Wind Speed Variation and its Effect on the High-rise Building Due to Urban Development: A Case Study at Northern Cyprus

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Abstract - *As its noticed overall for the last few years that the average wind speed is getting faster which is an incredible news for sustainable power source creation — in any event up to now, in the other hand its impact on tall structures, In under 20 years, the overall wind speed has expanded from around 11.26 km/h to about 11.90 km/h. Northern Cyprus is located in the Mediterranean sea which is a high-hazard zone, in which the structure ought to be intended to oppose lateral load for resisting the lateral imposed loads" Earth quick, wind loads ". One of the important factors to keep in mind is the wind .Northern Cyprus is still new to the high-rise building area, In this article, the effect of wind load on high –rise building was studied in three possible cities, and its changes based on climate change. The effect of wind load was studied based on the difference in the geography of the place, wind speed, and altitude above sea level, for the last seven years. The most important structural results related to wind and building behavior were studied and extracted according to the Ts 498-97 criteria. the results have shown the high-rise building behaviors under wind loads.*

Key Words: **Lateral force, Wind load, Ts 498-9, Northern Cyprus, Climate Change.**

1.INTRODUCTION

The development of buildings technology occurs due to fundamental, and technology goes towards making more efficiency. The development of structures systems to have more rentable spaces in crowed cities lands by constructing high rise buildings, before and their development up to now even taller and more useful structures to increase land used more economically. Tall buildings, which commenced from multi-story office towers in the last century, have evolved to huge structures like the Burj Dubai, the highest building in the world nowadays, and will be the second and the third next few years. we still need high rise buildings because of populations grow up rapidly all around the world, and the urbanization has resulted in high-density huge cities. Crowded cities with high rise buildings are more efficient for energy and land use. By making cities smaller, electricity and consumption are reduced transportation becomes less expensive and shortens distances, which in turn leads to a reduction in energy consumption by creating denser cities with high-rise buildings, more natural greenery can be saved globally. However, congestion will lead to balance. There are other design problems when these high-rise buildings are exposed to huge side forces. As buildings grow longer the wind speed increases on the upper floors due to huge wind forces. Accordingly, there ought to be an investigation of the connection between the height of the structure and the effect of wind speed variety and the consumption of materials and important wind power standards must be properly designed. Nowadays, Cyprus is attracting a large number of students because of its universities, which has led to an increase in its population, which in turn has led to an increase in the demand for High-rise buildings. As the demand for tall buildings increased, it was necessary to study the impact of the factors affecting them. The wind is an important factor to consider in the design phase. In this study, we will see results and comparisons for seven different years in three potential cities, which are the most populous.

2. THE IMPORTANCE OF WIND LOADS ON TALL BUILDINGS

Wind velocity is a difficult and unpredictable wonder due to the numerous flow conditions resulting from the influence of winds on installations. Wind consists of many vortices of different sizes and with rotational features in a general airflow that moves at a high speed compared to the winds in the upper layers. These swirls give high-speed winds or storms. Wind speed near the surface of the Earth is affected by the surface topography of the Earth's surface. Normal wind speeds change over a period of ten minutes or gradually as they rise above sea level.

3. WIND LOAD EFFECTS

The average wind speed runs on the structure. This means that wind energy is obtained from the average wind speed and the strength of the wind frequency provided by the field of the repeating current. The effect of wind movements and quality depends not only on a structure or a part of it, but also on the characteristics of the volatile wind quality, as well as the size and properties of the vibration of the structure or a portion of it. Based on what was previously said, in order to measure the wind load on the structure, it is important to evaluate and know the properties of wind movement and its speed, and the dynamic characteristics of the structure in general in terms of shape and dimensions. The variables that are taken into account when determining the type of volatile wind are:

A. Wind turbulence
B. Generating swirls behind the construction

The interaction between building shaking and the surrounding air flow of most buildings, and the effect of wind power fluctuation due to wind turbulence, predominates. For this situation, parallel wind loading on the basic tire along the breeze heading is noteworthy. In any case, for structures that have a height-to-area ratio, horizontal wind loads and the direction of torsion of the structure in general should not be ignored.

