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Strengthening of R.C Framed Structure Using Energy Dissipating Devices

[1]Shrikant Moger, [2]Praveen J.V

[1]CADS (M.Tech)4th sem, [2]Assistant Professor, Dept. of CIVIL Sri Siddhartha Institute of Technology Tumkuru, India

Abstract: **The Dampers which is added to the building scheme without any interruption to the present constituent of the building. In past days retrofitting structures are use full in the construction field however a good understanding of restraints involvement to increase the structure capacities and decreasing the seismic demand in specifically to the design process. In this work consider the energy dissipating devices for seismic strengthening of 5 stories concrete structure in this study involves viscous damping devices of V Type and Inverted V Type dampers with different effective stiffness, to prevent building damage or collapse in major earthquake.**

Keywords: **R.C Framed Structure, Energy Dissipating Devices, V Type dampers.**

1. INTRODUCTION

Seismic activity is one of the main natural hazards to the life on the ground and has affected innumerable cities and villages of almost every continent. The damage caused by earthquakes is mostly to manmade structures. Hundreds of small earthquakes happen around the world every day and every year earthquakes take the lives of thousands of people.

Earthquake is the hazardous movement which takes place due to strong ground motion causes collapse of structure and even structure may collapse. Earthquakes are infrequent forces on structures that may occur during the lifetime of buildings. As seismic waves move through the ground, they create a series of vibrations. These activities are translated into dynamic loads or inertial forces that cause the ground and anything attached to it to vibrate in a multifaceted manner. These inertial forces cause damage to buildings and other structures. In regions where seismicity is unimportant, the conventional design approach aims at the design of structural members in different such a way that static (gravitational) and dynamic loads (such as wind load) are withstand elastically. However, if this design approach was to be followed in cases where seismic excitation had to be taken into account, this might lead to energy useless and economically unacceptable design solutions. in addition this approach leads to higher masses and hence higher seismic forces. Therefore, but alternative design concepts are regularly chosen.

Seismic activity or seismic performance defines a structure's ability to perform its main functions, such as its safety and serviceability, at and after a particular earthquake exposure. A structure is normally considered safe if it does not cause danger to the lives and well-being of those in or around it by partially or entirely collapsing. A structure may be considered serviceable if it is able to fulfill its operational functions for which it was designed. Basic concepts of the earthquake engineering, implemented in the major building codes, assume that a building should live on a rare, very severe earthquake by satisfying significant damage but without internationally collapsing. On the other hand, it should remain operational for more frequent, but less severe seismic actions In recent years, considerable awareness has been paid to research and development of structural control devices, with particular concentrating on effects of wind and seismic response of buildings, these energy dissipating devices are mainly used to increase the seismic response of the active building which are susceptible as per change in code provision. Serious efforts have been undertaken to develop the structural control concept into a workable technology, and today we have many such devices installed in a wide variety of structures. Innovative techniques based on adding devices to the buildings with the main objective of dissipating the energy exerted by the earthquake. Some retrofitting procedures such as jacketing, base isolation and also by energy dissipating devices are used to suppress the shock and to toughen the effected structure.

Objectives:

1. To amplify the earthquake resistant capacity of superlative buildings using energy dissipating devices (Viscous restraint).

2. To determine weaker zones in the superlative structures which liable to collapse.

3. To evaluate the response of the ideal structures with and without energy dissipating devices (Viscous restraint) for earthquake loads.

2. METHODOLOGY

In the present study an ideal building model is selected. In the building model selected for the study, to strengthen the weaker zone in the structure force dissipating devices are installed and response of the building is studied. The selected models will be then analyzed as per IS1893:2002 and designed as per IS456:2000 then the model will be subjected to push over analysis.

The pushover analysis process is considered as one of the powerful apparatus for performance estimate of buildings with respect to objectives set in performance based earthquake engineering. The modeling is one of the important steps to be considered while conducting pushover analysis. In this study, building model considered is suitable for the determination of the nonlinear properties of each section in the structure that are quantified by potency and deformation capacities. The building is modeled and analyzed with and without the energy dissipating device of V Type viscous damper and Inverted V Type viscous damper with different properties of effective stiffness as shown in table using E Tabs. The result obtained is based on performance evaluation as per ATC 40 and FEMA 356. 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.

