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Comparison of Structural Behaviour of Building Before and After Application of Damper

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Abstract: ***Structural construction industry is growing as it has never been before; there is constantly something under new construction, even at places of odd habitats, thus; it requires to-pay direct attention in specific stresses generated by various loads in buildings via Dead load or Live load. Seismic forces are occasionally acting under internal earth mass disturbance but have high impact on the structural proficient unity of the building. Thus, new techniques like damper are formulated to overcome these seismic loads and thus make buildings more resistant to the earthquakes occurring in the world. This techniques not only make buildings sustainable but also save lives.***

Keywords: Seismic Loads, Dampers, Sustainable

1. Introduction

A new mechanism similar to that used in the shock control mechanism for car has been introduced for the shock absorption of the buildings during earthquake. This mechanism is known as Tuned Mass Dampers. A tuned mass damper, also known as a harmonic absorber, is a device mounted in structures to reduce the amplitude of mechanical vibrations. Their application can prevent discomfort, damage, or outright structural failure. They are frequently used in power transmission, automobiles, and buildings.

Typically, the dampers are huge concrete blocks or steel bodies mounted in skyscrapers or other structures, and moved in opposition to the resonance frequency oscillations of the structure by means of springs, fluid or pendulums. These dampers are easy to design as they work simply on the mechanism of spring. The spring coefficient K with MASS of the damper for tuning is considered and forces are then controlled, hence controlling the vibration.

Tuned mass dampers are very effective in controlling the vibrations of building effectively .They can be placed according to the requirement of the shock absorption needed. Hence they can be placed on the most vibrating member of building and thus the building can be made safe by using only selected members of the building which are weak to earthquake.

In this project, we are trying to analysis the building for earthquake resistance and place the tuned mass dampers on the failed floors so that, the building will remain sustainable during the earthquake shocks.

1.1. Objective of Study

The foremost objective of the present work is to examine the application of Tunned mass dampers and to compare the differences in the forces generated in the structure before and after application of damper.

2. Literature Review

A.V. Bhaskararao, R.S. Jangid [1], ‘’we learn Closed form expressions for the analytical responses of two adjacent SDOF structures connected with friction dampers are derived under earthquake excitation. Two numerical models for the evaluation of frictional force in the damper connecting MDOF structures are also proposed and are validated with the results obtained from the analytical model. From the trends in the results of the present study, the following conclusions are drawn: The seismic responses predicted by the analytical and the numerical models of frictional force in the connected damper closely match. The friction dampers are found to be very effective in reducing the earthquake responses of the adjacent connected structures. There exists an optimum slip force of friction dampers for minimum earthquake response of two adjacent connected structures.

MARSH [2] . “As the joints slip, the cantilevered walls provide the elastic restraint required to create the centring action that ensures a negligible residual displacement after the earthquake. The capacity to dissipate the input of seismic energy with a relatively small travel in the joints, thereby controlling the amplitude of the oscillations, was convincingly demonstrated. Instead of relying on cracking concrete and yielding steel as a means of energy dissipation, reusable sliding joints can limit damage to secondary items and greatly simplify post-earthquake rehabilitation. At that time it was also proposed that the slip be limited, to provide additional protection, but the idea had to be rejected as it led to very high impact forces. Although the use of friction dampers in coupled shear walls, composed of precast panels or in situ concrete, has received extensive research attention, the system has yet to be applied in a full scale structure.

Eduardo Miranda and Vitelmo V. Bertero. [3], “Strength reduction factors which permit estimation of inelastic strength demands from elastic strength demands are evaluated. Results from various investigations of strength reduction factors carried out over the last 30 years are reviewed, and their results are presented in a common format which facilitates their comparison. The main parameters that affect the magnitude of strength reductions are discussed. The evaluation of the results indicates that strength reductions are primarily influenced by the maximum tolerable displacement ductility demand, the period of the system and the soil conditions at the site. Simplified expressions of strength reduction factors to estimate inelastic design spectra as functions of these primary-influencing parameters are presented.

