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Seismic Response of Base Isolated Irregular Buildings

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Abstract

Earthquakes introduce large destruction in all structure especially in asymmetric structures. Base isolation is one the effective method to protect from damages. Among different isolators efficient one is friction pendulum system. Aim of the present study deals with comparison of seismic response of symmetric and asymmetric building with and without base isolator using SAP 2000. Parameters considered are displacement, acceleration, base shear, and time period.

Keywords: Acceleration, Asymmetric structure, Base isolator, Friction pendulum system, SAP 2000

I. INTRODUCTION

Earthquake is a major threat to structures and its surroundings. Buildings are classified into symmetric and asymmetric in which asymmetric buildings are more susceptible to earthquake than symmetric building. In order to counteract the effect of earthquake in buildings, we are using base isolators. Base isolator is nothing but a device that isolates the supper structure from substructure. Basic concept of base isolation is to increase the natural period of the structure to take it away from resonance with external excitation and also it keeps response of the structure within limit. By the provision of base isolator, acceleration of the structure get reduce and there by force action on each floor reduces. The present study is conducted to understand the structural behaviour of buildings with and without base isolators having regular and irregular plan under seismic loading. And also response of each building with varying height is also studied.

II. MODELLING

For the purpose of the study, a symmetric structure and an asymmetric structure with plan irregularity (L shaped) were modelled with varying height such as 8, 10, and 12 storeys. The building is modelled in SAP 2000. General building data is given in Table I. Plan of the buildings is as shown in Fig. 1.

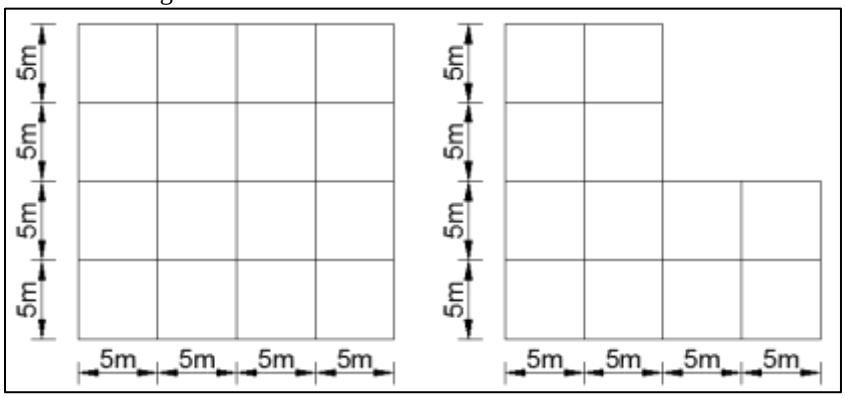


Fig. 1: Plan of the buildings (x-y plane)

Table – 1
Building Data

Area	*20mx20m*
Storey height	*3m*
Grade of concrete for beam and slab	*M25*
Grade of concrete for column	*M30*
Grade of steel	*Fe500*
Size of beam	*300mmx400mm*
Slab thickness	*160mm*

Assuming structure is located in California, zone 4 with a soil profile type with very dense soil and soft rock with seismic source type A and closest distance to known seismic source is 10km. By assigning the material properties and section properties the 3D models of twelve stored buildings are as shown in Fig. 2. Models of different storey height are also done.

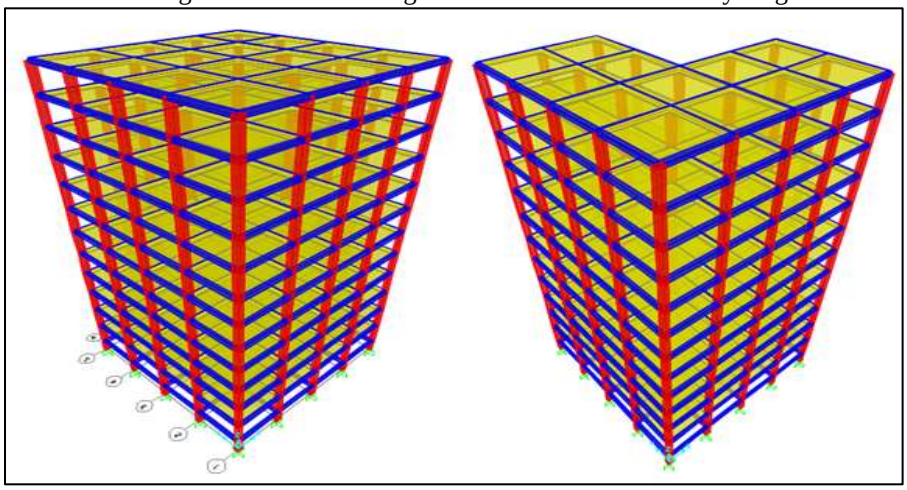


Fig. 2: 3D rendered view of the Square and L shape buildings with twelve storeys

For base isolation, here we provided Friction pendulum systems (FPS). Properties of FPS are given as link properties in SAP 2000 which is given in Table II.

