1.0 Introduction

1.1 Aim and Objective

This project is an integration project with Design Studio 5 in which we are assigned to design a community library in Petaling Street, Kuala Lumpur. The aim of this project is to integrate our understanding regarding the principles of lightings in relation with the context of our community design which is an urban infill site. The objective is to show our understanding about the principles of artificial lighting and daylight strategies (PSALI) in our final design, and also to prove our ability to solve problems in relation to sustainability issues during our design process.

1.2 Project Introduction

Figure 1.2.1 Site plan (NTS). Source: Author

The site that we have been assigned to design our community library is Petaling Street located in Kuala Lumpur area. We have choices of two microsites nearby Petaling Street, in which I have chosen Site B to design my community library. We were to design a community library within this urban infill site while at the same time, take into consideration key aspects of urban design and context in relation to architecture.

1.3 Site Analysis

Site analysis regarding the sun shading performances on site is done to improve the application of the principles of artificial lightings and daylight strategies (PSALI) in the community library design.

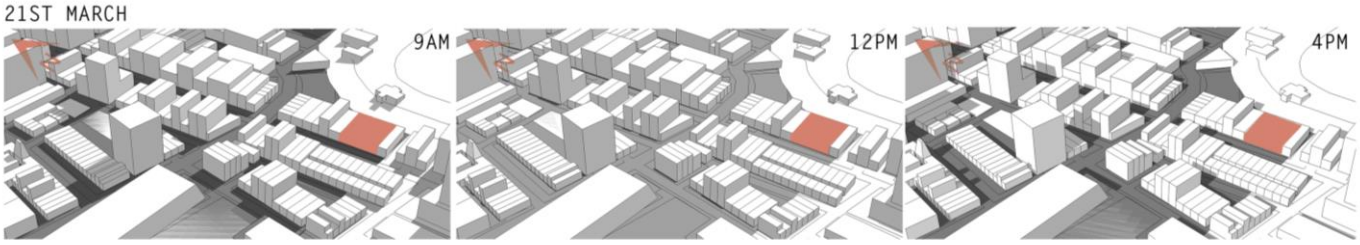

Figure 2.3.1 Sun shading analysis on 21st March. Source: Author

During morning and noon, the site is shaded when the sun is coming from the direction of East. While in the afternoon, the site is exposed to the sun from the direction of West. Windows and openings have to be carefully designed and placed at this direction to prevent heat gain and the same time ensuring the optimum illuminance level and visual comfort in the spaces of the library.

Figure 3.3.2 Sun shading analysis on 21st December. Source: Author

The sun is shining from South-East in the morning and noon, whereas the sun will be shining from South-West in the afternoon. Façade and the design of the openings/ windows should be carefully planned at this direction to improve illuminance level and also visual comfort of the users in the library.

1.4 Floor Plans

Ground Floor Plan

First Floor Plan

Second Floor Plan

2.0 Lighting Study

2.1 Bookstore Café, Ground Floor

2.1.1 Daylight Factor Analysis

Daylight factor is defined as the ratio of interior illuminance, E_i to available outdoor illuminance, E_o which is the unobstructed horizontal exterior illuminance:

$$DF = \frac{E_i \text{ (Indoor Illuminance)}}{E_o \text{ (Outdoor Illuminance)}} \times 100\%$$

Zone	DF (%)	Distribution
Very bright	>6	Large(including thermal and glare problem)
Bright	3-6	Good
Average	1-3	Fair
Dark	0-1	Poor

Table 2.1.1.1 Daylight factors and distribution. Source: Department of Standards Malaysia, 2007)

The daylight factor concept is applicable only when the sky illuminance distribution is known or can reasonably be estimated. In this case study, the average outdoor illuminance in Malaysia is assumed according to the standard which is 20000 lux (refer to Table 2.1.1.2).

Luminance Level (lux)	Example
120,000	Brightest sunlight
110,000	Bright sunlight
20,000	Shade illuminated by entire clear blue sky, midday
1000-2000	Typical overcast day, midday
400	Sunrise/ sunset on clear day (ambient illumination)
<200	Extreme of darkest storm clouds, midday
40	Fully overcast, sunrise/ sunset
<1	Extreme of darkest storm cloud, sunrise/ sunset

Table 2.1.1.2 Daylight intensity at different condition. Source: Department of Standards Malaysia, 2007)

Bookstore Café, Ground Floor

This bookstore café located at the ground floor is designed for the community to strengthen the relationship within the community and also to enhance the social environment on site. It is located as in its West façade is facing the main street Jalan Petaling, whereas the other side is facing an internal courtyard. Natural daylight can be penetrating into the space through the openings/ windows to provide natural illuminance effect. Hence, with the aid of natural day lighting, daylight use and visual comfort of the users can be maximized and controlled with lesser number of artificial lighting fixtures.