James M. Kelly et. Al. [4] "In the current code requirements for the design of base isolation systems for buildings located at near-fault sites, the design engineer is faced with very large design displacements for the isolators. To reduce these displacements, supplementary dampers are often prescribed. These dampers reduce displacements, but at the expense of significant increases in interstorey drifts and floor accelerations in the superstructure. An elementary analysis based on a simple model of an isolated structure is used to demonstrate this dilemma. The model is linear and is based on modal analysis, but includes the modal coupling terms caused by high levels of damping in the isolation system. The equations are solved by a method that avoids complex modal analysis. Estimates of the important response quantities are obtained by the response spectrum method. It is shown that as the damping in the isolation system increases, the contribution of the modal coupling terms due to isolator damping in response to the superstructure becomes the dominant term. The isolator displacement and structural base shear may be reduced, but the floor accelerations and interstorey drift are increased. The results show that the use of supplemental dampers in seismic isolation is a misplaced effort and alternative strategies to solve the problem are suggested.

3. Methodological Background

The background for this dissertation project lies within; catastrophic loss of humman life and wealth after earthquake vibrations, leaving behind bulk of dismentalled and scraped mass of structure. Which is quite heavy and requieres large machineries and equipments for removing of debried scrap.

Earthquake results in horizontal and vertical forces on structure due to inertia effects. Out of these horizontal forces are generally more critical for the stability of the structure. The effect of earthquake is similar to effect of acceleration on passenger standing in moving bus. When the bus starts moving suddenly, the passenger feels that somebody has pushed him backward. Similarly when the bus stops suddenly the passenger experience a push in the forward direction. Earthquake motion consists of a series of acceleration and deceleration, which results an imaginary forces, continuously changing its direction. Earthquake motion consists of a series of acceleration and deceleration, which results an imaginary forces, continuously changing its direction. The magnitude of the resulting forces on structure is generally higher than the forces for which the structure is designed. This causes yielding of the structure.

The experimental setup was done to analyse the effects of structural behavior after application of dampers STAAD.Pro software tool. The building is having seven stories and overall 31.5 m assembled as G + 14.6. The structural members includes both hoizontal and vertical members. The building is located at seismic zone 5, which is highly prone to earthsake effects and regular seismic actions due to various internal disturbances.

Structural details of LWC (G + 15) building:

1) Number of storey =7 (G + 6)
2) Height of storey = 31.5 m
3) Cross-section of beams = 200 x 450 mm
4) Cross-section of columns = 200 x 500 mm
5) Grade of concrete = M30
6) Grade of steel = Fe 415
7) Dead Load = -1 factor load and -4 kN/m2 as floor load.
8) Live Load = -2 KN/m2 on Floor
9) Seismic Load = As per IS: 1893– 2002, with Z = 0.1,

Analysis of Building: Analysis is done by using STAAD. Pro under design consideration IS: 456 - 2000 and IS: 13920 - 1993.

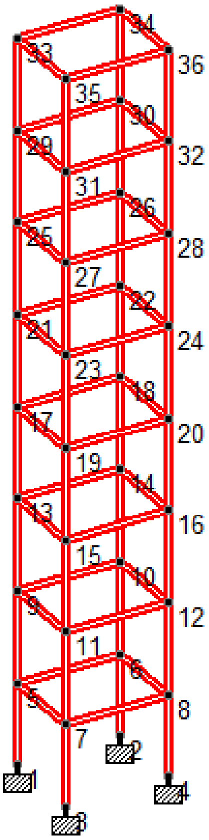


Figure 3.1: RCC structure framed in Staad.Pro

Results of this analysis are as follow

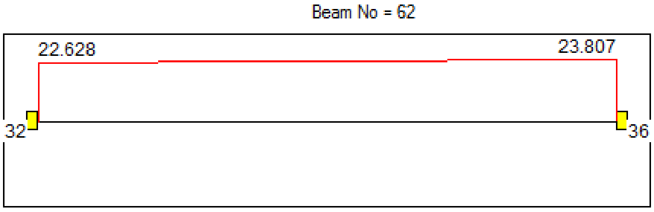


Figure 3.2: displacement at end point of column at floor 6

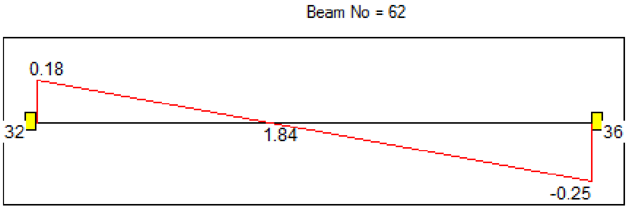
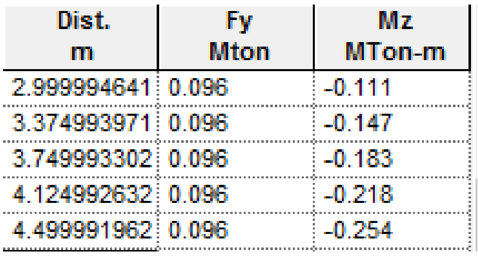


