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Investigation Podium Impact On High-Rise Building Subjected To Seismic Load

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ABSTRACT

Different types of structures are being developed in this contemporary environment for varied purposes. In this project, an explanation of both a structure with a sizable podium at the base and a construction without a podium was attempted. A podium below the building allows for more effective use of the available space. Podiums are versatile platforms that may be used to build both conventional and unconventional structures. On podiums, a range of uses, including residential, commercial, and others, are all allowed up to a certain height.

In order to meet the need for space, as well as for safety reasons and to give the structures a pleasing aspect, the podium structure and its analysis were developed. The building's lifespan can be greatly increased by installing a podium. To provide a complete perspective of the equivalent static technique and under gravity load with and without podium, this study used analytical software named E-TABS. It was advantageous to do the investigation using software. The building is roughly G+18 floors tall and has a medium soil type.

Keywords: High-rise structure, Podium structure, ETABS, Base shear, Storey Drift, Storey displacement.

I. INTRODUCTION

HIGH RISE BUILDING:

The rules from 2003 that govern how buildings are constructed define a tall building as one with at least four floors on top of the ground level and is at least 510 feet (15 meters) tall. In today's world, as more and more people live in one area, there's a bigger need for really tall buildings. This is because having more people means we need to use the land we have more efficiently. So, building really tall structures becomes more important to make sure we have enough space for everyone.

PODIUM STRUCTURE:

Imagine a really tall building that has a special lower part, which we call a "podium." This podium is designed to be super strong against earthquakes. Usually, in very tall buildings, the first floor is used for things like parking or shops. This part is wider than the upper floors. Some smart people have been studying how this podium part of the building works, especially how it handles shaking from side to side during an earthquake. They've written a lot about this in documents like IS 16700:2017 and PEER/ATC 72-1. Now, we know quite a bit about buildings that are only tall, with no special lower part. But not much research has been done on what happens when a tall building is connected at the bottom to a shorter building. We're interested in how the top of the tall building moves when it's connected to the shorter one below. This study is looking at that and how it changes when the shorter building hasmorefloors

To determine the tower's appropriate placement on the podium construction, the differential displacement and the strutting motion were applied. At the interface level, centrally positioned towers and those that are offset from the podium's center are both considered. At the podium-tower interaction, the podium is subjected to horizontal forces from the tower Reactive pressures are generated at the podium-tower contact to offset the upending events. The rear span of a cantilever is equivalent to the reacting mechanism. It seems sense that the suggested backstay mechanism could produce a strong shear stress against Wall of the podium, the tower. The in-plane flexibility of the floor structure linking the two walls controls how much shear force is generated. Early papers by Bevan Pitchard used a linear analysis of the tower walls to look into this.

Fig-1.2 Podium building example

II. REVIEW OF LITERATURE

[1] Banu – et al(2019).

podiums are often used around tall buildings for various purposes. When floors twist and bend, it's a concern for certain building types. Past research shows podiums can create significant differences in restraining forces, impacting safety and forces within podium floors.These forces can be reduced if floors are strong and don't bend much. To understand factors affecting these forces and building movement, the study examines different podium sizes and flexibility, including frameworks and flat floors.To minimize these forces, podiums have thicker walls and outriggers. The study also looks at how podiums affect building behavior and movement.

[2]Mehair Yacoubian - et al(2017)

Tall buildings with a base surrounding their walls, called podiums, are popular due to their usefulness. The podium affects how the walls of the tower work in a special way, as this study explains. The main reason for certain forces on levels above and below where the podium and tower meet is that the walls of the tower don't move together properly when pushed sideways.This study looks into why some parts of the tower's walls are more prone to getting damaged by these forces. It shows that if we assume the floors of the building are really stiff and don't move much, it can reduce these forces a lot. To understand how these forces affect the tower's walls better, the researchers used a complex computer model. This helps us see what might happen if we underestimate the strength these walls need to withstand these forces.