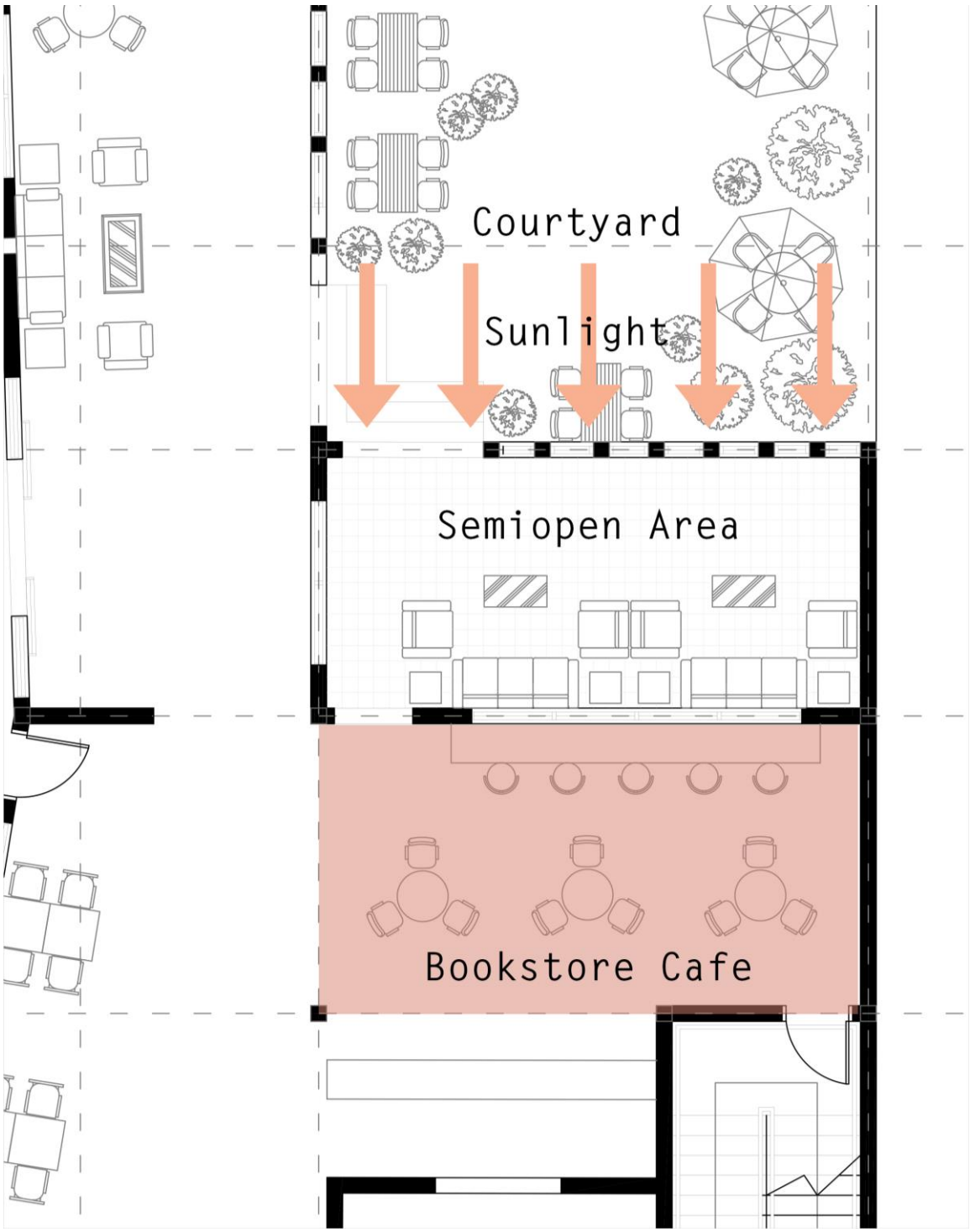

Figure 2.1.1.1 Direction of sunlight into the bookstore café (dimensions chosen using gridlines) on ground floor (NTS).

Daylight Factor Calculation

Floor Area (m^2)	3.6 x 6.9= 24.84
Area of façade exposed to sunlight (m^2)	Perimeter = 4m Height = 2m Area = 4 x 2= 8 m^2
Daylight Factor, DF	$DF = \frac{8}{24.84} \times 100\%$ = 0.322 x 100% = 32.2% x 0.1 = 3.2

E_o = 20000 lux

Therefore,

DF = E_i (Indoor Illuminance) x 100%
E_o (Outdoor Illuminance)

3.2 = (E_i / 20000) x 100%

E_i = (3.2/ 100) x 20000

= 640 lux

The bookstore café that has been designed has a daylight factor of 3.2% which falls under bright zone with good distribution. According to MS1525, the recommended illumination level of 200 lux is required for a space as a centre cafeteria/ dining area. Hence, the illumination level of 640 lux in this space has exceeded the standard recommendation. To maintain an optimum illumination level that is suitable for the usage of this space, light shelves are proposed to be integrated with the windows/ openings on both sides to prevent the penetration of direct sun light while at the same time remaining optimum indoor illuminance value and visual comfort of the users by reducing glare from bright surroundings.

