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The Relation of Residential Lighting and Occupants Behavior, Perception and Welfare

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Abstract:
Lighting is an essential component of interior design that provides functional and aesthetic qualities for the users of the space. The impact of Lighting not only on the reduction but also to highlight the beauty of residential space according to function and distribution of selected spaces is of interest in this study. The purpose of this research is to generate a complete overview of residential lighting that demonstrates the relation of residential lighting and residents users' perceptions. The question presented in this study addresses whether residential lighting has an effect on human behavior, which eventually impacts how the occupants feel comfort, safety, and relaxation.
The methodology of conducting research from the prior research involves the thematic approach, in which credible scholarly journal articles written between 1996 and 2010 were reviewed with the relation of occupants' behavior and residential lighting in mind. The objective of this paper is to explore-support, or nullify-whether lighting affects human behavior in residential environments through the evaluation of journal articles discussing occupant's behavior, perceptions, and energy efficiency that is impacted by lighting. The findings suggest lighting design in residential environments is essential for the well-being of occupants. While lighting may not directly affect occupants in a noticeable way, evidence from research indicates that occupants are in fact influenced by lighting. Designers must determine occupants' needs for light in every corner as appropriate to their specific family requirements, taking into account the activities that occur in every room of the house. Designing lighting should be accompanied by taking care of the designed environment, sensitive optical artistic inclinations, as well as the overall quality of lighting.

Keywords
- **Residential Lighting**
- **Occupants Behavior,**
- **Perception**
- **interior design**

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Introduction

Lighting is an essential component of interior design that provides functional and aesthetic qualities for occupants of the space. Residential applications of designs include lighting that is utilized to accommodate occupants through elements of physical and mental comfort. The following literature review addresses residential lighting according to its effects of human behavior, perceptions, and lighting efficiency.
Lighting helps you to accomplish some tasks such as reading, sewing, cooking, writing duties, and the exercise of identities and other activities. Residential Lighting should be comfortable, unobtrusive, glare-free, and with free-veiling effects.

Research Problem

Previous studies have focused on light, color, or windows in laboratory settings only, with little emphasis on real-life indoor working conditions. Problems with light in homes can lead to residents' anxiety and stress, adult patient suffering, and may result in a general decline in the health of growing infants. There is concern that minimizing light levels in homes will lead to home impairment that may impact people safety and well-being.
Lighting Cost analysis information related to environmental factors could aid in decision making during home renovation, easing financial concerns.

Research Question

The question presented in this literature review addresses whether residential lighting has an effect on human behavior, which eventually impacts how occupants feel comfort, safety, and relaxation. Does residential lighting have an effect on human behavior? And how occupant feels comfort, safety and relaxation depend on lighting design?

Research Methodology

The methodology of conducting research for the literature review involves the thematic approach, in which credible scholarly journal articles written between 1996 and 2010 were reviewed with the relation of occupants' behavior and residential lighting in mind.

Objective

The objective of this paper is to explore -support,

or nullify-whether lighting affects human behavior in residential environments through the evaluation of journal articles discussing occupants' behavior, perceptions, and energy efficiency as they are impacted by lighting. This study explained whether lighting conditions in residential environments affect the user's daily activities of those who live indoors in homes. Also, all data collected were used as a guide in designing lighting in residential home.

Findings

Information retrieved from journal articles indicates a correlation of residential lighting and human behavior, which in some cases influences the occupants' behavior, depending on the occupants' cultural and personal preferences. The evidence used to support the relation of lighting to occupants is shown through function, behavior, and energy efficiency, as described below:

Function

Functional and Aesthetic Lighting Design

The relationship between functional and aesthetic in lighting design is related to each other. Many of concepts in the lighting field are conscious of, and curious about, the aesthetic possibilities of lighting design (Jay, 2002).

Objective criteria in lighting design are usually based on measured visual performance. Functional and efficient performance of lighting is important, but the aesthetic effect is also important, such as the lighting in dining, breakfast, and hall areas. Lighting is considered ordered when the light source layout is proportional to the layout of the space; while lighting is considered coherent when modeling or shading is even across the space (Jay, 2002).

