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Seismic Performance Evaluation of a Building Incorporating Different Lateral Load Resisting Systems

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Abstract: Earthquakes produce significant lateral forces on structures, which may lead to excessive displacement, structural instability, and collapse if proper seismic resistant measures are not adopted. The present study focuses on the comparative seismic performance evaluation of a G+11 reinforced cement concrete (RCC) building incorporated with different vibration control system using ETABS 20. The building was analyzed for Seismic Zone V using the Response Spectrum Analysis (RSA) method in accordance with the provisions of IS 1893 (Part 1): 2016. Six structural models were considered in the study, namely bare frame structure, fluid viscous damper model, friction damper model, X-bracing model, shear wall model, and lead rubber bearing (LRB) base isolated model. The seismic performance of each model was evaluated based on parameters such as maximum storey displacement, storey drift and storey shear. The results obtained from the analysis indicate that the Shear Wall model provides the most effective reduction in displacement and drift due to its Enhanced stiffness, although the shear wall and bracing systems significantly improve structural stiffness but attract higher seismic forces hence greater base shear than bare frame model. The fluid viscous damper and friction damper showed overall good seismic performance by reducing the overall displacement, drift and storey shear without attracting higher seismic forces. The base isolated model increases the displacement due to increased flexibility in the structure but reduces drift and force transmission into the structure. The study concludes that vibration control systems considerably enhance the seismic performance of RCC structures and assist in improving structural safety in earthquake-prone regions.

Keywords: Seismic performance, Response Spectrum Analysis, Storey shear, Storey displacement, Storey drift, Dampers, Shear Wall, Bracings, Base isolators.

I. INTRODUCTION

Earthquakes are one of the most destructive natural hazards affecting buildings and infrastructure worldwide. In seismic prone regions, structures are subjected to dynamic lateral forces that may lead to excessive displacement, structural damage or complete collapse if proper seismic resistant measures are not adopted. Rapid urbanization and the increasing construction of multi storey buildings have made seismic safety an important consideration in structural engineering. Conventional reinforced cement concrete (RCC) buildings designed only for gravity loads often exhibit poor performance during strong ground motion, thereby necessitating the implementation of efficient seismic or lateral loads resistant systems.

In recent years, the concept of performance based seismic design has gained importance in structural engineering. The primary objective of this approach is to control structural response and minimize damage during earthquakes. Various vibration control devices and systems such as fluid viscous dampers, friction dampers, bracing systems, shear walls and base isolation techniques have been developed to improve the seismic performance of buildings. These systems either dissipate seismic energy, increase structural stiffness, or reduce the transmission of ground motion to the superstructure.

Fluid viscous dampers are energy dissipation devices that reduce structural vibrations by converting kinetic energy into heat through viscous action. Friction dampers dissipate energy through frictional resistance developed between sliding surfaces. Bracing systems improve lateral stiffness and stability of structures, while shear walls act as vertical lateral load resisting elements that effectively reduce storey displacement and drift. Base isolation systems, such as Lead Rubber Bearings (LRB), increase structural flexibility and reduce the transfer of seismic forces from the foundation to the structure. For evaluating the seismic behaviour of structures, several analysis methods are available, including equivalent static analysis, response spectrum analysis, pushover analysis, and time history analysis. Among these methods, response spectrum analysis is widely used for multi-storey buildings because it provides reliable estimation of dynamic structural response with comparatively lower computational effort. The analysis considers the contribution of different vibration modes and provides accurate evaluation of seismic response under earthquake loading.

In the present study, a G+11 RCC building located in Seismic Zone V is modelled and analyzed using ETABS 20. Six different structural models consisting of bare frame structure, fluid viscous dampers, friction dampers, X-bracing system, shear wall system, and lead rubber bearing (LRB) base isolation are considered. The seismic performance of these models is compared based on parameters such as Maximum storey displacement, storey drift and storey shear. The objective of the study is to identify the most effective vibration control system for improving the seismic performance of RCC buildings subjected to earthquake loading condition.

II. OBJECTIVES OF THE STUDY

The main objective of the present study is to evaluate and compare the seismic performance of a G+11 reinforced concrete (RCC) building incorporated with different vibration control system using Equivalent static analysis in ETABS 20.
The specific objectives of the study are as follows:

1) To model and analyse a G+11 RCC building located in Seismic Zone V using ETABS software.
2) To perform response spectrum analysis in accordance with the provisions of IS 1893 (Part 1): 2016.
3) To study the seismic behaviour of all structural models under earthquake loading.
4) To investigate the effectiveness of different vibration control system such as:
    - Fluid Viscous Dampers (FVD)
    - Friction Dampers
    - X-Bracing System
    - Shear Wall System
    - Lead Rubber Bearing (LRB) Base Isolation
5) To compare the seismic performance of all structural models based on:
    - Maximum Storey Displacement
    - Maximum Storey Drift
    - Maximum Storey Shear
6) To identify the most efficient vibration control system for improving seismic resistance and structural safety.

