Analysis of Wind Load on High Rise Building Located In Zone III

Satyam Shivam
VelloreInstituteofTechnology,Vellore-632014

Abstract- *ETABSsoftware represent extended three dimensional analysis of building systems. This paper checks the Wind Load design of a G+15 storied R.C. building model located in the urban areas of earthquake zone III using the finite element program (ETABS) and proposes the best and most economical retrofitting technique against wind load effect. The present work inspects the combined behavior of shear wall and Steel bracing system, and also the influence of their position in high rise residential building (G+15) under wind loading. Wind Load Analysis is done for each model with and without Shear Wall and combined Shear Wall and Steel Bracing. Each and every models were checked for the drift and displacement variations and measures were taken to rectify the problems and to find the most economical model*

Keywords- Wind Load Analysis, seismic vulnerability, finite element program, Steel Bracing, shear wall, structural deformation.

I. INTRODUCTION

The horizontal movement of free air on a vast scale is referred to as wind. Because it puts stresses on the building, it is very significant in the construction of tall structures. The average wind speed increases with height for tall structures, whereas the gustiness, or varied combinations of eddies (circular wind movement), decreases with height. Tall structures or towers can be buffeted by turbulence (strong, repeated gusts of wind). According to experts, all towering structures will wobble somewhat in the wind. However, architects must ensure that super-strong winds do not cause a skyscraper to collapse. A 'tall skyscraper' is a multi-story structure in which the majority of people rely on elevators to go about. Most nations refer to such structures as "high-rise buildings" although Britain and several European countries refer to them as "tower blocks." According to India's National Building Code 2005Tall buildings, as defined by the Council on Tall Buildings and Urban Habitat, are structures that are taller than normal buildings.

Buildings with a height of more than 50 metres are considered tall. A skyscraper is a structure with a height of more than 100 metres. Super Tall is a building with a height of more than 300 metres. Mega Tall is defined as a building at a height of more than 600 metres.

The motion of air in the atmosphere is referred to as wind. The reaction of buildings to wind is determined by the wind's properties. Wind is created when air flows from a high pressure area to a low pressure area. Due to the rotation of the Earth, air does not flow straight from high to low pressure, but is deflected to the right (in the Northern Hemisphere; to the left in the Southern Hemisphere), causing the wind to flow mostly around the high and low pressure zones.

Variation of Wind Velocity with Height-

The motion is resisted at the earth's surface, and the wind speed is lowered, due to surface friction. The wind speed decreases to zero at the surface and then increases with height; at the gradient height, the motion is free of the earth's frictional pull and will reach its gradient velocity. Gradient For level land, a height of 300 metres is required, while a height of 550 metres is required for extremely rugged terrain. These studies are carried out to assess the dynamic impacts of wind on structures before optimising the design to prevent these effects. A building's capacity to sway is determined by the amount of wind it receives. The speed of the wind increases as one rises in altitude.

Wind forces have two effects on tall constructions. A tall structure may be conceived of as a cantilever beam with one fixed end at the ground that bends with the largest deflection at the top due to wind pressure. The sway, or periodic motion, imparted to the building by the change in pressure when a vortex breaks away is perpendicular to the direction of the wind. As a result, a high-rise building must fulfil various performance criteria when subjected to wind forces.

AIM OF STUDY

The aim of the research is to propose the usage of both Shear Wall and Steel X Bracing systems in the same construction to make it safe and cost-effective. In addition, the usage of Shear Wall and Steel X Bracing systems is highlighted in this study in order to influence the design of wind load analysis on rise buildings for safe design within the limits set by standard standards of practice.

OBJECTIVES

- Check for the wind vulnerability high rise building using a trial and error method.
- To check the drift and displacement behavior of high rise building stiffened with both shear walls and X-bracing system subjected to wind load.
- To analyse the wind load on high rise building at zone III of different places.
- To analyse the sway in the building.
- To study different types of buildings with variable aspect ratios coming under zone III.
- To compare the variation of effect of wind velocity in buildings at both places.
- To study the wind parameters for RCC frame, RCC frame with Steel Bracing system, and RCC frame with shear wall.
- To compare the results of different models based on use and relative position of shear wall and Steel X-bracing system.
- To figure out the safest and most economical model after going through the obtained values of wind parameters like Base Shear, Storey Displacement, Storey Drift and Storey Stiffness.

II. THEORETICALBACKGROUND

Wind Load

Wind loading is one of the principal horizontal loads operating on bridges, and it must be taken into account in order to meet design criteria. Wind loading is a crucial loading on tall structures, and shear wall systems were designed to bear wind loads more efficiently and inexpensively as buildings go higher and higher. Dynamic wind impacts are also essential, since they can cause considerable vibrations not only in the direction of the wind, but also in the vertical and torsional directions.

Wind Load Analysis

Wind analysis is the process of determining the dynamic influence of wind on a structure and designing designs to minimize these effects. Buildings and their components must be built to resist the wind loads stipulated by the code. Wind loads must be calculated while designing a wind force resisting system, which includes structural elements, components, and cladding, to protect against shear, slide, overturning, and uplift. Wind analysis may be used to assess comfort, wind loads on structures, pollution, and natural ventilation, among other things.

Wind loading refers to the force of the wind on buildings and constructions. When the surface in issue has a flat face and the torsional directions are greater than zero, when the wind force in the along-wind direction is at its highest, this force is most effective.

Wind generates a random timedependent load with a mean and a fluctuating component. If the natural time period of a structure is shorter than one second, it is considered short and stiff. Wind gusts cause more flexible systems, such as towering structures, to respond dynamically. This Standard introduces methods for calculating the dynamic influence of wind on structures.

Wind Load Analysis is useful in drawing the displacement and drift variations of different model which is going to be useful in drawing the results for a specific data and to verify the model which is safe for design.

The difference in displacements between two successive storeys divided by the height of that storey is known as storey drift. And storey displacement is the absolute magnitude of the storey's displacement under the influence of lateral forces. The relevance of tale drift in partition/curtain wall design cannot be overstated. Deflection is the vertical displacement of a beam or floor system.

Deflection, which is connected with vertical loads, and drift, which is linked with lateral stresses, are two ways to express deformation. The vertical movement of a beam or floor system is referred to as deflection.

The amount of gravity load, the span of the structural member, and the moment of inertia of the structural member are all factors in determining deflection. The moment of inertia is a feature of a member's form that prevents it from bending and lowers deflection. The lesser the deflection, the bigger the moment of inertia.

Certain terminologies which needs to be given an eye on for becoming familiar with the process of Wind Load Analysis are as follows:

Procedures for Calculating Wind Load

Building and other structures' design wind loads must be determined using one of the following procedures:

(1) Simplified technique for low-rise basic diaphragm structures (Method 1).
(2) Analytical approach for regular-shaped buildings and structures (Method 2)
(3) Method 3 – For geometrically complicated constructions, a wind tunnel approach is used.

Method 1 – Simplified Procedure W= Building Weight

The simplified technique is employed in the design of simple diaphragm structures with flat, gabled, and hipped roofs with a mean roof height of not more than the least horizontal dimension or 60 feet (18.3 m), whichever is less, and subject to further limits.

Method 2 – Analytical Procedure

Wind loads for buildings and structures that do not meet the simplified procedure's requirements can be calculated using the analytical procedure if they are regular shaped, do not have response characteristics that make them subject to across-wind loading, vortex shedding, instability due to galloping or flutter, or do not have a site location that requires special consideration.

Method 3 – Wind Tunnel Procedure

Wind loads for buildings and structures that do not meet the streamlined procedure's requirements. Buildings and their components must be built to resist the wind loads stipulated by the code. In order to construct a wind-force-resisting system, it is necessary to calculate wind loads which resists shear, sliding, overturning, and uplift motions, including structural elements, components, and cladding.

Displacement Analysis

The method of estimating the entire consumer worth of competing pieces of business is known as displacement analysis. In most circumstances, the piece of business that generates the highest total customer value would be picked. A displacement calculation or analysis is a significant revenue management tool for hotels, and it should be completed on a regular basis by revenue managers on their primary accounts to assess the revenue gain: money displaced on designated days minus positive revenue on non restricted dates.

Drift Analysis

Drift analysis is the act of tracking your equipment's as-found data over time. This allows you to quickly see which pieces of equipment are regularly within tolerance and which require adjustment. You may make a better educated decision regarding calibration frequency based on this information.

Drift analysis is the act of tracking your equipment's as-found data over time. This allows you to quickly see which pieces of equipment are regularly within tolerance and which require adjustment. You may make a better educated decision regarding calibration frequency based on this information. For example, if you see that a piece of equipment has to be adjusted on a regular basis, you might want to raise the frequency to guarantee that it doesn't break down.

Displacement vs Drift

The difference in displacements between two successive storeys divided by the height of that storey is known as storey drift. And The absolute value of the storey displacement under the action of lateral forces is called storey displacement. The relevance of tale drift in partition/curtain wall design cannot be overstated. The lateral displacement of the tale in relation to the basis is known as storey displacement. The relative displacement of one tale from the other is known as storey drift. In the design of partitions and curtain walls, tale drift is critical. In general, when a structure's height grows, lateral loads (such as wind and earthquake) increase as well. While these types of responses become significant enough, the lateral load impact must be explicitly considered when constructing a skyscraper construction. Shear walls & bracing systems can help skyscraper structures resist lateral load effects. A shear wall is a structural system made up of shear panels that is used to mitigate the impact of lateral loads on a structure. Wind and seismic loads are the most typical loads for which shear walls are constructed, depending on the zone. The primary purpose of a shear wall is to strengthen the rigidity of the structure for lateral load resistance while also providing suitable stiffness and strength.

Shear Walls

A shear wall is a type of structural panel that can withstand lateral stresses. Wind and earthquake loads are examples of lateral forces, which are parallel to the plane of the wall. In basic words, lateral pressures would be able to push parallel structural panels of a structure over if perpendicular shear walls were not there to maintain them upright. When a structural member fails via shear, two sections of it are forced in opposite directions, similar to when scissors split a sheet of paper.

Shear walls are especially critical in big or high-rise structures, as well as structures in high-wind and seismic-prone environments.

Concrete or masonry are commonly used in the construction of shear walls. Steel braced frames, which may be quite good in thrashing out lateral pressures but are more expensive, can also reject shear forces. which is a structure of shear walls located in

Lateral pressures aim to create a rotating force on the shear wall, which causes a compression force at one corner and a tension force at the other owing to the shear wall responding as a single part. This 'couple' is reversed when the lateral force is applied from the other direction, implying that both sides of the shear wall must be capable of resolving both sorts of forces.

