

CITY WEATHERS: METEOROLOGY AND URBAN DESIGN 1950-2010

Manchester Architecture Research Centre (MARC)
Centre for the History of Science Technology and Medicine (CHSTM)
23-24 June 2011, at Chancellor's Hall, The University of Manchester

TITLE: Urban Microclimate – Designing the Spaces between Buildings

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ABSTRACT

The quality of life of millions of people living in cities can be improved if the factors that affect the urban microclimate are understood and the form of the city responds to them in a manner that is appropriate to its location. Underlying this approach is the idea that climatically responsive urban design is vital to any notion of sustainability: it enables individual buildings to make better use of 'natural' energy, it enhances the potential for pedestrian comfort and activity in outdoor spaces, and it encourages city dwellers to moderate their dependence on air-conditioned buildings and private vehicles (Erell et al, 2010). This paper suggests principles for successful integration of climatic strategies in urban planning processes, and provides case studies illustrating their implementation in practice.



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1. INTRODUCTION: THE PLANNING PROCESS

Modern architecture and urban planning are carried out by professionals from diverse fields. New developments and therefore the design process are driven by market forces in response to demand for housing, retail space, etc. Urban climate considerations must compete for attention and are likely to be addressed by specialist consultants. To be effective, climate consultants must recognize the often competing issues that planners typically face in the preparation of a town plan or an architectural design. In addition, information from multiple and sometimes conflicting sources must be reconciled. The problem is not to produce an idealized plan derived from climatic considerations, but rather to produce a workable plan that is economically viable and accepts that the planner must consider other factors, such as the requirements of transportation systems. Mills (2006) noted that “while the meteorologically ideal settlement serves a useful pedagogical purpose, it does not recognize planning realities where climate issues are rarely a dominant concern”.

2. MICROCLIMATE CONSIDERATIONS IN PLANNING: A PARADIGM

The integration of climate in the planning and design process may be improved if the following principles are observed (Erell, 2008; Mills et al, 2010):

- *Clear definition of goals:* Integration of climate in the planning and design process should not be seen as an end in itself, but rather as a means to achieving certain

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goals, which may be set by the developer, by planning authorities, or even by the architect himself - but should be clear and well-defined.

- *Unambiguous benefits*: The benefits to be reaped from attaining the goals of the design should be substantial. Their evaluation should take into account complex and realistic scenarios, if necessary using computerized predictive tools (Williamson and Erell, 2008). In the absence of quantitative studies on the effect of proposed designs upon climate, and on the basis of well-documented evidence from other planning professions, decision makers in general tend to downgrade the importance of climatic considerations in urban planning.
- *Integration*: The climatic analysis must be an integral part of the design process. It should be carried out as early as possible, before possible avenues are blocked off by uninformed decisions. Appropriate climatic strategies can rarely be applied retroactively to rectify errors made in the initial stages of the design.
- *Complexity*: In order to analyze a particular question, researchers often study its effects in isolation from other factors that may be involved. However, in real life, narrowly prescribed solutions can yield undesirable outcomes: In order to apply urban climatology effectively in the process of town planning, a comprehensive approach must be adopted, balancing diverse considerations such as pedestrian comfort and building energy savings.

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- *Subsidiarity*. While solutions which are applied early in the planning process tend to be the most cost effective, those which may be applied at later stages impose the fewest constraints on the overall design. It is thus of great value to be able to establish the benefits of a particular approach in general terms, without resorting to a unique policy required to achieve the desired goal.
- *Sustainability*. The success of a project is often gauged by its short-term economic return to the developers, so climatologists must be able to collaborate with other members of the design team to assess the economic effects of their recommendations on matters such as street width or building height, which may have significant economic implications. However, any evaluation of long-term sustainability should also take into account social aspects and environmental effects – where the contribution of climatologists may be particularly valuable.

3. CASE STUDIES

The paper will demonstrate the application of these principles in two projects: The first, a small residential complex of single-family detached houses in the desert highlands of Israel, was designed in the 1980s as Israel's first solar neighbourhood. The second, an open-air shopping mall in Beer Sheva that opened in 2010, is an example of how microclimate helped shape a commercial development.

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a. Neve Zin neighbourhood, Sde Boqer, Israel ¹

The Neve Zin neighbourhood of Sde Boqer in the Negev desert of Israel comprises a total of 79 private, single-family detached houses. Its significance lies in its unique master plan and building regulations, which were aimed specifically at promoting (though not mandating!) energy-conscious building design and creating an outdoor environment that responds to the local climate. Buildings in the neighbourhood were designed by independent architects commissioned by building owners: The role of the master plan was therefore limited to the creation of a framework within which the architects could operate, rather than to create a design complete in every detail. Design of the neighbourhood began in 1984, and the first buildings were occupied in 1990.

