EFFECTIVE CONTROL OF BULDING MOTION BY PALL FRICTION DAMPERS

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Abstract: Extensive use of friction joints in new and retrofitted buildings has demonstrated the economic advantages of this form of device to control the amplitude of building motion due to seismic action. This thesis addresses in particular the use of friction devices in conjunction with rigid structural frames, with concrete frames. Elastic overall behavior under wind loads, lateral loads, gravity loads under the action of the extreme earthquake that the building is capable of resisting is analyzed and energy dissipating capability of yielding members is added to that of the friction joints.

Structures for which friction dampers are suitable and the choice of the gravity loads and dynamic loads are discussed together with and without dampers in the concrete frames with different columns sizes and are analyzed in Response spectrum analysis (RSA) with the help of the commercial software ETABS. Results are figured out with the lateral displacement, storey shear, lateral forces, storey moment , and overturning moments and graphs are plotted.

Keywords: Response Spectrum analysis, lateral forces, overturning moments, ETABS etc,.

I.INTRODUCTION

Earthquakes are natural phenomena, which cause the ground to shake. The earth's interior is hot and in a molten state. As the lava comes to the surface, it cools and new land is formed. The lands so formed have to continuously keep drifting to allow new material to surface. According to the theory of plate tectonics, the entire surface of the earth can be considered to be like several plates, constantly on the move. The study of the characteristics of the earthquake ground motion and its effects on engineered structures are the subjects of earthquake engineering. In particular, the effect of earthquakes on structures and the design of structures to withstand earthquakes with no or minimum damage is the subject of earthquake resistant structural design. The secondary effects on structures, due to floods and landslides are generally outside its scope.

In such a scenario, the onus of making the building and structure safe in earthquake-prone areas lies on the designers, architects, and engineers who conceptualize these structures. Codes and recommendations, postulated by the relevant authorities, study of the behavior of structures in past earthquakes and understanding the physics of earthquake are some of the factors that helps in the designing of an earthquake resistant structure. Earthquakes create vibrations on the ground that are translated into dynamic loads which cause the ground and anything attached to it to vibrate in a complex manner and cause damage to buildings and other structures.

Civil engineering is continuously improving ways to cope with this inherent phenomenon. Conventional strategies of strengthening the system consume more materials and energy. Moreover, higher masses lead to higher seismic forces. Alternative strategies such as passive control systems are found to be effective in reducing the seismic and other dynamic effects on civil engineering structures.

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:

$$E = E_k + E_s + E_n + E_d \quad \text{……………………………………(1)}$$

In this equation(1), E is earthquake input energy, E_k is kinetic energy, E_s is reversible strain energy in the elastic range and E_h is the amount of wasted energy due to inelastic deformation and E_d is the amount of amortized energy by additional damper. In seismic isolation systems, use of energy dissipation systems, allocated a special place to their selves. Damping increasing is possible by using various methods such as the flow of a soft metal, two metal friction on each other and a piston motion within a slimy substance or visco-elastic behavior in materials such rubber-like substances.

PROPERTIES OF DAMPERS

Damping (β): Damping is an influence within or upon an oscillatory system that has the effect of reducing, restricting or preventing its oscillations. In physical systems, damping is produced by processes that dissipate the energy stored in the oscillation. Examples include viscous drag in mechanical systems, resistance in electronic oscillators, and absorption and scattering of light in optical oscillators. Damping not based on energy loss can be important in other oscillating systems such as those that occur in biological systems.

Damping Ratio (n): The damping ratio is a dimensionless measure describing how oscillations in a system decay after a disturbance. Many systems exhibit oscillatory behavior when they are disturbed from their position of static equilibrium. A mass suspended from a spring, for example, might, if pulled and released, bounce up and down. On each bounce, the system is trying to return to its equilibrium position, but overshoots it. Sometimes losses (e.g. frictional) damp the system and can cause the oscillations to gradually decay in amplitude towards zero or attenuate. The damping ratio is a measure of describing how rapidly the oscillations decay from one bounce to the next.

Stiffness (k) : The stiffness, *k*, of a body is a measure of the resistance offered by an elastic body to deformation.

II.LITERATURE REVIEW

Shaik Kamal Mohammed Azam, Vinod Hosur The dual structural system consisting of special moment resisting frame (SMRF) and concrete shear wall has better seismic performance due to improved lateral stiffness and lateral strength. A well designed system of shear walls in a building frame improves its seismic performance significantly. The configurations of RC moment resisting framed building structure with different arrangements of shear walls are considered for evaluation of seismic performance, so as to arrive at the suitable arrangement of shear wall in the structural framing system for better seismic resistance. A comparison of structural behavior in terms of strength, stiffness and damping characteristics is done by arranging shear walls at different locations/configurations in the structural framing system. The elastic (response spectrum analysis) as well as in-elastic (nonlinear static pushover analysis) analyses are carried out for the evaluation of seismic performance. The results of the study indicate that the provision of shear walls symmetrically in the outermost moment resisting frames of the building and preferably interconnected in mutually perpendicular directions forming a core will lead to better seismic performance.

Gang Li and Hong-Nan Li et al., (2013) A new type of metallic damper is presented in this study. It is so-called as "dual functions" metallic damper, since it has two characteristics of high initial stiffness and good energy dissipating capability. Its initial stiffness is increased through making it bearing exterior in-plane force, and its energy-dissipating capability is improved through making it different shapes. Quasi-static tests with scale and full-scale models of the metallic dampers specimens designed with above idea are carried out, respectively. Two outstanding metallic dampers named round-hole metallic damper (RHMD) and double X-shaped metallic damper (DXMD) were selected and the DXMD was applied in an actual steel structure to improve initial stiffness of original structure under normal use or frequency earthquake and to dissipate inputting energy during great earthquakes. In addition, a three-dimensional model was established using finite element software and dynamic response comparison of the steel structure with and without DXMDs was conducted. The results shown that the metallic dampers presented here not only provide certain stiffness in the normal application, but also are of good ability of energy dissipation. The inelastic deformation of metallic is an effective mechanism for input earthquake energy dissipation. A steel structure with eight stories is located in China. The columns in the frame are square steel tubes and H type steel and the beams are H type steel. The DXMDs are installed on each floor of the steel structure. Some conclusions and suggestions are presented as follows: The steel plate shape has an important influence on deformation and energy-dissipating capability of the metallic damper. The RHMD and the DXMD exhibit good performance on stiffness and energy dissipation.

