MID-SEMESTER REPORT

DEVELOPMENT ENGINEERING PROJECT (CP301)

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Table of Contents

1. *Title of the Project:*

Daylight System Using Optical Fibers

2. *Aim:*

The main aim is to design and fabricate a daylight system which utilizes sunlight to provide illumination to gloomy indoor places, without the aid of electricity.

3. *Introduction:*

Daylighting technologies have been growing in green buildings since the concept of energy saving was put forward. Daylight, an excellent natural light, has a positive impact on visual comfort and productivity.

Daylighting technology does not depend on energy conservation. It is a novel way of solar energy different from solar thermal power generation and photovoltaic applications. Reasonable measures can considerably reduce electric energy consumption in building illumination. It is suitable for a wide range of applications, such as offices, exhibition halls, nursing homes and so on.

The daylighting system is an optic-mechanical electric technology that collects day light outside to transmit into basement and room lacking natural light by fibers in high concentrated level.

The infrared (IR) and ultraviolet (UV) portions of solar radiation are separated and eliminated by lens and fibers so that the output flux is a cool light, the tone of the light being natural and gentle on the eyes; qualities that cannot be reproduced by any artificial illumination. This technology has the ability to bring sunlight much deeper into buildings without impacting space layout or heat gain issues that complicate most daylighting strategies. As products become commercially available and increasingly economically viable, these systems have the potential to conserve significant amounts of energy and improve indoor environmental quality across a variety of common applications.

Fixed daylighting systems are frequently used. The fixed system frees the structure from complexity. Our project aims to design a prototype for a portable daylighting system by making it small and easy-to-handle. Portable daylight systems are generally more useful as they are flexible and have the property of being able to be deconstructed and re-assembled.

Fig.1 Expected result from our system [8.1]

A lot of rural areas in India suffer from lack of electricity or power outage. Our system aims to provide a low-cost solution which can be implemented in these conditions leading to availability of indoor lighting where it is not available today.
Even in areas where electricity is readily-available, our system can help reduces the use of power, thus contributing to environmental sustainability.
This inspired us to choose this daylighting system as our topic for the development project and explore economical and cost-effective solution for the same.

4. *Background and Literature Review:*

In recent years, there have been numerous efforts to harvest solar power in pursuit of sustainable and renewable energy. This has led to emergence to various technologies that harvest solar energy in one form or another. Among the many innovative solutions, daylight harvesting systems have emerged as a promising approach to optimize light utilization withing indoor spaces.

Harnessing sunlight not also significantly reduce the reliance on artificial lighting but also reduces the load on eyes, thereby enhancing visual comfort.

Traditional daylight collecting systems frequently encounter obstacles such unequal light distribution, reliance on outside variables like the weather, and challenges accessing deep interiors of buildings. The use of optical fibers into daylight harvesting devices has drawn notice as a ground-breaking development in response to these difficulties. Optical fibers provide an innovative way around the drawbacks of traditional technologies to direct natural light deep into structures.
The core principle of daylight harvesting using optical fibers involves capturing sunlight at the building's exterior and guiding it through high-quality optical fibers to deliver uniform and controlled illumination throughout the indoor spaces. This technology holds significant potential for a wide range of applications.

Furthermore, Daylight systems have proven to save energy and cost. For schools, the cost savings have been estimated to range from $9000 to $32000 annually. The energy saving features used in this project have reduced the energy use for lighting, ventilation, and heating by 50% to 60%. The estimated payback period for daylight systems is considered to be three to five years. The study also showed that students had performance improvements by attending daylit schools [8.5].

Daylight systems have attracted a number of researches about various designs which could be utilised for applications such as residential, commercial, and industrial buildings, as well as educational institutions. We explore some of these works and their insights.

The study in [8.1] proposed a sophisticated daylight system using highly concentrating Fresnel Lens. It also presents a design for a solar tracking system which helps keep the array of lenses always facing towards the sun. The design presented in this paper is very cumbersome and requires sources of electricity, which is a factor that our design tries to avoid.

