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FAILURE CONTROL OF A SKYSCRAPER USING VARIOUS METHODS OF RETROFITTING METHODS USING ETABS AS A TOOL

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ABSTRACT:

A skyscraper is a multi-story tall building with more than 50 metres in height is referred to be a skyscraper. The amount of mass which a tower bears is mostly caused by the weight of the construction component itself. In most development designs, the covering's weight is normally far more apparent than the weight of the material it can support in excess of its appropriate proportion. In specialised words, the dead load, also known as the design load, is significantly greater than the live load. On the other hand, the effect of lateral stresses on a design is actually not predictable and grows quickly as a building's height rises. These lateral stresses will result in significant component shift and transfer. It is possible to try not to retrofit the design for these kinds of flaws. Retrofitting is the process of integrating new functions or technologies into existing systems in order to increase the stability of the building. Modifying existing buildings to increase their resistance to seismic activity, ground motion, or collapse of soil as a result of earthquakes is known as seismic retrofitting. The G+20 tower will be the centre of the current inquiry. A variety of retrofitting techniques, including shear walls, steel bracing, and friction dampers, will be tried. In Zone V, the pushover analysis and structural response analysis will both be carried out. With the use of the ETABS tool and seismic analysis performed in accordance with IS: 1893-2016, the reaction of the models may be evaluated in terms of lateral displacement, drift, story shear, and performance.

Key Words: Structural Analysis, Pushover Analysis, Skyscraper, ETABS, retrofitting methods, maximum story displacement, Story drift, Story shear, Stability.

I. INTRODUCTION

The term "skyscraper" was first applied to buildings of steel framed construction of at least 10 stories in the late 19th century, a result of public amazement at the tall buildings being built in major cities like Chicago, New York City, Tokyo, Beijing, etc…. the word "skyscraper" was first used to refer to structures with at least 10 floors and a steel frame in the late 19th century. Architectural historians subsequently improved the technical meaning of the term "skyscraper," basing it on technological advancements in the 1880s that made it possible to create towering, multi-story buildings. In contrast to load-bearing masonry buildings, which reached their practical maximum in 1891 with Chicago's Monad Nock Building, this concept was based on the steel skeleton. Skyscraper design and construction require creating livable, safe places in very tall structures. The structures must be able to hold their own weight, withstand wind as well as earthquakes, and safeguard inhabitants from fire. However, they must also be easily accessible, even on higher levels, and must provide the residents with amenities and a pleasant environment. Given the delicate balances between engineering, economics, and construction management, skyscraper design issues are among the most challenging. Skyscrapers are intricate constructions that need ongoing inspection and upkeep to maintain their structural integrity.

When there are structural defects in the horizontal load-bearing frames of a multi-story framework construction, earthquake damage often begins there. The organisation of mass, stiffness, and strength in both the horizontal and vertical axis of buildings determines how multi-storey framework constructions behave during strong seismic movements. Recent earthquakes, including the 2015 Nepal earthquake, in which multiple reinforced concrete structures were seriously damaged or toppled, have raised the idea that existing structures should be evaluated for their seismic compatibility. When there are structural defects in the horizontal load-bearing frames of a multi-story framework construction, earthquake damage often begins there. The mass distribution, stiffness, and strength in both the horizontal and vertical axis of buildings are key factors in how multi-story framework structures respond to significant seismic disturbances.

Retrofitting is the process of integrating new features or technologies into existing systems in order to increase the stability of the building. Retrofitting, to put it simply, is the process of making modifications to an existing structure in order to safeguard it against floods or other dangers like strong winds and earthquakes. Retrofitting is an improvement in construction technology, including techniques and supplies, to address the impacts of natural disasters on structures and their rising frequency and severity. Many of the homes created today were constructed at a time when little was known about the locations and frequency of floods and other dangerous occurrences or how to safeguard structures. Homes being built now may benefit from changes depending upon what we discover in the future. As a consequence, retrofitting has emerged as a crucial and essential hazard reduction method. Rehabilitating is a term that is often used to describe retrofitting particularly for seismic dangers.

Modifying existing buildings to increase their resistance to seismic activity, ground motion, or soil collapse as a result of earthquakes is known as seismic retrofitting. The necessity for seismic retrofitting is generally understood now that we have a better understanding of the seismic demand on buildings and thanks to recent experiences with big earthquakes close to metropolitan areas. Many buildings were planned without sufficient detailing as well as reinforcement for seismic protection prior to the adoption of current seismic codes in the late 1960s for industrialised nations (US, Japan, etc.) and the late 1970s for many other regions of the globe (Turkey, China, etc.). A variety of research projects were carried out in light of the pressing issue.

A. Overview of Retrofitting Methods:

- Strengthening of structural elements: Reinforcing existing columns, beams, and slabs.
- Base isolation: Installing isolators to decouple the building from ground motion.
- Damping devices: Implementing energy dissipation devices to absorb seismic forces.
- Structural bracing: Adding supplementary bracing elements to enhance lateral stability.

B. Performance Assessment Techniques:

- Non-destructive testing: Using techniques like ultrasonic testing and ground-penetrating radar to assess structural conditions.
- Structural health monitoring: Continuous monitoring of structural parameters using sensors to detect abnormalities and assess performance.

To analyse the skyscraper by retrofitting methods four models are developed as follows

Model I: RC Conventional Framed Structure

A reinforced concrete (RC) framed structure is a common type of building construction that utilizes reinforced concrete members, such as columns, beams, and slabs, to provide structural support and stability. RC framed structures are widely used due to their strength, durability, and versatility. The combination of reinforced concrete and steel reinforcement provides stability and resilience, making them suitable for a variety of building types and applications. Proper design, construction, and maintenance practices are essential for ensuring the longevity and safety of RC framed structures. The combination of steel reinforcement and concrete offers strength, durability, and flexibility, making RC framed structures widely used in residential, commercial, and industrial buildings.

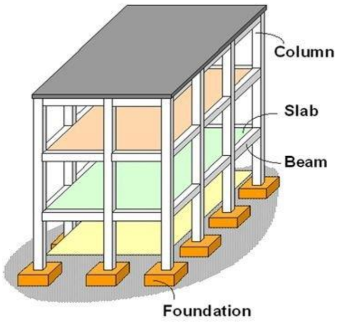


Fig.1 RC Conventional structure

Model II: Shear wall Structure

In order to transmit lateral stresses from external walls, floors, and roofs to the ground foundations in a direction parallel with its planes, a shear wall must have a rigid vertical diaphragm. Because of its great strength, stiffness, and ductility, RC shear walls are intended for usage in structures situated in seismic zones. Structural components composed of RCC are often given a significant amount of the lateral load on a structure as well as the shear force caused by load. Shear walls have a very high in-plane stiffness, which allows them to effectively regulate deflection and withstand lateral loads. If inter-storey deflections brought on by lateral loadings have to be regulated in some high-rise structures, the use of shear walls or its equivalent becomes crucial. Shear walls that have been properly constructed not only provide safety, but also offer an adequate level of defence against expensive structural and non-structural damage under seismic activity. Shear walls provide structures a great deal of stiffness and strength, which effectively lessens lateral displacement of the structure and, as a result, lessens structural damage. Shear walls will be strong and stiff enough to withstand horizontal forces provided they are correctly planned and built. In high-rise structures vulnerable to lateral wind & seismic stresses, shear walls are particularly crucial.

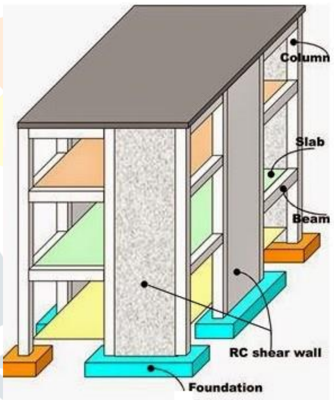


Fig.2 Shear wall structure

Model III: Steel Bracing Structure

An very effective and cost-effective way to withstand the horizontal forces in a frame construction is by using steel bracing. One of the most important retrofit techniques is bracing, which has been utilised to stabilise the bulk of the world's tallest building structures laterally. Because the diagonals operate under axial stress, bracing is effective because it only requires the smallest possible member sizes to provide rigidity as well as durability against horizontal shear. In order to increase the strength &/or ductility of existing structures, many researchers have looked at a variety of ways, including infilling walls, installing walls to already present columns, encasing columns, or adding steel bracing. By improving the lateral stiffness and capacity of the frame, a bracing system enhances the seismic performance of the structure. The bracing system allowed weight to be moved from the frame & into the braces instead of the weak columns, so boosting strength. For structures susceptible to lateral seismic or wind loads, steel braced frames provide efficient structural solutions. Therefore, it makes sense to repair reinforced concrete frames having insufficient lateral resistance using steel bracing systems.

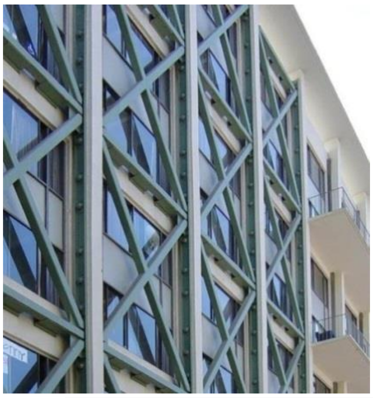


Fig.3 Steel Bracing Structure

Model IV: Friction Damper Structure

It is the most efficient, dependable, and cost-effective way to release energy. Here, the friction caused by the rubbing of surfaces against one another consumes the seismic energy. Friction has a much higher energy dissipation rate than any other approach (Viscous damper / yielding damper). The performance of a frictional damper is relatively little impacted by changes in temperature, velocity, etc. It has been transformed into among the most popular types of dampers due to its straightforward behaviour and straightforward installation. Rotational friction dampers are an example of friction dampers and are shown in Figure [4]. It may be used when seismic strengthening is being done on existing structures. It is inexpensive and needs minimal upkeep. Several steel plates move in opposing directions against one other to form the friction damper mechanism. Shims made of materials for friction pads are used to separate the steel plates. The friction between the layers that are rubbing against one other is how the damper releases energy. Surfaces made of materials aside from steel are also an option.

