TAYLOR'S UNIVERSITY

Wisdom · Integrity · Excellence

PROJECT 2

INTEGRATION WITH DESIGN STUDIO 5

(BRICKFIELDS COMMUNITY LIBRARY)

BUIDLING SCIENCE 2 (ARC 3413)

FINAL REPORT AND CALCULATION

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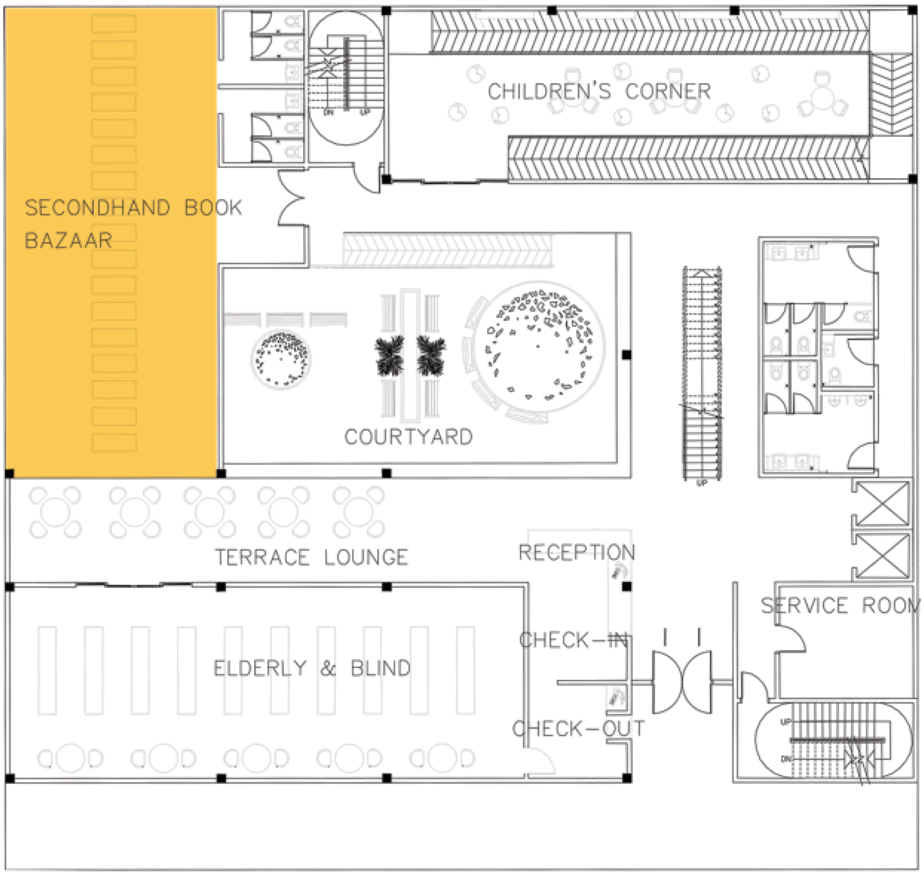
1.1 Day Lighting (Outdoor Secondhand Book Bazaar)

According to MS 1525, the daylight factor distribution are as follows:-

Zone	Daylight Factor (%)	Distribution
Very Bright	> 6	Very large with thermal and glare problems
Bright	3 - 6	Good
Average	1 - 3	Fair
Dark	0 - 1	Poor

The selected area which is the outdoor secondhand book bazaar is located at the ground floor with a triple volume height. Only one façade for this area is totally exposed to sunlight where else the other side is blocked by the main library block. Therefore, there are no artificial lighting that will be used in this area.



