Day lighting for Eco Housing

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WHAT IS ARCHITECTURE

Le Corbousier

Architecture is the wise, correct and magnificent play of volumes collected together under the light".

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  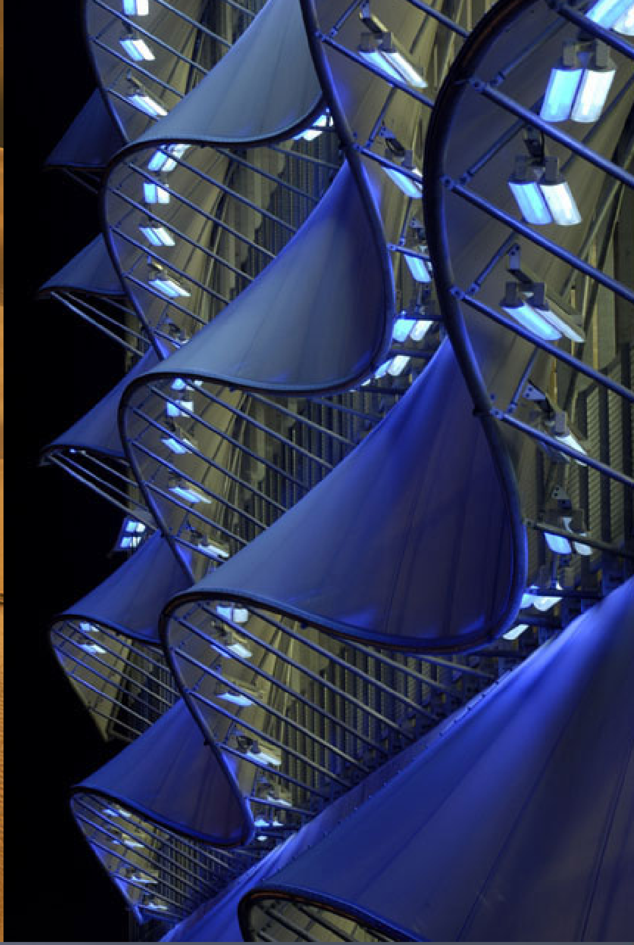

Nature… Light and Architecture

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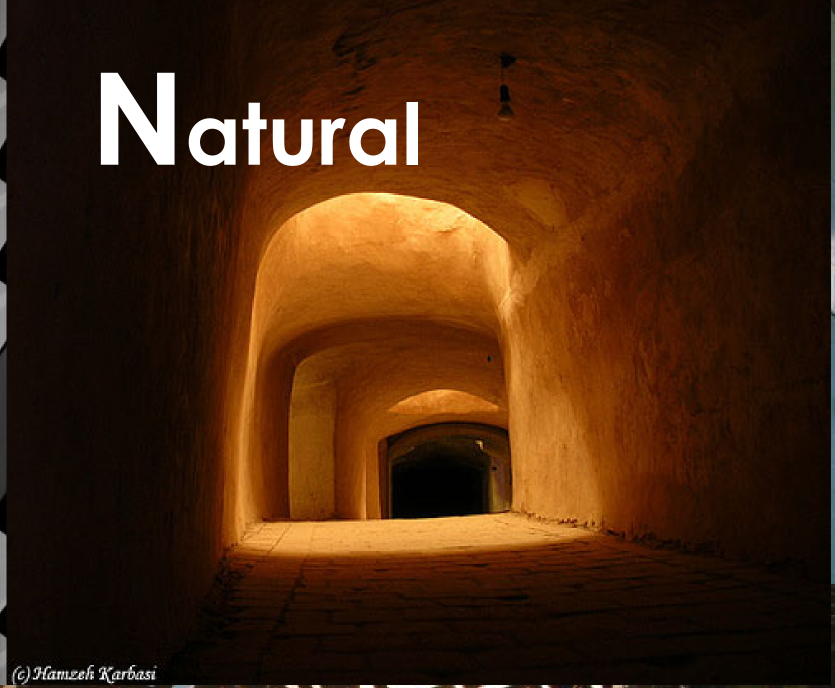
Natural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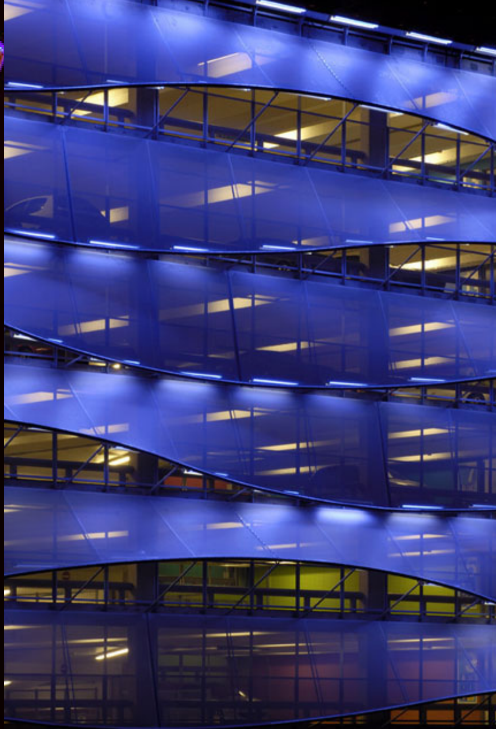
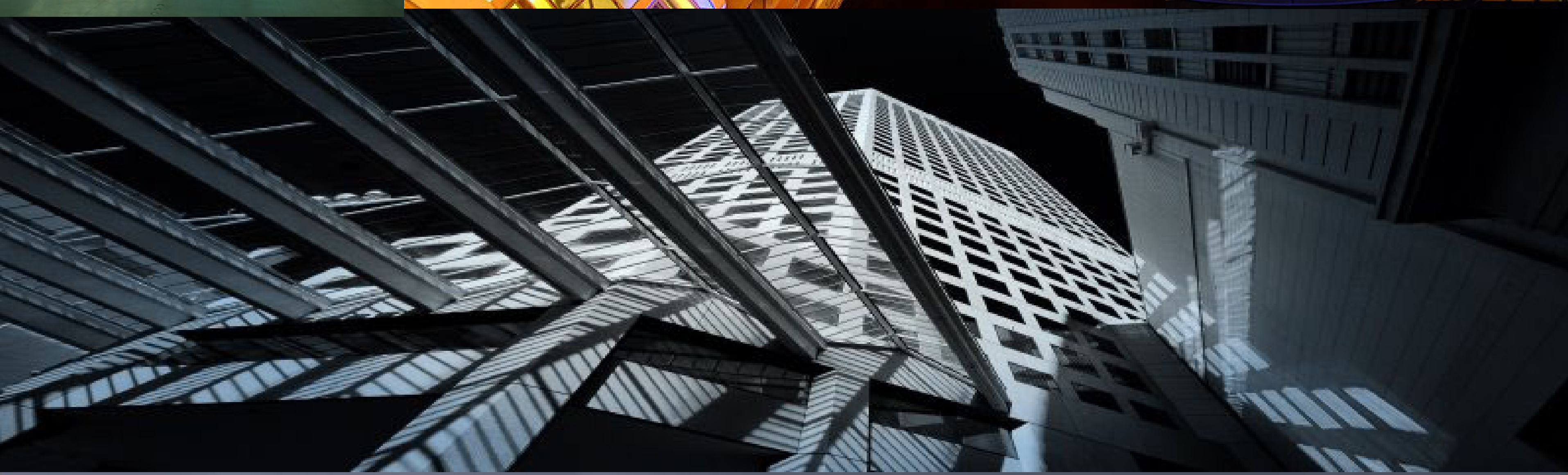
Artificial





Why Save energy?

Simply as it would save money!!

Why Save energy?

Global Warming

Address the National Crisis

Sustainability

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Integrating Daylight with Artificial Light for Energy Efficiency

Studies show that when day lighting strategies are employed with artificial lighting systems the lighting power densities in offices can be saved up to 0.2 W/sq.m.

2.2.2. Day-lighting

15

Ensure glare free & adequate day-lighting

Factors that affect Visual comforts inside the buildings

- Visibility
- Clarity
- Glare-free Light
- Window Design
- Shading
- Daylighting

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Eco Housing
Building a Better Tomorrow

prevalent wind direction to be determined through appropriate wind rose diagram.

- Total area of openings (inlet and outlet) should be a minimum of 30% of floor area.
- Provide a gap between horizontal louver and wall. Take rain protection.
- Provide verandas/balconies (any projection extending from building that is accessible and is minimum 1.2 m wide), which are open on three sides.
- Plant hedges at a distance of 2 m from building on the leeward side.

Submittal Requirement: Narrative (maximum 500 words with supporting drawings and sketches) should include climate responsive strategies for 1) natural ventilation 2) daylighting 3) solar control to ensure maximum thermal and visual comfort

Intent: To enable energy efficiency, thermal and visual comfort

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2.3 Roof should be protected against excessive heat gain by: appropriate insulation to give U-value as specified by Draft Energy Conservation Building Code 2005. Alternately provide roof garden for 100% of exposed roof area or provide 100% shading for 100% of exposed roof area — **10**

Submittal Requirement: Bill of quantities with roof specifications

Intent: To prevent roof heat gain

** Applicable only if space under the roof is a regularly occupied space*

2.4 Design for following daylight factors: — **10**

- Kitchen: 2.5
- Living room: 0.625
- Study room: 1.9

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Eco Housing & daylight

2.4	Design for following daylight factors: - Kitchen: 2.5 - Living room: 0.625 - Study room: 1.9	10

ERIA VERSION 1.0.

	- Circulation: 0.313 - 1 Daylight Factor = 80 lux - Demonstrate compliance by using an appropriate simulation tool
Submittal Requirement:	• Daylight based design • Simulated daylight levels under overcast sky conditions for a typical summer day
Intent:	Adequate daylight

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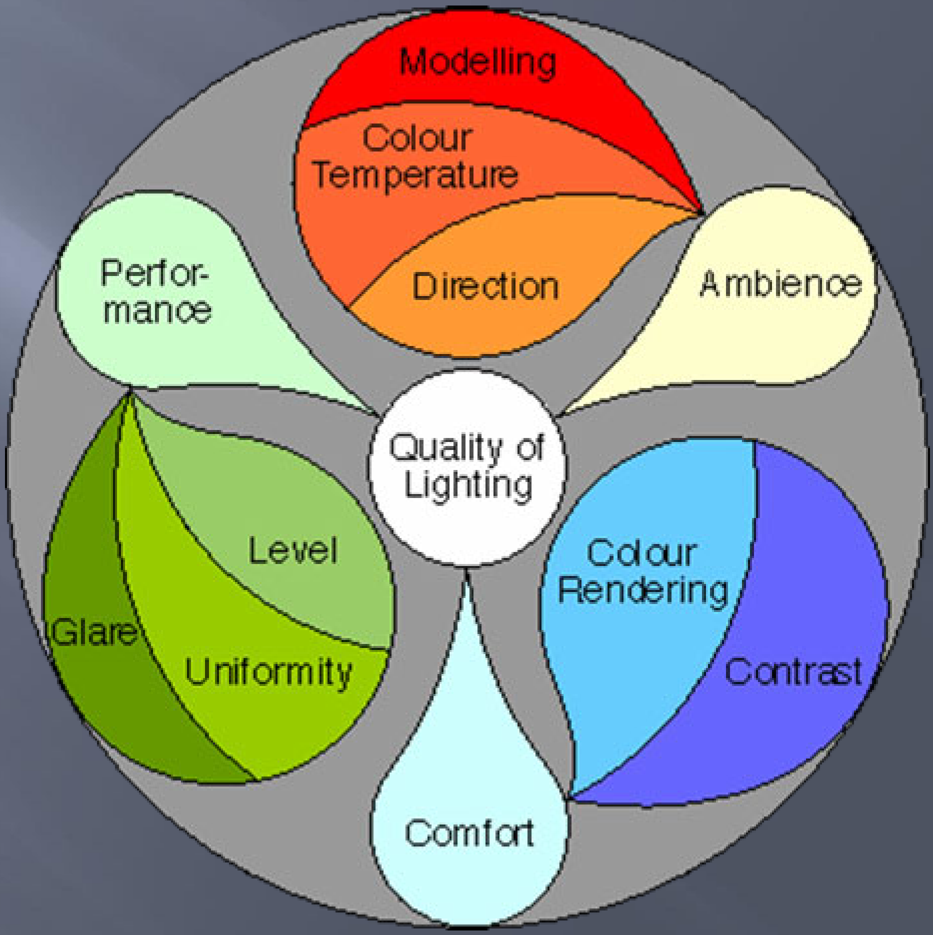
Design Objectives

- **Functional**
  - *Visibility*
  - *Clarity*
  - *Glare Free*
- **Aesthetic**
  - *Create*
  - *Highlight*
  - *Reveal*



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Day lighting Strategies

Conceptual Design

Decisions regarding

- *Siting*
- *Orientation*
- *Proportions*
- *Shape*
- *Apertures*

Day lighting Strategies

Design Phase

Decisions regarding

- *Façade details*
- *Interior finishes*
- *Integration of systems and services*

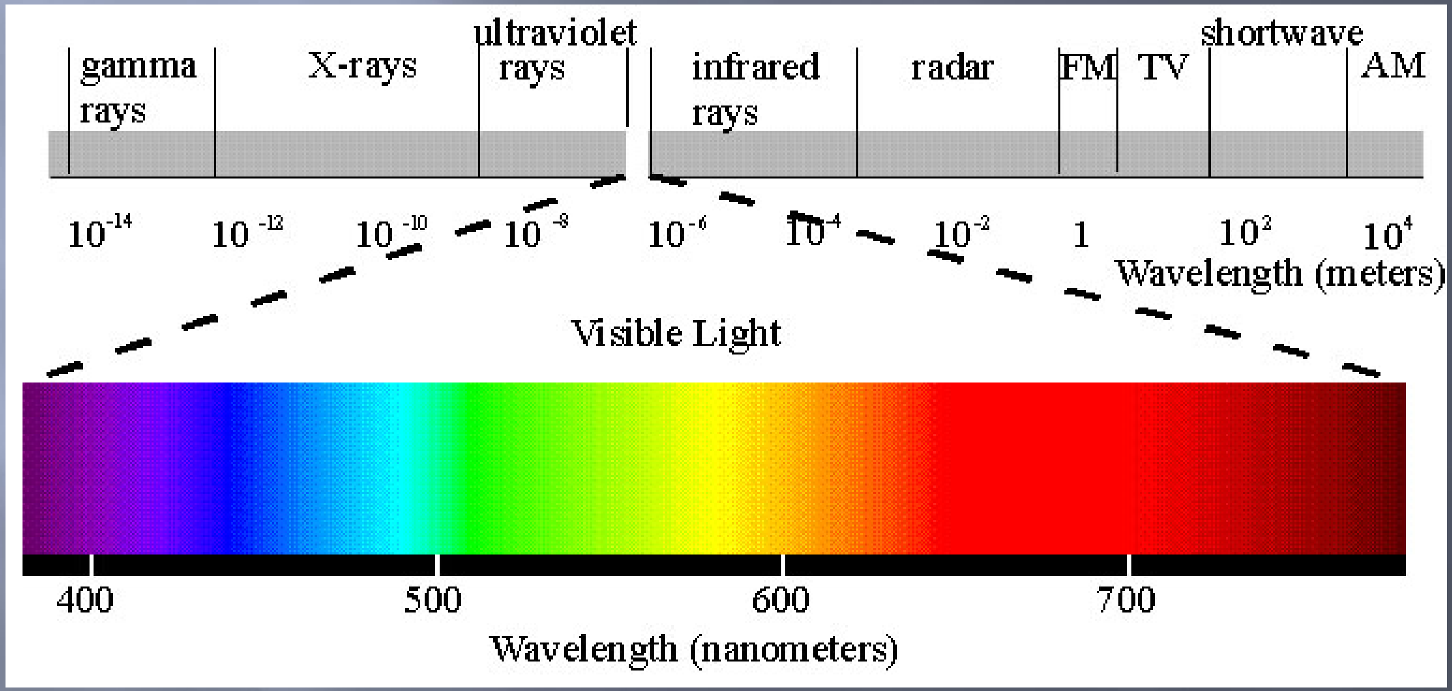
Day lighting Strategies

Construction & Commissioning

Decisions regarding

- *Selection of materials*
- *Detailing of lighting systems*
- *Calibration and Measurement*
- *Maintenance*

Background Study
Understanding Light



The spectrum of visible light ranges from wavelength of 0,00078 mm or 780 nm (nanometer) to a wavelength of 0,00038 mm (380 nm).

How much is available??

0.00005 lux	Starlight
0.0001 lux	Moonless overcast night sky
0.001 lux	Moonless clear night sky
0.01 lux	Quarter Moon
0.25 lux	Full Moon on a clear night
<1 lux	Moonlight
400 lux	Sunrise or sunset on a clear day.
32000 lux	Sunlight on an average day (min.)
100000 lux	Sunlight on an average day (max)

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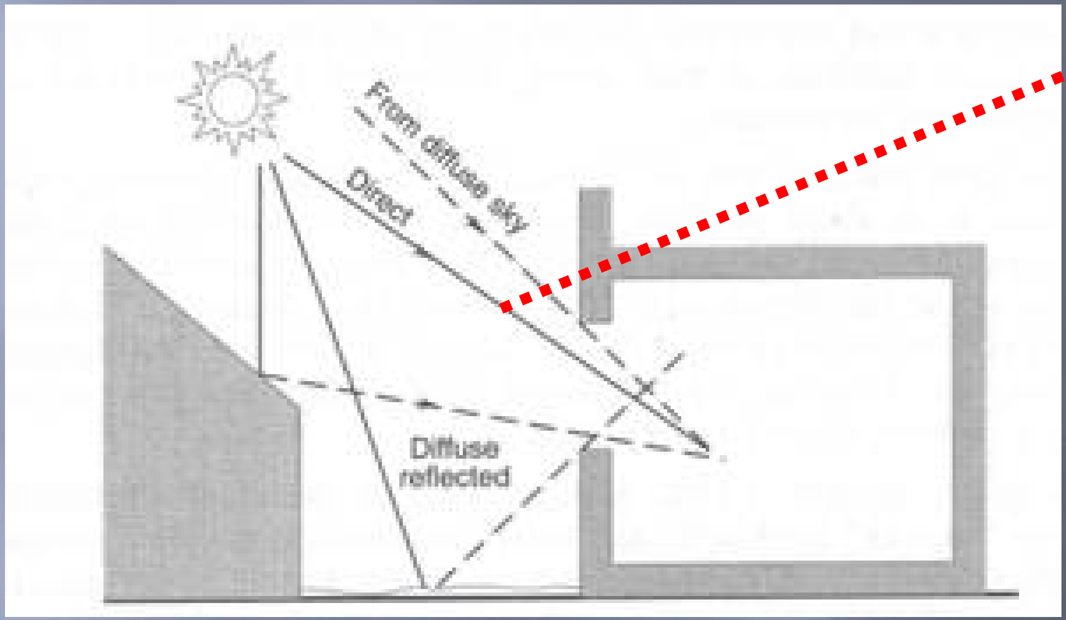
How much can be made available in an enclosed space?

Absolute methods allow the designer to make predictions about the illumination from daylight at the point of interest. The complication is, however, that the daylight availability varies with time, season, and weather conditions. Newer, computer based methods, therefore combine such simple methods with statistical weather data that is available for a variety of places.

- *Methods that determine absolute illuminance;*
- *Methods that determine relative illuminance.*

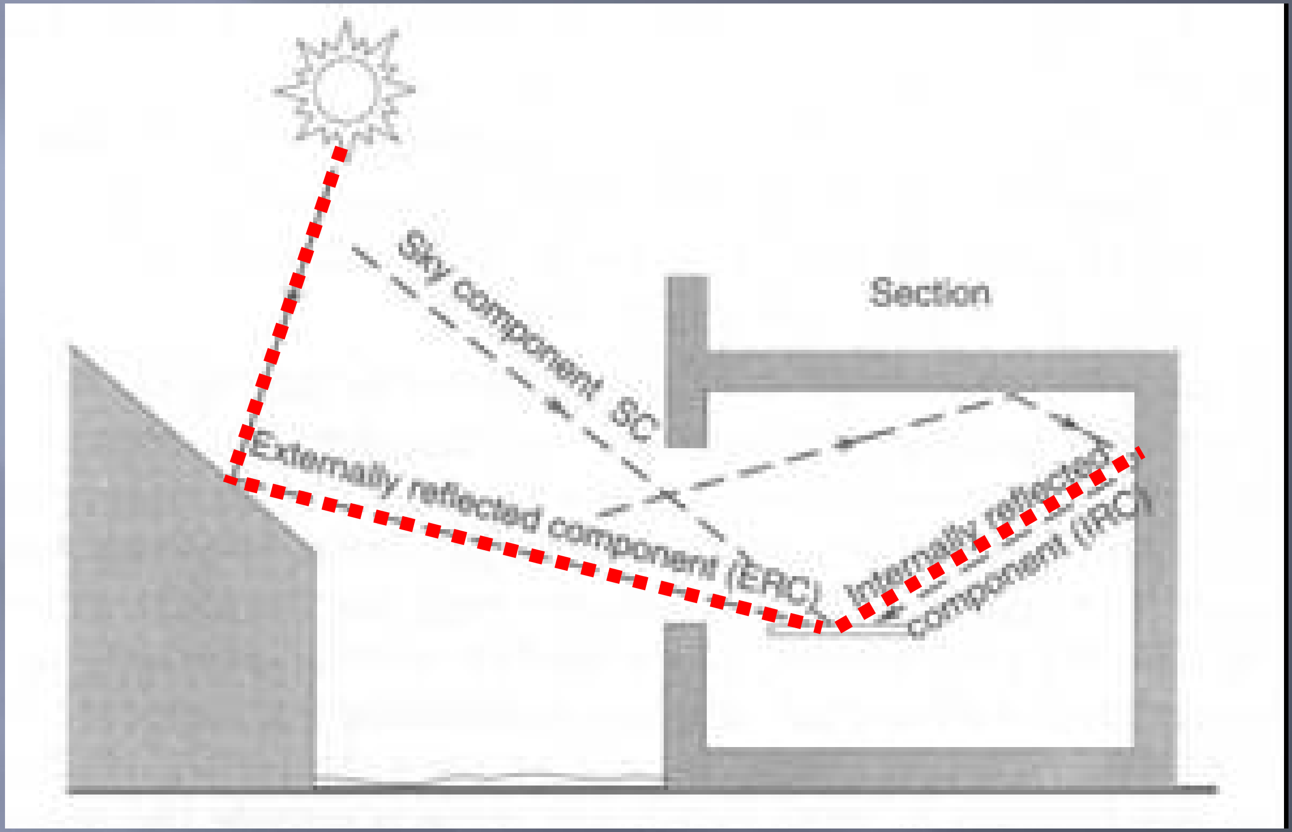


Direct sunlight is the most powerful source.

A summer sun can provide as much as 1000 W/m² of radiation measured in a plane normal to the sun's direction.

Daylight or natural light which is visible radiation can reach is in three different ways:

- Direct sunlight,
- Skylight which is sunlight that has been scattered in the atmosphere,
- Sunlight or skylight that has been reflected off the ground.



- The reflection of the outside ground is usually in the order of 0.2 or 20%. This means, that in addition to the sunlight and skylight, there is also an indirect component which can make quite a significant contribution to the light inside a building, especially since the light reflected off the ground will hit the ceiling which is usually very bright.