Steel Bracings

Steel bracing is a cost-efficient and highly effective way to resist horizontal forces in a frame construction. Most of the world's tallest building constructions need bracing to support them laterally, and it's also one of the most common retrofit procedures. Because the diagonals act in axial stress, bracing is excellent in imparting stiffness and strength against horizontal shear with small member sizes.

Various procedures such as infilling walls, adding walls to existing columns, encasing columns, and installing steel bracings to improve the strength and/or ductility of existing structures have been investigated by a number of researchers. By increasing the frame's lateral rigidity and capacity, a bracing system improves the frame's seismic performance. Load may be transmitted out of the frame and into the bracing system with the inclusion of the bracing system.

Bypassing the weak columns while increasing strength, the braces are used. Steel braced frames are strong structural solutions for structures that are subjected to lateral seismic or wind loads. As a result, upgrading reinforced-concrete frames with weak lateral resistance with steel-bracing systems is appealing.

Types of Bracings

SINGLE DIAGONALS

Trussing, also known as triangulation, is the process of putting diagonal structural elements into rectangular regions of a structural frame to assist stabilise it. If only one brace is employed, it must be strong enough to withstand tension and compression.

K-BRACING

At mid-height, K-braces connect to the columns. This frame allows for more flexibility in the supply of facade openings while also resulting in the least amount of bending in the floor beams. In seismic areas, K-bracing is typically avoided due to the risk of column failure if the compression brace buckles.

CROSS-BRACING

Two diagonal elements cross one other in cross-bracing (or X-bracing). These simply need to be tension-resistant, with one brace functioning at a time to resist sideways pressures, depending on the loading direction. Steel cables can therefore be utilised for cross-bracing. It also causes more bending in the floor beams.

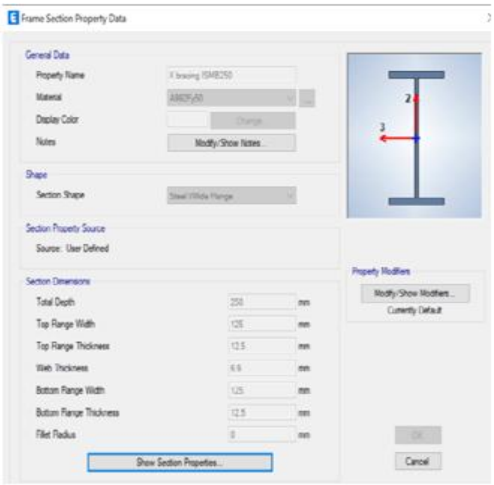
V-BRACING

Two diagonal members creating a V-shape go downwards from the top two corners of a horizontal member and meet at the lower horizontal member's centre point (left-hand diagram). The two members meet at a centre position on the top horizontal member in inverted V-bracing (right-hand figure, also known as chevron bracing).

Both approaches can drastically lower the compression brace's buckling capacity down below the tension yield capacity of the tension brace. There are two types of bracing systems, Concentric Bracing System and Eccentric Bracing System.

Type of Steel Bracing adopted in this work:

Steel section ISMB 250 is taken as a lateral load resisting system in this work. The section dimensions and properties associated with this section are as follows:



Property Name: X bracing ISMB250

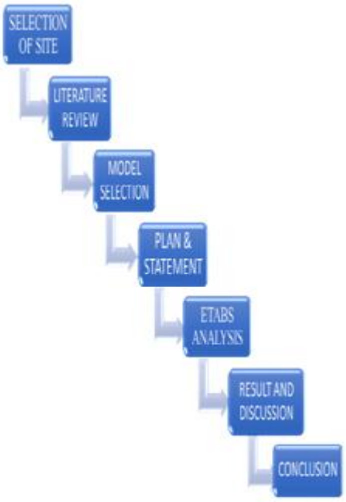
Material: A992Fy50

Section Shape: Steel Wide Flange

Source: User Defined

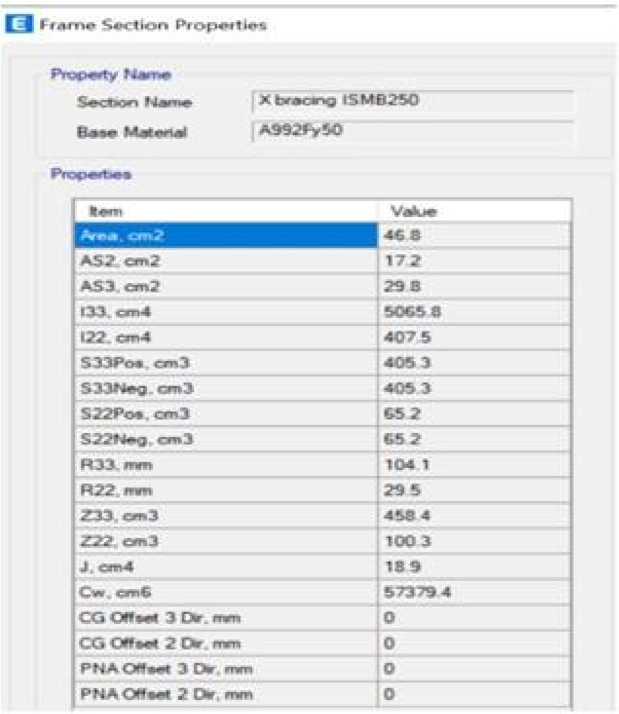
Total Depth	250	mm
Top Flange Width	125	mm
Top Flange Thickness	12.5	mm
Web Thickness	6.9	mm
Bottom Flange Width	125	mm
Bottom Flange Thickness	12.5	mm
Fillet Radius	0	mm

III. METHODOLOGY



LIST OF REFERENCE CODES

- IS CODE 875 : 1987 (Part -3) (Code for Indian Standard Criteria for wind loads on building and structures)
- IS CODE 875 : 1987 (Part 1) (Code of Practice for design loads other than wind for Buildings and Structures)
- IS CODE 875 : 1987 (PART 2) (Code of Practice for design loads other than Earthquake for Buildings and Structures)



Frame Section Properties

Property Name

Section Name: X bracing ISMB250

Base Material: A992Fy50

Properties

Item	Value
Area, cm2	46.8
AS2, cm2	17.2
AS3, cm2	29.8
I33, cm4	5065.8
I22, cm4	407.5
S33Pos, cm3	405.3
S33Neg, cm3	405.3
S22Pos, cm3	65.2
S22Neg, cm3	65.2
R33, mm	104.1
R22, mm	29.5
Z33, cm3	458.4
Z22, cm3	100.3
J, cm4	18.9
Cw, cm6	57379.4
CG Offset 3 Dir, mm	0
CG Offset 2 Dir, mm	0
PNA Offset 3 Dir, mm	0
PNA Offset 2 Dir, mm	0

Loads Considered

STATEMENT OF THE PROJECT

➢ Building Plan	20mx20m
➢ Type of Building	Residential
➢ Grade of Concrete	M 30
➢ Grade of Steel	HYSD Fe 415
➢ Tie Bar	Mild Fe 250
➢ Column Size	500mmx500mm
➢ Beam Size	350mmx250mm
➢ Steel X Bracing	ISMB 250
➢ Storey Height	3m
➢ Thickness of Slab	200mm
➢ Thickness of Shear Wall	230mm
➢ Seismic Zone	Zone III
➢ Importance Factor	1
➢ Seismic Zone Factor	0.16
➢ Total Height	48 m
➢ Total Length of Building	20 m
➢ Total Width of Building	20 m
➢ Shape of Building	Square
➢ Number of bays in X & Y directions	4
➢ Total Buildup Area	400 m²

IV. RESULTSANDDISCUSSIONS

Shear Walls feature high plane stiffness and strength, which allows them to withstand considerable horizontal loads while still supporting gravity loads, making them appropriate for a range of structural engineering applications. Cross bracing systems give structural rigidity and stability while also being cost-effective. The implementation of a lateral force resisting system to mitigate the influence of lateral forces encountered owing to earthquake or wind forces is also required by IS standards for structures more than three storeys located in seismic zones.

So, in this study, the design wind load in all models, whether plane framed or strengthened with shear walls in various patterns, as well as models strengthened with both shear walls and steel bracings in various patterns, has been kept firmly within the limits.

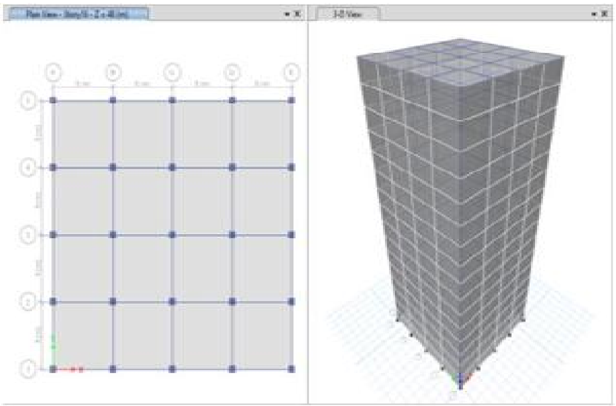
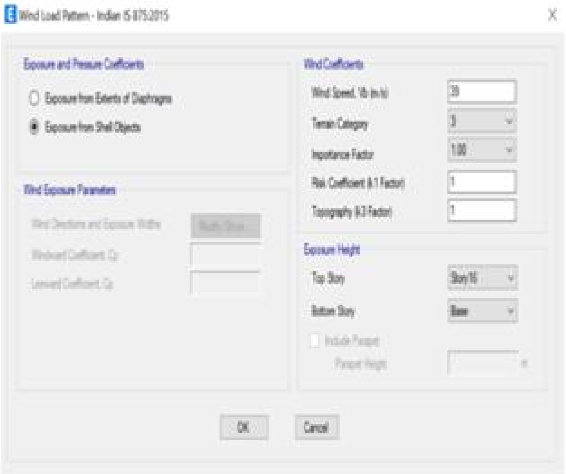


Fig1.(Model 1) Plan and 3D view of the R.C. building taken for assessing the Wind Load.

The basic and initial model is shown in Figure 1, which consists of a 20m × 20m layout with four bays each along the X and Y axes. The model is a G+15-story structure in seismic zone III, with medium-density soil. The columns are all 500mm × 500mm in size. The beams on the ground and first floors are 350mm x 250mm in size.