Daylight Factor Calculation

Floor Area (m^2)	117
Area of façade that is exposed to sunlight (m^2)	86.5
Exposed façade and skylight area to floor area ratio / Daylight Factor, DF	$\frac{86.5}{117}$ x 100% = 73.9% 73.9% x 0.1 = **7.39%**

Natural Illumination Calculation

Illuminance	Example
120,000 lux	Brightest sunlight
110,000 lux	Bright sunlight
20,000 lux	Shade illuminated by entire clear blue sky, midday
1,000 – 2,000 lux	Typical overcast day, midday
< 200 lux	Extreme of darkest storm clouds, midday
400 lux	Sunrise or sunset on a clear day (ambient illumination)
40 lux	Fully overcast, sunset/sunrise
< 1 lux	Extreme of darkest storm clouds, sunset/sunrise

E external = 20 000 lux

DF = $\frac{E\ Internal}{E\ External}$ x 100

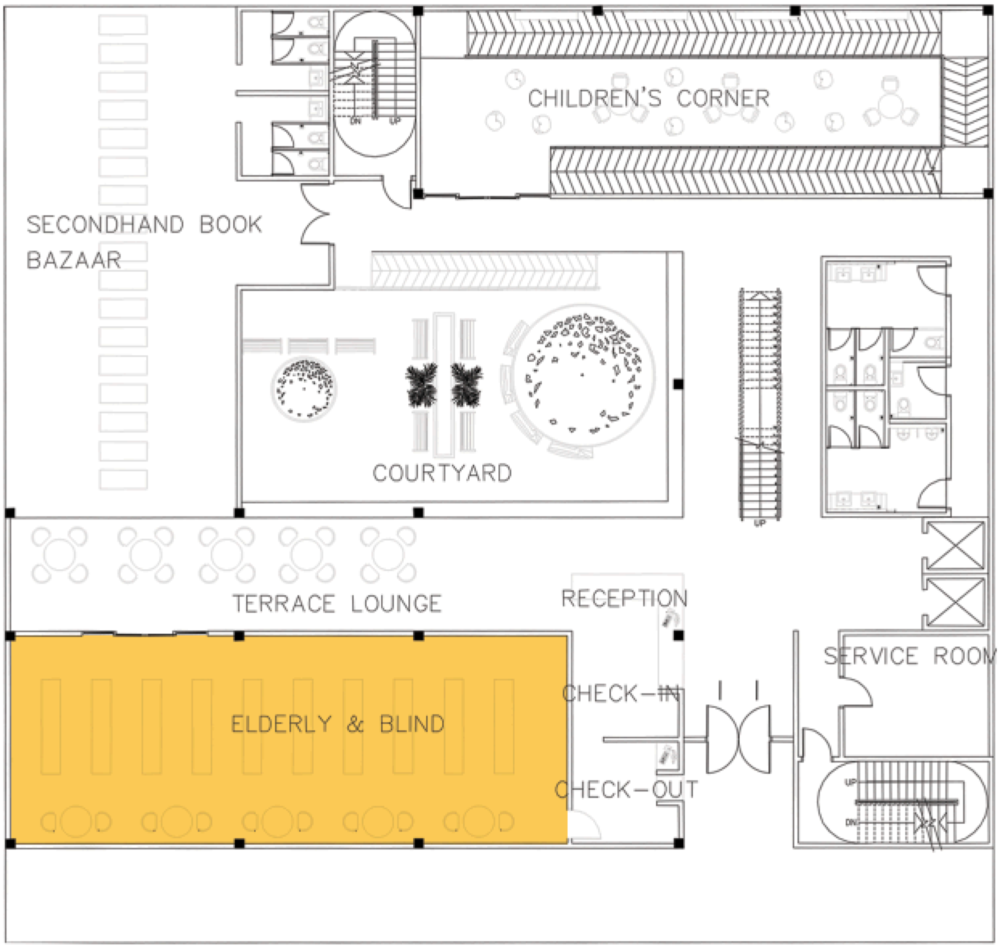
7.39% = $\frac{E\ Internal}{20000}$ x 100

E Internal = 7.39 x $\frac{20000}{100}$
= **1478 lux**

Conclusion

The outdoor secondhand book bazaar has a daylight factor of 7.39% and natural illumination of 1478 lux. This has the potential to result in thermal and glare problems. Thus, proper shading such as retractable roof is recommended.