[3]Geetha – et al(2019)

This study investigates how earthquakes affect a tall building connected to a base. Using computer models, they adjust the heights of both the building and the base. They compare two methods: one where the building's movement is measured against still conditions, and the other using a response spectrum analysis. The focus is on how the top of the building moves when sideways forces act during an earthquake. The study looks at how forces work at the point where the two buildings meet, preventing the tall one from tipping over.Interestingly, the base affects how forces are distributed in the upper walls. The way the tower sits on the base causes the walls to shift in a certain way. When the base is taller, the top of the building moves more. Additionally, the force that stabilizes the building where the tower connects to the base gets stronger as the base gets taller. This force varies depending on where the tower is placed on the base.

[4]Nandi – et al(2020)

Studying how buildings handle earthquakes using diaphragm layouts has become very important recently. Structural engineers have a big responsibility to choose the right structural systems carefully. One widely used system globally is a flexible or stiff floor plate connected by an inflatable diaphragm, which we often use in our analysis. In this research, we made models of buildings of different heights – some are sturdy, while others are more flexible. We also looked at whether the tall building is in the center or at the edge of the base. We tested the models with earthquake forces, response spectrum, and various gravitational loads. We also checked things like how much the building sways between floors and how quickly it naturally vibrates.

[5]Wensheng LU – et al(Aug 2010)

Their 2010 report summarises shaking table experiments of several scaled multitower highrise building models. The analysis of multi-tower structures is obviously incongruent with the strict floor assumption. A fresh analytical model that takes the impact of flexible transfer floors into account is proposed. The test results are contrasted with the theoretically predicted dynamic behaviour. Multi-tower high-rise buildings typically behave differently dynamically than regular high-rise buildings. First off, the floor mass distribution and lateral rigidity alter dramatically at various levels, favouring higher order vibration modes. Second, when there is an earthquake, the nearby members are readily destroyed. If cracks emerge after a higher intensity earthquake, causing the damages near the transfer floors, and each tower operates individually. Multi-tower high-rise structures drift can be considerably reduced by the flexible connections between the towers, and during a mild earthquake, they will be demolished and serve as energy dissipation members.

III. OBJECTIVES

1. To investigate the effects of the podium interference on the High rise structure.
2. To investigate how high-rise structures with podium interference respond to seismic force.
3. To investigate how high-rise buildings that include podium interference respond to gravity loads.

IV. METHODOLOGY

Building details

Podium area: 80m x 80m
Tower building: 45m x 45m
Zone 5 is been taken

4.1 Etabs

Etabs 2016 has a model of the structure.

Etabs is a unique software designed for analyzing and designing building structures. Unlike other programs, Etabs can manage all the tasks needed for structural analysis and design, making it stand out. It is contained in a very user-friendly setting and contains cutting-edge graphics and powerful algorithms. Ashraf co-authored the first structural engineering programme for the personal computer when he founded the privately held company in 1975. Since then, he has produced a number of products and their capabilities.

4.2 Advantages and Characteristics of ETABS

1) The intake, result, and mathematical answers method of ETABS is especially created to benefit from the distinctive physical and mathematical characteristics relating to building-type constructions.

2) As structural engineers employ nonlinear dynamic analysis in practise and make advantage of the more powerful computers available today to build a larger analytical model, the requirement for the special purpose programme is now more apparent than ever.

3) ETABS has completed a number of large-scale projects in recent years and has become recognized as the industry standard.

Material properties:

- Concrete's grade (M35)
- The steel grade (Fe500)
- Concrete's density (25 KN/m3)
- Brick wall density (18.869KN/m3)
- Flooring materials (1.2KN/m)
- Live load (3KN)

Members properties:

- The RC slab's thickness is 150 mm.

