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Parametric Study of Tall Structures with Altering Podium Height Inducing Backstay Effect with & Without Shear Wall

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ABSTRACT

In a tall building, generally the building has a wider plan area and higher lateral resistance at the lower story level than the above story levels. The present study focuses to understand the behaviour and effect on a tower connected by a podium at different levels with the consideration of several parameters under lateral load. The effect of backstay forces which is studied here are developed to resist the lateral overturning actions at the junction of tower interacted with podium from where the lateral load has been transferred. The critical effect of podium on the force distribution at and above junction is observed and on the basis of these parametric previous studies, one can easily understand the actual behaviour and do the necessary consideration in such conditions. For this purpose, the simulation model with varying podium height is created in the ETABs and it is analysed for the linear dynamic analysis as per IS 1893:2016. In this study, the effect on various parameters like displacement, drift, shear, moment etc of the tower connected with podium structure under response spectrum method of analysis is observed. The unfavourable effect of podium on the force distribution at and above the junction level of the structural wall is also observed.

Keywords: RC Building, Seismic Analysis, Backstay Effect, Podium, Tower, Shear wall.

The demand for tall structures is increasing due to rising population and land problems in metropolitan regions. Tall structures are becoming more popular in developing nations, including India. After a certain amount of horizontal development, no more land is accessible for growth in any city, especially in metro cities. As a result, multi storied towers became popular as a way to maximise land utilisation. High-rise buildings cannot be designed in the same manner that low and medium-rise structures are designed. Tall buildings are extremely complex engineering projects, so the most sophisticated design methods are required in tall structures. To satisfy the demand of government rules with the proper efficiency, the concept of Podium kind structures is introduced. The bottom few storeys have bigger plan dimensions than the towers in many tall structures and can be used for different purposes such as parking, retail shops, etc and can be considered as a podium for the tall building with the tower above. A podium is a term used to describe the base of a tall building. Podium in architecture is any of various elements that form the foot or base of a structure and have a low wall supporting columns, or the structurally or decoratively emphasized the lowest portion of a wall. A building's basement storey sometimes used as a podium. In many multi-functional tall buildings, this type of configuration is seen. The assembly of the tower-podium type of structure is shown in picture below.

One of the critical aspects of modelling building structures is dealing with at and below-grade components of the structure. The main aim of this research is commonly referred to as the backstay effect. Conventionally, tall buildings have been viewed as simple cantilever beams fixed at the base. While this resemblance is reasonable for the above-grade structure, a more accurate correlation would also include the effects of the below-grade structure, which behaves like a back span to the cantilever. In this phenomenon, the lateral system is considered as a beam overhanging one support, where that support is created by the diaphragm and foundation walls at the level where backstay forces have been developed. This effect is not limited to control at the grade

level. It can also see at setbacks with changes to the lateral system, the most common example being lower level podiums. They are often very wide in plan and with the introduction of lateral element; it becomes significantly stiffer than the structure above. This paper will focus on the most common example which is the effect of the ground floor or above diaphragm in contributing to backstay effects.

1.2 Backstay Effect

The bottom part of a tall structure that is larger in the floor plan and contains a significantly increased seismic force resistance when compared to the portion of the tower above can be considered as a podium structure. Many tall structures have an arrangement in which the below few storeys have a larger floor plan than the towers above, this type of construction is common in multi-storey buildings where the lower part of storeys often used for various purposes like retail stores, parking lot, meeting rooms etc.

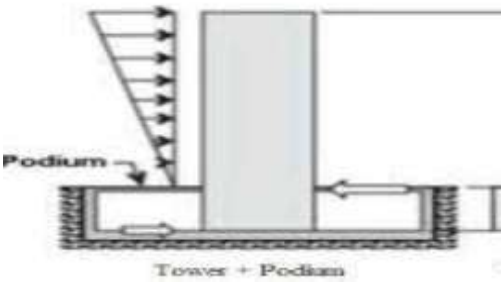


Fig. 1. Backstay action in a podium-tower assembly

The study enhances the effects of a setback on the dynamic response of the structure and design criteria to improve the response of setback building for lateral forces. The backstay effect which is most traceable in buildings with a distinct lateral system (ex: shear wall, core wall) which are connected with the base structure. It has been found that more than enough amount of study has been carried out on the displacement parameter for single tower connected by a podium structure in which the number of storeys in the podium structure is varied. In this present study, the behaviour of the single tower with different height of podium is carried out. To determine the optimum height of the podium will be determined which helps designer to consider this in a severe condition. Podium in a tall structure works as a separation between different building occupancy categories. It also serves as a diaphragm or the transfer slab for the transfer of lateral loads from the above superstructure and main lateral load resisting element in the tower to the structural walls and columns within the podium level.

