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Maximum Utilization of Daylight in Residential Interior Spaces of Dhaka City

Iar.Abhik Barua

Senior Lecturer, Department Of Interior Architecture, Shanto-Mariam University Of Creative Technology.

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ABSTRACT:
Daylight is the main patron to accumulate the energy consumption in the residential building because it is the most valued natural resources available to architects and engineers to extend the visual quality of interior spaces.

It is endorsed that a significant reduction in artificial lighting and consequent primary energy consumption can be achieved by maximizing the use of natural lighting (daylight). Therefore, strategies are needed for more daylight insertion in the interiors of the residential building where electricity demand is very high.

The main objectives of this study are to maximize of day lighting that can help to save energy consumption and to develop the daylight performances in common spaces in residential building in Dhaka city, Bangladesh.

Keywords: Daylight, Energy Consumption, Residential Building, Artificial Lighting, Daylight Simulation, Tropical Region.

I. INTRODUCTION

Daylight is one of the most important natural forces available to architects in their quest to enhance the visual quality of interior spaces. The demand of residential building is getting higher for it's over growing population. Therefore, a remarkable problem of energy crisis is seen to be created and subsequently demand of extra energy is increased for residential building to fulfill the demand of over population.

In order to minimize this problem numerous researches have been carried in the last few decades.

II. METHODOLOGY

A Literature Survey was conducted to provide a knowledge base for the research and information about related climatic issues and daylight design principles for the given context. The climatic characteristics of Dhaka city were studied to set the climatic imperatives with regard to the expected luminous environment of residences in Dhaka City.

This research helped in generating and altering models to be used during simulation studies and also gave a theoretical basis for providing design guidelines for the luminous environment of residences appropriate for urban areas of Dhaka.

Subsequently a pilot survey was conducted on a sample size of fifteen residences to identify the characteristics design features of recent development of residences of Dhaka, by analyzing different spaces., and their components which affect the luminous environment, like details of windows (type, material, sill, lintel, shading, internal blinds), height of different objects in residence interior (work plane, partition, ceiling height) etc. A total of five residences were then selected from these fifteen, for detailed luminous investigation having all the relevant features, as representative of the types of residences commonly emerging in Dhaka City. The simulation exercise aimed to understand the influencing factors relevant to daylight design and to formulate design suggestions.

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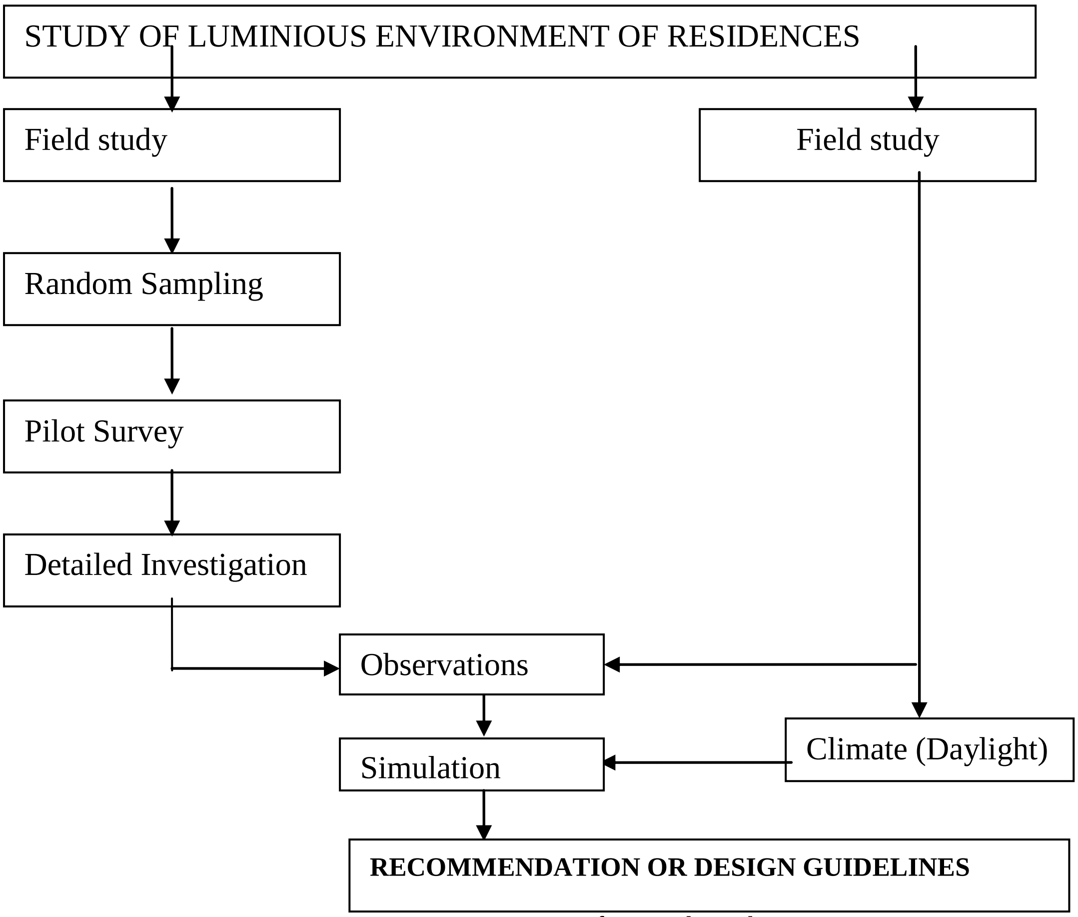