Column size

- C – (width 450 X depth 900)mm

Beam size

- B1 – (width 300 X depth 600)mm
- B2 – (width 300 X depth 680)mm

Storey height (3.35m)

Calculations of the load:

- Load on the outside wall = 19 x 0.23 x 3.3528 = 14.56 KN/m
- Finishing the load on the floor = 1.5KN/m^2
- Live load on slab =3KN

4.3 MODELLING IN ETABS

4.3.1MODEL 1

G+18 Residential building without podium

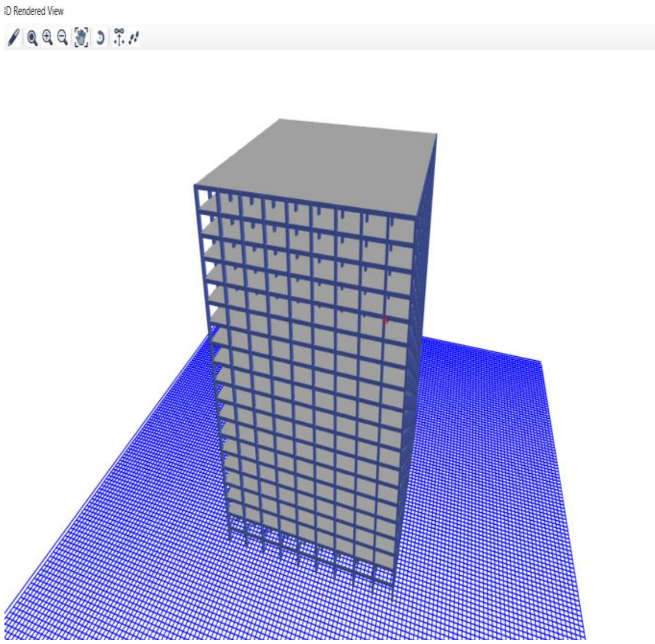

Fig 4.3.1 DIMENSIONAL VIEW OF MODEL 1

MODEL 2

4.3.2 G + 18 Residential Building with 4 podium floor center

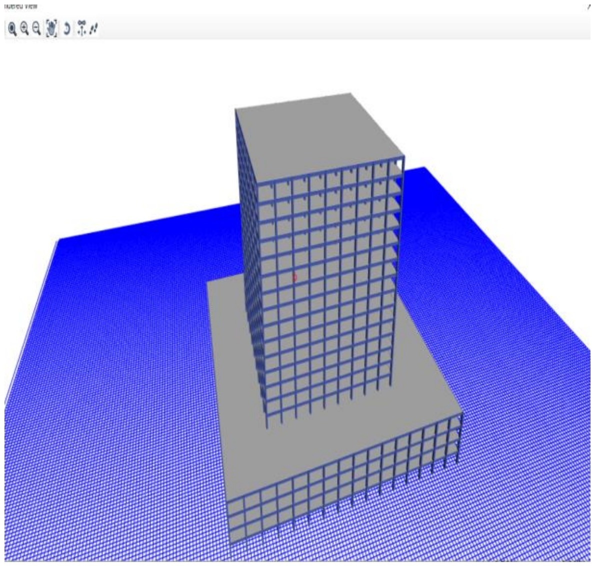

Fig 4.3.2 DIMENSIONAL VIEW OF MODEL 2

MODEL 3

4.3.3 G+18 Residential building with position change on 4 floor podium

