CHAPTER III

RESEARCH METHODS

3.1. Research Method

In this study, quantitative descriptive methods are employed, encompassing data collection, processing, analysis, evaluation, and the formulation of recommendations regarding illuminance and light power density across various room types within UMN's C and D Towers. The comprehensive methodology for this research is outlined in Figure 3.1 below.

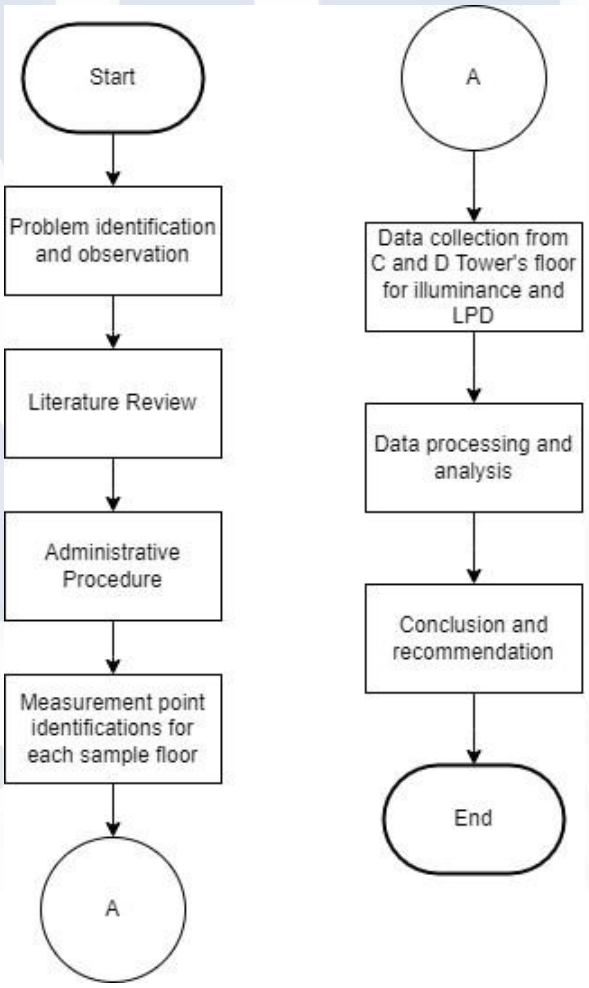


Figure 3.1 Research Method Flow Chart

3.2 Research Stages

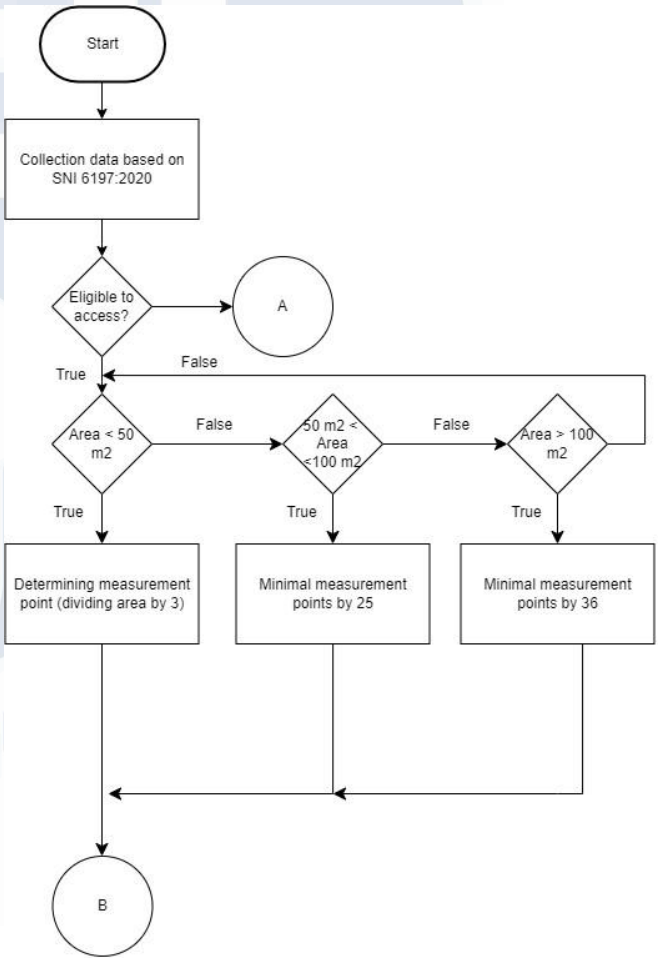
The research methodology's flow is delineated comprehensively through the following procedure:

1. Observing recent phenomena relevant to energy and carbon issues.
2. Identifying challenges associated with energy and carbon issues, particularly focusing on comfort and health aspects in buildings.
3. Narrowing down identified challenges to encompass visual comfort and health within building environments.
4. Strategizing and developing a research schematic, including selecting appropriate locations and timing by prevailing current conditions. The chosen location is UMN's C and D Towers, with the research scheduled from February to May 2024, covering specific time slots on days conducive to data collection.
5. Gather secondary data about visual comfort and health in building environments and categorize crucial information.
6. Identifying standards outlined in SNI and other relevant standards for visual comfort and health for buildings.
7. Conduct field surveys to delineate rooms and their respective functions, which will determine the final room samples from the C and D Towers.
8. Processing and finalizing administrative data for room access purposes.
9. Commencing data collection for illuminance and light power density, utilizing specialized instruments to measure illuminance at designated points within selected rooms, and collecting technical data for light power density (power usage and room area).
10. Organizing collected data into tables, calculating averages and standard deviations, and restructuring information into informative tables. The tables will be processed into graphs to help with visualization.

11. Analyzing the data through comparison with standards, drawing conclusions, and formulating recommendations to enhance visual comfort within the C and D Towers.
12. Compiling the research findings into a scientific article for publication.

3.3 Data Collection Technique

In this research, illuminance and light power density data are collected separately in simultaneous ways. The flow chart of the data collection technique can be shown in Figure 3.2.



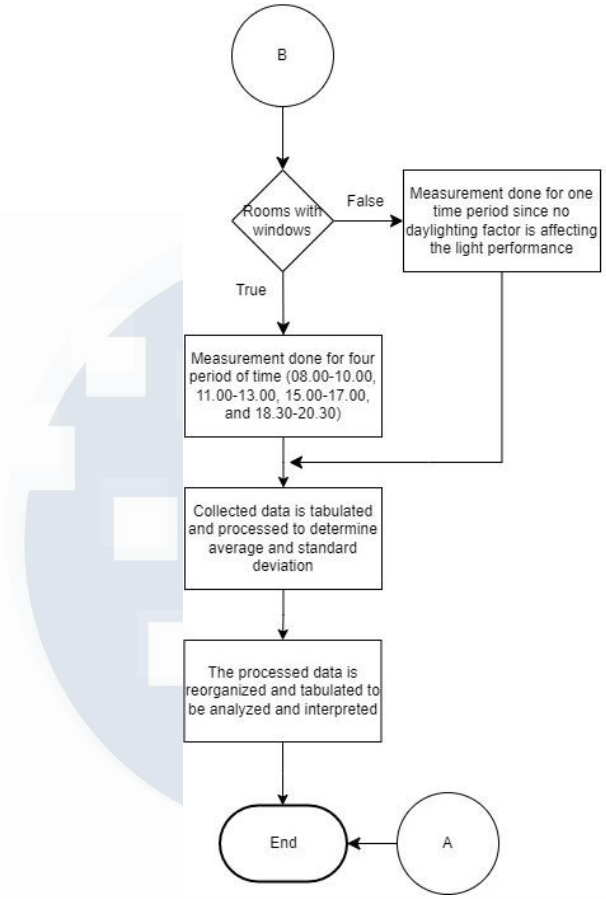


Figure 3.2 Flow Chart of The Data Collection Data Technique

To provide clearer understanding, each variable is elaborated as follows:

3.3.1 Illuminance Data Collection

Both C and D tower consists of classrooms, offices, storage, panel rooms, toilets, halls, and canteen as well as a parking area. Rooms within the C (New Media) and D (PK Ojong) Towers are appropriately categorized based on their designated functions and taken as sample as seen in Table 3.1.