1.3 Need of the Study

The need of present study is to compare the diaphragm effect for tall structures at junction level between tower and podium. Also to understand the phenomena of the Backstay effect observed in the tower-podium type structures by considering the provisions given in the Indian standards (IS 16700: 2017). This also helps to investigate the effect of increasing the number of storeys which can induce the backstay effect.

1.4 Objectives of the Study

- To understand the phenomena of the Backstay effect observed in the tower-podium type structures by considering the provisions given in the Indian standards (IS 16700: 2017) with varying heights of podium. With these parameters different models will be prepared & Compare on the basis of Drift, Displacement and Shear Parameters.
- Also it helps to understand the podium tower junction where shear force reversal was detected.
- To understand the effect of backstay by increasing the height of podium at different intervals.

2. Methodology

SPECIFICATIONS:

Different models for G+40 storey RC Structure of area 60 m x 60 m. have been prepared, designed and compared in zone V as per IS 1893:2016. The models with different properties of back stay effect with height variation have been compared with regular model whose performance and results were studied and compared.

Details of Models:

Model 1 – Regular G+40 RC Frame Tower of 60 m x 60 m area

Model 2 - Regular G+40 RC Frame Tower of 60 m x 60 m area with shear wall at the periphery

Model 3 – Regular G+40 RC Frame Tower of 20 m x 20 m area with podium height up to 10th floor

Model 4 - Regular G+40 RC Frame Tower of 20 m x 20 m area with podium height up to 10th floor and with shear wall at the periphery

Model 5 – Regular G+40 RC Frame Tower of 20 m x 20 m area with podium height up to 20th floor

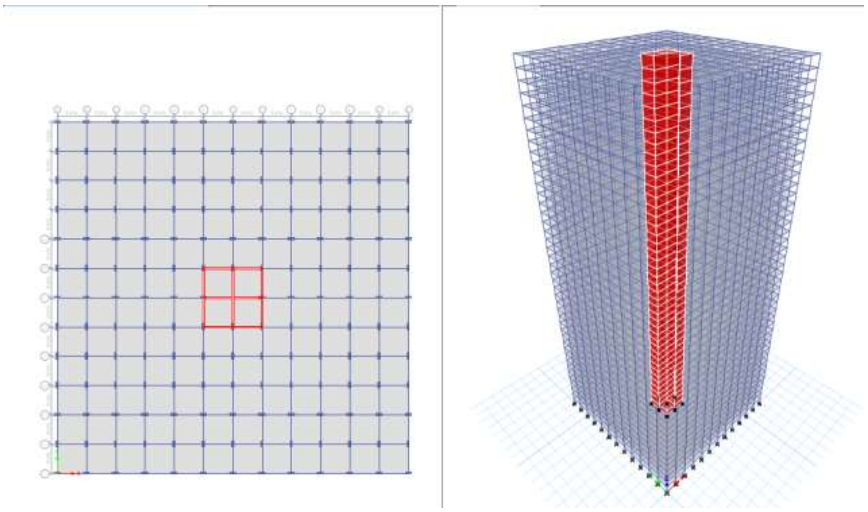
Model 6 - Regular G+40 RC Frame Tower of 20 m x 20 m area with podium height up to 20th floor and with shear wall at the periphery

Model 7 – Regular G+40 RC Frame Tower of 20 m x 20 m area with podium height up to 30th floor

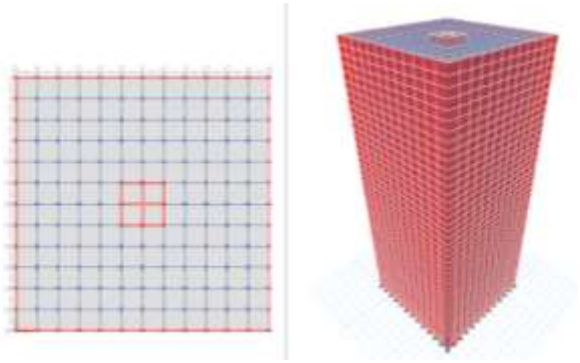
Model 8 - Regular G+40 RC Frame Tower of 20 m x 20 m area with podium height up to 30th floor and with shear wall at the periphery