4. BUILDINGS SPECIFICATIONS

The building consists of a ground floor with a height of 3.8 m, 4 podiums with an elevation of 3.0 m and 30 typical floors with an elevation 3.6 m. The building has an irregular plan for both podium and typical floors as shown in Figs. 2 and 3. The position of the building which has been modeled is supposed to be at Famagusta, North Nicosia, Girne in Northern Cyprus. This location has recognized by the variation of wind speed. The structure has been modeled as frames with rigid connections and shear walls to resist the wind force. Columns shape varies between circular and rectangular shapes with different sizes varies between diameters 500mm, 600mm for circular columns and 300*700mm to 350*1200 mm for rectangular columns. For slabs the thickness varies between 250 to 300 mm. for shear walls the thickness varies between 300 to 600 mm. Development of new architectural forms and flexible structural systems for buildings subject to wind action. In order for a desired behavior of these buildings, we need a better understanding of the interaction between construction and winds effect.

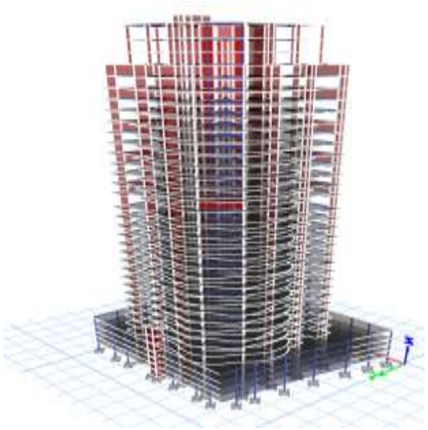

Fig -1: 3D-Model

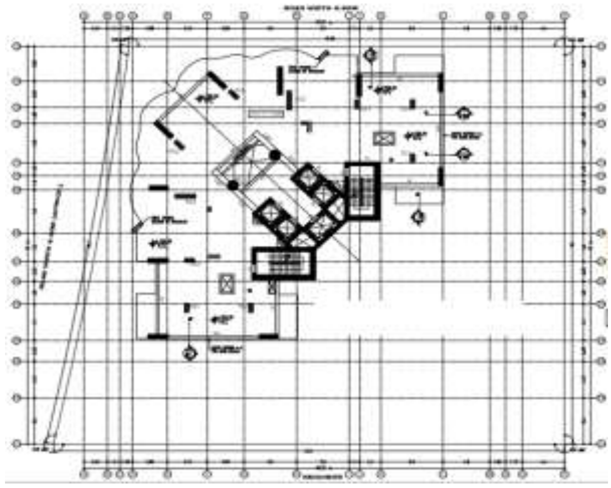

Fig -2: Typical floor plan

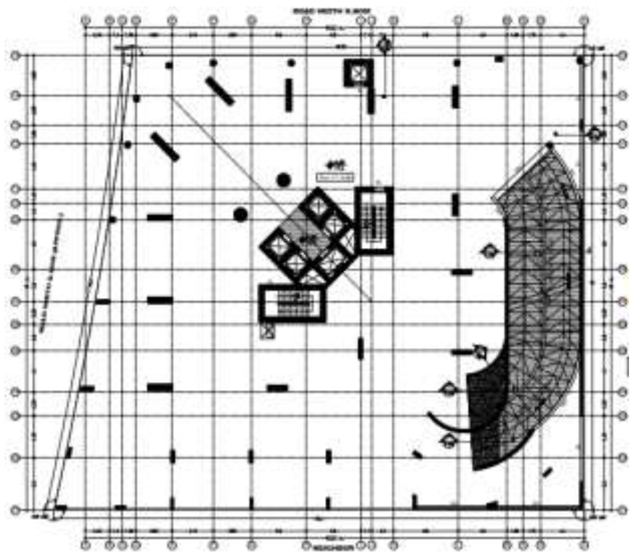

Fig -3: Podium Floor plan

5. AIM OF THIS STUDY

Study the behavior of high-rise building when exposed to wind loads, to determine the effect of wind load on various parameters such as floor displacement and lateral movement in the building.

6. METHDOLOGY

The building consists of G+4P+30 story which have irregular shape, total typical floor area 820 m^2, podium area 2110 m^2, and the floor height 3.6 m. The Diaphragm has been created for all floors, mass source used for this building is 25% of the live load and full dead load. The ETABS is used for analyzing high rise building. The North Cyprus is considered for this proposed data. Ts 498-97 code have been used for wind load combination.

Information about wind, its movement and speed are collected through practical measurements by special devices placed in stations Monitoring, and recording information for many years, then these results are analyzed, studied and processed by probabilistic statistical methods.

7. DESIGN CRITERIA

The structural model was designed according to TS498-97 applying ETABS2018 software. The Structures are subjected to various types of loading and wind speeds as shown in Table I and Figure 4, respectively. This is a simulation of reality. The inputs used to calculate wind loads have shown in Table 2.