1.2 Artificial Lighting (Elderly and Blind Reading Area)



Material Table

Component	Material	Function	Colour	Area (m^2)	Surface Type	Luminance Factor Range(%)
Ceiling	Concrete Finish	Ceiling	White	116.8	Reflective	70-80
Wall	Reinforced Concrete	Wall	Beige	52.8	Reflective	50-60
Floor	Concrete Cement	Floor	Grey	116.8	Reflective	20-30
Furniture	Fabric	Chair	Beige	3.0	Absorptive	25-35
	Timber	Shelf	Brown	18.0	Absorptive	30
	Timber	Table	Brown	3.5	Absorptive	30

According to MS 1525, the minimum lighting level required in a reading area is 300 lux.

Lumen Method Calculation

Location	Elderly and Blind Reading Area
Dimension of Room, L x W	6.6 x 17.7
Total Floor Area (m^2)	116.8
Mounting Height, h_m (m)	4.0 – 0.8 = 3.2
Room Index, K	K = $\frac{L \, x \, W}{(L+W)h_m}$ = $\frac{6.6 \, x \, 17.7}{(6.6+17.7)3.2}$ = 1.502
Room Reflectance (%)	C:70, W:50, F:30
Utilisation Factor (UF)	0.41
Maintenance Factor (MF)	0.75
Standard Illuminance Level Required (lux)	300
Number of fittings required, N	N = $\frac{E \, x \, A}{F \, X \, UF \, X \, MF}$ = $\frac{300 \, x \, 116.8}{(1600 \, X \, 3) \, X \, 0.41 \, X \, 0.75}$ = 23.7 = 24 24 Osram Rectangular T5 Fluorescent Grid Lighting are needed to meet the standard illuminance required in the reading area according to MS 1525.

Assume SHR ratio is 1:1, h_m = 3.2, therefore maximum spacing is 3.2

Width / maximum spacing = 17.7/3.2
= 5.5 (6 luminaires)

Length/ maximum spacing = 6.6 /3.2
= 2 luminaires

An array of 6 x 4 luminaires will satisfy the uniformity requirement, because the number of array satisfies the number of required luminaires along both sides.

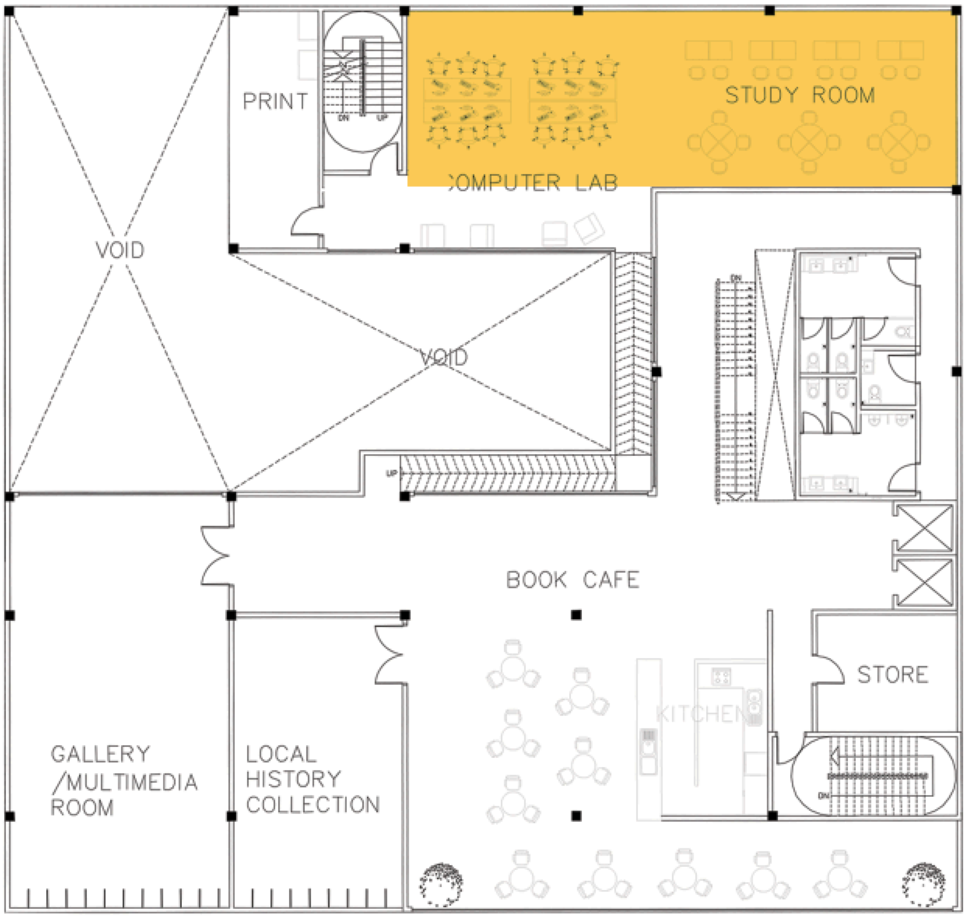
Therefore, the minimum number of luminaires required to achieve a maintained illuminance of 300 lux with acceptable uniformity is **24**.

