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Non-Linear Time history Analysis of Tall Structures for Seismic Load Using Damper under Different Soil Conditions

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Abstract: During major seismic actions, a significant amount of energy is induced to structures. This means by which this energy is dissipated, determines the level of structural degradation. Special emphasis is placed on avoiding loss of human lives due to the earthquake action. In order to achieve this, the structures are designed ductile so that energy is dissipated by the system's elements by bending, twisting or degradation. This dissipative mechanism involves significant degradation of the structures thus leading to significant post-earthquake rehabilitation costs. If the amount of energy induced in the structure can be controlled or, if part of it can be dissipated mechanically by independent structures, the seismic response of the buildings is improved and the potential damage greatly reduced.

These objectives can be achieved via new techniques such as enhancement of energy dissipation capacity of the structures using damping devices. When possible, design codes suggest the use of the last technique as a cheaper and more viable way to improve the behavior of structures subjected to earthquakes. The hereby paper proposes a time history analysis of structures equipped with frictional dampers, highlighting the benefits resulting from the use of such devices these are analyzed using the commercial software of SAP2000

Keywords: seismic loads, friction dampers, Time History Analysis, SAP2000.

I. INTRODUCTION

But nowadays need and demand of the latest generation and growing population has made the architects or engineers inevitable towards planning of irregular configurations. Hence earthquake engineering has become an important branch of civil engineering. Vibration control is having its roots primarily in aerospace related problems such as tracking and pointing, and in flexible space structures, the technology quickly moved into civil engineering and infrastructure-related issues, such as the protection of buildings and bridges from extreme loads of earthquakes and winds.

Earthquake in the simplest terms can be defined as Shaking and vibration at the surface of the earth resulting from underground movement along a fault plane. The vibrations produced by the earthquakes are due to seismic waves. Seismic waves are the most disastrous one. However, modern high rise buildings and tall structures cannot conveniently be geared up with these techniques. The safety and serviceability of any structure is thus endangered with the increasing elevation. As per the standard codes, a structure that can resist the highest earthquake that could possibly occur in that particular area can be called as an earthquake resistant structure. However, the most efficient way of designing earthquake resistant structure would be to minimize the deaths as well as minimize the destruction of functionality of the structural element. The most disastrous thing about earthquake is its unpredictability of time and place of occurrence.

DAMPERS:

Dampers are used to resist lateral forces coming on the structure. Dampers are the energy dissipating devices which also resist displacement of RC building during earthquake. These dampers help the structure to reduce the buckling of columns and beams and the stiffness of the structure is increased. At the time of earthquake multi-storey building is damaged and largedeformation occurred in multi-storey building. Dampers reduce vibration and deformation ofrc building during earthquake. There is lot of various types are used in RC building. This study deals with selection of suitable type of damper which will be more resistant to earthquake for the selected building.

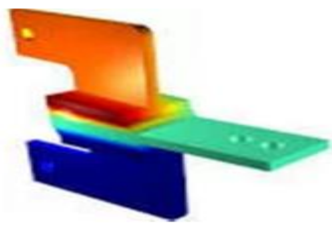
DIFFERENT TYPES OF DAMPERS

Viscous Damper

In this type of damper by using viscous fluid inside cylinder energy dissipated. Viscous dampers are used in high-rise building in seismic areas. Viscous damper reduces the vibrations induced by both strong wind and earthquake.

Visco-Elastic Dampers

Another type of damper is Visco-elastic dampers which stretch an elastomer in combination with metal parts. In Visco-elastic dampers, the energy is absorbed by utilising controlled shearing of solids.



Friction Damper

Friction dampers use metal or other surfaces in friction; and energy is absorbed by surfaces with fiction between them rubbing against each other. Typically a friction damper device consists of several steel plates sliding against each other in opposite directions.

OBJECTIVE OF THE STUDY

- To study seismic behavior of selected three models i.e.(low rise, medium rise, high rise) R.C.C. building with friction dampers by using SAP 2000 software.
- Compare various parameters namely base time period, base shear ,base moment, building displacement etc.
- To compare the response of the structure under dynamic loading with and without Damper structure.