Wind Load Pattern - Indian IS 875:2015

Exposure and Pressure Coefficients
○ Exposure from Extents of Diaphragms
● Exposure from Shell Objects

Wind Coefficients
Wind Speed, Vb (m/s): 39
Terrain Category: 3
Importance Factor: 1.00
Risk Coefficient (k1 Factor): 1
Topography (k3 Factor): 1

Exposure Height
Top Story: Story16
Bottom Story: Base
☐ Include Parapet

Fig. 2. Chart showing the Wind Load Pattern and Load Combination

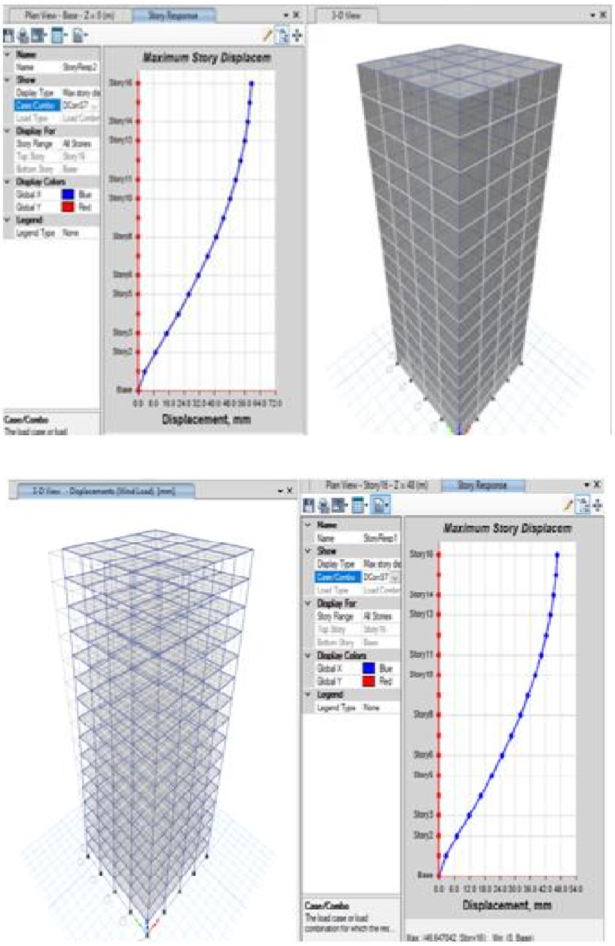


Fig3Displacement models and graph representation for Model 1 of both City.

Figure 3 demonstrates that the Displacement Analysis for Mumbai and Pune Model 1 is complete. The structures' displacement is depicted graphically in the picture above for each storey of both city buildings.

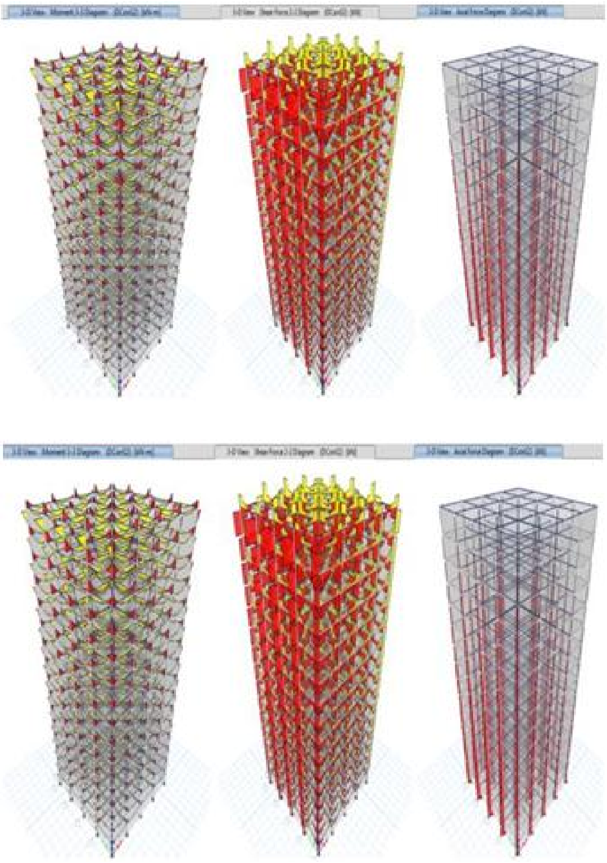
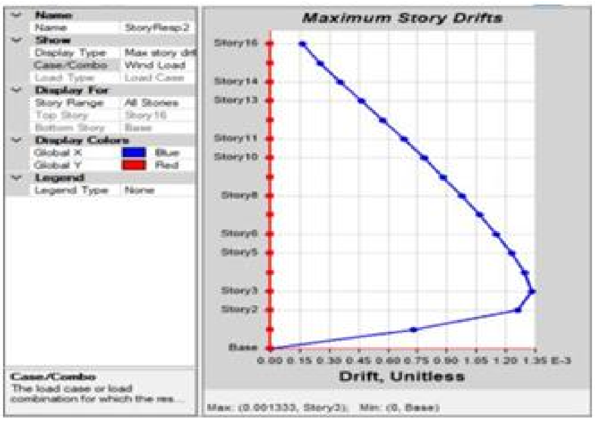


Fig4.Bending Moment Shear Force & Axial Force diagrams for both Mumbai And Pune .

In Figure 4 above after performing Bending Moment, Shear Force & Axial Force analysis for both Mumbai And Pune. In this it is found that the diagram view is almost similar as it is model but the values differs by satisfactory numbers.



Name

Name: StoryResp2

Show

Display Type: Max story drif

Case/Combo: Wind Load

Load Type: Load Case

Display For

Story Range: All Stories

Top Story: Story16

Bottom Story: Base

Display Colors

Global X: Blue

Global Y: Red

Legend

Legend Type: None

Case/Combo

The load case or load combination for which the res...

Max: (0.001333, Story3); Min: (0, Base)

Fig 5 Drift analysis and graphical view for both Mumbai and Pune of Model 1.

Table 1 Storeywise values of inter storey drift along X and Y directions for the Bare Framed Model.

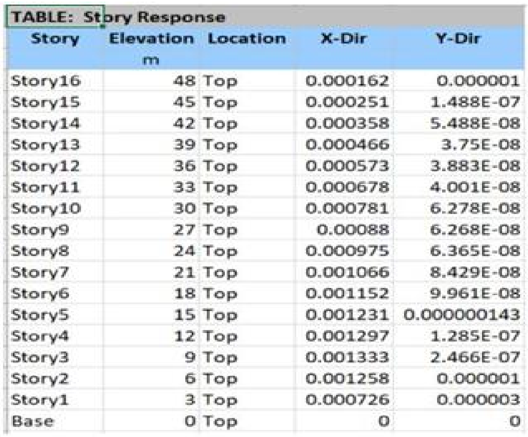


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000162	0.000001
Story15	45	Top	0.000251	1.488E-07
Story14	42	Top	0.000358	5.488E-08
Story13	39	Top	0.000466	3.75E-08
Story12	36	Top	0.000573	3.883E-08
Story11	33	Top	0.000678	4.001E-08
Story10	30	Top	0.000781	6.278E-08
Story9	27	Top	0.00088	6.268E-08
Story8	24	Top	0.000975	6.365E-08
Story7	21	Top	0.001066	8.429E-08
Story6	18	Top	0.001152	9.961E-08
Story5	15	Top	0.001231	0.000000143
Story4	12	Top	0.001297	1.285E-07
Story3	9	Top	0.001333	2.466E-07
Story2	6	Top	0.001258	0.000001
Story1	3	Top	0.000726	0.000003
Base	0	Top	0	0

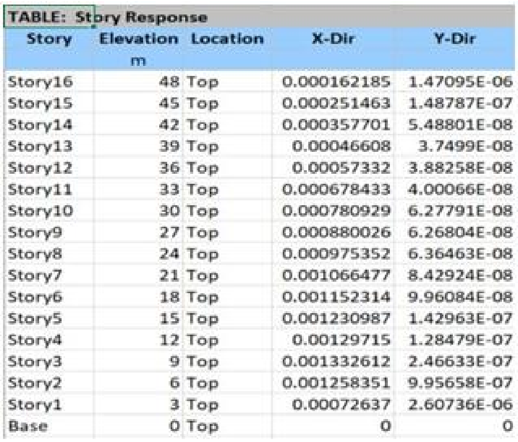


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000162185	1.47095E-06
Story15	45	Top	0.000251463	1.48787E-07
Story14	42	Top	0.000357701	5.48801E-08
Story13	39	Top	0.00046608	3.7499E-08
Story12	36	Top	0.00057332	3.88258E-08
Story11	33	Top	0.000678433	4.00066E-08
Story10	30	Top	0.000780929	6.27791E-08
Story9	27	Top	0.000880026	6.26804E-08
Story8	24	Top	0.000975352	6.36463E-08
Story7	21	Top	0.001066477	8.42924E-08
Story6	18	Top	0.001152314	9.96084E-08
Story5	15	Top	0.001230987	1.42963E-07
Story4	12	Top	0.00129715	1.28479E-07
Story3	9	Top	0.001332612	2.46633E-07
Story2	6	Top	0.001258351	9.95658E-07
Story1	3	Top	0.00072637	2.60736E-06
Base	0	Top	0	0

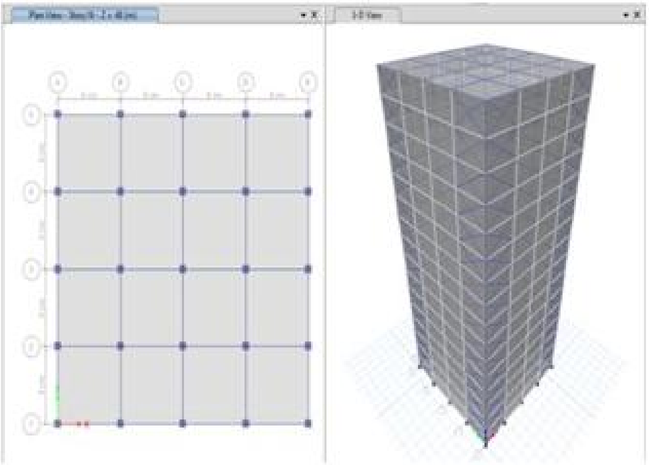


Fig6Moment Resisting Frame with Steel X Bracing System(Model2)

Fig 7 Displacement graph for Model 2

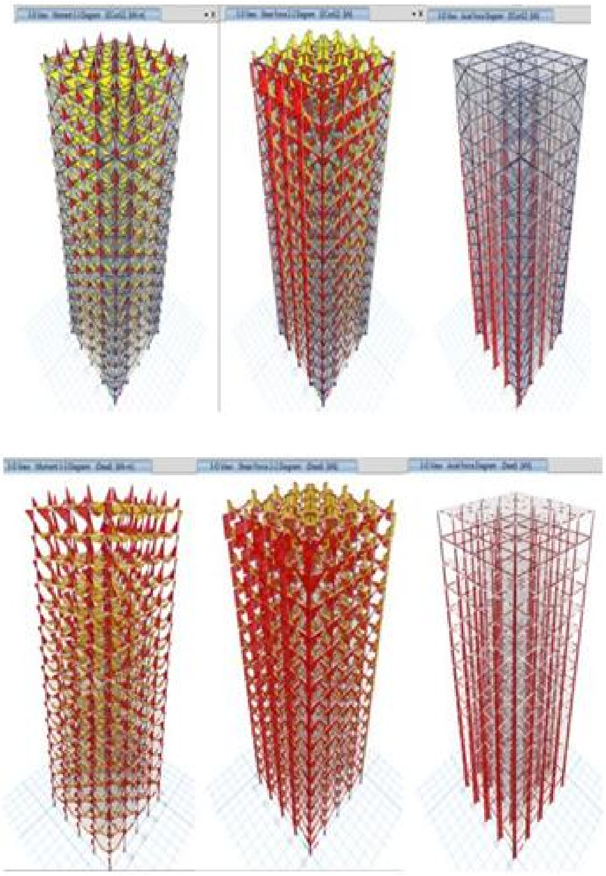


Fig 8 Bending Moment Shear Force & Axial Force diagrams for both Mumbai And Pune.

