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Performance Evaluation of Shear Wall, Dampers and bracings in high rise Buildings

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***Abstract**: During a seismic event, the input energy from the ground acceleration is transformed into both kinetic and potential (strain) energy which must be either absorbed or dissipated through heat. However, for strong earthquakes a large portion of the input energy will be absorbed by hysteretic action (damage to structure). So for many engineers, the most conventional approach to protect the structures (buildings and bridges) against the effects of earthquakes is to increase the stiffness. Energy dissipation systems in civil engineering structures are sought when it comes to removing unwanted energy such as earthquake and wind. Among these systems, there is combination of structural steel frames with passive energy dissipation provided.*

The field of Earthquake Engineering has existence from many years. Earthquake Engineers have made significant contributions to the seismic safety of several important structures in the country. Braced frames, besides other structural systems, such as moment resisting frames or shear walls, have been an effective and valuable method to enhance structures against lateral loads. In seismic excitations, inclined elements react as truss web elements which would bear compression or tension stresses. This axial reaction results in less moments and therefore smaller sizes in beam and column sections with respect to members in similar moment resisting frame. The study mainly focuses on the performance based design of high rise building with shear wall, X bracings, Friction dampers were introduced and compared with the general building. The results like story drifts, story displacements, story moments, shear force, and building torsion are compared by using commercial software of ETABS 9.7.4, In Zone IV and V with medium type of soil.

Keywords: high rise building with Shear wall, Bracings, friction dampers, ETABS 9.7.4, ZONE IV and ZONE V etc,.

1.Introduction

As the most vital images of today's urban communities, tall structures have turned into a wellspring of confidence in innovation and national pride, and have changed the idea of the cutting edge city alongside its scale and appearance. Because of the improvement of present day auxiliary frameworks and materials, the stature of a kilometre or more can be achieved. So it demonstrates that sky has no restriction for structural engineers. However, height of the building makes it more vulnerable to wind and earthquake induced lateral loads. To meet the serviceability requirements under the lateral loads .Traditionally, structures were over designed to resist dynamic forces, as such given off from a seismic activity. These structures would be high in stiffness and strength. So during a seismic activity they would absorb this energy and then deform beyond their elastic limit. Nowadays structural protective systems are designed to prevent this from happening. These modern structural protective systems can be divided into three parts. They are seismic isolation, passive energy dissipation and semi active and active systems.

The seismic performance of a building can be improved by using energy absorbing devices or shear walls. Passive control systems such as base isolation, dampers, bracing systems etc are found to be easy to install and cost effective as compared to previous one. Also shear walls are found very effective for open ground storey buildings. Use of dampers is now becoming cost effective solution to improve seismic performance of existing as well as new buildings.

2. PASSIVE ENERGY DEVICES

The main reason to use passive energy dissipation devices in a structure is to limit damaging deformations in structural components. The degree to which a certain device is able to accomplish this goal depends on the inherent properties of the basic structure, the properties of the device and its connecting elements, the characteristics of the ground motion. Device that have most commonly been used for seismic protection of structures include bracings, viscous fluid dampers, visco elastic solid dampers, friction dampers and metallic dampers. Semi-active dampers have also been used for seismic response control.

BRACINGS

Design of earthquake resistant structures in recent years has undergone several changes and improvements which have focused mainly on altering design criteria from ‘design based on resistance’ to ‘design based on performance’. As it is well-known, most of the current design methods of seismic codes are based on linear analysis of forces in structural elements along with controlling the inter-story drift values, and the codes try to consider the concept of structural plastic behavior by applying the so-called ‘Response Modification Factor’ (R).

TYPES OF BRACINGS

There are two major bracing systems:

- ✓ Vertical bracing system
- ✓ Horizontal bracing system

Vertical bracing system

Vertical bracing are diagonal bracings installed between two lines of columns. Not only does it transfer horizontal loads to the foundations (create load path for horizontal forces) but also it withstands overall sway of the structure.

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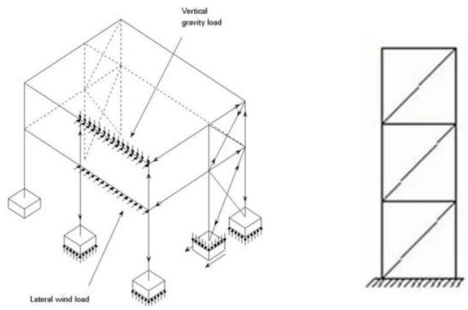

Fig 1.Configurations of vertical bracings include cross diagonals (cross bracing) and single diagonal.

Horizontal Bracing System

Horizontal bracing systems purpose is the transfer of horizontal loads from columns at the perimeter of the structure to the planes of vertical bracing. The horizontal forces on perimeter columns are generated because of wind force pressure on the cladding of the structure. There are two major types of horizontal bracing systems which are used in the multi-storey braced steel structure namely: diaphragms and discrete triangulated bracing. Regarding diaphragms, there are various types of floor systems that some of them provide perfect horizontal diaphragm such as composite floors whereas others such as precast concrete slabs need specific measures to satisfactory serve their purpose.

