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Quantitative and qualitative efficiency of daylight using optical Fiber lighting systems in Housing

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Abstract

The sad situation regarding modern buildings is that such buildings lack natural elements such as open air, sunlight, and the sky. A large number of modern apartments are just considered as a windowless dovecote. The present study was conducted in four steps. First, a preliminary framework for assessing the best way of tasks was found for the efficiency of the day light through content analysis method by collecting information from literature review of the optimal approach to internal and external sources. Then, the simulation method was selected from the available alternatives to obtain the daylight in the internal spaces of the housing. Finally, the alternative system was selected and calculations were performed using Dialux software with artificial lighting mode. Based on the results, optical fiber can be an appropriate replacement for natural light in interior spaces. In addition, fiber optics can bring natural light into deep floor plans in different floors, improve the efficiency of the building, increase the quality of living space by normalizing sleeping and waking conditions, raise disinfecting properties for residents, reduce the volume and emission of greenhouse gases, and save energy.

Keywords: Interior Lighting, Optimization and sustainability, Natural Lighting and Housing, Dialux, Optical Fiber.

1. INTRODUCTION

Diseases created by insufficient artificial lighting spread much greater than the situations where natural light is available [1, 2]. In addition, using electrical lighting systems leads to high cost, warming the air, and visual and mental fatigue [3]. The lamp light is regarded as more uniform than the natural one, while natural sunlight can be utilized for lighting the interiors of residential places which need light during the day. The replacement of fossil fuels by renewable energy including solar energy to reduce and save energy consumption and control supply and demand for energy to prevent the emissions of pollutant gas has attracted a lot of attention besides the energy crisis during the recent decades [4]. Further, the passage of time and development of new cities have led to the formation of dense and high-rise buildings and a dominant pattern in the massification of buildings in the plot, resulting in creating blind cores and deep plans which aim to transmit light with only one or two external fronts [5]. A deep plan has a depth which exceeds the passive zone and requires electrical energy for lighting and ventilation [6, 7]. In terms of energy efficiency in a building, a passive zone is considered as an area which can benefit daylight and natural ventilation passively. The depth of the passive zone can be considered to be about twice the height of the ceiling [8, 9].

2. METHOD

The present study was conducted in four main steps. First, the literature review and background was evaluated to achieve the concepts and principles required. Then, the method, simulation model, and lighting system were selected. Finally, a number of solutions were proposed based on the information obtained from the previous steps.

A five-story block was designed in which deep plans were applied to observe their challenge. Thus, the plan of different floors was simulated in Dialux software for winter daylight in an almost clear sky. Then, the spaces including bedroom, kitchen, bathroom, and corridor which do not receive enough light were simulated in two modes of lighting using the day lighting system such as fiber optics and lighting with artificial light such as electric lamps in Dialux.

3. Results and Discussion

To achieve brightness almost equal to that of artificial light, the $sp_{4\text{-}4}$ system was utilized to provide brightness between 3600-5200. However, the above-mentioned system consumes only 0-12 watts per hour for the solar tracking system.

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Table 1. Comparison of two systems in terms of light intensity

Bedroom	Surface	Average /Target	Min	Max
Electric lighting system	Room	150 /101	10	339
	Work plane	400 /380	204	788
Fiber optic system	Room	150 /120	20	265
	Work plane	580 /400	262	1110
Kitchen	Surface	Average /Target	Min	Max
Electric lighting system	Room	150 /112	10	391
	Work plane	300 /167	41.7	389
Fiber optic system	Room	150 /164	20	591
	Work plane	253 /300	64.1	558
Corridor	Surface	Average /Target	Min	Max
Electric lighting system	Ground	120 /119	52.7	166
Fiber optic system	Ground	120 /190	84.3	266
Bathroom	Surface	Average /Target	Min	Max
Electric lighting system	Work plane	120-200/ 118	19.5	225
Fiber optic system	Work plane	120-200/194	30.8	348

4. Conclusions

As indicated, this study seeks to eliminate the obstacle of natural light in some functional spaces in the deep plans of residential units. Applying artificial light creates a large number of obstacles in the field of health and dynamics of the living environment, consumption of large amounts of non-renewable energy and fossil fuels, and emission of greenhouse gases.

Optical fiber can be an appropriate alternative to artificial lighting, especially in Iran, due to its low location and latitude and sufficient sunlight in different months of the year and having an almost clear sky on most days of the year. In addition, optical fiber can bring natural light into deep plans in different floors, improve the productivity of the building, and increase the quality of living space for residents.

Based on the results, applying the aforementioned system reduces the power consumption for such spaces from 388.2 to 6 watts per hour, which is regarded as a significant reduction. In fact, the above-mentioned reduction occurs only for one residential floor during one hour, which saves 19410 W/h electricity or 582300 W/h during one month equivalent to approximately 600 kW/h for only a five-story when the system is used for example for five floors of two flats for an average of five hours per day.

Fiber optics cannot fully utilize daylight in spaces due to the limitations related to land, site, and area. In fact, applying such technology at a height of more than two floors compensates for the lack of light and has several advantages as follows.

- Reducing power consumption
- Decreasing emissions
- Having antiseptic properties
- Adjusting the circadian rhythm and sleep-wake cycle
- Eliminating the risk of electric shock and electrical connections.

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