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Day lighting in Healing Spaces

Study of effect of day lighting in healing architecture in Warm and Humid Climate of India

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ABSTRACT

The intent of this research is to explore how architecture can enlighten healing or provide spaces where healing can take place. The healing environments, make wellness centres less stressful and promote faster healing for patients and improve well-being for their families, as well as creating a pleasant, comfortable and safe work environment. Light impacts human health and performance by enabling performance of visual tasks, controlling the body's circadian system, affecting mood and perception, and by enabling critical chemical reactions in the body. Natural light should be incorporated into lighting design in healthcare settings, not only because it is beneficial to patients and staff, but also because it is light delivered to people at no cost and in a form that most people prefer. Study involves comparing healthcare settings in warm and humid climatic zones and how day lighting plays an important role in healing. Appropriate day lighting thus impacts outcomes in healthcare settings by reducing depression among patients, decreasing length of stay in hospitals, improving sleep and circadian rhythm, lessening agitation among patients, easing pain, and improving adjustment to night-shift work among staff. The appropriate positioning and optimisation of windows/ openings in the workplace and access to daylight have been linked with increased satisfaction with the surrounding environment.

Keywords : Healing Spaces, Lighting Design, Healthcare, Day Lighting

I. INTRODUCTION

The intent of this research is to explore how architecture can enlighten healing or provide spaces and events where healing can take place. We as human beings have an inner connection with our environment by physical, mental, emotional and spiritual means. Healing cannot be understood in isolation from the factors that operate in the dynamic life of an individual. These include the self, the family, the community, the environmental context within which life is carried forth and the world of spirit or essence.

The question is can lighting in architecture do the same? Besides, can architecture play a superior role in healing? Our built environment we often interact with the buildings themselves without knowing the fact of relationship between building and surroundings. This research summarize the principals of life enhancing role of architecture and planning in the healing process.

II. LIGHT IN BUILDINGS

Most healthcare settings, as well as other buildings, are lit by a combination of daylight entering through windows and skylights and electric-light sources. It is important to understand how these two types of light sources differ to understand their relative impacts on human health and performance. Sunlight is electromagnetic radiation in the wavelength range that can be absorbed by the photoreceptors of the eye. Sunlight provides a balanced spectrum of colours with elements in all parts of the visible wavelength range. Studies suggest that daylight is not inherently superior to artificial lighting for performance of most visual tasks. However, natural light has benefits over electric- light sources in regulating circadian rhythms and maintaining overall health.

A. HOW LIGHT IMPACTS HUMAN HEALTH AND PERFORMANCE

Light impacts human health and performance by four main mechanisms:

- ✓ Enabling performance of visual tasks
- ✓ Controlling the body's circadian system
- ✓ Affecting mood and perception
- ✓ Facilitating direct absorption for critical chemical reactions within the body (1).

B. ENABLING PERFORMANCE OF VISUAL TASKS

The most obvious effect of light on humans is in enabling vision and performance of visual tasks. According to Boyce and colleagues (2003), the nature of the task—as well as the amount, spectrum, and distribution of the light—determines the level of performance that is achieved. Performance on visual tasks gets better as light levels increase. (2) A study by Santamaria and Bennett (1981) shows that, if the amount and distribution of light are controlled, most everyday visual tasks (such as reading and writing) can be performed as well under artificial light sources (such as fluorescent light) as under daylight conditions. However, daylight is superior for tasks involving fine colour discrimination when it is provided at a high level without glare or any reduction in task visibility caused by veiling reflections or shadows. Another factor that affects performance on visual tasks is age, and the need for light increases as a function of age due to reduced transmittance of aging eye lenses. (1)

C. EFFECT OF DAYLIGHT ON HUMAN BODY

British Standard (BS 8206, 1992) treats daylight as two distinct sources of light: skylight, the diffuse light from the whole sky; and the sunlight, the direct solar beam. However, many research, mostly conducted by clinicians, consider daylight and sunlight as synonyms and describe the effect of daylight as the effect of sunlight. For example, the effect of sunlight on patient health, but measured the illumination inside hospital rooms by light meters, which are unable to distinguish between sunlight and skylight and provide the sum of sunlight and skylight measurement. Daylight is the sum of sunlight and skylight. (1) Day lighting, the technique that optimizes the use of natural light to illuminate interiors, is becoming increasingly popular; not only for its ability to transform the visual environment of the room dramatically, but also for its natural healing qualities . The quality and quantity of daylight have major impact on human body. As the effects are less quantifiable, benefits of daylight are often overlooked. Physiological and psychological impact of daylight is the outcomes of either some hormonal (e.g. serotonin/melatonin) activities or chemical reactions in the blood or skin (e.g. pigmentation). The impact of daylight on the psychological diseases are mostly due to lights incident on the retina of the eye and cause modification of individual endocrine, hormone, and metabolic state. (1)

