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Study and Analysis of Parameters for Daylighting System: A Review

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Abstract:
Extra care is required to be taken in the architecture to provide daylight in high-rise deep plan buildings.The daylight is always beneficial in terms of cost saving and human health. Components of a daylight system become crucial to get the maximum possible benefit. Fresnel lenses are in use for quite some time as concentrator of light. Their high light concentrating capacity and less spherical aberration make them suitable for using as concentrator. Study of the optics and geometry of Fresnel lens is very important in order to understand their capability. The role of geometrical parameters like slope angle and draft angle is discussed in this paper. Study of optical fibers is also important as their length dependent transmission gives a fluctuating value of efficiency for daylighting system. Much work has been done in past on Fresnel lenses and their usage indaylighting system but still much more is to be explored.

Keywords: **Daylighting System, Fresnel lens, Optical fiber, Geometry of lenses**

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1. Introduction

Light empowers sight and makes things visible. Light is absolutely a human sensation like sound, taste, smell and warmth. If eye is kept are surrounded by less visibility area for quite a while the eyes develops more sensitivity and a given amount of light will appear to be brighter than normally.Some standardized terms describe the visual sensitivity. These terms are Luminous flux, Luminous efficacy, Luminous intensity and Illuminance. These terms are both physical and psychological, since they depend on both the physical properties of the electromagnetic radiation and our perception. They describe the illuminance at a point, luminance of a surface and intensity of light in space.

Luminous flux describes the total flow of light from a light source. The output of a lamp is given in lumen (lm). The luminous efficacy is the relation between source's light output and its electrical input. Luminous intensity is the intensity of light, from a light source, in a certain direction with the unit candela (cd). The amount of light falling on a surface isilluminance, measured in lux (lx).

2. Daylighting

Daylighting is the made of direct sunlight, and diffused-skylight admitted into a building to lower the usage of electricity and saving energy. Daylighting is major factor considered in building design when the goal is to enhance the visual comfort or to reduce the usage of electric energy.In a world that focused on the sustainable development, carbon emission and global warming, the controlled use of natural light in office buildings has become an important aspect to enhance energy efficiency by reducing lighting, heating and cooling loads. The use of innovative daylighting systems can decrease a building's electricity usageandnoticeableimprovement in the quality of light can be seen.

The source of all daylight is the sun. The amount and quality of daylight varies with the proportion of direct to diffuse sun light. Solar radiation that reaches a site directly without being scattered within the earth's atmosphere is called direct sunlight. Light that is scattered in the atmosphere is called as diffused daylight. Light getting reflected from the ground also contributes to the daylight. The quality of the daylight varies with the different climate conditions, cloud type, site locations and orientation.

There are many conventional daylight techniques, which are used for the illumination purposes. Some of them are windows, clerestory windows, skylights, Atrium etc. However, problems like glare and excessive illumination limits their application. To enhance the usage of daylight as the primary source of illumination inside the buildings new daylighting systems are developed. They consist of developing the new innovative daylighting systems.

3. Innovative daylighting systems (IDS)

Toprovidedaylighting into deep, remote and windowless areas of the buildings where the admission of daylight is generally not possible, innovative daylighting systems (IDS) are developed. IDS aim to enhance the utilization of available daylight. Many IDS have been developed with advanced technologies covering a wide range of applications. These systems consist of mainly three parts which are light collector (or concentrator), light guide (or transmission device) and diffuser. The function of the light collector is to collect light both direct sunlight or diffuse skylight. Light guides are used to direct the collected daylight in particular direction through the building vertical voids, or via fiber optics or light pipes (ducts). The function of the diffuser is to illuminate the place with the light coming through the light guides.

Many Innovative daylighting systems (IDS)have been developed in the recent years but few of them have found their place in the market.Himawaridaylighting system, Paransdaylighting system, sunportaldaylighting system are some examples of some developed daylighting system There are some IDS, which are still in the prototype stage and there are ones, which are developed but are still under demonstration. Light guiding system in daylighting technology plays a vital role. Different types of light guiding techniques are developed. Fresnel lenses as collector and optical fibers as light guides are used in some of the daylighting systems.

4. Fresnel Lens

Centuries ago, it was observed that the focusing properties of a conventional lens are defined by the refracting surface. The bulk of material within the boundaries of the refracting surfaces has no effect (other than increasing absorption losses) on the optical properties of the lens. Fresnel lenses are based on this concept. The first Fresnel lens was invented by Augustin Jean Fresnel in 1822, a French mathematician and physicist. Fresnel’s original lens was used in a lighthouse.

