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Environmental comfort and urban spaces

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Summary

Nowadays, people are used to spend most of their time in urban spaces. Guaranteeing comfortable spaces is then an important goal in the urban planning since the micro-climatic conditions strongly influence the use of public spaces. The ‘Thermal Comfort’ becomes an important component of urban planning. In literature, ‘Thermal Comfort’ is defined as 'the condition of mind which expresses satisfaction with the... environment’[1]. Hence, this design goal has a very high level of complexity due to the interaction between the physiological acclimatization of individuals and the physical parameters characterizing the micro-climatic context.
How is it possible to modify urban spaces to make them more comfortable? Can a new methodology of analysis and design based on the comfort definition that will be suitable for different climate contexts be introduced? Should the outdoor environment be designed in order to assure occupants’ comfort and health? The present work is then going to discuss a methodology for outdoor spaces analysis and design that is aimed to achieve comfortable conditions in urban spaces.

Keywords: urban design, environmental comfort.

1. Proposed methodology

The proposed methodology (figure 1) has been developed introducing a case study (Piazza Università in Bozen-Bolzano - Italy) that has been chosen considering its potentiality as a small square.
The aim was to analyse this urban space in order to identify its critical points and its strengths in terms of comfort, provision and space exploitation.

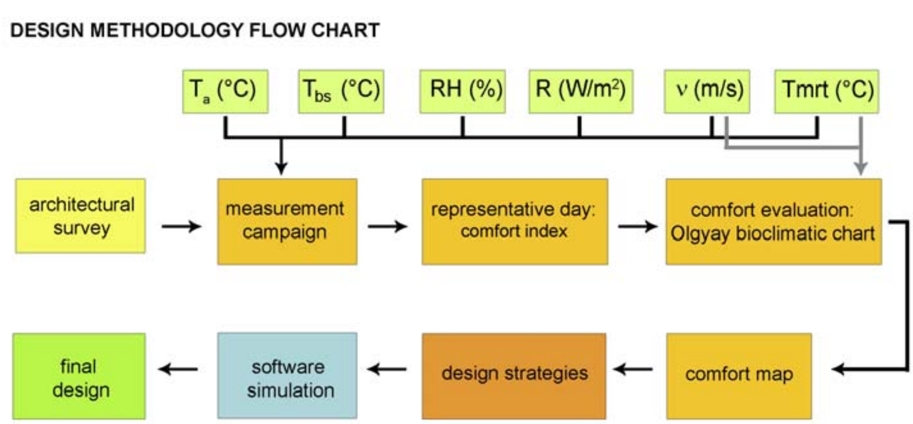

Fig. 1 Design methodology

1.1 Architectural survey

The architectural survey is a keystone in the analysis process. The most important aspect will concern the relations between the geometrical aspects and the solar radiation input with regard to the building façades and pavement materials.
Indeed the solar radiation has two effects at comfort level:

- interactions with the occupants;
- interactions with building and pavement that strongly influence their surface temperature in function of the properties of the their material (heat capacity and albedo).

The first one directly influences comfort provision at midday time while the second one will influence comfort condition in the evening. For those reasons the architectural survey aimed to investigate the use of materials within the piazza space and the interaction between buildings geometry and solar radiation. Some critical points were found during the analysis. The case study has been analysed throughout the Solar Pathfinder ™ tool combined with a geometrical survey (figure 2), taking into account the horizontal shadow projections and material properties of surrounding built environment, which specially affect the evening comfort.

Fig. 2 Solar input analysis by means of architectural survey and Solar Pathfinder ™

1.2 Measurement campaign

1.2.1 Tools and measurement methodology

The external climatic conditions have been recorded day by day by means of a mobile microclimatic weather station. Different probes have been chosen in accordance with the climatic parameters to be recorded:

- Thermo-hygrometer: air temperature (Ta,°C) and relative humidity (RH, %);
- Globo-thermometer: mean radiative temperature (Tmrt, °C);
- Anemometer: air flow direction and velocity (ν, m/s);
- Radiometer: global radiation (R, W/m^2).

Finally a thermocamera was also used to detect building and pavement surface temperatures.

The most important step was to choose a measurement methodology suitable to record the parameters within the analysed urban space. According to the different comfort needs, two different methodology were considered:

- midday time measurements. Since several external factors such as shadow, vegetation, etc. strongly influence the variability of the characteristic parameters (Ta, RH, ν, Tmrt, R) to consider in the analysis, the weather station has been continuously moved within the space following a precise grid on the pavement;
- evening time measurements. In order to assess the radiative exchange affecting comfort the weather station was placed in the middle of the square (static mode of measurements).