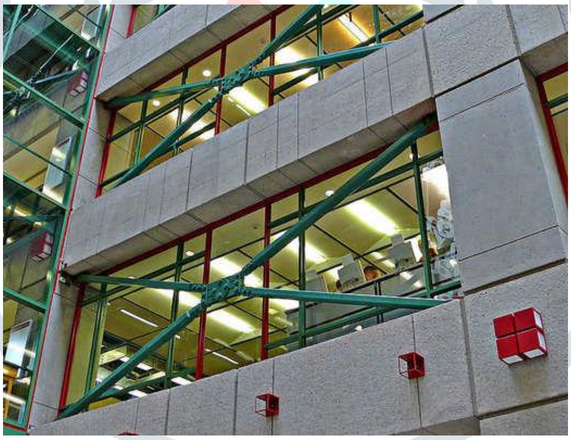


Fig.4 Friction Damper structure

II. LITERATURE REVIEW

Rosinblueth and Holtz et al., In their study of totally uniform structures, proposed a solution to a differential equation & provided tables that are helpful for symmetric structures. The method requires the first approximation, which improves in subsequent iterations, to describe the shear wall with the entire load if it's significantly stronger than the rest of the structure; otherwise, the starting distribution for horizontal shear between walls and frames could vary significantly.[1]

Mo and Jost (1993), among others According to the findings of this research, the maximum deflection for the El Centro record decreased by 30% as a consequence of the influence of concrete strength over the framed shear walls, which was caused by raising concrete strength between 25 MPa to 35.0 MPa. It aids in increasing the maximum shear force by 56% for ten-storey shear walls as well as the maximum deflection by 27% & the maximum shear force by 30% for five-storey shear walls. Steel yield stress from 413 MPa to 482 MPa has very little impact. Shear reinforcing thus proved inadequate to prevent a premature shear failure at the crucial portion.[2]

Ashok K. Jain and Satish Annigiri (1994) et al., They conducted study on the distribution of storey and floor eccentricity for various lateral load distribution along the building's height. The dynamic techniques defined as per IS: 1893 (1984) & UBC (1991) standards are assessed together with the static methods as per code for torsional analysis. Due to inadvertent eccentricity, the primary thrust. Both a two story, framed-shear wall building and a six story structure with setbacks were taken into consideration. It is appropriate to do a 3-D dynamic study of an asymmetric construction that takes into account the impact of unintentional eccentricity. In order to describe how to calculate design eccentricity & account for unintentional twisting, both in static and dynamic analysis, it is necessary to upgrade the torsional provision in IS: 1893 explanatorily.[3]

III. METHODOLOGY

Technique for study purpose various soil circumstances whichever is provided in IS456 in use in ETABS program. According to IS456 the Light, Medium, Rigid Strata with Variable base supports Based on movement and weight relation optimum construction were determined.

Modelling of Structural Systems

Basic to ETABS planning is the assumption that multi-story structures usually comprise of the same or comparable floor layouts that recur in the vertical position. Planning characteristics that simplify analytical-model creation, and mimic sophisticated earthquake systems, are enumerated as follows:

- Customized section shape and intrinsic behaviour
- Grouping of frames as well as shell elements
- Link assignment for simulating isolators, dampers, and some other complex earthquake systems
- Nonlinear hinge specification
- Editing and task tools for plan, perspective, and 3D views

3.1. RESPONSE SPECTRUM ANALYSIS

In accordance with IS-1893:2002, the total sum of the modal masses of every one of the modes taken into consideration for the analysis should be at least 90% of the overall seismic mass. For structures without any horizontal plan irregularities, ASCE 7-05, a Guide to the Planning of Diaphragms, allows diaphragms of concrete slabs or concrete stuffed metal decks with a span-to-depth ratio of 3:1 to be idealised as rigid; alternatively, the structural analysis shall expressly represent believed of the stiffness of the diaphragm without elaborating. Nasser et al. (1993), Mansur et al. (1999), and Abdalla and Kennedy (1988) provided information on how a gap within rectangular RC or prestressed beams impacts stress distributions and a concrete beam's capacity in the field of concrete beams having net openings. Sadly, there was little evidence that the theory was developed to include other configurations; it was just marked against readily available experimental findings.

3.2.PUSHOVER ANALYSIS:

Buildings experience significant inelastic deformation during strong earthquakes, and these dynamics change over time. As a result, inelastic science techniques that portray these dynamics are required to analyse the construction of a building. By locating letdown modes and the potential for dynamic breakdown, inelastic analytical tools seize the knowledge of structures. As opposed to pushover analysis, inelastic analysis methodologies effectively integrate inelastic analysis of time history with inelastic data seen.

The most accurate way to forecast the displacement and force requirements for different building components is to conduct an elastic-plastic time history research. In any case, since dynamic response is very sensitive to displaying and ground movement features, the use of inelastic time history analysis is currently restricted. It also requires access to a variety of deputy seismic ground recordings that monitor for disturbances and variations in their intensity, regularity, and durational properties.

Additionally, the use of inelastic time history analysis makes evaluating earthquake performance impractical due to calculation time, time required for information organisation, and decoding massive output. Due to its simplicity, inelastic static analysis, along with pushover analysis, is the favoured method for evaluating earthquake performance. Since it is typically simple and includes post flexible conduct, nonlinear static analysis, also known as pushover analysis, has been developed recently and has become the most common method of analysis for config and also earthquake implementation evaluation purposes. In any case, the approach includes certain estimations and improvements that a specific measure of variance is continually predicted to show up in pushover analysis seismic interest prediction.

In a sense, the modelling strategy for predicting earthquake requests should be investigated for low, intermediate, and high rise constructions by differentiating some concerns, for example, demonstrating non-linear part behaviour, algorithmic fully intend of the method, forms in the prognostications of various horizontal responsibility designs utilised during usual pushover analysis, and aptitude of conserved parallel stress designs in talking about wave propagation impacts

3.3.OBJECTIVES OF STUDY

A thorough literature study is carried outside to describe the goals of the thesis. The literature survey is reviewed and quickly outlined as follows:

1. To decide the capacity of different structure compared to conventional reinforced concrete structure as a parallel load opposing individuals.
2. Dynamic investigation of the tall framed structures considering response spectrum examination.
3. Utilization of Advanced diagnostic applications of software like Staad.Pro, Etabs for story response plot examination of horizontal load opposing structure and the inter story displacements.
4. To decide the capacity and dynamic investigation in the terms of maximum story displacement and story drift of the tall framed structure subjecting to IS load combinations.
5. To set up a reference study for the usage of retrofitting methods in the framed structures according code standards.

IV. BUILDING MODELLING AND ANALYSIS

For a analysis in ETABS firstly select the material property in define then add the required material which we use in design of g+20 structure.

By choosing define menu material properties in this case, we had first specified the material property. By providing the necessary information in the defining tab, we introduced additional material to make our structural elements (beams, columns, slabs, shear walls, steel bracing, and friction dampers). Then, by choosing the frame sections shown below, we defined section size and added the necessary sections for beams, columns, etc.

Building type	G + 20
Plan dimensions	25 x 25 m
No. of bay in X direction	5 Bays
No. of bay in Y direction	5 Bays
Typical storey height	3.3 m
Bottom storey height	3.0 m
Building height	72.3 m
Soil type	Type II (Medium Soils) Combined or Isolated RCC footings with the beams
Design criteria	(As Height of building is greater than 40m up to 90m type) Analysis for Zone V. Modal analysis using Response spectrum method and for performance Time history or Push-over analysis is to be performed for the maximum deformed zone.
Zone considering	V
Importance Factor, I	1
Response Reduction Factor, R	5 (SMRF) RC Building with Special Moment Resisting Frame
Performance factor, K	1.0 (Moment resistant frame with appropriate ductility details as given in IS: 437.6-1976* in reinforced concrete or steel)
Support condition of columns	Fixed

Table 1: Geometrical properties & location factors

Column size	450 x 600 mm
Beam size	300 x 450 mm
Thickness of slab	150 mm
Grade of concrete	M-40
Grade of steel	Fe-550
Steel X Bracing	ISMB 300
Shear wall thickness	230 mm

Table 2: Section & material properties

Wall load on external beams	13.11 kN/m
Wall load on internal beams	8.55 kN/m
Floor finish load	1.5 kN/m^2
Live load on floor	2 kN/m^2
Terrace finish load	1.5 kN/m^2
Dead load factor	1
Live load factor	0.25 (i.e., 25%)
Load combination considering live load	$1.2[DL + IL \pm (EL_X \pm 0.3\ EL_Y)]$ and $1.2[DL + IL \pm (EL_Y \pm 0.3\ EL_X)]$ and
Load combination without considering live load	$1.5[DL \pm (EL_X \pm 0.3\ EL_Y)]$ and $1.5[DL \pm (EL_Y \pm 0.3\ EL_X)]$ and

Table 3: Loading details

Mass in Kg	2200
Weight in kN	0.225
Effective stiffness in kN/m	20000
Effective damping in kN-s/m	4000
Link Type	Damper Exponential
Direction	U1
Non-Linearity	No