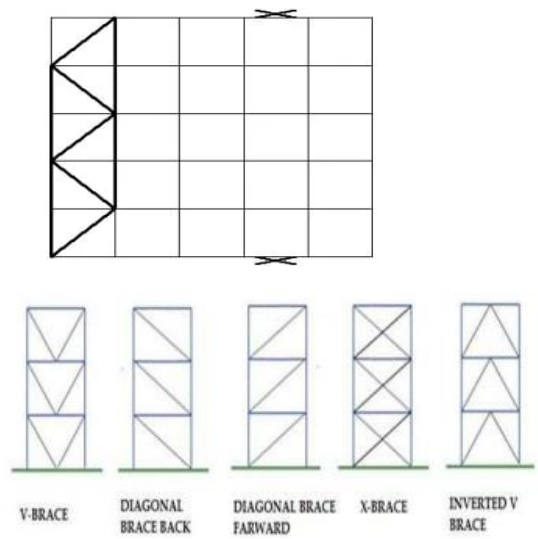

Fig 2: different types of bracings

DAMPERS

Dampers are classified based on their performance of friction, metal (flowing), viscous, viscoelastic; shape memory alloys (SMA) and mass dampers. Among the advantages of using dampers we can infer to high energy absorbance, easy to install and replace them as well as coordination to other structure members.

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.

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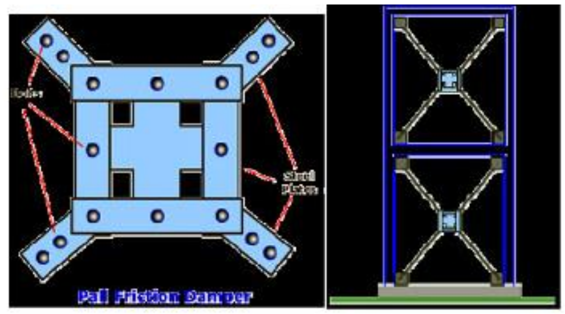
Fig 3:Friction dampers

PVD Damper

It is another type of friction damper and due to ease to installation, is one of the most widely used damper in structures. PVD damper can be used to create necessary damping for flexible structures, such as bending steel frame or to provide effective damping to relative stiffness of structures PVD damper is designed to installation where displacement can generate necessary damping such as installation of metal skeleton brace or concrete moment frame.

Pall Friction Damper

Another type of friction damper is Pall friction damper. This damper includes a bracing and some steel plate with friction screws. And they should be installed in the middle of bracing. Steel sheets are connected to each other by high strength bolts and they have a slip by a certain force, to each other.



Metallic Dampers

In this damper, transferred energy to the structure is spent to submission and non-linear behavior in used element in damper. In these dampers, metal inelastic deformation is used such as for formability metals such as steel and lead for energy dissipation.

Viscous Dampers

In this damper, by using viscous fluid inside a cylinder, energy is dissipated. Due to ease of installation, adaptability and coordination with other members also diversity in their sizes, viscous dampers have many applications in designing and retrofitting.

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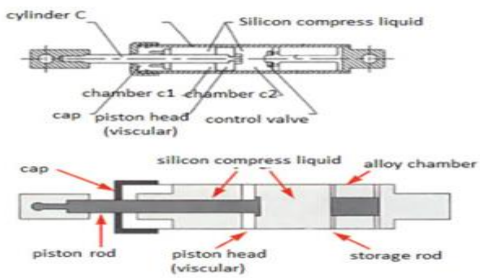


SHEAR WALL

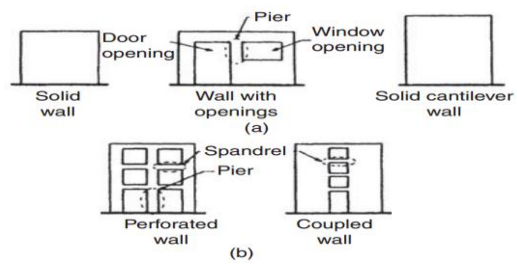
Shear wall is a structural member used to resist lateral forces i.e. parallel to the plane of the wall. For slender walls where the bending deformation is more, Shear wall resists the loads due to Cantilever Action.

In building construction, a rigid vertical diaphragm capable of transferring lateral forces from exterior walls, floors, and roofs to the ground foundation in a direction parallel to their planes. Examples are the reinforced-concrete wall. Lateral forces caused by wind, earthquake, and uneven settlement loads, in addition to the weight of structure and occupants; create powerful twisting (torsional) forces.