A Fresnel lensis used as a lightweight and better efficient alternative to conventional continuous surface optics. The principle of formation of a Fresnel lenscanbe understood in two ways. First is that the refraction occurs only at the optical interfaces (i.e. the lens surfaces), remove as much amount of optical material from the lens as possible while not changing the surface curvature. Second is that the continuous surface of a lens is “collapsed” onto a planer surface.Fig 1 shows the terms used in Fresnel lens; asgiven in Davis and kuhnlenz (2007).

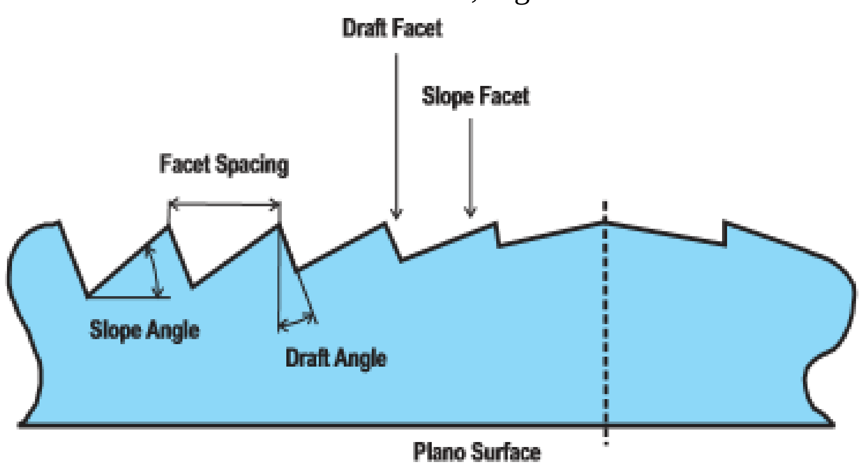

Fig 1 Terms used in Fresnel lens

Fig 1.1 shows the three main practical aspects in construction of a Fresnel lens and that are prism pitch or facet spacing, a slope angle and a draft angle. The slope angle is defined with respect to the plane of the lens and draft angle is defined with respect to the normal.

4.1 Factors affecting performance

There are two main geometric factors that affect the performance of Fresnel lens. One is Draft angle and second is corner facet radius. Both these factors are due to lack of precise production method therefore undesirable. Draft is given for the easy removal of lens from the mould after casting and corner radius produces because it is not possible to produce sharp edges with low cost production methods. Ideally 0˚ draft angle and 0 radius is desirable but 2-4˚ and 3-10µm radius is practically possible.

5. Transmission parameters in Fresnel lens

For any point on the surface of the Fresnel lens, following parameters may be computed:

(i) **Transmission after Reflection losses (T_{surf})**
Reflection losses are there when light crosses one medium to another medium with different refractive index. There losses occur at the boundary of lens. Fresnel lenses have two boundaries. So, reflection losses occur at both surfaces. These losses depend upon the incident angle and refractive index of both medias. After reflection through both surfaces the amount of light transmitted will be denoted by T_{surf}.

(ii) **Transmission after Geometrical losses (T_{geo})**
The transmittance accounting for the prism draft surface loss and loss due to the prism peak tip rounding, chromatic dispersion, incident angle variation, surface roughness and manufacturing errors is denoted by T_{geo}.

(iii) **Transmission after material absorption losses (T_{matl})**
There are losses due to light absorb by material as it passes through its thickness. This depends upon the choice of material, thickness of lens and type of incident light (Monochromatic, Dichromatic, Multichromatic). Transmission after considering only these losses will be denoted by T_{matl}.

All these terms multiplied together gives the total transmission efficiency of Fresnel lens.

$$T = T_{surf} \, . T_{geo} \, . T_{matl} \qquad \textbf{Eqn. (1)}$$

6. Optical fiber

An optical fiber is cylindrical shaped guide.It has two important components core and clad. Light is guided in the core through Total internal reflection (TIR) at core-clad boundary. Clad has slightly lower reflective index than core which facilitates the TIR. Angle made by light ray with core-clad boundary of fiber should be less than a critical angle for TIR. By snell's law, critical angle for the ray to guide inside by TIR is given as$\theta_c = \sin^{-1}({}^{n_2}/_{n_1})$.