With the progress of lighting research, nowadays the impact of daylight has been recognized more than only psychological. Light improves health and recovery rate by affecting the human body chemistry. Increased light intensity could reduce the common subclinical problems on hospital patients such as oversleeping, overeating, energy loss and disturbance in concentration. The impact of light on the physical diseases are mostly due to lights incident on the skin that results in production of vitamin D, skin tanning and dissociation of bilirubin. When daylight incident on the eye and/or the skin of human body, collectively it regulates circadian rhythm, improved motor skills, less physiological fatigue, and the overall improvement of task performance, those are vital for patient recovery under hospital environment. (1)

It has been found from several studies that bright daylight has positive impact on health. On the other hand, inadequate lighting can cause moodiness and cravings for carbohydrates It is also identified light as a nutrient for body similar to water or food for metabolic processes and Wurtman (1975) claimed that some of these important biological effects of light on body could be measured in a laboratory. The effects of incident light on body can be categorised in two levels. (1)

a) Indirect effect: when light incident on the eye and generate neural or neuroendocrine signal by the photoreceptor cell.

b) Direct effect: when light incident on the skin and cause photochemical reaction within the tissue.

D. THE IMPACT OF LIGHT ON OUTCOMES IN HEALTHCARE FACILITIES

Better outcomes for patients on the unit's bright side experienced less perceived stress.

- ✓ Experienced less pain
- ✓ Less analgesic medication per hour
- ✓ Less medication costs
- ✓ People prefer daylight to artificial sources of light for work and prefer to be close to windows
- ✓ Glare and thermal discomfort may impact mood and task performance negatively.

The findings from these studies vary because people's preferences and expectations may impact how they respond to different lighting conditions. Also, factors such as glare and thermal discomfort may actually affect mood and task performance negatively. While there isn't convincing evidence linking the presence of windows to improved mood and performance outcomes, it is clear that natural light is the preferred source of light for most people. It is important to provide access to daylight along with opportunity to control glare and lighting levels.

III. PSYCHOLOGY OF LIGHTING

Because we are dependent on light for perception, it is natural that we should be psychologically affected by it. Throughout our history we have attached metaphysical, even divine, qualities to light. Light plays a central role in our everyday lives and consciousness through the physiological processes that connect our health to it. We wonder at the beauty of a sunrise or sunset with its ever-changing colours. Sunlight gives us a sense of time and a connection with the outside world, a connection often needed by our inner biological clock. The history of architecture is one of a relationship between ourselves and sunlight. Light is often used by architects as a metaphor, a mood-giver or a carrier of a meaning in and of itself. The works of past and present master architects express this central role. Much of their work is highly acclaimed because of the magnificent interplay between structure, form, and light. The chapel of Notre- Dame-du-Haut at Ronchamp, France, by Le Corbusier is a boldly expressive free-form structure in which the symbiotic association between the form and the interior natural light identifies the essence of the building, making it the central element of the design concept. Through irregularly sized and shaped windows piercing the southern thick masonry wall of the chapel and from three light towers emerging through the roof much like wind catchers, light enters the space from multiple directions, bouncing off richly textured surfaces, and through coloured glass that imparts unequalled poetic and spiritual qualities that have made the building one of the icons of modern architecture. (2)

Fig 1 - Eg: Notre-Dame-du-Haut chapel, Ronchamp, France, Le Corbusier, 1950–1954.

