Vibration Control of Water Tank Staging Equipped X-plate Damper

G. Nirmala, Atulkumar Manchalwar, Sakshi Manchalwar

ABSTRACT: ***During post-earthquake requirement the staging of elevated water tanks are considered as essential structures. Failure of staging leads to collapse of watertank so required to control the vibration of staging. In This paper elevated circular tank supported with frame was modeled to control the vibration of staging. Non-linear dynamic analysis (time-history analysis) was performed on model by using SAP-2000 software to study the seismic behaviour. The additional dissipation of energy occurs by using damper constitute an effective technique for the earthquake reduction of staging members and In this study an attempt has been made to use the X-plate metallic steel damper for reducing the seismic response.***

Keywords: X-plate damper, Time history analysis, SAP 2000, Water tank, Energy dissipation device.

I. INTRODUCTION

Elevated water tanks are fundamental structures for all human beings and these are all plays main role in water supply system. During post-earthquake storage tanks are considered as requisite structures and to be in service. But during earthquake ground motions many water tanks are collapsing because of poor performance of water tank staging. In 1997 Jabalpur earthquake many water tanks were collapsed because poor performance of water tank staging. As per codes every structure must design without collapse and allowing damage. Earthquake releases some amount of energy this energy is responsible for damage of the structure. Higher intensity of energy leads to collapse of the structure.to reduce the damage of structure it possible by control the vibration using energy dissipation devices such as dampers.

According to many researchers the use of metallic damper is effective for the dissipation of seismic energy.theoritical and experimental studies have shown that the seismic response of the RC framed structure provided with X-plate steel and aluminum damper Manchalwar and bakre (2016) [7]. Seismic response of the tank structures are discussed mutual energy based criteria Gloria Terenzi et al (2016) [6]. Studied the behaviour of liquid storage slender and broad tanks isolated by variable frequency pendulum isolator Misry et.al (2011) [1]. Optimal location of dampers based on concept of generic algorithm Manchalwar and bakre (2018) [9].proposed a new device variable frequency pendulum isolator to know the seismic response of the liquid storage steel tank under six near fault ground motions Panchal and Jangid(2011) [3].

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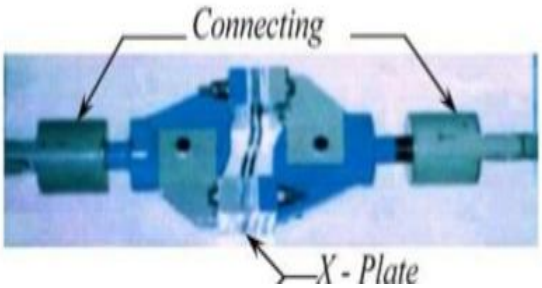
In this they used finite element technique to know the behaviour of liquid storage tanks under seismic loading Pogorzelski et.al (2011) [2]. Researchers made a concept to recognize the important parameters that affecting dynamic behaviour of the ground supported water tank Moslemi and kianoush (2012) [4]. Propose the techniques of optimal placement of viscous dampers for that reducing the seismic objectives including absolute acceleration and peak intensity Whittle et al (2011) [5]. Studied the properties damper like yield displacement, yield stiffness, yield force etc. understand the behaviour of damper and placement of damper Manchalwarth and Bakre (2019) [10].The researchers investigated about the response reduction factor to know the ductility behaviour of the water tank staging Lakhade.O et.al (2017) [8].

II. X-PLATE DAMPER

XPD is the one type of damper and it is X- in shape. XPD is the combination of single or multiple X-plate connections. The number of X-plates are decided based on the necessity of the system to deplete the external input seismic energy. XPD resists the large number of cycles of deformations. It gives the large amount energy dissipation and its energy dissipation independent on relative velocities dependents on relative displacements. XPD provides supplemental stiffness and supplemental damping to the structure so it is called as ADAS.

In BARC (Bhabha atomic research center) Mumbai, IIT Mumbai conducted many experiments to know the performance of X-plate damper. The researchers have Manchalwar and Bakre studied the performance of steel and aluminum X-plate dampers on RC structures and they concluded that the steel and aluminum dampers are very efficient in controlling the seismic response of the structure and XPDs of steel is more effective compared to the XPDs of aluminum with same thickness and same number of plates.