Figure 2.1: Structure of research work

III. DAY LIGHT AND RESIDENTIAL BUILDING

A building which is intended for several use and occupied continuously. A residence is that building where artificial light is the main contributor to the luminous environment of residence in Dhaka. Therefore, by reducing reliance on artificial lighting, daylight can be an effective means of saving on lighting energy. However, this reduction is also likely to affect other associated energy needs of spaces. Of all the large cities in the country, Dhaka has the highest consumption of electricity. Considering that finite resources of energy must be conserved in global terms, energy consciousness in the design of the luminous environment is essential. This will ideally lead to daylight residence buildings, with controlled supplementary electric lighting.

If daylight penetration of not given due consideration by the designer while locating and selecting size of windows, interior surfaces, lighting fixtures, etc. pressure will be created on the overall national energy demand. In such a context, the need to develop use of daylight in residential buildings, reducing dependence on artificial light, is necessary to save energy, which is extremely limited .Codes and standards exist for visual comfort, aiming to increase performance for equal energy spent in residences and need to be incorporated in lighting design. At the same time, the consequences of daylight inclusion, especially on cooling needs, also need investigation

3.1 Daylight Factor

Daylight or **the light of day** is the combination of all direct and indirect sunlight outdoors during the daytime. This includes direct sunlight, diffuse sky radiation, and (often) both of these reflected from the Earth and terrestrial objects. Sunlight scattered or reflected from objects in outer space (that is, beyond the Earth's atmosphere) is generally not considered daylight. Thus, moonlight is never considered daylight, despite being "indirect sunlight". Daytime is the period of time each day when daylight occurs.

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Daylight intensity in different conditions

Illuminance	**EXAMPLE**
120,000 lux	Brightest sunlight
110,000 lux	Bright sunlight
20,000 lux	Shade illuminated by entire clear blue sky, midday
10,000 - 25,000 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/rise

Table 3.1: Daylight intensity in different conditions

For comparison, nighttime illuminance levels are:

Illuminance	**EXAMPLE**
<1 lux	Moonlight
0.25 lux	Full Moon on a clear night
0.01 lux	Quarter Moon
0.002 lux	Starlight clear moonless night sky including airglow
0.0002 lux	Starlight clear moonless night sky excluding airglow
0.00014 lux	Venus at brightest
0.0001 lux	Starlight overcast moonless night sky

Table 3.2: nighttime luminance levels.

3.2 SOURCE OF DAYLIGHT

The origin of all daylight is the sun but the light may reach a work space via a number of paths. Direct sunlight is, no doubt, the brightest source. The other sources are the bright overcast sky, which is brighter than the clear blue sky. Daylight entering through windows under clear conditions illuminates an indoor point from five different sources as the day progresses. These are the sun, the circum-solar sky, the ground, opposite surfaces and the blue sky, with light entering downwards, upwards and horizontally. The available daylight that can replace artificial lighting is both direct sunlight and diffuse light form the sky. Sunlight reaching the thin layer of atmosphere is scattered, being redirected by the molecules that constitute air as well as by water and dust particles suspended in the air.