A. AFFECTING MOOD AND PERCEPTION

Boyce and colleagues describe studies that clearly show that people's moods are affected by different types of lighting conditions. Changes in mood are likely to affect changes in behaviour and performance at work. However, mood changes do not remain the same across different people with the same lighting conditions. Rather, for the same lighting conditions, an individual's discomfort, preferences, expectations, and gender impact how mood changes. Studies have shown that people prefer daylight to artificial sources of light for work and like to be close to windows (Heerwagen & Heerwagen, 1986). Heerwagen and Heerwagen found that office occupants preferred daylight over electric lighting for seven different purposes: psychological comfort, office appearance and pleasantness, general health, visual health, colour appearance of people and furnishings, work performance, and jobs requiring fine observation. Greater sunlight has also been linked to higher job satisfaction. (1)

Windows are a source of daylight and views, and it seems natural that the presence of windows at work would be related to improved mood and work performance. However, this has been challenging to prove. In some studies, having access to a window reduced negative mood in some people, though not in other studies (Boyce, Hunter, & Better outcomes for patients on the unit's bright side

- ✓ Experienced less perceived stress.
- ✓ Experienced less pain.
- ✓ Took 22% less analgesic medication per hour.
- ✓ Incurred 21% less medication costs.

Windows

- ✓ People prefer daylight to artificial sources of light for work and prefer to be close to windows.
- ✓ Glare and thermal discomfort may impact mood and task performance negatively.

Boyce and colleagues (2003) suggest that the findings from these studies vary because people's preferences and expectations may impact how they respond to different lighting conditions. Also, factors such as glare and thermal discomfort may actually affect mood and task performance negatively. While there isn't convincing evidence linking the presence of windows to improved mood and performance outcomes, it is clear that natural light is the preferred source of light for most people. It is important to provide access to daylight along with opportunity to control glare and lighting levels (Boyce, Hunter, & Howlett, 2003). (1)

B. LIGHT AND MOOD

Initial studies exploring lighting and human behavior focused on our preferences in lighting conditions, particularly in the workplace. The common results among these studies suggest that people prefer much higher light levels than those typically recommended by professional organizations. To cite only a few examples, American students were found to prefer illuminance levels as much as three times higher than those recommended. Office workers performing clerical work preferred light levels 50%. higher than those generally recommended (500 lux) according to two studies in the United States (Hughes and McNelis, 1978; Barnaby, 1980). A Dutch study found that office workers would prefer to have on average 800 lux more than was supplied by their electric lighting system, regardless of the amount of daylight available (Aarts, 1994). A similar result was found for

British office workers (Saunders, 1969). The consensus findings of these studies are not surprising since most of the lighting recommendations made by professional organizations are intended to be minimum light levels, with the expectation that actual levels would be higher. (1)

IV. FINDINGS: PHYSICAL ASPECTS AFFECTING DAY LIGHTING DESIGN

The physical factors affecting day lighting design have been identified in the pilot study of 4-bed indoor wards environment. The key findings on the physical aspects are explicitly noted qualitatively based on the critical observation and subjective testing. Hence, analysis is required in the next study to corroborate the qualitative observation and opinion with the quantitative data of luminance and illuminance of daylight in the ward environment with regard to visual comfort.

A. Building Orientation

In hospital building, orientation plays a major part in the early process of the design. In fact, it can be argued that is the highest priority in the design decision for achieving sustainable hospital environment. Regrettably, a preliminary finding seems to indicate that most healthcare designers regard physical planning issues as the topmost priority to be sorted out at the early stage of hospital design. This is due to the fact that designing a hospital building is generally accepted a complex task both: functionally and psychologically.

In theory, the decision on building orientation will subsequently influence the design of the physical aspects (i.e. shading devices, window opening, placement and profile). Similarly in hospital design, where creating a healing environment is the primary concern, orientation of the building does influence the design of the windows directly affecting the quality of day lighting (i.e. glare effect and daylight distribution) and access to outside view (i.e. optimize the surrounding scenery). Hence, it would have a significant impact on the end users' (i.e. patients, medical staff and visitors) experience and wellbeing. Providing access to outside view through a window would provide patients in the ward environments with a sense of orientation and connection to the external environment. Absence of this would have a negative impact on building users' as discovered by Verderber and Reuman. Investigation conducted in the pilot studies on building orientation illustrates the following:

It has been found that in the SIH building; most of the 4-bed wards are placed to face North-South direction. As a result, no direct bright light appears on the floor surface of the ward during the day. Most importantly, disability glare or discomfort glare are avoided. This would certainly be the outcome if the building orientation is placed in East-West direction, allowing the main elongated façade to face North-South.

Nevertheless, the SH-1 and SH-2 hospital buildings are not exactly oriented in the East-West directions. As a result, it is estimated that 20 to 30 per cent of the 4-bed wards are almost directly facing East and West. This results in the wards having direct bright light (at low angles) on the floor surface of the wards at certain period of the day. Consequently, patients and staff do experience unwanted warmth and discomfort glare.