Numerical Aperture is the measure of amount of light collect by fiber,is linked with the acceptance angle by Eqn. 2

$$\sin(\theta_a) = NA = (n_1^2 - n_2^2)^{1/2} \qquad \textbf{Eqn. (2)}$$

In case of optical fiber, the incident angle which is also known as acceptance angle plays an important role. This acceptance angle forms an acceptance cone. Rays within this acceptance cone are guided by total internal reflection.

7. Efficiency of Optical Fiber

Transmission efficiency of optical fibers is a function of refractive index and wavelength. The loss in transmission of any type of signal in fiber is known as attenuation. Attenuation or Attenuation rate is different for every material and it is measured in dB/km of dB/m. Attenuation also depends upon the length of fiber because light travels in optical fiber through total internal reflection and with every TIR there are some absorption losses by the clad of fiber. Attenuation for every material is different since it is property of material and wavelength dependent. Energy output and energy input of fiber are related by given Eqn. 3.

$$\emptyset_F = \frac{E_o}{E_i} = 10^{-\left(\frac{LdB_{loss}}{10}\right)} \qquad \textbf{Eqn. (3)}$$

Where:
$\emptyset_F$ = Transmission efficiency of optical fiber
E_o = Energy at exit of fiber
E_i = Energy at entrance of fiber
L = Length of fiber
dB_{loss} = Attenuation rate of fiber

8. Efficiency ofsystem

Efficiency of the system consists of efficiency of collector, efficiency of guiding device and efficiency of diffuser. All three parts have the losses associated with them. There are some reflection losses at the boundary of air and core of fiber. These losses are calculated with the help of Fresnel reflection equations. These losses combined with optical efficiency of fiber and transmission efficiency of Fresnel lens and transmission efficiency of diffuser will give total efficiency of system (T_{total})

$$T_{total} = T \cdot T_{fiber} \cdot \emptyset_F \cdot D \qquad \textbf{Eqn. (4)}$$

Where:
T = Average efficiency of lens
T_{fiber} = Transmission from air-core interface
$\emptyset_F$ = Transmission efficiency of optical fiber
D = Transmission efficiency of diffuser

9. Literature Review

The work of various authors in the area of daylighting is summarized in this section.

Biermann et al. (1998)calculated the light losses present inside the optical fiber. Attenuation rate of fiber varies with wavelength of incoming radiation and length of fiber. Losses in the fiber also varied with the diameters of core and clad. Keeping all other parameters same increase in diameter of core and clad increase the losses in fiber due to increase in Fresnel reflections. Three different fibers with 0.25, 0.375 and 0.5-inch core diameter are tested and 150-watt metal halide lamp used in three different types of illuminators. 1.4 to 2.4 percent per foot light loss is there when 0.25-inch diameter fiber is tested with all three illuminators. Likewise, 1.1 to 1.5 percent per foot light loss is recorded when all three diameter fibers are tested with one single illuminator. Light loss in the fiber depends upon length, diameter, and refractive index, incident angle of light on fiber and reflector type. Beam uniformity, Numerical Aperture and light loss are greatly influenced by reflector. Attenuation plots with respect to diameter of core and incident angle of light on fiber core are more useful then plotting single wavelength dependent attenuation. Jaramillo et al. (1999) studied the thermal behavior of optical fiber in transmitting solar energy application when parabolic concentrator is used and fiber is placed at the focal length of concentrator.. Temperature at the center of silica optical fiber reaches at design limit after 6 hrs of working when silica is used as reflective mirror surface and after 5 hrs when aluminum is used as reflective mirror surface. The reason behind is that different kind of radiations enter into the optical fiber after reflective through two different reflective mirror surfaces. For both cases efficiency of fibers is coming 85%. Results also shows that temperature at core of fiber reaches at design limit only within 50cm for 10m length of optical fiber.

Oakley et al. (2000)evaluated the daylight performance of light pipes. Six light pipes are installed at three different positions. All the six light pipes (A, B, C, D, E& F) are installed at different positions in three different areas of a building.In Beacon Energy Center-workshop highest value of illuminance is recorded as 461 lux which is directly underneath of light pipe. Lowest value is recoded as 4 lux at the darkest corner of the building. Light pipe E performs better than the light pipe A because of the bends in light pipe A. the average illuminance of the whole room was 78 lux with respect to the total outdoor illuminance of 44,000 lux which gives the internal to external ratio as 0.18%. Internal to external ratio for A was 0.3%, for E was 0.5% and 0.05% for the rest of the site of workshop. At West Beacon Farm-residential the highest and lowest illuminance was 1538 and 41 lux. The internal to external ratio of the illuminance was 0.48% and light pipe G performed better than the others with illuminance ratio of 1.2%. At Beacon Energy Center-small office the highest and lowest illuminance was 518 and 147 lux. The internal to external ratio of illuminance was 0.38% and light pipe E performed better than the other with illuminance ratio of 0.51%.