III.LITERATURE REVIEW

Several researchers have investigated the seismic behaviour of multi storey buildings using different analysis methods and vibration control mechanisms to improve structural performance during earthquakes. The studies mainly focused on reducing displacement, drift, and seismic force demand through the use of dampers, bracing systems, shear walls, and base isolation techniques.

Sinha A.K. and Singh Sharad (2017): Studied the seismic protection of RC frames using friction dampers through nonlinear time history analysis. The study evaluated displacement, drift, base shear, and energy dissipation. Results showed that friction dampers significantly reduce structural response. Energy dissipation was concentrated in dampers instead of structural members. The study highlighted the cost-effectiveness and simplicity of friction dampers. It emphasized the importance of damping in seismic design. The study concluded that friction dampers improve structural safety.

Priya K. Sumani & Rao (2017): Study Conducted seismic analysis of G+5 RCC building using base isolation technique in ETABS. The study compared fixed base and base-isolated structures under seismic Zone II conditions. Lead Rubber Bearings were used as isolators to increase flexibility. Parameters such as storey displacement, drift, shear, and acceleration were analysed. Results showed reduction in storey shear, drift, and acceleration in isolated structures. However, displacement increased due to increased flexibility. The study highlighted that base isolation reduces structural damage during earthquakes. It also emphasized importance of non-conventional seismic control methods. Graphical results confirmed improved seismic response. The study concluded that base isolation is an effective earthquake-resistant technique.

Harshitha M.K. and Vasudev M.V. (2018): Studied seismic performance of RC framed structures with steel bracings using ETABS. A G+10 building was analysed with different bracing configurations. Parameters such as displacement, base shear, and time period were evaluated. Results showed that bracing systems improve stiffness and reduce displacement. X-bracing was found most effective. The study highlighted improvement in energy absorption capacity. Comparative results confirmed better performance of braced structures. The research emphasized importance of bracing configuration. The study concluded that steel bracings enhance seismic resistance.

Chaudhary Ketan (2019): Studied the effect of bracing systems in steel structures using ETABS. Different bracing types such as X and diagonal were analysed. Parameters such as displacement and drift were evaluated. Results showed that X-bracing provides maximum stiffness. The study highlighted reduction in lateral displacement. Comparative analysis confirmed effectiveness of bracing systems. The research emphasized importance of structural strengthening. It was observed that bracing improves seismic performance significantly. The study concluded that bracing systems are efficient for lateral load resistance.

Dar Aamir Riyaz and Singh Simranjit (2019): This research describes dynamic analysis of tall tubular RCC buildings with base isolation using ETABS. Different structural systems such as simple frame, tube, and bundled tube were analysed. Lead Rubber Bearings were used as isolators. Parameters such as time period, displacement, base shear, and overturning moment were evaluated. Results showed that base isolation reduces seismic response significantly. The study observed that tubular structures perform better under seismic loading. It also highlighted improvement in dynamic characteristics due to isolation. Comparative analysis showed better performance in isolated systems. The study emphasized importance of advanced structural systems. It concluded that base isolation enhances performance of tall buildings.

Armaly Majd et al. (2019): Found the effectiveness of friction dampers compared to shear wall systems in high-rise RCC buildings using nonlinear time history analysis in ETABS. A 40-storey asymmetric building was analysed under real earthquake records (El Centro). Parameters such as storey displacement, drift, acceleration, and base shear were evaluated. Results showed that friction dampers significantly improved seismic performance when optimally placed. The study highlighted that dampers provide supplemental damping without increasing stiffness excessively. Compared to shear walls, dampers were more effective in maintaining building functionality after earthquakes. The study also emphasized optimization of damper number and location. Energy dissipation capacity was found to be higher in damped structures. The research concluded that friction dampers are efficient alternatives to conventional shear walls.

Banu Lakshmi Shireen. et al. (2019): studied the seismic response of a 10-storey RCC building with and without friction dampers using ETABS. The analysis was carried out using both response spectrum and nonlinear time history methods with Bhuj earthquake data. Different building configurations were considered to evaluate the effectiveness of friction dampers in reducing seismic response. The results showed that friction dampers significantly reduce pseudo spectral acceleration, velocity, and displacement, indicating improved structural performance. The study also observed that storey displacement and drift decrease when dampers are used. However, base shear was found to increase slightly due to the additional mass and stiffness introduced by the dampers. Proper placement and selection of dampers were identified as key factors influencing performance. Overall, the study concluded that friction dampers are effective passive energy dissipation devices for improving seismic resistance of structures.

