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Photoplumbing (Optical Fiber Lighting)

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Abstract: *Even on a grey day with an overcast sky there is normally excess of light outdoors in comparison with what is required at most work places indoors. This excess of light can be harvested, concentrated, amplified and distributed indoors by fibre optics to replace most of the electrical lighting. The whole system manually tracks the sun. In doing so, it could have an operation period of around 6hrs each day with its peak efficiency at noon. We analysed three systems. They are all biaxial tracking system. There are several benefits of day lighting, energy saving is one of them. Not only is electric lighting replaced, but also unwanted heating produced by lighting is reduced. Other benefits of day lighting include health advantages, reduction in carbon footprint, saving in money and psychological benefits that have been shown in studies. To design a fiber optic day lighting system, several aspects have to be considered. The collected light has to be concentrated to pass through fiber end. However, the availability of sunlight is unpredictable. These conditions should be main consideration for the designer of fibre optic day lighting system.*

Keywords: *Day lighting, Fiber Optics, Green Technology, Solar Concentrator, Solar tracking.*

I. Introduction

Nowadays most of the commercial buildings like school, banks, offices use lot of electricity during daytime for lighting purpose. Around 30%-40% of total electricity is used for lighting. Our main aim is to reduce this usage of electricity during daytime. After scouring we've found that at least four fibre optic daylighting systems exist already. It's Himawari, Parans SP3,HSL (Hybrid Solar Lighting) and Solux. The three systems utilize fresnel lenses to concentrate the light and one utilizes parabolic mirror. To maximize their potential all these systems employ precise solar tracking system. Each of these systems has their own benefits and drawbacks. The purpose of this paper is to compare these systems and to decide which one is better.

We're going to fabricate a reliable system for our project so we've decided to compare these four systems to find out which one is more suitable for Indian climate. By developing a suitable and more efficient daylight collecting and distributing system will lead us to a solution of the energy problem which is becoming more serious. Natural light is the requirement of our needs. There has been a research that sunlight has positive effects on our body. It can be used to reduce seasonal affective disorder and other illnesses [1].Research has confirmed user preference for daylight in working interiors, which has implications for user satisfaction and well-being.

Fig. 1 Schematic Representation of Day lighting.

II. Research

We've analysed four systems Himawari, PARANS SP3, HSL and Solux.

2.1 Himawari: This is a daylighting system based on concentrating Fresnel lenses and glass optical fibers. It was developed in Japan in the late 70ies by Prof. Kei Mori and it was named after the Japanese word for sunflower. The HIMAWARI solar lighting system transmits sunlight while screening out ultraviolet rays. Since the light is provided by the sun, it is gentle on the eyes and skin and creates a relaxed atmosphere which could never be provided by any artificial lighting system. The HIMAWARI system consists of a lens focusing unit and

optical fiber devices. Its outdoor collector can collect sunlight and transmit it through optical fibers to anywhere you want.

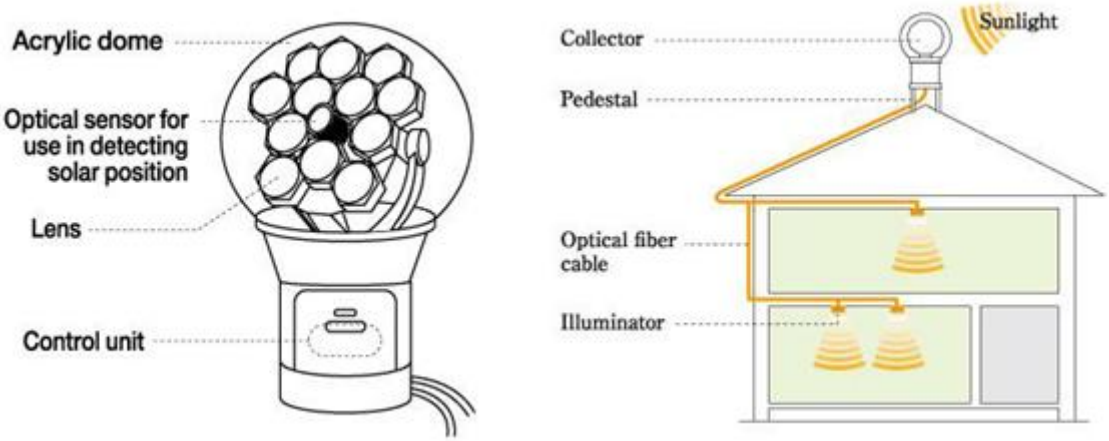

Fig. 2 Schematic Representation of Himawari System

Collected sunlight passes through quartz-glass optical fibers which transmit visual ray-dominated sunlight. Optical fibers are so thin and flexible that they can freely transmit light to rooms in any building. HIMAWARI is equipped with an automatic tracking system. A solar sensor and clock mechanism control the movement of the light-focusing lens so that it is always accurately aimed at the sun. Even when clouds block out the sun, the system can track the movement of the sun by calculating the trajectory and respond speedily to changes in the weather. [2]

Fig. 3 Himawari System

By using the acrylic dome covering the lenses and chromatic aberration through single lens focusing, the sun's UV can be eliminated. Since the HIMAWARI system screens out ultraviolet rays, it doesn't damage fibers.