III.RESEARCH METHODOLOGY

RESPONSE SPECTRUM ANALYSIS : 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). The standard response spectra for type of soil considered is applied to building for the analysis in ETABS 9.7.4 software. Following diagram shows the standard response spectrum for medium soil type and that can be given in the form of time period versus spectral acceleration coefficient (Sa/g).

MODELING DETAILS

In the present study, analysis of G+20 multi-story building in most severs zone for wind and earth quake forces is carried out.3D model is prepared for G+20 multi-story building is in ETABS. Building has a typical size of

Basic parameters considered for the analysis are :

S.NO	PARAMETERS CONSIDERED	DESCRIPTION
1	Utility of building	college building
2	Number of stories	G+20
3	Shape of building	Rectangular
4	Type of walls	Brick wall
5	Geometric details 1. Ground floor 2.storey to storey height	3.3 mts 3 mts
6.	Material details Concrete Grade All Steel Grades Bearing Capacity of Soil	M40 (COLUMNS AND BEAMS) HYSD reinforcement of Grade Fe415 200 KN/m^2
7	Type Of Construction	R.C.C FRAMED structure
8	Column	C1: 0.6m X 0.6m, C2: 0.55X0.55m, C3: 0.45X0.45m
9	Beams	B1: 0.55m X 0.60m, B2: 0.45X0.55m, B3: 0.40X0.45m
10	Slab	0.150m
11	Damper Properties Damping (β) : Damping Exponent (n): Stiffness (k):	50 0.5 200

LOADS ON THE STRUCTURE

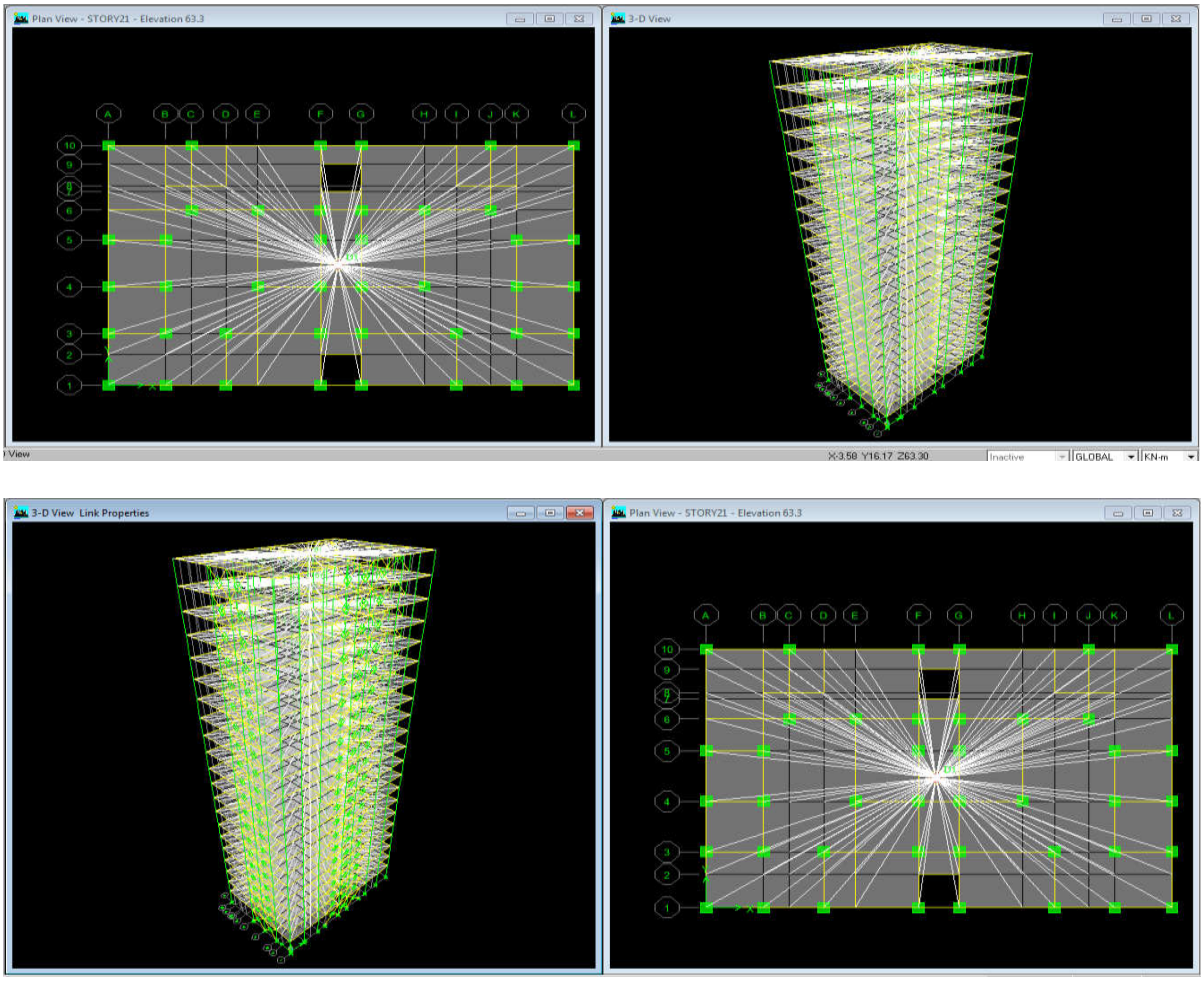
The types of loads acting on structures for buildings and other structures can be broadly classified as vertical loads, horizontal loads and longitudinal loads. The vertical loads consist of dead loads, live load and impact load. The horizontal loads comprises of wind load and earthquake load. The longitudinal loads i.e. tractive and braking forces are considered in special case of design of bridges, gantry girders etc.