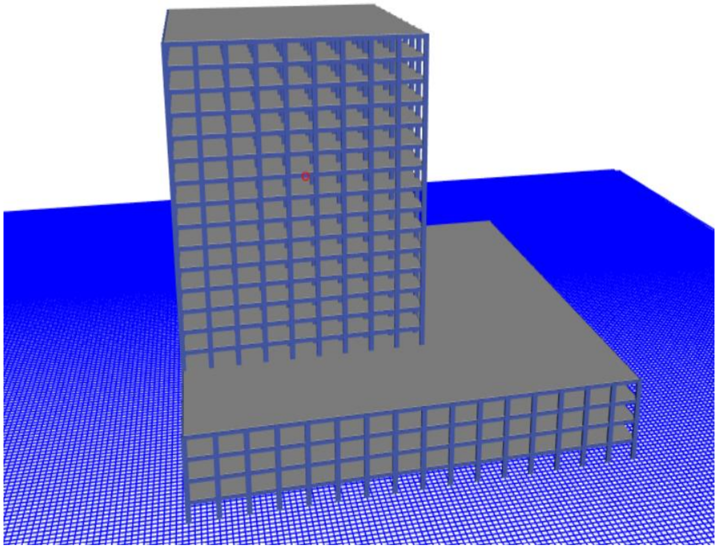

Fig 4.3.3 DIMENSIONAL VIEW OF MODEL 3

MODEL 4

4.3.4 G+18 Residential building with podium 3 floors at center

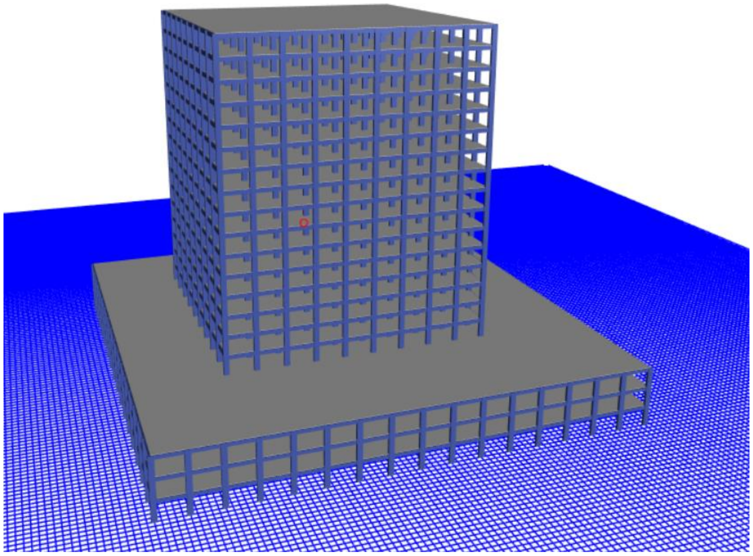

Fig 4.3.4 DIMENSIONAL VIEW OF MODEL 4

MODEL 5

4.3.5 G+18 Residential building with position change on 3 floor podium

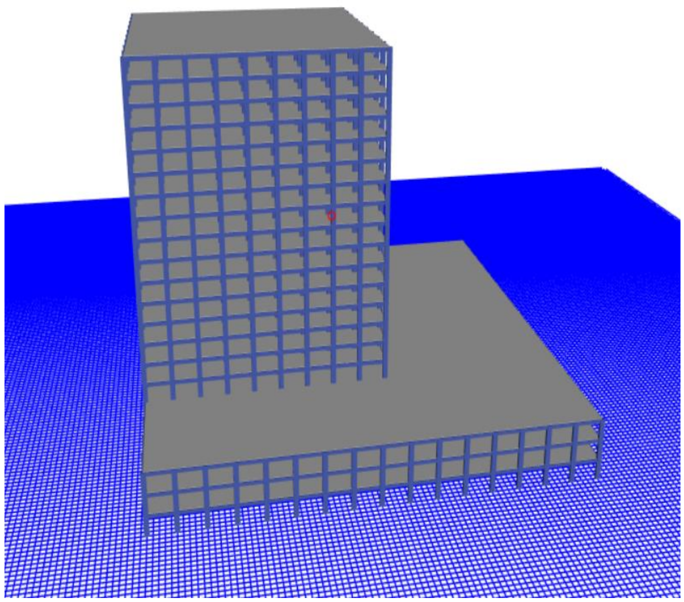

Fig 4.3.5 DIMENSIONAL VIEW OF MODEL 5

Techniques for analysis

ANALYSIS LINEAR STATIC: This is the type of analysis where the forces applied to a structure are connected in a straight-line way with the movement it makes. It's also used when the building has to handle forces that act like a simplified version of earthquake forces.