Bhoyar Aparna et al. (2019): This paper deals with the seismic performance of G+5 and G+10 buildings with friction dampers using ETABS. Response spectrum and time history analysis methods were used. Parameters such as storey drift, base shear, and bending moment were evaluated. Results showed that friction dampers reduce displacement and drift. However, base shear was slightly lower in structures without dampers. The study highlighted the importance of damper placement. Structural performance improved with dampers under seismic loading. The results confirmed effectiveness of friction dampers. The study concluded that dampers enhance seismic resistance.

Priyanka N. et al. (2019): This study shows the seismic performance of RC buildings with fluid viscous dampers using ETABS and time history analysis. The study evaluated parameters such as base shear, displacement, drift, and time period. Results showed up to 80% reduction in time period and significant reduction in base shear. Dampers effectively dissipated seismic energy and reduced structural response. Buildings with dampers showed improved stability and safety. The study considered multiple seismic zones and identified critical conditions. It also highlighted the importance of damping in earthquake-resistant design. The results confirmed the effectiveness of FVDs in seismic mitigation. The study concluded that viscous dampers are highly efficient devices in reducing vibration.

Al Agha Wesam and Umamaheswari Nambiappan (2020): Studied the seismic performance of RCC buildings with and without fluid viscous dampers using ETABS. The analysis was carried out using equivalent static, response spectrum, and time history methods. Parameters such as displacement, drift, base shear, and time period were evaluated. Results indicated that viscous dampers significantly reduce lateral deflection and improve stiffness. The study also observed a reduction in pseudo spectral acceleration and storey shear. Dampers enhanced energy dissipation and reduced seismic vibrations effectively. The performance of structures improved under both linear and nonlinear analysis. The study highlighted the adaptability and ease of installation of viscous dampers. It concluded that FVDs are highly efficient in improving seismic performance.

Choubisa Jitendra (2020): Compared the effect of building shape on seismic response using ETABS by comparing Box, H, Hollow, and U shapes. The analysis considered parameters such as storey drift, bending moment, and base reaction. Results showed that symmetrical shapes perform better under seismic loads. H and Hollow shapes had lower drift compared to U-shaped buildings. The study highlighted the importance of structural symmetry. It was observed that irregular shapes are more vulnerable. The analysis was performed using IS codes. The study emphasized proper planning of building geometry. It concluded that symmetry improves seismic performance.

Fernandes Milton et al. (2021): Compared the seismic behaviour of a G+25 RCC building with and without fluid viscous dampers using ETABS 2019. The analysis considered both wind and earthquake loading conditions. Parameters such as displacement, drift, and overturning moment were evaluated. Results indicated that fluid viscous dampers significantly reduce structural response. The study highlighted that taller buildings are more vulnerable to seismic effects. Dampers improved stiffness, ductility, and overall stability. It was also observed that proper bracing configuration enhances performance. The study emphasized the importance of damping devices in high-rise buildings. It concluded that FVDs are effective in reducing seismic vibrations.

Kaur Kamalroop and Singh, Balwinder (2021): Results shows seismic behaviour of symmetric and asymmetric structures with and without shear walls using ETABS. Various building configurations such as regular, L-shaped, and C-shaped were analysed. Parameters such as displacement, drift, and shear were evaluated. Results showed that irregular structures experience higher seismic response. Shear walls significantly improved stability and reduced drift. The study highlighted importance of structural symmetry. Comparative analysis confirmed better performance in regular structures. The research emphasized role of shear walls in irregular buildings. The study concluded that shear walls improve seismic resistance.

Rakesh B. et al. (2022): This paper discuss the seismic behaviour of multistorey RCC and steel buildings with viscous and friction dampers using ETABS. The analysis was performed using response spectrum method for different storey heights. Parameters such as base shear, storey drift, stiffness, and time period were evaluated. Results showed that dampers significantly reduce displacement and seismic forces. Viscous dampers performed better than friction dampers in controlling structural response. The study highlighted the role of energy dissipation devices in improving building safety. It also compared performance across different structural configurations. The inclusion of dampers reduced structural damage during earthquakes. The study concluded that viscous dampers are more effective for seismic control.