Types of loads acting on the structure are:

- Dead loads
- Imposed loads
- Wind loads
- Snow loads

- Earthquake loads
- Special loads

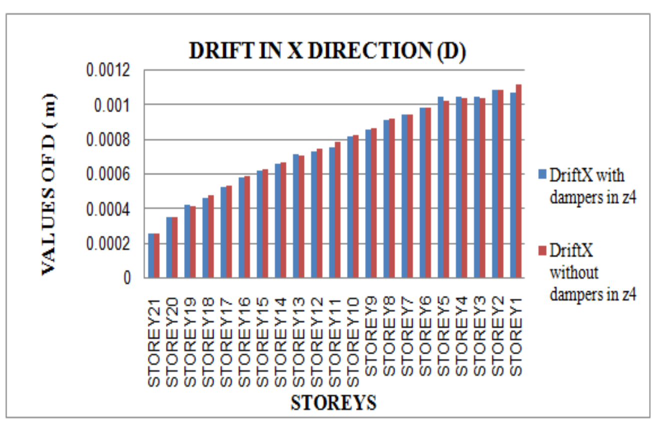
ETABS Models



IV.RESULTS AND ANALYSIS

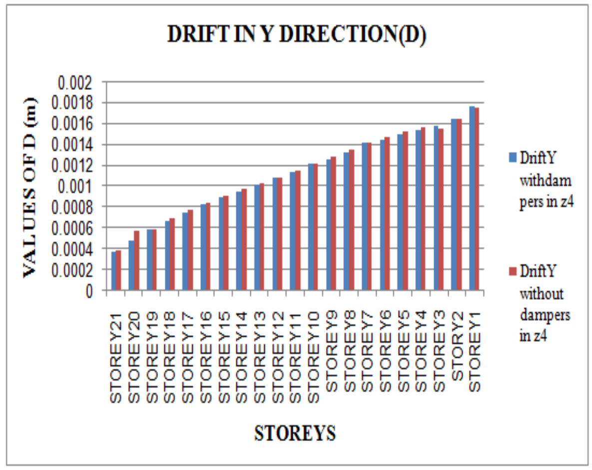
DRIFT IN X DIRECTION IN ZONE IV

STOREY	Load	Location	Drift X with dampers in z4 (m)	Drift X without dampers in z4(m)
STOREY21	STATIC	Bottom	0.000253	0.000253
STOREY20	STATIC	Bottom	0.000346	0.000346
STOREY19	STATIC	Bottom	0.000421	0.000407
STOREY18	STATIC	Bottom	0.000456	0.000473
STOREY17	STATIC	Bottom	0.000523	0.000532
STOREY16	STATIC	Bottom	0.000579	0.000582
STOREY15	STATIC	Bottom	0.000615	0.000626
STOREY14	STATIC	Bottom	0.000654	0.000666
STOREY13	STATIC	Bottom	0.000712	0.000704
STOREY12	STATIC	Bottom	0.000724	0.000742
STOREY11	STATIC	Bottom	0.000753	0.000781
STOREY10	STATIC	Bottom	0.000814	0.000822
STOREY9	STATIC	Bottom	0.000854	0.000864
STOREY8	STATIC	Bottom	0.000911	0.000915
STOREY7	STATIC	Bottom	0.000936	0.000936
STOREY6	STATIC	Bottom	0.000976	0.000976
STOREY5	STATIC	Bottom	0.001041	0.001015
STOREY4	STATIC	Bottom	0.001042	0.001033
STOREY3	STATIC	Bottom	0.001039	0.001032
STOREY2	STATIC	Bottom	0.001079	0.001084
STOREY1	STATIC	Bottom	0.001064	0.001114



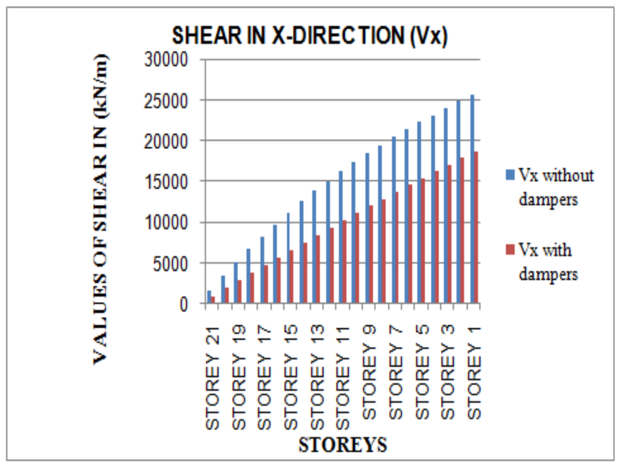
DRIFT IN Y DIRECTION IN ZONE IV

STOREY	Load	Location	Drift Y with dampers in z4 (m)	Drift Y without dampers in z4 (m)
STOREY21	STATIC	Bottom	0.000379	0.000389
STOREY20	STATIC	Bottom	0.00048	0.00058
STOREY19	STATIC	Bottom	0.000585	0.000595
STOREY18	STATIC	Bottom	0.000672	0.000692
STOREY17	STATIC	Bottom	0.000758	0.000778
STOREY16	STATIC	Bottom	0.000832	0.000852
STOREY15	STATIC	Bottom	0.000906	0.000916
STOREY14	STATIC	Bottom	0.000956	0.000976
STOREY13	STATIC	Bottom	0.001023	0.001033
STOREY12	STATIC	Bottom	0.001082	0.001092
STOREY11	STATIC	Bottom	0.001144	0.001154
STOREY10	STATIC	Bottom	0.001219	0.001219
STOREY9	STATIC	Bottom	0.001256	0.001286
STOREY8	STATIC	Bottom	0.001323	0.001353
STOREY7	STATIC	Bottom	0.001418	0.001418
STOREY6	STATIC	Bottom	0.001448	0.001478
STOREY5	STATIC	Bottom	0.001508	0.001528
STOREY4	STATIC	Bottom	0.001546	0.001566
STOREY3	STATIC	Bottom	0.001583	0.001563
STOREY2	STATIC	Bottom	0.001651	0.001651
STOREY1	STATIC	Bottom	0.001774	0.001754