The similar static lateral force technique is a simplified way for building structures that substitutes a static force spread laterally for the dynamic loading brought on by a forecast earthquake.

The static analysis is predicated on the following assumptions:

1. Assuming that the the framework is rigid.
2. It is presumed that perfect fixed relationship between the foundation and the structure.
3. Throughout the shaking of the ground, the entire structure experiences consistent accelerations.
4. An earthquake's impact is thought to act as a horizontal force on a specific loading point

The following variables are used to compare the results of these analyses:

Base shear

It represents a projected approximation of the highest anticipated sideways force generated by seismic events acting on the foundation of the building.

Storey drift

"Storey drift" floor level's horizontal movement the floor level directly underneath it. By dividing the storey drift by the height of the corresponding story within the building, the "storey drift ratio" measures this drift.

Storey displacement

Story displacement denotes the lateral movement of a floor level concerning the building's foundation. The lateral force-resisting mechanism serves to restrict the significant sideways shifting of the structure.

V. RESULTS

5.1 LINEAR STATIC ANALYSI

5.1.1 BASE SHEAR

Table 5.1.1 BASE SHEAR

Base Shear (KN)	Model no
7572	M1
14129	M2
14723	M3
12709	M4
12728	M5

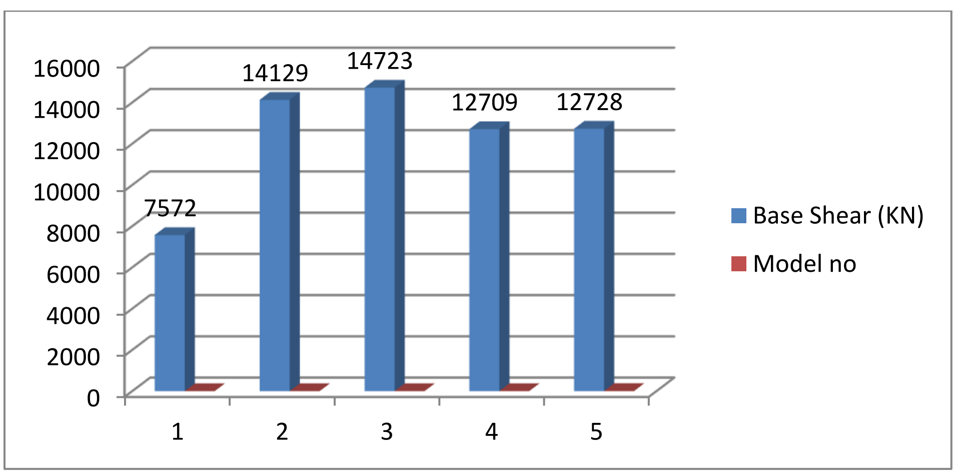

Fig.5.1.1.BASE SHEAR

Total 5 model are analysed, So model 2 (86.6%) ,model 3 (94%) ,model 4 (67.84%),model 5 (68.09%) with respect to model 1 (without podium)

Maximum base shear in model 3 is been observed and minimum base shear in model 1 respectively. Among above models . The model 3 give the best result.

