

# An Analysis of Day-Lighting Quality of an Architectural Design Studio:

## A Case Study on a Design Studio of Chattogram

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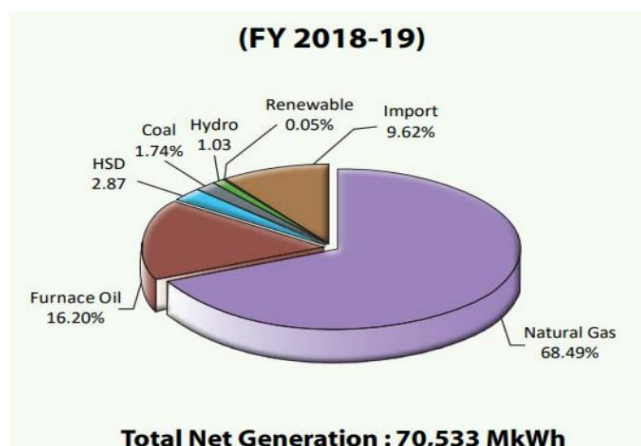
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**Abstract** – Day-lighting is correlated to the optimum output of the specific purpose of any interior space for which the building infrastructure is constructed. When it comes about designing a studio for student of architecture, it becomes more important because of its connection to creative work. The close link between daylight and productivity is evident from many literatures. However, due to the availability of electricity and provision of different artificial lighting, natural lighting strategies became negligible by designers. But with the rising concern of achieving sustainability, designers now try to revitalize day-lighting strategies in building construction. For this purpose, we need to evaluate the current situation of a space and find out the problem. This paper focuses to evaluate the current day-lighting quality of an architecture studio at two different days: one is typical clear sky day and another is overcast sky day. The finding indicates that adequate windows are provided in this studio which causes it illuminate within range during typical clear sky days but artificial lighting is required when the sky is overcasted.

**Key Words:** lighting, studio, illuminance level, window

### 1. INTRODUCTION

Industrialization and population growth cause tremendous problem of energy crisis which is seen to be created in various sectors and subsequently the demand of extra energy is increased. This increased demand of electricity is a one of the major reasons behind the depletion of renewable and non-renewable natural resources. Figure 1 shows the consumption of fuel in fiscal year 2018-2019 to generate electricity in Bangladesh.



**Fig-1:** Total Net Generation of electricity (National) By Fuel (Bangladesh Power Development Board, Annual report 2018-2019)

We're consuming these resources too fast that the nature can't restore them. We have used a year's worth of resources in seven months in 2018, reported in Global Footprint Network, [1]. Already we are observing some of the effects of resource overuse and the future generation will find the earth unlivable with scarcity of resources. We need to take proper steps about minimizing the consumption of natural resources from now and act accordingly to protect our planet for ourselves and future generations.

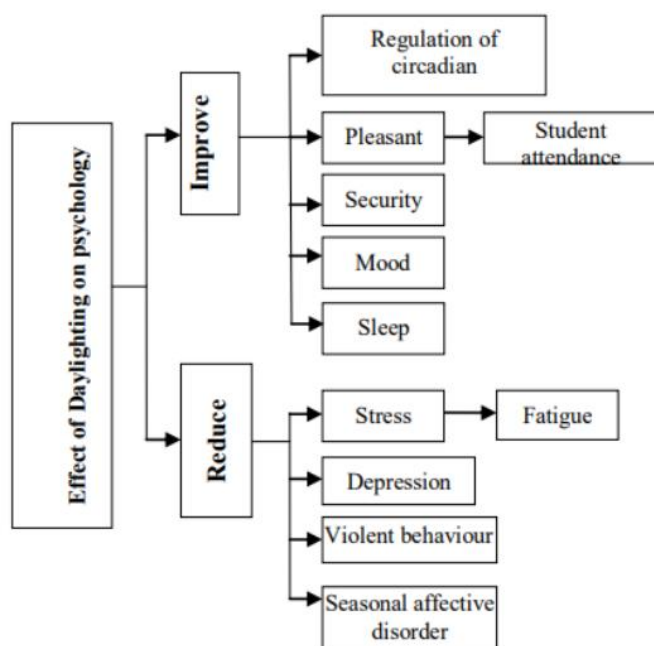
As a result of public concern about this fact, achieving sustainability has become the common interest of numerous disciplines [2] on order to decreasing the negative environmental impact of buildings by achieving efficiency and moderating the use of materials, energy, development space and the ecosystem [3]. Energy efficiency and sustainability are two inseparable parts of the infrastructure design and construction process [4].