Designers must organize lighting according to the layout of the space and ensure lighting coherence when shading. They should create an evenly-lit space in functional areas (e.g., kitchen, dining, and living room) and bring in task-specific lighting if more light is needed in certain areas. Also, they must utilize simple lighting fixtures in functional areas and utilize decorative fixtures in walls where the luminaires are more likely to be noticed. Designers must light each display area from its optimal angle in setting and living room. Designers should order leading the eye evenly from one area of emphasized importance to another. They also ought to produce dramatic appearances by creating high contrast lighting conditions(Jay, 2002).

Illumination and Apparent Brightness

Lighting brightness in residential applications can determine an important impact in occupants' behavior. Lighting temperature and color characteristics have an effect on apparent brightness, which is important for designers to consider when choosing lamps for interior lighting. Correlated Color Temperature (CCT), Color Rendering Index (CRI), Gamut Area, or chromaticity alone is not good predictors of brightness response because each one only describes a limited aspect of the lamp spectrum (Fotios, 2001).

Designers should know that when color temperature increases, the illuminance for equal brightness will decrease. They must use a prime color cool white fluorescent lamp (PCW) for greater visual clarity over a standard cool white fluorescent lamp (CW). HGHP and T8 lamps have an equal brightness and are significantly brighter than CW, WHPS, and MH lamps. Also, lamps with a higher CCT will be perceived as significantly brighter(Fotios, 2001).

Light can be measured objectively with a photometer providing a more precise and repeatable method than through subjective human vision. Retinal lighting (full field lighting) describes the visual responses to ambient lighting that help facilitate larger visual tasks. Different illuminance levels may be due to different photocell locations in each room, which will have a tendency to misrepresent the effect of the lamp spectrum in rooms that are matched for equal brightness(Fotios, 2001).

Safety and Lighting

People fall on stairs due to both the physical condition of the stairs (e.g., poor surface condition, objects on stairs, absent or poorly designed lighting). Users often practiced unsafe behavior (e.g., using stairs in the dark, leaving objects on stairs) when using stairs but they felt their precautions (e.g., counting stairs in the dark, no good lighting, and leaving objects only at the foot of the stairs) reduced the degree of risk. Designers have determined the occupants' perception of risks associated with stairs, and suggested ways to make stairs safer (Haslamet al., 2001).

Designers should install dimmer switches or motion sensors on lights in stairwells in homes of occupants who may neglect to light the stairs (e.g., to avoid waking up spouse). By using daylighting (e.g., windows) to guarantee that stairs are adequately illuminated during daylight hours is helpful, however ensuring that window placement does not cause excessive, debilitating glare is important (Haslamet al., 2001).

Lighting and Age Influence Reading Ability

The impact of age and luminance affects print legibility (deciphering words and letters) in homes, offices, and public spaces. Due to physiological changes to the eye as people age, it is important to provide adequate luminance in the

workplace and home to maintain and improve work and reading performance. Understanding how people actually illuminate homes, offices, and public spaces can help determine if light levels meet standards and can assist users investigating disorders influenced by seasonal light changes (Charness&Dijkstra, 1999).

Incandescent lighting was the most preferred lighting type and most people had specific preferences for room color. Women used nature, memorabilia, and color to identify their writing spaces while men used a desk area, privacy, and size to create a work space (Zavotka& Timmons, 1996).

Designers should add desk or ceiling light fixtures, use higher wattage lamps, and provide additional lighting to increase the luminance in office environments to improve productivity. Designers must provide suitable fixtures and light sources in homes and offices to ensure that light levels are sufficient for readers of all ages. They should ensure that areas where reading and writing occur are properly illuminated to improve legibility of print materials.

Behavior

Lighting for Everyday Activities

Daylighting has many benefits, both for energy savings, as well as for the occupants of the space. All lighting patterns were considered suitable for activities that did not require high visibility (e.g., yawning or stretching, resting, waiting, walking and talking, walking at a slow pace, and sitting) (Oyama, 2004).

