Study of High Rise Buildings for Varying Wind Pressure & Design of Façade of High Rise Building

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Abstract - *By increase in the height of building, stability of the building becomes the question of prime importance. Wind pressure increases with increase in height and also deflection. For building like Burj Khalifa where allowable deflection for such heights is 3 m which is uncomfortable for any human being inside the building. Thus studying wind load for various buildings at various locations helps an engineer to design the building before making live. Façades are the first aesthetical feature of a building that distinguish one building from another. They determine its distinctive appearance and are often the subject of controversial debate. Major advancements in façade technology gives Architects and Specialists the opportunity to vary the appearance of the building envelope, create an integrate grid system with all of their ideas, such as, windows, ventilation elements, aluminium features, etc. while maintaining a high level weather proofing. Façade works include such important building components as windows wall, Aluminium Fins, cladding panel, etc, that form an integral part of the external envelope of a building. It is, therefore, important to ensure façade structures are properly designed, installed and maintained, to provide an interesting living environment, while maintaining 'green' and safe living environment for the community.*

Key Words: **Wind Pressure, Wind Load, Facade, Window wall, Aluminium fins, Cladding panel**

1. INTRODUCTION

Wind has two aspects. The first beneficial one is that its energy can be utilized to generate power, sail boats and cool down the temperature on a hot day. The other a parasitic one is that it loads any and every object that comes in its way. The latter is the aspect an engineer is concerned with, since the load caused has to be sustained by a structure with the specified safety. All structures above ground have thus to be designed to resist wind loads. This introductory note is concerning the aspect of wind engineering dealing with engineering structures.

Wind load on a Tall building can be determined by:

1. Analytical Method given in the code IS 875: part 3-1987 which is given by A.G.Davenport(1967). The analytical method is usually acceptable for a building with regular shape and size and is almost based on the geometric properties of the building and without incorporating the effects of the nearby buildings.

2. Secondly the Estimation of Wind Load through Wind tunnel testing with as called building model used. In Wind Tunnel Testing for the structural design the Dynamic analysis of the scaled model building is done with Balendra's approach(1997)and for the cladding design the Surface Pressure Measurement analysis with Pressure Measurement system is done. Also the effects of the nearby buildings have been taken into consideration as the Interference effects on the buildings in a same procedure being used for an isolated building model.

Development in façades has made it more functional, providing designers with the flexibility to create high performance solutions, which are visually exciting, bothinternally and externally. One such example of high rise building is the SD Corp Imperial Edge, situated at Tardeo in Mumbai. As shown in the figure below the façade of the building is unique to distinguish and gives building aesthetics which are suitable to its name.

Major advancements in façade technology gives Architects and Specialists the opportunity to vary the appearance of the building envelope, create an integrate grid system with all of their ideas, such as, windows, ventilation elements, aluminum features, etc. while maintaining a high level weather proofing.

Façade works include such important building components as windows wall, curtain wall, cladding panel, glass glazing, entrance glazing etc, that form an integral part of the externalenvelope of a building.
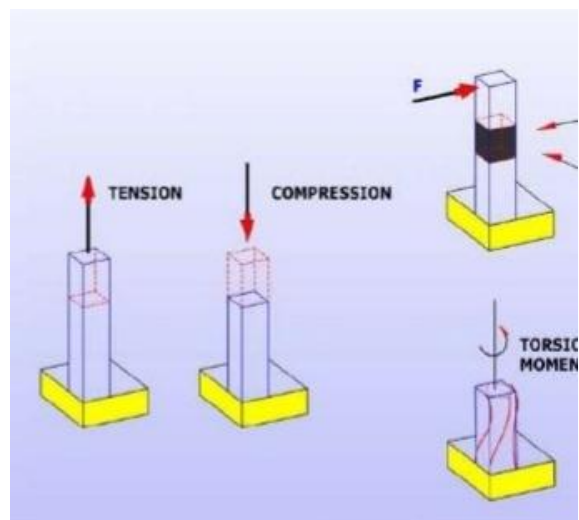
1.1 Objectives

1. To identify the wind speeds.
2. To analyze the behavior of wind at different time zones within a year.
3. To simulate the wind load on buildings.
4. To calculate deflections of building due to wind loads.
5. To design the shape of Aluminum profile that can withstand the wind load for façade of a high rise building.

1.2 Scope of Work

The study includes collection of data for buildings and wind loads, analyzing the wind behavior using software, calculation of deflection and other parameters, designing of building as per simulation. Design and analysis on aluminum for façade of a high rise building

2. Literature Review

K. Vishnu Haritha, Dr.I. Yamini Srivallie (2015)

According to them wind effect is predominant on tall structures depending on location of the structure, height of the structure. Further they discussed their paper is equivalent static method is used for analysis of wind loads on buildings with different aspect ratios. The aspect ratio can be varied by changing number of bays. Aspect ratio 1, 2, 3 were considered for present study. The analysis is carrie out using STAAD PRO.

Kiran Kamath, Shruthi (2013)

They explain the effect of different aspect ratios on the seismic performance of the steel frame structure with and without infill. Here, height of the building is kept constant and the base width is varied. Two types of frames are considered for the study, one with similar steel sections for maximum strength required for beam and column and the other with varying steel sections conforming to the strength and serviceability requirements to withstand the specified loading. ETABS is used for analysis and the comparison between the performances of frames with different aspect ratios is made using pushover curves and performance point. It is found that the presence of infill stiffness contributes significantly to the performance of the structure compared to bare frame.

D.R. Deshmukh, A.K. Yadav (2016)

They explain about High-rise structures which need more time for its time consuming and cumbersome calculations using conventional manual methods. Further they used software i.e. STAAD-Pro which provides a fast, efficient, easy to use and accurate platform for analyzing and designing structures. Their main principle of this project is to analysis and design a multi-storied building G+19 (3 dimensional frame) using STAAD Pro software. The design involves analyzing the whole structure by STAAD Pro. The design methods used in STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. They conclude that STAAD-PRO is a very powerful tool which can save much time and is very accurate in designs.

3. WIND LOAD DATA AT VARIOUS LOCATIONS:-

Wind loads and response to wind are important design parameters for many structures including bridges, high rise buildings, tall towers etc. it is nowadays essential to ensure that such structures can survive the high winds. Thus various forces acting on structural element can be represented with the below image shown.

3.1 Tension & compression

Two key types of forces involved in building any structure are **tension** and **compression**. Every material has the ability to hold up to a certain amount of tension and a certain amount of compression. A tension force is one that pulls materials apart. A compression force is one that squeezes material together.

3.2. Shear Force

A shear force is a force applied perpendicular to a surface, in opposition to an offsetforce acting in the opposite direction. This results in a shear strain. In simple terms, one part of the surface is pushed in one direction, while another part of the surface is pushed in the opposite direction.

3.3. Bending Moment

A bending moment is the reaction induced in a structural element when an external force or moment is applied to the element causing the element to bend. The most common or simplest structural element subjected to bending moments is the beam.

3.4 .Torsional Moment

Torsion is the twisting of a beam under the action of a torque.

