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High-performance renovation of Iranian historical buildings to substitute active lighting systems with natural light (case study: Shahi Bank, Tehran)

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Abstract

In this research, building lighting systems and façade glazing system and architectural design of `Shahi Bank` have been evaluated and developed on the basis of the analysis on natural light patterns, which have been derived based on the simulation process by ECOTECT software.
During the simulation process, both conditions before and after the design, have been examined and compared with each other. The results from simulations show that absence of appropriate light levels in the middle of the main hall can be solved by locating three light tubes, which could provide an adequate natural light level for this space.

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Keywords: high performance renovation; light distribution; natural light.

1. Introduction and Methodology

In this paper, some techniques and configuration that can be used for optimizing natural lighting without glare effects have been studied. Also we have studied the merits of each single and double skin façade and other additives that can be used to achieve better energy efficiency for traditional buildings. The strategies are implemented on a bank office building and evaluated based on the performance which is designate for office occupation.

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In addition, three types of façade system (Traditional façade (with brick as external layer), Single skin façade and Double skin façade) have been chosen as options for glazed area in order to explain and compare the following factors:

- *Architectural design:* In this part, the office building was designed within two stories and redesigned to have better performance for light distribution, considering this fact that this building is located at the city center of Tehran with a semi-arid climate.
- *Environmental design:* As a main objective of this research, three types of building's façades (traditional, single skin façade, and double skin façade) were compared with each other as options for renovation of the glazing areas.
- *Lighting:* The daylight level was analyzed using ECOTECT software in order to find the best solution for providing sufficient light level and enough visual comfort as well.

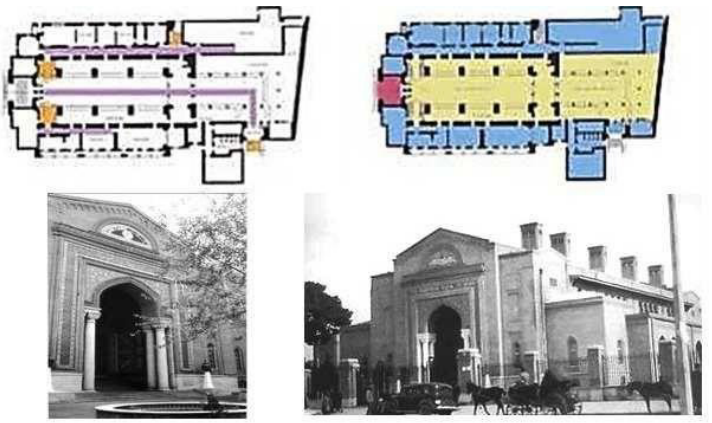

Fig. 1. Architectural design and the conventional distribution of lighting in interior space of the bank

2. Literature Review

"Double-skin facade is a special type of envelope, where a second skin, usually a transparent glazing, is placed in front of a regular building facade. The air space in between, called the channel, can be rather important. In general, the channel is ventilated (naturally, mechanically, or using a hybrid system) in order to diminish overheating problems in summer and to contribute to energy savings in winter."

Viljoen investigated the possibility of improving day lighting for double skinned office buildings [1]. Scale models were used in an artificial sky and computer simulations. This was to examine the effects of changes in re-entrant slots in the facade and lowering of the central area on the floor. The result showed that the daylight area can increase by equal to 23% when it uses a walkway or cavity option alone, as compared to re-entrant facade slots that produced no increase in the daylight area, lowering the central floor area produced an increase of up to 14% of light. None of the walkway options could produce a daylight area of greater than 53% of the total floor space.

In addition, Hien [2], Gratia [3] espoused that using DSF can reduce the lighting energy consumption by making full use of day lighting. Furthermore, in another related study, Kim [4] also evaluated the control performance of a daylight dimming system by using double skin envelop (DSE) configurations under a variety of daylight conditions. The purpose was to propose a better control alternative in a small-office space. Computer simulations were performed for photo sensors positioned at three distinctive locations in three different shielding conditions with three different sky conditions. The result showed that a partially shielded condition generally achieved good dimming performance under clear and intermediate cloudy skies.

On the other hand, Hoseggen [5] claimed that the additional glass layer reduced the indoor daylight illumination levels. According to Poirazis [6] the daylight properties of DSF are similar to other types of glazed facades (i.e. single skin facade). This means that an area within the floor space is considered to be daylight when it receives at least 300 lx for over 50% of the working year. Based on the previous mentioned studies, they demonstrated a lack of deep