The dimensions of beams and columns have been designed according to the span length. Other data used for the purpose of analysis have been taken from IS 1893:2016

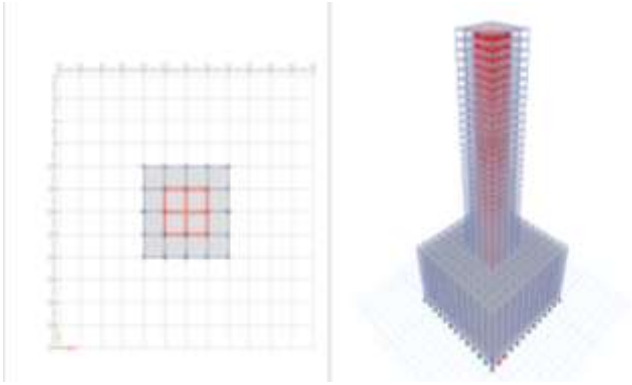
General Properties	
No. of storeys	G+40
Typical Storey Height	3.5 m.
Size of Column	500 x 1200
Size of Beam	300 x 500
Thickness of Slab	150 mm.
Thickness of Wall	230 mm.
Material Properties	
Grade of Concrete	M 40
Grade of Steel	Fe500
Type of Loading	
Wall Load	14 KN/m
Live Load	2.5 KN/m^2
Floor Finishing	1.5 KN/m^2
Seismic Details (IS 1893:2016)	
Seismic Zone	V
Zone Factor	0.36
Importance Factor	1
Type of Soil	II - Medium
Building Type (R)	5 (SMRF)



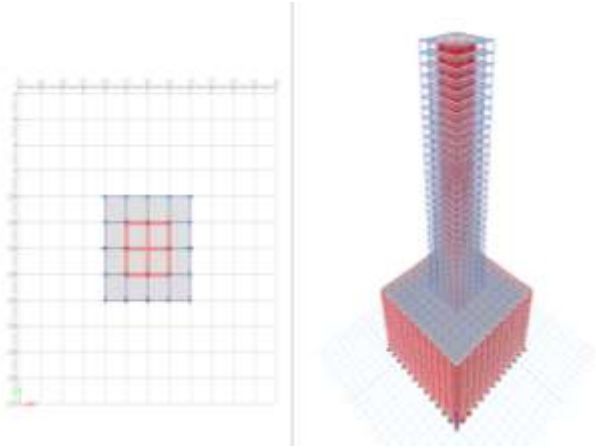
REGULAR STRUCTURE OF PLAN AREA 60m x 60m



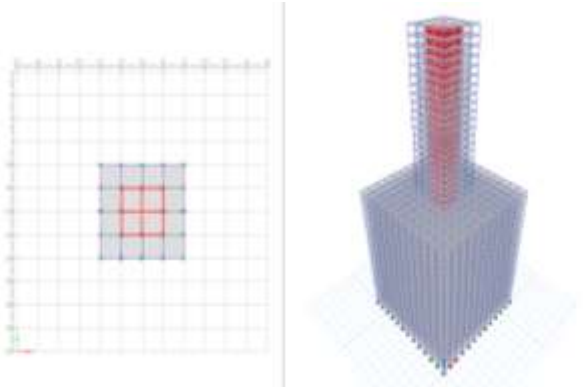
REGULAR STRUCTURE OF PLAN AREA 60m x 60m with shear wall at periphery



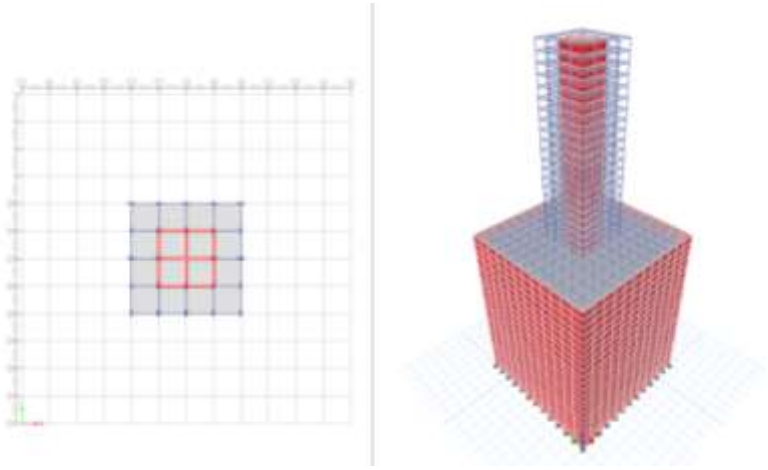
MODEL WITH PODIUM UP TO ¼ th of Total Height



