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Seismic Analysis of RC Building Employed with Fluid Viscous Damper

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Abstract: In this thesis we are concentrating on finding the effect of fluid viscous dampers on Multi-storey Using Etabs. A G+12 building was analyzed and from the results it was concluded that Employment of Fluid viscous dampers increase stiffness by 9 to 90 % in X- direction and 23 to 180% in Y-direction. Employment of Fluid viscous dampers reduces storey shear 36 to 73 % in X- direction and 27 to 71% in Y-direction.
Keywords: E-tabs., seismic zones, base shear, overturning moment, displacement.

I. INTRODUCTION

The findings will provide valuable insights into the performance enhancement of RC frame structurethrough VFD retrofitting, offering practical references for similar seismic retrofitting projects. Performance-Based Seismic Design (PBSD), which focuses on limiting the displacements, is evolving as a superior method over strength-based design. For important buildings expected to remain functional after the earthquake, PBSD can provide a guaranteed response when subjected to seismic hazards. The design philosophy is evolving toward performance-based design in which damage states are specifically defined. Also with the progress in research for controlling seismic vibrations, the addition of external control systems to mitigate the seismic vibration effect of the structure is coming out as a preeminent solution. Hence, designing a vibration control system for multi-storey frame systems is an important topic in structural engineering because it can help improve the safety and stability of buildings under extreme loads.

II. LITERATURE REVIEW

Pranav S. Brahmankar *et al 13* In this work a building with seventeen floors is analyzed with viscous damper at different levels and floors to reduce the vibrations and lateral sway of building. The building is analyzed according to their locations. Modelling, analysis and design of reinforced concrete structure shall be done in ETAB software to obtain the displacement, storey drift of building with different magnitudes of earthquakes. From the analysis it was concluded that The displacement of the structure is reduced by 57% by using fluid viscous damper FVD250 for response spectrum analysis. The displacement for top storey is reduced by 65% by using fluid viscous damper FVD250 for response spectrum analysis. The storey drift is reduced by 65% by using fluid viscous damper FVD 250 for response spectrum analysis.

Pengfei Ma *et al 14* This study evaluates viscous fluid dampers (VFDs) as a solution for seismic retrofitting of an existing four-story RC school building in China's high-seismicity zone. Nonlinear time-history analyses were conducted using ETABS under frequent earthquakes (FEs) and the maximum considered earthquake (MCE), comparing structural responses before and after retrofitting. The results demonstrate that VFDs reduced inter-story drift ratios by 10–40% (FEs) and 33–37% (MCE), ensuring compliance with code limits (1/50 under MCE). Base shear decreased by 34.6% (X-direction) and 32.3% (Y-direction), while dampers contributed 66.7% (X) and 40% (Y) of total energy dissipation under FEs, increasing to 74% (X) and 47% (Y) under the MCE. Additional damping ratios reached 3.3–3.7% (X) and 2.0–2.4% (Y), significantly mitigating plastic hinge formation. This study validates VFDs as a high-performance retrofitting solution for RC frames, offering superior energy dissipation compared to traditional methods. Key findings were, Effective drift control: VFDs reduced inter-story drift angles by 10–40% under FEs and33–37% under the MCE, ensuring compliance with stringent code limits (1/50 under the MCE). This demonstrates their efficacy in mitigating deformation-induced damage. Force and energy dissipation: Base shear reductions of 34.6% (X) and 32.3% (Y) under FEs highlight VFDs' ability to redistribute seismic forces. Dampers contributed 66.7% (X) and 40% (Y) of total energy dissipation under FEs, increasing to 74% (X) and 47% (Y) under the MCE, with additional damping ratios of 3.3–3.7% (X) and 2.0–2.4% (Y). Damage mitigation: Plastic hinge formation was delayed and controlled, preventing collapse-level damage. The structure remained within the Life Safety (LS) to Collapse Prevention (CP) performance range under the MCE. Practical implications: The study provides a validated framework for retrofitting RC frames in critical infrastructure (e.g., schools, hospitals) in seismic zones. The symmetric, perimeter-based damper configuration proved effective, offering a replicable design strategy.

Mani Kant Sah *et al 15* The prime objective of this paper was to study the effect of damper parameters for the design of nonlinear FVD on Reinforced concrete framed structure to enhance the seismic performance. A general finite element package of ETABS has been used to generate three dimensional model of four storey reinforced concrete building to undertake non-linear Time History analysis to capture the performance of building with and without damper for different damper parameters and different damper distribution. The main responses of comparison between structures modeled with different viscous damper parameters are story displacement, story drift, and Base shear. After analysis the results showed that installing non-linear FVD with appropriate parameters reduces the responses of structure during seismic event. The lower the velocity exponent the more efficient the viscous damping for seismic energy dissipation. Diagonal corner damper distribution is more effective than mid chevron (double diagonal) distribution of presented RC structure. It was found that Addition of FVD reduces the story displacement and story drift of the structure by selecting suitable damper parameters. The damping coefficient cannot be excessively large because it leads to rigidize the structure and tends to have larger base shear and output forces beyond the product scope. On the other hand, the damping coefficient value ought to create the extra damping ratio to meet the expected performance. The lower the velocity exponent the more efficient the viscous damping for seismic energy dissipation. In this study velocity exponent of 0.3 shows better option in reducing response of undertaken structures. Nonlinear viscous damper reduces Seismic base shear by 25 percent for four story RC frame structure with damping coefficient of 700 KN*(s/m) and velocity exponent value of 0.3 respectively. This study concludes that selecting damping coefficient value greater than optimum value will lead to increase the seismic base shear.

Kishan shrimali *et al 16* In this research study, the focus was on analyzing an RCC structure equipped with dampers. The objective was to assess the behaviour of the structure under seismic loads by applying earthquake time history analysis using Ahmedabad and E1Centro earthquake records within the ETABS software. Through this analysis, the think about pointed to supply experiences into the execution of the RCC structure with thick dampers, particularly in terms of relocation, story float, and base responses. This comparison highlights the variability in base reactions across different structural models equipped with dampers, underscoring the influence of damper placement and orientation on mitigating seismic forces and stabilizing building foundations.

Prafful S M *et al 17* This study considers, Performance of G+15 building of rectangular and square plan under lateral load and seismic loading with seismic zone V, based on soil type II (medium soil) and reduction factor 5 for special RC moment-resisting frame. It is evaluated by Static and Response Spectrum analysis for various load combinations as per IS: 1893:2002. Analysis of this structural systems are computed using E-TABS 2015 software. To check the performance of the building by considering, storey displacement of both building with and without Fluid viscous damper(FVD). The object of the study is to compare the results obtained from static and response spectrum analysis of rectangular building with square and rectangular column cross section and square building with square and rectangular column cross section with and without FVD. From the results of the static and response spectrum analysis on the bare frame and damped frame, the conclusions can were drawn. It was observed that in square frame it is symmetric in both the directions, the response quantities are also same in both the directions. Fluid viscous dampers can dissipate maximum portion of the seismic energy and hence reduce the energy input in the primary structure. The FVDs are capable of reducing both forces and displacements of the structure under seismic loads. Shear reduction in the building is obtained by providing FVD it makes structure cost effective. It can also be concluded that the fluid viscous dampers can be effectively used as one of the better alternatives for the conventional ductility-based design methods of earthquake resistant design of structures. From the observations the best percentage of reduction of displacement is more in RBRC.

