Performance evaluation of dynamic methods of Visual comfort energy conservation using Natural and Artificial light

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Abstract - This paper deals with the visual analysis for maintaining the visual comfort level, in the model room considered. The optimum position of blinds, to manage set point temperature of 24°C, as discussed in previous studies is investigated. For the set blind position, the illuminance inside the room is maintained at the prescribed value. The daylight integration into the interior is emphasized. The artificial light is switched ON or dimmed accordingly, to maintain the set-point illuminance level. The Energy consumption is calculated for different blind positions. The energy savings, hence obtained are investigated.The energy savings, hence obtained are investigated. This chapter also discusses the analysis of Natural and Artificial light.Visual comfort is the ability to position oneself within a building to see well enough to perform a task safely and easily. The visual comfort is achieved if the building has the right orientation of windows, with proper view, and not excessive daylight entry to cause glare. For visually comfortable environment using daylight autonomy techniques, a multi building design can ensure both the enhanced light and the aesthetic design. In these daysproper stabilization between natural &electric lighting has been known as optimum underconsideration of comfort, health & well being.

Keywords - Visual comfort, Energy conservation, Natural light, Artificial light, illuminance

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INTRODUCTION

India, the seventh biggest nation on the planet, is one of the main economies and home to more than one billion individuals living in different climatic zones. The nation's economy has been developing at a quicker pace, since the time the procedure of monetary changes began in 1991. Development assumes a significant job in its economy, contributing on a normal 6.5% of the GDP [1]. Business and private divisions keep on being a significant market for the development business. The segments expend a great deal of vitality for the duration of the existence pattern of structures, in this manner turning into a significant supporter of Green House Gas emanations. India faces a considerable test to meet its vitality needs and to give satisfactory vitality of wanted quality in different structures to the clients in a manageable way at sensible expenses. Given the spiralling urban development, the quantity of structures, vitality utilization and the resultant carbon emanations are on an ascent in the nation. 70% of the structures that will exist in India by 2030 are yet to be manufactured [2]. This implies India has a particular chance to acknowledge enormous reserve funds by consolidating different vitality effective measures during the plan and development stages. There is over half sparing potential in the structure part to address the difficulties of worldwide vitality and environmental change. Organizing vitality keen structure development across India will convey emotional reserve funds, as per master contemplates.

The Energy Statistics 2013 of India's National Statistical Organization (NSO) shows power represented more than 57 % of the all out vitality utilization during 2011-12 in India, and building division is as of now devouring near 40% of the power [3]. This is required to increment to 76% by 2040. An enormous amount of steady power request will originate from the private area in India. Building's warming and cooling are the most vitality concentrated exercises, trailed by power use for lighting and apparatuses [4]. India, being in a calm atmosphere, requests concentrated cooling than warming. Be that as it may, the vitality utilization can be decreased altogether by utilizing detached natural arrangements rather than mechanical ones [5]. Aloof plan permits structures to adjust all the more fittingly to their neighbourhood atmosphere and exploit normal vitality assets, for example, wind and warm lightness, to help condition their inside surroundings.

In many nations, private structures are answerable for a significant piece of the vitality utilization in the structure segment [6]. In India, the structure part expends about 40% of power out of which business area devours 8% while private segment represents 32% [7]. The vitality use power of the private structures is relied upon to develop due to the expansion in cooled territories, more access to power, and the increment in proprietorship and utilization of apparatuses by the inhabitants. Till date, India's policymakers have cantered around diminishing vitality utilization in new ad structures; however it is eminent that accomplishing a higher objective would rely upon the consideration of the private structures division in the objective region. Private structures make up 75% of India's development advertise, and up to this point has not been a need for vitality effectiveness arrangement. The potential for extending and adjusting existing vitality productivity arrangements to the private fragment is gigantic [8]. Until today, energy efficiency in buildings – in particular in the residential sector – has received limited attention in India. This has been due to the relatively low electricity tariffs, a fledgling market for energy-efficient materials, the lack of efficiency standards for building materials, and energy performance of buildings. Now, energy prices are high in India. Fusing vitality productivity gauges in new and existing buildings will assist India with accomplishing a solid vitality future and set aside cash while tending to the danger of environmental change [9].

