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Relation of Daylight with Space Configuration in Residence in Pune

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Abstract: Problem statement: To study the quality and quantity of daylight in residence in Pune with respect to the space configuration. The objectives are-To study change in quality, quantity and distribution of daylight. To study the role of openings design in day lighting. The methodology is experimentation by using various tools to measure illumination in different rooms, on a particular day. The expected results would be the change in quantity and quality of day lighting by change in orientation. This study will conclude on various factors that affect the daylight and eventually enhance the indoor environmental quality, eventually minimizing the energy usage for lighting.

Keywords
Quality and quantity of daylight, experimentation, orientation

I. Introduction

Day lighting is the practice of placing windows, openings and reflective surfaces so that during the day, natural light provides effective internal lighting. The prime function of a residence is to facilitate comfortable living. A comfortable visual environment is a function of the architectural configuration of the residence which changes the type of daylight that enters various spaces. Considering daylight while designing the residence not only increases efficiency, but improves health, and also reduces the energy consumption for lighting. To achieve comfortable conditions the dependability on active means has become a necessity. If the architecturally designed indoor space does not provide enough and well distributed lighting conditions, the occupiers resort to the use of artificial lights to meet their functional demands. India having abundant sunlight, yet we are moving towards active method of illuminating our home spaces. Each orientation has a different daylight quality at different times. The push behind using every square foot has resulted in absolutely basic daylight strategies, without giving much attention to orientation or space requirement. Careful design decisions on orientation, openings, shading devices could employ daylight, reducing the need for artificial lighting. Good day lighting design is inseparable from good architectural design and should be considered from the earliest stages of the design process.

II. Methodology

i) Measurement protocol-The illumination levels are measured by lux meter in the month of December for four timings of the day considering the namely 9 am, 12 pm, 3pm & 5pm. Measurements are taken at various points inside the residence by following a grid of 1mx1m. The measurement is taken at a height of 700 mm. The measurements are taken when all the curtains are drawn open, doors & windows are open. Two parameters that are considered are quantity & quality of daylight. Quantity is judged by the lux levels & quality is judged by light distribution, glare etc.

ii) Analyzing lux levels & daylight penetration with the help of Ecotect simulation software

The residence was modeled in simulation software ECOTECT for results. Pune weather file was used for simulation with external average illumination set to 8000 lux as given in NBC. The results for the existing residence were simulated and then compared to the results after retrofitting to understand the effect of the architectural configuration changes on the daylight in the residence.

III. Planning Configuration and Surroundings

Fig 1: Residence Plan showing measurement points

Description of residence

The residence is situated on second floor. Surroundings-north & east side has ground structures & south & west side has open plot & children's play area. The walls are painted white with one wall in bedroom & living room of dark shade like red, ochre & Olive green. Flooring is white tiles except master bedroom which is grey matt finish. The furniture is of grey & off white in master bedroom & brown & off white in other rooms. Kitchen has white & orange glossy finished furniture. The windows have a sill at 0.9 m and lintel at 2.1 m. The glass is clear glass fitted in white UPVC framing

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IV. MEASUREMENTS

Table 1: Quantity of daylight & light distribution

NBC recommended lux levels-150-200-300

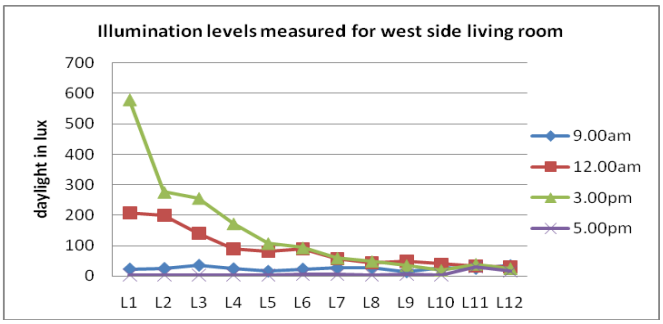

Fig 2: Illumination levels measured at various points in living room

Observations -Table 2 & Figure 4 indicate that living room receives ample light at 12 & 3 pm being on west side near the window & door but the quantity reduces in the depth of room. Points L1 to L5 receive acceptable illumination levels. After 12 pm it receives acceptable illumination levels as per NBC. Living room has balcony projection above cutting the west radiation but light penetration is comparatively less than other rooms.