Table 4: Properties of Friction Damper

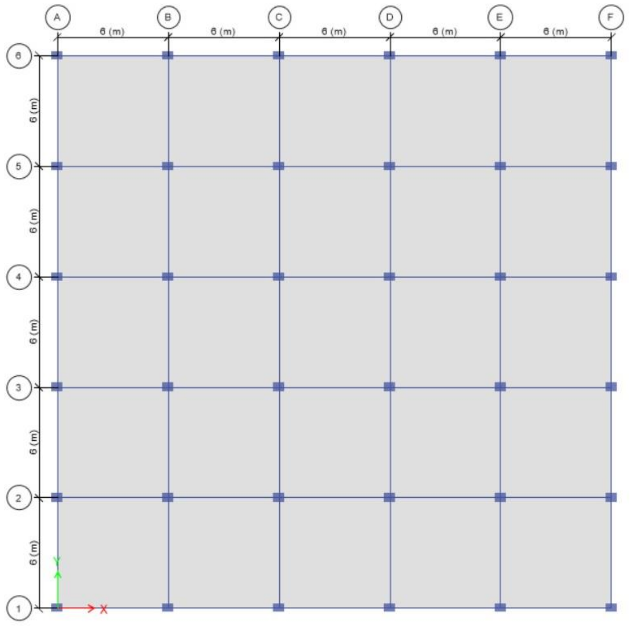


Fig 5. Plan Layout of structure

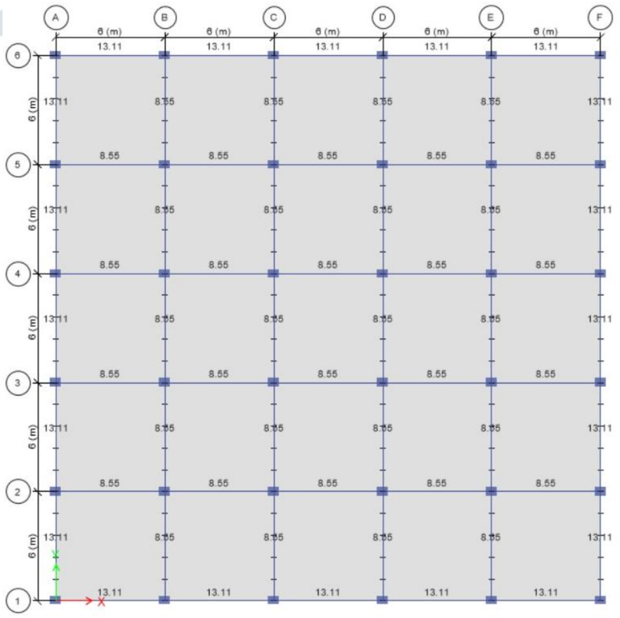


Fig 6. Dead Load on Beams

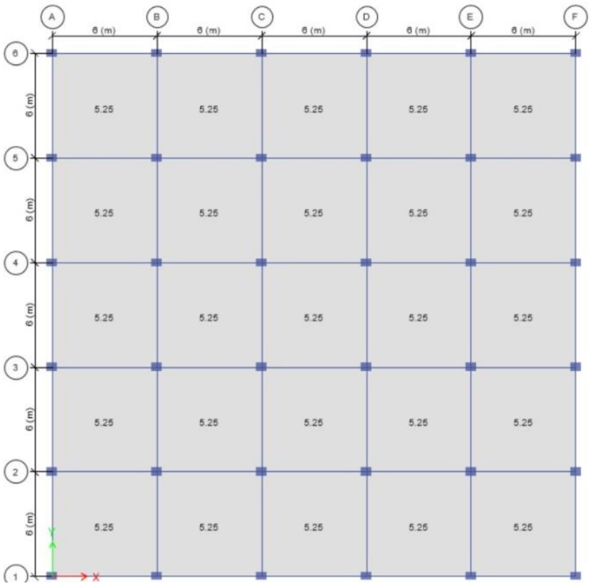


Fig 7. Dead Load on Slab

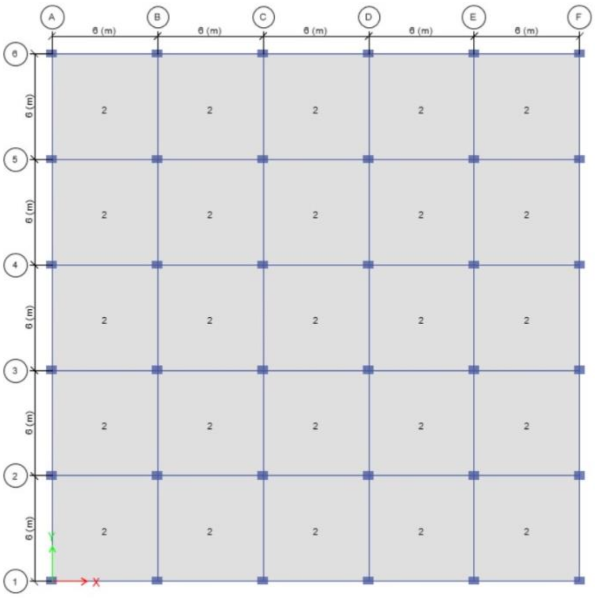


Fig 8. Live load on slab

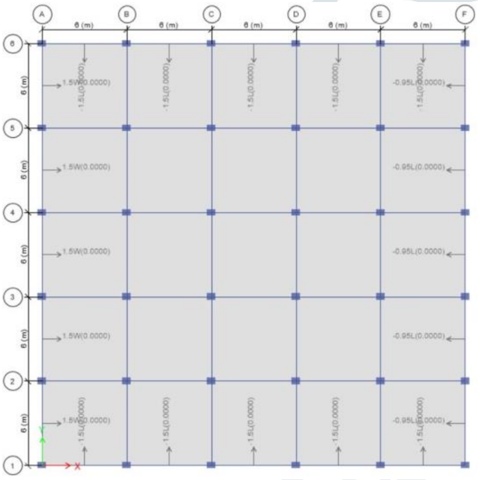


Fig 9. Wind pressure co-efficients of structure

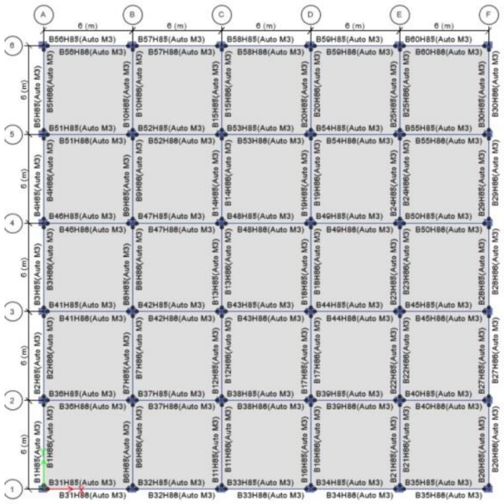


Fig 10. Hinge Properties

The output and display formats for moment, shear, axial force diagrams as well as deformed shapes are available after assigning all properties to beams, columns, slab shear walls, bracings, and applying loads. These may be arranged into customizable reports and intricate section cuts illustrating different local response measures.

