The influence of high-rise buildings on the environment

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ABSTRACT:This paper is a review of a number of experimental studies of the great impact of high- rise buildings on the urban wind conditions[1], the increase in reflection of the urban solar radiation, the prevention of the nocturnal cooling ventilation, the building up of urban heat islands, air pollution, a general human discomfort indoors and outdoors , social failure and isolation due to lack of normal neighborhood relations which can lead to depression and the increase in crime rate.

1 INTRODUCTION

High-rise buildings - according to Christopher Alexander (1977) - are exceeding the level of a tree in its natural surrounding, i.e., higher than 12 – 15 meters. The tombs of the Ancient Egyptians were the first high construction in history. So were the buildings of the Kingdom of Saba in Yemen and the Towers of Shiban in Hadramout in South Yemen, which did not change their character throughout the Yemenite, Indian and Islamic periods. These buildings merge with the surrounding mountains reaching a height of 30 meters with one to three meters thick walls of clay brick getting slimmer while getting higher (fig. 1a).

The year 1851 marked the beginning of the industrial revolution, the use of iron in constructing bridges and the building of the Crystal Palace in London. The production of concrete in 1870 helped in the fifties to reconstruct whole cities destroyed during World War II when there was an urgent need for adequate and affordable shelters for millions of people who became homeless as a result of the war. This was the beginning of the construction of high-rise buildings in Europe and America (Charles, 1981) and recently in several Arab oil producing countries

The fondness for high-rise buildings – according to Ali Raafat 2007 – is a human fondness for height and a wish to defy the earth gravitation force as it shows in the examples of the building the Pyramids of Giza (fig. 1b), the Zigurate in Babylon and other towers of several worship places. In addition the trend of modern architecture towards overwhelming constructions and exaggeration in dimensions and levels evolved combined with a competition between communities and architectures for original designs, lighter constructions and more expensive schemes. It has become a competition of construction technology between some South Asian countries, Europe, America and Arab oil producing countries (fig. 2) (Raafat, 2007).

[1] Urban wind is wind flowing over an open area, above and around the buildings attains a lower overall air speed and a higher turbulence due to the friction by the buildings.

Thus, traditional architecture emerges to become an industry of much consuming sector, changing horizontal earth shading buildings to vertical constructions separated by open areas developed in unfriendly environments and causing a financial burden for the community. Today, high-rise buildings are a symbol for development, progress and modernity without any rational consideration of the drawbacks on the environment and the occupants who are fascinated by altitude and distinctiveness.

