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Climatic aspects in urban design—a case study

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Abstract

We present a case study of a design of a new business district in Tel Aviv city. In this work climatic aspects were taken into consideration in the very early design stages. For that purpose, two models SustArc (Proceedings of the ISES 1997 Solar World Congress, Taejon, Korea, 1997, p. 148) and FLUENT 5.0.2 (Fluent's User's Guide, Fluent Inc., NH, USA, 1999) were applied in order to achieve solar and wind rights. The new business district was designed as a high-density urban area and is located near an old low-rise residential quarter. SustArc was used as a design tool to create the solar envelope that shows the maximum available volume in which it is possible to build without violating the solar rights of existing residential neighborhood, the main avenues and the pedestrian sidewalks. FLUENT, on the other hand, was implemented as an evaluative tool, in a trial and error method, until a design solution could be achieved, in which the wind rights of the residential neighborhood were preserved, while ensuring tolerable winds inside the business district. The paper presents the process of sun and wind controlled planning, as well as the recommendations.

Keywords: Solar rights; Wind rights; Urban design; Design tools

1. Introduction

During the conceptual design phase of urban districts, the designer deals with different geometrical characteristics related to the building's height and width, in relation to the open spaces and the pedestrian sidewalks. New buildings may create a different microclimate, like changing the wind regime and shading of existing neighborhoods, as well as in the new district. To protect solar rights, as well as wind rights, is a complex task. Moreover, tolerable winds should be achieved along the pedestrian sidewalks. The determination of a preferable design solution becomes specially complicated due to mutual influences. On the other hand, ignoring the solar rights at the stage of the preparation of the master plan may cause discomfort conditions around the buildings beyond repair.

Different design tools for solar insolation conscious design were developed. We can classify these tools into generation tools and evaluation tools. The generative design tools aid to define the proper geometry. Some examples are [1–6] for determining solar rights. These tools generate nomograms that present all possible solutions to a given problem. These nomograms are called "Solar Envelopes". The evaluation tools, on the other hand, analyze the performance of a given design. Some examples are Kroner and Abrey [7], Yezioro and Shaviv [8,9] and Capeluto and Shaviv [5] for evaluating solar rights for buildings and in open spaces among them. Heliodons are also used to evaluate the proposed design, namely a scaled down 3D physical model examined in the laboratory.

For microclimate and wind rights conscious design, there are today only evaluative design tools. These are either wind tunnel studies, or computational fluid dynamics (CFD) simulation tools. The CFD models are very powerful, require heavy calculations, but provide detailed results that can show clearly the defects in suggested designs. As a result, new design alternatives may be thought of and re-evaluated, until a good and satisfactory design is achieved.

In the design of the new business district in Tel Aviv (Fig. 1), we have used SustArc, as the design tool to evaluate the proposed design (Fig. 2). We have also used SustArc to create the solar envelope that shows the maximum available volume in which it is possible to build while keeping the solar rights of the existing neighborhood (Fig. 5). We used FLUENT to evaluate the existing situation, the proposed solution and the mitigation design, in which the wind rights to the residential neighborhood were preserved, while ensuring tolerable winds along the pedestrian sidewalks (Figs. 8

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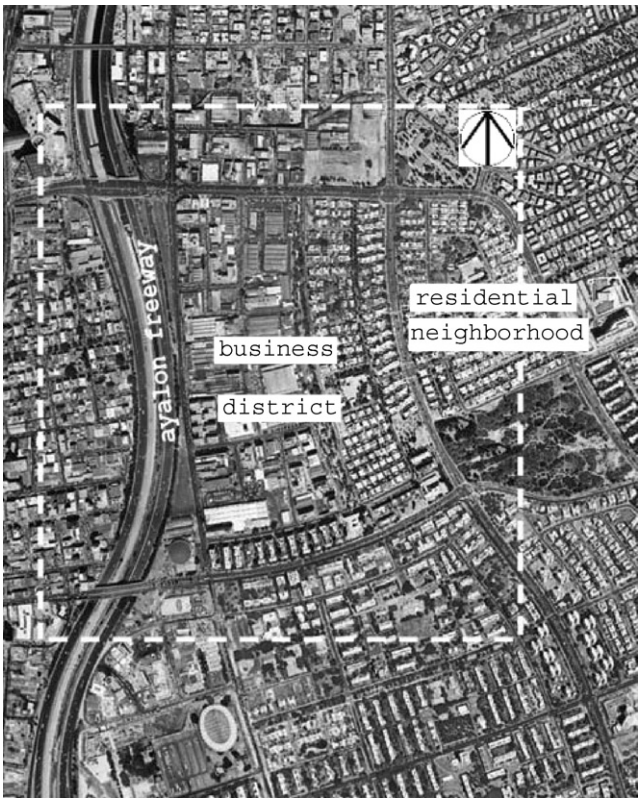