Designers should know the perceptions of the suitability of artificial light and daylighting in the performance of a variety of common tasks in homes. Measuring occupants' perceptions of the suitability of lighting for specific activities and behaviors should have a place when designing residential environments. Daylighting was characterized as being high in brightness, non-uniform, and fluctuating and was thought to be suitable for refreshment, negotiations, and meetings. Artificial light was characterized as bright, steady, and slightly uniform and was perceived as being unsuitable for writing documents, refreshing, and resting(Oyama, 2004).

Lighting Needs at Home

Poor lighting conditions threaten health and long-term well-being. The potential benefits of proper lighting are important when suggesting adaptive measures for individuals. Designers should know the potential of proper lighting to improve home safety for individuals, and make recommendations to improve low-vision awareness and prevent related falls in the home.They should consider the importance of proper lighting and how lighting needs differ between individuals. Designers must provide residents suitable lighting options and involve comfort for users when designing lighting. Designers should improve lighting techniques in the home (e.g., wall washing & wall grazing), and allow space for healthy vision setting at the same time (Slay, 2002).

Perceptions of Direct and Indirect Lighting

The ratio of direct to indirect lighting may affect the brightness, shadowing, visual comfort, and uniformity of light distribution, spaciousness(Houser & Tiller, 2002). Designers should make a room appear more spacious by using a greater amount of indirect lighting. Designers must identify human responses and preferences for direct (down-lighting) and indirect (up-lighting) lighting effects in residential environments. Designers must decrease shadow effects in a room by using a large indirect component in the lighting system. Designers must use uniform lighting requirements for acceptable visual comfort (glare and eye comfort), and achieve ceiling lighting uniformity. Indirect lighting is generally attributed to the use of uplights, whereas direct lighting is attributed to the use of downlights (e.g., bedrooms and bathrooms). Indirect lighting gives an overall sense of spaciousness to the room, whereby use of extensive direct lighting makes the room seem smaller and less spacious (Houser & Tiller, 2002).

Lighting Types on Performance and Mood

The influence of lighting on an individual may be impacted by social and cognitive processes, in addition to the characteristics of the lamp itself. In environments with varied surface colors, the lamp-type/surface color combination could influence a setting's aesthetic appeal, consequently impacting performance or mood as a function of cognitive processing. The beneficial effects of certain lighting types on performance and mood may be influenced by beliefs and individual expectations rather than facts about the lamp itself (Veitch, 1997).

Designers should know the influence of information about lighting on an individual's performance and mood when working in choosing lighting types and fixtures. Though choosing some lighting that is similar to natural daylight can improve an individual's performance, vision, and mood, existing research confirms an improved ability to accurately distinguish colors (Veitch, 1997).

Efficiency

Characteristics of Compact Fluorescent Lamps

Energy demands are increasing every year; increased use of compact fluorescent lamps may

reduce the need to build new power plants. Compact fluorescent lamps last longer and consume less energy than incandescent lamps; they save consumers money over the long run and can be used in regular, wired-in luminaries (Topalis, et al., 2002).

Designers should compare and contrast the initial cost and potential energy consumption of compact fluorescent and general lighting lamps when designing a residence. Also, designers must use compact fluorescent lamps in residential buildings to reduce lighting costs, and reduce harmonic voltages by either installing distributed filters or by improving the quality of electronic control gear to reduce energy consumption (Topalis, et al., 2002).

The Aesthetic Value of Energy Efficient Lighting

Over one fifth (22%) of electricity consumed in the United States is used for lighting and most (90%) residential lighting is incandescent. Using energy efficient lighting may be a way to reduce the emission of greenhouse gases (Banwell, et al., 2004).