Design goals

Sde Boqer has hot dry summers (on average, temperatures range from 17.3-32.2°C in July) and cool but sunny winters (3.8-14.9°C in January) (Bitan and Rubin, 1994). Average annual rainfall is approximately 80mm. Since solar radiation is plentiful - daily insolation on a horizontal surface averages about 3.3 kWh/m² in December and 7.7 kWh/m² in June – so passive solar heating may reduce building energy requirements substantially.

¹ Neve Zin was designed for the Israel Ministry of Housing by the Desert Architecture Unit at the Jacob Blaustein Institute for Desert Research, Ben Gurion University of the Negev. The design team was led by Dr. Yair Etzion.

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The overall goal of the design was to "create a modern desert neighbourhood that will be responsive to the harsh conditions of the environment and at the same time will provide dwellers with all modern facilities" (Etzion, 1990). This was to be achieved by strategies that deal with a variety of issues, including building thermal performance and pedestrian comfort in outdoor spaces. The design has many innovative aspects, but the following discussion will be limited to the issue of solar rights.

Solar access to all buildings was promoted through several features of the neighbourhood plan, including street orientation, restrictions on building location within each plot and an absolute height limit of 8 meters. In addition, solar access was specifically protected by means of a mandatory solar envelope, which defined the maximum height of any part of a building with respect to its location on the site. The solar envelope was presented in the form of an imaginary plane intersecting the southern-most setback line of a building plot at an angle of 26.5 degrees to the horizon (Figure 1), limiting the height of an adjacent building to the south. The limiting angle was calculated to allow the south façade of each building full exposure to the sun between 8:30 and 14:30 (local time) on the winter solstice, thus guaranteeing solar access throughout winter in the main sunshine hours.

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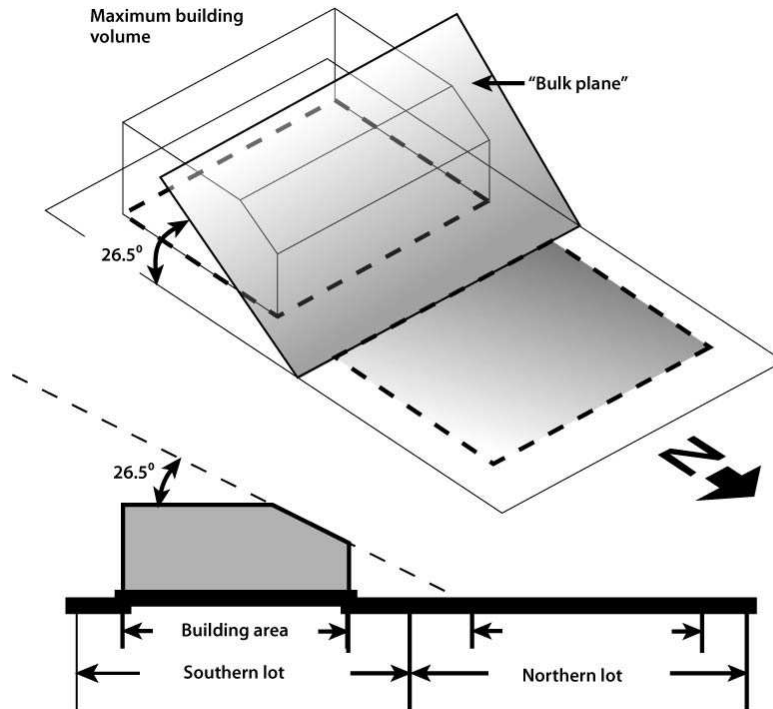


Figure 1. A simple 'solar envelope' guaranteeing solar access to a building, defined by an imaginary inclined plane, above which no part of the adjacent building may project.

b. 7th Avenue Mall, Beer Sheva, Israel ²

In Israel, traditional shopping streets are gradually giving way to malls, of two types: large fully enclosed buildings, air conditioned year round; or suburban 'power centres',

² The 7th Avenue Mall was designed by Malis Architects for the Shikun U'Binuy Group. The climate consultant for the project was architect Eran Kaftan.

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with low-rise retail buildings surrounding vast parking lots. Beer Sheva's 7th Avenue Mall, opened in 2010, is an attempt to realize the best of both models. It combines ease of access and convenient parking with modern, pedestrian-friendly open-air shopping.

Design goals

Like most malls, the 7th Avenue Mall combines dining and shopping. The complex aims to provide occupants with comfort and protection from the elements, yet at the same time to be inherently low-energy. The simplest option was to cover and air condition not only the shops, but also the circulation areas, creating one large building. This, however, would not have met the challenge of energy efficiency. Instead the design team sought to modify the microclimate of the main pedestrian axis and outdoor plazas within the development to improve human thermal comfort and to promote activity in these spaces – without resorting to conventional air conditioning of the space.

