Effect of tall building cluster on Environmental Quality within and in adjacent areas. (A case of Pune City.)

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Abstract— Today, tall building is a phenomenon that the world, particularly large cities are facing. Tall buildings are constructed in order to exploit the land, but have negative effects on the environment and create new problems including increase in congestion, environmental pollution and cut city-dweller' access to fresh air and sunlight. However, due to ever increasing population and land shortage, tall buildings cannot be avoided. This paper investigates the relationship of tall buildings with environmental parameters, namely sunlight, air temperature and wind patterns. The study is done to understand the impact on air temperature and wind pattern due to a group of 12 floors (36m) tall buildings. The study also aims to verify that the impacts studied in other research paper, hold true for a buildings with 36m height. The study is carried out in Pune and two case studies are considered for the study. Readings are taken at identified points. It is found that there is no air temperature variation observed due to the shadows casted by the buildings. The wind speeds however vary within and in adjacent areas. The variations observed are not only because of the heights but also due to architectural form and layout of the project.

Index Terms— tall buildings, environmental parameters, wind speed, air temperature, impact of building height, architectural form, environmental quality.

1 Introduction

Tall buildings may also be referred to as 'Multi Dwelling Unit' or 'Vertical cities'. Tall buildings have gained popularity throughout the world. They act as landmarks of the city; create a unique skyline and increase land use efficiency (K.Rangwala, Feb,2010). Tall buildings have the potential to decongest the urban sprawl on the ground and increase the urban density by housing higher number of people in lesser space (Ali, July 2012.). Tall buildings are constructed in order to exploit the land but have negative effects on the environment and create new problems including increase in congestion, environmental pollution, cut citizen access to fresh air and sunlight.

Although there is no precise definition that is universally accepted, various bodies have tried to define what 'high-rise 'means (Patil, February 2014):

- The New Shorter Oxford English Dictionary defines a high-rise as "a building having many stories".
- The International Conference on Fire Safety in high-rise Buildings defined a high-rise as "any structure where the height can have a serious impact on evacuation"
- The International Building Code (IBC 2000) and the Building Construction and Safety Code, NFPA 5000TM-2002,Paragraph 3.3.28.7 of the Life Safety Code®, 2006 edition, define high-rise buildings as buildings 75 feet or greater in height measured from the lowest level of fire department vehicle access to the floor of the highest occupiable story.
- The National Building Code of India (NBC), a tall building is one with four floors or more or a high-rise building is one 15 meters or more in height.
- The Pune Municipal Corporation (PMC) proposed that any building with a height of 36m (twelve floors) be categorized as a high rise.

2 Data of Pune

2.1 Climatic Data of Pune

Pune is located 18°31'13°N and 73°51'24°E. The study for the project is carried out in October. The climatic data considered for the base case, therefore for the month of October. The daytime and nighttime temperature of Pune in October is 31.8°C and 18.8°C respectively. The relative humidity is 63.8%. The prominent wind direction, in October, in morning and evening is west. Wind speed in the morning is 7km/h and in the evening it is 19km/h. (IMD)

2.2 High rise structures in Pune

Pune is the seventh largest city in India and second largest city in Maharashtra after Mumbai (L. KantaKumar, 2011). The distance from Mumbai is 148 kms. Pune Municipal Corporation (PMC) jurisdiction extends up to an area of 243.84 sq. km. housing 2.54 million populace within 144 wards. (Pune Municipal Corporation. Pune and Growth direction. Comprehensive mobility plan for Pune city.) The population of Pune accounts for 35 percent of the total Urban population in Pune District and 60 percent of total PMR population. The PMC's population has grown from 1.57 million in 1991 to 2.54 million in 2001, and in the last decade experienced a compounded annual growth rate of 4.94 percent. (L. KantaKumar, 2011) In Pune a high-rise building is defined as classified in the National Building Code (NBC). Any built structure, which is 36m and above is classified as a high-rise. The development pattern of Pune indicates that though suburb areas like Hinjewadi developed as IT hub, have witnessed high rise structures, most of the city and its peripheral suburbs have developed tall structures for residential use (Sundrani).

