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Evaluation of Availability of the Solar Radiation Shield in Air Temperature Measurement Survey

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To examine the availability of the Solar Radiation Shield in the measurement of air temperature, air temperatures were measured in a thermometer shelter and the Solar Radiation Shield. A difference was observed in a monthly mean air temperature according to the thermometer shelter and the Solar Radiation Shield. However when taking the measurement accuracy (±0.3℃) into account, the difference according to the thermometer shelter and the Solar Radiation Shield was within the precision of each device. Similar mean diurnal variations of the air temperature were observed in the thermometer shelter and the Solar Radiation Shield although a difference was observed in the daytime, being greatest from 14:00 to 16:00. In contrast the air temperatures measured in the thermometer shelter and the Solar Radiation Shield were approximately the same at night. In conclusion, the Solar Radiation Shield can be applied in measuring the air temperature as the thermometer shelter is although both air temperatures should be compared with an air temperature measured in a forcibly ventilated shelter.

I INTRODUCTION

Air temperature is one of the most important parameters for the detection of climate change and the understanding of the urban heat island phenomenon[1-4]. It is preferable that air temperature be measured by using a forcibly ventilated shelter or at 1.5 m above ground by a thermometer shelter installed on the grass; however, the optimal conditions cannot always be achieved. In the current study, air temperatures were measured in different conditions by using different types of shelters to examine the appropriateness of the shelters.

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II MATERIALS AND METHODS

1 Research site and period

Air temperatures were measured in May 2005 in a thermometer shelter and the Solar Radiation Shield (Davis Instruments Corp., California, USA) installed on the roof (about 25 m above ground) of a six-story building, the Hyogo Prefectural Institute of Public Health and Environmental Sciences. The thermometer shelter is made of wood, and the Solar Radiation Shield is made of UV stabilized white thermoplastic plates. Both the thermometer shelter and the Solar Radiation Shield are naturally ventilated.

2 Measurement device and frequency

Air temperatures were measured by a Thermo Recorder TR-72U (T&D Corporation, Nagano, Japan). The measurement resolution was 0.1℃. The measurement accuracy was ±0.3℃. Air temperatures

were measured at 10-minute intervals, and hourly mean air temperatures were used for analyses.

3 Statistical analysis

The least significant difference (LSD) was used in analyses of the variations of daily mean, daily-highest, and daily-lowest air temperatures.

Ⅲ RESULTS AND DISCUSSION

1 Comparison of air temperatures based on daily mean, daily-highest, and daily-lowest air temperatures

Statistical parameters of air temperatures measured in the thermometer shelter and the Solar Radiation Shield are summarized in Table 1. The analysis by LSD clarified that there was no significant difference ($p>0.05$) in daily mean, daily-highest, and daily-lowest air temperatures according to the thermometer shelter and the Solar Radiation Shield.

The differences in daily mean, daily-highest, and daily-lowest air temperatures measured at the thermometer shelter and the Solar Radiation Shield are shown in Fig. 1. The vertical and horizontal axes show the difference in air temperature according to the thermometer shelter and the Solar Radiation Shield (thermometer shelter - Solar Radiation Shield) and the time of measurement shown by day, respectively. The mean differences in daily mean, daily-highest, and daily-lowest air temperatures were 0.14℃, 0.28, and 0.01, respectively. A larger difference was observed in daily-highest air temperature than in daily-lowest air temperature. The larger difference in daily-highest air temperature was due to a diurnal variation of air temperature, which will be mentioned in detail later. Taking into account the measurement accuracy (±0.3℃) of the device used in the air temperature measurement, the differences in air temperatures according to the thermometer shelter and the Solar Radiation Shield can be concluded to be within the precision of each device.

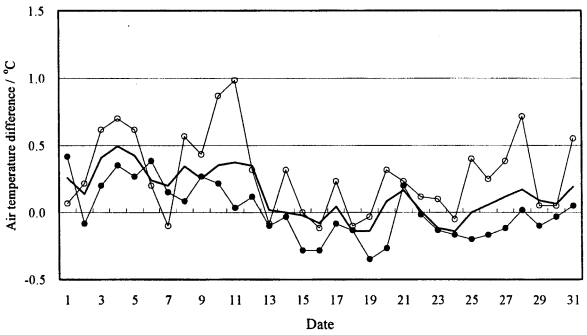

Fig. 1 Differences in daily mean, daily-highest, and daily-lowest air temperatures measured in the thermometer shelter and the Solar Radiation Shield. No mark, open circle (○), and filled circle (●) show daily mean, daily-highest, and daily-lowest, respectively.