2.2 <u>Parans SP3</u>: This system also uses array of fresnel lenses the only difference is that this model uses square shaped Fresnel lenses. This system consists an array of 36 fresnel lenses which are connected with 36 optical fibers. Each lens is coupled with reflecting filter which filters out harmful UV and Infra radiation which results in reduction of heat. The light is obtained by this system is beneficial for health and it also creates relaxed atmosphere.

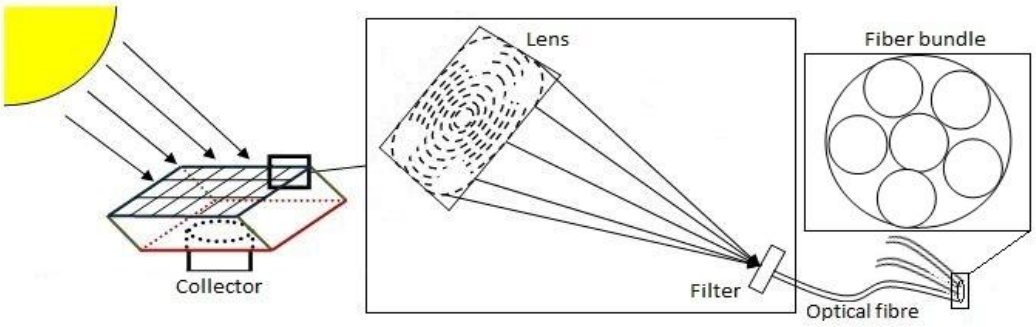

Fig. 4 Schematic Representation of Parans SP3

This system employs biaxial tracker which consist of two degrees of freedom. Horizontal axis rotates about 360° and vertical axis rotates about 180°. After collecting and filtering sunlight it is then passed through 36 PMMA optical fibres which are coupled directly to the lens-filter system. [3]

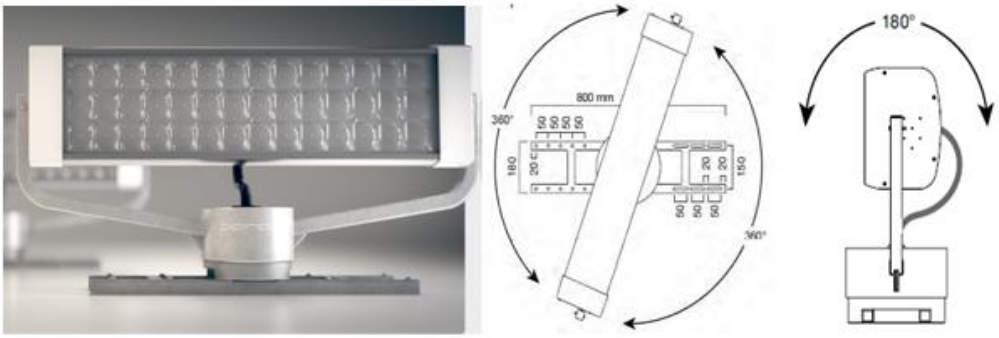

Fig 5.Parans SP3 System

2.3 <u>Hybrid Solar Lighting</u>:Hybrid solar lighting (HSL) is a technology that collects sunlight and distributes it intothe interior of a building via optical fibers. A solar collector concentrates the light into anoptical fiber bundle and transports that light into the building, where it is released in controlled manner to replace a portion of the lumens required for lighting. Hybrid solarlighting increases the amount of lumens inside the building per watt of electricity beingused to light interior space. Unlike conventional electric lamps, hybrid solar lighting system produces virtually no waste heat.

The HSL consisted of five major components: the system mounting base, the primary and secondary mirror- mount casting, the primary mirror, the secondary mirror, and the fiber/mixing rod holder. The primary parabolic mirror receives sunlight and concentrates it towards secondary elliptical mirror. The secondary mirror is made of Borosilicate which has property of filtering harmful UV and Infrared radiation. The secondary mirror then concentrates light at its focal point where fiber optic receiver is located which collects sunlight and carry it to the other end of fiber via total internal reflection.