TYPES OF SHEAR WALL

A shear wall with openings can be analyzed as a frame composed of short stiff wall segments (also called piers). In many shear walls, a regular pattern of windows or doors, or both, is required for functional considerations. In such cases, the walls between the openings may be interconnected by spandrels (or beams), resulting in coupled shear walls.

The connecting elements (i.e., beams) between coupled shear walls typically require horizontal and vertical reinforcement to transfer shear from one segment of the wall to the other. When the connecting elements are incapable of transferring shear from one shear wall to the other, the walls are referred to as non-coupled and can be analyzed as cantilevers fixed at the base.



3. Objective of the study

- To find the seismic behavior of the high rise buildings with shear wall, dampers, and bracings and compared with the bare framed structure to analyze the seismic behavior.
- To find the story displacement, building torsion and bending moment, shear force of the structure with shear wall, friction dampers, X shaped bracings and compared with bare framed structure.
- To find the best suitable structure that suited for the different seismic zone of zone IV and zone V among the structural buildings.
- To design the high rise structure by using commercial software like ETABS 9.7.2
- To analyze the structure by ductile based design to resist against the gravity loads and global loads .
- To analysis the structural model by using the response spectrum analysis as per the IS1893:2002(part 1).

4. SCOPE OF THE STUDY

1. In this thesis 25 storey concrete frame is analyzed for the rectangular plan of 30x20 m by considering Z-IV and Z-V for soil type-II.
2. In this paper models are compared for different types of energy dissipation devices such as X bracing, dampers, shear wall by placing in different positions.
3. Results are obtained by considering the parameters like storey displacement, storey drift and storey shear.

4. Literature Review

A.Jesumi1, M.G. Rajendran2(2013) et and all,. has targeted on working out the inexpensive bracing gizmo for a given sort of tower heights. during this study 5 lattice towers with distinctive bracing configurations such as the X-B, K and Y bracings have been sculptured for a given vary of height. The heights of the towers ar 40m and 50m with a base breadth of 2m and 5m severally. The tower of peak 40m has 13 panels and therefore the tower of high 50m has 16 panels. 70-72% of the peak is provided for the tapered half and 28-30% of the peak is provided for the instantly a part of the tower.

The tower has been sculptured victimization geometric coordinates. The leg, diagonal bracings and horizontal bracings ar given perspective sections. `Modulus, Poisson's magnitude relation, density, alpha and damping ar the fabric homes used for the analysis. A subfigure dome was assumed to be attached at the head panels of the towers. The towers are analyzed brooding about it to behave as an area structure with pin joints, for dynamic wind loading and optimized style became completed. The displacements associated weights of the towers received had been as compared to achieve at an top-rated resolution.

Analytical studies were conferred to find the foremost applicable association and price-effective bracing machine of gold-bearing lattice towers for the powerful resistance against lateral forces. The joint displacement and weights ar the widespread parameters received from the analysis. However, there is not any adequate knowledge regarding the permissible displacement for towers. From the outcomes non heritable, Y bracing has been found to be the foremost at intervals your suggests that bracing system up to a height of 50m.

5. PROBLEM STATEMENT

Type of building : Residential buildings

Shape of the building : Rectangular building

Size of columns : 0.55X0.55 mts

Size of beams : 0.45X0.45 mts

Size of slab :0.125 mts

Material property : M40 , Fe415

IS codes used : IS 456:2000, IS 800:2007, IS 1893:2002(part 1), IS 875

LOADS CONSIDERED : DEAD ,LIVE,FLOOR,EARTHQUAKE, WIND LOADS

SPECIAL CONSIDERATIONS: X BRACINGS FRICTION DAMPERS, SHEAR WALLS

SESIMIC ANALYSIS :RESPONSE SPRECTRUM ANALYSIS

6. LOADS ACTING ON THE STRUCTURE

Types of loads acting on the structure are:

- Dead loads
- Imposed loads
- Wind loads
- Earthquake loads

Dead load:

All permanent constructions of the structure form the dead loads. The dead load comprises of the weights of walls, partitions floor finishes, false ceilings, false floors and the other permanent constructions in the buildings. The dead load loads may be calculated from the dimensions of various members and their unit weights. the unit weights of plain concrete and reinforced concrete made with sand and gravel or crushed natural stone aggregate may be taken as 24 kN/m” and 25 kN/m” respectively.

IMPOSED LOADS:

Imposed load is produced by the intended use or occupancy of a building including the weight of movable partitions, distributed and concentrated loads, load due to impact and vibration and dust loads. Imposed loads do not include loads due to wind, seismic activity, snow, and loads imposed due to temperature changes to which the structure will be subjected to, creep and shrinkage of the structure, the differential settlements to which the structure may undergo.

The code gives the values of live loads for the following occupancy classification:

- Residential buildings – dwelling houses, hotels, hostels, boiler rooms and plant rooms, garages.
- Educational buildings
- Assembly buildings
- Business and office buildings
- Mercantile buildings
- Industrial buildings and
- Storage rooms.