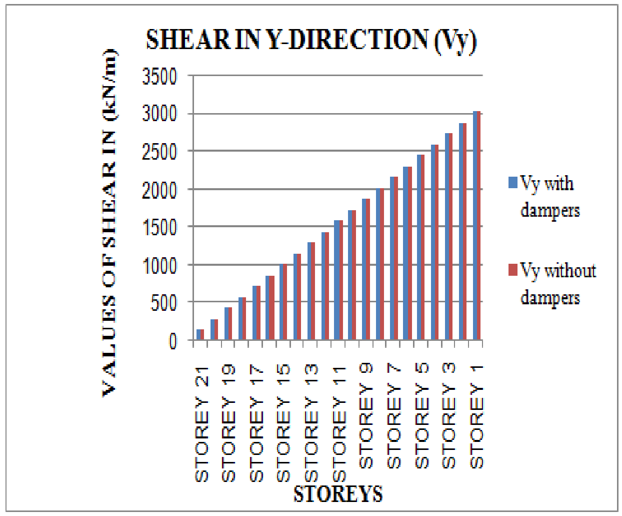
SHEAR FORCE IN XDIRECTION IN ZONE IV

STOREY	Load	Location	Vx without dampers in Z4 in (kN/m)	Vx with dampers in Z4 in (kN/m)
STOREY21	STATIC	Bottom	1600.13	980.08
STOREY20	STATIC	Bottom	3415.03	1963.19
STOREY19	STATIC	Bottom	5134.61	2930.77
STOREY18	STATIC	Bottom	6763.66	3883.6
STOREY17	STATIC	Bottom	8307	4822.49
STOREY16	STATIC	Bottom	9769.43	5748.19
STOREY15	STATIC	Bottom	11183.91	6669.97
STOREY14	STATIC	Bottom	12538.94	7583.7
STOREY13	STATIC	Bottom	13822.09	8484.98
STOREY12	STATIC	Bottom	15038.56	9374.72
STOREY11	STATIC	Bottom	16193.55	10253.8
STOREY10	STATIC	Bottom	17324.15	11132.73
STOREY 9	STATIC	Bottom	18401.36	12002.12
STOREY 8	STATIC	Bottom	19426.67	12861.77
STOREY 7	STATIC	Bottom	20405.96	13712.76
STOREY 6	STATIC	Bottom	21345.1	14556.21
STOREY 5	STATIC	Bottom	22249.97	15393.22
STOREY 4	STATIC	Bottom	23126.44	16224.89
STOREY 3	STATIC	Bottom	23980.39	17052.33
STOREY 2	STATIC	Bottom	24817.69	17876.65
STOREY 1	STATIC	Bottom	25644.6	18698.98



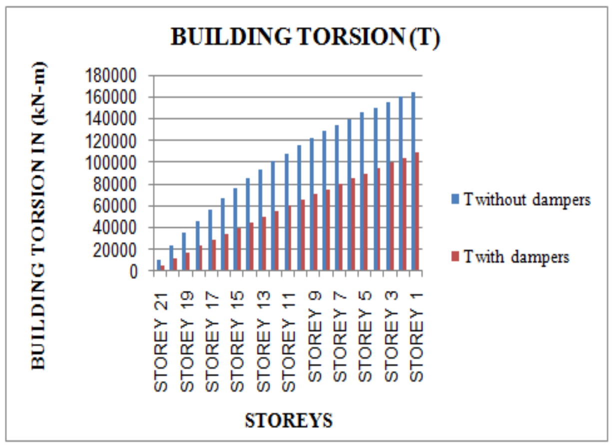
SHEAR FORCE IN Y DIRECTION IN ZONE IV

STOREY	Load	Location	Vy with dampers in Z4 in (kN/m)	Vy without dampers in Z4 in (kN/m)
STOREY21	STATIC	Bottom	144	144
STOREY20	STATIC	Bottom	288	288
STOREY19	STATIC	Bottom	432	432
STOREY18	STATIC	Bottom	576	576
STOREY17	STATIC	Bottom	720	720
STOREY16	STATIC	Bottom	864	864
STOREY15	STATIC	Bottom	1008	1008
STOREY14	STATIC	Bottom	1152	1152
STOREY13	STATIC	Bottom	1296	1296
STOREY12	STATIC	Bottom	1440	1440
STOREY11	STATIC	Bottom	1584	1584
STOREY10	STATIC	Bottom	1728	1728
STOREY 9	STATIC	Bottom	1872	1872
STOREY 8	STATIC	Bottom	2016	2016
STOREY 7	STATIC	Bottom	2160	2160
STOREY 6	STATIC	Bottom	2304	2304
STOREY 5	STATIC	Bottom	2448	2448
STOREY 4	STATIC	Bottom	2592	2592
STOREY 3	STATIC	Bottom	2736	2736
STOREY 2	STATIC	Bottom	2880	2880
STOREY 1	STATIC	Bottom	3024	3024



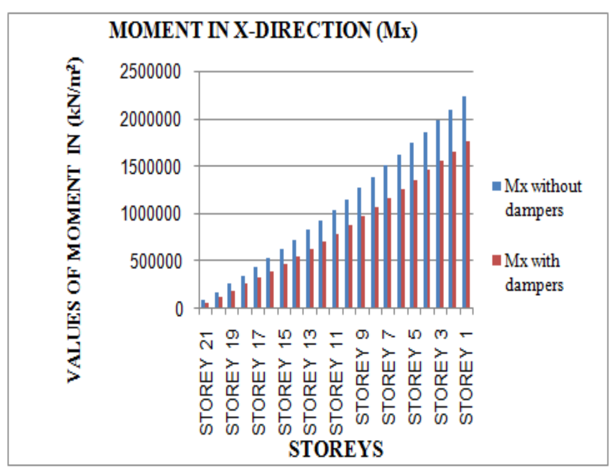
BUILDING TORSION IN X DIRECTION IN ZONE IV

STOREY	Load	Location	T without dampers in Z4 in (kN-m)	T with dampers in Z4 in (kN-m)
STOREY21	STATIC	Bottom	10912.397	5897.609
STOREY20	STATIC	Bottom	23525.106	11804.941
STOREY19	STATIC	Bottom	35370.974	17588.759
STOREY18	STATIC	Bottom	46488.664	23255.29
STOREY17	STATIC	Bottom	56916.841	28810.761
STOREY16	STATIC	Bottom	66694.17	34261.401
STOREY15	STATIC	Bottom	76086.405	39681.696
STOREY14	STATIC	Bottom	84979.898	45032.092
STOREY13	STATIC	Bottom	93297.882	50284.119
STOREY12	STATIC	Bottom	101081.962	55444.889
STOREY11	STATIC	Bottom	108373.74	60521.513
STOREY10	STATIC	Bottom	115493.074	65604.741
STOREY 9	STATIC	Bottom	122177.28	70610.219
STOREY 8	STATIC	Bottom	128442.84	75537.508
STOREY 7	STATIC	Bottom	134337.15	80395.46
STOREY 6	STATIC	Bottom	139907.601	85192.926
STOREY 5	STATIC	Bottom	145201.589	89938.757
STOREY 4	STATIC	Bottom	150266.507	94641.807
STOREY 3	STATIC	Bottom	155149.748	99310.925
STOREY 2	STATIC	Bottom	159898.707	103954.963
STOREY 1	STATIC	Bottom	164563.775	108583.097



