Abstract

The objective of this paper is to propose strategies to increase the market value of Tokyo’s existing office buildings using natural lighting as an integral part of office renovation. Value in Tokyo office buildings has traditionally been judged in terms of a limited range of considerations — location, functionality and architectural aesthetics. Recently however, the decision-making factors which drive the market value of Tokyo’s office buildings have widely recognized the benefits of a broader range of considerations associated with “environmentally friendly building” which offers higher quality indoor working environments and improved energy efficiency. With such an increased consciousness of environmentally responsible practices, office renovation with natural lighting provides an appropriate response to the demands of the recent Tokyo office market.

Current techniques in Tokyo office renovations associated with natural lighting only tend to focus on shading functions to avoid overheating and glare problems. This paper offers an innovative office renovation design framework which aims to provide effective natural lighting control solutions which function to enhance interior natural lighting through distribution to the interior while maintaining the shading function. This framework seeks to integrate team decision making and a simplified natural lighting evaluation software with the design process to optimize natural lighting conditions in office environments. Through the design of effective natural lighting control devices, office renovations can provide more comfortable and delightful office environments which have a high potential for increasing worker productivity, while increasing energy efficiency.

The objective of this study is to position natural lighting strategies as an integral part of office renovation planning and to suggest that natural lighting provides innovative techniques to increase the market value of Tokyo’s existing office buildings. Effective natural lighting control devices can take advantage of the benefits of external natural lighting even within Tokyo’s dense urban situation and distribute them to office interiors. This paper argues for analysis at a preliminary stage of renovation, to identify the effective design parameters for installing natural lighting control devices and to evaluate the potential of lighting control devices for improving indoor environmental performance.

1. Research Software
A flexible 3-D modeling and environmental evaluation software, ECOTECT v5.0, is used for this study. The advantage of ECOTECT is that it is easy to use, provides quick and relatively accurate results, and can be used to evaluate models of varying complexity (including models with a limited scope of input data). As such, it can be a very useful research tool for testing and modifying designs even at early stages of the design.
process where only more general input data are available. This flexibility makes it well suited for use in an iterative process of modification and evaluation in this study.

1) Construct a 3-dimensional model of a typical Tokyo office building (see section 2)
2) Construct 3-dimensional models of natural lighting control devices, and allow for modifications to the design parameters
3) Measure the area of the 600 lux minimum standard lighting level from the window (recommended as the minimum lighting level for desk surface from Ministry of Construction)

2. Configuration for the Hypothetical Office Building
Using the ECOTECT modelling software, a hypothetical office building is modelled to explore the potential for the widespread application of effective natural lighting control devices as an integral part of office renovation. The following is a description of the features of the hypothetical office building (designed in 1970's and 1980's):

1) A 9-storey office building located in an urban environment.
2) The building height is 31m (based on Japanese Building Code from the 1970's).
3) The building measures a typical 27m long and 25m deep, with the main facade facing south.
4) The floor to ceiling height of each level is 2,500mm.
5) The building has 1,600 x 1,200mm clear single pane windows, no internal blinds, no overhangs over the windows.
6) The occupancy schedule is 8:00 a.m. to 6:00 p.m., 5 days per week.
7) The building is installed with typical electrical lighting systems — having a high lighting density of 20.6 W/m² per year and 2,400 hours per year (Ministry of Construction, 2001).
8) The building is surrounded by local obstructions from 5m to 50m with the same characteristics as the hypothetical building.

3. Effective Natural Lighting Control Devices
The key design parameters for each of the natural lighting control devices described below (fig.1) are examined using ECOTECT v5. with Tokyo’s sun positions (latitude 35.60, longitude 139.70) using the hypothetical Tokyo's office building (see section 2).