Designers must know and evaluate the public preferences for energy efficient fluorescent lighting in a model home. As the average size and ceiling heights of American homes increase, more lighting equipment and lamp wattage are required for residential lighting. It is important for designers to utilize the features of new fluorescent technology (e.g., small size, dimming capability, range of correlated color temperatures, wattages, and lengths) to provide indirect, ambient lighting in homes. Designers have to substitute screw-based compact fluorescent lamps in decorative luminaires equipped with standard incandescent lamps to increase energy efficiency. They should incorporate architectural features (e.g., coves and valances) in the design of the home to provide concealed locations for linear fluorescent lamps. Designers must consider details of the home (e.g., architectural features and color schemes) and of the homeowner (e.g., lifestyle) when developing lighting designs for a new home. Energy efficient lamps and lighting strategies may be beneficial to residents; long-life lamps require less changing (and reduce ladder-related risk) and their indirect illumination may improve task lighting. Lighting plans early in the design phase of the house can reduce the need for changes, upgrades, and consequent higher costs later during construction (Banwell, et al., 2004).

Occupants preferred visual characteristics of energy efficient lighting (e.g., does not cause unattractive shadows, feels comfortable, people and colors look attractive) in their homes. Energy efficient lighting may increase illuminance and decrease maintenance and costs for homeowners. Characteristics of energy efficient lighting (i.e., higher efficacy, longer life) may reduce energy costs, especially in high use areas (e.g., kitchen) (Banwell, et al., 2004).

Daylighting Saves Energy

Artificial lighting is one of the leading energy-consuming sources in residential environments. Using daylight to illuminate buildings may reduce energy consumption and make the indoors livelier and more pleasant (Li & Lam, 2003).

Designers must provide windows for daylight and proper daylight-linked controls for luminaires to save energy on indoor lighting. They must consider specifying low-illuminance fixtures (luminaires) with daylight-linked lighting control systems in interiors to maximize energy savings. Also, they should provide top-up daylight controls (controls that vary lamp light according to the prevailing light level in a space) on luminaires for environments designed with high levels of indoor illuminance. Daylight is the best source of light for good color rendering, and it makes an interior look lively and attractive.

Lights Life and Dimming

Designers should give attention the relationship between lamp dimming (due to inclusion of daylighting) and the total life hours of lamps during designing homes. Natural daylight and artificial lighting can be combined in room illumination by using fluorescent lamps with automatically dimmed ballasts. By using automatic lighting controls, energy consumption can be reduced by 30%-70% (Tetri, 2002).

Designers should design lighting environments with daylight-linked control systems to save energy, since dimming will not affect the performance and life of the lamp. They must incorporate electronic ballasts in lighting systems to minimize energy consumption and maximize the life of the lamps. Also, switching fluorescent ballasts on and off is more detrimental to lamp life and energy consumption than dimming when setting automatic dimming controls (Tetri, 2002).

Lighting design theories

There are many lighting applications that one can study, but this paper will focus on lighting for the home environment. A home lighting plan must be developed to suit different lifestyles. Designers must determine occupants' needs for light in every space as appropriate to the residents' specific needs. This should take into account the activities that occur in every room of the house. Design projects revolve around three dimensions: The scientific dimension, the technologic dimension, and the artistic dimension. Artistic dimension revolve around three functions: Pragmatic

function, symbolic function, and psychological function. The lighting scheme renders the space: Spacious or cluttered, appealing or appalling, exciting or depressing, and pleasing or boring. All of which ultimately have an impact on the mood and behavior of the occupant in the built environment.

There are different lighting designs theories depend on type's impression:

1. ***Impression of Spaciousness***

A moderate amount of general ambient lighting, a greater amount of perimeter lighting, and warm colors should appear to advance and cool colors to recede (Gordon, 2003; Michel, 1996). It uses of secular surfaces, such as mirrored walls can double the sense of space. Mirrors reflect the opposite walls to stretch a room's boundaries. To maximize this impression, lighting should be directed toward the un-mirrored walls. If the room is small, attention should be put on distant objects to permit the eyes to focus beyond the immediate environment and thus erases the possible claustrophobia. Distant objects should be illuminated to catch the attention. Also, if the room is small, the furniture should be kept to a minimum (Gordon, 2003; Michel, 1996) (see Figure: 1).