- *The advantage with analysis methods that produce relative illuminance values is that the results are independent of naturally occurring fluctuations of the available daylight.*

- *As a result, different design scenarios can be easily compared to one another, even for different sites.*

- *A typical example is the daylight factor approach.*

- *The drawback is, however, that no statement about the absolute illuminance can be made unless the sky conditions are well-defined, in which case absolute illumination method applies.*

- *The daylight factor (DF) is a very common and easy to use measure for the subjective daylight quality in a room.*
- *It describes the ratio of outside illuminance over inside illuminance, expressed in per cent. The higher the DF, the more natural light is available in the room.*
- *DF = 100 * Ein / Eext*
  - E_{in} - *inside illuminance at a fixed point*
  - E_{ext} - *outside horizontal illuminance under an overcast (CIE sky) or uniform sky.*

- **The E_{in} illuminance can be considered as the sum of three different illuminances:**
  - *the direct iluminance if the sky is visible from the considered point (ED)*
  - *the illuminance due to the reflections on the outside environment (EER)*
  - *the illuminance due to the reflections on the inside surfaces (EIR)*
- *Hence, the daylight factor depends on the sum of three components:*

DF = DC + ERC + IRC

  - *DC - direct component /SC (sky component)*
  - *ERC - externally reflected component*
  - *IRC - internally reflected component*

DC - direct component /SC (sky component) depends on

Area of the sky visible from the point under consideration

(area of the window,quality of glass,external obstruction I.e.trees etc.)

ERC - externally reflected component

Area of the external surface visible from the point under consideration as well as the reflectance of these surfaces.

IRC - internally reflected component

Area of the room,the ratio of the walls to the window area and the reflection of the wall surfaces

STANDARDISED SKY MODELS

- *As clouds form and move through the sky, the distribution of light can change almost minute by minute. This means that we cannot really design for any specific distribution, but must rely on 'average' conditions.*

- *The Commission International de 'Eclairage (CIE) has developed a series of mathematical models of ideal luminous distributions under different sky conditions - of which the three most common are clear, uniform and overcast*

- *As a worst-case, the* **overcast** *sky condition is usually used. However in some tropical regions the* **uniform** *sky is considered*

The Sky component (SC) and the externally reflected component (ERC) are found by using the daylight protractors

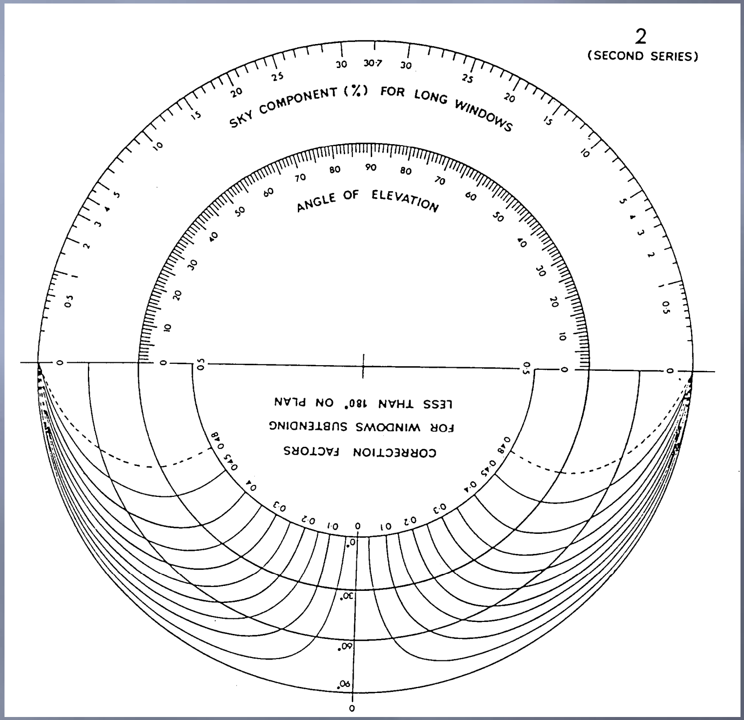
- *There are 2 series of protractors*
  - *For the sky of uniform luminance*
  - *CIE sky luminance distribution*

- *Series 1 protractor to be used to predict SC under clear sky,tropical conditions.*
- *Series 2 protractors should be used In overcast sky conditions.*

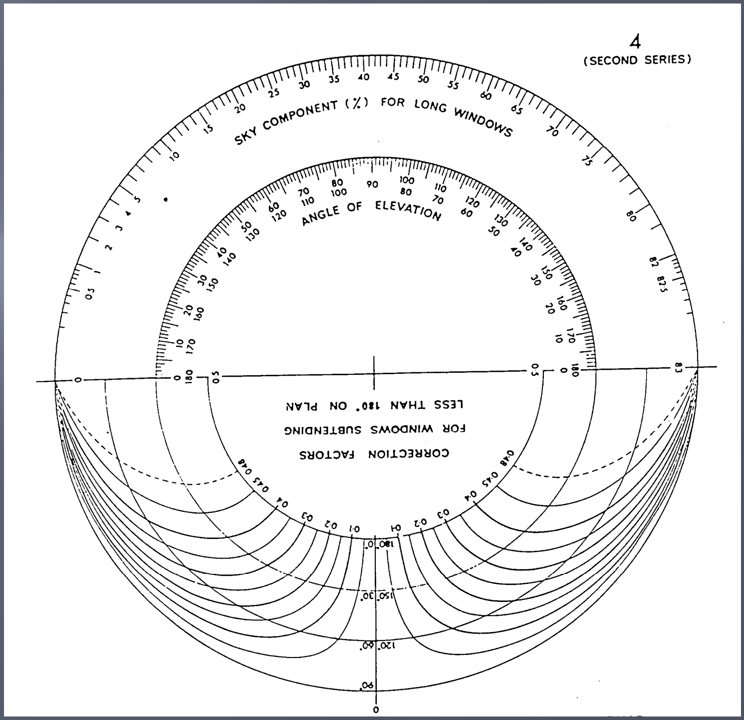
- *Uniform sky protractors are available for the following window configurations:*
  - *Vertical glazing*
  - *Horizontal glazing*
  - *Glazing sloped 30° to horizontal*
  - *Glazing sloped 60° to horizontal*
  - *Unglazed vertical openings*

BRE protractors

The Building Research Establishment BRE (formerly the Building Research Station BRS) developed a set of protractors which give direct reading of the sky component in percentages. There are ten nos. of such protractors, of which five are for the uniform sky and five for the CIE sky:



BRS Sky Component Protractor for Vertical Glazing



BRS Sky Component Protractor for Horizontal Glazing

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Case Example for using BRE Protractor and Nomogram for checking the illumination level for a given task point

- *Take a room which is to be used as bedroom, measuring 4m x 4m ,height 3m .*
- *Place a window of 1.2m x 1.2m in the center of any external wall.*
- *Sill level 0.9 m.*
- *Consider the walls painted with white distemper and vetrified ceramic tile flooring.*
- *Calculate the D.F. and check if this window provides the required illumination level at a working plane in the room at a distance of 2m from the window and 1 m from one of the longer sides, as prescribed in NBC.*

FINAL SKY COMPONENT

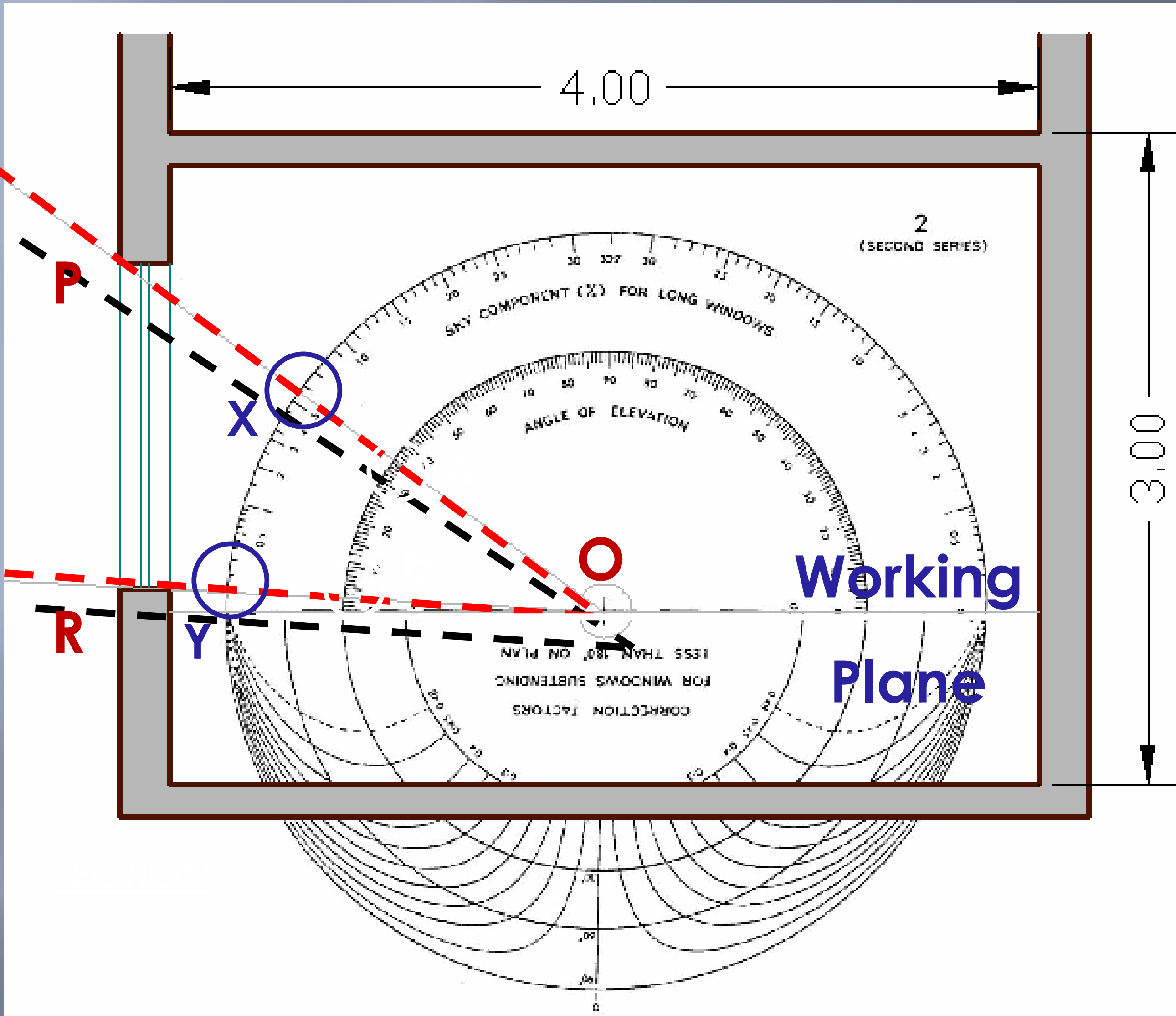
= (INITIAL SKY COMPONENT x CORRECTION FACTOR)

•TO FIND OUT THE INITIAL SKY COMPONENT…………….

A SECTION THROUGH THE WINDOW AND 'A' SIDE OF THE APPROPRIATE BRE PROTRACTOR NEEDS TO BE USED.

•TO FIND OUT THE CORRECTION FACTOR…………………

•A PLAN AND 'B' SIDE OF THE APPROPRIATE BRE PROTRACTOR NEEDS TO BE USED



The steps to be taken in establishing the sky component are :

1. Take a section of the room, draw the working plane and on it the point to be considered (O).
2. Connect the limits of aperture (or edges of obstruction) to point O, i.e., lines PO and RO.
3. Place the protractor with scale A uppermost, base line on the working plane with the centre on point O.
4. Read the values where lines PO and RO intersect the perimeter scale: the difference of the two values is the initial SC.
5. Read the altitude angles where lines OP and RO intersect the 'angle of elevation' scale and take the average of the two readings.

i) INITIAL SC = READING X – READING Y

INITIAL SC = (5.6 – 0.1) = 5.5

ii) AVERAGE OF ANGLE ‘a’ AND ‘b’

= (36 + 3)/2 = 19.5 degrees

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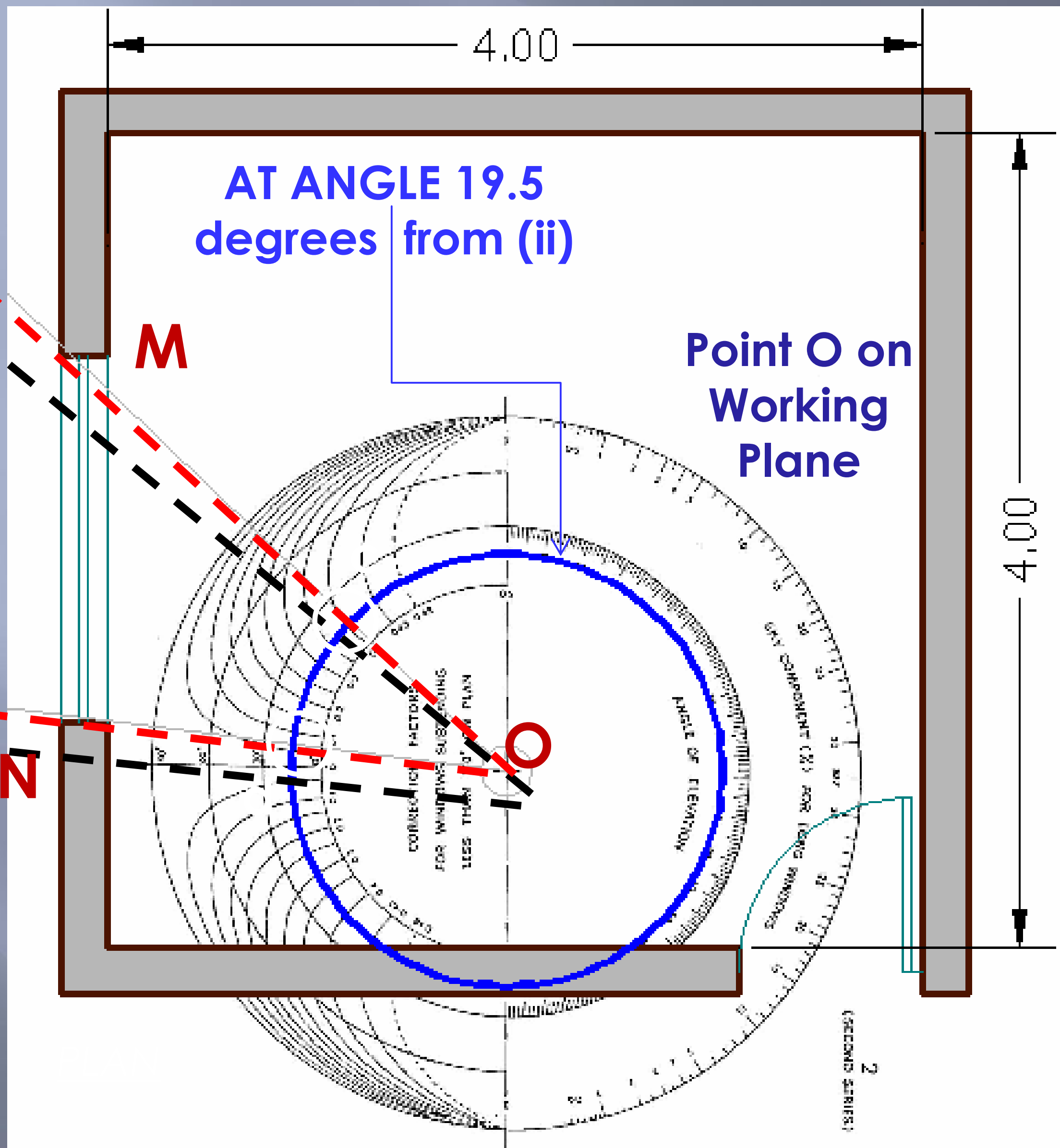

1. Take the room plan and mark position of the point to be considered (O).
2. Connect the limits of aperture with point O, i.e., lines MO and NO.
3. Place the protractor with scale B towards the window, base line parallel to the window with the centre on point O.
4. Four concentric semicircles are marked on the protractor 0 deg, 30 deg, 60 deg and 90 deg. Select the one according to the corresponding elevation angle obtained in step 5, if necessary interpolating an imaginary semi-circle. Unless the reference point is very close to the window, this will normally be well below 30 deg and will not have much effect.
5. Where Lines MO and NO intersect this semicircle read the values along the short curves on the scale of the inner semicircle.
6. If the two intersection points are on either side of the centre line, add the two values obtained: if they are on the same side, take the difference of the two values. This will be a correction factor.

iii) CORRECTION FACTOR

= (c - d)

= (0.41 – 0.07) = 0.34

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Multiply the initial SC (step i) by the correction factor (step iii) to obtain the sky component.

iv) THEREFORE FINAL SKY COMPONENT

= (5.5 X 0.34)

= <u>1.87</u>

ERC

- *If there are no obstructions outside the window, there will be no ERC.*
- *If, however, there are objects higher than the line RO, the light reflected from these objects will reach the point considered, and will contribute to the lighting at that point. This may make an important contribution to the day lighting, particularly in crowded urban situations.*
- *The magnitude of this contribution is expressed by the ERC, which can be found as follows:*

  - *Find the equivalent SC, which would be obtained from the same area of sky were it not obstructed, following the steps described above.*

  - *Multiply this value*
  - *If series 1 (uniform sky)by 0.5 times the average reflectance of obstructing surfaces, or if this is unknown, by a factor of 0.1.*
  - *If series 2 (CIE sky) by average reflectance of opposing surface or a value of 0.2*

As we have used BRE Protractor series 2 we can multiply the Final sky component (step iv) by 0.2 as prescribed in order to obtain the EXTERNALLY REFLECTED COMPONENT (ERC)

v) THEREFORE ERC = (1.87 X 0.2)

= 0.374

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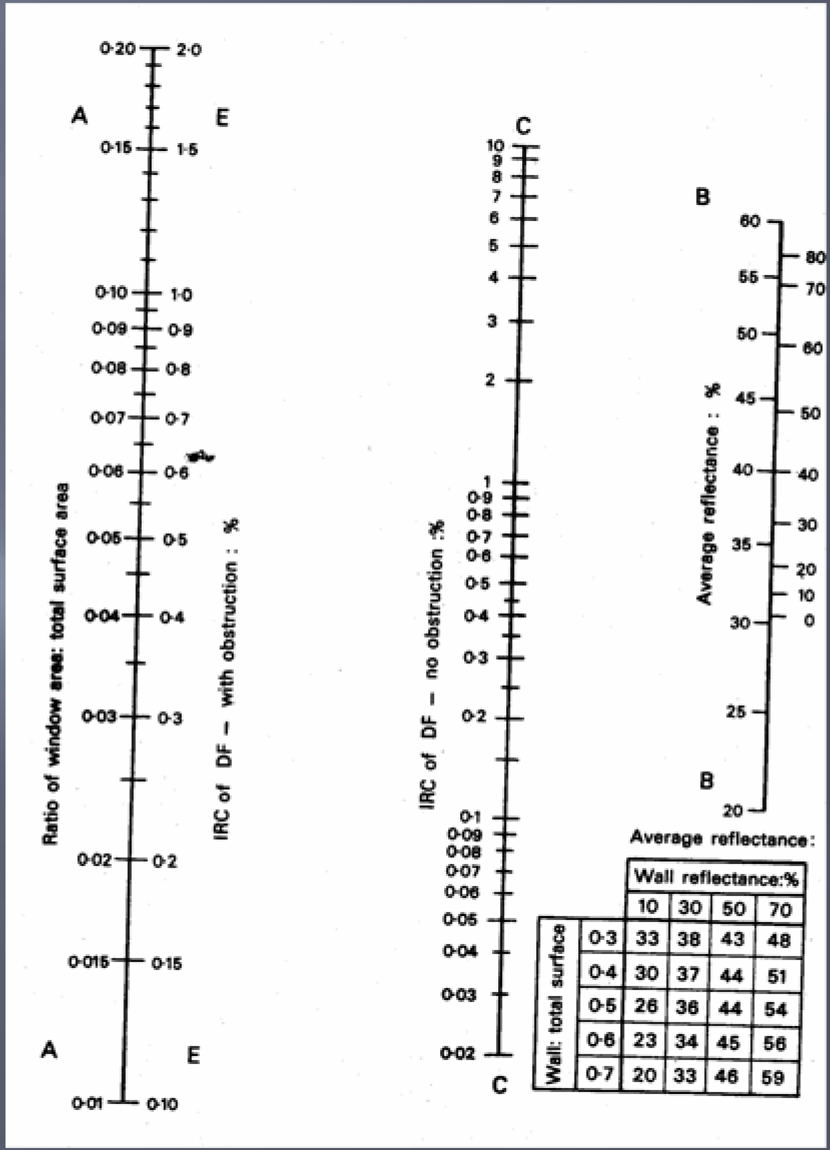
IRC-Internally Reflected Component

- *Much of the light entering through the window will reach the point considered only after reflection from the walls, ceiling and other surfaces inside the room.*

- *The magnitude of this contribution to the day lighting of the point considered is expressed by the IRC. This will normally be fairly uniform throughout the room, thus for most problems it is sufficient to find the average IRC value. The simplest method uses the <u>nomogram.</u>*



		Wall reflectance:%			
		10	30	50	70
Wall: total surface	0·3	33	38	43	48
	0·4	30	37	44	51
	0·5	26	36	44	54
	0·6	23	34	45	56
	0·7	20	33	46	59

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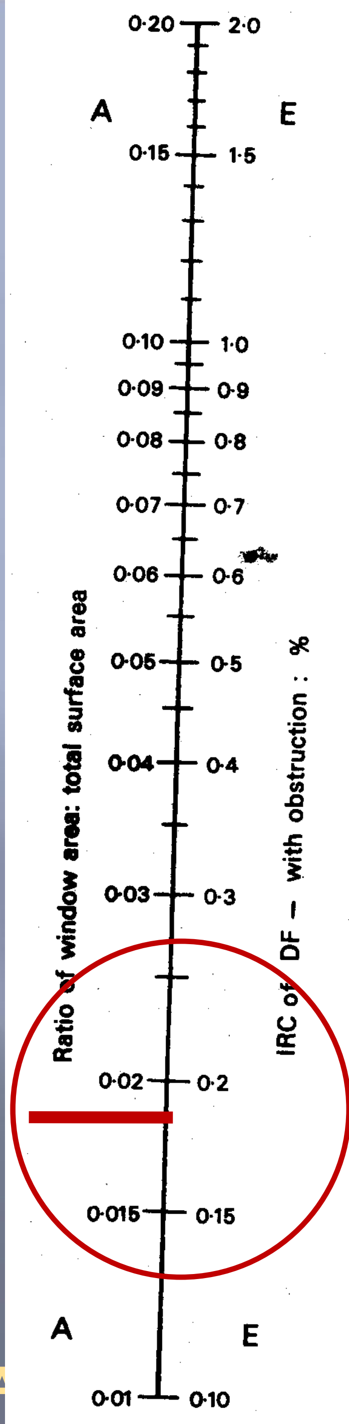
- **LRV -Light Reflectance Value** *is a measure of how much light is reflected from a coloured material. It is given as a percentage where white has a value of 100% and black has a value of 0%.*



1. *Find the window area and find the total room surface area (floor,ceiling and walls, including windows) and calculate the ratio of window to total surface area. Locate this value on scale A of the nomogram.*

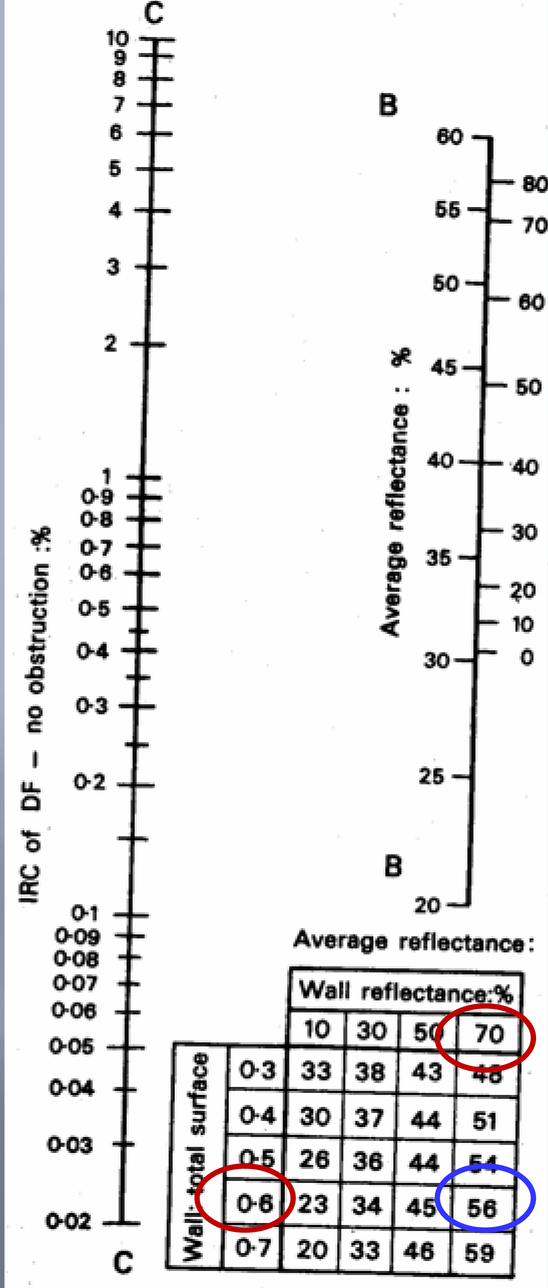
i) WINDOW AREA = (1.20 X 1.20)

= 1.44

ii) TOTAL ROOM SURFACE AREA = 80 sq.m.

iii) RATIO 1.44/ 80 = 0.018

Scale 'A' and 'E' of Nomogram



Wall: total surface	10	30	50	70
0·3	33	38	43	48
0·4	30	37	44	51
0·5	26	36	44	54
0·6	23	34	45	56
0·7	20	33	46	59

2) *Find the area of all the walls and calculate the ratio of wall to total surface area. Locate this value in the first column of the small table (alongside the nomogram).*

3) *Locate the wall reflectance value across the top of this table and read the average reflectance at the intersection of column and line (interpolating, if necessary, both vertically and horizontally). Or calculate an area-weighted mean reflectance (assume glass reflectance is 20%).*

iv) WALL AREA = 48 SQ.M.

