OPEN SPACE DESIGN STUDY ON THE BASIS OF EXTREME MICROCLIMATE AND SPATIAL BEHAVIOR IN NORTHERN CHINA

Zhiming Guo[1*], Tsuyoshi Setoguchi[1], Norihiro Watanabe[1] and Ke Huo[2]

[1] Faculty of Engineering, Graduate School of Engineering, Hokkaido University, Sapporo, Japan
[2] JangHo Architecture College, Northeastern University, Shenyang, China

Abstract: Microclimate in open space affected by the urban layout and spatial forms plays an important role in the outdoor comfort, thus the outdoor activities based on the comfort sensation will directly affected by the microclimate. An outstanding open space should satisfy different requirements of outdoor activities and create relatively comfortable sensation. Most studies have been conducted on these relationships only above 0 Celsius degree. However, only few have focused on extreme situations in both hot and cold seasons. Therefore, from microclimate perspective, taking people's comfort and spatial behaviors as criterions, this research discussed how the open space forms affect microclimate, thus affect comfort sensation and spatial behaviors. The outcomes may provide some useful insights for planners and architects to understand the relationship among microclimate, open space and people. Results showed that microclimate obviously affected people's comfort. In hot season, shade and air-flow played crucial roles in outdoor comfort. People tend to stay outside in the shade and the area with higher air velocity. After sunset is popular period for outdoor activities. In cold season, at the same ambient temperature, lower air velocity raised the comfort level. Shade also had influences on comfort sensation but do not affect spatial behaviors significantly. This paper also proposes optimization design proposals of densely populated open space based on extreme microclimate and spatial behaviour.

INTRODUCTION

Open space that accommodate daily social activities plays an important role in cities. One of open space design targets is attracting more people to enjoy the outdoor environment (Carr, 1993; Marcus, 1997; Gehl, 2011; Maruani, 2007). Most open spaces are based on a type of open space formed by streets and buildings. One of the main types of open space is urban canyon that defined as the space composed of the street and its flanking buildings (Nunez, 1977). The city commercial zones are mostly planned in downtown urban canyons which are densely populated, and convenient for traffic. These properties lead to crucial status of urban canyon. For field surveys of urban canyon space, researching the commercial open space has obvious typicality and research value (Spagnolo, 2003).

∗ Correspondence to: Zhiming Guo, Tel.: +81-080-5722-6688. E-mail: burningrain1988@eis.hokudai.ac.jp

On the basis of spatial types in the urban canyon, the microclimate undergoes complex changes, thus affecting outdoor activities dramatically. Many studies have researched outdoor thermal comfort and outdoor activities influenced by microclimate (Nikolopoulou, 2007; Shimazaki, 2011; Thorsson, 2007; Eliasson, 2007). An increasing number of researchers have focused on the relationship between the microclimate and urban forms. Several studies have proved that shade and exposure to sunlight greatly influence ambient temperature in urban canyon, thus affecting users' feelings of comfort (Bourbia, 2010; Hwang, 2011; Andreou, 2012; Andreou, 2013, 2014; Shahrestani, 2015). Erell et al. (2012) have provided new perspective on interaction between microclimate and urban landscape for architects and urban designers. Among them, however, few studies have researched regions that suffer wide differences in temperature between summer and winter.

The relationship between microclimate and people's reactions, including comfort sensation and spatial behaviours in urban canyon should be paid more attention, especially in extreme weather. Li (1994) researched on small urban spaces in New York in winter to study the spatial behaviour influenced by climatic conditions. By using microclimate monitoring and interviews, Lai (2014) conducted a field survey at a park in northern China revealed the relationship between human comfort and each parameter of boreal climate. Furthermore, this research estimated northerners' comfort level and cold-resistant level. Baruch (1998) discussed the relationship among building, design, and climate, introducing design principles in different climate regions, broadly including cold regions. Using wind and snow tunnel simulation and evaluation, Setoguchi et al. (2004, 2006, 2007, 2009) and Watanabe et al. (2016) discussed design procedures for winter cities, especially those suffering heavy snow. They discussed urban structures and building forms which are

suitable for outdoor activities in cold season. Meng (2010) provided open space design guidelines for downtown areas suffering strong winds and low winter temperatures by simulating various types of downtown, high-rise buildings in a wind tunnel.

An outstanding open space should satisfy different requirements of outdoor comfort in different climate conditions. Other than the indoor space which can be created to satisfy the needs of the occupants, the outdoor space which affected by urban microclimate should be built by understanding the microclimate and should responds to them in appropriate ways (Erell et al.,2012). By researching the extreme urban microclimate situation, this study may provide useful insights for planner, architects and environment engineers to demonstrate the microclimate factors affected outdoor comfort significantly. Through microclimate measurement with public feedback in a central open space in northern China, this research discusses important elements that significantly affect people's sensations and behaviours, especially, how to optimize the open space design to prevent poor situations in hot summer and cold winter.

METHODOLOGY

Study area

The study case is a canyon type open space located in the central area of Shenyang in northern China (41°48′01.11″N, 123°27′49.33″E), which has long, severely cold winter and relatively short summer (Chinese State Bureau of Technology Supervision (CSBTS), 1994). The annual temperature range which undergoes over 62°C (China Meteorological Administration, 2014) is relatively larger than that of other areas; however, several weeks in summer also suffer high temperatures.
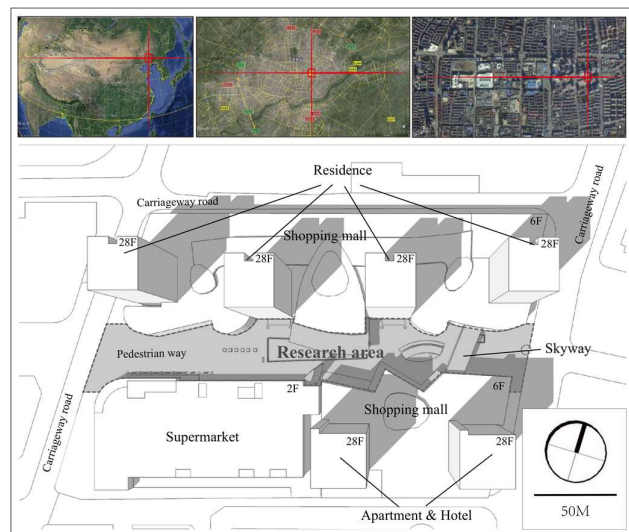

Fig. 1 Research area in Shenyang, northern China.

The study area is located at the mid-street in Shenhe district, Shenyang with approximately 400–600 thousands of tourists per day (Zhang, 2008), named as one of the most popular public spaces in the downtown area. There are resourceful public facilities with building area of about 282,700 m^2 like shopping malls, supermarkets, residences, hotels, and apartments. The subway station is located at the second underground floor of a shopping mall. As **Fig.1** shows, this place is a pedestrian street canyon (approximately 35×280 m^2). The area is mostly covered with hard materials with several tree pools. There are more than 20 entrances of the buildings opening to the pedestrian street. As an integrated public area, many and various subjects can be found to participate as references in the research.