1) internal natural lighting control devices
2) internal + external natural lighting control devices
3) internal + external + ceiling natural lighting control devices

As a result of the interior natural lighting evaluation using ECOTECT, internal + external + ceiling lighting control devices provide the most effective distribution performance while maintaining shading performance under Tokyo's urban context. In section 4, the analysis has focused on determining the specific parameters for this control device.
4. Site Specific Office Building Design Case Study

The site specific case study provided here aims to demonstrate a process of analysis for the configuration and evaluation of effective natural lighting control devices (internal + external + ceiling) for office renovations in the Tokyo context. The hypothetical office building is set in a specific location with a fixed obstruction distance of 10 m (a typical street width in Tokyo), and fixed obstruction height of 31 m. With fixed obstructions, the available direct sunlighting during a year becomes varied on the different floor level. Therefore, natural lighting control devices can take on different configurations for different floors (fig. 2):

The fig. 3, 4, 5 and 6 present a graphical summary showing the resulting of the annual average interior natural lighting performance of each added to the effective natural control devices to retrofit the hypothetical building. This comparison is shown for both clear and overcast sky conditions. These figures show the percent increase in natural lighting under both clear and overcast sky conditions:

1) compared with the hypothetical building with no control devices (fig. 3 and 5)
2) compared with the hypothetical building with curtain wall renovation (fig. 4 and 6)

4.1. Clear Sky Condition

Under clear sky conditions, a comparison of interior natural lighting performance for the internal + external + ceiling device configurations with the hypothetical building with no control devices shows the following results (fig. 3):

1) 4th floor to 9th floor
   a) Internal + external + ceiling control devices are effective in increasing interior natural lighting performance by approximately 80% within 3 m to 7 m from the façade while maintaining appropriate shading performance.

2) 1st floor to 3rd floor
   a) Internal + external + ceiling control devices are effective in producing a uniform increase in interior natural lighting performance of approximately 40%.

   b) Internal + external + ceiling control devices are effective to extend the 600 lux interior natural lighting performance area to twice the depth limit of the existing condition (without control devices) for all floors.

Under clear sky conditions, a comparison of interior natural lighting performance for the internal + external + ceiling device configurations with curtain walls shows the following results (fig. 4):

1) 1st floor to 9th floor
   a) Internal + external + ceiling control devices are effective to extend the 600 lux interior natural lighting performance area up to 6 times the 600 lux depth
produced by curtain walls while providing sufficient shading performance equal to that produced by the curtain wall.

b) For the lower floors, internal + external + ceiling control devices are effective in increasing the interior natural lighting performance by approximately 150% within 6 m.

4.2. Overcast Sky Conditions
Under overcast sky conditions, a comparison of interior natural lighting performance for the internal + external + ceiling device configurations with the hypothetical building with no control devices shows the following results (fig. 5):

1) 1st floor to 9th floor
   a) Internal + external + ceiling control devices are effective in producing a uniform increase in the interior natural lighting performance of approximately 40 to 60%.

   b) Internal + external + ceiling control devices are effective in extending the 600 lux interior natural lighting standard depth by up to 2 m from the 1st floor to 9th floor.

Under clear sky conditions, a comparison of interior natural lighting performance for the internal + external + ceiling device configurations with curtain walls shows the following results (fig. 6):

1) 1st floor to 9th floor
   a) Internal + external + ceiling control devices are effective in increasing interior natural lighting performance by approximately 80%. The area which indicates a 100% improvement reflects the impact of positive distribution in contrast to the curtain walls’ screening effect.

This analysis of interior natural lighting performance under clear and overcast sky conditions suggests that the combined internal + external + ceiling control devices are effective in increasing interior natural lighting performance for all floors compared with both the hypothetical building with no control devices and curtain walls.

5. Energy Consumption and Operation Cost of Electrical Lighting Systems
When interior natural lighting performance is improved, the area of natural 600 lux standard lighting level (recommended as the minimum lighting level for desk surfaces) is extended, and electrical lighting systems need only function as supplemental lighting sources to respond to fluctuations through dimming or switching systems. As a result, energy consumption and operation cost are dramatically reduced.
1) Internal + external + ceiling with high energy efficiency electrical lighting systems with the dimming systems reduce energy consumption by 31% and operation costs by 35% compared with hypothetical office interior condition.

2) Internal + external + ceiling with high energy efficiency electrical lighting systems with the dimming systems reduce energy consumption by 16% and operation costs by 15% compared with curtain wall renovation.

The results of the analysis in this study emphasize that effective natural lighting control devices enhance interior natural lighting performance and reduce energy consumption and operation costs of electrical lighting systems within the context of a typical older existing office building in Tokyo. This innovative approach to office renovation design reveals the potential opportunities in natural lighting control devices, and provides a framework which allows these opportunities to be realized effectively to increase the market value of Tokyo's existing office buildings.

Works Cited