3.3 COMPONENT OF DAYLIGHT

Light form the sky reaches a particular point in a room as being composed of three distinct components. They are;

a) Sky component
b) External reflected component
c) Internal reflected component

3.3.1. Sky component

Sky component is the illuminance received at a point in the interior of a building, directly from the sky. The sky component normally refers to the diffuse sky; i.e. it is not used to describe direct sunlight. This component depends upon there being a view of the sky from the point in the room being considered. It is the view of the sky that gets larger as the point in the room being considered. It is mainly the sky component that leads to the strong variation of light intensity in a sidelit room.

3.3.2. External reflected component

The externally reflected component is the illuminance in the interior due to light reflected form external obstructions. The external reflected component is particularly relevant in dense urban situations, where, owing to the closeness of building, a view of the sky may be limited or even completely absent for all but positions very close to the window. The ERC will tend to come form a low angle close to horizontal. Depending on reflectivity of the obstruction, this may penetrate deeper into the space than the sky component, but because of the absorption of light by the external obstruction it will generally be much weaker.

3.3.3. Internal reflected component

Internal reflected component is the illuminance received at a point and is composed of light received indirectly from daylight that is inter-reflected around the internal surfaces of the space. It is obvious form that any light that is reflected form below the horizontal must be reflected a second time on the ceiling or upper wall of the room, in order to illuminate the horizontal plane, and will thus end up as the internal reflected component.

An important characteristic of the IRC is that it is fairly uniform all over the room. At the back of the room it is often the case that there is no SC and sometimes, in an L shaped room for instance, no ERC. Clearly the IRC then becomes very important.

3.4 THE BENEFITS OF DAYLIGHTING

Daylight is a full-spectrum source of light to which human vision is adapted. Recent studies have shown that proper daylighting of a building can increase productivity, decrease sick time and even increase sales.1 Daylighting has two general benefits: it can improve the quality of light in a space and reduce the amount of electrical lighting required. More importantly, daylight provides tremendous psychological benefits to building occupants; this should be a main goal of daylighting rather than the simple reduction of electrical lighting requirements. Good daylighting design requires consideration of a range of complex concerns. Since Canadians spend as much as 90 per cent of their time indoors, our good health is directly associated with receiving
optimal levels of quality light.

IV. CLIMATE OF DHAKA CITY

4.1 INTRODUCTION

In Bangladesh, the demand of residential building is increasing high for it's over growing population. Therefore, a tremendous problem of energy crisis is seen to be created and subsequently demand of extra energy is increased for residential building to fulfill the demand of over population. In order to minimize this problem numerous researches have been carried in the last few decades. This paper presents the results of simulations of daylight strategies in one simple pattern of room with six different windows configurations. Therefore, strategies are needed for more daylight inclusion in the interiors of the residential building where electricity demand is very high. The main objectives of this study are to identify parameters of day lighting that can help to save energy consumption and to develop the daylight performances in a simple room in residential building in Dhaka city, Bangladesh. This study also helps the Bangladesh National Building Code (BNBC) to identify the minimum daylight parameters for a typical residential building which is constructed by local materials.

4.2 CLIMATE OF DHAKA CITY

Dhaka city has mainly three different seasons. These are:

1. The hot dry season (March-May)
2. The hot humid season (June- November)
3. The cool dry season (December- February)

April is considered as hottest month and is considered average temperature is available as 30.3 – 34.8 degree c

January is considered as coldest month and is considered average temperature is available as 9 – 15.2 degree c

Table: Sky condition with respect to cloud covers for year (Joarder, AR, 2007.)

Type of Sky	Hot Dry	Warm Humid		Cool Dry Dec-Feb	Total Day
	Pre-Monson March-May	Monsoon June-Sept	Post-Monsoon Oct-Nov		
Clear Sky	62	38	39	77	215
Overcast Sky	30	84	22	14	150
Total Days	92	122	61	90	365

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Figure3.1: sky condition

Sky condition with respect to cloud cover for year is shown in Table 1. It is seen that April is the hottest month with average temperature of 32 deg C and January is the coldest month with temperature of 15 degree C.

V. LITERATURE REVIEW

5.1 BUILDING FORM AND DAYLIGHT PENETRATION

To maximize daylighting potential, a shallow floor plate is preferred. Alternatively, inner courtyards, roof monitors and atriums can bring light into central cores, especially in low buildings. This Guide provides information that is primarily relevant for perimeter daylighting conditions.