Table -1: Load cases

Load cases	
Load Patterns	**Magnitude**
Dead Load (DL)	own-weight of the building
Live load (LL)	2 kN/m2 according to (TS498) for residential building
Additional Dead Load (SDL)	2 kN/m2

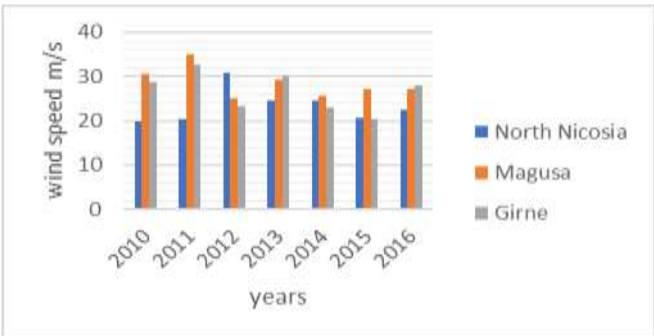

Fig -4: Wind speed

Table -2: wind load parameters

Wind load parameters	
Lateral wind load parameters	**Value**
(Cp), Windward coefficient	0.8
(Cp), leeward coefficient,	0.5
(Cr), Coefficient of dynamic	1
Exposure height	Base-top Roof
(LLRF), Live load reduction factor	0.3

8. RESULTS AND DISCUSSIONS

The action of building due to wind loads shown in this area through the utilization of different wind speed as per various years by applying ETABS software version 2018, all results were represented as follow

8.1 Maximum Story Displacement

Lateral displacement had been calculated due to several real wind speed for seven years. the design displacement is studied using static linear analysis under code-specified actions considering the effects of cracked sections, and all results are shown in the next figures.
Story displacement: is the displacement of the story with respect to the base of the structure.

$$\delta_x = \frac{C_{d*}\delta_{xe}}{I_e}$$

Where,

δ_x= story displacement

δ_{xe}= elastic deflection calculated from design forces

C_d = deflection amplification factor according to Table 12.2-1

I = importance factor according to table 11.5.1

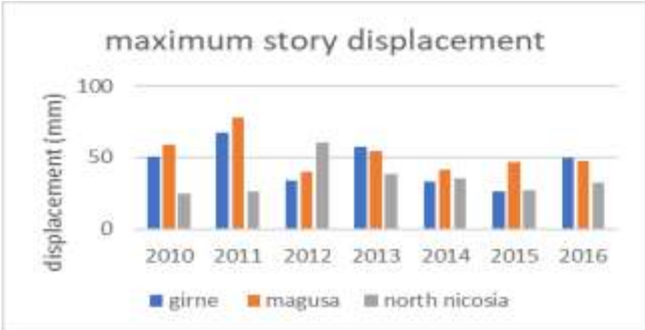

Fig -5: Story displacement

8.2 Overturning Moments

Wind effects on tall buildings for more than 6 floors, such as high tanks and other high buildings, because it adds an extra moment (on the columns and foundations) to increase the design stresses of the structural elements, etc., and the depth of the foundations under the soil, and therefore must be taken into account when designing the resistance to winds and earthquakes. The following law: F = PA. The structure shall be prepared to counter overturning moment effects caused by the wind forces. The foundations of structures shall be designed for not less than 75% of the foundation. (ASCE/SEI 7-16) overturning design moment.

overturning moment = wind force * Hight to level under consideration.

$$M_x = \sum_{i=x}^{n} Fi(hi - hx)$$

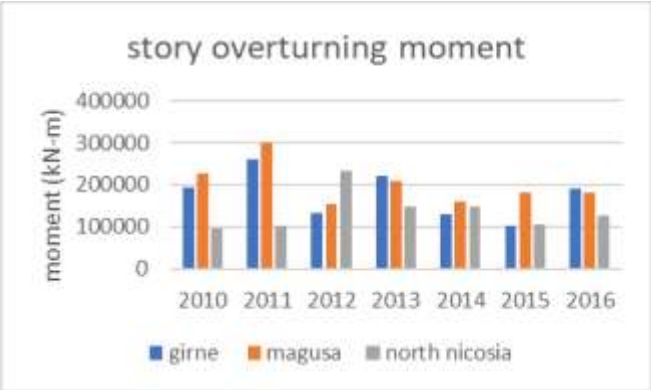

Fig -6: Story overturning moment

8.3 Story Shear

Story shear is the graph showing how much lateral load acting per story. The lower you go, the greater the shear becomes. The wind design for shear at any story (Vx) [(kN)] have extracted from the following equation:

$$Vx = \sum_{i=x}^{i=n} Fi$$

Fig -7: Story shear

8.4 Story Drift

story drifting is the difference between the two successive floor displacements divided by the height of that floor, and estimating the floor drift is important to ensure that no annotations occur in the architectural interior divisions. It must be studied so that it does not exceed the permissible limits for erosion, otherwise there will be a collapse or cracks at the very least for the walls. For walls on exterior surfaces, this can prove disastrous. The displacement is controlled to mitigate the effects of secondary P-DELTA effects and to the overall stability of the structure.

