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COMPARISON STUDY OF LATERAL LOAD RESISTING SYSTEMS OF MULTISTORIED BUILDING BY CONSIDERING HIGH SEISMIC ZONE

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ABSTRACT:

Since ancient times, everyone has known that earthquakes may inflict calamities. Modern structures are more vulnerable to earthquakes because they are thinner and more easily swayed. Buildings may already be made more earthquake-proof thanks to the work of engineers and experts.

Many credible studies have shown that the use of lateral load resisting elements within the building layout significantly improves the structure's performance in earthquakes. The present research makes use of a 15Mx12m design. Utilising the software package ETABS 9.7.4, the operation has been carried out for the diverse cases of spur walls, bracings, and dampers at varied heights. In this study, a maximum height of 33.3 metres is taken into account.

INTRODUCTION

Seismic features such as base shear, lateral displacements, and lateral drifts have been studied and simulated. Zone V and medium soil types were the subjects of the investigation, in accordance with IS 1893-2002.

A variety of words may be used to characterise this kind of construction, including clean frame, bracings, shear walls, dampers, lateral load resisting systems, drifts, time period, base shear, seismic zone, and soft soil.
Earthquakes are one of the greatest dangers to life on our planet, having flattened cities and villages on almost every continent. Earthquakes are among the most scary natural catastrophes that people fear because they may cause buildings and other things to collapse very instantly. And almost majority of the structures destroyed by earthquakes are man-made. Another way earthquakes kill people is by damaging man-made infrastructure including buildings, dams, bridges, and landslides. Many earthquakes provide little to no notice before they hit, which makes earthquake engineering even more challenging.

Some of the most serious problems with earthquake design arise from the architect's first concept decision. No amount of engineering can ensure that a structure is earthquake resistant if its design is inadequate. Damage from earthquakes demonstrates that building form is crucial to their reaction. In an ideal building form, the elevation and plan are simple, regular, and symmetrical. These characteristics improve a structure's uniform and predictable distribution of forces, whereas anomalies will surely lead to a more dynamic response, in certain parts of the building at least. Additionally, large-area constructions could not act as anticipated because of unpredictable differences in ground behaviour. As a result, the building experiences uneven shaking throughout, leading to noticeable issues. Buildings that have a large ratio of floor space to height, in contrast, will produce significant overturning moments. Torsional from ground motion might be a major problem due to the building's unusual shape. The need to consider torsional moment along a vertical axis when designing for cases where the centres of gravity and resistance are not in the same place is used to demonstrate the idea. There are three viable options for ensuring a building's seismic reaction is adequate. Aside from plastic hinges, the three most common types of mechanical devices used for structural control are isolation and energy absorption.

DAMPERS

Energy Dissipation System (Dampers)

Mechanics that channel the force of an earthquake into certain tools that may bend or break under the strain. They lessen the amount of seismic stress on a building by increasing energy dissipation in that building. The structure does not rely on them. Dampers absorb some of the seismic energy that passes through them, reducing the building's tremors. Actions by When seismic waves from the earth begin to infiltrate a building's foundation and cause the base to move, the presence or absence of dampers in the structure makes a difference. The structure will not move from its current location because of inertia.

SHEAR WALL

To transmit lateral stresses from outside walls, floors and roofs to the ground foundation in a direction parallel to their planes, a building's foundation may be reinforced with a shear wall, which is a stiff vertical diaphragm. The vertical truss and reinforced-concrete walls are two such examples. Torsional forces are very strong because they combine the lateral forces produced by wind, earthquakes, and uneven settlement loads with the weight of the building and its inhabitants. A structure may be sheared to pieces by these forces. A stiff wall, either attached to the outside of the frame or placed within it, may be used to reinforce it and keep it from rotating at the joints. Having shear walls is crucial for tall structures that are vulnerable to seismic and lateral wind impacts.

BRACINGS

Braced frames develop their resistance to lateral forces by the bracing action of diagonal members. The braces induce forces in the associated beams and columns so that all work together like a truss with all members subjected to stresses that are primarily axial.

BRACED STRUCTURE LITERATURE REVIEW

Baikerikar Abhijeet and Kanagali Kanchan

Disasters caused by earthquakes have been known to humans since ancient times. Due to their heightened sensitivity to seismic shaking and thinner construction, modern structures are more likely to collapse during an earthquake. Scientists and engineers have long worked to ensure that these structures can withstand earthquakes. Several empirical research have shown that using lateral load resisting technology in building design greatly improves earthquake performance. We examined several shear wall and bracing designs at different heights, up to 75 m, using ETABS 9.7.0, a square grid with dimensions of 20 m x 5 m bays in all directions. To study the effects of different scenarios and altitudes, seismic components such base shear, lateral displacements, and lateral drifts are simulated. Extensive research has been conducted on Zone V and all soil types listed in IS 1893-2002.