The **amount** of light that penetrates a room depends upon the window orientation, size and glazing characteristics. The **distance** that adequate daylighting will penetrate into a room depends upon window location and interior surfaces. There is a direct relationship between the height of the window head and the depth of daylight penetration. Typically adequate daylight will penetrate one and one half times the height of the window head, although it may penetrate a distance of twice the height under direct sunshine. Daylight penetration into a space can be increased by using light shelves. This is a horizontal element with a high-reflectance upper surface that reflects light onto the ceiling and deeper into a space. Light shelves can be interior or exterior, in which case they also can provide shading.

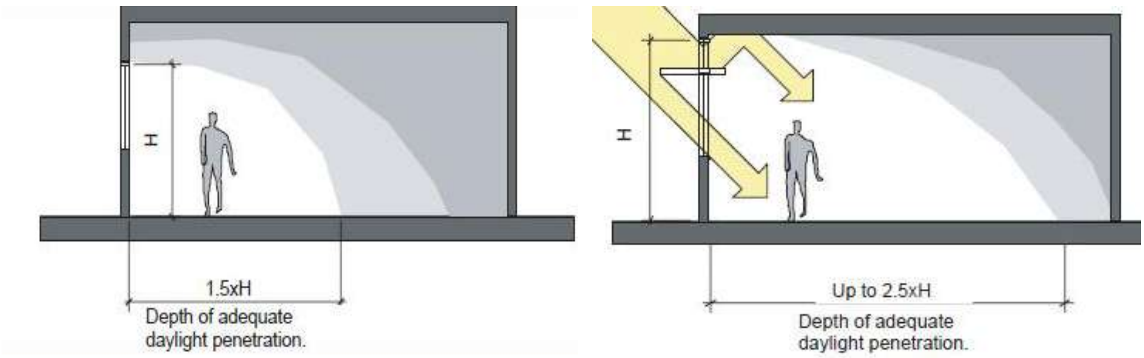

Figure: 5.5.1: daylight penetration

Skylights and light pipes can provide daylight through a roof to the interior spaces below. Skylights often also allow heat gain in the summer time and can be a potential source of glare. Diffusing glazing can help alleviate this problem. Light pipes collect light through an exterior transparent dome and bring it to the interior through a reflecting metal pipe and a diffuser at the ceiling level of the space. The efficiency of fixed light pipes is reduced by absorption from the walls of the pipe. The light is reflected repeatedly as it travels through the pipe. The light loss is proportional to the length-to-width ratio of the pipe (the more times the light is reflected within the pipe, the more light is absorbed). Properly sized light pipes are effective at bringing daylight to interior spaces without the associated heat gain and glare problems of skylights. To maximize useful daylight, service spaces should be in areas with the least daylight access. However, designers should consider providing day lighting to stairways and corridors, as views of the outside will encourage users and allow light to penetrate deeper into the building.

5.2 LIGHT REFLECTANCE VALUES (LRV)

Light Reflectance Value (LRV) is the total quantity of visible and useable light reflected by a surface in all directions and at all wavelengths when illuminated by a light source. The light reflectance value (LRV) is the proportion of light reflected by a colour, as measured in daylight conditions. The greater the light reflectance value, the lighter the colour. White and very bright yellows have the highest light reflectance values and are therefore recommended for highlighting key safety features. Bright blues, on the other hand, have comparatively low light reflectance values. The main purpose of these values is to allow measured contrast between two surfaces which need to be readily distinguishable to all who use the environment. In static conditions, a difference in these values of 30% or more is considered to be adequate, though a best practice application would employ a considerably stronger contrast than this, particularly in relation to key safety features, where the strongest possible contrast should be used. This guidance uses a scale of 0 -100, where 0 = black and therefore total light absorption, whereas white = 100 and therefore total light reflection. We provide LRV values for all laminates in the availability table.

Figure: 5.2.1: LRV scale

LRV is a measurement that tells you how much light a color reflects, and conversely how much it absorbs. LRV runs on a scale from 0% to 100%. Zero assumed to be an absolute black and 100% being an assumed perfectly reflective white. An absolute black or perfectly reflecting white does not exist in our everyday terms. Approximately speaking, the average blackest black has a LRV of 5% and the whitest white 85%. Some yellows can measure up into the 80′s or 90′s as well.

It is true that LRV communicates a lot about a potential wall color, possibly provides even more of a sense of the color than those very small color chips – and we all know the issues with relying on just the small color chips.

