A Study on Weather Data for Air Conditioning Equipment Design Report I - Weather Data in Busan from 1970 through 2003

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ABSTRACT: For the purpose of processing weather data for air conditioning equipment design in Busan area Korea, this study collected weather observations made by Busan weather Administration from 1970 to 2003, and then established external conditions for heating and air-conditioning design. For changes of temperature in external conditions for design, the highest temperature had little changed, whereas the lowest had been on the rise as the years went by through the 1970s, 1980s, 1990s, and 2000s, but insolation has a little lessened. Absolute humidity does not show a significant change but an incessant rise.

1. Introduction

It is said that large cities undergo serious weather changes today. In particular, temperature between the urban center and its subcenter reveals a vast difference, which makes us feel a sure different effective temperature. Therefore, weather data in Busan area used for weather data were derived from statistics in the 1970s prior to 1980s, not recent ones. In this context, this study purpose to provide data for air conditioning equipment design in the Busan area by arranging those weather data.

Since the development of thermal load calculation by the Response Factor method in the 1960s, weather data at intervals of an hour were needed.

However, weather data are kept as digital records at intervals of 6 hours in Busan from 1970 through April 1982. Thereafter, weather observations have been made at intervals of 3 hours from May 1982 through Mar. 23, 1998, and 24 times a day since Mar. 24, 1998, observations have been made. However, unstable observations have been kept from Nov. 16, 1998 through Dec. 20, 1998. The computerized file of these observations is called SDP (Surface Daily Data Observation Point).

Weather measuring equipments and measurements used for practical observations by Busan weather Administration since 1981 are shown in Table 1.

Temperature is measured with a dry-bulb thermometer every hour, but platinum resistance thermometer has been used since 1987.

Measurements of temperature have been carried out for the most part by Automatic Weather System (AWS) since 1990. Of course, measurements are carried out not merely by the dry-bulb thermometer but also by the magnetic thermometer but merely used as reference values. Humidity is also measured with

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Table 1 Collection of weather data in Busan weather administration

Sorts of measuring equipments		
Temperature	Humidity	Insolation
Dry-bulb thermometer: at intervals of 1 hour	Digital magnetic hygrometer: at intervals of 1 hour	F. L pyrheliometer (81.1.1~): at intervals of hour (kept by the administration)
Magnetic thermometer: at intervals of 1 hour		Silver plate pyrheliometer (Dec. 16, 1987~): at intervals of 1 hour (auxiliary meter)
Platinum resistance thermometer: at intervals of 1 hour		Tracing direct pyrheliometer: continuous recording
AWS (Automatic Weather System (90. 1))		

the digital magnetic hygrometer at intervals of 1 hour.

These values are measured as values of relative humidity but converted by an absolute temperature-measuring equipment. Insolation measurements have depended very largely upon the F. L. pyrheliometer but have been substituted with the silver plate pyrheliometer since 1987. And then since February 1990, the tracing direct pyrheliometer installed by Ministry of Power and Resources formed the mainstream and the silver plate pyrheliometer played an auxiliary role.

2. Analysis of long-term weather data

Kim[1] reported the long term weather data, which was based on data of the 1980s but not included those of the 1970s. It carried out a survey of weather changes in the 1990s.

Weather factors consists of six factors: dry-bulb temperature, absolute humidity, insolation, wind direction, wind velocity, and cloudiness. In order to make out standard weather data, insolation needs to be divided into direct insolation and sky insolation. However, they are not divided -because this study does not make out standard weather data. Though data in the 2000s for a short period of 4 years are considered to be of no significance in data processing, they are included for reference.

2.1 Yearly changes in the yearly mean temperature (Fig. 1)

The mean temperature in Busan for 33 years

Table 2 An outlook of weather data

Year	Data
1970s	1) Temperature: Recorded every 6 hours from 3 o'clock. 4 data a day. 2) Humidity: Same as temperature. 3) Insolation: No records.
1980s	1) Temperature: Same as in the 1970s from 1980 through Apr. 30, 1982. Reorded every 3 hours from May 1, 1882 through Mar. 23, 1998. 2) Humidity: Same as temperature. 3) Insolation: Recorded from January 1980.
1990s	Temperature: Recorded 24 hours a day from Mar. 24, 1998.
2000s	All data 24 hours a day kept.

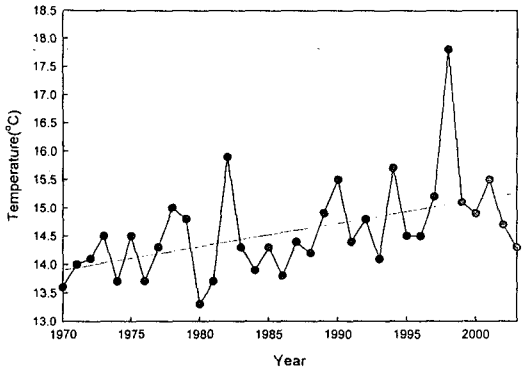

Fig. 1 Secular changes in temperature.

