B-56 **Diagnose on reductional effect of global and regional environmental load in an office building with low-environmental load technologies (Abstract of the Final Report)**

Contact person ICHINOSE, Toshiaki
Senior Research Scientist, Center for Global Environmental Research
National Institute for Environmental Studies
Onogawa 16-2, Tsukuba, Ibaraki, 305-8506 Japan
Tel: +81-29-850-2598 Fax: +81-29-858-2645
E-mail: toshiaki@nies.go.jp

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1.Introduction

In Japan, the reduction of energy consumption for space cooling, accompanied by anthropogenic heat emission in summer, is an important issue. The aim of this study is to evaluate total adaptation of advanced energy saving technologies applied to a building of NIES (National Institute for Environmental Studies, in Tsukuba, Japan), CCRH (Climate Change Research Hall: since April 2001: three story RC structure: 4,900m^2). Especially the effect on the reduction of the impact for indoor and outdoor thermal environment is focused. These technologies are the control of solar shading and day-lighting, indoor ventilation system, several kinds of roof structure. In the CCRH (Photo 1), behavior of energy and air have been monitored in the schedule of three years.

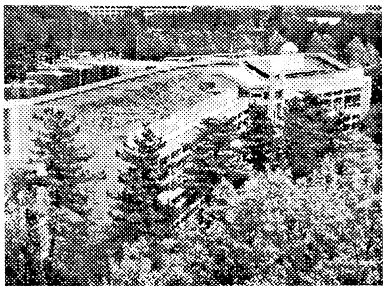

Photo 1 CCRH in NIES

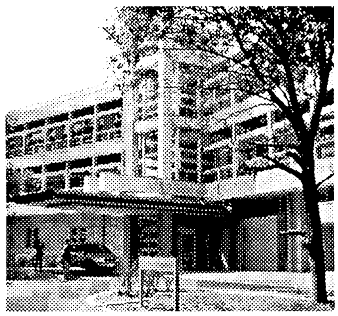

Photo 2 South facade

2.Research Objective

Technologies, which are applied to the CCRH, will be evaluated of their lifecycle performance, individually. Rooftop greening, PV panels coverage, sun shading with overhung, self-regulating-transmittance glass (TT-glass) and cross ventilation design were applied to the CCRH. Taking into consideration on hot and humid climate, the CCRH was specially designed to be adapted to summer and medium seasons' condition. In addition, necessary information for more rational design practice is collected and arranged as a design tool.

3. Evaluation of Energy Saving Methods in The CCRH: Effects of Thermo-Tropic Glass

In consideration of the solar-shading and thermal insulation performance, double-glazed windows (low-emissivity coated glass and Thermo-Tropic glass; LE+TT) were fitted in the office areas (floor area 630 m^2) on the 2nd and 3rd floors on the south side of the CCRH. This TT-glass is a newly developed autonomous response-type dimming glass and it autonomously changes state from clear and light-transmitting to opaque and light-scattering in response to changing environmental conditions according to the time of day, weather, and season. The outer pane has a LE coating with selectable transmittance, and the inner pane is TT glass. Fig. 1 shows a cross-section of the window. In consideration of the visibility for workers, the TT window installation was limited to 900 mm in height from the floor, and the upper windows were fitted with LE glass only. Balcony surfaces on the 3rd floor were coated with high-albedo paint to reflect light indoors. Used in conjunction with inverter-controlled lighting, this was anticipated to reduce lighting power consumption and the accompanying cooling load.

The thermo-graphic image in Fig. 2 shows that the extent of dimming is generally consistent with the glass area above the phase-change temperature (30 deg C). The automatic solar shading provided by the installation of TT glass also appears to have eliminated any increase in cooling load due to direct incident sunlight on internal floor or other surfaces. The graph in Fig. 3 shows that the cooling load is virtually unaffected by the solar radiation on the window in each season. It can also be seen in Fig. 4 that the lighting power consumption rate falls as the amount of solar radiation increases. The lighting power consumption rate over the year was reduced by as much as 25% on the entire south-side 2nd and 3rd floors of the building (Fig. 5). These results demonstrate that areas exposed to solar radiation are shaded, and that natural light can be used more effectively, thus achieving both solar shading and natural lighting at the same time. With respect to the thermal environment, more than 70% of respondents replied "comfortable" or "relatively comfortable" throughout the year. With respect to the light environment, 90% of respondents answered "comfortable" or "relatively comfortable" throughout the year (Fig. 6). Thus, the workers appear generally satisfied with their thermal and light environments.

