Effect of Variation in Height of Roof Top Towers & Buildings on Lateral Load Analysis of the R.C.C Buildings

A Dissertation Submitted in Partial Fulfillment
for the Award of the Degree of

Master of Engineering
in
Civil Engineering (Structures)

Submitted by
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Candidate's Declaration Certificate

This is to declare that the minor project titled "**Effect of Variation height of Roof Top Towers & Building on Lateral Load Analysis of the R.C.C Buildings"** is the bonafide record of work done by me for the partial fulfillment of the requirements for the degree of Master of Engineering in Civil Engineering (Structural Engineering), Delhi College of Engineering.

This project has been carried out under the supervision of Dr. (Mrs.) P.R.Bose, Head of Deptt. and Shri Alok Verma, Lecturer, Delhi College of Engineering.

I have not submitted the matter embodied in this report for the award any other degree or diploma.

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This is to certify that the above statements made by the candidate are correct to the best of our knowledge.

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Abstract

Towers are important structural components used for various purposes in today's life. Communication and transmission line towers are widely used to transmit data and electricity respectively over long distances. Transmission line towers essentially rest on ground due to their large dimensions. Communication towers either rest on ground or are installed on the roof top of the buildings depending on the size of the tower and also on the availability of the space. The roof top communication towers are mainly used in metropolitan cities like Delhi where the space is available at a premium and the rapid expansion of the telecom network has necessitated their installation in large number. The advantage of a roof top tower is the utilization of the height of the building in covering a greater area. The close proximity of such towers permits them to be of small height up to 20 meters.

The common practice for analyzing roof top towers is to first analyze the tower as a separate structure and then transfer the forces generated in this tower to the building where it is to be installed. The wind forces in the tower are calculated by assuming it to be standing on the roof top. This report tries to differ in this approach by modeling the tower as a part of a three and a six storey building located in Delhi and compares the results with that of traditional methodology.

The position of a tower on the plan of the building is likely to affect the forces generated in the tower as well as in the building. This aspect can be studied by modeling the tower at different positions on the plan of the building and comparing various parameters like the time period of the combined system, forces and moments generated in the building and in the tower and the displacements at the locations where the tower is supported on to the building. Similarly the effect of the tower on the building will vary with increasing building height. This report analyzes this effect by repeating the numerical study for a four storeys, seven storey and ten storey building.

Objectives of the Project

The various objectives of this project report are listed below:

- To study the present state of art and state of practice for roof top communication towers by literature survey and by carrying out visits to various roof top tower.

- To study the Codes and guidelines applicable to such towers.

- To carry out a numerical analysis of roof top towers and study the following:

    - Effect of roof top towers on building forces when considered as a part of the building.
    - Effect of the position of the tower in the building plan on the forces in the building.
    - The effect of the roof top tower on building forces with increase in building height.
    - The effect of the roof top tower on building force with the decrease in tower height.
    - The effects of the roof top tower on building when consider wind load and seismic load.

- Comparing the results obtained from the two approaches of roof top tower design – one in which the without tower and other with tower is considered as a part of the building

- To suggest the scope of further study.

Chapter One

Literature Survey

Introduction

A tower can be defined as a vertical structure, which is generally more vertical than linear. In communications, the term refers to a structure, which supports antennae. In other words, it is a tall skeleton structure with relatively small cross-section, which has a large ratio between height and maximum width. It is a freely standing self supporting structure fixed to the base or foundation. Following paragraphs deal with the theoretical part of the various literature including types of towers, various types of bracing configurations, loadings on the towers .

Classification

Towers (short, medium, tall) are mostly used for bridges, communications systems, electric power transmission, distribution networks, overhead tanks etc.

Towers are mainly of two types:

1. guyed towers
2. self-supporting towers

The towers have vertical or inclined trusses for the sides while the cross-section of the tower in the plan is either a triangle, rectangle a regular polygon. Such towers are also called lattice towers. Free-standing towers act as cantilever trusses in carrying the wind and seismic loads. These towers demand more steel but less base area and are suitable in many situations. Most of the TV, MW, power transmission, flood light towers are free standing towers.

The guyed towers are supported by guy wires which transmit the wind loads to the ground. These towers are much lighter than the free standing type but require a large free space to anchor guy wires.

Moments due to wind loads is quite large in self-supporting towers which behaved as cantilever whereas the moments are small in guyed towers whose behavior is like a continuous beam on elastic supports.

The characteristics of tower types can be summarized as below.

Characteristics of Self Supporting (SS) Towers, Guyed Towers and Monopoles

A. Self-Supporting Lattice Towers
- Three or four sided (mostly three)
- Requires less land area compared to guyed towers
- Moderate cost to build, excluding real estate
- Can be built as high as ~ 1,000 feet
- Can be modified after construction
- Aesthetically, considered less pleasing

B. Guyed Towers
- Slender column supported by guy cables
- Requires a relatively large land area to place guys and anchors (guy radius ~ 40-80% of tower height)
- Least costly tower to build, excluding real estate
- Can be built as high as ~2,000 feet
- Tend to be used primarily by Broadcast industry (radio and TV)
- Most easily modified

C. Monopoles
- Tubular, free-standing, tapered (stepped or continuous) structure
- Requires less land area compared to other towers
- Foundation is significant
- Most costly, excluding real estate
- Tend to be deployed in urban areas

- Can be built as high as ~ 250 feet
- Nearly impossible to modify
- Not as rigid -- top deflection may be a problem

Based on the placement of tower, communication towers can be classified in to the following two groups:

• Green Field Tower

• Roof Top Tower

If the tower is erected on the natural ground after excavation of soil and provided with suitable foundation system then this tower is called Green Field Tower. Similarly if the tower is erected on the existing building by raising the existing columns and provided with tie beams as foundation in between the columns, it is called Roof Top Tower.

The height of roof top tower varies generally from 9m to 30m where as the height of green field communication tower varies from 30m to 200m depending on the line of sight required. Green field towers are preferable in rural areas where land is available and in urban areas most of the towers are of roof top as it is difficult to acquire open land for green field towers. Roof top towers are more economical as compared to Green field towers as the height of building is utilized in reducing the height of tower required.

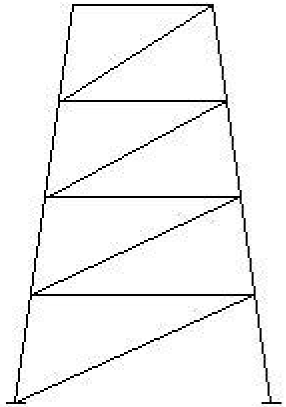
This report deals with the self-supporting lattice towers only. Before discussing the design methodology, it is necessary to mention the configurations of lattice towers, various loads acting on the towers and the Codes to be followed for their design.

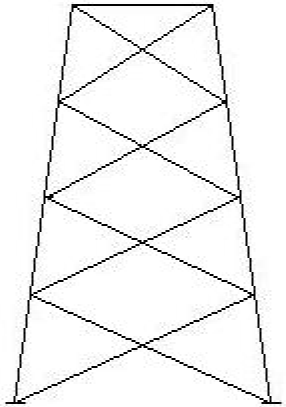
Lattice Tower Configurations and Bracings

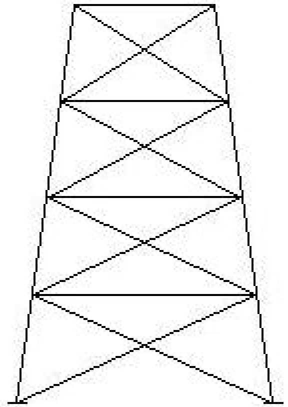
The corner vertical or nearly vertical members of the towers are called legs or column members and they are the main load bearing elements. The leg members are interconnected by bracings with or without horizontals with carry a nominal force. The leg and bracing members will be under compression in some load conditions therefore the slenderness ratio of the members' plays important role.

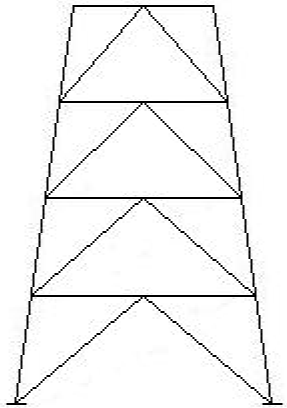
The various types of bracings used in towers are as mentioned below:

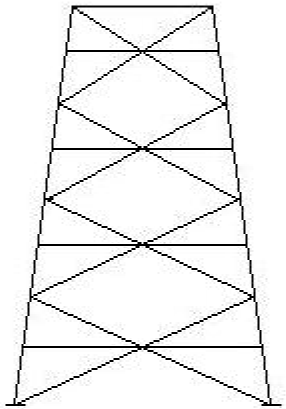
1. Single diagonal bracings: This is the simplest form of bracing. The wind shear at any level is shared by the single diagonal of the panel. Such bracing is used for towers up to 30 m height.
2. X-X bracing: This is a double diagonal system without horizontal bracing, and used for towers up to 50 m height. It is a statically determinate structure.
3. X-B bracing: This is a double diagonal system with horizontal bracings. Such bracings are quite rigid, and may be used for towers up to 50 m height. The structure is statically indeterminate. The horizontal members are redundant members and carry only nominal stresses.
4. K-bracing: Such a bracing gives large head room, and hence K-bracing can be used in lower panels where large head room is required. The structure is statically determinate. Such bracing can be used for towers of 50 to 200 m height.
5. X B X bracing: This is a combination of XX and XB bracing where horizontal members are provided only at the level of crossing of diagonals. The structure is statically indeterminate. However, the length of the diagonal is reduced. Such bracing can be used for towers of 50 to 200 m height.
6. W-bracing: This system uses a number of overlapping diagonals. The system is statically indeterminate. However, the effective length of diagonals is reduced and the system is quite rigid.
7. Y-bracing: This system gives larger headroom and can be used for lower panels. It is statically determinate.
8. Arch bracing: Such a bracing can be adopted for wider panels. This system also provides greater headroom and is statically determinate.

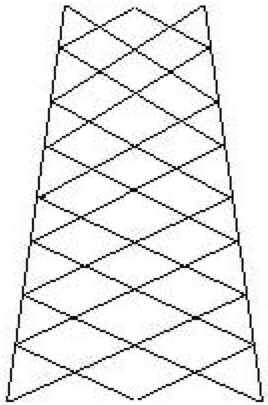

Single Diagonal Bracing

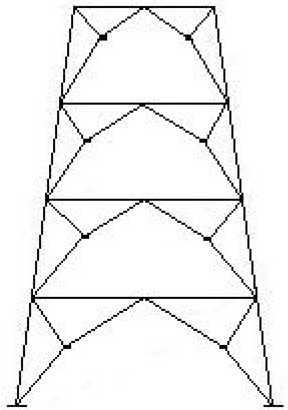

Double Diagonal X-X Bracing

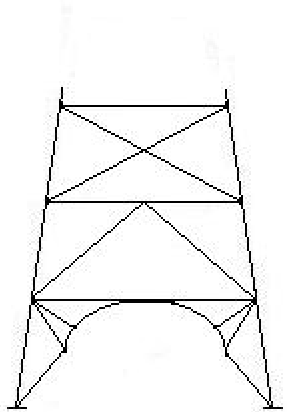

X-B Bracing


K - Bracing


XBX Bracing


W Bracing


Y Bracing


Arch Bracing

Lattice Tower Loading

The towers are invariably analyzed as trusses, the loads are applied at joints and members are designed as either ties or as struts. The loads on the tower consist of the following:

1. Member weights.
2. Platform and railing weights.
3. Antennae weights.
4. Ladder and lift loads.
5. Gusset and secondary bracings.
6. Wind load.
7. Seismic loads.
8. Lifting or hoisting loads.
9. Dynamic effects.
10. Erection loads.
11. Live loads.

The first five sets of loads are fixed type of which member weights are structural design dependents while the rest are based on functional aspect. Wind and seismic loads are the most important of all and often control the design. The seismic load may not be critical as the mass of the structure is not heavy and near the ground. The criticality of the wind or seismic effects has to be examined. Dynamic effects due to wind become critical in slender and tall towers. In most cases of towers up to 100 m height, the dynamic effect may not control the design. Live loads on towers are negligible when compared with the other loads.

Since wind loads affect the tower design the most, hence it is necessary to cover them in detail. In case of roof top towers, seismic loads are also crucial as the collapse of towers during earthquake can cause severe damages to the surroundings. The discussion on seismic loads is done after the wind loads.

Wind Loads

Wind is the air in motion relative to the surface of the earth. Since the vertical components of atmospheric motion are relatively small, especially near the surface of the earth, the term 'wind' denotes almost exclusively to horizontal wind. *Wind pressure*, therefore, acts horizontally on the exposed vertical surfaces of walls, columns, chimneys, towers etc. and inclined roof surfaces.

All exposed structures are affected to some degree by wind forces. The liability of a structure to high wind pressures depends not only upon the geographical location and proximity of the obstructions to air flow but also upon the characteristics of the structure itself.

Design Wind Speed as per IS: 875 -1987

The design wind speed V_z is obtained by multiplying the basic wind speed (V_b) by the factors k_1, k_2 and k_3.

$V_z = V_b * k_1 * k_2 * k_3$

Where

V_b = the basic wind speed in m/s at 10 m height

k_1 = probability factor (or risk coefficient)

k_2 = terrain, height and structure size factor

k_3 = topography factor

Basic Wind Speed

For basic wind speed, India has been divided into six zones. The map given in the Code gives the basic wind speed for some important cities/towns.

Probability factor k_1

Basic wind speeds given in the map have been worked out for 50 years return period. The *design life* of structure is based on the functional aspect as well as the importance of the structure. The factor k_1 is based on statistical concepts which take account of the degree of reliability required and period of time in years during which there will be exposure to wind, that is life of the structure.

The Code has tabulated the values of k_1 on the basis of class of structure and the basic wind speed.

Terrain, height and structure size factor k_2

This factor takes into account terrain roughness, height and size of structure.

Terrain categories: Selection of terrain categories is made with due regard to the effect of obstructions which constitute the ground surface roughness. The terrain on which specific structure stands is grouped under *four* categories.

Category 1: This represents exposed open terrain with few or no obstructions and in which the average height of any object surrounding the structure is less than 1.5 m. This includes open sea coasts and flat treeless plains.

Category 2: This represents open terrain with well scattered obstructions having height generally between 1.5 to 10 m. This includes air fields, open park lands and underdeveloped sparsely built-up outskirts of towns and suburbs.

Category 3: This represents terrain with numerous closely spaced obstructions having size of building structures up to 10 m in height with or without a few isolated tall structures. This category includes well wooded areas, shrubs, towns and industrial areas fully or partially developed.

Category 4: This represents terrain with numerous large high closely spaced obstructions. This category includes large city centers, generally with obstructions above 25 m and well developed industrial areas.

Structure Size: Buildings or structures are classified into the following three different classes depending upon on their size (that is, greater horizontal or vertical dimension).

Class A: Structures having maximum dimension less than 20 m.

Class B: Structures having maximum dimension between 20 m and 50 m.

Class C: Structures having maximum dimension more than 50 m.

Height:

The design wind speed is a function of height at which the design wind speed is being computed. It should be noted that for a given structure, out of the three factors k_1 , k_2 and k_3 , factors k_1 and k_3 are fixed depending on the zone, life of structure, terrain category and class of structure while factor k_2 varies with the *height of the element* (of the structure) at which the design wind speed is being computed.

Topography factor k_3

The basic wind speed takes into account the general level of site above sea level. This does not allow for allow for local topographic features such as hills, valleys, cliffs, or ridges which can significantly affect wind speed in their vicinity. The effect of topography is to accelerate wind near the summits of hills or crests of cliffs and decelerate the wind in valleys or near the foot of cliffs, steep escarpments or ridges.

The effect of topography will be significant at a site when the upwind slope is greater than about 3^0 and below that, the value of k_3 may be taken equal to 1.0.

Design Wind Pressure

The design wind pressure at any height above mean ground level is given by:

$$p_z = 0.6 * V_z^2$$

where p_z = design wind pressure in N/m^2 at height z.

The total wind load on the structure is given by:

$F = C_f * A_e * p_z$

Where F = wind force acting in a direction specified.

A_e = effective frontal area of the structure.

p_z = design wind pressure

C_f = force coefficient for the structure.

In case of towers, it depends upon the solidity ratio φ of the tower.

Φ = solidity ratio = obstruction area of front face/gross area of front face

For towers, φ varies from 0.15 to 0.3, and is to be assumed in the beginning of the design. After designing the members, the assumed solidity ratio is compared with the actual solidity ratio to test the adequacy of the structure.

Tower Appurtenances: The wind load on Tower Appurtenances such as ladders, conduits, lights, elevators etc. shall be calculated using appropriate net pressure coefficients for these elements. Allowance may be made for shielding effect from other elements.

Tower mountings: The pressure on antennae mountings can be computed by suitably selecting pressure coefficients.

Seismic Loads

The seismic load analysis in our country is done in accordance with IS: 1893-2002. The Part I of the code deals with the criteria for design of earthquake resistant buildings. The seismic load analysis of towers is done on the basis of this Code by treating the tower as an appendage to the building. Since the collapse of tower due to an earthquake can be of severe damage to the surroundings, the code stipulates stringent provisions in this regard.

For vertical projections such as towers, the horizontal seismic coefficient has to be the five times the basic seismic factor specified for that zone. However, this increased coefficient is only for designing the projection part and for designing their connection with the main structure.

The horizontal base shear V_B as per IS 1893-2002 is given by

$$V_B = A_h * W$$

where

A_h = design horizontal seismic coefficient

W = effective weight of the structure

The design horizontal seismic coefficient A_h for a structure shall be determined by the following expression:

$$A_h = \frac{Z\, I\, S_a}{2\, R\, g} \qquad (1)$$

where,

Z = zone factor as given in table below.
I = importance factor
R = Response Reduction factor
S_a / g = Average response acceleration coefficient for rock or soil sites as given by the figure below.

Seismic Zone	II	III	IV	V
Intensity	Low	Moderate	Severe	Very Severe
Z	0.1	0.16	0.24	0.36

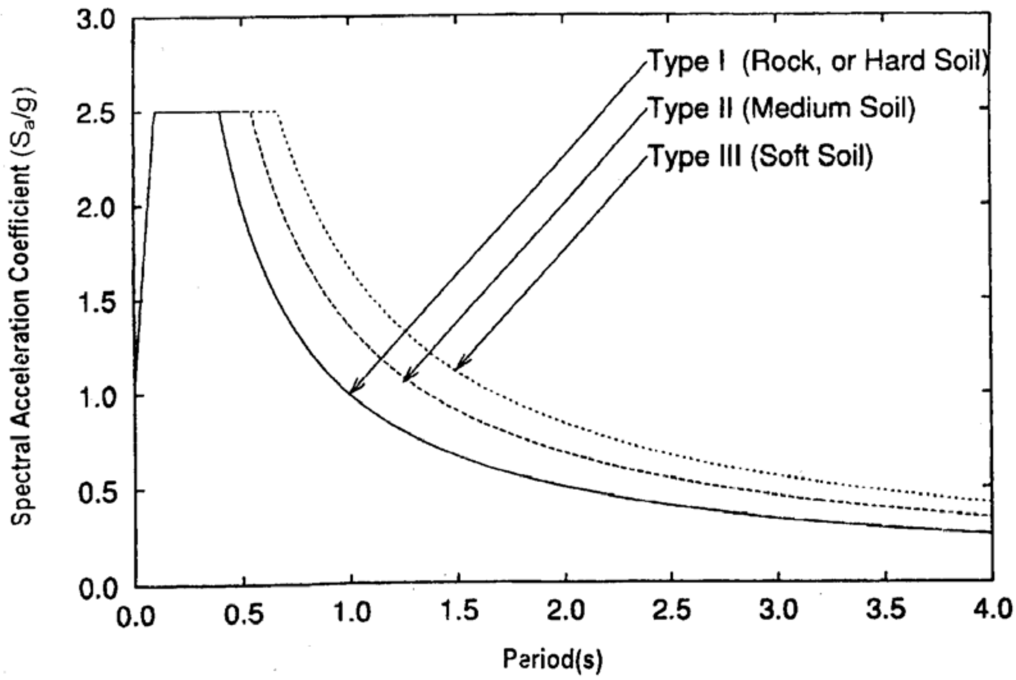


Figure giving Response Spectra for 5% damping

The code specifies two methods for calculating design seismic force and its distribution to different levels along the height of the structure. These methods are namely static and dynamic analysis. Since this report does the dynamic analysis by the response spectrum method, this method is discussed below.
According to this method:
Design lateral force at each floor in each mode is given by

$$Q_{ik} = A_K * \Phi_{ik} * P_K * W_i$$

where,

A_k = Design horizontal acceleration spectrum value as per (1) using the natural period of vibration (T_K) of mode k.

Φ_{ik} = Mode shape coefficient at floor I in mode k.

W_i = seismic weight of floor i.

P_K = modal participation factor of mode k.

The base shear is obtained by adding the design lateral force at each floor starting from the top storey. The peak storey shear force in storey i due to all modes considered is obtained by combining those due to each mode as per Complete Quadratic Combination method.

Codes for Tower Design

The following Codes are generally used for analyzing & designing of towers globally.

1. **ANSI/TIA/EIA-222-F-1996**: is a set of American standards published by the Telecommunications Industry Association Standards and Technology Department.
2. **IS 802:** Use of structural steel in overhead transmission line towers – code of practice (Part 1 – Material Loads and Permissible stresses).
3. **BS 8100:** British design code for Lattice Towers and Masts.
4. **IS 875 -1987:** Code of Practice for Design Loads (other than earthquake) for Buildings and structures (Part 3) Wind Loads.
5. **IS 1893 -1984:** Criteria for Earthquake Resistant Design of Structures (Part 1) General Provisions And Buildings
6. **IS 800-1984:** of Practice for General Construction in Steel.

Planning a tower project

The planning of a tower project is a challenging task. The structural engineer's skills are tested to provide an economical configuration. The process can be divided into the following two categories for convenience

1. **Site Considerations**

- Detailed topography analysis
- Soil surface and sub-surface analysis
- Site and foundation engineering
- Wind and weather conditions analysis
- Structural analysis and integrity
- Long-range viability and maintenance
- Materials requirements

2. **Tower Considerations**

- Height of the tower
- Space available for installation of tower
- Type of building available
- Type of tower & facilities required
  - a) Ladder or step bolts
  - b) Cable tray for supporting cables
  - c) Safety Cage for the ladder
  - d) Levels of platforms required
  - e) Size of platform required at each level
  - f) Finish of tower- hot dip galvanized with painting or without painting
  - g) Aviation Obstruction Light

Information Required

1. Height of the tower: The cost of a tower varies exponentially with the height of the tower, that is, when the tower height is doubled, the cost of the tower is much more than 2 times. Moreover, if the height of the tower is less than what is required by "Line Of Sight" considerations, then the communication will be erratic and very purpose of installing a tower is defeated

2. Space available for installation of tower: In highly populated cities, the real estate is at a very high premium. The space available may be able to take a narrow base tower only. If high rise buildings exist adjacent to tower installation site, then foundation design will need special considerations.

3. Type of building available: If it is desired that the tower be installed on roof top, then complete details of building structure, i.e. spacing of columns, beam sizes, reinforcements, slab details, height of each floor, etc are required to ascertain, whether building is structurally suitable to take the load of the tower & the load generated due to wind on tower. If tower is to be installed on ground, then information about the soil i.e. soil condition, water table height etc will be required.

4. Type of tower & facilities required: what is required-triangular tower or a square tower? You may need a circular or octagonal platform at top. If your antenna system has space diversity requirement, then that must be specified. The tower is normally constructed from angles or pipes & plates with bolted construction. If welded or any other type of construction is required, then that should be specified.

5. Wind Speed, which the tower will be required to withstand.

6. Loads on the tower: information like the number of antennae, physical sizes thereof and the height of installation, future requirement of antennae and other equipment load likely to be put on tower is required

7.Permissible limits of twist & sway in tower in operational wind

The performance of a communication antenna in wind conditions depends on the twist and sway of the antenna, directivity of the antenna, and the spare capacity of signal strength in the system design. Typically a value of 1 degree is acceptable. If lesser value is desired, then that should be specified.

Chapter Two

General Methodology for Roof Top Tower Analysis

The following paragraph discusses the general method followed for the analysis of the roof top towers, that is, the steps to be followed for calculating the forces in the given tower configuration for the loads as applicable.

Analysis of Roof top Lattice Towers

1. Wind Load Analysis

The following steps are generally involved:

1. The wind pressure is calculated at the top horizontal member of each panel. While designing the roof top tower, the height of building should be considered in calculating Gust Response Factors (GRF).
2. The force thus calculated (explained below) is applied at the nodes (joints) by equally dividing the force calculated.
3. The wind forces on the ladder, cable racks, antennae and its mountings should be calculated and applied to the respective nodes.
4. Since wind can change its direction, hence the loads are to be applied in the opposite direction also.
5. In case of square towers, the diagonal wind is to be resolved in two mutually perpendicular directions and then applied to the nodes.
6. The combinations of dead load and the wind loads give the forces in each member and the maximum of the force obtained is used to check the adequacy of that member.
7. A factor of safety of 1.2 is usually considered sufficient.

The calculation of force coefficient forms the most important part of analysis. This requires the calculation of solidity ratio, which is the ratio of net effective area of a panel to the total area of the panel.

The force coefficient used for wind load calculations depends on the solidity ratio. The table below shows the variation of force coefficient on solidity ratio.

Solidity Ratio Φ	Tower Base		$DV_z < 6$ m/s		$DV_z > 6$ m/s	
	Square	Triangular	Face	Corner	Face	Corner
0.05	4.0	3.3	2.4	2.5	1.1	1.2
0.1	3.8	3.1	2.2	2.3	1.2	1.3
0.2	3.3	2.7	1.9	2.1	1.3	1.6
0.3	2.8	2.3	1.7	1.9	1.4	1.6
0.4	2.3	1.9	1.6	1.9	1.4	1.6
0.5	2.1	1.5	1.4	1.9	1.4	1.6

The coefficients are to be multiplied by 1.2 for square sided towers for wind blowing on corners.

D = diameter of rounded members in meters

V_z = wind velocity in m/s

After the calculation of solidity ratio, the force coefficient is calculated by interpolation if required so. Thus the force on the panel is calculated and distributed to the nodes as explained earlier.

2. <u>Seismic Load Analysis</u>

The effect of seismic forces on the towers can be analyzed either by the static method or by the dynamic analysis. The fundamental difference between the two methods lies in their approach of calculation of the design seismic force and its distribution to different levels along the height of the structure.

The numerical problem in this report has been analyzed using the Response Spectrum Method. The design spectrum, as given by clause 6.4.2 of IS: 1893-2002, has been used to calculate the design horizontal acceleration spectrum value i.e. $A_{h.}$

Since towers are like appendages to the building on which they are installed, they are subjected to larger motions than the building itself. Therefore the Code stipulates stringent provisions for their design. For vertical projections such as

towers, the horizontal seismic coefficient has to be the five times the basic seismic factor specified for that zone. However, this increase
coefficient is only for designing the projection part and for designing their connection with the main structure.