Table 3.1 Selected Floor Sampling Data

C Floor Level	Function	D Floor Level	Function
Basement	Parking Area	Basement	Parking Area
1	Canteen	1	Hall
2	Office	2	Architecture Faculty
3	Class and Hall	3	Hotel Operations Faculty
7	Laboratory and Class	5	Laboratory
10	Laboratory and Class	6	Class
Total of C = 5 Floors out of 12 Total of D = 9 Floors out of 18 *Not including basement		7	CollaboHub and Space
		8	Class
		10	Magister Class and Laboratory
		12	Class
		15	Class and Lounge

Every floor will undergo comprehensive measurements for each room, excluding toilets and storage areas as their data collection is deemed less significant, although selected samples are taken. Each room's measurement points will be determined based on its area. The classifications include:

- Area below 50 m^2 = One point represents maximum by 3 m^2.
- Area between 50 m^2 and 100 m^2 = Minimum of 25 measurement points.

- Area above 100 m^2 = Minimum of 36 measurement points.

In this scenario, each selected room will be measured according to the previously established classifications. Tables 3.2 and 3.3, as a results for measurement, which the measurement points method is based on SNI 7062-2019, are included to outline the number of measurement points based on room areas. Notably, for toilets and storage areas below 50 m², the designated measurement points are 16 and 8, respectively.

Table 3.2 Measurement Points for Tower C

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
1	Basement	-	Parking Lot	3607.21	36
2		-	Building Management Office	72.40	25
3	1	-	Canteen	2855.70	36
4	2	-	Student Service Office	54.26	25
5		-	Career Development Center Office	64.60	25
6		-	Research and Community Outreach Office	66.32	25
7		-	Biro Informasi Akademik Office	66.04	25
8		-	Student Support Office	63.74	25
9		-	Student Development Office	121.30	36
10		-	Finance Office	37.61	25
11		-	Counselling Room	17.23	16
12		-	Toilet	43.35	25
13		-	Panel Room	10.34	3
14		-	LPPM Office	55.41	25
15		9	Storage	63.45	25
16		-	Accounting and Tax Centre Office	88.43	25
17		-	Lecturer Office	114.84	36
18		-	International Office	72.35	25
19		-	Kompas Corner	54.55	25
20		-	ITC Gallery Room	114.56	36
21		-	Class (Inactive)	105.66	36

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
22	3	1	Class	54.20	25
23		2	Class	64.50	25
24		3	Class	66.80	25
25		4	Class	66.10	25
26		5	Class	64.00	25
27		6	Class	55.30	25
28		7	Class	56.70	25
29		8	Class	64.80	25
30		9	Class	88.00	25
31		11	Class	72.40	25
32		12	Class	54.80	25
33		Halmahera	Meeting Room	116.10	36
34		Saparua	Meeting Room	116.60	36
35		10	Lecture Hall	210.14	36
36	7	1	Class	102.57	36
37		2	Certified Ethical Hacker Laboratory	113.34	36
38		3	Green Building and Energy Laboratory	115.90	36
39		4	Green Building and Energy Laboratory	105.30	36
40		5	Business Intelligent Laboratory	105.26	36
41		6	Computer Laboratory	116.26	36
42		7	BIM Laboratory	114.69	36
43		8	Computer Laboratory	104.81	36
44		9	News Graphic and Design Laboratory	115.14	36
45		10	Computer Laboratory	100.10	36
46		Toilet	Toilet	43.09	16

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
47	10	1	Class	65.00	25
48		2	Class	74.73	25
49		3	Class	76.30	25
50		4	Class	76.14	25
51		5	Class	74.73	25
52		6	Class	65.62	25
53		7	Class	65.47	25
54		8	Class	75.20	25
55		9	Class	76.77	25
56		10	Class	77.08	25
57		11	Class	74.42	25
58		12	Class	65.00	25
59		13	Class	100.95	36
60		14	Class	114.76	36
61		Storage	Storage	24.49	8

Table 3.3 Measurement Points for Tower D

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
1	Basement	Parking Lot	Parking Lot	5829	36
3	1	Lecture Theatre	Lecture Theatre	490	36
4	2	1	Studio	92.5	25
5		2	Studio	121.1	36
6		3	Studio	117.2979	36
7		4	Studio	125.1	36
8		5	Studio	61.6	25
9		6	Lecturer Office	61.8	25
10		7	Lecturer Office	91.2	25
11		8	Studio	93.3	25
12		9	Studio	93.4	25
13		10	Studio	92.1	25
14	3	Lobby	Receptionist Room	59.18	25
15			Beverage	169.7	36
16			Laundry Laboratory	74.05031	25
17			Dry Storage	21.36067	16
18			Cold Room	30.04733	16
19			Washing Area	28.62329	16
20			Cooking Class 1	40.15805	16
21			Cooking Class 2	154.0816	36
22			Utensil Storage	15.37968	16
23			Baking Class	85.58507	25
24			Housekeeping Laboratory	51.1	25
25			Kelas 1	66.78768	25
26			Kelas 2	107.3729	36
27			Lecturer Office	148.9551	36
28			Gas Storage	42.61	16