Other than wind load there are many forces that too act on a building that play crucial role in designing a building structure. Below image gives a brief idea and understanding for such loads that are to be considered.

Wind flow differently at different locations on earth. For our considered region i.e. Dubai, Standards used is ASCE-7 which is American standards.
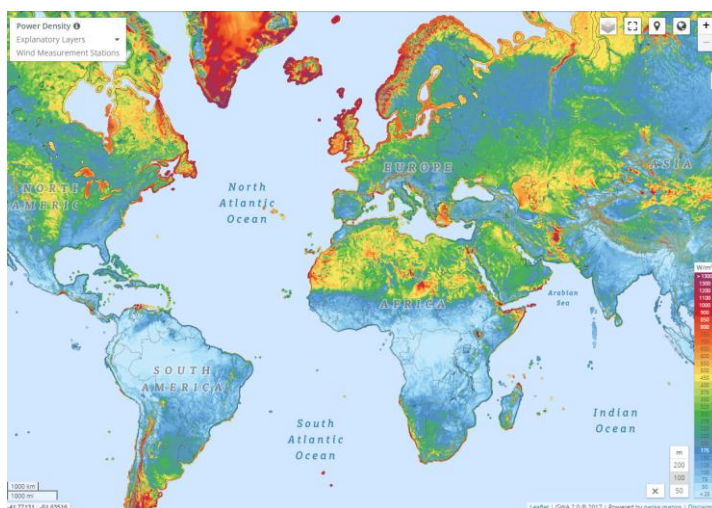
As of now for India, the National building code of India (NBC 1970) and the Indian standards (IS 1965) provide maps of country specifying 'design wind pressures' in various zone
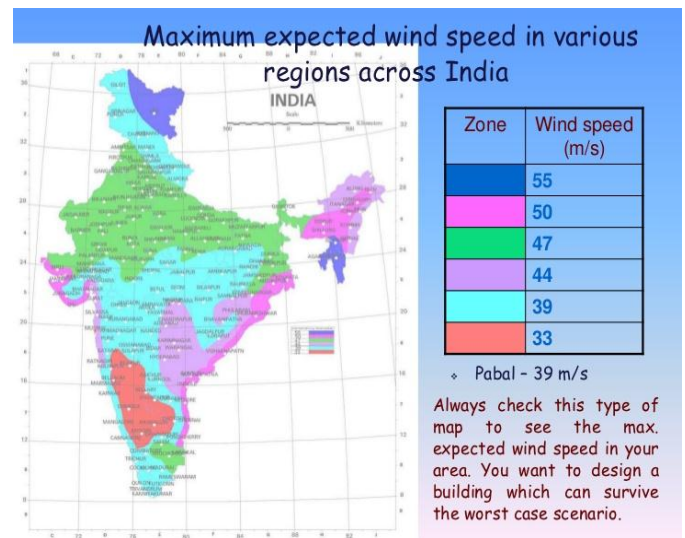
4. ANALYZING WIND LOADS USING STAAD PRO:-

For structure stability and wind load analysis we are here using software STAAD.ProV8i. STAAD Pro is an abbreviation for Structural Analysis and Designing Program. It helps in designing from simple beam to sky scraper and analyze whether it will fail at applied load or pass.

4.1 Open STAAD.ProV8i. Click New project. Click Space. Give file name "Wind load analysis". And specify the location if needed. Select length and force units as meter and Kilo Newton. Click on Next.
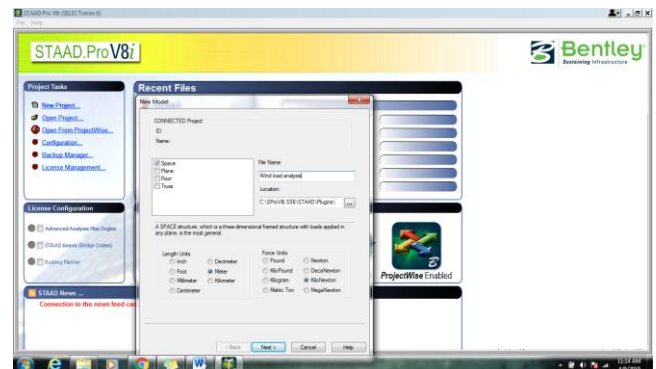
4.2 Check on Add Beam. Click Finish.
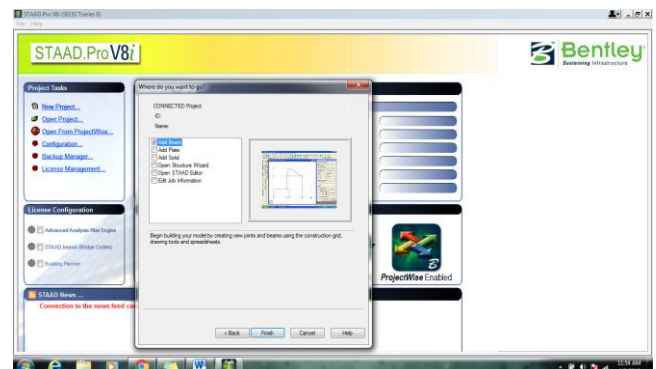
4.3 Below will be the work station for us to start our work.
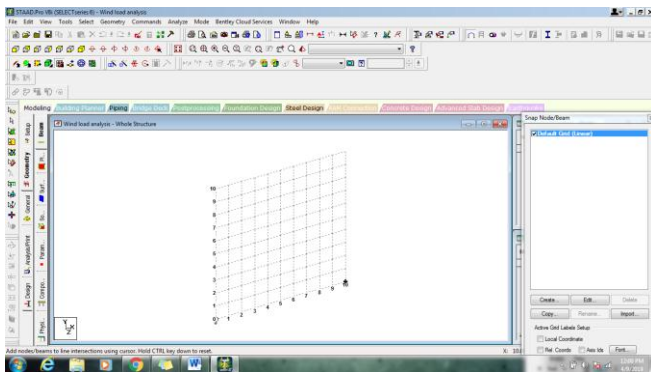
4.4 Click on geometry and select Run Structure Wizard.
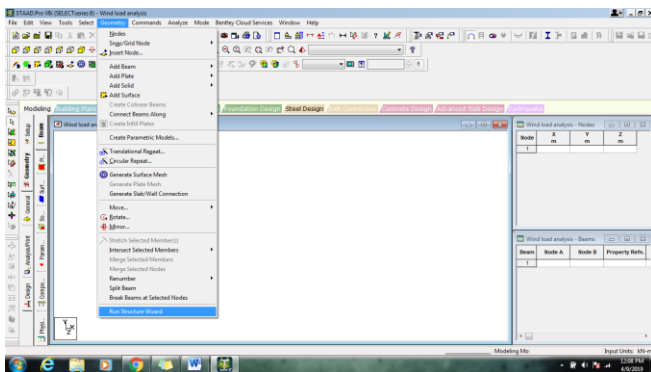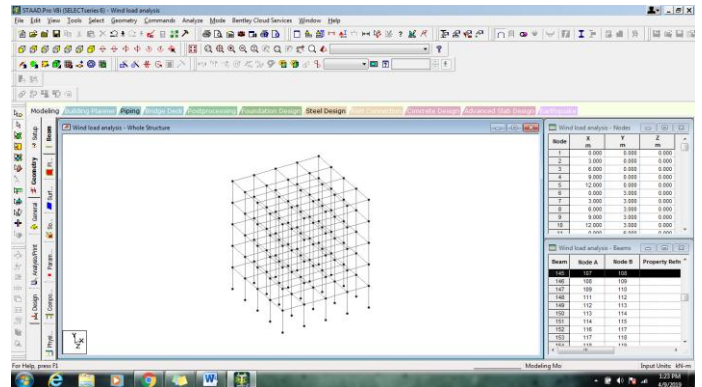