Field survey

The hottest period in summer and coldest period in winter were chosen to research the extreme climate situation on the basis of 5 years (2009–2014) daily maximum and minimum temperatures from July to September in summer and December to February in winter (**Fig. 2**). Jul. 28–Aug.9, 2015 (12 days in summer) and Jan. 15–29 (15days in winter), 2016 were chosen as the survey periods.

Depending on space characteristic, 4 areas named west centre line, east centre line, north edge side and south edge side, including 15 measurement points were chosen (**Fig. 3**). As shown in **Table 1**, the microclimate parameters were recorded at each point every 15 minutes from 9:30 to 20:00, including ambient temperature (T_a), air velocity (V), relative humidity (RH), globe temperature (T_g) and shade situation. The wind chill (WC) will be recorded during the winter survey day.

Mean radiant temperature (T_{mrt}) is defined as the "uniform temperature of an imaginary enclosure in which the radiant heat transfer from the human body equals the radiant heat transfer in actual non-uniform enclosure" (ASHRAE, 2001). It is put forward based on the exchange of radiant energy between two objects by emitting and adsorbing heat. In this study, the Tmrt is estimated by the globe temperature method. Depending

on the previous study, there are relatively small differences between the globe temperature methods and other complicated methods (Thorsson, 2007). T_{mrt} is calculated based on the following formula (ASHRAE, 2001):

$$T_{mrt} = \left[(T_g + 273)^4 + \frac{1.10 \times 10^8 V^{0.6}}{\varepsilon D^{0.4}} (T_g - T_a) \right]^{\frac{1}{4}} - 273 \quad (1)$$

where T_{mrt} is mean radiant temperature (°C), T_g is globe temperature (°C), T_a is air temperature, V is air velocity (m/s), D is globe diameter (m) (in this study D=0.075m), ε is emissivity (0.95 for black-colored globe).

The Physiological Equivalent Temperature (PET) (Mayer, 1987) was employed in this research as a reference of the objective thermal comfort level. It can be defined as a temperature dimension index in degrees Celsius (°C) based on the Munich Energy-balance model for Individuals (MEMI) (Höppe, 1999). The PET can be calculated by using the software (e.g., RayMan) (Matzarakis, 2007) with inputting parameters of positional information, basic human factors, T_a, V, RH and T_{mrt}. It is also used by the human bio-meteorological evaluation of climate in urban and regional planning in German (VDI 3787) (VDI, 1998).

The environmental comfort sensation votes (CSV) which can be defined as subjectively integrated reactions of local people to the environment were also collected (**Table 2**) (Tanabe, 1988).

Panoramic images and the time-lapse videos were taken during the survey to calculate the people present (**Fig. 3**). As a comparison research of people present in and out of shade in summer and winter, two clear days, Aug.4, 2015 (summer) and Jan. 22, 2016 (winter) were chosen to analyze the spatial positions by counting and drawing down the people's position according to the panoramas and videos every 30 minutes. Besides the real shade situation recording, this study also simulated the shade in Aug. 4th and Jan. 22nd as references of the behaviour analyses depending on the solar incident angle (China Meteorological Bureau, 2005; Mohurd, 1994).
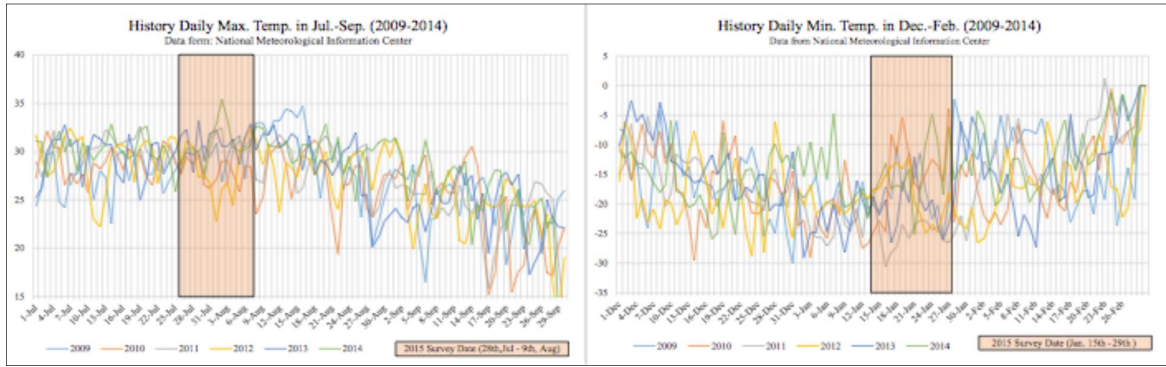
Fig. 2 Historical daily maximum and minimum temperatures from July to September and December to February 2009–2014 (China Meteorological Administration, 2014).
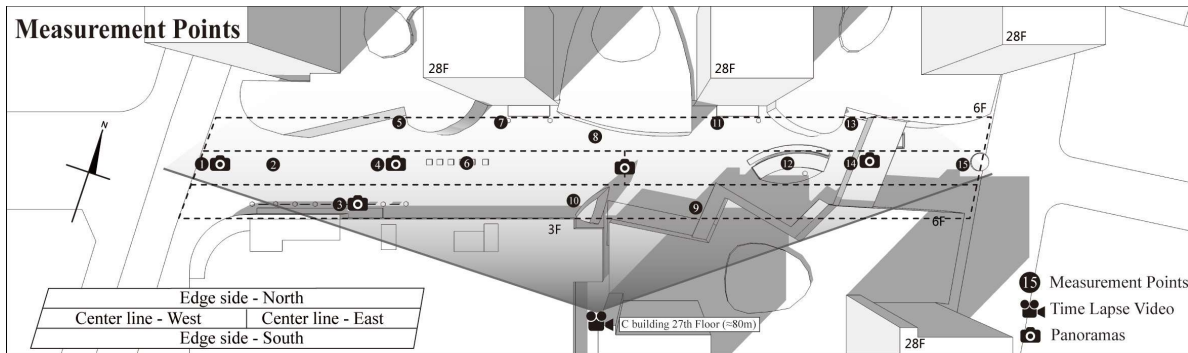

Fig. 3 Space types, position information, and measurement methods of central open space, Shenyang, Northern China.