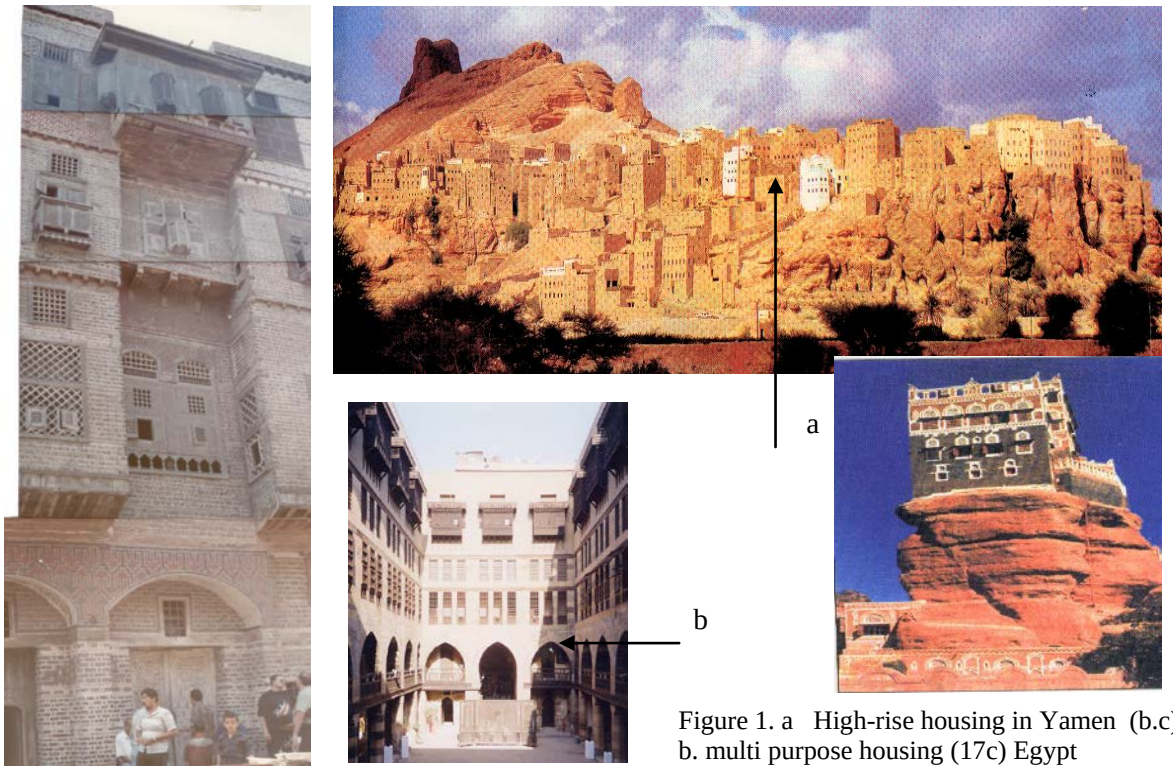


Figure 1. a High-rise housing in Yamen (b.c) b. multi purpose housing (17c) Egypt

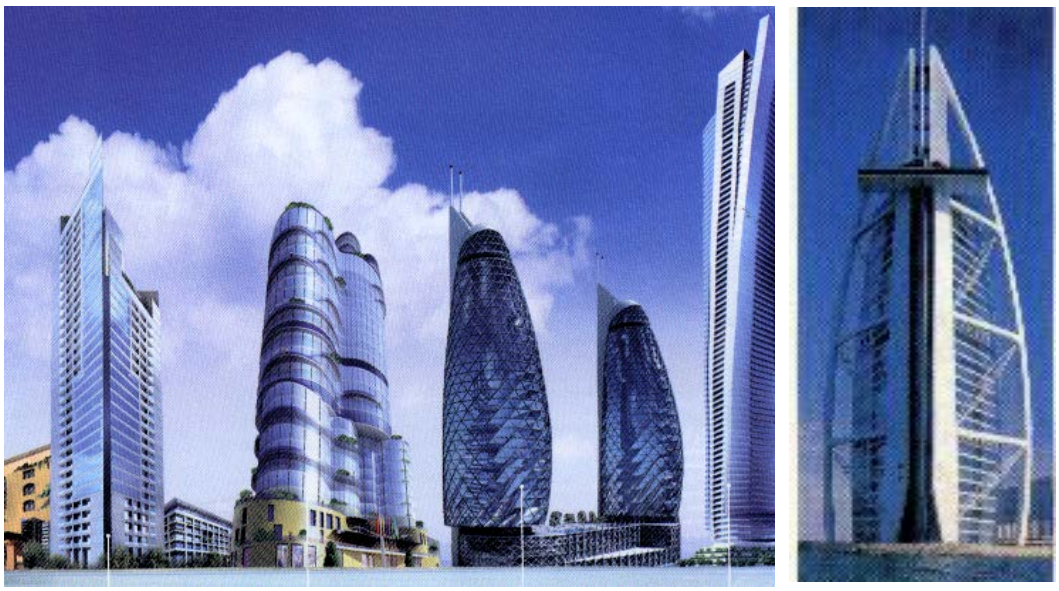


Figure 2 High-rise buildings in Arab desert and the competition of height, form and materials

2 PREVIOUS EXPERIEMENTAL STUDIES

There are many experiemental studies evaluating the effect of high-rise buildings on environmental issues. The following points present the most important aspects.

2.1 The effect of high-rise building on the urban wind

Experemental studies using wind tunnels showed that rise in the elevation of a building increases the distance of the wind shadow, and minimizes the air flow inleeward direction, i.e. behind the building at the street level , while increasing the depth till four times of its height does not effect the wind shadow (fig.3) (Sleeper, 1981).
Near high-rise buildings the local wind speed is high even in summer (fig.5). In addition, high-rise buildings create a turbulent flow of the gradient wind as a result of increasing the roughness of the boundary layer surface. Urban areas with higher density and buildings similar in elevations have better ventilation conditions than areas with lower density and fixed height of buildings (fig. 4) (Givoni, 1998). Thus, a compact horizontal urban mass with gradient height, aerial spain and bended crossing allies- as was in medieval and Islamic architecture- protects the ground surface from the solar radiation and allows the air flow and the nocturnal ventilation.