2.3 Role of building on Climate

Tall buildings have an effect on the urban wind pattern. 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. Experimental 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 in leeward direction, i.e. behind the building at the street level , while increasing the depth till four times of its height does not affect the wind shadow. (Sleeper, 1981) 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 (Aldeberky).

3 Methodology

Pune city is identified as an emergent metropolis. Many neighboring villages and districts populace have migrated to the city for better jobs and education. This has lead to urban sprawl, rise in housing demand and rise in cost of land. As a result highrise projects are being proposed more in the residential sector. The environmental impact is observed to be greater in and around a group of tall buildings.

To study the impact on wind, temperature and daylight in Pune, two case studies were identified. 1. Karishma Society, Haveli, Pune 2. Samrajya Petkar, Balwantapuram, Pune. Both the selected projects have buildings with heights up to 12 floors (36m).The study is carried out for 4 days, in the month of October, by taking readings on site. The device used to take readings is an Environment Meter. The readings are taken at specific identified points. The test points were identified based on a calculative diagrammatic study of wind pattern and solar shading angles. Measurements of air temperature, relative humidity and wind speed were taken outside at height of about 1.80 meters. The final value is recorded on an average of 20 seconds. Readings are taken 2 times in a day, morning, between 9am to 11am and evening, between 4pm to 6pm. The timings identified are due to the evident change of sun position, which in turn also affects the wind flow.

The unit of air temperature measurement was in °C and wind speed was measured in km/hr.

4 Results

4.1 Project details

The Karishma Society has nine 12 floor (36m) towers and three 10 floor (30m) towers. The project site is surrounded by 18m wide road to the west and 9m wide road to the north. It is planned with all the building towers at the periphery with a common central open space. The planning is peripheral but there are no built structures at the corners.

The Samrajya Petkar Society has twelve towers of 12 floors (36m). It is surrounded by 12m wide road from the west and north and 9m wide road from the east. The planning of the project is such that there is a continuous built mass, with no gap at the corners.

Case Study 1 : Karishma Society, Haveli, Pune

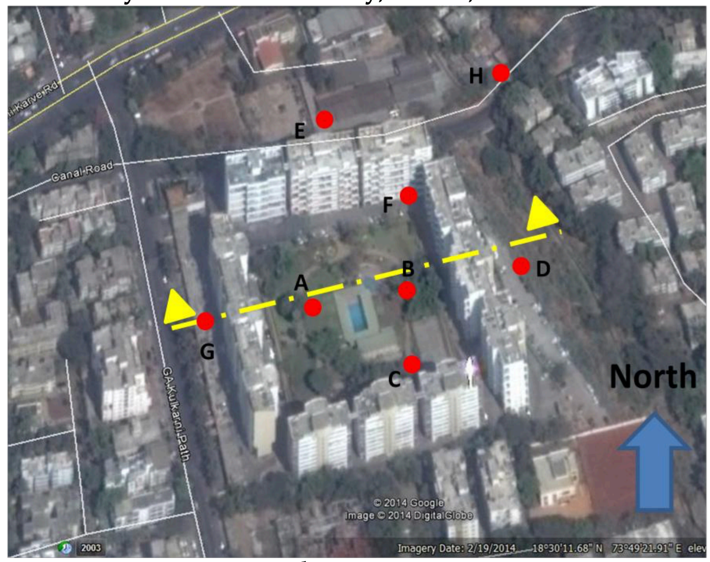

Fig.1. : Location of Karishma Society and various points of measurement

Case Study 2: Petkar Samrajya, Balvantapuram, Pune.