II.LITERATURE REVIEW

Avtar PALL[1]and R. Tina PALL[2] et all,.(1999) Benefit-cost analysis approach suggests performance-based design for most modern buildings. The conventional structural systems are highly unlikely to provide adequate performance in the event of a major earthquake. With the emergence of Pall Friction Dampers, it has now become economically feasible to design high performance structures. Their low cost and maintenance free characteristics suggest wide application for new construction as well as for retrofit of existing buildings. Public sectors, private sectors, developers and developing countries are all benefiting from this technology. They have been used for the seismic protection of more than 80 major building projects, including the Boeing Commercial Airplane Factory at Everett, WA – the world's largest building in volume.The use of Pall Friction Dampers has shown to provide a practical, economical and effective approach for the performance-based design of new and retrofit of existing structures to resist major earthquakes. The low cost and maintenance free characteristics of Pall Friction Dampers suggest wide application. Public sector, private sector and developers, including developing countries, are using and benefiting from Pall Friction Damper technology.

W.Q. Liu, H. Wang, S.G. Wang, & D.S. Du et all,.(2012) The influence of soil-structure interaction (SSI) on damage spectra of passive energy dissipating structures is investigated under seismic loading. The well-known model of Park and Ang was selected for damage estimation. A systematic lumped-parameter model is used to modeled the dynamic behaviour of the foundation sitting on soil. The passive energy dissipation devices are assumed to be viscous type. The structure is modeled as a single degree of freedom (SDOF) system which is based on the bilinear model. The results are presented in the form of damage spectra of parameters variations. For building systems without energy dissipation devices, it is found that when the shear wave velocity of soil Vs decreases, the SSI substantially increases the damage index of short-period buildings. However, the damage index of long-period buildings decreases with the decrease of the shear wave velocity of soil Vs . For the structures with passive energy dissipation devices, especially for the structures with high damping, SSI gradually increases the damage index of short-period and long-period buildings. Therefore, SSI has more influence on structures with passive energy dissipation devices than on structures without the devices.

III.METHODOLOGY

The equivalent static method of analysis specified on the Indian standard building codes(IS 1893:2002 Part I) are based on the single mode of response with simple corrections to get the higher modal responses. This type of method is appropriate for simple regular structures. For the complex structures the simplified procedures do not take in account. Therefore the dynamic analysis is the preferred method for complex structures or structures with irregular geometry. As per IS 1893 (2002) clause 7.8dynamic analysis can be performed to obtain the design seismic force, to its distribution to different levels along the height of the building, to various lateral loads resisting elements, for the following buildings:

a)Regular buildings **—** Those greater than 40 m in height in Zones IV andzone V those greater than 90 m in height in Zones II and III Modeling as per 7.8.4.5 can be used.

b)irregular buildings (as defined in 7.1) — All framed buildings higher than 12m inZones IV and zone V those greater than 40m in height in Zones II , III.

For irregular buildings less than 40m height, dynamic analysis even though not mandatory is recommended.

The damping value should be taken as 2 for steel buildings and for the combination of steel and concrete structure, the average damping is taken between 2 and 5.

PROBLEM STATEMENT

In building plan was taken in seismic zone V for seismic analysis of the building (G+5,G+10) with dampered building and undampered building (general building). The basic specifications of the building are:

Plan Size	36 m x 32 m
Beam Size	300 mm × 450 mm;
Column size	450 mm × 300 mm
Storey Height	3.0 m;
Bottom storey	3.3 mts
Materials used	M40 & Fe415;
Depth of slab	150 mm
Imposed load	3 kN/m^2
Unit weight of concrete	25 kN/m^3

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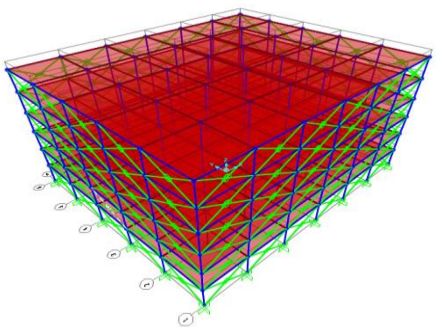
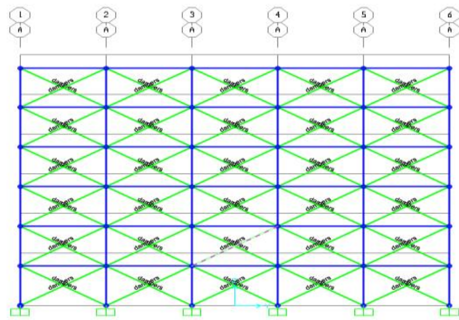
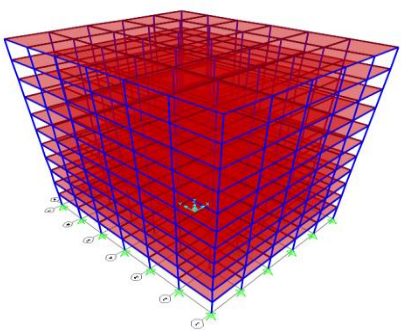
Safe bearing capacity of soil	200 N/mm^2