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
29	5	1	Macintosh Laboratory	95	25
30		2	Multimedia Laboratory	96.2	25
31		3	Computer Laboratory	96.3	25
32		4	Computer Laboratory	94.9	25
33		5	Spare Room	63	25
34		6	Class	96.8	25
35		7	Computer Laboratory	97.1	25
36		8	Computer Laboratory	95.2	25
37		9	Computer Laboratory	94.28142	25
38		10	Computer Laboratory	100	25
39		11	Computer Laboratory	63.3	25
40		12	Computer Laboratory	94.7	25
41	6	1	Class	96	25
42		2	Collaborative Learning Class	96	25
43		3	Collaborative Learning Class	96	25
44		4	Collaborative Learning Class	96	25
45		5	Class	96	25
46		6	Class	61.8	25
47		7	Class	96	25
48		8	Class	96	25
49		9	Class	96	25
50		10	Class	96	25
51		11	Class	96	25
52		12	Class	63	25
53		13	Class	63	25
54		14	Class	100	25
55	7	CollaboHub	Meeting Room	163	36
56		CollaboSpace	Meeting Room	63	25

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
57	8	1	Class	62.4	25
58		2	Class	96.28889	25
59		3	Class	97.08889	25
60		4	Class	96.71111	25
61		5	Class	94.55556	25
62		6	Class	64.4	25
63		7	Class	61.8	25
64		8	Class	94.82222	25
65		9	Class	96.77778	25
66		10	Class	98	25
67		11	Class	96.11111	25
68		Toilet	Toilet	44.89	25
69		Storage	Storage	22.67	8
70	10	1	Magister Ilmu Komunikasi Class	96	25
71		2	MMT Class	97	25
72		3	BIPA UMN Madya Class	96	25
73		4	BIPA UMN Pemula Class	96	25
74		5	Continuing Education Department Office	64	25
75		6	IELTS Test Laboratory	62	25
76		7	Class	96	25
77		8	Class	96	25
78		9	Class	96	25
79		10	Class	96	25
80		11	Class	64	25
81		12	Inactive Room	62	25
82		13	BIPA UMN Akhir Class	62	25
83		14	Inactive Room	100	25

Number	Floor Level	Room Number	Function	Area (m^2)	Measurement Points
84	12	1	Class	62	25
85		2	Class	97	25
86		3	Class	96	25
87		4	Class	96	25
88		5	Class	96	25
89		6	Class	62	25
90		7	Class	62	25
91		8	Class	96	25
92		9	Class	96	25
93		10	Class	96	25
94		11	Class	96	25
95		12	Class	62	25
96		13	Class	62	25
97		14	Class	100	25
98	15	1	Class	96	25
99		2	Class	96	25
100		3	Class	96	25
101		4	Class	96	25
102		5	Class	62	25
103		6	Class	62	25
104		7	Class	96	25
105		8	Class	96	25
106		9	Class	96	25
107		10	Class	96	25
108		Student Lounge 2	Meeting Room	220	36

To enhance clarity, Figures 3.3, 3.4, 3.5, 3.6, 3.8, and 3.9 provide visual representations of the measurement point locations for various room types.