Figure 3.3: shear of column at floor 6

Table 3.1: Shear of column at floor 6



Dist. m	Fy Mton	Mz MTon-m
2.999994641	0.096	-0.111
3.374993971	0.096	-0.147
3.749993302	0.096	-0.183
4.124992632	0.096	-0.218
4.499991962	0.096	-0.254

Then the dampers are applied to the structure

Another analysis is done so in which application of damper is done. For the damper we require stiffness of spring K and mass M, which is combined to form mass damper. For the calculation of K, we have deflection as 33.4 mm and horizontal force acting on the building is 96 Mton. Therefore stiffness K is given by:

$$K = \frac{F}{d}$$

Where d is displacement of the column.

$$K = \frac{96\text{Mton}}{33.4\text{mm}}$$

Therefore stiffness K = 27.78 Kn/mm

Seismic weights: Also, mass has to be applied, therefore calculation of design lateral forces has to be done.

Floor area is 4m x 5m, since the live load class is 3kN/sq.m, only 50% of the live load is lumped at the floors. At roof, no live load is to be lumped. Hence, the total seismic weight on the floors and the roof is:

Floors:

W1 = W2 = W3 = W4 = W5 = W6 = 4 x 5 x 2500 x 0.11+ 150 x 4 x 5 = 83.36 KN

Roof:

W7 = 4 x 5 x 2500 x 0.11 = 54 KN

Total seismic weight of the structure,

W = ΣWi = 83.36 x6 + 54 x 1 = 554.2 KN say 554 KN

Fundamental Period: The fundamental natural period of vibration (Ta), in seconds of a moment resisting building without brick infill panels may be estimated by empirical expression:

$$Ta = 0.075h^{.75}$$

$$Ta = 0.075(31.5)^{.75}$$

$$Ta = 0.997$$

For the seismic zone V, the zone factor is 0.36 (table 2, IS 1893), being a general building the importance factor is 1 (table 6, of IS: 1893). The response reduction factor for ordinary building is 3.0. Hence

$$Ah = \frac{ZISa}{2Rg}$$

$$Ah = 0.36 \text{ X } 1.0 \text{ X } 2.5/\ 2 \text{ X } 3$$

$$Ah = 0.15$$

Design base shear:

$$Vb = Ah \text{ x } W = 0.15 \text{ x } 554 \text{ KN} = 83.1 \text{ KN}$$

Table 3.7: Lateral Load distribution with height by the Static Method

Storey Level	Wt (KN)	hi(m)	Wihi^2 / (1000)	Wihi2 / ∑Wihi2	Lateral force at i^{th} level for EL (KN)
7	54	31.5	53.58	0.26	21.5
6	83.36	27	60.77	0.29	24.4
5	83.36	22.5	42.20	0.20	16.9
4	83.36	18	27.01	0.13	10.8
3	83.36	13.5	15.19	0.07	6.1
2	83.36	9	6.75	0.03	2.7
1	83.36	4.5	1.69	0.01	0.7

Since maximum deflection and maximum horizontal force happend at the top and bottom of the column, therefore to counteract the horizontal forces, horizontal mass of -20KN is applied to the columns.

4. Result Analysis

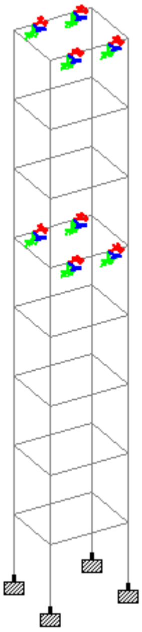


Figure 4.1: Arrangement of spring and mass at the beam

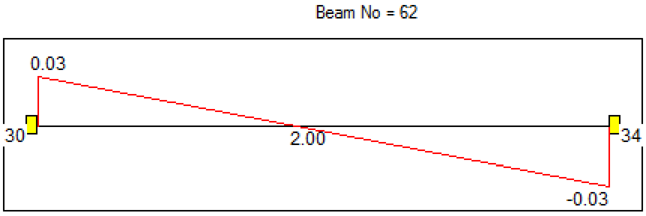
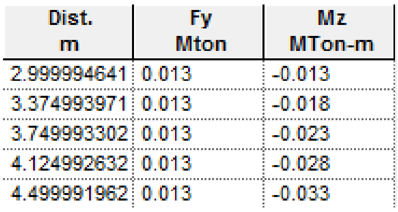