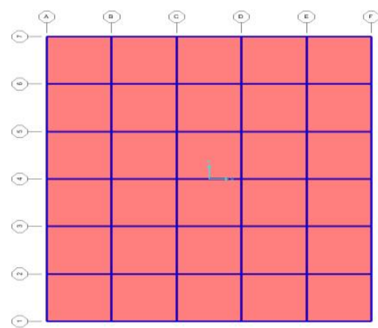
G+5 (LOW RISE BUILDINGS



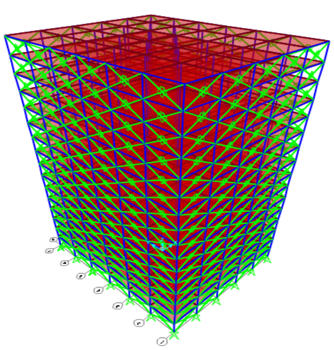


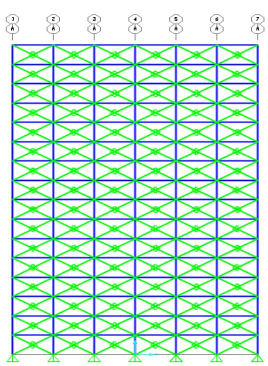
G+10 (MEDIUM RISE BUILDINGS)





G+15 (HIGH RISE BUILDINGS)





IV .RESULTS AND ANALYSIS

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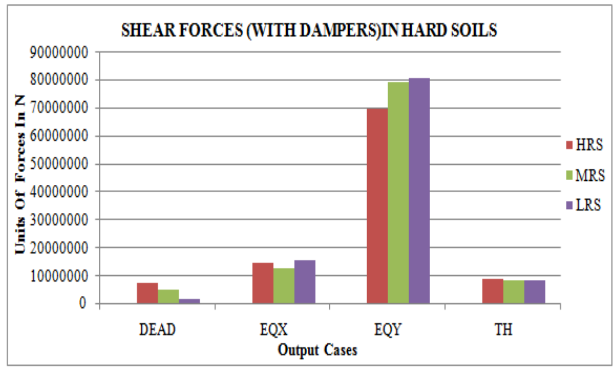
ANALYSIS OF DIFFERENT STRUCTURES IN DIFFERENT TYPES OF SOIL TYPES

HARD SOIL

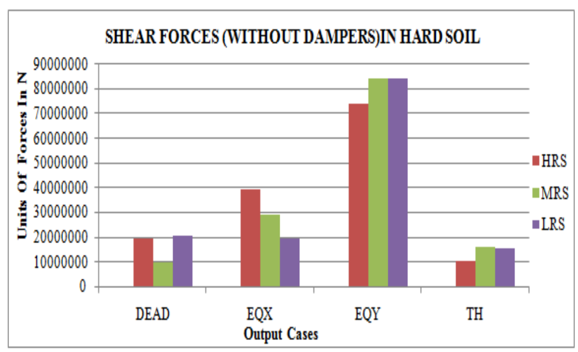
FORCES

WITH DAMPERS	FORCES	HRS	MRS	LRS
DEAD	CF (N)	7124000	5014000	1638700
EQX	CF (N)	14654721	12654721	15544300
EQY	CF (N)	69562010	79562130	80786540
TH	CF (N)	8856410	8256610	8145230



Showing shear forces (without dampers) in Hard Soil

WITHOUT DAMPERS	FORCES	HRS	MRS	LRS
DEAD	CF (N)	19442000	9721000	20416600
EQX	CF (N)	39267854	29267854	19315785
EQY	CF (N)	74197850	84197850	84197850
TH	CF (N)	10365120	16009880	15609880