Figure 3.3 Tower C Basement Measurement Points

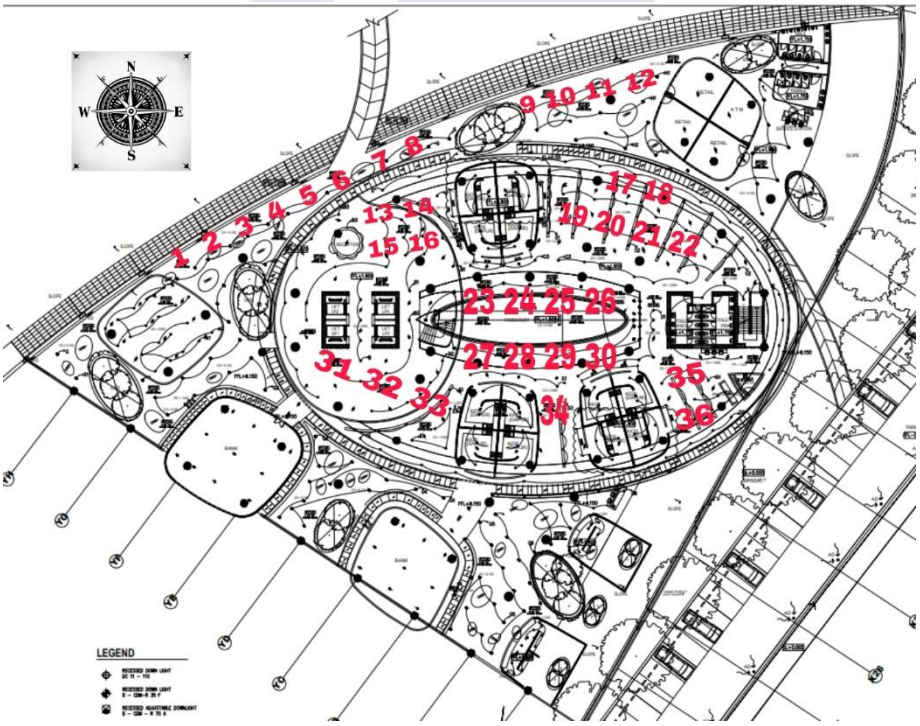


Figure 3.4 Tower C Canteen Measurement Points

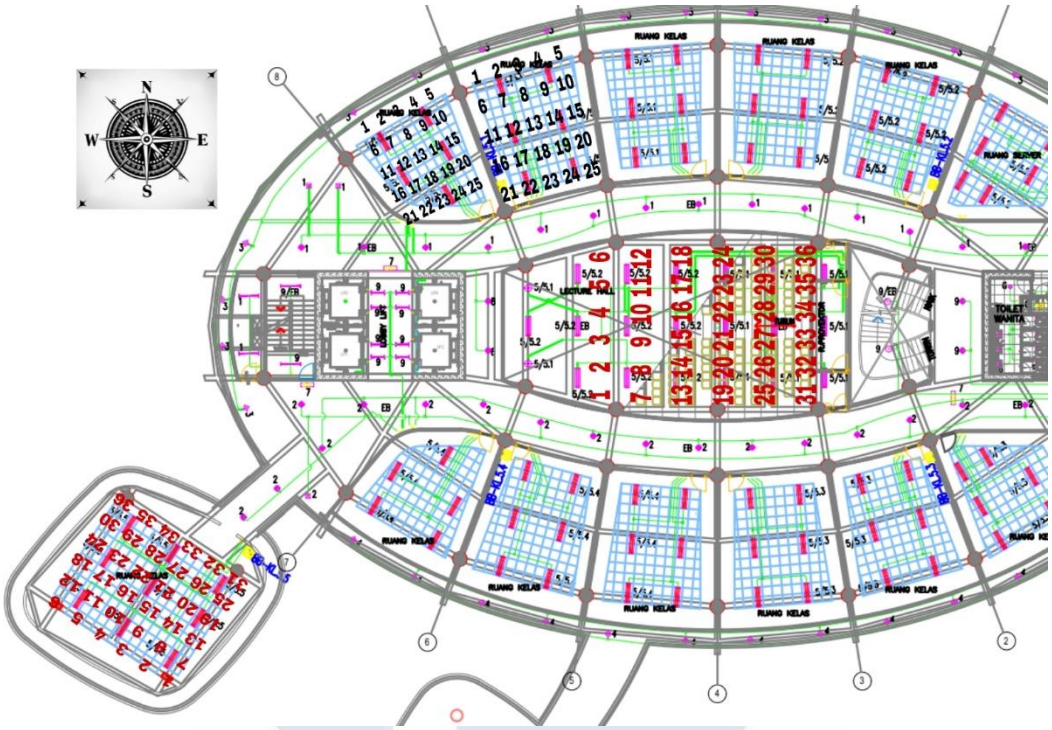


Figure 3.5 Tower C Class and Meeting Rooms Measurement Points in Third Floor

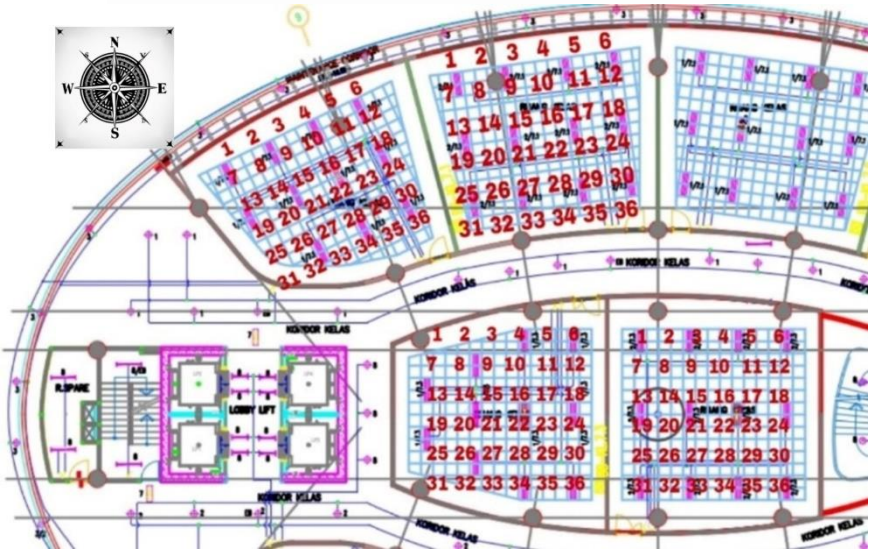


Figure 3.6 Tower C Laboratories Measurement Points in Seventh Floor

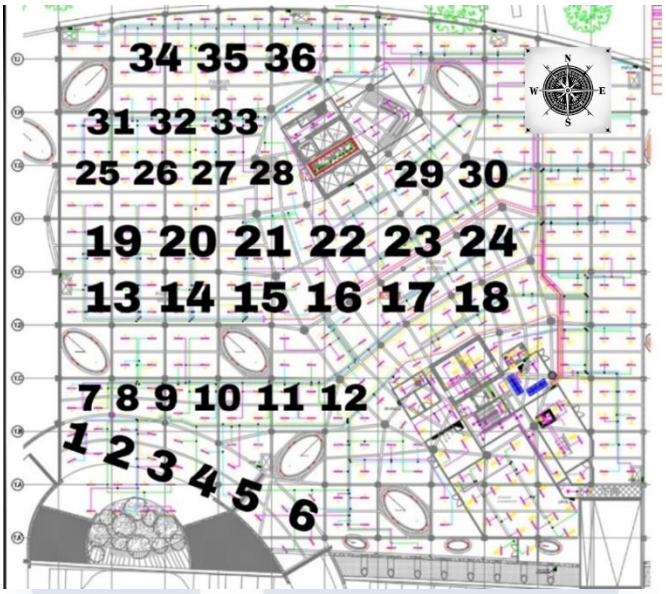


Figure 3.7 Tower D Basement Measurement Points

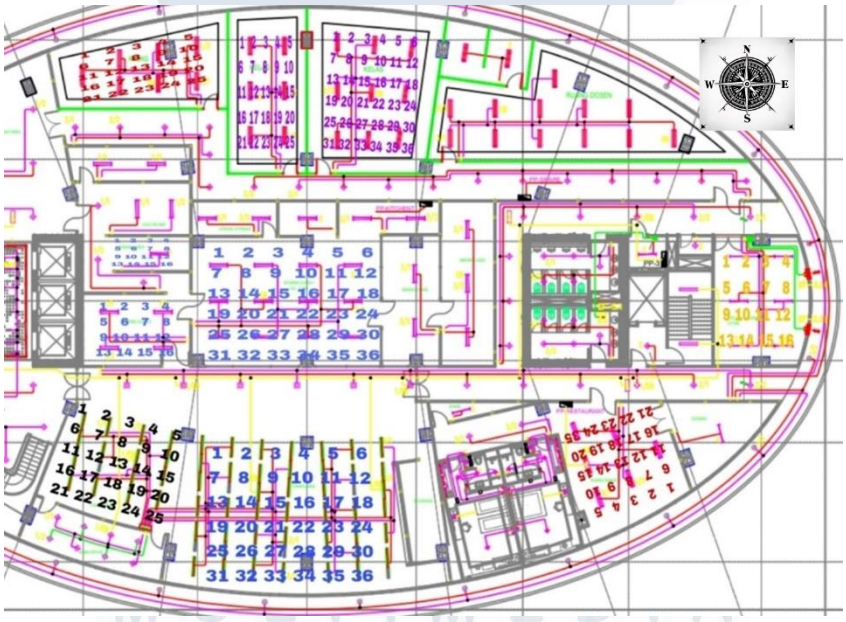


Figure 3.8 Tower D Hotel Operation Faculty Measurement Points in Third Floor

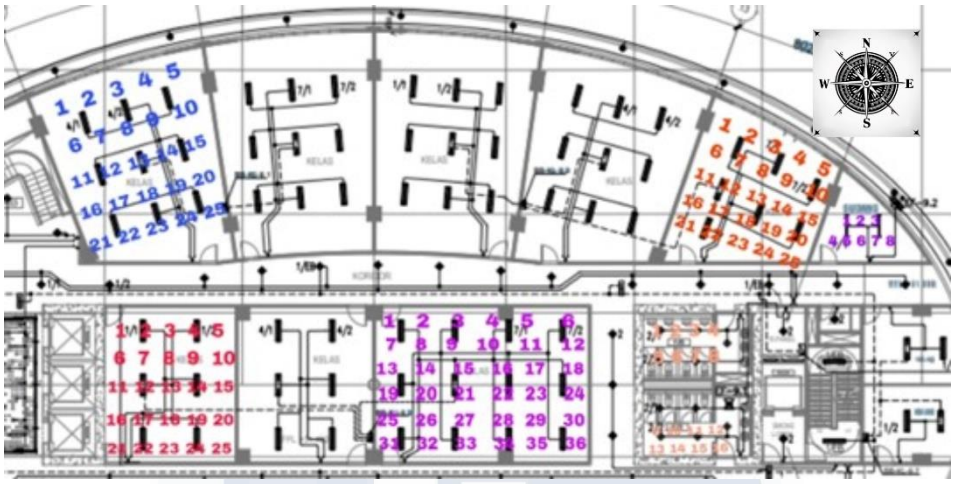


Figure 3.9 Tower D's Classes, Laboratories, Architecture Studios, Toilets, and Storage Measurement Points

The provided figures utilize distinct color codes to differentiate between different room usages. In Figure 3.5 for Tower C, black indicates classrooms while orange denotes meeting rooms (specifically, Halmahera and