Table – 2
Parameters required in SAP2000 for defining FPB

Direction	*Parameters*	*8 storey*		*10 storey*		*12 storey*	
		Square	*L*	*Square*	*L*	*Square*	*L*
U1	*Linear effective stiffness (kN/m)*	*15000000*	*15000000*	*15000000*	*15000000*	*15000000*	*15000000*
	Non-linear effective stiffness (kN/m)	*15000000*	*15000000*	*15000000*	*15000000*	*15000000*	*15000000*
U2 and U3	*Linear effective Stiffness (kN/m)*	*789.57*	*533.37*	*761.06*	*544.22*	*554.99*	*513.59*
	Non-linear effective stiffness (kN/m)	*15034.49*	*8167.74*	*14632.95*	*8519.42*	*10783.94*	*8191.74*
	Friction coefficient, slow	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*	*0.03*
	Friction coefficient, fast	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*	*0.06*
	Rate parameter	*40*	*40*	*40*	*40*	*40*	*40*
	Radius of sliding surface	*5.52*	*7.90*	*7.16*	*9.57*	*11.81*	*12.03*

Equivalent static analysis and time history analysis are done in this study. Time history analysis is done to assess the behaviour of the structure under dynamic loading. The dynamic load applied to the structure is El-Centro earthquake of magnitude 7 and is used for obtaining the various responses.

III. RESULTS AND DISCUSSIONS

The results of analysis conducted are discussed in detail. The parameters such as time period, lateral displacement, storey acceleration and base shear were compared.

A. Displacement

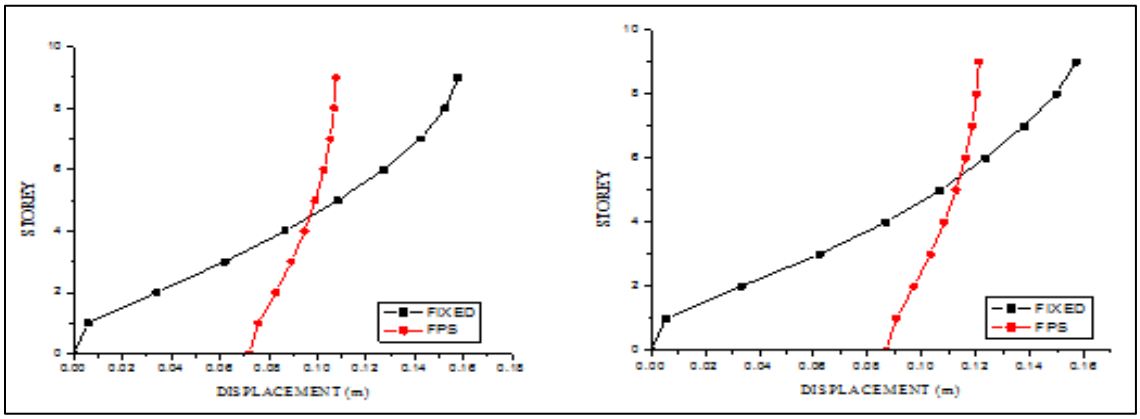


Fig. 3: a) Square shape building with 8 storeys b) L shape building with 8 storeys

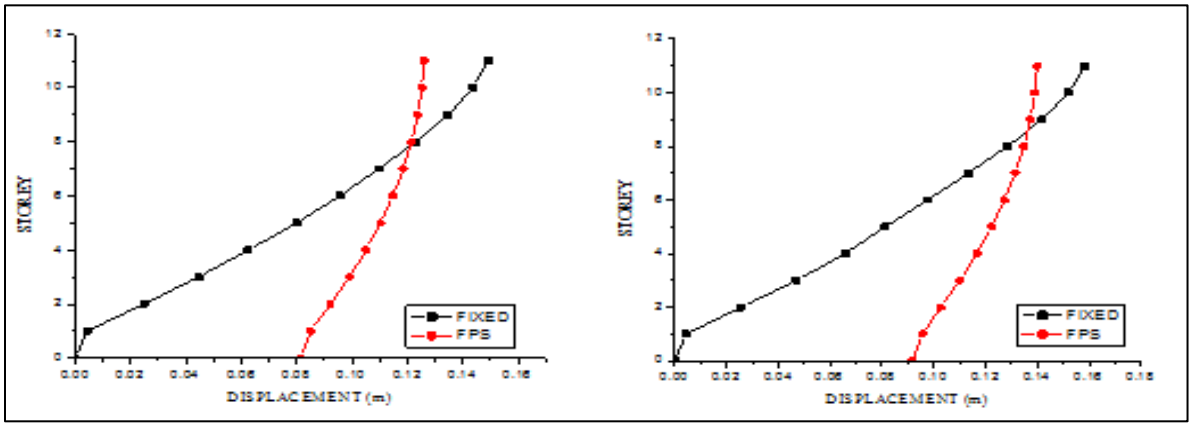


Fig. 3: c) Square shape building with 10 storeys d) L shape building with 10 storeys