Type of luminaire used is as follows:-

Type of Light	**Quantity**	**Luminious Flux (lm)**
Osram Rectangular T5 Fluorescent Grid Lighting (3 luminaires in 1 grid)  Wattage Level: 32W Colour temperature: 2700K Luminous Flux Level: 1600lm	24	1600 lm per fluorescent tube 4800 per grid lighting

1.3 PSALI – Permanent Supplementary Artificial Lighting of Interiors (Computer Room)

PSALI is a system of combined artificial lighting and daylighting, where the two are blended together to provide an even illumination. Parts of the room are permanently lit by artificial light. The principle of PSALI is to provide illumination that appears to be of good daylight character even though most of the working illumination may be from artificial light. The distribution of light provided by PSALI means that illumination increases gradually towards the windows. The supplementary illumination provided by PSALI can be found by choosing a design lighting level and subtracting the contribution of daylight. The lamps used for PSALI should match natural light in colour appearance (Colour Corrected Temperature, CCT). Fluorescent tubes with a CCT of 4000-6500K are often used for PSALI, often with recessed fitting. PSALI is also used to control the switching of lights on and off as daylight levels go up and down. In bright light all illumination may be provided by daylight. At night all lighting is artificial. Light-level switching of luminaires is known as photo-electric switching.



Daylight Factor Calculation

Floor Area (m^2)	105.05
Area of window (m^2)	56
Exposed façade and skylight area to floor area ratio / Daylight Factor, DF	$\frac{56}{105.05}$ x 100% = 53.3% 53.3% x 0.1 = **5.33%**

<u>Natural Illumination Calculation</u>

Illuminance	Example
120,000 lux	Brightest sunlight
110,000 lux	Bright sunlight
20,000 lux	Shade illuminated by entire clear blue sky, midday
1,000 – 2,000 lux	Typical overcast day, midday
< 200 lux	Extreme of darkest storm clouds, midday
400 lux	Sunrise or sunset on a clear day (ambient illumination)
40 lux	Fully overcast, sunset/sunrise
< 1 lux	Extreme of darkest storm clouds, sunset/sunrise

E external = 20 000 lux

DF = $\frac{E\ Internal}{E\ External}$ x 100

7.39% = $\frac{E\ Internal}{20000}$ x 100

E external = 5.33 x $\frac{20000}{100}$

= **1066 lux**

Material Table

Component	**Material**	**Function**	**Colour**	**Area (m^2)**	**Surface Type**	**Luminance Factor Range(%)**
Ceiling	Concrete Finish	Ceiling	White	105.05	Reflective	70-80
Wall	Reinforced Concrete	Wall	Beige	75.74	Reflective	50-60
Floor	Carpet	Floor	Black	105.05	Absorptive	10
Furniture	Fabric	Chair	Beige	7.2	Absorptive	25-35
	Timber	Table	Brown	18	Absorptive	30

According to MS 1525, the minimum lighting level required in a computer room is 300 lux.