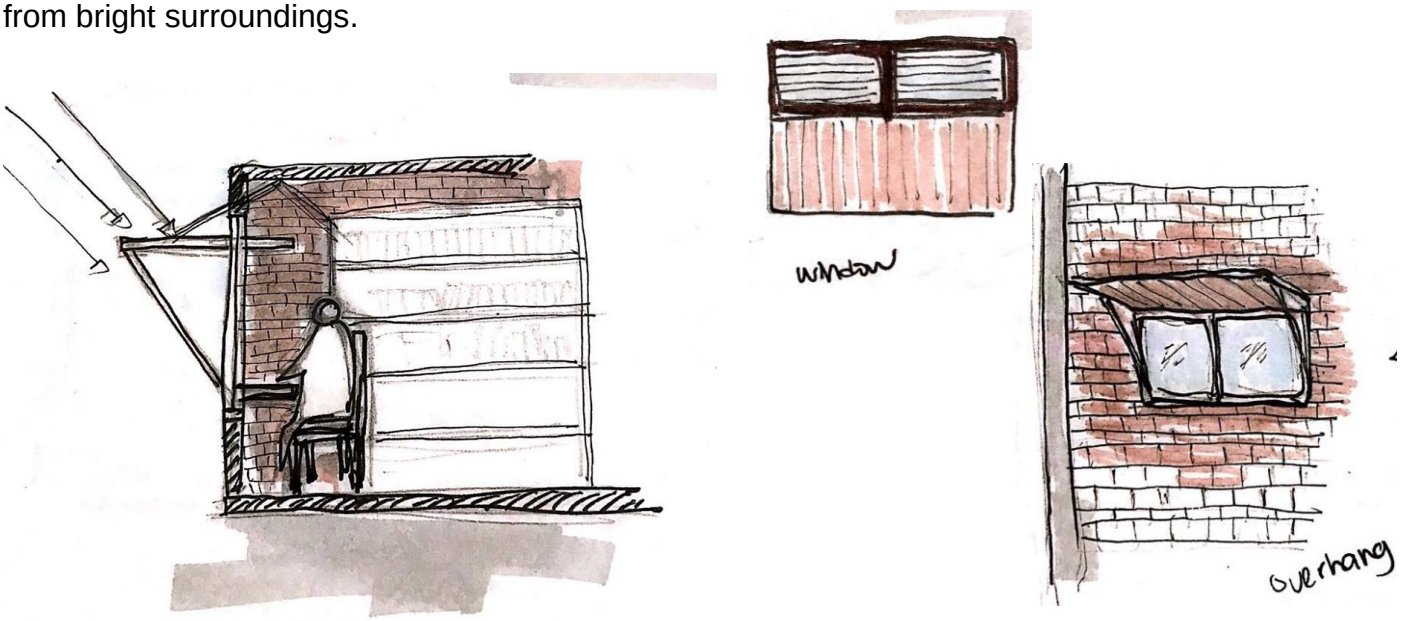

Figure 2.1.1.2 Sketches about the proposal of light shelves.

2.1.2 Artificial Lighting Analysis

Utilisation Factor

Utilization Factor																			
Ceiling (%)		70						50						30					
Wall (%)		50		30		10		50		30		10		50		30		10	
Floor (%)		30	10	30	10	30	10	30	10	30	10	30	10	30	10	30	10	30	10
Room Index	0.60	.27	.26	.22	.22	.19	.19	.26	.24	.22	.21	.19	.18	.26	.25	.21	.21	.19	.18
	0.80	.33	.31	.28	.27	.23	.23	.32	.30	.27	.26	.24	.23	.31	.30	.27	.26	.23	.23
	1.00	.38	.36	.32	.30	.28	.28	.36	.35	.32	.31	.29	.27	.35	.34	.31	.30	.28	.27
	1.25	.43	.40	.37	.35	.33	.32	.41	.39	.36	.35	.33	.32	.39	.37	.35	.34	.32	.31
	1.50	.47	.43	.41	.39	.37	.35	.44	.42	.40	.37	.36	.35	.42	.40	.39	.37	.36	.35
	2.00	.52	.47	.47	.44	.43	.41	.49	.46	.45	.43	.42	.40	.47	.45	.44	.42	.41	.40
	2.50	.56	.50	.51	.47	.48	.44	.53	.49	.49	.46	.46	.44	.50	.48	.47	.45	.45	.43
	3.00	.59	.52	.55	.49	.51	.47	.55	.52	.52	.48	.49	.46	.52	.50	.50	.48	.47	.46
	4.00	.62	.55	.59	.52	.56	.51	.58	.53	.56	.52	.53	.50	.55	.52	.53	.51	.51	.49
	5.00	.64	.56	.62	.55	.59	.53	.60	.55	.58	.53	.56	.52	.57	.54	.55	.52	.52	.51

Table 2.1.2.1 Utilization factors for some luminaries.