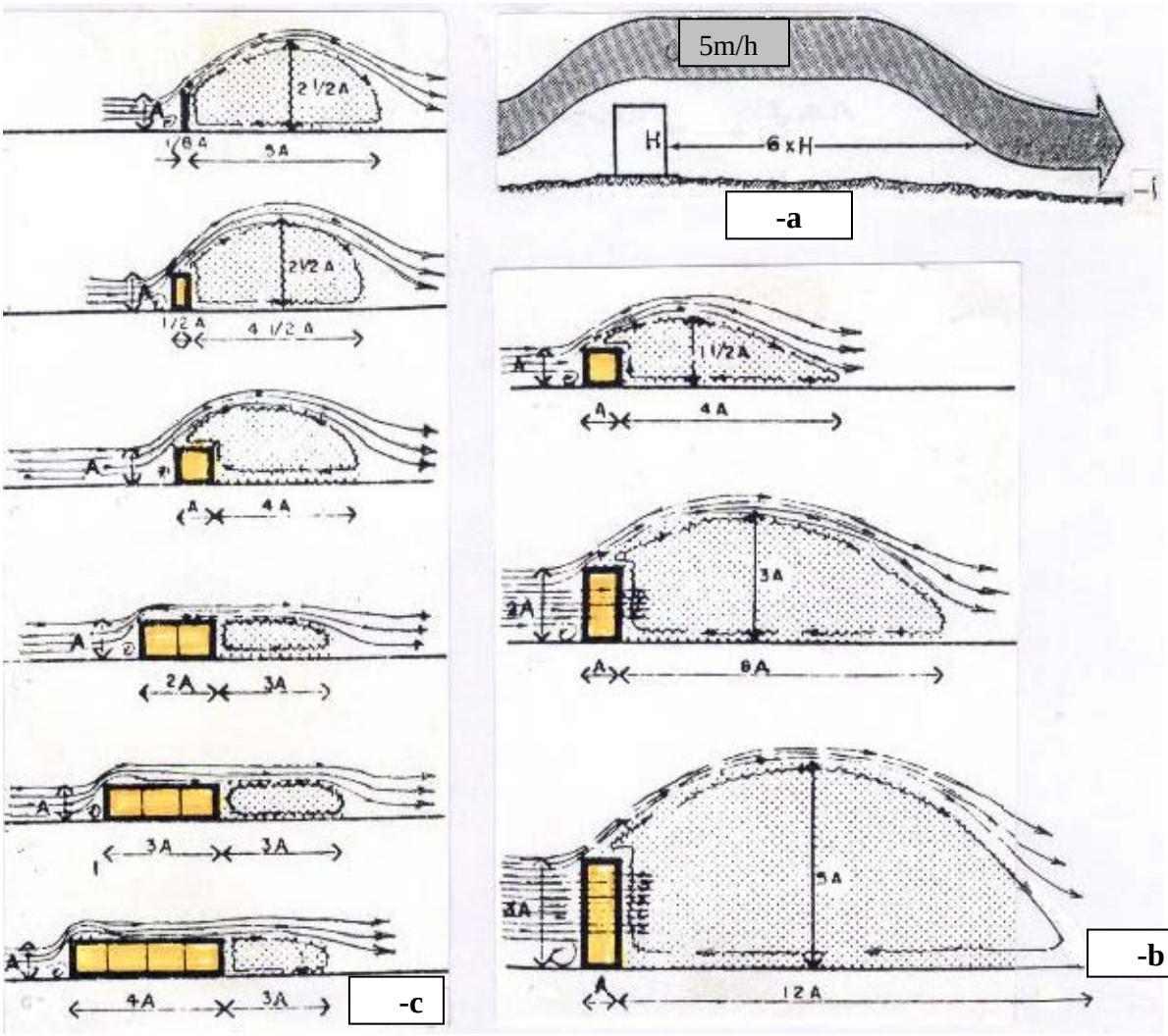


Figure 3 Wind shadow increases: a. by increasing the air velocity, b. increasing building height, c. it doesn't increase by increasing building depth- till four times of building height (Sleeper 1981).