The building's height is directly proportionate to the increases in drift and lateral displacements. When compared to the other instances, Case 1 (Bare Frame) causes the biggest lateral displacements and drifts.Inserting shear walls and bracings into the bare frame significantly decreases drift and lateral displacements. For example, when soil texture changes from hard to soft, lateral displacements, base shear, and drifts all increase significantly. This is an important finding from the previous studies. With soft soil, you need to be extra careful. Because time is directly proportional to mass, the time needed to finish a building's activities increases as the building's height does as well. From what we can see, Case 2 (the Middle Shear Wall) is the most productive and efficient of the bunch. Base shear decreases with the passage of time. Shear walls and bracings, once installed, significantly shorten the duration.

Shaik, A.K. Mohammed Azam and Vinod Hosur

Improved performance during seismic events is achieved by the dual structural system consisting of a concrete shear wall and a special moment resistant frame (SMRF), thanks to its increased lateral stiffness and strength. Integrating a well-planned system of shear walls into a building's structure significantly improves its seismic performance. In order to find the best structural framing system for increased seismic resistance, we test several configurations of RC moment resistant framed building structures with different shear wall arrangements. We may test the structure's stiffness, damping properties, and strength by arranging the shear walls in different ways within the framework. Response spectra and nonlinear static pushover are two examples of the analytical methods used to evaluate seismic performance. Based on the study, shear walls should be symmetrically placed in the outermost moment resistant frames of the structure and preferably connected in mutually perpendicular directions to form a core for superior seismic performance.

Abhijeet Baikerikar, Kanchan Kanagali

We know that earthquakes cause disasters from ancient times. These days, buildings are thinner and more prone to swaying, making them more perilous in the event of an earthquake. In the past, engineers and researchers have sought to make the buildings as earthquake resistant as possible. The use of lateral load resisting technologies into building layouts has been shown to significantly enhance seismic performance in several empirical investigations. In this study, we used ETABS 9.7.0 software, a square grid with dimensions of 20 m x 5 m in all directions, to analyse various situations involving shear walls and bracings at varying heights; the highest height that was taken into account was 75 m. Seismic factors such as base shear, lateral displacements, and lateral drifts are modelled to investigate the impact of various situations and heights. Zone V and all soil types described in IS 1893-2002 have been thoroughly studied. Topics covered include seismic zone, soft soil, lateral displacements, bracings, shear walls, lateral load resisting systems, time period, response spectrum method, and base shear.

SHEAR WALL BRACINGS AND DAMPERS SHEAR WALLS

Shear walls are vertical structural components that are capable of withstanding the lateral loads and the combined shear, moment, and axial forces applied by gravity. In most cases, reinforced concrete walls—which may include lift wells or shear walls—are necessary for multi-story structures. When a structure's centroid and mass centre are in perfect alignment, the result is optimal design. Installing a shear wall is a great approach to fortify a building's framework because of its principal function: increasing stiffness for lateral load resistance.To protect themselves from the lateral loads caused by earthquakes and wind, modern skyscrapers often use shear walls as a vertical structural component (see image). Typical rectangular cross sections are not the only possible for shear walls; cannel, T, L, barbell, box, etc., cross sections are also possible. Walls help to enclose areas, while cores store and transport utilities like elevators. As a general rule, holes must be made into walls in order to install windows on exterior walls, doors or passageways on internal walls, or lift cores. There may be differences in the size and positioning of openings from an architectural and functional standpoint.

In recent years, shear wall construction has gained popularity for use in high-rise structures, especially those that house service apartments or function as office or commercial towers. Results for structures with 30–35 stories have shown the system's efficacy (MARSONO & SUBEDI, 2000). No tall building including a shear wall has collapsed as a result of an earthquake or strong wind in the thirty years that records have been kept (FINTEL, 1995).

