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Ventilation windows and automatic blinds help to control heat and lighting

submitted by the Japanese National Team

In designing and constructing its new R&D Centre, the Tokyo Electric Power Company (TEPCO) had two main aims: to provide a comfortable working environment and to conserve as much energy as possible. To achieve these aims, attention focused on the control of heating and lighting, especially in perimeter zones near glazed areas. The major features included ventilation windows with integral automatically controlled blinds, and daylight compensation lighting controls. Together, these have significantly reduced heating and lighting loads.

Introduction

TEPCO built its new research and development centre in order to integrate its four existing research installations into one site. During the design and planning phase TEPCO concentrated on rationalising energy use as far as possible at an electric utility's R&D facility, whilst maintaining a comfortable indoor working environment suitable for creative activity. Work on the new site was completed in September 1994.

Outline of the centre

The centre comprises two main buildings, as shown in the photograph. The research building (11 stories above ground and one below, with a total floor area of 27,360 m²) lies at the centre of the site (around 46,000 m²), with a welfare/ conference building (three stories above ground and one below, around 9,911 m²) on the northern border. An entrance lobby (1,121 m²) connects the two buildings.

A typical floor of the research building is 64 m long in an east-west direction and 28.8 m wide in a north-south direction. To minimise the heat load, the windows are arranged on the north- and south-facing walls. The east and west sides of the building form the core sections, where machine/electric rooms and common facilities, such as lifts and lavatories, are located. The rectangular working space (51.2 m by 28.8 m) is divided into a northern laboratory area and a southern open plan study room without partition walls, where booths separated by low partitions provide privacy for each researcher. The outside balconies on the north and south sides provide emergency escape routes.

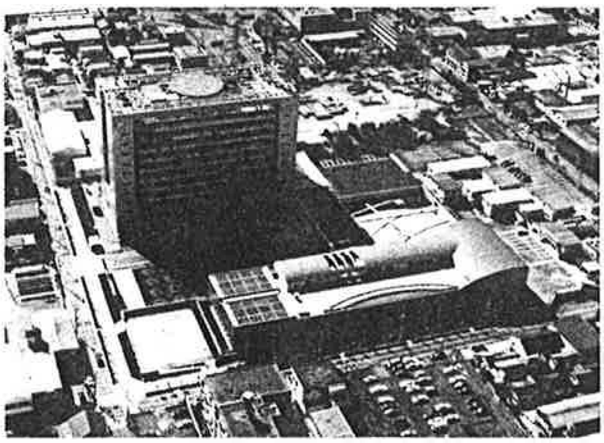
Control of heat and light in the research building

To deal properly with the demands for both heat and light, it is essential that offices are shaded appropriately against insolation. However, it is also possible to significantly reduce the energy consumption for lighting, and thus the cooling load caused by lighting, by using incoming sunlight as a light source and controlling artificial lighting in accordance with incoming daylight levels. In order to balance these needs, the south side of the research building was fitted with ventilation windows with integral automatic control blinds. A lighting control system was also installed, which was capable of continuously dimming artificial lighting near the windows over a wide dimming range (**Figure 1**).

Ventilation window

The ventilation window is a double window with an integral venetian blind between the two panes. Indoor air passing between the panes cools the slats of the blind and removes the solar heat. This air then exits through an outlet at the top of the window (**Figure 1**). In this way, the window reduces the solar heat gain and the overall heat transfer coefficient to between 1/3 and 1/2 that of ordinary windows. The ventilation window thus not only considerably reduces the cooling load caused by excessive

Photo: Overall view of the R&D Centre (seen from the north).



solar radiation, but also eliminates the need for perimeter air-conditioning units.

Automatic control blind

By automatically controlling the angle of the slats, the blind stops direct solar radiation over a certain intensity from penetrating the room beyond a given distance from the window. This prevents incoming sunlight from adversely affecting thermal comfort and increasing the cooling load. If there is no sunlight, the slats are flat or raised, providing an outside view and improving the amenity's psychological aspects (**Figure 2**).

Daylight-compensation lighting control system

This control system calculates the level of daylight in a room according to the state of the blind. It then uses this information to dim or turn off the lights in a particular order, up to the second row from the window (**Figure 1**). The luminaire selected to prevent this lighting control from causing discomfort to the occupants in the room is an HF type 1 with an electronic high-frequency ballast using an inverter. This luminaire can be dimmed from 0-100%.

Optimum light control

Luminaires factor in light depreciation by the degradation of lamps with the passage of time and light loss resulting from dirt build-up on their surface. The light from a luminaire immediately after installation or cleaning is therefore around 40% higher than the design value. To prevent excessive illumination, the light output is automatically tuned once a month, at night, using the inverters in the electronic ballasts.