Table 1. Sensor specifications and measurement height

Sensor	Parameter	Accuracy	Resolution	Range	Setting place
Kestrel 4500	V	3%	0.1 m/s	0.6 to 40.0 m/s	From point No. 1 to No. 15, 1.5m as the average height of the head.
	T_a	0.5 °C	0.1 °C	−29.0 to 70.0 °C	
	RH	3.0 %	0.1 %	5 to 95% non-condensing	
	WC (winter)	0.9°C	0.1°C	Refer to Ranges for the V and T_a Sensors	
TR-71Ui	T_g	0.3°C	0.1 °C	-40 to 110 °C	

Note: Wind chill temperature (WC) results from combining the effect of air velocity and ambient temperature. Calculated based on the NWS Wind Chill Temperature Index (The National Weather Service (NWS), 2011).

Table 2. The scale used by participants for subjective responses about comfort sensation during field surveys.

Value	Comfort sensation vote
−3	Very uncomfortable
−2	Uncomfortable and unacceptable
−1	Uncomfortable, but acceptable
0	Neutral
1	Slightly comfortable
2	Comfortable
3	Very comfortable

Sensation analysis with microclimate parameters

During the survey, 2489 groups of microclimate data and the corresponding CSV in summer and 2501 groups in winter were collected. The measured T_a range were 24.4–35.9°C in summer, −21.6–2.2°C in winter. The maximum temperature range between summer and winter was 57.5°C. The measured air velocity range were 0–7.1 m/s in summer and 0–4.8 m/s in winter. The mean air velocity in summer was 1.2m/s higher than in winter (1m/s). The RH range were 36–100% in summer (mean RH was 38.8%) and 20–56.2% in winter (mean RH was 20%).

RESULTS

Table 3 displays the correlations (Blalock, 1972) between CSV and microclimate data by using the software IBM SPSS Statistics (Version 20.0.0) (N $_{summer}$=2489, N $_{winter}$=2501). It can be used to evaluate the microclimate elements which will affect the comfort level greater. The higher the correlation coefficient, the greater influence on comfortable level. A measure of linear correlation between the two variables X and Y, a value is given between +1 and −1, inclusively, with 1 indicating total positive correlation, 0 indicating no correlation, and −1 indicating total negative correlation.

The results indicated that in summer (**Table 3a**), all measured factors except wind chill affected CSV significantly. Among them, shade had the highest correlation (r = −0.464) with CSV, followed by RH (r = 0.449). T_a was third, with a coefficient of −0.421, follow

by the T_{mrt} (r = −0.234). The weakest correlation with CSV was air velocity, with a coefficient of 0.222. More shade, lower T_a, higher air velocity, and higher RH improved sensations of comfort.

In winter (**Table 3b**), wind chill is employed as an important part for comfort evaluation. There are significant correlations between CSV and all measured factors. T_{mrt} affected CSV most with a coefficient of 0.336, followed by wind chill (r = 0.310). Correlation coefficients decreased gradually from T_a (r = 0.298) and shade (r = 0.236) to air velocity (-0.074). Higher wind chill, less shade, higher T_a, and lower air velocity improve comfort sensations.

Consequently, all the parameters mentioned in this part will affect the CSV. However, there is no

Table 3a. Correlations between comfort sensation votes (CSV) and microclimates in summer

		CSV	Shade	T_a	Tmrt	V	RH
summer	CSV	1					
	Shade	-.464**	1				
	T_a	-.421**	.288**	1			
	Tmrt	-.234**	.250**	.215**	1		
	V	.222**	-.080**	-.157**	.216**	1	
	RH	.449**	-.287**	-.685**	-.283**	.165**	1

** Correlation is significant at the 0.01 level (2-tailed).

Table 3b. Correlations between comfort sensation votes (CSV) and microclimates in winter

		CSV	Shade	Ta	Tmrt	V	WC
winter	CSV	1					
	Shade	.236**	1				
	Ta	.298**	.036**	1			
	Tmrt	.336**	.157**	.461**	1		
	V	-.074**	-0.008	.124**	.260**	1	
	WC	.310**	.038*	.894**	.321**	-.290**	1

** Correlation is significant at the 0.01 level (2-tailed).

Note：CSV-comfort sensation votes, Ta- air temperature, Tmrt – mean temperature radiant, V-air velocity, RH-relative humidity.
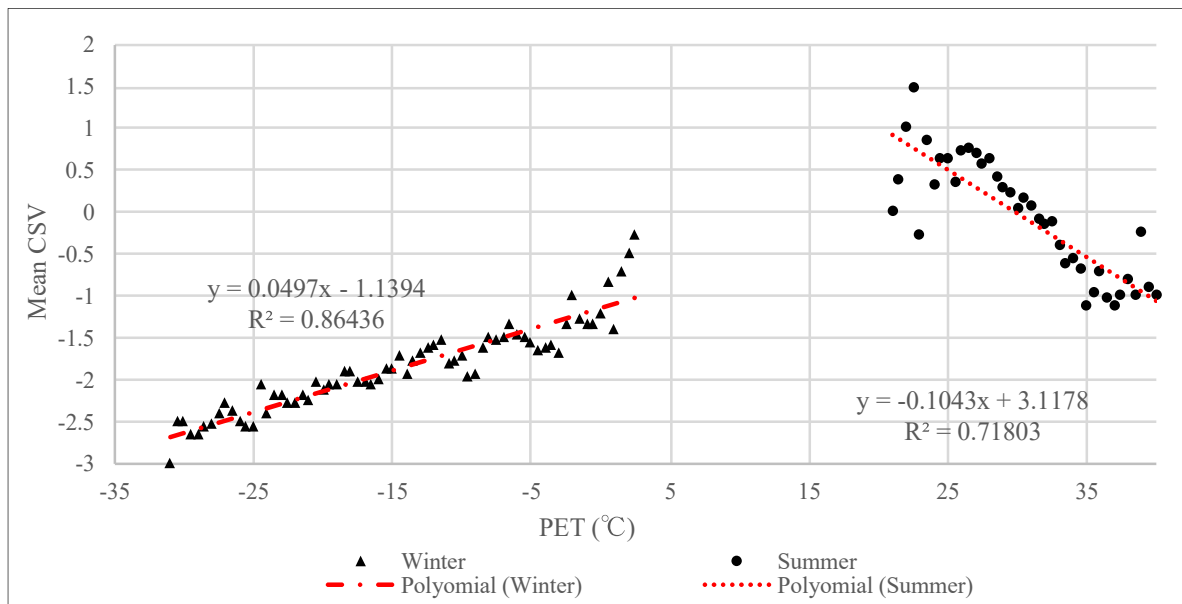
Fig. 4 Relationship between mean CSV and PET.

correlation coefficients above 0.5, that is, no single parameter will affect the CSV as a leading role. All the factors have come together on the comfort level.