Bhavik Patel *et al 18* In this research ETABS 2018 software have been utilized. Utilizing Push over and Time history analysis, the seismic reaction of the RCC building considered in this study is assessed and compared with and without FVD. It has been seen that in Time History analysis, up to 90% reduction in the time period is observed when FVD are utilized. FVD250 reduces the Base Shear of the structures up to 70%. Consequently, FVD's can be utilized in RCC multistory structures to reduce the seismic reaction successfully. It was observed that symmetrical buildings are performing well in terms of response of the structure when compared to the unsymmetrical buildings irrespective of the floor plan. In evaluating the seismic performance of structures, the prediction of damage in structures is difficult to estimate by using the push-over analysis when compared with the Time history analysis.

Ansh Jindal *et al 19* In this work they had formulated 4 models with difference in positions of dampers. for sourcing the earthquake data, we have referred to Center for Engineering Strong Motion Data, & Pacific Earthquake Engineering Research Center (PEER), for the Ground Motion Database. Here we wanted to collect the best possible ground motion database available so that we can apply and use that in ETABS 19 to carry out analysis our models. After analysis it was found that There is at the least 60% decrease in term in response spectrum curves while Fluid Viscous Damper is used. FVD 500 reduces the base Shear of the structures by means

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of 60% in Time history evaluation. The top story displacements are minimized by 20 % with use of FVD It's miles most optimum to location damper at third story rather than 2d and 4th tale because it substantially reduces base shear. In evaluating the seismic verall performance of systems, the prediction of damage in structures are tough to estimate by way of the usage of the frenzy-over evaluation whilst in comparison with the Time history evaluation

Shaikh Jawwaad *et al 20* This paper focuses on evaluating different patterns on 12 story structure and contrasting their effectiveness on diverse structures and comparing its effectiveness of pattern on 17 story structure. This report employs response spectrum analysis to produce results that are more precise. From the following Research it was concluded that Viscous Dampers Are Efficient in reducing the displacement of building. The displacement in Structure with damper 1st pattern and without damper is 42 mm to 33.3 form patten2. That gives the reduction in displacement of 8mm or about 20.71%. With Different patterns comes different efficiency. The minimum displacement was observed in pattern 6 which gives us the most efficient pattern. The Min displacement pattern of damper was confirmed by both 12 storey structure and 17 storey structure. The Max displacement was observed in pattern 2 the arrangement of damper is not recommended in structure, its efficiency was verified on 17 storey structure with same pattern comparing it without viscous fluid damper. With the increase in number of damper the lateral load increase.

Kapil P. Gunjal *et al 21* This paper tries to emphasize on the various approaches and methods used along with FVD to effectively minimise the seismic response of buildings and to get better results against seismic forces. It was found that To minimize the seismic response of the building structures, FVD plays an important role by reducing inter-storey drifts, base shear, overturning moments, axial forces etc. with desirable cost control. Compare to other types of dampers, FVD has higher life expectancy which is almost near or more than design life of building structure which totally nullify the maintenance cost for dampers. Different methods of bracing for FVD (chevron, toggle, base plate, K-type) provide ease of installation in any desired shapes and position of the bare frame models with effective functioning. For the seismic response reduction of high rise building, nonlinear FVD with $\alpha<1$ are most suitable compare to linear FVD due to their hysteresis behavior which allows them to dissipate more energy during seismic excitations. For the optimization of the damper's placement more research have to be done to improve the accuracy of the placement and numbers of dampers required for the betterment in the economical aspect of the dampers.

III.CASE CONSIDERATION AND MODELLING

Table 3.1 General structural parameters

Parameter	Value
Live load	2 KN/m2
Live load at Floor with mass irregularity	4 KN/m2
Density of concrete	25 KN/m3
Thickness of slab	150 mm
Depth of beam	450 mm
Width of beam	300 mm
Dimension of column	300 x 600 mm
Thickness of outside wall	230 mm
Thickness of Parapet wall (1m)	100 mm
Height of floor	3.50 m
Earthquake zone	III
Damping ratio	5%
Type of soil	Medium Stiff
Type of structure	Special moment resisting frame
Response reduction factor	5
Importance factor	1.0
Number of Storey's	13 (G+12)
Depth of Foundation	1.50 m
Wind Load	Vb = 50 m/s
Terrain category	1
Risk Factor K1	1
Topography factor K3	1

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Table 3.2 Model details

Model Description	Label
RCC Building without Fluid Viscous Dampers	Model 1
RCC Building with Fluid Viscous Dampers	Model 2