WIND LOAD:

Wind is air in motion relative to the surface of the earth. The primary cause of wind is traced to earth’s rotation and differences in terrestrial radiation. The radiation effects are primarily responsible for convection either upwards or downwards. The wind generally blows horizontal to the ground at high wind speeds

Design Wind Speed (V,)

The basic wind speed (V,) for any site shall be obtained from and shall be modified to include the following effects to get design wind velocity at any height (V,) for the chosen structure:

a) Risk level;

b) Terrain roughness, height and size of structure; and

c) Local topography.

It can be mathematically expressed as follows: Where:

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V = Vb * kl * k* ks

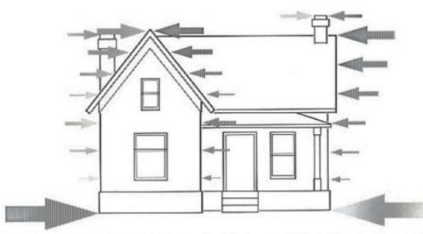
Vb = design wind speed at any height z in m/s

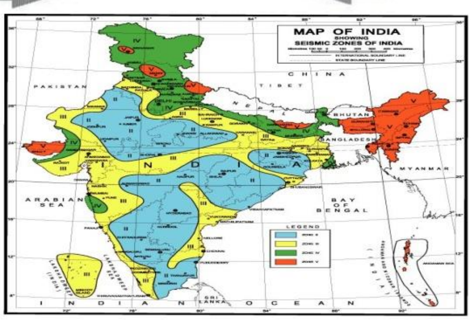
kl = probability factor (risk coefficient)

k = terrain, height and structure size factor and ks = topography factor

SEISMIC LOAD

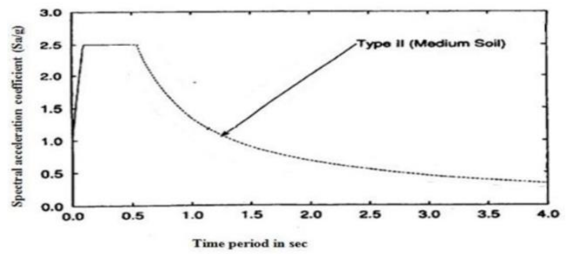
The design lateral force shall first be computed for the building as a whole. This design lateral force shall then be distributed to the various floor levels.





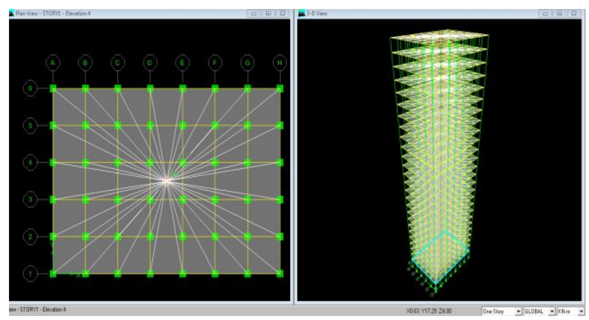
Response spectrum method

The representation of maximum response of idealized single degree freedom system having certain period and damping, during earthquake ground motions. This analysis is carried out according to the code IS 1893-2002 (part1). Here type of soil, seismic zone factor should be entered from IS 1893-2002 (part1).