Energy-efficient lighting and indoor environmental quality (lighting comfort) is an important feature of sustainability and green architecture [5]. Moreover, daylight can influence reading, task involvement, productivity [6, 7].

In architecture education, design-studio is the most important space for student to develop their learning process such as projecting different style of drawing, conceiving design and exercising on visual composition etc. Other than that, students share their thinking, ideas and learnings with the studio mates [8]. Certainly, the design studio is the heart of the architecture education and the space quality is different to a traditional classroom from pedagogical, sociological, ideological and epistemological points of view [9].

In comparison to others students in design studio spend more time which can have a great impact on their work, health and well-being. Proper day-lighting in studio not only promotes a healthy learning environment but also affects the psychology and overall wellbeing of students. Many studies have been conducted to find out the impact of daylight on human psychology and the result of their studies is showed in figure 2.

Study shows that classroom conditions can be improved by ensuring good daylighting which promotes students learning potentiality, and reduces absenteeism rate in classrooms [11]. Previous research by Heschong et al. (1999) [12] found that compared with non-day-lit classrooms, productivity of student improved by 20% in day-lit classrooms. In classrooms with proper daylighting, students displayed 20% to 26% faster learning rates than those with low levels of daylight. He also compared the impact of daylighting in several schools in the same country for more than 4 years. The result showed that day-lighting positively affects student performance.



**Fig- 2:** Effect of day-lighting on psychological function [10]

Findings of many researches indicates that architects when designing or revitalizing any learning environment, they must focus on providing adequate daylight not only to save natural resources but also to improve their performances. Recommended Values of illumination for educational buildings have been introduced in many countries as well as in Bangladesh. From Bangladesh National Building Code (BNBC) 2020, we can learn about some recommended values relevant to studio works. As students in design studio need to perform different class work, artwork, model making in different scales (relevant to embroidery and sewing room, Laboratory work), and computer work (like offices) also, the recommended value ranges from 300 to 500 lux [4] which is illustrated in table 1.

**Table-1:** Recommended Values of Illumination for Educational Buildings (BNBC 2020)

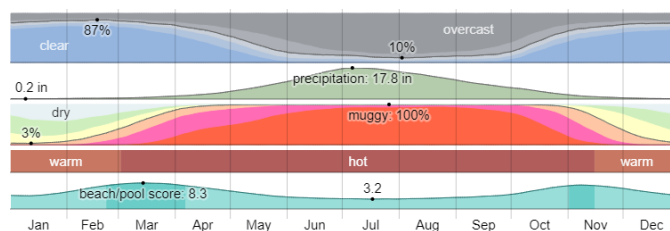
Area or Activity	Illuminance (lux)	Area or Activity	Illuminance (lux)
<b>School &amp; College:</b>			
Assembly hall	150	Offices	300
		Staff rooms and common rooms	150
		Corridors	100
Class and Lecture rooms	300	Stairs	100
		Gymnasium	100
		General	150
Embroidery and sewing rooms	500	Matches	300
Laboratories	350		
Art rooms	400		

This paper aims to identify the quality of daylighting of an architecture studio at Chittagong University of Engineering & Technology, located in Chattogram, Bangladesh so that we can evaluate the deviations from the standard for future improvement.

## 2. CLIMATE OF CHATTOGRAM CITY

This research is conducted in Chattogram, Bangladesh. The weather of Chattogram is characterized by tropical monsoon climate. From April to May, pre-monsoon season is identified which is very hot. From June to October, it is sunny and

monsoon season which is warm, cloudy and wet. The cool and dry season is from November to March. The warmest month is April with an average maximum temperature of 31°C (87°F) and the coldest month is January with an average maximum temperature of 26°C (78°F) [13]. Figure 3 shows the weather of Chattogram by month.

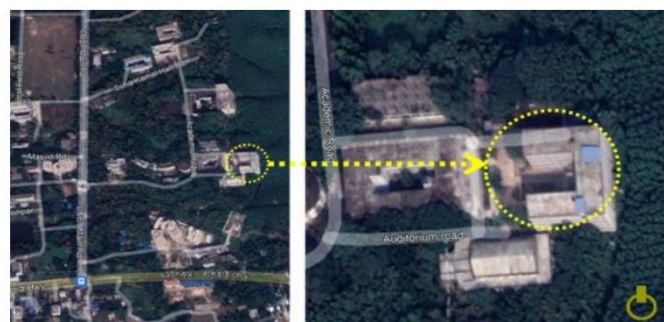


**Fig- 3:** Chattogram weather by month [14].

Over the course of the year, the temperature typically varies from 58°F to 90°F and is rarely below 53°F or above 93°F [14].