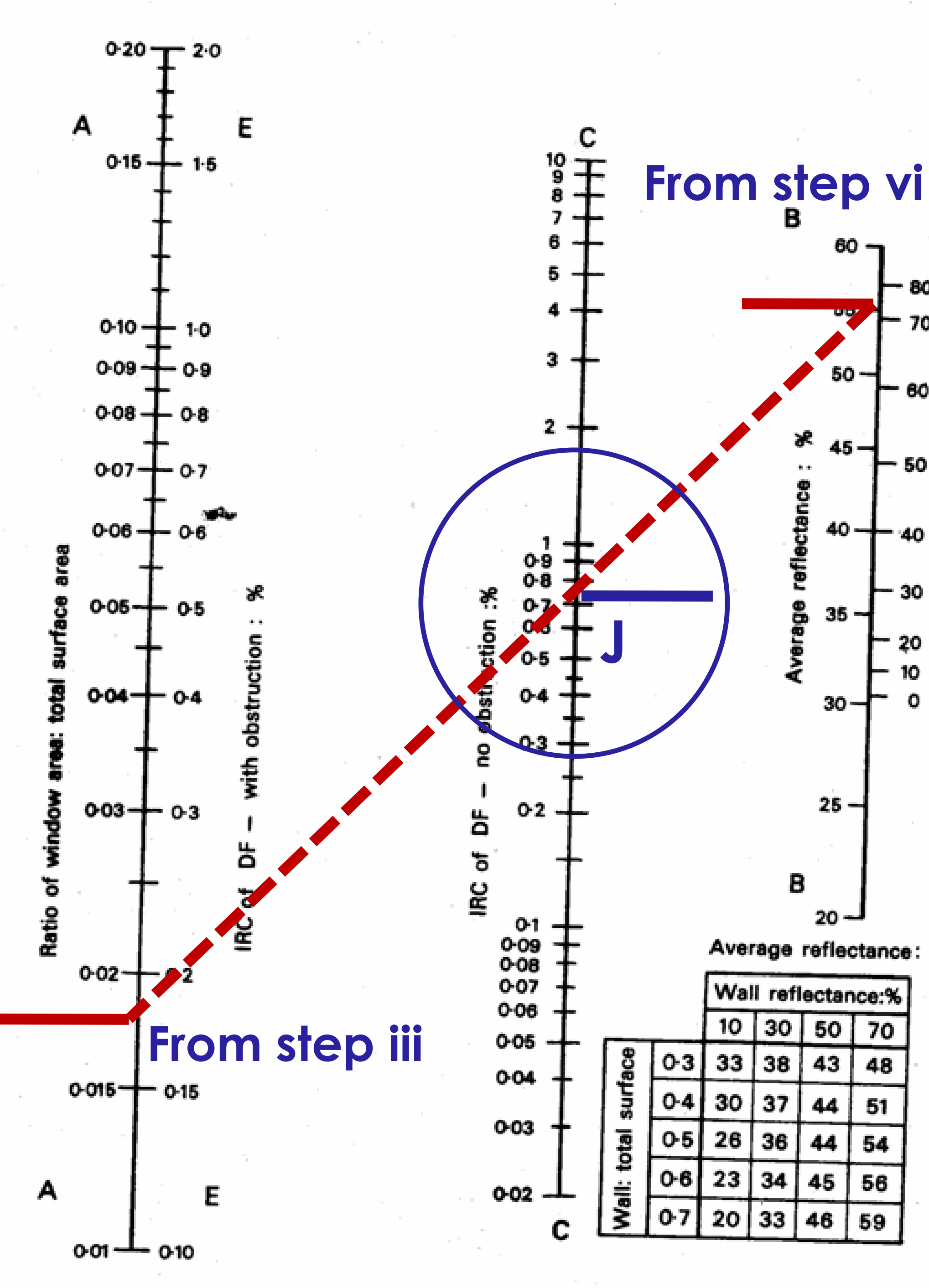
v) RATIO OF WALL AREA TO TOTAL SURFACE

AREA = 48/80 = 0.6

vi) THEREFORE AVERAGE REFLECTANCE =

56%

Scale 'B' and 'C' and Table for reflectance calculation



		Wall reflectance:%			
		10	30	50	70
Wall: total surface	0·3	33	38	43	48
	0·4	30	37	44	51
	0·5	26	36	44	54
	0·6	23	34	45	56
	0·7	20	33	46	59

4. *Locate the average reflectance value on scale B and lay a straight- edge from this point across to scale A (to value obtained in step iii).*

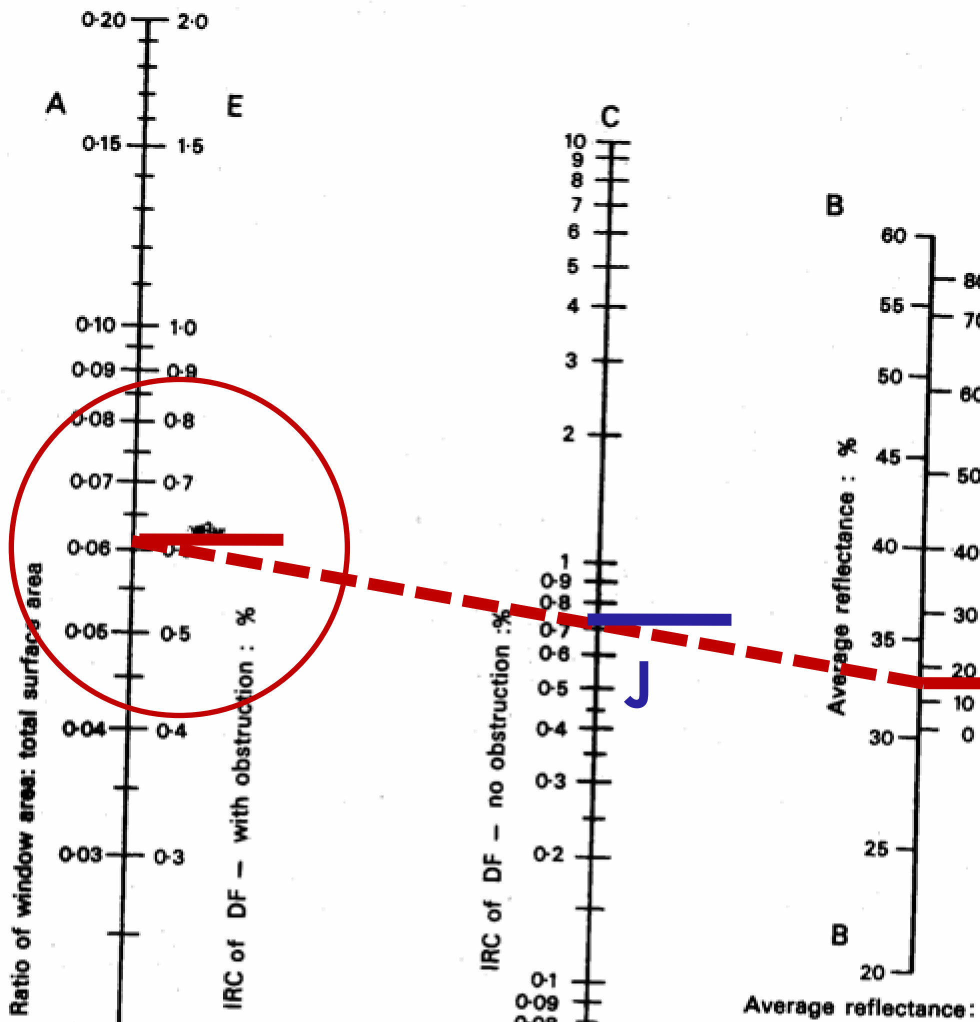
5. *Where this intersects scale C, read the value which gives the average IRC if there is no external obstruction.*

vii) THEREFORE

AVERAGE IRC

VALUE = 0.75

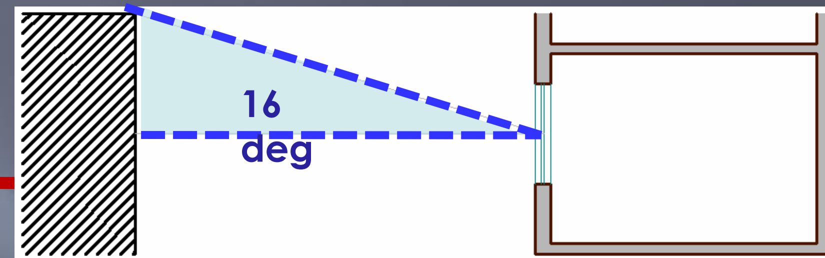
Case without external obstruction



Wall: total surface	Wall reflectance:%			
	10	30	50	70
0·3	33	38	43	48
0·4	30	37	44	51
0·5	26	36	44	54
0·6	23	34	45	56
0·7	20	33	46	59

6. *If there is an external obstruction, locate its angle from the horizontal, measured at the centre of window, on scale D.*

7. *Lay the straight-edge from this point on scale D through the point on scale C and read the average IRC value on scale E.*



viii) THEREFORE AVERAGE IRC VALUE = 0.60

Case with external obstruction

DF = SC + ERC + IRC

= (1.87 + 0.374 +0.60)

= 2.844

Average External Ilumination in Indian context is taken to be 8000 lux

Therefore, the Internal illumination at the point on working plane,

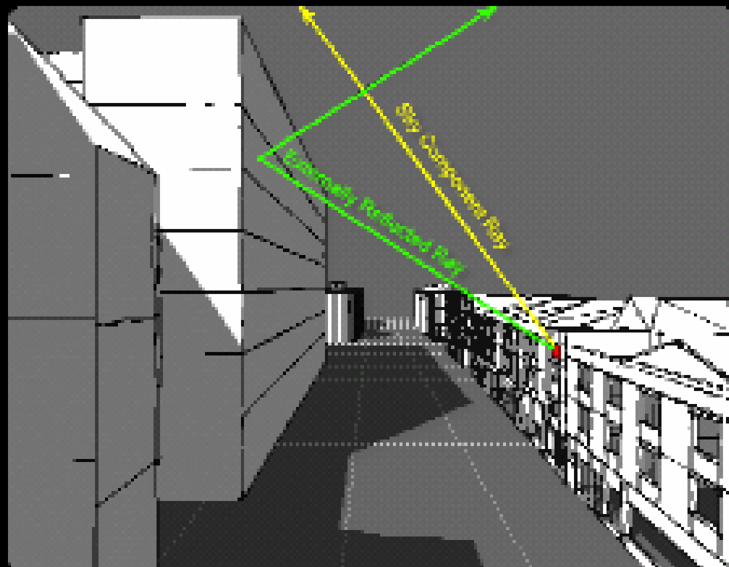
$$DF = \frac{\text{Internal illumination}}{\text{External illumination}} \times 100$$

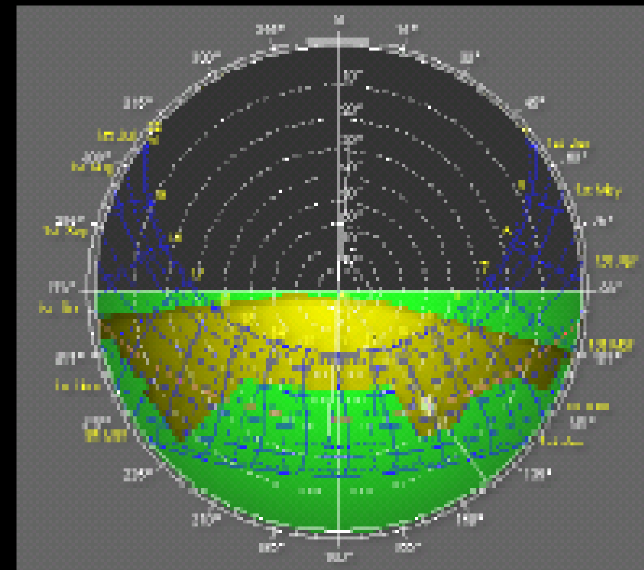
$$\text{Internal illumination} = \frac{2.844 \times 8000}{100} = 227.52 \text{ LUX}$$

AS PER NBC, LUX LEVEL REQUIREMENT FOR BEDROOM IS 200 LUX.

HENCE SUFFECIENT ILLUMINATION

Split Flux Method in Ecotect





Square One web site

An Externally Reflected Component (ERC) is modified by:

- luminance of the sky it would have hit
- reflectance of the material assigned to the external object
- relative surface angle and glazing transmittances

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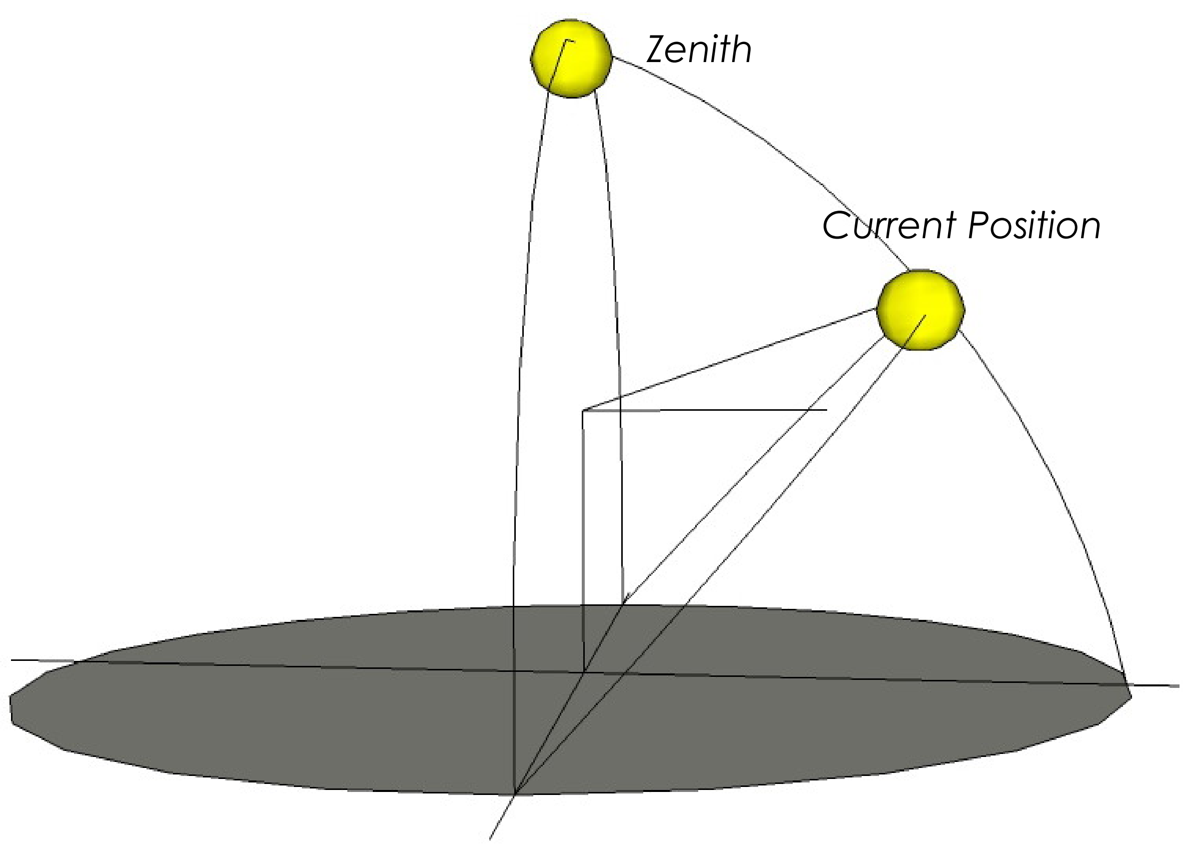
Background Study
Study of the Sun

<u>The Solar Altitude Angle (γ)</u> :

It is the vertical angle at the point of observation between the horizontal plane and the line connecting the sun with the observer. The solar altitude angles are represented by concentric circles on the solar chart, the exterior angle being 0˚ and the angles increasing towards the interior ending with 90˚ in the center.

<u>The Solar Azimuth Angle (α)</u> :

It is the angle at the point of observation measured on a horizontal plane between the northerly direction and the point on the horizon circle where it is intersected by an arc of the vertical circle, going through the zenith and the sun's position. These are represented by angle markings on the outer circle of the solar chart.



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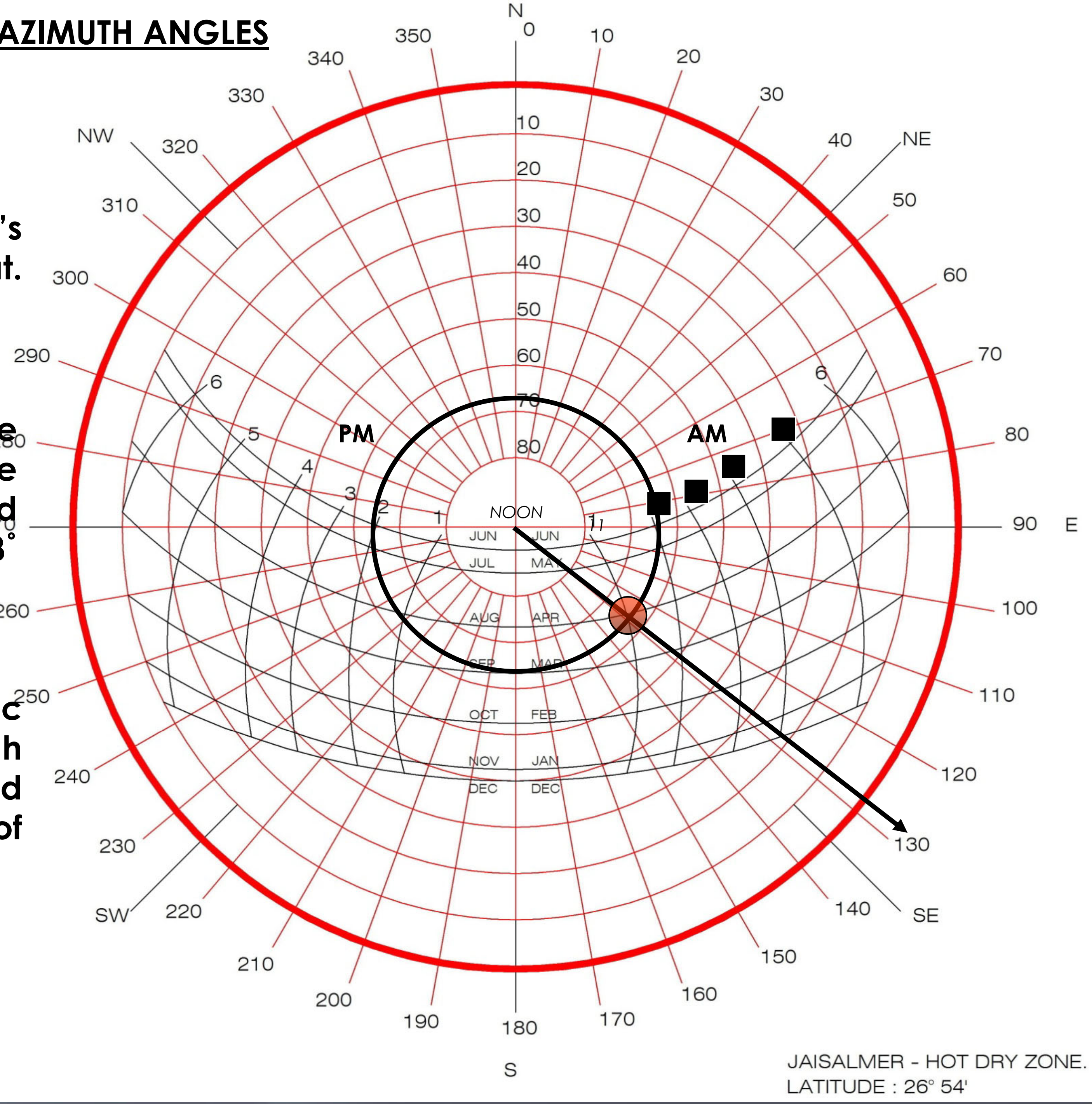
FINDING ALTITUDE AND AZIMUTH ANGLES

To detemine the sun's position at 26˚54'N lat. at 11 am on April 21,

Follow the radial line that runs through the intersection and read the azimuth of 128˚ East of South.

Follow the concentric ring that runs through the itersection and read the altitude of 73˚.