Figure 4.2: Shear at floor 6

Table 4.1: Shear at floor 6 at different distances



Dist. m	Fy Mton	Mz MTon-m
2.999994641	0.013	-0.013
3.374993971	0.013	-0.018
3.749993302	0.013	-0.023
4.124992632	0.013	-0.028
4.499991962	0.013	-0.033

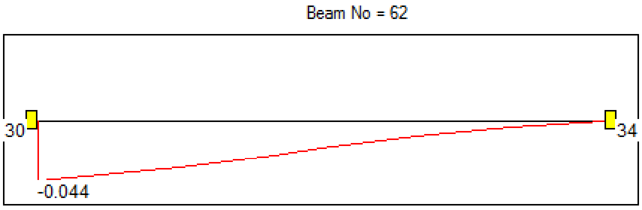
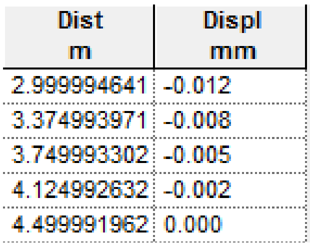


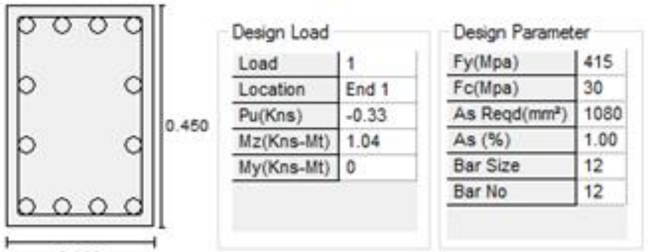
Figure 4.3: Displacement at floor 6

Table 4.2: Displacement at floor 6 at different distances



Dist m	Displ mm
2.999994641	-0.012
3.374993971	-0.008
3.749993302	-0.005
4.124992632	-0.002
4.499991962	0.000

Concrete Design of Beam and Column
COLUMN NO. 20 DESIGN RESULTS
M30 Fe415 (Main) Fe415 (Sec.)
Length: 4500.0 mm CROSS SECTION: 450.0 mm X 300.0 mm COVER: 40.0 mm
** **Guiding Load Case:** 1 END JOINT: 20 TENSION COLUMN
Reqd. Steel Area: 1080.00 Sq.mm.
Reqd. Concrete Area: 133920.00 Sq.mm.
MAIN REINFORCEMENT: Provide 12 - 12 dia. (1.01%, 1357.17 Sq.mm.)
(Equally distributed)
Tie Reinforcement: Provide 8 mm dia. rectangular ties @ 190 mm c/c
Section Capacity Based On Reinforcement Required (KNS-MET)
Puz: 2144.07 Muz1 : 46.83 Muy1 : 73.96
Interaction Ratio: 0.02 (as per Cl. 39.6, IS456:2000)
Section Capacity Based On Reinforcement Provided (KNS-MET)



Design Load

Load	1
Location	End 1
Pu(Kns)	-0.33
Mz(Kns-Mt)	1.04
My(Kns-Mt)	0

Design Parameter

Fy(Mpa)	415
Fc(Mpa)	30
As Reqd(mm²)	1080
As (%)	1.00
Bar Size	12
Bar No	12

Figure 4.6: Reinforcement detail of column 20 after application of dampers

5. Result Discussion

From the above tabulated results, design calculations and the figures, it has been shown that, firstly when the building is subjected to earthquake loading, there was noticeable displacement at the column. But after the application of damper which contains a spring and a mass, there is reduction in the displacement of the column. Since the main concern during the earthquake is the deformation of building, but in this analysis, since the deflection of the structure is reduced, the building can be made sustainable for the earthquake forces.