4.5 Select Frame Models in model type.
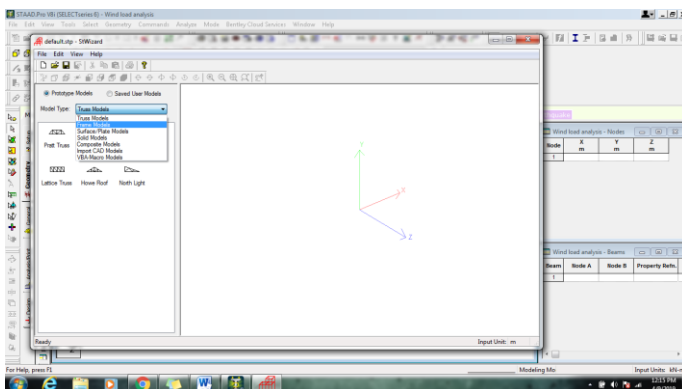
4.6 Double click Bay frame, enter parameter for building i.e. length, height and width and click on apply.
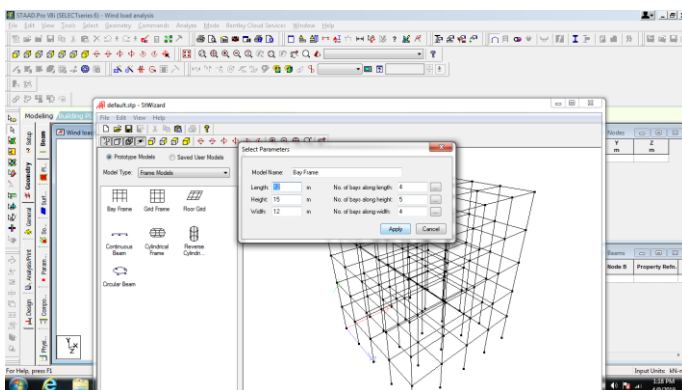
4.7 Window will show a 3D mesh like structure which is our building on which we are analysing the wind pressure. Close the window and save the file. On right hand side we can see the coordinates of each node of the building.