5.1.2 STOREY DRIFT

Table 5.1.2 STOREY DRIFT

NO OF STORIES	**STOREY DRIFT**				
	M1	M2	M3	M4	M5
Story19	0.000187	0.000264	0.000266	0.000244	0.000244
Story18	0.000267	0.000382	0.000387	0.000351	0.000351
Story17	0.000352	0.000504	0.000513	0.000461	0.000461
Story16	0.000431	0.000615	0.000628	0.000562	0.000563
Story15	0.000501	0.000714	0.000729	0.000652	0.000652
Story14	0.000563	0.000799	0.000818	0.00073	0.00073
Story13	0.000616	0.000873	0.000893	0.000796	0.000796
Story12	0.00066	0.000934	0.000957	0.000852	0.000852
Story11	0.000697	0.000985	0.001009	0.000898	0.000898
Story10	0.000727	0.001025	0.00105	0.000935	0.000935
Story9	0.00075	0.001055	0.001081	0.000963	0.000963
Story8	0.000768	0.001075	0.001102	0.000983	0.000983
Story7	0.000779	0.00108	0.001108	0.000994	0.000994
Story6	0.000786	0.001052	0.001079	0.000993	0.000993
Story5	0.000787	0.000911	0.000937	0.000961	0.000962
Story4	0.00078	0.000533	0.000534	0.000825	0.000832
Story3	0.000756	0.000504	0.000458	0.000468	0.000472
Story2	0.000686	0.000445	0.000244	0.000404	0.000407
Story1	0.000375	0.000246	0	0.000221	0.000222

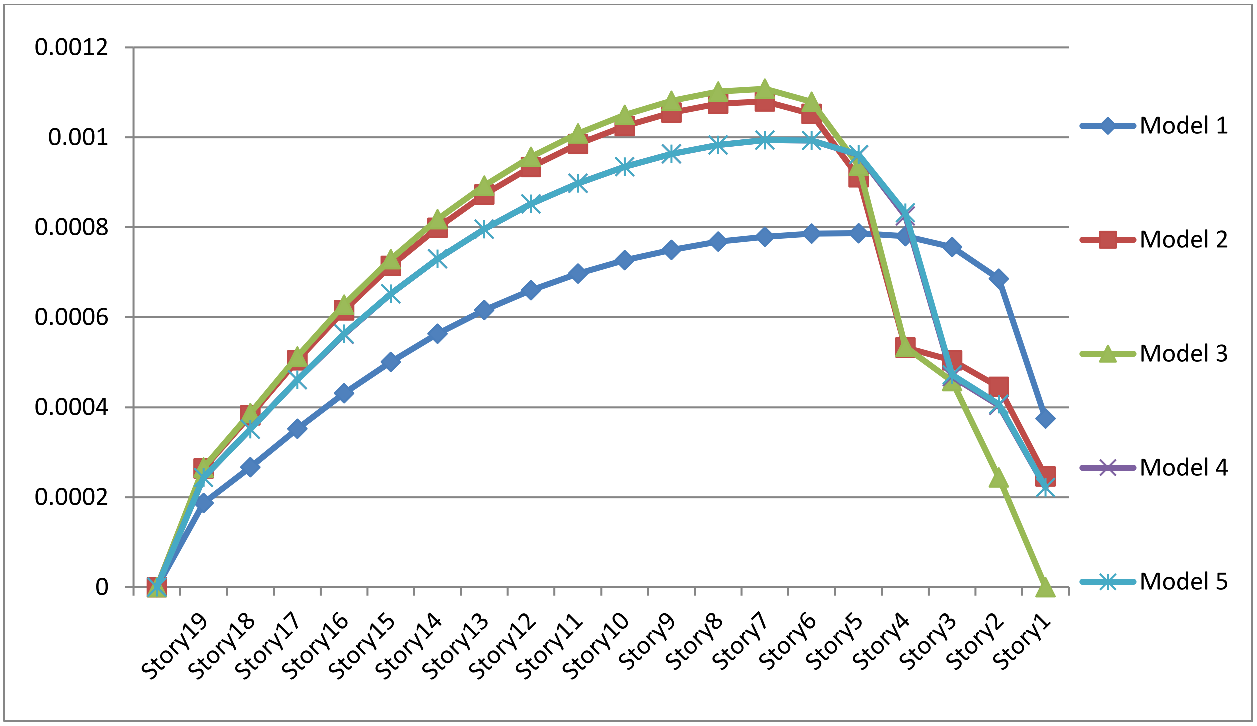

Fig.5.1.2.STOREY DRIFT

Total 5 model are analysed. So when comparing each model's average story drift with Model 1, Model 2 has an average story drift about (28.80%) higher, Model 3 has an average story drift about (34.95%) higher, Model 4 has an average story drift about (21.43%) higher, and Model 5 has an average story drift about (21.48%) higher.