A reflectance value of a material's surface colour measures the amount of visible and usable light that reflects from (or absorbs into) that surface. These reflectance values should be used as guidelines to predict how light or dark a colour will appear and so to calculate the number and type of light fixtures needed to provide a certain amount of light for interior spaces.

Material Reflectance Value

Colour	Reflectance
White, off-white, light shades of grey, brown, blue	75% - 90%
Medium green, yellow, brown, grey	30% - 60%
Dark grey, medium blue	10% - 20%
Dark blue, green, wood panelling	5% - 10%

Table 2.1.2.2 Reflectance values based on the colour of the surface.

The reflectance values of the material are determined according to the colours of different furnishes for example the ceilings, walls, flooring and tables.

Lighting Fixture Properties

Legend			
PHILIPS			
Type of light	Artificial light	Power (W)	13
Type of fixture	CoreLine SlimDownlight	Luminous flux (lm)	1000
Type of luminaries	830 Warm white	Colour temperature (K)	3000
Type of artificial light source	LED Light	Average life rate (hours)	15000

According to MS1525, the recommended illumination level for centre cafeterias/ dining area is 200 lux.

Lumen Method Calculation

Zone	Bookstore Cafe		
Dimension of space, L x W	3.6 x 6.9		
Total Floor Area (m^2)	24.84		
Reflectance Value	Ceiling= 0.8	Walls= 0.1	Working plane= 0.1
Type of Luminaries	CoreLine SlimDownlight		
Luminous Flux (lm)	1000		
Mounting Height, H_m (m)	2.92		
Room Index, K $K = \frac{\mathrm{L\ x\ W}}{\mathrm{Hm\ (L+W)}}$	$K = \frac{3.6 \text{ x } 6.9}{2.92\ (3.6+6.9)} = \frac{24.84}{30.66} = 0.81$		
Utilization Factor, UF	0.23		
Maintenance Factor, MF	0.8		
Standard Illuminance Level (lux)	200		
Number of Luminaires, N $N = \frac{\mathrm{E\ x\ A}}{\mathrm{F\ x\ UF\ x\ MF}}$	$N = \frac{200 \text{ x } 24.84}{1000 \text{ x } 0.23 \text{ x } 0.8} = \frac{4968}{184} = 27$		

For filament lamps in direct luminaries:

Smax = 1.0 x H_m

Where,

- Smax = Maximum horizontal spacing between fittings
- H_m = Mounted height of fitting above the working plane

Smax = 1.0 x H_m
= 1.0 x 2.92
= 2.92m

Smax = 2.92m, therefore, in this space, if we set the spacing between the luminaries, S to be 1.2m.

First spacing from the wall will be half of the S, which is: 1.2m/ 2 = 0.6m

R = N/ Number of spacing line in S

= 27/ 3

= 9

Whereas the spacing on R is

6.9m/ 9

= 0.767m

The first spacing line from the wall is half of the R which is

0.767m/ 2

= 0.3835m

Fitting Layout

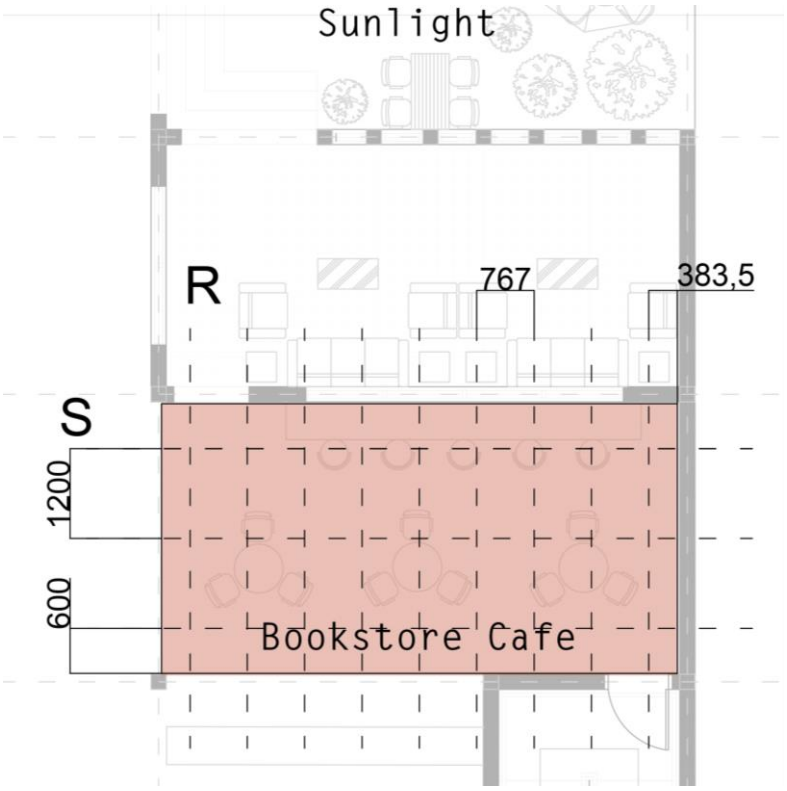

Figure 2.1.2.1 Spacing (in mm) of the luminaries in Bookstore Cafe (NTS).