SHADOW ANGLES

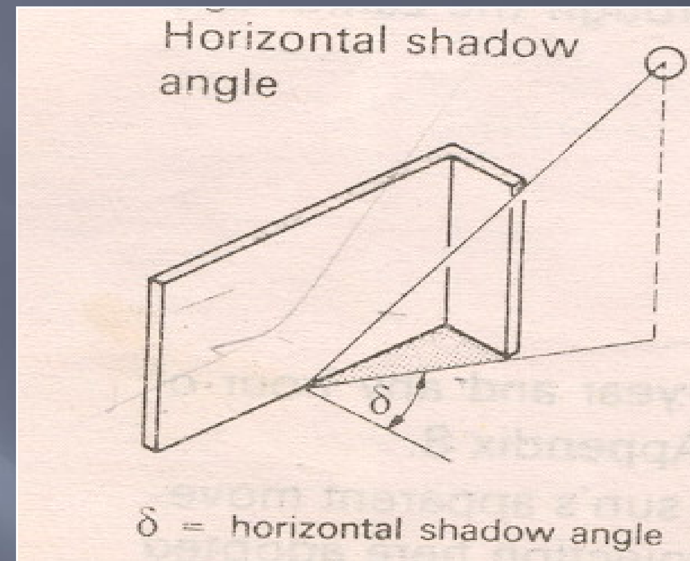
Horizontal and vertical shadow angles describe the length of shadows on any wall surface.

The Horizontal Shadow Angle (δ) :

This angle can be found out by the difference between the solar azimuth angle (α) and the wall azimuth (direction of the wall measured in angles from a northerly direction).

$$\boxed{\delta = \alpha - W\alpha}$$

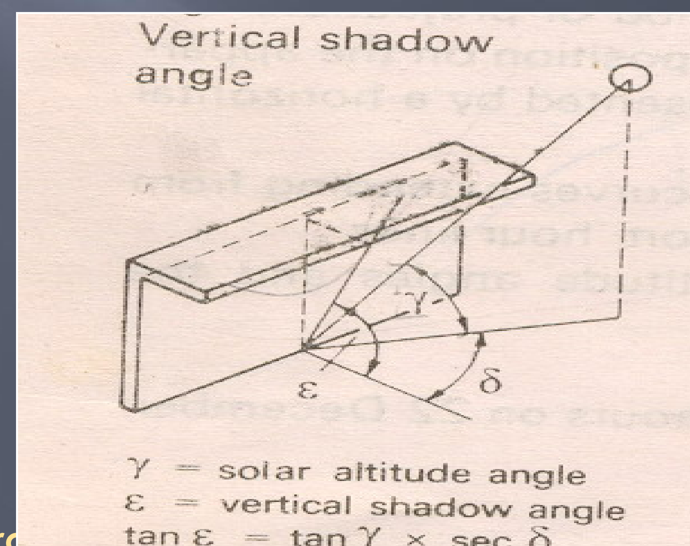
This angle is used for designing vertical shading devices.

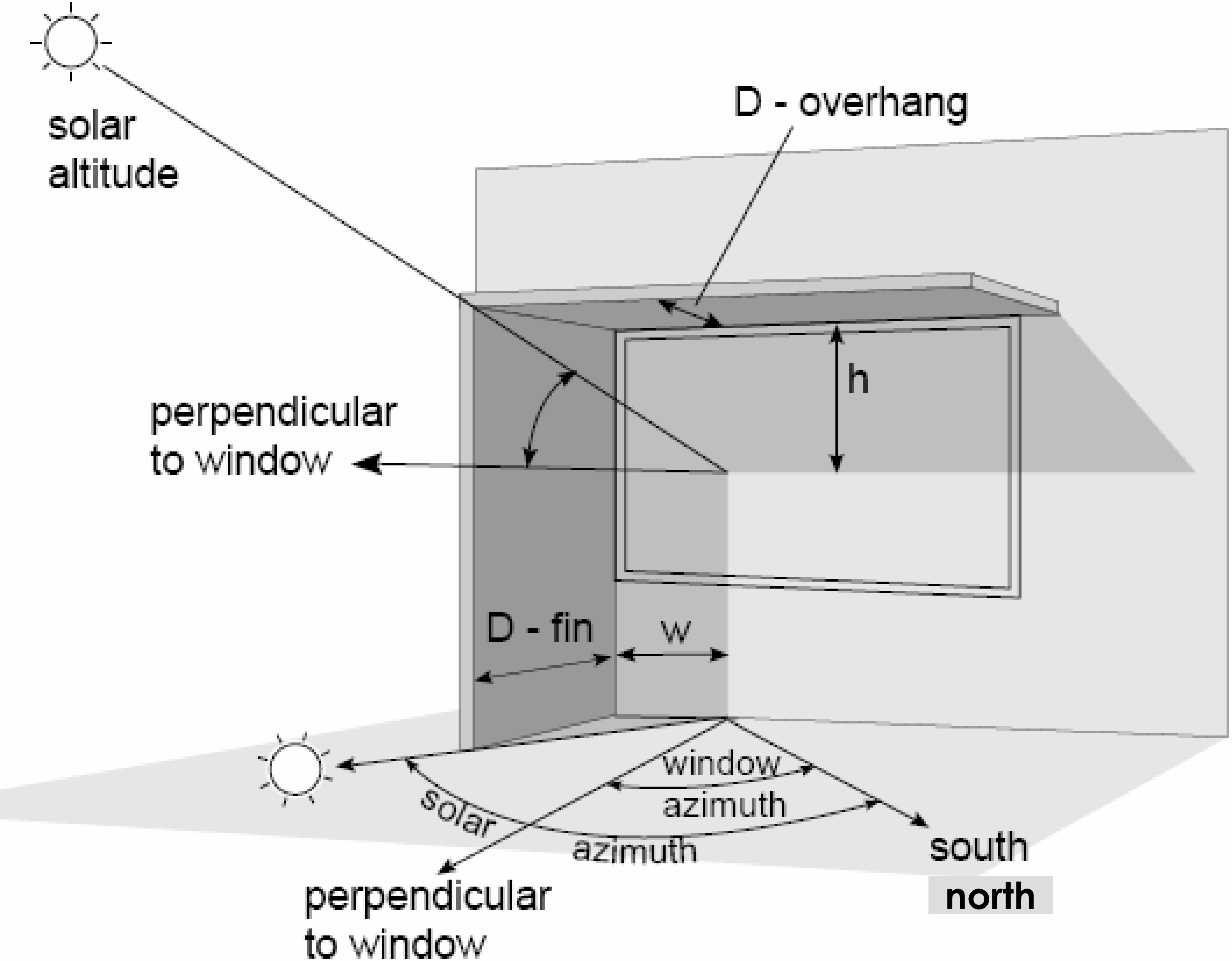


The Vertical Shadow Angle (∈) : This is found out by the following equation :

$$\boxed{\tan \in = \tan \gamma \times \sec \delta}$$

This angle is used for the designing of the horizontal shading devices and is measured on a vertical plane.




solar
altitude
D - overhang
h
perpendicular
to window
D - fin
w
window
azimuth
solar
azimuth
south
north
perpendicular
to window

Feasibilty Study

Step 1: Calculate the predicted window-to-wall ratio (WWR) for a typical bay or office.

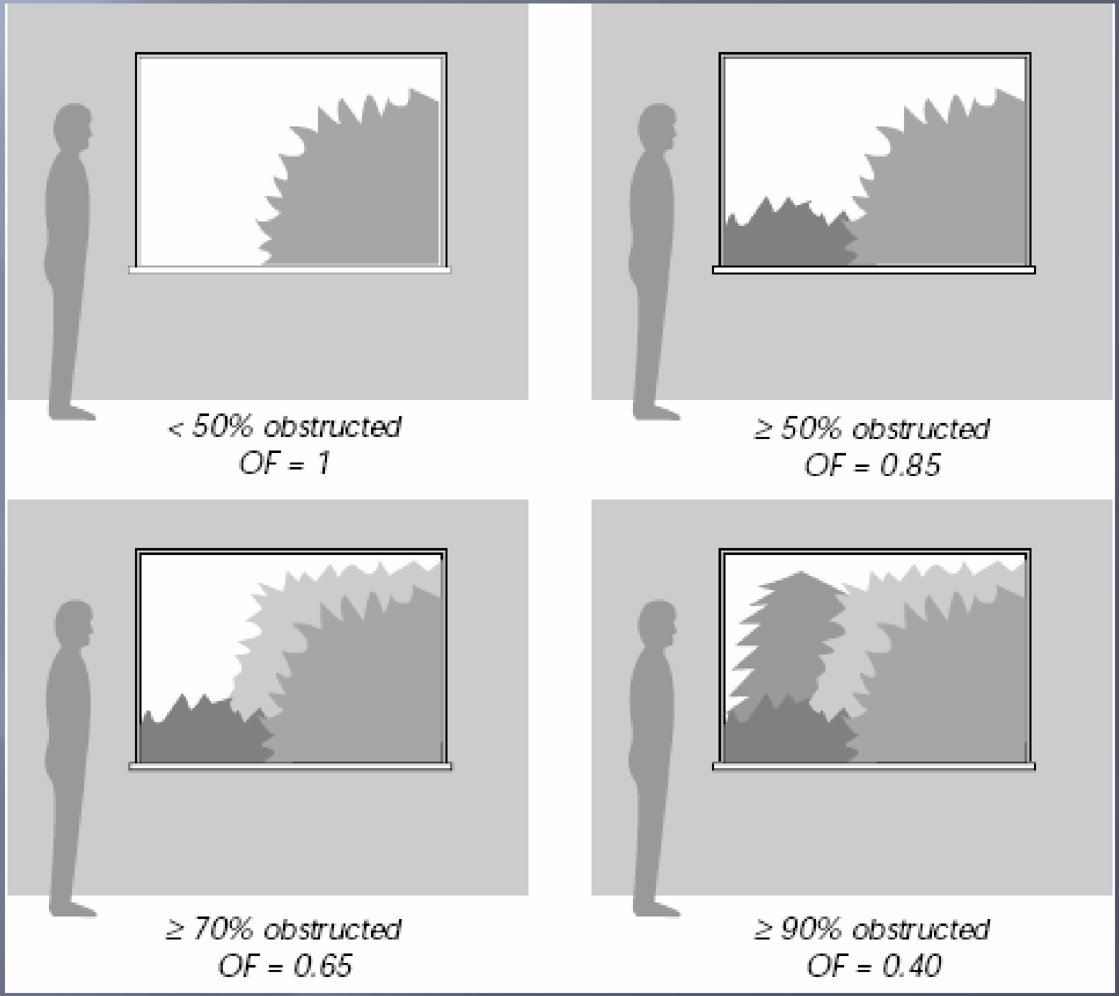
- *If unknown, use 0.35 for a typical, moderately strip-glazed building. If larger windows are anticipated, use*
- *0.50. For smaller punched windows, use 0.25.*

Step 2: Make a preliminary glazing selection and note the visible transmittance (VT).

Generic Glazing type (1/4" panes)	Typical VT
Single pane clear	0.89
Single pane tint - green or blue-green	0.70
Single pane tint - blue	0.57
Single pane tint - bronze	0.53
Single pane tint - gray	0.42
Single pane tint - extra dark	0.14
Single pane light reflective	0.35
Single pane medium reflective	0.25
Single pane high reflective	0.12
Double pane clear *	0.80
Double pane tint - green or blue-green	0.65
Double pane tint - blue	0.51

Generic Glazing type (1/4" panes)	Typical VT
Double pane tint - bronze	0.47
Double pane tint - gray	0.39
Double pane light reflective	0.30
Double pane medium reflective	0.20
Double pane high reflective	0.10
Double pane low-E clear	0.70
Double pane low-E tint - green or blue-green	0.63
Double pane low-E tint - blue	0.49
Double pane low-E tint - bronze	0.45
Double pane low-E tint - gray	0.37
Suspended low-E film products	0.27-0.60

Step 3: Estimate the obstruction factor (OF).



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Step 4: Calculate the feasibility factor.

- *Window-to-wall ratio multiplied by visible transmittance multiplied by obstruction factor equals feasibility factor.*

________ x ________ x ________ = ____________________

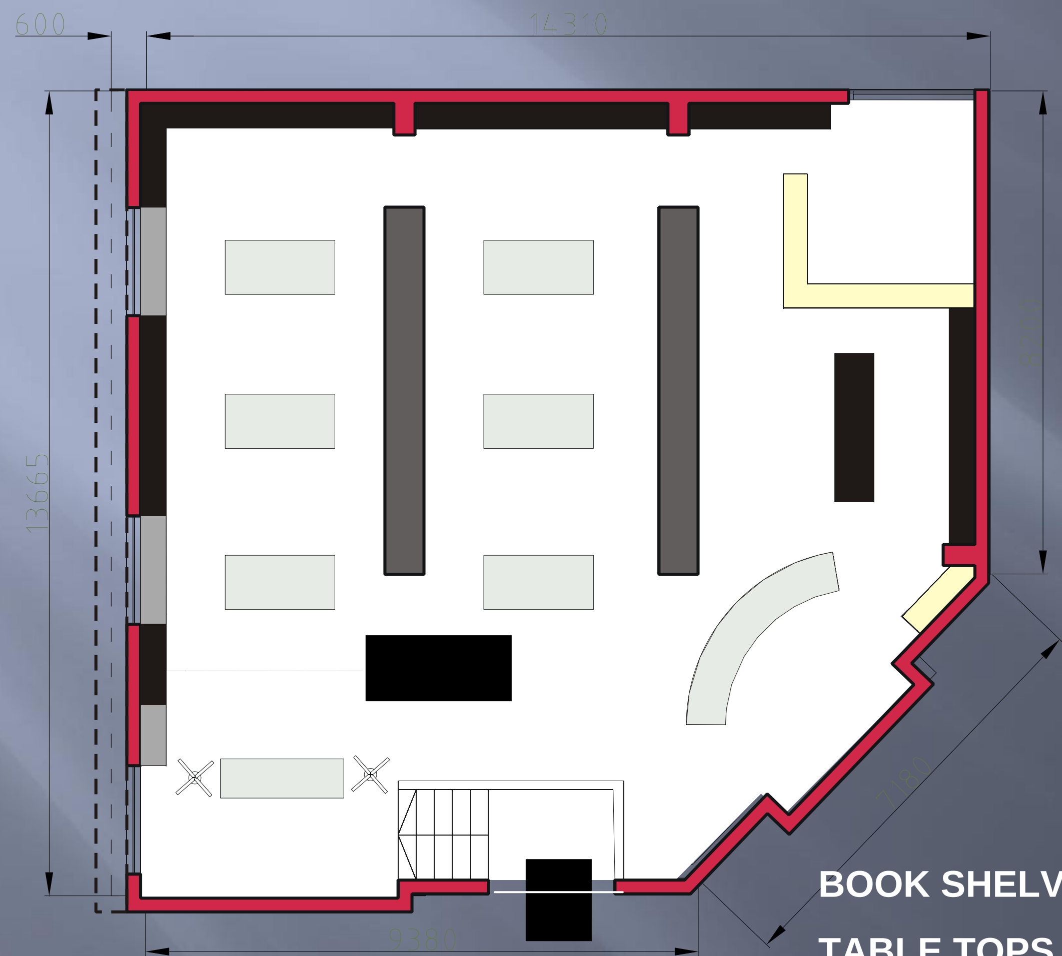
WWR *VT* *OF* *Feasibility Factor*

- *If Feasibility Factor > 0.25, then day lighting has the potential for significant energy savings.*
- *If Feasibility Factor < 0.25, then consider removing obstructions, increasing window area, or increasing VT.*
- *If these modifications are not possible, it is unlikely that day lighting will be a cost-effective energy-saving strategy.*

5. STUDY AREA SPECIFICATIONS

3 WINDOWS ON THE EAST

3 VENTILATORS ON THE SOUTH



VOLUME	715 CU.MTS.
LIBRARY AREA	170 SQ.MTS.
WALL AREA	220 SQ.MTS.
WALL AREA OCCUPIED BY BOOK SHELVE	45 SQ.MTS.
OPENINGS –	
WINDOWS	9.75 SQ.MTS.
VENTILATORS	4.50 SQ.MTS.
DOOR	3.75 SQ.MTS.
TOTAL (W)	14.25 SQ.MTS. (8.38%)

FLOORING – LIGHT IVORY CERAMIC TILES (MATT)

WALL PAINT – OFF WHITE

CEILING PAINT – WHITE DISTEMPER

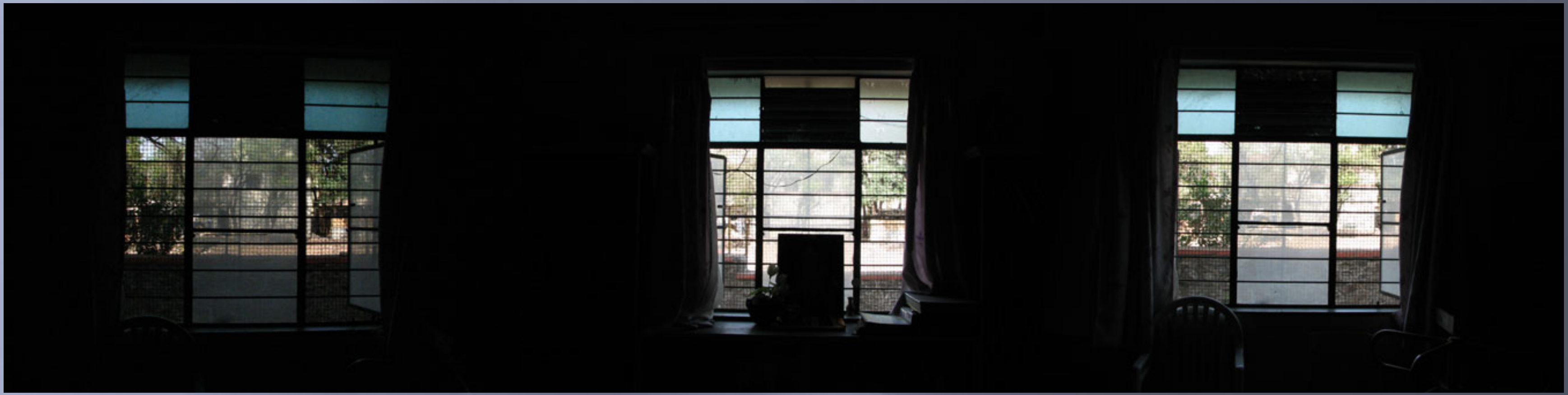
BOOK SHELVES – BLACK LAMINATE

TABLE TOPS – OFF-WHITE (MATT) LAMINATE

WINDOW CURTAINS – LIGHT PINK

CHAIRS – PLASTIC, WHITE COLOUR

SKY VIEW

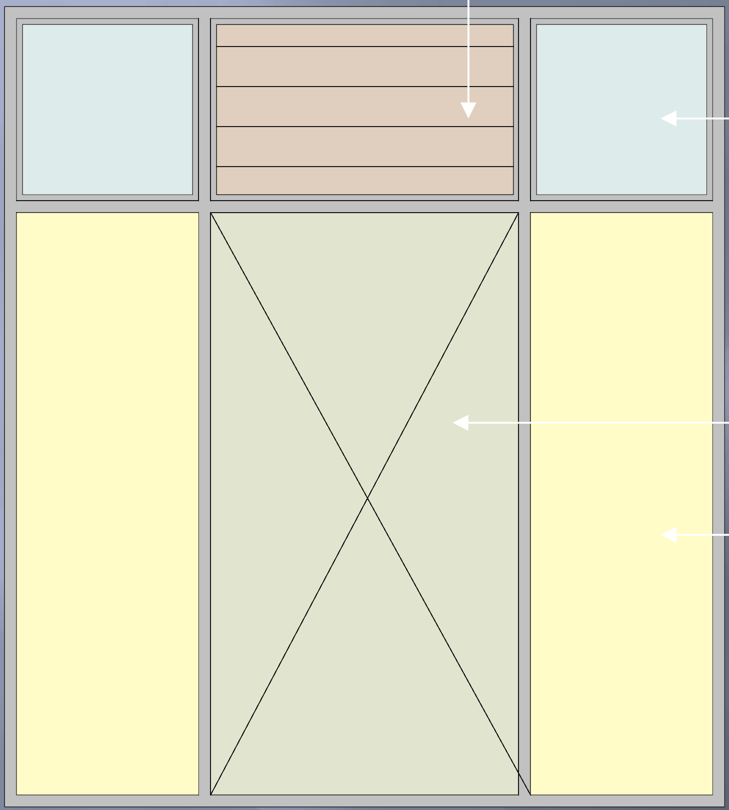


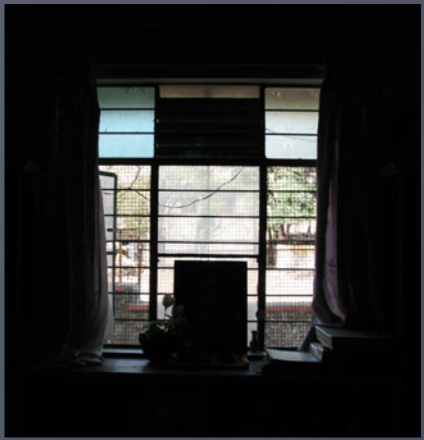
SKY VIEW – APPROX 10%

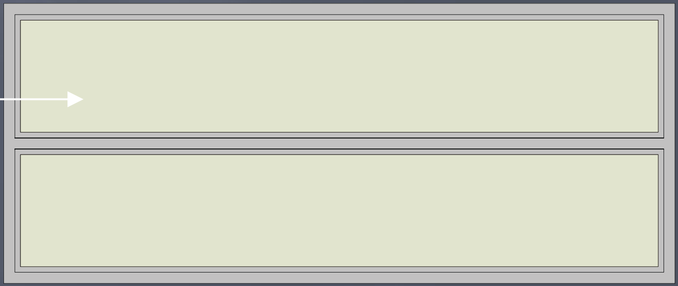
EXTERNALLY REFLECTED – APPROX 65%

FROSTED GLASS – 25%

EXISTING WINDOW DESIGN







EXISTING VENTILATOR

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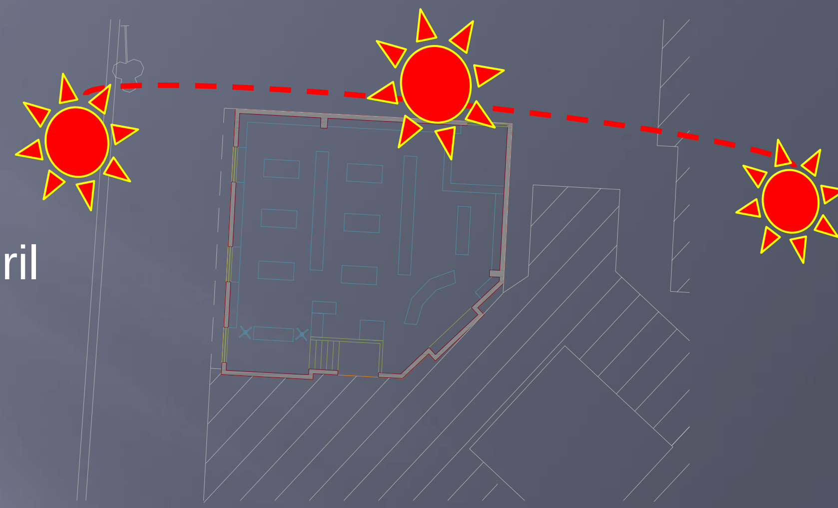
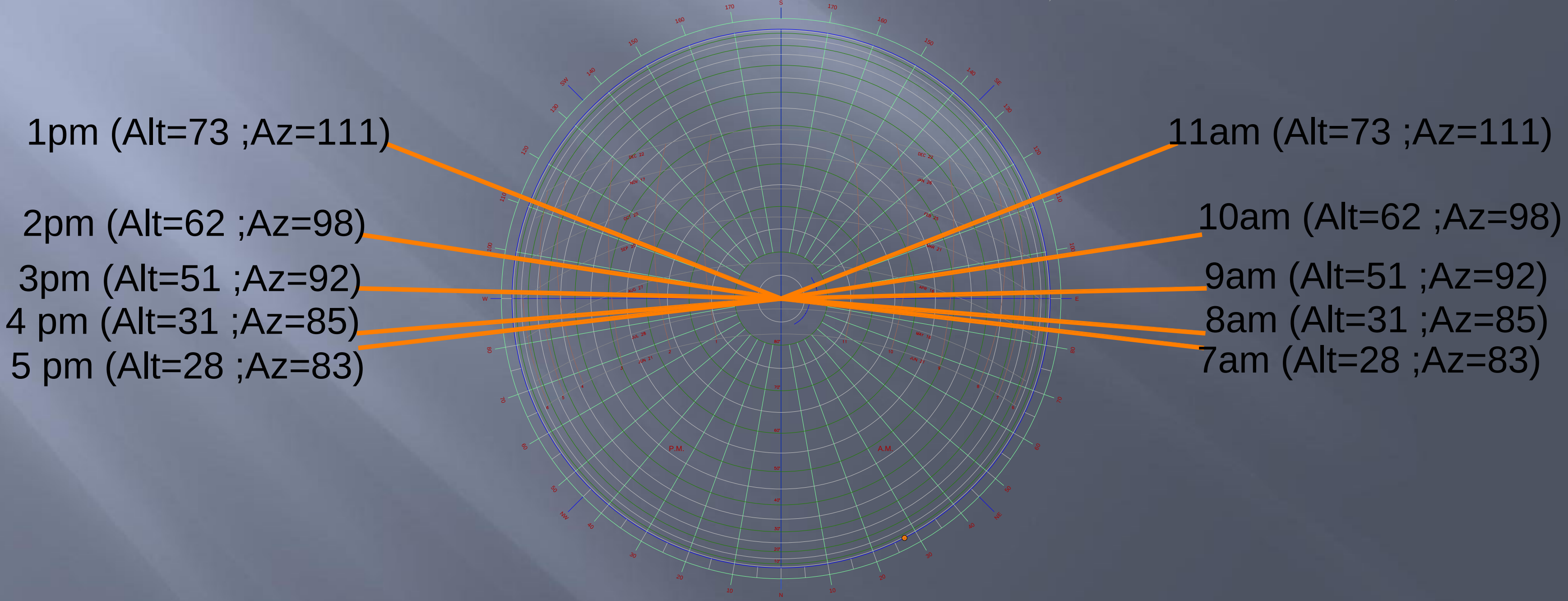
6. SUN PATH DIAGRAM