The structure of private buildings significantly affects regular day to day existences of individuals. As vitality utilization from private buildings is anticipated to ascend by in excess of multiple times by 2050, it is of essential significance for India to create vitality productivity methodologies concentrated on the private segment to restrain the present pattern of unfeasible raising vitality request (Global Buildings Performance (GBP) Network and Centre for Environmental Planning and Technology" [10]. The investigation explicitly centreson surveying the job of the structure envelope, especially rooftops, according to agreeable cooling frameworks and machines, in accomplishing vitality productivity in abodes in the Indian private segment.

Vitality required in buildings is for the most part towards giving warm solace. Vitality reserve funds in a structure can be accomplished by proper vitality productive plan of building envelopes [11]. These structure envelopes go about as the interface between the inside of the structure and the open air condition, including the dividers, rooftop, and establishment; fills in as a warm boundary and assumes a significant job in deciding the measure of vitality important to keep up an agreeable indoor condition comparative with the outside condition [12]. It is the key factor that decides the quality and controls the indoor conditions independent of transient open air conditions. Building envelope includes a setup of building materials, the thermo physical properties of which, decide the climatic reaction of the envelope. To diminish the vitality utilization in buildings, it is important to comprehend the warm performance of the structure envelope on the indoor condition. A structure's climatic reaction is controlled by the pervasive introduction conditions (smaller scale atmosphere) and the capacity of the structure envelope to manage warm transmittance (building material science). This capacity to latently thermo-manage the indoor warm solace is dictated by the materials designing the envelope geometry [13].

The warm performance of a structure alludes to the way toward demonstrating the vitality move between a structure and its environment. For a melded structure, it evaluates the warming and cooling load and subsequently, the estimating and determination of HVAC gear can be accurately made. For a non-melded structure, it computes the temperature variety inside the structure over a predefined time and encourages one to gauge the length of awkward periods [14]. These evaluations empower one to decide the viability of the plan of a structure and help in developing improved structures for acknowledging vitality productive buildings with agreeable indoor conditions. The present research tries to develop a scientific ranking system for various roofs which will be a user friendly manual so that users can avoid tedious calculations and use any of the listed roof systems readily.

The event of hot uneasiness during the daytime is a difficult issue for the residents living in tropical districts. This drives the residents to look eagerly on warm solace conditions. In tropical areas, the most unmistakable segment that influences warm solace is the rooftop design as rooftops are presented to coordinate sun oriented radiation and the edge of frequency is near the ordinary during the more sultry pieces of the day [15]. Rooftops contribute colossally to building heat gain contrasted with vertical surfaces, for example, dividers, chiefly in light of the fact that the rooftops are presented to the sun all through the daytime [16]. Rooftops can speak to half 70% of the absolute fenced in area loads for a structure. The rooftop commonly gets critical measures of sunlight based radiation and therefore speaks to both a worry for vitality utilization just as an open door for natural articulation. The rooftop is the place the structure meets the sky and in this manner the plan of the material framework ought to consider the materials and development attributes as well as the opportunities for ecological mix [17]. India, being a tropical nation, where daytime temperature is as high as 38°C on a normal and diurnal temperature variety is medium to high; it is basic to investigate the warm performance of any material framework before it is embraced [18]. This examination presents issues and structure systems for the rooftop being a functioning member in naturally responsive design. Private buildings in India, particularly the low ascent buildings are found to experience high power heat transmission from the structure envelope, whereby the rooftop speaks to around 70% of warmth gain. This examination presents a structure that will give a smart curio which will decide the ideal rooftop engineering as per the warm solace conditions in private buildings.