Lecture Hall). Moving to Tower D in Figure 3.8, purple signifies classrooms, light blue represents kitchen areas, dark blue signifies beverage rooms, black indicates receptionist areas, red denotes laboratories, and yellow symbolizes gas storage. Figure 3.9 illustrates the distribution of measurement points for various room types, a pattern that is largely consistent across floors containing classrooms, laboratories, studios, storage areas, and toilets in Tower D. Rooms labeled with blue, red, orange, and light purple numbers pertain to classrooms, laboratories, and studios with sizes of 96 m², 63 m², 63 m², and 100 m² respectively. Meanwhile, dark purple indicates storage areas, and cream denotes toilet measurement points.

Additionally, several factors outlined in SNI 7062-2019 must be taken into account during the measurement process, including [61]:

- Measurements are repeated 3 times at the same location points.

- Measurements must taken at a height of 0.8 m from the floor for general measurements
- The sensor of the lux/environment meter must be adjacent to the surface that is intended to be measured.
- The researchers position themselves to avoid light obstruction towards the sensor.
- The researchers should not wear reflective clothes that will disrupt the measurement result.

Moreover, this research will also use the equation from SNI 6197-2020 for comparison purpose which is shown in equation (1).

$$N = \frac{E\ average \times A}{F_i \times K_p \times K_d} \quad (1)$$

which can be reorganized to form equations (2)

$$\frac{N}{A}(F_i \times UF \times MF) = E_{average} \quad (2)$$

to show the estimated E or illuminance (lux) in each selected room by collecting the specification data of the lamp used such as the luminous flux or Fi (lumen), utilization factor UF or Kp by 0.5, maintenance factor MF or Kd by 0.6, area or A (m^2), and number of lamps or N.