Figure 1: Lighting design theory: Impression of Spaciousness in home

2. ***Impression of Perceptual Clarity***

This may be obtained with a high level of uniform, white light. Emphasis is placed on overhead lighting with large, visible, direct type of luminaires (e.g., fluorescent troffers, luminous ceilings) as opposed to perimeter lighting with cove or indirect light, or wall brackets (Gordon, 2003; Michel, 1996). Painted surfaces, walls and ceilings in a light color of a high reflectance, as opposed to patterned wallpapers, are preferred. If there is no visual task, the lighting scheme may contribute to boredom because there are no stimulating elements in the spatial formation (Gordon, 2003; Michel, 1996) (see Figure: 2).

Figure 2: Lighting design theory: Impression of Perceptual Clarity in home.

3. ***Impression of Relaxation***

Relaxation implies rest for the tired body (Gordon, 2003; Michel, 1996). All glares are to be avoided. Very low level of ambient light from accentuated or wall wash light in a non-uniform pattern provides this relaxed atmosphere. Table lamps, accent or wall wash, rather than large ceiling mounted luminaires should be used, and dimmer switches can fine tune the lighting level to

individual requirements (Gordon, 2003; Michel, 1996). In general, invisible light sources, low illuminance, subdued color, low wall brightness, fading to a dark upper ceiling are most restful (see Figure: 3).

Figure 3: Lighting design theory: Impression of relaxation in home

4. Impression of Privacy

A non-uniform lighting pattern, with a center lighting level dimmed but a higher brightness beyond, yields an impression of privacy (Gordon, 2003; Michel, 1996). Impressions of Privacy are desired in restaurants or bars, where customers tend to congregate in under lighted areas, but prefer a view that is brighter. Experiments show that the preferred visual task is a warm tone (e.g., incandescent or candles), as opposed to fluorescent or mercury lamps (Gordon, 2003; Michel, 1996) (see Figure: 4).

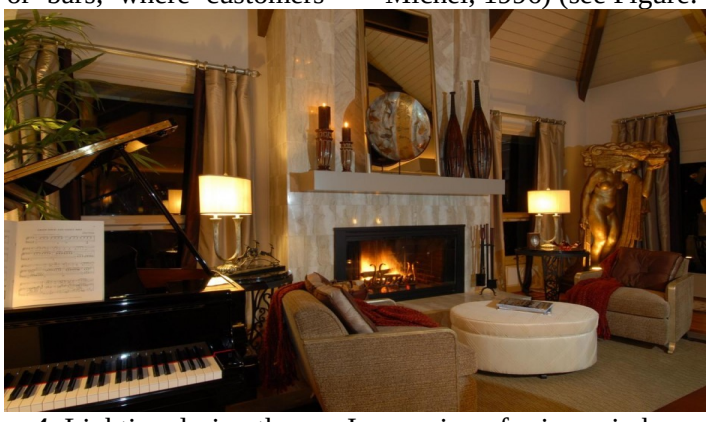

Figure 4: Lighting design theory: Impression of privacy in home.

5. Impression of Pleasantness

This is the most sought after environment in almost all applications, particularly in an office like atmosphere, in which a steady use of the eyes is involved (Gordon, 2003; Michel, 1996). Practical experiments conducted by experts in the field have provided a general answer: A non-uniform lighting with strong emphasis on peripherals (walls in particular) is the most appropriate (Gordon, 2003; Michel, 1996) (see Figure: 5).

Figure 5: Lighting design theory: Impression of pleasantness in home.

6. Impression of Boredom and Monotony

Boredom and monotony occur when the visual tasks are uninteresting, and no stimulation emanates from the spatial elements, including environmental lighting (Gordon, 2003; Michel, 1996). Uniform blankets of light throughout the room and a consistent dull-colored perimeter often contribute to boredom, monotony and unpleasantness (Gordon, 2003; Michel, 1996) (see Figure: 6).

Figure 6: Lighting design theory: Impression of boredom and monotony in home

7. Impression of Depression

Dim light and dim dark colored surroundings in black or dark brown are often the major contributors to depression (Gordon, 2003; Michel, 1996). A room paneled dark brown, covered in dark brown or black carpet, and equipped with low-level lighting is an example (Gordon, 2003; Michel, 1996) (see Figure: 7).