Feuermann et al. (2002)calculated the light leakage losses in optical fibers. Light losses firstly occur at entry of the fiber due to Fresnel reflection losses and then light gets absorb by the cladding part of optical fiber. Cladding absorption losses will be there no matter how perfect the total internal reflection is. This absorption loss is small but if Fresnel reflection inside the fiber gets increased then the net effect of these losses will be measurable. The refractive index of clad is an imaginary quantity not a real value. Fresnel losses at air-core interface and absorption losses through clad surface greatly affected by incident angle of light from air side. The more accurately this imaginary part's parameter calculated the more accuracy in transmission efficiency of fiber achievable. Purity of the core material also influence the absorption losses Onaygil and Guler (2003)determined the energy saving by implementing daylight responsive lighting control system. Six luminaries are presents in three parallel rows each of which has two 58W fluorescent lamps. Maximum illumination by artificial light in office is 1500 lux. When combined effect of artificial and daylighting on working desk exceed 500 lux artificial lighting was switched off by control system. Without the daylight, to maintain 500 lux on working desk 4600 Wh of energy is required so difference in values of energy requirement is energy saving. Date was collected for in total of 174 days. Average daily energy consumption shows that for every month requirement of artificial light is less than 4600 Wh. Average daily energy consumption shows that season wise average value of artificial light requirement is less than 4600 Wh. Average daily energy consumption shows that artificial energy requirement was less than 4600 Wh for different days of the year. For the month of June and July energy saving was highest and for the months of December and January it was lowest.

Franzetti et al. (2004) analyzed the coupling effect of artificial light and daylight on the thermal loads and the energetic needs in office buildings. Diffuse component of daylight is calculated with the help of extended daylight factor. Daylight components along with direct solar component give the total amount of daylight present inside the building. Study shows that experimental results goes very well with the analytical Perez model for calculating diffuse outside horizontal illuminance with a correlation coefficient of 0.984. This study also shows that calculated and measured working plane illuminance has a correlation coefficient of 0.9. Lighting, heating and cooling requirement inside a building exactly tells how much surplus artificial energy is required after total available indoor daylight. Ryu et al. (2006) developed a modular facet Fresnel lens to achieve a uniform intensity on absorber plan. Uniformity of the intensity is achieved by super positioning of flux from one type of facets to the other type of facets. Rays from each lens area are refractive upon a solar cell area which has either same or smaller dimensions than the lens area. Ray tracing was performed for 3x3, 5x5, 7x7, 9x9, 11x11 sized Fresnel lens, iteratively. Every lens shows different effective transmission variation with respect to f-number. Below f/1, the transmission efficiency decreases rapidly. 3x3 array Fresnel lens performs best at all f-numbers and becomes saturated at 80% for f-number greater than f/1.2.

Davis and Kuhnlenz (2007)discussed about the geometry and geometrical parameters of Fresnel lens. Basic terms that are used in optics like focal length, f-number and transmission efficiency are given. Geometrical parameters slope angle and draft angle becomes very important when transmission efficiency is concerned. The main focused of authors is to define parameter selection criteria (mainly facet pitch) for a Fresnel lens which is used in image formation application. Efficiency for Acrylic based Collimating and Concentrating Groove in and Groove Out designs is plotted. Morie fringes minimization formula depends on the facet pitch. Facet pitch of lens is also optimized with respect to focal length. Application of Fresnel lens as Magnifier, Collimator and Concentrator is discussed with analytical formulas.Kandilliand Ulgen (2008)calculated the availability of daylight and luminous efficacy of global irradiance for Izmir, Turkey. Aydinli model, IESNA model, Perez model are some existing sky model which are considered valid. Data from meteorological station of Solar Energy Institute is used.Monthly average outdoor illumination was plots with respect to solar hour shows that Perez and IESNA model has high values of illuminance then the Aydinli model. Further Perez model shows the frequency of luminous efficacy made a peak at 110 lm/W which was excepted as luminous efficacy of daylight. Different correlation equations between hourly average daylight illuminance by Adyinli, global illuminance by Perez, daylight illuminance by IESNA and measured hourly global radiation gives different correlation coefficients (0.9563 for Adyinli, 0.9994 for Perez, 0.9747 for IESNA). These values show Perez model gives precise value of luminous efficacy. Arthur (2009) developed the equations for different transmission terms. Normal vectors, output ray vector, lens focal length and coordinate position are linked through equations. Fresnel lens equations are available in different texts such as Born and Wolf and Hecht and Zajac are manipulated into the convenient form then a basic mathematical model for the prism peak rounding is given to analyze the losses in transmission. Only concentration of collimated light input is investigated and groove facing short conjugate (GFSC) is found to be more promising at zero to low rounding ratios. But at higher rounding ratios, performance of both lenses is nearly same.