4.8 Once the structure is ready we have to specify the columns and beams to the building. So for that click on "General" at left side of the window and click "Define" on the dialog box that appears.
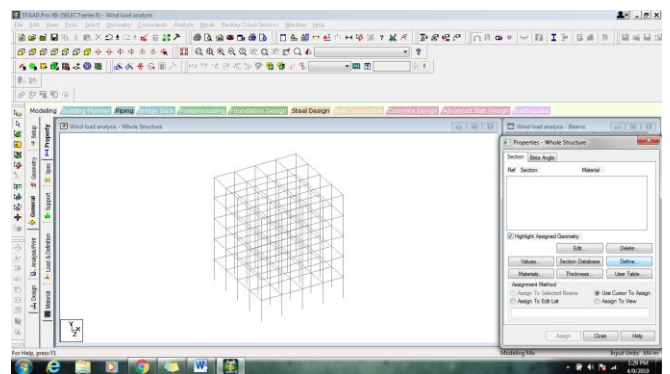
4.9 "Define" tab will help us to mention the shape and size of the column and beam. We will select rectangular concrete column with size 700mmX250mm. Click Add and add the next dimension for beams 250mmX250mm. Finally click on Add and Close the dialog box.
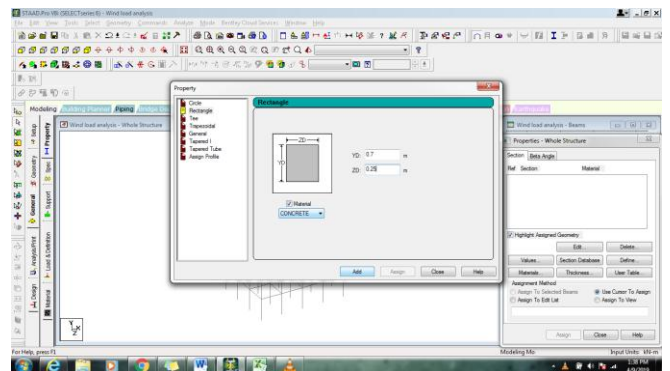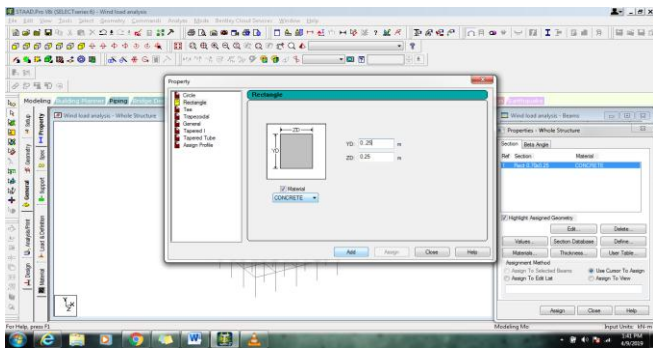
4.10 Select the first section and assign the vertical lines as columns by clicking on "Y" in "beams parallel to" in "select" in menu tool bar at the top.
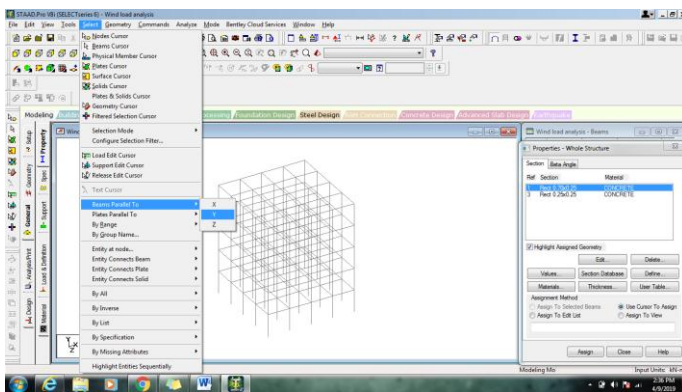
4.11 Click on "Assign to selected beams" and click "Assign button". Save the file.
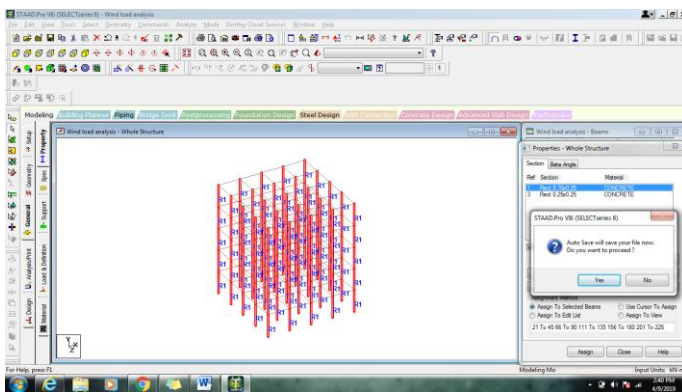
4.12 Similarly for beams select X and Z directions for assigning beams to the building. Click on Assign and save the file.
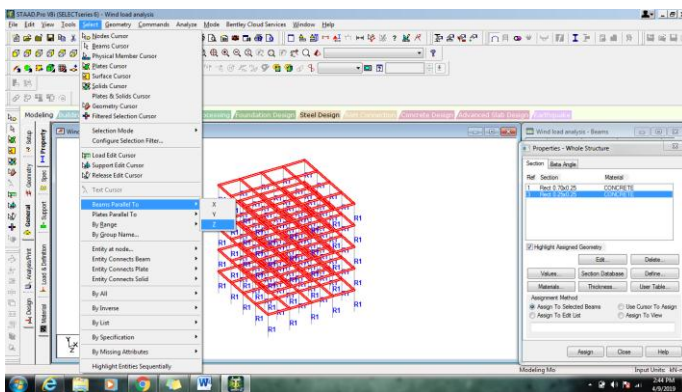
4.13 Save the file and we will have the screen showing the full structure with nomenclature to identify the beam and column.
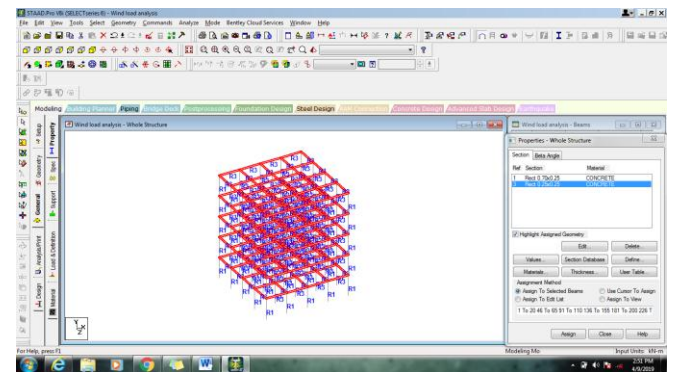
4.14 Next step is to assign the fix supports at the botom of the pillars of the building. So to do so Click on supports at the left side of the screen at the tool bar.
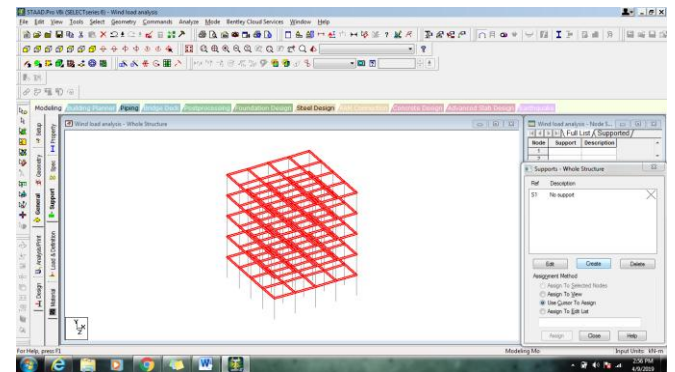
4.15 Click on create and under fixed option click on "Add".
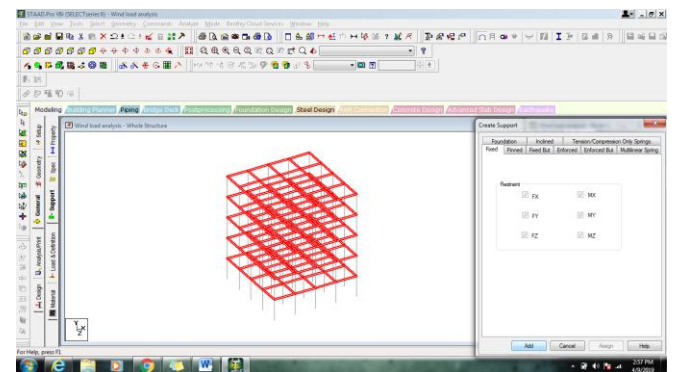
4.16 Select the bottom most nodes of a structure which are the fixed support for the building in our case.
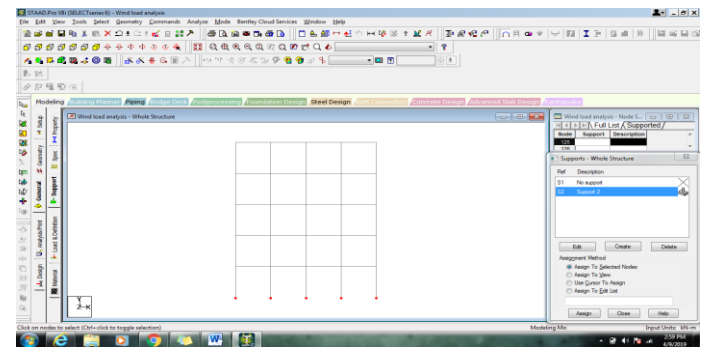
4.17 Opt for "Assign to selected nodes" and click "Assign". We can see the supports applied at the nodes.
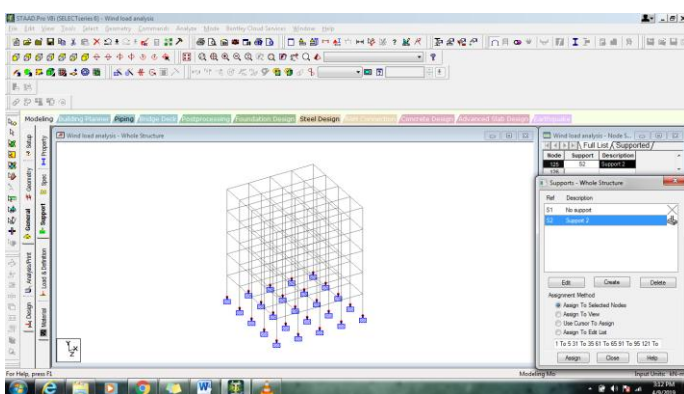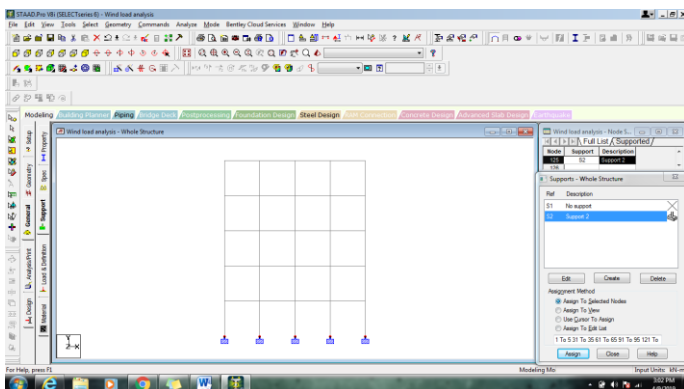
4.18 Next step for the building is to assign various loads that a building generally observes. As mentioned in chapter 1 we here are using Dead load, Live load and Wind load for our analysis. Although there are many other loads but for simplicity of our calculation we are zeroing to these 3 loads. So to assign the same **in** STAAD Pro click on "Loads & Definition" in left side of the screen.
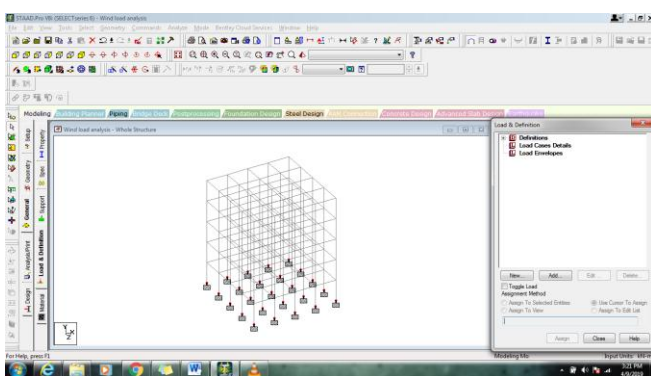
4.19 Select "Load cases Details" and click Add. In the load case dialog box select "Dead" in loading Type and name it as Dead load then click on "Add" and select next loading type as "Live" and name it as Live load. Click "Add". Similarly select "Wind" and name it as Wind load. Click "Add" and close.
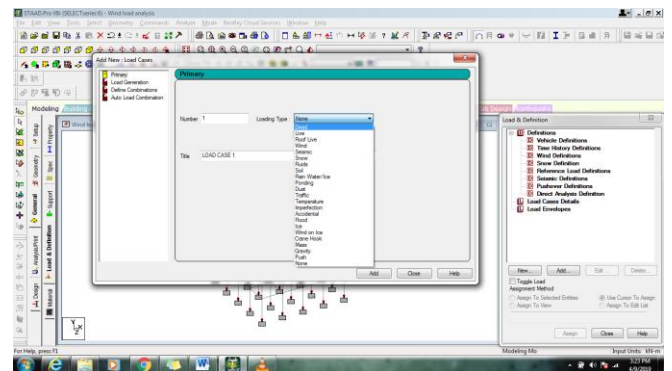
4.20 What we see on screen is the 3 loads added under Load case details. And now we have to assign values to these loads.
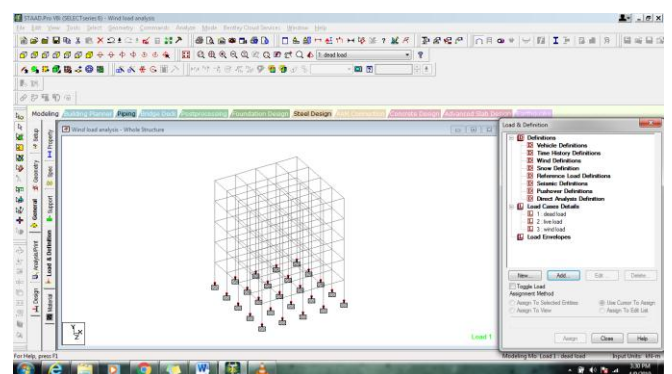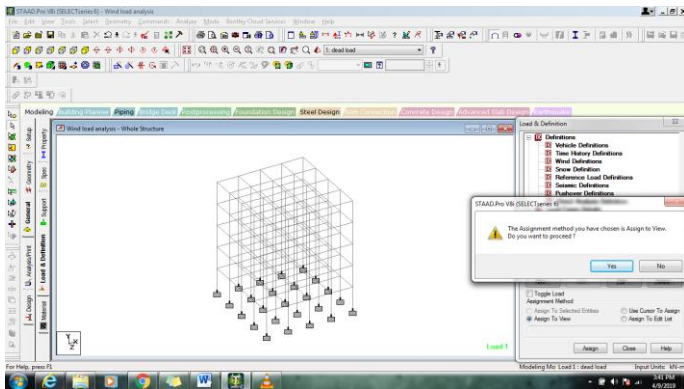

