bench.

d. The lack of numbers vitrinite ceiling can be caused by distribution system-direct lighting, hung and the use of reflectors in luminaires led light reflected to the ceiling the mring only 10% and ranged from light reflected to the working areas 75%.

e. The lack of numbers vitrinite acoustic wood wall can be caused by a form of acoustic walls and berceruk. On the wooden walls used color combination of yellow and the foam use red brick.

With the results of the measurements, existing conditions, symptoms and the analysis above, it needs to be done to repair design alternatives search illumination average and layout in order to achieve the standard.

By referring to the level of illumination of the formula advanced by [9] as follows:

$$E = \frac{N \times n \times \Phi \times CU \times MF}{A}$$

E = strong lighting /illumination (lux)
N = The amount of luminaires
n = The amount of the light every luminaires
Φ = Lumen produced every a lamp (lumen)
CU = *Coefficient of Utilization*

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

MF = *Maintenance Factor*
A = Broad the floor (m^2)
and lack of illumination (e) can be caused by:
a. The lack of lighting levels (Φ) of the total area of the space (A), affected by the number of lights and lamp lumen.
b. The low value of the Coefficient of Utilization, influenced by the level of the light distribution of luminariess, the distance, broad the floor, the proportion of vitrinite and space surface (floor, wall and ceiling).
c. Low Maintenance Factor influenced by factors which can be counted as a factor the maintenance or Lamp Dirt Depreciation factor (LDD) and a light source Lamp Lumen Depreciation (IT).
Through the following calculation, can be known strong lighting the room if lights on all

- E (The average result of measuring) = 201,26 lux
- N = 42 buah (tiap luminair terdapat 2 lampu)
- Φ TL-D 36 W/54 Philips = 2500 lumen/lampu
- CU = 0,65
- MF = LDD X LLD = 0,85 x 0,86 = 0,731 ≈ 0,73
- A = 14,4 m x 14,4 m = 207,36 m^2

$$E = \frac{N \times n \times \Phi \times CU \times MF}{A} = \frac{42x2x2500\ lm \times 0,65x0,73}{207,36\ m^2 \times 207,36\ m^2}$$

$$= 480,54\ lux < 500\ lux$$

From the above calculation results obtained that the average illumination will only reach 480,54 lux or stay will be under 500 lux standards even though the lights on all. Look at the condition, then there are some alternatives that can be used to improve the illumination of the average public lecture room HASANUDDIN UNIVERSITY Faculty of engineering, namely:
a. The condition of existing space not altered maintained the color, including wall of timber repair only done on installing lighting based on a calculation that is adapted to the existing minimum standards of illumination.
b. Existing space conditions modified by replacing the wooden wall paint and foam (acoustic) of light yellow and the light pink getting more light, the colors white and light grey for contrast, because although the white higher reflektansinya, but could potentially cause glare.
c. Fixed space conditions, the number of luminaires and lamps are fixed but the color was changed from light TL-D 36/51 color daylight (lumen output = 2500 lm/lamp) and the TL-D 36/33 color cool white (output = 2850 lumens lamp lm/).
d. Wooden wall paint was changed to light gray or white, the number of luminaires and lamps and lamp color changed from TL-D 36/51 color daylight (lumen output = 2500 lm/lamp) and the TL-D 36 W cool white color (output = 2850 lumens lamp lm/)

VI. CONCLUSION

1. The amount of lamps, luminaires range of working areas, vitrinite surface (floor, walls, ceiling), and the placement of luminaires lamps age affects the level of illumination.
2. Alternative improvement of artificial illumination at public lecture halls UNHAS that can be done namely:
a) Iincrease the number, vitrinite wall increased the number of lights and type of lights and color change can increase the strong illumination.
b) To meet the spacing criteria in the placement of luminaires, lighting can be more evenly distributed

REFERENCES

[1] Rashid, M.S.B, 2002. Physiological Reaction to Light: The Understanding of Lighting Design Trough Health and Visual Safety. Makalah disajikan dalam The 6th International Seminar on Sustainable Environment and Architecture, Department of Architecture, Institute Technology Bandung, Bandung 19 – 20 September 2005.

[2] Westinghouse Lamp Division. 1963. Lighting Handbook. Westinghouse Electric Corporation Bloomfield: New Jersey.

[3] Pritchard, D.C. 1986. Interior Lighting Design, 6th Ed, the Lighting Industry Federation Ltd and the Electricity Council: London.

[4] Pritchard, D.C. 1986. Interior Lighting Design, 6th Ed, the Lighting Industry Federation Ltd and the Electricity Council: London.

ISSN: 2319-5967
ISO 9001:2008 Certified
International Journal of Engineering Science and Innovative Technology (IJESIT)
Volume 2, Issue 4, July 2013

[5] Stein, B and Reynolds, J.S in Kristanto, L. 2004. Penelitian Terhadap Kuat Penerangan dan Hubungannya dengan Reflektansi Warna Dinding Studi Kasus Ruang Kelas Unika Mandala Surabaya, (Online), (www.digilib.petra.ac.id, diakses 10 November 2007).

[6] Sorcar, P.C, 1987. Architectural Lighting for Commercial Interiors, 10th ed, John Wiley & Sons Inc: New York.

[7] Kristanto, L. 2004. Penelitian Terhadap Kuat Penerangan dan Hubungannya dengan Reflektansi Warna Dinding Studi Kasus Ruang Kelas Unika Mandala Surabaya, (Online), (www.digilib.petra.ac.id, diakses 10 November 2007).

[8] Mc Guinness. W.J. 1971. Mechanical and Electrical Equipment for Buildings. John Wiley and Sons Inc: New York.

[9] Www.cibse.org. diakses 11 November 2007.

[10] www.iesna.org. diakses 11 November 2007.

[11] www.licth.de/en/your-lighting-adviser.com, diakses 11 November 2007.

[12] www.krisbow.com, diakses 30 January 2008.

[13] www.sh.yy.com, diakses 19 Juni 2008.

AUTHOR BIOGRAPHY

Wasilah[1]
[1]wasilahsahabuddin06372@gmail.com
[1]Architecture/Lecture/Science of Technology of Faculty, Islamic State of Alauddin University

Josef Prijotomo[2]
[2]josefp.pasca@gmail.com
[2]Architecture/Professor/Doctoral Program of Architecture Department of Sepuluh November of Technology of Surabaya (ITS)

Murni Rachmawati[3]
[3]murnitoni@yahoo.co.id
[3]Arrchitecture/Head of Department/ Doctoral Program of Architecture Department of Sepuluh November of Technology of Surabaya (ITS)