Effect of Tree placement on Wind Flow Pattern in building in Warm and Humid Climate

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Abstract— When air is moving it exerts a pressure against the surface which increases its flow, it is assumed that air flows freely .Generally the wind flows in the parallel directions, and whenever a barrier is introduced in the direction of wind, wind either flows above or through it with a variable of changing their velocity. The air flows in variety of ways depending upon the obstruction introduced in respect of their position.
Due to the changing pattern of living and increasing urbanization the local suburban or surroundings has been drastically changed. The high rise buildings present changes the wind pattern .The research discusses the complexity of wind flow around the buildings in combination of tree obstructions, through the variability in the height of building to see the impact and changes occurring in pattern and velocity.

Index Terms— Ventilation, air flow pattern, warm & humid climate, critical months,simulation

1 Introduction

When wind hits the face of the building, the flow splits and is diverted into several streams, the orientation and number depending on the angle of wind incidence relative to building edges. Planting can affect the movement of wind through and about building dependent on the way it is used, it can increase or decrease the natural air flow through the building .Depending upon the local climate conditions and the prevailing wind direction and speed every place has its variable wind pattern, wind plays an important strategy in warm and humid climate as it is a necessary requirement for such climate for ventilation, so it is very important to study the variable patterns of wind around the buildings of variable heights.

The placement of trees nears the building or placing it to some distance in the direction likely to changes the not only the wind pattern but also the wind velocity around the building. Trees reduce wind speed by increasing the resistance to wind flow. Within the canopy of single tree wind is light and almost unrelated to external wind.
"An isolated tree acts almost like a solid barrier to the wind forcing the wind over and around, thus wind speed can be increased at the edges of a tree or stand" (Reifsnyer 1955)

The prevailing wind speed is not always the same speed when it encounters the buildings as discussed above the wind speed changes with the change of obstruction placed between and also due to the change in height of the building. This study will help in observing the wind velocity reaching the different floors of different heights when the tree is placed at three different positions in month August, November.

Buildbings having even moderately different shapes, such as L- or U-shaped structures formed by two or three rectangular blocks, can generate flow patterns too dense to generalize for design. To determine flow conditions influenced by surrounding buildings or topography, wind tunnel or water channel tests of physical scale models or tests of existing buildings are required. However, if a building is oriented perpendicular to the wind, it can be considered as consisting of several independent rectangular blocks. As wind impinges on a building, airflow separates at the building edges, generating recirculation zones over downwind surfaces (roof, side and downwind walls) and extending into the downwind wake. On the upwind wall, surface flow patterns are largely influenced by approach wind characteristics.

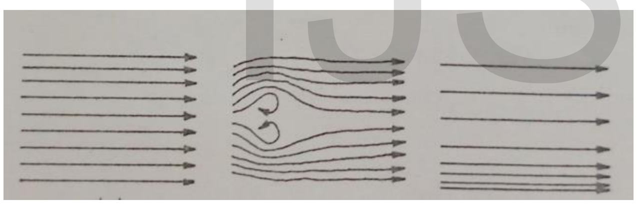
Higher wind speed at roof level causes a larger pressure on the upper part of the wall than near the ground, which leads to downwash on the lower one-half to two-thirds of the building.
The shape of the buildings is a main feature of airflow patterns around buildings. This extends from overall building geometry to projections from its surfaces such as eaves columns, beams, and floor slabs, to attached elements such as sun screens. The variety and scale of such projections prevents a detailed description, but detailed wind tunnel studies have been conducted to measure local wind pressure distributions near such architectural details. Parapet walls tend to give some protection to flat roof from high suctions generated by vortex flows at roof edges. Projecting eaves, walls and floors, slabs, used together prevent cross- flow across the surface of the windward walls. And provide more and even distribution of positive wind pressure for more efficient natural ventilation of buildings.
Accurate evaluation and prediction of wind loads and proper mitigations are very important in reducing the adverse effects of wind in the built environment. In addition to the mean and the background (due to turbulent fluctuations) loads on rigid buildings, flexible structures will be subjected to resonant wind loads as well. The primary source of the along-wind motion is the pressure fluctuations in the windward and leeward faces due to the fluctuation in the approach flow and its interaction with the building.

LIMITATION:

- The limitation to this research is that it is being analyzed for a particular climate, warm and humid.
- Only two parameters of microclimate that is tree and wind impact is to be Considered.
- The observation is being analyzed on G+2,and G+12 height building.
- The tree taken for simulation is Bhendi tree (Thespasia populnea) height 15 m is kept constant in all the cases, as it is native tree of Mumbai and is found mostly in all the regions.