Kandilli et al. (2009)calculated the transmission performance of an optical fiber based daylighting system. Plastic optical fiber is preferred instead of glass optical fiber to avoid the fiber bundle bending. A metal halide neutral white lamp, an optical filter, a focusing lens and a cooling fan is used for the experiment. Two optical fiber bundles of different lengths are used to calculate the transmission performance of fiber optical bundles (FOB). Two type of different diameters fiber are used to minimize the heating effect caused by scattering of light at the entrance of FOB. Different experiments were carried out and results shows that transmission efficiency varies from 69 to 80% with bending radius. Luminous efficacy changes from 369 to 337 with different bending radius.Wang et al. (2010) successfully developed a Fluorescent fiber solar concentrator (FFSC)to use in daylighting applications. FFSC plate is made of 150 pieces of 1m to 2mm diameter fluorescent fibers. These pieces of fibers are attached to a 1200x1200mm^2 PMMA material plate. Three colors for the fiber pieces are used to cover the full spectral band. Light collected from these fluorescent fibers is transported by 10m long and 2mm diameter PMMA optical fiber. Solar radiation received by FFSC is recorded by Pyrometer. A reflector plate of large area is used under FFSC to increase the light absorption. Various parameters like light-to-light efficiency, lighting effect, energy-to-energy efficiency, luminous efficacy become important in analyzing a new design for daylighting collector. Light to light efficiency is nothing butratio of illumination measurement at fiber end to that outside illuminance.

Kang et al. (2011) used a circular Fresnel lens and PMMA plastic optical fiber (POF) to evaluate the performance of daylighting system. Small diameter (60mm) circular Fresnel lenses were used. Experiment was conducted on two different days for 7 hours. Lumen was measured in 30 mins interval. Theoretical efficiency was calculated by multiply the concentrator efficiency, transmission efficiency and diffuser efficiency. Actual system efficiency was calculated by dividing the light output from the diffuser with the light entering into the condenser. Actual efficiency was calculated for every measured value of lumen and after that, an average value of the actual efficiency is calculated for the day. Difference in both the values of efficiency was due to the loss in connecting different parts of the system.Arthur et al. (2011)discussed about the optics and manufacturing of Fresnel lenses. Based on the engineering experiment was done with varied process parameters to investigate the prism facet rounding. To use the injection molding process for Fresnel lens manufacturing, precise process control is required. Prism rounding radius is one of the main factors which affects the quality and performance of Fresnel lens. For maximum performance a sharp prism peak is required. From the results of experiment an approximation was made to relate prism rounding ratio to prism aspect ratio. Prism rounding ratio is defined as prism facet rounding radius to prism pitch and prism aspect ratio is defined as prism peak to valley height to prism pitch. Effect of the prism peak rounding on the performance is analyzed. Finally, they discussed the Pressure, Volume, Temperature relationship for a polymer that must befollowed in a molding process.

Wallhead et al. (2012) discussed about the various kinds of losses namely Geometric, Absorption and Reflection losses in the transmission through Fresnel lens. Authors designed a double total internal reflection (D-TIR) Fresnel lens for solar light collecting purpose. Conventional Fresnel lenses are compared with single TIR and Double TIR design lenses. Lens transmission for all three lenses is compared with collection half angle. For a receiver diameter of 3mm D-TIR Fresnel lens that they also called a hybrid lens is able to concentrate the 86% of light as compared to a conventional lens of same geometry that is able to concentrate only 71% of incoming light. Also results show that at 3 mm D-TIR lens is able to concentrate 99% of its maximum possible concentration. According to authors, 20% improvement in the transmission efficiency is there with this new design.