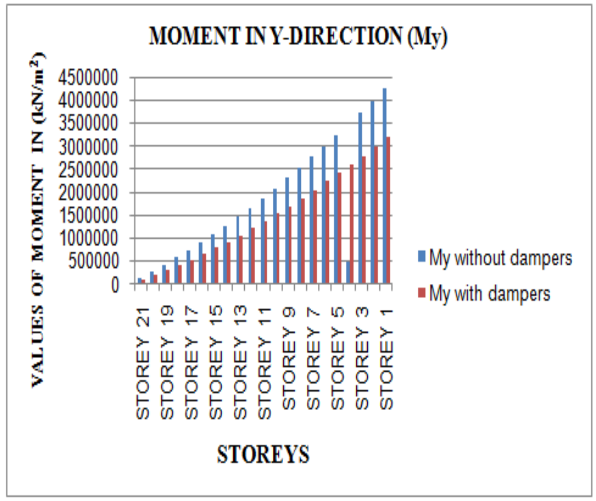
BUILDING MOMENT IN X DIRECTION IN ZONE IV

STOREY	Load	Location	Mx without dampers in Z4 in (kN/m^2)	Mx with dampers in Z4 in (kN/m^2)
STOREY21	STATIC	Bottom	86862.439	64496.504
STOREY20	STATIC	Bottom	174156.877	129425.009
STOREY19	STATIC	Bottom	261883.316	194785.513
STOREY18	STATIC	Bottom	350041.754	260578.017
STOREY17	STATIC	Bottom	438632.193	326802.521
STOREY16	STATIC	Bottom	527654.631	393459.026
STOREY15	STATIC	Bottom	627848.792	471286.187
STOREY14	STATIC	Bottom	728474.952	549545.347
STOREY13	STATIC	Bottom	829533.112	628236.508
STOREY12	STATIC	Bottom	931023.272	707359.669
STOREY11	STATIC	Bottom	1032945.433	786914.83
STOREY10	STATIC	Bottom	1149593.661	881197.124
STOREY 9	STATIC	Bottom	1266673.889	975911.418
STOREY 8	STATIC	Bottom	1384186.117	1071057.712
STOREY 7	STATIC	Bottom	1502130.346	1166636.006
STOREY 6	STATIC	Bottom	1620506.574	1262646.3
STOREY 5	STATIC	Bottom	1739314.802	1359088.594
STOREY 4	STATIC	Bottom	1858555.03	1455962.888
STOREY 3	STATIC	Bottom	1978227.258	1553269.182
STOREY 2	STATIC	Bottom	2098331.487	1651007.476
STOREY 1	STATIC	Bottom	2233491.711	1758409.215



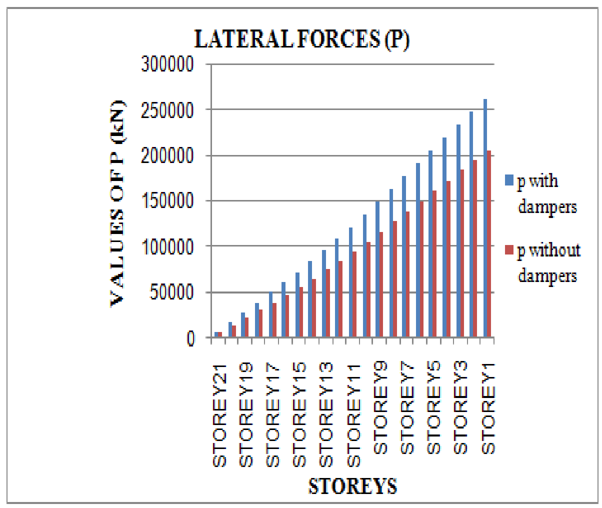
BUILDING MOMENT IN Y DIRECTION IN ZONE IV

STOREY	Load	Location	My without dampers in Z4 in (kN/m²)	My with dampers in Z4 in (kN/m²)
STOREY21	STATIC	Bottom	137857.964	102054.49
STOREY20	STATIC	Bottom	281160.627	207058.288
STOREY19	STATIC	Bottom	429622.01	314964.824
STOREY18	STATIC	Bottom	582970.549	425729.88
STOREY17	STATIC	Bottom	740949.102	539311.582
STOREY16	STATIC	Bottom	903314.946	655670.407
STOREY15	STATIC	Bottom	1086745.694	791614.156
STOREY14	STATIC	Bottom	1274241.517	930299.084
STOREY13	STATIC	Bottom	1465586.792	1071687.856
STOREY12	STATIC	Bottom	1660581.486	1215745.832
STOREY11	STATIC	Bottom	1859041.149	1362441.075
STOREY10	STATIC	Bottom	2081208.035	1532090.405
STOREY 9	STATIC	Bottom	2306606.551	1704347.91
STOREY 8	STATIC	Bottom	2535081.001	1879184.338
STOREY 7	STATIC	Bottom	2766493.318	2056573.745
STOREY 6	STATIC	Bottom	3000723.058	2236493.5
STOREY 5	STATIC	Bottom	3237667.4	2418924.284
STOREY 4	STATIC	Bottom	477241.16	2603850.091
STOREY 3	STATIC	Bottom	3719376.77	2791258.225
STOREY 2	STATIC	Bottom	3964024.29	2981139.302
STOREY 1	STATIC	Bottom	4255599.59	3203045.53



Lateral loads (P)

