

Seismic Isolation System using U-Shaped Steel Damper



G. Jyothi Sri Sravya, Atulkumar Manchalwar

Abstract: In the present paper base isolation system is analyzed and its seismic behavior is investigated using U-shaped steel dampers as an isolator by placing it at the bottom of the structure. It is the most popular way of protecting the structure using control techniques for earthquake ground motion. The dampers significantly reduced damage factors such as displacement and drift. To reduce structural response to external forces, which can be accomplished through the use of special protective systems. So to prevent these damages, seismic isolation technique can be used for newly constructed structures. The time history analysis of the time domain on this structure is conducted by using SAP2000 software.

Keywords: Isolation, U-shaped damper, Time history Analysis, SAP2000, MDOF.

I. INTRODUCTION:

According to the literature, this use of base isolation was first proposed in the year 1909 and thereafter eventually developed into a full-scale industry for seismic infrastructure protection in regions prone to earthquakes, see e.g., Markov *et.al* (2016) [5]. Base isolators are designed to function at much greater efficient ductilities than any of those considered usual non-linear un-isolated structures, see e.g., Manchalwar (2019) [1]. These days the base isolation strategies speak to an intriguing plan procedure for decoupling the structure from the harming impacts because of ground increasing speeds if there should be an occurrence of seismic occasions. The most common and effective practice is to place seismic isolators at the base of a structures to deflect the seismic energy. Zhou (2016) [5] The superstructure is decoupled from earthquake ground movement in seismically base isolated structures by adding a dynamic interface between the foundation and the structure core. A popular design method for earthquake resistance is the use of seismic isolation devices between both the superstructure and the substructure to reduce the transmission of seismic forces from the ground to the structure. A. Komur (2015) [7] The isolation mechanism thus moves the time period of the structure to a high value and/or dissipates the energy through damping, reducing the amount of force that can be transferred to the super structure to significantly minimize inter-story drift and floor acceleration, see e.g., Matsagar and Jangid (2018). [4]

Manuscript published on November 30, 2019.

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Dampers were modeled in each story on the building's outer frame. The dampers significantly decreased measures of damage such as displacement and drift. The inelastic deformation function of metallic instruments provides an effective mechanism for the vibration regulation of a structure.

To rising a structure's seismic response see e.g., Manchalwar and Bakre (2018). The building structure was evaluated in this work without and with total dampers and the response quantities such as maximum displacement, maximum inter-story drift, axial force, shear force and bending moment has been compared, see e.g., Manchalwar and Bakre (2016) [3]

The aim of this work is to assess the quality of isolated systems which are used to protect the structure, previous studies were conducted to evaluate the quality of isolated entities in the building. In contrast, surface movements, structural responses and reactions to equipment and multidirectional naturally. Previous methods. Either (a) previous model reduction methods for hysteretic systems are limited to reducing only the systems linear aspects. (b) Nonlinear process approximation using modal superposition of time-varying modes. See e.g. P. Harvey Jr. et al. (2015)

II. U-SHAPED STEEL DAMPER

The U-shaped damper is a new steel damper made of rolled steel of high quality.

This absorbs seismic energy and utilizes balanced restore for ce characteristics to minimize movement during earthquakes . The base isolation U-shaped damper exhibits near identical hysteretic behavior in all directions (360°).It is economical compared to conventional base isolation steel rod dampers, with low cost relative to the level of shear yield strength.The level of damage following an earthquake can be ascertained visually.The damper section can also be replaced after the seismic activity, in the unlikely event that this is necessary.



Fig. 1. U-shaped steel isolator (A. Watanabe and K. Suzuki, 2015)

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III. BASE ISOLATION BUILDING MODEL

A 5-storey base-isolated structure is modelled as SDOF with fundamental mode, this study is taken from the Zhang and Phillips, (2015) as a basic depiction of simple low rise structure. The fundamental natural period of the superstructure (fixed-base structure) is 0.54 s and the damping ratio is 2%.

See e.g. Zhang *et al.* (2015). The parameters of the model are shown in Table 1. The model shown in the fig is of both fixed-base and base-isolated conditions, and had a lumped parameter model on each story with one degree of freedom. It is assumed that this model will remain linear-elastic during all external excitations.