B. Window Design

In the research fraternity of healing environment, there is a growing consensus recognising the window as one of the most significant physical aspects for patients and medical staff physically, psychologically and mentally. There are two benefits of windows: one is daylight and the other is view. In an empirical research conducted by keep and others as quoted by Jana et al. (2005); of two groups of individuals in the intensive ward therapy unit: one was unit without windows, and the other with translucent windows; indicates that patients with translucent widows were more oriented during their stay and gain better health outcomes such as avoiding sleep disorders, hallucinations and delusions. Even with translucent windows in this aspect do provide the vital link to the outside world for patients and the feeling of orientation helped to maintain their normalcy (Jana et al., 2005). Conversely, a well-designed window is not an intuitive task; it requires careful architectural, environmental and cultural considerations (Todd, 2007).

V. LIGHTING SYSTEM DESIGN

Luminous intensity, luminance, luminous flux and illuminance are the four basic parameters used in lighting system design. Different types of lamps used in lighting system design with their luminous efficiency and lamp service life is given in Table 1. The various factors to be considered in the design of lighting system for hospitals are :

Natural Illumination: The provision of natural illumination and access to windows is always appreciated by patients and should be considered in the design. Also it is required to limit sun penetration so that thermal and visual discomforts do not occur.

Type of Lamp	Lumens per watt	Average lamp life in hours	Color rendering
Incandescent	8–25	1000–2000	100
Fluorescent	60–600	10000–24000	82–95
High Pressure Sodium (HPS)	45–110	12000–24000	83
Low Pressure Sodium (LPS)	80–180	10000–18000	5
Metal halide	60–100	10000–15000	87–93
LED	28–79	25000–100000	40–85

Table 1- Lamp efficiency and service life

i) As the common lines of sight for the patient in the hospital is toward the ceiling and the top portion of the opposite walls, design should avoid glare to patients, while still providing good visibility to hospital professionals. A limiting glare index is recommended for each application6). Discomfort glare is quantified by the Unified Glare Rating (UGR) derived using equation (1) below. (4)

Lb = background luminance (cd/m2), excluding the contribution of the glare sources.

$$UGR = 8\log_{10}\frac{0.25}{L_b}\sum\frac{L_S^2\ 3}{p^2}$$

LS= luminance of the luminaire (cd/m2).

= solid angle subtended at the observer's eye by the luminaire (steradians).

P= Guth position index.

Typically UGR values ranges from 13 to 306. The lower the value, the less is the discomfort. (3)

ii) Colour rendering requirements: The ability of a light source to render colours of surfaces accurately can be conveniently quantified by The Commission Internationale de l'Eclairage (CIE) general colour rendering index. The colour rendering index is used to compare the colour rendering characteristics of various types of lamp. Eight test colours are illuminated by a reference source, which is a black body radiator of 5000 K correlated colour temperature or 'reconstituted' daylight if more than 5000 K is needed). These eight colours are then illuminated by the test lamp. The average of the colour differences produced between the source and the test lamps provides a measure of the colour rendering properties of the test lamp. The recommended values are given in Table.

iii) Recommended reflectance values are given Table.

Area	Illuminance in Lux	Limiting glare index	Minimum colour rendering
General lighting	100	19	80
Waiting rooms	200	22	80
Corridors: during the day	200	22	80
Corridors: at night	50	22	80
Day rooms	200	22	80
Staff office	500	19	80
Staff rooms	300	19	80
Reading lighting	300	19	80
Simple examinations	300	19	80
Examination and Treatment wards	1000	19	80

Table 2 - Recommended lighting requirements for different areas in a hospital (3)

Surface	Reflectance
Ceiling	0.7 or higher
Walls	0.5–0.7
Partitions	0.4–0.7
Floor	0.1–0.3
Furniture	0.2–0.5
Window blinds	0.4–0.6

Table 3 - Recommended Reflectance ranges

VI. COMPUTER SIMULATION USING DIALUX

Computer programs are preferred in architectural projects to design the lighting systems. Using simulation, concepts can be visually compared during the design phase in order for decisions to be made prior to construction particularly in the lighting calculations due to its ability to provide visual impact of the lighting design for the projects without requiring any real life applications either for all or part of the project such as adding furniture or placing certain interior elements. It also provides an easy way to calculate the required lighting installations and optimize the energy usage. (3)