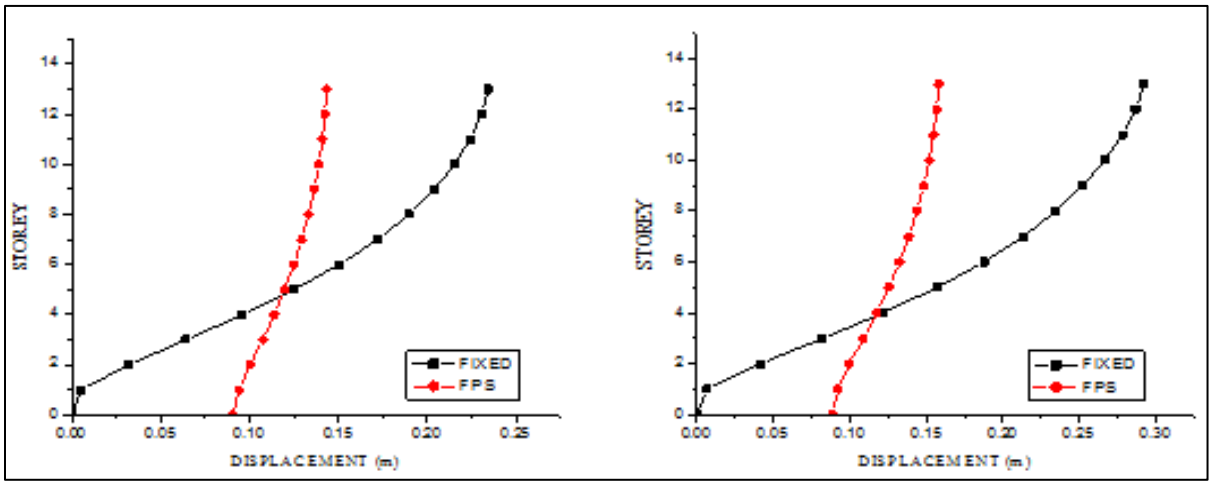
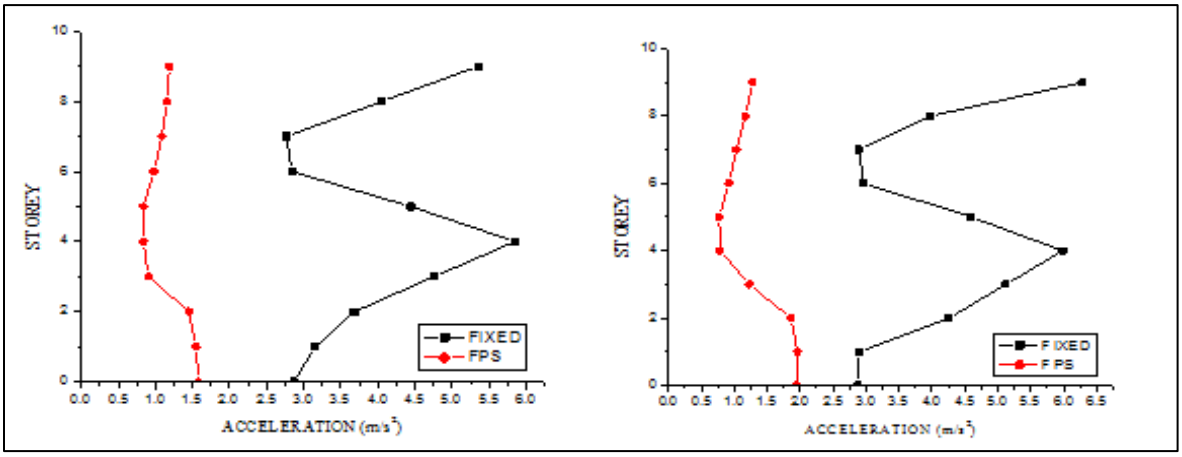


Fig. 3: e) Square shape building with 12 storeys f) L shape building with 12 storeys