In Figure 8 above after performing Bending Moment, Shear Force & Axial Force analysis for both Mumbai And Pune. In this it is found that the diagram view is distinctly similar as it is easily understand the dense difference between both Mumbai and Pune model and the values differs by satisfactory numbers.

Fig 9 Drift analysis and graphical view for both Mumbai and Pune of Model 2.

The study done on the second model, the framed model, yielded table 3 on the preceding page. The table shows the values of inter storey drifts in both the X and Y directions, storey per storey. Storey drift shall not exceed 0.004 times the storey height, according to IS 1893 Part 1: 2016. The permitted limit is 12mm in our situation because the storey height is 3m. Table 3 shows that all of the values are well inside the allowed range. As a result, the structure's storey drift may be more than expected, although it is still within acceptable limits. Hence the structure may show higher values of storey drift but are within the permissible values.

Table2. Storey wise values of inter storey drift along X and Y directions for the 2nd Model.

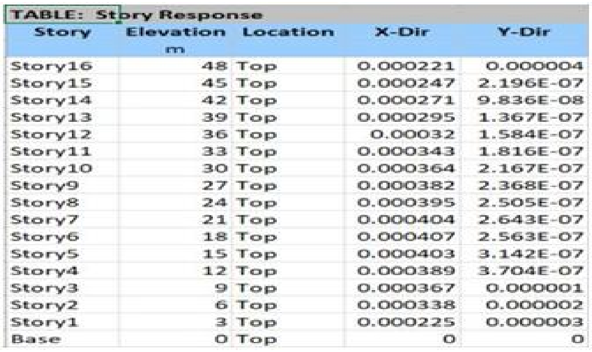


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000221	0.000004
Story15	45	Top	0.000247	2.196E-07
Story14	42	Top	0.000271	9.836E-08
Story13	39	Top	0.000295	1.367E-07
Story12	36	Top	0.00032	1.584E-07
Story11	33	Top	0.000343	1.816E-07
Story10	30	Top	0.000364	2.167E-07
Story9	27	Top	0.000382	2.368E-07
Story8	24	Top	0.000395	2.505E-07
Story7	21	Top	0.000404	2.643E-07
Story6	18	Top	0.000407	2.563E-07
Story5	15	Top	0.000403	3.142E-07
Story4	12	Top	0.000389	3.704E-07
Story3	9	Top	0.000367	0.000001
Story2	6	Top	0.000338	0.000002
Story1	3	Top	0.000225	0.000003
Base	0	Top	0	0

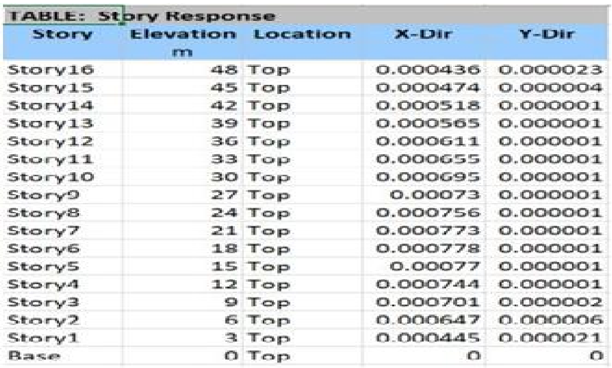


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000436	0.000023
Story15	45	Top	0.000474	0.000004
Story14	42	Top	0.000518	0.000001
Story13	39	Top	0.000565	0.000001
Story12	36	Top	0.000611	0.000001
Story11	33	Top	0.000655	0.000001
Story10	30	Top	0.000695	0.000001
Story9	27	Top	0.00073	0.000001
Story8	24	Top	0.000756	0.000001
Story7	21	Top	0.000773	0.000001
Story6	18	Top	0.000778	0.000001
Story5	15	Top	0.00077	0.000001
Story4	12	Top	0.000744	0.000001
Story3	9	Top	0.000701	0.000002
Story2	6	Top	0.000647	0.000006
Story1	3	Top	0.000445	0.000021
Base	0	Top	0	0

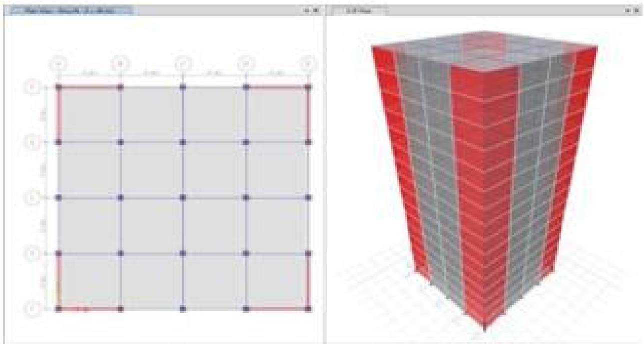


Fig 10. Moment Resisting Frame with Shear Wall positioned atthe transverse bays of each corner (Model3).

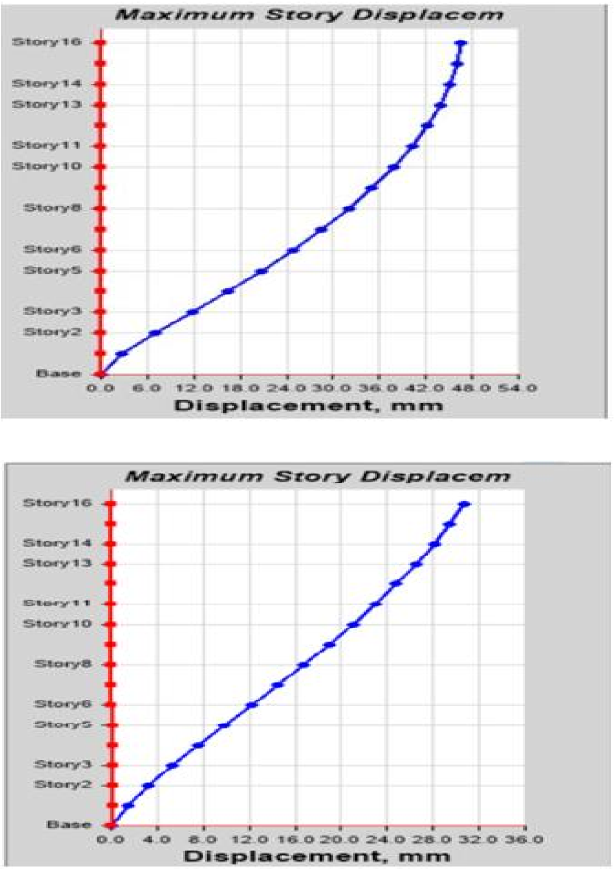
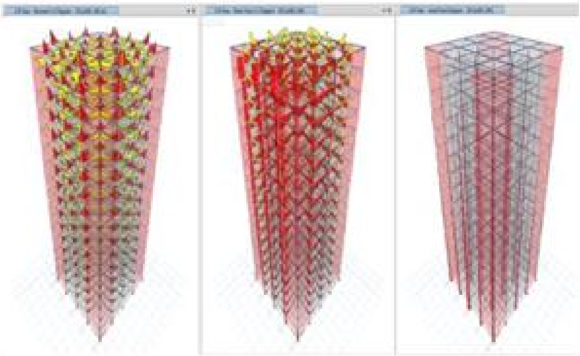


Fig. 11.Displacement graph for model 3.



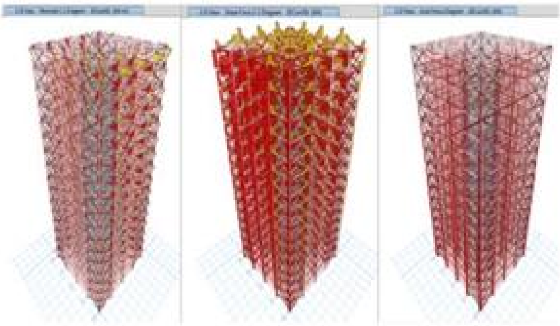
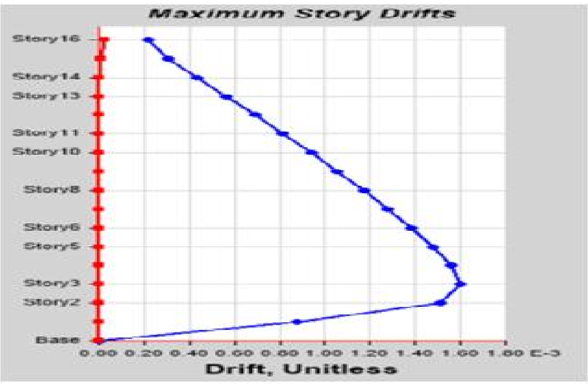
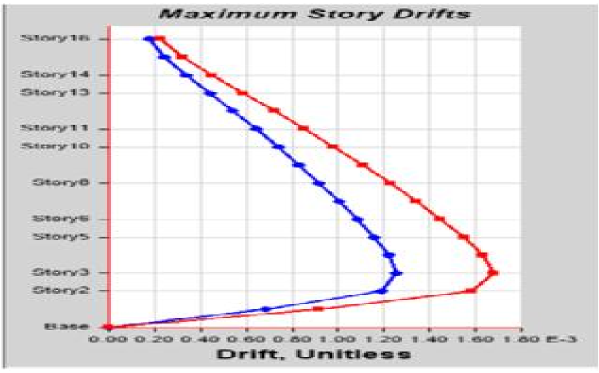


Fig12 Bending Moment Shear Force & Axial Force diagrams for both Mumbai And Pune

In Figure 9 above after performing Bending Moment, Shear Force & Axial Force analysis forboth Mumbai And Pune. In this it is found that the diagram view is distinctly similar as it is easilyunderstand the dense difference between both Mumbai and Pune model and the values differsby satisfactory numbers.