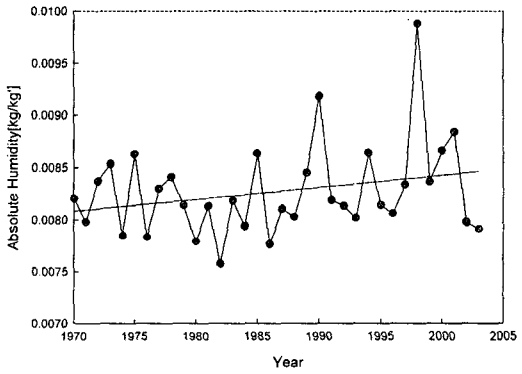

Fig. 2 Secular changes in absolute humidity.

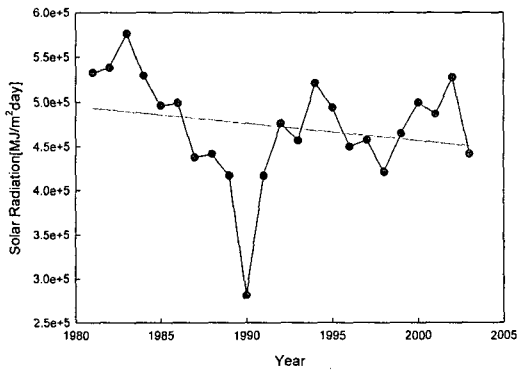

Fig. 3 Secular changes in integrating daily mean insolation.

shows an approximately 1.5℃ rise. It seems to be a higher rise, as compared with 1.2℃ in Tokyo, Japan. It repeats fluctuations on the level of about 0.1~1.5℃ along with an immaterial rise. The hottest year was 1998, while the coldest was 1980.

2.2 Secular changes in the yearly mean absolute humidity (Fig. 2)

This absolute humidity is converted from dry-bulb temperature and relative humidity. It varies with years but shows a slow rising tendency. It points to an approximately 0.2 g/kg rise. The year of the highest absolute humidity is 1998, whereas the lowest 1982.

2.3 Secular changes in the integrating daily mean insolation

Insolation prior to 1980 in Busan was not recorded and it has been measured with the highly precise thermoelectric all-weather pyrheliometer since 1981, showing changes on the level of the yearly mean 450~500 kJ/m^{2}h, with no regularity. Insolation reflects a decreasing tendency, which needs an interpretation. The year with the most insolation is 1983, while that with the least 1990.

3. Statistical analysis and investigation of external weather conditions

3.1 Synopsis

External conditions for design are needed for statistical processing of weather observations (temperature, absolute humidity, and insolation) in the past and as well as for calculating the capacity of heating and air conditioning devices. Those in this study were made out based on the Technical Advisory Committee (TAC) method.

3.2. How to make out

External conditions for design were made out every 10 years and then weather changes

Table 3 External conditions for design (TAC 2.5%)

	Cooling data						Heating data			
	Temp. (℃)		AH (g/kg)		Ins. (W/m^2)		Temp. (℃)		AH (g/kg)	
	80	90	80	90	80	90	80	90	80	90
1	26.9	26.9	19.73	19.00	0	0	−5.8	−4.4	0.81	0.72
2	26.8	26.7	19.54	18.84	0	0	−6.0	−4.6	0.82	0.76
3	26.5	27.1	19.61	19.28	0	0	−6.4	−4.4	0.80	0.84
4	26.4	26.4	19.40	19.14	0	0	−6.6	−4.8	0.84	0.90
5	26.3	26.6	19.43	19.03	37	14	−6.9	−5.1	0.87	0.89
6	26.3	26.7	19.35	19.07	161	96	−7.0	−5.2	0.85	0.89
7	26.7	26.5	19.49	19.22	264	234	−7.1	−5.9	0.87	0.96
8	27.4	27.1	19.99	19.30	520	404	−7.0	−5.9	0.88	0.96
9	29.3	29.3	20.60	19.70	660	552	−6.3	−4.6	0.92	0.93
10	30.4	29.1	20.77	20.15	782	673	−5.5	−4.2	0.93	0.95
11	31.4	29.8	21.21	20.34	846	754	−4.4	−3.0	0.99	0.77
12	31.9	32.1	21.09	20.17	856	781	−2.9	−0.8	1.01	0.89
13	32.1	30.4	21.24	20.64	846	757	−2.1	−0.7	1.00	0.75
14	32.0	30.7	20.88	20.35	782	683	−1.1	0.55	1.01	0.72
15	32.1	32.2	20.60	19.97	531	566	−0.6	1.4	0.99	0.80
16	32.0	30.6	20.37	20.43	357	418	−0.4	1.2	0.98	0.61
17	31.5	29.9	20.22	19.45	189	251	−0.9	0.35	0.92	0.54
18	30.9	30.8	20.13	19.39	55	93	−2.0	−0.2	0.87	0.70
19	29.7	28.4	20.00	18.90	9	12	−2.8	−1.2	0.85	0.55
20	28.6	27.9	20.00	18.73	0	0	−3.5	−1.9	0.82	0.59
21	28.1	28.2	20.09	19.51	0	0	−4.2	−2.2	0.78	0.72
22	27.7	27.2	19.95	18.67	0	0	−4.5	−3.0	0.78	0.67
23	27.4	27.2	19.95	18.66	0	0	−5.0	−3.4	0.79	0.63
24	27.1	27.6	19.78	19.49	0	0	−5.4	−0.3	0.80	0.77
Av.	28.98	28.56	20.14	19.48	6,895	6,288	−4.35	−2.60	0.88	