In this article, DIALux simulation software is used for the analysis. Professional lighting designers have been utilizing DIALux software due to its many features such as the Render feature, user-friendliness, the ability to optimize the lighting distribution and quantity which will lead to energy efficient lighting system design. For these reasons DIALux based simulation is proposed in this article. The simulation also helps to check compliance with requirements specified in standards, such as uniformity of illuminance and the recommended lux level. (3)

A. CASE STUDY

One of the leading Wellness Centre Ayurvedagram Health Retreat in Bangalore is considered for the case study. The area of treatment block is 482 sq. m (21m X 21m)

- Dimension of each treatment room is 10m X 10m
- Dimension of each toilet is 2.3m X 2.3m

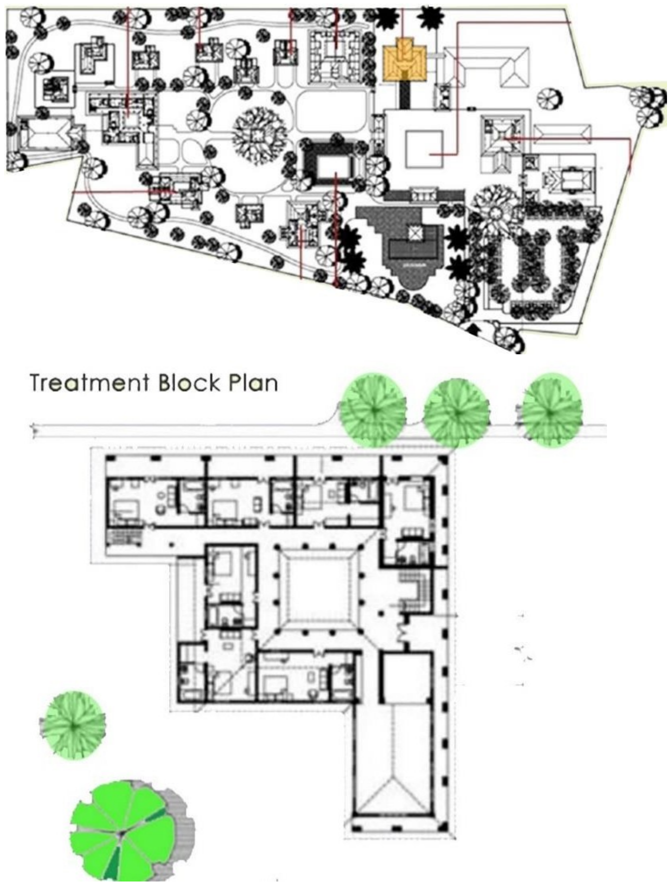


Fig 2- The site plan of Ayurvedagram Health Retreat

The Diagnostic and Treatment room is a rectangle of 10 m wide, 10 m long and the height of the room is 4 m. This room is divided into small diagnostic rooms separated from each other by sliding wall. The reflection coefficients (supposed diffuse) of the walls are ρ wall = 0.5, floor ρ wall = 0.2, and the ceiling ρ ceiling = 0.79. The required Lux level as per table is 1000 lx. The measurement of required illumination was taken on a work plane that has a height 0.850 m and a grid of 32x32 points were selected. The maintenance factor is assumed as 0.8. The visual comfort shall match the glare index and the colour rendering index is set as per the recommended standards (According to standards). The price of energy consumption for healthcare applications in Bangalore is 10Rs. per unit of energy (kWh) consumed. Three lighting scenarios were applied to know the visual comfort through glare effect, colour rendering and the power consumption of the diagnostic and treatment room of the hospital through the use of different types of lamps like incandescent, CFL and LED lamps. In the design, the working hours of the hospital is assumed to be 24 h a day, seven days a week. DIALux 7.1 simulation software is used for the daylight analysis on Ayurvedagram Health retreat and the simulation results are shown for each scenario.

B. Scenario 1 (Existing)

The typical diagnostic and treatment room in Ayurvedagram is illuminated through the use of down light equipped with compact fluorescent lamps.

