Seismic Pounding Mitigation Using TMD in Reinforced Concrete Structures

Amrutha K. S., Anima P.

Abstract—Earthquakes often occur on the earth's crust leads to serious issues to the environment and its belongings. Seismic pounding can be defined as the collision of adjacent buildings due to severe ground motions. The seismic pounding phenomenon and its mitigation technique are discussed in this paper. The mitigation measure includes providing separate Tuned Mass Damper (TMD) on the top of both buildings. From the study it is evident that the TMDs were effective in mitigating seismic pounding in reinforced concrete structures.

Index Terms—collision, crust, mitigation, seismic pounding, TMD.

1 Introduction

EARTHQUAKES are the most destructive natural phenomenon which can be defined as the violent shaking of the surface of earth as a result of sudden release of energy from the earth's crust. Seismic analysis is used for calculating the response of a structure during earthquakes. Seismic pounding is defined as the collision of adjacent buildings during earthquake. The primary reason for seismic pounding to occur is the insufficient separation distance between the adjacent buildings. Impact loads produced by the pounding of buildings will superimpose on the loads produced by the ground acceleration. When the impact loads from pounding of the structures are too high, the structural system of the building has to be modified to reduce the response. If the structures are in planning stage the easiest way to avoid pounding is to provide the safe separation distance between the buildings as given by the code. Various efficient and cost effective mitigation measures commonly employed to avoid pounding induced collapse of buildings are the use of shear walls, bracing system, jacketing and dampers. Among these different types of dampers such as tuned mass damper, viscous damper, friction damper, tuned liquid damper etc. were commonly employed to reduce the pounding effect.

2 Methodology

The case study structure is reinforced concrete buildings assumed to be located in zone V as per IS: 1893-2002 in medium soil and an importance factor of 1 is adopted. Building-1: G+12 building having 4 bays in X and 3 bays in Y directions with a width of 5m each. Building-2: G+9 building having 3 bays in X and Y directions respectively with a width of 5m each.

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Both buildings are assumed to be fixed at the ground level and separated by a seismic gap of 25mm using gap elements of stiffness 980000kN/m linked at 9 nodes between the buildings from the roof level of lower building.

TABLE 1
Material Property

Grade of concrete	M25
Grade of steel	Fe 415
Floor to floor height	3.2m
Slab thickness	150 mm
Column	600 x 600 mm
Beam	300 x 450 mm
Live load on all floors	3 kN/m^2
Floor finish	1 kN/m^2

In this study seismic pounding between the two adjacent buildings are analyzed by carrying out nonlinear dynamic time history analysis on the structure using the ground excitation data of El Centro earthquake in SAP2000 v.19.2.2. Then both the buildings are equipped with tuned mass damper (TMD) on the top of each building and analyzed by carrying out the nonlinear dynamic time history analysis. The graph of the El Centro ground motion function is divided into 6000 points of acceleration data and is equally spaced at 0.002 sec as shown in Fig.1.

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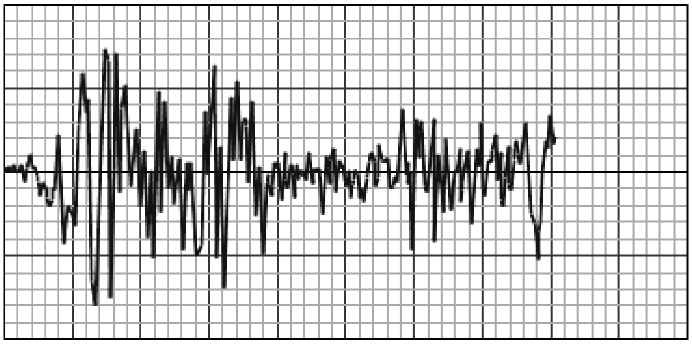

Fig.1: El Centro Earthquake Data

Fig.2 shows the plan view of the adjacent G+12 and G+9 buildings while Fig.3 shows the elevation of the same model.

