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Vibration control Of High Rise Building With Viscous Dampers Using ETABS

Y.Sarath Kumar Reddy[1], M.S.Anantha Venkatesh [2]

[1] *M.Tech Student,CIVIL, SVR Engineering college ,Hyderabad,Andhrapradesh,India.*

[2] *Head Of The Dept,CIVIL , SVR Engineering college ,Nandyala,Andhrapradesh,India.*

ABSTRACT:

Earthquake load is becoming a great concern in our country as because not a single zone can be designated as earthquake resistant zone. One of the most important aspects is to construct a building structure, which can resist the seismic force efficiently. Study is made on the different structural arrangement to find out the most optimized solution to produce an efficient safe earthquake resistant building.

The basic principles of design for vertical and lateral loads (wind & seismic) are the same for low, medium or high rise building. But a building gets high both vertical & lateral loads become controlling factors. The vertical loads increase in direct proportion to the floor area and number of floors. In contrast to this, the effect of lateral loads on a building is not linear and increase rapidly with increase in height. Due to these lateral loads, moments on steel components will be very high. By providing viscous dampers these moments can be reduced.

In the present analysis, a residential building with 20 floors is analyzed with columns, columns with viscous dampers at different locations were for all the 2 cases. The building is analyzed in Zone 2 & Zone 5 with three soils in both static & Dynamic Analysis. Moments, Shear, Displacement were compared for all the cases. It is observed that the deflection was reduced by providing the Viscous dampers .

A commercial package ETABS2013 has been utilized for analyzing high-rise building of 60m height and for zone-II & zone-V. The result has been compared using tables & graph to find out the most optimized solution.

IndexTerms:Dampers,Retrofitting,ETABS

I.INTRODUCTION

Earthquake load is becoming a great concern in our country as because not a single zone can be designated as earthquake resistant zone. One of the most important aspects is to construct a building structure, which can resist the seismic force efficiently. Study is made on the different structural arrangement to find out the most optimized solution to produce an efficient safe earthquake resistant building.

The basic principles of design for vertical and lateral loads (wind & seismic) are the same for low, medium or high rise building. But a building gets high both vertical & lateral loads become controlling factors. The vertical loads increase in direct proportion to the floor area and number of floors. In contrast to this, the effect of lateral loads on a building is not linear and increase rapidly with increase in height. Due to these lateral loads, moments on steel components will be very high. By providing viscous dampers these moments can be reduced.

In the present analysis, a residential building with 20 floors is analyzed with columns, columns with viscous dampers at different locations were for all the 2 cases. The building is analyzed in Zone 2 & Zone 5 with three soils in both static & Dynamic Analysis. Moments, Shear, Displacement were compared for all the cases. It is observed that the deflection was reduced by providing the Viscous dampers .

A commercial package ETABS2013 has been utilized for analyzing high-rise building of 60m height and for zone-II & zone-V. The result has been compared using tables & graph to find out the most optimized solution. Concluding remark has been made on the basis of this analysis & comparison tables.

II. METHODOLOGY FOR RETROFITTING OF EXISTING BUILDING :

2.1 **Concept of retrofitting**

Retrofitting is technical interventions in structural system of a building that improve the resistance to earthquake by optimizing the strength, ductility and earthquake loads. Strength of the building is generated from the structural dimensions, materials, shape, and number of structural elements, etc. Ductility of the building is generated from good detailing, materials used, degree of seismic resistant, etc. Earthquake load is generated from the site seismicity, mass of the structures, importance of buildings, degree of seismic resistant, etc. Seismic retrofit of an existing building most often would be more challenging than designing a new one. The first step of seismic evaluation aims at detecting the deficiencies of the building. Seismic retrofitting of existing structures is one of the most effective methods of reducing the risk of human life and damage of the buildings. Retrofitting procedures could be selected and applied so that the performance objective of the retrofit depends upon the importance of the structure and the desired structural performance during a seismic event with a particular recurrence interval.

Due to the variety of structural condition of building, it is hard to develop typical rules for retrofitting. Each building has different approaches depending on the structural deficiencies. Hence, engineers are needed to prepare and design the retrofitting approaches. In the design of retrofitting approach, the engineer must comply with the building codes. The results generated by the adopted retrofitting techniques must fulfill the minimum requirements on the buildings codes, such as deformation, detailing, strength, etc.

2.2 Causes of failure

Following were the main causes of failure and damages to the buildings India.