Maximum story drift in model 3 is been observed and minimum story drift in model 1 respectively.

Among above 5 models, Model 1 gives the best result.

5.1.3 STOREY DISPLACEMENT

Table 5.1.3 STOREY DISPLACEMENT

NO OF STORIES	STOREY DISPLACEMENT(MM)				
	M1	M2	M3	M4	M5
Story19	38.445	46.723	46.059	44.432	44.491
Story18	37.819	45.838	45.169	43.616	43.672
Story17	36.925	44.559	43.871	42.441	42.496
Story16	35.747	42.872	42.154	40.897	40.95
Story15	34.304	40.812	40.051	39.013	39.065
Story14	32.624	38.421	37.608	36.829	36.88
Story13	30.738	35.743	34.868	34.384	34.435
Story12	28.675	32.819	31.876	31.717	31.768
Story11	26.463	29.69	28.671	28.862	28.913
Story10	24.127	26.392	25.292	25.853	25.905
Story9	21.691	22.959	21.775	22.722	22.774
Story8	19.177	19.424	18.153	19.497	19.549
Story7	16.606	15.822	14.462	16.204	16.257
Story6	13.995	12.202	10.751	12.874	12.928
Story5	11.362	8.678	7.137	9.549	9.601
Story4	8.726	5.825	4.14	6.331	6.378
Story3	6.113	4.039	2.35	3.696	3.72
Story2	3.582	2.352	0.816	2.13	2.139
Story1	1.314	0.86	0	0.775	0.777