Properties of added damper

Element	Weight (KN)	Effective stiffness (KN/cm)	Effective damping (KN-s/m)
D0	19.24	2500	10
D1	19.24	3000	10
D2	19.24	5000	10
D3	19.24	7000	10

3. LITERATURE REVIEW

Costas A. Syrmakezis. (2006) In this paper structural retrofitting using inactive control devices has been presented. The application of restraint elements has been investigated either for modern or for historical structures. Particularities of each of the two types, affecting the mechanical structural properties, the modeling recreation assumptions and the conception of the retrofitting design, have been accessible.

The procedure of structural analysis and design, using dampers, has been established through two case studies: a modern reinforced concrete structure, "section B" of Adios Andreas hospital, and an historical masonry one, the Adios Panteleimonas church and its conjugated Cistern. In the first case, non disruption of the hospital operation is desired, which can only be satisfied by retrofitting, incorporating damper braces into the load-bearing system of the structure. The application of this retrofitting system can also satisfy the criterion of minimization of displacements, in order to avoid damage of electro-mechanical equipment. As calculated by analysis, displacements along the earthquake loading direction have been compact at 49, 12% of the actual structure displacements, while, for the construction of concrete jackets the respective value has been equal to 67, 46%.

For the historical structure, requirements related to reversibility and compatibility of interventions can be met by the use of dampers. The evaluation of the susceptibility decrease has been established through a fragility curves diagram dampers have been proved to considerably improve the seismic response.

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D. Escolano-Margarit et al., (2012) This paper provides partial results of an on-going research aimed at investigating the seismic reaction of reinforced concrete (RC) frames equipped with hysteretic type energy dissipating devices (EDD). From a prototype RC frame structure designed only for magnitude loads, a test model scaled in geometry to 2/5 was defined and built in the Laboratory of Structures of the University of Granada. Four EDDs were installed in the test model to provide the same seismic resistance than a conventional RC bare frame designed for maintain magnitude and seismic loads following current codes. The test model with EDDs was subjected to numerous seismic simulations with the shaking table of Laboratory of structures of the University of Granada. The test results provide empirical evidences on the efficiency of the EDDs to prevent damage on the main frame and concentrating the inelastic deformations on the EDDs.

The frame structure was designed to resist only magnitude loads, leaving to the restraints the responsibility of the whole earthquake resistance. The main findings of this investigational study may be summarized as follows:

- The inclusion of the energy dissipation devices in the RC frame structure provided the necessary lateral strength to resist the maximum design earthquake.
- The inclusion of hysteretic dampers satisfied and even enhanced, the expected Structural performance level (SPL) considered in design for all the seismic hazard levels considered.

Dr. R. B. khadiranaikar et al., (2013) this document presents a way of using energy dissipation devices for seismic strengthening of a RC framed structure. The aim of the scheme is to improve the capacity of the building to resist the earthquake using energy dissipation devices, particularly viscous restraints of different types such as single diagonal, double diagonal, inverted V and V type of viscous dampers with different percentages of damping such as 10%, 20% and 30% to prevent building from collapse in a major earthquake and also to control the damage during shaking. The performance of the buildings is assessed as per the procedure prescribed in ATC-40 and FEMA 356.

- The similarity of the results both in X and Y direction of all the type of viscous restraints indicates that by installing restraints in the structures we can decrease the base shear of the building. So by reducing base shear in the concrete frame structure, we can enlarge the capacity of the building to resist the earthquake.
- By comparing the results of both single diagonal and double diagonal type of viscous restraints the percentage reduction in base shear of single diagonal is 26.60% and double diagonal is 26.52%. So the percentage reduction in double diagonal is low but providing double diagonal type of viscous restraints is better than single diagonal type of viscous dampers, because we don't know in which direction seismic activity will occur.
- By installing the viscous restraints of different types at 10, 20, 30% of damping we can increase the fundamental natural period which makes the structure more elastic during seismic activity. And by comparing fundamental natural period of all the four type of viscous restraints the increase in fundamental natural period of V type of viscous restraint is more.
- By comparing the results of performance point in x and y direction, we can conclude that after installing restraints the performance level from region LS-CP comes to region A-B. So, by installing restraints we can improve the performance level of the building to resist the earthquake.
- By installing viscous dampers we can reduce the displacement in the building which makes the building earthquake resistant.
- Model without restraints collapse at step 6, after installing single diagonal type of restraints building also collapse at step 6, in double diagonal type of dampers building collapse at step 8 and for both inverted V and V type of dampers building collapse at step 10.so by installing restraints with different percentage of damping in the structure we can increase the lateral load coming to the building during seismic activity