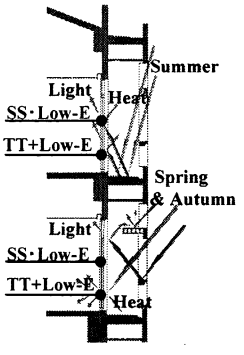

Fig.1 Cross-section of window

Visual image Thermograph

Fig.2 Window's condition and corresponding thermograph

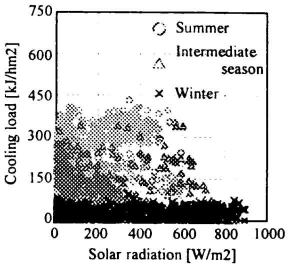

Fig.3 Relationship between the amount of solar radiation on the south window and the cooling load

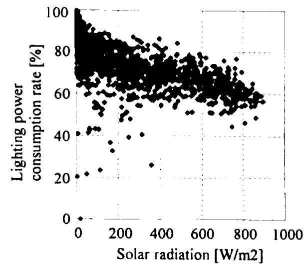

Fig.4 Relationship between the amount of solar radiation on the south window and the lighting power consumption rate

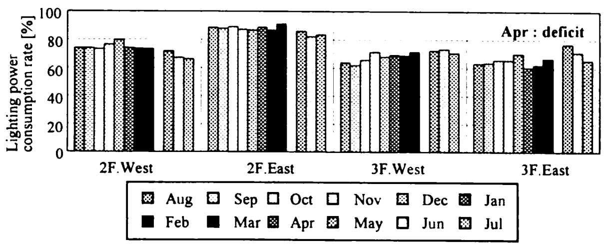

Fig.5 Energy conservation in lighting power consumption rate in each month

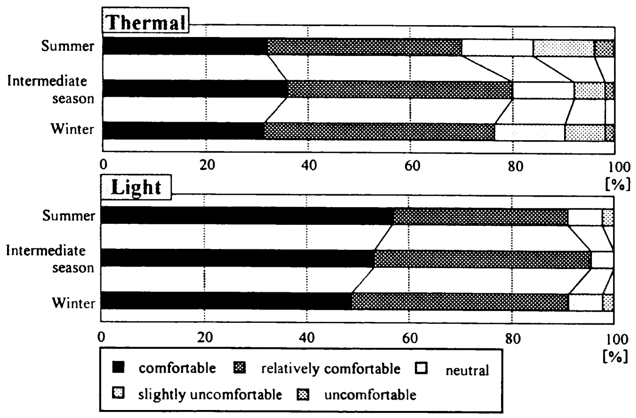

Fig.6 Results of questionnaire concerning thermal and light

4.Long-term Observation of Radiation Balance, Soil Temperature and Heat Flux at Eco-Building with Sedum Rooftop Greening Technology

Heat island phenomenon is recognized one of the serious problem in the large city. For the mitigation of thermal pollution in the city, rooftop greening technology for the office building is becoming popular in recent years. The long-term observation of radiation balance, soil temperature and heat flux on the roof of the CCRH started from the middle of September 2002.

Simultaneously the following experiments in other rooftop space were performed in microscopic aspect. In summer 2002, investigations on the temperature and the heat flux diffusion process of rooftop greening were implemented to examine the effect of vegetation density and irrigation on local thermal conditions. The sample sites with unplanted soil, low-density plantings, high-density plantings, and irrigation plantings and no-irrigation plantings with low-density plantings were set up. The temperatures were measured at the surface of planting area and beneath the soil mat of each plot, and then compared to each other. It was found that, when the soil was wet by rain and irrigation, these daily maximum temperatures were low, and the differences of temperatures with vegetation density were not significant. Besides, when the soil was dry in dry spell under no irrigation, these daily maximum temperatures were high, although these temperatures of higher-density plantings could be lower. A detailed analysis for the heat flux diffusion process revealed that heat flow directs from soil to building in the daytime and from soil to atmosphere in the nighttime. Both the values of daytime heat outflow to building and nighttime one to atmosphere were bigger in low-density plantings and smaller in high-density plantings. It is considered to be due to differences in evapo-transpiration value in daytime and radiative cooling in nighttime.