The horizontal base shear V_B as per IS 1893-2002 is given by

$$V_B = A_h * W$$

where,

A_h = design horizontal seismic coefficient

W = effective weight of the structure

In practice, the roof top towers can be analyzed for seismic forces in two ways. First, they can be assumed to be rested on ground and are analyzed for the seismic loads. The support reactions so obtained are then transferred to the roof of the building where the tower is supposed to be installed. The building is then analyzed with this increased load to check any possible failure. Second method of analyzing the roof top towers for seismic loads is to model the tower along with the building and analyze the whole structure as one unit. This report tries to study the differences in the time period, forces generated in the building due these to approaches.

The forces and reactions obtained by the STAAD analysis are used for designing the individual members, connections, base plate and anchor bolts.

Stiffness Analysis

The stiffness analysis implemented in STAAD is based on the matrix displacement method. In the matrix analysis of structures by the displacement method, the structure is first idealized into an assembly of discrete structural components (frame members or finite elements). Each component has an assumed form of displacement in a manner which satisfies the force equilibrium and displacement compatibility at the joints.

Assumptions of the Analysis

For a complete analysis of the structure, the necessary matrices are generated on the basis of the following assumptions:

1. The structure is idealized into an assembly of beam, plate and solid type elements joined together at their vertices (nodes). The assemblage is loaded and reacted by concentrated loads acting at the nodes. These loads may be both forces and moments which may act in any specified direction.
2. A beam member is a longitudinal structural member having a constant, doubly symmetric or near-doubly symmetric cross section along its length. Beam members always carry axial forces. They may also be subjected to shear and bending in two arbitrary perpendicular planes, and they may also be subjected to torsion.
3. Internal and external loads acting on each node are in equilibrium. If tensional or bending properties are defined for any member, six degrees of freedom are considered at each node (i.e. three translational and three rotational) in the generation of relevant matrices. If the member is defined as truss member (i.e. carrying only axial forces) then only the three degrees (translational) of freedom are considered at each node.
4. Two types of coordinate systems are used in the generation of the required matrices and are referred to as local and global system

Chapter Three

Numerical Study

In this report, 3 roof top communication towers have been analyses – in a set of same position on plan of a four storey building (12 meters high), a seven storey building (21 meters high)and a ten storey building (30 meter height). All the towers are of 12 m height, 15 m height and 18m height loaded with same number and type of antennae (4 GSM Antennae 0.262m X 1.58m). They are located in same wind zone having basic wind speed of 47 m/s and in seismic zone IV. The bracing configuration of the towers is same for all of them. All the towers are of square plan are fabricated using standard steel angles available in the market.

The towers are first analyzed as separate structures and the reactions so obtained are transferred to the building. As a second approach, they are analyzed as a part of the building itself for the wind as well as the seismic loads. The results obtained from two approaches have been compared. The data used in the numerical study is given below:

Tower Data

Height of Tower	**=**	**12 m , 15m and 18m**
Base width of tower	**=**	**2.5 m**
Top width of tower	**=**	**1.5 m, 1.2m and 1.0m**
Panel heights	**=**	**1 panel of 4 m height.** **4 panels each of 1.5 m height.** **1 panel of 5m height.** **4 panels each of 2.5m height.**
Plan Shape of tower	**=**	**Square.**
Structural Steel type	**=**	**Angles.**
Antenna particulars	**=**	**4 no. GSM Antenna at top.** **0.262 m X 1.58 m**

Building Data

Number of Storeys	**=**	**4m, 7m and 10 m**

Height of the building	**=**	**12m, 21 and 30m**
Length of the building	**=**	**11.7 m**
Width of the building	**=**	**18.2 m**
Column size	**=**	**0.45 m X 0.45 m**
Beam size	**=**	**0.23 m X 0.5 m**
Concrete Grade used	**=**	**M30**
Steel Grade used	**=**	**Fe 415**

Wind Data

Basic wind speed	**=**	**47 m/s (City: Delhi)**
Terrain Category	**=**	**2 (as per IS: 875-1987)**
Class of structure	**=**	**B**

Seismic Data

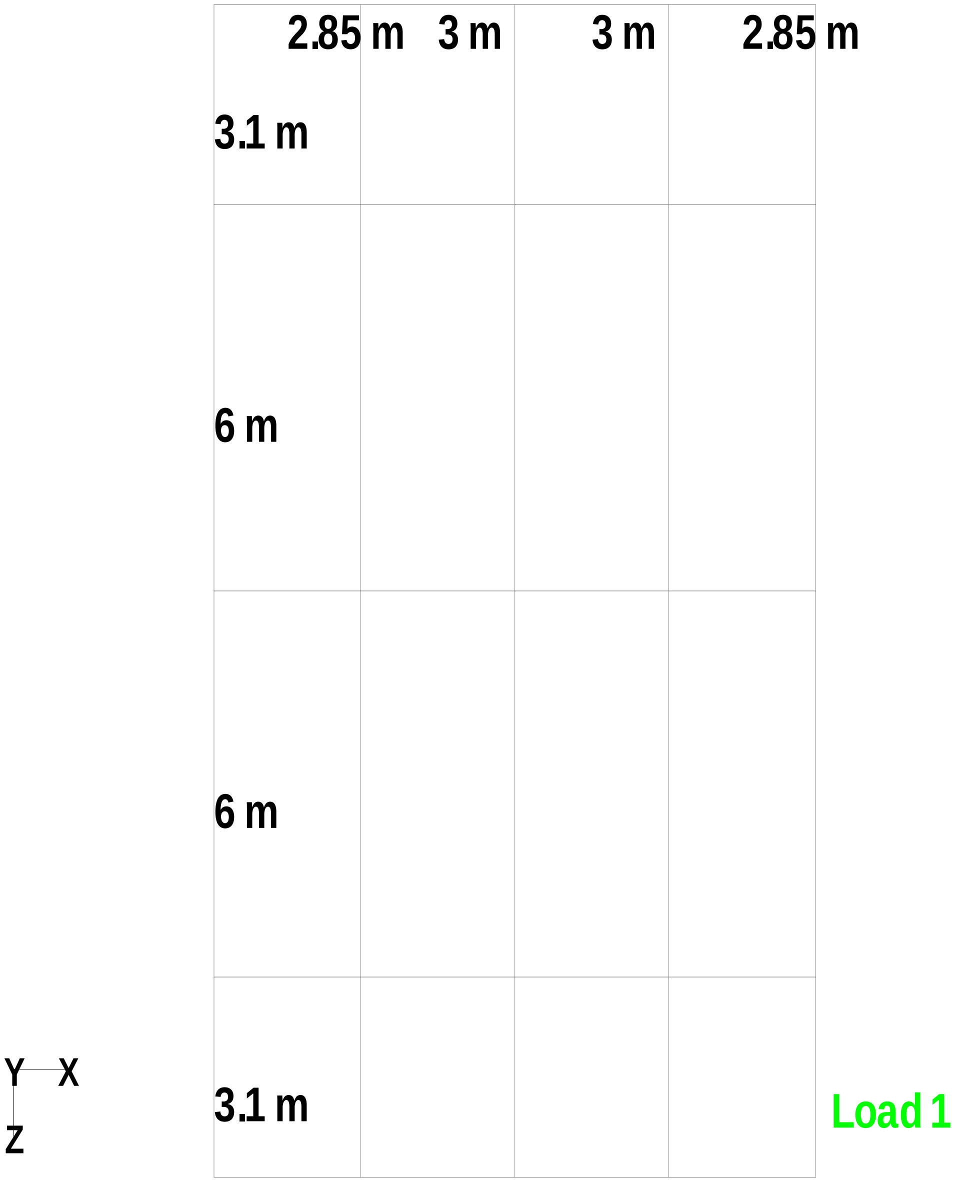
Seismic Zone	**=**	**IV**
Soil type	**=**	**Medium Soil**

The building along with the tower has been analyzed for the following load combinations.

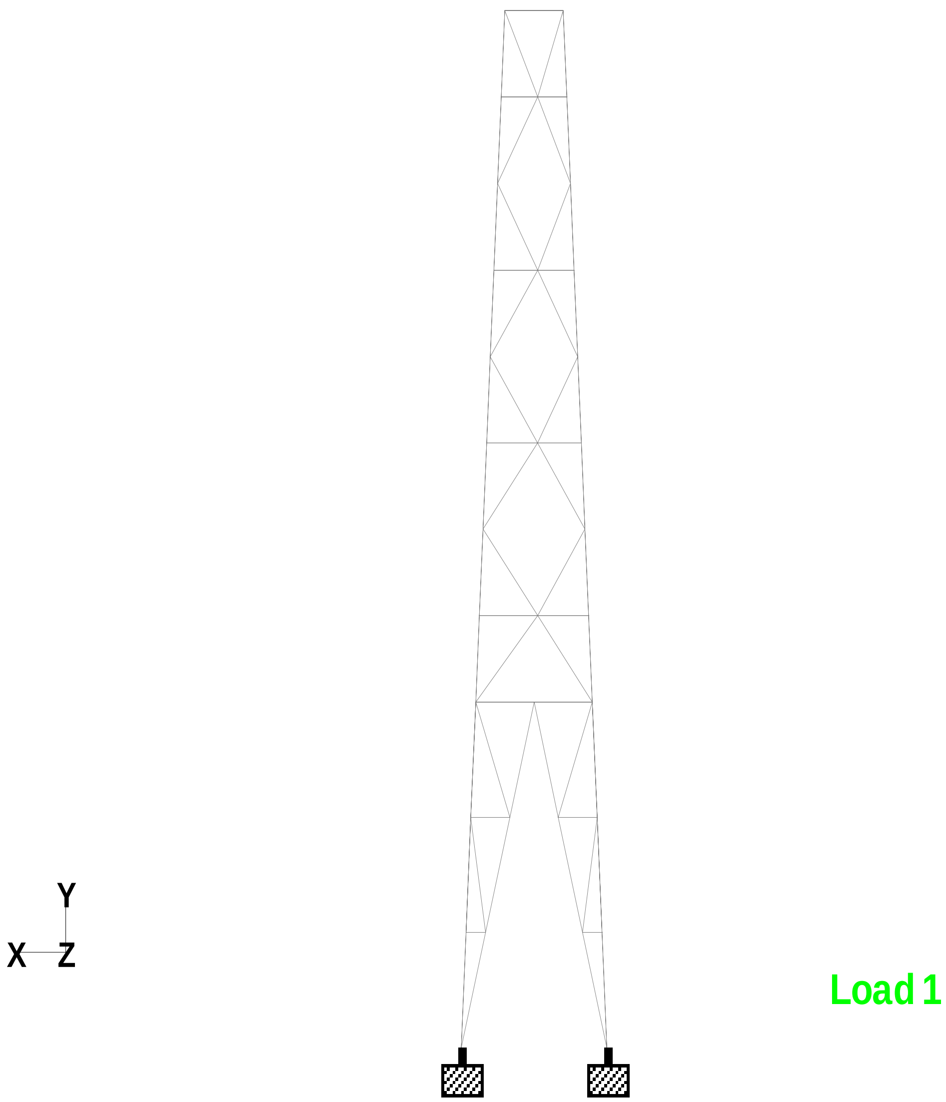
- **Dead Load + Imposed Load.**
- **Dead Load + Imposed Load ± Earthquake Load.**
- **Dead Load ± Earthquake Load.**
- **Dead Load + Imposed Load ± Wind Load.**
- **Dead Load ± Wind Load.**

The characteristics of wind mentioned in IS: 875 (Part-3)-1987 are taken for computing wind loads whereas the seismic analysis has been carried in accordance to the IS: 1893 (Part-1)-2002.

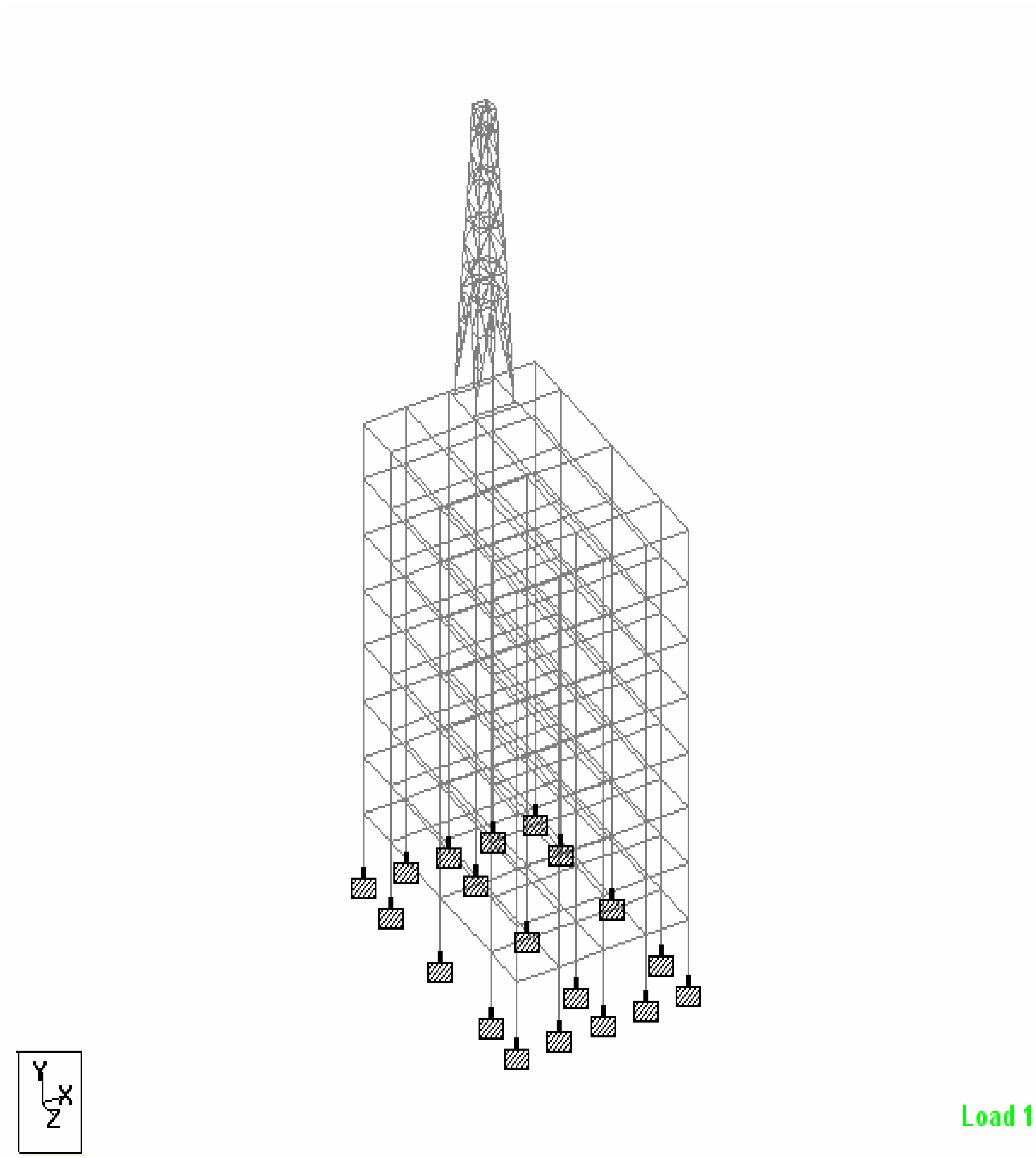
The building plan and the four locations of towers on the building plan are given below The calculation of wind load on the buildings and on various tower panels follows the plan drawingThe different results obtained are tabulated and discussed after the tabulation.



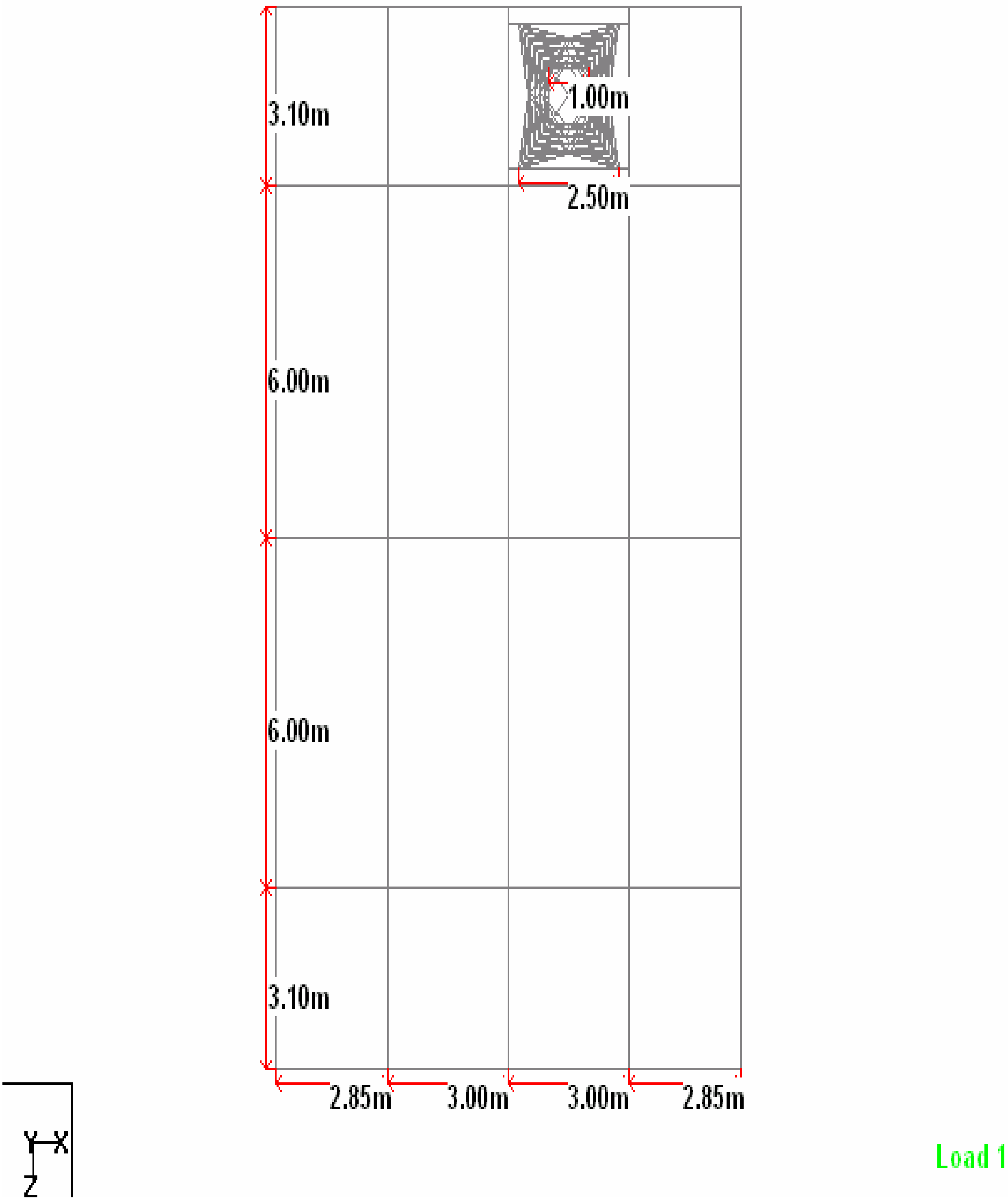
Plan of the building



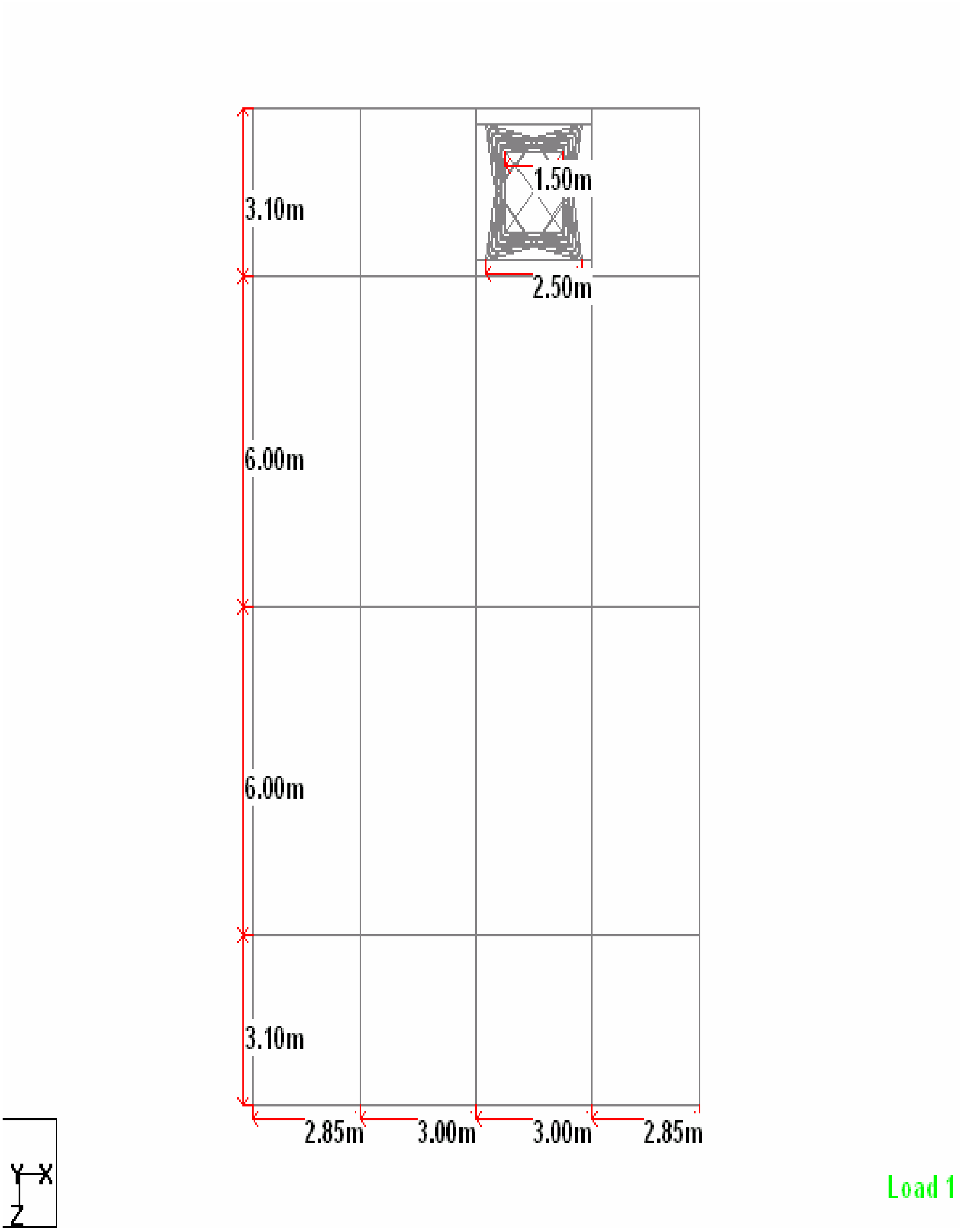
Elevation of the tower



Seven storey building with 15m Tower



Plan of the Building with 18m Tower



Plan of the Building with 12m Tower

WIND LOAD CALCULATIONS FOR FOUR STOREY BUILDING

The design wind speed V_z is obtained by multiplying the basic wind speed (V_b) by the factors k_1, k_2 and k_3.

$V_z = V_b * k_1 * k_2 * k_3$

Where,

V_b = the basic wind speed in m/s at 10 m height
k_1 = probability factor (or risk coefficient)
k_2 = terrain, height and structure size factor
k_3 = topography factor
V_b = 47 m/s for Delhi
k_1 = 1.0
k_2 = varies with the height as given in the table below
k_3 = 1.0
Therefore, $V_z = 47 * k_2$

Since, $p_z = 0.6 * V_z^2 = 1325.4 * k_2^2$ N/m^2

Now, as per IS 875 Part III Table 2 for terrain category 2, the factor k_2 varies with height as follows:

	k_2	
Height (m)	Class A	Class B
10	1	0.98
15	1.05	1.02
20	1.07	1.05
30	1.12	1.1
50	1.17	1.15

For wind in z direction, (see figure)
C_f = 1.05(from Figure 4A of IS: 875 Part III – 1987)
Now,

$F = C_f * A_e * p_z$
$F = 1.05 * 1325.4 * A_e$ N
Therefore,
F = 11.89 kN for panels having A_e = 8.55 sq.mt, &
F = 11.89 kN for panels having A_e = 9 sq.mt.

The nodal forces so calculated have been marked in the figure.

For wind in x direction, (see figure)

C_f = 1.24 (from Figure 4B of IS: 875 Part III – 1987)

Now,

$F = C_f * A_e * p_z$

$F = 1.24 * 1325.4 * A_e$ N

Therefore,

F = 15.28 kN for panels having A_e = 9.3 sq.mt, &

F = 29.58 kN for panels having A_e = 18 sq.mt.

The nodal forces so calculated have been marked in the figure.

WIND LOAD CALCULATIONS FOR SEVEN STOREY BUILDING

The expression for the design pressure remains same as above.

$p_z = 0.6 * V_z^2 \quad = 1325.4 * k_2^2$ N/m^2

For wind in z direction, (see figure)

C_f = 1.15 (from Figure 4A of IS: 875 Part III – 1987)

Now,

$F = C_f * A_e * p_z$

$F = 1.15 * 1325.4 * A_e$ N

Therefore,

F = 13.01 kN for panels having A_e = 8.55 sq.mt, &

F = 13.01 kN for panels having A_e = 9 sq.mt.

The nodal forces so calculated have been marked in the figure.

For wind in x direction, (see figure)

C_f = 1.2 (from Figure 4B of IS: 875 Part III – 1987)

Now,

$F = C_f * A_e * p_z$

$F = 1.25 * 1325.4 * A_e$ N

Therefore,

F = 15.40 kN for panels having A_e = 9.3 sq.mt, &

F = 29.82 kN for panels having A_e = 18 sq.mt.

The nodal forces so calculated have been marked in the figure.

WIND LOAD CALCULATIONS FOR TEN STOREY BUILDING

The design wind speed V_z is obtained by multiplying the basic wind speed (V_b) by the factors k_1, k_2 and k_3.