Conclusion

Total number of 27 luminaries are required within this café space to achieve recommended illumination level of 200 lux with the spacing and layout of the luminaires as shown above.

2.1.3 PSALI- Permanent Supplementary Artificial Lighting of Interiors

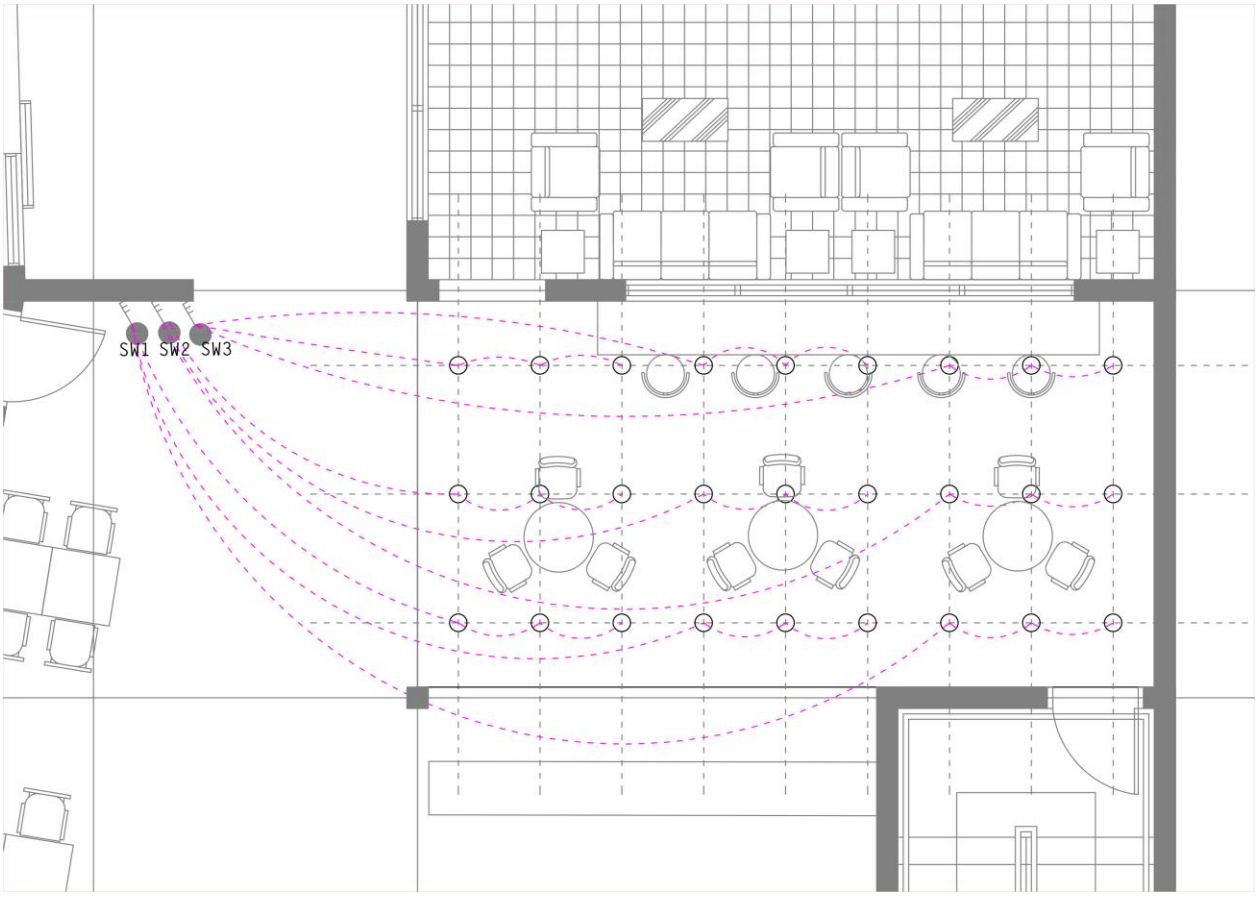

Figure 2.1.3.1 PSALI method for placing luminaires in bookstore café area (NTS).

Total number of 27 luminaries are required in this area to achieve recommended illumination level of 200 lux. With the fixture spacing calculated, the PSALI scheme in this space is proposed as such:

The total number of 27 luminaires are connected to 3 three-way switches named SW1, SW2 and SW3. This is because each switch can only be connected to maximum 3 fixtures at one time, hence total number of 3 three-way switches are proposed in this scheme.