On the roof of the CCRH, soil temperature of bare land in a fine daytime (average of 24 days since September 18 in 2002) was 10 deg C higher than well-vegetated part, and fell rapidly after the sunset. On the other hand, the variation of soil temperature of the vegetated part was small and calm. Surface temperature on the inclined part was higher than the flat part, but the temperature difference between the inclined part and the flat extended from 2.1 deg C in September to 10.9 deg C in January at noon, because the difference of relative solar altitude between the inclined part and the flat was obviously shown in winter. Rooftop planting decreased the surface temperature and its temporal variability, and the impact to the air temperature above the vegetated part was smaller than the ordinary building top.

5.Experimental Research about Using Cross Ventilation in A Low-rise Office Building: Discharge Coefficient by Actual Measuring of Ventilation Rate

The CCRH was designed to have effective openings to induce much cross ventilation by utilizing wind (sea-breeze from the Pacific Ocean) and the orientation is such that southerly winds are incident on the façade. In this study, the cross ventilation performance of the CCRH is validated on the basis of the numerical simulation, on-situ measurement and wind tunnel experiment. The results on real measurement for indoor environment of the CCRH, as a low-rise office building and external wind environment around the CCRH, which was designed in order to take wind easily and for natural ventilation using stack effect, will be shown.

To estimate ventilation rate correctly, calculating the discharge coefficients, wind pressure coefficients and so on are necessary. It is usual to refer the knowledge of anamnestic researches for natural ventilation designing in practical standpoint. Furthermore, this study showed the investigation by comparing the knowledge of anamnestic researches to results on real measurement.

6.Development of A Heat Balance Model of PV Panels to Assess PV Installation Impacts on The Urban Heat Island Effect

Photovoltaic (PV) panels and green plantings on the rooftop of buildings are considered as potential countermeasures for mitigating environmental impacts such as CO_2 emissions and urban heat island (UHI) effects. In this study, the authors aim to assess the total impact of large-scale installation of PV panels on the UHI effect and energy consumption for cooling. In 2001, in order to assess the total impact, they developed the PV panel's heat balance sub-model for their UHI simulation system. They installed a PV panel (150 m^2) on the roof of the CCRH and carried out measurements of PV panel's heat balance in order to develop the PV panel's heat balance model. They compared the simulation results and observed data to verify the PV panel's heat balance sub-model. Difference between the observed sensible heat flux from the PV panel and simulated values was less than 10%. In 2002, they chose 30 case study areas from the 23 wards of Tokyo and estimated the impacts on the summer UHI and energy consumption for cooling in the 23 wards for PV panel installation. Results indicated that the impact of installation of PV panels on the UHI effect appears to be negligible and the shading effect of rooftop PV panel installation was calculated to decrease energy consumption for cooling by ~3% for office area and 3~7% for residential area in comparison to buildings without PV panels. In 2003, they estimated the year-round impact of large-scale installation of PV panels and green planting on air temperature and energy consumption for heating as well as cooling. Results indicated that the impact of installation of PV panels on the UHI effect appears to be negligible even in the winter period and installation of PV panels appears to be more effective than that of green planting on the year-round energy consumption for air conditioning.

7.Discussions and Conclusions

In the CCRH, monitoring of temperature, radiation, light, and energy consumption, and the questionnaires for office workers have been made over a period of the three years, with particular emphasis on seasonal variations. The data have been analyzed from different viewpoint such as energy conservation, indoor thermal and lightness environment, and regulate their merits and demerits systematically with the consideration of influences of those methods.

A numerical simulation using SMASH model of annual cooling load of the CCRH in case of total adaptation showed 52% reduction. The results of this study will be used to amend the current design standard of office building in hot and humid climatic zone from viewpoint of mitigation of urban thermal pollution. The result of an inventory analysis on the lifecycle performance of the CCRH using a software for LCA developed by AIJ (the Architectural Institute of Japan), applying the data measured in this study (ex. energy consumption in every 15 minutes for each division of the CCRH), also showed 12-15% reduction of LCE, $LCCO_2$ and LCcost.

Especially, through measurements for an application of TT glass at the CCRH and a questionnaire survey, TT glass has been shown to provide both solar shading and natural lighting. This results in appreciably energy savings when combined with canopies, balconies and lighting control, and appears to be acceptable to workers using these rooms.