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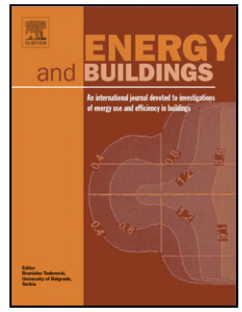

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Towards Energy Efficient Skyscrapers

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ABSTRACT: As of 2007 more than half of the world's population is living in urban areas (a figure expected to rise to 60% by 2030). Thus, the liveability of the high-density city is gradually becoming a central point of focus and concern. A successful skyscraper model of urban planning could provide the possibility to increase city-space vertically as opposed to the current continuous expansion outward, which has obvious environmental consequences. However, skyscraper development, as well as all other new construction and gradually the older building stock, has to comply with current strict regulations on building energy efficiency. Contemporary high-rise examples do not present a sustainable solution to an increasing population or as models of prosperity, as they are linked to high-energy demand, environmental and social imbalances.

This paper looks at design strategies towards promoting skyscraper energy efficiency by considering a climatically responsive design, where orientation, the thermal properties of the building envelope and the effect of altitude, become the main design tools. Initial simulations were performed for a residential and an office reference structure 100m high. Different scenarios were implemented for gradually upgrading the building envelope and studying its relationship with the changing microclimate with altitude (wind speed increase and dry bulb temperature drop) between ground and top level. The advanced envelope was then simulated to up to 400m high (120 stories high), and heating and cooling loads were compared in relation to different building heights and uses.

EnergyPlus is used as the main simulation tool as it accounts for wind speed increase and dry bulb temperature drop with height. The location chosen is Tel Aviv, Israel, a city already growing upwards and expected to have a significant increase in skyscraper construction in the coming years. The results of the simulations performed present the base upon which further design strategies can be implemented towards reducing the environmental impact of this challenging building type.

Keywords: building envelope, climatically responsive design, energy efficiency, hot climate, office, residential, simulations at different heights, skyscraper

1. Introduction

World population is growing at a very fast pace and this affects the growth and density of the urban environments, with cities like Hong Kong and Mumbai having densities of 20,000 people/km^2, compared to London's 5,100 and New York's 1,750 people/km^2 [1]. As of 2007 more than half of the world's population lives in urban areas, a figure expected to rise to 60% by 2030 [2]. This makes the livability of high-density city a central point of interest and concern. Thus, it is possible to predict that high-density urban environments will soon be the norm and will dictate an increase in building demand. The increase in population, migration towards the cities, and the advancing industrialization have promoted the typology of the skyscraper as an important high-density living solution to the already dense urban centres of many of the world's megacities.

According to a research report by the Council of Tall Buildings and Urban Habitat (CTBUH), skyscrapers 200m high and more around the world until 2015, were located as follows: China (348), South Korea (48), Rest of Asia (140), Australia (27), Europe (37), Middle East (120), USA (169) [3]. In addition, skyscraper construction is gradually spreading beyond the limits of megacities, cities whose population exceeds 10 million people, with places like Tel Aviv, in the already dense centre of Israel, changing their planning policies to allow for future skyscraper construction. Figures 1 and 2 show current skyscraper