$V_z = V_b * k_1 * k_2 * k_3$

Where
V_b = the basic wind speed in m/s at 10 m height
k_1 = probability factor (or risk coefficient)
k_2 = terrain, height and structure size factor
k_3 = topography factor

V_b = 47 m/s for Delhi
$k_1 = 1.0$
k_2 = varies with the height as given in the table below
$k_3 = 1.0$

Therefore, $V_z = 47 * k_2$

Since, $p_z = 0.6 * V_z^2$
$= 1325.4 * k_2^2$ N/m^2

Now, as per IS 875 Part III Table 2 for terrain category 2, the factor k_2 varies with height as follows.

	k_2	
Height (m)	Class A	Class B
10	1	0.98
15	1.05	1.02
20	1.07	1.05
30	1.12	1.1
50	1.17	1.15

For wind in z direction, (see figure)

C_f = 1.3 (from Figure 4A of IS: 875 Part III – 1987)

Now,
$F = C_f * A_e * p_z$
$F = 1.3 * 1325.4 * A_e$ N
Therefore,
F = 17.82 kN for panels having A_e = 8.55 sq.mt, &
F = 18.76 kN for panels having A_e = 9 sq.mt.

The nodal forces so calculated have been marked in fig.

CALCULATION OF WIND LOAD ALONG HEIGHT OF 18 M TOWER ON TEN STOREY BUILDIN

WIND LOAD DIRECTIONS

1. WIND LOAD ALONG X OR Z DIRECTION
2. WIND LOAD ALONG DIAGONAL

CALCULATION OF DESIGN WIND LOADS AS PER IS 875

Basic wind speed = 47 m/s

Design wind speed Vz = k1*k2*k3*Vb

Terrain Category 2 Class of Structure B

$F = C_f * A_e * p_d$

Solidity Ratio φ	C_f
0.05	4
0.1	3.8
0.2	3.3
0.3	2.8
0.4	2.3
0.5	2.1

Panel No.	Height	k
1	36.75	1.0
2	38.25	1.0
3	40.75	1.1
4	43.25	1.1
5	48.75	1.1

Member	Height(m)	Section B	Section L	Exposed Area	Nos	Total Area	Top Width	Bottom Width	Panel Height	Panel Area	Solidity Ratio	C
Antenna		0.262	1.58	0.41	4	1.64						1
Panel No.5	48.75											
Main Leg		0.05	2.5	0.13	2	0.26						
Horizontal		0.05	2.125	0.11	1	0.11						
Diagonal		0.05	2.75	0.14	2	0.28						
Cage Flat		0.045	2.5	0.11	3	0.33						
Ladder		0.045	2.5	0.11	1	0.11						
Rungs		0.016	0.4	0.01	8	0.08						
Total						1.17	1	1.25	2.5	2.81	0.42	2.
Panel No.4	43.25											
Main Leg		0.05	2.5	0.13	2	0.26						
Horizontal		0.05	1.375	0.07	1	0.07						
Diagonal		0.05	2.86	0.14	2	0.28						
Cage Flat		0.03	2.5	0.08	3	0.24						
Ladder		0.045	2.5	0.11	1	0.11						
Rungs		0.016	0.4	0.01	8	0.08						
Total						1.04	1.25	1.5	2.5	3.44	0.3	3
PanelNo.3	40.75											
Main Leg		0.05	2.5	0.13	2	0.26						
Horizontal		0.05	1.625	0.08	1	0.08						
Diagonal		0.05	2.97	0.15	2	0.3						
Cage Flat		0.03	2.5	0.08	3	0.24						
Ladder		0.045	2.5	0.11	1	0.11						
Rungs		0.016	0.4	0.01	8	0.08						
Total						1.07	1.5	1.75	2.5	4.06	0.26	3
Panel No.2	38.25											
Main Leg		0.06	2.5	0.15	2	0.3						
Horizontal		0.05	1.875	0.09	1	0.09						

Diagonal		0.05	3.13	0.16	2	0.32						
Cage Flat		0.03	2.5	0.08	3	0.24						
Ladder		0.045	2.5	0.11	1	0.11						
Rungs		0.016	0.4	0.01	8	0.08						
Total						1.14	1.75	2	2.5	4.69	0.24	3.2
Panel No.1	36.75											
Main Leg		0.08	5	0.4	2	0.8						
Horizontal		0.05	2	0.1	1	0.1						
Diagonal		0.05	5.155	0.26	2	0.52						
Inclined		0.05	4.452	0.22	2	0.44						
Cage Flat		0.03	5	0.15	3	0.45						
Ladder		0.045	5	0.23	1	0.23						
Rungs		0.016	0.4	0.01	15	0.15						
Total						2.69	2	2.5	5	11.25	0.24	3.2

LOAD DISTRIBUTION ON NODAL POINTS OF 18 m TOWER ON TEN STOREY BUILDING

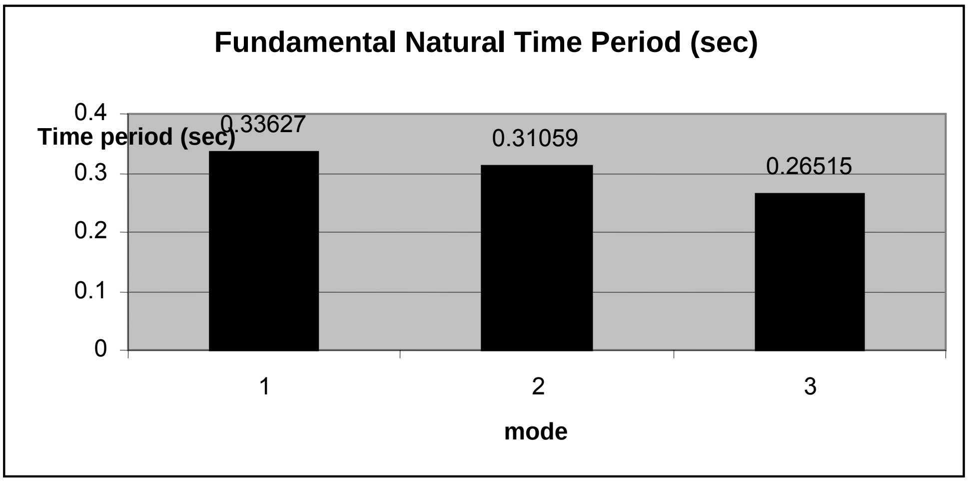
Panel No.	F (kN)	Load Distribution	Load on Nodes	Total load on nodes	Normal Load on each node	Total Diagonal Load	X & Z Components on L&R Node	Middle Node
5	4.04	Top	2.87	2.87	1.385	3.464	0.61	1.20
		Bottom	2.87					
4	4.50	Top	3.170	6.140	3.012	7.388	1.25	2.60
		Bottom	3.170					
3	4.95	Top	3.685	6.780	3.340	7.838	1.30	2.81
		Bottom	3.685					
2	5.30	Top	3.595	4.910	3.5525	8.666	1.44	2.91
		Bottom	3.595					
1	13.01	Top	8.3755	12.07	5.9810	14.499	2.49	5.06
		Bottom	8.3755	8.375	4.1275	10.07	3.10	3.48

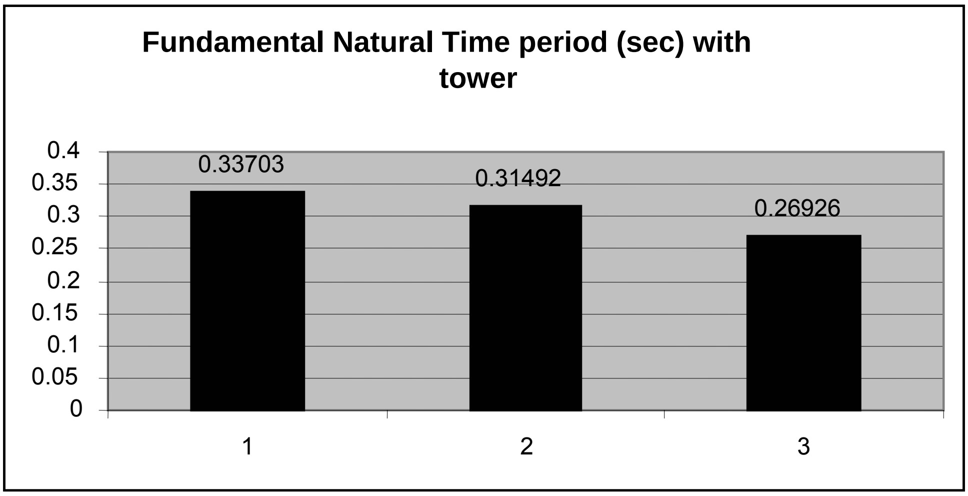
Time Periods Of the FOUR Storey Building with 12 meter high Tower

TIME PERIOD OF THE BUILDING WITHOUT TOWER		
MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	3.215	0.33627
2	3.452	0.31059
3	4.235	0.26515

TIME PERIOD OF THE BUILDING WITH TOWER

MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	3.158	0.33703
2	3.391	0.31492
3	4.012	0.26926

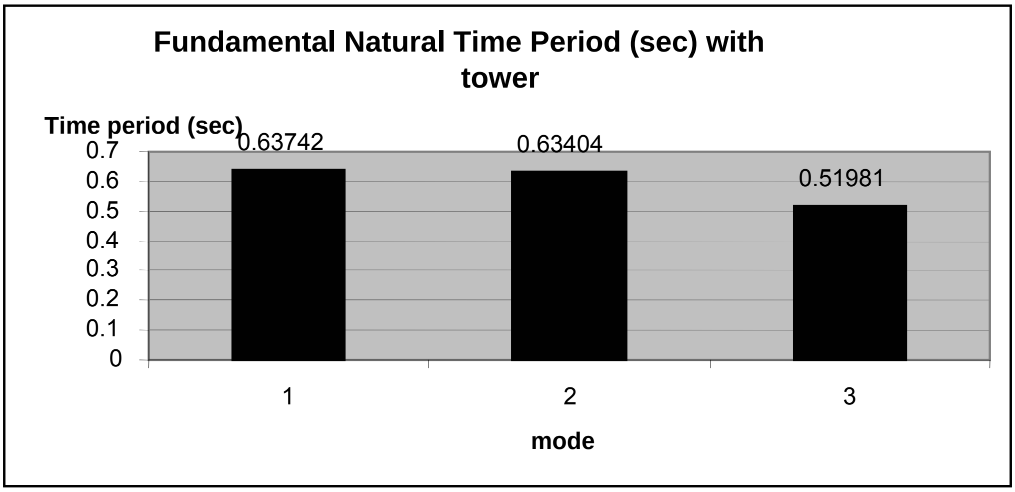


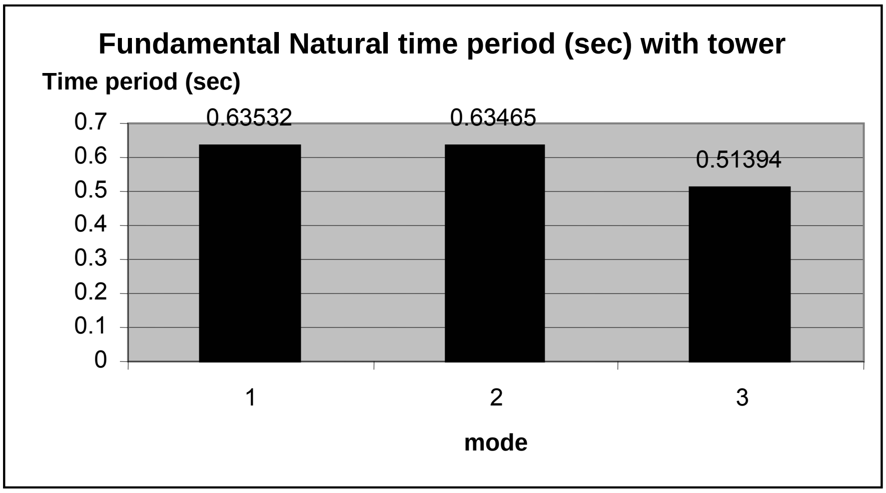


Time Periods Of the SEVEN Storey Building with 15 meter high Tower

TIME PERIOD OF THE BUILDING WITHOUT TOWER		
MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	1.785	0.63742
2	1.796	0.63404
3	2.441	0.51981

TIME PERIOD OF THE BUILDING WITH TOWER		
MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	1.578	0.63532
2	1.586	0.63465
3	2.452	0.51394

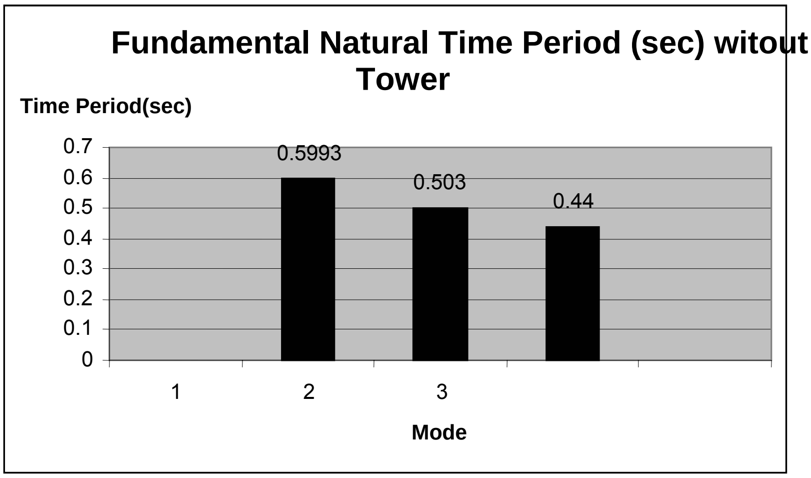


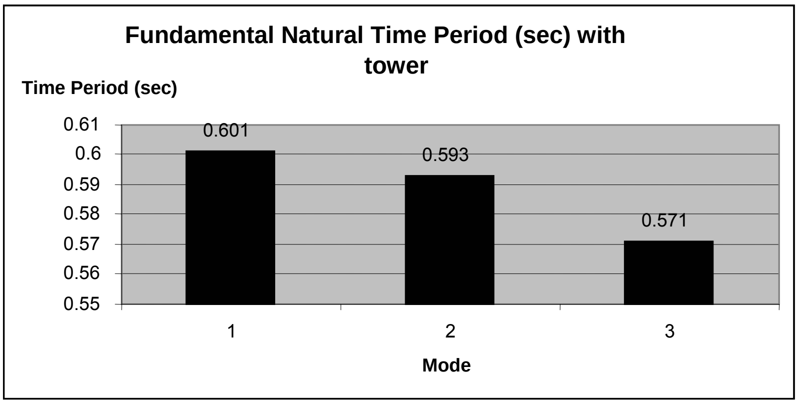


Time Periods Of the TEN Storey Building with 18 meter high Tower

TIME PERIOD OF THE BUILDING WITHOUT TOWER		
MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	1.986	0.5993
2	1.986	0.503
3	2.26	0.44

TIME PERIOD OF THE BUILDING WITH TOWER		
MODE	FREQUENCY(CYCLES/SEC)	PERIOD(SEC)
1	1.982	0.601
2	1.971	0.593
3	2.21	0.571





The following are the load cases as considered in the analysis of the building and towers

Load Case Number	Description
1	Seismic Load (EQ) in X Dir
2	Seismic Load (EQ) in Z Dir
3	Dead Load (DL)
4	Live Load (LL)
5	Wind Load (WL) in X Dir
6	Wind Load (WL) in Z Dir
7	1.5(DL + LL)
8	1.2(DL + LL + EQX)
9	1.2(DL + LL – EQX)
10	1.2(DL + LL + EQZ)
11	1.2(DL + LL – EQZ)
12	1.5(DL + EQX)
13	1.5(DL – EQX)
14	1.5(DL + EQZ)
15	1.5(DL - EQZ)
16	1.2(DL + LL + WLX)
17	1.2(DL + LL - WLX)
18	1.2(DL + LL + WLZ)
19	1.2(DL + LL - WLZ)
20	1.5(DL + WLX)
21	1.5(DL - WLX)
22	1.5(DL + WLZ)
23	1.5(DL - WLZ)

SUPPRT REACTION OF THE TOWER TO BE INSTALLED ON FOUR STOREY BUILDING							
Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
1	2 SEISMIC Z	1.001	41.219	15.489	32.295	1.344	2.062
	5 WIND X	-14.508	-28.809	0.054	0.061	-0.915	22.016
	6 WIND Z	-0.181	-13.025	-8.58	-11.688	0.811	0.413
	7 DL+LL	1.316	131.816	1.726	1.873	0.112	-1.207
2	2 SEISMIC Z	1.353	23.64	16.645	38.601	1.017	2.404
	5 WIND X	-14.163	0.25	0.093	-0.073	-0.465	25.184
	6 WIND Z	-0.383	-10.438	-13.808	-17.358	0.679	0.602
	7 DL+LL	0.098	203.629	8.52	8.508	0.053	-0.006
3	2 SEISMIC Z	1.282	70.414	21.085	44.05	0.292	2.327
	5 WIND X	-13.172	-44.515	-0.099	-0.257	-0.699	24.141
	6 WIND Z	-0.318	-67.056	-15.231	-19.249	0.175	0.52
	7 (DL+LL)	-0.042	198.01	2.932	3.136	0.015	0.158
4	2 SEISMIC Z	1.302	30.243	17.014	39.589	0.775	2.334
	5 WIND X	-13.693	44.063	-0.218	0.017	-0.57	24.585
	6 WIND Z	-0.049	-36.565	-13.998	-18.195	-0.404	0.238
	7 (DL+LL)	-0.369	227.798	8.538	8.681	-0.01	0.505
5	2 SEISMIC Z	1.034	41.557	16.335	34.088	1.185	2.069
	5 WIND X	-10.625	33.777	0.078	0.178	-0.791	21.564
	6 WIND Z	-0.134	-16.033	-9.496	-13.732	-0.621	0.307
	7 1.5(DL+LL)	-1.576	132.523	1.796	2.066	0.083	1.697
6	2 SEISMIC Z	1.629	38.8	18.99	35.728	0.926	2.464
	5 WIND X	-25.199	-14.826	0.071	0.09	-1.037	31.039
	6 WIND Z	0.611	12.078	-6.849	-12.674	0.565	-0.794
	7 (DL+LL)	15.316	349.933	5.148	5.166	0.092	-15.451
7	2 SEISMIC Z	1.23	80.242	26.078	48.951	0.257	2.366
	5 WIND X	-16.886	-18.09	0.044	-0.131	-0.738	32.985
	6 WIND Z	0.359	84.707	-11.173	-20.928	0.131	-0.515
	7(DL+LL)	0.175	626.111	8.84	8.83	-0.015	-0.37
8	2 SEISMIC Z	1.78	45.529	20.021	37.701	0.766	2.595
	5 WIND X	-13.456	26.656	0.06	0.149	-0.969	29.351
	6 WIND Z	-0.613	26.84	-7.994	-14.939	-0.401	0.415
	7 (DL+LL)	-15.14	345.705	5.273	5.413	0.017	14.874
9	2 SEISMIC Z	0.47	0.452	16.686	33.505	1.221	1.028
	5 WIND X	-33.77	-15.776	0.084	0.158	0.255	41.804
	6 WIND Z	0.052	0.074	-5.89	-11.625	0.642	-0.138
	7 1.5(DL+LL)	23.379	473.4	-0.024	-0.052	-0.001	-23.375
10	2 SEISMIC Z	0.587	0.95	23.075	46.074	0.217	1.143
	5 WIND X	-23.287	0.767	-0.106	-0.281	0.032	44.822
	6 WIND Z	0.12	2.239	-9.811	-19.385	0.121	-0.201
	7 (DL+LL)	0.081	828.879	-0.075	-0.161	-0.04	-0.17
11	2 SEISMIC Z	0.47	0.747	17.598	35.359	1.204	1.027
	5 WIND X	-18.221	16.411	0.023	0.06	0.284	39.543
	6 WIND Z	0.019	1.367	-6.924	-13.779	-0.669	-0.107
	7 (DL+LL)	-23.247	472.983	0.087	0.187	-0.007	23.066
12	2 SEISMIC Z	1.494	38.939	18.995	35.736	0.863	1.858

	5 WIND X	-22.95	-9.535	0.127	0.253	1.346	25.555
	6 WIND Z	-0.539	-12.239	-6.564	-12.201	0.49	0.575
	7(DL+LL)	15.205	349.506	-5.199	-5.271	-0.024	-15.151
13	2 SEISMIC Z	0.753	60.103	26.172	49.059	0.198	1.42
	5 WIND X	-14.081	-1.194	-0.13	-0.309	0.785	26.946
	6 WIND Z	-0.064	-24.152	-10.833	-20.229	0.107	0.092
	7 (DL+LL)	0.024	594.614	-9.002	-9.158	-0.03	-0.039
14	2 SEISMIC Z	1.502	41.475	20.025	37.702	0.81	1.845
	5 WIND X	-11.155	9.174	0.017	0.003	1.284	23.849
	6 WIND Z	0.521	-16.327	-7.725	-14.48	-0.42	-0.502
	7 (DL+LL)	-15.195	350.08	-5.069	-5.011	0.027	15.111
15	2 SEISMIC Z	0.368	40.406	15.494	32.303	1.296	0.772
	5 WIND X	-11.109	-16.761	0.127	0.265	1.083	14.824
	6 WIND Z	0.096	12.667	-5.358	-11.005	0.692	-0.216
	7 DL+LL	1.403	132.703	-1.761	-1.962	-0.003	-1.405
16	2 SEISMIC Z	0.52	22.696	16.657	38.617	0.981	0.919
	5 WIND X	-9.496	3.294	-0.277	-0.477	0.644	16.755
	6 WIND Z	0.169	7.976	-7.255	-16.015	0.598	-0.281
	7 DL+LL	0.2	203.67	-8.588	-8.755	0.018	-0.219
17	2 SEISMIC Z	0.479	52.467	21.205	44.188	0.286	0.873
	5 WIND X	-8.937	1.118	-0.104	-0.286	0.546	16.135
	6 WIND Z	0.129	21.67	-8.799	-18.209	0.151	-0.229
	7 1.5(DL+LL)	-0.006	190.359	-2.94	-3.318	-0.038	0.009
18	2 SEISMIC Z	0.487	23.883	17.057	39.63	0.822	0.874
	5 WIND X	-9.29	-2.794	0.168	0.486	0.521	16.418
	6 WIND Z	0.093	10.233	-7.549	-16.936	-0.409	-0.179
	7 (DL+LL)	-0.211	203.282	-8.543	-8.55	-0.037	0.236
19	2 SEISMIC Z	0.397	42.503	16.341	34.092	1.215	0.778
	5 WIND X	-7.063	16.791	-0.009	-0.033	1.033	14.218
	6 WIND Z	0.111	15.982	-6.302	-13.071	-0.619	-0.189
	7 DL+LL	-1.411	132.229	-1.66	-1.729	0.024	1.42

SUPPORT REACTION OF THE TOWER TO BE INSTALLED ON SEVEN STOREY BUILDING							
Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
1	2 SEISMIC Z	0.244	167.545	32.329	70.183	0.606	0.43
	5 WIND X	-28.049	-122.339	0.733	1.339	-0.915	50.899
	6 WIND Z	-0.205	-67.696	-17.957	-31.626	0.716	0.546
	7 1.5(DL+LL)	1.561	319.736	2.29	2.506	0.032	-1.57
2	2 SEISMIC Z	0.347	92.549	26.265	65.305	0.542	0.631
	5 WIND X	-32.286	-1.276	0.55	0.842	-0.446	58.558
	6 WIND Z	-0.501	-43.553	-20.987	-34.194	0.538	0.829
	71.5 (DL+LL)	0.457	440.506	9.025	9.121	-0.016	-0.475
3	2 SEISMIC Z	0.337	170.539	34.935	75.967	0.059	0.619
	5 WIND X	-30.805	-36.072	0.054	0.055	-0.52	57.058
	6 WIND Z	-0.435	-110.957	-24.379	-37.958	0.095	0.751
	7 1.5(DL+LL)	0.038	466.296	3.928	4.333	0.001	-0.027
4	2 SEISMIC Z	0.338	96.253	26.396	65.651	0.456	0.617
	5 WIND X	-31.855	30.238	-0.62	-0.954	-0.433	57.999
	6 WIND Z	-0.272	-68.772	-21.186	-34.816	-0.342	0.577
	7 1.5(DL+LL)	-0.471	459.524	8.99	9.089	0.013	0.509
5	2 SEISMIC Z	0.494	168.406	32.676	70.941	0.541	0.748
	5 WIND X	-24.065	134.465	-0.736	-1.344	-0.849	50.353
	6 WIND Z	-0.322	-73.747	-18.644	-33.2	-0.51	0.619
	7 1.5(DL+LL)	-1.622	325.348	2.296	2.538	-0.027	1.651
6	2 SEISMIC Z	2.27	147.097	40.123	77.821	0.393	2.22
	5 WIND X	-35.445	-62.819	0.862	1.476	-1.309	56.433
	6 WIND Z	1.103	57.988	-18.135	-34.756	0.481	-1.032
	7 1.5(DL+LL)	15.375	716.251	5.837	5.907	0.046	-15.298
7	2 SEISMIC Z	0.164	190.644	43.967	84.825	0.053	0.347
	5 WIND X	-30.626	-20.239	0.06	0.059	-0.808	61.806
	6 WIND Z	-0.054	135.375	-21.913	-41.765	0.083	0.132
	7 1.5(DL+LL)	0.008	1214.175	10.184	10.333	0.001	-0.006
8	2 SEISMIC Z	2.379	150.938	40.551	78.658	0.344	2.475
	5 WIND X	-23.596	76.808	-0.877	-1.492	-1.247	54.679
	6 WIND Z	-1.19	75.814	-19.005	-36.51	-0.315	1.275
	7 1.5(DL+LL)	-15.391	718.447	5.846	5.941	-0.043	15.319
9	2 SEISMIC Z	0.033	0.1	35.296	73.147	0.579	0.077
	5 WIND X	-46.051	-54.906	0.655	1.327	0.28	72.811
	6 WIND Z	0.027	0.51	-15.815	-32.375	0.608	-0.052
	7 1.5(DL+LL)	23.741	1019.964	-0.015	-0.033	-0.002	-23.66
10	2 SEISMIC Z	0.043	0.571	38.812	79.846	0.051	0.087
	5 WIND X	-39.91	0.035	0.022	0.019	0.192	80.096
	6 WIND Z	0.026	5.398	-19.292	-38.971	0.067	-0.05
	7 1.5(DL+LL)	0.016	1745.021	-0.019	-0.02	-0.001	-0.037
11	2 SEISMIC Z	0.032	0.316	35.676	73.939	0.537	0.076
	5 WIND X	-30.464	55.664	-0.669	-1.34	0.268	70.525
	6 WIND Z	0.005	2.619	-16.626	-34.073	-0.504	-0.029
	7 1.5(DL+LL)	-23.713	1019.69	0.002	0.01	-0.002	23.592
12	2 SEISMIC Z	2.262	147.127	40.124	77.822	0.391	2.206