Table 2: Illumination levels measured for west side living room highlighting the readings required as per NBC

Points measured in living room	9.00am	12.00am	3.00pm	5.00pm
L1	23	208	580	2
L2	25	200	275	2
L3	35	140	255	2
L4	24	90	171	2
L5	16	80	106	3
L6	23	90	92	4
L7	27	58	58	4
L8	27	44	47	3
L9	14	50	34	6
L10	26	40	18	2
L11	25	33	38	30
L12	34	30	24	15

NBC recommended lux levels for Food preparations & cooking- 200-500-700, Dinning room-150-200-300

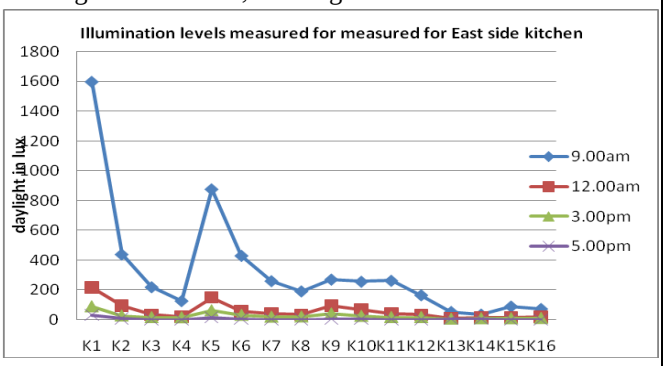

Fig 3: Illumination levels measured at various points in kitchen

Observations- East sunrays penetrate the kitchen throughout the day. No glare is experienced as the room is under lit. The dinning area is under lit throughout the day. The kitchen has attached dry balcony & projection above too so the light penetration in the deep portion of dining is very less.

Table 3: Illumination levels measured for North East side kitchen highlighting the readings required as per NBC

Points measured in kitchen	9.00am	12.00am	3.00pm	5.00pm
K1	1599	217	90	32
K2	439	95	28	9
K3	219	34	17	3
K4	126	20	16	1
K5	877	150	63	17
K6	430	58	32	8
K7	260	40	20	3
K8	191	34	21	3
K9	270	96	42	6
K10	256	68	26	6
K11	262	43	18	3
K12	165	34	18	3
K13	53	9	6	4
K14	35	15	9	4
K15	89	14	9	2
K16	73	20	11	2

NBC recommended lux levels for bedrooms-30-50-100

Table 4: Illumination levels measured for East side kitchen highlighting the readings required as per NBC

children's bedroom	9.00am	12.00am	3.00pm	5.00pm
C1	90	303	528	6

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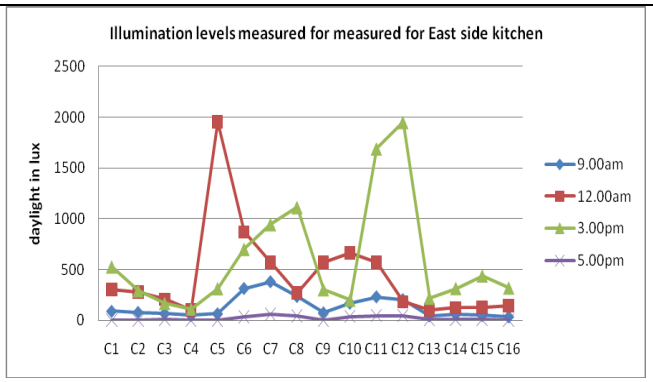

Fig 4: Illumination levels measured at various points in children's bedroom

Observations- The Points near window receive more light than required as per the NBC for maximum time of the day. This will cause glare resulting in straining the eyes. The readings after 12 & 3 pm are high. The points near the wardrobe are in shade.