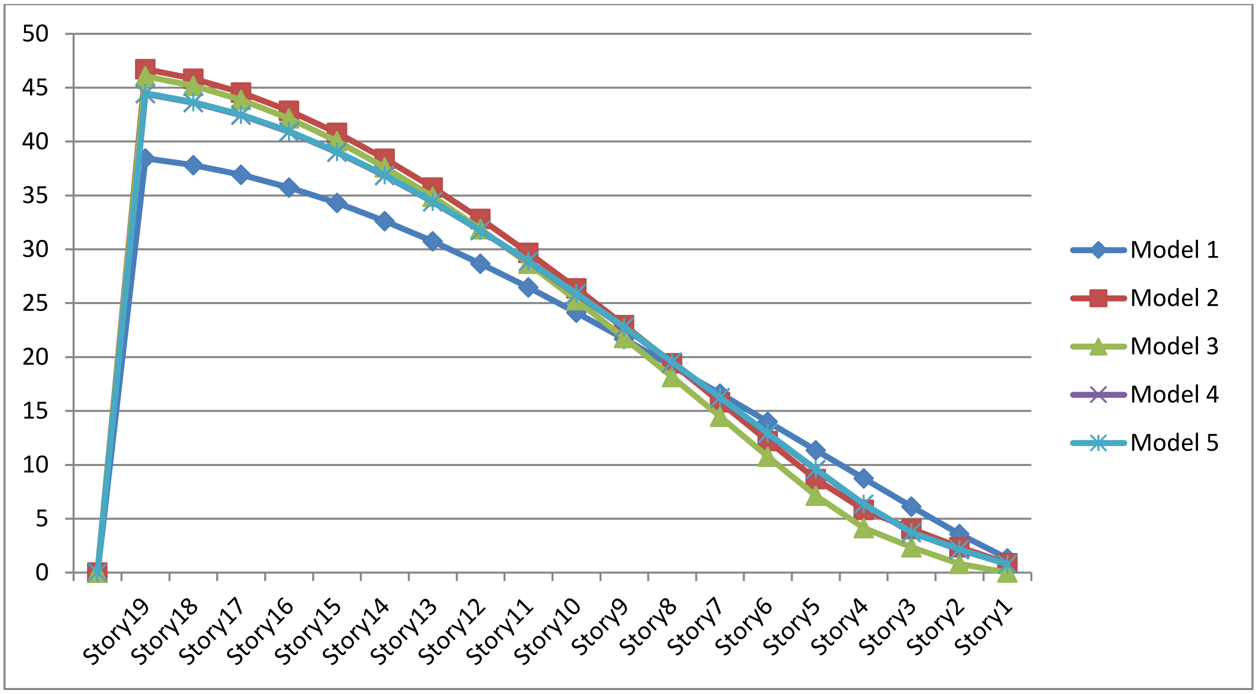

Fig.5.1.3.STOREY DISPLACEMENT

Total 5 model are analysed. So, when comparing each model's maximum displacement with Model 1, Model 2 has a maximum displacement about (21.53%) higher, Model 3 has a maximum displacement about(19.79%) higher, Model 4 has a maximum displacement about (15.59%) higher, and Model 5 has a maximum displacement about (15.77%) higher.
So, among the five models, Model 3 has the maximum story displacement of 46.059.
Among above 5 models, Model 1 gives the best result.

5.2 UNDER THE EFFECT OF GRAVITY LOAD

REACTION AND BENDING MOMENT IN X-DIRECTION OF ALL MODELS

Table 5.2.1 MODELS

MODELS	FX	MX
1	6.8515	6.2952
2	17.6842	17.3578
3	27.1794	24.2776
4	18.4662	17.8120
5	19.3829	17.8542

Total 5 models where analysed, So both "FX" and "MX" columns, the values of Models 2, 3, 4, and 5 are compared to Model 1. In the majority of instances, the figures surpass those in Model 1. with the differences ranging from approximately 1% to around 21%. This comparison gives you an idea of how the values in the other models deviate from the values in M 1 for both columns.

VI. CONCLUSIONS

1. In linear static analysis, the initial model (model 1) with no podium has a base shear of 7572 KN. Comparatively, model 2 exhibits 88.19% more base shear, model 3 shows 88.05% more, and model 4 indicates 78.79% more base shear than the baseline model.

2. The highest floor displacement in linear static analysis is noted in model 1,Model 2 has an average story drift about (28.80%) higher, Model 3 has an average story drift about (34.95%) higher, Model 4 has an average story drift about (21.43%) higher, and Model 5 has an average story drift about (21.48%) higher.

3. The greatest floor movement in linear static analysis is seen in model 1, Model 2 has a maximum displacement about (21.53%) higher, Model 3 has a maximum displacement about(19.79%) higher, Model 4 has a maximum displacement about (15.59%) higher, and Model 5 has a maximum displacement about (15.77%) higher.

4. The values generally increase from Model 1 to Model 3 and then decrease slightly in Models 4 and 5.

5. The values experience fluctuations but generally increase from Model 1 to Model 3, followed by a decrease in Models 4 and 5.

6. Overall, the "FX" and "MX" values follow a pattern of increase up to Model 3 and then show some variation in subsequent models.

6.1 FUTURE SCOPE OF STUDY

In this study, a linear static method is used to examine how a tall RCC building behaves, both with and without a podium. The findings regarding seismic factors from the entire analysis are summarized below.

1) Planning and building multi-tower structures according to precise earthquake resistant concepts and techniques is essential.

2) Elements near the top of the podium roof and the lower part of the tower should be made stronger. This might mean increasing the amount of reinforcement and making improvements to concrete walls, columns, floor slabs, and beams.

3) It's important to carefully consider the flexibility of walls, columns, and beams in the critical area.

4) The prototype buildings will have sensors and site assessments that will increase the field's knowledge and analytical methods.

5) The building's look can be altered to a greater extent by employing the podium.

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