MOMENTS

Showing Moments (With Dampers) in Hard Soil

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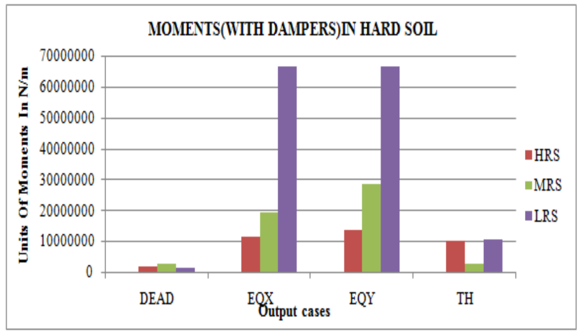
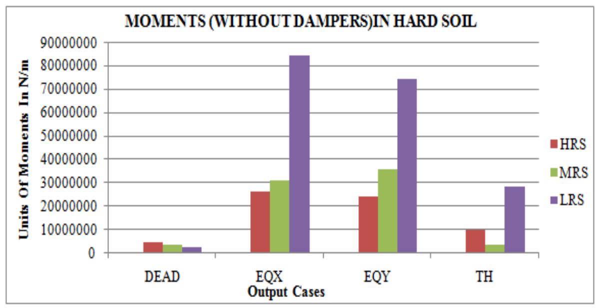
WITH DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(m)	1642200	2540000	1470000
EQX	CM(m)	11254600	1.91E+07	6.6E+07
EQY	CM(m)	13422500	28242100	66449569
TH	CM(m)	9900000	2799449	10560000



Showing Moments (Without Dampers) in Hard Soil

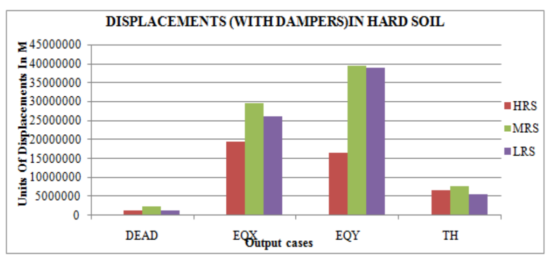
WITHOUT DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(N/m)	4926600	3920000	2480000
EQX	CM(N/m)	26351400	31145612	84706630
EQY	CM(N/m)	24262300	36259554	74676000
TH	CM(N/m)	10140000	3891000	28350000



DISPLACEMENTS

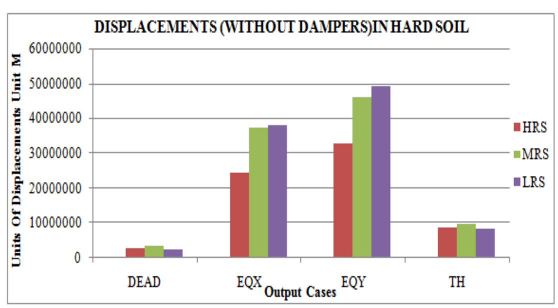
Showing Displacements (with dampers) in Hard Soil

WITH DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(m)	1642200	2540000	1470000
EQX	CM(m)	11254600	1.91E+07	6.6E+07
EQY	CM(m)	13422500	28242100	66449569
TH	CM(m)	9900000	2799449	10560000



Showing Displacements (without dampers) in Hard Soil

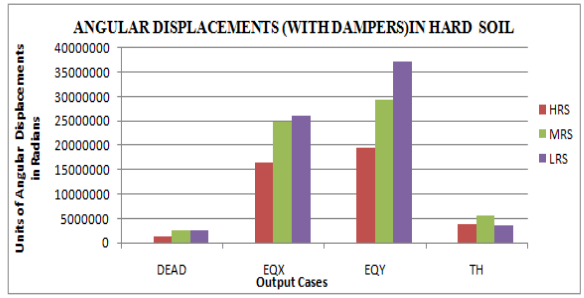
WITHOUT DAMPERS	DISPLACEMENTS	HRS	MRS	LRS
DEAD	CD (m)	2912000	3642000	2381000
EQX	CD (m)	24561000	37425000	38156000
EQY	CD (m)	32888000	45945600	49271900
TH	CD (m)	8849780	9891000	8219000



ANGULAR DISPLACEMENT

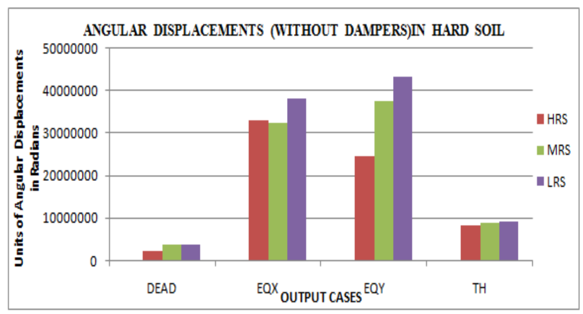
Showing Angular Displacements (with dampers) in Hard Soil