1.2.2 Grid of measurements

Piazza Università was divided by means of a squared analysis grid of 5 x 5 meters that allowed to identify the different critical points where the measurements were needed. At first, a geometrical approach was considered but the usage of space by occupants involved a more flexible system based on the compromise between the accessibility of the points and geometrical needs. The car and bicycle parking, for example, were considered and the grid was arranged to overpass them introducing some triangular mesh and preserving its dimensions in that way.

2. Comfort evaluation

2.1.1 The representative days: choice and analyses

The measurements were taken day by day during the summer period but, according to the purpose of the present work, only representative days were taken into account.

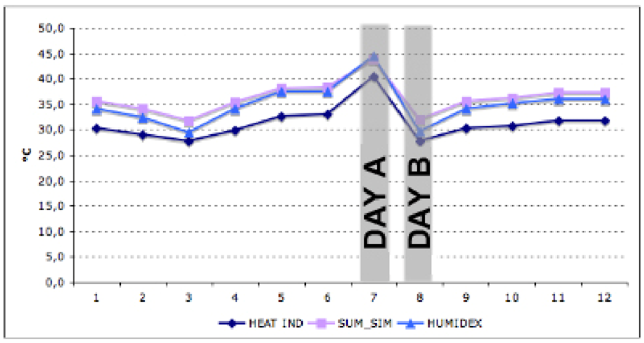

Fig. 3 Comparison between the different index.

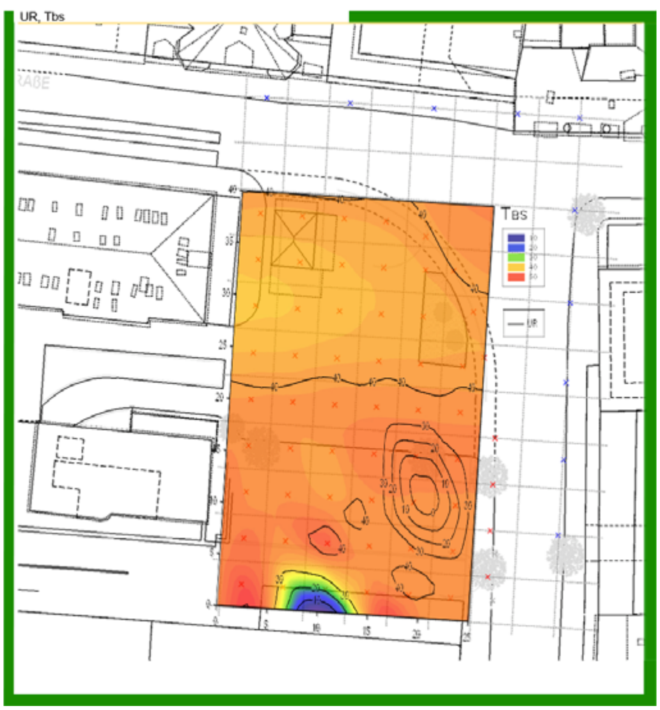

Fig. 4 Midday Comfort. For the chosen day the dry-bulb temperature and relative humidity were plotted in the plan to focus on the critical area within the piazza

Consequently the most important comfort indexes (Heat Index, Summer Simmer, Humidex and Operative temperature) were considered to check which dayshad the most uncomfortable conditions and to verify which design action could be introduced to improve them (figure 3). The first three index focused on the effect of Ta and RH were used for the midday analysis while the last one was used for the evening evaluations.

Taking into consideration only the data from the selected days (as explained before) with the Sigma Plot software, it was possible to obtain a graphic representation of the temperatures (Tbs, Tmrt), indicated by the colour range that goes from cold blue (low temperatures) to warm orange (warm temperatures). The relative humidity variation is represented in figure 4 as a series of concentric lines (contour).

2.1.2 The Olgyay approach

In order to obtain a map of the points of discomfort of the square shapes (figure 6) during the selected days, we proceed with the help of bioclimatic Olgyays chart that is suitable for external assessments. This chart is one of the first attempts at an environmentally conscious building design and was developed in the 1950s to incorporate the outdoor climate into building design. The chart indicates the zones of human comfort in relation to air temperature and humidity, mean radiant temperature (Tmrt), wind speed, solar radiation and evaporative cooling. The comfort zone is in the centre, with winter and summer ranges indicated separately (taking seasonal adaptation into account). It was translated of 5 degrees Celsius in order to adapt to the latitude of Bolzano (Latitude 46.5000 N - Longitude 11.3333 E). This chart was used to evaluate the comfort conditions during the analysed days. The chart was used both to assess the actual comfort condition recorded during the measurements campaign and to evaluate the design mitigation action that could be introduced.