Pune latitude – 18deg

The exercise is conducted in the month of April

The sun- path in this month shows negligible inclination and is almost overhead



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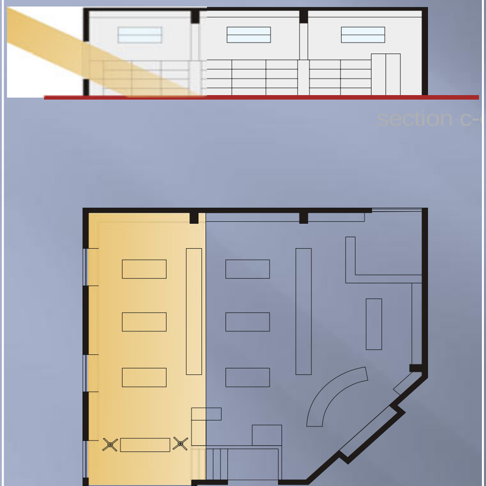
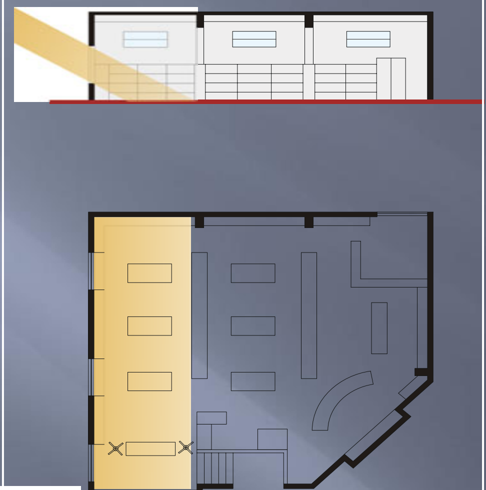
7. EXTENT OF DIRECT LIGHT PENETRATION

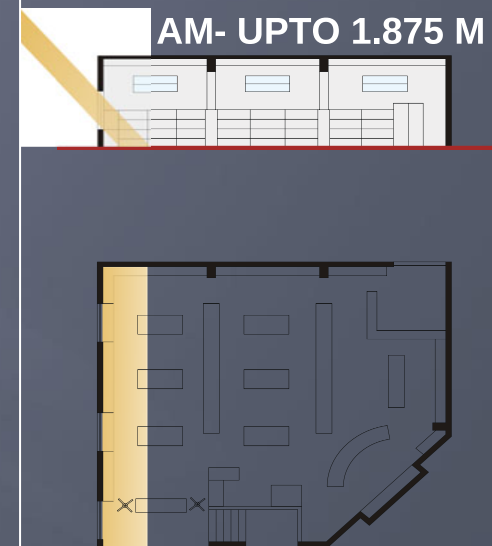
7:00 AM- UPTO 4.9 M



8:00 AM- UPTO 4.2 M



AM- UPTO 1.875 M



10:00 AM- UPTO 1.2 M

11:00 AM- UPTO 0.6 M

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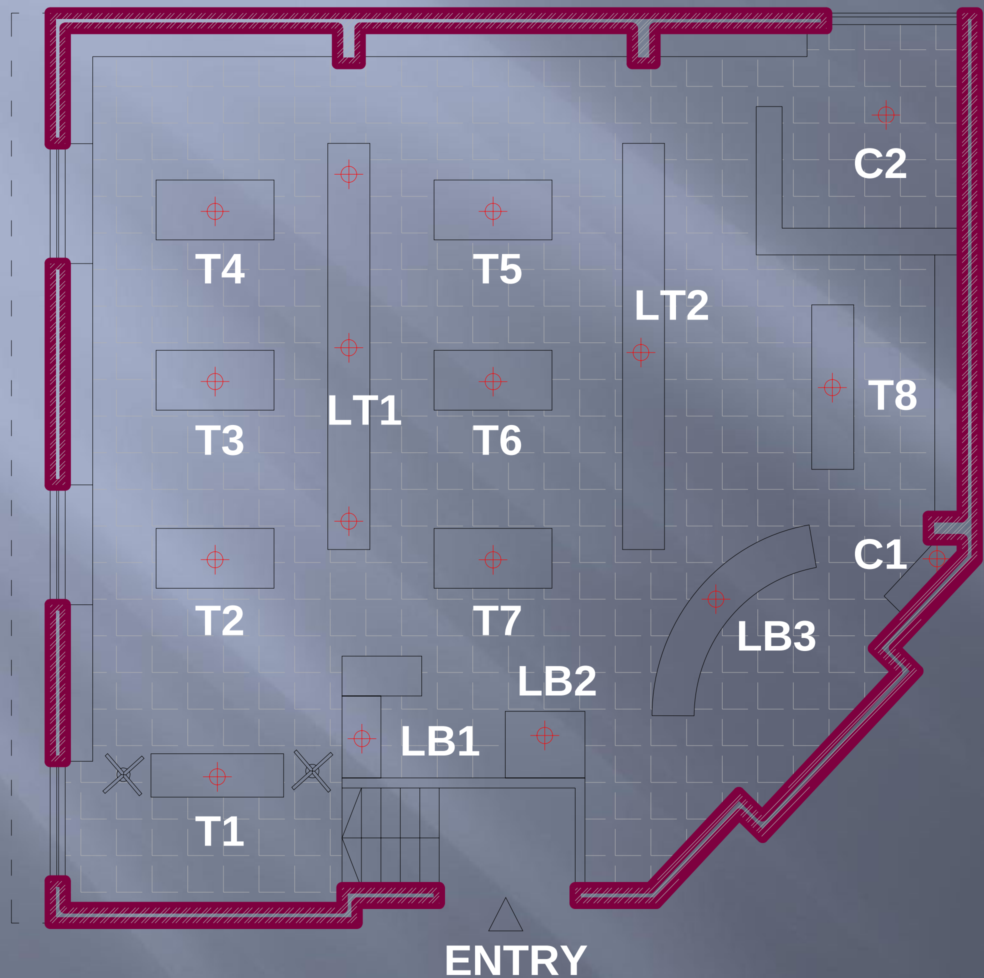
8. LOCATION OF TEST POINTS - HORIZONTAL



T1 TO T8 – READING TABLE TOPS AT HEIGHT OF 0.75 M FROM FFL

LT1 AND LT2 – LONG TABLE AT THE WORKING HEIGHT OF 0.75 M FROM FFL

LB1-LB3 – LIBRARIAN'S WORK STATION AT THE WORKING HEIGHT OF 0.75 M FROM FFL

FFL – FINISHED FLOOR LEVEL

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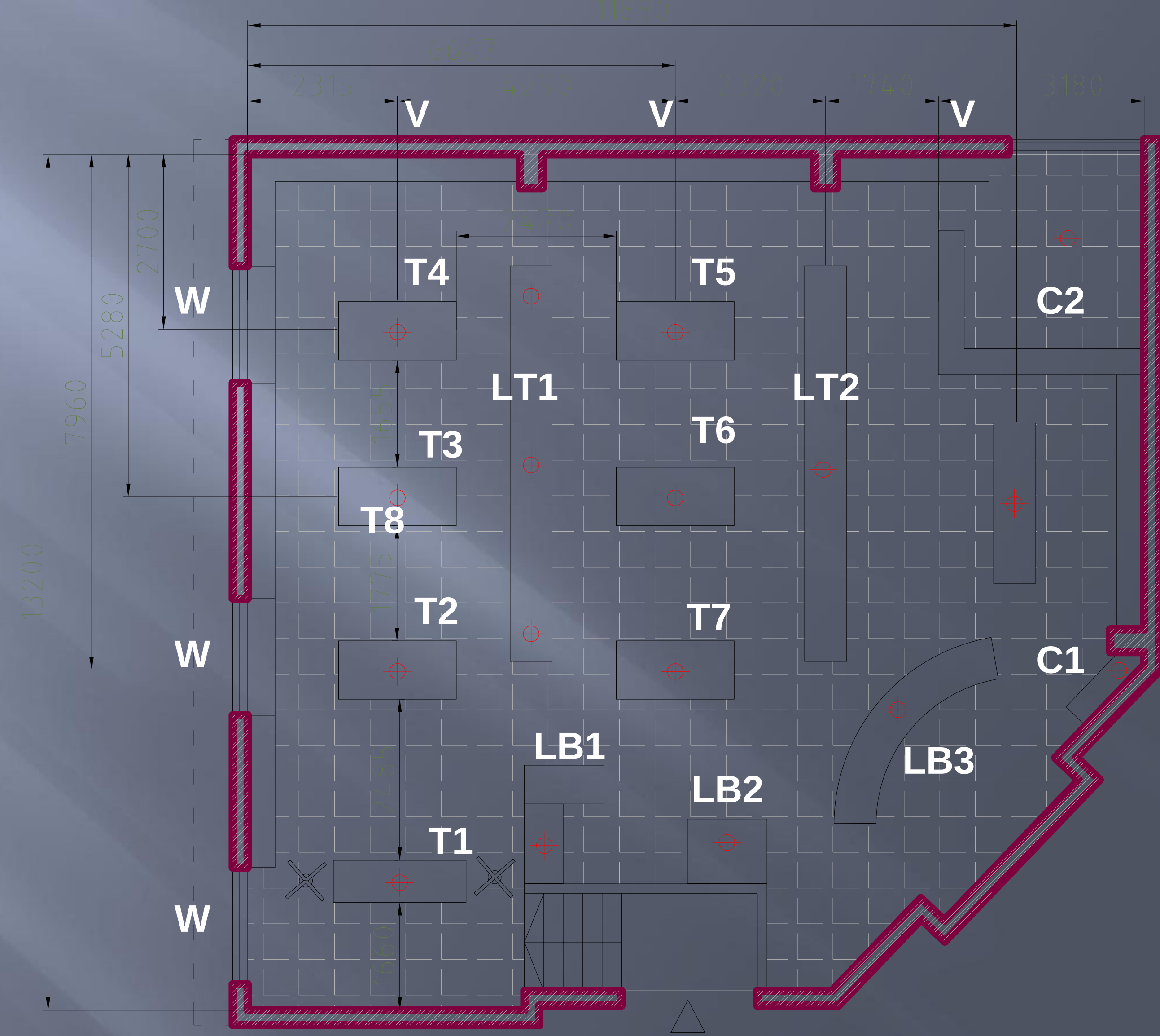
LOCATIONS OF TEST POINTS wrt WINDOWS AND VENTILATORS



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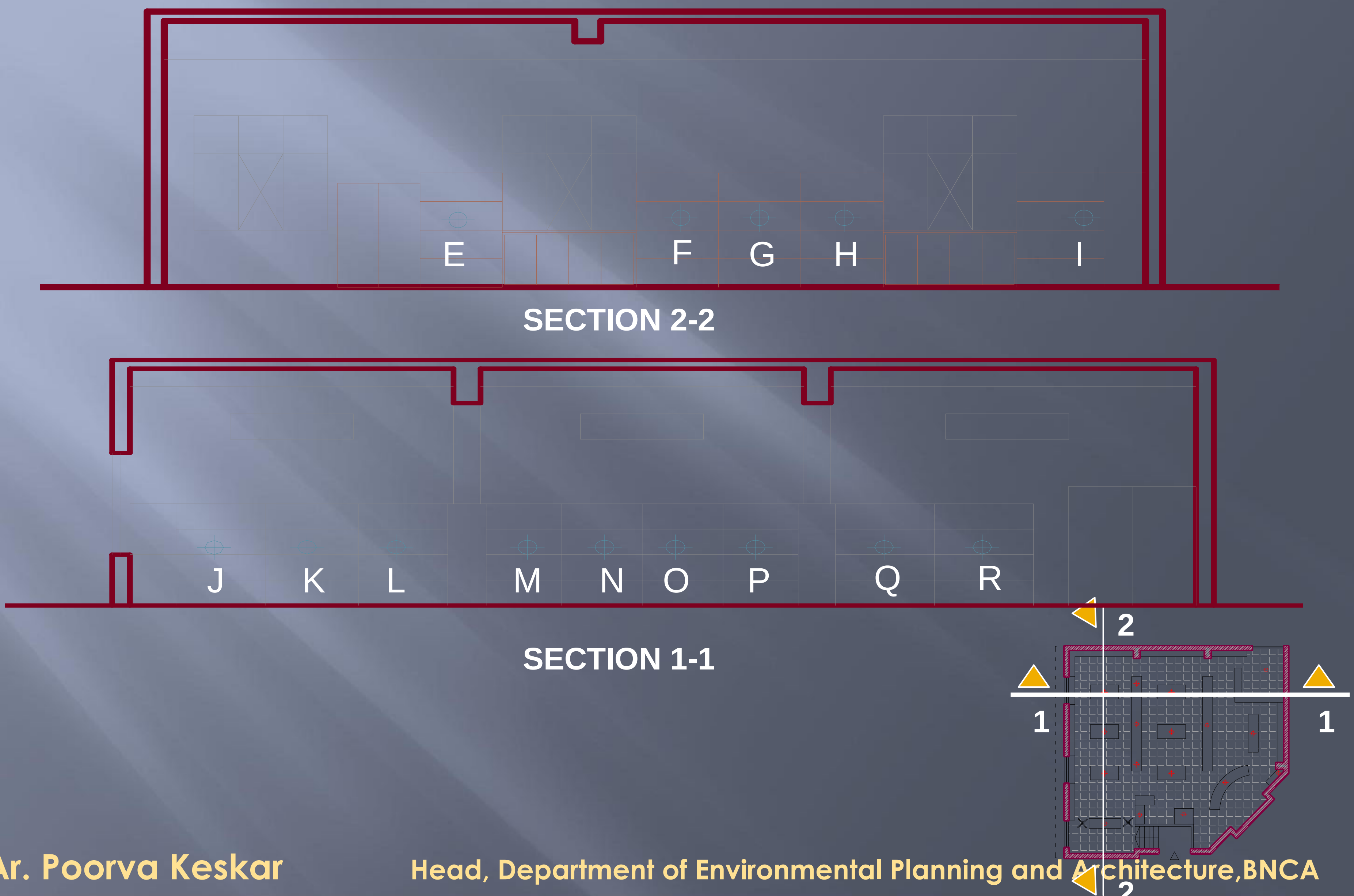
9. LOCATION OF TEST POINTS - VERTICAL



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10. TABLE OF ILLUMINATION LEVELS – HORIZONTAL TEST POINTS

					HORIZONTAL SURFACES						
PTS	7.00 AM	8.00 AM	9.00AM	10.00 AM	11.00 AM	12.00 NOON	1.00 PM	2.00 PM	3.00 PM	4.00 PM	5.00 PM
T1	320	590	728	1172	380	340	320	140	118	85	109
T2	700	1041	1020	720	304	286	216	162	116	93	85
T3	66	203	180	174	128	135	95	74	62	39	38
T4	650	535	700	468	313	249	325	166	150	136	136
T5	32	78	96	67	59	57	55	44	32	18	14
T6	25	75	96	69	53	59	48	37	31	19	14
T7	42	91	103	84	57	51	39	27	18	14	12
T8	14	35	35	30	27	28	26	23	17	11	9
LIBRARIAN T1	68	162	197	148	102	91	67	42	20	31	25
LIBRARIAN T2	23	68	74	53	35	32	27	21	16	12	8
LIBRARIAN T3	18	45	45	34	28	24	23	17	13	8	7
LONG TABLE 1	88,63,55	132,110,104	194,142,134	130,108,112	110,77,82	81,76,73	75,62,68	57,38,56	40,38,41	24,22,26	20,20,21
LONG TABLE 2	17	50	55	42	32	37	35	28	23	14	10
W1	1291	590	1197	1763	1044	1092	757	582	451	248	275
W2	1636	1168	243	1860	1915	1412	629	646	450	683	369
W3	1800	856	240	3020	1440	1145	990	790	695	513	502
CORNER 1	6	18	19	17	11	10	10	9	7	6	4
CORNER 2	25	40	63	63	68	56	55	45	31	22	18

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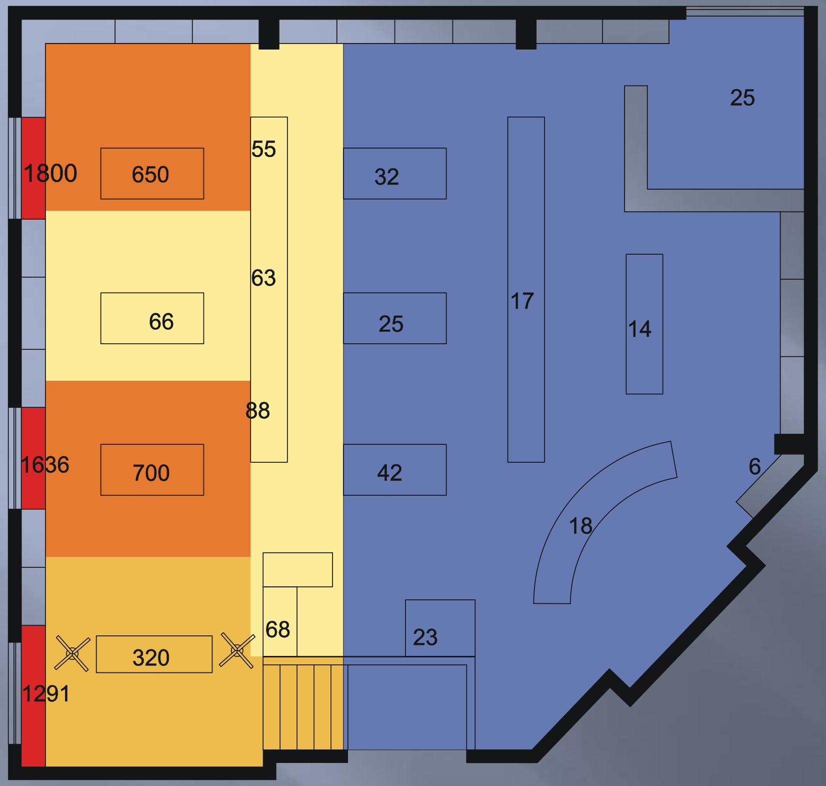
11. TABLE OF ILLUMINATION LEVELS – VERTICAL TEST POINTS

					VERTICAL RACKS					
pts	8.00 AM	9.00AM	10.00 AM	11.00 AM	12.00 NOON	1.00 PM	2.00 PM	3.00 PM	4.00 PM	5.00 PM
ENCYCLOPAEDIA	174	88	83	51	55	41	25	26	13	15
E	120	106	83	60	50	38	28	28	16	14
G	75	82	71	51	43	35	27	24	16	11
H	113	126	70	57	46	44	35	24	15	13
I	225	231	166	66	34	49	46	25	13	13
J	294	402	418	238	193	195	155	146	125	95
K	192	310	223	139	114	97	92	96	74	57
L	154	170	132	87	75	60	57	62	42	36
M	62	78	60	34	33	31	25	20	13	8
N	58	76	64	44	36	34	26	20	11	11
O	64	74	58	34	32	29	25	29	14	15
P	60	64	45	37	31	23	20	23	13	12
Q	32	40	32	20	20	17	16	13	8	7
R	17	26	22	21	22	17	18	15	9	8
S	30	36	28	25	19	20	16	13	9	7
M.ARCH.ENV	41	46	34	35	28	26	24	22	16	13
LANDSCAPE	48	52	49	33	28	25	29	25	23	17
V	46	54	40	29	24	25	29	24	22	18
THESIS 1	30	41	34	20	13	15	22	21	14	13
THESIS 2	17	26	20	18	27	21	13	13	10	9
NOTICE BOARD 1	567	660	618	340	290	218	13	125	110	80
NOTICE BOARD 2	289	336	205	128	124	101	85	55	58	38