M. K. Dethariya and B. J. Shah. (2011) During august-2007 Peru seismic activity many multi-storeyed buildings in urban areas was collapsed and suffered wide spread damages. Post seismic activity observations exposed many deficiencies in these structures including non-adoption of seismic engineering practices and lack of seismic resistant features. The seismic performance of a building can be improved by using energy absorbing devices, which may be active

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or passive in nature. Active control techniques have not found much appreciation due to its high cost and large instrumentation set up. Whereas, passive control systems such as base isolation, dampers, bracing systems etc. are found to be easy to install and cost efficient as compared to previous one. Use of restraints is now becoming cost effective solution to improve seismic performance of existing as well as new buildings. This document deals with use of viscous restraint in the building. A nine storied building frame is analyzed with and without braced type viscous restraint placed at different storey level. Nonlinear time history analysis is carried out using SAP2000 software and comparisons are shown in a tabulated and graphical format.

The study concludes as listed below,

- With the deployment of viscous restraint in the structure is the highest response and drift reduces.
- The performance of VDD is more superior to the usual (Bare) frame. By the provision of viscous restraints up to five stories, highest drift is reduced from 3.187% to 1.19%.
- Main factor for reduction of response of the structure is different parameters connected in the selection of restraints like stiffness, damping coefficient and exponent. Thus these varying parameters give the different response during time history analysis.
- The maximum acceleration decreases from 2.2% to 0.4% and base shear increase from 0.8% to 1.67% by providing restraints up to five stories.

4. ANALYSIS METHODS

Analysis methods are broadly classified as linear static, linear dynamic, nonlinear static and nonlinear dynamic methods. In these the first two methods are suitable when the structural loads are small and no point, the load will reach to collapse load and are differs in obtaining the level of forces and their distribution along the height of the structure. Whereas the non- linear static and non-linear dynamic analysis are the improved methods over linear approach. During earthquake loads the structural loading will reach to collapse load and the material stresses will be above yield stresses. So in that case material nonlinearity and geometrical nonlinearity should be incorporated into the analysis to get better results. These methods also provide information on the strength, deformation and ductility of the structures as well as distribution of demands.

5. DESCRIPTION OF STRUCTURAL MODEL

An ideal five-storey (G+4) reinforced concrete moment frame building is chosen for study. The building is kept symmetric in both orthogonal directions measures approximately 44m each way in plan at all floor levels. Storey height is about 4m at all elevations. The roof and floors having slab of thickness 125 mm. The beams in the building are of 0.3m x 0.6m and columns in the building are taken to be square of 0.4m square. The building is considered to be located in seismic zone V and intended for office use. Concrete with compressive strength of 20 MPa and steel with yield strength of 415 MPa are used for design. The unit weight of the concrete is taken as 25kN/m^3. The earthquake load calculations have been done as per the three revisions of IS 1893-2002. Live load of 3KN/m^2.

6. RESULT AND DISCUSSION

BASE SHEAR AND PERFORMANCE LEVEL:

Table: the values for comparison of results in x direction with different damper and its properties.