The study done on the third model, the framed model, yielded in table 3 on the preceding page. The table shows the values of inter storey drifts in both the X and Y directions, storey per storey. Storey drift shall not exceed 0.004 times the storey height, according to IS 1893 Part 1: 2016. The permitted limit is 12mm in our situation because the storey height is 3m. Table 3 shows that all of the values are well inside the allowed range. As a result, the structure's storey drift may be more than expected, although it is still within acceptable limits. Hence the structure may show higher values of storey drift but are within the permissible values.

Table 3 Storey wise values of inter storey drift along X and Y directions for the 3rd Model.

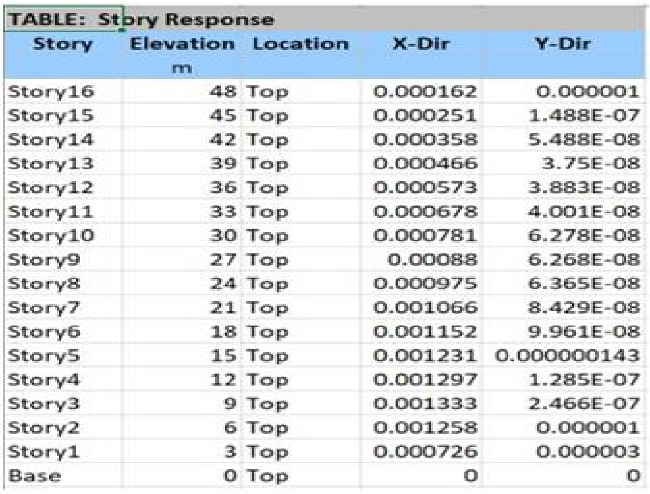


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000162	0.000001
Story15	45	Top	0.000251	1.488E-07
Story14	42	Top	0.000358	5.488E-08
Story13	39	Top	0.000466	3.75E-08
Story12	36	Top	0.000573	3.883E-08
Story11	33	Top	0.000678	4.001E-08
Story10	30	Top	0.000781	6.278E-08
Story9	27	Top	0.00088	6.268E-08
Story8	24	Top	0.000975	6.365E-08
Story7	21	Top	0.001066	8.429E-08
Story6	18	Top	0.001152	9.961E-08
Story5	15	Top	0.001231	0.000000143
Story4	12	Top	0.001297	1.285E-07
Story3	9	Top	0.001333	2.466E-07
Story2	6	Top	0.001258	0.000001
Story1	3	Top	0.000726	0.000003
Base	0	Top	0	0

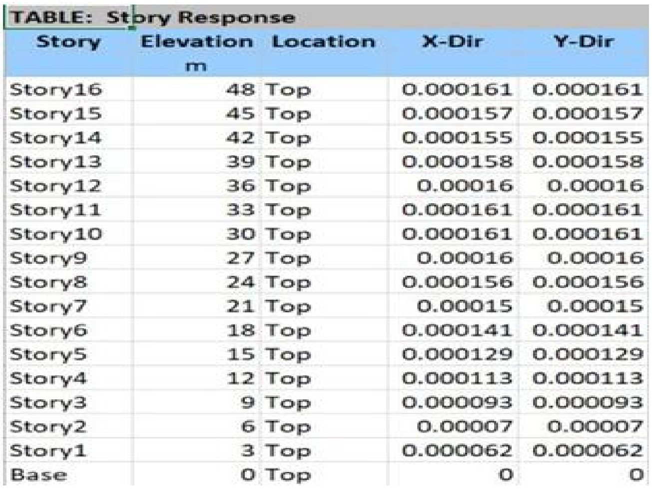


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000161	0.000161
Story15	45	Top	0.000157	0.000157
Story14	42	Top	0.000155	0.000155
Story13	39	Top	0.000158	0.000158
Story12	36	Top	0.00016	0.00016
Story11	33	Top	0.000161	0.000161
Story10	30	Top	0.000161	0.000161
Story9	27	Top	0.00016	0.00016
Story8	24	Top	0.000156	0.000156
Story7	21	Top	0.00015	0.00015
Story6	18	Top	0.000141	0.000141
Story5	15	Top	0.000129	0.000129
Story4	12	Top	0.000113	0.000113
Story3	9	Top	0.000093	0.000093
Story2	6	Top	0.00007	0.00007
Story1	3	Top	0.000062	0.000062
Base	0	Top	0	0

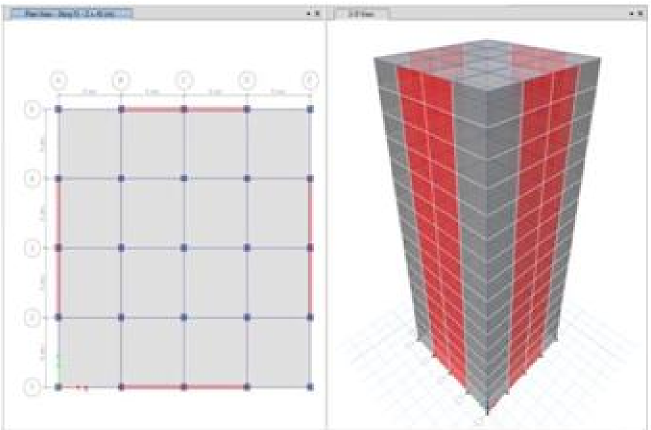


Fig13.Moment Resisting Frame with Shear Wall positioned at the middle of each side (Model 4).

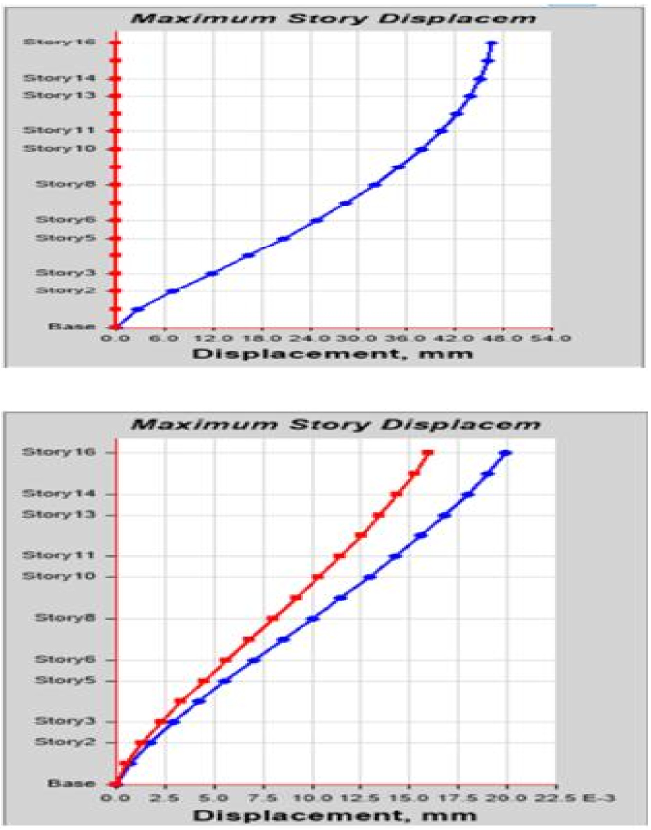


Fig 14 Displacement graph for Model 4

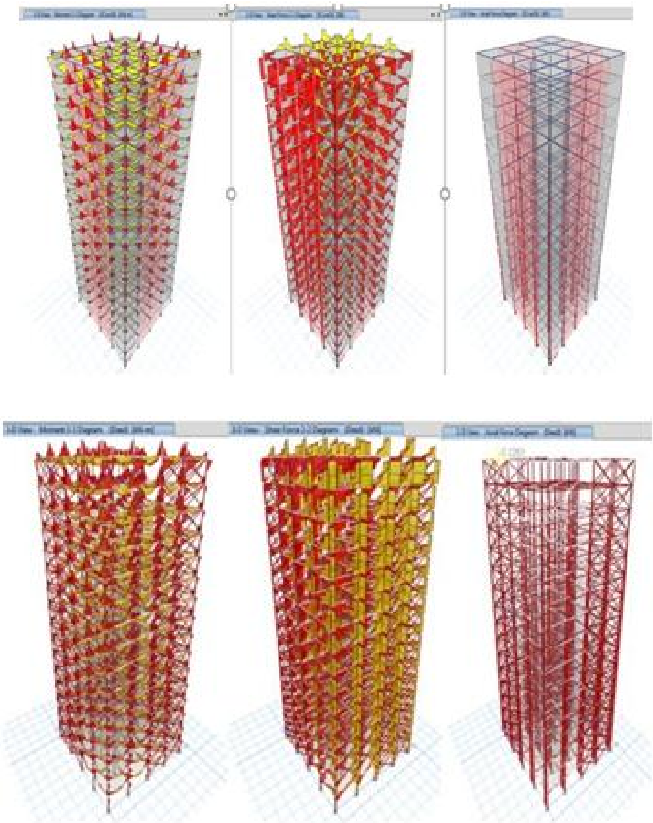
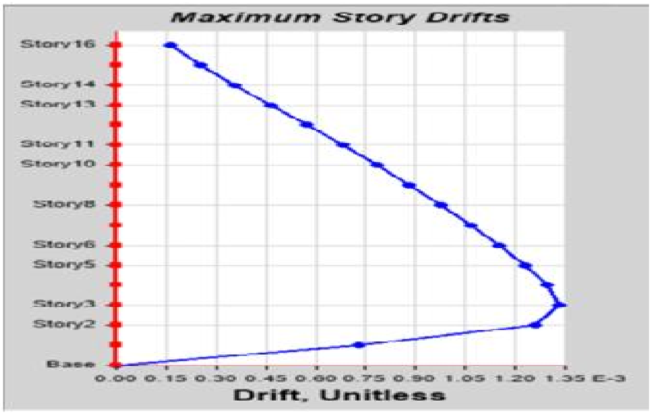


Fig 15 Bending Moment Shear Force & Axial Force diagrams for both Mumbai And Pune

In Figure 15 above after performing Bending Moment, Shear Force & Axial Force analysis forboth Mumbai And Pune. In this it is found that the diagram view is distinctly similar as it is easily understand the dense difference between both Mumbai and Pune model and the values differs by satisfactory numbers.



The inter storey drift may be calculated theoretically by subtracting the upper and lower storey displacements from the storey height. According to IS 1893 Part 1: 2016, the permitted value of storey drift should be less than 0.004 times the storey height. Because our storey height is 3m, the maximum allowable thickness is 12mm. Table 8 further demonstrates that all of the numbers are well inside the allowed range. As a result, the building's storey drift values may be higher, but they are still within permissible limits.

Table 4 Storey wise values of inter storey drift along X and Y directions for the 4th Model.