4.21 Assign factor 1 in downward direction i.e. -1 in negative Y direction.
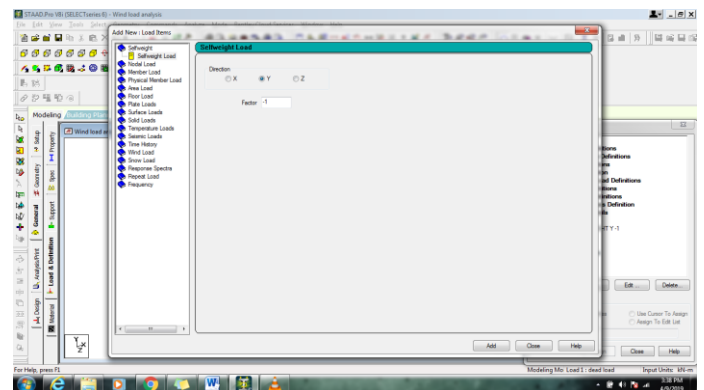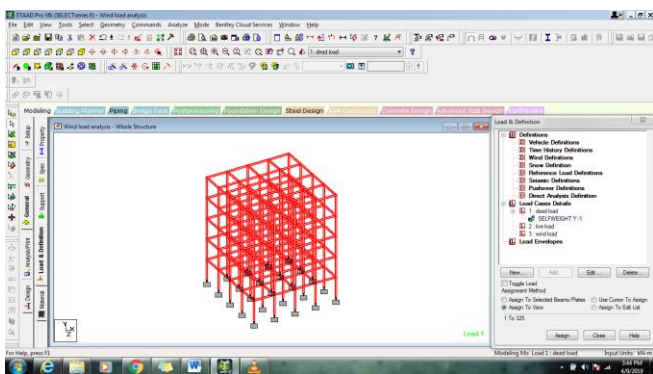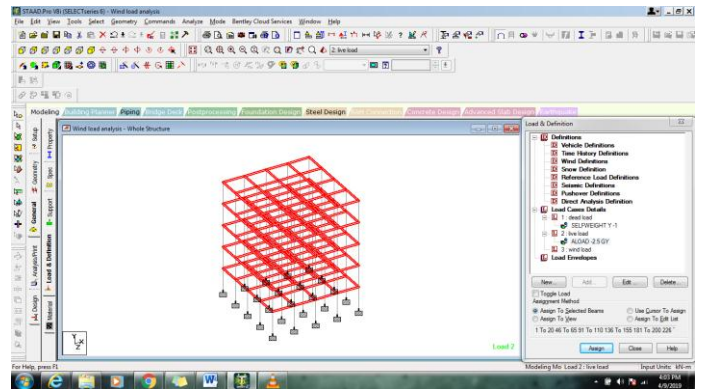