Warming, Ventilation and Air Conditioning frameworks (HVAC) are the most vitality expending among the buildings administrations. Higher expectations for everyday comforts lead to dynamic climatization of buildings, for example, workplaces and inns, and furthermore living arrangements. One of the maintainable ways to deal with cooling buildings by common methods is the detached cooling methodology [19]. Inactive structure reacts to neighbourhood atmosphere and site conditions so as to amplify the solace and strength of clients while limiting vitality use. The way to structuring a detached structure is to exploit the neighbourhood atmosphere. Latent cooling alludes to any advancements or configuration highlights received to decrease the temperature of buildings without the requirement for power utilization. „Passive Architecture" has an incredible preferred position in that it requires no outer vitality source and hence has neither a running expense nor does it add to natural contamination [20]. Ongoing years have seen a recharged enthusiasm for ecological well disposed aloof structure vitality effectiveness techniques. They are being imagined as a reasonable answer for the issues of vitality emergency and natural contamination. The basic idea of passive design is to let in daylight, heat and airflow only when they are most beneficial, and to exclude them when they are not. In addition, the building envelope, itself, should be used to speed the transfer of excess heat into the outdoor environment. It has been deferent to mechanical air conditioning method &likeimportant part of sustainable building.This research organized according in section 2, Review of related concepts and literature has been described, Section 3 deals with the research methodology used in this research, Section 4 discussed about results adopted based on methodology, Finally Section 5 described conclusion and future work.

LITERATURE REVIEW

In [1] showed that energy consumption under building may decreased by enhancing performance of windows.

In [2] explained computer based analysis &design techniques to create environmental simulation models on which the thermal comfort ranges and air conditioning loads in a residential house were predicted.

In [3] used Matlab/Simulink to implement basic building HVAC method. This system predicted temperature changes under building &estimated count of energy which is needs to achieve comfort level. Location of building, physical properties of the building, gains & heating method as well as weather were considered for estimation. This model has the advantage of its less computational resources and its simplicity.

In [4] presented the building thermal temperature regulation using nonlinear stochastic Model Predictive Control (MPC). The prediction of weather and occupancy was used to minimize the energy consumption. This was carried without violating the thermal comfort. Hence the authors proposed an effective method to minimize the energy consumption using stochastic predictive controller.

In [5] integrated the green energy sources like natural luminance and natural radiation with artificial lights and heat pumps. Antiglare logic and logic for accounting of the solar radiation were introduced. This intelligent building controller has achieved better energy efficiency and hence reduces the energy consumption.

In [6] showed that human thermal comfort is not reflected adequately by only PMV. In order to reflect human thermal comfort in an interior, the humidity control is very important. The range of humidity for human comfort is between 30 % and 60%.

In [7] specified that for the occupant to be satisfied with the environment, both the thermal and the visual comfort have to be achieved. By reducing cooling loads i.e. avoiding additional energy consuming devices for cooling, the thermal comfort can be achieved. For optimization, the building simulation software tools can be used.

In [8] proposed a technique, in which energy consumption is reduced by maintaining the thermal comfort. The thermal comfort is defined in terms of PMV index. Simulation of two case studies was carried out and the results of both showed conservation of energy.

In [9] optimized the design of passive buildings using the simulation through an approach which is comfortable. Solar shading that plays a very important role in Tropical climate has been emphasized. The solar shades are developed depending on the availability of daylight inside the room and the percentage of thermal comfort required.

In [10] studied the environmental monitoring with on-site observations and measurements of temperature and humidity. The results were then transferred to computer medium to create the environmental simulation models on which the thermal comfort ranges and A Clouds of the solar house were predicted. Finally, necessary recommendations for the renovation study were provided based on these predictions. With this study, possible uses and subsequent advantages of computer-based environmental analysis and design techniques on renovation of existing buildings are revealed.

In [11] carried out a simulation study by varying the cooling temperature set points, which clearly show that using a static set point, the thermal environment in a building cannot be controlled. The occupants will feel discomfort with the higher set points, which are not varied. Such higher set points are also not advisable. Hence in order to achieve comfort inside a building, a varied set point is advisable.

In [12] highlighted the importance of lighting control method utilizing day lighting to decrease energy consumption & gives occupants along visual comfort. Visual comfort & energy saving were achieved under office building through means of visual environmental control, by focusing on luminance and glare index in day lighting. The authors suggested lighting control strategies and shading devices to avoid the disturbing glare & incorporate increase daylight. It was proved that the dynamic shading was necessary for energy efficient anti glare control technique and hence to achieve visual comfort.