1. Old buildings constructed without considering engineering principles or modern construction practices
2. New Buildings not being designed to Indian earthquake codes
3. Lack of knowledge, understanding or training in the use of these codes by local engineers
4. Buildings erected without owners seeking proper engineering advice
5. Improper detailing of masonry and reinforced structures
6. Poor materials, construction and workmanship used, particularly in commercial buildings
7. Alterations and extensions being carried out without proper regard for effects on structure during an earthquake.
8. Buildings having poor quality foundations or foundations built on poor soils.
9. Little or no regularity authority administering or policing the codes.

2.3 Methods of retrofitting

a) Addition of RC structural walls
b) Steel jacketing
c) Concrete jacketing
d) FRP wrapping etc.

2.4 Recent Retrofitting Methods

There are many relatively new technologies developed for seismic Retrofitting which are based on “Response control”. These techniques includes providing additional damping using dampers (Elastoplastic dampers, friction dampers, tuned mass and tuned liquid dampers, viscoelastic dampers, lead extrusion dampers etc.) and techniques such as base isolation which are introduced to take care of seismic control. Among these the addition of viscoelastic dampers are adopted because due to their smaller sizes, which make them more applicable specially for retrofitting of existing buildings, and their stiffness, which have very important role on regulating of the flexibility rate of the flexible frame and stability control of the system. The benefits of retrofitting include the reduction in the loss of lives and damage of the essential facilities, and functional continuity of the life line structures. For an existing structure of good condition, the cost of retrofitting tends to be smaller than the replacement cost. Thus, the retrofitting of structures is an essential component of long term disaster mitigation.

2.5 Viscoelastic damper

The application of viscoelastic materials to vibration control can be dated back to the 1950s when it was first used on aircraft as means of controlling vibration-induced fatigue in airframes. Since that time, it has been widely used in aircrafts and aerospace structures for vibration reduction. Its application to civil engineering structures appears to have begun in 1969 when 10,000 viscoelastic dampers were installed in each of the twin towers of the World Trade Centre in New York to help resist wind loads. Seismic applications of viscoelastic dampers have a more recent origin. Forces generated due to earthquake are more and larger damping is required for vibration control compared to damping required for control of wind-induced vibrations. Furthermore, during earthquake shaking, energy input into the structure is usually spread over a wider frequency range, requiring more effective use of the viscoelastic materials. Extensive analytical and experimental studies in the seismic domain have led to the first seismic retrofit of an existing building using viscoelastic dampers (designated as VED here after) in the U.S. in 1993.

III DESCRIPTION

A structure can be defined as a body which can resist the applied loads without appreciable deformations.

Civil engineering structures are created to serve some specific functions like human habitation, transportation, bridges, storage etc. in a safe and economical way. A structure is an assemblage of individual elements like pinned elements (truss elements) beam element, column, shear wall slab cable or arch. Structural engineering is concerned with the planning, designing and the construction of structures.

Structure analysis involves the determination of the forces and displacements of the structures or components of a structure. Design process involves the selection and detailing of the components that make up the structural system.

The main object of reinforced concrete

design is to achieve a structure that will result in a safe economical solution.

Statement of project

Salient features

1.Utility of building: Residential complex
2.No.of.Stories :G+20
3.Type of Construction: R.C.C framed structure
4.Types of walls: Brick wall

Geometry Details

Width of the building : 24m
Height of building : 60m
Height of the floor : 3m

Materials

1.concrete grade :M30
2.All steel grades :Fe415 grade

Size of Structural Members

Column Size:

From ground floor to tenth floor: 1000 mm X 750 mm

From eleventh floor to twentieth floor: 450 mm X 750 mm

Beam Size: 400 mm X 650 mm

Slab Thickness: 120 mm

Viscous dampers on each elevation

Grade of Concrete and Steel: M30; Fe 415 Steel

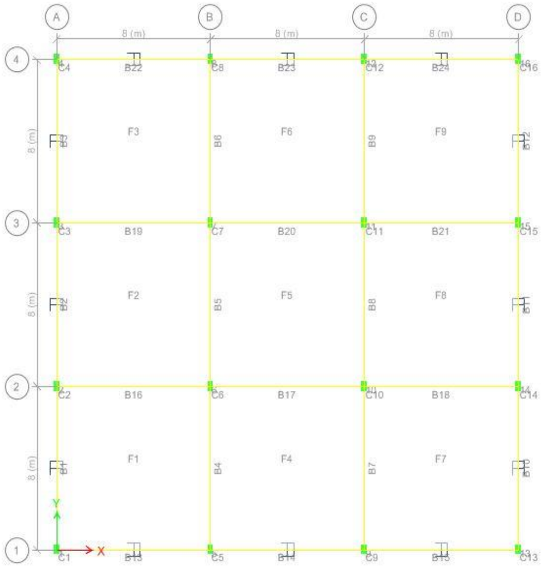


Fig 3.1 showing plan view of high rise building

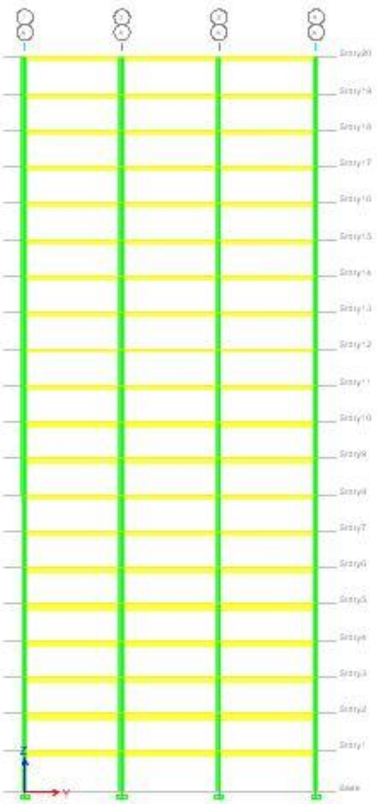


fig:3.2 showing elevation view of high rise building with out dampers

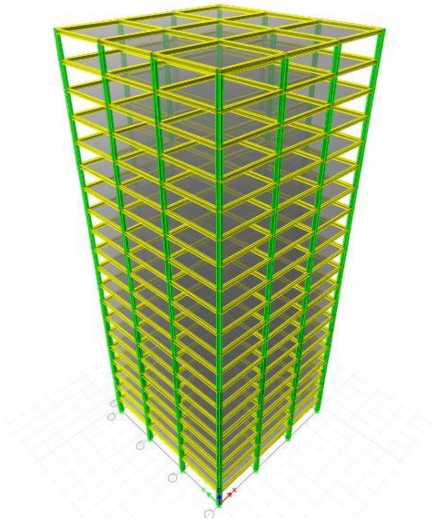


Fig 3.3 showing 3d view of high rise building with out dampers

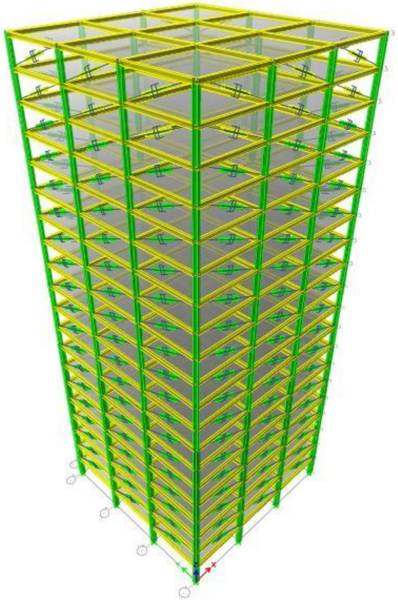


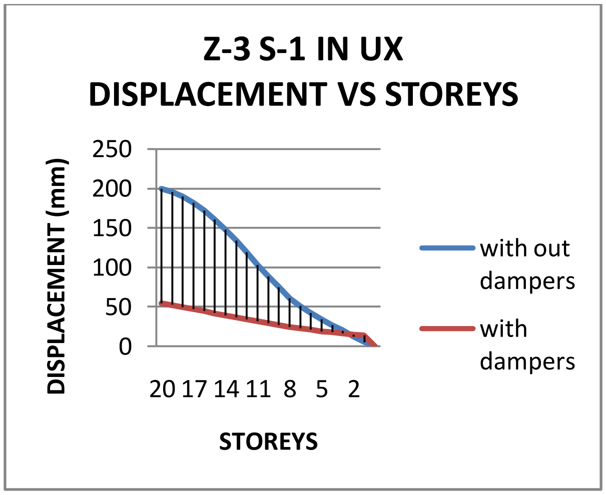
Fig 3.4 showing 3d view of high rise building with dampers