12. ILLUMINATION ZONES…

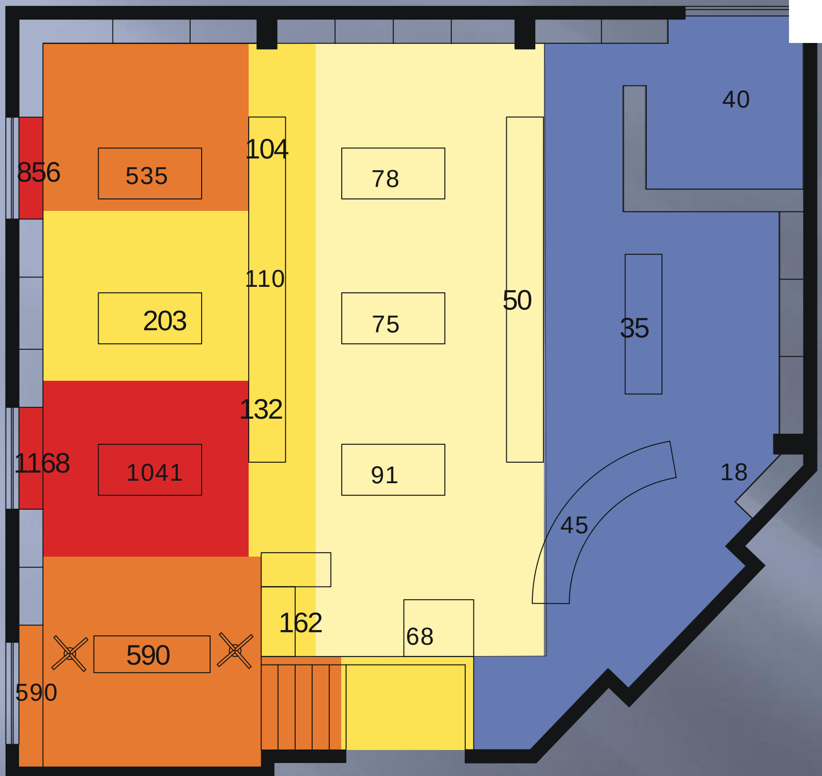


7:00 AM

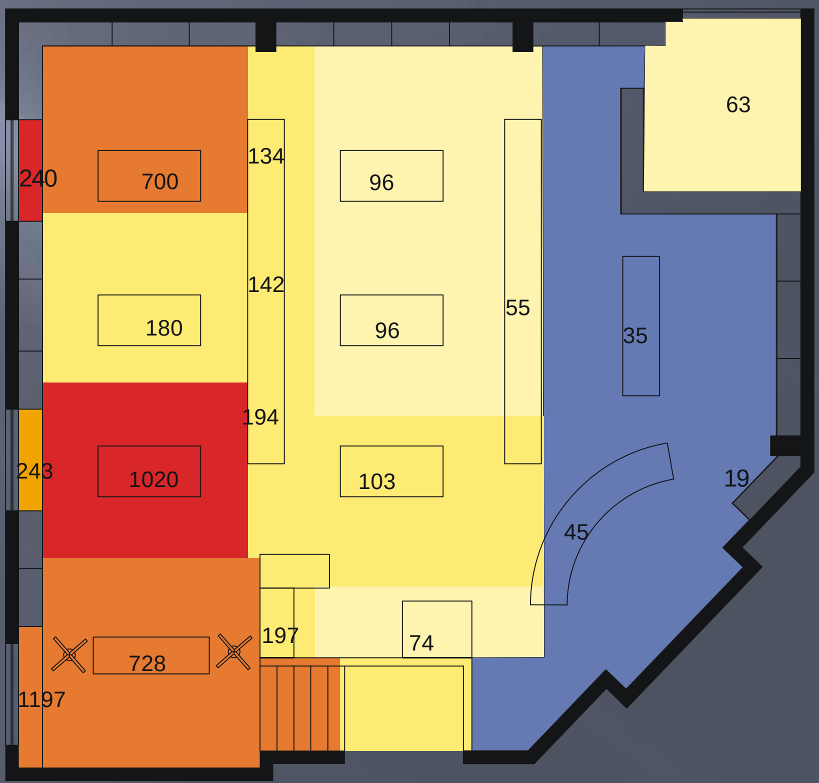
LEGEND FOR LUX LEVELS

- ABOVE 800 LUX-EXTREMELY HIGH
- 500 - 800 LUX - HIGH
- 200 - 500 LUX – DESIRED LVL
- 100 - 200 LUX- LOW
- 50 - 100 LUX- VERY LOW
- BELOW 50 LUX –EXTREMELY LOW

12. ILLUMINATION ZONES…



8:00 AM



9:00 AM

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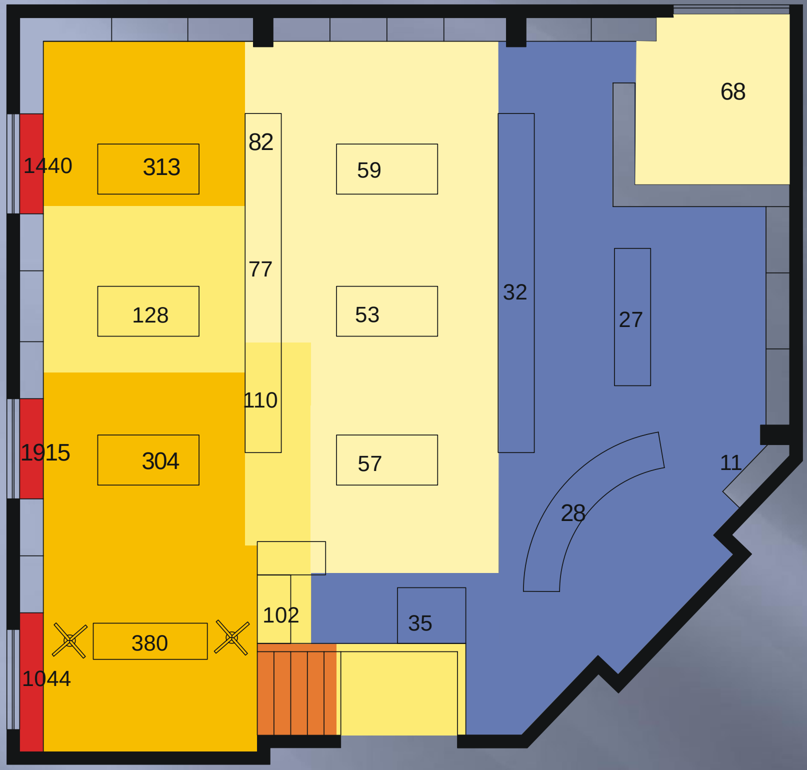
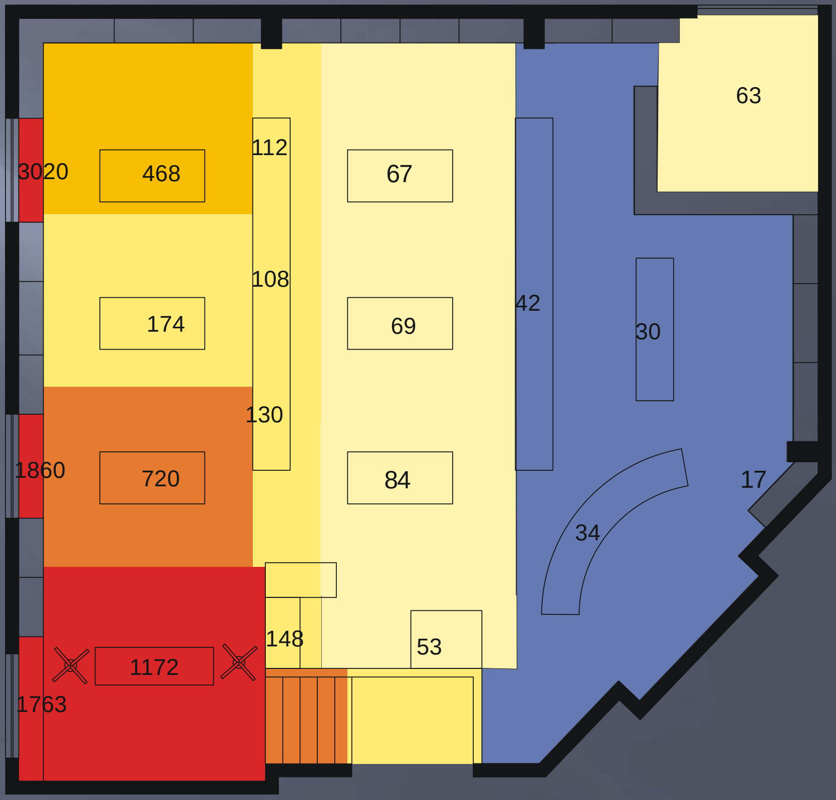
12. ILLUMINATION ZONES…



11:00 AM



10:00 AM

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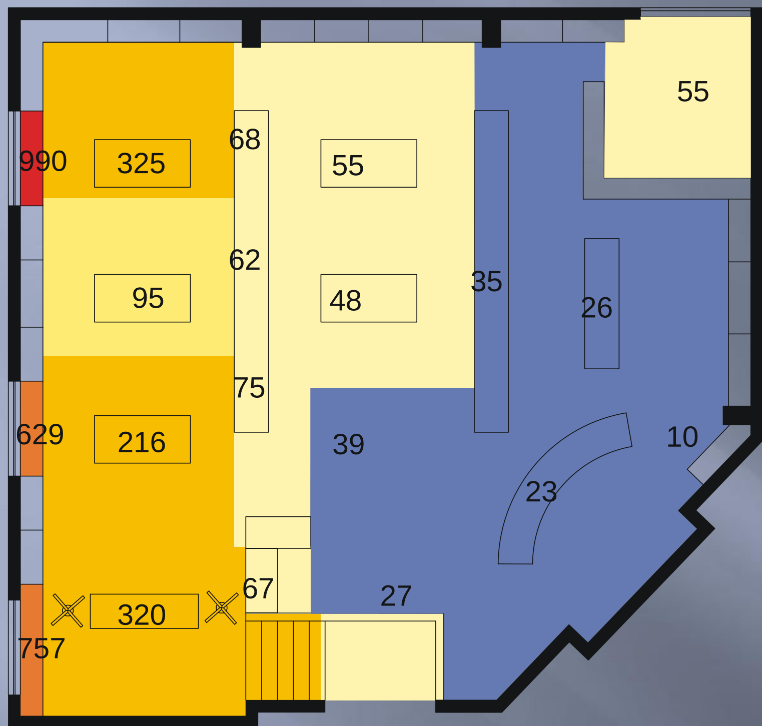
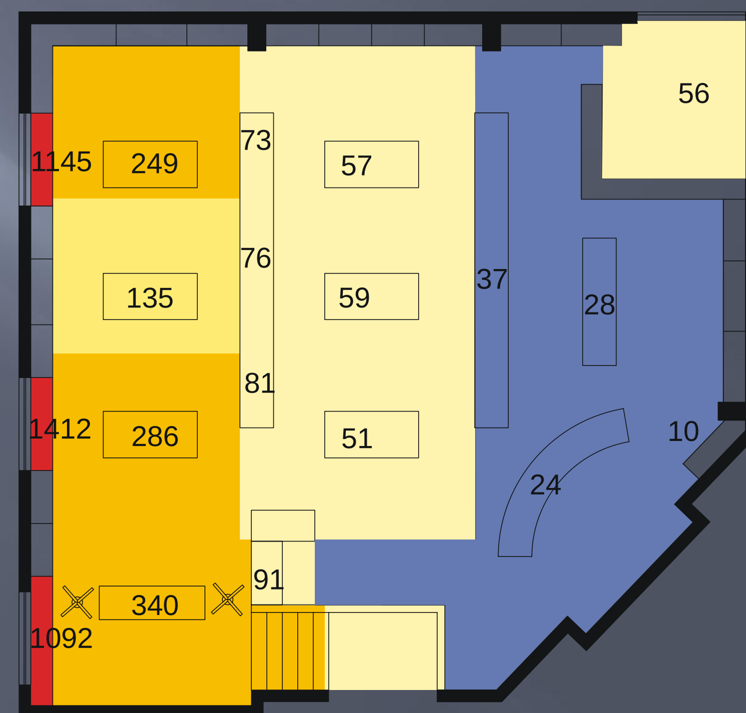
12. ILLUMINATION ZONES…



01:00 PM



12:00 NOON

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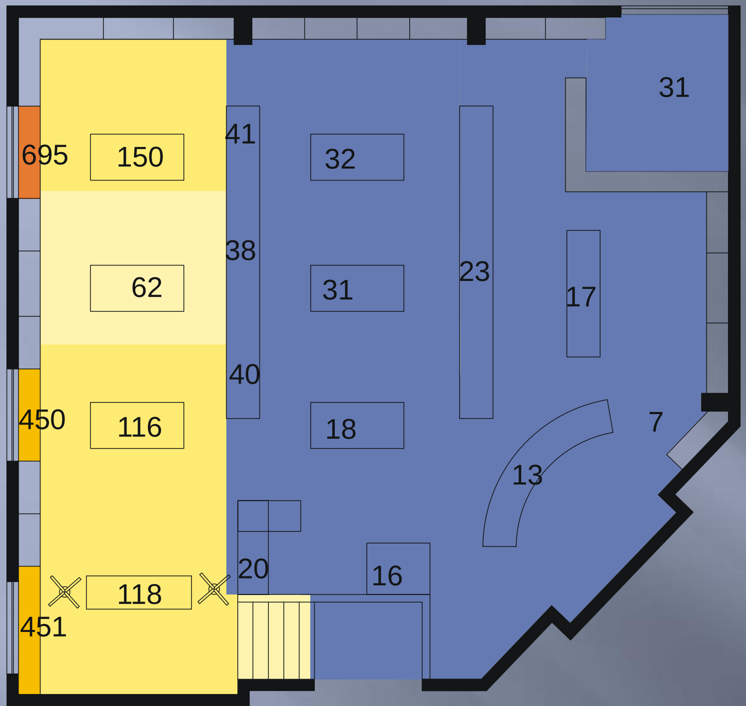
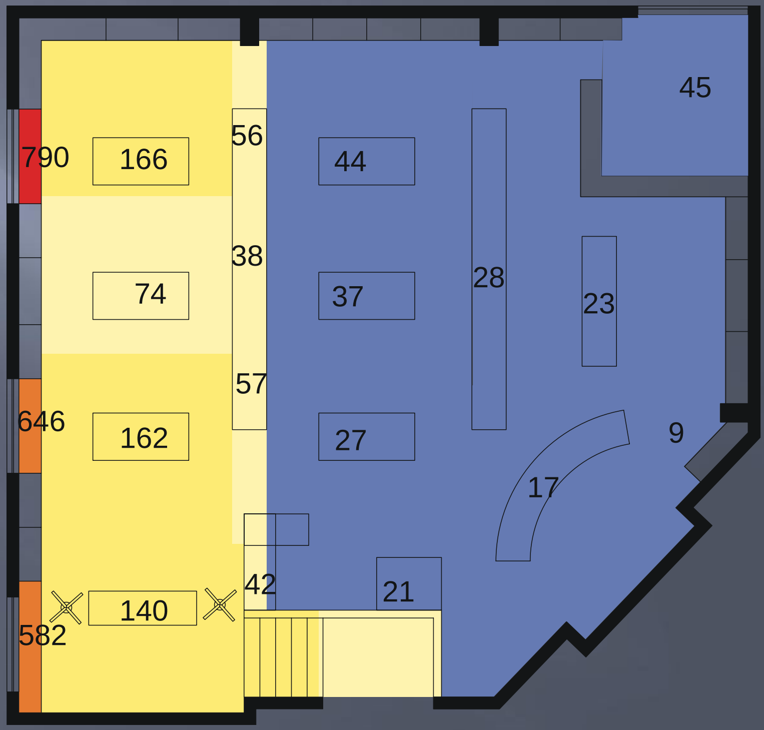
12. ILLUMINATION ZONES…



03:00 PM



02:00 PM

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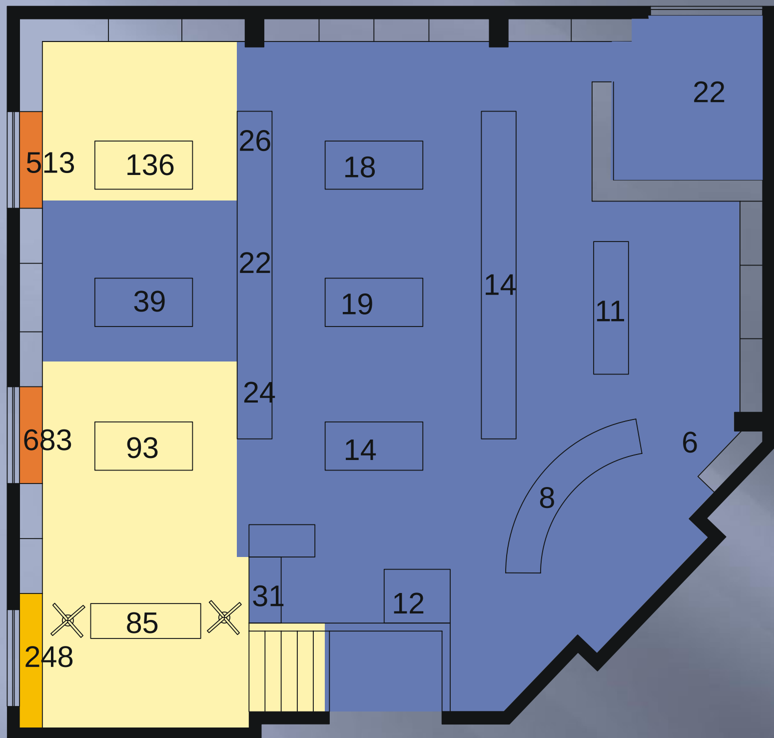
12. ILLUMINATION ZONES…



04:00 PM

05:00 PM

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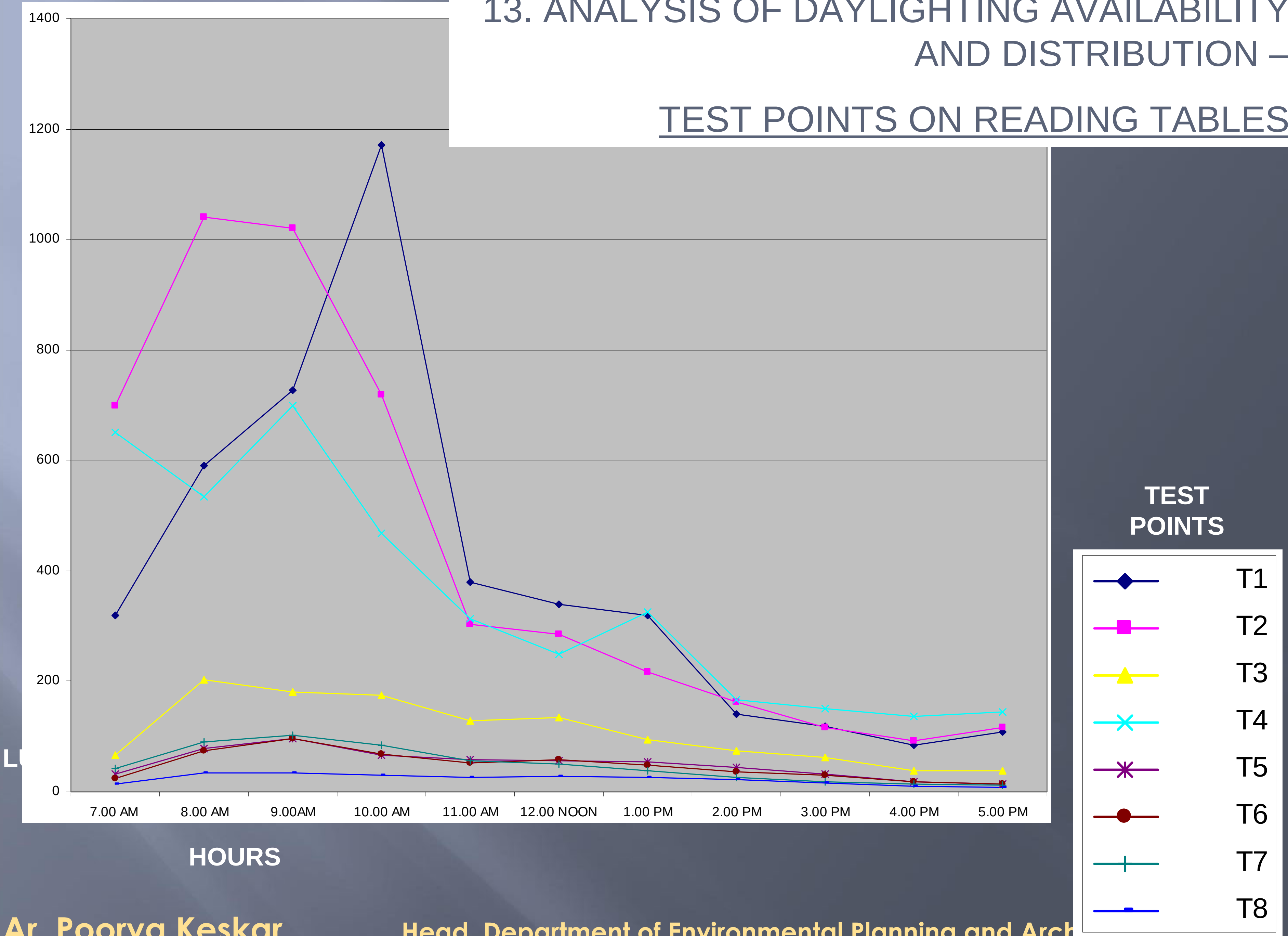
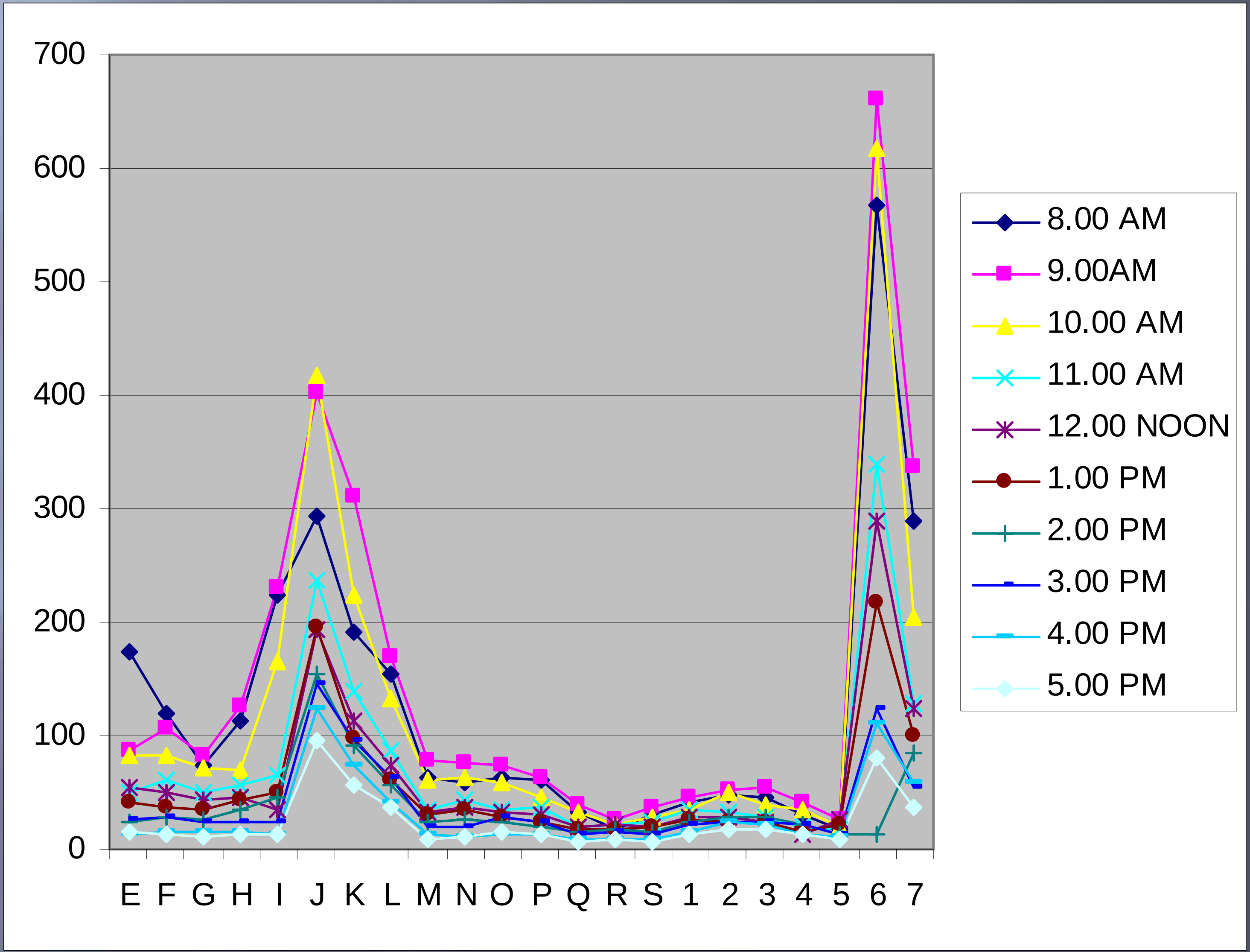
13. ANALYSIS OF DAYLIGHTING AVAILABILITY AND DISTRIBUTION –