Rani Anu and Raghavu Sreerench (2022): studied the seismic performance of a 12-storey RCC building with and without X-braced friction dampers using ETABS and nonlinear time history analysis. The study evaluated parameters such as storey displacement, drift, shear, stiffness, and overturning moment. Friction dampers were modelled as link elements and incorporated in bracing systems to enhance energy dissipation. Results (tables on page 4) showed that storey shear and overturning moment were reduced significantly in structures with dampers. However, a slight increase in displacement and drift was observed due to energy dissipation behaviour. The study highlighted that friction dampers improve seismic performance by reducing internal forces. It also emphasized the importance of proper bracing configuration. Overall, friction dampers proved effective in enhancing structural safety. The study concluded that such systems are suitable for seismic retrofitting of buildings.

Trotea Mario et al. (2023): The influence of damping coefficient on seismic behaviour using fluid viscous dampers in ETABS. Different damping values were analysed to evaluate displacement and damper forces. Results showed up to 50% reduction in displacement with higher damping values. However, damper forces increased significantly. The study highlighted the need for optimal damping selection. It concluded that damping coefficient plays a crucial role in seismic performance.

Habib Ahosan et al. (2024): the efficiency of fluid viscous dampers in improving the seismic performance of a 10-storey RCC building using ETABS. A 3D finite element model was developed to simulate real building conditions. The study evaluated parameters such as displacement, drift, base shear, and natural time period. Results showed that fluid viscous dampers significantly reduce deformation and seismic forces. The dampers absorbed and dissipated earthquake energy effectively, improving structural stability. It was also observed that buildings with dampers had reduced storey drift compared to conventional structures. The installation of dampers increased safety and structural lifespan. The study emphasized the importance of damping systems in seismic zones. It concluded that fluid viscous dampers are highly effective for seismic mitigation.

Randive Limesh Kumar and Yadav Jyoti (2024) investigated the seismic performance of an eight-storey irregular “C”-shaped RCC building using base isolation (LRB), friction dampers, and their combined application in ETABS. The study was conducted using response spectrum analysis as per IS 1893:2016, considering parameters such as time period, base shear, storey displacement, and storey drift. Four models were analysed: conventional building, building with friction dampers, building with base isolation, and a combined system with both LRB and friction dampers. The results showed that base isolation significantly increases the time period and reduces base shear, while friction dampers effectively reduce displacement and drift.

However, friction dampers alone were found to increase base shear. The combined system demonstrated the best performance by reducing base shear, displacement, and storey drift simultaneously. Maximum reduction in storey drift (about 64%) was observed in the combined system. The study concludes that the integration of base isolation and friction dampers provides superior seismic performance compared to individual systems.

Tanpure Harshada A and Dr. Kawade U.R., and Sengupta A.A. (2024): The seismic behaviour of RCC buildings with friction dampers using ETABS and response spectrum analysis. The study focused on improving structural stability and reducing lateral responses under seismic loading. Various damper locations such as center and edges were analysed and compared with a bare frame structure. Parameters such as storey displacement, drift, and base shear were evaluated. Results indicated that friction dampers effectively reduce seismic response and improve structural performance. It was observed that central placement of dampers provides maximum efficiency. The dampers also enhanced stiffness and ductility of the structure. The study highlighted the importance of energy dissipation in earthquake-resistant design. It concluded that friction dampers are economical and efficient devices for vibration control.

Kori Krishna Kumar and Singhai Ankita (2024): Reviewed seismic performance of structures with bracing and base isolation systems. The study evaluated parameters such as storey shear, displacement, and overturning moment. Results showed that both bracing and base isolation improve seismic performance. Cross bracing and LRB isolators were found most effective. The study highlighted importance of system selection. It emphasized role of energy dissipation devices. Comparative analysis showed advantages of combined systems. The research discussed modern seismic control techniques. The study concluded that hybrid systems provide best performance.

Jain Shubham and Grover R.K. (2024): The study presents a comprehensive review of seismic analysis and design considerations for underground and partially underground structures. The authors discussed the increasing use of underground facilities such as metro stations, tunnels, parking structures, water tanks, and underground shelters due to rapid urbanization and land scarcity. The paper highlights that although underground structures are generally less vulnerable to seismic forces compared to above-ground structures, they are not completely safe during earthquakes and therefore require proper seismic analysis and design. Various research works conducted using analytical software such as STAAD Pro were reviewed in the study. The authors summarized different parameters considered by researchers, including storey drift, base shear, soil-structure interaction, displacement, bending moments, and seismic deformation. Several studies concluded that shear walls, soil-structure interaction analysis, and proper seismic detailing significantly improve the performance of underground structures during earthquake loading.

Shreevash Gaurav and Kushwaha S.S. (2025): Reviewed the seismic performance of buildings with shear walls and friction dampers. The study compared stiffness-based and damping-based systems. Results showed that shear walls increase stiffness while dampers dissipate energy. The study highlighted advantages of hybrid systems. It emphasized the importance of placement and design. The review concluded that combining both systems gives optimal performance.