In [13] simulated various shading strategies with South & North facing windows alongdeferent floor areas & window sizes. An assessment of energy needs was performed for ventilation cooling, heating & lighting. The results showed energy needs for offices is affected through the choice of shading strategy. In addition, the shading devices also contribute to lowered thermal transmittance. Using large windows and highly glazed façade the access to daylight is increased, along with solar gain and view to the outside world. The temperature inside the room increases by using non shaded windows, which, in turn, affect the thermal comfort and glare negatively.

In [14] described impact of utilizing shading instrument on visual environment, air temperature & operatorcommunication under offices facing south west direction. The effect of shading devices on improving the luminance level and the controlling air temperature was demonstrated by real-time experiments and computer simulations. Analysis described temperature under office placealong shading instruments compared with workplaceexcept shading instrumenthas beendecreased for favourable level. Visual environment has been enhanced throughmanaging luminance level, enhancing uniformity & removing glare.

In [15] focussed on achieving visual comfort and energy keeping integrating day light & artificial light in heattemperature nature. Visual operations & energy saving were predicted for various 3 kinds of glazed windows. Valid amount of decrease under cooling &building energy reduction has been analysed for all types of glazing.

RESEARCH METHODOLOGY

Daylight Utilization

The place of sun changes at the time of entire day & it is necessary to track the path of the sun, for accurate day lighting Integration analysis.

The changing position of the sun, throughout the year is represented by stereographic diagrams as shown in Figure 1for any location on the Earth, the path of Sun mayforwarded on the flattened hemisphere for different times of the year.

Horizontal area counted clockwise from north base line or meridian has been known like Azimuth angle. They are marked on the diagram with 15º increments. The altitude angle is 0 at sunrise and 90º when the Sun is directly above our head. They are concentric circular dotted lines, which run through centre of diagram along 10º increment.

Path of Sun on any particular day is represented by Date lines. They run from East to West as shown in Fig. 3.1. Position of Sun for particular hour throughout year is represented by Hour lines. Their shape is in the form of ‘8’. The position of the sun is given by the intersection of date and hour lines

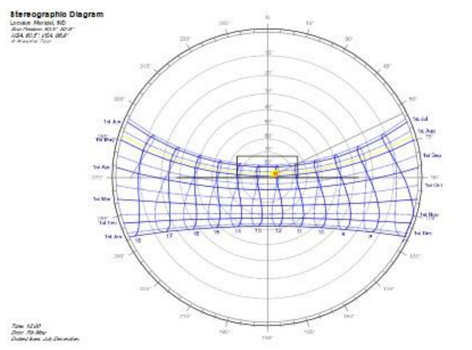

Fig.1. the Stereographic Diagram

In order to control glare, balance heat gain, adjust variations in availability of daylight and uniformity in illuminance, the natural light has to be utilized with a careful planning.The usage of artificial light has to be minimized by utilizing the daylight appropriately. This can significantly decrease energy consumption because of lighting and cooling loads & maintaining comfort of occupant. The Thermal and visual comfort can be maintained using an appropriate control strategy for the automated window blinds.

Research process

The analysis is carried out in the model room considered, by simulation and practically as follows:

- The variation of illuminance inside the room due to daylight, is investigated with the following conditions:
- Work bench height of 0.85 m.
- Every Hour 9 to 5pm

- Different blind positions namely: 0^0, 15^0, 30^0, 45^0, 60^0, 75^0, 90^0 (fully closed)
- Window positions
- East to West
- North to South
- East direction
- West direction
- North direction
- South direction
- Window blind is set to an optimum position to minimize the heat gain for the set temperature (24°C as mentioned in Chapter 5) inside the model office room.
- Artificial light is adjusted to manage recommended illumination level of 500 lux.

Energy consumed due to lighting as well as AC for different positions of the blinds is examined.