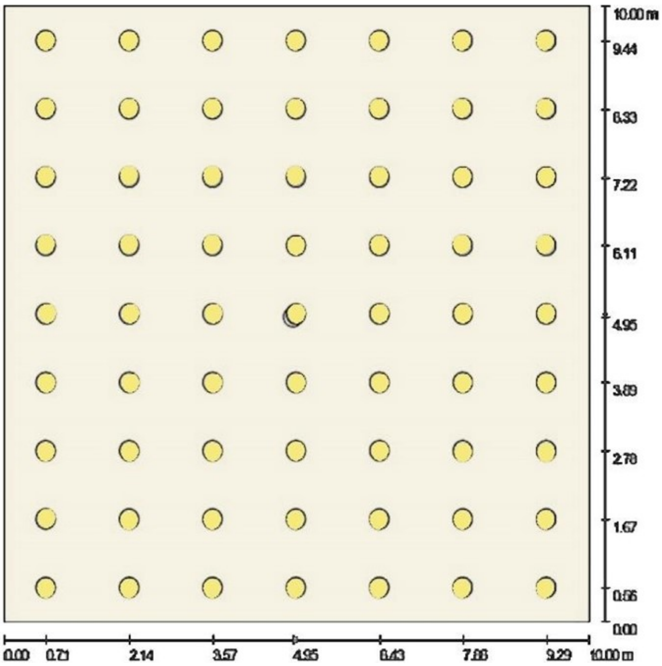


Fig 3- Layout Plan

The luminaire layout plan is shown in Figure above. 3-D rendering is shown in Figure which is an accurate representation of the lighting effect. It shows effect of lighting on different area in the room.

Consider, the single treatment room with an area of l= 10m, width= 10m, height= 4m. The ceiling to desk height is 2m

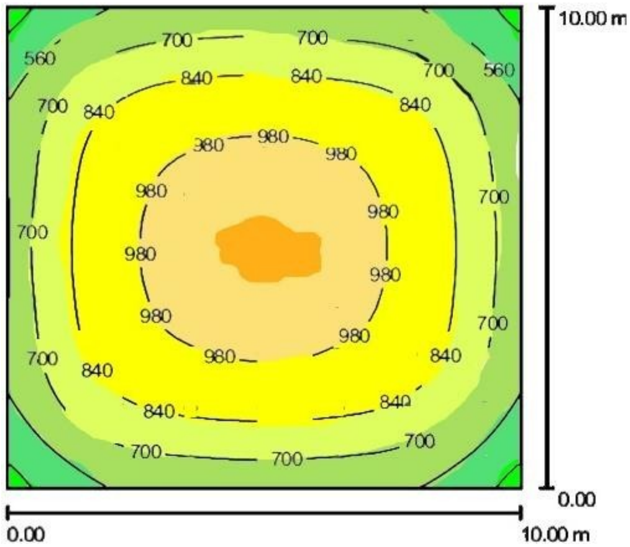


Fig 4- Lighting distribution values

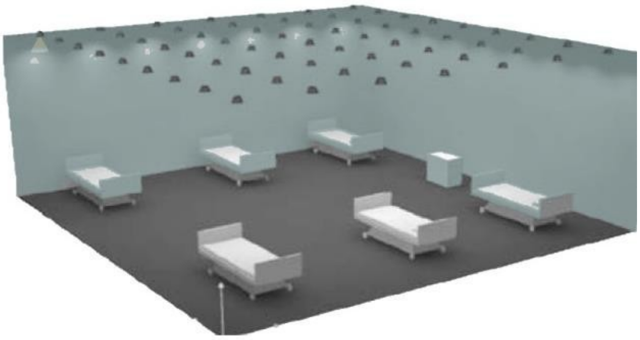
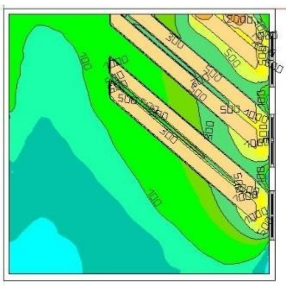


Fig 5-3d rendering

The area to be illuminated to a general level of 250 lux using twin lamp 32 watt CFL luminaires with a SHR of 1.25. Each lamp has an initial output (Efficiency) of 85 lumen per watt. The lamps Maintenance Factor (MF) is 0.63, Utilization Factor is 0.69 and space height ratio (SHR) is 1.25. (Standards taken into account from ECBC manual for artificial lighting).