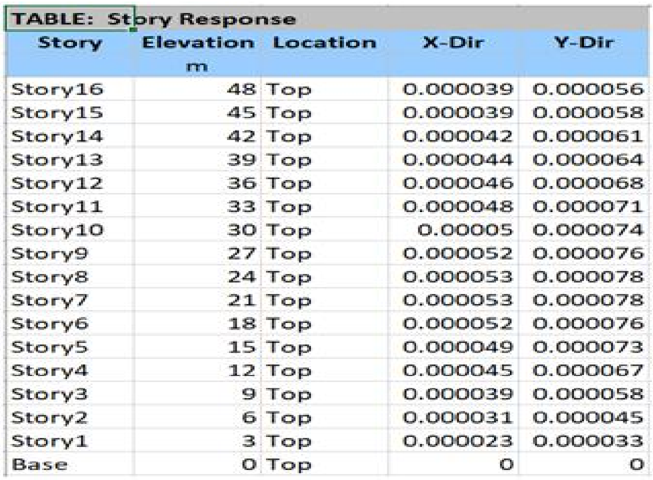


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000039	0.000056
Story15	45	Top	0.000039	0.000058
Story14	42	Top	0.000042	0.000061
Story13	39	Top	0.000044	0.000064
Story12	36	Top	0.000046	0.000068
Story11	33	Top	0.000048	0.000071
Story10	30	Top	0.00005	0.000074
Story9	27	Top	0.000052	0.000076
Story8	24	Top	0.000053	0.000078
Story7	21	Top	0.000053	0.000078
Story6	18	Top	0.000052	0.000076
Story5	15	Top	0.000049	0.000073
Story4	12	Top	0.000045	0.000067
Story3	9	Top	0.000039	0.000058
Story2	6	Top	0.000031	0.000045
Story1	3	Top	0.000023	0.000033
Base	0	Top	0	0

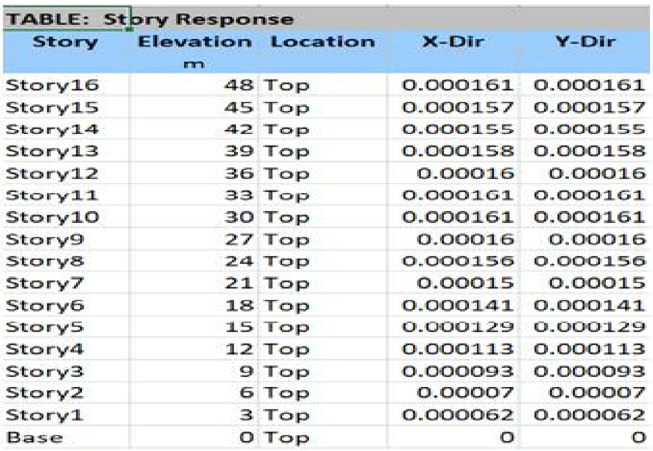


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000161	0.000161
Story15	45	Top	0.000157	0.000157
Story14	42	Top	0.000155	0.000155
Story13	39	Top	0.000158	0.000158
Story12	36	Top	0.00016	0.00016
Story11	33	Top	0.000161	0.000161
Story10	30	Top	0.000161	0.000161
Story9	27	Top	0.00016	0.00016
Story8	24	Top	0.000156	0.000156
Story7	21	Top	0.00015	0.00015
Story6	18	Top	0.000141	0.000141
Story5	15	Top	0.000129	0.000129
Story4	12	Top	0.000113	0.000113
Story3	9	Top	0.000093	0.000093
Story2	6	Top	0.00007	0.00007
Story1	3	Top	0.000062	0.000062
Base	0	Top	0	0

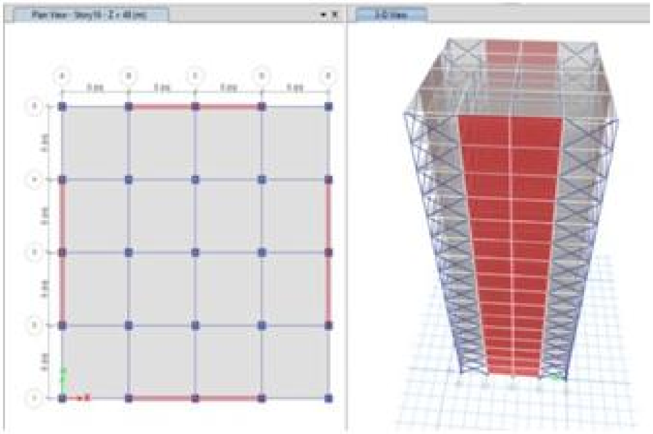


Fig 16Moment Resisting Frame with Shear Wall and Steel X-Bracing system positioned at alternate bays at each corner (Model 5).

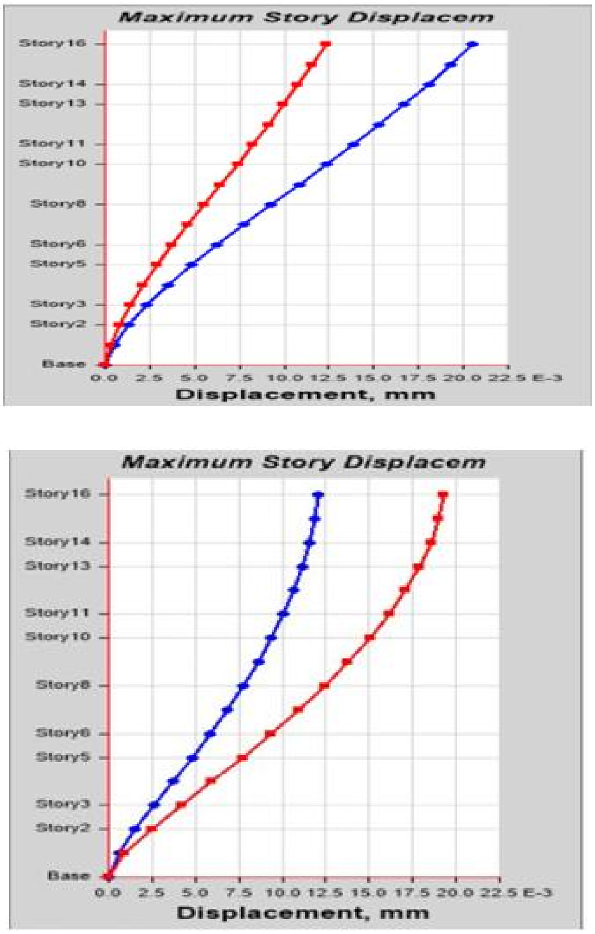
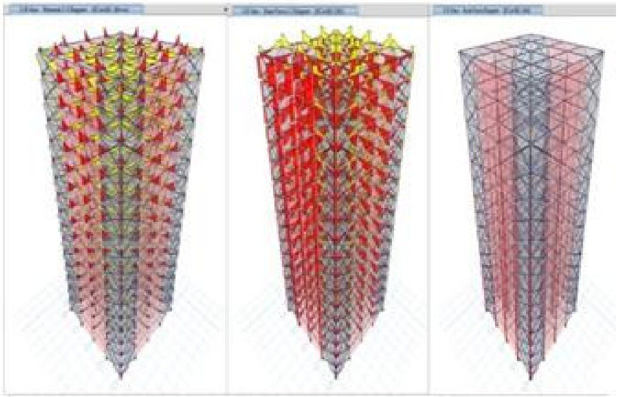


Fig17 Displacement graph for Model 5.



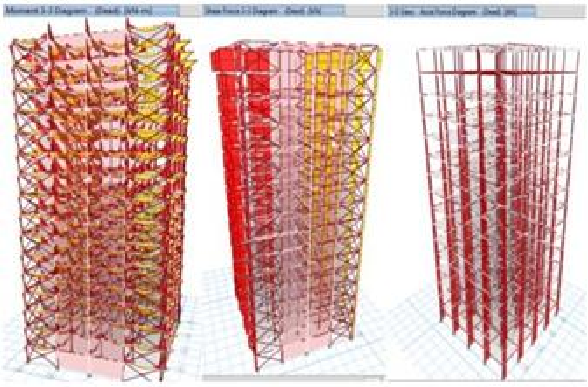
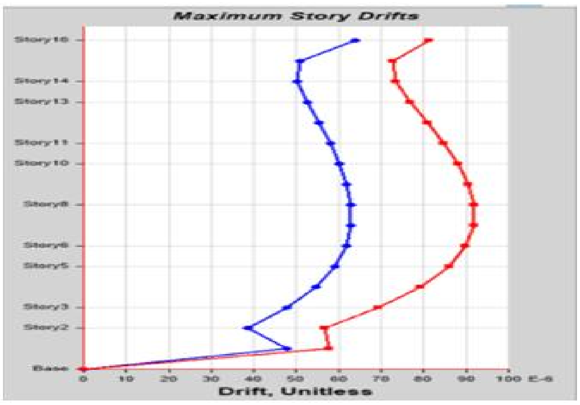


Fig18. Bending Moment Shear Force & Axial Force diagrams for both Mumbai And Pune.

In Figure 18 above after performing Bending Moment, Shear Force & Axial Force analysis for both Mumbai and Pune. In this it is found that the diagram view is distinctly similar as it is easily understand the dense difference between both Mumbai and Pune model and the values differs by satisfactory numbers.



Storey per storey, the table depicts the inter-storey drifts inboth the X and Y directions. The inter-story drift is calculated by subtracting the upper and lower storey displacements from the storey height. Storey drift must be less than 0.004 times the storey height, according to IS 1893 Part 1: 2016. The maximum allowable thickness is 12mm because the storey height in our circumstance is 3m. Table 10 further demonstrates that all of the results fall within the acceptable range. As a result, the building's storey drift values may be higher, but they're still acceptable.

Table 5 Storey wise values of inter storey drift along X and Y directions for the 5th Model.