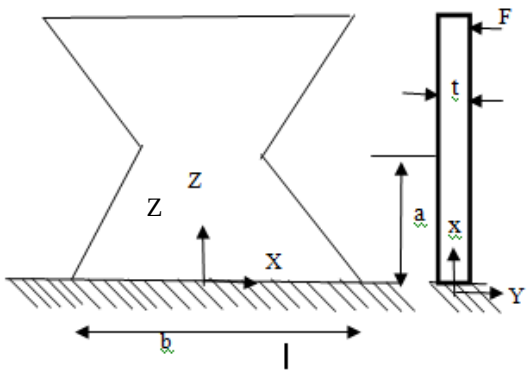


Fig.1 Typical XPDFrom beam theory XPD properties are expressed as,

$$F_y = \frac{\sigma_y b t^2}{6a} n$$

$$q = \frac{2\sigma_y a^2}{Et}$$

$$K_d = \frac{F_y}{q}$$

$$K_d = \frac{Ebt^3}{12a^3}\, n$$

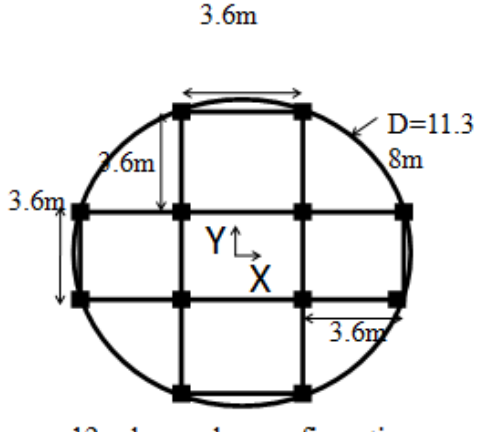
Where, F_y is the yield force, q is the yield Displacement and $_d$ is the initial stiffness of the XPD; a, b and t are represents the height, width and thickness of the damper respectively. E and σ_y are modulus of elasticity and yield stress of the damper shown in Fig .1

Table 1 Sectional properties

Capacity of the Tank(ML)	Diameter of the Tank(m)	Column Size (mm)	Bottom Beam Size(mm)	Brace Beam Size (mm)
0.6	11.38	400×400	350×700	300×550

III. PROBLEM STATEMENT

For this study 12 column 24m staging of elevated water tank supported with frame staging is modeled in SAP 2000.Plan and Elevation of water tank are shown in the Fig.2and it is taken from the O.Lakhadeet.al.the dimensions of the structural member shown Table.1



12 column plan configuration

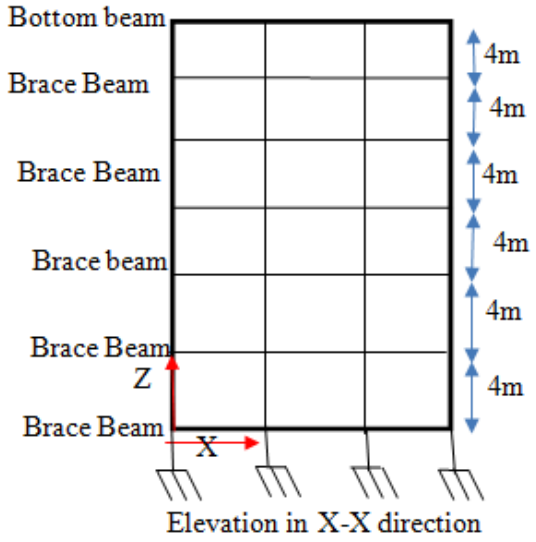


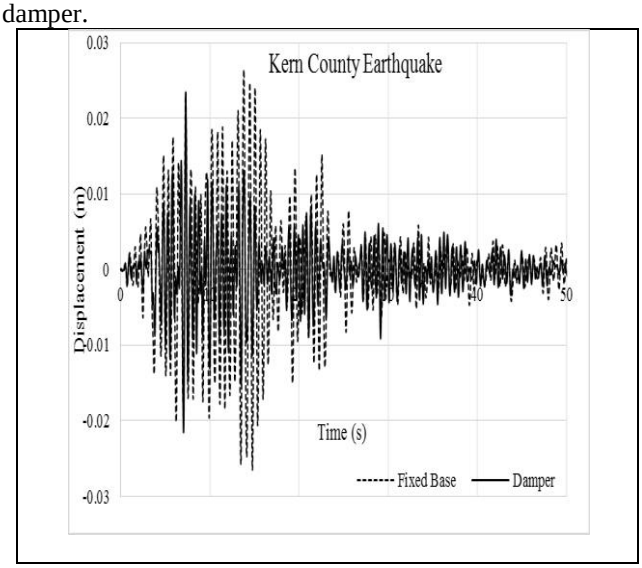
Fig.2 plan and elevation of water tank

IV. PERFORMANCE OF THE STRUCTURE

Nonlinear dynamic analysis (time history analysis) has been performed in SAP 2000 to know the effectiveness of the XPD. For this study a simple circular elevated water tank is modelled. At the beginning, frame staging is considered with XPD.i.edampers are equipped outer side of the staging in X-direction and correlated with the without damper. For this analysis four real ground motions are considered and dimensions of the triangular part of X-plate i.e. Height, width and thickness are 40, 60 and 4mm respectively.