5.3 Light Reflective value of the paint

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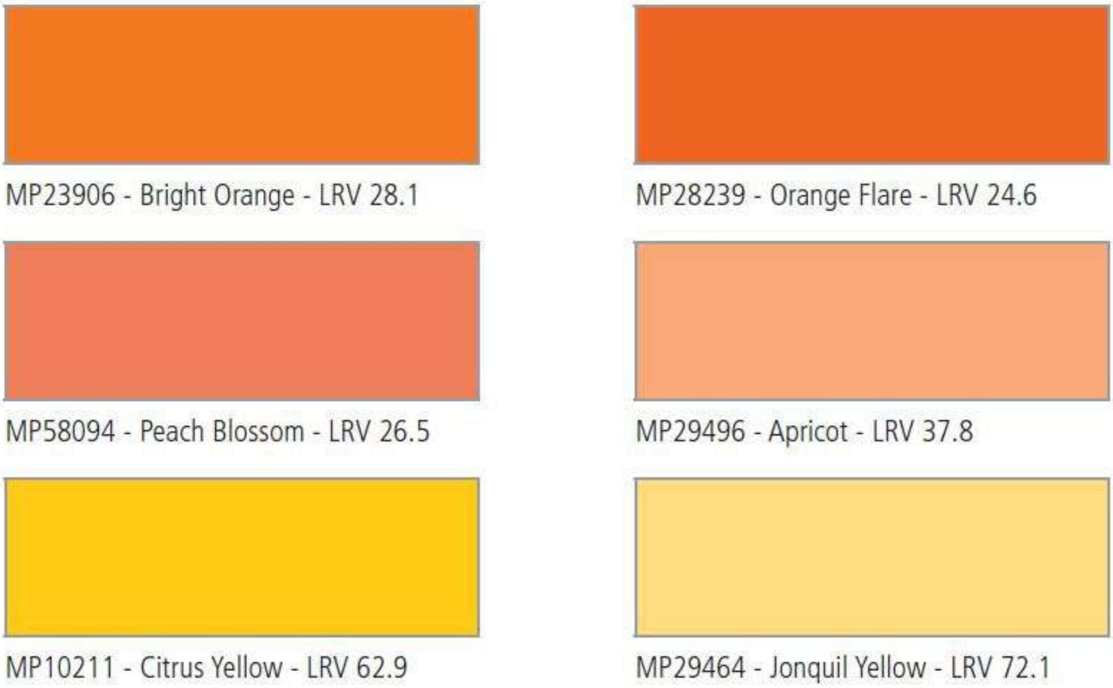

It is clear that high reflectivity is important, but most commonly used materials and finishes are not very reflective, as one can see from the measurements below. Final finishes for surfaces common in interior spaces, such as wood, linoleum, and fabric (felt and linen), have a maximum of 40% Light Reflectance Value (LRV).