A. Plan of Model

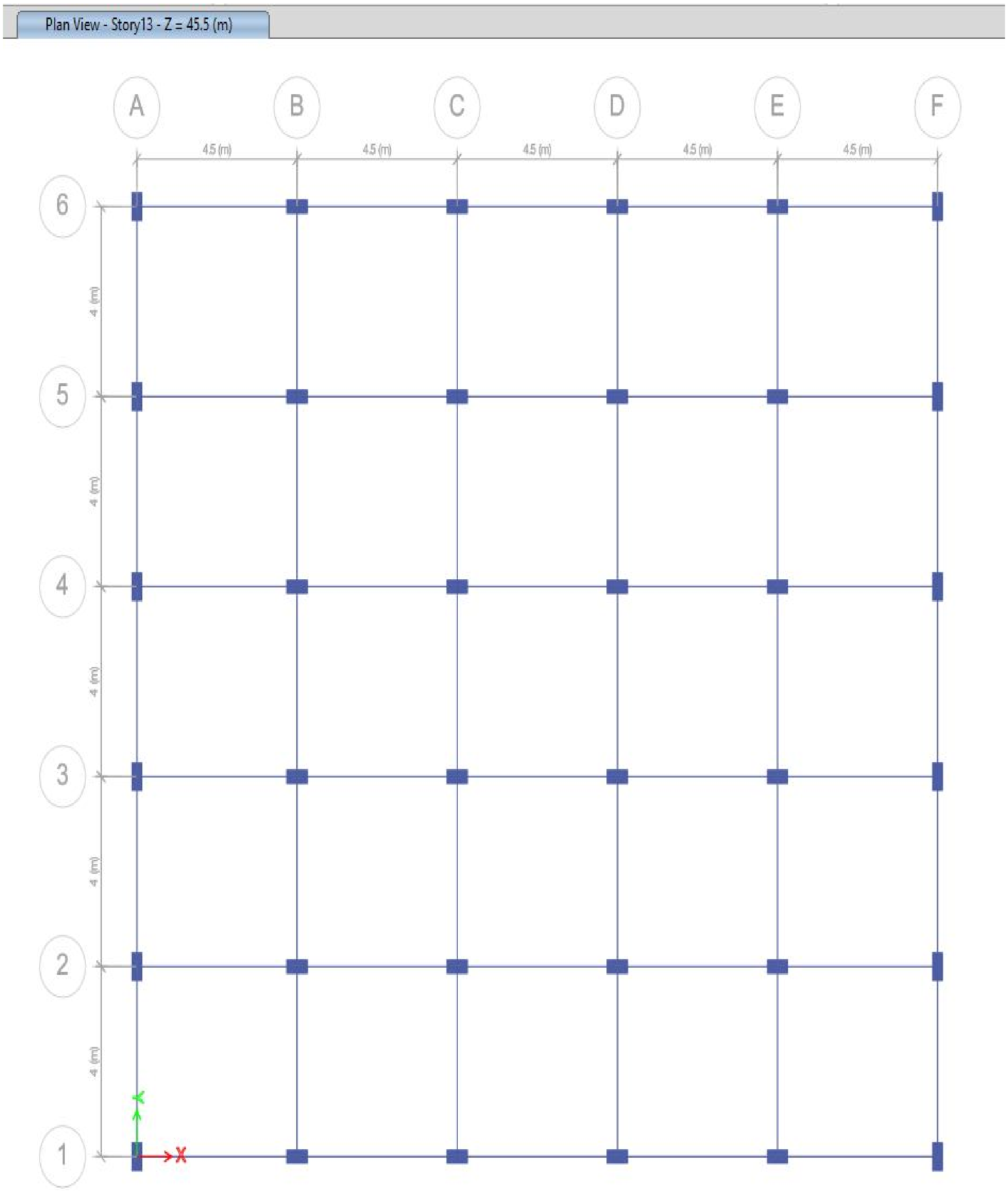

Fig 3.1 Plan of model

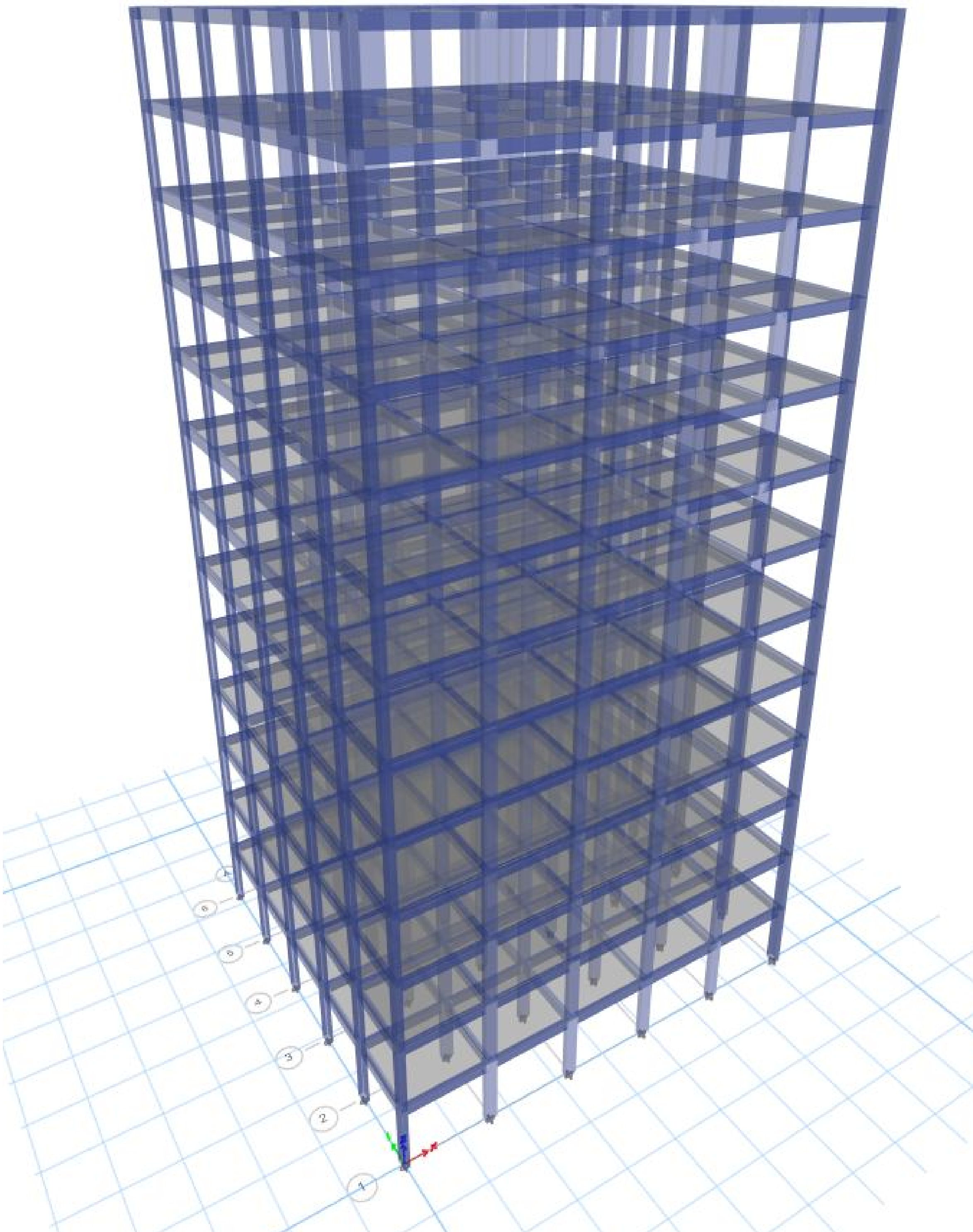

Fig 3.2 3D view of model 01 (without FVD)

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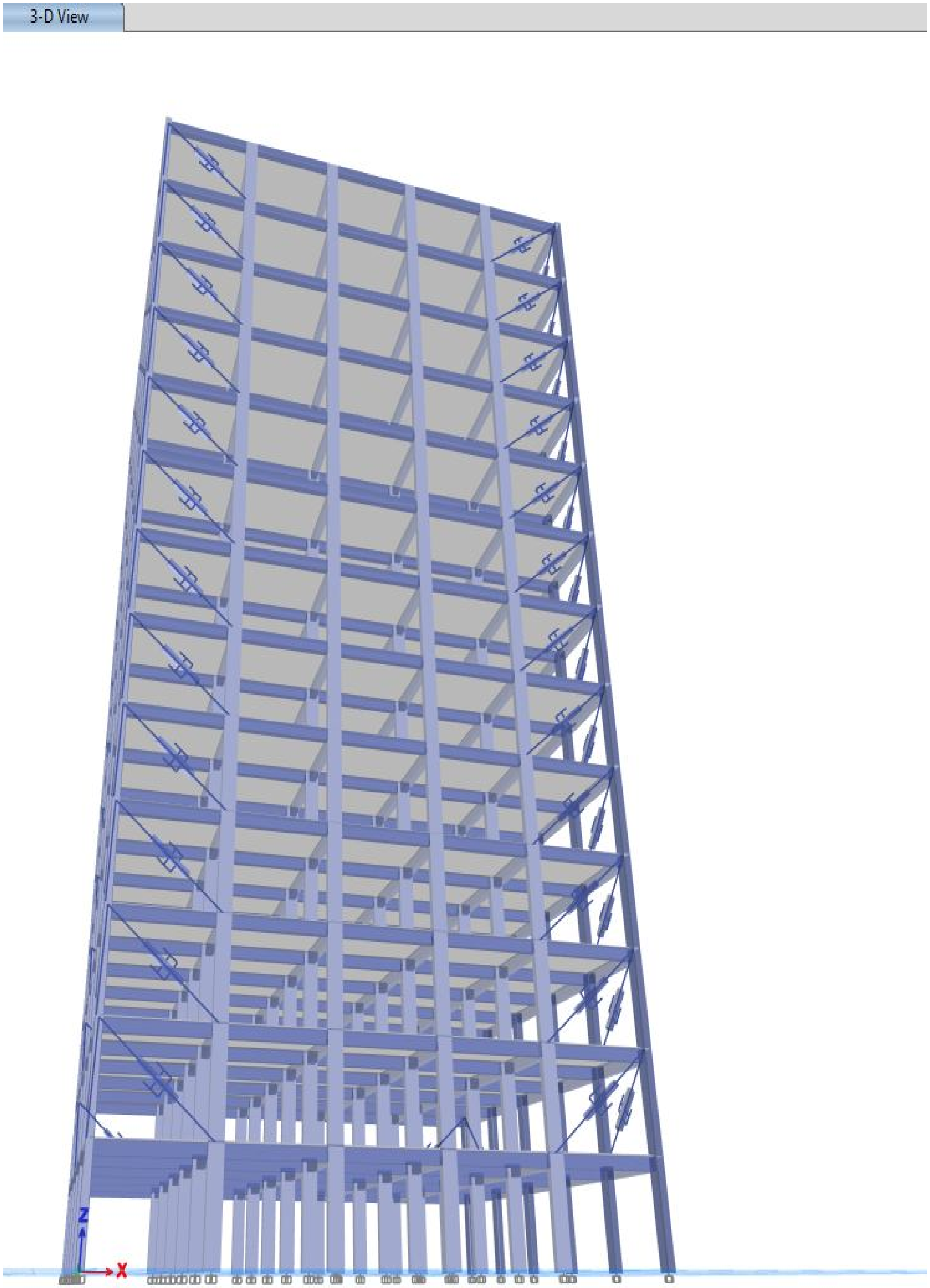