i DISPLACEMENT COMPARISION

To know the behaviourof X-plate steel damper, here the nonlinear time history analysis has been conducted in SAP2000. Below Fig.3. represent the time history analysis graphs offour earthquakesthat are Imperial Valley – Displacement (m) Vs Time(s),Kern country-Displacement (m) Vs Time(s),Northridge-Displacement(m) Vs Time(s),Loma Pritea-Displacement (m) Vs Time(s).From these results it is observed that the displacement of the structure is reduced with XPD compared to the without damper.



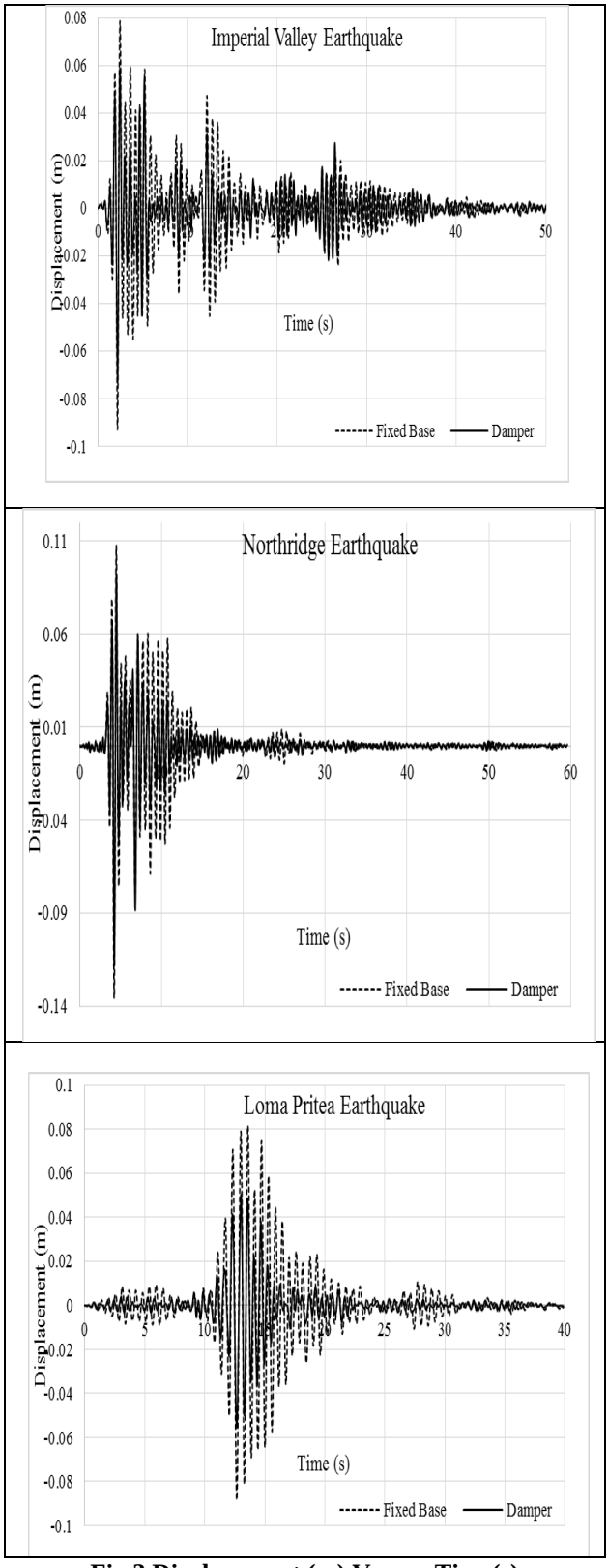


Fig.3 Displacement (m) Versus Time(s)

ii ENERGY COMPARISION

Input Energywhich occurredon the structure when subjected to the earthquake excitation and the hysteretic energy is measure of dissipation of input energy. By perfuming nonlinear time history analysis,from the Fig.4.It is noted that dissipation of energy increases with XPD damper