In **Fig. 4**, for every 0.5°C of PET interval, the mean CSV was calculated in both summer and winter as suggested by Ref. (Lin, 2008). The PET ranges were −31.7 to 3.1°C (cold season) and 21 to 40.9°C (hot season). Linear regression was conducted as follows:

Cold season:
$$y = 0.0497x − 1.1394 \ (R^2 = 0.86436) \tag{2}$$
Hot season:
$$y = −0.1043x + 3.1178 \ (R^2 = 0.71803) \tag{3}$$

The correlation between mean CSV and PET in both summer and winter were higher than 0.7 (R^2=0.86 in winter, R^2=0.72 in summer). The regression coefficients were 0.0497 in winter and −0.1043 in summer. The results indicate that comparing with the cold season, the residents in Shenyang were more sensitive to hot season. With the scale for subjective responses about comfort sensation in Table 2, the unacceptable PET range is lower than −17.32°C in winter. The neutral PET is 29.89°C in summer.

Studies had been conducted that residents in different areas shows environmental adaptability and individual differences (Nikolopoulou, 2001; Oliveira, 2007). In this research, the comfort sensation of residents in Shenyang was collected with corresponding microclimate data. Considering about the regional and individual differences, more than 2400 groups of data were employed for the sensation tendency research.

By analysing mean CSV at the same ambient temperature, air velocity, and relative humidity in summer, ambient temperature, air velocity, and wind chill in winter, the following change trends were found: In summer, as **Fig. 5** shows, CSV decreased with increasing ambient temperature, decreasing air velocity, and rose in relative humidity. Among these meteorological parameters, 29.6°C of T_a, 1.1 m/s of air velocity, and 67% of RH were threshold values for whether the environment was comfortable or not. When the T_a is higher than 31.9°C and the RH is lower than 52%, it can be seen to be uncomfortable situation. To sum up, in summer, lower ambient temperature, higher air velocity and relative humidity are more comfortable.

In winter, all the CSV was below 0°C, that is, all the measured microclimate cannot satisfy people's comfort level. CSV decreased with increasing air velocity and decreasing ambient temperature and wind chill (Fig. 6). Among them, −14.4°C of T_a, −16.5°C of WC, and 1.6 m/s of air velocity were environmental threshold values that can be accepted or not. Consequently, in winter, lower air velocity, higher ambient temperature and wind chill will make the outdoor environment more comfortable.

Relationships between comfort sensations votes (CSV), microclimate, and time

Previous studies had demonstrated that shade affect the solar radiation, thus affect the thermal sensation greatly (Lin, 2010; Hwang, 2011). Among the microclimate parameters, shade situation is easy to be distinguished and calculated. Therefore, separating the shade situation to analyse the relationship among mean CSV, microclimate factors and time may provide some distinct insights on the outdoor environment research.

Fig. 7 shows the relations among microclimate factors and CSV as a function of time in different shade situations, the following results were obtained:

In summer, CSV curves in and out of shade are obviously separate. In the morning (before 10:00 a.m.) the CSV was higher than other periods. In the evening (after 5:00 p.m.), most people feel comfortable. T_a and RH change with time gradually. From morning, T_a increase gradually until 14:30 p.m. After 14:30 p.m., the T_a started to decrease gradually. The RH was opposite to the T_a with higher rate of change. Air velocity was not about time but significantly affects instantaneous CSV.

In winter, all the measured CSV was below 0 Celsius temperature. From morning, CSV curving in and out of shade separated gradually. From 13:00 p.m. to 15:00 p.m., higher CSV can be measured especially out of the shade. T_a and RH changed gradually with time, however, wind chill changed with air velocity, significantly affected instantaneous CSV.

Consequently, the RH and T_a will change with time. It can be suggesting that according to the solar radiation and spatial characteristics, some of the microclimate factors will change gradually with time. Meanwhile, the air velocity which is not related to time will also affect the CSV significantly. By according to the ruler guide in **Fig. 5**, almost all the instantaneous change was due with the air-flow.

People present study is another way to evaluate the environmental quality. Two days (Aug. 4, 2015 in summer and Jan. 22, 2016 in winter) were chosen to compare the differences between summer and winter by the following reasons: First, two days were all clear days. There were no influences by cloud. Secondly, these two days were all workdays and there were no commercial events during the survey periods. The pedestrian volume can be seen as normal levels. As **Fig. 8** shows, both in summer and winter, total numbers relate to the time of day. The average total number in summer (212.10) was twice than that in winter (99.76). The least number of people were recorded during the morning (9:30−10:30) in both summer and winter. Since all the shopping malls open at 10:00, it can be speculated that the number of people affected by the function of open space.

In summer, during the afternoon, the total number was least at 14:30, but after sunset (no direct sunlight in the study area) at about 16:45, numbers of people increased substantially. In the outdoor space, approximately 30% of people were stationary. Before sunset, the number of stationary people remained stable, and approximately 60% of them stayed in the shade. Hence, afternoon before sunset was the most unpopular time in summer, but after sunset, more people came outside.

In winter, the biggest number of people were recorded around 3 o'clock p.m. People not in the shade related significantly to time change, and there were almost no stationary people outside. Consequently, from lunchtime (12:00−13:00) to sunset at about 16:30 was the most attractive period for people in winter.

Microclimate analysis at each measurement point

Microclimate comparison among different areas and points were conducted. Based on different spatial characteristics, the results of microclimate are as the **Fig.9**. In summer and winter, the ambient temperature and humidity did not show large differences among each point. Relative humidity at north side where can get more sunlight was lower. Air-flow affected by the
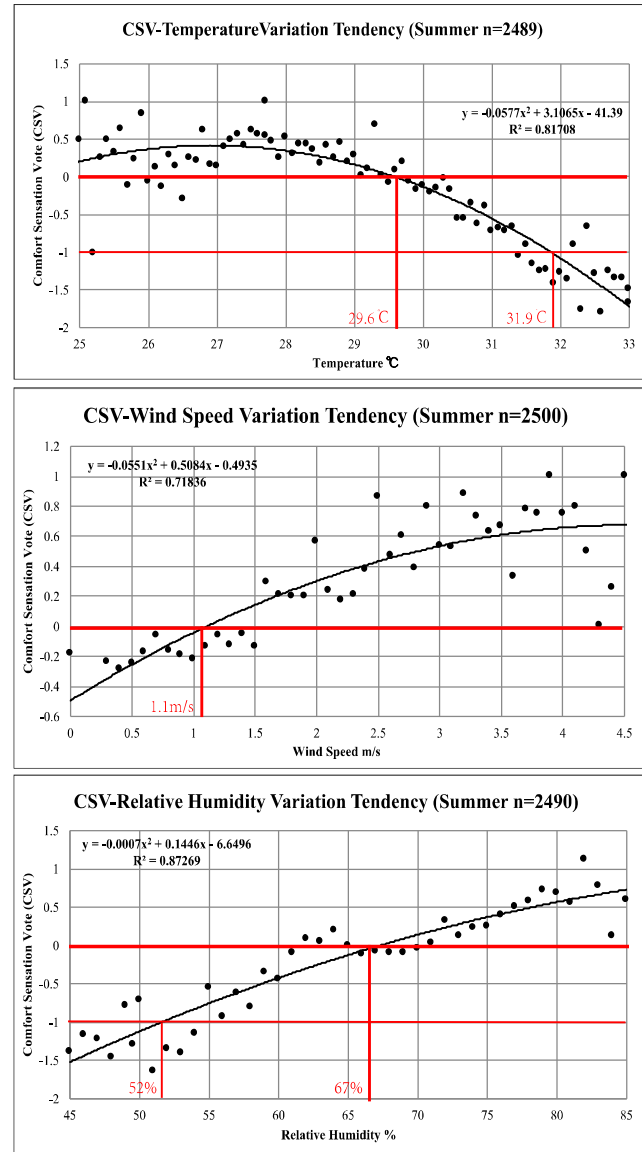