March 21



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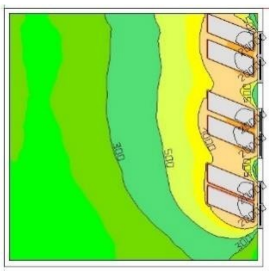
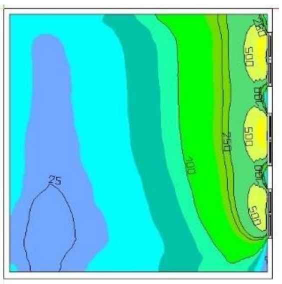
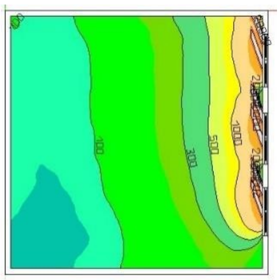


9:00 am **9:00 am**





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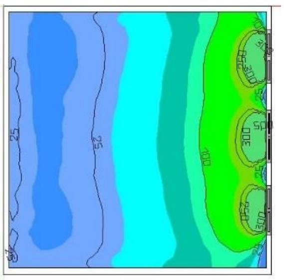
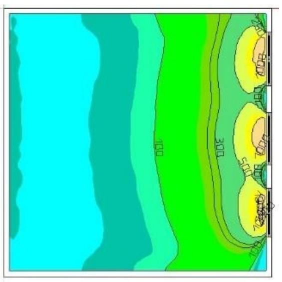
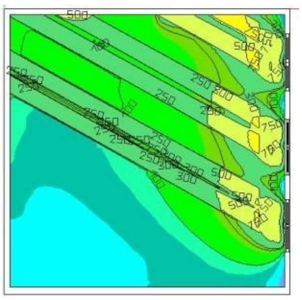




3:00 pm **3:00 pm**



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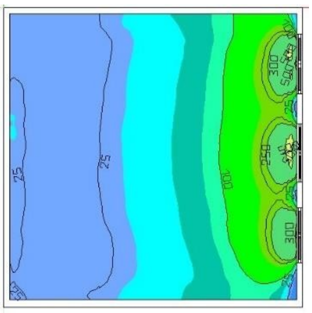

3:00 pm **Sep 21**

Fig 6 - Day lighting analysis on the treatment rooms in different months

From the daylight analysis it is clearly evident that the natural lighting available is not enough to meet the lighting requirements of the treatment spaces. Hence the role of artificial lighting always comes into play.

From the above values, while considering all the major months (summer and winter solstices) the average illuminance comes around to be around 513.11 lx.

C. IMPLICATIONS

There is strong evidence that light is critical to human functioning and can be extremely beneficial to patients as well as staff in healthcare settings. Adequate lighting conditions are essential for performance of visual tasks by staff in hospitals, and poor lighting conditions can result in errors. A point that must be noted in this regard is that lighting levels preferred by people are significantly higher than today's indoor lighting standards and correspond to levels where biological stimulation can occur. It also suggest that biological lighting needs of humans are different from visual lighting needs, and lack of adequate light for biological stimulation can lead to health and performance problems. This is particularly important for staff who work during night shifts, but is also relevant for staff who work for long periods of time without exposure to daylight. (4)

There is also strong evidence that shows that exposure to light helps in reducing depression, alleviating pain, and improving sleep and circadian rhythms among patients and, thus, supports the healing process. Clearly, an important goal for facility designers should be to fulfil human needs for light and provide a high-quality lighted environment.

Building interiors are lit by a combination of daylight and electric lighting. There is clearly a strong preference for daylight over electric light. Daylight entering through windows can be extremely beneficial to patients, provided there is no glare and it is possible to control light levels. (4)

However, in addition to natural light, electric light is needed in all parts of the hospital, though the need for artificial lighting can be reduced by efficient utilization of sunlight wherever possible. While making decisions regarding lighting, economic factors (first costs, energy consumption, and maintenance) must also be taken into consideration.

Where good colour rendering and bright, changing, visual environments are desirable, energy efficient natural light is ideal. Wherever possible in healthcare settings, natural light should be incorporated into lighting design not only because it is beneficial to patients and staff, but also because it is light delivered at no cost and in a form that is preferable to most people.

VII. RESULTS AND CONCLUSIONS

There is no doubt that lighting is an important factor for the hospital staff, patients and to the utilities provider. It helps hospital staff in performing their work and it also helps patients in their journey to speedy recovery. Therefore visual comfort and energy use shall be considered in determining the right type of light in the hospital lighting system design.