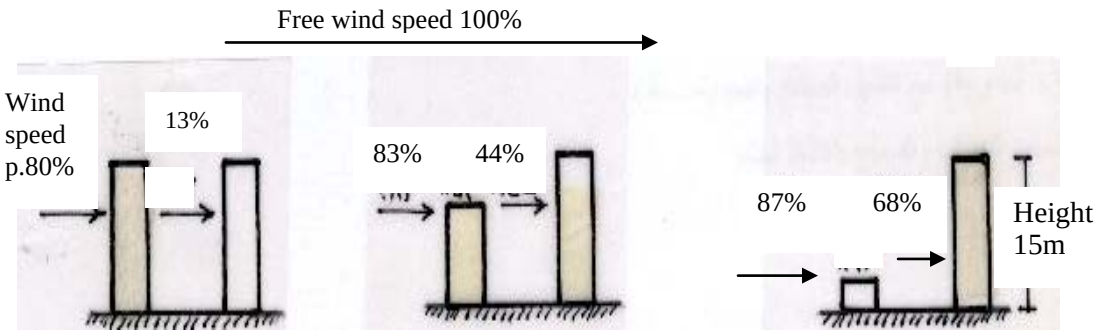
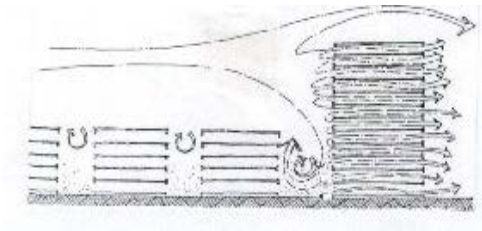


Figure 4 Wind speed proportions in out door spaces through buildings with deferent height (Drawn by Aldeberky A. 2005 after Fathy, N. 1997).

2. 2 Effect of hight-rise buildings on the urban radiation

Hight-rise buildings absorb direct and reflected solar radiationof the surrounded low-rise buildings, and convert it into heat – convection of long waves radiation – that stored in the urban mass (fig.6). When most of the urban buildings are of about the same height, the emission of long-wave radiation from the roofs is like that from an open area, and the intensity of the radiant loss is maximized. When the buildings are of diferent heights, however, the walls of the higher buildings absorb part of the reflected and emitted radiation and block part of the sky, thus reducing the amount of solar reflection and long-waveemission from the roofs of the lower buildings. The result is a reduction of the overall radiant heat loss from within the urban canopy. Even the case of a lone building standing in an open area, a wall sees and exchanges radiation with only half of the sky dome. Therefore, the outgoing long-wave radiation from a vertical wall is less than one-half of that emitted from a roof in similar area (Givoni, 1998).



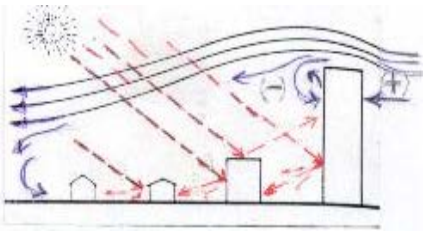


Figure 5 High-rise building enhance vortex and pollution around it (Givoni 1998).
Figure 6 High-rise building prevent wind and reflect solar radiation on low-rise buildings

2.3 High-rise buildings affect nocturnal ventilative cooling

Nocturnal radiation is a major climatic factor to reduse the heat energy of urban mass – convective heat loss- in hot dry regions. The effect of that factor decrease by increasing the density and the height of built-up urban mass; High-rise buildings store solar energy during the day time and release it sloly in low speed of local wind especially at night. The vertical distance between cool wind above buildings roofs and ground surface are long that cause lower rate of radient cooling during the nights. Buildings height that are similar with trees height- 12 m to 15m – penetrate nocturnal ventilative cooling to the ground level; Also enclosured courts store cool radiation through built-up urban area.