$$\Delta = \delta_x - \delta_{x-1}$$

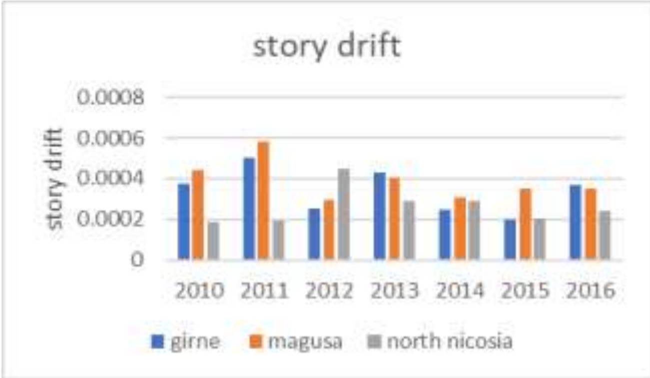

Fig -8: Story drift

8.5 Story Force

The effect of wind pressure on tall towers is contradicted by shrinking the flat front of the building facing the wind whenever we rise vertically. This likewise gives more rigidity to the top where the weight is more on the lower floors and gradually decreases as we go vertically towards the top.

Story force can be calculated as shown below:

- story force = p X A
- where,
- P = wind speed pressure
- A = area of surface subjected to wind pressure

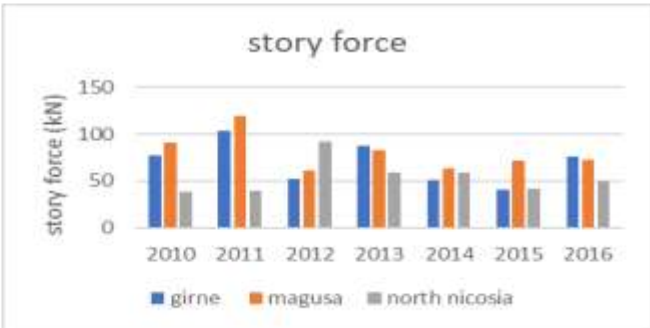

Fig -9: Story force

8.6 Comparison

The below figure shows the comparison between the different areas under the average wind speed for each location and the structure parameters affected by variation of speed average.

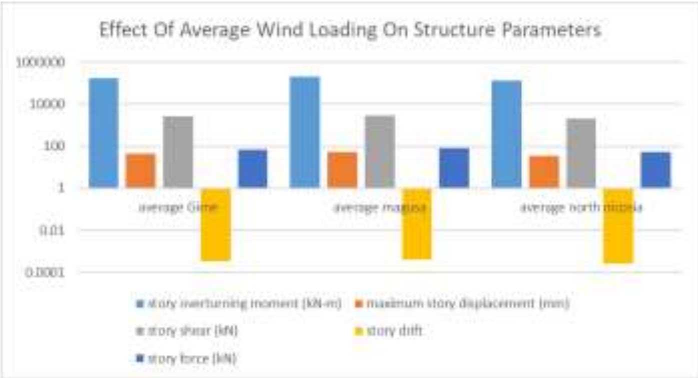

Fig -10: Average wind loading

9. CONCLUSIONS

Wind speed can be affected more than earthquake forces, especially in areas that are characterized by high wind speeds. Wind generates horizontal forces at each floor. These forces are transferred to columns and walls. The main elements should be designed according to the structural system used, either bearing wall or moment resisting frame or dual System then moves these horizontal forces to the foundations.

What's more, the effect of wind pressure on tall towers is contradicted by shrinking the flat front of the building facing the wind whenever we rise vertically. This likewise gives more rigidity to the top where the weight is more on the lower floors and gradually decreases as follows, we go vertically towards the top. For this reason, when we look at the skyscrapers and an example of this, the Burj Khalifa in Dubai, we find that the higher we go up, the dimension of the tower decreases in order to reduce the impact of wind pressure and increase the stability of the building.

As per our study and as per the average wind speeds it has been found that the minimum average wind speed is taking place at North Nicosia which leads us to know that the cost of constructing a high-rise building in North Nicosia will be more economical since the structure parameters will be at its minimum values, because of minimizing the reinforcement quantities and member sizes .

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