	5 WIND X	-33.313	-45.304	0.659	1.384	1.782	51.228
	6 WIND Z	-1.041	-58.148	-17.823	-34.237	0.443	0.963
	7 1.5(DL+LL)	15.366	715.591	-5.867	-5.971	-0.049	-15.298
13	2 SEISMIC Z	0.174	185.78	43.985	84.845	0.051	0.368
	5 WIND X	-27.952	-1.12	0.006	0	1.174	56.068
	6 WIND Z	0.053	-81.702	-21.479	-40.922	0.077	-0.137
	7 1.5(DL+LL)	0.007	1187.657	-10.162	-10.311	-0.003	-0.015
14	2 SEISMIC Z	2.386	149.634	40.555	78.662	0.345	2.491
	5 WIND X	-21.482	45.109	-0.66	-1.381	1.7	49.492
	6 WIND Z	1.173	-65.397	-18.725	-36.025	-0.294	-1.263
	7 1.5(DL+LL)	-15.356	715.899	-5.844	-5.923	0.04	15.273
15	2 SEISMIC Z	0.246	167.368	32.33	70.184	0.605	0.435
	5 WIND X	-24.191	-95.421	0.531	1.27	1.314	42.69
	6 WIND Z	0.171	66.907	-14.403	-30.871	0.644	-0.481
	7 1.5(DL+LL)	1.557	320.416	-2.313	-2.564	-0.034	-1.571
16	2 SEISMIC Z	0.346	92.085	26.27	65.311	0.541	0.631
	5 WIND X	-27.064	7.258	-0.143	0.111	0.787	49.016
	6 WIND Z	0.386	38.102	-13.779	-32.723	0.495	-0.687
	7 1.5(DL+LL)	0.431	438.394	-8.998	-9.102	0.011	-0.454
17	2 SEISMIC Z	0.335	167.601	34.957	75.992	0.058	0.619
	5 WIND X	-25.935	1.165	0.011	0.004	0.811	47.858
	6 WIND Z	0.354	74.215	-17.187	-36.684	0.091	-0.647
	7 1.5(DL+LL)	-0.004	453.758	-3.882	-4.287	-0.003	0.006
18	2 SEISMIC Z	0.345	93.121	26.407	65.663	0.458	0.626
	5 WIND X	-26.859	-6.563	0.091	-0.203	0.758	48.682
	6 WIND Z	0.339	41.681	-14.026	-33.396	-0.306	-0.623
	7 1.5(DL+LL)	-0.438	438.193	-9.003	-9.102	-0.018	0.466
19	2 SEISMIC Z	0.504	168.161	32.681	70.946	0.541	0.759
	5 WIND X	-20.141	95.314	-0.529	-1.263	1.227	42.084
	6 WIND Z	0.384	71.365	-15.128	-32.486	-0.454	-0.663
	7 1.5(DL+LL)	-1.562	320.059	-2.296	-2.521	0.026	1.582

SUPPORT REACTION OF THE TOWER TO BE INSTALLED ON TEN STOREY BUILDING							
Node	L/C	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
1	3 DL+LL	0.507	83.878	0.714	0.779	-0.009	-0.511
	5 WL Z	0.019	139.899	22.672	74.38	-0.139	-0.041
	6 WL X	17.147	128.998	1.722	5.49	0.782	54.926
	7 SEISMIC Z	4.529	202.013	17.837	62.865	1.495	14.081
2	3 DL+LL	0.135	150.73	1.357	1.469	-0.009	-0.142
	5 WL Z	0.016	140.145	23.239	75.591	-0.147	-0.031
	6 WL X	21.676	7.865	0.78	2.626	0.755	59.359
	7 SEISMIC Z	5.583	254.239	16.854	60.191	1.429	15.104
3	3 DL+LL	-0.001	160.984	1.39	1.512	0	0.001
	5 WL Z	0.002	141.743	23.494	76.163	0	-0.003
	6 WL X	21.443	29.63	0.053	0.197	0.745	59.143
	7 SEISMIC Z	5.532	623.514	15.529	57.33	1.399	15.057
4	3 DL+LL	-0.135	150.161	1.357	1.47	0.009	0.143
	5 WL Z	-0.015	142.765	23.233	75.584	0.147	0.029
	6 WL X	21.626	17.469	0.85	2.884	0.758	59.298
	7 SEISMIC Z	5.755	590.193	15.155	55.879	1.407	15.269
5	3 DL+LL	-0.507	83.874	0.714	0.78	0.009	0.511
	5 WL Z	-0.02	140.279	22.67	74.378	0.139	0.04
	6 WL X	17.151	132.137	1.797	5.758	0.788	54.905
	7 SEISMIC Z	4.645	265.933	15.365	55.406	1.485	14.183
6	3 DL+LL	1.019	214.017	2.317	2.325	-0.007	-1.022
	5 WL Z	-0.012	-96.507	26.062	77.732	-0.099	0.026
	6 WL X	16.431	139.939	1.964	5.729	0.758	52.785
	7 SEISMIC Z	2.584	157.005	20.778	65.749	1.489	8.293
7	3 DL+LL	0.295	389.887	4.569	4.571	-0.007	-0.307
	5 WL Z	-0.01	-96.718	26.693	79.029	-0.12	0.02
	6 WL X	20.779	3.305	0.901	2.744	0.748	57.027
	7 SEISMIC Z	3.354	189.025	19.705	62.987	1.439	9.032
8	3 DL+LL	0	411.27	4.729	4.735	0	0
	5 WL Z	-0.002	-98.261	26.971	79.629	0	0.001
	6 WL X	20.541	29.153	0.061	0.204	0.737	56.792
	7 SEISMIC Z	3.271	574.441	18.38	60.138	1.414	8.948
9	3 DL+LL	-0.295	390.107	4.57	4.572	0.007	0.307
	5 WL Z	0.011	-99.459	26.688	79.023	0.12	-0.022
	6 WL X	20.714	30.087	0.987	3.018	0.75	56.929
	7 SEISMIC Z	3.154	486.073	17.916	58.597	1.422	8.816
10	3 DL+LL	-1.019	214.182	2.317	2.326	0.007	1.023
	5 WL Z	0.015	-96.818	26.061	77.73	0.099	-0.03
	6 WL X	16.411	144.123	2.052	6.009	0.762	52.7
	7 SEISMIC Z	2.502	178.714	18.002	57.994	1.48	8.17
11	3 DL+LL	1.089	292.928	0	0.001	0	-1.097
	5 WL Z	0.001	0	23.364	75.229	-0.147	-0.002
	6 WL X	15.452	119.497	1.768	5.547	0.823	49.406
	7 SEISMIC Z	1.515	6.893	18.429	63.458	1.535	4.594
12	3 DL+LL	0.361	530.592	0	0	0	-0.375

	5 WL Z	0.001	0.022	24.085	76.719	-0.159	-0.002
	6 WL X	19.482	4.547	0.799	2.642	0.776	53.328
	7 SEISMIC Z	1.867	1.817	17.524	60.868	1.443	4.929
13	3 DL+LL	0	562.119	0	0	0	0
	5 WL Z	0	0.143	24.369	77.344	0	0
	6 WL X	19.288	0.388	0.055	0.198	0.766	53.128
	7 SEISMIC Z	1.841	9.296	16.853	58.692	1.419	4.896
14	3 DL+LL	-0.361	530.607	0	0	0	0.375
	5 WL Z	-0.001	-0.01	24.084	76.718	0.159	0.002
	6 WL X	19.448	4.257	0.878	2.91	0.777	53.248
	7 SEISMIC Z	1.863	6.435	16.359	57.117	1.423	4.909
15	3 DL+LL	-1.089	292.942	0	0.001	0	1.098
	5 WL Z	-0.001	-0.006	23.363	75.228	0.147	0.002
	6 WL X	15.396	119.505	1.846	5.816	0.821	49.262
	7 SEISMIC Z	1.498	7.353	16.009	56.059	1.517	4.547
16	3 DL+LL	1.019	213.966	-2.317	-2.324	0.007	-1.023
	5 WL Z	0.023	96.493	26.44	78.427	-0.139	-0.045
	6 WL X	13.832	99.686	1.975	5.758	0.864	44.254
	7 SEISMIC Z	4.773	158.426	20.779	65.747	1.464	15.21
17	3 DL+LL	0.296	389.886	-4.569	-4.571	0.007	-0.308
	5 WL Z	0.017	96.582	27.407	80.328	-0.157	-0.032
	6 WL X	17.452	7.766	0.897	2.735	0.808	47.784
	7 SEISMIC Z	6.01	144.108	19.776	63.07	1.422	16.407
18	3 DL+LL	0	412.512	-4.731	-4.737	0	0
	5 WL Z	0	96.597	27.736	81.02	0	0.001
	6 WL X	17.281	0.475	0.065	0.208	0.799	47.614
	7 SEISMIC Z	5.944	146.951	18.96	60.77	1.397	16.336
19	3 DL+LL	-0.296	389.873	-4.569	-4.571	-0.007	0.308
	5 WL Z	-0.018	96.572	27.406	80.326	0.157	0.034
	6 WL X	17.43	8.141	0.983	3.011	0.807	47.732
	7 SEISMIC Z	5.993	145.739	18.419	59.146	1.409	16.369
20	3 DL+LL	-1.019	213.945	-2.317	-2.324	-0.007	1.023
	5 WL Z	-0.024	96.487	26.44	78.425	0.138	0.048
	6 WL X	13.794	99.548	2.062	6.035	0.858	44.158
	7 SEISMIC Z	4.75	140.479	18.077	58.084	1.457	15.144
21	3 DL+LL	0.507	83.949	-0.714	-0.778	0.01	-0.511
	5 WL Z	-0.03	-139.933	23.23	75.423	-0.235	0.062
	6 WL X	12.974	108.665	1.734	5.524	0.854	41.735
	7 SEISMIC Z	6.74	201.044	17.838	62.863	1.479	21.002
22	3 DL+LL	0.134	150.629	-1.357	-1.469	0.009	-0.142
	5 WL Z	-0.023	-140.035	24.314	77.578	-0.219	0.045
	6 WL X	16.416	4.327	0.776	2.617	0.793	45.107
	7 SEISMIC Z	8.423	213.273	16.94	60.29	1.417	22.643
23	3 DL+LL	0	159.964	-1.393	-1.514	0	0
	5 WL Z	0	-140.045	24.636	78.277	0	0.001
	6 WL X	16.264	0.701	0.056	0.199	0.78	44.968
	7 SEISMIC Z	8.342	216.116	16.221	58.092	1.388	22.563
24	3 DL+LL	-0.134	150.649	-1.357	-1.469	-0.009	0.141
	5 WL Z	0.022	-140.02	24.313	77.576	0.219	-0.042
	6 WL X	16.409	5.357	0.85	2.88	0.793	45.089

Comparison of Forces in Beams of Four Storey Building with Tower

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITHOUT TOWER									
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**835**	0	0	0	0	0
Min Fx	11	1 SEISMIC X	30	**-55**	-46	0	0	0	-36
Max Fy	65	8 1.2(DL+LL+ELX)	29	-12	**108**	0	0	0	188
Min Fy	106	8 1.2(DL+LL+ELX)	29	-15	**-105**	0	0	0	20
Max Fz	7	14 1.5(DL+ELZ)	7	348	0	**54**	0	90	0
Min Fz	13	14 1.5(DL+ELZ)	32	105	0	**-55**	0	-60	0
Max Mx	66	10 1.2(DL+LL+ELZ)	31	-8	62	2	**7**	2	68
Min Mx	62	10 1.2(DL+LL+ELZ)	77	-11	18	-2	**-7**	-2	-62
Max My	13	14 1.5(DL+ELZ)	13	348	0	48	0	**94**	0
Min My	7	11 1.2(DL+LL-ELZ)	7	391	0	-36	0	**-81**	0
Max Mz	65	8 1.2(DL+LL+ELX)	29	-13	108	0	0	0	**185**
Min Mz	10	13 1.5(DL-ELX)	10	299	-90	0	0	0	**-179**

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITH TOWER									
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**835**	0	0	0	0	0
Min Fx	189	21 1.5(DL-WLX)	104	**-96**	-13	-7	0	-1	0
Max Fy	182	21 1.5(DL-WLX)	96	25	**121**	11	7	-5	2
Min Fy	179	21 1.5(DL-WLX)	61	16	**-138**	-26	1	-7	42
Max Fz	26	10 1.2(DL+LL+ELZ)	26	329	1	**41**	1	21	2
Min Fz	32	10 1.2(DL+LL+ELZ)	51	237	-1	**-41**	-1	-63	-1
Max Mx	185	22 1.5(DL+WLZ)	100	-11	82	17	**14**	0	10
Min Mx	185	23 1.5(DL-WLZ)	100	9	-96	-16	**-11**	-1	-9
Max My	13	14 1.5(DL+ELZ)	13	322	1	36	1	**74**	2
Min My	7	11 1.2(DL+LL-ELZ)	7	401	-1	-23	-1	**-65**	-2
Max Mz	106	9 1.2(DL+LL-ELX)	29	-12	-59	0	0	0	**152**
Min Mz	10	13 1.5(DL-ELX)	10	295	-58	-1	0	-2	**-116**

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITH TOWER									
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**835**	0	0	0	0	0
Min Fx	188	20 1.5(DL+WLX)	103	**-94**	17	-7	0	-1	0
Max Fy	183	22 1.5(DL+WLZ)	96	18	**128**	-13	-12	3	24
Min Fy	181	20 1.5(DL+WLX)	61	19	**-135**	20	-5	6	41
Max Fz	26	10 1.2(DL+LL+ELZ)	26	382	1	**42**	0	22	1
Min Fz	32	10 1.2(DL+LL+ELZ)	51	238	-1	**-42**	0	-64	-1
Max Mx	182	23 1.5(DL-WLZ)	95	16	96	15	**11**	-4	11
Min Mx	179	22 1.5(DL+WLZ)	96	39	-127	17	**-20**	-3	-17
Max My	13	14 1.5(DL+ELZ)	13	328	1	37	0	**76**	2
Min My	7	11 1.2(DL+LL-ELZ)	7	412	-2	-24	0	**-66**	-3
Max Mz	65	8 1.2(DL+LL+ELX)	29	-12	96	0	0	0	**154**
Min Mz	10	13 1.5(DL-ELX)	10	298	-58	-1	0	-1	**-118**

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITH TOWER									
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**834**	0	0	0	0	0
Min Fx	45	5 WIND X	45	**-75**	16	0	-1	0	14
Max Fy	65	8 1.2(DL+LL+ELX)	29	-11	**108**	0	0	0	180
Min Fy	106	8 1.2(DL+LL+ELX)	29	-15	**-105**	0	0	0	20
Max Fz	7	14 1.5(DL+ELZ)	7	386	0	**54**	0	93	0
Min Fz	13	14 1.5(DL+ELZ)	32	97	0	**-53**	0	-61	-1
Max Mx	115	10 1.2(DL+LL+ELZ)	80	-6	-16	2	**8**	3	-40
Min Mx	117	10 1.2(DL+LL+ELZ)	33	-10	-60	-2	**-7**	-2	47
Max My	13	14 1.5(DL+ELZ)	13	351	0	49	0	**98**	1
Min My	7	11 1.2(DL+LL-ELZ)	7	408	0	-34	0	**-83**	-1
Max Mz	106	9 1.2(DL+LL-ELX)	29	-11	-49	0	0	0	**185**
Min Mz	10	13 1.5(DL-ELX)	10	297	-89	0	0	0	**-179**

Comparison of Forces in Beams of SEVEN Storey Building with Tower

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITHOUT TOWER									
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**1785**	0	0	0	0	0
Min Fx	5	1 SEISMIC X	24	**-198**	-37	0	-1	-1	-33
Max Fy	161	8 1.2(DL+LL+ELX)	47	5	**118**	0	0	0	200
Min Fy	185	8 1.2(DL+LL+ELX)	49	-3	**-113**	0	0	0	-13
Max Fz	26	14 1.5(DL+ELZ)	26	607	0	**92**	0	125	0
Min Fz	32	14 1.5(DL+ELZ)	51	105	0	**-90**	0	-129	0
Max Mx	184	10 1.2(DL+LL+ELZ)	143	1	-11	2	**12**	3	-30
Min Mx	186	10 1.2(DL+LL+ELZ)	52	0	-65	-2	**-13**	-3	42
Max My	13	14 1.5(DL+ELZ)	13	773	0	76	0	**158**	0
Min My	7	11 1.2(DL+LL-ELZ)	7	688	0	-55	0	**-135**	0
Max Mz	185	9 1.2(DL+LL-ELX)	49	5	-41	0	0	0	**205**
Min Mz	10	13 1.5(DL-ELX)	10	579	-88	0	0	0	**-185**

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITH TOWER									
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**1785**	0	0	0	0	0
Min Fx	5	1 SEISMIC X	24	**-168**	-31	-1	-1	-1	-27
Max Fy	351	20 1.5(DL+WLX)	118	21	**159**	27	-5	-8	49
Min Fy	356	22 1.5(DL+WLZ)	121	49	**-146**	21	-21	3	11
Max Fz	26	14 1.5(DL+ELZ)	26	609	0	**78**	0	104	0
Min Fz	32	14 1.5(DL+ELZ)	51	149	0	**-78**	0	-109	0
Max Mx	359	23 1.5(DL-WLZ)	170	22	119	19	**18**	-4	13
Min Mx	356	22 1.5(DL+WLZ)	171	49	-139	21	**-25**	-4	-31
Max My	13	14 1.5(DL+ELZ)	13	725	0	64	0	**138**	1
Min My	26	11 1.2(DL+LL-ELZ)	26	626	0	-41	0	**-119**	0
Max Mz	161	8 1.2(DL+LL+ELX)	47	5	106	0	0	0	**188**
Min Mz	10	13 1.5(DL-ELX)	10	582	-71	0	0	0	**-149**

MAXIMUM & MINIMUM FORCES IN THE BUILDING WITH TOWER LOAD										
	Beam	**L/C**	**Node**	**Fx kN**	**Fy kN**	**Fz kN**	**Mx kNm**	**My kNm**	**Mz kNm**
Max Fx	10	7 1.5(DL+LL)	10	**1745**	0	0	0	0	0
Min Fx	5	1 SEISMIC X	24	**-201**	-38	-1	-1	-1	-33
Max Fy	161	8 1.2(DL+LL+ELX)	47	5	**113**	0	0	0	200
Min Fy	185	8 1.2(DL+LL+ELX)	49	-3	**-113**	0	0	0	-13
Max Fz	26	14 1.5(DL+ELZ)	26	627	0	**89**	0	126	0
Min Fz	32	14 1.5(DL+ELZ)	51	101	0	**-89**	0	-130	0
Max Mx	184	10 1.2(DL+LL+ELZ)	143	1	-11	2	**11**	3	-30
Min Mx	186	10 1.2(DL+LL+ELZ)	52	0	-66	-2	**-11**	-3	42
Max My	13	14 1.5(DL+ELZ)	13	777	0	77	0	**155**	0
Min My	7	11 1.2(DL+LL-ELZ)	7	696	0	-55	0	**-130**	0
Max Mz	161	8 1.2(DL+LL+ELX)	47	5	113	0	0	0	**200**
Min Mz	10	13 1.5(DL-ELX)	10	580	-88	0	0	0	**-182**

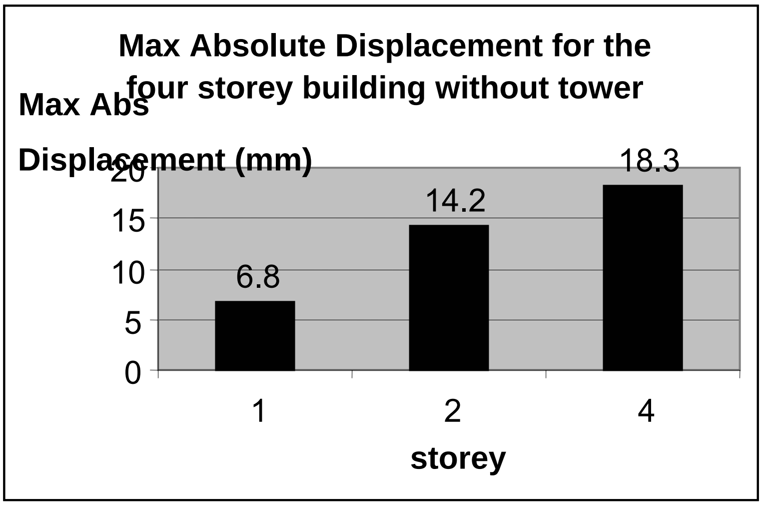
Min My	7	11 1.2(DL+LL-ELZ)	7	697	0	-55	0	**-130**	0
Max Mz	161	8 1.2(DL+LL+ELX)	47	5	113	0	0	0	**201**
Min Mz	10	13 1.5(DL-ELX)	10	596	-88	0	0	0	**-183**

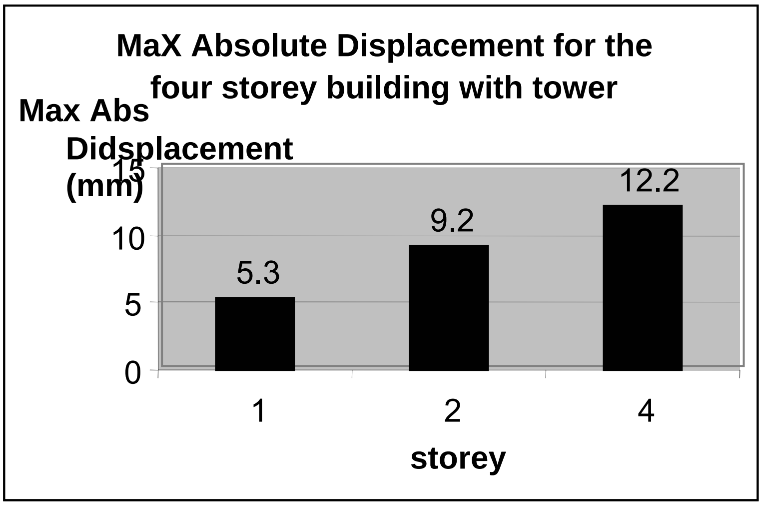
Comparison of Forces in Beams of TEN Storey Building with Tower

	MAXIMUMAM & MINIMUM FORCE IN THE TEN STOREY BUILDING WITH TOWER								
	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	53	18 1.2(DL+LL+WLX)	13	1766.96	23.145	0.064	0.919	0.237	63.754
Min Fx	50	6 WL X	35	-144.123	-16.411	-2.052	-0.762	-0.155	-3.604
Max Fy	621	18 1.2(DL+LL+WLX)	234	15.818	98.14	-5.803	7.366	2.075	19.755
Min Fy	827	18 1.2(DL+LL+WLX)	228	9.652	-103.28	-15.843	-5.75	-1.431	16.247
Max Fz	113	20 1.2(DL+LL+WLZ)	33	1112.709	-0.013	52.939	0	-92.32	-0.017
Min Fz	578	18 1.2(DL+LL+WLX)	243	134.441	-4.285	-35.403	-0.598	-64.029	-11.199
Max Mx	832	18 1.2(DL+LL+WLX)	252	14.855	39.159	11.874	16.383	0.386	4.398
Min Mx	830	18 1.2(DL+LL+WLX)	229	7.886	-95.468	-7.926	-8.988	-2.101	15.7
Max My	568	20 1.2(DL+LL+WLZ)	233	138.74	1.271	44.896	0.027	91.626	-3.089
Min My	48	20 1.2(DL+LL+WLZ)	8	1250.465	-0.005	45.213	0	-108.424	-0.006
Max Mz	160	20 1.2(DL+LL+WLZ)	63	13.06	-75.479	0.001	0	0.002	103.905
Min Mz	42	19 1.2(DL+LL-WLX)	2	640.331	-26.421	2.945	-0.928	-7.345	-71.665

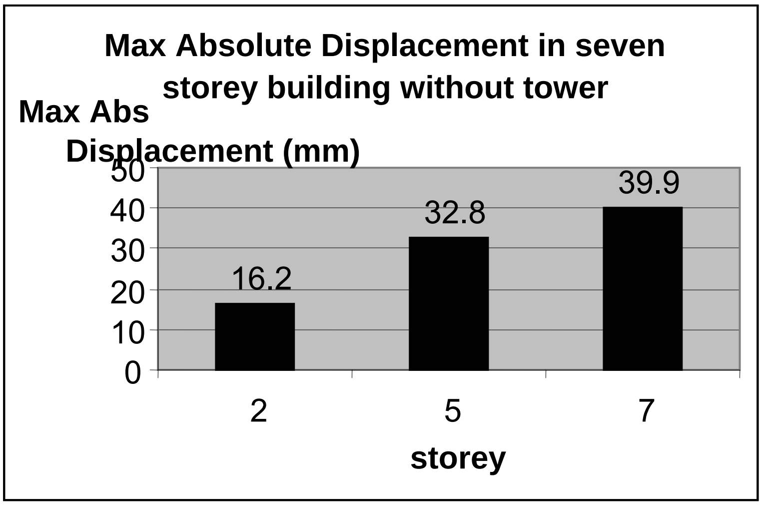
	MAXIMUM &MINIMUM FORCE IN THE BUILDING WITHOUT TOWER (TEN STOREY BUILDING)								
	Beam	L/C	Node	Fx kN	Fy kN	Fz kN	Mx kNm	My kNm	Mz kNm
Max Fx	52	9 1.5(DL+LL)	12	2207.865	0	0	0	0	0
Min Fx	62	6 WLZ	22	-370.423	0	63.014	0	-201.723	0
Max Fy	159	25 1.5(DL-WLZ)	72	-51.256	122.366	0	0	0	173.231
Min Fy	162	24 1.5(DL+WLZ)	52	12.887	-122.421	0	0	0	173.328
Max Fz	112	24 1.5(DL+WLZ)	32	635.052	0	116.973	0	-215.829	0
Min Fz	122	25 1.5(DL-WLZ)	42	635.466	0	-116.304	0	213.946	0
Max Mx	110	23 1.5(DL-WLX)	30	827.757	-30.541	13.653	3.934	-22.523	-57.85
Min Mx	114	22 1.5(DL+WLX)	34	818.033	30.523	13.732	-3.944	-22.783	57.978
Max My	57	25 1.5(DL-WLZ)	17	699.098	0	-115.733	0	322.59	0
Min My	47	24 1.5(DL+WLZ)	7	699.212	0	113.202	0	-317.974	0
Max Mz	162	24 1.5(DL+WLZ)	52	12.887	-122.421	0	0	0	173.328
Min Mz	51	15 1.5(DL-EQX)	11	1298.3	-63.318	0	0	0	-167.228