RESULTS AND DISCUSSION

Manually the readings were recorded in the model room for illuminance and energy consumed. In order to measure the luminance, the room has been characterised under nine equal grids and the readings were noted down at each of the grid. The average illuminance was calculated using the 9-point method. The readings were recorded from 9 am to 5 pm between 22nd December and 21st March, during which the sun is on the South of the meridian

Two windows at a time

Two opposite windows were considered at a time for the analysis. If once the East and West windows were considered, the next time North and South windows were considered. The illuminance values obtained from daylight for different blind positions, and at various times of day were recorded. Reading's regards variation in illuminance, hence obtained, plotted. Figures from 1 to 6describedoutputs of Illuminance vs. time of day for different blind positions, and both the window positions viz., East-West and North-South, respectively.

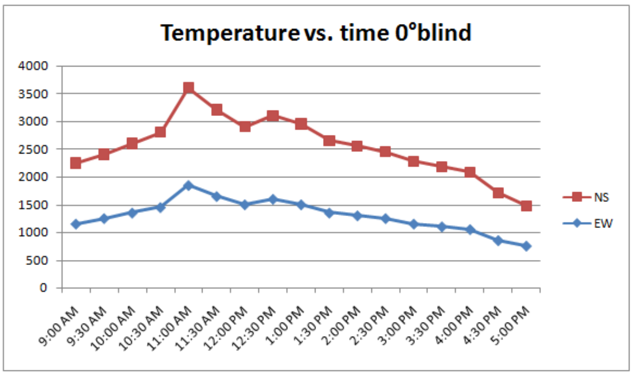