## 3. LOCATION AND DESCRIPTION OF THE BUILDING

The investigation was conducted at the fourth year architecture studio which is located at second floor, Academic building - 5, Chittagong University of Engineering & Technology (CUET), Raozan, Chattogram-4349, Bangladesh. The location of the building is showed in figure 4. This is a 'U' shaped building with two wings in north and south. The building is facing toward the west. The studio room is located at the end of the north wing in west side. The room is north-south oriented and designed with an open plan system, rectangular shape with L/W/H: 55'6" X 30'6" X 12'. The natural lighting data of this room was collected as a case study of current day-lighting quality evaluation process.



**Fig- 4:** Site location of the building

The entrance corridor is located at south side and 5 sliding windows of 5'X5' are provided on the south wall of the studio room. On the north wall there are 8 sliding windows of same size. Clearstory windows of 2' height are also provided on both north and south side of the studio room. There are also two full height slit window with fixed glass on the west wall of this room and east wall is fully blocked. The room walls and ceiling are painted with bright colors with no texture and the floor is plastered with cement. The artificial lighting of fluorescent lamps are arranged with grid patterns on the ceiling. Area of

this studio is 1692.75 sqft that accommodates 32 students. The exterior of the building and interior of the studio room are showed in figure 5 and 6 respectively.



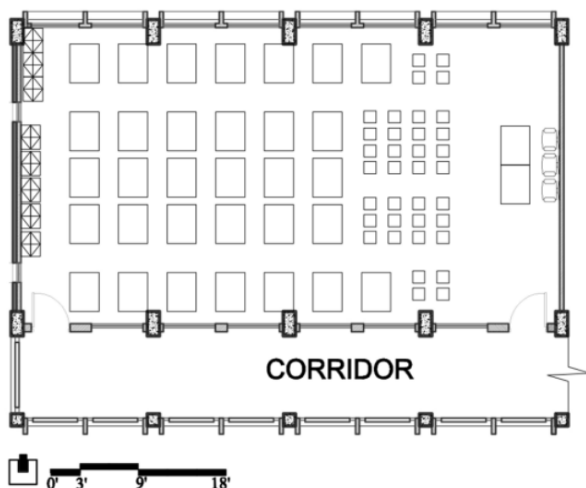
**Fig-5:** Exterior of Academic building - 5, CUET



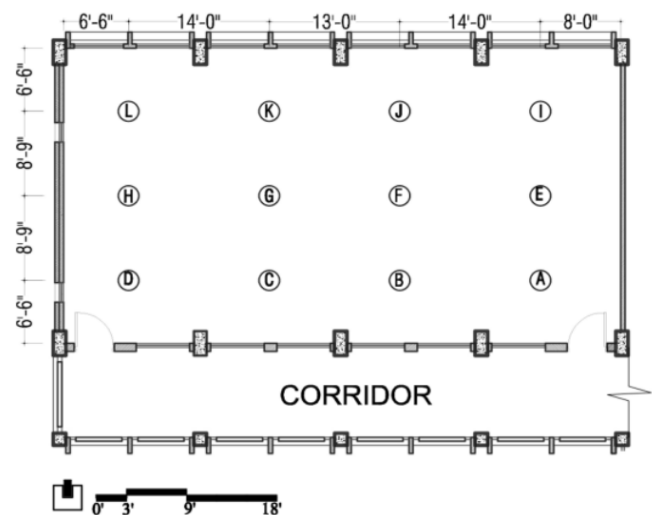
**Fig-6:** Interior of the studio room

## 4. METHODOLOGY

The studio room has provision of both day-lighting and artificial lighting. To analyze the day-lighting quality of the space, it was important to ensure that all the artificial lights were switched off before the test was started. To conduct the experiment Two consecutive days were selected: a clear sky day and an overcast day. As we found from previous study that on a typical clear sky day, the average daylight illuminance of a space can be 5.4 times greater than that of an overcast day [15]. So, to find out the possible lower illuminance level of that space we chose an overcast sky day beside a typical clear sky day. 12 specific positions were fixed and reading was taken at four specific times that of 10am, 12pm, 2pm and 4pm on each day. The layout of the studio is shown in figure 7 and the locations selected for taking measurement are shown in figure 8.