Time scheduling

Timers automatically switch off all lights in the research building between 12:00 - 13:00, and 19:00 - 22:00. Occupants requiring light during these times can manually switch lights on themselves. This control can reduce lighting power consumption by 10%.

The integrated application of these lighting controls halves the power used for lighting and reduces the cooling load from lighting by about 10%.

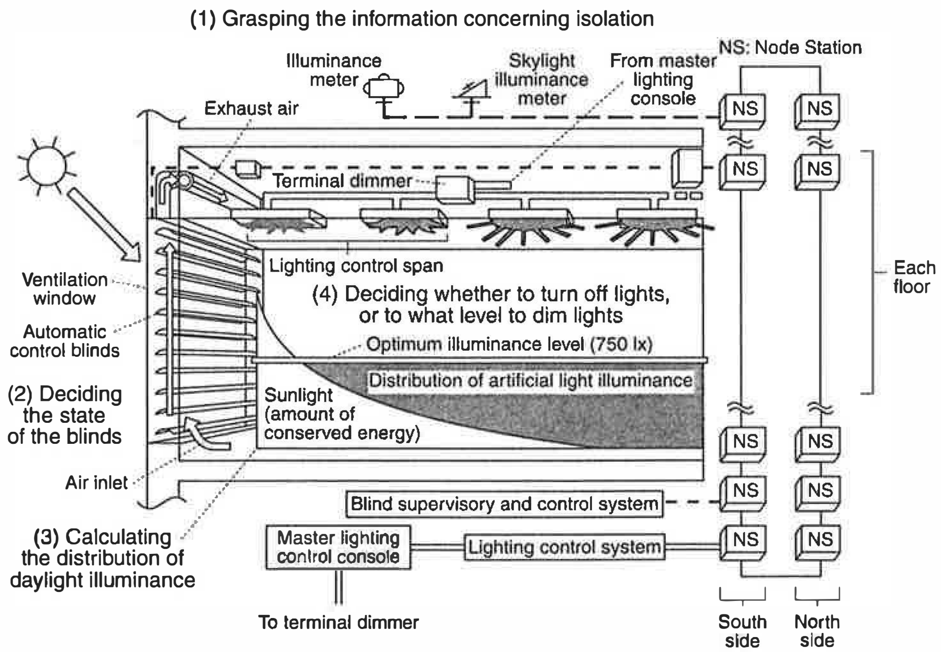
Control of heat and light in the entrance lobby

Entrance lobbies are generally required to be large, bright and open spaces. However, this creates problems when the aim is to maintain a good thermal environment and save energy. The entrance lobby of the R&D Centre is also large. Connecting the research building to the south with the welfare/conference building to the north, the lobby is 55 m long (north-south direction), 15 m wide and 8 m high. It has large glazed areas on the east and west sides (**Figure 3**). To create a comfortable and energy-efficient space in this lobby, automatically-controlled exterior blinds and double glazing with integral low-emissivity (low-e) film were installed.

Automatically-controlled exterior blinds

The automatic exterior blinds adjust the angle of their slats, raising or lowering them in the same manner as the automatic blinds in the research building. This prevents direct solar radiation above a certain intensity from entering the lobby, whilst allowing an outside view as much as possible. If the wind blows with a velocity exceeding 5 m/sec, the exterior blinds are automatically rolled up to prevent damage. A study based on a simulation showed that the blinds reduced the cooling load to just 1/5 that of interior blinds with the same solar shading characteristics. During the winter months the blinds are raised to allow insolation in the lobby, and thus lessen the heating load.

Figure 1: Ventilation window and daylight-compensation lighting control system (south side).



Double glazing with integral low-e film

This double glazing improves heat insulation and solar shading, whilst allowing visible rays to pass through largely unimpeded. This is achieved by using a low-e film, selected for its particular wavelength characteristics, in the gap between the two panes. A simulation to assess the effectiveness of this double glazing in winter indicated that it reduced the amount of heat dissipation to between 1/6 and 1/4 that of single glazing alone, or single glazing and interior blinds.

As shown in **Figure 3**, the entrance lobby is supplied with conditioned air through a ceiling outlet in summer and through a floor outlet in winter. The aforementioned measures, applied in combination with this inlet/outlet switching system, help reduce the thermal energy used by the air-conditioning unit to a maximum of 548.3 kJ (152.3 Wh_{th})/m² per hour in summer and 364.1 kJ (101.1 Wh_{th})/m² per hour in winter. These levels are very low for such a glazed area. In addition to the energy savings, the measures help to maintain thermal comfort.

Conclusions

The above control technologies for perimeter zones significantly reduce the heating load and the power consumed for lighting, as well as providing a comfortable environment in the offices and entrance lobby. Other features installed at the new R&D facility include a cold air distribution system based on ice storage, and a next-generation building management and control system. A building operation working group has been established for targeted energy operation management. As a result of all these measures, the specific annual primary energy consumption at the centre has been reduced to 1,340 MJ (372.2 kWh_{th})/m² per year. This is 35% lower than a standard building of this type.