Fig. 5 CSV- ambient temperature, air velocity, and relative humidity variation tendency (Summer).

spatial forms at center line was higher than edge sides. The highest mean air velocity in both summer and winter were found at the point No.14, where located at the narrowest place in canyon. The lowest mean air velocity was in No.5 located at building corner which can be realized as shelter from the wind.

Furthermore, the mean CSV show regularity as different microclimate. In summer and winter, the mean CSV distributions are just opposite to each other. In summer, the highest mean CSV was found at the east

center line where located at the long shade and relatively narrow space with high air-flow. The lowest mean CSV was located at west center line named as unshaded and wide area where suffered relatively low air velocity. In winter, the north edge space with relatively lower air velocity and short shade got the highest mean CSV. The east center line with higher air velocity and longer shade got the lowest mean CSV. Consequently, different spatial forms will cause different microclimate conditions, thus affect the comfort level. The air velocity and shade situation are the two factors that easy to be affected by spatial form.

Two special points (Nos.5 and 14) with extreme microclimate were chosen to evaluate the microclimate factors difference during a continuous period (Aug. 1st-4th, 2015 in summer, Jan. 22nd-25th, 2016 in winter). These two points also had relatively exceptional T_a and RH. In **Fig. 10**, there are huge difference in air velocity and temperature between No.5 and No.14. Air velocity at No. 14 which is located at canyon "entrances" was higher than at Nos. 5 located at building corner. According to the previous study by H. Wu (1994), the skyway above the point No.14 can be seen as a diverter of air-flow. The wind pass through the skyway was separated into two parts. The area of air duct was decreased by the skyway. The air volume per unit area was increased. That caused the air velocity under the skyway to increase. The building corner at No.5 can resist the air-flow from the vertical direction. At the same time, it can also lead the air-flow from parallel direction to skim over the corner.
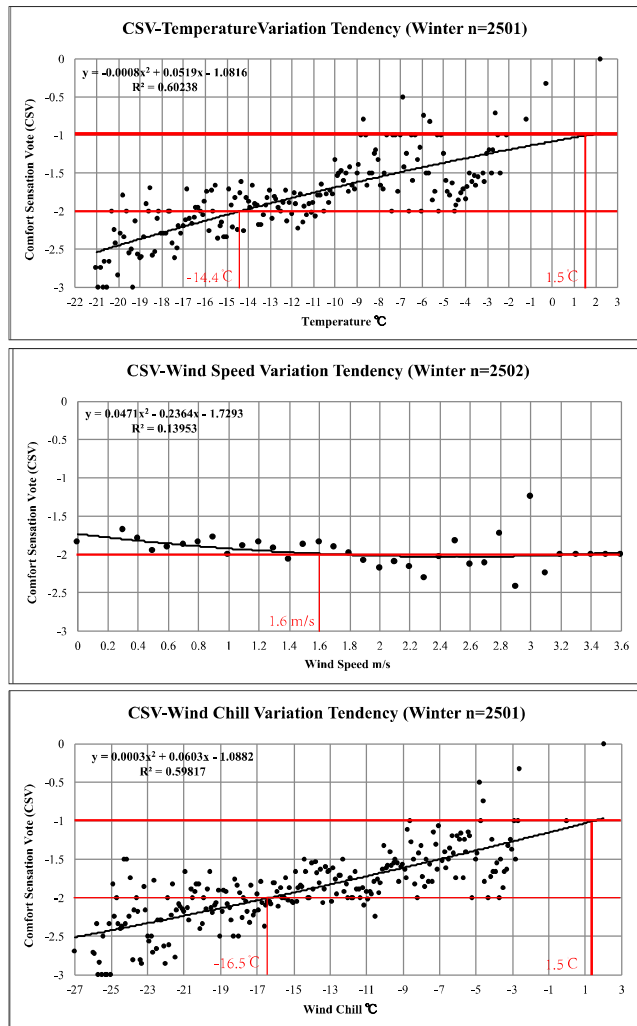

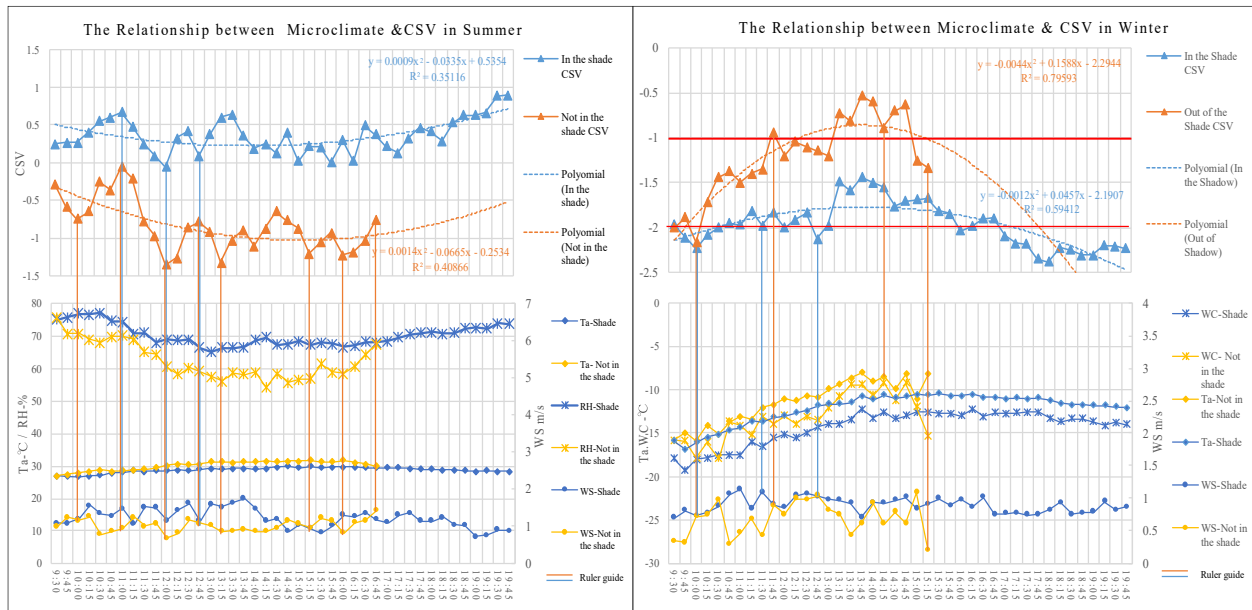**Fig. 6** CSV- ambient temperature, air velocity, and wind chill variation tendency (Winter).