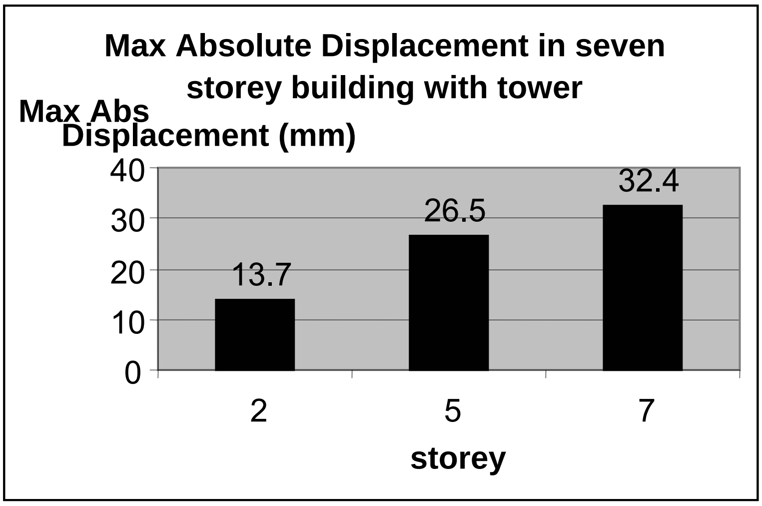
	Maximum absolute displacement in FOUR Storey Building(mm)		
	First Storey	Second Storey	four Storey
without tower	6.8	14.2	18.3
with tower	5.3	9.2	12.2



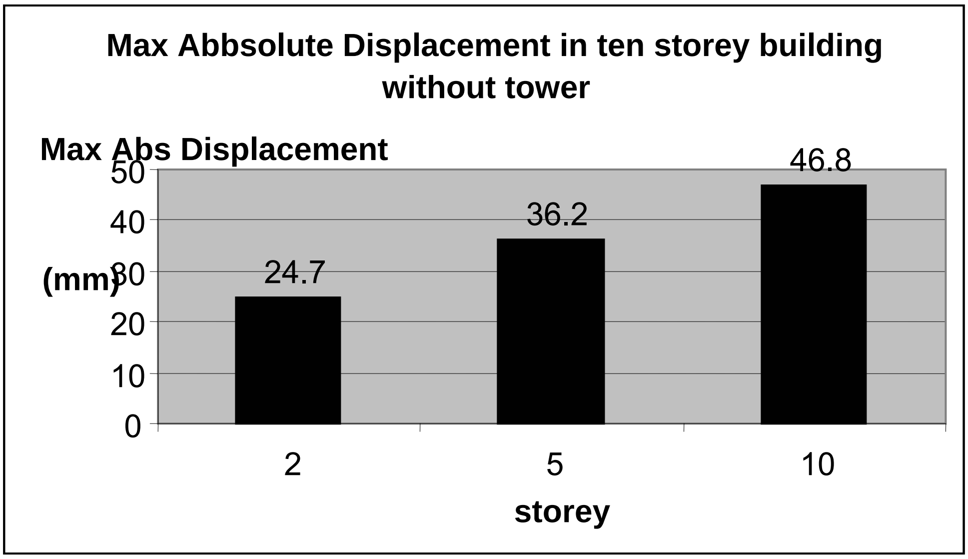


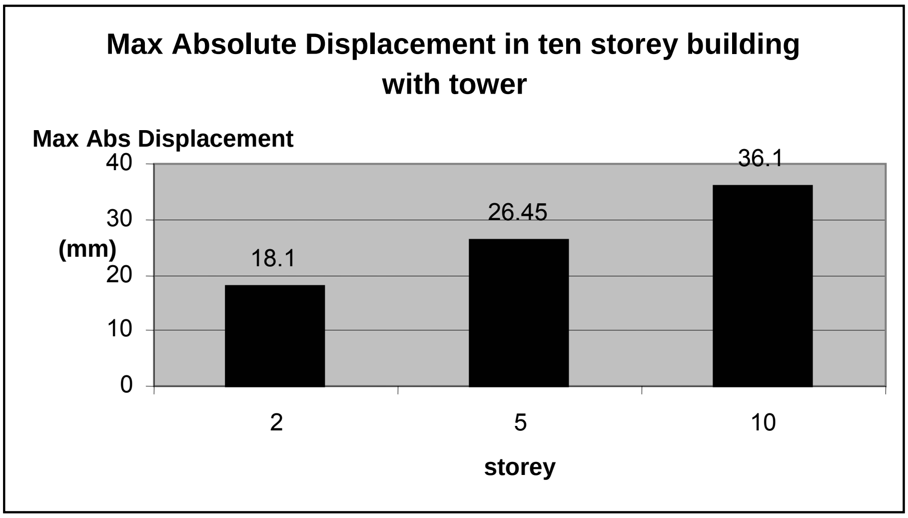
	Maximum absolute displacement in SEVEN Storey Building(mm)		
	Second Storey	Five Storey	Top Storey
without tower	16.2	32.8	39.9
with tower	13.7	26.5	32.4



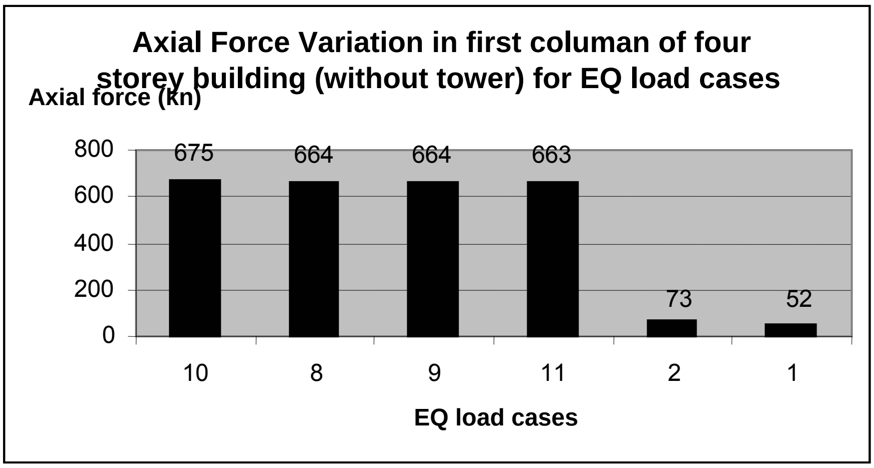


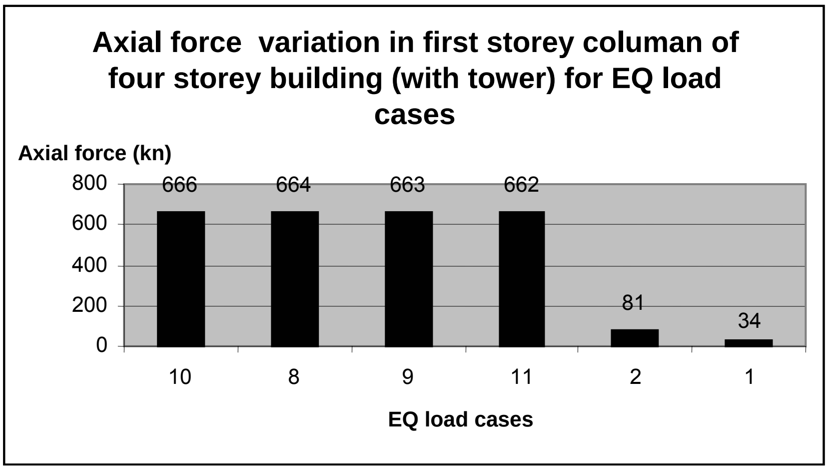
	Maximum absolute displacement in TEN Storey Building(mm)		
	Third Storey	Sixth Storey	Top Storey
without tower	24.7	36.2	.46.8
with tower	18.1	26.45	36.1



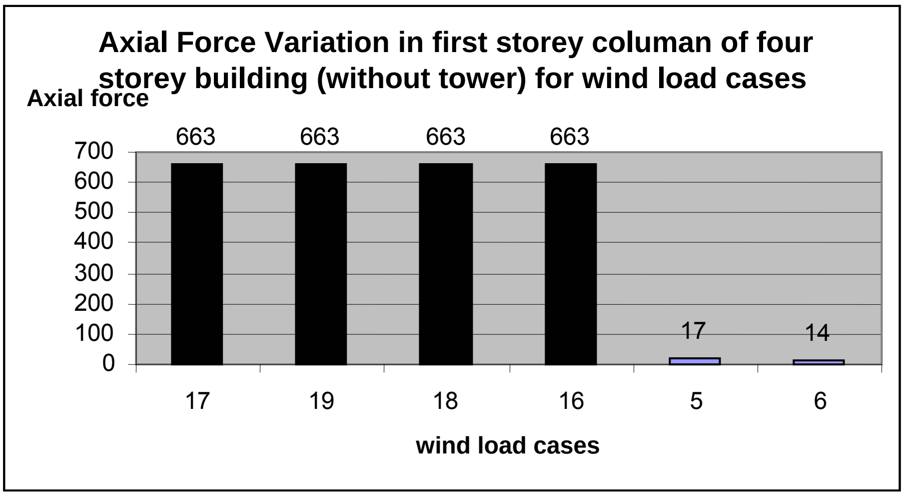


Axial Forces in Columns of the FOUR Storey building without and with tower						
First Storey Columns						
Without Tower				With Tower		
Earthquake Load Cases						
Column	Load Case	Axial (kN)		Column	Load Case	Axial (kN)
22	10	675		22	10	666
22	8	664		22	8	664
22	9	664		22	9	663
22	11	663		22	11	662
23	2	73		23	2	81
26	1	52		26	1	34
Wind Load Cases						
22	17	663		22	18	665
22	19	663		22	16	664
22	18	663		22	17	662
22	16	663		22	19	661
23	5	17		23	6	85
26	6	14		26	5	45
Top Storey Columns						
Without Tower				With tower		
Earthquake Load Cases						
Column	Load Case	Axial (kN)		Column	Load Case	Axial (kN)
239	10	158		239	10	186
239	8	158		239	8	152
239	9	158		239	9	148
239	11	148		239	11	147
243	2	12		243	2	35
240	1	9		240	1	19
Wind Load Cases						
239	17	148		239	18	218
239	19	148		239	17	157
239	18	148		239	16	150
239	16	148		239	19	147
243	5	2		243	6	70
240	6	2		240	5	55

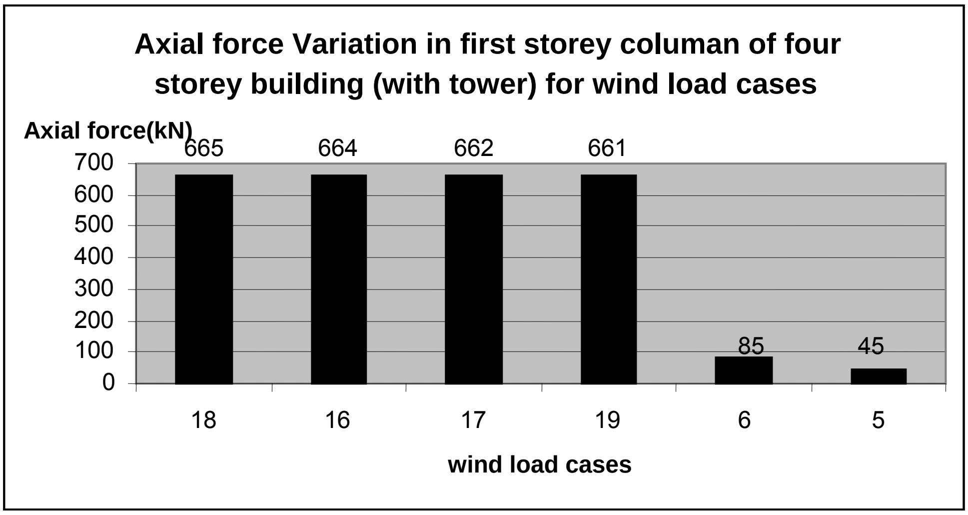




Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

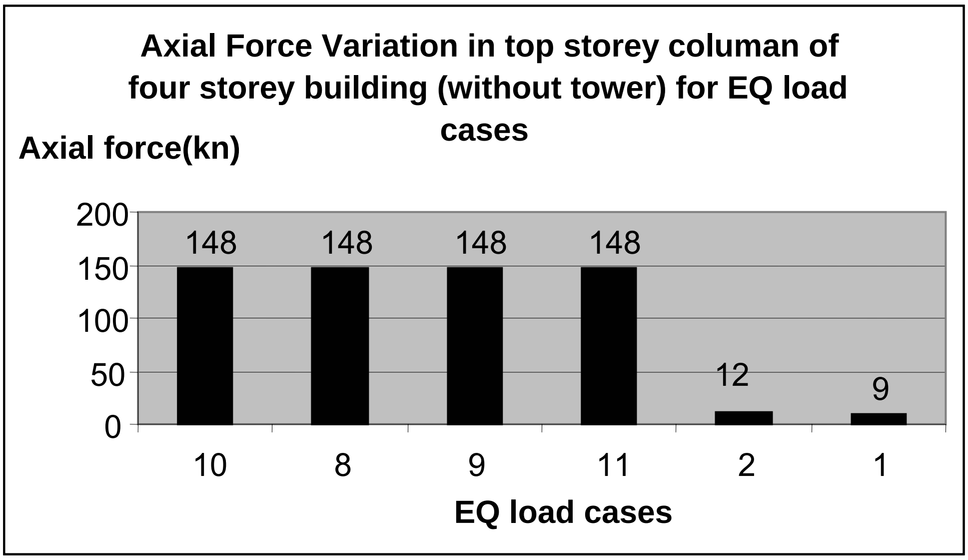


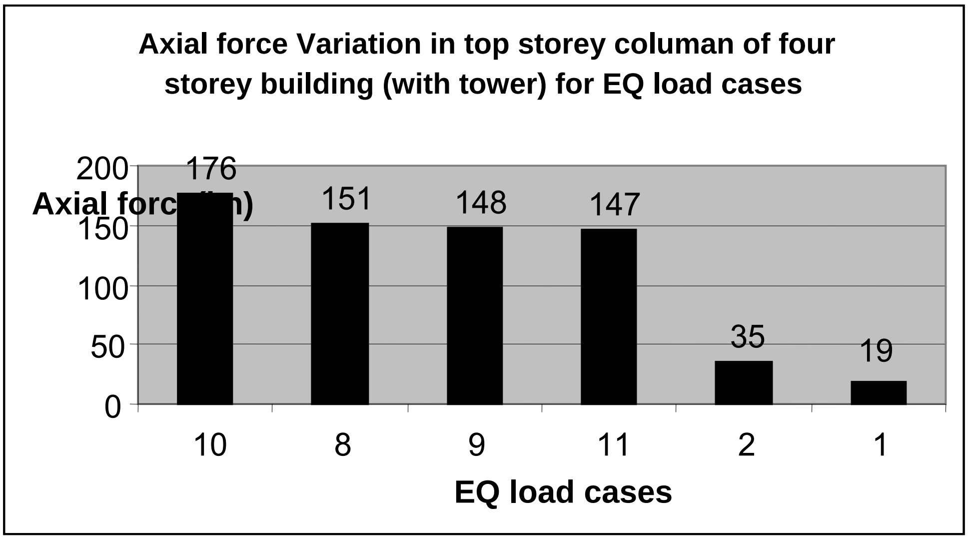
Axial Force Variation in first storey columan of four storey building (without tower) for wind load cases



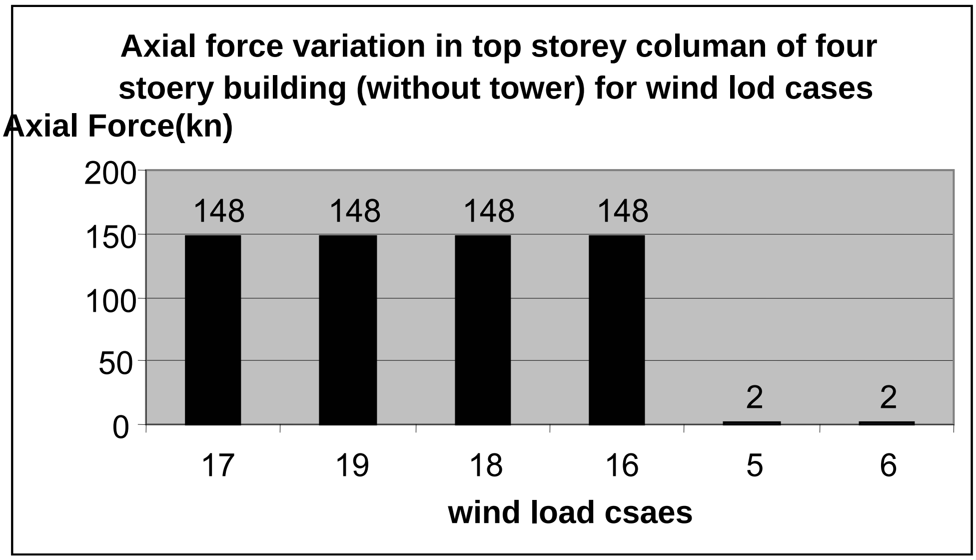
Axial force Variation in first storey columan of four storey building (with tower) for wind load cases

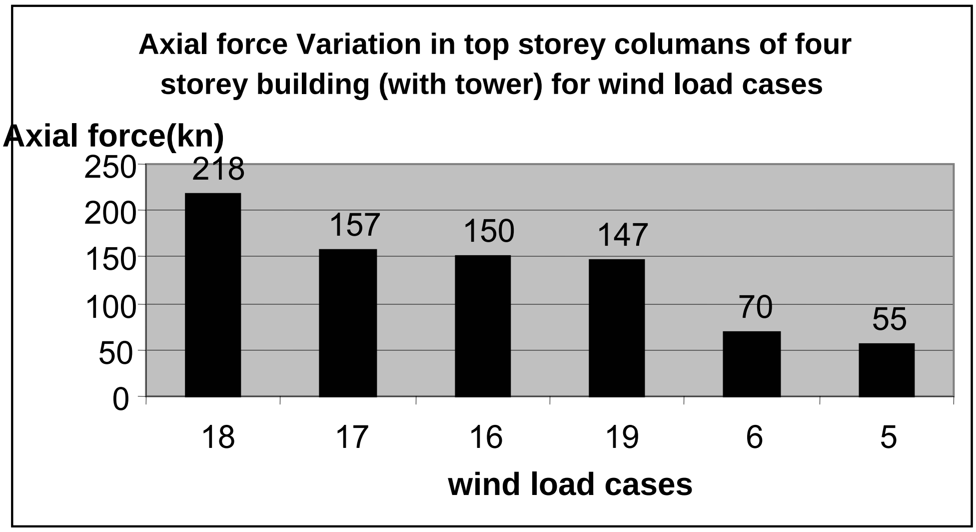
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





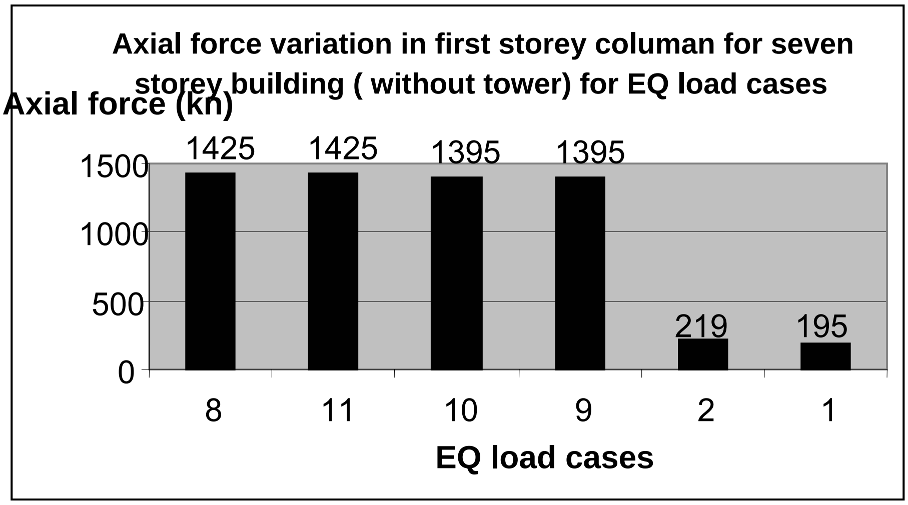
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

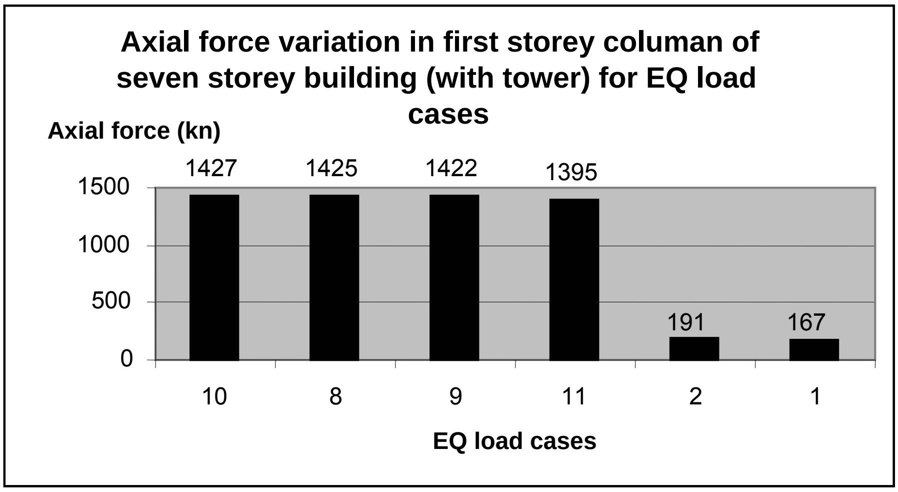




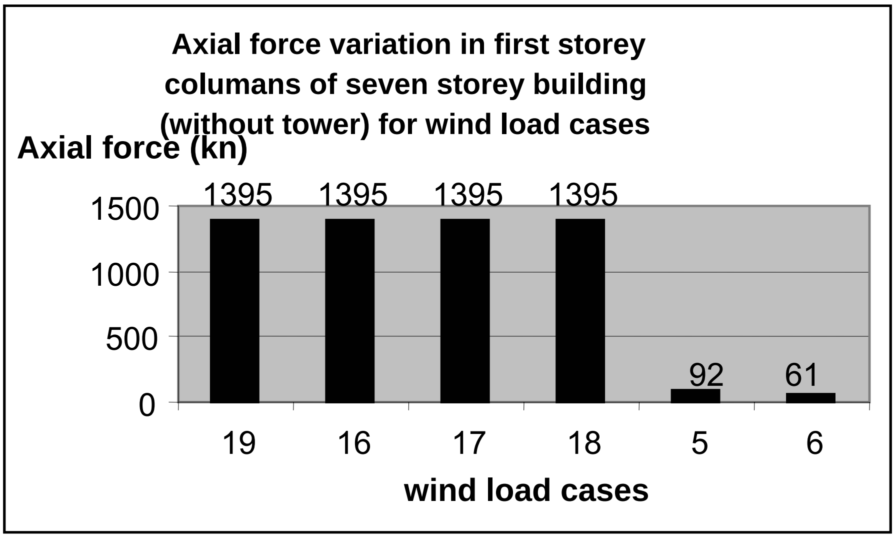
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

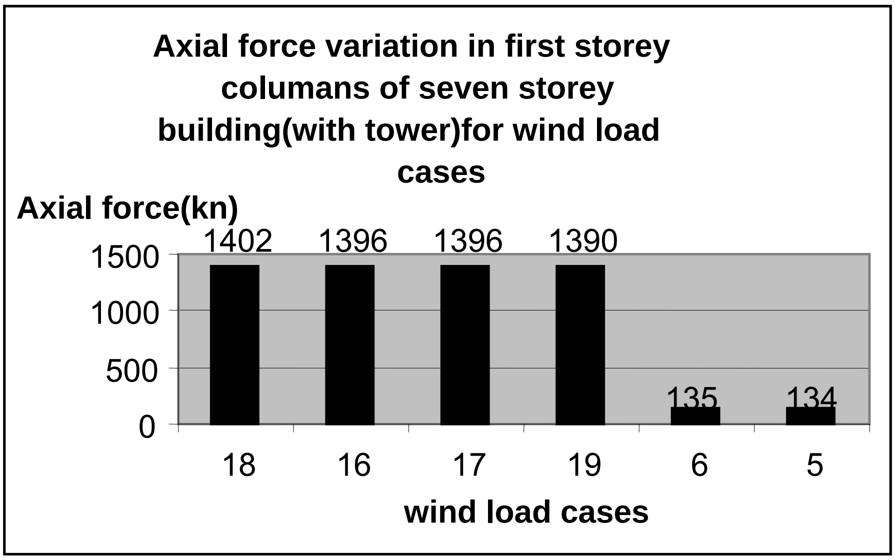
Axial Forces in Columns of the SEVEN Storey building without and with tower					
First Storey Columns					
Without Tower			With Tower		
Earthquake Load Cases					
Column	Load Case	Axial (kN)	Column	Load Case	Axial (kN)
22	8	1425	22	10	1427
22	11	1425	22	8	1425
22	10	1395	22	9	1422
22	9	1395	22	11	1395
23	2	219	23	2	191
26	1	195	26	1	167
Wind Load Cases					
22	19	1425	22	18	1428
22	16	1425	22	16	1426
22	17	1395	22	17	1396
22	18	1395	22	19	1390
23	5	92	23	6	135
26	6	61	26	5	134
Top Storey Columns					
Without Tower			With tower		
Earthquake Load Cases					
Column	Load Case	Axial (kN)	Column	Load Case	Axial (kN)
	8	145	454	10	145
454	10	145	454	8	144
454	11	144	454	9	144
454	9	140	454	11	140
454	2	7	455	1	13
455	1	5		2	10
454	17	145	454	18	216
454	19	144	454	16	149
454	18	143	454	17	146
454	16	140	454	19	137
455	5	2	454	6	81
	6	1	455	5	69