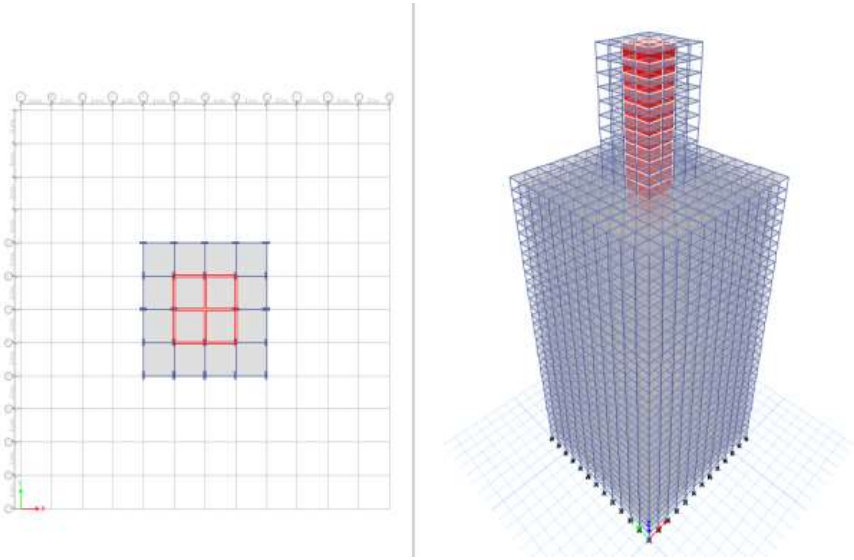
MODEL WITH PODIUM UP TO ¼ th of Total Height and shear wall at Periphery



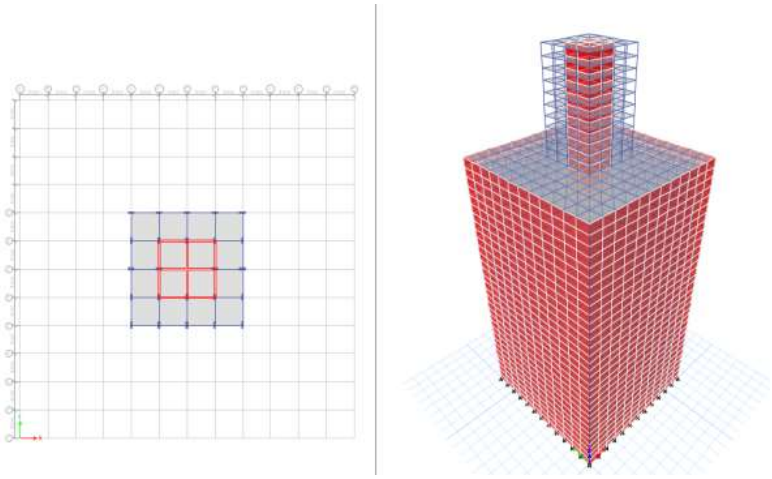
MODEL WITH PODIUM UP TO 1/2 of Total Height