2 Comparison of air temperatures based on diurnal variation

Mean diurnal variations of air temperatures measured in the thermometer shelter and the Solar Radiation Shield are shown in Fig. 2. Similar mean diurnal variations were observed. The daily-highest and daily-lowest air temperatures appeared at 14:00 and 5:00, respectively, in both mean diurnal variations. On the other hand, some differences were also observed. The air temperature measured in the Solar Radiation Shield was approximately 0.3℃ lower than that in the thermometer shelter in the daytime. The difference was largest from 14:00 to 16:00. In contrast, the air temperature measured

Table 1 Statistical paramenters for air temperature measurement in thermometer shelter and the Solar Radiation Shield

℃ except N

		N	Mean	Median	Minimum	Maximum	Standard deviation	Standard error
Thermometer shelter	Daily mean	31	18.8	18.6	16.1	22.2	1.68	0.30
	Daily-highest	31	22.3	22.1	19.5	27.2	2.11	0.38
	Daily-lowest	31	15.5	15.6	11.0	18.8	2.29	0.41
Solar Radiation Shield	Daily mean	31	18.7	18.6	16.1	22.1	1.71	0.31
	Daily-highest	31	22.1	21.8	19.1	27.1	2.13	0.38
	Daily-lowest	31	15.4	15.8	11.2	19.0	2.28	0.41

in the Solar Radiation Shield was approximately the same as that in the thermometer shelter at night.

The air temperature generally is highest at about 14:00. In contrast, Dr. Miyazaki (private communication) clarified that the measurement of the highest air temperature in a thermometer shelter occurs a few hours later than in a forcibly ventilated shelter. The delay observed in the thermometer shelter is mainly due to the relatively large heat capacity of a thermometer shelter and insufficient ventilation. However, in the current study, the air temperature in the thermometer shelter and the Solar Radiation Shield reached the highest level at 14:00, as mentioned above, suggesting that measurements were done properly in the current study. One of the presumed reasons for these proper measurements was the height (25 m above ground) of the research site as related to wind velocity, which increases with altitude[5]. In the current study, the air temperature was measured at a site 25 m above ground, presumably providing a higher wind velocity compared with that at ground level. A high wind velocity promotes ventilation, resulting in the proper measurement of temperature.

On the other hand, it is preferable that air temperature be measured by using a forcibly ventilated shelter or at 1.5 m above ground by a thermometer shelter installed on the grass. In the current study, both air temperatures were measured on the roof of the six-story building, and the roof was covered with a waterproof sheet, not grass. Therefore, both air temperatures should be compared with air temperature that is measured in the optimal conditions mentioned above and then evaluated. However, our results indicate that the daily-lowest air temperature measured in the Solar Radiation Shield can be evaluated comparably with that measured in the thermometer shelter.

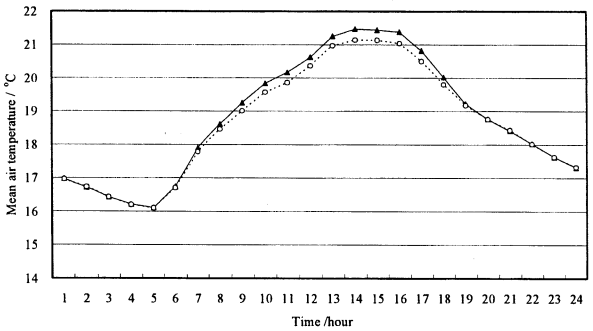

Fig. 2 Mean diurnal variations of air temperatures measured in the thermometer shelter and the Solar Radiation Shield. Filled triangle (▲) and open circle (○) show thermometer shelter and the Solar Radiation Shield, respectively.

IV CONCLUSION

The availability of the Solar Radiation Shield in the air temperature measurement survey was examined. The findings can be summarized as follows;

1. A difference was observed in a monthly mean air temperature according to the thermometer shelter and the Solar Radiation Shield although the difference was within the precision of measurement device.
2. Similar mean diurnal variations of the air temperature were observed in the thermometer shelter and the Solar Radiation Shield.
3. The air temperatures measured in the thermometer shelter and the Solar Radiation Shield were approximately the same at night although a difference was observed in the daytime, being greatest from 14:00 to 16:00.
4. In conclusion, the Solar Radiation Shield can be applied in measuring the air temperature as the thermometer shelter, although both air temperatures should be compared with an air temperature measured in a forcibly ventilated shelter.

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[ノート]

気温測定調査における簡易自然通風シェルター（Solar Radiation Shield）の利用可能性の検証

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要　約

気温を測定する際の簡易自然通風シェルター（Solar Radiation Shield）の利用可能性を検討するために，百葉箱と簡易自然通風シェルターを利用して気温を測定した．百葉箱及び簡易自然通風シェルターで測定された月平均気温に差が観測されたが，温度計の測定精度（平均気温±0.3℃）を考慮すると，その差は測定機材の誤差範囲内の差であると考えられた．また，類似した平均日変化を示す一方で，14時から16時にかけて最大となる気温差が観測された．一方，夜間の平均気温は百葉箱及び簡易自然通風シェルターでほぼ同じ値を示した．百葉箱及び簡易自然通風シェルターのいずれについても強制通風シェルターによる結果と比較する必要はあるが，簡易自然通風シェルターは百葉箱と同様に気温測定に利用することが可能であると考えられた．