2.4 High-rise buildings increase urban temperature,decrease evaporation

Size and density of the built-up area effect urban areas temperatures. Centers of urbab areas temperatures of large cities are higher - 2°- 10°c- than suburbs of countryside (Lechner, 1991). The largest elevations of the urban temperatures occur during clear and still-air nights, that is defined as "Urban Heat Island'. The density of high-rise building in city centers results in concentrated heat genration by the high-density land use (traffic, lighting, heat exhaust,..), and contribute to the development of the urban heat island (Givoni, 1998).
High-rise buildings absorb trees and ground evaporation in order to reduce its heat energy. There was a feild measurement for the heat island in north and south America and Europe' s cities, the heat island in the over population tropical cities are weaker than in American and Europian ones. In tropical cities the buildings' height are low and arranged in a more compact configuration than in temperate areas. That low high-rise buildings allow the interaction between cool air above roofs levels and streets level (fig.7) (Givoni, 1998).

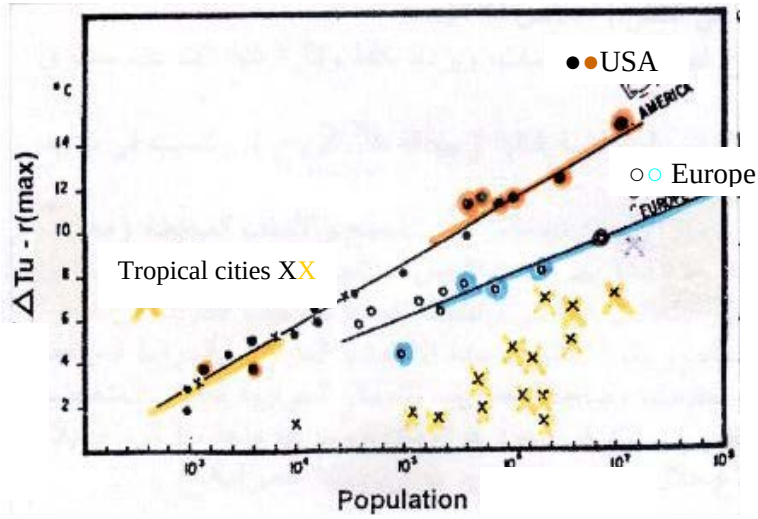


Figure 7 Urban heat island intensity was higher in USA & Europe than the over populated tropical cities, related to towers and intensive human activities (Givoni 1998).

2.5 High-rise buildings affect wind comfort in out doors and indoors

Pedestrians may experience discomfort due to the high speed and turbulent wind in front and on the sides of these buildings. In addition to the chilling effect of the wind, it causes disturbances in walking, by blowing dust and leaves, lifting dresses, blowing off hats, and so on. The problems in the building itself range from difficulties in opening entrance doors, noises from windows and various attachments, and rain penetration due to the lifting effect of the wind over the windward façade of the upper stories and the whole leeward façade. The problems to the environment include damage to plants, dowenwash of chimney flues, and erosion of deaches in th case of seafront buildings. The various changes in the pedestrian level wind environment, brought by high-rise buildings, such as: (Givoni, 1998)
• Accelerated winds near building corners.
• Reverse flow in front of the building.
• Turbulent airflow in the wakes behind, and at the sides of, a tall building.
• Accelerated flow through constricted areas, such as passages, arcades, and spacas under buildings on piles.
• Funnelling and conversion of airflow in spacas between buildings.

2. 6 High-rise buildings inhance air pollutants

Local wind speed near high-rise buildings are very high and troublesome, even in summer. The ventilation conditions in the urban space and major street with high vehicular traffic, have significant impact on the concentration of air pollutants at the street level. The higher the velocity and turbulence of the wind at street level, the greater is the mixing of the highly polluted low-level air with cleaner air flowing above the urban canopy (fig. 8) (Givoni, 1998).
An experemental study about computer simulation in Cambridge University proved that the compacted mass with nearness height have protect each other from dusty wind, where the air turbulent get calm after that distance as long as tall buildings doesn't stand in away (fig. 9) (Merghany, 2002).