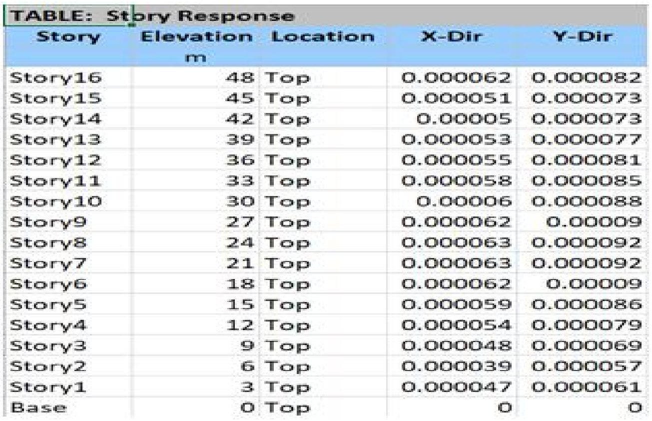


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000062	0.000082
Story15	45	Top	0.000051	0.000073
Story14	42	Top	0.00005	0.000073
Story13	39	Top	0.000053	0.000077
Story12	36	Top	0.000055	0.000081
Story11	33	Top	0.000058	0.000085
Story10	30	Top	0.00006	0.000088
Story9	27	Top	0.000062	0.00009
Story8	24	Top	0.000063	0.000092
Story7	21	Top	0.000063	0.000092
Story6	18	Top	0.000062	0.00009
Story5	15	Top	0.000059	0.000086
Story4	12	Top	0.000054	0.000079
Story3	9	Top	0.000048	0.000069
Story2	6	Top	0.000039	0.000057
Story1	3	Top	0.000047	0.000061
Base	0	Top	0	0

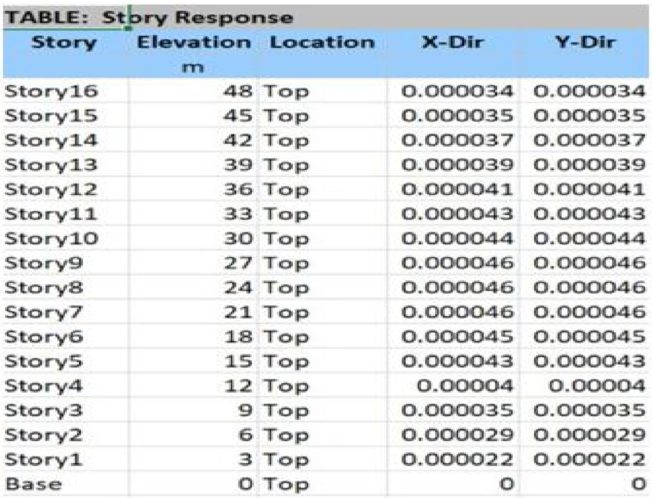


TABLE: Story Response

Story	Elevation m	Location	X-Dir	Y-Dir
Story16	48	Top	0.000034	0.000034
Story15	45	Top	0.000035	0.000035
Story14	42	Top	0.000037	0.000037
Story13	39	Top	0.000039	0.000039
Story12	36	Top	0.000041	0.000041
Story11	33	Top	0.000043	0.000043
Story10	30	Top	0.000044	0.000044
Story9	27	Top	0.000046	0.000046
Story8	24	Top	0.000046	0.000046
Story7	21	Top	0.000046	0.000046
Story6	18	Top	0.000045	0.000045
Story5	15	Top	0.000043	0.000043
Story4	12	Top	0.00004	0.00004
Story3	9	Top	0.000035	0.000035
Story2	6	Top	0.000029	0.000029
Story1	3	Top	0.000022	0.000022
Base	0	Top	0	0

Outcomes of the project with reference to the comparison of displacement and drift of every Models.

The difference in displacements between two subsequent stories divided by the height of that storey is known as level drift. And The absolute size of the storey displacement under the effect of lateral pressures is called storey displacement. It is impossible to overstate the relevance of storey drift in the building of partitions and curtain walls. The lateral displacement of the storey in relation to the foundation is known as storey displacement. The relative displacement of one tale from the next is known as storey drift. In the design of partitions and curtain walls, tale drift is critical.

MUMBAI

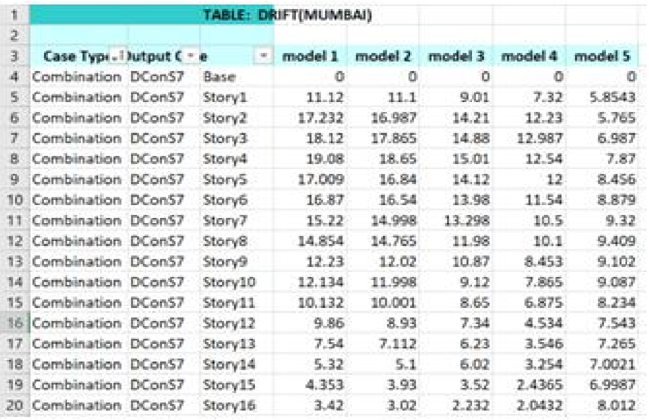
Table 6 Displacement Comparison of each Models of Mumbai

TABLE: Joint Displacements

Case Typ	utput C	e	model	model	model	model	model 5
Combination	DConS7	Base	0	0	0	0	0
Combination	DConS7	Story1	3.242	2.5664	3.001	2.65	1.2234
Combination	DConS7	Story2	8.238	7.212	6.834	6.2654	1.5546
Combination	DConS7	Story3	14.935	12.987	12.453	11.8456	2.9876
Combination	DConS7	Story4	22.9864	17.876	16.879	15.654	3.9453
Combination	DConS7	Story5	25.874	22.564	23.987	19.546	5.8675
Combination	DConS7	Story6	31.976	25.4564	24.987	22.556	6.987
Combination	DConS7	Story7	36.973	28.234	28.675	26.987	8.435
Combination	DConS7	Story8	40.567	34.6754	32.987	29.334	10.456
Combination	DConS7	Story9	44.893	35.2896	36.9867	32.907	12.098
Combination	DConS7	Story10	48.94	42.786	38.986	35.998	13.987
Combination	DConS7	Story11	51.964	43.8976	40.987	39.667	17.876
Combination	DConS7	Story12	53.975	44.6575	43.654	41.445	18.654
Combination	DConS7	Story13	56.2343	45.978	44.983	43.786	19.435
Combination	DConS7	Story14	57.3234	47.687	46.0456	44.897	20.987
Combination	DConS7	Story15	58.909	48.01	46.9875	45.989	21.6575
Combination	DConS7	Story16	59.2456	48.123	47.287	46.554	22.6578

Fig 19 Graphical Representation of Mumbai Models for Displacement .

Table 7 Drift Comparison of each Models of Mumbai



1	TABLE: DRIFT(MUMBAI)							
2								
3	Case Typ	utput C	e	model 1	model 2	model 3	model 4	model 5
4	Combination	DConS7	Base	0	0	0	0	0
5	Combination	DConS7	Story1	11.12	11.1	9.01	7.32	5.8543
6	Combination	DConS7	Story2	17.232	16.987	14.21	12.23	5.765
7	Combination	DConS7	Story3	18.12	17.865	14.88	12.987	6.987
8	Combination	DConS7	Story4	19.08	18.65	15.01	12.54	7.87
9	Combination	DConS7	Story5	17.009	16.84	14.12	12	8.456
10	Combination	DConS7	Story6	16.87	16.54	13.98	11.54	8.879
11	Combination	DConS7	Story7	15.22	14.998	13.298	10.5	9.32
12	Combination	DConS7	Story8	14.854	14.765	11.98	10.1	9.409
13	Combination	DConS7	Story9	12.23	12.02	10.87	8.453	9.102
14	Combination	DConS7	Story10	12.134	11.998	9.12	7.865	9.087
15	Combination	DConS7	Story11	10.132	10.001	8.65	6.875	8.234
16	Combination	DConS7	Story12	9.86	8.93	7.34	4.534	7.543
17	Combination	DConS7	Story13	7.54	7.112	6.23	3.546	7.265
18	Combination	DConS7	Story14	5.32	5.1	6.02	3.254	7.0021
19	Combination	DConS7	Story15	4.353	3.93	3.52	2.4365	6.9987
20	Combination	DConS7	Story16	3.42	3.02	2.232	2.0432	8.012

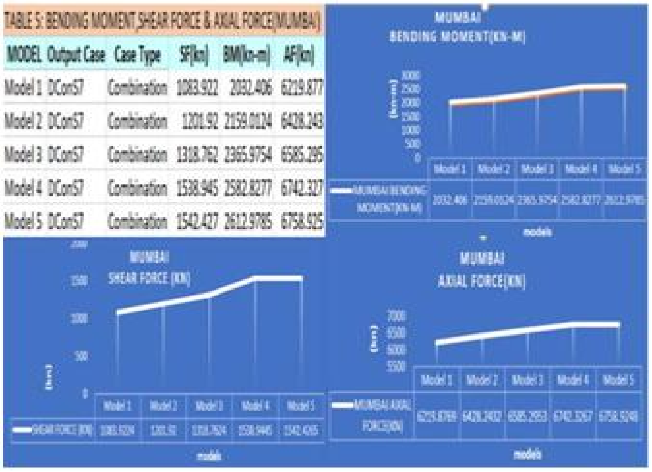


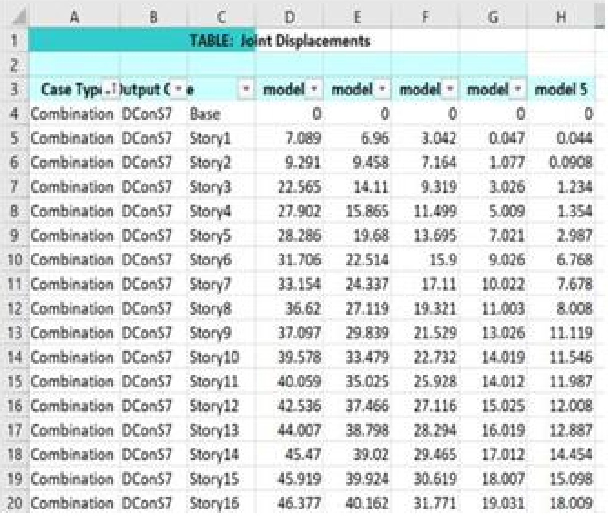
TABLE 5: BENDING MOMENT,SHEAR FORCE & AXIAL FORCE(MUMBAI)

MODEL	Output Case	Case Type	SF(kn)	BM(kn-m)	AF(kn)
Model 1	DConS7	Combination	1083.922	2032.406	6219.877
Model 2	DConS7	Combination	1201.92	2159.0124	6428.243
Model 3	DConS7	Combination	1318.762	2365.9754	6585.295
Model 4	DConS7	Combination	1538.945	2582.8277	6742.327
Model 5	DConS7	Combination	1542.427	2612.9785	6758.925

Fig 20 Graphical Representation of Mumbai Models for Drift Table 8 Bending Moment shear Force and Axial Force Comparison