Fig 3.3 3D view of model 02 (with FVD)

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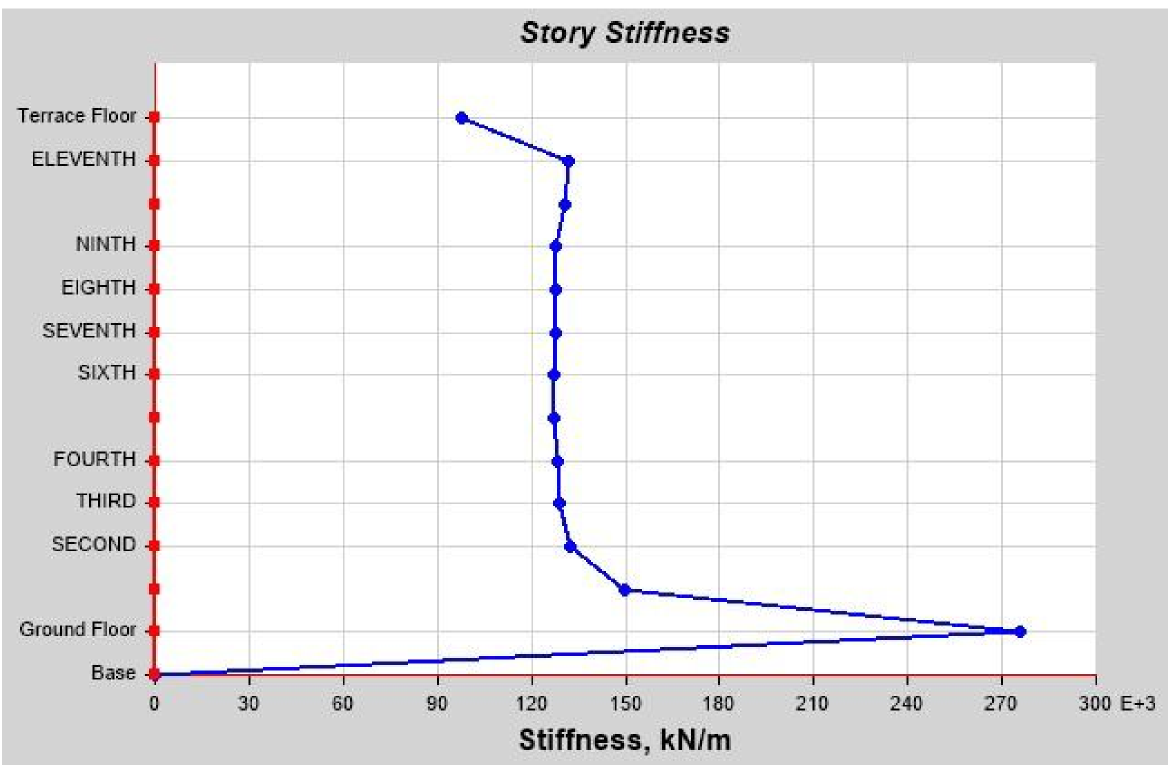
IV. RESULTS AND DISCUSSIONS

A. *Maximum Storey Stiffness in X direction*

Table 4.1 Comparison between storey stiffness of model 01 and model 02 in X-direction

Sr No	Storey Number	Results without FVD (Kn/M)	Results with FVD (Kn/M)
01	13	95	130
02	12	130	105
03	11	138	110
04	10	125	110
05	09	125	110
06	08	125	110
07	07	125	110
08	06	127	115
09	05	127	118
10	04	128	110
11	03	130	185
12	02	150	545
13	01	280	530