From visual comfort perspectives, LED can be considered the best choice in hospital lighting system design as the main cause of visual discomfort is not associated with it. Also, since DC voltage is used to power LED lights, it doesn't produce or cause flickering. Discomfort glare can be eliminated for the LED lighting.

Some of the major findings are been discussed in the table below.

Objectives	Methodology	Key Findings	Research publications
1. To understand the impact of daylight (positive and negative) on patients' psychological, physical, and physiological health.	Literature Review	For an overall progress of hospital patients' health, both psychological and physiological improvements are necessary. Impact of daylight on patients' psychology and physical diseases related to bones and cancers are well established. The physiological impact of	• Conference Paper (2009). A Systematic Study of the Therapeutic Impact of Daylight Associated with Clinical Recovery. Ha (5) CIRIC PhD workshop, 2nd Annual International Conference, 1-3 April, Brighton, UK, pp.25-31. • Conference Paper (2009). The Changing Perspective of Daylight Design to Face the Challenge of Climate Change. 3rd CIB International Conference, SASBE, June
		daylight on patient LoS needs to be established based on sound evidence.	15-19, Delft, The Netherlands.
2. To identify the range of daylight intensities within which patient LoS inside in- patient room is expected to be reduced.	Literature Review	The patients, who experienced higher (above 2000 lx) and lower (below 190 lx) levels of daylight in the maximum time inside hospital in- patient rooms, needed significantly more time (extra 29-42 hours) to recover compared to the patients who experienced moderate levels of daylight (between 190 lx to 2000 lx) throughout their stay inside	• Therapeutic Daylight for Hospital Patients: A Search for the Benchmarks". European Conference on Design for Health, July, Sheffield, UK. [in press]. • Poster (2009). Implementation of Therapeutic Daylight on Hospital Design to Accelerate Clinical Recovery: A Search for Knowledge Gap and Development of an Evidence Based Methodology. ACHSE National

		in-patient rooms .	Congress, 4-7 August, Gold Coast, Australia.
3. To develop a concept to incorporate therapeutic effect of daylight in the design of hospital in-patient rooms, effectively.	Literature study	A specially designed 45• inclined high window (Sky Window) configurations performed better than traditional typical standard hospital window configurations in order to enhance therapeutic effect of daylight inside in-patient rooms more effectively.	• Conference Paper (2012). Daylight Simulation in Architectural Practice: Shading Design for Hospitals in London". International Seminar on Architecture: Education, Practice and Research, 02 - 04 February, Dhaka, Bangladesh. [in press]. • Journal Paper (2012). Impact of Climate Change on the Constructed Luminous Environment: An Evaluation for the Hospital In-patient Rooms Located in London". The International journal of the Constructed Environment. [in press].
4. To conceptualise the impact of climate change on indoor daylight levels and its contribution to daylit in- patient rooms, designed for therapeutic purpose.		The average indoor illumination at test point (patients head) can raise a maximum 8% in the future (2080-2100) compared to the present (1983-2004). To protect the indoor from increased daylight levels, internal blinds will be needed to shut down more often/ time during day hours, which might create a negative impact on patient LoS due to lack of POV.	• Daylit Hospitals to accelerate clinical recovery. Health and Life Sciences Research Student Conference, Loughborough University, 14 March, Loughborough, UK. • Poster (2010). Use of Daylight to Accelerate Clinical Recovery. Poster Competition for PGRs, Loughborough University, 7 May, Loughborough, UK. • Poster (2009). Innovative Healthcare Design with Daylighting to Support Clinical Recovery. Engineering and Physical Sciences Research Council (EPSRC) Panel Review, University of Reading, Reading, UK, 23 September

VIII. CONCLUSION

One of the opportunities of day lighting in architecture is that, through the design of form, space and materiality, it can order our relationships with each other and our environment by creating interactive settings for life. It can do this in such a way as to provide opportunities to improve our sense of well- being, enrich our lives, make our lives healthier and more pleasurable. Our well-being is intimately linked with such moments of delight. To an extent, such stimuli happen all the time, often without being recognised or designed, but when they are orchestrated throughout a building the effect is cumulative. A poor building has few such moments and leaves our lives impoverished, whereas a successful piece of architecture is one where there is an accumulation of many moments of delight that support the five ways of well-being.

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