In the bioclimatic chart the point representing the climatic conditions of each representative day according and considering the weather station location were plotted. For each point some other considerations were taken into account to check if an expansion of comfort zone could be considered according to the following assumptions:

- Tmrt recorded < Tmrt proposed; ν recorded < ν (wind speed) proposed ==> good conditions of comfort;
- Tmrt recorded < Tmrt proposed; ν recorded > ν (wind speed) proposed ==> adequate conditions of comfort;
- Tmrt recorded > Tmrt proposed ; ν recorded > ν (wind speed) proposed ==> little comfort conditions.

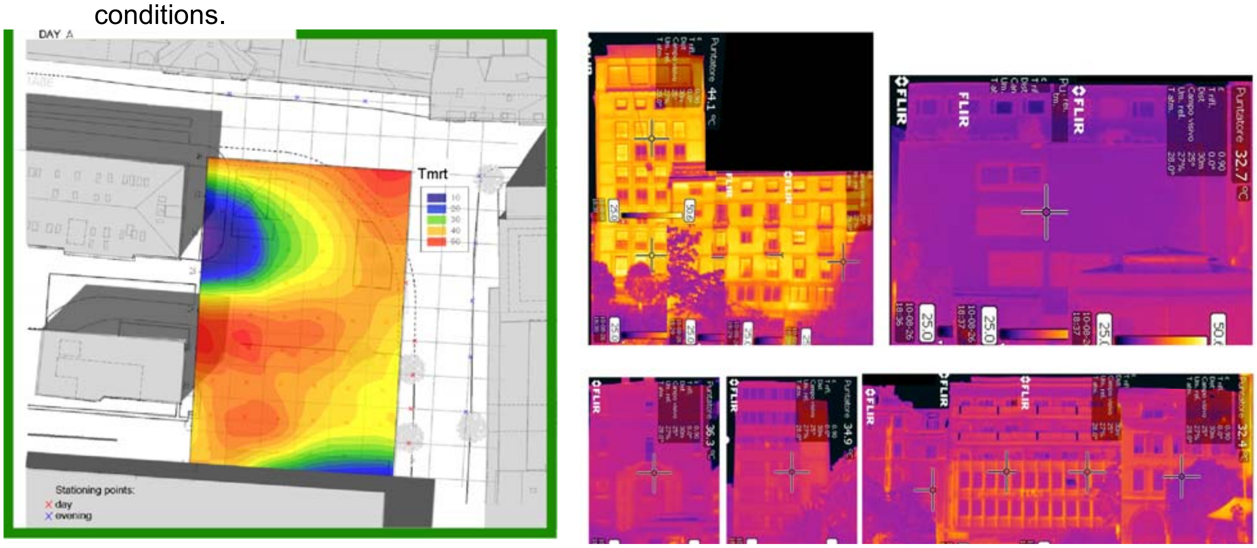

Fig. 5 Evening Comfort. For the chosen day the surface temperature were analysed by means of redrawing and IR-pictures

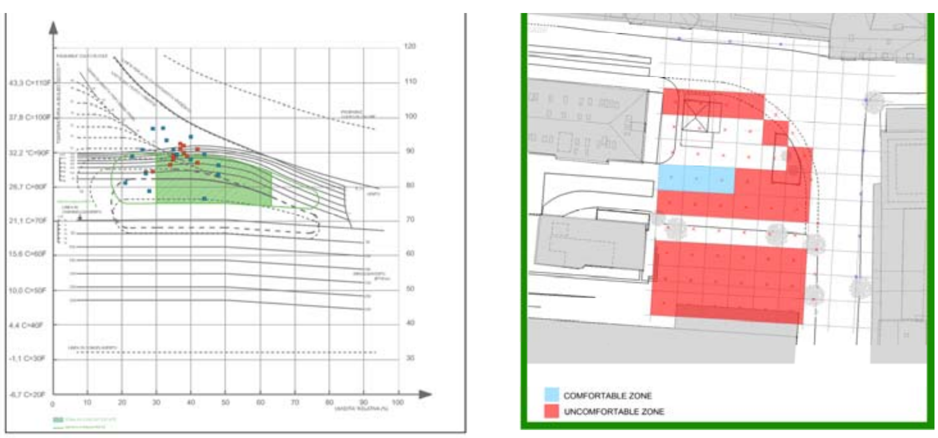

Fig. 6 Olgyay evaluations. Starting from the recorded climatic data, the Olgyay chart allowed to evaluate the comfort condition point by point. These evaluations have been plotted in the plan