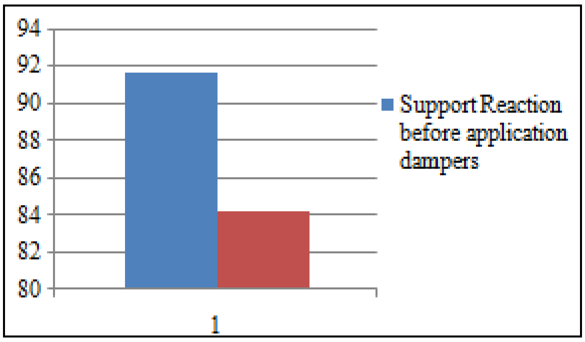
The arrangement of spring and mass has thus reduced the failure of building for the earthquake forces and made the structure sustainable. The arrangement is very simple and its workability can be designed with further study of its mechanism. This arrangement has caused reduction in support reactions, beam forces and deflection. The comparision in the results for the column can be seen as:-

Table 4.6: Support reaction at the Support Before application of dampers

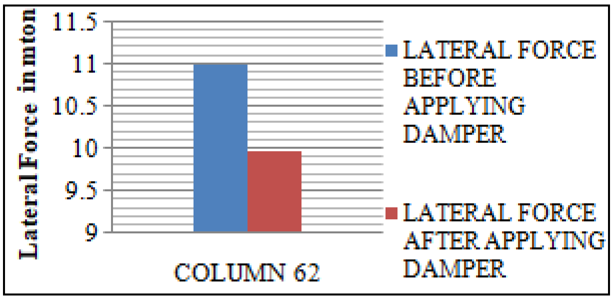
	Horizontal	Vertical	Horizontal	Moment		
Node	Fx Mton	Fy Mton	Fz Mton	Mx MTon-m	My MTon-m	Mz MTon-m
1	0.394	91.8	0.309	0.408	0	-0.523
2	-0.394	91.8	0.309	0.408	0	0.523
3	0.394	91.8	-0.309	-0.408	0	-0.523
4	-0.394	91.8	-0.309	-0.408	0	0.52

Table 4.7: Support reaction at the Support after application of dampers

	Horizontal	Vertical	Horizontal	Moment		
Node	Fx Mton	Fy Mton	Fz Mton	Mx MTon-m	My MTon-m	Mz MTon-m
1	0.45	89.614	0.282	0.374	0	-0.594
2	-0.45	89.614	0.282	0.374	0	0.594
3	0.45	89.614	-0.282	-0.374	0	-0.594
4	-0.45	89.614	-0.282	-0.374	0	0.594



Graph 4.1: Comparison of support reactions for both analyses



Graph 4.2: Comparison of Lateral Force for both analyses

6. Conclusion

- A damper is designed which consists of simple spring and mass connection that resembles the shock up of vehicle.
- Spring damper is designed by observing deflection and lateral forces acting on the member and hence stiffness of spring is calculated.

- The mass applied to the structure is calculated by the static lateral load analysis and this mass is applied to the floors on which springs are attached.
- The analysis is done first without the applications of dampers so that the actual reactions and load is observed and then according to the results obtained dampers are applied.
- The reaction at the support is decreased by 2.381% due to the damper application as more forces get transferred to the supports.
- The lateral forces acting on the beam due to earthquake forces is reduced by 9.26% and beam is designed safely.
- The deflection of the column, (which is the main concern for earthquake resistant building) is reduced by 98.8152%.
- Shear forces of the member has also been reduced by 88% due the application of dampers.
- This damper can be applied to only selected floors that have maximum deflection and lateral forces acting on it.
- This damper is of simple assembly that can be applied easily to the structure.
- The main purpose of the project is to reduce the complex assembly of the damper to the easy damper consisting of mass and spring.
- The damper is workable and easy to handle.

7. Future Scope of Work

In this project, analysis is done with the application of damper that is composed by simple application of spring and mass. This works as the shock up same as in the vehicle.Generally buildings are provided with heavy and complex dampers, thus this project provides the simple and integrated way for the application of damper on the buildings.Future buildings are now designed and planned so that they provide maximum utility for the occupants. Thus this damper connection is a beam column connection that will reduce the complex connection methods and will not hinder the utility of the building. This analysis is precisely done for the floor that has failed in deflection. Thus an only selected floor has to be applied for the dampers. Hence this analysis is termed as Selective Damping.

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