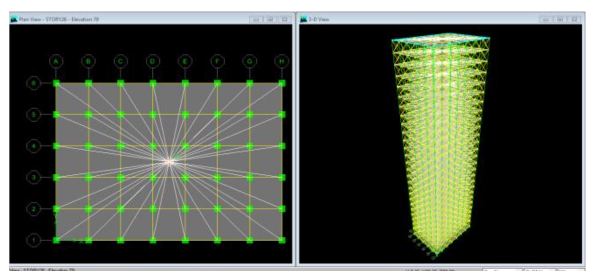


ETABS MODELLING

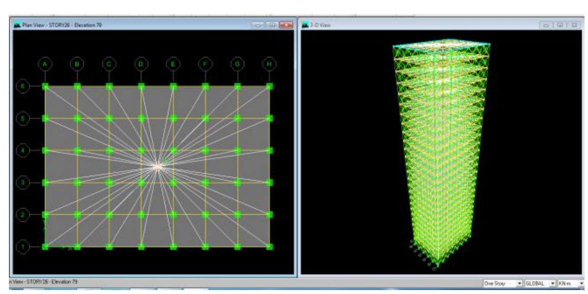
A.GENERAL BUILDING



B.BRACED BUILDING



C.DAMPERS BUILDING



D.SHEAR BUILDING

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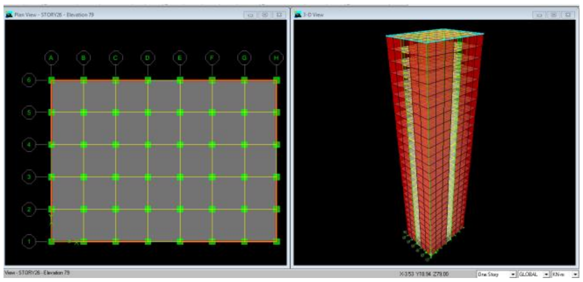
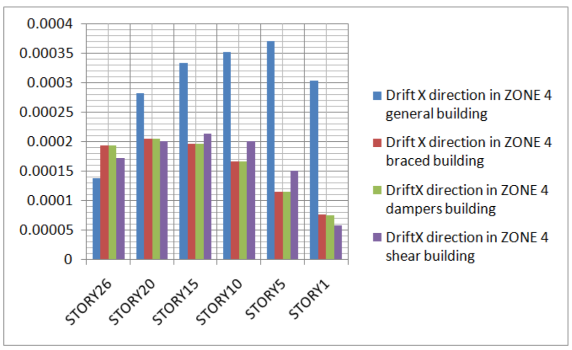


7. RESULTS AND ANALYSIS

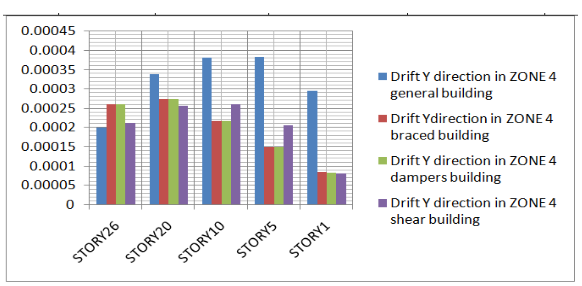
DRIFT X DIRECTION IN ZONE IV

Story	Load	Drift X direction in ZONE 4 general building	Drift X direction in ZONE 4 braced building	Drift X direction in ZONE 4 dampers building	Drift X direction in ZONE 4 shear building
STORY26	RSA	0.000137	0.000193	0.000193	0.000172
STORY20	RSA	0.000283	0.000205	0.000205	0.000201
STORY15	RSA	0.000334	0.000197	0.000197	0.000213
STORY10	RSA	0.000352	0.000167	0.000167	0.0002
STORY5	RSA	0.000371	0.000114	0.000114	0.00015
STORY1	RSA	0.000304	0.000076	0.000074	0.000058



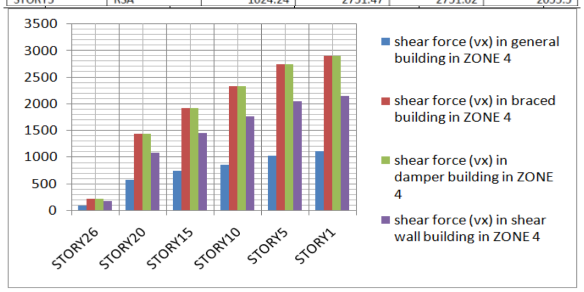
DRIFT Y IN ZONE V

Story	Load	Drift Y direction in ZONE 4 general building	Drift Y direction in ZONE 4 braced building	Drift Y direction in ZONE 4 dampers building	Drift Y direction in ZONE 4 shear building
STORY26	RSA	0.000199	0.000261	0.000261	0.000211
STORY20	RSA	0.000339	0.000273	0.000273	0.000256
STORY10	RSA	0.000382	0.000218	0.000218	0.000261
STORY5	RSA	0.000384	0.000148	0.000148	0.000206
STORY1	RSA	0.000296	0.000084	0.000082	0.00008



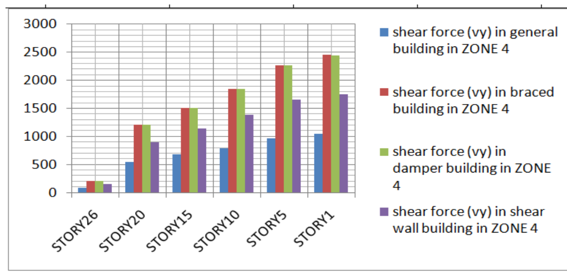
SHEAR FORCE IN X DIRECTION IN ZONE IV

Story	Load	shear force (vx) in general building in ZONE 4	shear force (vx) in braced building in ZONE 4	shear force (vx) in damper building in ZONE 4	shear force (vx) in shear wall building in ZONE 4
STORY26	RSA	85.35	212.02	212.01	167.06
STORY20	RSA	564.6	1438.26	1438.11	1081.58
STORY15	RSA	735.2	1918.78	1918.7	1450.69
STORY10	RSA	851.5	2335.88	2336.06	1767.97
STORY5	RSA	1024.24	2751.47	2751.02	2055.5