DAMPERS

In seismic structures upgrading, one of the lateral force reduction caused by the earthquake is use of dampers. During an earthquake, high energy is applied to the structure. This energy is applied in two types of kinetic and potential (strain) to structure and it is absorbed or amortized. If structure is free of damping, its vibration will be continuously, but due to the material damping, vibration is reduced. Input energy caused by earthquake to structure is presented in the following equation:

$$E = E_k + E_s + E_n + E_d \quad (1)$$

Here, E represents the input energy of the earthquake, Ek stands for kinetic energy, Es for reversible strain energy in the elastic range, Eh for the amount of energy lost due to inelastic deformation, and Ed for the amount of energy amortised by the additional damper. Seismic isolation systems that use energy dissipation technologies have a specific place for them. Possible methods for improving damping include the flow of a pliable metal, the friction between two metals, the piston's movement within a slimy substance, or the viscoelastic behaviour of materials, such as rubber-like substances.

Structural Reaction Modulation via Damping

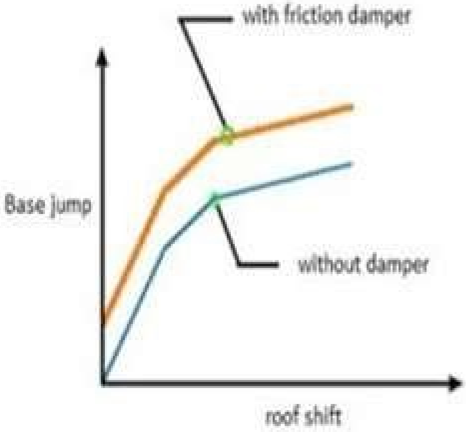
The acceleration and displacement that make up the structural reaction are dampened when the damping amount is increased. At low frequencies (around zero), damping has little effect on the spectrum amount; at high frequencies, it accelerates the response. Figures 1 and 2 show that the damping effect is most apparent in the frequency range of 0.3 to 2.5 seconds.

TYPES OF DAMPERS

Different types of dampers are defined by their characteristics and how they work: frictional, metal-flowing, viscous, viscoelastic, shape memory alloy (SMA), and mass. Dampers have several benefits, including a high energy absorption rate, ease of installation and replacement, and synchronisation with other structural parts. in the year 2006, according to the journal.

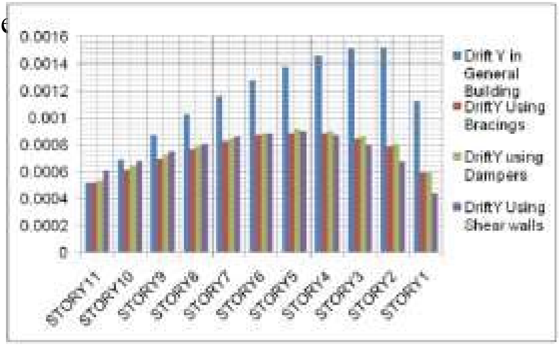
Friction Dampers

In this type of damper, seismic energy is spent in overcoming friction in the contact surfaces. Among other features of these dampers can be classified as avoiding fatigue in served loads (due to the non- active dampers under load) and their performance independent to loading velocity and ambient temperature. These dampers are installed in parallel to bracing (journal, 2006).



The effect of using friction dampers on structure capacity curve

Rotational friction dampers are shown. Because of ve



and make, this type of damper is converted to one the most common types of friction dampers.

(Warn, 2004)Using rotational friction dampers in retrofitting.

BRACINGS

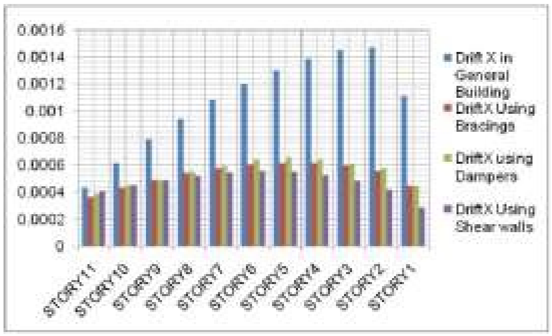
Any building that is likely to experience lateral stresses should have a braced frame installed. A bracing frame strengthens a building to withstand lateral forces like earthquake and wind. Members of a braced frame are often constructed from structural steel, a material that performs well in both compression and tension.

The bracing system distributes the lateral stresses, while the frame's beams and columns take up the vertical loads. In addition to lowering lateral displacement and column bending moments, braced frames are cost-effective, simple to construct, and provide the necessary design freedom to achieve the necessary stiffness and strength.

But, bracing, depending on their placement, may be a pain since they muck with façade designs and opening placements. In response, bracing has become an integral part of the design of many modernist and high-tech structures.