Bilro et al. (2012)discussed about the plastic optical fiber (POF) technology. Mechanical, Thermal and Optical properties of the plastic optical fiber are important for review and comparison with the glass optical fiber gives a criterion of selection. Low cost and easy bending features are causes of popularity of plastic optical fiber in daylighting applications. Two categories of optical fibers namely Step index and Graded index are mentioned and their historical background and properties are discussed. Different sensing techniques for plastic optical fiber are available. Structural health monitoring, medicine, Environment, biology and chemistry are some application areas which are discussed by authors. Research should be carried out to develop new POF material to reduce losses associated with high attenuation coefficients.Molini et al. (2013)developed a model for collector of a daylighting system which they named as Truncated Compound Parabolic Concentrator (T-CPC). The purpose of a collector is to collect the maximum possible flux and direct the light with a given angle into a pipe or fiber of high reflectivity. T-CPC are arranged in a matrix and with horizontal guide as transmission unit, whole system is simulated in optical design software ASAP. Results from the optimization process shows that T-CPC is able to give more energy output and improved light's flux uniformity. This also minimizes the system's dependence on solar incident angle. Reflection losses are also minimized due to controlled aperture angle of T-CPC.

Kumar et al. (2014) discussed the importance of Fresnel lens and their use to collect the solar radiation. Various types of solar collectors are discussed which are in use. Some drawbacks associated with the conventional reflector are there which raise the need of a more accurate type of collector of concentrating of solar energy. Fresnel lenses are a good alternative for concentrating the solar radiations. Normal refraction phenomenon, Single and Double Total Internal Reflection occurs at the Fresnel lens groove surface are of great concern since these phenomena tell about the reflection and refraction angle. Facet corner rounding radius and draft angle are some manufacturing requirement that cannot be avoided. Geometrical, surface and material are three important losses occurred in the lenses though due to reduce thickness material absorption losses are not very high as compared to other conventional lenses. Some advantages and limitations of using the Fresnel lenses in the concentrating solar power are mentioned.Song et al. (2014) developed a daylighting system consists of an optical fiber and a double axis sun tracking model. Mathematical formulas and computational processing is used to track the sun. Tracking is done with the help of GPS sensors. Amount of the light lost between the sun tracking system and optical fibers is mathematically related with the offset angle between the same. Illuminance of a particular area of the building is captured at different times. Illumination distribution of illuminated work plane is recorded before and after the opening of the device. The experimental results also show the relationship between the incident solar illuminance and output light flux of the optical fibers. Overall transmission efficiency and sun tracking error is calculated and plotted at different times. Sun trajectory prediction control program keeps overall transmission efficiency with in a stable range over a long period that has the practical implication in visual comfort.

Ullah and Wang (2015)developed a system using concave parabolic reflector as collector and optical fibers as transmission device. A model with concave parabolic reflector and plano concave lens combination is used. The use of parabolic reflector gives concentration ratio as high as 1000. Silica optical fiber with core and clad diameter of 1.457 and 1.8 mm and Plastic optical fiber with core and clad diameter of 1.98 and 2 mm giving the best match of fiber bundle for the concentrator. Critical bend radius is an important factor to minimize the bending loss. Fiber bundle has a surface area of 78.54 mm^2. This suggests that a convergent lens should be used at the exit of fiber. Focal length of this lens is calculated by lens maker's formula. Simulations results of LightTools software shows the indoor illumination of 6x4x2.75 m room at different times of the day. Indoor illumination was more uniform and more light flux is achieved than most of the previously used reflectors. An average of 50% electric energy can be saved by using this approach.Qin et al. (2015)developed a daylighting system for improve lighting in a highway tunnel threshold zone. Collector, sun tracking system, quartz optical fibers and fiber optic irradiator are part of present daylighting system. Quartz optical fiber has high transmission efficiency and losses of the order of 0.01 dB/m. Design Length of threshold zone is a function tunnel overhead clearance (h) and stopping sight distance (Ds) and illumination is a function of outside illumination and reduction coefficient. With 60 km/h as the design limit, longitudinal slope of 2% and overhead clearance of 7.2 m, design length of the threshold zone was come out as 30.55 m. with reduction coefficient as 0.022 and outdoor luminance as 3794 lux in the month of April, luminance in the threshold zone should be around 83.47 lux. Actual value of the luminance inside the tunnel is by measurement is 181.31 lux which shows that arrangement met the requirement. Transmission efficiency of an optical fiber depends upon the length of the fiber. Optical transmission losses were only 12.9% for a 30-m length of fiber. Optical software DIALux also shows that designed arrangement met with the enhanced lighting demands.