Lumen Method Calculation

Location	Computer Room
Dimension of Room, L x W	18.05 x 5.82
Total Floor Area (m^2)	105.05
Mounting Height, h_m (m)	3.0 – 0.8 = 2.2
Room Index, K	K = $\frac{L\ x\ W}{(L+W)h_m}$ = $\frac{18.05\ x\ 5.82}{(18.05+5.82)2.2}$ = 2.00
Room Reflectance (%)	C:70, W:50, F:10
Utilisation Factor (UF)	0.47
Maintenance Factor (MF)	0.75
Standard Illuminance Level Required (lux)	300
Number of fittings required, N	N = $\frac{E\ x\ A}{F\ X\ UF\ X\ MF}$ =$\frac{300\ x\ 105.05}{(4000)\ X\ 0.47\ X\ 0.75}$ = 22.35 = 23 23, 65 Watt CFL - 6500K Full Spectrum Daylight are needed to meet the standard illuminance required in the reading area according to MS 1525.

Assume SHR ratio is 1:1, h_m = 2.2, therefore maximum spacing is 2.2

Width / maximum spacing = 18.05/2.2
= 8.2 (9 luminaires)

Length/ maximum spacing = 5.82 /2.2
= 2.6 (3 luminaires)

An array of 9 x 3 luminaires will satisfy the uniformity requirement, because the number of array satisfies the number of required luminaires along both sides.

Therefore, the minimum number of luminaires required to achieve a maintained illuminance of 300 lux with acceptable uniformity is **27**.

Type of luminaire used is as follows:-

Type of Light	Quantity	Luminious Flux (lm)
65 Watt CFL - 6500K Full Spectrum Daylight  Wattage Level: 65W Colour temperature: 6500K Luminous Flux Level: 4000lm	27	4000

Conclusion

During the day, the computer room is well lit by the natural lighting through the curtain wall on the back façade at 1066 lux which is more than what is required by MS 1525 in a computer room. However during the evening, the the artificial light dims down but the 35 numbers of 65 Watt CFL – 6500K Full Spectrum Daylight will ensure that the lighting level is coordinated so that it does not change abruptly.

2.1 External Noise Sound Pressure Level

$$\boldsymbol{SIL = 10\log\left(\frac{I}{I_o}\right)}$$

Where I = the intensity of sound being measured, (W/m^2)
I_0= the intensity of the threshold of hearing, taken as 10^{-12}

Peak Hour

Traffic Noise from Jalan Sultan Abdul Samad (front): 80dB

$$SIL = 10\log\left(\frac{I_1}{I_o}\right)$$
$$80 = 10\log\left(\frac{I_1}{I_o}\right)$$
$$log^{-1}8 = \frac{I_1}{1\ X\ 10^{-12}}$$
$$I_1 = 1\ X\ 10^{-12}\ X\ 10^{8}$$
$$I_1 = 1\ X\ 10^{-4}$$

Human Noise from market at back lane: 55dB

$$SIL = 10\log\left(\frac{I_2}{I_o}\right)$$
$$55 = 10\log\left(\frac{I_2}{I_o}\right)$$
$$log^{-1}5.5 = \frac{I_2}{1\ X\ 10^{-12}}$$
$$I_2 = 1\ X\ 10^{-12}\ X\ 3.16\ X\ 10^{5}$$
$$I_2 = 3.16\ X\ 10^{-7}$$