Fig. 1. An aerial view of the business district.

and 9). The paper presents the design process along with the different design tools implemented to create the solutions and to simulate and evaluate the proposed design. Using these tools we could develop rules and design guidelines that ensure proper insolation and ventilation in the existing residential neighborhood as well as creating good microclimatic conditions inside the new business district.

2. Sun, winds and urban design

There are many places in which urban design take into consideration solar rights and winds protection. Let us mention a few: New York, Boston, Chicago, Philadelphia, Pittsburgh and San Francisco, in the USA, Calgary, Edmonton, Halifax, London, Montreal, Ottawa and Toronto, in Canada [10]. Many tall buildings were built during the past in all of the above cities. These tall buildings caused different problems, like shading, loss of daylight, and creation of strong winds around the tall buildings on one hand, and at the same time avoid good ventilation by creating wind stagnation at some parts around them. From the accumulating experience, the city leaders and designers recognized the need to control the changes in the microclimatic conditions created by a proposed design. In many cities, large projects, including tall buildings, require wind studies, as well as shading evaluation. Nevertheless, in most places, the planning control for wind protection and solar insolation are not mandatory and are not imposed by standards, but rather open to negotiations with the developers.

Defining urban standards can be carried on along three different approaches [10]:

a. Prescriptive and descriptive standards, in which the exact physical solution is given. For example, the specific maximum height of buildings in the inner city neighborhood of San Francisco is dictated along with the angle of the slope of a plan that cut the upper floors further from the street.
b. Performance standards, in which the expected performance of the design is given. For example, Boston zoning ordinance dictates for some downtown areas, that "No net increase in shadow is permitted between 8 a.m. and

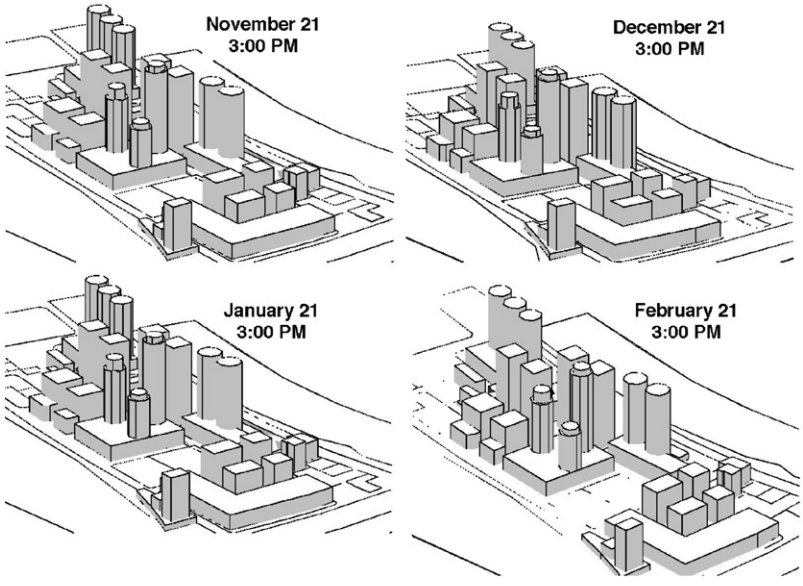

Fig. 2. Sun-view presenting the shading of the main green avenue (the area adjacent to the tall buildings from the right) and the residential neighborhood (the long square on the right).