SHEAR FORCE IN Y DIRECTION IN ZONE IV

Story	Load	shear force (vy) in general building in ZONE 4	shear force (vy) in braced building in ZONE 4	shear force (vy) in damper building in ZONE 4	shear force (vy) in shear wall building in ZONE 4
STORY26	RSA	84.6	201.87	201.8	145.38
STORY20	RSA	539.73	1203.36	1202.94	901.23
STORY15	RSA	683.21	1500.47	1500.47	1139.2
STORY10	RSA	787.96	1846.2	1846.4	1380.5
STORY5	RSA	962.78	2263.49	2263.08	1658.51
STORY1	RSA	1043.4	2452.4	2449.44	1745.43



BUILDING TORSION IN ZONE IV

Story	Load	building torsion in general building in ZONE 4	building torsion in braced building in ZONE 4	building torsion in damper building in ZONE 4	building torsion in shear wall building in ZONE 4
STORY26	RSA	1094.957	2649.788	2649.164	1974.81
STORY20	RSA	7074.424	16613.48	16609.42	12463.94
STORY15	RSA	9048.016	21338.03	21337.77	16169.65
STORY10	RSA	10451.64	26128.46	26130.92	19645.15
STORY5	RSA	12696.71	31475.37	31469.85	23257.66
STORY1	RSA	13733.99	33746.59	33713.76	24374.91

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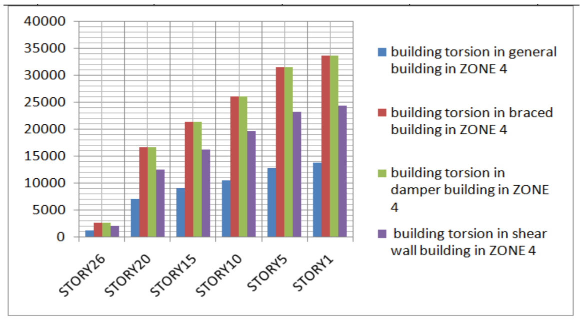
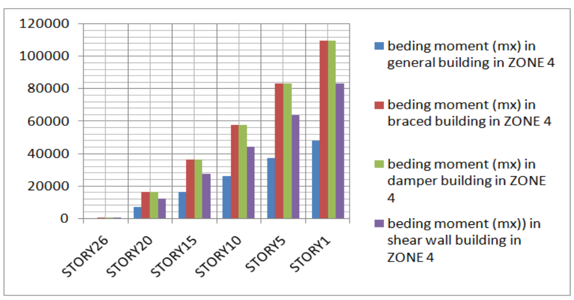


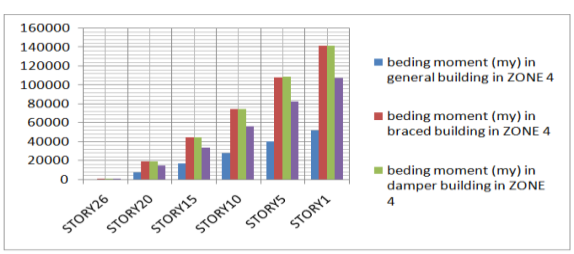
BUILDING MOMENT IN X DIRECTION IN ZONE IV

Story	Load	bending moment (mx) in general building in ZONE 4	bending moment (mx) in braced building in ZONE 4	bending moment (mx) in damper building in ZONE 4	bending moment (mx)) in shear wall building in ZONE 4
STORY26	RSA	253.799	605.614	605.408	436.127
STORY20	RSA	7013.784	16322.19	16316.03	11927.68
STORY15	RSA	16413.89	36075.34	36065.28	27332.45
STORY10	RSA	26435.64	57835.77	57831.85	44271.82
STORY5	RSA	37247.34	83367.11	83374.83	63687.54
STORY1	RSA	48148.6	109618.9	109626.7	83089.78



BUILDING MOMENT IN Y DIRECTION ZONE IV

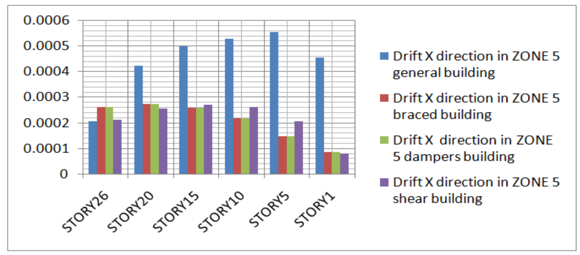
Story	Load	bending moment (my) in general building in ZONE 4	bending moment (my) in braced building in ZONE 4	bending moment (my) in damper building in ZONE 4	bending moment (my)) in shear wall building in ZONE 4
STORY26	RSA	256.062	636.047	636.021	501.172
STORY20	RSA	7247.144	18635.28	18633.7	14052.1
STORY15	RSA	17286.85	44244.58	44240.12	33363.41
STORY10	RSA	28311.91	74151.24	74147.92	56054.32
STORY5	RSA	40256.27	108462.1	108463.5	82086.3
STORY1	RSA	52086.73	141848.4	141846.2	107132.9