TEST POINTS ON READING TABLES



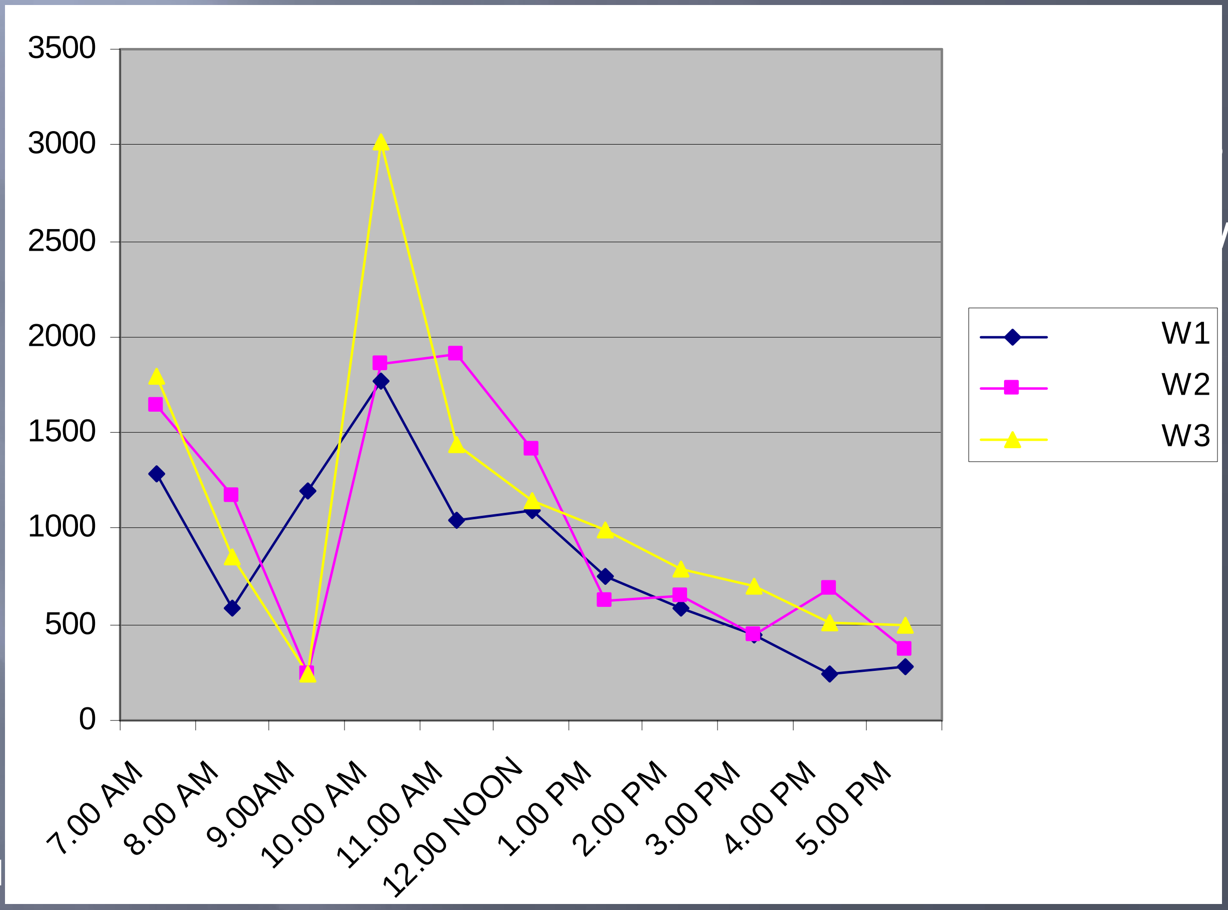
13. ANALYSIS OF DAYLIGHTING AVAILABILITY AND DISTRIBUTION – TEST POINTS ON BOOK SHELVES – ON VERTICAL

LUX



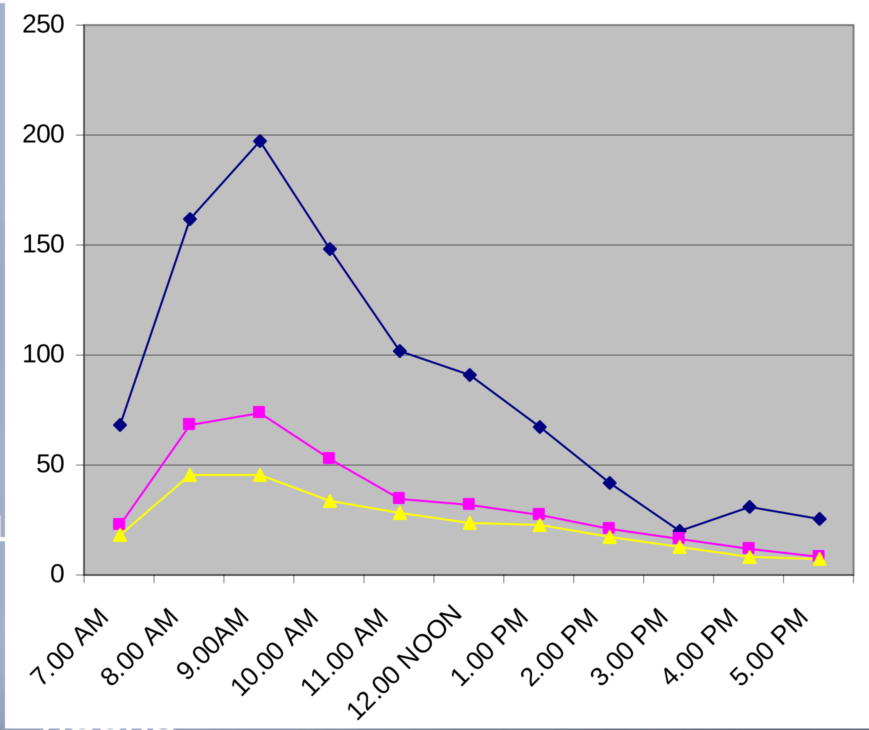
13. ANALYSIS OF DAYLIGHTING AVAILABILITY AND DISTRIBUTION – TEST POINTS AT WINDOW CILL HT. 0.9 M FROM FFL

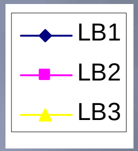
LUX



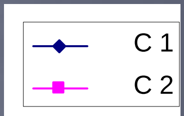
Ar. Poorva Keskar Head, Department of Environmental Planning and Architecture,BNCA

13. ANALYSIS OF DAYLIGHTING AVAILABILITY AND DISTRIBUTION –

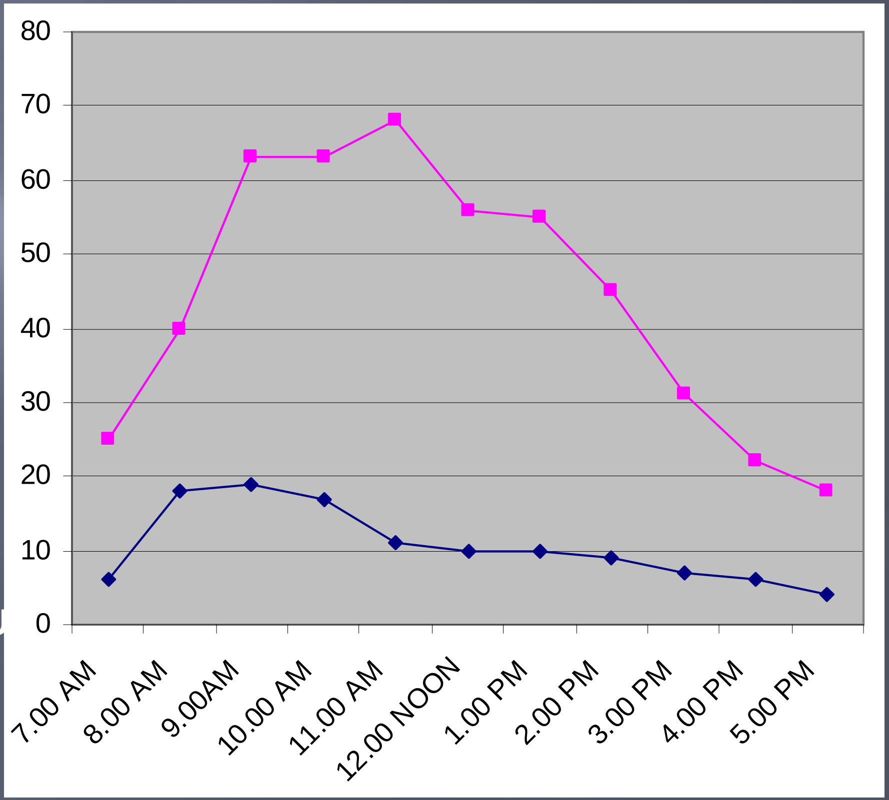




TEST POINTS AT LIBRARIANS WORKING TABLE

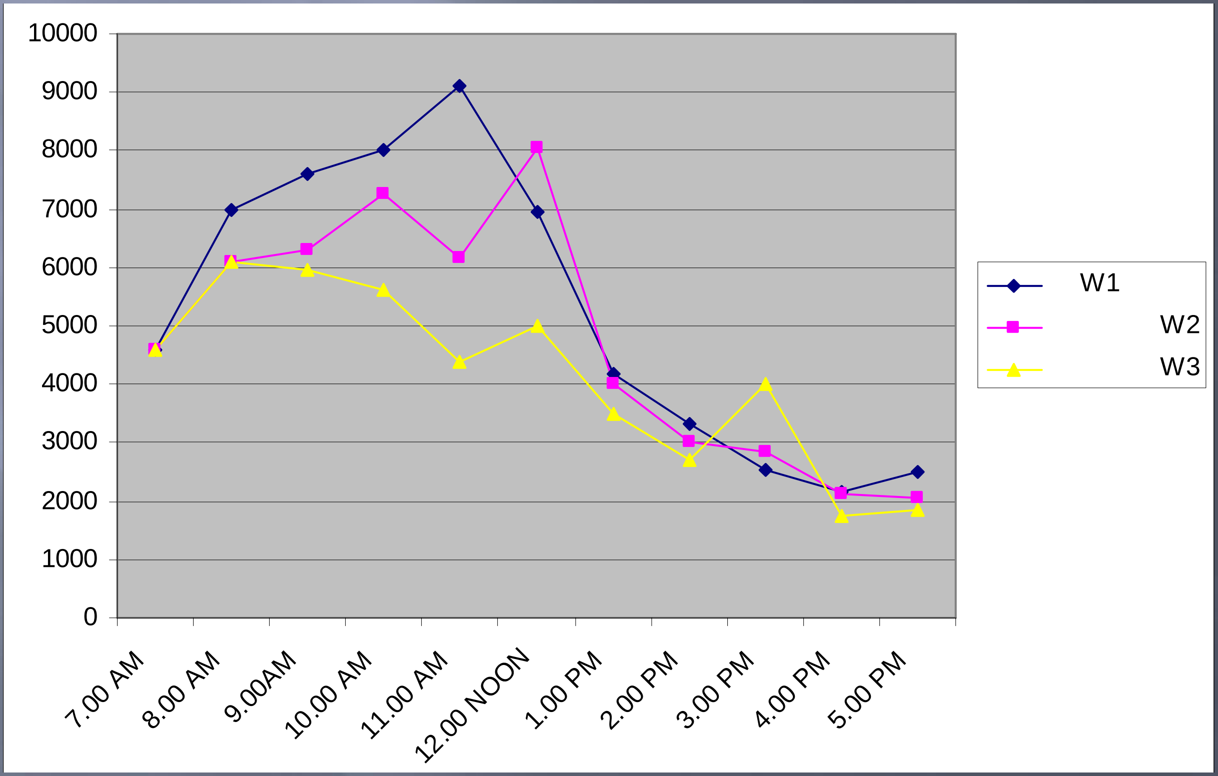


TEST POINTS AT CORNER POINTS



EXTERNAL ILLUMINATION LEVELS –MEASURED AT 0.3 M AWAY FROM THE RESPECTIVE WINDOW OPENINGS AND READINGS TAKEN IN SHADE

				OUTSIDE ILLUMINATION							
PTS	7.00 AM	8.00 AM	9.00AM	10.00 AM	11.00 AM	12.00 NOON	1.00 PM	2.00 PM	3.00 PM	4.00 PM	5.00 PM
W1	4600	6980	7600	8000	9100	6950	4180	3320	2540	2160	2500
W2	4600	6100	6300	7250	6170	8050	4010	3010	2850	2140	2070
W3	4600	6100	5950	5600	4400	5000	3500	2720	4000	1750	1860



LUX

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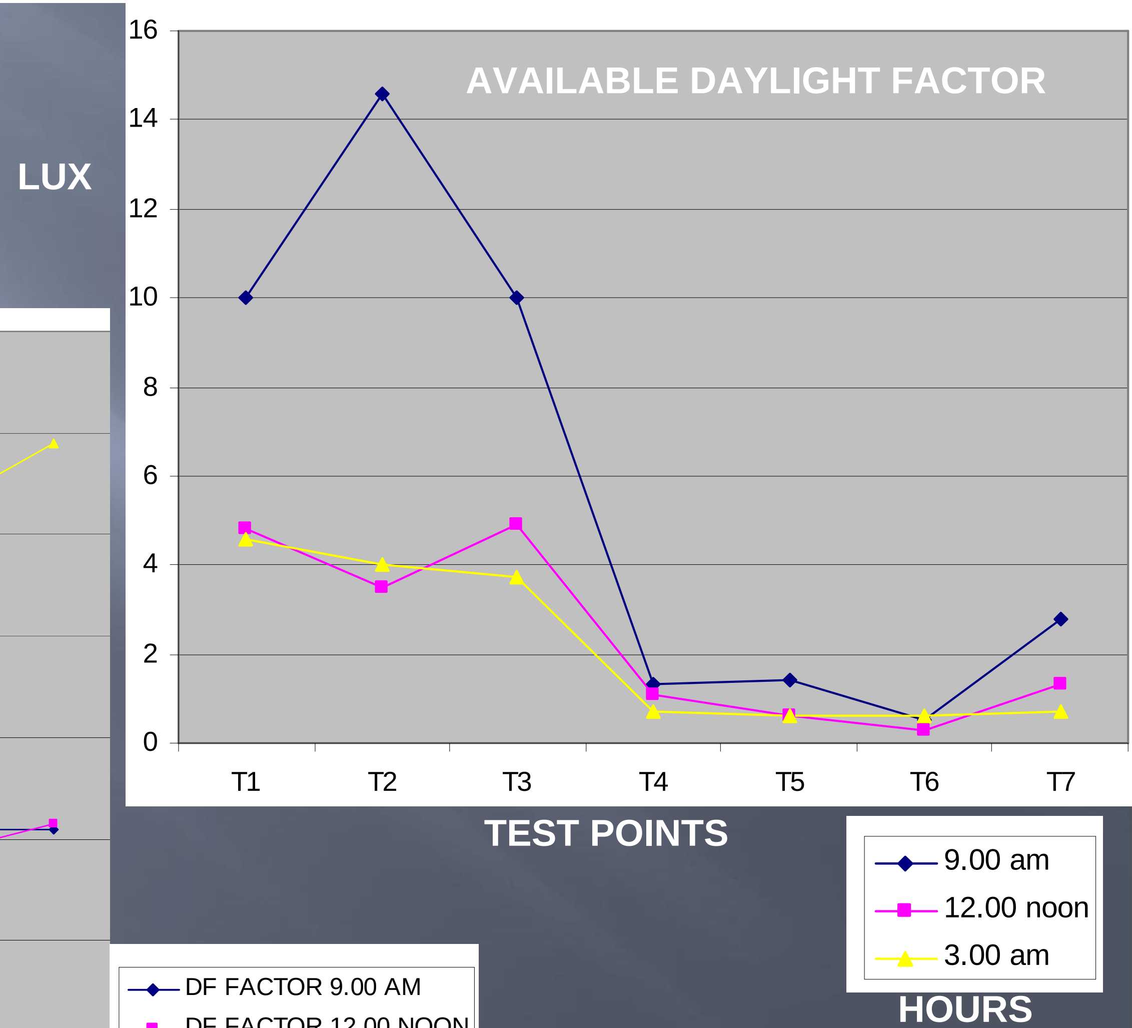
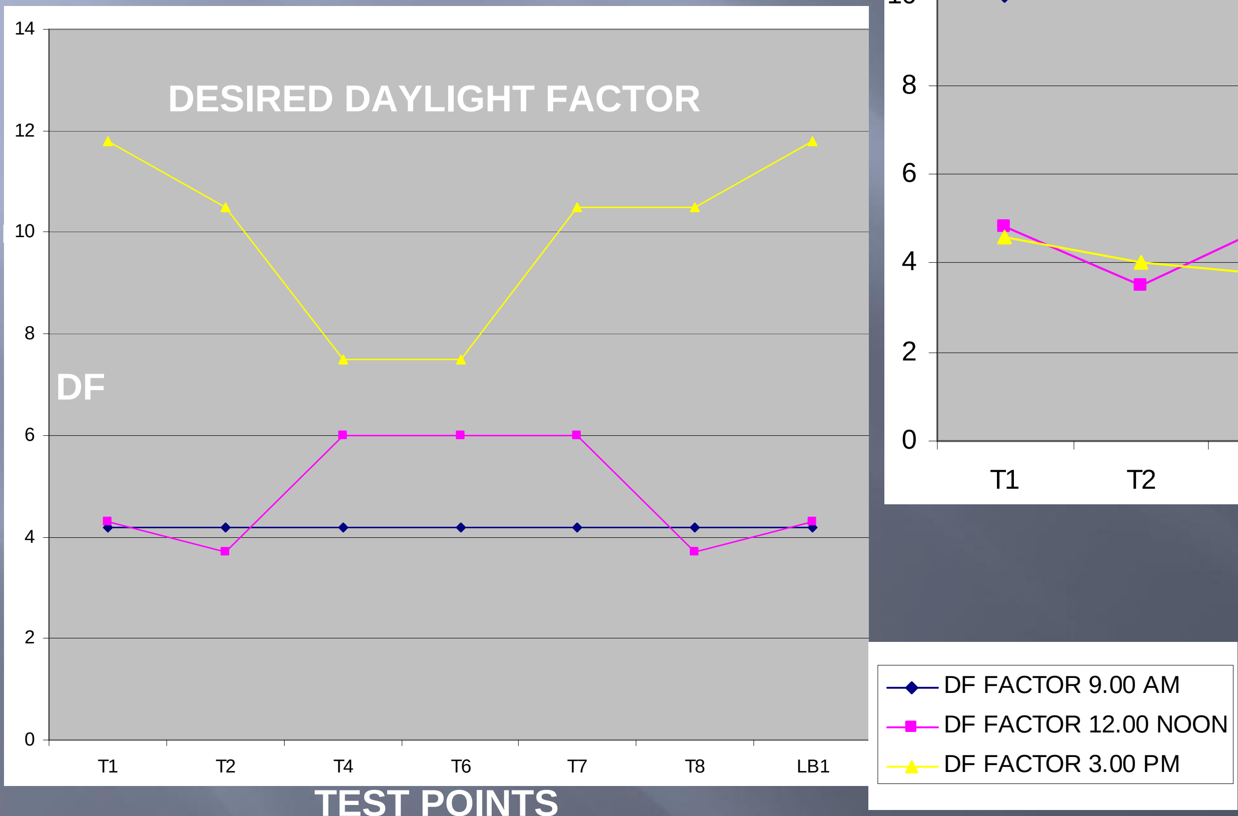
13. ANALYSIS OF DAYLIGHTING AVAILABILITY AND DISTRIBUTION – DAYLIGHT FACTOR

PTS	9.00 am	12.00 noon	3.00 am
T1	10	4.8	4.6
T2	14.6	3.5	4
T3	10	4.9	3.75
T4	1.3	1.1	0.7
T5	1.4	0.6	0.6
T6	0.5	0.3	0.59
T7	2.8	1.3	0.7





•LARGE VARIATION IN THE DF - INDICATES EXTREMELY POOR DISTRIBUTION.

•DAYLIGHT FACTOR INSUFFECIENT FOR READING

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14. CONCLUSIONS

- LIMITED DAYLIGHT PENETRATION DUE TO THE NUMBER, DESIGN-MATERIALS (TYPE OF GLASS) & HEIGHT AND LIMITED ORIENTATION OF WINDOWS.
- FROSTED GLASS FOR VENTILATORS REDUCES THE DAYLIGHT PENETRATION, INSTEAD A CLEAR GLASS VENTILATOR WOULD ALLOW MORE REFLECTION FROM CEILING.
- TOTAL OPENING AREA IS ONLY 8.5% OF THE FLOOR AREA. THE PMC STANDARDS ALSO PRESCRIBE AN OPENING AREA OF 20 % MINIMUM FOR ADEQUATE DAYLIGHT. THUS THE LIBRARY IS POORELY DAY LIT.
- VENTILATORS ON THE SOUTH SIDE ARE INSUFFECIENT, MOREOVER BECAUSE OF THE FROSTED GLASS.
- THE LAYOUT OF THE LIBRARY IS SUCH THAT IT OCCUPIES MOST OF THE WALL SURFACES, HENCE AFFECTS THE QUANTUM OF DAYLIGHT THAT COULD BE AVAILABLE BY INTERNAL REFLECTION. ALSO IT OFFERS WINDOW AREA LIMITATION.
- THE DAYLIGHTING SOLUTIONS IN EXISTENCE ARE FAR AWAY FROM THE POTENTIAL DAYLIGHT THAT COULD BE ENVISAGED BASED ON ITS ORIENTATION.

14. CONCLUSIONS

- THERE IS A HEAVY GAP IN THE DAYLIGHT DISTRIBUTION. THIS IS EVIDENT FROM THE DAYLIGHT FACTOR GRAPH. THE DF RANGES FROM 14% TO 0.3%
- THE LIBRARY HAS TO DEPEND 100% ON ARTIFICIAL LIGHTING. THIS NOT USED INCREASES THE ELECTRIC CONSUMPTION, BUT ALSO ADDS ON TO THE HEAT GAIN OF THE LIBRARY.
- NOT AT ALL TIMES IN A DAY, THE LIBRARY IS USED TO ITS FULL CAPACITY, STILL THE ARTIFICIAL LIGHTING IS KEPT CONSTANT.
- THE BOOK SHELVES CONSUME THE WALL SURFACES WHICH COULD HAVE BEEN AVAILABLE FOR IR. ALSO THE BLACK COLOUR OF THE SHELVE ADDS TO THE PROBLEM.
- THERE EXIST LIGHT AND DARK AREAS IN THE LIBRARY AT THE SAME TIME, WHICH CAN CAUSE VISUAL DISCOMFORT.