4.22 Click "Add" and "Close". Opt for "Assign to views".
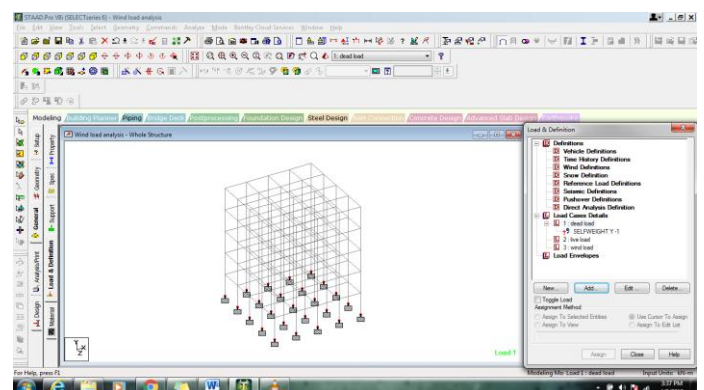
4.23 Click "Assign" and click "Yes"

4.24 For Live load click on "Add" Select area load and mention 2.5KN/m2 in negative Y direction. This includes all the loads that a building is considered to be facing in actual.
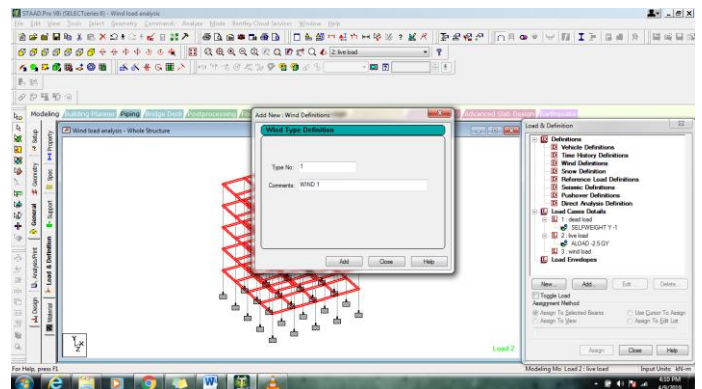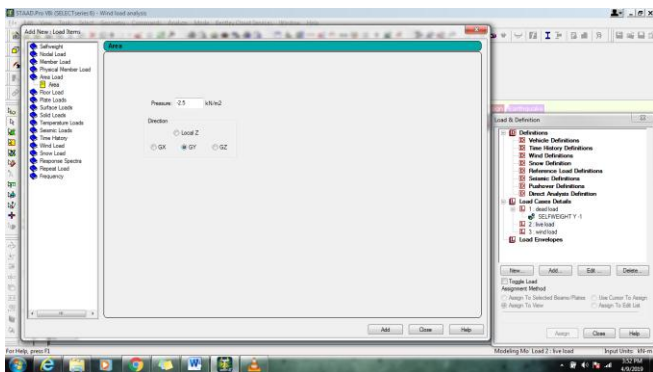

4.25 Click on "Close"

4.26 Select on ALOAD under Live load, select beams parallel to X & Z under select drop down list.Then opt for "Assign to selected beams" and click on "Assign"


4.27 Now for assigning wind load we have to first define the type of wind load our building is situated at. There are many standards that we consider while calculating the wind speed. We have Indian standards IS-875 (Part 3) -1987 or American standards ASCE-7 or Russian standards SNiP 2.01.07-2011 or SNiP 2.01.07-85. So click on wind definitions and click "Add".

4.28 Click on TYPE1 WIND 1 and click"Add". In Intensity dialog box select the standard from options given or fill the table if using Indian standards. In our case since our building is in Dubai ie Middle east si we are using American standard for wind intensity and so click on "calculate as per ASCE-7".
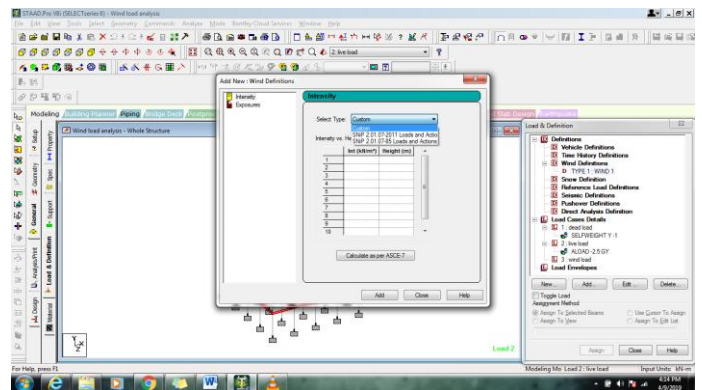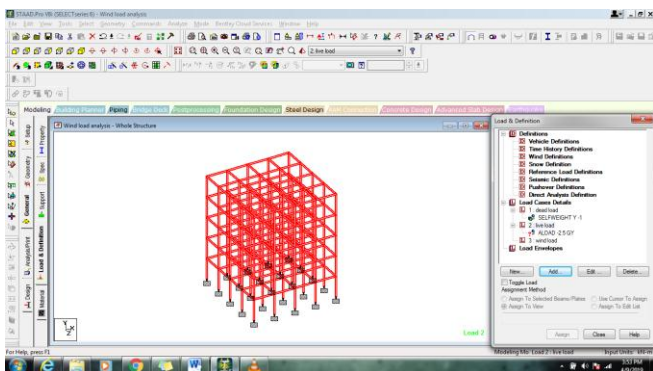
4.29 Click on "Ok" when dialog box appears for american standard.
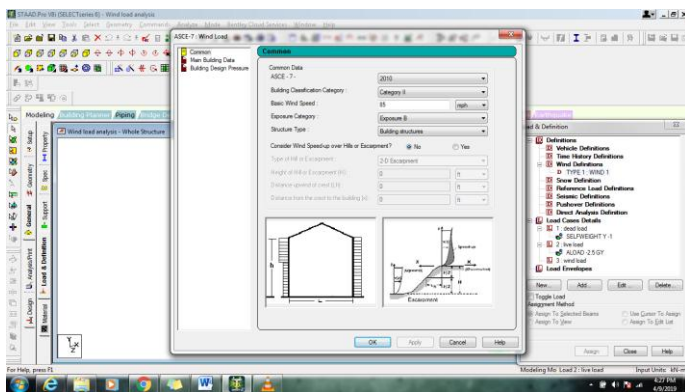
4.30 Table will be automatically filled with the wind intensity and different heights as per the standards. Click on "Add". Enter the factor value to 0.8 for 80% of wall occupancy(exposure). This factor specifies the percentage of area on a wall where wind will directly strike. Because there may be door and windows or refuge floors where wind will directly pass through the building.
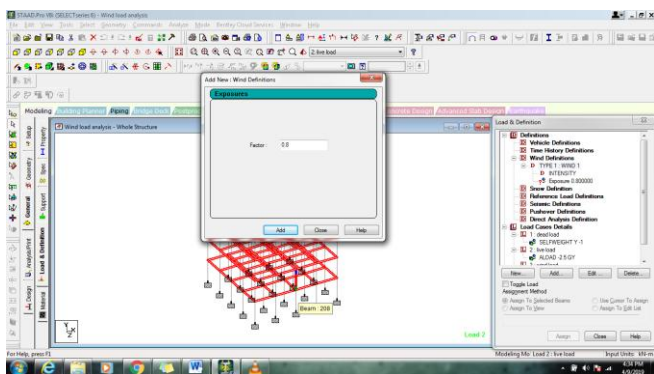