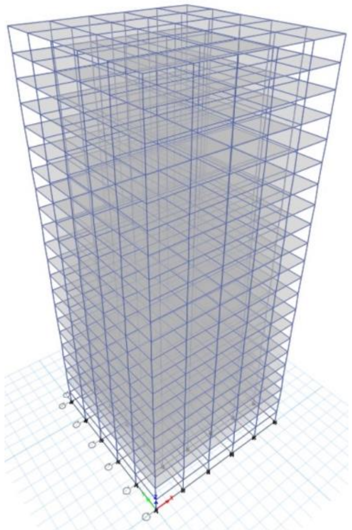


Fig 11. 3D view of Model I

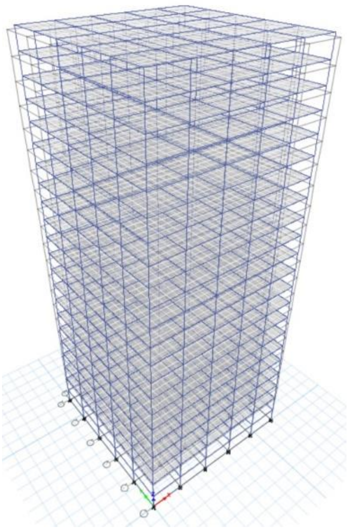


Fig 12. Deformed shape of Model I

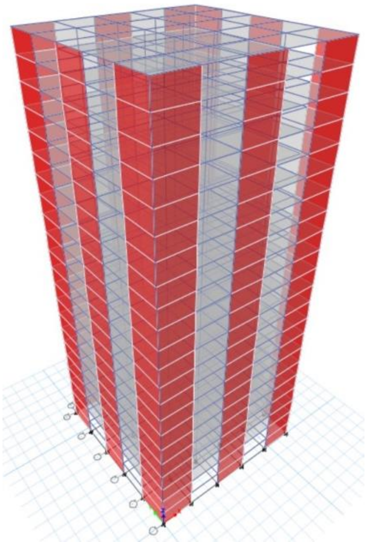


Fig 13. 3D View of Model II

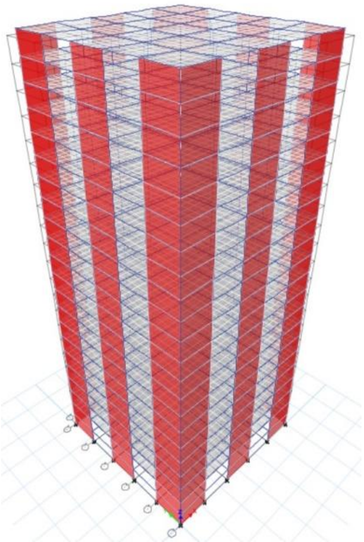


Fig 14. Deformation of Model II

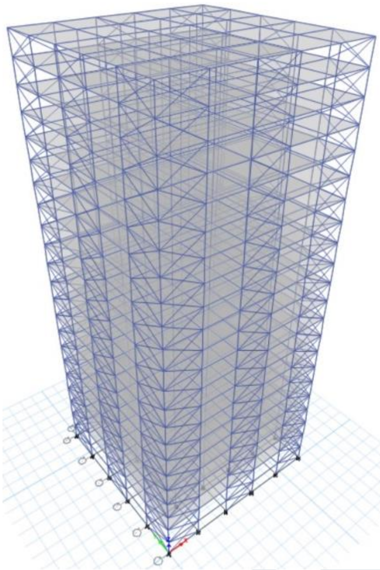


Fig 15. 3D View of Model III

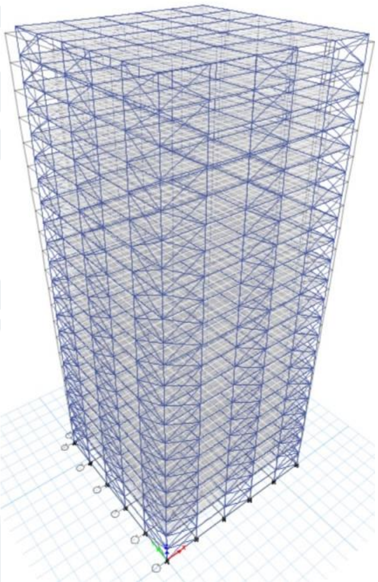


Fig 16. Deformation of Model III

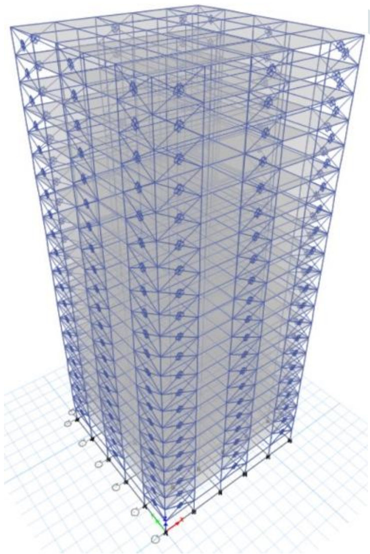


Fig 17. 3D View of Model IV

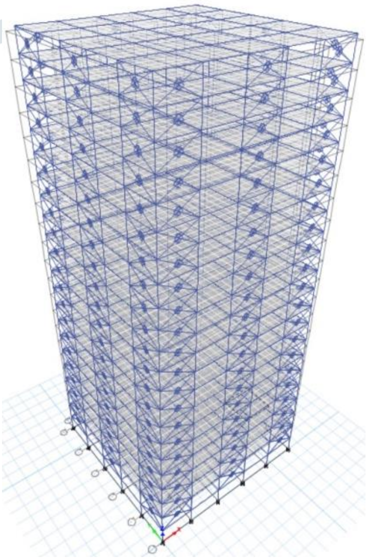


Fig 18. Deformation of Model IV

Here the deformation which caused due to performing response spectrum analysis for the RC conventional structure, in the same manner we got the results of different structure subjected to seismic effects and performing the response spectrum analysis are presented below in results and discussions.

V. RESULTS AND DISSCUSIONS

The chosen building model are reviewed through pushover analysis. In order to specify gravity and imposed types of loads for the earthquake region V, pushover analysis was first undertaken utilizing response spectrum analysis. The finest seismographic effect on the RC framed structure, a lateral non-linear pushover analysis was then accomplished using displacement control. The following are the terms in which the response spectrum results are presented in form of story response plots.

Maximum story Displacement: The tale's lateral displacement with respect to the base is referred to as story displacement. The excessive lateral movement of the building may be controlled by the lateral force-resisting system. The acceptable lateral displacement limit in the event of a wind load is H/500 (but some people may use H/400).

Maximum story Drift: Story drift is calculated by dividing the distance between two adjacent stories by the height of each story.

Maximum story Shear: The total of the lateral pressures exerted at each level of the structure is the maximum story shear. As floor forces are added from the top to the bottom of the building to determine cumulative story shears, they should increase as you descend.

5.1.1 MAXIMUM STORY DISPLACEMENT - (Response Spectrum) ZONE V

STORY	MODEL I (mm)	MODEL II (mm)	MODEL III (mm)	MODEL IV (mm)
Story 20	116.592	48.609	63.524	79.699
Story 19	115.395	46.064	61.449	78.576
Story 18	113.675	43.494	59.153	77.098
Story 17	111.409	40.905	56.71	75.27
Story 16	108.619	38.296	54.13	73.11
Story 15	105.33	35.673	51.422	70.632
Story 14	101.566	33.039	48.598	67.855
Story 13	97.348	30.402	45.667	64.798
Story 12	92.701	27.767	42.636	61.479
Story 11	87.651	25.142	39.517	57.918
Story 10	82.221	22.534	36.322	54.134
Story 9	76.433	19.953	33.064	50.143
Story 8	70.308	17.408	29.762	45.965
Story 7	63.868	14.916	26.434	41.619
Story 6	57.136	12.494	23.098	37.125
Story 5	50.142	10.167	19.776	32.499
Story 4	42.908	7.964	16.489	27.751
Story 3	35.449	5.923	13.264	22.884
Story 2	27.778	4.087	10.129	17.904
Story 1	19.92	2.508	7.124	12.836
Ground Floor	11.944	1.248	4.295	7.83
Plinth Level	4.124	0.407	1.753	3.868
Column Base	0	0	0	0