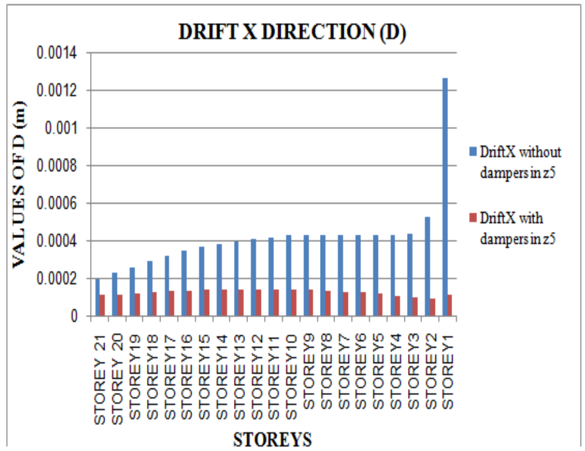
STOREY	Load	Location	p with dampers in (kN)	p without dampers in (kN)
STOREY21	STATIC	Bottom	6678.81	6678.81
STOREY20	STATIC	Bottom	17554.19	14809.08
STOREY19	STATIC	Bottom	28429.57	22939.35
STOREY18	STATIC	Bottom	39304.95	31069.61
STOREY17	STATIC	Bottom	50180.33	39199.88
STOREY16	STATIC	Bottom	61055.71	47330.15
STOREY15	STATIC	Bottom	72541	56070.33
STOREY14	STATIC	Bottom	84795.94	65580
STOREY13	STATIC	Bottom	97050.89	75089.68
STOREY12	STATIC	Bottom	109305.83	84599.36
STOREY11	STATIC	Bottom	121560.77	94109.04
STOREY10	STATIC	Bottom	135105.15	104908.16
STOREY9	STATIC	Bottom	149071.73	116129.62
STOREY8	STATIC	Bottom	163038.31	127351.09
STOREY7	STATIC	Bottom	177004.89	138572.56
STOREY6	STATIC	Bottom	190971.47	149794.02
STOREY5	STATIC	Bottom	204938.05	161015.49
STOREY4	STATIC	Bottom	218904.63	172236.96
STOREY3	STATIC	Bottom	232871.2	183458.42
STOREY2	STATIC	Bottom	246837.78	194679.89
STOREY1	STATIC	Bottom	260804.36	205901.35



2.ZONE V RESULTS

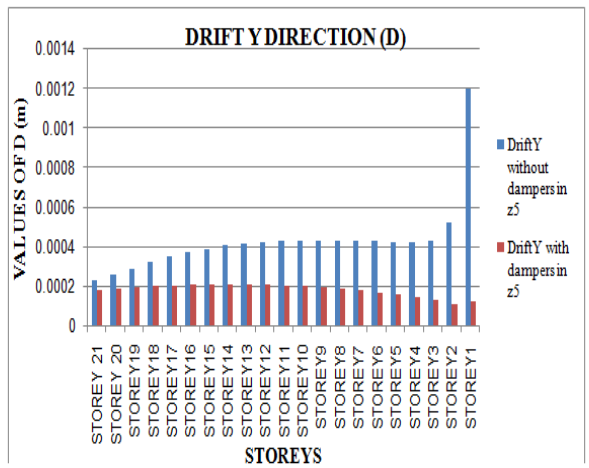
Values of drift in X-direction (Zone-5)

STOREY	Load	Location	Drift X without dampers in z5 in (m)	Drift X with dampers in z5 in (m)
STOREY21	STATIC	Bottom	0.0002	0.00011
STOREY20	STATIC	Bottom	0.00023	0.000113
STOREY19	STATIC	Bottom	0.00026	0.000119
STOREY18	STATIC	Bottom	0.00029	0.000124
STOREY17	STATIC	Bottom	0.00032	0.000129
STOREY16	STATIC	Bottom	0.00035	0.000133
STOREY15	STATIC	Bottom	0.00037	0.000136
STOREY14	STATIC	Bottom	0.00038	0.000138
STOREY13	STATIC	Bottom	0.0004	0.000139
STOREY12	STATIC	Bottom	0.00041	0.00014
STOREY11	STATIC	Bottom	0.00042	0.000139
STOREY10	STATIC	Bottom	0.00043	0.000137
STOREY9	STATIC	Bottom	0.00043	0.000135
STOREY8	STATIC	Bottom	0.00043	0.000131
STOREY7	STATIC	Bottom	0.00043	0.000126
STOREY6	STATIC	Bottom	0.00043	0.000121
STOREY5	STATIC	Bottom	0.00043	0.000114
STOREY4	STATIC	Bottom	0.00043	0.000106
STOREY3	STATIC	Bottom	0.00044	0.000097
STOREY2	STATIC	Bottom	0.00052	0.000089
STOREY1	STATIC	Bottom	0.00126	0.000107



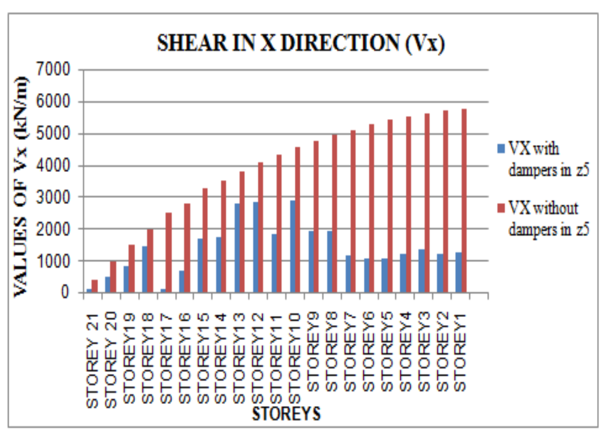
Values of drift in Y-direction (Zone-5)

STOREY	Load	Location	Drift Y without dampers in z5 in (m)	Drift Y with dampers in z5in (m)
STOREY21	STATIC	Bottom	0.00023	0.000181
STOREY20	STATIC	Bottom	0.00026	0.000187
STOREY19	STATIC	Bottom	0.00029	0.000193
STOREY18	STATIC	Bottom	0.00032	0.000197
STOREY17	STATIC	Bottom	0.00035	0.000201
STOREY16	STATIC	Bottom	0.00037	0.000204
STOREY15	STATIC	Bottom	0.00039	0.000206
STOREY14	STATIC	Bottom	0.0004	0.000207
STOREY13	STATIC	Bottom	0.00041	0.000207
STOREY12	STATIC	Bottom	0.00042	0.000205
STOREY11	STATIC	Bottom	0.00043	0.000201
STOREY10	STATIC	Bottom	0.00043	0.000197
STOREY9	STATIC	Bottom	0.00043	0.000191
STOREY8	STATIC	Bottom	0.00043	0.000184
STOREY7	STATIC	Bottom	0.00043	0.000175
STOREY6	STATIC	Bottom	0.00042	0.000165
STOREY5	STATIC	Bottom	0.00042	0.000153
STOREY4	STATIC	Bottom	0.00042	0.00014
STOREY3	STATIC	Bottom	0.00043	0.000125
STOREY2	STATIC	Bottom	0.00052	0.000107
STOREY1	STATIC	Bottom	0.00119	0.000122