In [8.2], the design proposed is a sleeker version of one above. It uses mirror in the solar collector component instead of highly-focusing Fresnel lens. This system also uses integrated a sun-tracking system and proposed two different designs for it. The first uses a photocell to measure the intensity of incoming light and modulates the tracking motors to point the collector in the direction of maximum light intensity while the second strategy utilizes electronic micro-controllers to calculate the celestial bearing of the sun relative to the earth and align the collector accordingly. Both of these strategies are viable for a system seeking to use a solar tracker.

The study in [8.3] talks about use of light tubes in daylight systems. It lists various configurations of light tubes such as single light-tube, double light tube or two separate light-tubes. The work analyses the differences in setup required for each of them and compares their performance in common office building. It concludes that a single light-tube design is better than the other two aforementioned designs.

The author in [8.4] explores the concept of “photoplumbing” and compares four different designs to analyse their effectiveness in the Indian climate. These designs were called “HIMAWARI”, “Parans sp3”, “Hybrid Solar Lighting” and “Solux” daylighting system. After the study, both “Parans sp3” and “Hybrid Solar Lighting” systems performed better than the other two and concepts from those systems help us in making better design for our system.

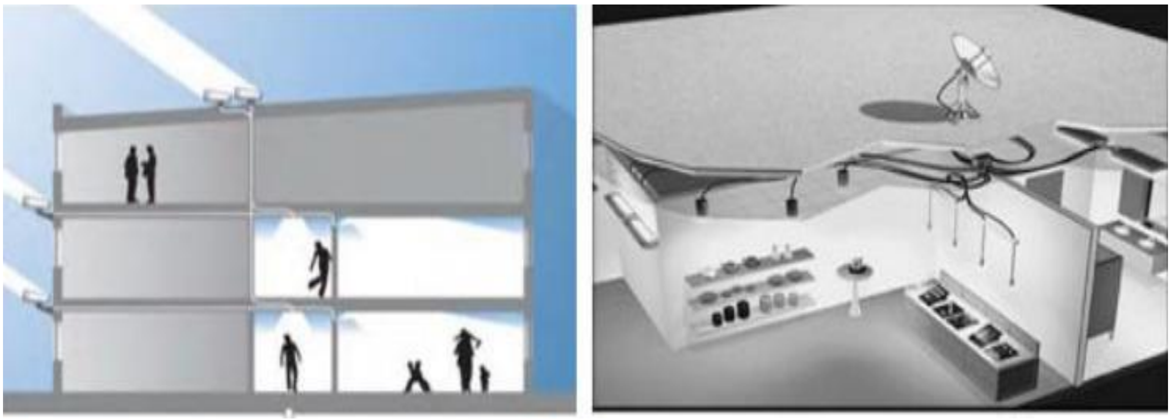

Fig.2 Schematic Representation of Day lighting [8.4]

The reference [8.5] is a collection of various case studies about the benefit of daylighting system in schools. The case studies describe schools that were approved by school boards and administrators to incorporate the benefits of daylighting into their learning environments. It suggests that incorporating natural daylight into school environments can have positive effects on both student health and academic outcomes. The authors argue that such improvements are achievable at a reasonable cost for educational institutions.

[8.6] is one of the works we found that also does not incorporate a tracking component. This design makes use of both optical fibres and light pipe technology to overcome their respective limitations. The study claims, through both their theoretical analysis and field test, that their system has the same reception feature as the traditional optical fiber system with a tracking device and that its graph of the illuminance roughly follows the fluctuation of the curve of the solar irradiance.

The work in [8.7] goes in detail about the vertical pipes and their use in illuminating the central parts of buildings not reached by sunlight. This study provides a comprehensive design for using light pipes to distribute light at different floors of the building. The reported about an increase in illumination of about a factor of seven for lower level of building for low elevations of sun with the use of a sun-tracker.