MODEL WITH PODIUM UP TO 1/2 of Total Height with shear wall at periphery

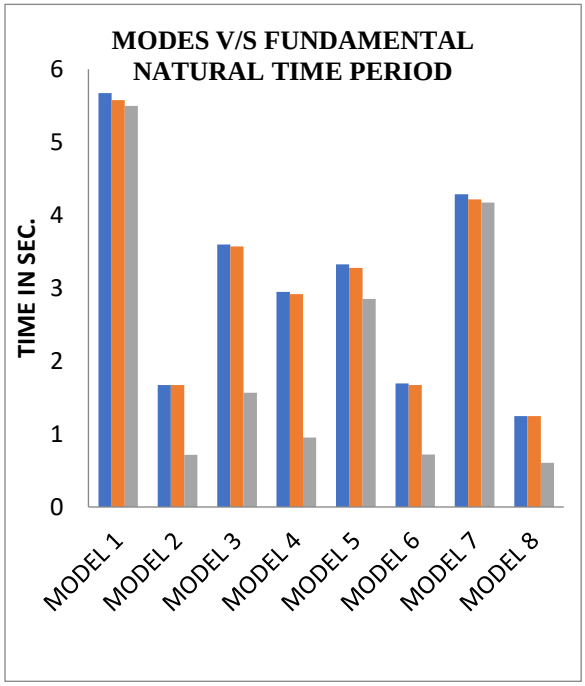


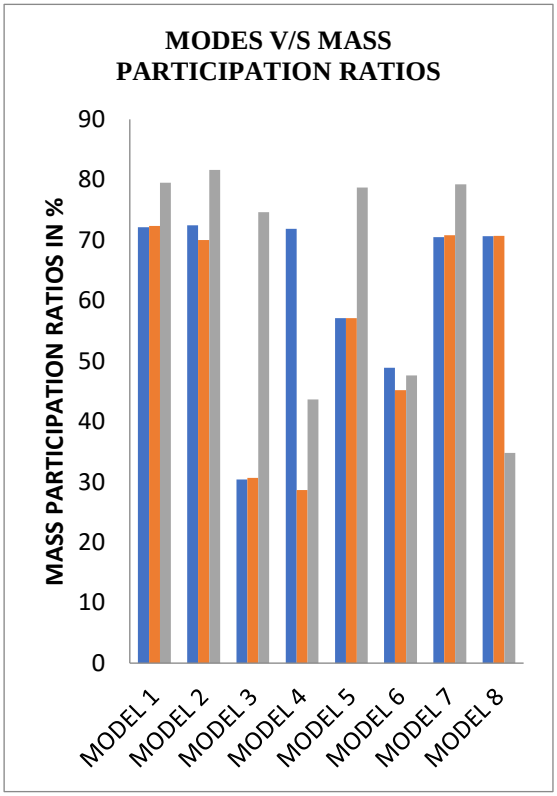
MODEL WITH PODIUM UP TO 3/4 of Total Height

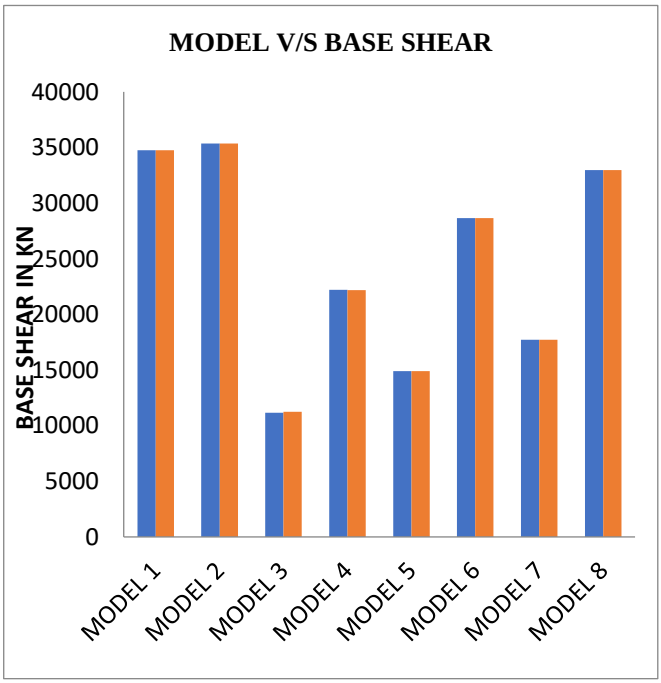


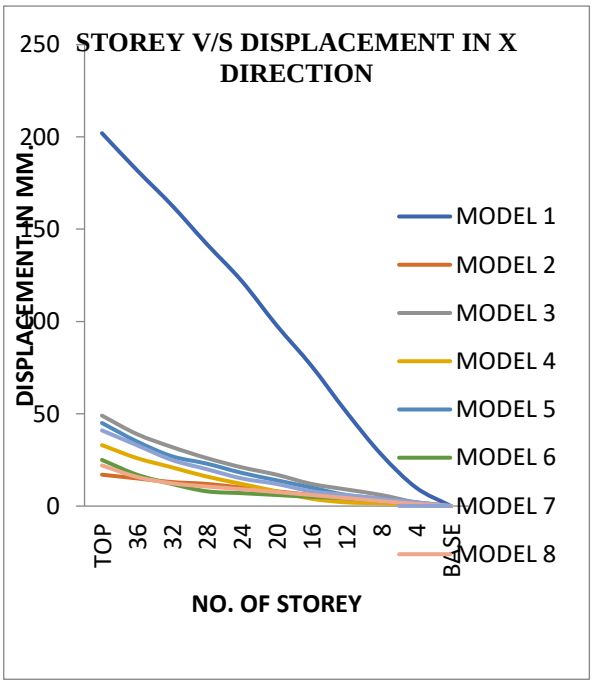
MODEL WITH PODIUM UP TO 3/4 of Total Height with shear wall at periphery