Figure 7: Lighting design theory: Impression of depression in home.

8. Impression of Drama, Gaiety, and Excitement

Non uniform lighting of varying brightness, including such extremes as sparkles and glitter, moving or flashing light and peripherals of stimulating color patterns express drama and excitement (Gordon, 2003; Michel, 1996). This environment also tends to encourage conversation (see Figure: 8).

Figure 8: Lighting design theory: Impression of drama, gaiety, and excitement in home.

9. Impression of Confusion and Clutter

An impression of confusion is felt when non-uniform lighting and or color patterns clash with spatial information (Gordon, 2003; Michel, 1996) (see Figure: 9).

10. Impression of Cave Effect and Insecurity

A cave effect is achieved when a highly illuminated task area is located inside a large room with dark peripherals (Gordon, 2003; Michel, 1996). If the visual task is illuminated with table lamps or localized, self-standing forms (not on the ceiling) and no other light sources exist for ambient perimeter lighting; the effect is at its maximum (Gordon, 2003; Michel, 1996) (see Figure: 10).

Figure 9: Lighting design theory: Impression of confusion and clutter in home.

Figure 10: Lighting design theory: Impression of cave effect and insecurity in home.

Design Project

Designers should be aware of the importance of the Lighting Reflectance Value (LRV) of the color under investigation. For instance, we do know that dark colors absorb light, however brighter colors reflect light. We must also take into account multi-purpose rooms; these spaces might need a flexible lighting design, including different lighting possibilities. When choosing lighting fixture units, one should consider the financial resources, durability, and maintenance (see Figures: 11-22):

Figure 11: Floor plan (GF & FF).

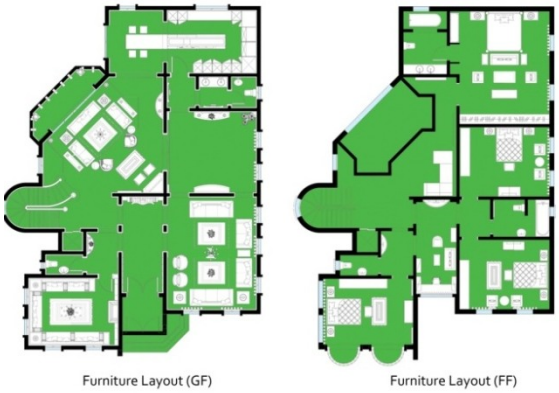

Figure 12: Furniture layout (GF & FF).

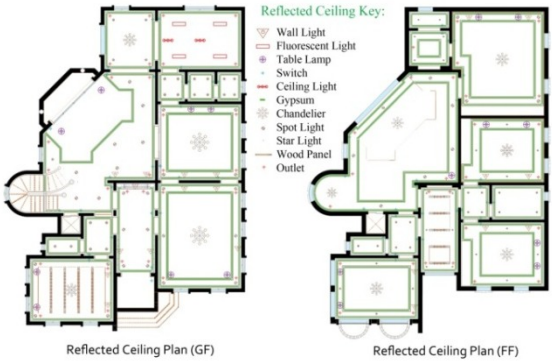

Figure 13: Reflected ceiling plan (GF & FF).

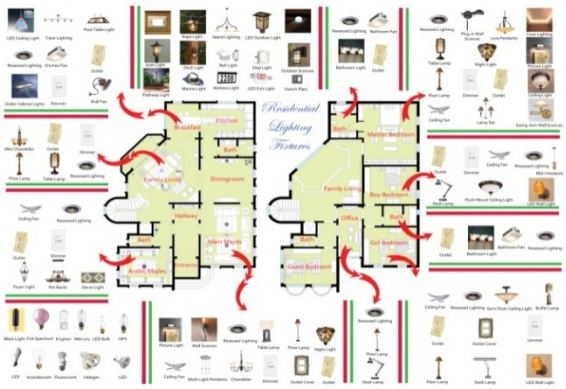

Figure 14: Lighting fixtures collection (GF & FF).