ZONE V

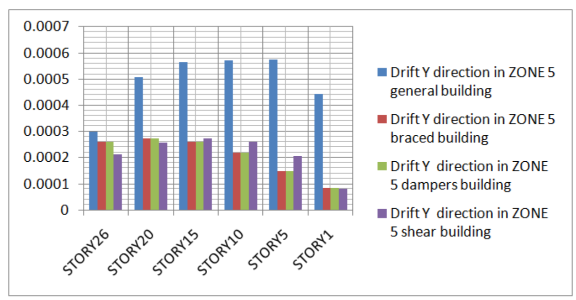
DRIFT IN X DIRECTION ZONE V

Story	Load	Drift X direction in ZONE 5 general building	Drift X direction in ZONE 5 braced building	Drift X direction in ZONE 5 dampers building	Drift X direction in ZONE 5 shear building
STORY26	RSA	0.000206	0.000261	0.000261	0.000211
STORY20	RSA	0.000424	0.000273	0.000273	0.000256
STORY15	RSA	0.000501	0.000259	0.000259	0.000272
STORY10	RSA	0.000528	0.000218	0.000218	0.000261
STORY5	RSA	0.000557	0.000148	0.000148	0.000206
STORY1	RSA	0.000456	0.000084	0.000084	0.00008



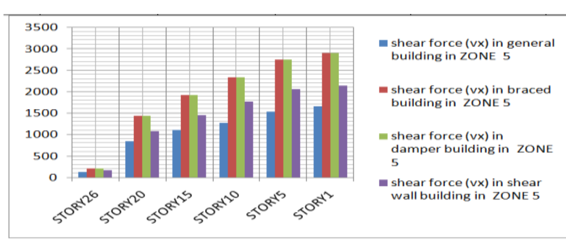
DRIFT IN Y DIRECTION ZONE V

Story	Load	Drift Y direction in ZONE 5 general building	Drift Y direction in ZONE 5 braced building	Drift Y direction in ZONE 5 dampers building	Drift Y direction in ZONE 5 shear building
STORY26	RSA	0.000298	0.000261	0.000261	0.000211
STORY20	RSA	0.000509	0.000273	0.000273	0.000256
STORY15	RSA	0.000569	0.000259	0.000259	0.000272
STORY10	RSA	0.000573	0.000218	0.000218	0.000261
STORY5	RSA	0.000576	0.000148	0.000148	0.000206
STORY1	RSA	0.000444	0.000084	0.000084	0.00008



SHEAR FORCE IN X DIRECTION ZONE V

Story	Load	shear force (vx) in general building in ZONE 5	shear force (vx) in braced building in ZONE 5	shear force (vx) in damper building in ZONE 5	shear force (vx) in shear wall building in ZONE 5
STORY26	RSA	128.03	212.02	212.02	167.06
STORY20	RSA	846.9	1438.26	1438.26	1081.58
STORY15	RSA	1102.8	1918.78	1918.77	1450.69
STORY10	RSA	1277.26	2335.88	2335.88	1767.97
STORY5	RSA	1536.36	2751.47	2751.47	2055.5
STORY1	RSA	1656.44	2908.25	2908.24	2142.71



SHEAR FORCE IN Y DIRECTION ZONE V

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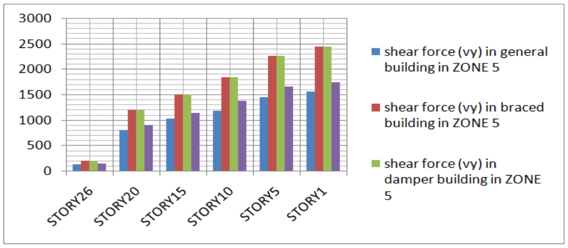
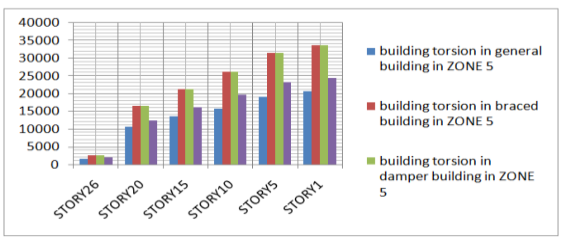
Story	Load	shear force (vy) in general building in ZONE 5	shear force (vy) in braced building in ZONE 5	shear force (vy) in damper building in ZONE 5	shear force (vy) in shear wall building in ZONE 5
STORY26	RSA	126.9	201.87	201.87	145.38
STORY20	RSA	809.59	1203.36	1203.36	901.23
STORY15	RSA	1024.82	1500.47	1500.47	1139.2
STORY10	RSA	1181.94	1846.2	1846.2	1380.5
STORY5	RSA	1444.17	2263.49	2263.49	1658.51
STORY1	RSA	1565.11	2452.4	2452.4	1745.43