IV. RESULTS

displacement comparison values & graphs in dynamic analysis

Table 4.1 Showing comparison values of Displacement in z-3 s-1

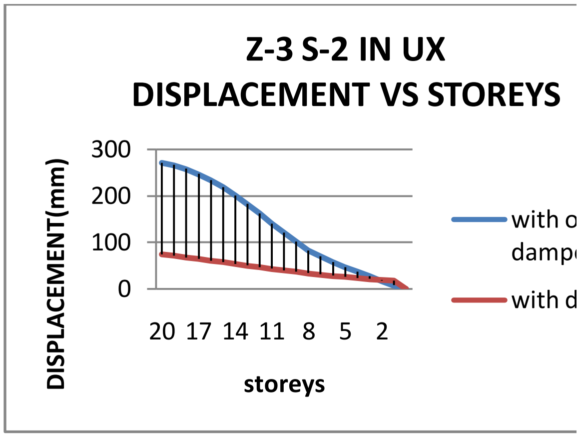
storey	displacement (x-dir) in mm	
	with out dampers	with dampers
20	199.4	54.9
19	195.7	52.5
18	189.7	49.9
17	181.6	47.4
16	171.8	44.8
15	160.6	42.1
14	147.9	39.5
13	134	36.9
12	119	34.3
11	103.2	31.8
10	88.6	29.4
9	75	27.1
8	60.8	24.9
7	51.4	22.9
6	42.1	21
5	34	19.2
4	27	17.7
3	19.9	16.2
2	12.5	15
1	5.4	13.9
0	0	0



Graph 4.1Showing Displacement variation in z-3 s-1

Table 4.2 Showing comparison values of Displacement in z-3 s-2

storey	displacement (x-dir) in mm	
	with out dampers	with dampers
20	271.2	74.4
19	266.2	71.1
18	257.9	67.7
17	247	64.3
16	233.7	60.8
15	218.4	57.3
14	201.1	53.7
13	182.2	50.2
12	161.8	46.6
11	140.4	43.2
10	120.5	39.8
9	101.9	36.6
8	82.7	33.6
7	69.9	30.7
6	57.3	28
5	46.3	25.5
4	36.7	23.2
3	27	21.2
2	17	19.5
1	7.3	17.9
0	0	0

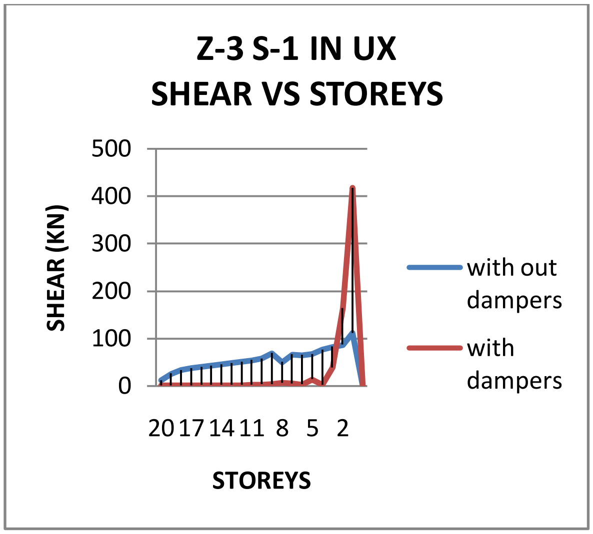


Graph 4.2 Showing Displacement variation in z-3 s-2

Shear comparison values & graphs in dynamic analysis

Table 4.3 Showing comparison values of Shear in z-3 s-1

storey	shear (x-dir) inKN	
	with out dampers	with dampers
20	12.2	0.89
19	26.16	0.96
18	33.33	1.17
17	37.25	1.36
16	39.9	1.54
15	42.9	1.69
14	45.83	1.88
13	47.95	1.92
12	50.47	1.94
11	54.07	2.47
10	57.38	3.29
9	69.01	3.59
8	50.03	6.13
7	66.2	4.86
6	64.89	3.14
5	66.98	13.96
4	76.39	2.58
3	82.55	39.12
2	86.68	164.44
1	111.55	417.23
0	0	0