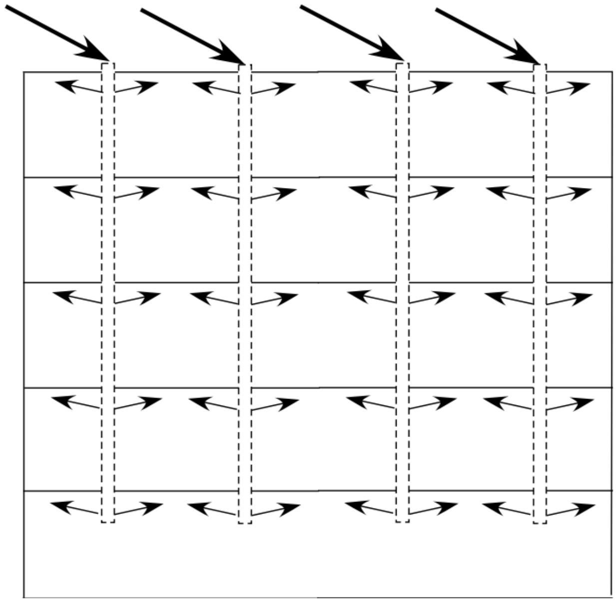

Fig.3 Basic design of daylighting system using natural light to a five-level building [8.7]

All of these studies have explored different aspects of daylighting systems and have helped us to know about various design considerations while making a daylight system. We have learned about the limitations of these designs and also their features which seem to have been outside the scope of our project.

- ***Objective***

  With our learnings from these studies, our objective is to devise a robust and compact daylight system with minimum cost. While most of these solutions have not been researches, we aim to make a system is ready to be used in day-to-day life conditions out-of-the-box and is cost-effective, environmentally friendly, and easy to deploy and maintain.

5. *Experimental and Analytical Details:*

Our project is centred around harnessing solar energy through an innovative system comprising a concave dish solar collector designed to concentrate sunlight onto a focal point. At this focal point, we have devised a circular disc type setup housing multiple plano-convex lenses connected to optical fibers. The fundamental objective of our endeavour is to capture sunlight efficiently and transmit it to areas where natural light is limited or inaccessible.

The concept of utilizing solar energy for indoor illumination not only presents an opportunity to reduce reliance on conventional electricity but also offers numerous benefits associated with natural sunlight. By focusing sunlight onto the circular disc equipped with lenses and optical fibers, we aim to create a robust system capable of transferring solar energy effectively to interior spaces.

However, in the pursuit of this goal, we anticipate potential challenges, particularly regarding heating issues at the focal point. The concentration of sunlight at a single point can lead to a significant rise in temperature, which may necessitate a cooling mechanism to prevent overheating and ensure the optimal functioning of the system.

To address this concern, we have proposed the implementation of a pump radiator system designed to dissipate excess heat generated at the focal point. By circulating a cooling fluid through the system, we aim to maintain an optimal temperature range, thereby mitigating the risk of damage due to overheating and ensuring consistent performance.

Furthermore, as part of our project roadmap, we have outlined the potential integration of a solar tracker system using Arduino technology. A solar tracker would enable us to optimize the orientation of the solar collector dish, ensuring maximum exposure to sunlight throughout the day. While this aspect represents a future enhancement, our primary focus at this stage is to establish the feasibility of transferring sunlight to areas devoid of natural light.

The implications of our project extend beyond mere energy efficiency. By harnessing solar energy for indoor lighting, we envision significant cost savings in terms of electricity bills, particularly in settings where traditional lighting solutions are impractical or costly to implement. Moreover, the introduction of natural sunlight into interior spaces offers various health and wellness benefits, including improved mood, productivity, and overall well-being.

In essence, our project represents a convergence of renewable energy technology and innovative design principles aimed at addressing the challenges of indoor lighting in areas with limited access to natural light. Through meticulous planning, experimentation, and iterative refinement, we aspire to develop a scalable solution that not only reduces environmental impact but also enhances the quality of indoor living environments.

As we embark on this journey, we recognize the importance of collaboration, interdisciplinary expertise, and continuous learning. By leveraging the collective knowledge and resources available to us, we are confident in our ability to overcome challenges, achieve our objectives, and contribute meaningfully to the advancement of sustainable energy solutions.

6. *Work done and Work to be done:*

Work done:

In this part of our project, we've been busy designing a prototype for a special daylighting device. We've looked into how daylighting works and tried to find affordable and creative ways to make our design stand out. We used a computer program called SolidWorks to simulate our design and make sure it works well.

Our plan includes using plano-convex lenses, which are specific types of lenses that help manipulate light for our device. These lenses are essential for optimizing how the light spreads, making our daylighting device efficient. We carefully considered things like focal length and material properties before deciding on these lenses.