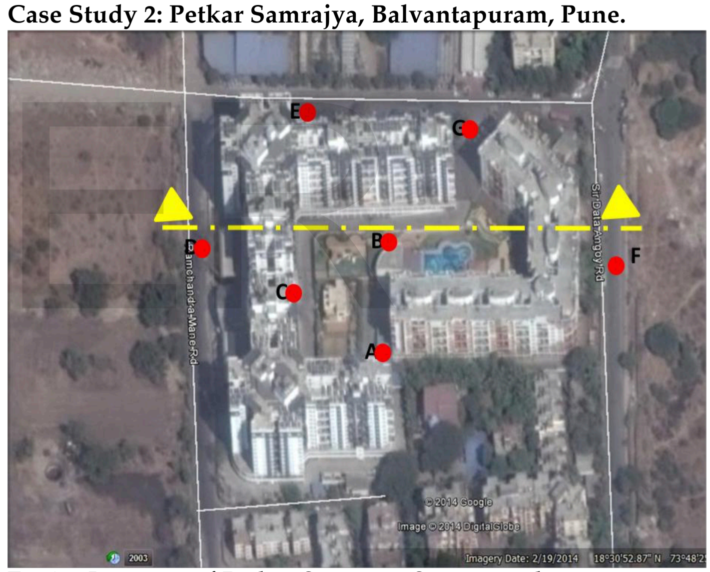

Fig.2. :Location of Petkar Samrajya Society and various points of measurement.

Both the cases, have rectangular building profiles. Both the projects are surrounded by buildings with height up to 6 floors (18m). It is a medium density lowrise residential development. The shadow pattern of the project was studied using google sketch-up, a modelling software. The lengths of the shadows casted by the buildings are plotted by drawing sections through the site.

4.2 Temperature and Shadow Analysis

The average length of shadow cast in the morning, when the vertical sun angle (VSA) is 53°, is 25m. The average length of shadow casted in the evening, when the vertical sun angle (VSA) is 33°, is 50m.

Fig.3. :Diagram showing shadows casted by the buildings (Karishma Society).

Fig.4. :Diagram showing shadows casted by the buildings (Petkar Samrajya Society).

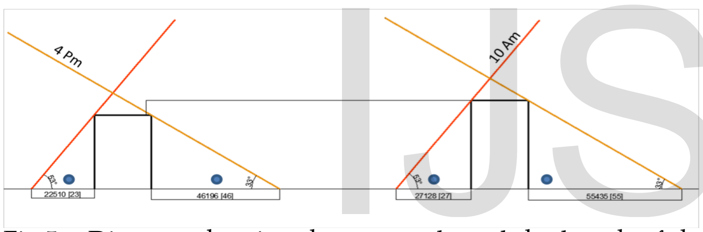

Fig.5. : Diagram showing the sun angle and the length of the shadow casted (Karishma Society).

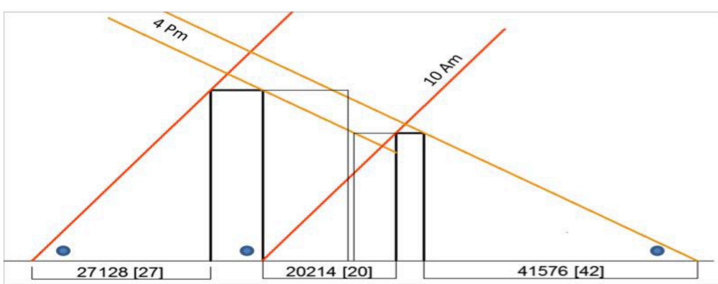

Fig.6. : Diagram showing the sun angle and the length of the shadow casted (Petkar Samrajya Society).

The planning of Karishma is such that the buildings do not cast shadow on each other (Figure 5 : Diagram showing the sun angle and the length of the shadow casted (Karishma Society). The planning of Petkar Samrajya is such that the building is casting shadow on another building within the project (Figure 6 : Diagram showing the sun angle and the length of the shadow casted (Petkar Samrajya Society). The readings taken at the points, in both the cases, where shadows are cast, confirm no change in the air temperature is recorded, at that and other points. The projects towers are shading the adjacent areas, blocking sunlight access to those buildings. The projects are located in the central part of the city, which is warmest throughout the year. This is because the outer sheathing of the large buildings reflects a significant part of the incident solar radiation away from the building, encouraging a temperature increase between the high rises, and the formation of an urban heat island (Makhelouf, 2012). But as the projects studied are surrounded by dense settlement, heat island effect is observed there too. The average air temperature recorded is 2°C more than the temperature stated in Indian Metrological Data (IMD).