PUNE

Table 9 Displacement Comparison of each Models of Pune



	A	B	C	D	E	F	G	H
1	TABLE: Joint Displacements							
2								
3	Case Typ	Output C	e	model	model	model	model	model 5
4	Combination	DConS7	Base	0	0	0	0	0
5	Combination	DConS7	Story1	7.089	6.96	3.042	0.047	0.044
6	Combination	DConS7	Story2	9.291	9.458	7.164	1.077	0.0908
7	Combination	DConS7	Story3	22.565	14.11	9.319	3.026	1.234
8	Combination	DConS7	Story4	27.902	15.865	11.499	5.009	1.354
9	Combination	DConS7	Story5	28.286	19.68	13.695	7.021	2.987
10	Combination	DConS7	Story6	31.706	22.514	15.9	9.026	6.768
11	Combination	DConS7	Story7	33.154	24.337	17.11	10.022	7.678
12	Combination	DConS7	Story8	36.62	27.119	19.321	11.003	8.008
13	Combination	DConS7	Story9	37.097	29.839	21.529	13.026	11.119
14	Combination	DConS7	Story10	39.578	33.479	22.732	14.019	11.546
15	Combination	DConS7	Story11	40.059	35.025	25.928	14.012	11.987
16	Combination	DConS7	Story12	42.536	37.466	27.116	15.025	12.008
17	Combination	DConS7	Story13	44.007	38.798	28.294	16.019	12.887
18	Combination	DConS7	Story14	45.47	39.02	29.465	17.012	14.454
19	Combination	DConS7	Story15	45.919	39.924	30.619	18.007	15.098
20	Combination	DConS7	Story16	46.377	40.162	31.771	19.031	18.009

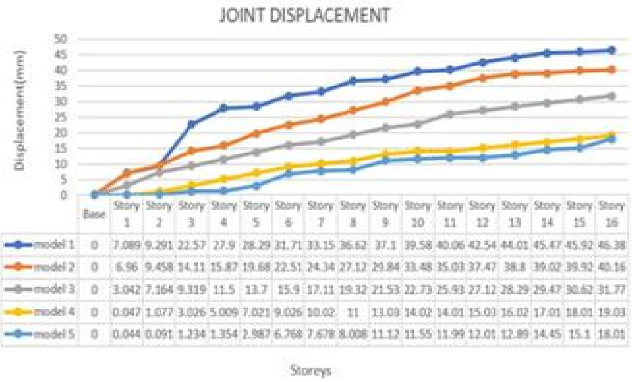
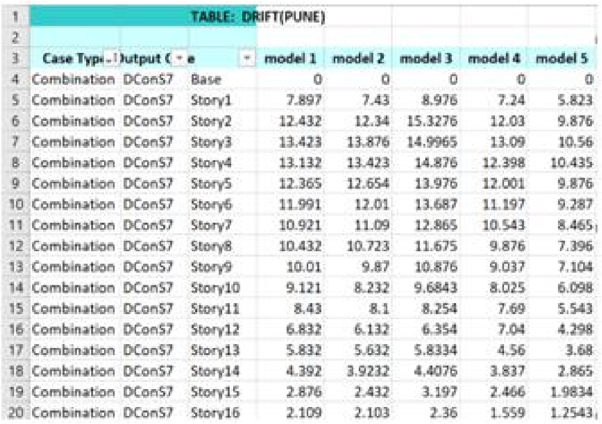


Fig 21 Graphical Representation of Pune Model for Displacement

Table 10. Drift comparison of each model of Pune



1	TABLE: DRIFT(PUNE)						
2							
3	Case Typ	Output C	e	model 1	model 2	model 3	model 4	model 5
4	Combination	DConS7	Base	0	0	0	0	0
5	Combination	DConS7	Story1	7.897	7.43	8.976	7.24	5.823
6	Combination	DConS7	Story2	12.432	12.34	15.3276	12.03	9.876
7	Combination	DConS7	Story3	13.423	13.876	14.9965	13.09	10.56
8	Combination	DConS7	Story4	13.132	13.423	14.876	12.398	10.435
9	Combination	DConS7	Story5	12.365	12.654	13.976	12.001	9.876
10	Combination	DConS7	Story6	11.991	12.01	13.687	11.197	9.287
11	Combination	DConS7	Story7	10.921	11.09	12.865	10.543	8.465
12	Combination	DConS7	Story8	10.432	10.723	11.675	9.876	7.396
13	Combination	DConS7	Story9	10.01	9.87	10.876	9.037	7.104
14	Combination	DConS7	Story10	9.121	8.232	9.6843	8.025	6.098
15	Combination	DConS7	Story11	8.43	8.1	8.254	7.69	5.543
16	Combination	DConS7	Story12	6.832	6.132	6.354	7.04	4.298
17	Combination	DConS7	Story13	5.832	5.632	5.8334	4.56	3.68
18	Combination	DConS7	Story14	4.392	3.9232	4.4076	3.837	2.865
19	Combination	DConS7	Story15	2.876	2.432	3.197	2.466	1.9834
20	Combination	DConS7	Story16	2.109	2.103	2.36	1.559	1.2543

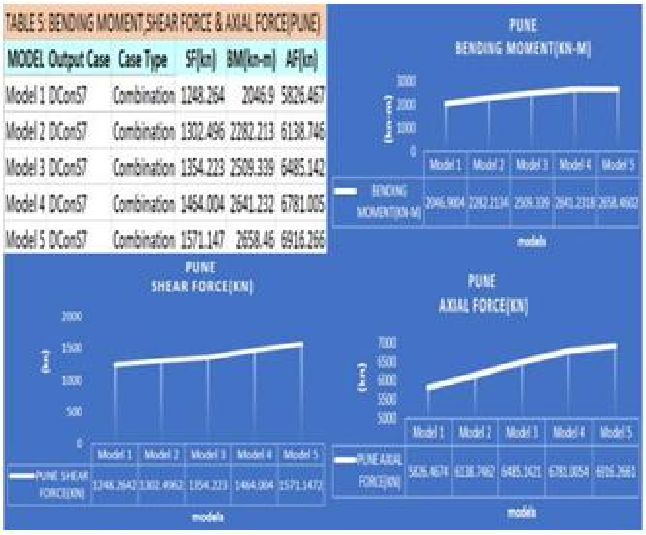


TABLE 5: BENDING MOMENT,SHEAR FORCE & AXIAL FORCE(PUNE)

MODEL	Output Case	Case Type	SF(kn)	BM(kn-m)	AF(kn)
Model 1	DConS7	Combination	1248.264	2046.9	5826.467
Model 2	DConS7	Combination	1302.496	2282.213	6138.746
Model 3	DConS7	Combination	1354.223	2509.339	6485.142
Model 4	DConS7	Combination	1464.004	2641.232	6781.005
Model 5	DConS7	Combination	1571.147	2658.46	6916.266

Fig. 22 Drift Comparison of each Models of Pune.

Table 11 Bending Moment shear Force and Axial Force Comparison

V. CONCLUSIONS

The following conclusions were drawn out from the study of five different models of Mumbai and Pune coming in Zone III

- The Base Shear of structures with shear walls and steel bracing systems is greater than that of buildings without shear walls and bracing systems, resulting in increased structural rigidity.
- By the use of shear walls and Steel Bracing system the storey drift is brought to its limitations.
- The wind load is being analysed according to IS 875:2015.

- Study has been carried out in different types of buildings with variable aspect ratios coming under zone III.
- The comparison between two different building in different places coming in different zones.
- Wind load has the ability to bring a building to sway.
- The performance of the structures is done by using trail and error method in Etabs.
- The model which got the lesser values for drift and displacement is suitable model for design.
- The model 5 is the most economical of all the five models analyzed.
- Also the model 5 shows better performance both in terms of storey drift and Base Shear. Also with displacement the model 5 shows better results.
- As a result model 5 is recommended as the preferred solution for retrofitting a multistorey structure in seismic Zone III.

REFERENCS

[1] Pendharkar (2016). "Influence of Aspect ratio and plan configurations on seismic performance of multi-storied regular RCC building: by Response Spectrum Analysis". International Research Journal of Engineering and Technology (IRJET), 293-299.

[2] S. K. Sadh, U. Pendharkar (2016). "Influence of Aspect ratio and plan configurations on seismic performance of multi-storied regular RCC building: by Response Spectrum Analysis". International Research Journal of Engineering and Technology (IRJET), 293-299.

[3] M. Araujo, J. M. Castro, X. Romao& R. Delgado (2012), "Comparative Study of the European and American Seismic Safety Assessment Procedures for Existing Steel Buildings".

[4] Jaime Landingin, Hugo Rodrigues, Humberto Varum, António Arêde (2013),"Comparative Analysis of RC Irregular Buildings Designed According to Different Seismic Design Codes", The Open Construction and Building Technology Journal, 2013, Volume 7:221-229.

[5] Vinit Dhanvijay, Prof. Deepa Telang, Vikrant Nair (2015). "Comparative Study of Different Codes in Seismic Assessment ". International Research Journal of Engineering and Technology (IRJET), 1371-1381.

[6] Kothari, C. R. (2004), Research methodology: Methods and techniques, New Age International Publications.

[7] W. B. Li and S. N. Wang, "Design of wind resistance for lightweight steel building," in Proceedings of the 2005 National Conference on Building Steel Structure Industry, pp. 195–209, Beihai, Guangxi, China, April 2005.

[8] Shahid Ul Islam, Rajesh Goel, Pooja Sharma, (2018)."Seismic Co-action of Shear Wall and Reinforced CementConcreteBracingSysteminhighriseCommercialBuildingusingSTAAD.Pro,"IJEDR,vol.6,issue3,2018.

[9] X. X. Zhang, "Estimation of Probabilistic Extreme Wind Load Effect with Consideration of Directionality and Uncertainty," Texas Tech University, TX, USA, 2015, Master Thesis.

[10] J.S. Grossman, "Slender concrete structures – the new edge", ACI Structural Journal 87 (1) (1990) 39-52.

[11] Viswanath K.G., Prakash K.B., Anant Desai, "Seismic Analysis of Steel Braced reinforced Concrete Frames".

[12] H. L. Xue, H. J. Liu, H. Y. Peng, Y. Luo, and K. Lin, "Wind load and structural parameters estimation from incomplete measurements," Shock and Vibration, vol. 2019, Article ID 4862983, 20 pages, 2019.

[13] G. Chowdhury, I. Canino, A. Mirmiran, N. Suksawang, and T. Baheru, "Wind-loading effects on roof-to-wall connections of timber residential buildings," Journal of Engineering Mechanics, vol. 139, no. 3, pp. 386–395, 2013.

[14] Yao, Y. Quan, and M. Gu, "Combination method of wind load about high-rise buildings based on probability analysis," Journal of Tongji University, vol. 44, pp. 1032–1037, 2016.

[15] X. Zhuang, X. Dong, J. M. Ding, and Y. M. Zhen, "Non-Gaussian features of wind pressure fluctuations on a rectangular high-rise building," Journal of Building Structures, vol. 37, pp. 13–18, 2016.

[16] M.Araujo,J.M.Castro,X.Romao& R.Delgado(2012),"ComparativeStudyoftheEuropeanandAmericanSeismicSafetyAssessmentProceduresfor ExistingSteelBuildings".

[17] Y. Quan, F. Wang, and M. Gu, "A method for estimation of extreme values of wind pressure on buildings based on the generalized extreme-value theory," Mathematical Problems in Engineering, vol. 2014, Article ID 926253, 22 pages, 2014.