**Fig-7:** Layout of the Design Studio



**Fig- 8:** Location of the 12 positions marked by letters.

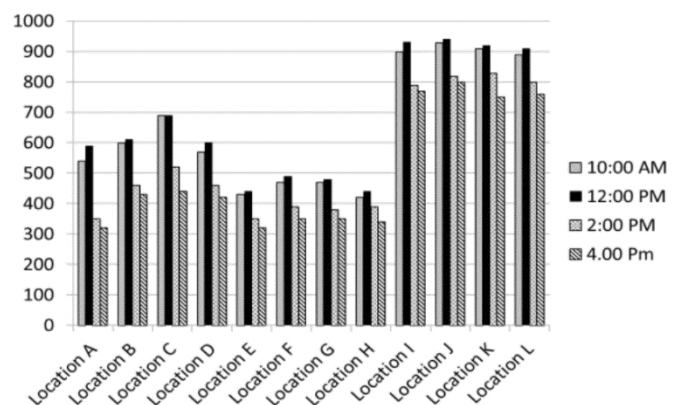
The reading was taken at two consecutive days: a clear sky day and overcast sky day. Reading was taken at four specific times that of 10am, 12pm, 2pm and 4pm on each day. The lighting level reading was measured by using Lutron LM 8102, environment meter showed in figure 9.



**Fig-9:** Lutron LM 8102

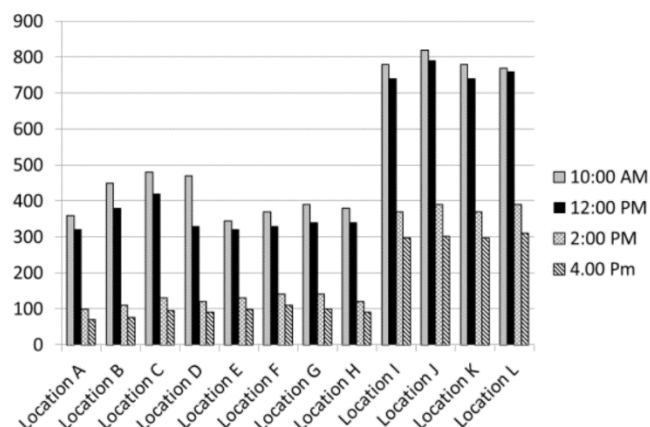
## 5. RESULT AND DISCUSSION

Two specific days were selected for conducting the experiment. A typical clear sky day which is denoted as day 1 is dated 24 November, 2021. An overcast sky day is denoted as day 02 which is dated 25 December, 2021 [16]. Figure 10 and 11 shows the illuminance level at the 12 specific positions of that studio space against the four-specific time (10am, 12pm, 2pm and 4pm) on day 01 and day 02.



**Fig-10:** Illuminance in lux against time (clear sky day)





**Fig-11:** Illuminance in lux against time (Overcast sky day)

The two figures show the average illuminance level of the studio room is 593 lux on typical clear sky day and 341 lux on overcast sky day. Though these average values satisfy the recommendation, we need to analyze the value of different locations precisely.

From the data analysis of the above two figure, we can divide the whole studio space into 3 regions according to indoor illuminance level. → Region 01 (comprises point A, B, C, D) is located near the south wall of the studio room. Moderate level of illuminance is found here compared to other two regions. → Region 02 (comprises point E, F, G, H) is located at the middle column of the studio room. Lower level of illuminance is found here compared to other two regions. → Region 03 (comprises point I, J, K, L) is located near the north wall of the studio room. Higher level of illuminance is found here compared to other two regions. The average, maximum and minimum illuminance level of the three regions on clear sky day and overcast sky day are compared in table 02.

**Table 2:** Comparison of illuminance level on typical clear sky day and overcast day

Different Regions and Parameters		Illuminance level in clear sky condition (Lux)	Illuminance level in overcast sky condition (Lux)
Region 01 (A, B, C, D)	Average	518	232
	Maximum	690	480
	Minimum	320	70
Region 02 (E, F, G, H)	Average	407	234
	Maximum	490	390
	Minimum	320	90
Region 03 (I, J, K, L)	Average	853	557
	Maximum	940	820
	Minimum	750	297

From different studies we have come to know that maximum illuminance level for detailed drawing work is 1000 lux [17]. Table 2 indicates that illuminance level on clear sky condition is adequate for studio space as the minimum illuminance level is 320 lux which maintains the recommended range and maximum is 940 lux which is below 1000 lux (required for detailed drawing [17]). But illuminance level on overcast sky condition is not adequate at every position. From location A to H, 16 reads were found below 300 lux at 2 pm and 4 pm. The

lowest value was 70 lux which is too much lower than the minimum recommended value 300 lux. This study indicates that adequate windows are provided in this studio for which there is no need of artificial light during typical clear sky days. But artificial lighting is required when the sky is overcasted which are already provided in the studio room.