AH: Absolute Humidity, Ins: Insolation

investigated. Insolation in the 1970s are excluded because it was not measured. External conditions for design, TAC 2.5%, in Busan in the 1980s and 1990s were made out.

Table 3 shows external conditions for design, TAC 2.5%. In the meantime, the data in the 1980s were those quoted from those for 10 years from 1981 to 1990.

The TAC method calculates local temperature, absolute humidity, and insolation by excessive point percent of weather data every hour (24 hours a day). The TAC 2.5% indicates the upper 2.5% value in June to September for conditions for air conditioning design, while the lower absolute humidity 2.5% in December to Mar. for conditions for heating design.

Weather data in the 1990s in Table 3 were recorded at intervals of 3 hours from 1990 to 1998 but 24 hours a day from Mar. 24, 1998 up to date. Therefore, the number of data every 3 hours up to 1998 comes to 1,212, and the number of data every hour 155. When they are applied to the lower 2.5%, they correspond to the lower 30.8th value and the 3.9th value, respectively. Thereupon, the black marks in the table indicates the lower 30th and 31st mean value as data of every 3 hours, whereas the grey marks as data posterior to 1998 indicates the lower 3rd and 4th mean value.

3.3. Comparison of values by year

A comparison was carried out of external conditions for design every 10 years on the basis of TAC 2.5%.

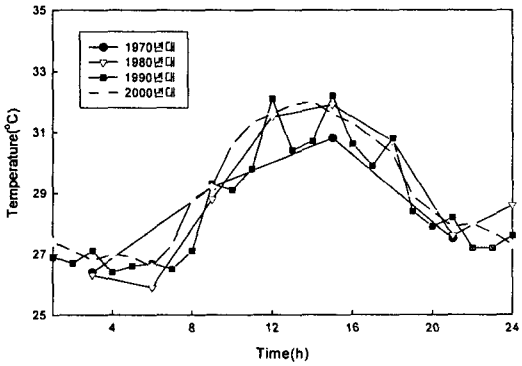

Fig. 4 Comparison of conditions for air conditioning design (temperature).

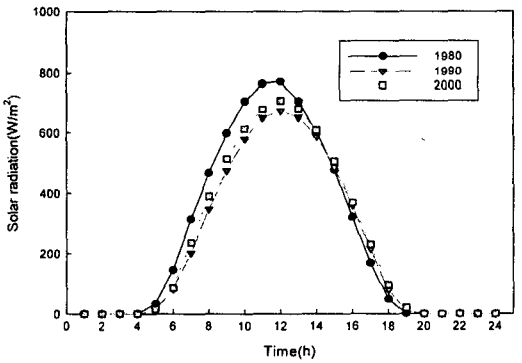

Fig. 5 Comparison of conditions for air conditioning design (insolation).

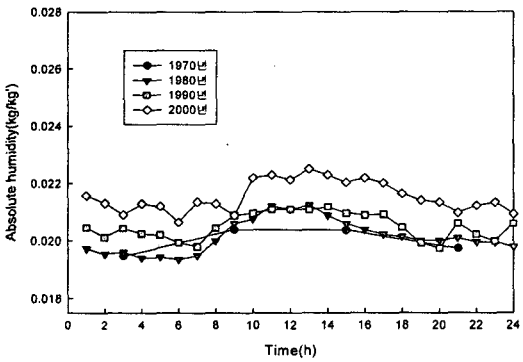

Fig. 6 Comparison of conditions of air conditioning design (absolute humidity).

3.3.1 External conditions for cooling

(1) Temperature (Fig. 4)

The temperature here shows a similar tendency every year, but its value in 2000 is higher than that in other years.

The highest temperature in the 1990 points out 32.2℃ at 16 : 00 in the 1990s, whereas the lowest 25.9℃ at 6 : 00 in the 1980s. The lowest of the highest temperature by year indicates 30.4℃, in the 2000s, while the highest, 32.2℃ in the 1990s. The lowest of the lowest temperature in the 1960s was 26.4℃, and the lowest has been on the rise year in year out.