Fig. 7 Relationships among mean CSV, microclimate factors with time in different shade situations.
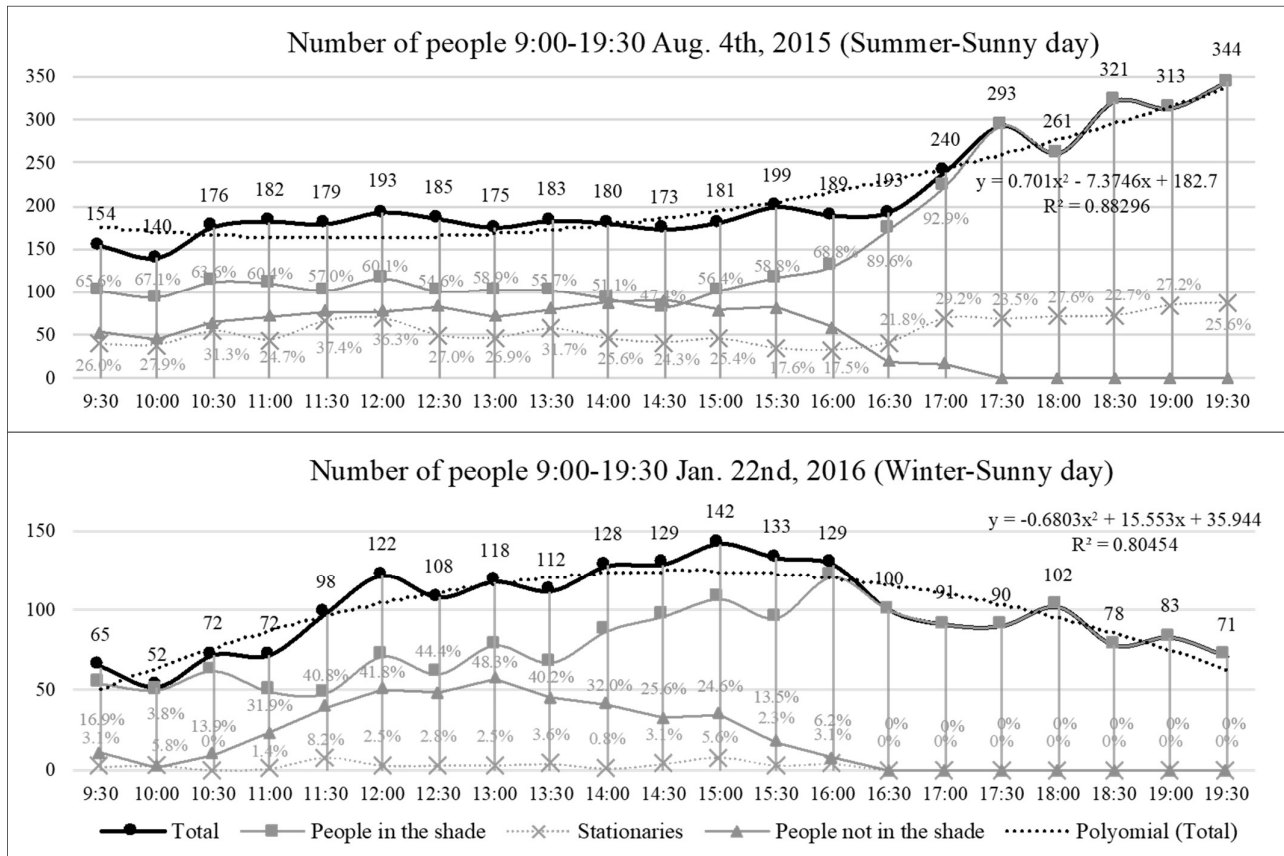
Fig. 8 Number of people present in sunny day at research site (Aug. 4, 2015 and Jan. 22, 2016).
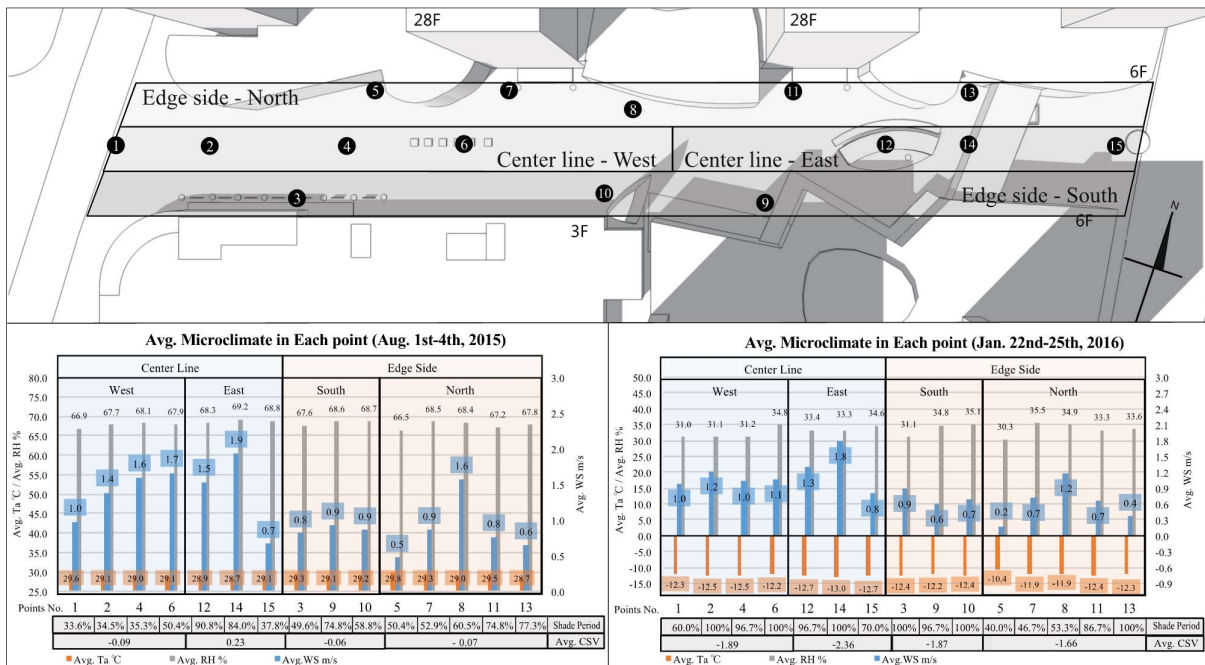