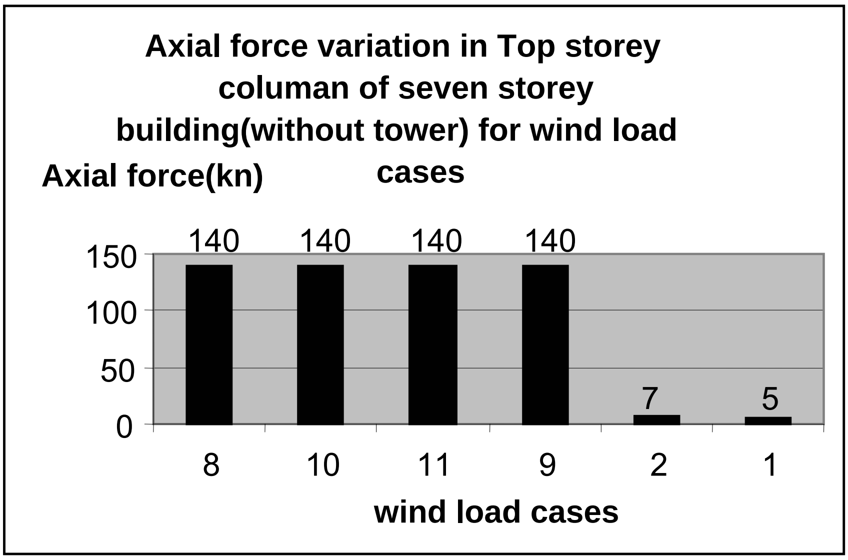


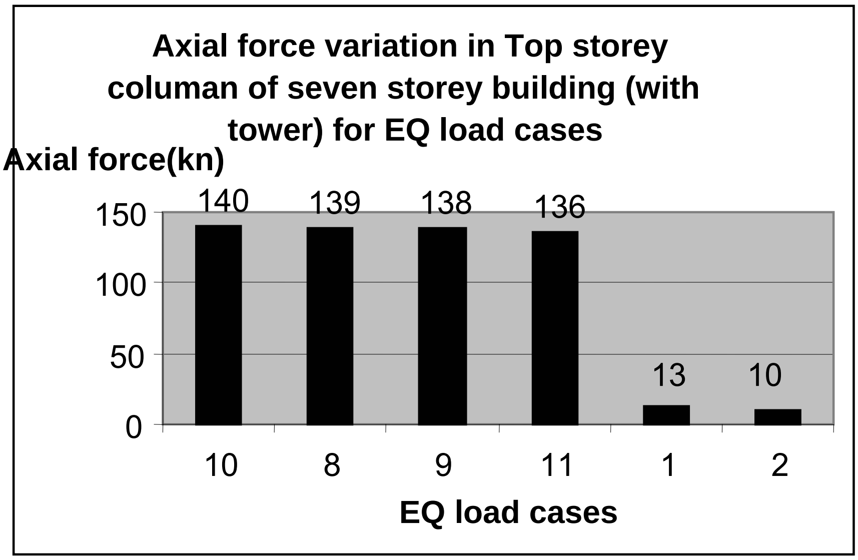
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)



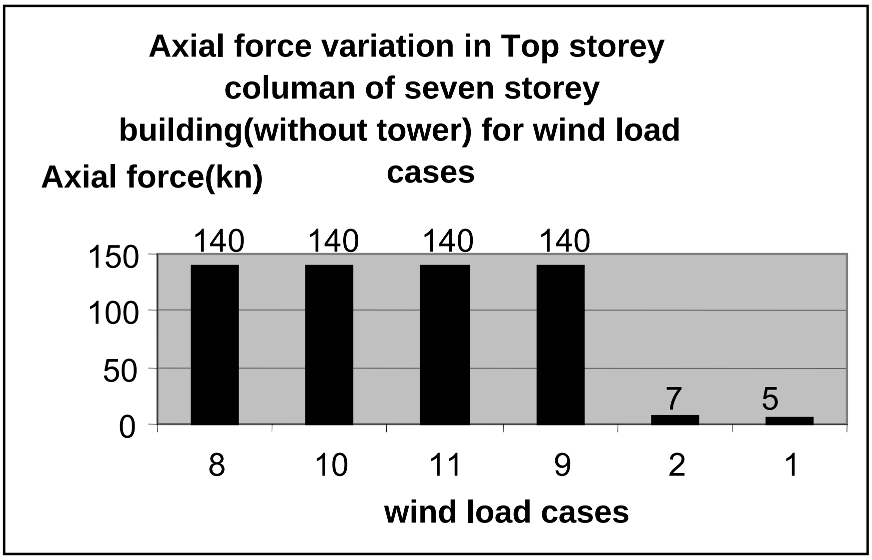


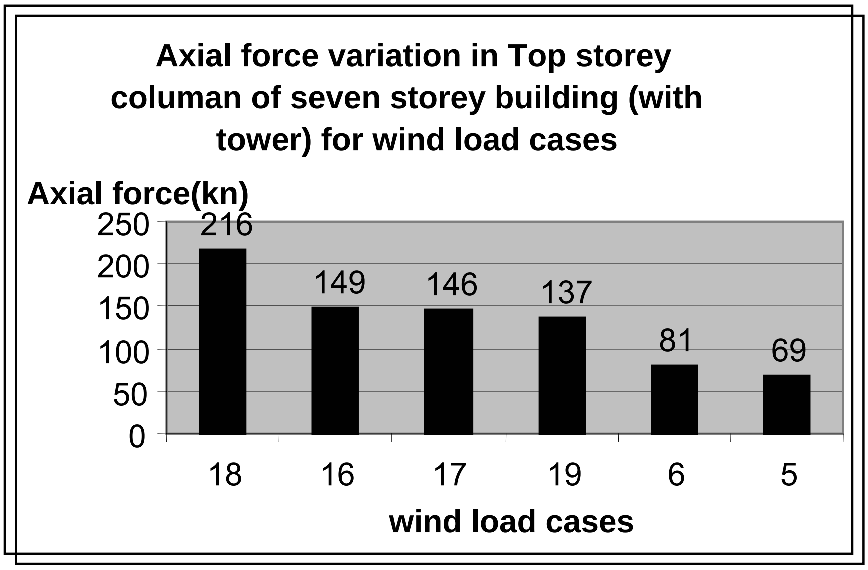
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





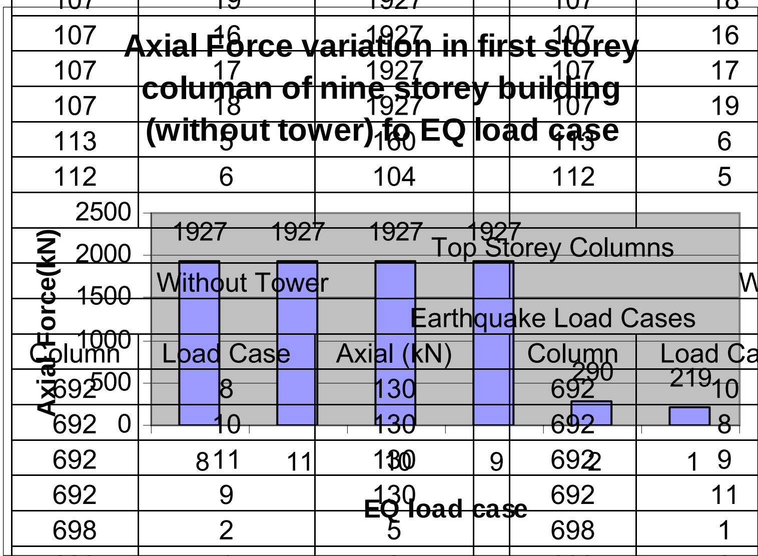
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

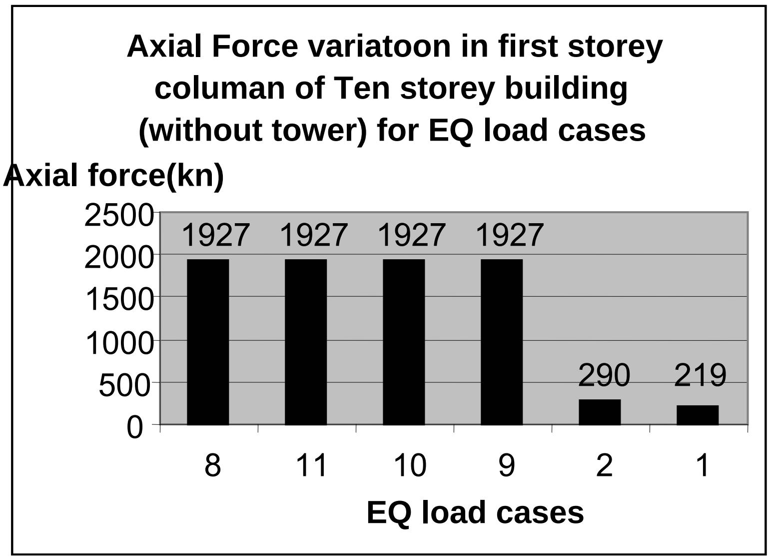


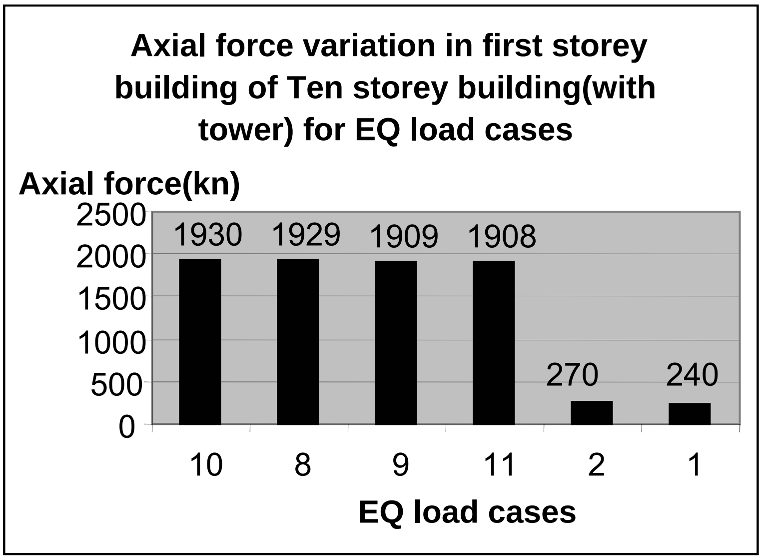


Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

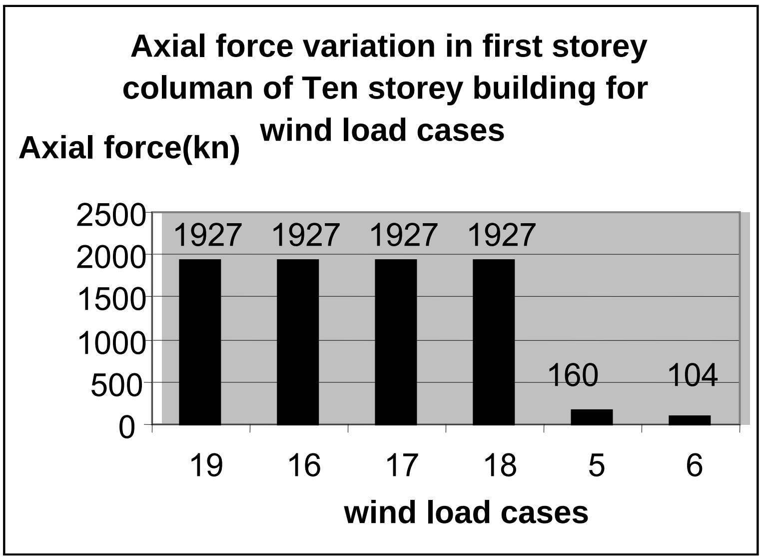
Axial Forces in Columns of the TEN Storey building without and with tower						
First Storey Columns						
Without Tower				With Tower		
Earthquake Load Cases						
Column	Load Case	Axial (kN)		Column	Load Case	Axial (kN)
107	8	1927		107	10	1930
107	11	1927		107	8	1929
107	10	1927		107	9	1909
107	9	1927		107	11	1908
113	2	290		113	2	270
112	1	219		112	1	240
Wind Load Cases						
107	19	1927		107	18	1939
107	16	1927		107	16	1909
107	17	1927		107	17	1908
107	18	1927		107	19	1906
113	5	160		113	6	179
112	6	104		112	5	178
Top Storey Columns						
Without Tower				With tower		
Earthquake Load Cases						
Column	Load Case	Axial (kN)		Column	Load Case	Axial (kN)
692	8	130		692	10	132
692	10	130		692	8	131
692	11	130		692	9	128
692	9	130		692	11	125
698	2	5		698	1	8
693	1	3		693	2	6
Wind Load Cases						
692	17	130		692	18	210
692	19	130		692	16	137
692	18	130		692	17	138
692	16	130		692	19	129
698	5	2		698	6	89
693	6	1		693	5	80

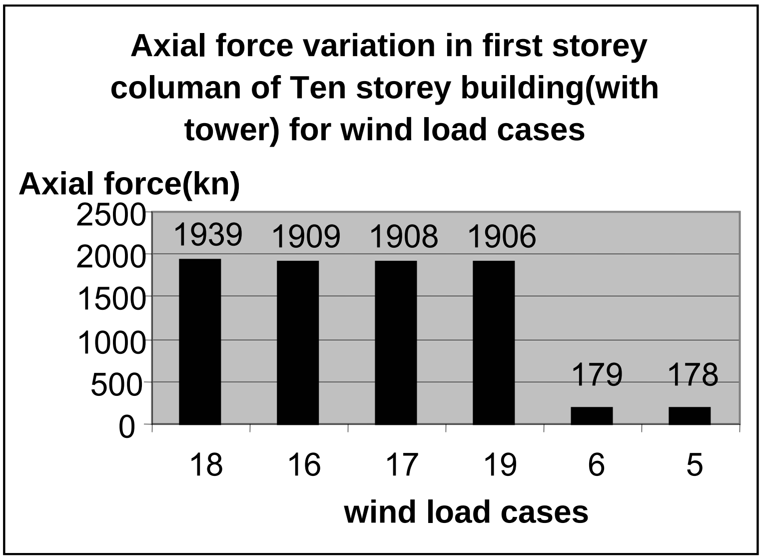




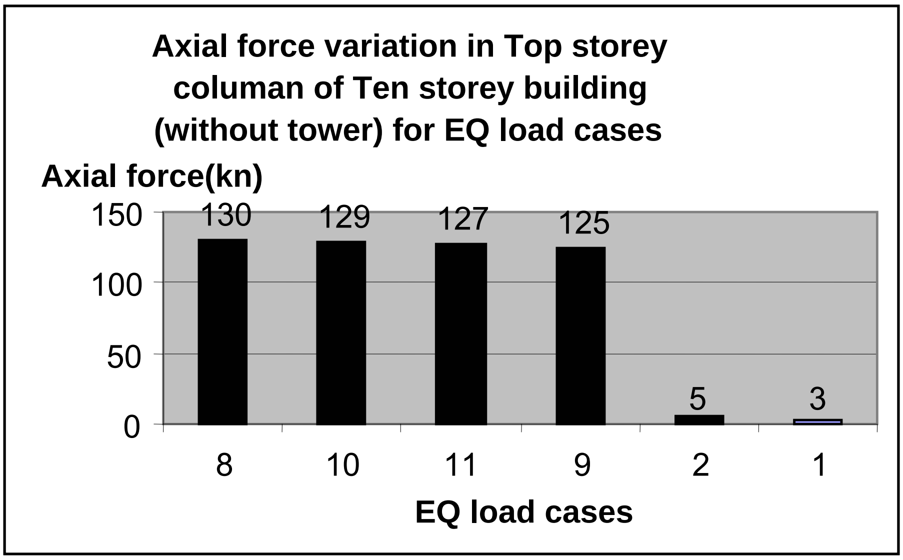


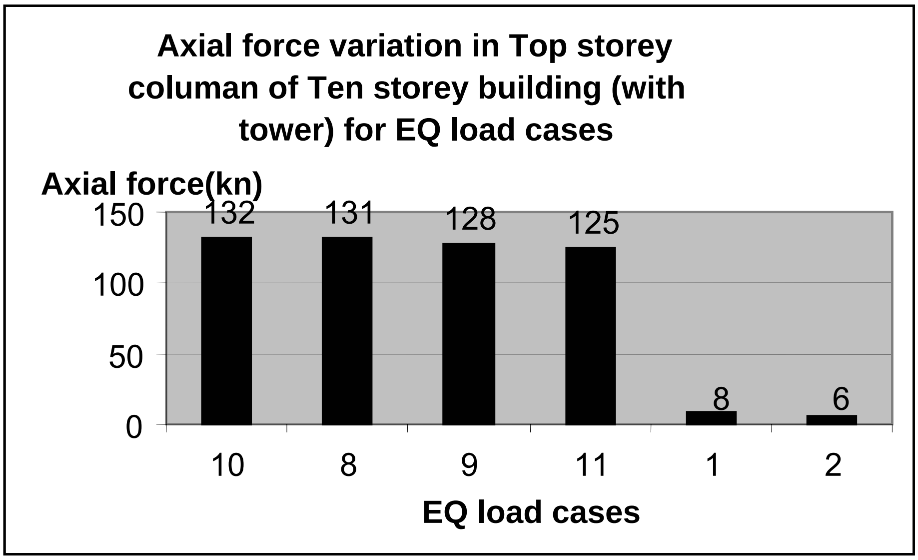
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)



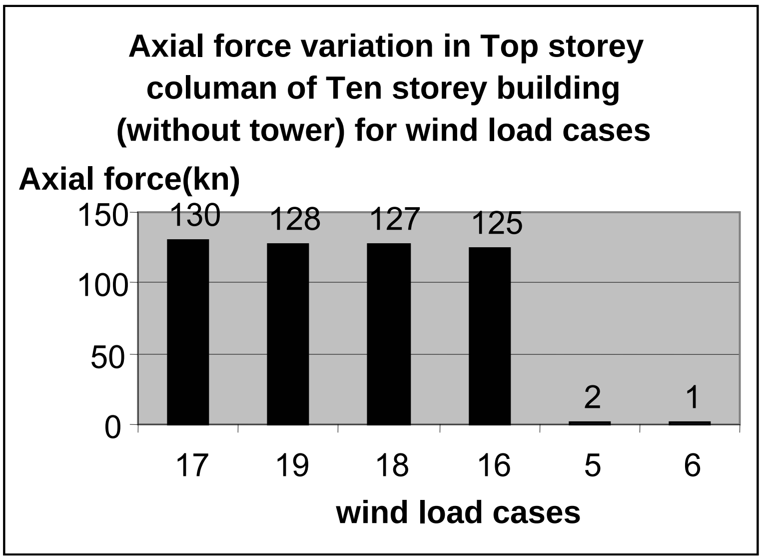


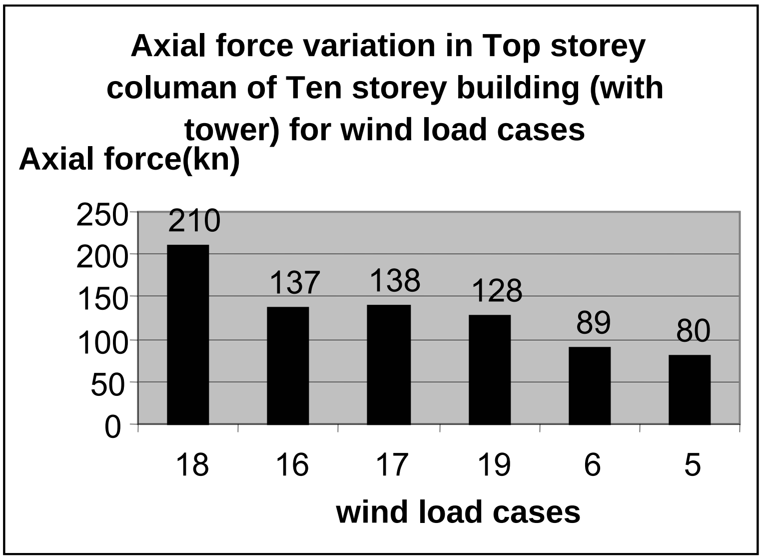
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





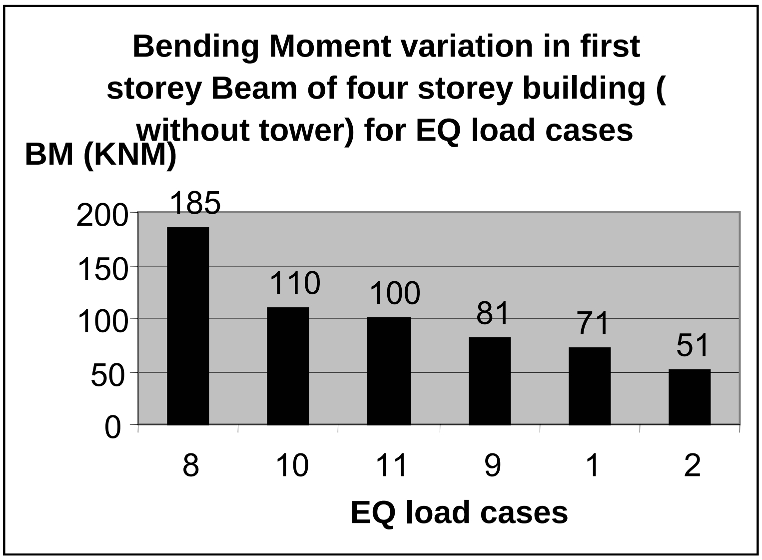
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)



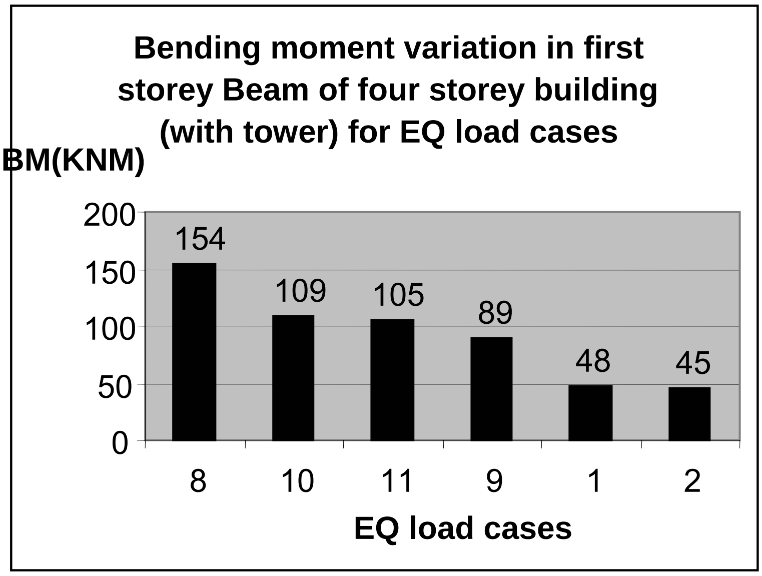


Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

Bending Moments in Beams of the FOUR Storey building without and with 12M tower						
First Storey Beams						
Without Tower				**With Tower**		
Earthquake Load Cases						
Beam	Load Case	BM		Beam	Load Case	BM
77	8	185		77	8	154
77	10	110		77	10	109
77	11	100		77	11	105
138	9	81		138	9	89
138	1	71		138	1	48
144	2	51		144	2	45
Wind Load Cases						
77	17	128		77	17	127
77	19	109		77	18	105
77	18	105		77	19	104
138	16	89		138	16	88
138	6	2		138	6	3
144	5	1		144	5	1
Top Storey Beams						
Without Tower				With tower		
Earthquake Load Cases						
Beam	Load Case	BM		Beam	Load Case	BM
473	8	88		473	8	77
473	10	56		473	10	56
473	11	54		473	11	54
507	9	45		507	9	46
489	1	29		489	1	19
476	2	18		476	2	16
Wind Load Cases						
473	17	61		473	17	61
473	18	54		473	18	56
473	19	54		473	19	52
507	16	48		507	16	48
489	6	1		489	6	19
476	5	0		476	5	16

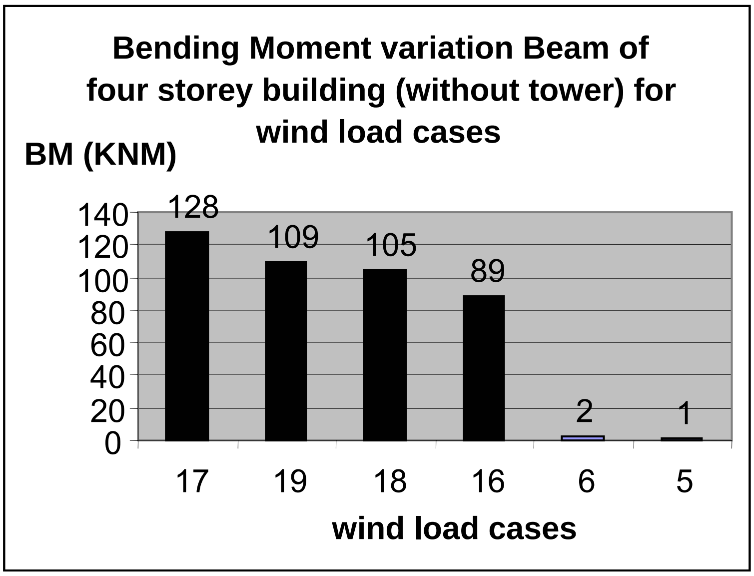


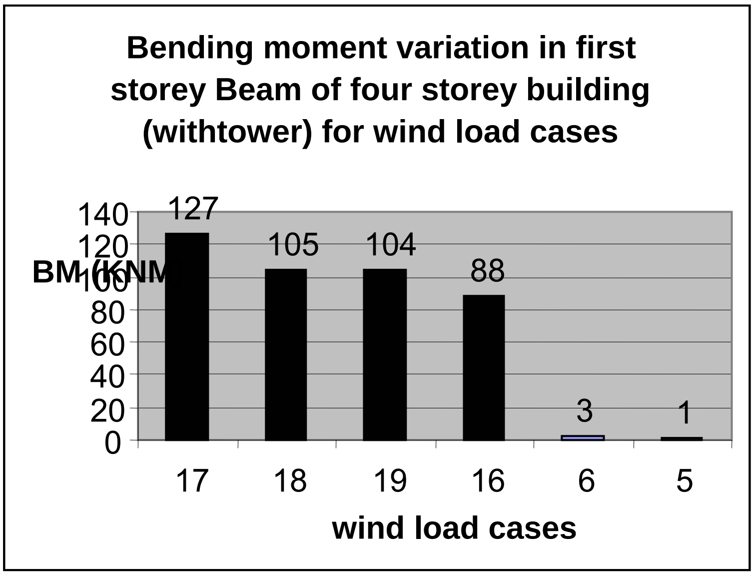
Bending Moment variation in first storey Beam of four storey building (without tower) for EQ load cases



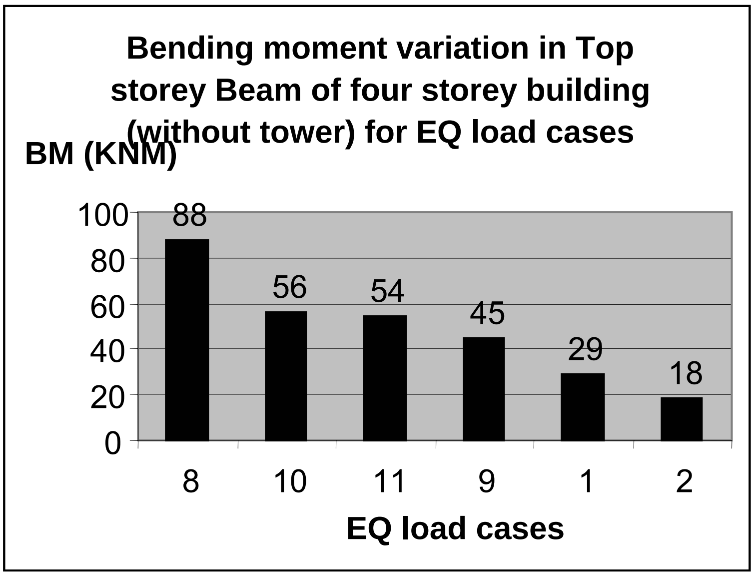
Bending moment variation in first storey Beam of four storey building (with tower) for EQ load cases