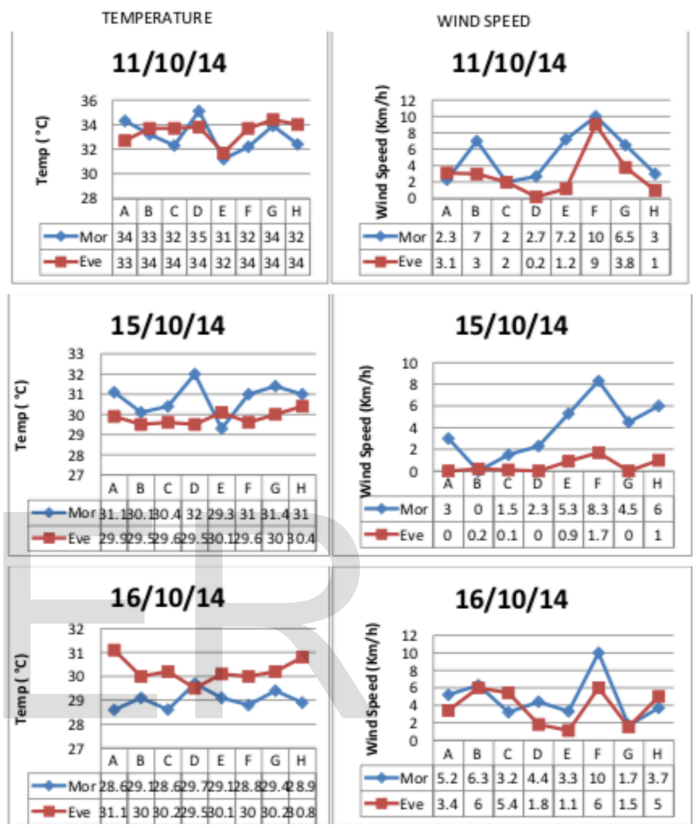

Fig.7. : Graph showing readings of air temperature and wind speed (Karishma Society).

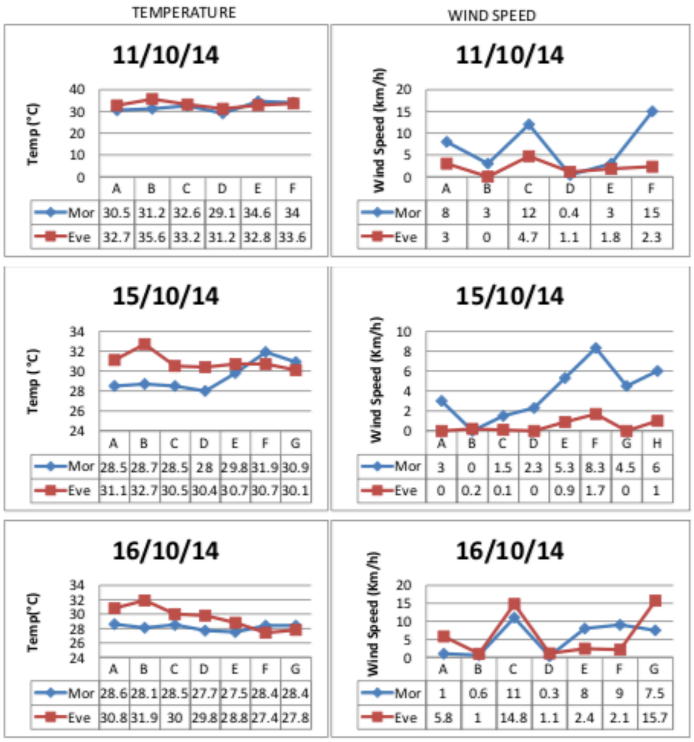

Fig.8. : Graph showing readings of air temperature and wind speed (Petkar Samrajya)

Both the graphs show a comparison of two parameters, Air temperature and Wind Speed. The comparison is in between the various test points and the change in the air temperature and wind speed conditions, at two different times of the day. The blue line indicates morning readings, whereas the red line indicates evening readings.

4.3 Wind analysis

High-rises are exposed to stronger wind flows because of their heights. They create several disturbances in the urban wind pattern. (Thurow, 1978 and 1983) In case of Karishma the wind speed recorded at test point F, which is in between 2 towers, is the highest. The lowest wind speed is recorded at point D, which is the base of the building on the leeward side.