Total Intensity, I = (1 X 10^{-4}) + (3.16 X 10^{-7}) = 1 X 10^{-4}

$$SIL = 10\log\left(\frac{I}{I_o}\right)$$
$$= 10\log\left(\frac{1\ X\ 10^{-4}}{1.0\ X\ 10^{-12}}\right)$$
$$= 80$$

The sound intensity level during peak hour is 80dB

Non-peak hour

Traffic Noise from Jalan Sultan Abdul Samad (front): 75dB

$$SIL = 10\log\left(\frac{I_1}{I_o}\right)$$

$$75 = 10\log\left(\frac{I_1}{I_o}\right)$$

$$log^{-1}7.5 = \frac{I_1}{1\ X\ 10^{-12}}$$

$$I_1 = 1\ X\ 10^{-12}\ X\ 3.16\ X\ 10^{7}$$

$$I_1 = 3.16\ X\ 10^{-5}$$

Human Noise from market at back lane: 40dB

$$SIL = 10\log\left(\frac{I_2}{I_o}\right)$$

$$40 = 10\log\left(\frac{I_2}{I_o}\right)$$

$$log^{-1}4 = \frac{I_2}{1\ X\ 10^{-12}}$$

$$I_2 = 1\ X\ 10^{-12}\ X\ 1\ X\ 10^{4}$$

$$I_2 = 1\ X\ 10^{-8}$$

Total Intensity, I = ($3.16\ X\ 10^{-5}$) + ($1\ X\ 10^{-8}$) = $3.16\ X\ 10^{-5}$

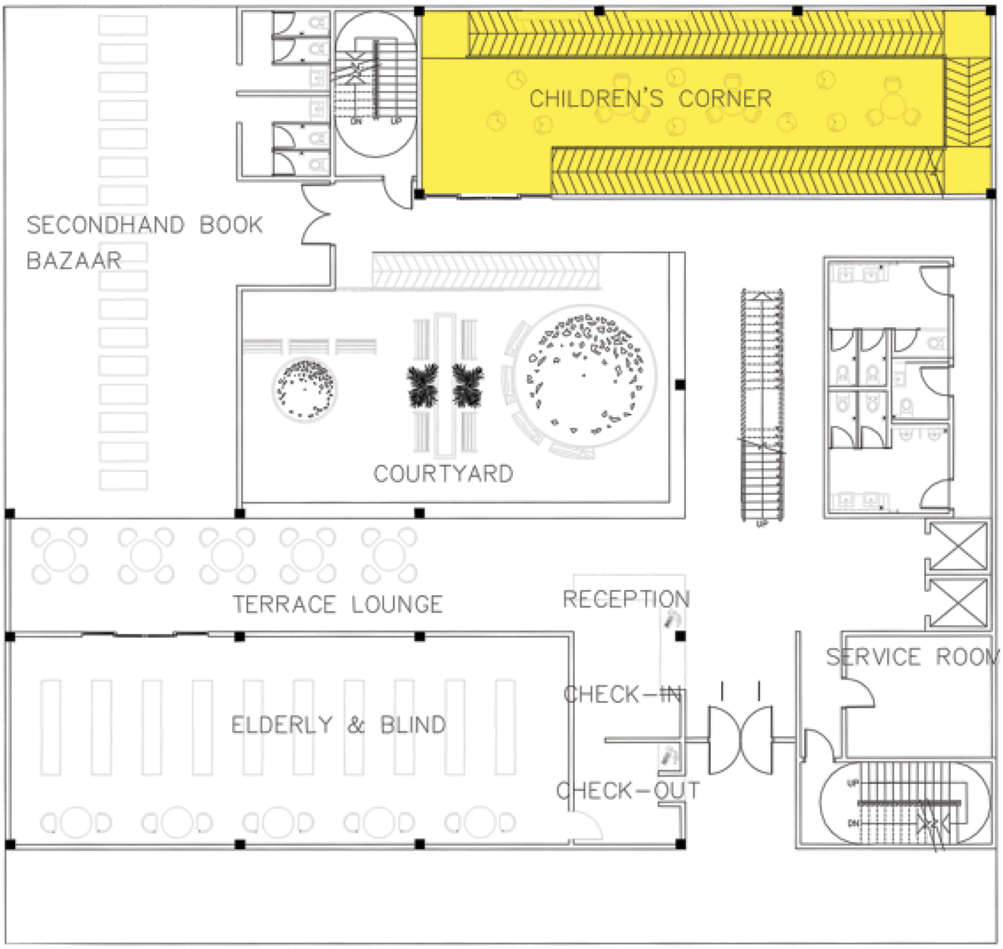
$$SIL = 10\log\left(\frac{I}{I_o}\right)$$