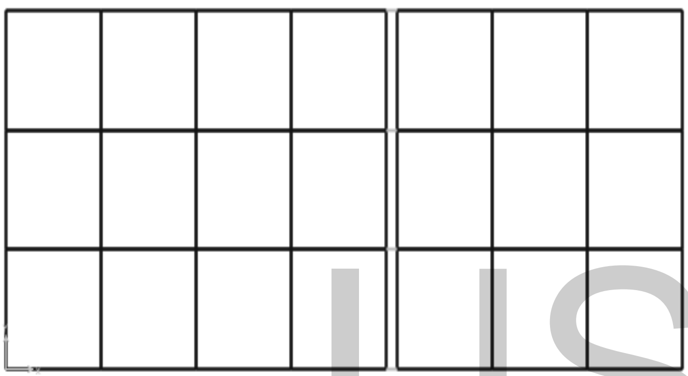

Fig.2: Plan view

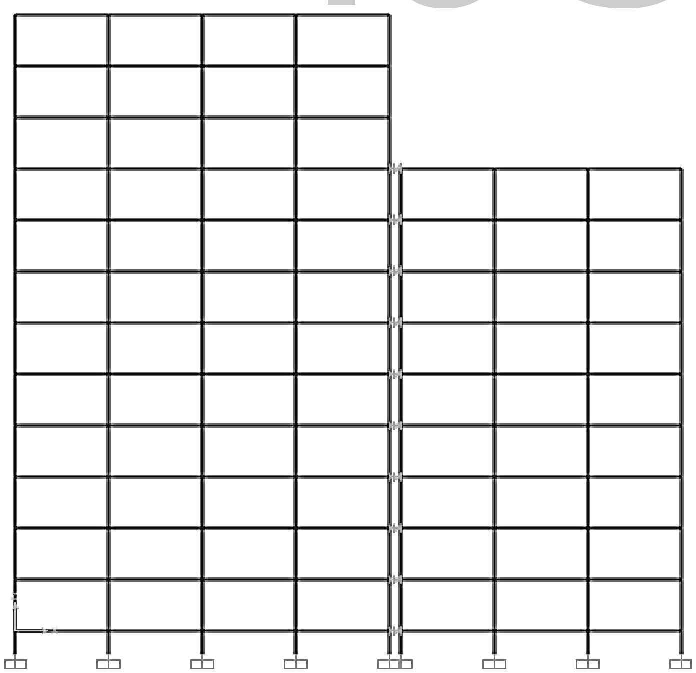

Fig.3: Building Model

Table 2 shows the stiffness of TMD mounted on top of the buildings which is obtained through calculations.

TABLE 2
Stiffness of TMD

Building No.	Stiffness (kN/m)		
	U□	U_2	U_3
Building-1	160000	1570.96	1570.96
Building-2	180000	1582.19	1582.19

3 RESULTS

Time period of the taller as well as shorter building are equal for both the models with TMD and without TMD.

TABLE 3
Time Period

Mode	Time Period (s)	
	Without TMD	With TMD
1	1.6075	1.6075
2	1.47196	1.47196
3	1.23066	1.23066
4	1.10034	1.10034
5	0.51828	0.51828

The pounding force obtained for model without TMD and with TMD is 2672kN and 1662kN as shown in the Fig.4 and Fig.5 respectively.

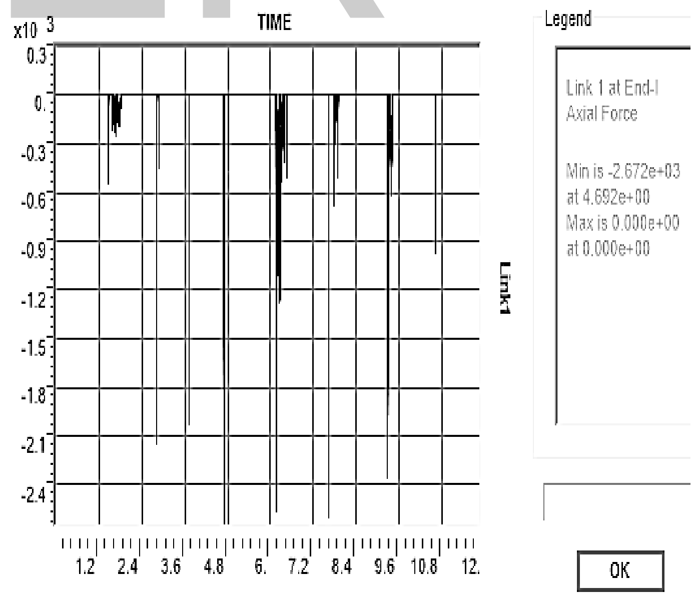

Fig.4: Pounding Force without TMD

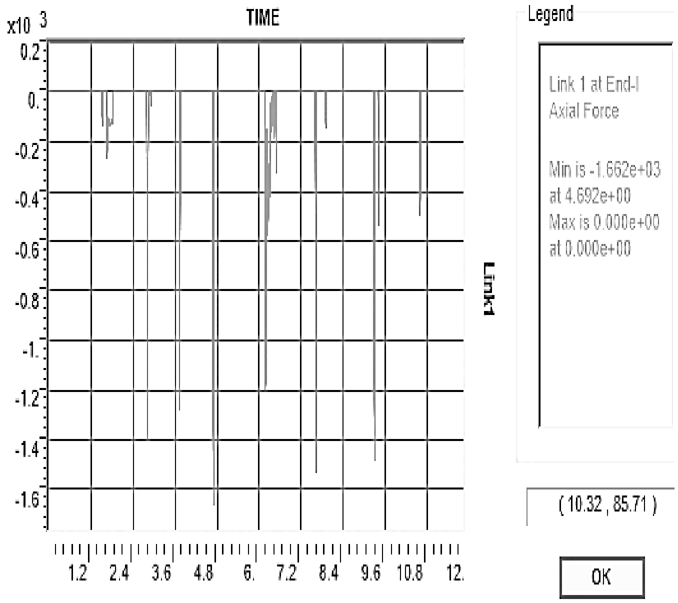

Fig.5: Pounding Force with TMD

4 Discussions

SAP2000 v.19.2.2 is used to compute the response of 12-storey (G+12) and 9-storey (G+9) buildings separated by a distance of 25mm by carrying out nonlinear dynamic time history analysis using the El Centro earthquake data. Results from the response spectrum analysis provided the natural frequencies and time period of the buildings whereas the results from time history analysis have been used to observe pounding force coming on the structures during severe ground motions.

Time period of both buildings remains same with and without TMD. The fundamental time period of taller building is obtained as 1.6075s while for the shorter building as 1.23066s. The pounding force without TMD is 2672kN whereas pounding force with TMD mounted on the top of both buildings is 1662kN. Therefore there is a reduction in pounding force by 37.79%.

5 Conclusions

The major conclusions can be summarized as given below:

- When impact loads from pounding of the structures are too high, the structural system has to be modified to reduce the response
- If the buildings are in planning stage the easiest way to avoid pounding is to provide the safe separation distance between buildings
- From this study providing TMDs on the top of buildings was found to be effective in reducing pounding induced damage

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