Utilization factors are influenced by various factors including light intensity distribution from luminaires, comparison of internal and external lamp luminaires, reflections from surroundings such as walls and floors, positioning (hanging or installed), and room dimensions. These factors contribute to values ranging from 0% to 100%, depending on the luminaire class and the percentage of light direction (up or down). For instance, assuming a direct-indirect setup with a utilization factor of 0.5. Maintenance factors encompass considerations like lamp surface and luminaire cleanliness, room surface cleanliness, losses in lamp operation, and output reduction due to voltage drops. Generally, well-maintained rooms have

maintenance factors between 0.6 and 0.9; for this research, a value of 0.6 will be utilized. Both values of UF and MF will be utilized for all rooms illuminance calculation with the sense as an anticipation for the least optimum conditions for the current lighting system in both towers.

The measurement instrument will rely on an environment meter for illuminance measurements, with data processing and visualization facilitated by Microsoft Excel. The obtained illuminance (E), both from manual measurements as depicted in Figure 3.10 and calculations will be compared to SNI 6197-2020 standards based on room function.

Figure 3.10 Measurement Documentation

3.3.2 Light Power Density Data Collection

Technical data is crucial for assessing light power density. This includes details such as the lamp type, its power rating, luminous flux, and the quantity of lamps used for illumination during activities. These data points will be gathered based on the specific conditions of each room, organized into tables, and then compared against the standards outlined in SNI 6197-2020. The methodology employed in this context is general.

3.4 Data Analysis Technique

In this research, the collected and organized data will undergo analysis. This process involves comparing the measured results with the standards specified in SNI 6197-2020 for illuminance and light power density, as detailed in Table 3.4. These standards are tailored to various room types, including offices, meeting rooms, parking lots, archive storage areas, classrooms, laboratories, computer labs, exhibition spaces, canteens, cleaning rooms, fine dining areas, lounges, toilets, reception areas, kitchens, eating spaces, and multipurpose rooms, among others.

Additional tools, such as tables, will be utilized to visually present the results and facilitate comparisons. The outcome of this analysis will indicate the proximity of the measured values to the established standards, providing insights into the necessity for enhancing visual comfort.

Table 3.4 Illuminance and Light Power Density Standard According to SNI 6197:2020 [22]

Type of Room	Illuminance (Lux)	Light Power Density (W/m^2)
Office		
Working Room	350	7.53
Meeting Room	300	7.53
Drawing Room	750	7.53
Parking Lot	100	7.53
Archive Storage	150	7.53
Education Institute		
Classroom	350	7.53
Laboratory	500	7.53
Computer Laboratory	500	7.53
Exhibition	300	7.53
Canteen	200	7.53
Parking Lot	100	1.4
Restaurant		
Fine Dining Room	30	8.61
Lounge	100	8.61
Cleaning Room	100	8.61
Toilet	200	8.61
Hotel		
Receptionist Room	200	6.03
Kitchen	300	6.03
Eating Room (Restaurant)	250	6.03
Multipurpose Room	250	6.03

3.5 Research Limitation

This research is done with limitations as specified below:

1. The period of this research is not done periodically over a year but conducted from January 2024 to May 2024 as sampling data.
2. The research does not cover all floor levels and every room in UMN's Tower C and D since several areas are prohibited and not eligible for access. Thus, the researcher maximizes sampled floor levels and rooms with the hope of giving optimum outcome. The sampled floors for C Tower consist of basement, first, second, third, seventh, and tenth. Whilst for D Tower consists of basement, first (Lecture Theatre), second, third, fifth, sixth, seventh (CollaboSpace and CollaboHub), eight, tenth, twelfth, and fifteenth.
3. Several technical data are also not accessible such as the exact number and specification for lamps that are currently installed in the canteen and basement as well as its areas (excluding tenants' part).
4. Elements of photometry are narrowed down to illuminance which does not consider glare factors.
5. The tool used in this research is DT-8820 Environment meter in which has been compared extensively with lux meters to provide similar outcome.
6. No simulation using software and surveys are done in this research since the intended highlights have been evaluation and assessment for illuminance and light power density condition on UMN's C and D existing lighting system compared to the SNI standard.

With time and manpower as well as the availability of access and technical data, detailed and careful conduction of this research can be done thoroughly to give the optimum outcomes. The desired outcome will serve as a layered basis that highlights specific information that can help UMN improve in readjusting the lighting system to support occupants' comfort.