$$= 10\log\left(\frac{3.16\ X\ 10^{-5}}{1.0\ X\ 10^{-12}}\right)$$

=74.99

The sound intensity level during non-peak hour is 74.99dB

2.2 Reverberation Time, RT (Children's' Reading Area, Ground Floor)



Component	Material	Function	Area (m^2)	Absorption Coefficient (500Hz)	Sound Absorption
Ceiling	Concrete	Ceiling	105.05	0.05	5.25
Wall	Reinforced Concrete	Wall	152.04	0.05	7.60
	Glass	Window	8.4	0.10	0.84
Floor	Wood	Flooring	105.05	0.05	5.25
Furniture	Fabric	Chair	5.1	0.28	1.43
	Timber	Shelf	25.2	0.1	2.52
	Timber	Table	2.1	0.1	0.21
People			25	0.46	11.50
				Total Absorption	34.60

RT = (0.16 X V)/A
= (0.16 X 315.15) / 105.05
= 0.48s

The current children's' reading area reverberation time of 0.48s does not meet the requirement of a standard reverberation time of less than 1.0s for a library.

Therefore, acoustic panels with an absorption coefficient of 0.85 can be introduced along the walls to help reduce the overall reverberation time. The area of acoustic panels however have to be calculated.

Component	**Material**	**Function**	**Area (m^2)**	**Absorption Coefficient (500Hz)**	**Sound Absorption**
Ceiling	Concrete	Ceiling	105.05	0.05	5.25
Wall	Reinforced Concrete	Wall	152.04	0.05	7.60
	Glass	Window	8.4	0.10	0.84
	Softsound Panels	Acoustic Panels	x	0.87	0.87x
Floor	Wood	Flooring	105.05	0.05	5.25
Furniture	Fabric	Chair	5.1	0.28	1.43
	Timber	Shelf	25.2	0.1	2.52
	Timber	Table	2.1	0.1	0.21
People			25	0.46	11.50
				Total Absorption	34.60 + 0.87x