3. Results

3.1.1 Design strategies and considerations

The analyses allowed the critical point at comfort level within the piazza to be discovered. According to the Olgyay bioclimatic chart some design strategies could improve comfort conditions.
A distinction between midday and evening case is needed. Thus most important design strategy to provide comfort during the midday is to introduce some vegetation elements that could enable shadowed spaces with the piazza and could lower air temperature by means of evapotranspiration. While as shown in the infrared pictures, during the evening, it is necessary to lower surface temperatures changing the material of building profile. Indeed the most critical area of the square is the floor made of porphyry and the basement of east building.

3.1.2 Software simulation

Several urban simulations by means of ENVI-met software were performed starting from the actual recorded climatic data. The aim was to compare thermal conditions with different ground surfaces with or without vegetation elements.
ENVI-met is a three-dimensional non-hydrostatic model for the simulation of surface-plant-air interactions within urban environments.
It is designed for microscale with a typical horizontal resolution from 0.5 to 10 m and a typical time frame of 24 to 48 hours with a time step of 10 sec at maximum. This resolution allows to analyze small-scale interactions between individual buildings, surfaces and plants [3].
Figure 7 shows a scenario where we increased the cover of trees using *Quercus pubescens* (Downy Oak) which is a native species [4] and is the most frequent tree species in the City of Bolzano tree inventory. This scenario was modeled using ENVI-met.
The software uses input values for vegetation, buildings, ground surfaces, soils and climatic conditions.
Moreover, the Leaf area density (LAD) values required for ENVI-met database were calculated using the empirical LAD model of Lalic and Mihailovic [5]. Furthermore, the model was solved 10 times to produce LAD values at different heights of the trees [6].

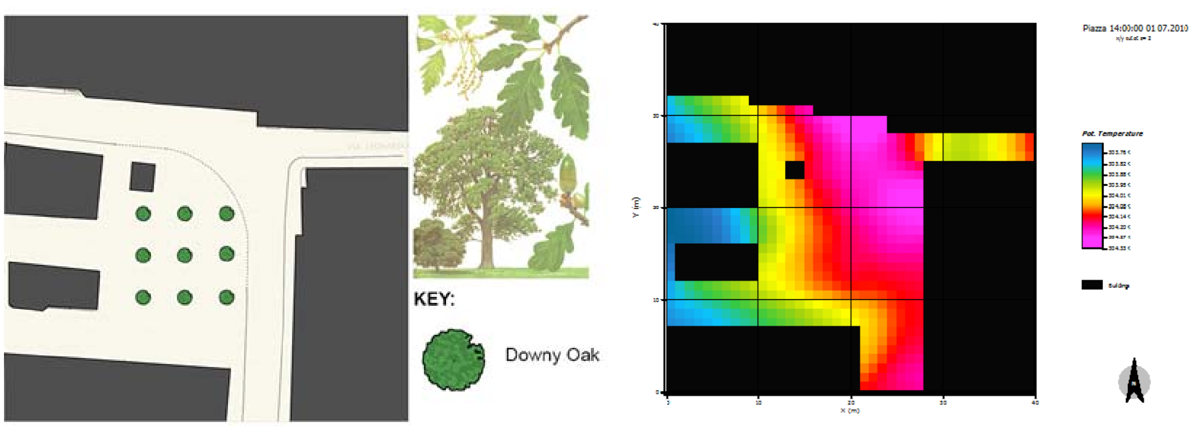

Fig. 7 ENVI-met simulation. Herewith the scenario characterised by the use of trees within the piazza and its effect on the air temperature

4. Conclusion

To conclude, a method to understand the key variables of a microclimate outdoor space has been presented. The most important aspect concerns the integration between the comfort analyses and the design process in order to create a climatically pleasant space for human activities [7].
Future developments of this research will concern a comparison between ENVI-met scenario and

cost-benefits analysis. We expect this ongoing research to lead to some interesting results. Hopefully the results of the research will be used as design guidelines for landscape architects, architects and urban designers. Future studies include research on different urban trees and sustainable materials.

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