The HSL collector houses a sun- tracking control board used to calculate thesun's position based on latitude, longitude, and time of day.The control board uses a microprocessor to determine the positions in the azimuth and zenith Earth- based coordinate system. [4]

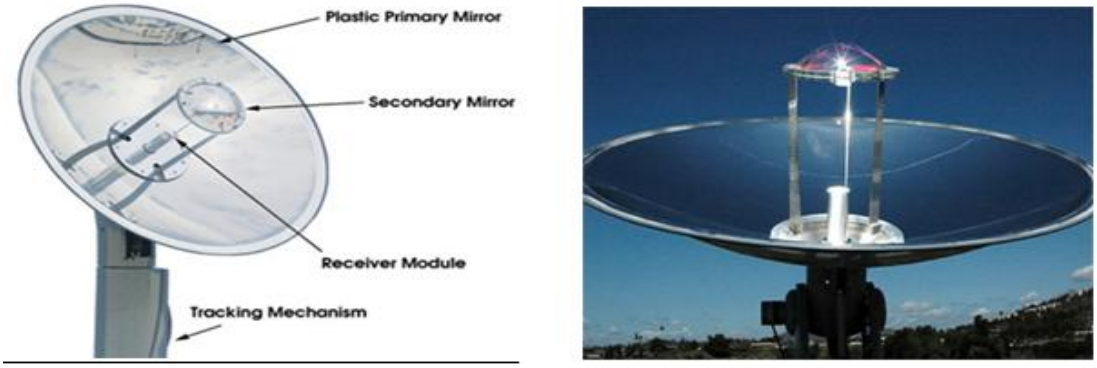

Fig. 6 Hybrid Solar Lighting System

2.4 Solux: This is Fresnel lens-based daylighting system developed by German company Bomin Solar Research (BSR). The collected sunlight is transmitted by liquid light guide. A first demonstration system with three collectors has been installed at German museum of technology in Berlin along with other daylighting system. The collector is sun tracking biaxial unit. The concentrated and filtered sunlight from the collector is fed to liquid light guide. This is flexible pipe 2cm in diameter filled with an optical clear liquid made up of several components. [5]

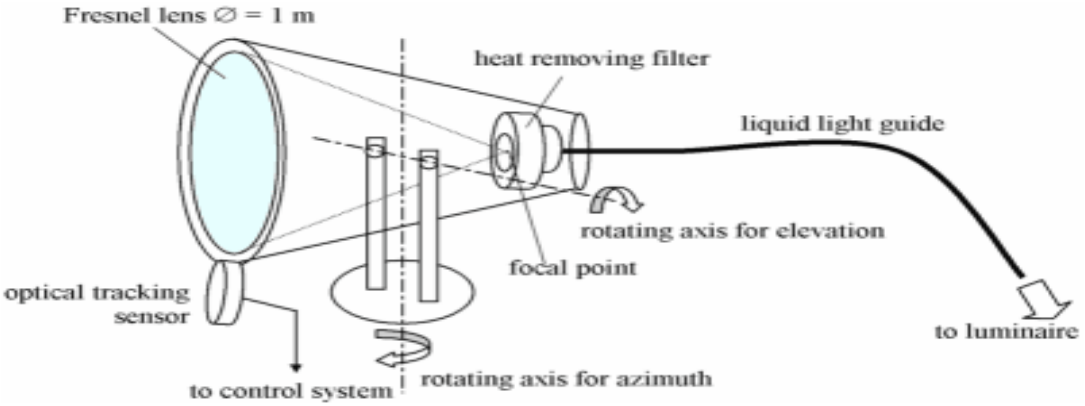

Fig. 7 Schematic Representation of Solux

Fig. 8 Solux System

III. Observations

Sr. no	Name of system	Technology used	Efficiency (1. 4m-single story (2. 8m-double story building)	Output	Economy (USD) for 10 x 10 meter room
1.	Himawari	Use of Fresnel lens as light guide.	1. 70% 2. 50%	1630 -2000 lm (98000 lux)	6000-7000$
2.	Parans sp3	Use of Fresnel lens as light guide.	1. 80% 2. 60%	7500- 10000 lm (75000 lux)	5000-6000$
3.	Hybrid solar lighting	Use of parabolic mirror as light guide.	1. 50% 2. 30%	4170-6250 lm (100000 lux)	3000-4000$
4.	Solux	Use of Fresnel lens and liquid light guide	1. 30% 2. 20%	2000-3000 lm (100000 lux)	1500-2000$

IV. Conclusion

Thus we've analysed four day lighting systems namely Himawari, Parans sp3, Hybrid Solar Lighting and Solux system. We've compared these four systems with respect to different parameters like techniques used for concentration of daylight, initial and maintenance costs, reliability, efficiencies and outputs. [6]

After analysis we came to know that Parans sp3 and hybrid solar lighting system are more efficient systems than the other ones because these systems have less maintenance costs, more reliable and efficient. We ruled out Himawari and Soluxdaylighting system because of their high initial and maintenance costs and comparatively low outputs.

V. Acknowledgment

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