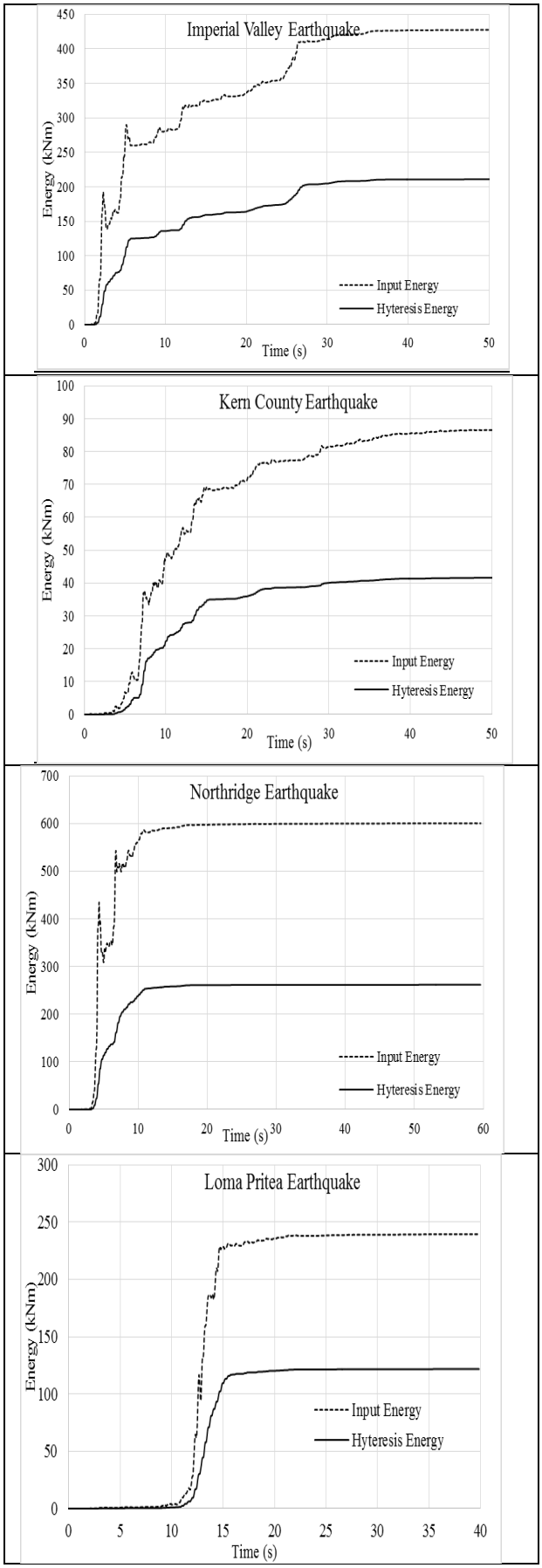


Fig.4 Energy (kNm) Versus Time(s)

iii.SHEAR COMPARISION

From table2and table 3 it is observed that the shear force and bending moment are decreased by about 15-40% coronation of X-plate damper.

Table-2 shear comparison

Column	Earthquake	Shear Force (kN)	
		Without	*With XPD*
Corner Column	Imperial Valley Earthquake	299.259	211.098
	Kern County Earthquake	96.39	81.559
	Loma Pritea Earthquake	285.553	178.881
	Northridge Earthquake	353.792	290.974
Inner Column	Imperial Valley Earthquake	452.304	319.941
	Kern County Earthquake	145.888	123.916
	Loma Pritea Earthquake	433.319	271.394
	Northridge Earthquake	538.227	443.781

Table-3 Moment comparison

Column	Earthquake	Moment (kNm)	
		Without	*With XPD*
Corner Column	Imperial Valley Earthquake	557.881	394.4768
	Kern County Earthquake	179.896	152.9198
	Loma Pritea Earthquake	535.117	334.8113
	Northridge Earthquake	666.482	549.1147
Inner Column	Imperial Valley Earthquake	654.332	463.3447
	Kern County Earthquake	211.155	179.7804
	Loma Pritea Earthquake	628.438	393.3773
	Northridge Earthquake	782.668	645.7974

V. CONCLUSION

Dampers that are very efficient in dissipation of energy and minimizing the seismic response of the structure. The main objective of this study was to reduce the damage of the structure when subjected to real seismic ground motions. Many number ofanalyses have been conducted to reach the acceptable conclusions. Based on properties of damper and structure configuration size of the XPD was decided and the analysis was carried out on the staging with and without damper. From this results decided that behaviour of the staging with damper and concluded that the XPD of steel are very efficient in reducing seismic response of the staging such as displacement, shear force, moment, and increase the dissipation of energy.

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