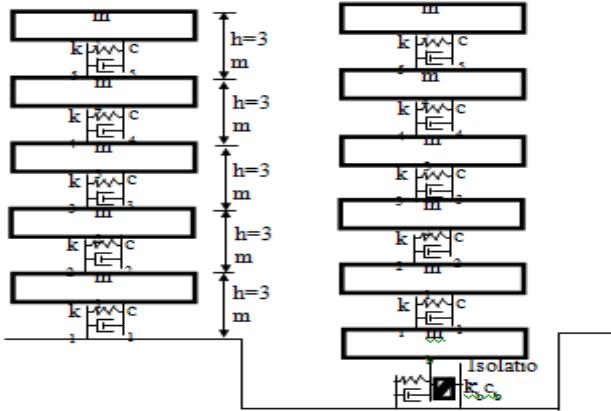


Fig. 2 Schematic of 5-story fixed-base and base-isolated structure model

Table 1. Parameters of 5-Story Fixed-Base and Base-Isolated Structure models.

Floor mass (kg)	Story Stiffness (kN/m)	Damping coefficient (kg/s)
$c_1 = 34,814$	$m_1 = 53,073$	$k_1 = 101,196$
$c_2 = 30,138$	$m_2 = 53,073$	$k_2 = 87,279$
$c_3 = 29,618$	$m_3 = 53,073$	$k_3 = 85,863$
$c_4 = 25,981$	$m_4 = 53,073$	$k_4 = 74,862$
$c_5 = 19,745$	$m_5 = 53,073$	$k_5 = 57,177$

i. Base shear comparison

To access the U shape steel damper performance, the non-linear time history analysis has been carried out in SAP-2000 software. In the following figures we observe the time history graphs of Imperial Valley- Energy (kN) Vs Time (s), Kern Country- Energy (kN) Vs Time (s), Northridge- Energy (kN) Vs Time (s) and Loma Pritea- Energy (kN) Vs Time (s). While application of U-shaped steel dampers we have observed that the seismic waves can be controlled in a very large scaleand the structure has very less deformation.

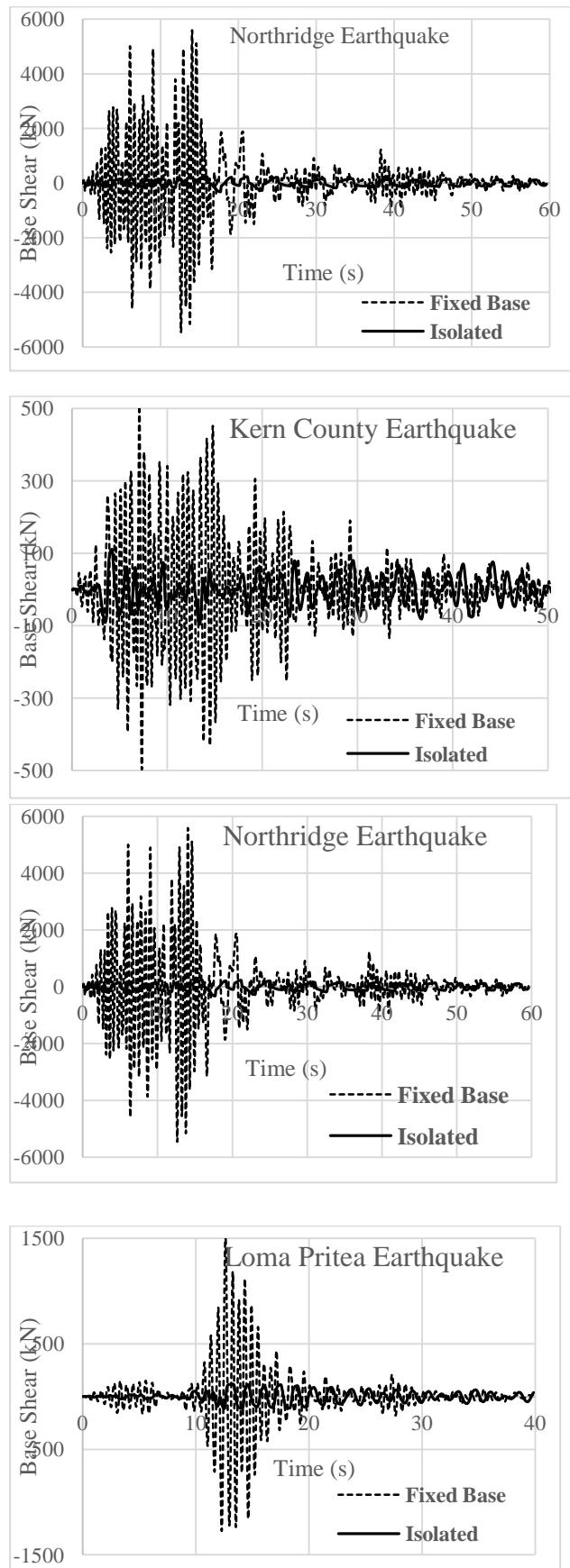


Fig-3 Base shear (kN) versus Time (s)

ii. Acceleration comparison

Acceleration is the frequency of the object's velocity vs. time. The acceleration of an object is the net result of all the forces that work on the body. In the following figures we observe the time history graphs of Imperial Valley- Energy (m/s^2) Vs Time (s), Kern- EnergyCountry (m/s^2) Vs Time (s), Northridge- Energy (m/s^2) Vs Time (s) and LomaPritea-Energy(m/s^2) Vs Time (s). It has been observed that U shaped steel dampers can control the seismic waves to a very large degree and can protect the structure from any future earthquakes.