C2	80	280	294	7
C3	68	208	169	12
C4	49	101	112	6
C5	66	1956	315	7
C6	315	870	702	36
C7	381	570	945	64
C8	236	270	1113	49
C9	76	572	304	8
C10	170	661	200	42
C11	233	570	1690	50
C12	205	180	1951	51
C13	46	100	220	9
C14	62	123	316	10
C15	50	126	440	10
C16	35	144	320	4

NBC recommended lux levels for bedrooms-30-50-100

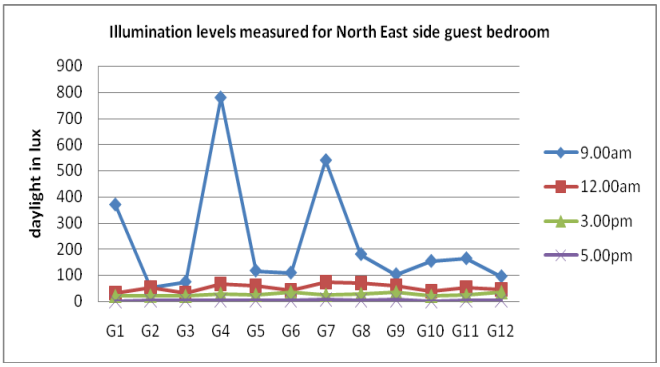

Fig 5: Illumination levels measured at various points North East side guest bedroom plan

Observations-the guest room receives ample light throughout the day. At 5 the room is under lit.

Table 5: Illumination levels measured for north East side guest bedroom highlighting the readings required as per NBC

Points measured in Guest bedroom	**9.00am**	**12.00am**	**3.00pm**	**5.00pm**
G1	370	33	21	1
G2	54	52	22	3
G3	74	32	21	4
G4	780	66	29	4
G5	117	58	25	5
G6	109	43	35	5
G7	540	73	25	7
G8	180	70	28	4
G9	103	58	35	6
G10	154	38	21	1
G11	164	53	23	3
G12	95	46	35	4

NBC recommended lux levels for bedrooms-30-50-100

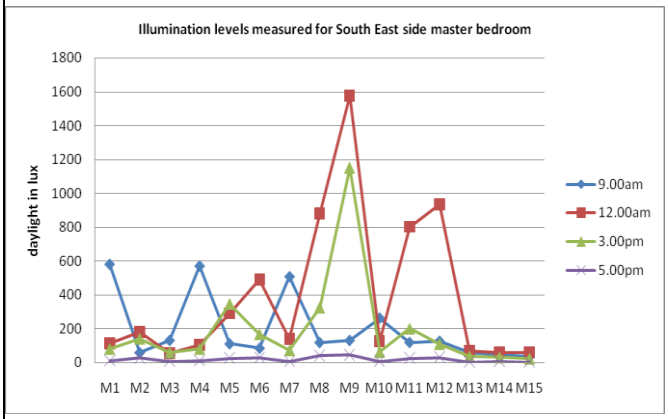

Fig 6: Illumination levels measured at various points in master bedroom

Observations- The near window zone receives glare. The light distribution throughout the room is good though

Table 6: Illumination levels measured for South East side master bedroom highlighting the readings required as per NBC

Points measured in master bedroom	**9.00am**	**12.00am**	**3.00pm**	**5.00pm**
M1	580	113	80	11
M2	60	180	140	27
M3	132	54	60	7
M4	570	105	80	11
M5	112	290	346	25
M6	86	490	167	28
M7	507	140	72	6
M8	120	882	325	40
M9	132	1578	1152	45

having dark coloured flooring, wall & furniture. The points near the wardrobe are in shade. There is grey matte flooring so light distribution is good.

M10	264	128	62	7
M11	120	802	200	25
M12	128	936	109	30
M13	60	68	36	3
M14	48	60	30	6
M15	38	59	22	3

V. Retrofitting Objectives and Measures

i) East side kitchen & west side living room

Retrofitting objectives

1. Increase quantity of daylight keeping even distribution.
2. Increase penetration of daylight

Retrofitting measures

- Adding wide light shelf from external wall surface at 2.5 m height for better light distribution & penetration.
- Adding glass partition in between kitchen & living within the furniture so as to allow passage of light from both rooms.
- Position windows to direct light to ceiling
- Introduce more light coloured surfaces for good distribution.
- Place windows near room surfaces for distributing light on walls and ceiling
- Large areas of dark color are not to be used.

ii) North Side guest bedroom

Retrofitting objectives

1. When sun travels wholly in southern hemisphere taking very short path, hence there direct sunlight penetration in the rooms facing east and south while the guestroom on north side receive diffused light for all the day time.