Figure 2: Blind control.

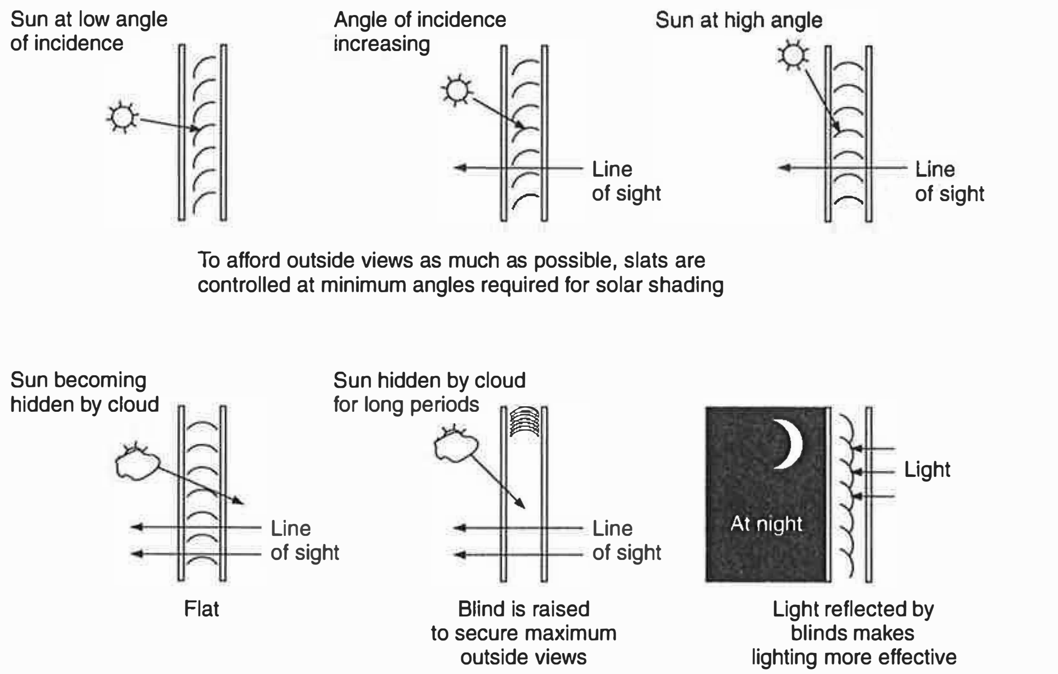
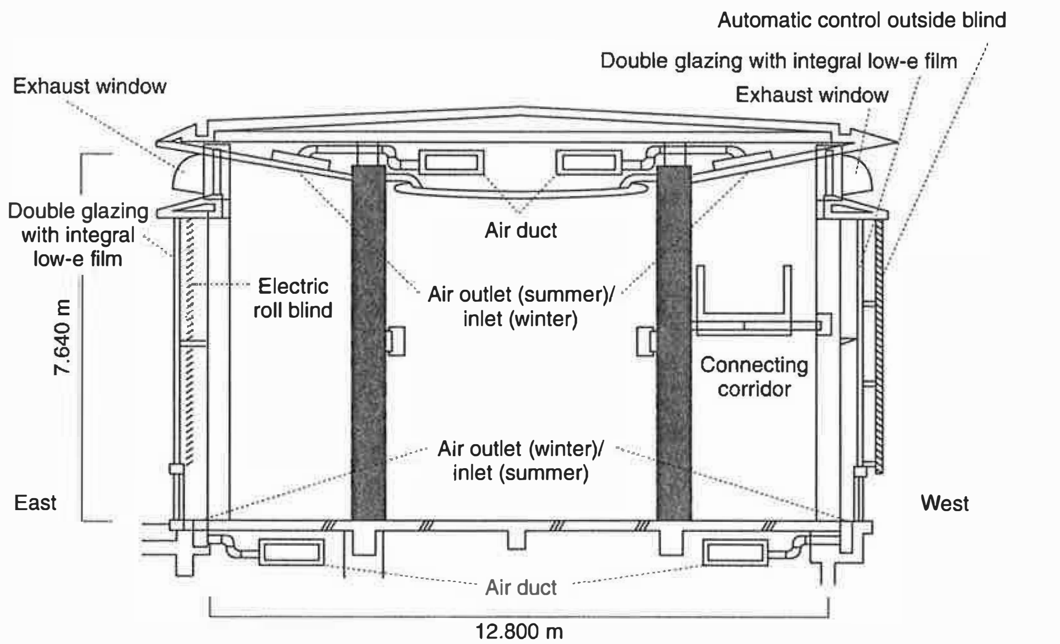


Figure 3: Cross-section of entrance lobby.



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