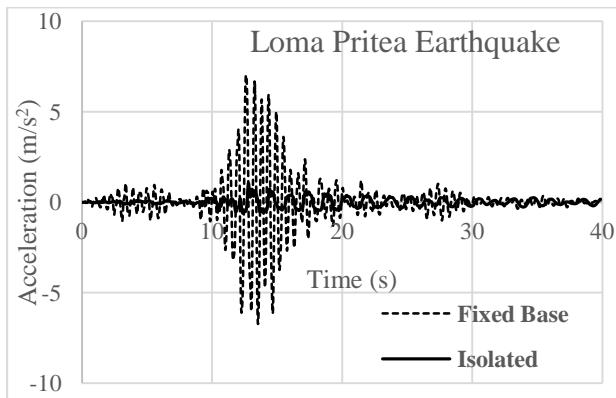
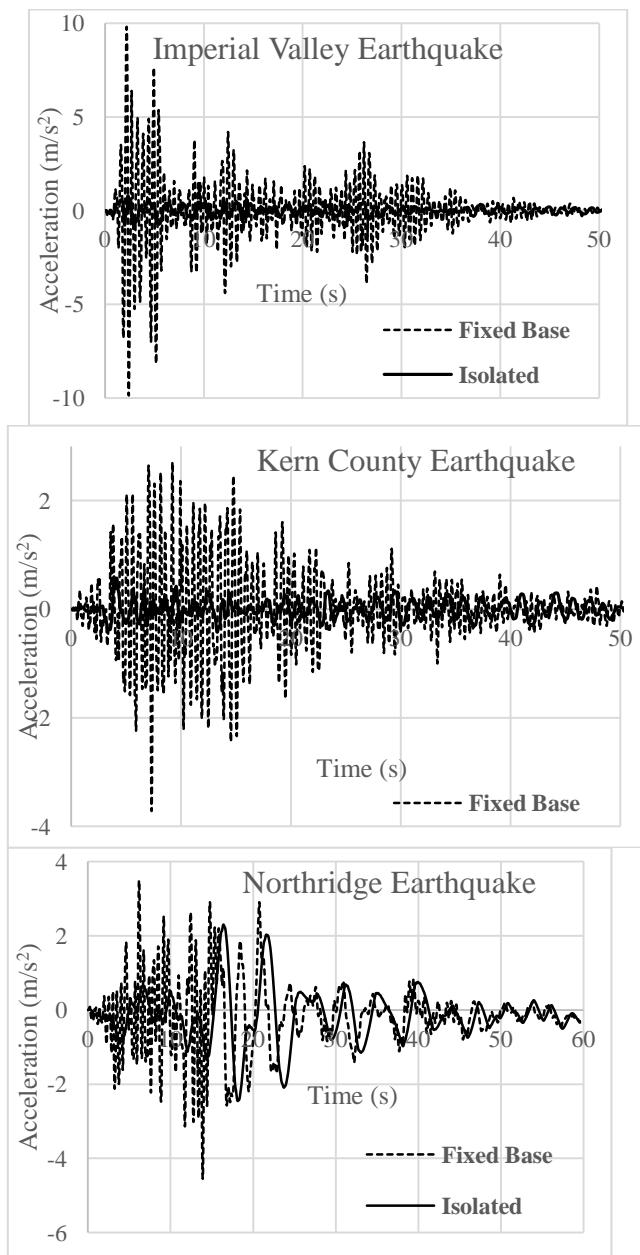
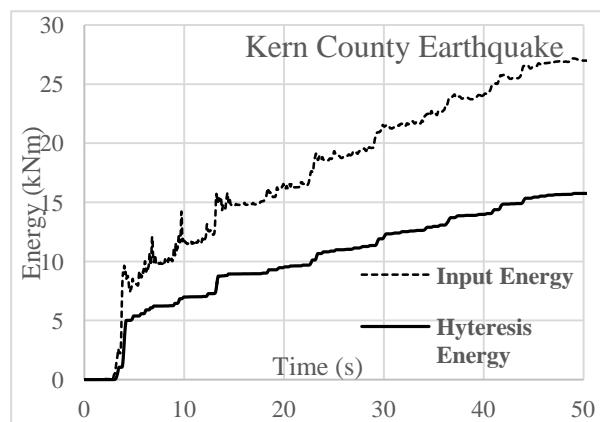
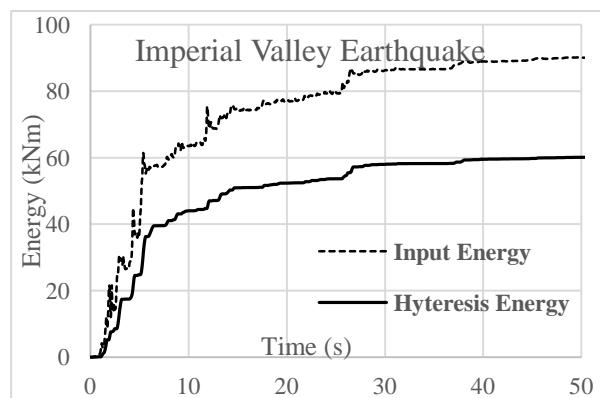


