Effects of Exterior Blinds and Heat-generating Double-glazing in an Office Building

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ABSTRACT: In an office building, which has various heat sources such as lighting, people, PCs and other equipment, solar shading has much importance from the viewpoint of reducing the cooling load. In Japan, however, it is rather difficult to use exterior blinds because of exposure to strong winds such as typhoons. In this study, we tried to evaluate the thermal performance of newly developed climb-up type exterior blinds, measuring the thermal environment in an actual office building in Tokyo throughout the year. The thermal effect of heat generating double glazing on the building perimeter area in winter was also evaluated. The results showed the potentiality of a simplified perimeter air-conditioning system.

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1. INTRODUCTION

In the series of studies¹⁻⁵, solar shading and natural light utilization systems have been reported for the purpose of improvement of energy-saving properties and comfort in the perimeter spaces of an office, close to the windows. In this report, we investigate the effectiveness of a method for reducing the impact of solar radiation and outdoor air temperature by exterior blinds and a heat generating double glazing.

The exterior blinds provide an effective means for solar shading control. In Japan, it is, however, difficult to adopt them because of strong winds such as typhoons. In this study, exterior blinds, which are enhanced in wind resistance by a newly developed blinds slat structure, drive system and control system, are used in combination with heat-generating double glazing. The combination of exterior blinds with heat-generating double glazing is expected to eliminate the need for building perimeter air conditioning measures.

2. OUTLINE OF THE BUILDING

The subject was a high-rise office building in Tokyo (Fig. 1). Fig. 2 shows the structure of the windows. For the building, on most of the surface of the façade facing east and west, sunlight shielding by automatically controlled exterior blinds and improvement of the window vicinity environment by heat-generating double glazing in winter are implemented. Further, lighting control utilizing daylight and lighting reduction/turn-off control using a sensor of human presence are implemented.
3. SOLAR SHADING PERFORMANCE OF EXTERIOR BLINDS

The main design aim of the newly developed blinds was increased strength to resist strong winds such as typhoons. The slats of the blinds are extruded hollow members made of aluminium, and the blinds are raised and lowered by the drive chains built into the mullions. They can be used without problem in winds of speeds up to 25 mps. For safety, the sensors detect wind exceeding 15 mps, at which time the blinds are automatically lowered into storage at each floor level. They are motorized and computer controlled, and so their angle and other aspects are adjusted according to the incident solar radiation.

For comparison with the exterior blinds, two types of conventional blinds (Light colored and Medium colored) were installed and thermography was used to measure the temperature difference in the west façade at the interior window surface in each case.

Fig. 4 shows the results of measurement at the peak of intensity of solar radiation on a representative day of actual measurement (Fig. 3).

![Figure 3: Change in temperature and PMV (17/Oct/2003)](image)

It is seen that the surface temperature of the window when the exterior blind (Medium colored) is installed is lower by more than 10°C than when the medium colored interior blind is installed and by about 5°C when the light colored interior blind is installed. Also in the thermal image (Fig. 5) of the entire window surface, a large moderation of the effects of solar radiation is observed when compared with the case where 2 panes of window shade solar radiation using conventional interior blinds. For the PMV value (Measurement point: 1.0 m away from the west side window surface, 1.5 m above the floor surface), an appropriate value of around 0.5 is shown.

![Figure 5: Interior view of west windows (17/Oct/2003, 13:30)](image)

4. CONSIDERATION ON HEAT-GENERATING DOUBLE GLAZING

The heat-generating double glazing has an air layer of 12 mm in thickness. The planar heating element heats the inner glass and prevents cold draft and condensation. The electric energy required for heating is considered to be slight, requiring the power supply only for a few short periods in winter in an office building in Tokyo.

A perimeter area with heating was compared with one without heating at the windows in the east and west during a winter night (West surface: With heating, East surface: Without heating). Fig. 6 shows the results of actual measurement before and after heating at the west surface.

![Figure 6: Change in glass temp. by heating glass(40W/m2)](image)
Before heating, the window surface remained at around 18°C due to the air gap and low-e (low emissivity) effect of the metal heat-generating layer in spite of the fact that the outdoor air temperature was below 4°C, and after heating by electric power charge (40 W/m²), it rose by about 4°C, approaching normal room temperature. In addition, the temperature rise was close to the value calculated beforehand. Fig. 7 shows that the PMV values rise with heating of the window surface, approaching zero. When compared with the east surface without heat generation, the temperature difference between the east window surface and the west window surface was about 4°C, about the same as the temperature rise of the west surface. From the aforementioned, it can be said that the heat-generating double glazing is effective for improvement of the thermal environment of the perimeter area in winter.

Figure 7: Change in temperature, PMV and Electric power (15/Jan/2004)

5. ENERGY CONSUMPTION FOR LIGHTING AND AIR-CONDITIONING

Fig. 8 shows a diagram of correlation between the intensity of solar radiation on the west side window surface and the output rate of electricity for lighting in the indoor west side half of the building floor in the working hours (weekday 9:00 - 18:00) from August through December 2003.

At the perimeter, the electricity output rate generally lowered with increase in intensity of solar radiation, and the daylight was effectively utilized by control of the protective angle of the blind. The interior conditions were controlled to maintain a low electricity output rate for each month by the sensor for detection of human presence, which reduces the intensity of lighting at a place where a person is absent, and the control of keeping appropriate lighting intensity (Set lighting intensity: 800 lx) (Fig. 9).

Figure 9: Lighting power consumption rate (West, Aug ~ Dec)

Fig. 10 shows the correlation between the intensity of solar radiation on the west side window surface and the amount of cooling load (Indoor load: Calculated from the quantity of airflow and the temperature difference between inflow and outflow) in the weekday working hours in midseason.

At the perimeter, there is almost no increase in the indoor amount of forced air heat transfer with increase of the intensity of solar radiation on the window surface, and the difference in tendency between the perimeter and the central interior area is observed to be small. This is considered attributable to the proper shielding of the thermal load of solar radiation by the exterior blind. Furthermore, this is also confirmed by the diagram of correlation (Fig. 11) with the cooling load focused on the entire west side of the interior (AHU load: Calculated from the chilled
water flow and the temperature difference between inflow and outflow).

![Figure 11: Relationship between amount of solar radiation and cooling load (West, Autumn)](image)

From the abovementioned, it can be said that the envelope system provides the building with features allowing utilization of natural light, thus restraining the thermal inflow and also maintaining a comfortable indoor environment.

6. CONCLUSION

In the study, it is indicated that the exterior blinds, heat-generating double glazing and control of lighting make the shielding of solar radiation compatible with the utilization of natural light, deal with disturbing external factors effectively reduce the difference in load between the central area and the perimeter area. It can be said that the system is effective as a means to avoid non-energy-saving conditions and make the perimeter space by windows comfortable.

REFERENCES