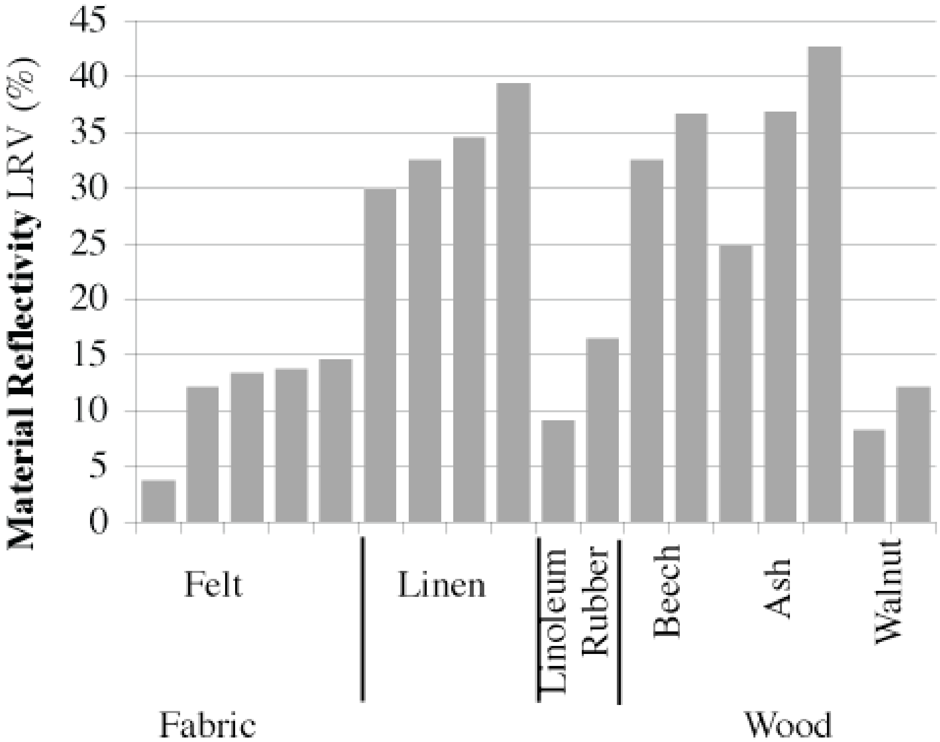

Figure: 5.3.2: LRV of Different material

LRV refers to the percentage of light reflected by the paint color regardless of how much light is present. The LRV number is a measurement, a piece of data and is one of the few things about a color that is a consistent factor. No matter from what direction the natural light enters a room, no matter what reflection of color you get from the other elements in the room, no matter what other conditions exist that will affect the context in which the wall color is experienced, the LRV is the LRV. However LRV can be misleading when it comes to yellow. Yellow is one of the most reflective hues in the spectrum. In addition, the more area it covers it grows more intense exponentially. People err when choosing yellow more than any other color. They end up with a too bright Lemon Chiffon yellow that borders on needing eye protection to enter the room when they really were going for a softer, more muted Buttercream color.

VI. CASE STUDIES & PILOT SURVEY

The common spaces residence covered in the pilot survey are;

Living Room
Family Living
Dining

The items covered in the pilot survey are;

Details of window
Floor finished material
Wall finished material
Ceiling Finished material
Daylight Illumination
Soft furnishing
Two surveyed data given in below

6.1 Case study 01

ROAD 10, HOUSE27, SECTOR 09, UTTARA, DHAKA.

Figure6.1.1: Google MAP:

Observations of spaces

Common spaces of Residential Building like;
Living Area
Dining Area
Family Living Area

Observations of study are;

Window sizes
Reflectance Value of
Curtain
Floor material
Ceiling material
Wall material
Day Light factors of the common spaces

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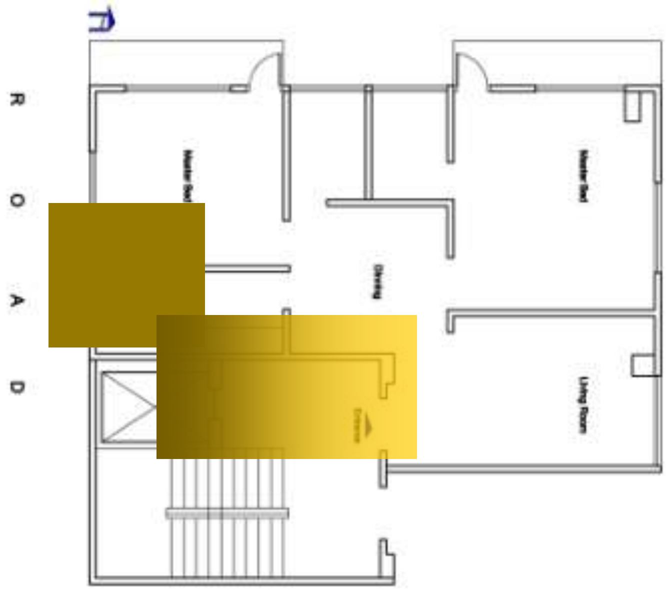
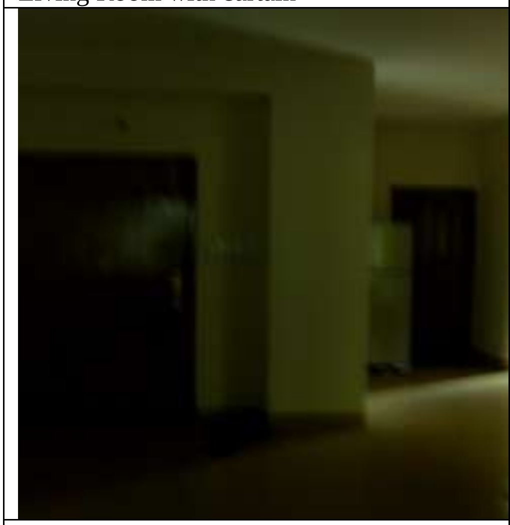