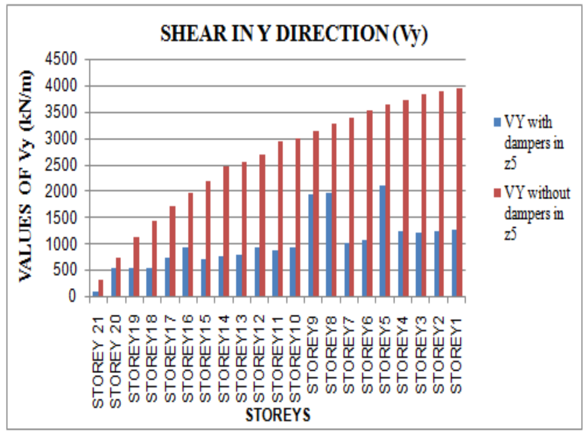
Values of shear in X-direction (Zone-5)

STOREY	Load	Location	Vx with dampers in z5 in (kN/m)	Vx without dampers in z5 in (kN/m)
STOREY21	STATIC	Bottom	125.53	433.11
STOREY20	STATIC	Bottom	540.22	989.96
STOREY19	STATIC	Bottom	855.18	1513.21
STOREY18	STATIC	Bottom	1458.98	1984.34
STOREY17	STATIC	Bottom	150.68	2518
STOREY16	STATIC	Bottom	729.89	2827.07
STOREY15	STATIC	Bottom	1696.89	3279.51
STOREY14	STATIC	Bottom	1752.62	3508.21
STOREY13	STATIC	Bottom	2798.71	3806.62
STOREY12	STATIC	Bottom	2837.34	4078.44
STOREY11	STATIC	Bottom	1871.12	4327.16
STOREY10	STATIC	Bottom	2902.81	4565.71
STOREY9	STATIC	Bottom	1934.97	4766.11
STOREY8	STATIC	Bottom	1969.59	4959.35
STOREY7	STATIC	Bottom	1207.81	5115.36
STOREY6	STATIC	Bottom	1079.77	5293.13
STOREY5	STATIC	Bottom	1095.61	5431
STOREY4	STATIC	Bottom	1240.72	5547.03
STOREY3	STATIC	Bottom	1385.98	5639.43
STOREY2	STATIC	Bottom	1247.92	5706.98
STOREY1	STATIC	Bottom	1283.97	5752.63



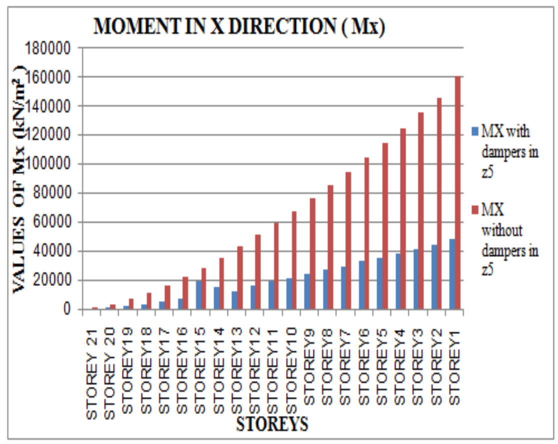
Values of shear in Y-direction (Zone-5)

STOREY	Load	Location	Vy with dampers in z5 in (kN/m)	Vy without dampers in z5 in (kN/m)
STOREY21	STATIC	Bottom	118.15	339.81
STOREY20	STATIC	Bottom	545.73	758.53
STOREY19	STATIC	Bottom	563.06	1130.31
STOREY18	STATIC	Bottom	568.74	1454.86
STOREY17	STATIC	Bottom	761.84	1735.17
STOREY16	STATIC	Bottom	942.05	1976.9
STOREY15	STATIC	Bottom	709.7	2187.36
STOREY14	STATIC	Bottom	765.81	2474.21
STOREY13	STATIC	Bottom	812.07	2554.17
STOREY12	STATIC	Bottom	950.73	2702.29
STOREY11	STATIC	Bottom	884.49	2951.83
STOREY10	STATIC	Bottom	936.19	2994.67
STOREY9	STATIC	Bottom	1948.45	3141.91
STOREY8	STATIC	Bottom	1983.36	3264.23
STOREY7	STATIC	Bottom	1032.14	3391.81
STOREY6	STATIC	Bottom	1084.96	3523.94
STOREY5	STATIC	Bottom	2110.97	3628.55
STOREY4	STATIC	Bottom	1258.54	3732.07
STOREY3	STATIC	Bottom	1215.46	3829.92
STOREY2	STATIC	Bottom	1259.05	3877.74
STOREY1	STATIC	Bottom	1286.42	3946.14



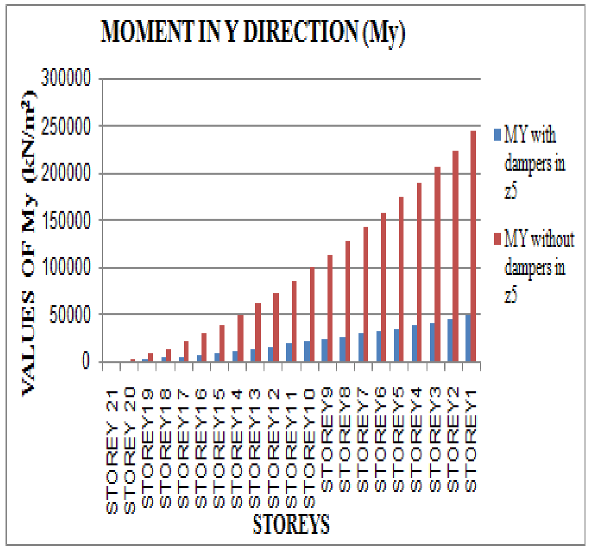
Values of moment in X-direction (Zone-5)