Wind speed is low at test point G, because the podium effect is created. It prevents the downwash winds from reaching the pedestrian level (B).In case of Petkar Samrajya the highest wind speed is recorded at test point C which is between two buildings (C). Test point C is located in the opening between the two towers, facing the windward side, thus encouraging strong wind through the opening. Wind speed is also high at test point F which is outside the project site.

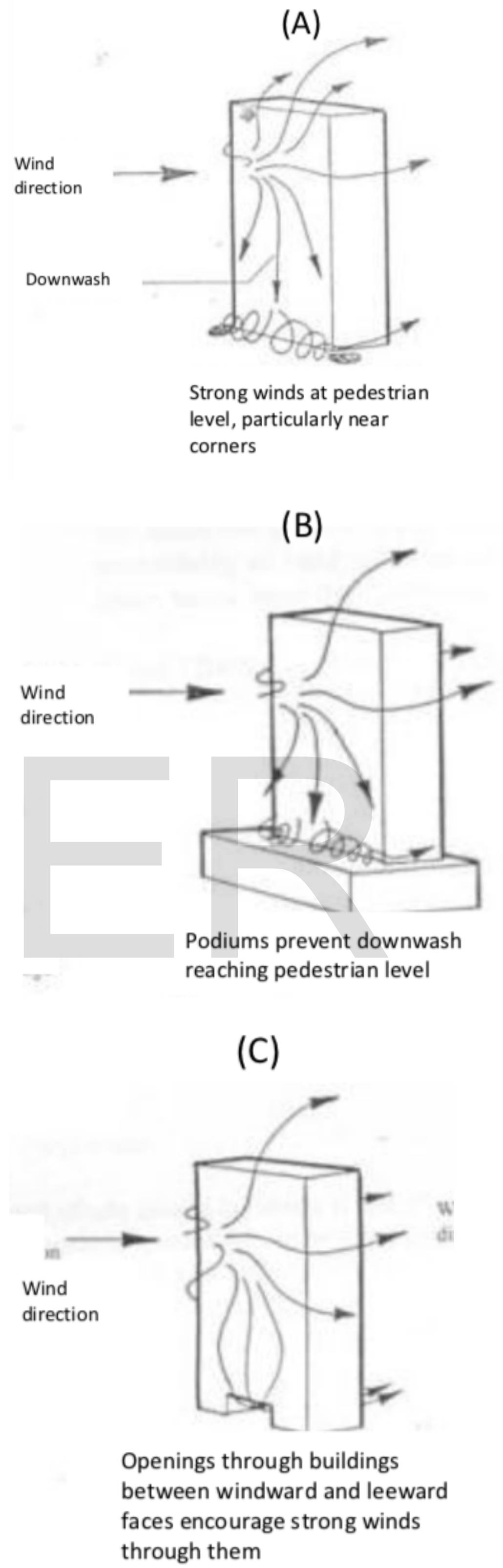

Fig.9. : Wind patterns created around rectangular, streamlined buildings

The planning of the project is such that the longer façade of the building is facing the windward side. This blocks the wind and reduces the wind speed on the leeward side. The layout of the two projects is similar in terms of the orientation, building height and building profile. The only difference is the absence of built mass at the site corner. In case of Karishma the openings at the corner of the site, experience maximum wind speed. This is due to the corner effect. Corner effect increases the wind velocity, created by wind moving around the building. As a result the central open space in Karishma has higher wind speeds than Petkar Samrajya. In case of Petkar Samrajya, high wind speed due to corner effect is recorded on the adjoining north road at pedestrian level.

Fig.10. : Variations in wind velocity (Karishma Society)

Fig.11. : Variations in wind velocity (Petkar Samrajya)

5 Conclusion

Tall buildings have an impact and play an important role on climate or weather and environment, where changing climate factors are related to sunlight and wind. From the study it can be concluded that the effect of building on winds is a result of their height, their architectural form, and their layout. Temperature variation is not observed due to the shadows casted by the buildings, either within or in adjacent areas. Mutual shading caused due to the building height, in the adjacent areas, may cause occupant discomfort, due to less sunlight. The areas within and adjacent to the project have varied wind velocities recorded. Tall buildings create unique wind patterns around them. Efficiently using this wind pattern can provide comfortable conditions within and in adjacent areas.

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