4.31 Click on "Assign" under TYPE1 WIND1. Click on "yes".
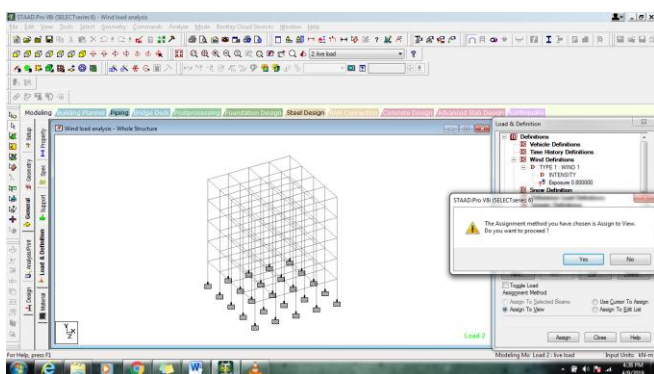
4.32 Click on Wind load and click "Add". A new dialog box appears. Click on wind load again. Since wind will flow in horizontal direction ie X & Z direction. Also considering all sides as windward face. For Y dierection i.e. height of the building (15m as per our consideration) we can keep the maximum range to 16m.
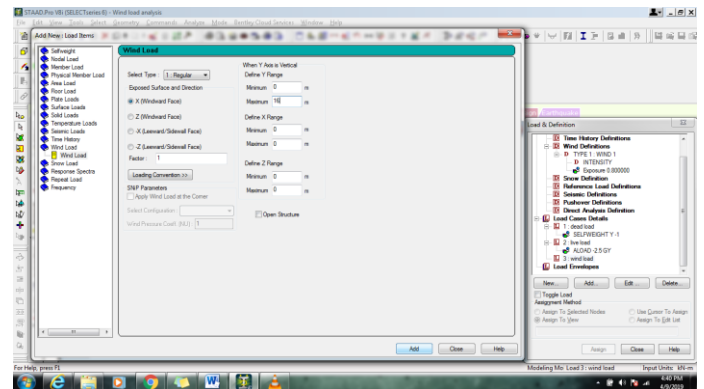

4.32 Considering 4 sides to a building, add all sides with the suitable parameters i.e. +ve X , +ve Z, -ve X and –ve Z. Thus we have screen as shown below.
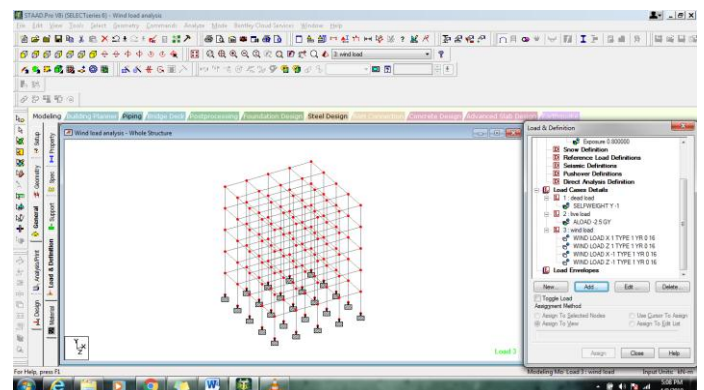

4.33 Applying wind loads from all sides we can start the analysis for the same and see what are the effect on the building with the wind load applied. Click on "Analysis/Print at left side of the screen. Click on "All" and Click on "Add".
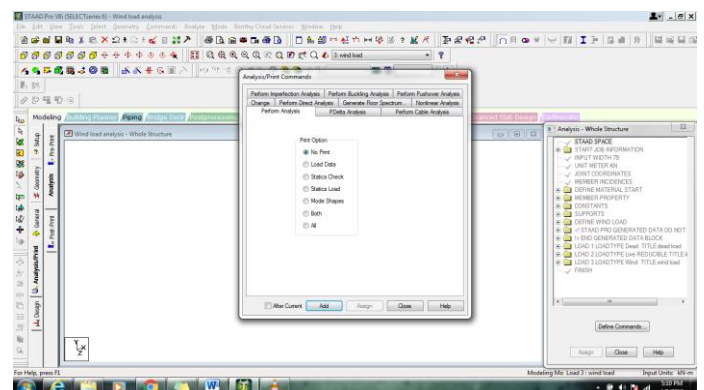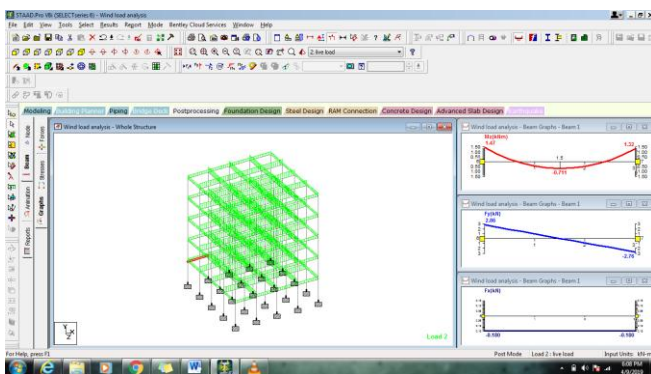
4.34 Click on "Run Analysis" from drop down list of "Analyze" on Top menu toolbar.
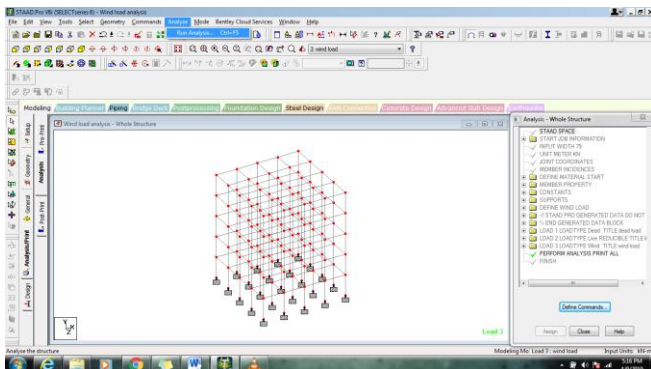

4.35 Report will be generated with few errors if any. This report gives all the details that we have considered while studying the building with applied loads.
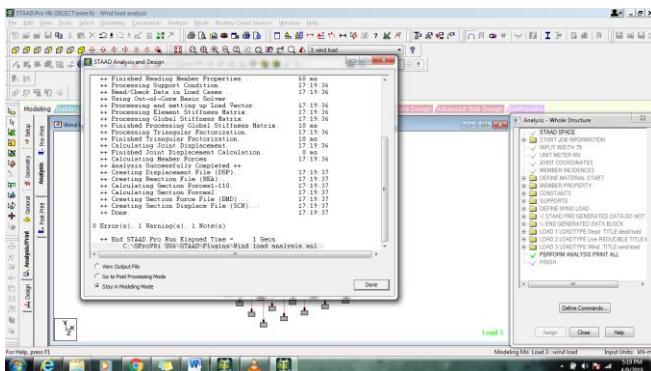
4.36 Results can be shown graphically as shown below.