3 THE INFLUENCE OF HIGH RISE BUILDINGS ON SOCIAL LIFE

One can lose his physical and psychological sense of safety and security when living in high-rise buildings detached from nature. Normal social relations of neighbourhoods suffer, and as the concept of these towers requires leaving open spaces between them to allow the circulation of air, it is a financial burden for the communities to reasonably fill these areas and develop them socially. The Saint Louis project in the United States is an example for the failure of the concept of high-rise buildings. In 1952 -1955, 33 buildings consisting of 13 floors each, were constructed. The designer, Minoro Yamazaki, had even won an architecture award for this project. But, because so many people were living so close together under the prevailing circumstances criminality rates were very high , consequently the lack of controlled semi-private spaces, and the project proved to be a complete social failure; it led finally into blowing up the 3000 units leaving the rubble as a symbol of a negative scheme which had not taken human needs into consideration (fig. 10) (Charles, 1981).

Figure 10 Pruitt Igoe housing in St. Louis1955, 3000 housing units were blown up in 1972 (William 1981).

4 THE GREEN TOWERS

The characteristic feature of green and intelligent buildings is their low consumption of energy and their use of renewable and non-polluting power sources like solar energy for electricity and heating instead of fossil fuels. After the forbidden of Arab oil in order to liberate Sinai in 1973, the industrial world started looking for alternatives, especially with the growing awareness for the environment, and considering that oil is apt to run dry in the foreseeable future. Thus, the trend for passive, green, sustainable and intelligent architecture emerged. Green towers were built in South Asia, Europe and America in a way to avoid causing pollution and air drafts, planting much green in terraces and windows in the upper floors. Sun breakers were installed to protect from the direct sunshine. This suits humid climates in need for ventilation around the buildings and in areas where pedestrians walk. The average temperature is not to exceed that of the human skin, which is about 32°–34°, in order not to increase the heat gain above and around those separated high-rise buildings. In spite of all precautions mentioned, the negative impact of these buildings on its surroundings could not be prevented. Climate change, global warming, heavy rains, vigorous storms and other natural disasters might be a warning for us to come to terms with nature and find a balance between our material, spiritual and vital demands.

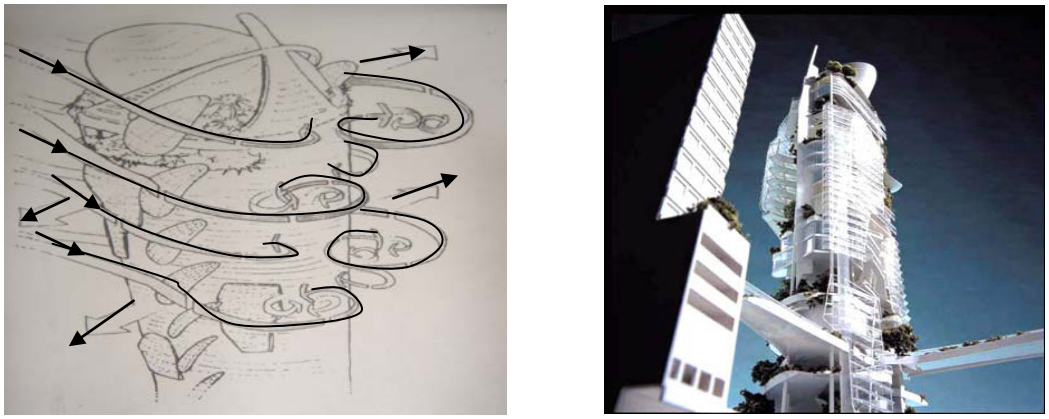


Figure 11 Sculptured high-rise building in tropic area with surrounded vortex.

5 RECOMMENDATIONS

- Buildings not so much diverging in their levels are positive expressions for human, urban and architectural development.
-The level of a tree giving shade to the building and not preventing the airflow is the ideal elevation in every aspect. Pedestrians feel a human standard, and the occupants of the places still sense the life on the street and directly enjoy the fresh and cool air purified by plants all over.
-The elevation might rise a little around the housing areas, near main roads and open spaces to satisfy the necessity of nearby services.
- It is essentially important to raise the environmental awareness and provide literature about modern ecological issues accessible, and to choose what is suitable financially, ecologically and socially. Moreover, the nessicity of the mediocrity in urban environment and human behavior.

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