Nair Arunima R. and Kale Rohini C. (2025): the comparative seismic performance of buildings with shear walls and fluid viscous dampers using ETABS. The analysis evaluated displacement, drift, shear, and stiffness under response spectrum method. Results showed that shear walls significantly increase stiffness and reduce deformation. Fluid viscous dampers effectively dissipate energy without increasing stiffness. Corner placement of dampers was found most effective. The study highlighted advantages of both systems. It suggested that hybrid systems provide best performance. The comparison was done under identical conditions. The study concluded that combined use of shear walls and dampers is optimal.

Mishra Prabhanshu and Grover R.K. (2025): The study investigates the seismic performance of a G+15 steel moment-resisting frame using nonlinear static pushover analysis. The analysis was carried out using STAAD Pro software in accordance with FEMA-356, ATC-40, IS 1893 (Part 1): 2016, and IS 800: 2007 provisions. The objective of the study was to evaluate the inelastic behaviour, ductility, hinge formation, and performance level of the steel structure under seismic loading. The authors discussed the importance of pushover analysis as an effective tool for performance-based seismic design. Unlike conventional elastic analysis, pushover analysis helps in understanding the nonlinear behaviour of structures, including plastic hinge formation, stiffness degradation, and collapse mechanisms.

The study showed that the structure exhibited linear behaviour initially, followed by nonlinear response beyond a certain displacement level. The maximum base shear achieved was 8416.24 KN at a roof displacement of 74.29 mm, after which stiffness degradation was observed.

IV. METHODOLOGY

The present study focuses on the comparative seismic performance evaluation of a G+11 reinforced cement concrete (RCC) building incorporated with different vibration control system. The structural modelling and analysis were carried out using ETABS 20 in accordance with the provisions of IS 1893 (Part 1): 2016, IS 875 Parts, IS 456: 2000 and other relevant codes.

A regular and symmetrical G+11 RCC building was considered for the study and modelled with identical structural and loading parameters for all cases. The building was assumed to be located in Seismic Zone V and the site type is assumed to be 3 (soft soil), which represents the highest seismic risk zone in India. The response spectrum analysis was used to obtain seismic parameters like displacement, inter storey drift and storey shear. Modal responses were combined using the CQC method. As per IS 1893, dynamic base shear was scaled to match the equivalent static base shear. To evaluate the dynamic response of the structure under earthquake loading, the seismic response was analyzed in both principal directions using response spectrum load cases RSX and RSY. Comparative analysis was then carried out to identify the most effective vibration control system for improving seismic resistance and structural safety of the building.

The study included six different structural models:

1) Bare Frame Structure (Model 1)
2) Fluid Viscous Damper Model (Model 2)
3) Friction Damper Model (Model 3)
4) X-Bracing Model (Model 4)
5) Shear Wall Model (Model 5)
6) Lead Rubber Bearing (LRB) Base-Isolated Model (Model 6)

V. STRUCTURAL MODELLING

The structural modelling of the G+11 reinforced cement concrete (RCC) building was carried out using ETABS 20. The building was modelled as a regular and symmetrical multi storey structure located in Seismic Zone V and analyzed using the Response Spectrum Analysis method. The plan geometry, loading conditions, material properties, and analysis parameters were kept identical for all models to ensure accurate comparative evaluation. Only the respective vibration control system was modified in each model.
The parameters used in modelling are given below,

Table 1: Considered Parameter for all Models (1-6)

Number of Grids in X direction	4
Number of Grids in Y direction	4
Spacing of Grid Lines in X direction	4.5m
Spacing of Grid Lines in Y direction	4.5m
Number of Storeys’	12
Typical Storey Height	2.7m
Ground Floor Height	2.7m
Size of Beam	400x400mm
Size of Column	6000x600mm
Thickness of Slab	150mm
Type of Support	Fixed (except for LRB)
Type of Soil	3 (Soft Soil)
Damping ratio	5%
Earthquake Zone	V
Time Period	Program Calculated

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Earthquake Zone factor	0.36
Importance Factor	1
Response Reduction Factor	3
Concrete Grade	M35
Steel Grade	HYSD 550
Type of Construction	RCC Frame Structure
Assumed exterior wall thickness	230mm
Assumed interior wall thickness	115mm
Unit weight of Concrete	25 kN/m^3
Unit weight of masonary	20 kN/m^3
Exterior wall Load	11.73 kN/m
Interior wall Load	5.8 kN/m
Parapet wall load	2 kN/m^2
Dead load of slab	3.75 kN/m^2
Live load on slab	3 kN/m^2

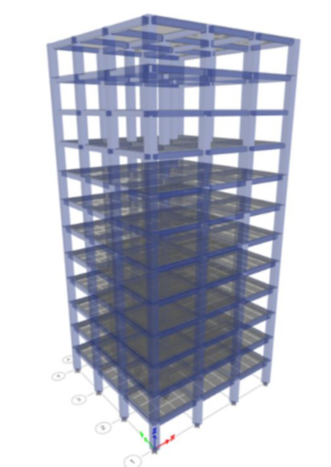

Fig 1: 3D View of Bare Frame Structure.