Dampers	**Base force (KN)**	**Performance level**	**Base force (KN)**	**Performance level**	**% of resistance**
Directio-n x	**Without dampers**		**With Dampers**		
I	15161.2	LS-CP	-	-	-
VD0	15161.2	LS-CP	18965.72	IO-LS	25.093
VD1	15161.2	LS-CP	19534.53	IO-LS	28.844
VD2	15161.2	LS-CP	21296.34	IO-LS	40.465

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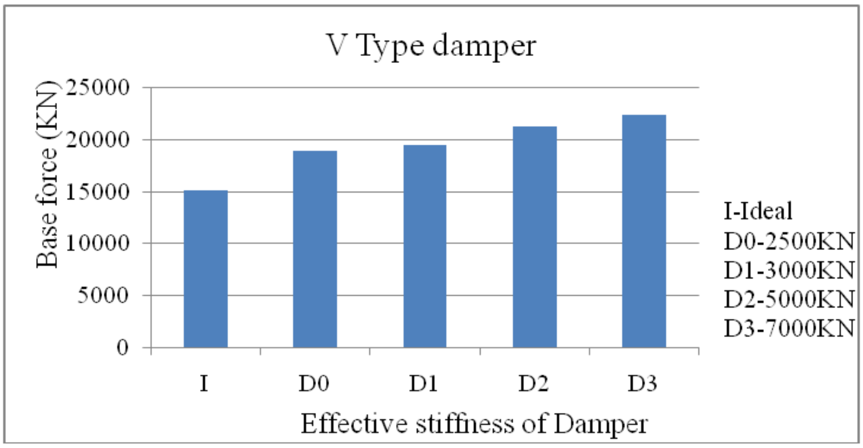
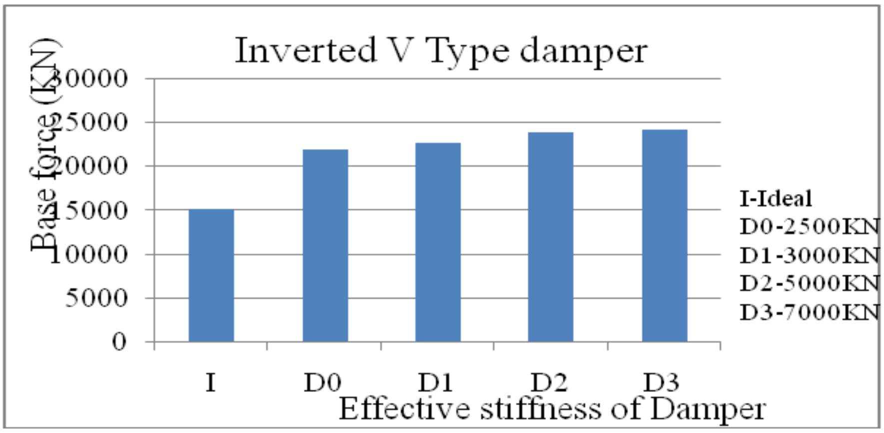
VD3	15161.2	LS-CP	22422.99	IO-LS	47.896
IVD0	15161.2	LS-CP	22075.56	IO-LS	45.604
IVD1	15161.2	LS-CP	22775.83	IO-LS	50.223
IVD2	15161.2	LS-CP	23920.23	B-IO	57.771
IVD3	15161.2	LS-CP	24227.74	B-IO	59.80

V-Type; IV-Inverted V Type. D0, D1, D2, D3-damper properties mentioned in Table

The variation of base shears with different effective stiffness of damper in V Type damper in x-direction



The variation of base shears with different effective stiffness of damper in Inverted V Type damper in x-direction



7. CONCLUSIONS

- The comparison of the results both in X and Y direction of all the type with different efficient stiffness of viscous restraints indicates that by installing dampers in the structures we can increase the base shear resisting capability of the building.

- By comparing the results of both V Type and Inverted V type of viscous restraints the percentage resistance is more in buildings with Inverted V Type than in buildings with V Type restraints. Therefore, providing Inverted V type of viscous restraints is better than V type of viscous dampers.

- By comparing the results of performance point in x and y direction, we can conclude that after installing restraints the performance level from region LS-CP comes to region B-IO. So, by installing restraints we can improve the performance level of the building to resist the earthquake.

- By comparing the results of hinge status in both x and y direction, we can conclude that after installing restraints the hinge status from plastic region comes to elastic region i.e., A-B which means it is no damage region and the building is in safer range.

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- By comparing the results of ductility in both x and y directions, it can be concluded that the ductility of building increases with V Type damper for effective stiffness of 2500KN and 3000KN and decreases with 5000KN and 7000KN.

- By comparing the results of ductility in both x and y directions, it can be concluded that the ductility of building increases with increasing effective stiffness in Inverted V damper.

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