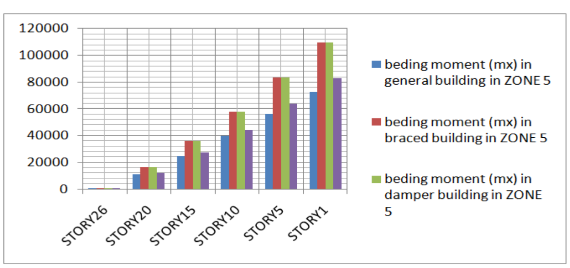
BUILDING TORSION IN ZONE V

Story	Load	building torsion in general building in ZONE 5	building torsion in braced building in ZONE 5	building torsion in damper building in ZONE 5	building torsion in shear wall building in ZONE 5
STORY26	RSA	1642.435	2649.788	2649.786	1974.81
STORY20	RSA	10611.64	16613.48	16613.43	12463.94
STORY15	RSA	13572.02	21338.03	21338.04	16169.65
STORY10	RSA	15677.46	26128.46	26128.58	19645.15
STORY5	RSA	19045.07	31475.37	31475.37	23257.66
STORY1	RSA	20600.98	33746.59	33746.46	24374.91



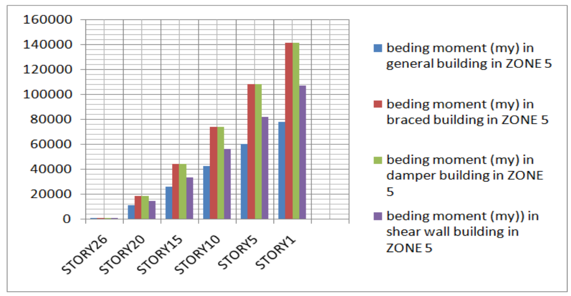
BENDING MOMENT IN X DIRECTION ZONE V

Story	Load	bending moment (mx) in general building in ZONE 5	bending moment (mx) in braced building in ZONE 5	bending moment (mx) in damper building in ZONE 5	bending moment (mx)) in shear wall building in ZONE 5
STORY26	RSA	380.699	605.614	605.614	436.127
STORY20	RSA	10520.68	16322.19	16322.19	11927.68
STORY15	RSA	24620.84	36075.34	36075.35	27332.45
STORY10	RSA	39653.46	57835.77	57835.77	44271.82
STORY5	RSA	55871.01	83367.11	83367.12	63687.54
STORY1	RSA	72222.9	109618.9	109618.9	83089.78



BENDING MOMENT IN Y DIRECTION ZONE V

Story	Load	bending moment (my) in general building in ZONE 5	bending moment (my) in braced building in ZONE 5	bending moment (my) in damper building in ZONE 5	bending moment (my)) in shear wall building in ZONE 5
STORY26	RSA	384.093	636.047	636.049	501.172
STORY20	RSA	10870.72	18635.28	18635.3	14052.1
STORY15	RSA	25930.28	44244.58	44244.57	33363.41
STORY10	RSA	42467.87	74151.24	74151.21	56054.32
STORY5	RSA	60384.41	108462.1	108462.1	82086.3
STORY1	RSA	78130.09	141848.4	141848.3	107132.9



8.CONCLUSIONS

- The drift value in X and Y direction in zone IV and ZONE V ,Braced building and dampers shows the significant effect in the zone IV and ZONE V . The drift values in the shear wall and general building is having high story drift.
- Shear force in general building has less values compared to the other structures. But in the stiffness concern the shear wall building is the best suited structure in the high seismic zones ZONE IV, and ZONE V.
- The building torsion is also less in the shear wall due to its lateral support with shear wall in the building.
- The lateral force resisting system has also been well performed while placing shear wall and bracing and dampers.
- Shear walls and braces improved the seismic performance of frames. The shear walls reduced the maximum lateral displacement at the top of 20, 15 and 10 storey.

- The friction dampers are found to be very effective in reducing the earthquake responses of the adjacent connected structures.
- The performance of building structure in seismic loading is improved to great extent.
- Working with the commercial software like ETABS saves a lot of time , accurate results can be obtained.
- Analyzing the above results the best suited structure to building high seismic zone IV,V is dampers building , braced building and shear wall building.
- The dampers building shows the least delections, bending moments and shear forces in the high seismic zones.
- The base shear obtained are lesser for model with damper than normal frame and very higher for the shear wall.
- This study also demonstrated that the introduction of energy dissipation in buildings results in a greater homogeneity of the relative

displacements in height, in order to get a more regular behavior of the building.

- In order to optimize the solution, by maximizing the seismic performance of the structure, it was concluded that the distribution of energy dissipation along the building should be in accordance to the evolution of displacements in height. More powerful dampers should be condensed where the displacements are higher, reducing at the same time, the displacements and the base shear force.

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