Table 5. Maximum Story Displacement of Structure

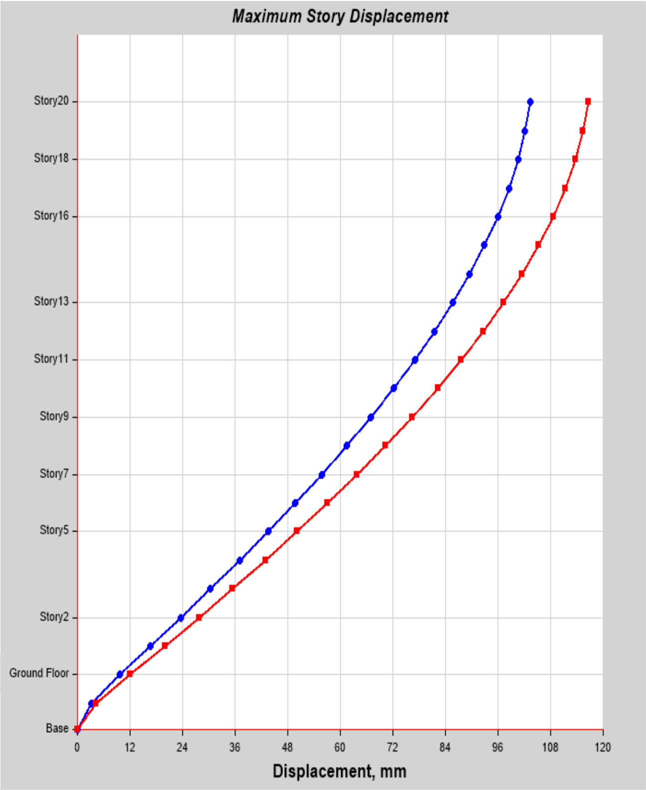


Fig 19. Maximum Story Displacement of Model I

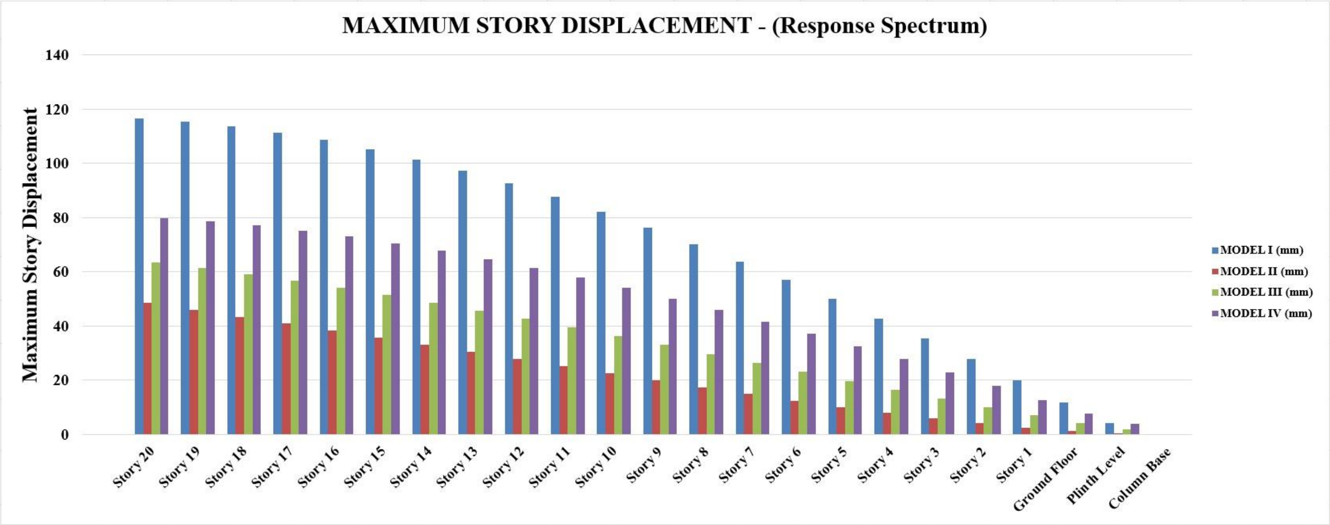


Fig 20. Comparison graph of Maximum Story Displacement

5.1.2 MAXIMUM STORY DRIFT- (Response Spectrum) ZONE V

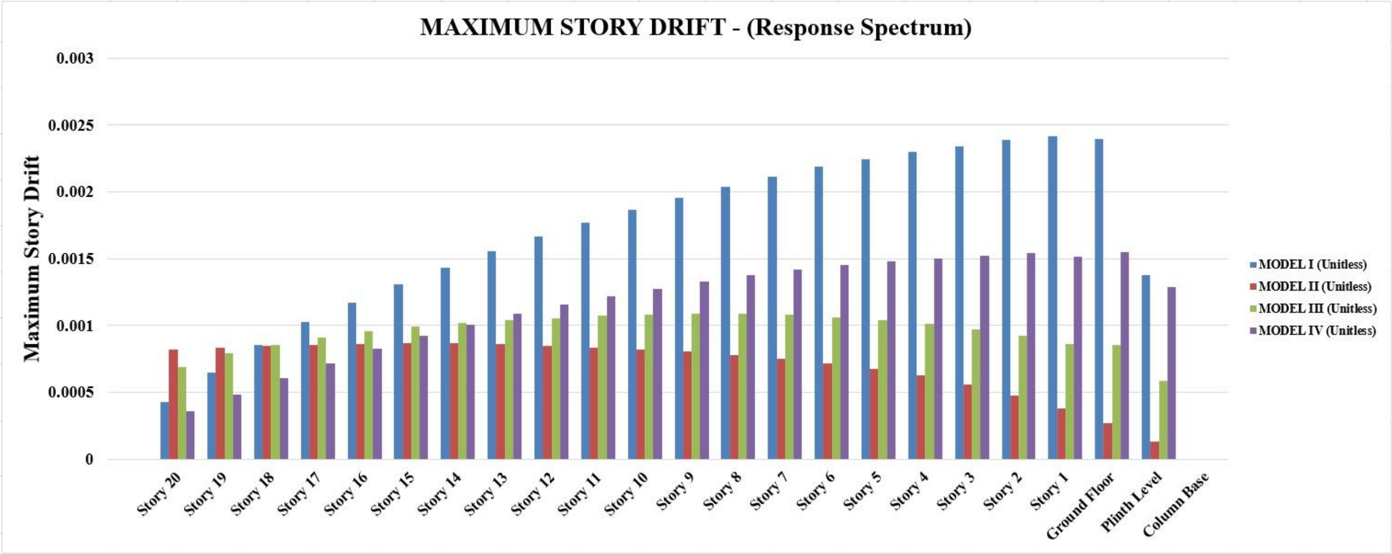


Fig 21. Comparison graph of Maximum Story Drift

STORY	MODEL I (Unitless)	MODEL II (Unitless)	MODEL III (Unitless)	MODEL IV (Unitless)
Story 20	0.000431	0.000819	0.000693	0.000361
Story 19	0.000646	0.000834	0.000791	0.000487
Story 18	0.000852	0.000847	0.000858	0.000608
Story 17	0.001027	0.000857	0.000913	0.000721
Story 16	0.001175	0.000864	0.000957	0.000825
Story 15	0.001308	0.000867	0.000991	0.000921
Story 14	0.001435	0.000866	0.001018	0.001008
Story 13	0.001557	0.00086	0.00104	0.001086
Story 12	0.00167	0.000851	0.001058	0.001156
Story 11	0.001773	0.000838	0.001073	0.001219
Story 10	0.001867	0.000823	0.001083	0.001276
Story 9	0.001954	0.000804	0.001089	0.00133
Story 8	0.002038	0.000781	0.001087	0.001379
Story 7	0.002117	0.000753	0.00108	0.001421
Story 6	0.002187	0.000719	0.001065	0.001454
Story 5	0.002246	0.000677	0.001042	0.001481
Story 4	0.002297	0.000625	0.001011	0.001503
Story 3	0.002344	0.00056	0.000972	0.001524
Story 2	0.002389	0.00048	0.000922	0.001542
Story 1	0.002419	0.000383	0.000862	0.001519
Ground Floor	0.002398	0.000272	0.000852	0.001552
Plinth Level	0.001375	0.000136	0.000584	0.001289
Column Base	0	0	0	0

Table 6. Maximum Story Drift of Structure

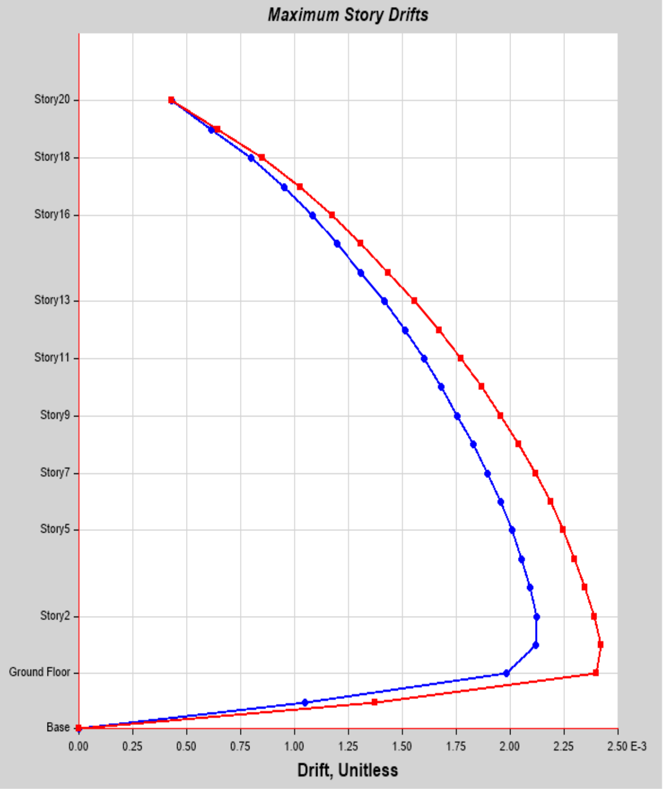


Fig 22. Maximum Story Drift of Model I

5.1.3 MAXIMUM STORY SHEAR- (Response Spectrum) ZONE V

STORY	MODEL I (kN)	MODEL II (kN)	MODEL III (kN)	MODEL IV (kN)
Story 20	376.2325	1128.893	631.9962	263.0187
Story 19	717.4311	2051.5817	1167.7751	517.0819
Story 18	997.0528	2697.4188	1566.0478	749.9965
Story 17	1215.9602	3107.679	1833.1491	961.6211
Story 16	1392.8622	3342.136	2000.746	1154.8784
Story 15	1553.1523	3463.4268	2114.143	1332.3407
Story 14	1713.0155	3521.304	2213.516	1494.2392
Story 13	1872.1668	3547.8727	2319.0372	1639.6959
Story 12	2021.0634	3566.7324	2431.2479	1769.8046
Story 11	2153.6111	3605.6347	2543.6942	1889.2768
Story 10	2273.3519	3697.7978	2653.5828	2004.4266
Story 9	2389.2404	3868.255	2762.3153	2118.6594
Story 8	2506.2733	4119.5076	2870.1402	2229.6135
Story 7	2620.5371	4433.3906	2974.1942	2331.28
Story 6	2723.6472	4786.3893	3073.843	2419.9597
Story 5	2811.9221	5161.2063	3177.7902	2499.1909
Story 4	2891.1696	5544.9581	3303.3259	2578.9212
Story 3	2971.9157	5919.2321	3463.7378	2668.0536
Story 2	3058.3245	6254.1649	3652.3585	2765.3147
Story 1	3140.7853	6514.2695	3838.3489	2856.3929
Ground Floor	3200.0584	6673.8675	3978.5784	2921.3643
Plinth Level	3208.32	6699.0801	4000.3803	2931.3343
Column Base	0	0	0	0

Table 7. Maximum Story Shear of Structure

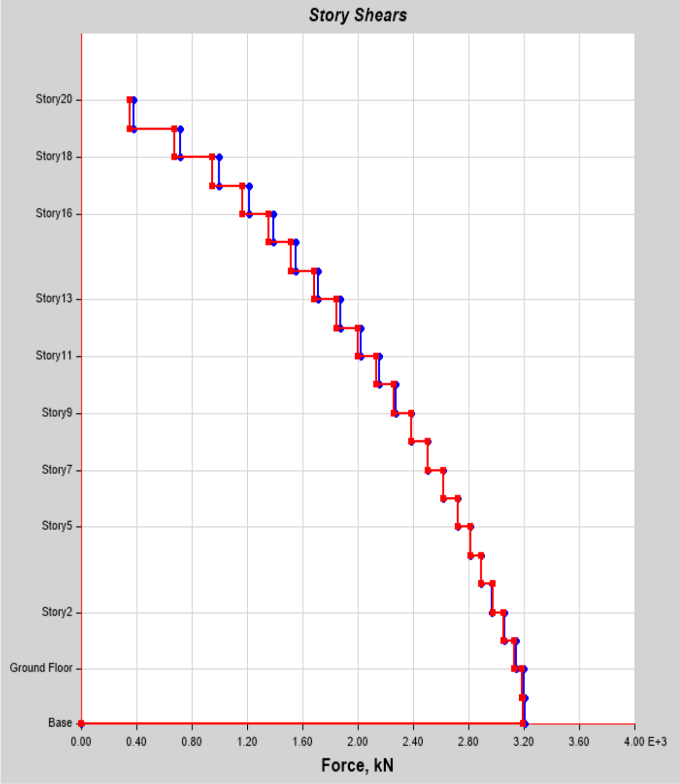


Fig 23. Maximum Story Shear of Model I

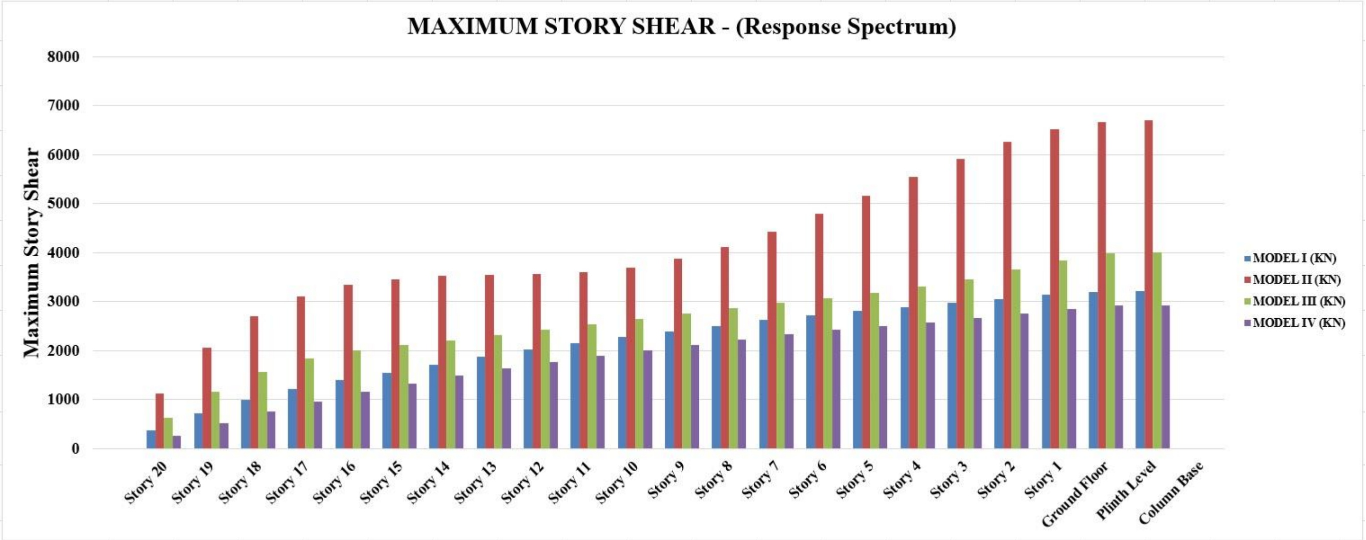


Fig 24. Comparison graph of Maximum Story Shear

From the above results it can be noted that shear wall structure have the greater impact in the retrofitting techniques when compared to all the structures and next steel bracing structure have the impact on retrofitting techniques after the shear wall structure and then the friction damper structure have the better results than the conventional RC framed structure.