Table 2: Fluid Viscous Damper Properties.

Link Type = Exponential
Taylor Device Number = 17120
Mass of FVD = 44 kg
Force of FVD = 250 kN
Damping exponent ‘α’ = 0.3
Damping coefficient kN $(s/m)^{\alpha}$ = 497
Damper placement at corners

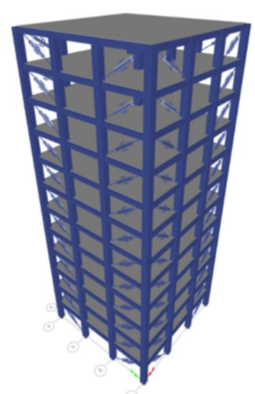

Fig 2: 3D View of Structure and Arrangement of Dampers (Both FVD and friction damper). They appear the same because both are selected as exponential damper types, so ETABS represents them identically.

Table 3: Friction Damper Properties.

Link Type = Exponential
Mass = 80 kg
Weight= 0.784 kN
Effective Stiffness = 108855 kN/m
Yield strength or Slip load = 250 kN
Damper placement at corners

Table 4: Bracing Properties.

Bracing Type = X-Bracing
Bracing Material= Fe250
Steel Section Used = ISMB250
Section Shape Type= Wide Flange/I-section
Bracing placement at corners

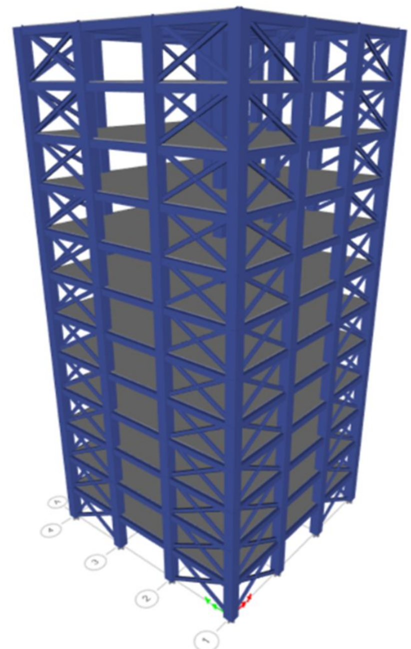

Fig 3: 3D View of Structure and Arrangement of X-Bracing.

Table 5: Shear Wall Properties.

Shear Wall Thickness= 150mm
Wall Material = M25
Pier Label used = “Shear Wall”
Modelling Type = Shell Thin
Shear wall placement at corners

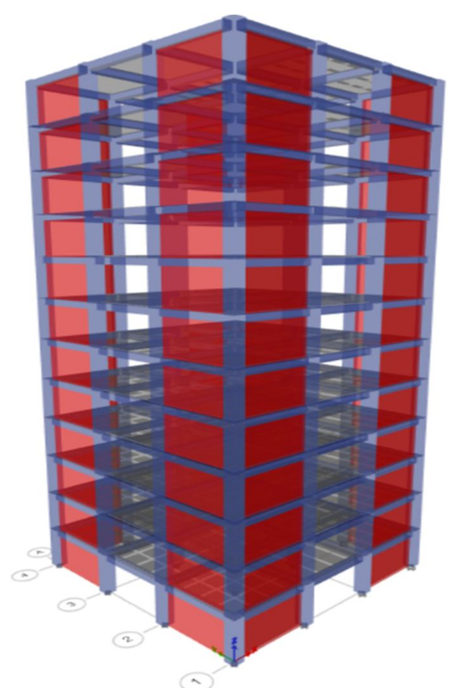

Fig 4: 3D View of Structure and Arrangement of Shear Wall.

