A METHODOLOGY FOR BIOCLIMATIC MICROSCALE MAPPING OF OPEN SPACES

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Abstract

In the framework of a current European research project (RUROS – Rediscovering the Urban Realm and Open Spaces) a methodology for bioclimatic comfort mapping has been developed. In connection with a couple of design guidelines this methodology is dedicated very much to the need of urban decision makers, planners and architects. The comfort maps refer to an urban environment on the scale of neighbourhood and aim to assist in predicting and assessing bioclimatic conditions, use of space and influence of urban design.

Key words: bioclimate, mapping, open space planning

1. INTRODUCTION

Generally it is recognized that the quality of open urban spaces contributes to quality of life within cities. So there is strong public interest in creating attractive open spaces. Besides different factors (e.g. visual or audible comfort, social environment) thermal comfort is one important issue. The acceptance and use of open spaces is influenced by the microclimatic conditions offered to the citizens, whereas the microclimate as such as well as the thermal sensation have a strong dependency on the urban design and show a high temporal and spatial variation.

In Denmark e.g., the need for knowledge on designing open spaces with climatic consideration has become increasingly important, as in the last 40 years the outdoor urban life has expanded dramatically up to around seven months a year, from April to November, whereas 20-30 years ago, it was around four months a year, from May to September (Kofoed, N.-U. 2002).

Thus, it raises the question how to assess thermal comfort conditions in connection with behaviour of people, use of space and urban design. State-of-the-art are bioclimatological indices such as PMV or PET (VDI 1998) predicting the average thermal sensation on base of meteorological parameters as well as clothing and activity of people. Unfortunately the calculation of these indices in the context of microscale urban environment is a task to be done by experts and (in practice) often a question of time and costs. E.g. in order to receive a spatial pattern of PMV or PET detailed information on meteorological conditions of an open space is needed, which has to be collected from field surveys or to be calculated by computer simulations. These disadvantages give ground to think about providing urban designers, planners and decision makers with alternative adequate techniques or tools for assessing different planning scenarios in terms of comfort situation and use of space.

The developed mapping methodology focuses on spatial analysis of thermal comfort zones.

2. METHODOLOGY OF COMFORT MAPPING

The methodology for mapping thermal comfort conditions in the urban context has been developed on the basis of field survey results, whereas the methodology itself is nearly independent from the availability of respective data.

2.1. Field surveys

From the field surveys it has been obtained an extensive dataset concerning comfort conditions, use of outdoor space and social character of two public open spaces in Kassel (Bahnhofsplatz and Florentiner Platz).

The surveys combined two main issues, namely an environmental and as well a kind of human monitoring. I.e. on the one hand meteorological measurements of the thermal environment have been carried through, whereas on the other hand people have been studied through observations and personal interviews. The studies have been carried out every season, during different weather conditions, taking account of morning, lunchtime and afternoon periods.

Thus, the field surveys provide extensive information on the climatic parameters (air and globe temperature, humidity, wind speed, global radiation etc.) and their variation in time and space.

The first step towards thermal mapping was analyzing the spatial distribution of meteorological parameters and comfort indices (PMV, PET) as well as comfort evaluation of interviewees and use of space of the sites

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(Katzschner et al. 2002). With that a complete picture of urban climate conditions was given and thermal comfort zones could be derived.

Due to a predefined spatial grid the climatic data are linked with the results of the field surveys’ interviews and observations as well as with the characteristics of the site (e.g. sealed or green surfaces, height of buildings etc.). So from the field studies a close connection between man’s behaviour, morphological structures and thermal comfort is given, from which evaluation of thermal comfort situation as well as accompanying planning advice can be derived. In this way the field surveys provide a suitable and important basis towards the development and verification of the comfort mapping methodology.

2.2. Mapping procedure

Figure 1 shows the basic structure of the thermal comfort zoning process developed. The most important aim was to focus on an easy-to-use and easy-to-understand tool/methodology addressed and dedicated to the special interest and needs of planners and architects. In consequence, for general use in the context of urban planning, it has been derived a „simple“ methodology taking into consideration three main influencing issues:

- morphology of the site (geometry of buildings, surfaces (ground / facades), vegetation)
- meteorological parameters and
- time parameters.