During the brightest portion of day (when the daylight factor is high), only SW1 needs to be turned on. When the daylight factor drops, SW2 can be switched on to assist SW1. During night time in which the daylight factor is extremely low, SW3 will have to be switched on to have better illumination performance.

2.2 Open Study Area, First Floor

2.2.1 Daylight Factor Analysis

Open Study Area, First Floor

This open study area is located at the first floor of the library in which it is designated to encourage to community in sharing their knowledge, stories or even their memories of site. This is to enhance the relationship between each community while at the same time, engaging them with the beauty of the nature through various openings. Atriums/ courtyards are implemented on the North and south side of the open study area to capture natural light, lighting up this area that is facing inside. This is to maximize the day light use while at the same time, ensuring the visual comfort of the occupants.

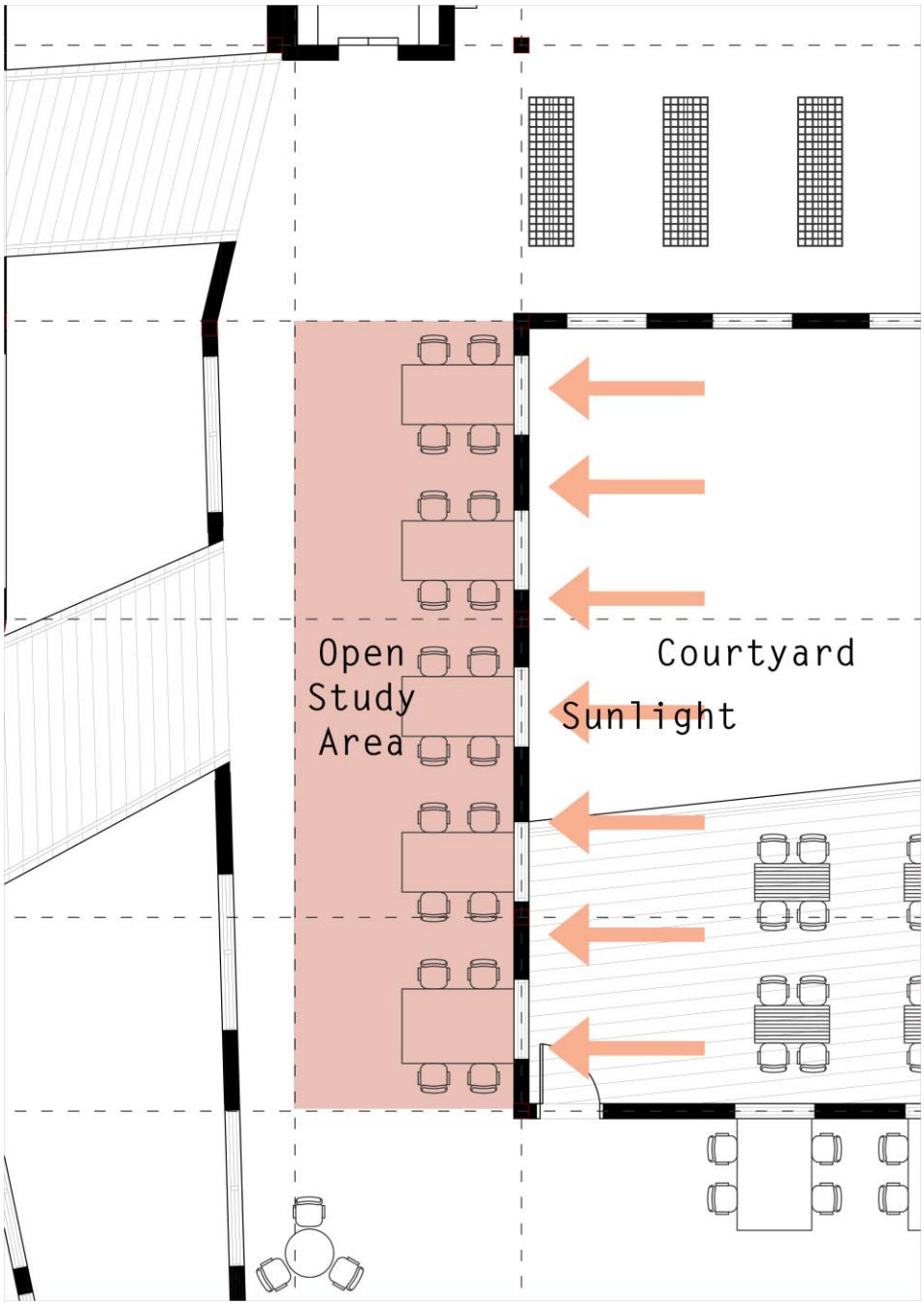

Figure 2.2.1.1 Direction of sunlight into open study area (dimensions chosen using gridlines) on first floor (NTS).