Graph 4.1 Etabs Storey Stifness result graph for model 01 in X-direction

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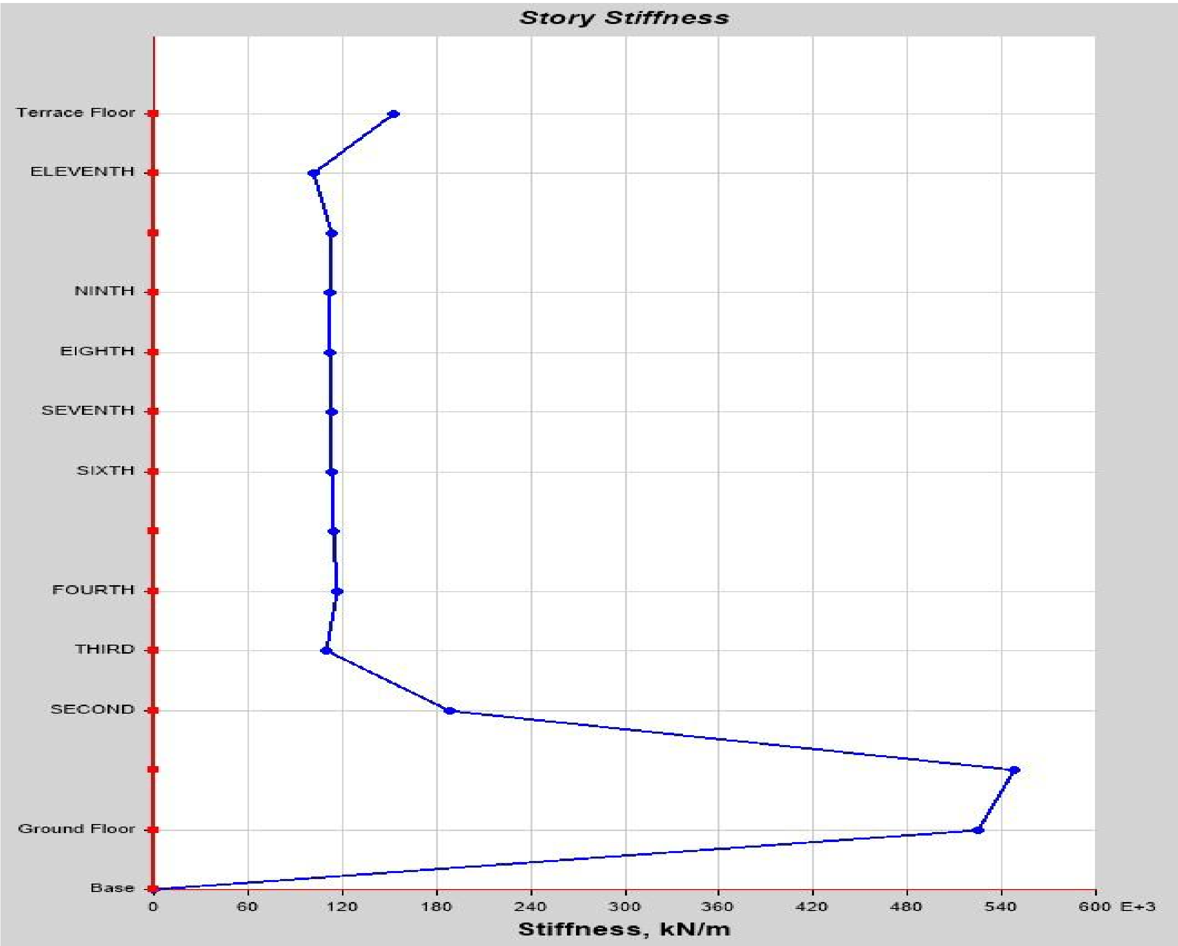
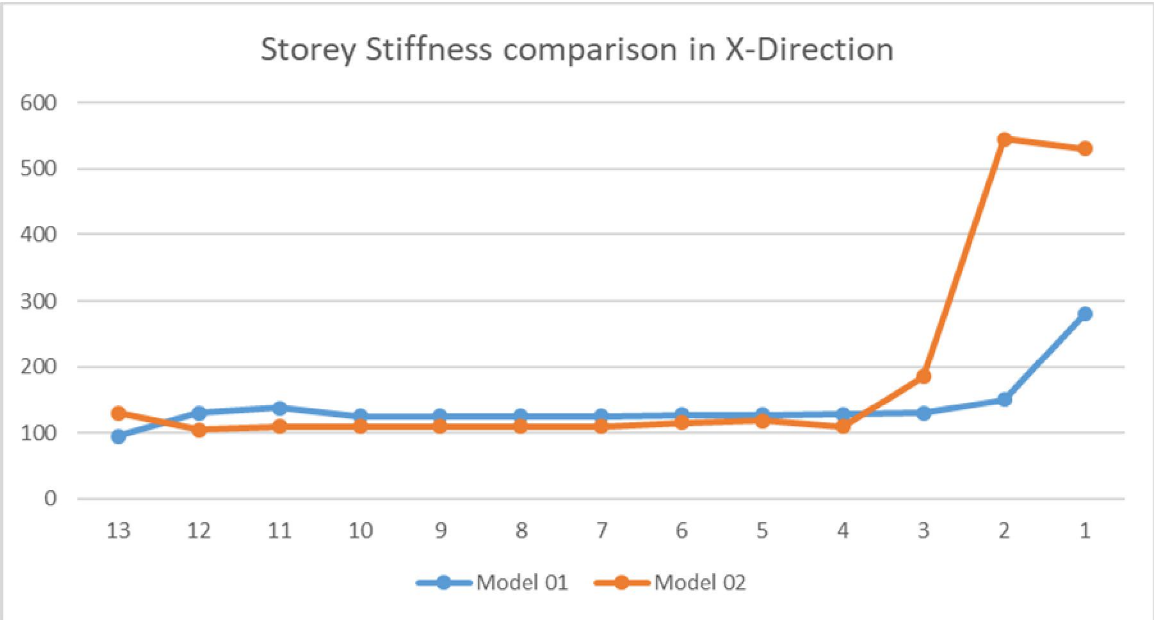


Graph 4.2 Etabs Storey Stifness result graph for model 02 in X-direction



Graph 4.3 Comparison between storey Stiffness of model 01 and model 02 in X-direction

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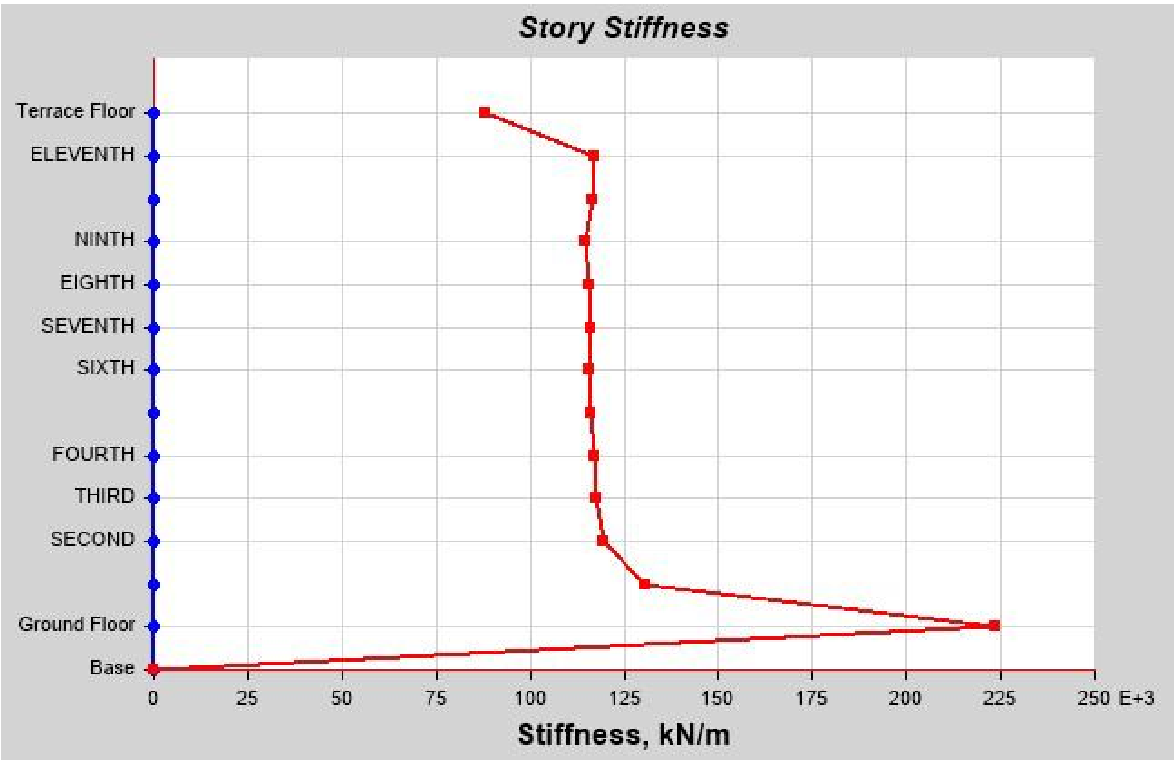
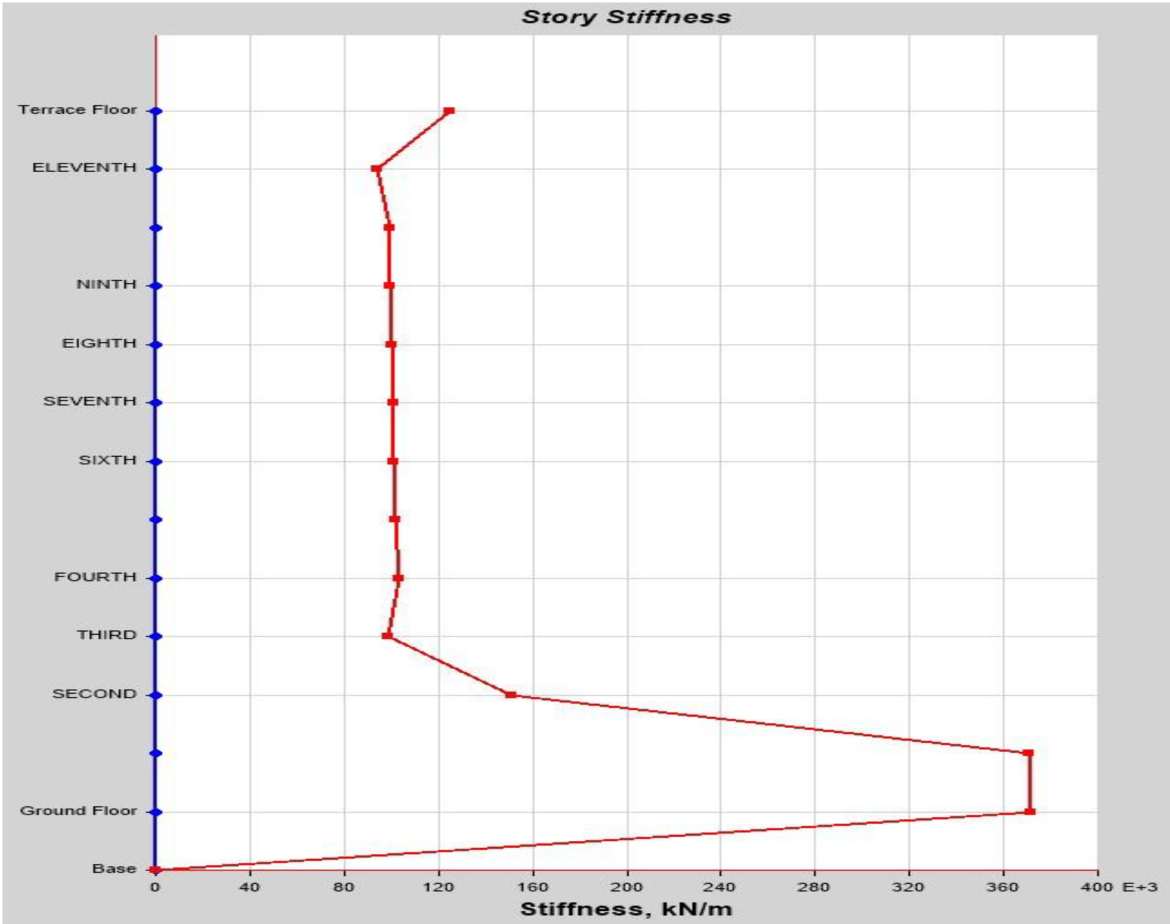
B. Maximum Storey Stiffness in Y Direction