## 6. SCOPE AND LIMITATIONS

It requires further study if the provided artificial lights are adequate or not. Questionnaire survey from the students could validate the result more precisely. Another important issue is about collecting more data. Because in this study, reading of only one typical clear sky day and one overcast sky day have been considered which were not adequate. It was necessary to conduct the survey in some more days of different season to get more accurate result. Moreover, some degree of uncertainty has been ignored.

## 7. CONCLUSION

It is evident from different studies that achieving sustainability and student friendly learning environment is closely related to lighting condition of that space. Specific lighting requirement for specific purpose of a space can be fulfilled by careful incorporation of natural lighting strategies. From this research it has been shown that illuminance level in this architecture studio is sufficient for typical clear sky day but in overcast sky day the illuminance level is not in the recommended range level according to BNBC standards.

## ACKNOWLEDGEMENT

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## REFERENCES

1. Independent news, accessed 31 July, 2023, [Humans have used a year's worth of Earth's resources in just seven months | The Independent | The Independent](https://www.independent.co.uk/news/world/earth-2023-07-31/)
2. Zen, I.S., Subramaniam, D., Sulaiman, H., Omar, W. and Salim, M.R., 2016. Institutionalize waste minimization governance towards campus sustainability: A case study of Green Office initiatives in Universiti Teknologi Malaysia. *Journal of Cleaner Production*, 135, pp.1407- 1422
3. Sustainable architecture, accessed 31 July, 2023, [https://en.wikipedia.org/wiki/Sustainable\\_architecture](https://en.wikipedia.org/wiki/Sustainable_architecture)
4. Bangladesh National Building Code (BNBC), 2020 by Government of the People's Republic of Bangladesh, Ministry of Housing and Public Works
5. "Malaysia Standard (MS1525)," 2014.
6. Kilic, D.K. and Hasirci, D., 2011. Daylighting concepts for university libraries and their influences on users' satisfaction. *The Journal of Academic Librarianship*, 37(6), pp.471-479.
7. Othman, A.R. and Mazli, M.A.M., 2012. Influences of Daylighting towards Readers' Satisfaction at Raja Tun Uda Public Library, Shah Alam. *Procedia-Social and Behavioral Sciences*, 68, pp.244-257.

8. Fazidah Hanim, H., Zafuan, H. and Amani, F., 2015., "Environmental Psychology : An Analysis on Lighting Efficiency of the Architecture Studio in UiTM Perak," no. October, pp. 7–8.
9. Sagun, A., Demirkan, H. and Goktepe, M., 2001. A framework for the design studio in web-based education. *Journal of Art & Design Education*, 20(3), pp.332-342.
10. Mirrahimi, S., Ibrahim, N.N. and Surat, M., 2013, April. Effect of day-lighting on student health and performance. In *Proceedings of the 15th International Conference on Mathematical and Computational Methods in Science and Engineering*, Kuala Lumpur, Malaysia (pp. 2-4).
11. Al-Mohaisen, A. and Khattab, O., 2006. Green Classroom: Daylighting-conscious design for Kuwait autism center. *Global Built Environment Review-GBER*, 5(3), pp.11-19.
12. Gelfand, L., 2010. *Sustainable school architecture: Design for elementary and secondary schools*. John Wiley & Sons.
13. Weather and Climate, accessed 31 July, 2023, [Climate Chittagong, averages - Weather and Climate \(weather-and-climate.com\)](https://weather-and-climate.com/averages-weather-and-climate)
14. Climate and Average Weather Year Round in Chittagong, accessed 31 July, 2023, [Chittagong Climate, Weather By Month, Average Temperature \(Bangladesh\) - Weather Spark](https://chittagongclimate.com/WeatherByMonth/AverageTemperature/Bangladesh-WeatherSpark)
15. Overen, O.K., Meyer, E.L. and Makaka, G., 2019, June. A Commercial Building Lighting Demand-Side Management through Passive Solar Design. In *IOP Conference Series: Earth and Environmental Science* (Vol. 290, No. 1, p. 012148). IOP Publishing.
16. AccuWeather, accessed 31 July, 2023, [Chittagong, Chittagong, Bangladesh Weather Forecast | AccuWeather](https://www.accuweather.com/en/bd/chittagong/Chittagong-Bangladesh-Weather-Forecast)
17. The Engineering Tool Box, accessed 31 July, 2023, [Illuminance - Recommended Light Level \(engineeringtoolbox.com\)](https://www.engineeringtoolbox.com/illuminance-recommended-light-level-d_194.html)