(2) Insolation (Fig. 5)

Horizontal sky insolation reflects a radiant form around 12 : 00. The most insolation is shown in 1980. The peak insolation by year is 768 W/m^2 at 12 : 00 in the 1980s, while the minimum 768 W/m^2 at 12 : 00 in the 1980s, while the lowest of the peak insolation 671 W/m^2 at 12 o'clock in the 1990s.

(3) Absolute humidity (Fig. 6)

Diurnal difference of absolute humidity indicates 0.000915 kg/kg in the 1970s, 0.001875 kg/kg in the 1980s, 0.00144 kg/kg in the 1990, and 0.001845 in the 2000s, which is approximately 0.0195 less and shows a comparatively small change by time zone.

The highest absolute humidity in the 2,000s points to 0.0225 kg/kg at 13 : 00. The minimum absolute humidity in the 1970s 0.0195 kg/kg at 3 : 00. The absolute humidity in the 1980s made reference to that in Reference No. 1. The minimum absolute humidity, including these data, is 0.0194 kg/kg at 5 : 00 and 6 : 00 in the 1980s.

3.3.2 External conditions for heating

(1) Temperature (Fig. 7)

The highest of the lowest temperature at 7 : 00 in the 2000s is −5.4℃, whereas the highest of the highest temperature is 1.8℃ at

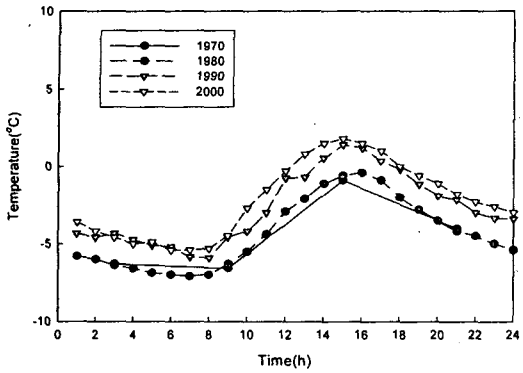

Fig. 7 Comparison of conditions for air conditioning design (temperature).

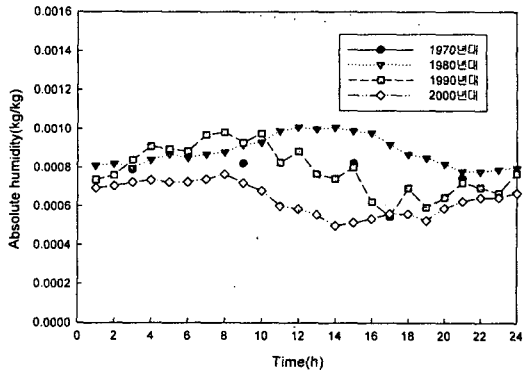

Fig. 8 Comparison of conditions for heating design (absolute humidity).

15 : 00 in the 2000s. The lowest of the lowest temperature −7.1℃ at 7 : 00 in the 1980s, which is very low, as compared with that in other years. However, in consideration of these lower value data, it may be predicted that the temperature in the 1970s would be lower than that in the 1980s. The lowest of the highest temperature is −0.4℃ at 16 : 00 in the 1980s. It is obvious that the lowest temperature by year is on the increase as the years go by.

(2) Absolute humidity (Fig. 8)

Absolute humidity shows almost no change by time zone and all fall under the range of 1.1~1.5 g/kg. That in the 1970s is low on the level of about 1.1~1.3 g/kg, while that in the 1960s is high on the level of about 1.2~1.5 g/kg.

4. Conclusion

This study investigated weather factors in Busan for 34 years from the 1970s to 2003. For temperature changes in external conditions for heating and air conditioning design, the highest daily temperature shows a slim change but the lowest temperature had been on the rise as the years go by through in the 1970s, 1980s, 1990s, and 2000s, and as a result, diurnal difference of temperature was on the decrease. Furthermore, absolute humidity shows a slow rise with no big change. This study hopes that these data would be used for practices of air conditioning equipment design. And one thing to make mention of here is that it is appropriate to establish external conditions for design used as indicators for environmental design as part of air conditioning equipment design, in the unit of 10 years inasmuch as thermal load or every meterological factor has its unique characteristics.

References

1. Kim, J.-R., 1994, Research on Busan Weather Data for Air Conditioning Equipment Design, MS Thesis, National Fisheries University of Busan, Korea.
2. Meterological Administration.
3. Takeda, H. and Inoue, K., 2004, Tokyo Weather Data for Air Conditioning – Part 3 Weather Changes over 40 Years from 1960 to 1999, HSACSJ, No. 94, Jul., pp. 115-121.