Figure 6.1.2: **Plan, Day** light penetration

Figure 6.1.3. **Case study01 & Pilot survey of interior spaces**

	
Living Room with curtain	Living room with out curtain
	

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6.2 Case study02
1ST FLOOR, ROAD12, HOUSE43, SECTOR 09, UTTARA, DHAKA.
Google Map

Figure6.2.1: Google MAP:

OBSERVATIONS OF SPACES
Common spaces of Residential Building like;
Living Area
Dining Area
Family Living Area

OBSERVATIONS OF STUDY ARE;
Window sizes
Reflectance Value of
Curtain
Floor material
Ceiling material
Wall material
Day Light factors of the common spaces

Case study02

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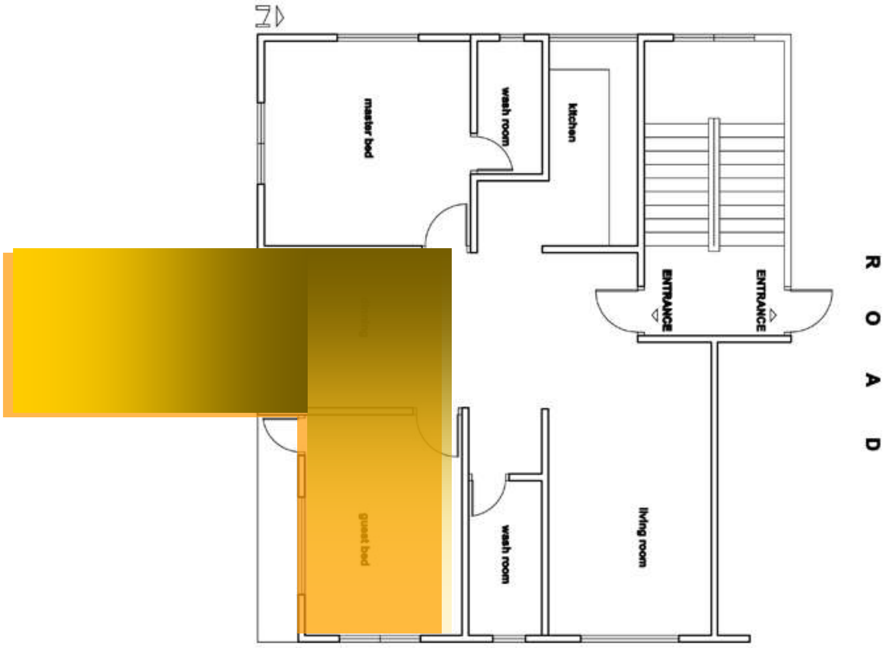

Figure: 6.2.2: **Plan**, Survey area

Figure: 6.2.3: **Case study02 & Pilot survey of interior spaces**

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VII. FINDINGS OF THE PILOT SURVEY

As Dhaka city possesses almost similar climatic, geographical, technological and other aspects in its different part, the characteristics features are also quite similar for residence in different area. Some variations on features were however identified during the survey. Most of the residence used coffee color glass with coffee color frame and furniture material are wooden polished and wall nut color and most of the soft furnishing and hard furnishing are brown color.

The findings of pilot survey can be summarized as below;

Daylight penetration on work plane will be high if the windows start from work

Plane height and terminate to the ceiling.

Lack of sense of Furnishings color

No standard for window

Lack of sense of reflective material

VIII. RECOMMENDATION

The findings of the field survey helped to identify the general problems related to daylight inclusion of residences in Dhaka and to fix the criteria for generating a model for simulation.

The findings of this section are based on simulation results considering the Daylight Factor Concept. From the study, the following recommendations were drawn for residence design in the context of urban Dhaka to improve the luminous environment of residence. Some step could be introduce for enhancing the daylight in residential building are;

1. Free up the windows

Perhaps the best way to start is by clearing the windows of obstruction and opening them up to the sunlight. Many windows have bars or heavy drapes that prevent the maximum amount of light from getting through. Similarly, windows are often grimier – and consequently less clear – than they ideally could be.

2. Repaint the walls

Dark walls absorb light while brighter walls tend to reflect it. On this note, repainted walls is a great way to get more use out of the natural light that filters through home's windows.