Table 6: Base Isolator (LRB) Properties

Link Type = Rubber Isolator
Support Type = Point Springs
Direction = U1, U2, U3 (U2=U3=nonlinear)
For U1: Effective Stiffness = 2740420.35 kN/m
For U1: Effective Damping = 0
For U2=U3: Effective Stiffness = 7743.61
For U2=U3: Effective Damping = 0.05
For U2=U3: Distance from End J = 0
For U2=U3: Stiffness = 2363.82
For U2=U3: Yield Strength = 41.9457
For U2=U3: post Yield Stiffness Ratio = 0.1
Support Spring named= LRB spring

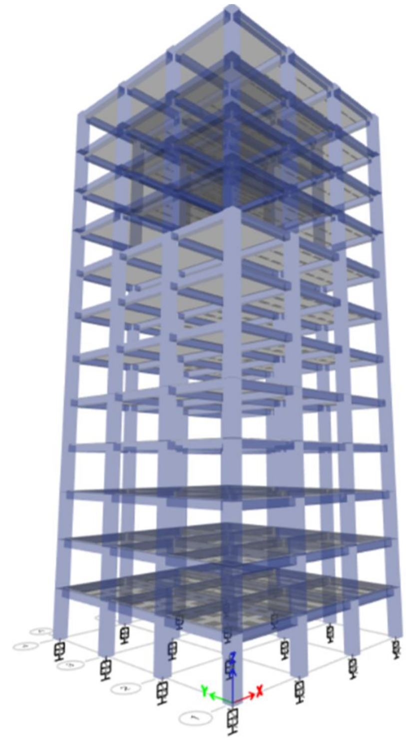

Fig 5: 3D View of Structure and Arrangement of LRBs.

VI. RESULTS AND DISCUSSION

The seismic analysis of all six structural models was carried out using the Response spectrum analysis method. The performance of each model was evaluated and compared based on important seismic response parameters such as maximum storey displacement, storey drift and storey shear. The comparative results obtained from the analysis clearly indicate the influence of different vibration control system on the seismic behaviour of the structure. The bare frame structure exhibited the highest storey displacement, storey shear and drift among all the models due to the absence of any additional vibration control system. The introduction of fluid viscous dampers significantly reduced the displacement, drift and storey shear values because of their ability to dissipate seismic energy effectively through viscous action. The friction damper model also demonstrated improved seismic performance by reducing lateral response through frictional energy dissipation. The X-bracing and shear wall systems increased the overall stiffness of the structure, resulting in lower displacement and drift values compared to the bare frame model. However, due to increased stiffness, these systems attracted comparatively higher seismic forces therefore more storey shear. Among these systems, the shear wall model showed most reduction in deformation response because of its strong lateral load-resisting capability. The base isolated model exhibited different behaviour compared to other structural systems. The introduction of Lead Rubber Bearing (LRB) isolators increased the flexibility and fundamental time period of the structure, thereby reducing the transmission of seismic forces to the superstructure. Although the displacement values increased slightly, the reduction in storey drifts and storey shear, force demand confirmed the effectiveness of base isolation in improving seismic performance. The overall comparison of results indicates that fluid viscous dampers provide the most balanced seismic performance by effectively reducing both displacement and force demand without excessively increasing structural stiffness. The study demonstrates that the selection of an appropriate vibration control devices or system plays an important role in enhancing the seismic safety and performance of multi storey RCC buildings located in earthquake prone regions.

Since the structure considered is a simple rectangular building and having symmetrical geometry and uniform stiffness distribution therefore, the values for Response spectrum Load Cases RSX and RSY (for X and Y directions) are identical, so to keep comparison simple only the values for RSX Load Case are considered.

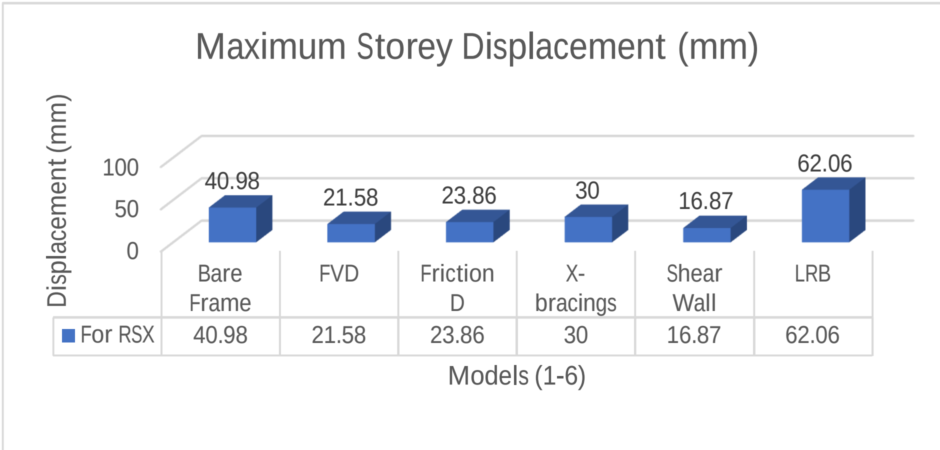

Fig 6: Comparison of Maximum displacement for RSX load case.