Daylight Factor Calculation

Floor Area (m^2)	3.3 x 10.6= 34.98
Area of façade exposed to sunlight (m^2)	Perimeter = 8m Height = 1.2m Area = 8 x 1.2= 9.6m^2
Daylight Factor, DF	$DF = \frac{9.6}{34.98} \times 100\%$ = 0.274 x 100% = 27.4% x 0.1 = 2.74

E_o = 20000 lux

Therefore,

DF = E_i (Indoor Illuminance) x 100%
E_o (Outdoor Illuminance)

2.74 = (E_i / 20000) x 100%

E_i = (2.74/ 100) x 20000

= 548 lux

This open study area on first floor has a daylight factor of 2.74% which falls under average zone with fair distribution. According to MS1525, the recommended illumination level of 300-500 lux is required for a reading space in a library. Hence, the illumination level of 548 lux in this space has slightly exceeded the standard recommendation. To maintain an optimum illumination level suitable for a reading space in a library, fixed vertical elements are adequate to control the direct glare at the north-facing façade. Besides, by planting more trees at the courtyard could help protecting the open study area from the sun and also ensuring visual comfort while maintaining standard illuminance level inside.

Figure 2.2.1.2 Sketches of the proposal of vertical shading elements and trees.

2.2.2 Artificial Lighting Analysis

Lighting Fixture Properties

Legend			
PHILIPS			
Type of light	Artificial light	Power (W)	40
Type of fixture	SmartBalance, suspended	Luminous flux (lm)	3000
Type of luminaries	White	Colour temperature (K)	3000
Type of artificial light source	Philips Fortimo LED Line 1R	Average life rate (hours)	70000

According to MS1525, the recommended illumination level for reading area in library is 300-500 lux.

Lumen Method Calculation

Zone	Open Study Area		
Dimension of space, L x W	3.3 x 10.6		
Total Floor Area (m^2)	34.98		
Reflectance Value	Ceiling= 0.8	Walls= 0.1	Working plane= 0.1
Type of Luminaries	SmartBalance, suspended		
Luminous Flux (lm)	3000		
Mounting Height, H_m (m)	2.6		
Room Index, K $K = \frac{\mathrm{L\ x\ W}}{\mathrm{Hm\ (L+W)}}$	$K = \frac{3.3 \text{ x } 10.6}{2.6\ (3.3+10.6)} = \frac{34.98}{36.14} = 0.97$		
Utilization Factor, UF	0.28		
Maintenance Factor, MF	0.8		
Standard Illuminance Level (lux)	400		
Number of Luminaires, N $N = \frac{\mathrm{E\ x\ A}}{\mathrm{F\ x\ UF\ x\ MF}}$	$N = \frac{400 \text{ x } 34.98}{3000 \text{ x } 0.28 \text{ x } 0.8} = \frac{13992}{672} = 20.82 = 21$		

For filament lamps in direct luminaries:

Smax = 1.0 x H_m

Where,

- Smax = Maximum horizontal spacing between fittings
- H_m = Mounted height of fitting above the working plane

Smax = 1.0 x H_m
= 1.0 x 2.6
= 2.6m

Smax = 2.6m, therefore, in this space, if we set the spacing between the luminaries, S to be 2.12m.

First spacing from the wall will be half of the S, which is: 2.12m/ 2 = 1.06m

R = N/ Number of spacing line in S

= 21/ 5

= 4.2

= 5

Whereas the spacing on R is

3.3m/ 5

= 0.66m

The first spacing line from the wall is half of the R which is

0.66m/ 2

= 0.33m

Fitting Layout

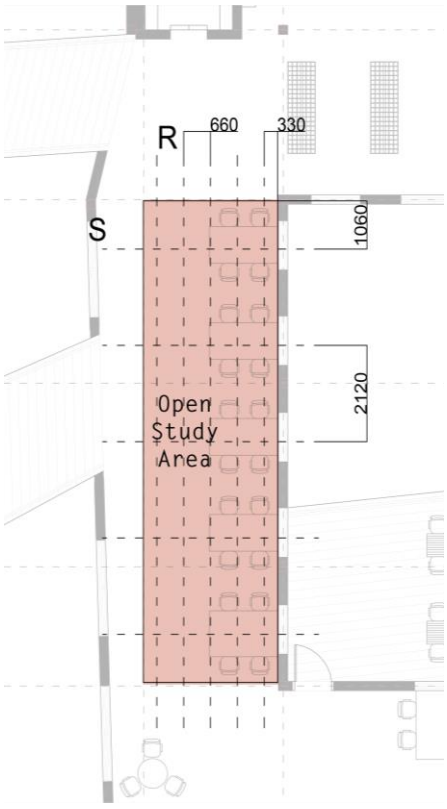

Figure 2.2.2.1 Spacing (in mm) of the luminaries in Bookstore Café (NTS).