WITH DAMPERS	ANGULAR DISPLACEMENTS	HRS	MRS	LRS
DEAD	CAD(Radians)	1234000	2540000	2504000
EQX	CAD(Radians)	16444000	24925000	26125000
EQY	CAD(Radians)	19562000	29425000	37256000
TH	CAD(Radians)	3856410	5556610	3451700



Showing Angular Displacements (without dampers) in Hard Soil

WITHOUT DAMPERS	ANGULAR DISPLACEMENTS	HRS	MRS	LRS
DEAD	CAD(Radians)	2412000	3920000	3972000
EQX	CAD(Radians)	32888000	32353000	38156000
EQY	CAD(Radians)	24561000	37425000	43215000
TH	CAD(Radians)	8365120	9009880	9335000

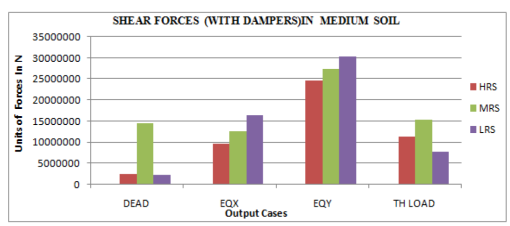


MEDIUM SOIL

FORCES

Showing shear forces (with dampers) in Medium Soil

WITH DAMPERS	FORCES	HRS	MRS	LRS
DEAD	CF (N)	2506000	14546780	2302000
EQX	CF (N)	9720000	12654721	16490000
EQY	CF (N)	24750000	27467000	30412000
TH	CF (N)	11354700	15343600	7856410



showing shear forces (without dampers) in medium soil

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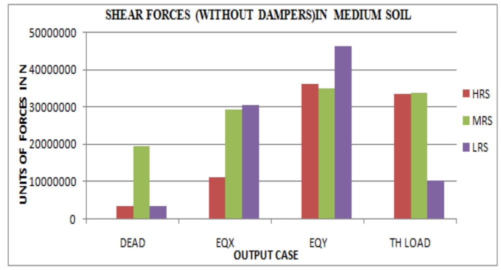
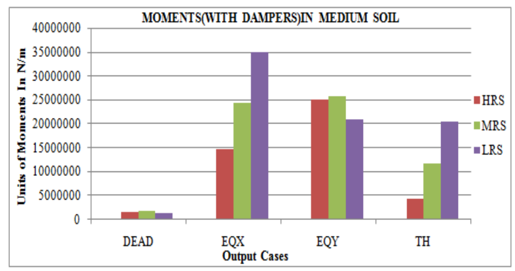
WITHOUT DAMPERS	FORCES	HRS	MRS	LRS
DEAD	CF (N)	3616000	19416600	3591000
EQX	CF (N)	11245654	29267854	30412000
EQY	CF (N)	36187000	35024000	46298000
TH	CF (N)	33547000	33651200	10484000



MOMENTS

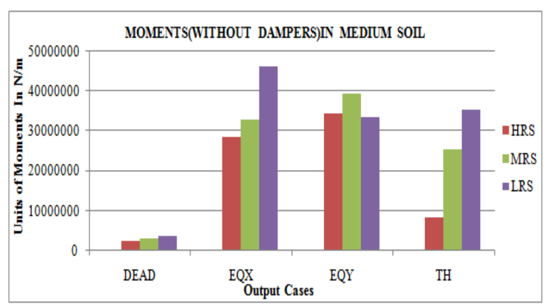
Showing Moments (with dampers) in Medium Soil

WITH DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(N/m)	1504000	1778000	1474000
EQX	CM(N/m)	14735000	24310000	35024000
EQY	CM(N/m)	2.52E+07	25643210	21031000
TH	CM(N/m)	4442000	11638700	20416600