Since we want to show the deflection of a building with the change in wind load so below are the graphical comparisons that will help us see and predict that building is safe or not.
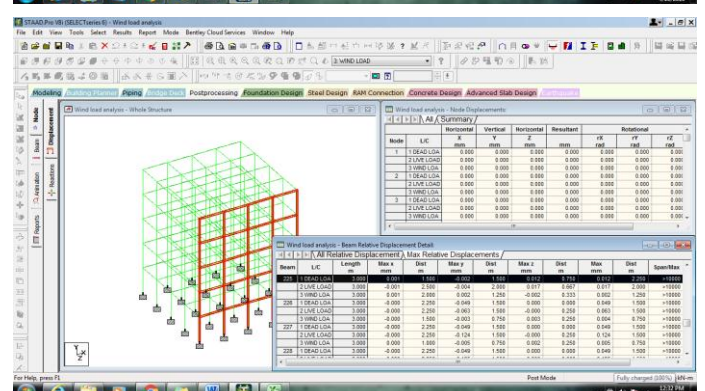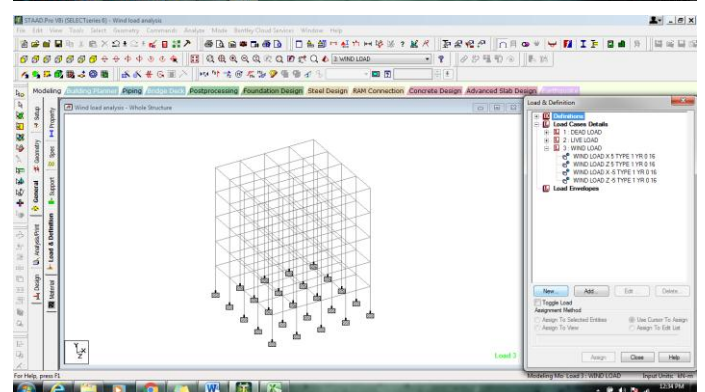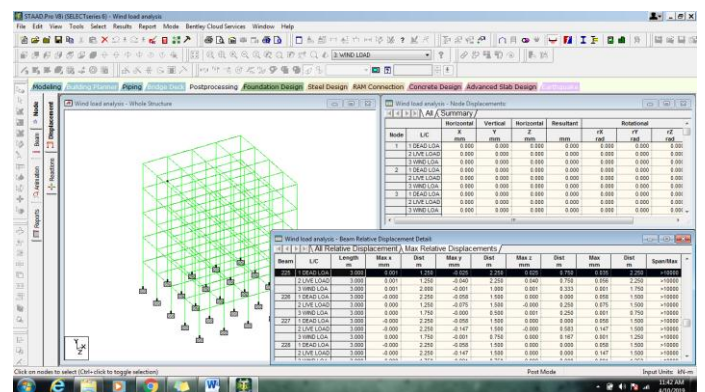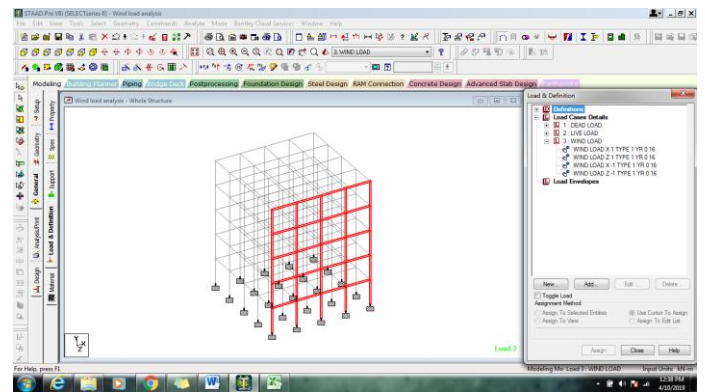
GRAPHICAL COMPARISON FOR DIFFERENT DESIGNS:-

Similarly for windload factor 1 and 5 graphs for moment and forces drastically change as shown in the below images.
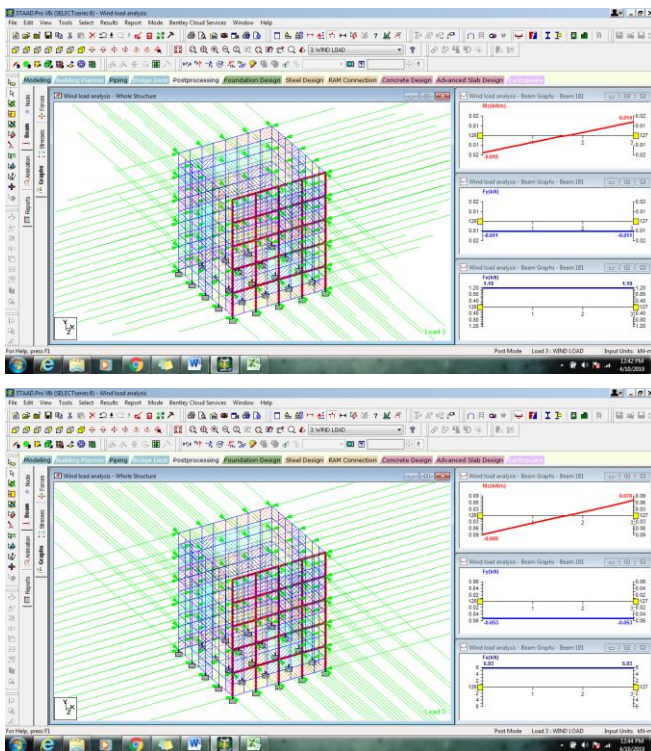
Engineering & Science (IJTIMES) Impact Factor: 3.45 (SJIF-2015), e-ISSN:2455-2585 Volume 4, Issue 02, February-2018

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CREDITS

5. CONCLUSIONS

1. Using software STAAD Pro for analyzing the deflection and stresses in a building can help anyone to check the stability of the building.

2. It helps in predicting the safety of the human before even erection of a building. Its user friendly and easy to operate.

3. Statics and graphs can help us to understand the changes happening with the change in the input parameters

4. By using the software we can well conclude that deflection increases with increase in the wind load on any building. It increases with even increase in height of the building and once we are aware with the negatives of the design then designer can change the design that will be economical and safe in all respect.

5. STAAD Pro can be a perfect tool for the building structure designs

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