Fig.2. Illuminance vs. Time for 0° blinds

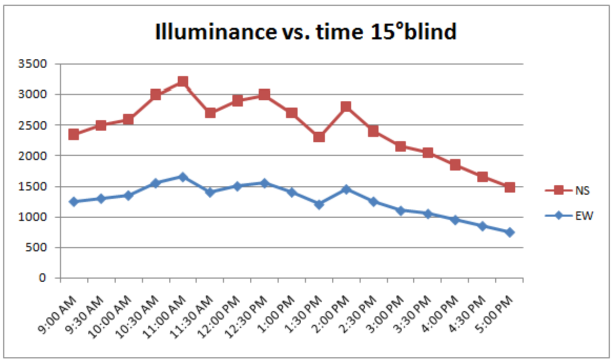

Fig.3. Illuminance vs. Time for 15° blinds

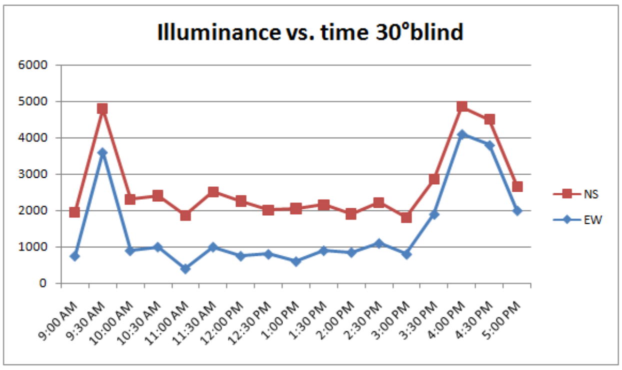

Fig.4. Illuminance vs. Time for 30° blinds

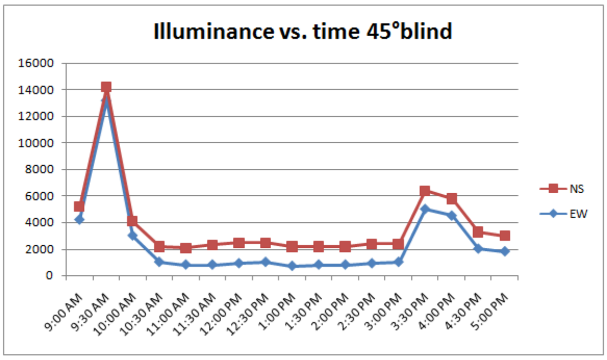

Fig.5. Illuminance vs. Time for 45° blinds

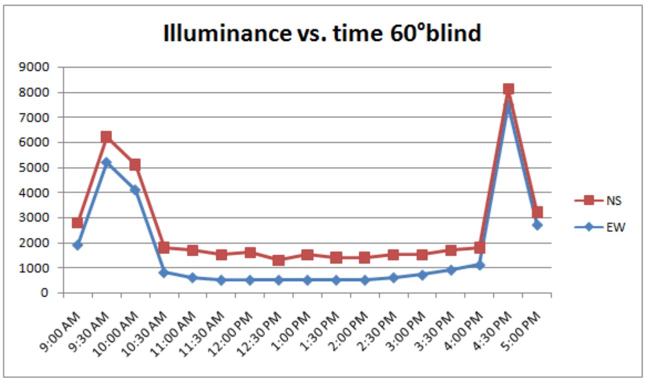

Fig.6. Illuminance vs. Time for 60° blinds

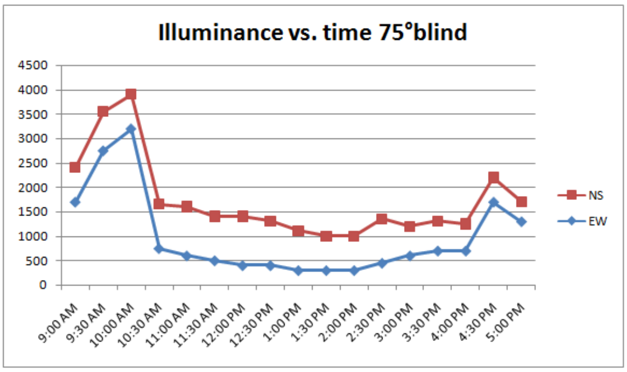

Fig.7. Illuminance vs. Time for 75° blinds

From the above graphs, it is observed that the variation in illuminance for the two-window positions is dependent on the different blind positions and the time of the day. In either of the two windows considered, the illuminance value is above 500 lux, which is the set point value. The artificial light usage is not significant.

One Window at a time

In order to showcase the role of artificial light in ensuring the visual comfort, one window is considered at a time for further analysis. The variation of illuminance for East, West, North and South window was recorded.