Showing Moments (without dampers) in Medium Soil

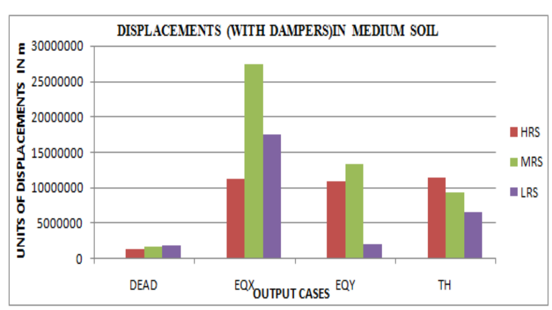
WITHOUT DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(m)	2343000	2972000	3616000
EQX	CM(m)	28715000	32879000	46298000
EQY	CM(m)	34482300	39352100	33484000
TH	CM(m)	8258500	25343600	35280000



DISPLACEMENTS

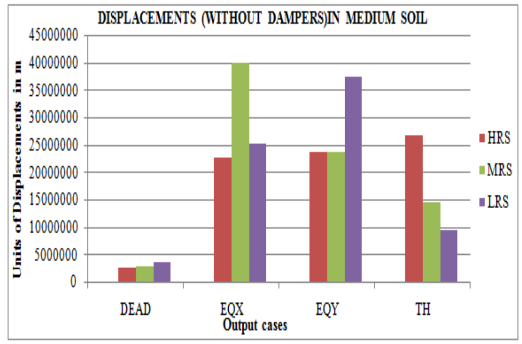
Showing Displacements (with dampers) in Medium Soil

WITH DAMPERS	DISPLACEMENTS	HRS	MRS	LRS
DEAD	CD (m)	1303000	1654200	1845000
EQX	CD (m)	11281000	27475000	17475000
EQY	CD (m)	1.10E+07	13423000	2.16E+06
TH	CD (m)	11440000	9450000	6540000



DISPLACEMENTS (WITHOUT DAMPERS)IN MEDIUM SOIL

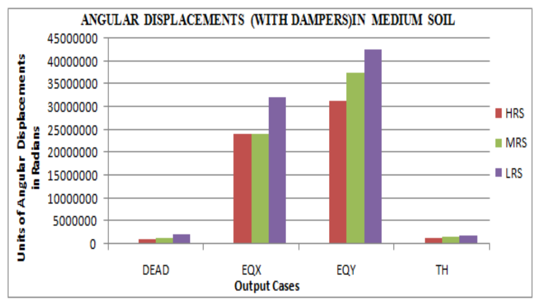
WITHOUT DAMPERS	DISPLACEMENTS	HRS	MRS	LRS
DEAD	CD (m)	2606000	2682000	3528000
EQX	CD (m)	22562000	39845000	25112000
EQY	CD (m)	23537000	23537000	37451000
TH	CD (m)	26820000	14450000	9528000



ANGULAR DISPLACEMENTS

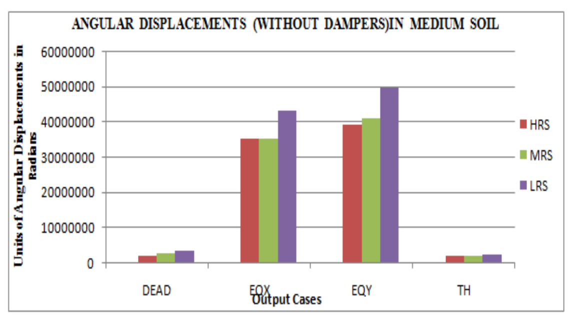
Showing Angular Displacements (with dampers) in Medium Soil

WITH DAMPERS	ANGULAR DISPLACEMENTS	HRS	MRS	LRS
DEAD	CAD(Radians)	1125000	1.31E+06	2125000
EQX	CAD(Radians)	24091000	24091000	32154000
EQY	CAD(Radians)	3.12E+07	37451000	42516000
TH	CAD(Radians)	1277000	1548000	1845000



Showing Angular Displacements (without dampers) in Medium Soil

WITHOUT DAMPERS	ANGULAR DISPLACEMENTS	HRS	MRS	LRS
DEAD	CAD(Radians)	2234000	2752000	3752000
EQX	CAD(Radians)	35256000	35256000	43215000
EQY	CAD(Radians)	3.95E+07	41328000	49896000
TH	CAD(Radians)	2145000	2345000	2564000