Concerning meteorological parameters there is a focus on solar/thermal radiation and wind speed. These two aspects have a high spatial and temporal variation, causing different comfort situations within one site at the same time. Air temperature and vapour pressure are more homogeneous, so they become important in the context of "calibration" and evaluation.

Concerning time parameters the analysis are concentrated on specific periods of time, to be defined in dependency of underlying questions.

Finally a spatial distribution of zones with similar comfort conditions is given, followed by an evaluation in terms of risk or suitability.

The issues design and use of open space are considered as influencing factors/variables acting in two different "directions": on the one hand they influence the mapping and evaluation results, on the other hand the evaluation can cause the need for changes/adaptation in design, use of space etc.

Figure 2 presents the mapping procedure in more detail. As mentioned before the meteorological parameters radiation and wind are the most influential. In dependency of morphological structure and surfaces these issues will be analyzed (using different tools) and classified. (E.g. short wave radiation can be calculated by TOWNSCOPE software easily; thermal radiation can be derived from global radiation in combination with surface characteristics, also reflected radiation is an important indicator.) The combination of the three thematic maps delivers a thermal zoning which has to be calibrated e.g. by comfort indices out of measurements. With this there is the possibility of adapting the methodology to different climatic zones. An additional consideration of the sky view factor gives important information and assistance in interpreting the comfort situation in the course of year or day.

In comparison with the calculation of state-of-the-art indices (e.g. PMV or PET) the described methodology is quite simple, but it seems to be appropriate in order to facilitate and guarantee the consideration of climatic aspects in planning processes as easily and often as possible.
3. RESULTS

Up to now the mapping procedure has been carried out (using different software packages and a GISystem) for two sites in Kassel and compared with the results of the accompanying field surveys. The above described theoretical approach has been proved to be suitable and has been fixed in detail, whereas the concluding steps of calibration and evaluation are still in progress.

Here some of the provisional results shall be given.

3.1. Thermal Comfort Map

Figure 3 shows a comfort zoning map for Florentiner Platz. It refers to the radiation pattern of a sunny day at summer solstice and has a range of several classes representing areas with similar comfort conditions. Concerning the perception and evaluation of users it can be stated from the field surveys, that people like to have a certain grade of physiological (heat) stress. Sunny areas with PMV values > 0 have been requested and preferred almost all through the year. Only during really hot summer days more and more people complained about discomfort and the comparatively cooler (shady and windy) zones of Florentiner Platz became frequented and evaluated as comfortable. Thus, the predominant usage pattern (café under big trees in the "dark mapped" centre of site) is not very well-suited to the thermal comfort situation. But considering and evaluating the climatic pattern of the whole site it has to be emphasized that the range of comfort is quite high. The occurring inhomogeneous structure facilitates different activities of potential users and offers the possibility to choose between different thermal conditions.

3.2. Characterization via Sky View Factor

Figure 5 presents a comparison between the sky view factor (calculated by TOWNSCOPE software) for Florentiner Platz and Bahnhofsplatz. Both sites are situated in the city centre of Kassel, but they differ considerably in size, proportions and vegetation. The mean sky view factor (SVF) for the comparatively small Florentiner Platz with several old big trees in its centre is 36 %, whereas for the Bahnhofsplatz it is 58 %. In addition to the thermal comfort maps this difference informs about the comfort situation in the course of day or year: The higher the SVF, the extremer the thermal difference between night and day or summer and winter. In consequence the Florentiner Platz tends to have a bit more even thermal situation than the Bahnhofsplatz.

3.3. Conclusions

Once completed in all details, a methodology of drawing microclimatic thermal comfort maps will be available, which can be applied to any site in a very simple and effective way. From the comfort maps a predicting comparison and assessment between different alternative design conceptions can be achieved which is devoted very much to the need of urban planning and related fields. Moreover a characterization and assessment of different city structures as well as climatic and urban patterns can be derived.
Fig. 5: Sky view factor calculated for Bahnhofplatz (mean: 58%) and Florentiner Platz (mean: 36%)

References


Kofoed, N.-U., 2002, 1st annual report of RUROS project, Kopenhagen

VDI, 1998, Environmental meteorology – methods for the human-biometeorological evaluation of climate and air hygiene for urban and regional planning at regional level – part I: climate, Düsseldorf

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