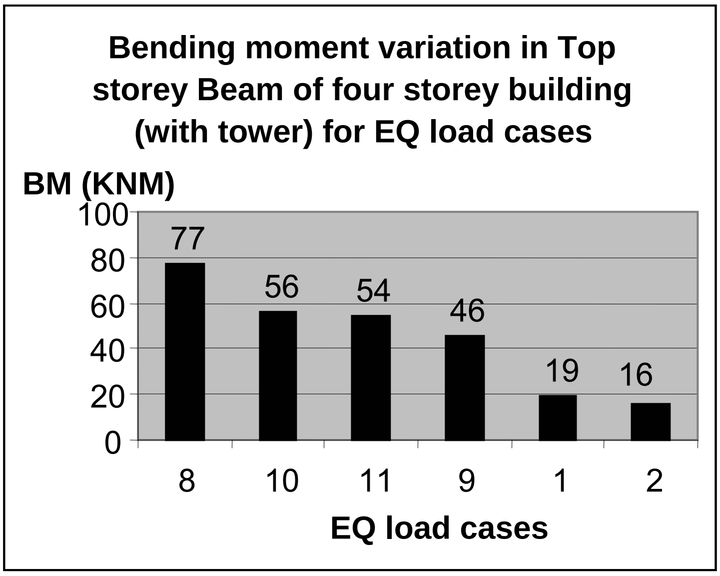
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)



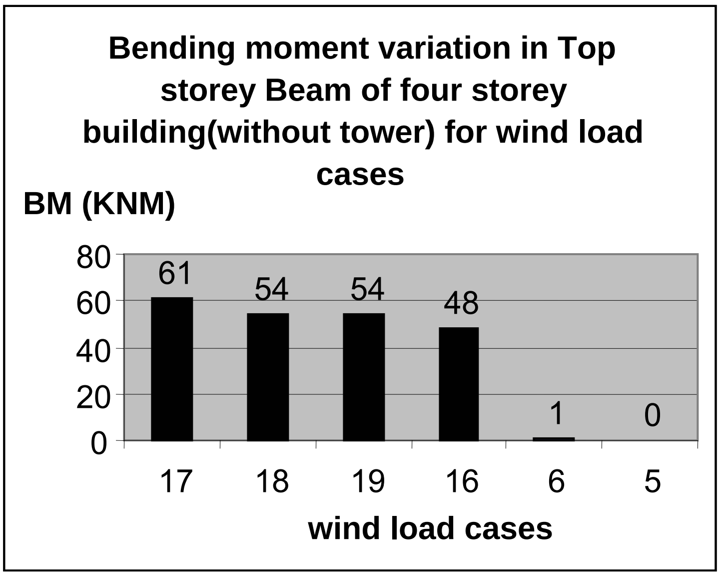


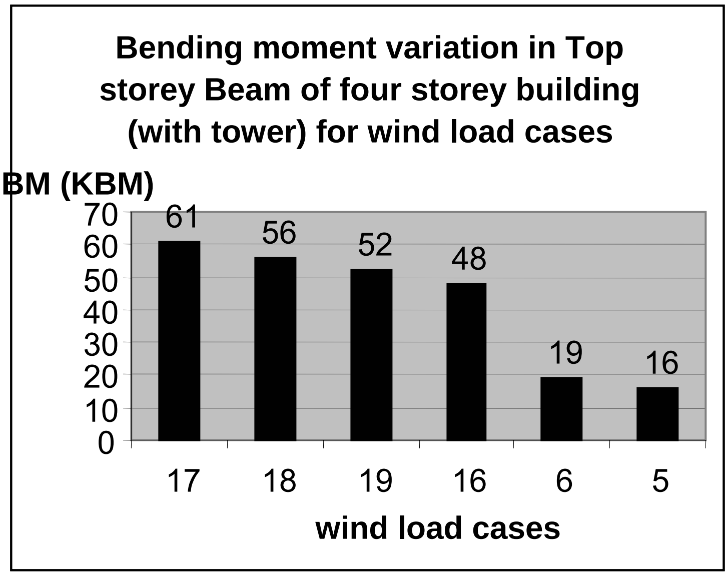
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





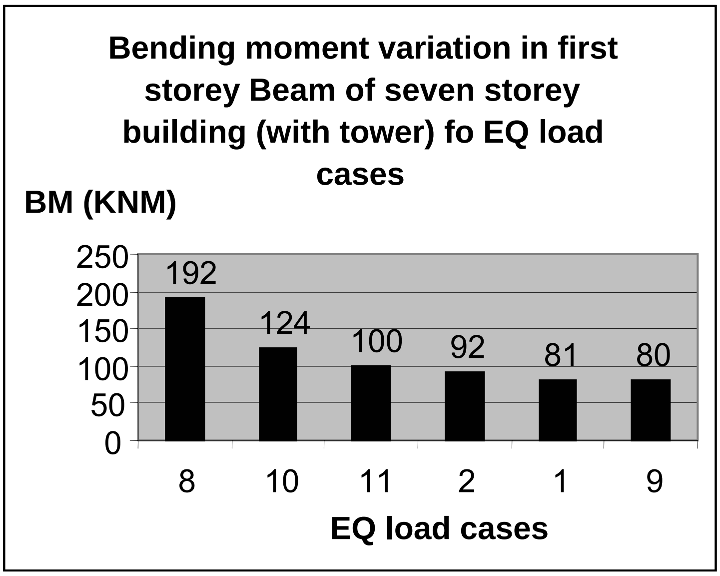
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

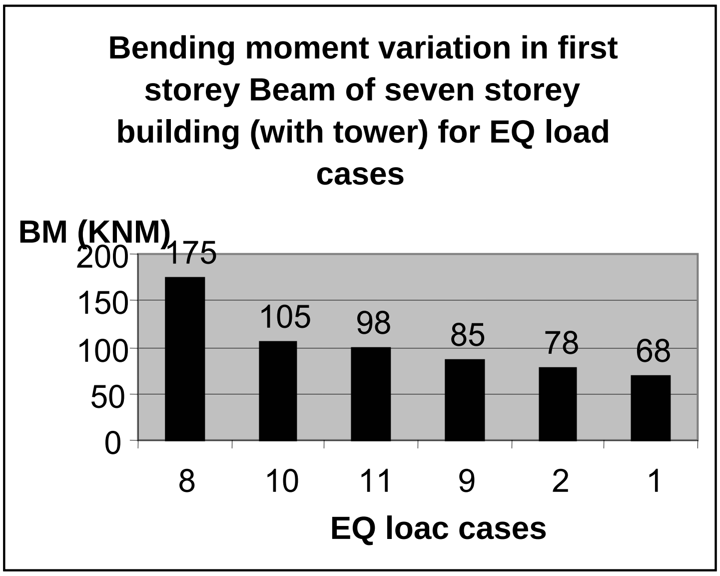




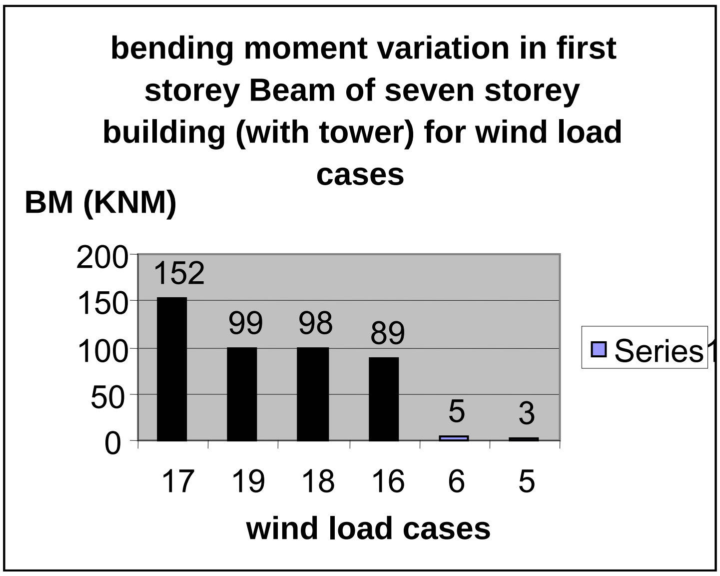
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

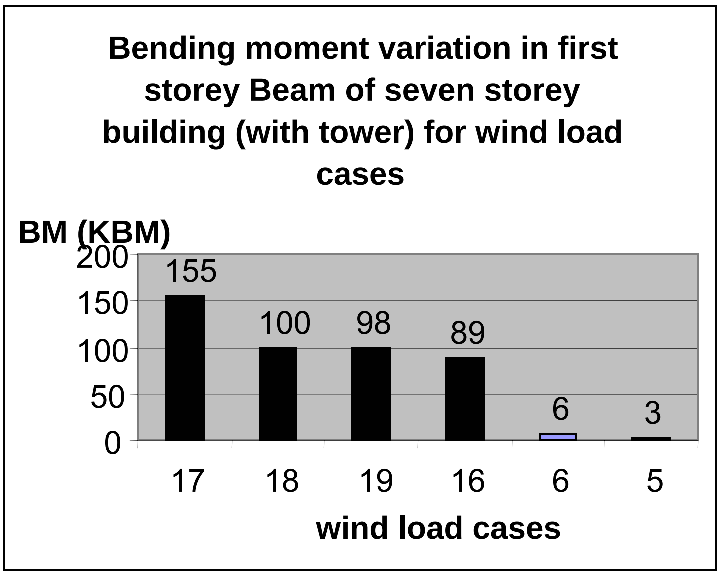
Bending Moments in Beams of the SEVEN Storey building without and with tower						
First Storey Beams						
Without Tower				**With Tower**		
Earthquake Load Cases						
Beam	Load Case	BM		Beam	Load Case	BM
133	8	192		133	8	175
133	10	124		133	10	105
133	11	100		133	11	98
133	2	92		133	9	85
162	1	81		162	2	78
166	9	80		166	1	68
Wind Load Cases						
133	17	152		133	17	155
133	19	99		133	18	100
133	18	98		133	19	98
133	16	89		133	16	89
162	6	5		162	6	6
166	5	3		166	5	3
Top Storey Beams						
Without Tower				**With tower**		
Earthquake Load Cases						
Beam	Load Case	BM		Beam	Load Case	BM
473	8	72		473	8	68
473	10	52		473	10	52
473	11	50		473	11	50
473	9	46		473	9	46
507	1	16		507	1	14
489	2	15		489	2	14
Wind Load Cases						
473	17	55		473	17	56
473	19	52		473	16	52
473	18	50		473	18	51
473	16	48		473	19	51
507	5	1		507	6	23
489	6	1		489	5	21



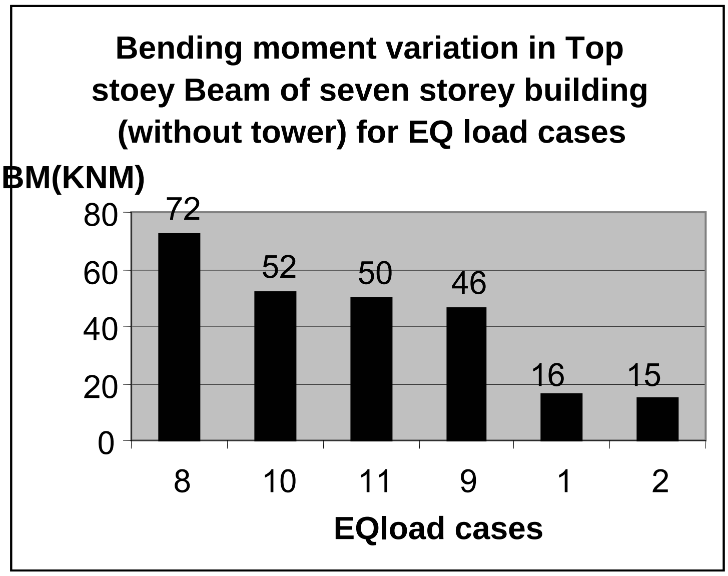


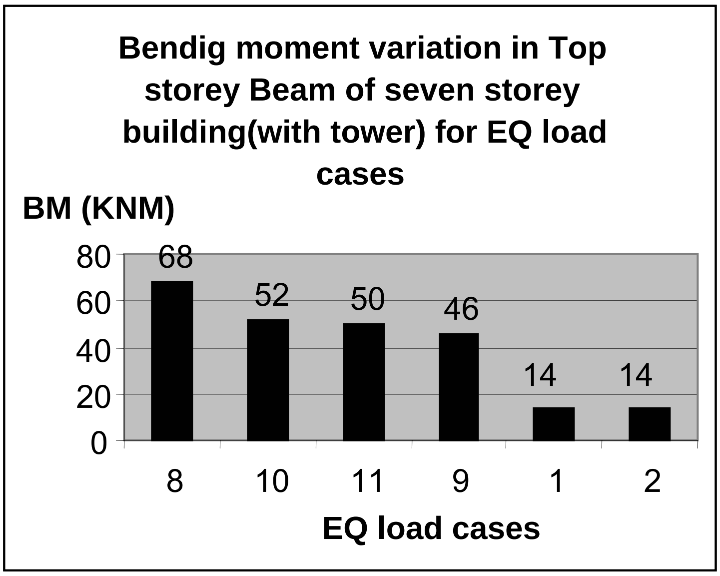
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)



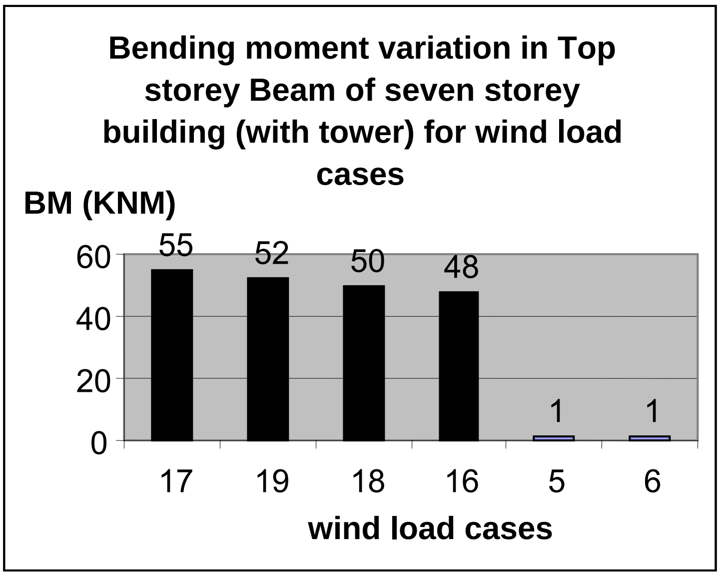


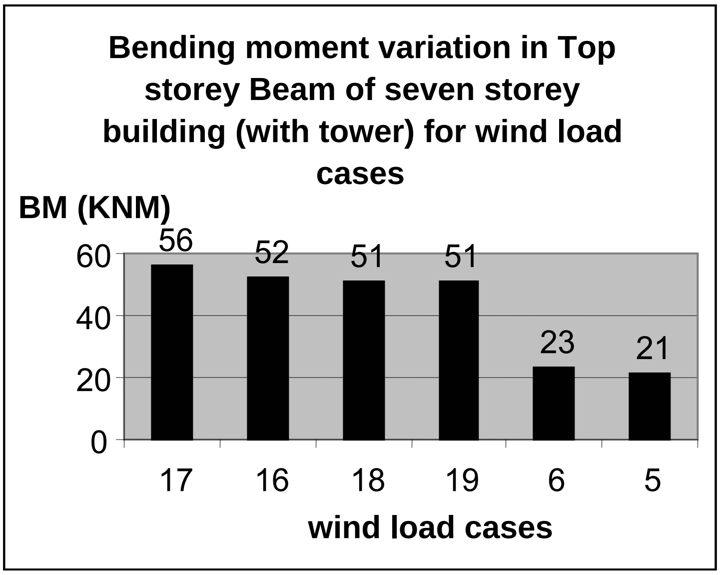
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





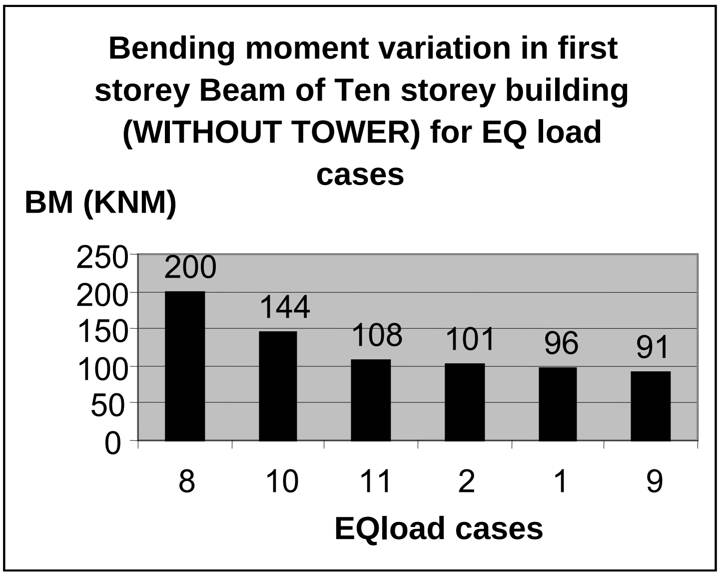
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

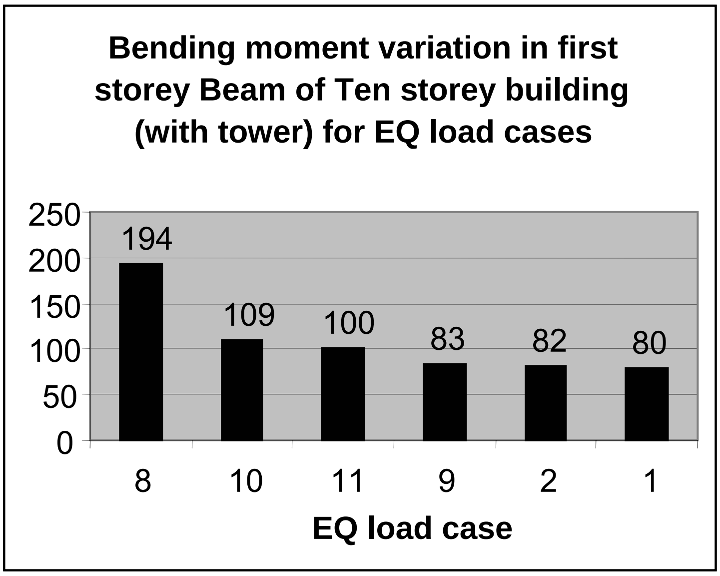




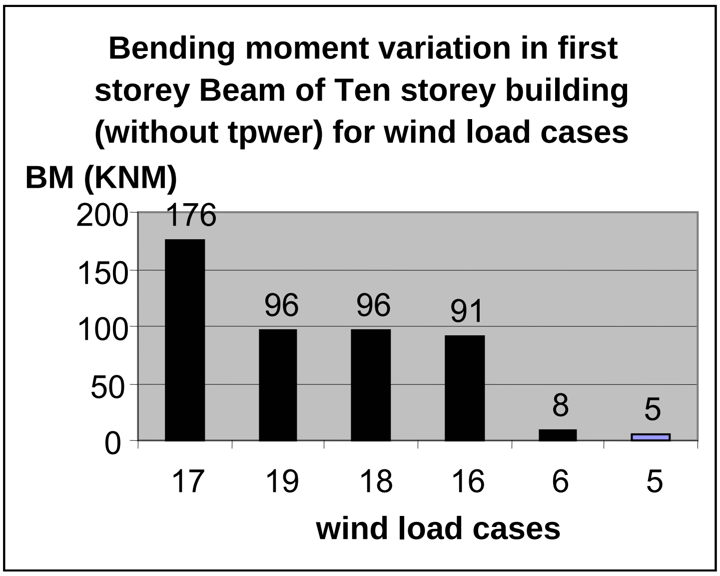
Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

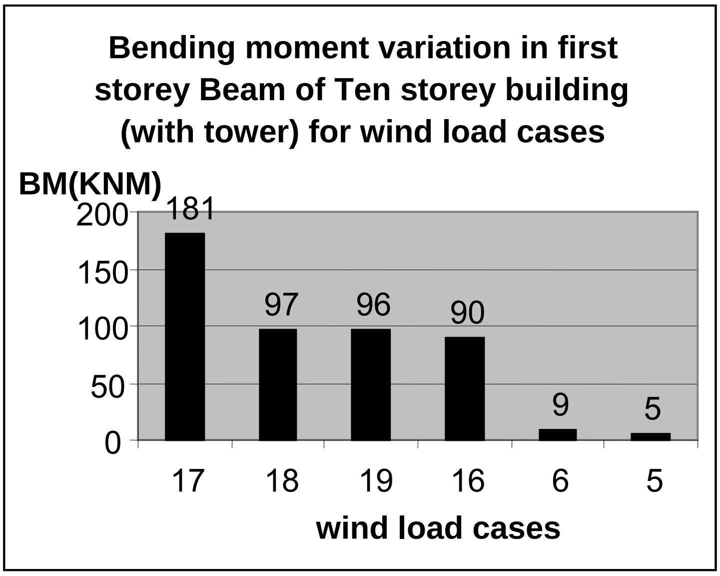
Bending Moments in Beams of the TEN Storey building without and with tower						
First Storey Beams						
Without Tower				**With Tower**		
Earthquake Load Cases						
Beam	Load Case	BM		Beam	Load Case	BM
166	8	200		166	8	194
166	10	144		166	10	109
162	11	108		162	11	100
162	2	101		162	9	83
137	1	96		137	2	82
137	9	91		137	1	80
Wind Load Cases						
166	17	176			17	181
166	19	96		166	18	97
162	18	96		166	19	96
162	16	91		162	16	90
137	6	8		162	6	9
137	5	5		137	5	5
				137		
Top Storey Beams						
Without Tower				With tower		
Earthquake Load Cases						
Beam	Load Case	BM		Beam	Load Case	BM
718	8	52		718	8	55
718	10	46		718	10	45
718	11	46		718	11	45
718	9	45		718	9	40
751	1	13		751	1	12
747	2	11		747	2	10
Wind Load Cases						
718	17	46		718	17	55
718	19	45		718	16	50
718	18	45		718	18	48
718	16	44		718	19	48
751	5	1		751	6	20
747	6	1		747	5	18



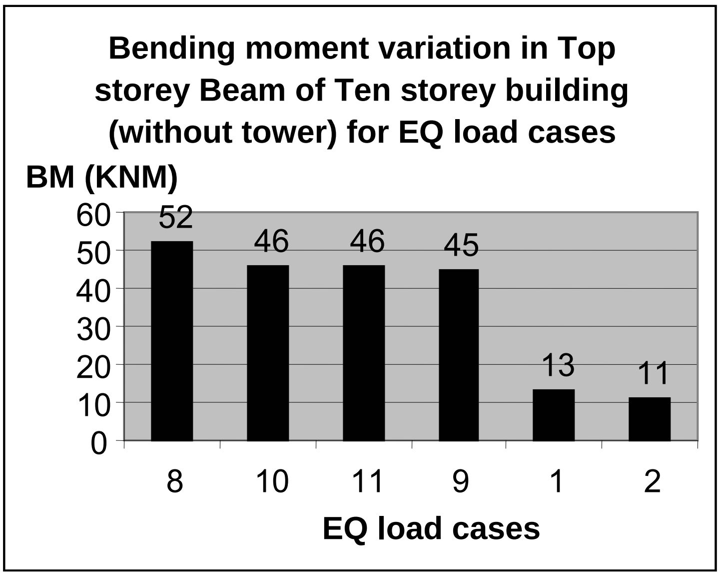


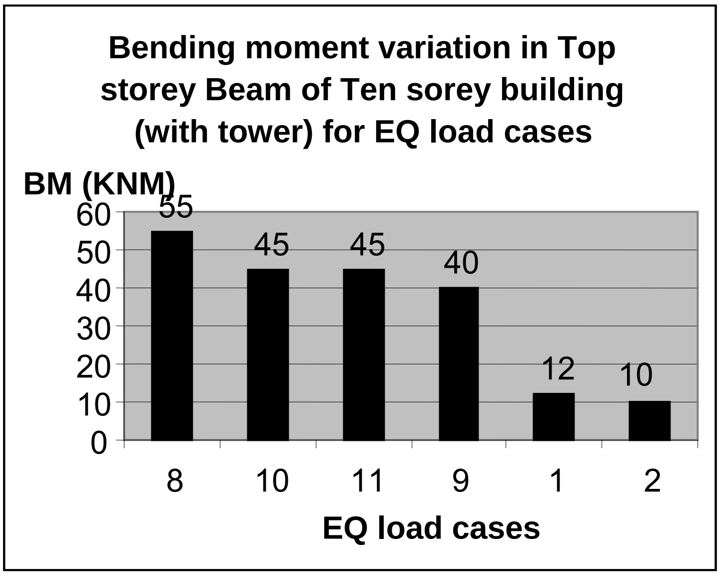
Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)



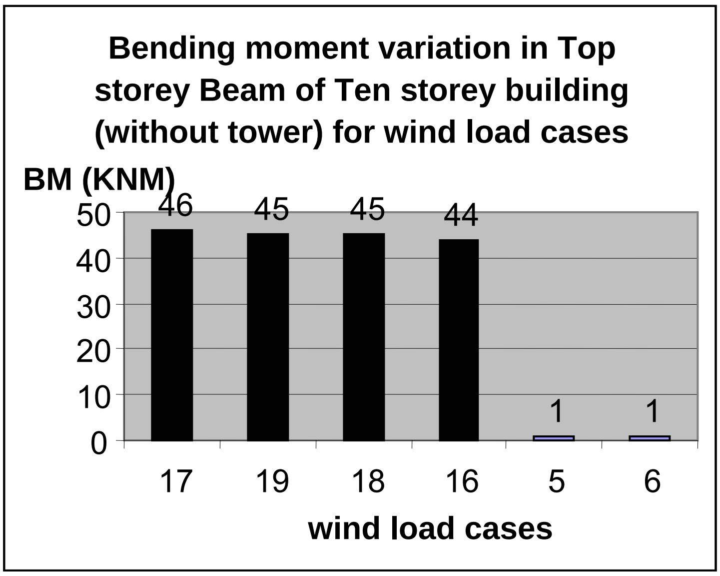


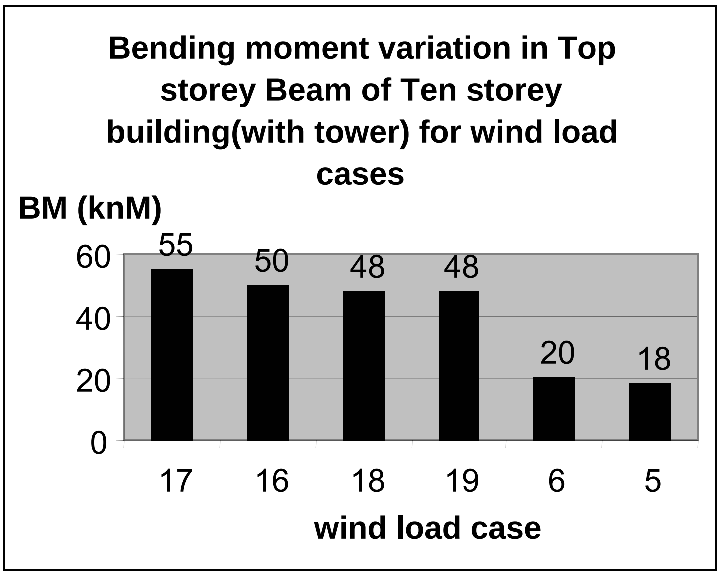
Load case						
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





Load case					
1	Seismic load (EQ)in x dir			11	DL+LL-EQ in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)





Load case					
1	Seismic load (EQ)in x dir			19	DL+LL-WL in z dir
2	Seismic load (EQ)in z dir			5	Wind Load (WL) in X Dir
8	DL+LL+EQ in x dir			6	Wind Load (WL) in Z Dir
9	DL+LL-EQ in x dir			17	1.2(DL + LL - WLX
10	DL+LL+EQ in z dir			18	1.2(DL + LL + WLZ)

Chapter Four

Discussion of Results

The results obtained from the analysis of the problem can be divided in to three sets – one for the four storey building, seven storey building and other for the ten storey building.