Now performing the Non-linear static Pushover analysis in the displacement control manner we got the results in terms of target displacement and performance point and base shear.

These define as follows:

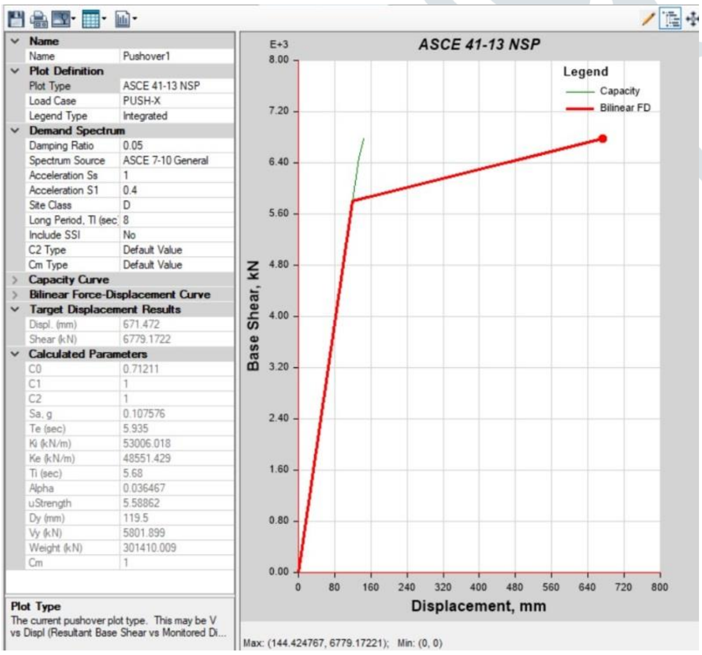
a) **Target displacement:** Target displacement is the maximum drift that a structure may experience under seismic stresses without completely collapsing.

b) **Performance point:** For a certain damping ratio, the Performance Point—which denotes the condition of the structure's maximum inelastic capacity—can be discovered by finding the intersection of the Capacity Spectrum and Demand Spectrum.

c) **Base shear:** Base shear is a measure of the greatest predicted lateral force that seismic activity will exert at the base of the structure.

5.2 RESULTS FROM PUSHOVER ANALYSIS - ZONE-V

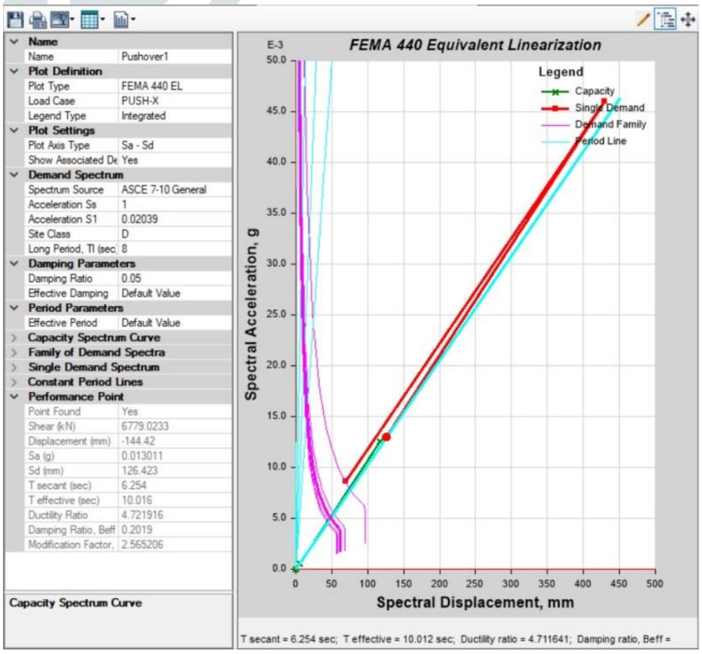
5.2.1. MODEL I: (CONVENTIONAL RC STRUCTURE)



Name	
Name	Pushover1
Plot Definition	
Plot Type	ASCE 41-13 NSP
Load Case	PUSH-X
Legend Type	Integrated
Demand Spectrum	
Damping Ratio	0.05
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.4
Site Class	D
Long Period, Tl (sec	8
Include SSI	No
C2 Type	Default Value
Cm Type	Default Value
Capacity Curve	
Bilinear Force-Displacement Curve	
Target Displacement Results	
Displ. (mm)	671.472
Shear (kN)	6779.1722
Calculated Parameters	
C0	0.71211
C1	1
C2	1
Sa, g	0.107576
Te (sec)	5.935
Ki (kN/m)	53006.018
Ke (kN/m)	48551.429
Ti (sec)	5.68
Alpha	0.036467
uStrength	5.58862
Dy (mm)	119.5
Vy (kN)	5801.899
Weight (kN)	301410.009
Cm	1

Plot Type
The current pushover plot type. This may be V vs Displ (Resultant Base Shear vs Monitored Di...

Max: (144.424767, 6779.17221); Min: (0, 0)



Name	
Name	Pushover1
Plot Definition	
Plot Type	FEMA 440 EL
Load Case	PUSH-X
Legend Type	Integrated
Plot Settings	
Plot Axis Type	Sa - Sd
Show Associated De	Yes
Demand Spectrum	
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.02039
Site Class	D
Long Period, Tl (sec	8
Damping Parameters	
Damping Ratio	0.05
Effective Damping	Default Value
Period Parameters	
Effective Period	Default Value
Capacity Spectrum Curve	
Family of Demand Spectra	
Single Demand Spectrum	
Constant Period Lines	
Performance Point	
Point Found	Yes
Shear (kN)	6779.0233
Displacement (mm)	-144.42
Sa (g)	0.013011
Sd (mm)	126.423
T secant (sec)	6.254
T effective (sec)	10.016
Ductility Ratio	4.721916
Damping Ratio, Beff	0.2019
Modification Factor,	2.565206

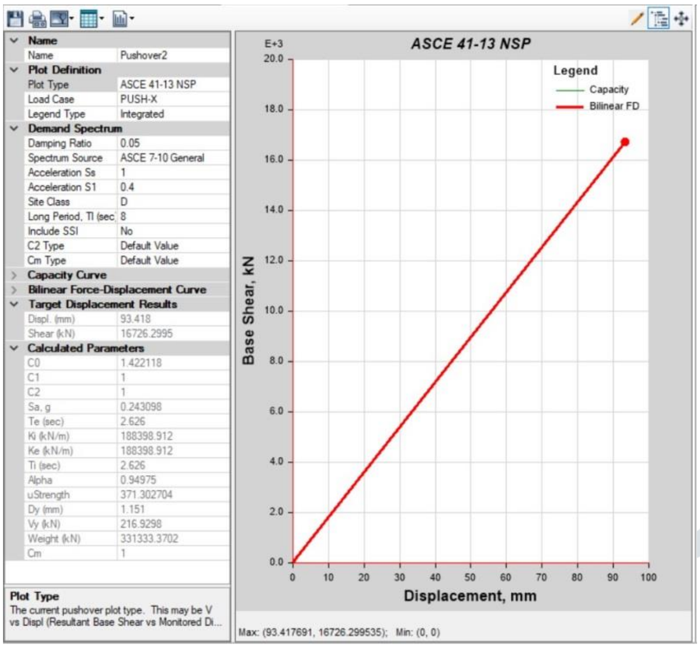
Capacity Spectrum Curve

T secant = 6.254 sec; T effective = 10.012 sec; Ductility ratio = 4.711641; Damping ratio, Beff =

Fig 25. Target Displacement Point Results from ASCE 41-13 NSP

Fig 26. Performance Point Results from FEMA 440 EL

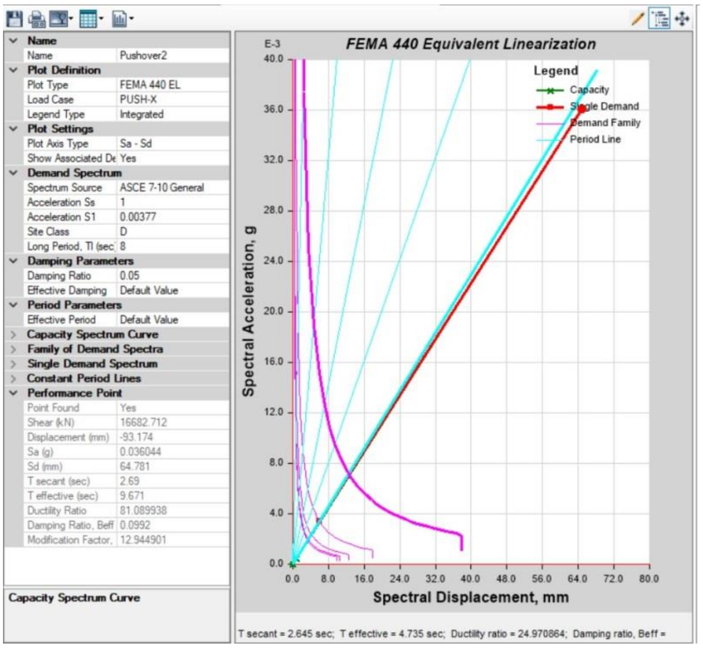
5.2.2. MODEL II: (SHEAR WALL STRUCTURE)



Name	
Name	Pushover2
Plot Definition	
Plot Type	ASCE 41-13 NSP
Load Case	PUSH-X
Legend Type	Integrated
Demand Spectrum	
Damping Ratio	0.05
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.4
Site Class	D
Long Period, Tl (sec	8
Include SSI	No
C2 Type	Default Value
Cm Type	Default Value
Capacity Curve	
Bilinear Force-Displacement Curve	
Target Displacement Results	
Displ. (mm)	93.418
Shear (kN)	16726.2995
Calculated Parameters	
C0	1.422118
C1	1
C2	1
Sa, g	0.243098
Te (sec)	2.626
Ki (kN/m)	188398.912
Ke (kN/m)	188398.912
Ti (sec)	2.626
Alpha	0.94975
uStrength	371.302704
Dy (mm)	1.151
Vy (kN)	216.9298
Weight (kN)	331333.3702
Cm	1

Plot Type
The current pushover plot type. This may be V vs Displ (Resultant Base Shear vs Monitored Di...