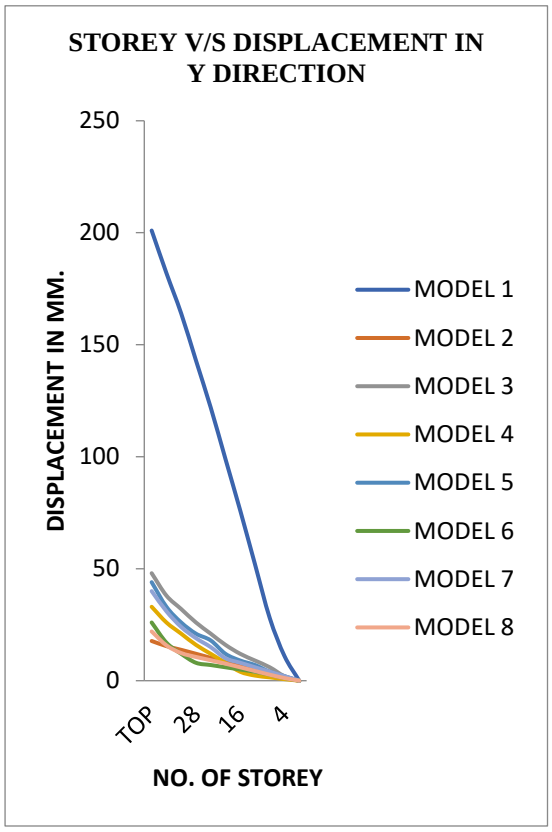
3. RESULTS –

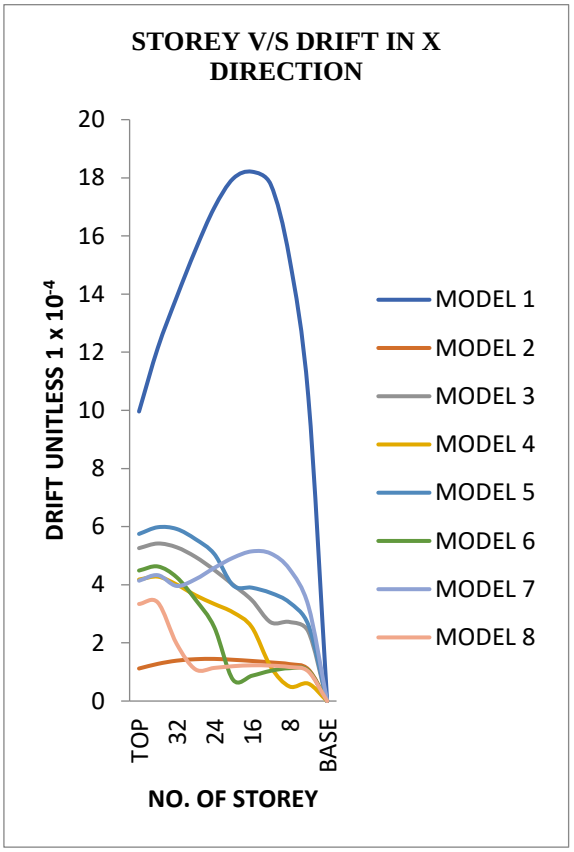

MODES V/S FUNDAMENTAL NATURAL TIME PERIOD
TIME IN SEC.
0
1
2
3
4
5
6
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8