1. Types of Air flow:

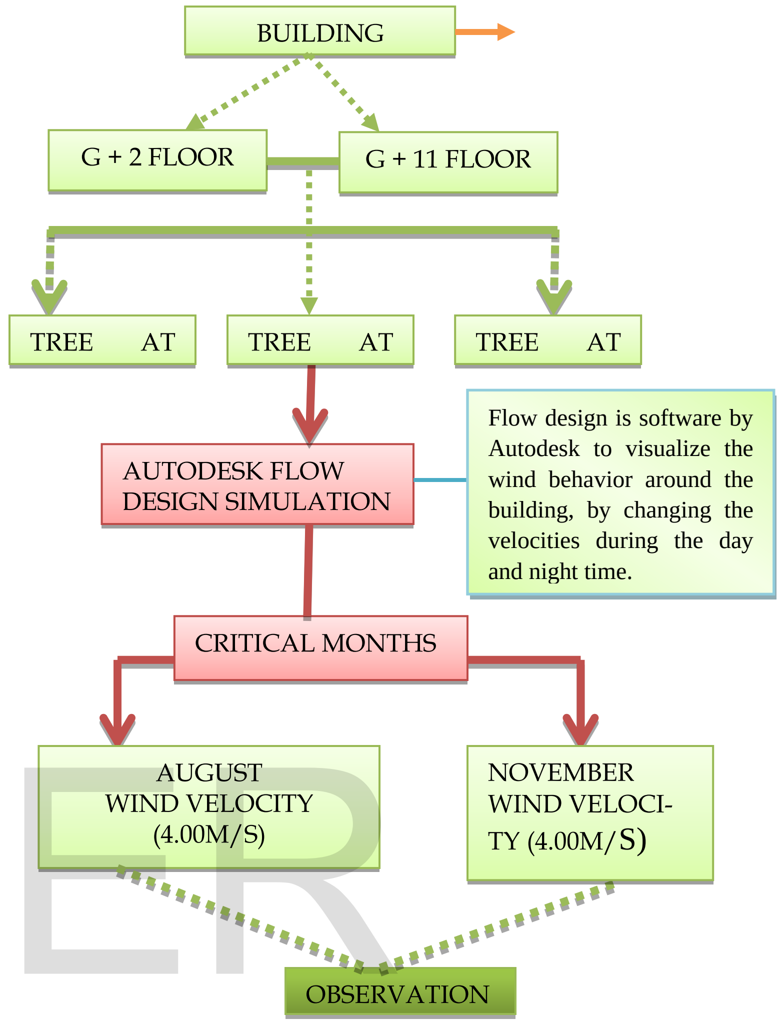
There are a number of different types of wind flow which may be categorized depending on whether the wind is viewed from an elevation or plan form.in elevation there are three basic types of wind flow.
Laminar air flow – layers of wind flows on top of another in parallel pattern (this occurs fairly regularly and is predictable)
Turbulent air flow – Air masses moving in same direction but in random pattern.
Separated air flow – Layers of air varying in momentum



Laminar air flow Turbulent air flow Separated air flow

2. The basic principles of wind flow are:

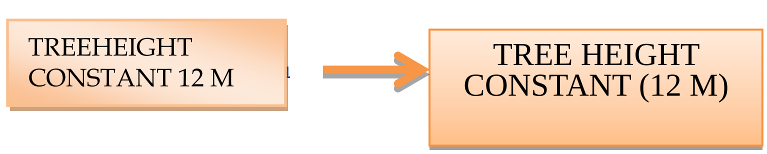
- The wind in the first 1.8 to 3 m above the earth surface is that of the most interest to the human user of the environment.
- Winds upto 15 m to 18 m above earth surface have some effect on the human being walking or sitting or at near ground level.
- Whenever the wind flows over a streamlined surface or over a bluff body the boundary layer of air generally speeds up creating a low pressure area between the boundary layer and the surface of the element.



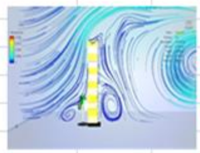
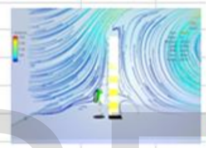
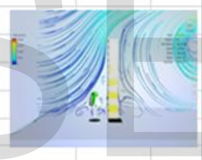
CASE SELECTION:

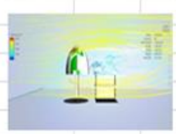
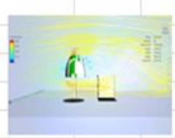
The cases selected to support my research were based on the climatic data of Mumbai taking critical climates, August and November wind velocities the tree selected Bhendi tree(Thespesia populnea) is native tree of Mumbai of height 12 m. The distances of the tree is determined by the local byelaws of Mumbai for setback that is 3m ,6 m, and 9m from the building to see the impact .
CITY – MUMBAI
LOCATION – 19º 07′ N 72º 51′ E
CLIMATE – WARM & HUMID , **MSL** – 15 M

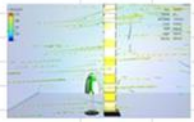
METHODLOGY OF CASE:



MONTH	VELOCITY	CASE	DISTANCE	HEIGHT	SIMULATION	OBSERVATION	RESULT
			Tree at distance of 3 m			dense Turbulent air flow floors is around 4.5m/s 4 - 4.3m/s inside the building light breeze	when tree distance is increased by 3 m the wind speed is enhanced by 0.3 %
AUGUST	4.00 M/S	G+ 2 floor	Tree at distance of 6 m	12 M		laminar air flow floors is around 4.0 – 4.5 m/s 4.3- 4.9m/s inside the building light breeze	In this case the wind speed is enhanced by 0.9 % when the tree is at a distance of 6m.
			Tree at distance of 9 m			laminar to separated air flow 4.5 – 4.9 m/s to the floors. 4.1 – 4.5 m/s inside the build. light breeze	In this case the wind speed is enhanced by 0.5 % when the tree is at a distance of 9 m.

MONTH	VELOCIT	CASE	DISTANCE	HEIGHT	SIMULATION	OBSERVATION	RESULT
			Tree at distance of 3 m			separated air flow /turbulent 4 – 10 m/s to the floors 6.5- 7m/s inside the building. Gentle breeze	The wind speed has been enhanced by 3% inside the buildng when the tree is at 3 m for G+ 11 floor building.
AUGUST	4.00 M/S	G+11 floor	Tree at distance of 6 m	12 m		separated air flow 1 – 8 m/s to the floors 7.5- 8m/s inside the building. Gentle breeze	In this case the wind speed is enhanced by 4% when the tree is at a distance of 6 m.
			Tree at distance of 9 m			separated air flow 5 – 9m/s to the floors 7.5- 8m/s inside the building. Gentle breeze	The rate of enhancement of wind is same as above when the distance is increased to 9 m that is by 1%.

MONTH	VELOCITY	CASE	DISTANCE	HEIGHT	SIMULATION	OBSERVATION	RESULT
			Tree at distance of 3 m			turbulent air flow floors is around 1 – 1.2 m/s. 1.2 – 3 m/s inside the building light breeze	At a distance of 3 m when wind speed is 1.72 m/s the wind is enhanced by 1.7%
NOVEMBER	1.72 M/S	G+ 2 floor	Tree at distance of 6 m	12 M		laminar air flow floors is around 3- 3.1m/s. 2.5 – 3.1 m/s inside the building light breeze	In this case the wind speed is enhanced by 1.7 % when the tree is at a distance of 6 m.
			Tree at distance of 9 m			laminar to separated air flow floors is around 3 – 3.3 m/s. 2.5 – 3.5 m/s inside the building light breeze	In this case the wind speed is enhanced by 1.78 % when the tree is at a distance of 9 m.

MONTH	VELOCITY	CASE	DISTANCE	HEIGHT	SIMULATION	OBSERVATION	RESULT
			Tree at distance of 3 m			laminar air flow 1 – 2 m/s to the floors 1.2- 1.5m/s inside the building. light air	
NOVEMBER	1.72 M/S	G+ 11 floor	Tree at distance of 6 m	12 M		laminar air flow 1 – 2 m/s to the floors 1.5- 1.7m/s inside the building. light air	Since the wind speed is less and the distance of the tree wind speed is increased to the floors but inside the building it is being reduced by 0.3 % comparing it to geting inside in all the distances when it is at 3 m ,6m and 9m .
			Tree at distance of 9 m			laminar air flow 1 – 2 m/s to the floors 1.5- 1.7m/s inside the building. light air	

CONCLUSIONS:

It is being observed that by simulating the cases to have the best cross ventilation for different height of building depending upon the four different climates are:

CASE 1 (G+ 2)

1. Building height above (g+2) floors the wind has effect on building dually like the floors near the foliage and the upper floors so the distance of 9 m is found out to be ideal distance for enhanced ventilation.
2. 9 m is found out to be best distance for enhanced ventilation in the month of august.
3. November month was same in terms of distance that is 9 m is observed to be the best distance.

CASE 2: (G+ 11)

1. From the overall observation the high rise building have the enhanced ventilation when the tree was placed at distances of 9 m as the the crown of tree helps the wind to facilitate the wind velocity thereby increasing the velocity inside the building.
2. The May and August month shows that the availability of wind velocity inside the floor is 6 m/s to make it comfortable for the occupant it is to be obstructed with the help of pergolas etc.
3. The distance of 9 m is found to be ideal for the month of November for cross ventilation

REFERENCES:

- Sun, Wind and Light (Mark Dekay and G.Z.Brown)
- Controlling Air Movement: A manual for Architecture and Building(Terry. S. Boutet)
- Climate and Ventilation (kimmo kuismanen)
- Landscape Planning for Energy Conservation (Gary O. Robinette)
- Trees of Mumbai (Naresh Chaturvedi)