Now, to turn our design into a real thing, we need a bunch of items. We're talking about optical fibers, plano-convex lenses, a concave mirror, and PVC pipes etc. We've already reached out to different sellers to get these things, and we're expecting to receive them in the next few weeks.

Once we have all the necessary items, we'll start putting our design into action. We know there might be challenges along the way, but we're ready to face and fix any mistakes that pop up. It's like a step-by-step process to make sure our daylighting device becomes a success.

Our next big phase involves bringing together what we've learned, what our design looks like on the computer, and actually making it happen. Our main goal is not just to meet our original idea but to go beyond and make a daylighting device that's super effective, creative, and doesn't cost a lot. We're confident that by planning carefully, getting the right materials, and solving problems as they come, we'll end up with a fantastic daylighting solution.

Work to be done:

This next phase is a crucial step from concept to execution, and it will need a lot of work and accuracy. Tasks cover a range of topics essential to the completion of the project. Every stage, from obtaining materials to assembling, calibrating, and testing the system, necessitates painstaking attention to detail. This stage creates the link between idea and reality, setting the stage for a project's effective execution and goal achievement. This includes:

- **Thorough Testing of Optical Components:** To ensure the accuracy, robustness, and usefulness of different optical components, including lenses, fibers, and related parts, our team will put them through a thorough testing procedure. Light transmission efficiency, structural integrity, and compatibility with planned applications are just a few of the factors that will be tested.

- **Curvature Measurement and Preparation:** We are going to start our experiment by choosing discs that have different curvatures. Mirror shades will be added to these discs to enable accurate measuring. We will precisely determine each disc's curvature using cutting-edge methods and equipment, guaranteeing consistency and dependability in our data.

- **Optimal Lens Positioning:** After we have the curvature data, we will go on to aligning the lens with respect to the disc. For light manipulation to be successful, alignment must be optimized. We will carefully tune the lens's height in relation to the disc's curvature and focal length, using exact computations and experimental verification to guarantee the intended result.

- **Secure Binding of Optical Fibers:** Securing the binding of the optical fibers will be one of our main goals as we go forward into the period of actual execution. To maximize the effectiveness of sunlight transmission through the fibers, this technique is essential. We will carefully tie the fibers together using specific tools and materials in order to minimize losses and maximize the amount of sunlight that may be captured.

7. *Conclusion:*

In our project of "The Daylight System Using Optical Fibers", we tried to find a transformative solution poised to address the crucial challenge of indoor lighting accessibility, particularly in regions grappling with electricity shortages. With a central aim of harnessing sunlight in a manner that is not only efficient but also cost-effective, portable, and user-friendly, our system stands out as compared to other daylight optical systems. The project recognizing the intrinsic value of natural light in enhancing visual comfort and productivity within indoor spaces.

The inspiration drawn from the challenges faced by rural areas in India, where electricity shortages occur the most, this motivated us to look for low-cost solution with widespread applicability. Moreover, the project recognizes its relevance even in areas with consistent electricity access, aiming to contribute to energy conservation and environmental sustainability. The decision to embark on this journey was fueled by a vision of providing economical and cost-effective solutions, resonating with the needs of the society.

Currently our project is in the design phase, which is just the beginning of our journey, there is a significant amount of work that lies ahead in bringing the "Daylight System Using Optical Fibers" to fruition. The system aims to collect and transmit sunlight into interior spaces using a concave dish, some mirror sheets, convex lenses and optical fibers. As we are anticipating potential heating issues at the focal point, we plan on implementing a pump radiator system to counter this problem and ensure optimal heat management. Furthermore, if time permits, we plan to incorporate a solar tracker using Arduino. This additional feature, if executed successfully, will enhance the overall efficiency of our daylighting system. The next phase of our project involves transitioning from design to practical implementation, where the robustness and effectiveness of our system will be put to the test. In this phase we will try to address any unforeseen challenges and optimize the performance of our prototype.

In conclusion we believe that our project "Daylight System Using Optical Fibers" will provide an economical and sustainable solutions that will eliminate the problem of illumination in rural areas as well as find application in closed spaces that require illumination.

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