Retrofitting measures

1. Increase the WWR on the North wall to increase the quantity of light entering the window.

iii) South Side bedrooms

Retrofitting objectives

1. To reduce the illumination in the near window zone and also achieve even distribution of daylight.
2. Also solar altitude angle varies from 30^0 to 50^0 causing direct sun penetration through eastern and southern windows.

Retrofitting measures

- WWR on south can be reduced to curb the excessive illumination levels by lifting up the sill of these windows from 0.9 m to 1.2 m.
- Incorporate shading elements with windows to cut down harsh light
- Supply window coverings that allow individual control

iv) General Recommendations

- Size the windows and select the glazing at the same time.
- Use horizontal window shapes for more even light distribution
- Treat each window orientation differently for best daylight results
- Choose matte over shiny surface finishes. Matte finishes are recommended for good distribution of daylight and no reflected glare (hot spots).

VI. Retrofitting results from ECOTECT

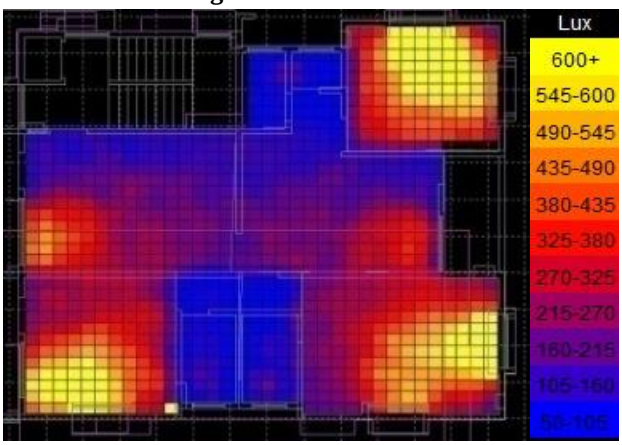

Fig 7: lux levels-Single door

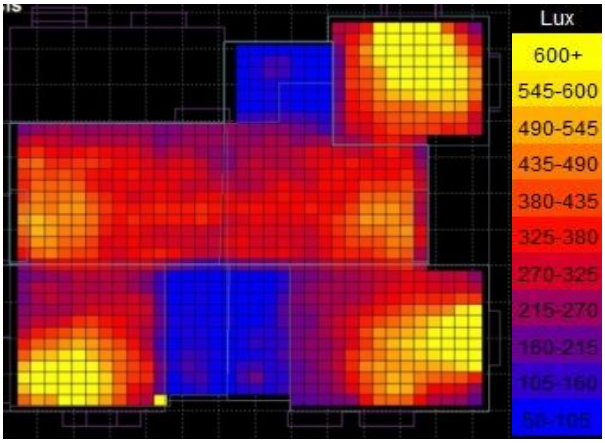

Fig 8: lux levels Larger opening French door

To achieve the benchmark mentioned by NBC and ECBC certain alterations were done in fenestration design, size, and location of openings and colour of surface from where light is reflected. There was deficit of light available in kitchen and living as it is having opening from one side that too shaded with balcony. So giving larger opening in the form of a French door was the measure adopted & tested. Lower sill levels on

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north and east side provides larger daylight penetration from east as suns angle is lower. Lighter white coloured internal surfaces reflect more light.

V. Conclusion

Human beings by nature are accustomed to live and work more comfortably in sunlight. Poorly designed day lit areas can be worse than spaces with no daylight. So Both economics and imperatives of health and aesthetics favour the practical use of daylight in the buildings. Simply adding a large number of windows to a building to let the daylight in the space can create excessive glare and unwanted heat gain making the space unusable. Proper design & careful decisions (size, orientation, shape, WWR, placement of windows) of windows (vision & daylight), light shelves, shading devices, skylights, use of colours & finishes will aid to ample naturally day lit spaces in turn saving energy & reducing energy costs associated with artificial lighting.

VI. Acknowledgements

I would like to acknowledge Sinhgad college of Architecture for providing the lux meters for the experimentation.

VII. References

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