Support structures

Two bracing mechanisms give the necessary resistance to horizontal forces:



Story	Drift Y in General Building	DriftY Using Bracings	DriftY using Dampers	DriftY Using Shear walls
STORY11	0.000511	0.000517	0.000537	0.000605
STORY10	0.000693	0.000614	0.000644	0.000679
STORY9	0.000869	0.000696	0.000722	0.000745
STORY8	0.001026	0.000768	0.000788	0.000807
STORY7	0.001163	0.000826	0.000845	0.000837
STORY6	0.00128	0.000867	0.000885	0.000889
STORY5	0.001379	0.000888	0.000912	0.000895
STORY4	0.001459	0.000884	0.000899	0.000868
STORY3	0.001517	0.00085	0.00086	0.000799
STORY2	0.001522	0.000786	0.00081	0.000676
STORY1	0.001126	0.000592	0.000592	0.000439

Bracing that runs vertically

The transmission of horizontal forces to ground level is accomplished by load channels provided by bracing between column lines in vertical planes. A minimum of three vertical bracing planes were necessary for framed structures to withstand torsion around a vertical axis and brace in both planar and transverse directions.

Supporting horizontally

Loads may be transferred from the horizontal planes to the vertical bracing planes via the load routes provided by the bracing at each floor level. Although the floor system could provide enough resistance, horizontal bracing is required at every level. Bracing may be necessary for roofs.

RESULTS AND ANALYSIS

DRIFT IN X DIRECTION

Story	Drift X in General Building	DriftX Using Bracings	DriftX using Dampers	DriftX Using Shear walls
STORY11	0.000433	0.000362	0.000382	0.00041
STORY10	0.000613	0.000431	0.000451	0.000453
STORY9	0.000788	0.000488	0.000488	0.000489
STORY8	0.000944	0.000537	0.000547	0.00052
STORY7	0.001082	0.000576	0.000586	0.000543
STORY6	0.001201	0.000603	0.000633	0.000554
STORY5	0.001304	0.000616	0.000656	0.000551
STORY4	0.00139	0.000614	0.000634	0.000529
STORY3	0.001456	0.000594	0.00061	0.000485
STORY2	0.001474	0.000537	0.000577	0.000415
STORY1	0.00111	0.000446	0.000446	0.000288

DRIFT IN Y DIRECTION

STORY SHEAR

Story	Force VX in general building	Force VX for Bracing systems	Force VX in Dampers	Force VX in Shear wall
STORY11	-637.37	-731.52	-731.52	-920.88
STORY10	-1320.13	-1475.35	-1675.35	-1875.6
STORY9	-1917.44	-2138.46	-2188.46	-2735.93
STORY8	-2456.1	-2729.27	-2769.27	-3517.29
STORY7	-2942.95	-3256.18	-3276.18	-4227.1
STORY6	-3384.8	-3727.61	-3787.61	-4874.77
STORY5	-3788.47	-4151.95	-4161.95	-5469.71
STORY4	-4160.78	-4537.61	-4577.61	-6021.33
STORY3	-4508.54	-4893.01	-5112.01	-6539.09
STORY2	-4838.58	-5226.55	-5226.55	-7032.35
STORY1	-5137.78	-5546.75	-5546.75	-7526.42

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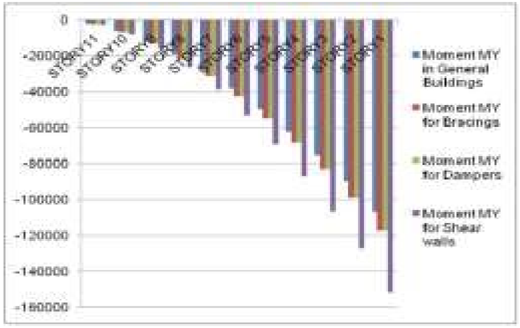
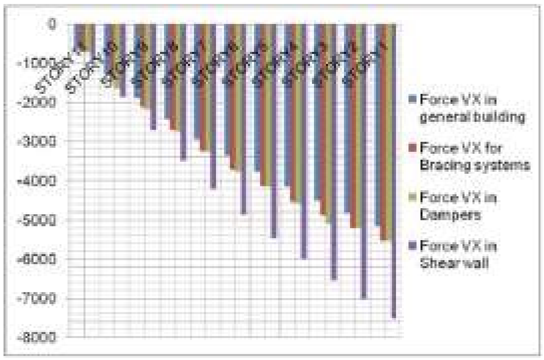
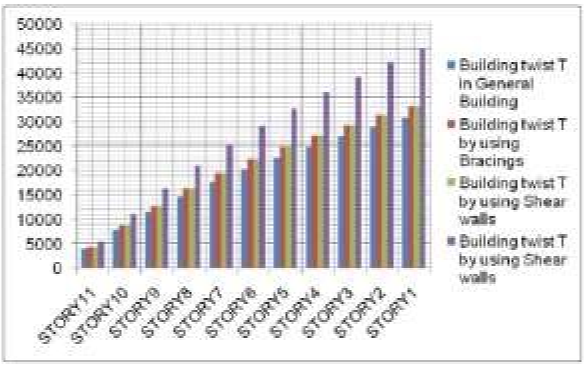