15. RECOMMENDATIONS

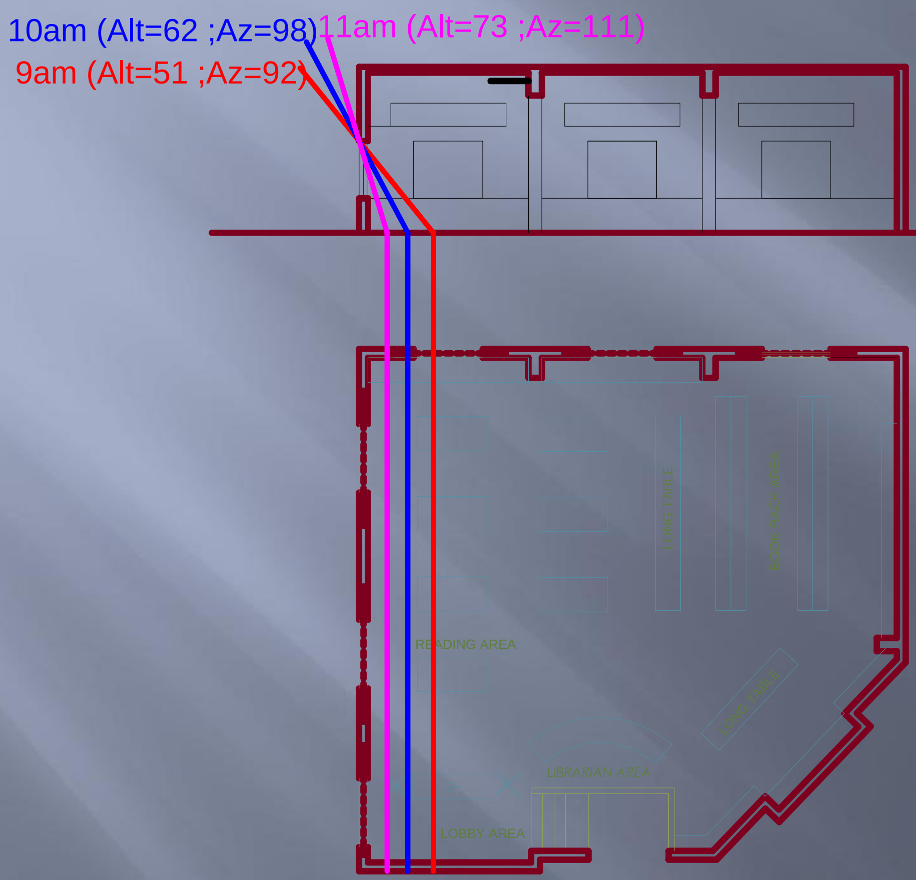
1. Modification in the basic design/ layout of the Library
2. Modification of the existing Window design
3. Introduction of different design elements viz – light shelves, ceiling reflectors etc to ensure penetration and distribution of daylight.
4. Window openings –

   Ventilators could be added on the east side

   Continuous strip ventilators could be taken on the south side with clear glass (with proper shading device to allow only diffused light.

   Add windows on the South side as per the layout change recommendation

15. RECOMMENDATIONS



INTRODUCTION OF LIGHT SHELF

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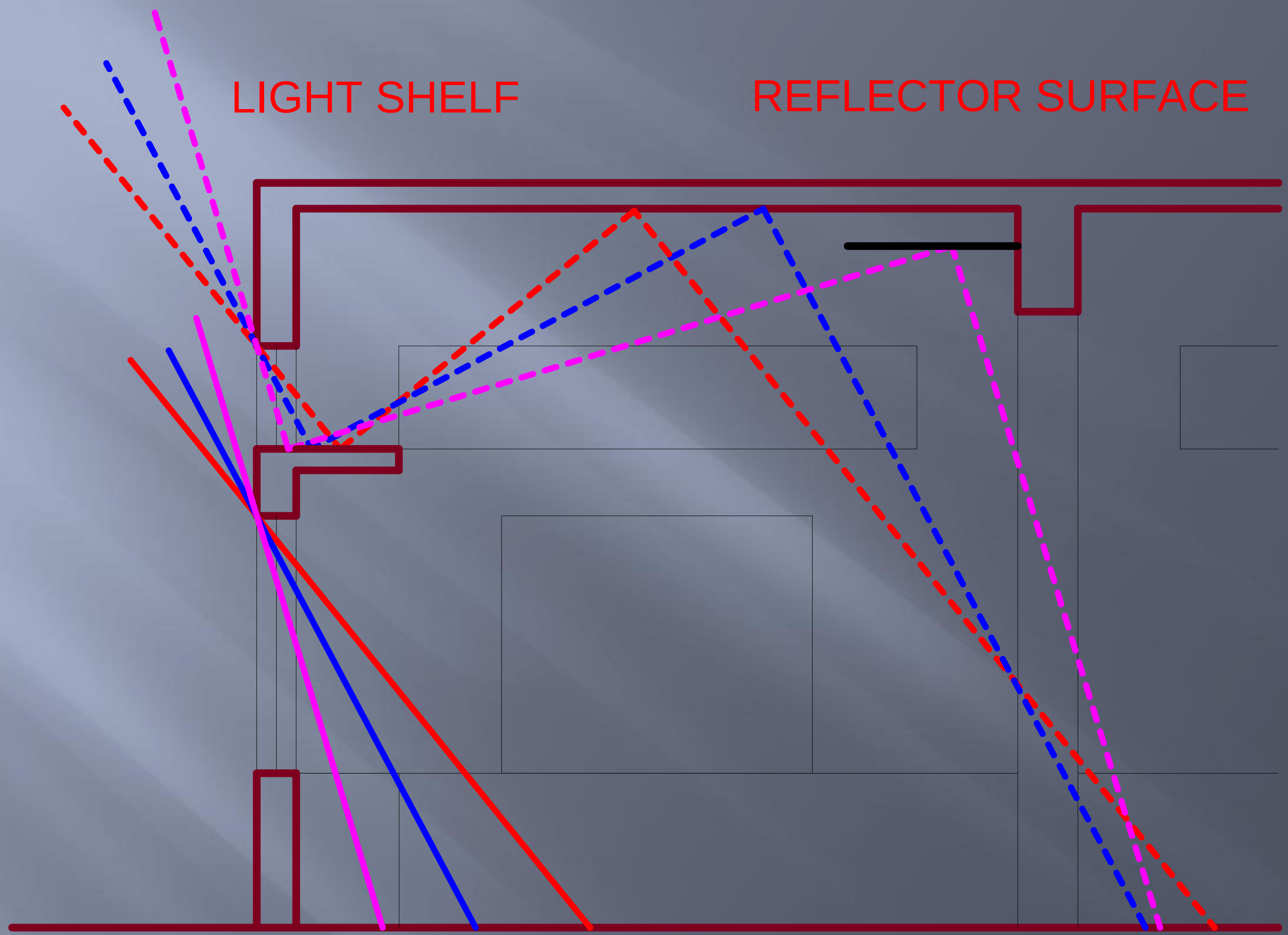
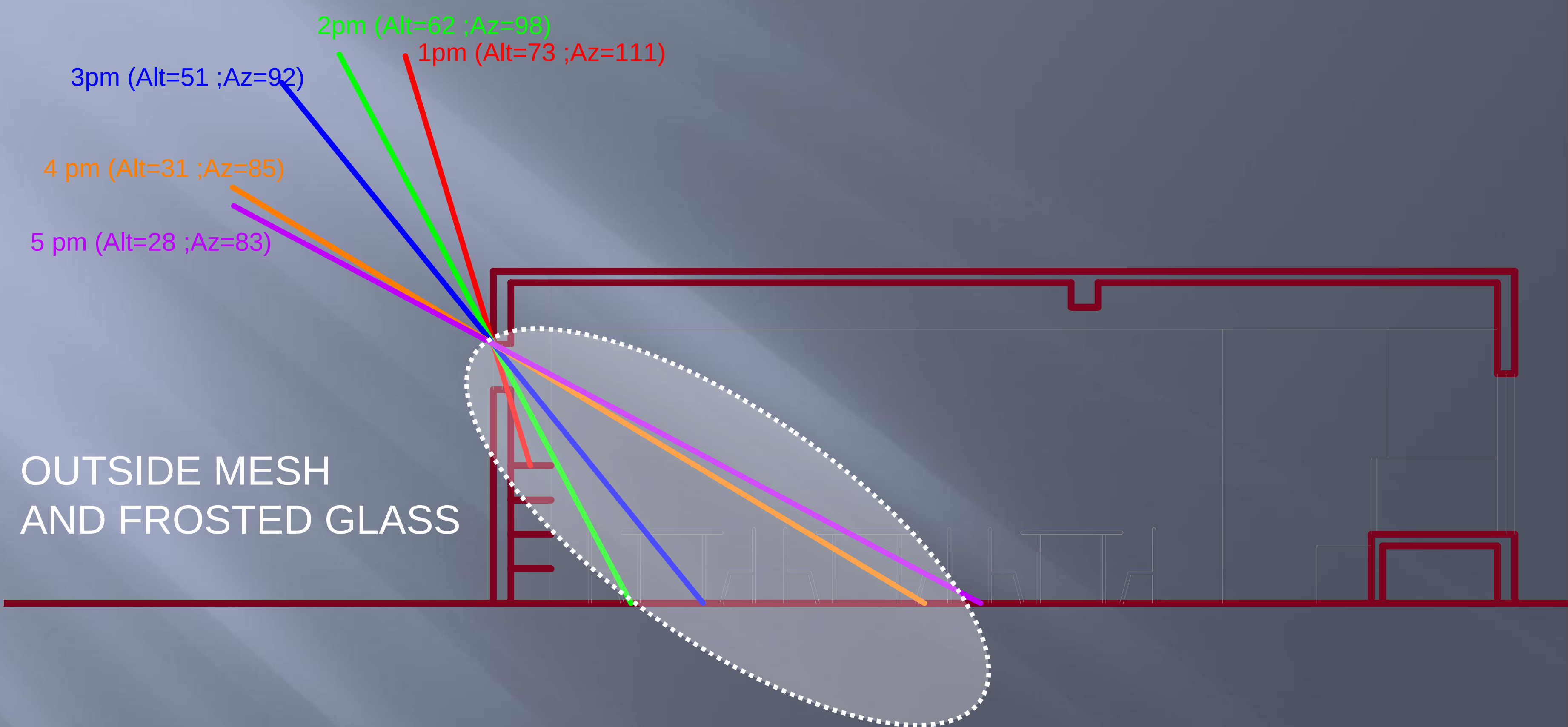
Head, Department of Environmental Planning and Architecture,BNCA

15. RECOMMENDATIONS



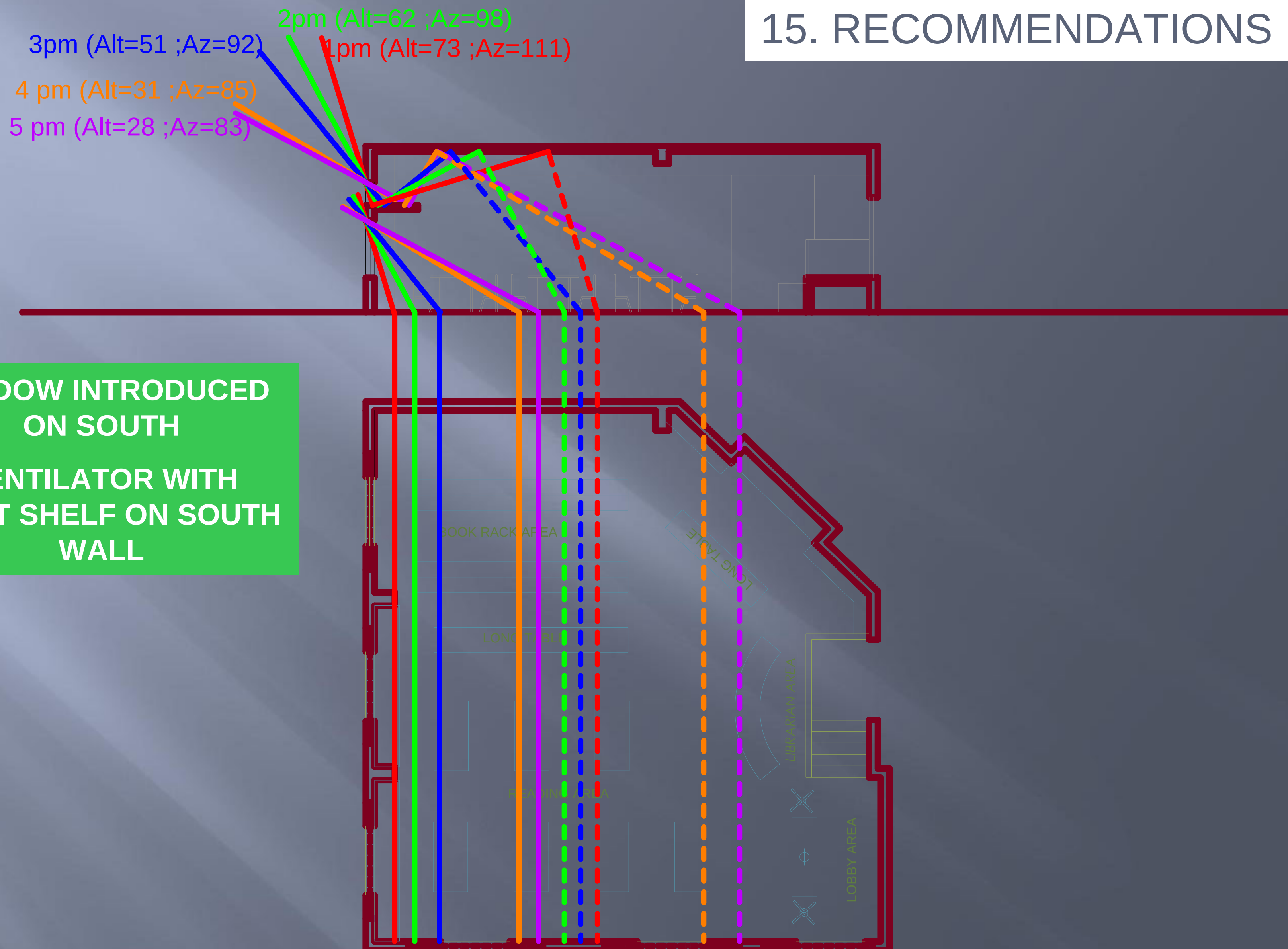
INTRODUCTION ADDITIONAL VENTILATOR AND LIGHT SHELF ALONG WITH REFLECTORS AT THE CEILING

15. RECOMMENDATIONS



CLEAR GLASS WOULD ALLOW DEEPER PENETRATION OF DAYLIGHT AS AGAINST THE CURRENT FROSTED GLASS

15. RECOMMENDATIONS

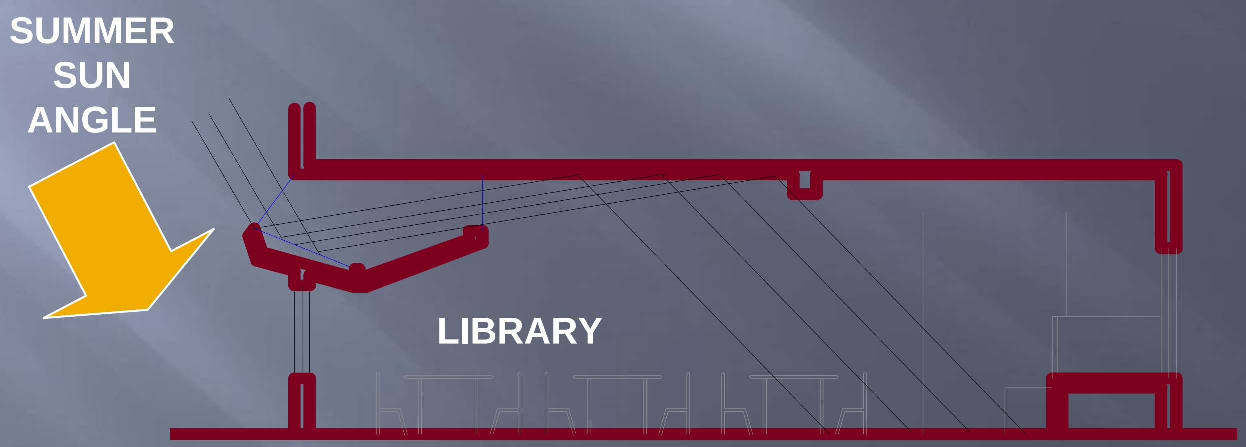


WINDOW INTRODUCED ON SOUTH

VENTILATOR WITH LIGHT SHELF ON SOUTH WALL

15. RECOMMENDATIONS

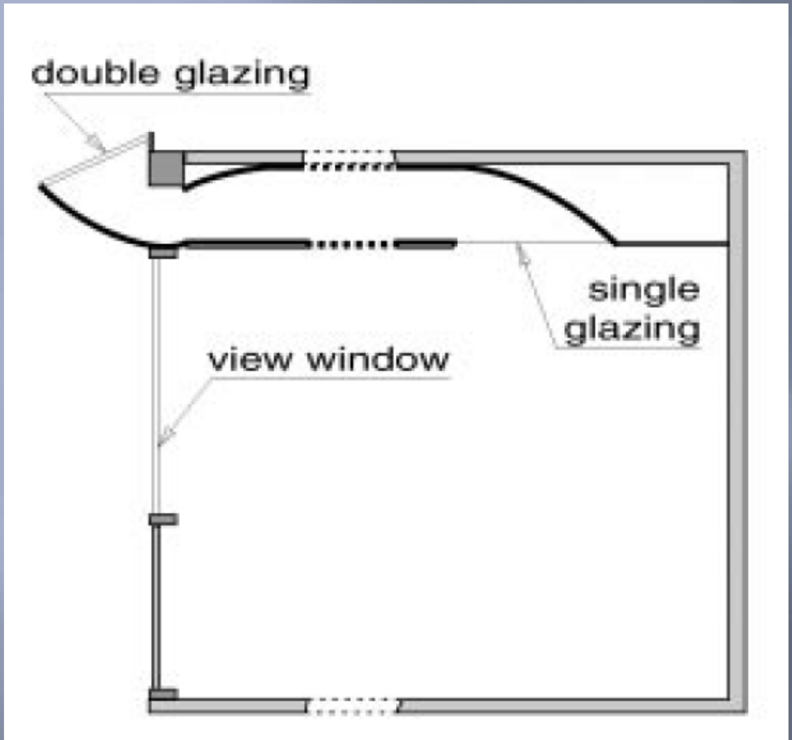
SUN-TRACKING LIGHT SHELF



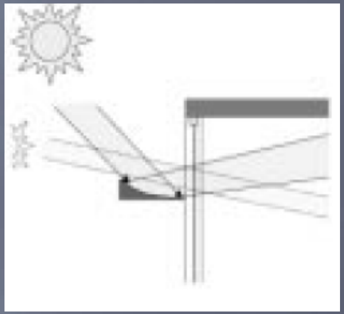
SUN-TRACKING LIGHT SHELF

Ar. Poorva Keskar
Head, Department of Environmental Planning and Architecture,BNCA

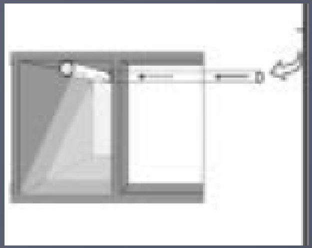
15. RECOMMENDATIONS…. CONCEPTUAL-YET TO BE WORKED OUT



LIGHT CATCHER



EXTERNAL LIGHT SHELF



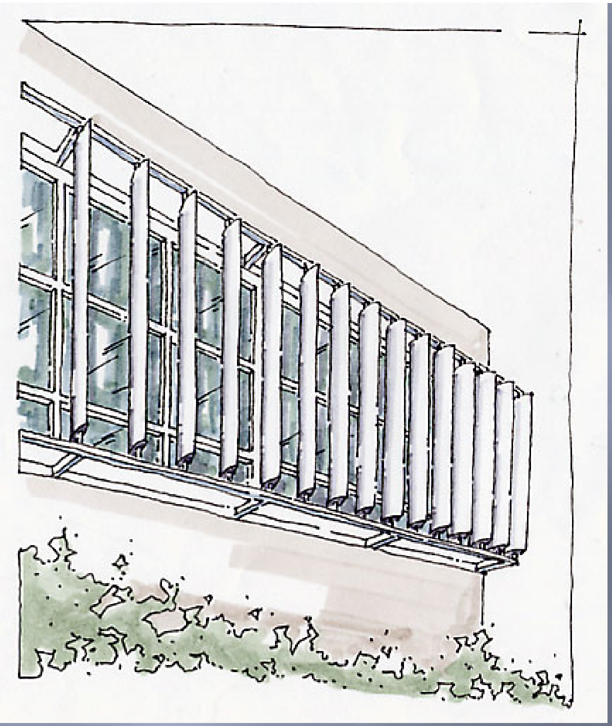
LIGHT PIPE

Ar. Poorva Keskar Head, Department of Environmental Planning and Architecture,BNCA

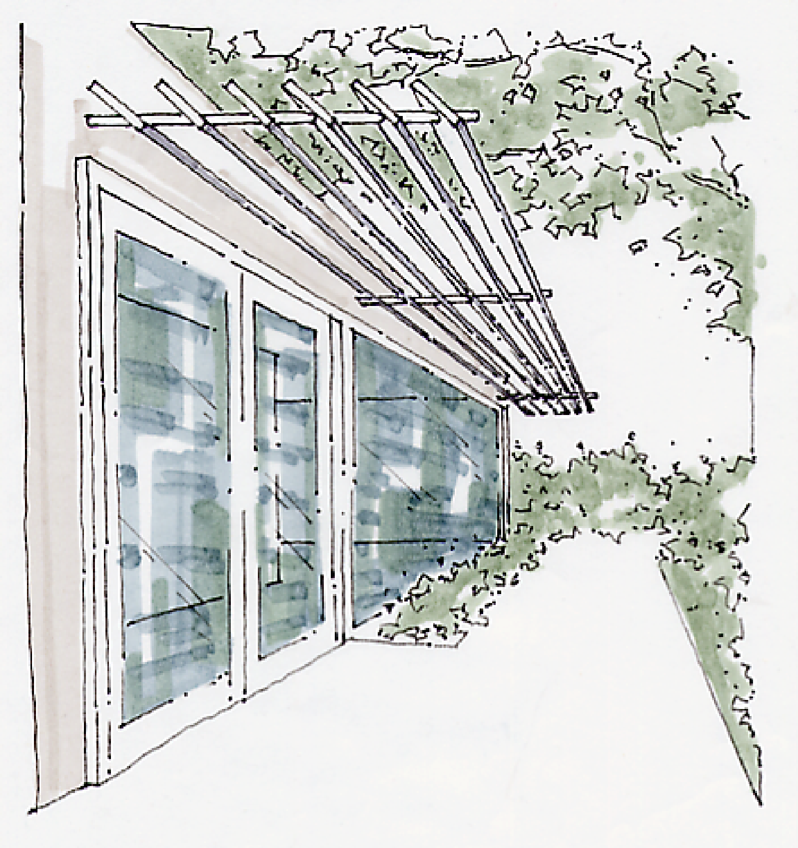
15. RECOMMENDATIONS

High clerestory window in an exterior wall, with a back reflecting surface to provide light on the vertical surfaces of the stacks at the wall.

15. RECOMMENDATIONS



Vertical sunshade for the east or west elevation of a library. The open design allows view out and daylight penetration. This design should be augmented with internal shades for low perpendicular sun angles.



Horizontal sunshade for the south elevation of a library. structure that excludes all direct sunlight, but is open to allow diffuse daylight to pass through.