Figure 15: Main Majlis plan & Reflecting Ceiling (GF).

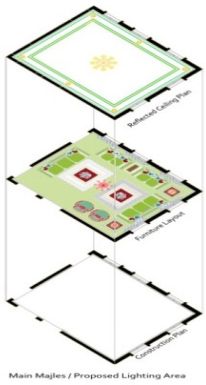

Figure 16: Main majlis plan, furniture layout, and Reflecting Ceiling (GF)

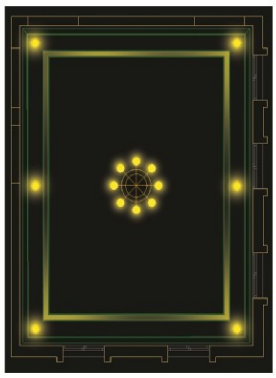

Figure 17: Lighting effect in Main Majlis Ceiling (GF).

Figure 18: Main Majlis West Elevation (GF).

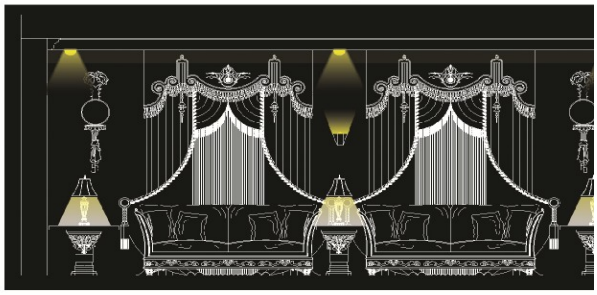

Figure 19: Lighting effect West elevation / Main Majlis (GF).

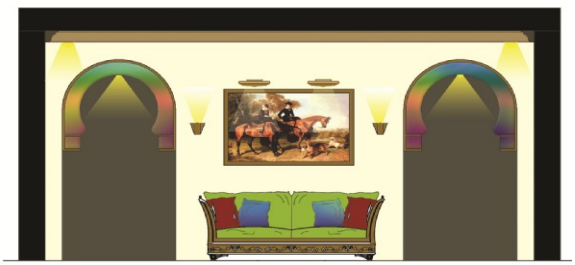

Figure 20: Main Majlis South Elevation (GF).

Figure 21: Lighting effects in South Elevation / Main Majlis (GF).

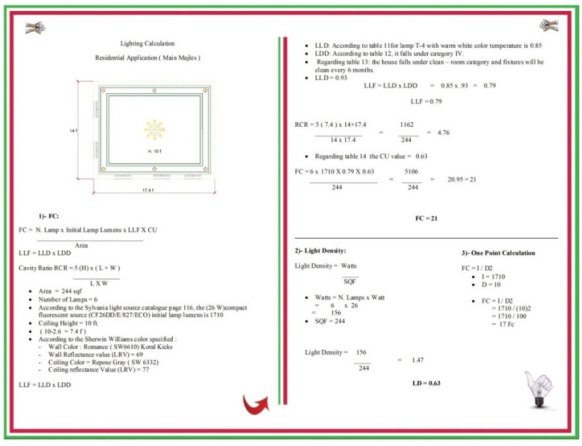

Figure 22: Lighting calculation for Main Majlis (GF).

Conclusion

In conclusion, lighting design in residential environments is essential for the well-being of occupants. While lighting may not directly affect occupants in a noticeable way, evidence from research indicates that occupants are in fact influenced by lighting. It is pertinent that designers are aware of the impacts that environments have on occupants. Lighting is an important component of design that aids in creating and preserving the well-being of users.

As this literature review offers insight on behavior, function, and energy efficiency in residential lighting, additional research should be addressed in order to generate a more complete

overview of residential lighting that demonstrates the relation of residential lighting and occupants' behavior. Due to a lack in available current research on a direct relationship of the effect of lighting on occupants' behavior, this literature review only provides the basics for the beginning of an in-depth review of residential environments, lighting, and occupants' behavior. Further research needs to be conducted to form a more complete understanding of the effects of lighting on occupants' behavior in the built environment.

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