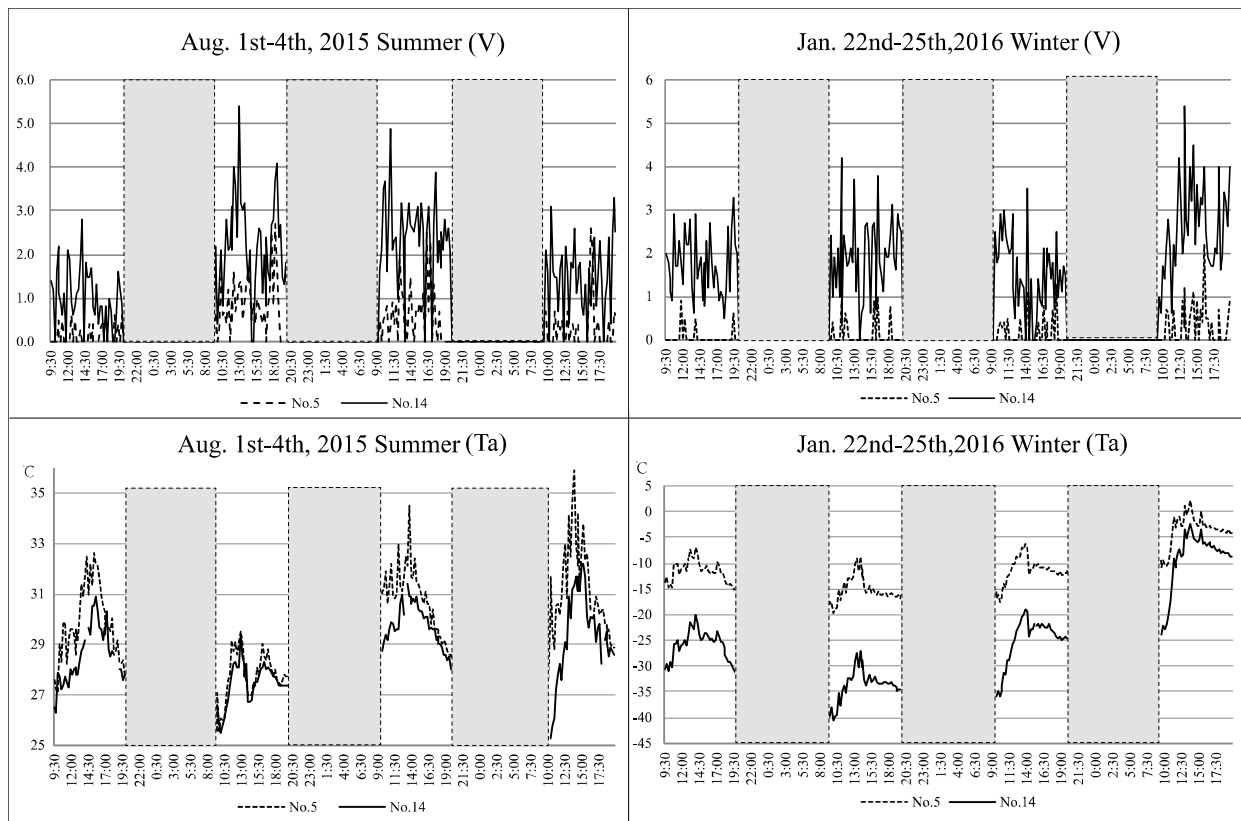**Fig. 9** Mean microclimate data at each point with mean CSV for Shenyang, northern China.

Fig. 10 Air velocity and ambient temperature distributions at measurement points Nos. 5 and 14 in summer and winter.

Differences in T_a between the highest point (No. 5) and lowest point (No. 14) vary with shade situations. The difference in temperature between these two points can reach 6.4°C in summer and 9.5°C in winter. In terms of their spatial characteristics, No. 5 is located at the north edge of the building and is exposed to sunlight and solar reflection from the glass building. On the contrary, No. 14 is under the skyway with almost no sunlight all day long; it is also far from the building's reflection. Therefore, people can feel higher CSV at No. 14 in summer, with lower ambient temperature, and lower CSV at No. 5 in winter.

Consequently, because of the different spatial forms, there are huge differences on microclimate in the same place to affect comfort sensation. Outdoor distributions of people influenced by shade and spatial forms was conducted in two clear days (Aug. 4, 2015 and Jan. 22, 2016) between summer and winter. On the basis of solar simulation and high-resolution photographs, the position of people was recorded every 30 minutes. **Figs 11–12** shows the analyses of position relationships with shade simulation results.

In summer, according to the results 3.3, the south side suffer higher CSV than north. The area in west centre line is not popular by pedestrians. Instead, as **Fig. 11** shows, the east side with long periods of shade, abundant seats and other facilities can gather more people than the west side. There are sufficient seats

inside the shade at the Nos. 3, 9, 11 and 12, and there are also seats under vegetation which can provide shade at No. 6. Most of the stationaries will choose these places to stay. From the above, the necessary factors for the people who stay outside in summer are shade and rest facilities.

In winter, as shown in **Fig. 12**, people distribute evenly. Shade and rest facilities do not affect the position distribution seriously. Meanwhile, a few of people who stay outside will choose sunlight place or the place related to their destinations, for example: the entrance of the supermarket or the shopping mall or the subway station. The rest facilities and shade are not the necessary factors of attracting people to stay or sit outside in winter.

Consequently, in summer, shade influences the overall distributions of people obviously. Rest facilities with sufficient shade also attract people. In winter, no strong relations were found between shade situation and distributions of people.