Max: (93.417691, 16726.299535); Min: (0, 0)



Name	
Name	Pushover2
Plot Definition	
Plot Type	FEMA 440 EL
Load Case	PUSH-X
Legend Type	Integrated
Plot Settings	
Plot Axis Type	Sa - Sd
Show Associated De	Yes
Demand Spectrum	
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.00377
Site Class	D
Long Period, Tl (sec	8
Damping Parameters	
Damping Ratio	0.05
Effective Damping	Default Value
Period Parameters	
Effective Period	Default Value
Capacity Spectrum Curve	
Family of Demand Spectra	
Single Demand Spectrum	
Constant Period Lines	
Performance Point	
Point Found	Yes
Shear (kN)	16682.712
Displacement (mm)	-93.174
Sa (g)	0.036044
Sd (mm)	64.781
T secant (sec)	2.69
T effective (sec)	9.671
Ductility Ratio	81.089938
Damping Ratio, Beff	0.0992
Modification Factor,	12.944901

Capacity Spectrum Curve

T secant = 2.645 sec; T effective = 4.735 sec; Ductility ratio = 24.970864; Damping ratio, Beff =

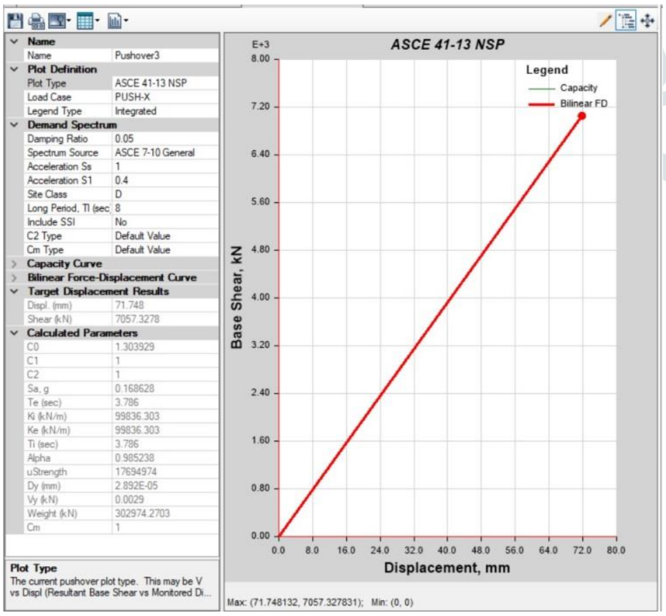
Fig 27. Target Displacement Point Results from ASCE 41-13 NSP

Fig 28. Performance Point Results from FEMA 440 EL

MODEL	**Target Displacement Point**	**Performance Point**
MODEL I	671.472 mm	144.42 mm
	6779.1722 kN	6779.0233 kN
MODEL II	93.418 mm	93.174 mm
	16726.2995 kN	16682.712 kN

Table 8. Target displacement and performance point for Model I and Model II

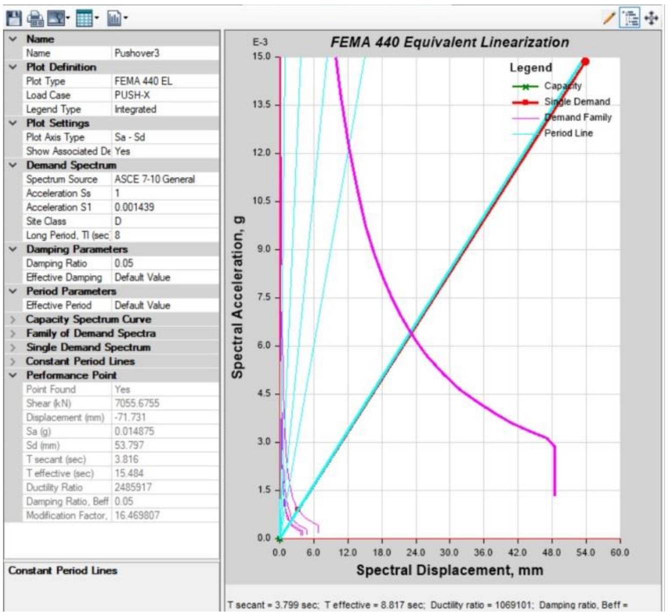
5.2.3. MODEL III: (STEEL BRACINGS STRUCTURE)



Name	
Name	Pushover3
Plot Definition	
Plot Type	ASCE 41-13 NSP
Load Case	PUSH-X
Legend Type	Integrated
Demand Spectrum	
Damping Ratio	0.05
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.4
Site Class	D
Long Period, Tl (sec	8
Include SSI	No
C2 Type	Default Value
Cm Type	Default Value
Capacity Curve	
Bilinear Force-Displacement Curve	
Target Displacement Results	
Displ. (mm)	71.748
Shear (kN)	7057.3278
Calculated Parameters	
C0	1.303929
C1	1
C2	1
Sa, g	0.168628
Te (sec)	3.786
Ki (kN/m)	99836.303
Ke (kN/m)	99836.303
Ti (sec)	3.786
Alpha	0.985238
uStrength	17694974
Dy (mm)	2.892E-05
Vy (kN)	0.0029
Weight (kN)	302974.2703
Cm	1

Plot Type
The current pushover plot type. This may be V vs Displ (Resultant Base Shear vs Monitored Di...

Max: (71.748132, 7057.327831); Min: (0, 0)



Name	
Name	Pushover3
Plot Definition	
Plot Type	FEMA 440 EL
Load Case	PUSH-X
Legend Type	Integrated
Plot Settings	
Plot Axis Type	Sa - Sd
Show Associated De	Yes
Demand Spectrum	
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.001439
Site Class	D
Long Period, Tl (sec	8
Damping Parameters	
Damping Ratio	0.05
Effective Damping	Default Value
Period Parameters	
Effective Period	Default Value
Capacity Spectrum Curve	
Family of Demand Spectra	
Single Demand Spectrum	
Constant Period Lines	
Performance Point	
Point Found	Yes
Shear (kN)	7055.6755
Displacement (mm)	-71.731
Sa (g)	0.014875
Sd (mm)	53.797
T secant (sec)	3.816
T effective (sec)	15.484
Ductility Ratio	2485917
Damping Ratio, Beff	0.05
Modification Factor,	16.469807

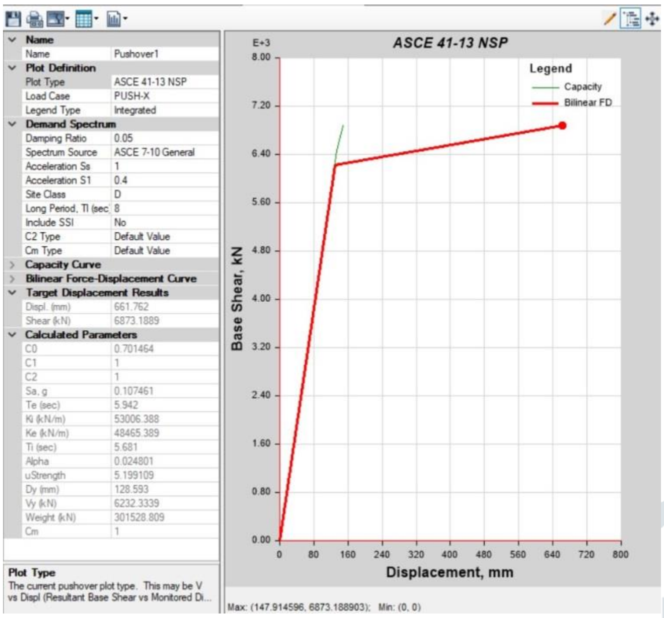
Constant Period Lines

T secant = 3.799 sec; T effective = 8.817 sec; Ductility ratio = 1069101; Damping ratio, Beff =

Fig 29. Target Displacement Point Results from ASCE 41-13 NSP

Fig 30. Performance Point Results from FEMA 440 EL

5.2.4. MODEL IV: (FRICTION DAMPER STRUCTURE)

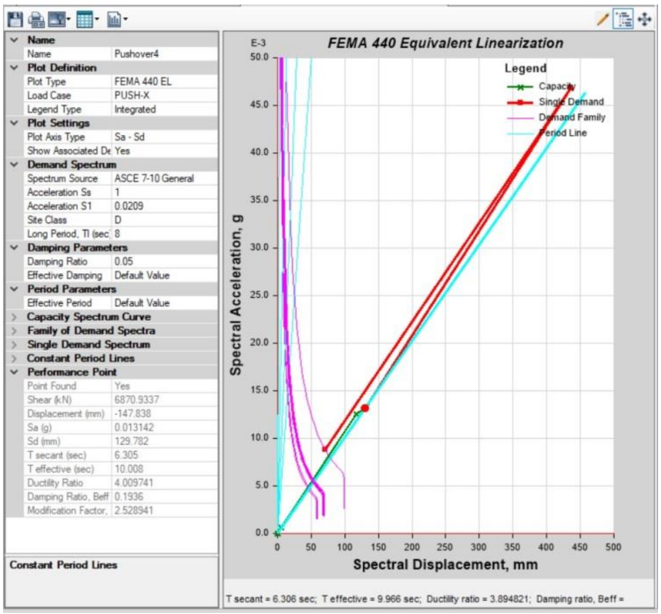


Name	
Name	Pushover1
Plot Definition	
Plot Type	ASCE 41-13 NSP
Load Case	PUSH-X
Legend Type	Integrated
Demand Spectrum	
Damping Ratio	0.05
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.4
Site Class	D
Long Period, Tl (sec	8
Include SSI	No
C2 Type	Default Value
Cm Type	Default Value
Capacity Curve	
Bilinear Force-Displacement Curve	
Target Displacement Results	
Displ. (mm)	661.762
Shear (kN)	6873.1889
Calculated Parameters	
C0	0.701464
C1	1
C2	1
Sa, g	0.107461
Te (sec)	5.942
Ki (kN/m)	53006.388
Ke (kN/m)	48465.389
Ti (sec)	5.681
Alpha	0.024801
uStrength	5.199109
Dy (mm)	128.593
Vy (kN)	6232.3339
Weight (kN)	301528.809
Cm	1

Plot Type

The current pushover plot type. This may be V vs Displ (Resultant Base Shear vs Monitored Di...