LOOSE SOIL

FORCES

Showing shear forces (with dampers) inLoose Soil

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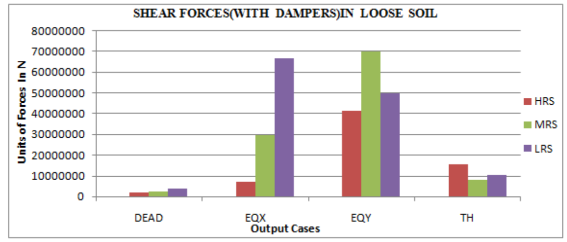
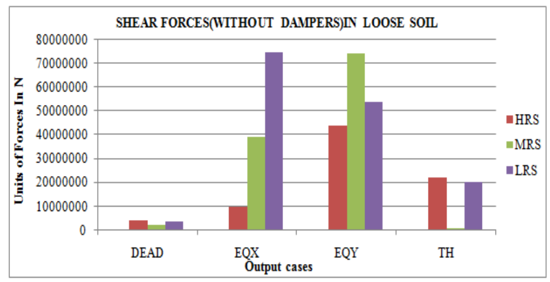
WITH DAMPERS	FORCES	HRS	MRS	LRS
DEAD	CF (N)	2014000	2258500	3528000
EQX	CF (N)	7144000	29654721	66449569
EQY	CF (N)	41253400	69562010	49632510
TH	CF (N)	15451700	7890000	10451700



Showing shear forces (without dampers) inLoose Soil

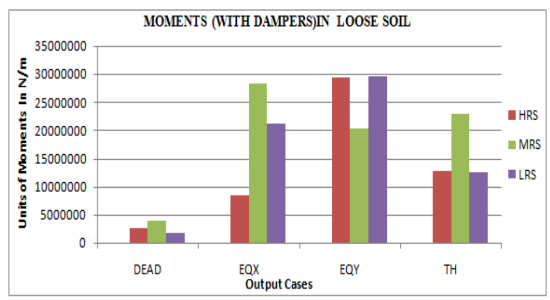
WITHOUT DAMPERS	FORCES	HRS	MRS	LRS
DEAD	CF (N)	4484000	2534360	3916000
EQX	CF (N)	9720080	39267854	74676000
EQY	CF (N)	44197850	74197850	54197850
TH	CF (N)	22335000	1014000	20335000



MOMENTS

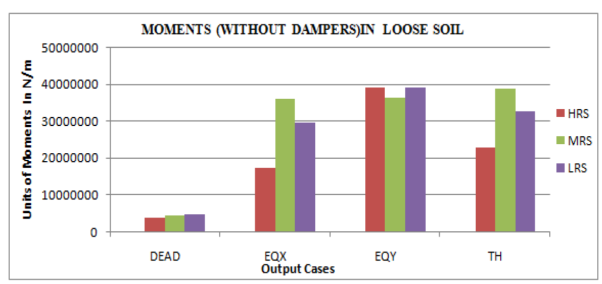
Showing Moments (with dampers) in Loose Soil

WITH DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(m)	2540000	3880000	1642200
EQX	CM(m)	8444120	28242100	2.11E+07
EQY	CM(m)	2.93E+07	20399200	29654721
TH	CM(m)	12654100	22799449	12456000



Showing Moments (without dampers) in Loose Soil

WITHOUT DAMPERS	MOMENTS	HRS	MRS	LRS
DEAD	CM(m)	3920000	4512000	4926600
EQX	CM(m)	17413332	36259554	29722300
EQY	CM(m)	39352100	36638755	39267854
TH	CM(m)	22988000	38910000	32835000



DISPLACEMENTS

Showing Displacements (with dampers) in Loose Soil

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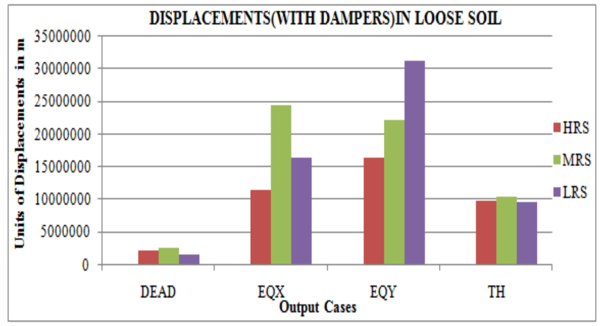
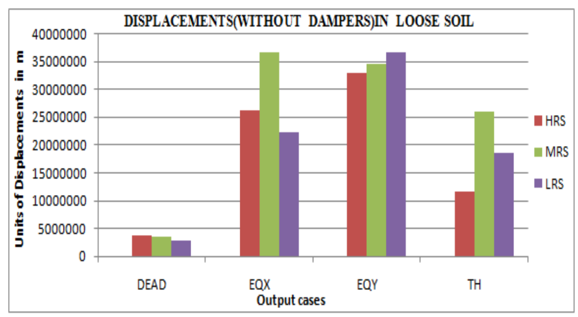
WITH DAMPERS	DISPLACEMENTS	HRS	MRS	LRS
DEAD	CD (m)	2302000	2682000	1724000
EQX	CD (m)	11564000	24445600	16444000
EQY	CD (m)	16444000	22144000	31225600
TH	CD (m)	9956000	10426500	9659365