STOREY	Load	Location	Mx with dampers in z5 in (kN/m^2)	Mx without dampers in z5 in (kN/m^2)
STOREY21	STATIC	Bottom	454.436	1019.415
STOREY20	STATIC	Bottom	1191.57	3294.532
STOREY19	STATIC	Bottom	2185.49	6682.925
STOREY18	STATIC	Bottom	3585.82	11039
STOREY17	STATIC	Bottom	5269.03	16222.88
STOREY16	STATIC	Bottom	7199.97	22107.81
STOREY15	STATIC	Bottom	19308.5	28585.59
STOREY14	STATIC	Bottom	15586.3	35569.11
STOREY13	STATIC	Bottom	12988.4	42991.99
STOREY12	STATIC	Bottom	16454.9	50805.95
STOREY11	STATIC	Bottom	19152.1	58966.86
STOREY10	STATIC	Bottom	21673.2	67480.76
STOREY9	STATIC	Bottom	24339	76300.64
STOREY8	STATIC	Bottom	27057.5	85454.15
STOREY7	STATIC	Bottom	29803.3	94741.99
STOREY6	STATIC	Bottom	33615.7	104556.3
STOREY5	STATIC	Bottom	35497.5	114528.5
STOREY4	STATIC	Bottom	38462.3	124766.7
STOREY3	STATIC	Bottom	41522.3	135372.8
STOREY2	STATIC	Bottom	44686.6	145890.6
STOREY1	STATIC	Bottom	49068.2	160564.4



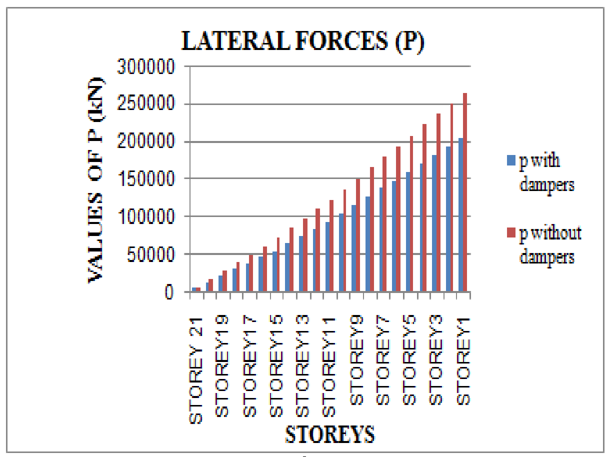
Values of moment in Y-direction

STOREY	Load	Location	My with dampers in z5 in (kN/m²)	My without dampers in z5 in (kN/m²)
STOREY21	STATIC	Bottom	346.585	1299.323
STOREY20	STATIC	Bottom	1267.2	4259.971
STOREY19	STATIC	Bottom	2132.48	8768.531
STOREY18	STATIC	Bottom	3548.56	14706.17
STOREY17	STATIC	Bottom	5168.32	21951.88
STOREY16	STATIC	Bottom	7052.86	30385.74
STOREY15	STATIC	Bottom	9123.16	39891.96
STOREY14	STATIC	Bottom	11361.8	50361.58
STOREY13	STATIC	Bottom	13724.5	61694.45
STOREY12	STATIC	Bottom	16185.9	73800.57
STOREY11	STATIC	Bottom	18717.6	86600.4
STOREY10	STATIC	Bottom	21294.3	100124.4
STOREY9	STATIC	Bottom	23923.6	114011.9
STOREY8	STATIC	Bottom	26594.7	128508.8
STOREY7	STATIC	Bottom	29317.5	143465.8
STOREY6	STATIC	Bottom	32095	158845.9
STOREY5	STATIC	Bottom	34941.3	174532.2
STOREY4	STATIC	Bottom	37859	190646.4
STOREY3	STATIC	Bottom	40899.7	206988.3
STOREY2	STATIC	Bottom	44011.4	223455
STOREY1	STATIC	Bottom	48330.6	245773.6



LATERAL FORCES (P)

STOREY	Load	Location	p with dampers (kN)	p without dampers (kN)
STOREY21	STATIC	Bottom	6678.81	6924.55
STOREY20	STATIC	Bottom	14809.1	18045.67
STOREY19	STATIC	Bottom	22939.4	29166.78
STOREY18	STATIC	Bottom	31069.6	40287.9
STOREY17	STATIC	Bottom	39199.9	51409.02
STOREY16	STATIC	Bottom	47330.2	62530.14
STOREY15	STATIC	Bottom	56070.3	74261.17
STOREY14	STATIC	Bottom	65580.2	86761.85
STOREY13	STATIC	Bottom	75090	99262.53
STOREY12	STATIC	Bottom	84599.8	111763.2
STOREY11	STATIC	Bottom	94109.6	124263.9
STOREY10	STATIC	Bottom	104909	138054
STOREY9	STATIC	Bottom	116130	152266.3
STOREY8	STATIC	Bottom	127352	166478.6
STOREY7	STATIC	Bottom	138573	180691
STOREY6	STATIC	Bottom	149795	194903.3
STOREY5	STATIC	Bottom	161016	209115.6
STOREY4	STATIC	Bottom	172238	223327.9
STOREY3	STATIC	Bottom	183459	237540.2
STOREY2	STATIC	Bottom	194681	251752.5
STOREY1	STATIC	Bottom	205902	265964.9



V. CONCLUSION

Upon the results of investigations the following conclusions were made:

1. The drift values in the X and Y direction shows higher values of the structure without dampers, the displacement of story with dampers was reduced, it shows that the structure with dampers can be used for high rise buildings in the high seismic zone.
2. Lateral displacements due to earthquake forces reduce by providing friction dampers.
3. Storey drift also reduces thus shear resistance of the building increases.
4. Base shear of the building increases by providing friction dampers.

5. The effectiveness of friction dampers in controlling lateral displacements storey drifts due to earthquake force is observed in response spectrum analysis.
6. From above results it is clear that by adding friction dampers building response of a structure get reduced by significant amount.
7. The results of this investigation show that, the response of structure can be dramatically reduced by using friction damper without increasing the stiffness of the structure.
8. Friction dampers are unique in combating the wind forces, for its friction material, whereas other dampers are suitable mostly for earthquake forces only.
9. The performance of friction damper devices is much better for the tall buildings with slender design.

SCOPE FOR FURTHER STUDY

Maintenance of friction damper is done by conducting prototype testing. Prototype testing is required to demonstrate the performance of damper when subjected to number of cycles and travel expected during maximum credible earthquake. 20 cycles to maximum design slip load is specified. A variation of ±15% from the target value is permitted. The number of cycles is enough to confirm the uniformity in performance and influence of temperature change. In production the slip force is kept ±10% of design value to ensure that the specified tolerance is satisfied, and the acceptance tests on the finished assembly are confined to the force-displacement properties. Random checks are performed on 10% of dampers before shipping.

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