Fig. 4. Acceleration (m/s^2) versus Time (s)

iii. Energy comparison

In variation of Energy (kNm) versus Time (s) graph, as the energy increases the isolator can resist the seismic waves up to an energy limit known as Hysteresis Energy. The Hysteresis energy is that which protects the structure from seismic waves and does not allow the structure to deform up to a maximum limit. In the following figures we observe the time history graphs of Imperial Valley (m/s^2) Vs Time (s), Kern Country- Energy (m/s^2) Vs Time (s), Northridge-Energy (m/s^2) Vs Time (s) and Loma Pritea- Energy (kNm) Vs Time (s). So by using the U-shaped steel dampers we can control the structure through deformation.



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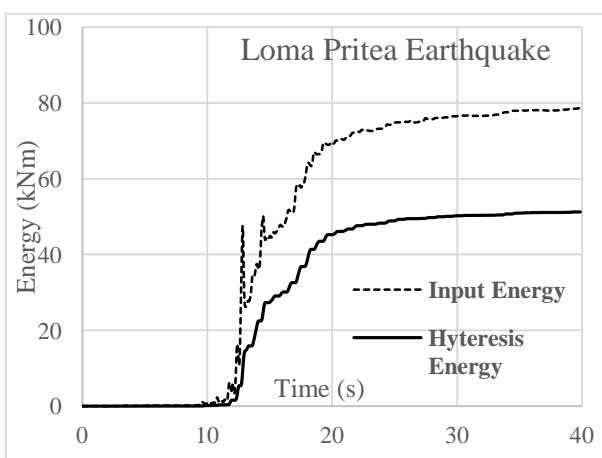
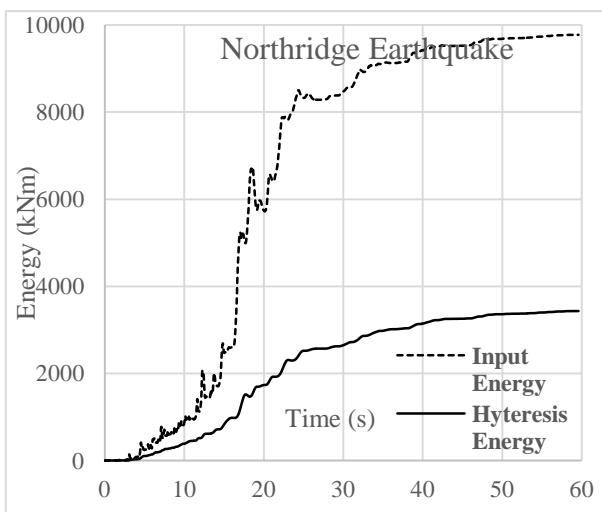


Fig. 5. Energy (kNm) versus Time (s)

IV. CONCLUSION

To access the U-shaped steel damper performance, the non-linear time history analysis has been carried out in SAP-2000 software. U-shaped steel damper is more active to reduce the seismic impact on the structure. By applying the U shaped steel damper it has a chance of less deformation, so it is safe for the structure to apply U-shaped steel dampers. It is understood that the supplementary energy dissipation devices are very effective in reducing structural system earthquake performance. Therefore, the main objectives of this study was to find the most effective arrangement of steel dampers that, when subjected to real earthquake ground motions, gives optimum use of damper and minimal damage to buildings. Initially, damper properties such as stiffness, damping coefficient, masses, etc. were tested. Based on the properties analysis was performed on structure with dampers, and the results were taken out in the form of graphs.

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