3. Use reflective flooring

On a similar note, reflective floor surfaces can be equally helpful in creating a brighter interior space. The best options for this approach are white tile floors and well-shined hardwood flooring. Dark carpets, on the other hand, are generally to be avoided.

4. Replace wood and brick surfaces with glass

Any wall in interior spaces currently composed of wood, brick, or plaster can be replaced with glass so as to bring in more light. Glass can also be used as a reflective material in kitchen designs and other interior spaces.

5. Install a skylight

It goes without saying that a skylight can obviously help bring more natural light into residence. It can maximize its benefit by placing a new skylight in a room that, by design, doesn't get much sun. Candidates include bathrooms, walk-in closets, and hallway corridors.

6. Enlarge the windows

Bigger windows will quickly translate into more light absorbed into the home.

7. Raise the ceilings

Large rooms are usually more capable of trapping and reflecting natural light. Towards that end, knocking down the ceilings, eliminating the attic, and making common areas taller can help these rooms feel far airier and brighter.

8. Maximize mirrors

There is one final reflective material that can be used to increase light: mirrors. While mirrors will surely bounce any sunlight onto opposing walls, make sure to position these mirrors so as to avoid directing the sun straight into a person's eye.

9. Using Reflective materials

It is found that daylight is influenced by the External Reflective material, internal reflective material; window sizes. Day light factor could be enhanced by taking the following steps;

Light Reflective soft furnishing

Light Reflective floor finishes

Light Reflective window glass and frame

Resizing the window

Location of window

Light Reflective ceiling material

Light Reflective wall finishes

Using Mirror in the Interior space

IX. CONCLUSION

These experiments showed that the eye is capable of making separate judgments about color reflectivity, and therefore the results provide a proof of my hypothesis:

1. That designers/people overestimate colors and can't tell their Light Reflectivity by just looking at the color or the surface.
2. That the most colorful colors are not necessarily the darkest ones.
3. That the average rooms can appear very colorful without changing room reflectivity.

The implications from these results are that designers should not rely on their intuition but need tools to optimize color reflectivity and the use of other surfaces and materials of higher reflectivity in interior spaces to improve lighting efficiency and visual comfort without losing the design effect. Day lighting is well documented, as is the architectural role of reflectivity, but the connection between day lighting and reflectivity and color reflectivity needs to be further explored. Further testing will be done to determine how position affects the perception of color. My hypothesis is that low reflective interior surface effects like rich color can be achieved with little change to the space's overall reflectivity. In the case of rich colors, some surfaces (for example, walls) play a less important role in delivering average room reflectivity than others and are candidates for locating color if those same surfaces are primary to the perception of the overall color of the space. These results will be evaluated to find a rule for the perception of color, which will lead to design applications for the use of color in interior spaces. This will be pursued further in a large experiment.

REFERENCES

[1]. Ahmed, Z.N. 1987. The effects of Climate on the design and Location of windows for Buildings in Bangladesh, MPhil thesis (unpublished), Sheffield City Polytechnic.

[2]. BNBC. 1993. Bangladesh National Building Codes, Housing and Building Research Institute and Bangladesh Standards and Testing Institute, City Art press Ltd, Dhaka.

[3]. International Energy Agency. 2000. Daylight in Buildings, a source book on daylighting systems and components, A report of IEA Solar Heating and Cooling Task

[4]. Energy Conservation in Buildings and Community Systems Programme, Annex 29, July.

[5]. Joarder, M.A.R, Ahmed, Z.N., Price, A.D.F. and Mourshed M.M. 2009. Daylight Simulation for Sustainable Urban Residence Building Design in Dhaka, Bangladesh:

[6]. Decision-making for Internal Blind Configurations, 2nd International Conference on Whole Life Urban Sustainability and its Assessment, 22-24 April, (SUE-MoT 2009), Loughborough, UK, pp. 218-41.

[7]. Joarder, M.A.R. 2007. A Study of Daylight Inclusion in Luminous Environment of Residences in Dhaka City, M. Arch Thesis (unpublished), Department of Architecture, BUET, Dhaka.

[8]. A.G.S. 2000. Architectural Graphic Standards, John Wiley & Sons, Inc. New York, CD Rom Versions.

[9]. Ahmed, K.S. 1995. Approaches to Bioclimatic Urban Design for the Tropics with Special Reference to Dhaka, Bangladesh, Phd. Thesis (unpublished),Architectural Association School of Architecture, London, U.K.