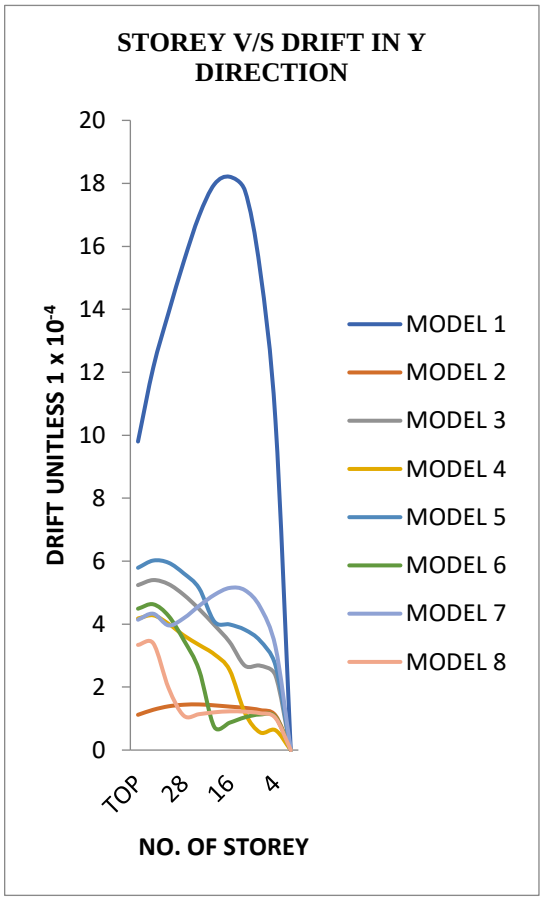

MODES V/S MASS PARTICIPATION RATIOS
MASS PARTICIPATION RATIOS IN %
0
10
20
30
40
50
60
70
80
90
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8

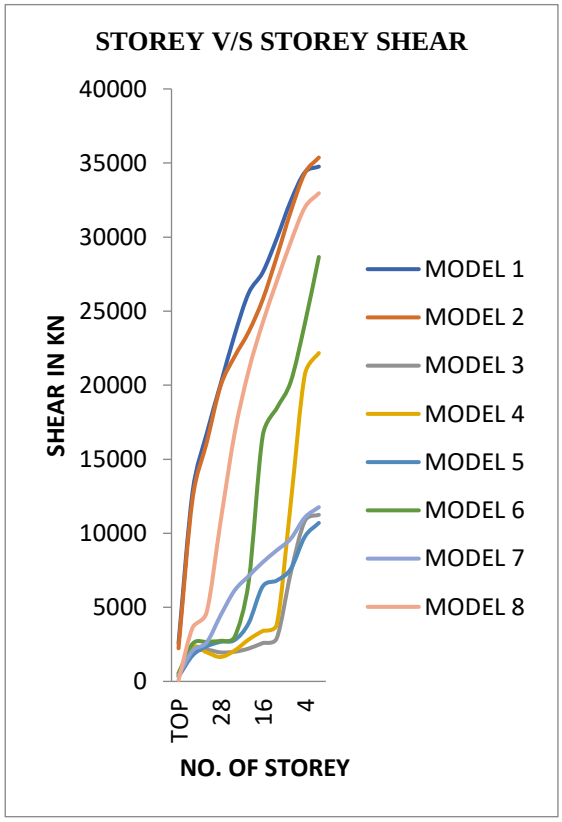

MODEL V/S BASE SHEAR
BASE SHEAR IN KN
0
5000
10000
15000
20000
25000
30000
35000
40000
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8

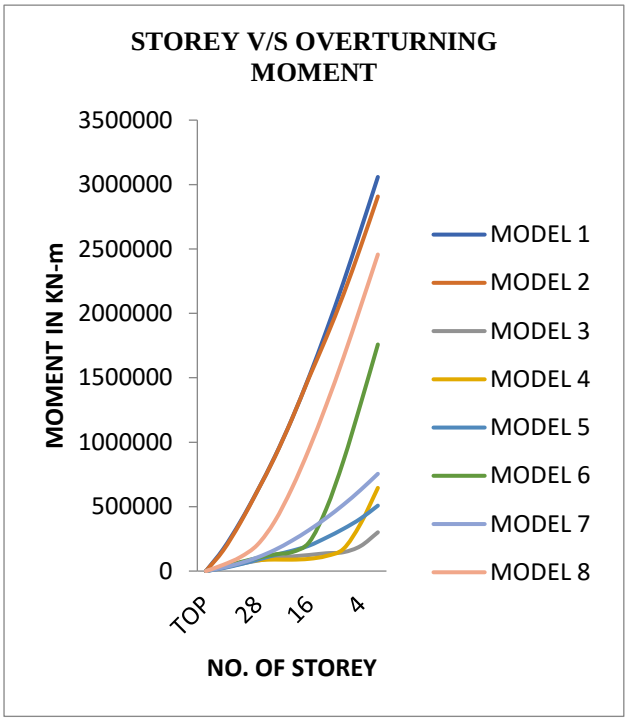

STOREY V/S DISPLACEMENT IN X DIRECTION
DISPLACEMENT IN MM
0
50
100
150
200
250
TOP
36
32
28
24
20
16
12
8
4
BASE
NO. OF STOREY
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8