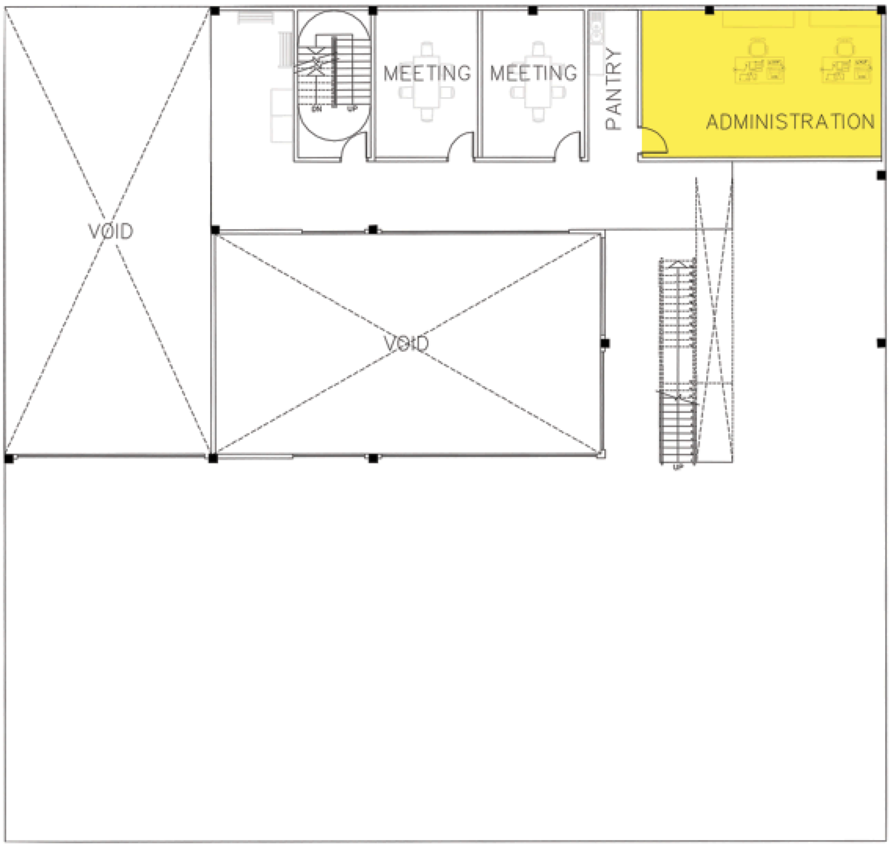
To obtain an optimum reverberation time of maximum 1.0s, the area of acoustic panels required is calculated as follows:-

1.0 = (0.16 x 315.15) / (34.60 + 0.75x)
0.75x = 15.82
Therefore x = **21.1m²**

Conclusion

This implies that an area of 21.1m² of acoustic panels will be able to reduce the reverberation time of the children's reading area to 1.0s.

2.3 Sound Reduction Index, SRI Calculation (Administration Office)



Component	Material	Colour	Finish	Surface Area (m^2), (A)	Sound Reduction Index, (R)(500Hz)	Transmission Coefficient, (T) $T = \frac{1}{log^{-1}(\frac{R}{10})}$
Wall	Reinforced Concrete 	White	Smooth	44.7	54	3.981 X 10^{-6}
Window	Glass 	Transparent	Reflective	11.84	26	2.512 X 10^{-3}
Door	Wood 	Brown	Rough	1.89	28	1.585 X 10^{-3}

	Glass 	Transparent	Reflective	1.89	30	$1 X 10^{-3}$

$$T_0 = \frac{(T_1 X A_1) + (T_2 X A_2) + (T_3 X A_3) + (T_4 X A_4) + (T_5 X A_5)}{A_1 + A_2 + A_3 + A_4 + A_5}$$
$$= \frac{(3.981 X 10^{-6} X 44.7) + (2.512 X 10^{-3} X 11.84) + (1.585 X 10^{-3} X 1.89) + (1 X 10^{-3} X 1.89)}{44.7 + 11.84 + 1.89 + 1.89}$$
$$= \frac{(1.780 X 10^{-4}) + (0.030) + (2.996 X 10^{-3}) + (1.89 X 10^{-3})}{60.32}$$
$$= \frac{(0.035)}{60.32}$$
$$= 5.813 X 10^{-4}$$

$$R = 10 \log(\frac{1}{T_0})$$
$$R = 10 \log(\frac{1}{5.813 X 10^{-4}})$$
$$R = 10 \log(1720.28)$$
$$R = 32.36$$

Hence the overall SRI = 32.36dB

Conclusion

Since the noise level from the back lane from human activities is 55dB, the sound can be reduced by 32.36dB to 22.64dB. The administration office is able to reduce its noise level to reach the noise criteria of quiet environmental perception once transferred to another space through the medium in between.

References:

1) Storey, S. (2002). Lighting Design. London. Pavilion Books.
2) Stein, Benjamin & Reynolds, John S. 2000. Mechanical and electrical Equipment for Buildings. New York, John Wiley.
3) Karlen, M & Benya, J. (2004). Lighting Design Basics. Hoboken, New Jersey.