Conclusion

Total number of 21 luminaries are required within this reading space to achieve recommended illumination level of 400 lux with the spacing and layout of the luminaires as shown.

2.2.3 PSALI- Permanent Supplementary Artificial Lighting of Interiors

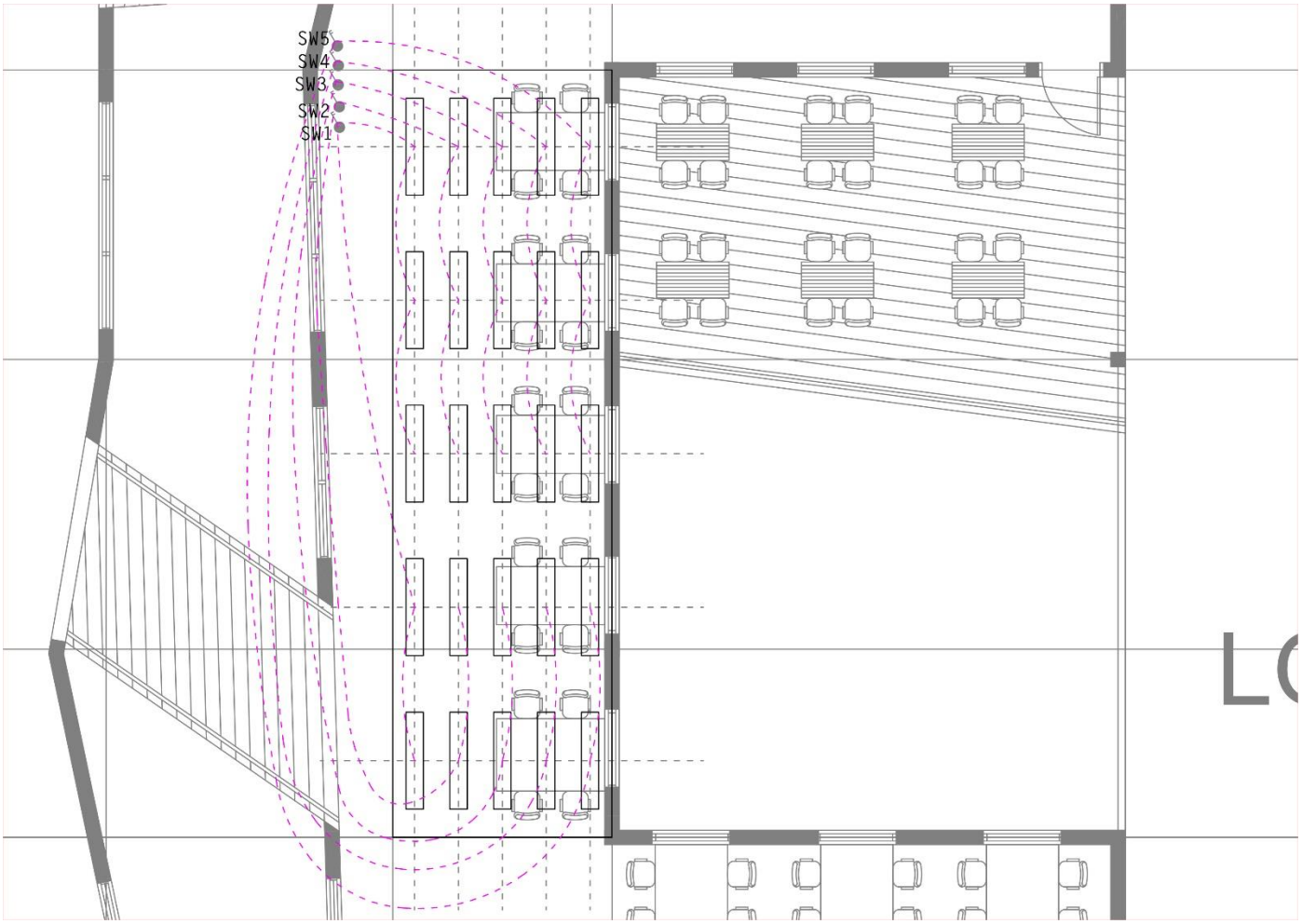

Figure 2.2.3.1 PSALI method for placing luminaires in open study area (NTS).

Total number of 21 luminaries are required in this area to achieve recommended illumination level of 400 lux. With the fixture spacing calculated, the PSALI scheme in this space is proposed as such:

The total number of 21 luminaires are connected to 5 two-way switches named SW1, SW2, SW3, SW4 and SW5. This is because each switch can only be connected to maximum 3 fixtures at one time, hence total number of 5 two-way switches are proposed in this scheme.

During the brightest portion of day (when the daylight factor is high), only SW1 needs to be turned on. When the daylight factor drops, SW2, SW3 and SW 4 can be switched in replace of SW1. During night time in which the daylight factor is extremely low, SW5 will have to be switched on to have better illumination performance.

3.0 Reference

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