Climate-related response

The climate of Beer Sheva is similar to that of Sde Boqer, but a little more humid and slightly warmer: mean daily temperatures range from 6.0 to 16.4 °C in January and from 18.5 to 32.9 °C in July. Since winters in Beer Sheva are relatively mild with few rainy days, the climatic design focuses on providing thermal comfort in shopping hours during the hot, dry summer. This was achieved by a comprehensive strategy for reducing radiant loads, promoting air movement and providing evaporative cooling in selected areas.

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Shading: The design combines a variety of shading elements to control sunlight in all pedestrian areas. The shading elements include colonnades along the shop fronts on one side of the main north-south axis, pergolas, fixed fabric shading in plazas and moveable fabric awnings extending from one side of the street to the other along the east-west axis (Figure 2). The shading not only reduces the exposure of pedestrians to direct sunlight, but also reduces the amount of light that reaches building surfaces and pavement: these in turn reflect less light and, because they are cooler than exposed surfaces, also emit less radiant heat.



Figure 2.

All circulation areas are shaded by a combination of pergolas and removable fabric awnings.

Air movement: Although Beer Sheva experiences a regular westerly breeze in the afternoons and early evening hours, the wind also carries dust and is considered by many to be unpleasant. The main pedestrian axis provides protection from this wind, yet allows some flow of air that may penetrate between the various shading elements constructed at roof height. Air movement is augmented outside shop windows in the

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covered colonnade by means of mechanical fans, which are operated during the warmest hours of the day (Figure 3).



Figure 3.

Ceiling fans promote air movement in shaded areas outside shop display windows.

Vegetation: Trees were planted along the entire length of the main axis, primarily to complement the shade canopies and to filter the bright sunlight (Figure 4). When the trees are mature they will provide a continuous leaf canopy. Bushes and flowers planted in shallow planters along the major pedestrian paths enhance the aesthetics but also create a 'softer' visual environment by reducing reflections from the exposed central part of the street.

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Figure 4.

Trees planted along the entire length of the central circulation spine will provide a continuous leaf canopy when mature.

Evaporative cooling: The Mall has two fairly small open-air plazas, which are surrounded by cafes and restaurants. Each of the plazas has a small water fountain, and is shaded by a tent-like fabric canopy. However, the plazas are dominated by down-draft cool towers 18 meters tall (Figure 5). The towers provide air chilled by evaporation to a temperature of about 22-24 deg C, which is directed to the dining areas adjacent to the pools. Operation of the towers is controlled by computer in response to meteorological data monitored on the roof of the building. Water sprayers are turned on progressively as the air becomes warmer and drier. Air flow is generated by (negative) buoyancy of the relatively cool, moist air, augmented by a mechanical fan capable of delivering 60,000 m³ of air per hour. Wind catchers oriented in the direction of the prevailing wind support pure wind-driven operation when the breeze is sufficiently strong.

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Figure 5.

Cafes in the two plazas enjoy evaporative cooling from small fountains and from a downdraft cool tower.

4. COMMENTARY

The projects described in the two case studies were designed by architects who were strongly motivated to create environmentally responsive designs. They, in effect, brought their own agenda to projects that could otherwise have evolved differently. Their understanding of the Negev climate led them to establish clear objectives that could be addressed by means of specific architectural responses.

The clients were very different in terms of their policy and degree of involvement in the design process:

Neve Zin was procured by the Israel Ministry of Housing at a time when energy issues were a low priority, and there was no imperative to create a groundbreaking design.

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However, to its credit, it was happy to experiment: the project in question was small, located in a rather remote (for Israel) peripheral community and keenly supported by a very involved group of potential residents who were members of the housing association that was to run the community. Unfortunately, although the neighbourhood has proved extremely successful, the Ministry has not adopted its primary features in subsequent projects: climate consultants are usually part of the design team for new developments, but their role is typically minor and climate is not a generator of urban form as it was in Neve Zin.

The 7th Avenue Mall, on the other hand, was designed for a real estate group that has established a policy of supporting environmentally sensitive design and wanted this particular project to be innovative and to stand out from the conventional mall designs. The management was closely involved in the design process and was a partner to all major decisions. The project was carried out within a fairly tight budget and all expenses were monitored closely, but there was full support for the completion of 'non-essential' elements such as shading devices and the downdraft cool towers. It is important to note that the effectiveness of these features, and in turn the overall performance of the project, are very much dependent on basic design decisions that were made early in the process.

Each of these two projects is therefore unique in significant ways, and together they show that the successful integration of climatic design principles is often *context-specific*. While general rules may inform the design process, they do not replace it. It is vital, then,

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that architects and planners become fluent in the 'language' of climatically-informed urban design, and that global imperatives are, in the end, translated into locally appropriate solutions.

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