Vu et al. (2016)developed a cost effective optical fiber daylighting system using modified compound parabolic concentrators. Simulation is carried out to determine an optimal design structure of M-CPC. Developed M-CPC has the high tolerance for input angle that provided the basis of the replacement of a highly precise sun tracking system with a lower accurate sun tracking system. M-CPC is designed by considering the relationship between different parameters. Different designs for M-CPC are analyzed for different focal lengths and an optimal focal length is selected based on the efficiency. It also proposed a simple injection molding method to manufacture the M-CPC for mass production.Singh et al. (2016) discussed about the solar lighting system and latest technological advancement. The basis of the study was to discuss the various types of hybrid systems used for solar lightings. Main features of the hybrid lighting systems, commercially available systems and latest advanced system are studied. Some of the discussed system are ORNL, SCIS, Parans, Himawari, American sundoiler, Suncentral, Ciralight sun tracker etc. It is stated that these systems are beneficial in terms of energy conservation but cost is a major factor which is restricting their widespread use.

Sedki and Maaroufi (2017)developed a fiber based optical daylighting system with a solution to heating problem of plastic optical fiber (POF). Parabolic solar concentrator which was used as collector is formed by mirror tile pieces. Single axis sun tracking system and Polymethyl Methacrylate (PMMA) fiber was used in the system. The main part of this system is triple heat filtration which is kept at the focal length of parabolic concentrator. In the first level UV and infrared rays are filtered using a filter; second level is vacuum where heat (associated with infrared) is vented out which lowers the temp of the beam; third level is a Plano concave mirror which produces uniform illumination. The maximum temperature inside fiber during the analysis was measured as 32° C which was much lower than the maximum exposure temperature of PMMA fiber (70° C). From the analysis it is concluded that illuminance from the system with triple heat filtration is lower than the system without heat filtration till 2PM. After 2PM, illuminance from system without filtration decreased rapidly due to melting of the fiber at entrance. On the other hand, system with filtration gives better illumination due inclusion of filtration devices.

Ullah et al. (2017) developed an arrangement for collector and transmission part of daylighting system. An eight-fold Fresnel lens as the primary optical element (POE) and an octagonal spherical fiber connector as the secondary optical element (SOE) are used. Both are used as collectors. Two types of optical fibers are used: Silica Optical Fiber (SOF) and Plastic Optical Fiber (POF). Numerical aperture and Fresnel reflection losses are of major concern in fibers. Single layer and bi-layer prismatic diffuser simulation results made a comparison for the illumination at desired area. The proposed design was verified by simulation. Finally, they have compared the different reflectors used as collectors and graphically showed that the proposed eight-fold Fresnel lens gives the best indoor illuminance.Wong (2017) started discussion with the need of alternative to artificial lighting. Daylight measurement parameters are discussed. Daylight is said to be the most widely accepted daylighting measurement parameter. Innovative daylighting systems, which the authors divided into two categories namely light guiding system (LGS) and light transporting system (LTS). A few LGS and LTS systems were discussed and problems associated with them were highlighted. Author has given a brief about the methods and various simulation tools that can be used for investigating daylighting performance in the building.

10. Conclusions

With the increase focus on global greenhouse gas reduction, green building concept has become more popular. Green building rating system on the basis of usage of more amounts of natural resources has revived the interest in daylighting. This paper presents the overview of daylight and its importance. Some innovative daylight system use Fresnel lens and optical fibers as collector and guiding device respectively. Discussion on Fresnel lens geometry, factor affecting its performance is necessary to notice the behavior of light pre and post reflection. Transmission parameters of Fresnel lens are of high important as losses associated and its transmission efficiency can be computed.Optical fibers are important light guide devices used in daylighting system. So,related terminology and relations are important when fibers are linked to collectors.Dependency of the fiber efficiency on length and attenuation rate shows the criteria for choosing a length for fiber with desired material. System efficiency includes the transmission efficiency of lens, efficiency of optical fiber, transmission efficiency of diffuser and efficiency after transmission loss through air-core interface. Parametric study of daylighting components will help in deciding combination of components for particular application.

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