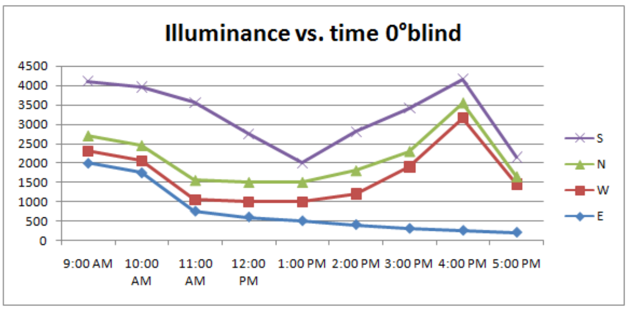

Fig.8. Illuminance vs. Time for 0° blinds

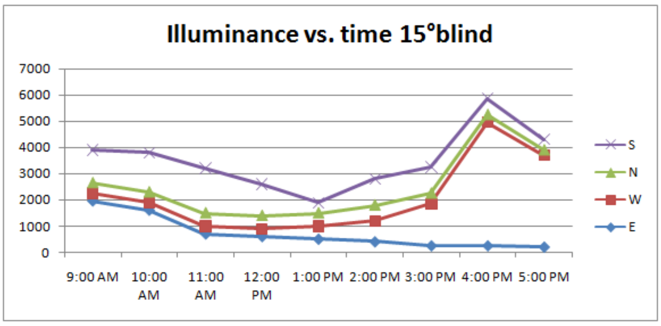

Fig.9. Illuminance vs. Time for 15° blinds

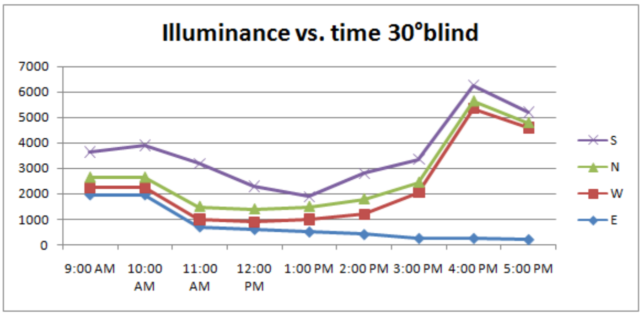

Fig.10. Illuminance vs. Time for 30° blinds

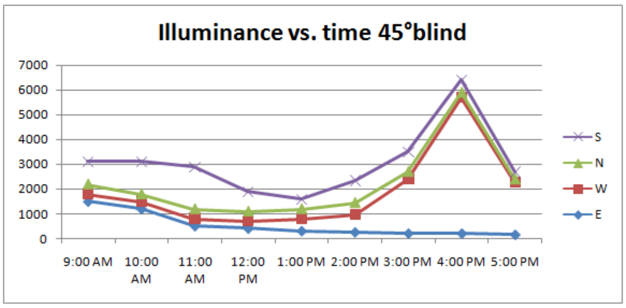

Fig.11. Illuminance vs. Time for 45° blinds

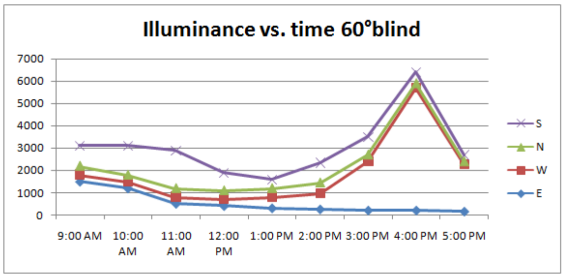

Fig.12. Illuminance vs. Time for 60° blinds

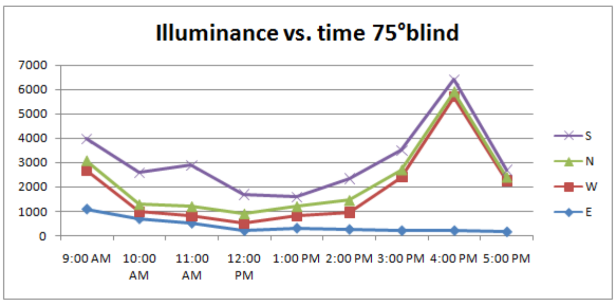

Fig.13. Illuminancevs. Time for 75° blinds

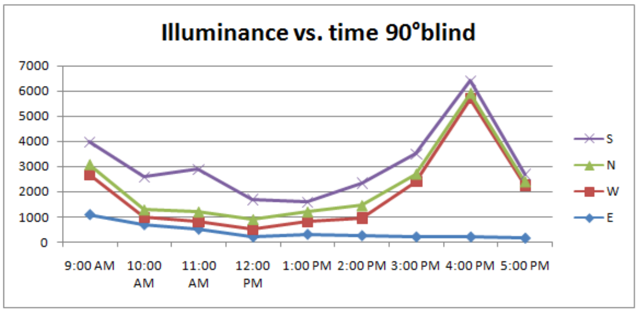

Fig.14. Illuminance vs. Time for 90° blinds

The Figures from 6 to 12 represent the variation of illuminance with respect to day time regards different blind positions. It was analysed that East and the West windows show extreme readings for morning and evening respectively. It is also observed that the South window shows higher deviations from the ideal illuminance level, whereas the North window shows the readings that are closest to the required set-point illuminance levels (500 lux). Hence the North window is considered for further analysis.

CONCLUSION AND FUTURE WORK

The variation in illuminance was analyzed for different window positions viz., North to South, East to West, East, West, and North& South. The average illuminance in the room was very much above 500 lux for North-South, East-West, East, West and South-sided windows. The average illuminance value is below 500 lux for North-sided window. In order to highlight the significance of the role of artificial light in ensuring visual comfort to the occupant along with allowing daylight integration into the interior, North-sided window is considered for further analysis. Furthersimulation was carried out for five different locations in India with for cardinal window positions individually, throughout the year for different window blind positions. It wasobserved that the energy consumption varied for different locations, window positions and blind position. Minimum energy consumption was for North sided window.

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