CONCLUSIONS

By using microclimate and human comfort as standards for environmental evaluation, this research conducted a field survey at a downtown pedestrian street both in hot summer and cold winter which have not been studied in the past. By analyzing how extreme
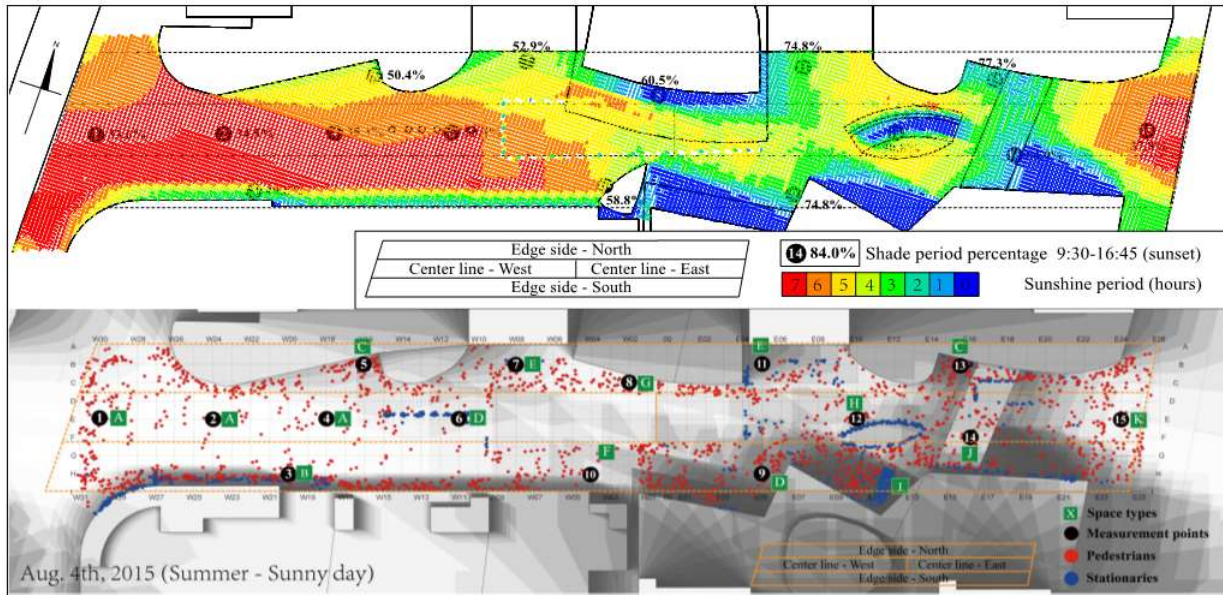
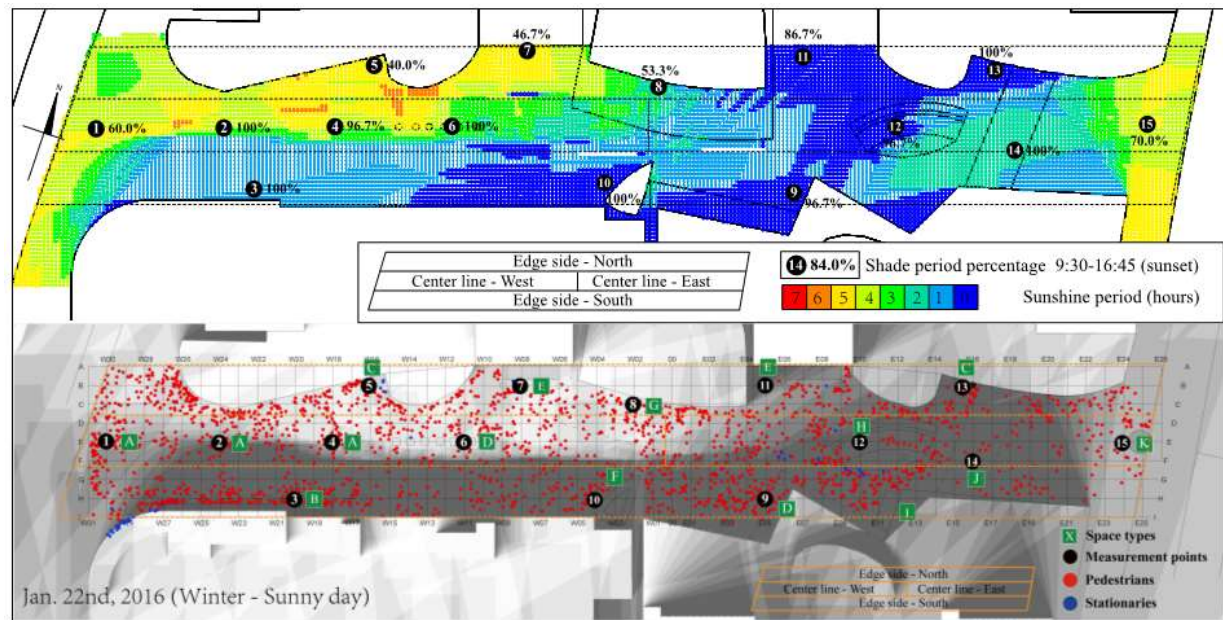**Fig. 11** The position relationship with shade situation in summer.

Fig. 12 The position relationship with shade situation in winter.

weather situations influenced human behaviour and comfort, the study aimed to discover the microclimate associated with open space use, to support further open space design. The survey has demonstrated the following:

- Microclimate obviously affected people's comfort. In addition, the influence effect in summer and winter were distinct. No single parameter will affect the spatial comfort as a leading role. All the factors have come together on the comfort sensation.

- In summer, lower T_a, higher air velocity, RH and more shade brought higher CSV. 29.6°C of T_a, 1.1 m/s of air velocity, and 67% of RH were threshold values for whether the environment was comfortable or not. In winter, higher T_a, lower air velocity and less shade, caused higher CSV. −14.4°C of T_a, −16.5°C of WC, and 1.6 m/s of air velocity were environmental threshold values that can be accepted or not.

- The residents in Shenyang were more sensitive to hot season than cold season.

- Among all meteorological factors, change of T_a, RH, and shade situation were closely related to time and changed evenly. However, air velocity changed unevenly and significantly affected instantaneous comfort.
- Spatial form affected the shade situation and air velocity, and further affected comfort sensation.
- The human present is related to microclimate that change along with time, that is, in summer, afternoon before sunset (at about 16:45) was the most unpopular time, but after sunset, more people came outside. From lunchtime (12:00−13:00) to sunset at about 16:30 was the most attractive period for people in winter.
- Different spatial forms cause the differences of microclimate, thus affect comfort sensation. In summer, shade influences the overall distributions of people obviously. Rest facilities with sufficient shade also attract people. In winter, no strong relations were found between shade situation and distributions of people.

In such kind of city central open space suffering hot summer and cold winter, grasping the rules of the microclimate which affect the people's sensation and spatial behaviours can help the planners to create more comfortable open space. By optimizing the spatial form, it is possible to change the wind environment and shade situation better. Meanwhile, understanding the time-microclimate rules, arranging the open space facilities in suitable time and season are important to raise the space utilization. From the conclusions above, densely populated open space design guidelines based on extreme microclimate and spatial behaviour are proposed:

- In hot season, attractive open space design should focus on rest facilities with shade and ventilation. In the daytime, setting the broad-leaved vegetation and roofs on the widely open space can raise the comfort level. Adding rest facilities at the well-ventilated areas also can raise the environment comfort. Meanwhile, nightscape design should be especially considered.
- In cold season, the rest area should be arranged to combine well with relative behaviours around the buildings. Meanwhile, shelter from wind is a key point for a better winter environment. The design of the daytime environment, especially from noon to sunset, should be properly addressed.

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