The results for the analysis of four storey building with12m towers can be summarized as below.

1. The maximum axial force in the first storey column in the building with tower 34% during the earthquake loading in X direction as compared to the building without the tower.
2. The maximum displacement in the top storey column in the building with tower decreases 65.43% during the earthquake loading in X direction as compared to the building without the tower.

3. For the earthquake loading in X direction, the maximum bending moment in the first storey beam decreases by 37% for the tower as compared to the building without the tower

4 For the earthquake loading in X direction, the maximum bending moment in the top storey beam decreases by 34% for the tower whereas it increases by 34% the building without the tower in first storey building

5 When the earthquake loading is considered acting along the dead and the live loading, the maximum bending moment in the first storey beam decreases by 17% when the building with tower.

The wind load effect on the axial forces in the columns of the first and top storey and on the bending moments in the beams of the first and top storey of the four storey building is as below.

1. The maximum axial force in the first storey column increases in with tower. The maximum increase of 1.3% occurs for with the tower consider earthquake load and wind load.
2. The maximum axial force in the top storey column increases in with tower. The maximum increase of 15.90% with tower in earthquake load but 47.29% increase in wind load cases. .
3. The maximum axial force in the top storey column due to dead, live and wind load combination increases for the tower. The maximum increase of 32% occurs for with the tower.
4. The maximum bending moment in the first storey beam remains constant with the tower.

5. The maximum bending moment in the top storey beam decease with tower condition.
6. The maximum bending moment in the top storey beam due to dead, live and wind load combination remains same with the towers

The results for the analysis of the seven storey building with can be summarized as below.

1. The maximum axial force in the first storey column in the building with tower remain same but decreases by 16% during the earthquake loading in Z direction as compared to the building without the tower.
2. The maximum axial force in the top storey column in the building with tower remains same. it increases by 71% during the earthquake loading in Z direction as compared to the building without the tower..
3. For the earthquake loading in X direction, the maximum bending moment in the first storey beam decreases by 18% for compared to the building without the tower.
4. For the earthquake loading in X direction, the maximum bending moment in the top storey beam decreases by 12.5% for with tower. it increases by 19% when the tower as compared to the building without the tower.
5. When the earthquake loading is considered acting along the dead and the live loading, the maximum bending moment in the first storey beam decreases by 9.5% for all tower.

The wind load effect on the axial forces in the columns of the first and top storey and on the bending moments in the beams of the first and top storey of the seven storey building is as below.

1. The maximum axial force in the first storey column increases of 84% with tower..
2. The maximum axial force in the top storey column increases of 54.28% in wind load cases with tower..
3. The maximum axial force in the first storey column due to the combination of dead, live and wind load increases marginally when with tower. The maximum increase of 5%with tower.
4. The maximum axial force in the top storey column due to dead, live and wind load combination increases in with tower. The maximum increase of 57% with tower.
5. The maximum bending moment in the first storey beam remains constant with the tower.
6. The maximum bending moment in the top storey beam remain constant with tower but increase in wind load cases.
7. The maximum bending moment in the top storey beam due to dead, live and wind load combination remains same with the towers.

The results for the analysis of ten storey building with towers can be summarized as below

1 The maximum axial force in the first storey column in the building with tower 30% during the earthquake loading in X direction as compared to the building without the tower.
2 The maximum displacement in the top storey column in the building with tower decreases 53.42% during the earthquake loading in X direction as compared to the building without the tower.

3. for the earthquake loading in X direction, the maximum bending Moment in the top storey beam decreases by 31% for the tower Whereas it increases by 31% the building without the tower in first Storey building.

4 When the earthquake loading is considered acting along the dead and the live loading, the maximum bending moment in the first storey beam decreases by 15% when the building with tower

The wind load effect on the axial forces in the columns of the first and top storey and on the bending moments in the beams of the first and top storey of the ten storey building is as below.

1. The maximum axial force in the first storey column increases of 54% with tower..
2. The maximum axial force in the top storey column increases of 44.38% in wind load cases with tower..
3. The maximum axial force in the first storey column due to the combination of dead, live and wind load increases marginally when with tower. The maximum increase of 4% with tower.
4. The maximum axial force in the top storey column due to dead, live and wind load combination increases in with tower. The maximum increase of 49% with tower.
5. The maximum bending moment in the first storey beam remains constant with the tower.
6. The maximum bending moment in the top storey beam remain constant with tower but increase in wind load cases.
7. The maximum bending moment in the top storey beam due to dead, live and wind load combination remains same with the towers.

The fundamental time period also remains unchanged in both buildings with tower.

The absolute top storey displacement of both the buildings reduces with tower. The reduction is by 37% in case of four storey building, 22% for the seven storey building and 115% for ten storey building.

Chapter Five

Conclusions

From the results obtained as above, the following conclusions can be drawn.

1. The results obtained by lumping the tower mass on the building roof and those obtained by modeling the tower on the roof are different.

2. The absolute storey displacement of a building gets reduced with tower. The reduction is more for smaller building heights.

3. The effect of earthquake loading on the buildings with roof top towers is to reduce the axial forces in bottom storey columns and to increase the same in the top storey columns. The effect is more predominant in smaller building heights.

4. The location of the tower on the building plan decides the increase or decrease in the maximum bending moment in the top storey beam. Thus certain locations may prove advantageous so as to cause reduction in forces.

5. The wind force increases the axial forces in the columns of the buildings with roof top towers. The increase in axial forces is more in case of higher buildings.

6. The maximum bending moments in top storey beams of the buildings with roof top towers increase substantially due to the wind load.

7. The earthquake loading governs the design of buildings without towers whereas the wind load becomes equally critical for building with roof top towers. This effect will be more so in case of high towers on high rise buildings.

Chapter Six

Scope of Further Study

There could be many permutations and computations of the said problem and each one would present a unique solution when analyses. The scope can be summarized as below.

- The plan of the building can be unsymmetrical as against the symmetrical plan chosen in this report.

- Different characteristics of a masonry building and a steel tower necessitate the analysis of the tower as a secondary system. This can be done by developing response spectra at the roof height and analyzing the tower for these spectra.

- Since towers are being installed over unreinforced masonry structures also, the effect of these towers on the seismic response of such buildings can be studied.

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END JOB INFORMATION
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E 2.67185e+007
POISSON 0.17
DENSITY 23.5616
ALPHA 1e-005
DAMP 0.05
ISOTROPIC STEEL
E 2.05e+008
POISSON 0.3
DENSITY 76.8195
ALPHA 1.2e-005

```
DAMP 0.03
END DEFINE MATERIAL
CONSTANTS
MATERIAL CONCRETE MEMB 41 TO 616 618 TO 627 636 638 640 642 824
TO 828 830 -
832 TO 834
MATERIAL STEEL MEMB 639 641 643 TO 676 678 TO 688 696 TO 699 701
TO 703 710 -
711 TO 823
MEMBER PROPERTY INDIAN
41 TO 65 106 TO 130 171 TO 195 236 TO 260 301 TO 325 366 TO 390 431 TO
455 -
496 TO 520 561 TO 585 PRIS YD 0.45 ZD 0.45
66 TO 105 131 TO 170 196 TO 235 261 TO 300 326 TO 365 391 TO 430 456 TO
495 -
521 TO 560 586 TO 616 618 TO 627 830 PRIS YD 0.23 ZD 0.5
* sizes fo the top beams
824 TO 828 832 TO 834 PRIS YD 0.23 ZD 0.5
MEMBER PROPERTY INDIAN
*TOWER
*MAIN PANAL 1
639 643 644 646 647 652 659 660 664 665 TABLE ST ISA90X90X8
*MAIN PANEL 2
645 648 TO 651 654 TO 658 661 TO 663 666 TO 668 TABLE ST ISA75X75X6
*MAIN PANEL 3
751 TO 767 769 TO 771 784 TO 787 796 TO 799 812 TO 815 TABLE ST
ISA50X50X6
*DIAG PANEL 1
641 678 TO 680 684 TO 687 711 712 714 715 718 TO 721 727 TO 732 735 736
739 -
740 TO 745 TABLE ST ISA60X60X6
*MAIN PANEL 4
653 674 676 696 698 699 710 713 722 TO 726 749 750 TABLE ST ISA60X60X6
*DIAG PANEL 2 3 4
776 TO 783 788 TO 795 800 TO 807 816 TO 823 TABLE ST ISA60X60X6
*MAIN PANEL 5
808 TO 811 TABLE ST ISA50X50X6
MEMBER PROPERTY INDIAN
*PEDESTAL
636 638 640 642 PRIS YD 0.4 ZD 0.4
* PANEL
669 TO 673 675 681 TO 683 688 697 701 TO 703 716 717 733 734 737 738 -
746 TO 748 768 772 TO 775 TABLE ST ISA50X50X6
SUPPORTS
1 TO 25 FIXED
CUT OFF MODE SHAPE 21
```

```
DEFINE 1893 LOAD
ZONE 0.24 RF 3 I 1.5 SS 2 ST 2
SELFWEIGHT
SLAVE RIGID MASTER 233 JOINT 251 TO 254
LOAD 1 DL
FLOOR LOAD
YRANGE 0 27 FLOAD -3.5 XRANGE 0 11.7 ZRANGE 0 18.2
LOAD 2 LL
SELFWEIGHT Y -1
FLOOR LOAD
YRANGE 0 27 FLOAD -3.5 XRANGE 0 11.7 ZRANGE 0 18.2
LOAD 3 DL+LL
FLOOR LOAD
YRANGE 0 27 FLOAD -3.5 XRANGE 0 11.7 ZRANGE 0 18.2
LOAD 4 SEISMIC X
SELFWEIGHT X 1
SELFWEIGHT Y 1
SELFWEIGHT Z 1
JOINT LOAD
255 256 FX 0.3
255 256 FY 0.3
255 256 FZ 0.3
273 279 FX 0.48
273 279 FY 0.48
273 279 FZ 0.48
278 285 FX 0.36
278 285 FY 0.36
278 285 FZ 0.36
275 281 FX 0.36
275 281 FY 0.36
275 281 FZ 0.36
265 266 FX 0.53
265 266 FY 0.53
265 266 FZ 0.53
JOINT LOAD
1 FX 8.946
2 FX 8.946
3 FX 8.946
4 FX 8.946
5 FX 8.946
6 FX 8.946
7 FX 8.946
8 FX 8.946
9 FX 8.946
10 FX 8.946
11 FX 8.946
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12 FX 8.946
13 FX 8.946
14 FX 8.946
15 FX 8.946
16 FX 8.946
17 FX 8.946
18 FX 8.946
19 FX 8.946
20 FX 8.946
21 FX 8.946
22 FX 8.946
23 FX 8.946
24 FX 8.946
25 FX 8.946
26 FX 70.658
27 FX 71.632
28 FX 70.658
29 FX 45.636
30 FX 95.384
31 FX 161.982
32 FX 164.88
33 FX 161.982
34 FX 95.384
35 FX 117.898
36 FX 203.197
37 FX 207.029
38 FX 203.197
39 FX 117.898
40 FX 95.384
41 FX 161.982
42 FX 164.88
43 FX 161.982
44 FX 95.384
45 FX 45.636
46 FX 70.658
47 FX 71.632
48 FX 70.658
49 FX 45.636
50 FX 45.636
51 FX 71.31
52 FX 72.4
53 FX 71.31
54 FX 46.183
55 FX 95.213
56 FX 161.234
57 FX 164.257

58 FX 161.234
59 FX 95.213
60 FX 117.879
61 FX 202.695
62 FX 206.661
63 FX 202.695
64 FX 117.879
65 FX 95.213
66 FX 161.234
67 FX 164.257
68 FX 161.234
69 FX 95.213
70 FX 46.183
71 FX 71.31
72 FX 72.4
73 FX 71.31
74 FX 46.183
75 FX 46.183
76 FX 71.17
77 FX 72.23
78 FX 71.17
79 FX 46.061
80 FX 95.251
81 FX 161.397
82 FX 164.39
83 FX 161.397
84 FX 95.251
85 FX 117.884
86 FX 202.808
87 FX 206.74
88 FX 202.808
89 FX 117.884
90 FX 95.251
91 FX 161.398
92 FX 164.39
93 FX 161.397
94 FX 95.251
95 FX 46.061
96 FX 71.17
97 FX 72.23
98 FX 71.17
99 FX 46.061
100 FX 46.061
101 FX 71.201
102 FX 72.269
103 FX 71.201

104 FX 46.089
105 FX 95.243
106 FX 161.361
107 FX 164.361
108 FX 161.36
109 FX 95.243
110 FX 117.882
111 FX 202.782
112 FX 206.723
113 FX 202.782
114 FX 117.882
115 FX 95.243
116 FX 161.361
117 FX 164.361
118 FX 161.361
119 FX 95.243
120 FX 46.089
121 FX 71.201
122 FX 72.269
123 FX 71.201
124 FX 46.089
125 FX 46.089
126 FX 71.19
127 FX 72.254
128 FX 71.19
129 FX 46.078
130 FX 95.246
131 FX 161.374
132 FX 164.371
133 FX 161.374
134 FX 95.246
135 FX 117.883
136 FX 202.792
137 FX 206.729
138 FX 202.792
139 FX 117.883
140 FX 95.246
141 FX 161.374
142 FX 164.371
143 FX 161.374
144 FX 95.246
145 FX 46.078
146 FX 71.19
147 FX 72.254
148 FX 71.19
149 FX 46.078

150 FX 46.078
151 FX 71.213
152 FX 72.285
153 FX 71.213
154 FX 46.101
155 FX 95.239
156 FX 161.345
157 FX 164.35
158 FX 161.345
159 FX 95.239
160 FX 117.882
161 FX 202.77
162 FX 206.716
163 FX 202.77
164 FX 117.882
165 FX 95.239
166 FX 161.345
167 FX 164.35
168 FX 161.345
169 FX 95.239
170 FX 46.101
171 FX 71.213
172 FX 72.285
173 FX 71.213
174 FX 46.101
175 FX 46.101
176 FX 71.112
177 FX 72.155
178 FX 71.112
179 FX 46.005
180 FX 95.267
181 FX 161.47
182 FX 164.444
183 FX 161.469
184 FX 95.267
185 FX 117.887
186 FX 202.861
187 FX 206.774
188 FX 202.861
189 FX 117.887
190 FX 95.267
191 FX 161.47
192 FX 164.444
193 FX 161.47
194 FX 95.267
195 FX 46.005

196 FX 71.112
197 FX 72.155
198 FX 71.112
199 FX 46.005
200 FX 46.005
201 FX 71.586
202 FX 72.743
203 FX 71.586
204 FX 46.433
205 FX 95.138
206 FX 160.903
207 FX 163.997
208 FX 160.903
209 FX 95.138
210 FX 117.867
211 FX 202.46
212 FX 206.502
213 FX 202.46
214 FX 117.867
215 FX 95.138
216 FX 160.903
217 FX 163.997
218 FX 160.903
219 FX 95.138
220 FX 46.433
221 FX 71.586
222 FX 72.743
223 FX 71.586
224 FX 46.433
225 FX 46.433
226 FX 60.418
227 FX 61.124
228 FX 60.418
229 FX 35.565
230 FX 86.784
231 FX 154.548
232 FX 157.161
233 FX 154.548
234 FX 86.784
235 FX 108.997
236 FX 195.294
237 FX 198.819
238 FX 195.294
239 FX 108.997
240 FX 86.784
241 FX 154.548

242 FX 157.161
243 FX 154.548
244 FX 86.784
245 FX 35.565
246 FX 60.418
247 FX 61.124
248 FX 60.418
249 FX 35.565
250 FX 35.565
1 FZ 8.946
2 FZ 8.946
3 FZ 8.946
4 FZ 8.946
5 FZ 8.946
6 FZ 8.946
7 FZ 8.946
8 FZ 8.946
9 FZ 8.946
10 FZ 8.946
11 FZ 8.946
12 FZ 8.946
13 FZ 8.946
14 FZ 8.946
15 FZ 8.946
16 FZ 8.946
17 FZ 8.946
18 FZ 8.946
19 FZ 8.946
20 FZ 8.946
21 FZ 8.946
22 FZ 8.946
23 FZ 8.946
24 FZ 8.946
25 FZ 8.946
26 FZ 70.658
27 FZ 71.632
28 FZ 70.658
29 FZ 45.636
30 FZ 95.384
31 FZ 161.982
32 FZ 164.88
33 FZ 161.982
34 FZ 95.384
35 FZ 117.898
36 FZ 203.197
37 FZ 207.029

38 FZ 203.197
39 FZ 117.898
40 FZ 95.384
41 FZ 161.982
42 FZ 164.88
43 FZ 161.982
44 FZ 95.384
45 FZ 45.636
46 FZ 70.658
47 FZ 71.632
48 FZ 70.658
49 FZ 45.636
50 FZ 45.636
51 FZ 71.31
52 FZ 72.4
53 FZ 71.31
54 FZ 46.183
55 FZ 95.213
56 FZ 161.234
57 FZ 164.257
58 FZ 161.234
59 FZ 95.213
60 FZ 117.879
61 FZ 202.695
62 FZ 206.661
63 FZ 202.695
64 FZ 117.879
65 FZ 95.213
66 FZ 161.234
67 FZ 164.257
68 FZ 161.234
69 FZ 95.213
70 FZ 46.183
71 FZ 71.31
72 FZ 72.4
73 FZ 71.31
74 FZ 46.183
75 FZ 46.183
76 FZ 71.17
77 FZ 72.23
78 FZ 71.17
79 FZ 46.061
80 FZ 95.251
81 FZ 161.397
82 FZ 164.39
83 FZ 161.397

84 FZ 95.251
85 FZ 117.884
86 FZ 202.808
87 FZ 206.74
88 FZ 202.808
89 FZ 117.884
90 FZ 95.251
91 FZ 161.398
92 FZ 164.39
93 FZ 161.397
94 FZ 95.251
95 FZ 46.061
96 FZ 71.17
97 FZ 72.23
98 FZ 71.17
99 FZ 46.061
100 FZ 46.061
101 FZ 71.201
102 FZ 72.269
103 FZ 71.201
104 FZ 46.089
105 FZ 95.243
106 FZ 161.361
107 FZ 164.361
108 FZ 161.36
109 FZ 95.243
110 FZ 117.882
111 FZ 202.782
112 FZ 206.723
113 FZ 202.782
114 FZ 117.882
115 FZ 95.243
116 FZ 161.361
117 FZ 164.361
118 FZ 161.361
119 FZ 95.243
120 FZ 46.089
121 FZ 71.201
122 FZ 72.269
123 FZ 71.201
124 FZ 46.089
125 FZ 46.089
126 FZ 71.19
127 FZ 72.254
128 FZ 71.19
129 FZ 46.078

130 FZ 95.246
131 FZ 161.374
132 FZ 164.371
133 FZ 161.374
134 FZ 95.246
135 FZ 117.883
136 FZ 202.792
137 FZ 206.729
138 FZ 202.792
139 FZ 117.883
140 FZ 95.246
141 FZ 161.374
142 FZ 164.371
143 FZ 161.374
144 FZ 95.246
145 FZ 46.078
146 FZ 71.19
147 FZ 72.254
148 FZ 71.19
149 FZ 46.078
150 FZ 46.078
151 FZ 71.213
152 FZ 72.285
153 FZ 71.213
154 FZ 46.101
155 FZ 95.239
156 FZ 161.345
157 FZ 164.35
158 FZ 161.345
159 FZ 95.239
160 FZ 117.882
161 FZ 202.77
162 FZ 206.716
163 FZ 202.77
164 FZ 117.882
165 FZ 95.239
166 FZ 161.345
167 FZ 164.35
168 FZ 161.345
169 FZ 95.239
170 FZ 46.101
171 FZ 71.213
172 FZ 72.285
173 FZ 71.213
174 FZ 46.101
175 FZ 46.101

176 FZ 71.112
177 FZ 72.155
178 FZ 71.112
179 FZ 46.005
180 FZ 95.267
181 FZ 161.47
182 FZ 164.444
183 FZ 161.469
184 FZ 95.267
185 FZ 117.887
186 FZ 202.861
187 FZ 206.774
188 FZ 202.861
189 FZ 117.887
190 FZ 95.267
191 FZ 161.47
192 FZ 164.444
193 FZ 161.47
194 FZ 95.267
195 FZ 46.005
196 FZ 71.112
197 FZ 72.155
198 FZ 71.112
199 FZ 46.005
200 FZ 46.005
201 FZ 71.586
202 FZ 72.743
203 FZ 71.586
204 FZ 46.433
205 FZ 95.138
206 FZ 160.903
207 FZ 163.997
208 FZ 160.903
209 FZ 95.138
210 FZ 117.867
211 FZ 202.46
212 FZ 206.502
213 FZ 202.46
214 FZ 117.867
215 FZ 95.138
216 FZ 160.903
217 FZ 163.997
218 FZ 160.903
219 FZ 95.138
220 FZ 46.433
221 FZ 71.586

222 FZ 72.743
223 FZ 71.586
224 FZ 46.433
225 FZ 46.433
226 FZ 60.418
227 FZ 61.124
228 FZ 60.418
229 FZ 35.565
230 FZ 86.784
231 FZ 154.548
232 FZ 157.161
233 FZ 154.548
234 FZ 86.784
235 FZ 108.997
236 FZ 195.294
237 FZ 198.819
238 FZ 195.294
239 FZ 108.997
240 FZ 86.784
241 FZ 154.548
242 FZ 157.161
243 FZ 154.548
244 FZ 86.784
245 FZ 35.565
246 FZ 60.418
247 FZ 61.124
248 FZ 60.418
249 FZ 35.565
250 FZ 35.565
LOAD 5 WL Z
JOINT LOAD
46 50 71 75 96 100 121 125 146 150 171 175 196 200 221 225 FZ -8.91
47 49 72 74 97 99 122 124 147 149 172 174 197 199 222 224 FZ -18.3
48 73 98 123 148 173 198 223 FZ -18.78
246 250 FZ -4.46
247 249 FZ -9.15
248 FZ -9.38
LOAD 6 WL X
JOINT LOAD
226 246 FX 4.21
26 46 51 71 76 96 101 121 126 146 151 171 176 196 201 221 FX 8.42
231 241 FX 12.36
31 41 56 66 81 91 106 116 131 141 156 166 181 191 206 216 FX 24.72
236 FX 16.3
36 61 86 111 136 161 186 211 FX 32.6
*TOWER

```
255 256 FX 2.5225
255 256 FY 2.5225
255 256 FZ 2.5225
273 279 FX 2.78
273 279 FY 2.78
273 279 FZ 2.78
278 285 FX 2.975
278 285 FY 2.975
278 285 FZ 2.975
275 281 FX 2.905
275 281 FY 2.905
275 281 FZ 2.905
265 266 FX 3.5125
265 266 FY 3.5125
265 266 FZ 3.5125
*GSM ANTENNA AT TOP
255 TO 258 FY -0.898
*PALTFORM & CABLE RACK LOAD
SPECTRUM CQC 1893 TOR X 0.06 ACC SCALE 1 DAMP 0.05 LIN MIS
SOIL TYPE 2
LOAD 7 SEISMIC Z
SPECTRUM CQC 1893 TOR Z 0.06 ACC SCALE 1 DAMP 0.05 LIN MIS
SOIL TYPE 2
LOAD COMB 8 DL+1.25*LL
1 1.0 2 1.25
LOAD COMB 9 DL+0.25*LL
 1 1.0 2 0.25
 LOAD COMB 10 1.2(DL+LL+ELX)
1 1.2 2 1.2 4 1.2
LOAD COMB 11 1.2(DL+LL-ELX)
1 1.2 2 1.2 4 -1.2
LOAD COMB 12 1.2(DL+LL+ELZ)
1 1.2 2 1.2 4 1.2
LOAD COMB 13 1.2(DL+LL-ELZ)
1 1.2 2 1.2 4 -1.2
LOAD COMB 14 1.5(DL+ELX)
1 1.5 4 1.5
LOAD COMB 15 1.5(DL-ELX)
1 1.5 4 -1.5
LOAD COMB 16 1.5(DL+ELZ)
1 1.5 4 1.5
LOAD COMB 17 1.5(DL-ELZ)
1 1.5 4 -1.5
LOAD COMB 18 1.2(DL+LL+WLX)
1 1.2 2 1.2 6 1.2
LOAD COMB 19 1.2(DL+LL-WLX)
```

```
1 1.2 2 1.2 6 -1.2
LOAD COMB 20 1.2(DL+LL+WLZ)
1 1.2 2 1.2 5 1.2
LOAD COMB 21 1.2(DL+LL-WLZ)
1 1.2 2 1.2 5 -1.2
LOAD COMB 22 1.5(DL+WLX)
1 1.5 6 1.5
LOAD COMB 23 1.5(DL-WLX)
1 1.5 6 -1.5
LOAD COMB 24 1.5(DL+WLZ)
1 1.5 5 1.5
LOAD COMB 25 1.5(DL-WLZ)
1 1.5 5 -1.5
PERFORM ANALYSIS
PRINT ANALYSIS RESULTS
PRINT SUPPORT REACTION
PRINT MODE SHAPE
PERFORM ANALYSIS
LOAD LIST 1 TO 25
PRINT SUPPORT REACTION LIST 1 TO 254
PERFORM ANALYSIS
PRINT SUPPORT REACTION LIST 1 TO 258 265 TO 299 303 307 TO 335
PRINT JOINT DISPLACEMENTS LIST 1 TO 258 265 TO 299 303 307 TO 339
FINISH
```