Table 4.2 Comparison between storey stiffness of model 01 and model 02 in Y-direction

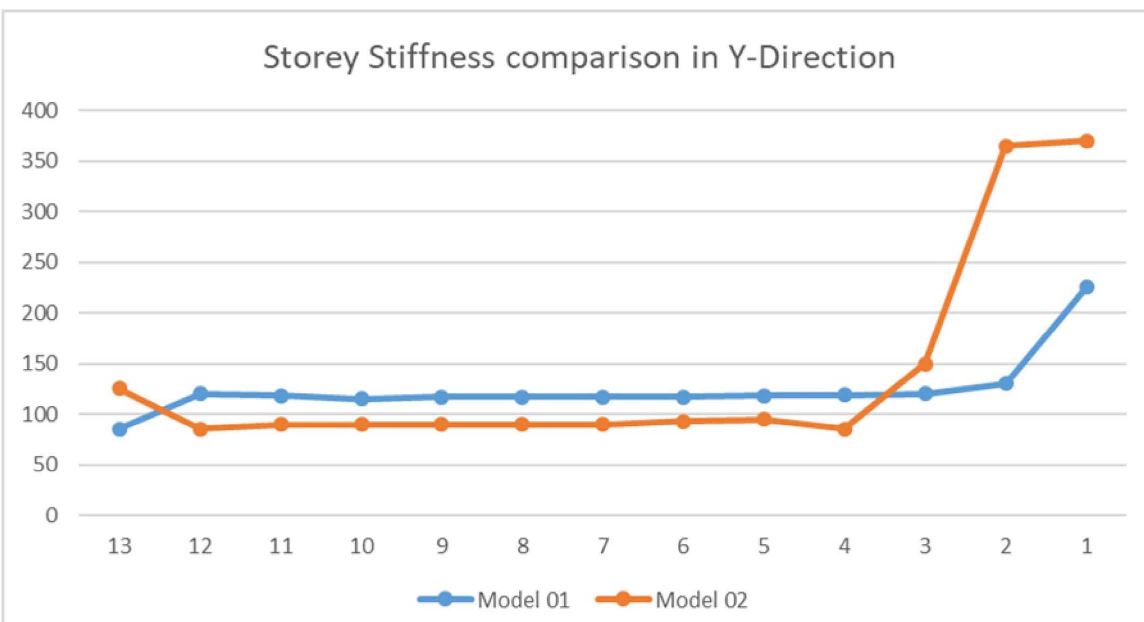
Sr No	Storey Number	Results without FVD (Kn/M)	Results with FVD (Kn/M)
01	13	85	125
02	12	120	85
03	11	118	90
04	10	115	90
05	09	117	90
06	08	117	90
07	07	117	90
08	06	117	93
09	05	118	95
10	04	119	85
11	03	120	150
12	02	130	365
13	01	225	370



Graph 4.4 Etabs Storey Stifness result graph for model 01 in Y-direction



Graph 4.5 Etabs Storey Stifness result graph for model 02 in Y-direction



Graph 4.6 Comparison between storey Stiffness of model 01 and model 02 in Y-direction

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C. Maximum storey Shear in X direction

Table 4.3 Comparison between storey Shear of model 01 and model 02 in X-direction

Sr No	Storey Number	Results without FVD (KN) (X10^3)	Results with FVD (KN) (X10^3)
01	13	0.20	0.55
02	12	0.40	0.30
03	11	0.50	0.40
04	10	0.63	0.40
05	09	0.70	0.40
06	08	0.80	0.40
07	07	0.85	0.38
08	06	0.95	0.35
09	05	1.00	0.30
10	04	1.05	0.28
11	03	1.10	0.35
12	02	1.15	0.65
13	01	1.23	2.27