Max: (147.914596, 6873.188903); Min: (0, 0)



Name	
Name	Pushover4
Plot Definition	
Plot Type	FEMA 440 EL
Load Case	PUSH-X
Legend Type	Integrated
Plot Settings	
Plot Axis Type	Sa - Sd
Show Associated De	Yes
Demand Spectrum	
Spectrum Source	ASCE 7-10 General
Acceleration Ss	1
Acceleration S1	0.0209
Site Class	D
Long Period, Tl (sec	8
Damping Parameters	
Damping Ratio	0.05
Effective Damping	Default Value
Period Parameters	
Effective Period	Default Value
Capacity Spectrum Curve	
Family of Demand Spectra	
Single Demand Spectrum	
Constant Period Lines	
Performance Point	
Point Found	Yes
Shear (kN)	6870.9337
Displacement (mm)	-147.838
Sa (g)	0.013142
Sd (mm)	129.782
T secant (sec)	6.305
T effective (sec)	10.008
Ductility Ratio	4.009741
Damping Ratio, Beff	0.1936
Modification Factor,	2.528941

Constant Period Lines

T secant = 6.306 sec; T effective = 9.966 sec; Ductility ratio = 3.894821; Damping ratio, Beff =

Fig 31. Target Displacement Point Results from ASCE 41-13 NSP

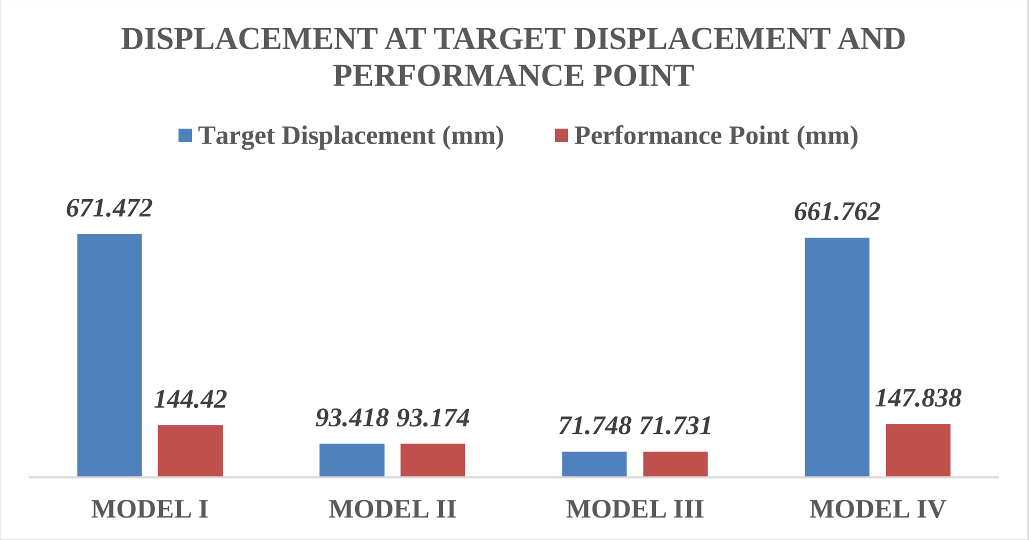
Fig 32. Performance Point Results from FEMA 440 EL

MODEL	Target Displacement Point	Performance Point
MODEL III	671.472 mm	144.42 mm
	6779.1722 kN	6779.0233 kN
MODEL IV	93.418 mm	93.174 mm
	16726.2995 kN	16682.712 kN

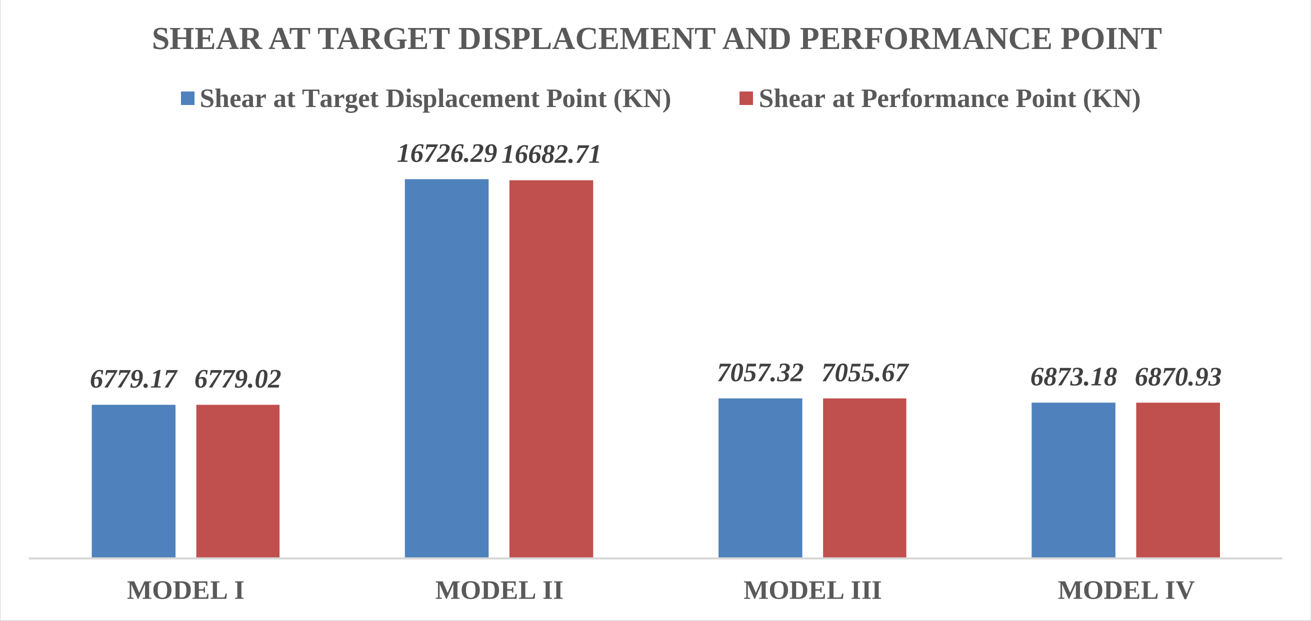
Table 9. Target displacement and performance point for Model III and Model IV

5.3. COMPARISION FROM PUSHOVER ANALYSIS

MODEL	Target Displacement (mm)	Performance Point (mm)
MODEL I	671.472	144.42
MODEL II	93.418	93.174
MODEL III	71.748	71.731
MODEL IV	661.762	147.838



MODEL	**Shear at Target Displacement Point (KN)**	**Shear at Performance Point (KN)**
MODEL I	6779.1722	6779.0233
MODEL II	16726.2995	16682.712
MODEL III	7057.3278	7055.6755
MODEL IV	6873.1889	6870.9337



Due to the seismic effects in the Zone IV the maximum shear occurs at base of the structure, maximum story displacement occurred at the top story which is story 20 and the maximum displacement of the structure is found out.

Both models' push over curves practically coincide in the Y direction. The Pushover Curves derived from this investigation demonstrate that the reaction of the building under the friction damper construction is not significantly different.

The performance point and target displacement results also follow the same phenomenon as the maximum story displacement. Model II has the lower displacement results than all the Models

From the above figures Model II have the compatibly more lateral displacement and performance points when performing nonlinearstatic pushover analysis.

VI. CONCLUSIONS

1. The building is more resistant to seismic acceleration due to the shear wall construction. When a structure is modelled, the results of the modal analysis reveal certain peculiar modes. However, it is discovered that such forms get very little mass engagement. As a result, these modes won't materially alter the building's reaction.
2. Shear wall structures are the best retrofits for response spectrum analysis since they provide the greatest findings out of all three of the retrofits that were tested.
3. According to this work, pushover analyses may not considerably alter the seismic behaviour of framed buildings when friction damper structures are modelled.
4. The Pushover Curves obtained from this study indicate that the response of the friction damper structure is not significantly different from that of the conventional structure, but it is still more efficient to use the friction damper structure than the conventional structure because the performance point is much closer and is attained at 147.838 mm for Zone V, and the results from the response spectrum analysis are much better than those from the conventional structure.
5. When comparing retrofitted structures to conventional structures in Zone V, the maximum story displacement, story drift, and base shear were significantly reduced. As a result, the multi-story buildings attracted fewer seismic pressures.
6. The installation of steel bracings additionally impacts how the structures respond to earthquakes. For all the parameters, models using steel bracing systems demonstrated satisfactory responsiveness, similar to a shear wall construction.
7. For models II, III, and IV, base shear has risen while narrative displacement and tale drifts have decreased.

Hence according to this study, the building is merely safe when it is retrofitted and further it needs to be retrofitted with different challenges.

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