STOREY V/S DISPLACEMENT IN Y DIRECTION
DISPLACEMENT IN MM.
250
200
150
100
50
0
TOP
28
16
4
NO. OF STOREY
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8


STOREY V/S DRIFT IN X DIRECTION
DRIFT UNITLESS 1 x 10-4
20
18
16
14
12
10
8
6
4
2
0
TOP
32
24
16
8
BASE
NO. OF STOREY
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8


STOREY V/S DRIFT IN Y DIRECTION
DRIFT UNITLESS 1 x 10-4
20
18
16
14
12
10
8
6
4
2
0
TOP
28
16
4
NO. OF STOREY
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8


STOREY V/S STOREY SHEAR
SHEAR IN KN
40000
35000
30000
25000
20000
15000
10000
5000
0
TOP
28
16
4
NO. OF STOREY
MODEL 1
MODEL 2
MODEL 3
MODEL 4
MODEL 5
MODEL 6
MODEL 7
MODEL 8



4. CONCLUSION

Following conclusion have been made from this study -

- A tall building structure with free standing tower configuration had maximum time period which indicates the building is flexible in nature. Consideration of backstay effect in tall storey structure increases lateral stiffness resulting in reducing the overall time period of the structure.
- With an increase in the height of the podium in the Tower-Podium arrangement, the top Storey displacement of the structure decreases up to 24% in both X and Y directions as compared to free standing tower configuration only.
- The effect of backstay diaphragm results in increased mass therefore resulting in proportional increase in base shear up to 20% for the tower podium structure. Though for low rise structure the stiffness of building the benefit of backstay diaphragm was not much when compared to high rise structure..
- Displacement gradually reduces 5% more with effect of retaining wall.
- The increase in the height of podiums in towers with podium type of structures leads to an increase in Storey Shear at the main backstay diaphragm junction level. Also leads to a rise in the backstay force at the Tower podium junction level.
- When the number of podium storey increases, the overturning moment due to the backstay effect also increases up to 25% than the conventional building.

5. REFERENCES

1. Mehair Yacoubian, Nelson Lam, John L. Wilson, “Effects of podium interference on shear force distribution in tower walls supporting tall buildings”, (Elsevier, 2017).
2. Babak Rajaee And Perry Adebar. 2009. “Seismic design of high-rise concrete walls: reverse shear due to diaphragms below flexural hinge.” ASCE / August 2009, DOI :- 10.1061/(ASCE)0733-9445(2009)135:8(916)
3. Md Taqiuddin, Dr. V Lakshmi Shireen Banu, “Numerical study on behavior of non-tower building attached with tower”, Volume:6, Issue:9 (IRJET,2019)
4. Geetha, Kiran Kamath, “Seismic performance of a tall multi storey tower connected by a large podium”, Volume:8, Issue:2 (IJRTE, 2019).
5. Ankan Kumar Nandi, Jairaj C, “Backstay effect of diaphragm in tall building”, Volume:9, Issue:3 (IJITEE, 2020)
6. Kishan B. Champaneriya, Vishal B. Patel, Atul N. Desai, “Effect of backstay on tall structure with podium structure”, Volume 7, Issue 2, (IJARSCT 2021)

7. Kush Shah, Hiren Desai & Dhara Shah, "Effect of backstay on 3B+G+20 storey RC building", National Conference on Structural Engineering, NCRASE – 2020, 21-22 August 2020, National Institute of Technology Jamshedpur, Jharkhand India.

8. Nirav Bhatu1, Prof. Vishal B. Patel2, Prof. Pratiti Bhatt3, "Effect of Backstay on Tall Structures with Podium", International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 09 Issue: 04 | Apr 2022 www.irjet.net p-ISSN: 2395-0072.

9. Hardik B. Rangani1 and Dr. Vinubhai R. Patel2, "Benefits of Backstay Effect in Design of Podium Structure for Tall Building as Per IS 16700:2017", IJARSCT ISSN (Online) 2581-9429 International Journal of Advanced Research in Science, Communication and Technology (IJARSCT) Volume 2, Issue 6, June 2022 PP 113 – 117.