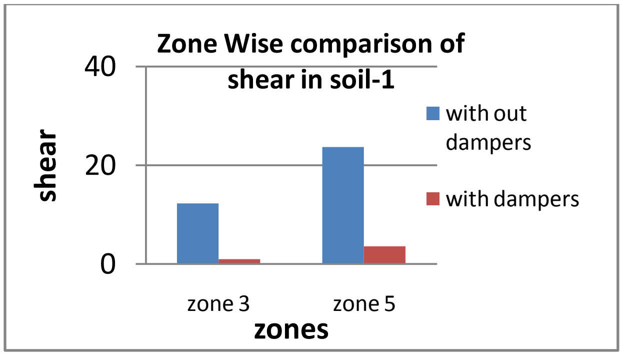


Graph 4.3 Showing Shear variation in z-3 s-1

zone wise shear comparison values in dynamic analysis

Table 4.4 Showing zone wise comparison values of soil-1 in dynamic analysis

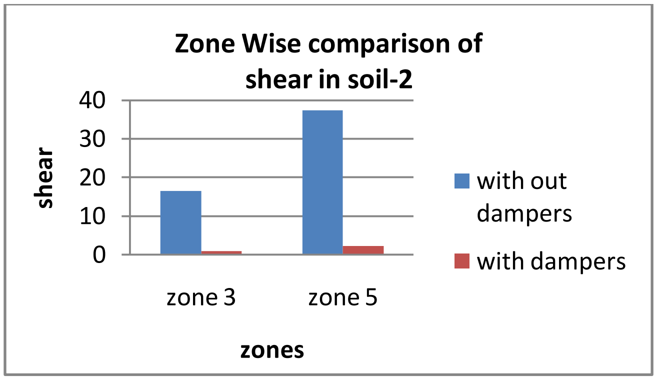
zones	soil-1	
	with out dampers	with dampers
zone 3	12.2	0.89
zone 5	23.62	3.57



Graph 4.4Showing zonewise shear variation of soil-1 in dynamic analysis

Table 4.5 Showing zone wise comparison values of soil-1 in dynamic analysis

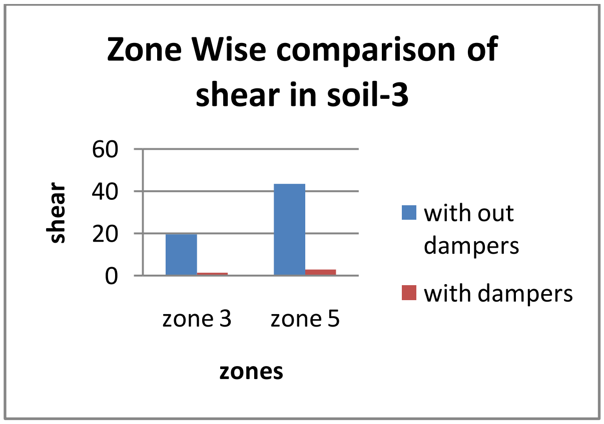
zones	soil-2	
	with out dampers	with dampers
zone 3	16.58	1.04
zone 5	37.31	2.34



Graph 4.5 Showing zonewise shear variation of soil-1 in dynamic analysis

Table 4.6 Showing zone wise comparison values of soil-1 in dynamic analysis

zones	soil-3	
	with out dampers	with dampers
zone 3	19.29	1.18
zone 5	43.42	2.66



Graph 4.6 Showing zonewise shear variation of soil-1 in dynamic analysis

V.CONCLUSION

1. **1.** Displacement is compared for two models i.e,, with out dampers & with dampers at top storey of a high rise building in zone-3 & zone -5 in each soil it is observed that 50% displacement is reduced when the dampers are provided at each elevation.
2. **2.** Shear is compared for two models i.e,, with out dampers & with dampers at top storey of a high rise building in zone-3 & zone -5 in each soil it is observed that 40% shear is reduced when the dampers are provided at each elevation.
3. **3.** Moment is compared for two models i.e,, with out dampers & with dampers at top storey of a high rise building in zone-3 & zone -5 in each soil it is observed that 45% moment is reduced when the dampers are provided at each elevation.

4. Displacement is also compared in dynamic analysis for zone-3 & zone-5 at each soil.

At soil-1, 50% of displacement is reduced from zone-3 to zone -5.

At soil-2, 60% of displacement is reduced from zone-3 to zone -5.

At soil-3, 65% of displacement is reduced from zone-3 to zone -5.

5. Shear is also compared in dynamic analysis for zone-3 & zone-5 at each soil.

At soil-1, 30% of displacement is reduced from zone-3 to zone -5.

At soil-2, 50% of displacement is reduced from zone-3 to zone -5.

At soil-3, 55% of displacement is reduced from zone-3 to zone -5.

6. Displacement is also compared in dynamic analysis for zone-3 & zone-5 at each soil.

At soil-1, 40% of displacement is reduced from zone-3 to zone -5.

At soil-2, 55% of displacement is reduced from zone-3 to zone -5.

At soil-3, 65% of displacement is reduced from zone-3 to zone -5

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BIODATA

Author

Y.Sarath Kumar Reddy Presently persuing his M.Tech (structural engg) in CIVIL Dept SVR Engineering College,Nandyala ,AndhraPradesh,India.

CoAuthor

M.S.Anantha Venkatesh M.Tech (structural engg) Presently working as **HOD in Dept of CIVIL Engineering,**SVR Engineering College,Nandyala, AndhraPradesh,India.