Showing Displacements (without dampers) in Loose Soil

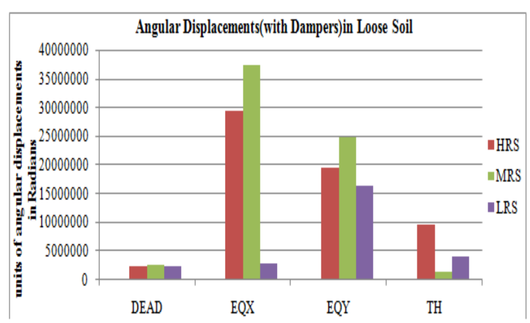
WITHOUT DAMPERS	DISPLACEMENTS	HRS	MRS	LRS
DEAD	CD (m)	3591000	3528000	2682000
EQX	CD (m)	26042000	36444000	22144000
EQY	CD (m)	32888000	34561000	36422000
TH	CD (m)	11459900	25790000	18497800



ANGULAR DISPLACEMENTS

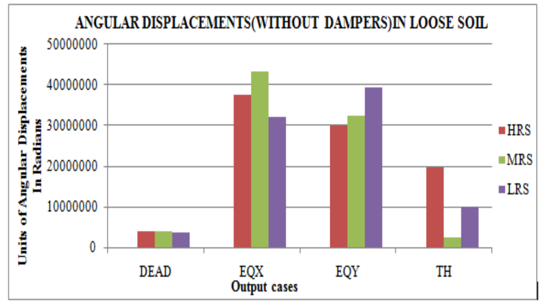
Showing Angular Displacements (with dampers) in Loose Soil

WITH DAMPERS	ANGULAR DISPLACEMENTS	HRS	MRS	LRS
DEAD	CAD(Radians)	2504000	2540000	2302000
EQX	CAD(Radians)	29425000	37256000	2865000
EQY	CAD(Radians)	19545000	24925000	1.6E+07
TH	CAD(Radians)	9724000	1470000	4144000



Showing Angular Displacements (without dampers) in Loose Soil

WITHOUT DAMPERS	ANGULAR DISPLACEMENTS	HRS	MRS	LRS
DEAD	CAD(Radians)	3972000	3920000	3591000
EQX	CAD(Radians)	37425000	43215000	32154000
EQY	CAD(Radians)	29856000	32353000	39358000
TH	CAD(Radians)	19720001	2540000	9934360



IV.CONCLUSIONS

On the basis of present study and reviewed literature the following conclusions can be drawn:

- Seismic performance of building can be improved by providing energy dissipating device (damper), which absorb the input energy during earthquake.
- It is obvious that increases in energy dissipation of structural systems are an essential strategy to withstand the effect of probable earthquakes. Due to limited energy dissipation capacity of actual steel material, friction connections with unlimited energy dissipation capacity observed in cyclic tests, maybe considered as a favorite alternative for conventional structural systems.
- The based on the results obtained, the shear force in the different structures i.e. (High rise, medium, low rise) the values shows that the hard soil is having very high values and very less values in the soft soil due to the soil type conditions the depth of the foundation is varies.
- The moment results also shows that the values in the hard soil is having very high values and very less values in the soft soil due to the soil type conditions the depth of the foundation is varies.
- The best suitable structure for the hard soil is the low-rise structures, because the values in the hard soil show greater values in the structure.
- The best suitable structure in the medium soil is the high-rise structures can be considered that the values in the base reactions and Joint Displacements, and section cut forces are shows moderate results.
- The frame is safer when damper is provided up to top floor from base.
- Damper help in reducing the effect of lateral deflection.
- Seismic performance of building after application of damper is much better when we provide dampers.
- Base shear reduction one can make the structure cost effective.

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