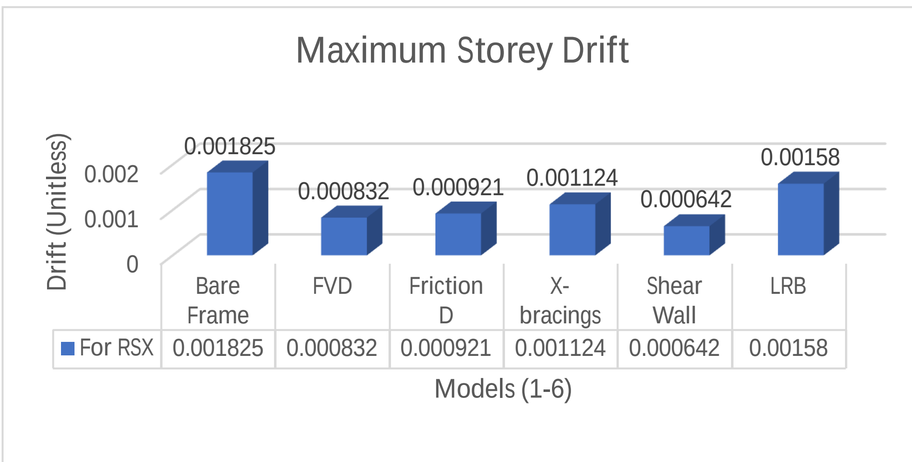

Figure 7: Comparison of Maximum Storey Drift for RSX load case.

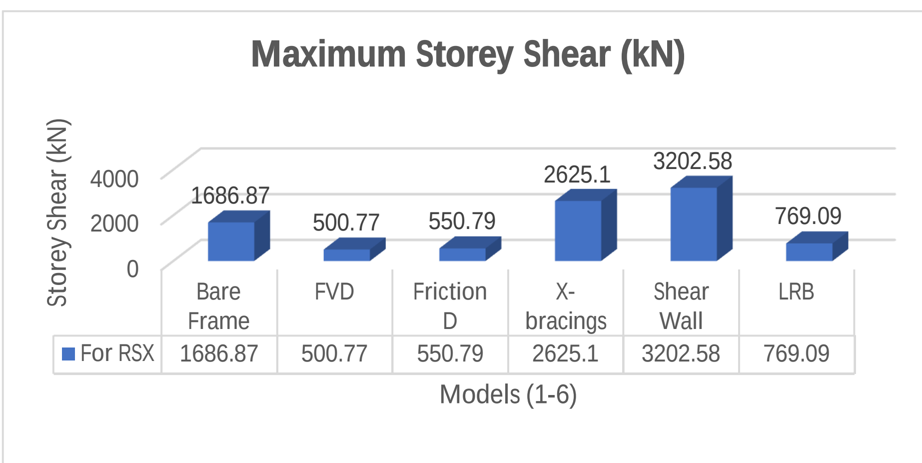

Figure 8: Comparison of Maximum Storey Shear for RSX load case.

VII. CONCLUSIONS

The present study focused on the comparative seismic performance evaluation of a G+11 reinforced cement concrete (RCC) building using different vibration control devices or system in ETABS 20. Response Spectrum Analysis (RSA) method was carried out for Seismic Zone V in accordance with the provisions of IS 1893 (Part 1): 2016 and other relevant codes. Six different structural models consisting of bare frame structure, fluid viscous dampers, friction dampers, X bracing system, shear wall system, and lead rubber bearing (LRB) base isolation system were analyzed and compared.

From the analysis results, it was observed that the bare frame structure exhibited the maximum displacement and drift due to the absence of any seismic control mechanisms. The fluid viscous damper model showed the best overall seismic performance by significantly reducing storey displacement, storey drift, and structural vibration through efficient energy dissipation. The friction damper model also improved the structural response by dissipating seismic energy through frictional resistance.

The X-bracing and shear wall systems enhanced the stiffness of the structure and effectively controlled lateral deformation. Among these, the shear wall model showed most reduction in displacement and drift due to its high lateral load-resisting capacity. However, the increased stiffness resulted in comparatively higher storey shear and force demand.

The base isolated model behaved differently from other systems by increasing the flexibility and fundamental time period of the structure. The Lead Rubber Bearing (LRB) isolators effectively reduced the transmission of seismic forces to the superstructure and lowered the storey shear values, thereby improving seismic safety.

Overall, the study concludes that vibration control mechanisms significantly improve the seismic performance of RCC buildings. Among all the considered systems, fluid viscous dampers were found to be the most effective in achieving balanced seismic performance by reducing both deformation and force demand. The findings of the study can be useful for selecting suitable seismic control systems for multi storey buildings located in earthquake prone regions.

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