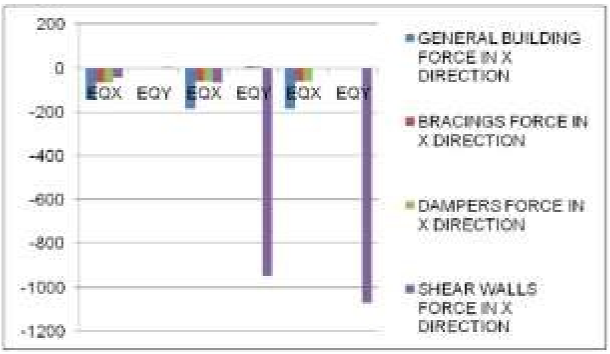
Story	Building twist T in General Building	Building twist T by using Bracings	Building twist T by using Dampers	Building twist T by using Shear walls
STORY11	3944.245	4389.112	4389.112	5525.297
STORY10	7920.79	8852.077	8852.077	11241.6
STORY9	11504.61	12830.77	12830.77	16415.39
STORY8	14736.62	16375.63	16375.63	21103.77
STORY7	17657.72	19337.1	19337.1	25362.61
STORY6	20308.83	22365.64	22365.64	29248.62
STORY5	22730.85	24911.68	24911.68	32818.28
STORY4	24964.68	27225.67	27225.67	36128.08
STORY3	27051.25	29358.06	29358.06	39234.52
STORY2	29031.45	31339.3	31339.3	42194.08
STORY1	30946.66	33280.39	33280.39	45138.53

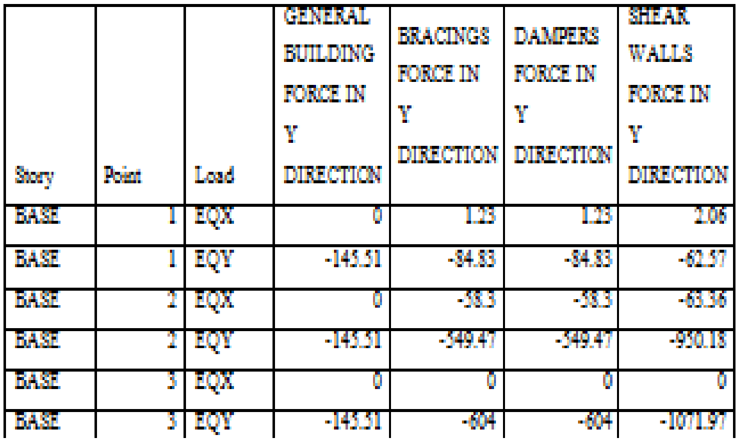


Story	Moment MY in General Buildings	Moment MY for Bracings	Moment MY for Dampers	Moment MY for Shear walls
STORY11	-1972.12	-2194.56	-2194.56	-2526.4
STORY10	-5932.52	-6620.6	-6620.6	-7910.95
STORY9	-11684.8	-13036	-13036	-15882.5
STORY8	-19035.1	-21225.8	-21225.8	-26198.1
STORY7	-27882	-30992.3	-30992.3	-38643.2
STORY6	-38036.4	-42175.2	-42175.2	-53031.2
STORY5	-49401.8	-54631	-54631	-69204.1
STORY4	-61884.2	-68243.8	-68243.8	-87031.9
STORY3	-75409.8	-82922.9	-82922.9	-106413
STORY2	-89925.5	-98602.5	-98602.5	-127274
STORY1	-106946	-116907	-116907	-151825