Graph 4.7 Etabs Storey Shear result graph for model 01 in X-direction

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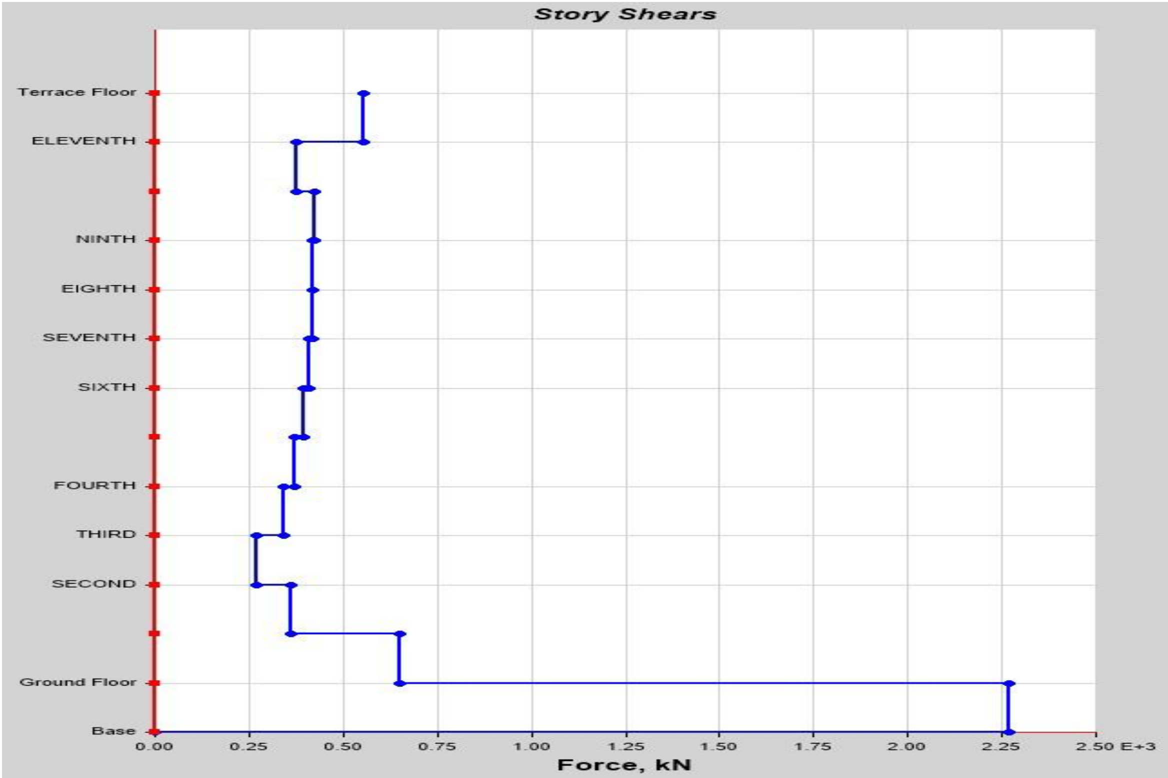
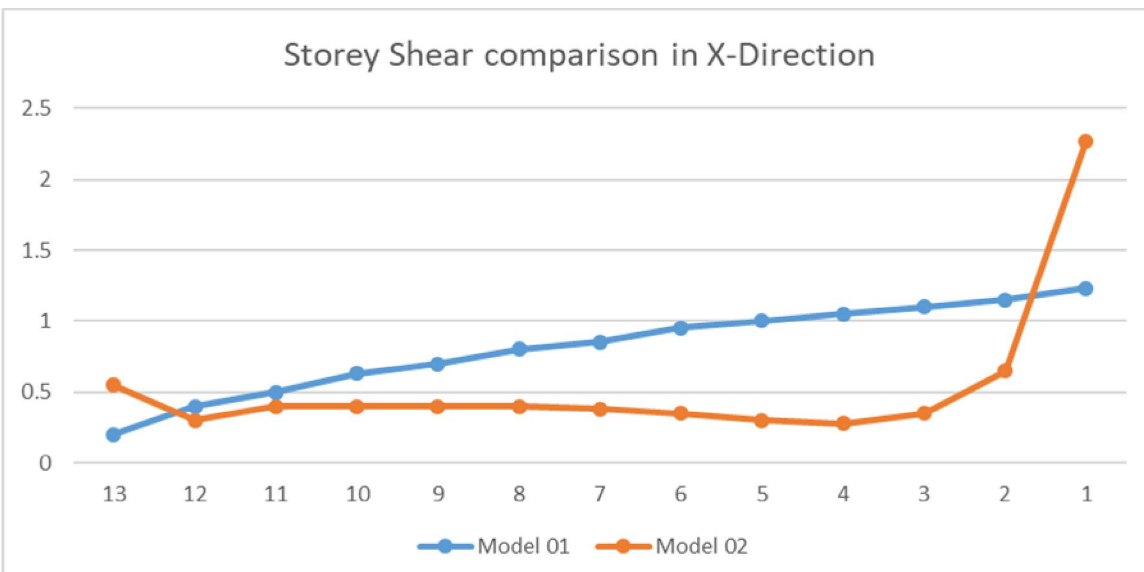


Graph 4.8 Etabs Storey Stifness result graph for model 02 in X-direction



Graph 4.9 Comparison between storey Shear of model 01 and model 02 in X-direction

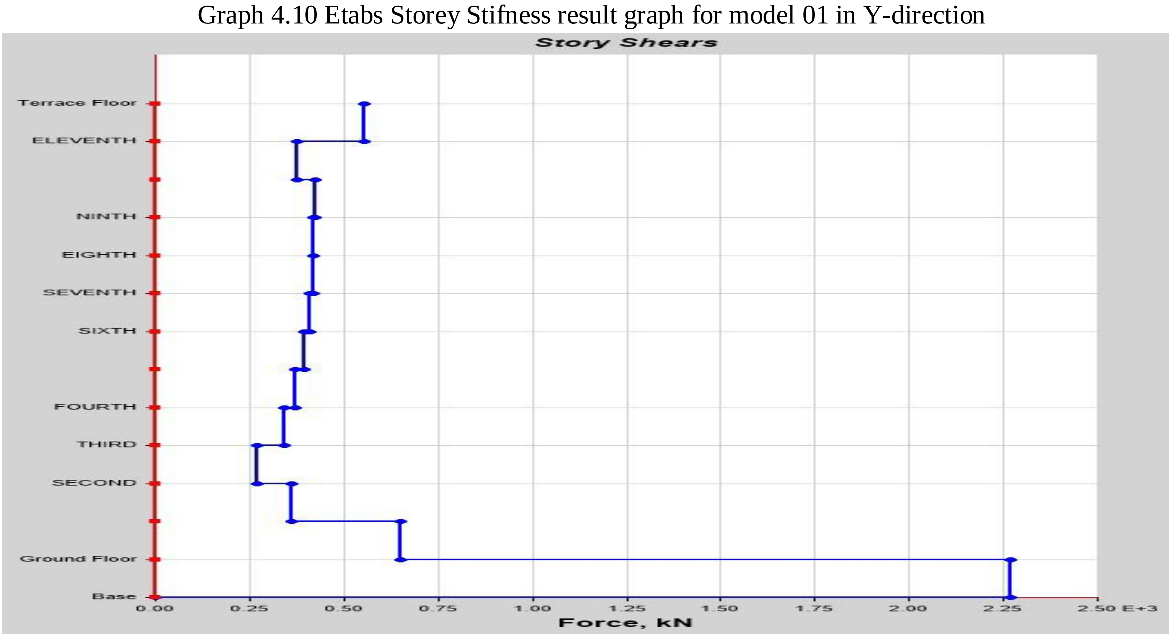
D. Maximum Storey Shear in Y direction

Table 5.8 Comparison between storey Shear of model 01 and model 02 in Y-direction