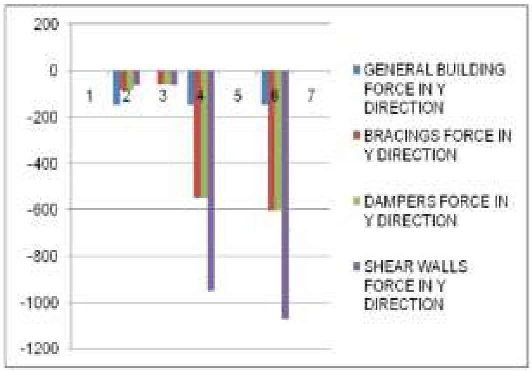
Story	Point	Load	GENERAL BUILDING FORCE IN X DIRECTION (FX)	BRACINGS FORCE IN X DIRECTION (FX)	DAMPERS FORCE IN X DIRECTION (FX)	SHEAR WALLS FORCE IN X DIRECTION (FX)
BASE	1	EQX	-144.95	-66.21	-66.21	-43.27
BASE	1	EQY	0	1.54	1.54	2.9
BASE	2	EQX	-185.36	-61.03	-61.03	-63.36
BASE	2	EQY	0	7.17	7.17	-950.18
BASE	3	EQX	-185.36	-60.24	-60.24	0
BASE	3	EQY	0	0	0	-1071.97

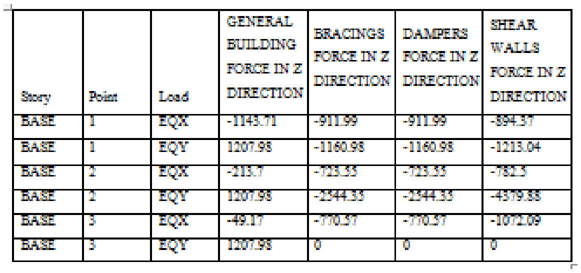
SUPPORT REACTIONS



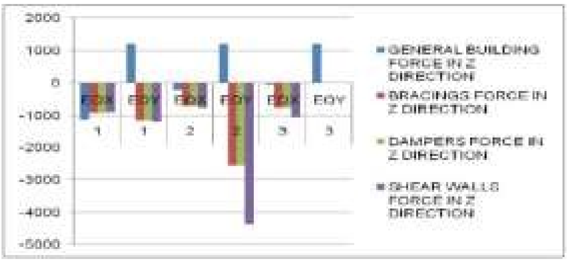


Story	Point	Load	GENERAL BUILDING FORCE IN Y DIRECTION	BRACINGS FORCE IN Y DIRECTION	DAMPERS FORCE IN Y DIRECTION	SHEAR WALLS FORCE IN Y DIRECTION
BASE	1	EQX	0	1.23	1.23	2.06
BASE	1	EQY	-145.51	-84.83	-84.83	-62.57
BASE	2	EQX	0	-58.3	-58.3	-63.36
BASE	2	EQY	-145.51	-549.47	-549.47	-950.18
BASE	3	EQX	0	0	0	0
BASE	3	EQY	-145.51	-604	-604	-1071.97





Story	Point	Load	GENERAL BUILDING FORCE IN Z DIRECTION	BRACINGS FORCE IN Z DIRECTION	DAMPERS FORCE IN Z DIRECTION	SHEAR WALLS FORCE IN Z DIRECTION
BASE	1	EQX	-1145.71	-911.99	-911.99	-894.37
BASE	1	EQY	1207.98	-1160.98	-1160.98	-1213.04
BASE	2	EQX	-213.7	-723.55	-723.55	-782.5
BASE	2	EQY	1207.98	-2544.33	-2544.33	-4379.88
BASE	3	EQX	-49.17	-770.37	-770.37	-1072.09
BASE	3	EQY	1207.98	0	0	0



CONCLUSIONS

The following are the conclusions are:

1. When comparing Bracings and Dampers to conventional Buildings, the drifts or displacements of buildings with shear walls are smaller.
2. In contrast to the bracing, shear wall, and dampers scenarios, the whole building displays the most pronounced displacements and drifts.
3. Shear wall construction is certainly the most efficient and effective way, according to the study.

4. Using shear walls results in the maximum story shear for forces (V) and moment (M) compared to the other three scenarios (general, bracing, and dampers).
5. The shear wall scenario also has the highest building twist (T) value compared to other scenarios.
6. The narrative shear values consistently increase from story 11 to story 1 (top to bottom story).
7. The support responses for the shear wall instances were lower than those for the other situations in the investigation.

In regions with greater seismic intensities, a combination of shear walls and dampers is the most cost-effective option, while shear wall systems alone are not enough.

SCOPE FOR FURTHUR WORK

The research may be expanded to account for varying building design sizes by comparing the findings of systems located at different places.

- Additional research may be conducted by using other methods and for varying heights.

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