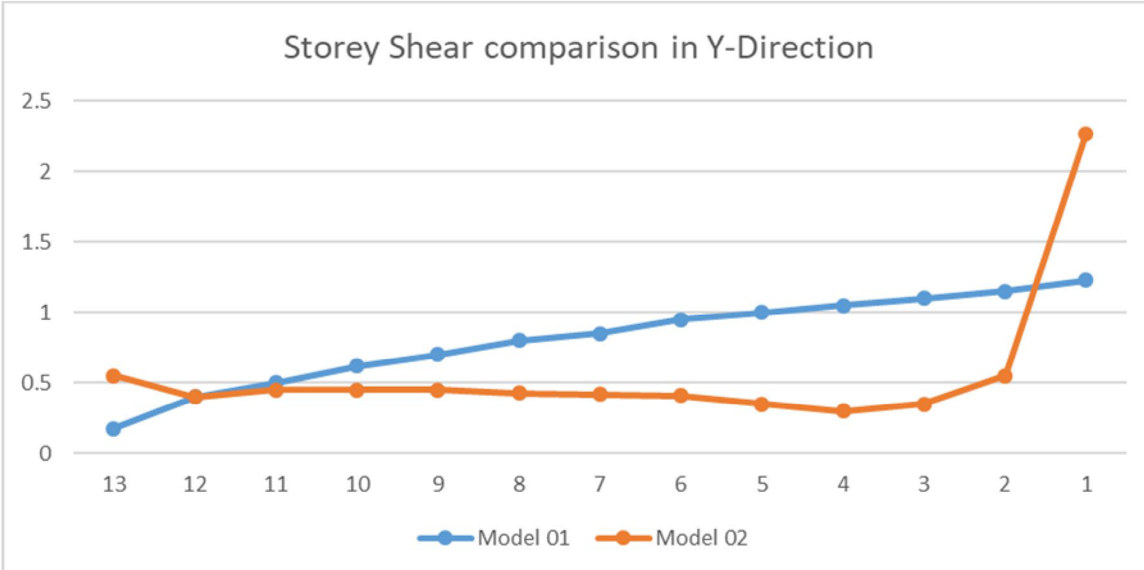
Sr No	Storey Number	Results without FVD (KN) (X10^3)	Results with FVD (KN) (X10^3)
01	13	0.18	0.55
02	12	0.40	0.40
03	11	0.50	0.45

04	10	0.62	0.45
05	09	0.70	0.45
06	08	0.80	0.43
07	07	0.85	0.42
08	06	0.95	0.41
09	05	1.00	0.35
10	04	1.05	0.30
11	03	1.10	0.35
12	02	1.15	0.55
13	01	1.23	2.27

Graph 4.10 Etabs Storey Stifness result graph for model 01 in Y-direction



Graph 4.11 Etabs Storey Stifness result graph for model 02 in Y-direction



Graph 4.12 Comparison between storey Shear of model 01 and model 02 in Y-direction

V. CONCULSIONS

1) Employment of Fluid viscous dampers increase stiffness by 9 to 90 % in X- direction and 23 to 180% in Y-direction
2) Employment of Fluid viscous dampers reduces storey shear 36 to 73 % in X- direction and 27 to 71% in Y-direction.

VI. ACKNOWLEDGMENT

It gives me great pleasure on bringing out the report entitled.

"Seismic Analysis of RC building employed with fluid viscous damper**"**

No undertaking of the magnitude involved in the preparation of this project can be accomplished alone. Many have contributed till the successful acknowledge the assistance of the following individuals and would like to thank each one of them.

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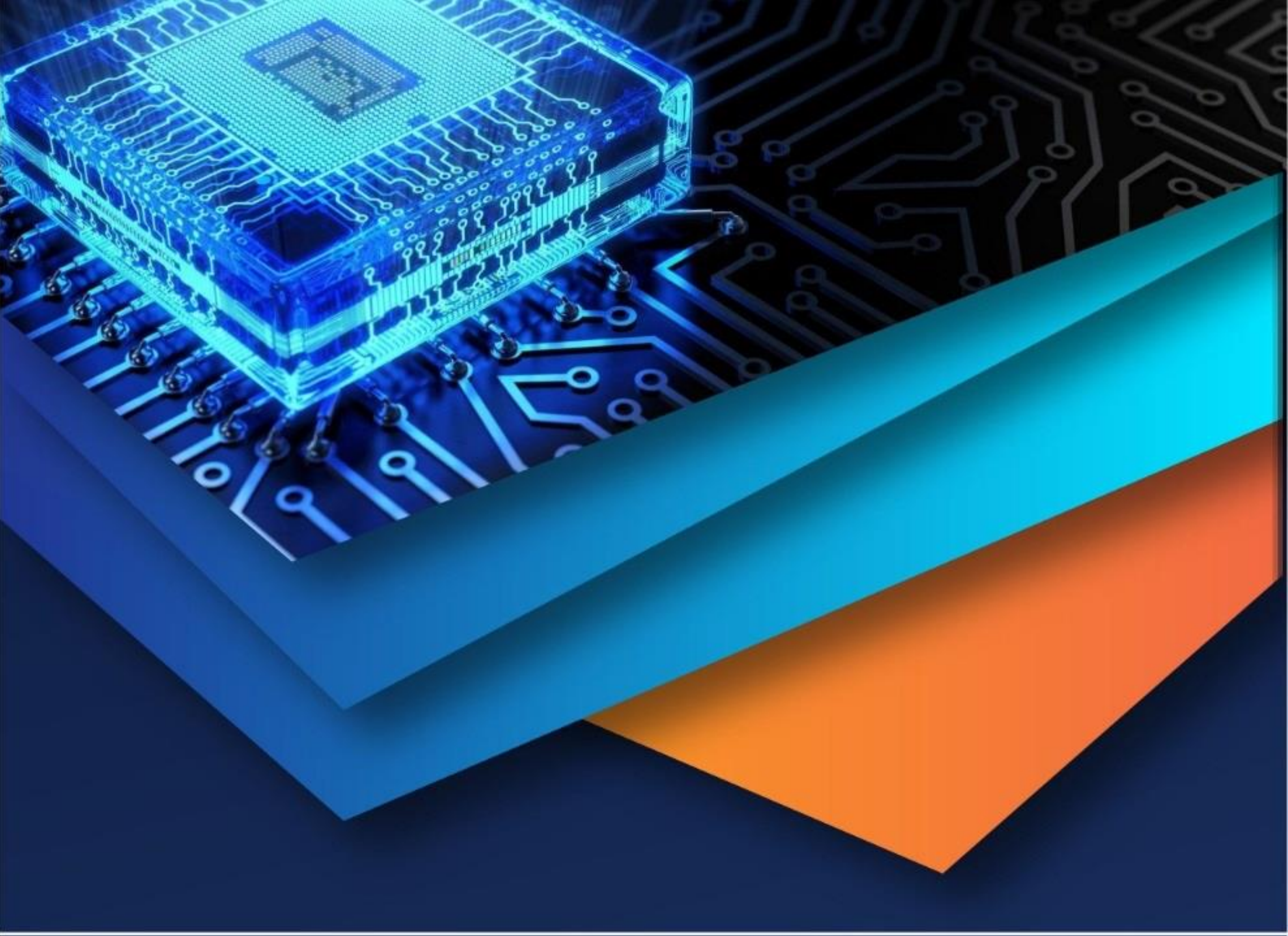

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