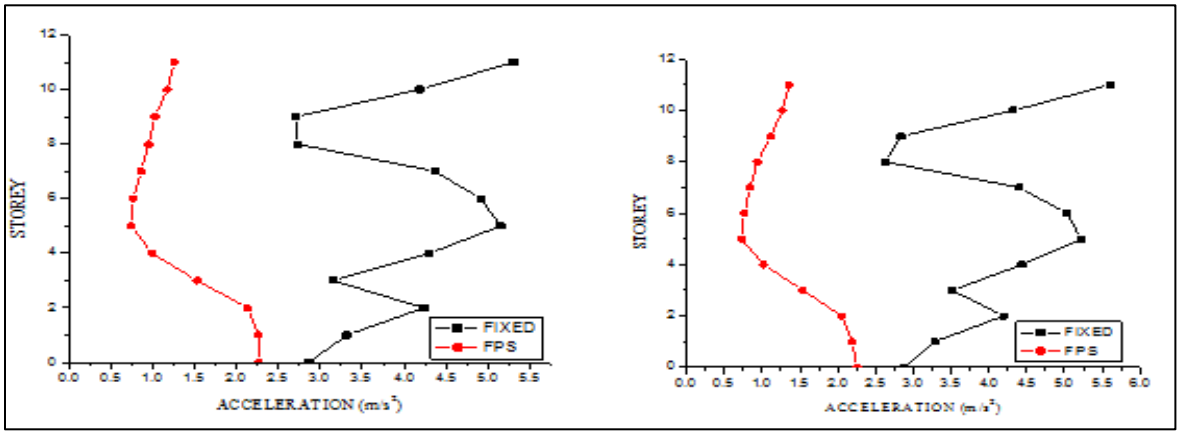
Fig. 3: Displacement of fixed base and FPS

In the case of fixed base building, displacement is zero at the base and increases as storey height increases. But in the case of FPS, there is a small displacement at the base and as storey height increases, the displacement values increases by a negligible amount. So the comfort level for people inside the isolated building is very high. L shape buildings have slightly higher displacement than square shape building. The percentage reduction in displacement by using FPS for each model is calculated as in Table III.

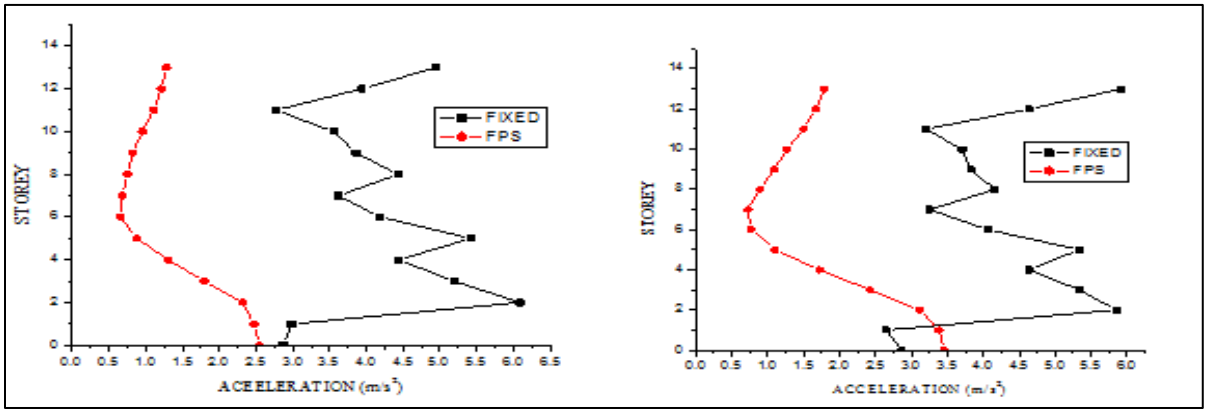
B. Acceleration



a) Square shape building with 8 storeys b) L shape building with 8 storeys



c) Square shape building with 10 storeys d) L shape building with 10 storeys



e) Square shape building with 12 storeys f) L shape building with 12 storeys

Fig. 4: Acceleration of fixed base and FPS

Acceleration of fixed base building is much higher than isolated building. Friction pendulum system isolators show considerable reduction in acceleration and it is tabulated in Table III. By the reduction in acceleration lateral load acting to each floor get reduced.

C. *Base Shear and Time Period*

Base shear for square shape building is higher than L shape building and also it is more for fixed base building than base isolated building. Time period for the fixed base building is much less than base isolated building and also it is more for L shaped building than square shaped building. Increase in time period decreases the lateral force developed due to seismic load. Percentage increase in time period and percentage reduction in base shear are tabulated in Table III.

Table – 3
Comparison of results

	8 storey		*10 storey*		*12 storey*	
	Square	*L*	*Square*	*L*	*Square*	*L*
% reduction in displacement	*31.74*	*22.76*	*15.45*	*11.57*	*38.91*	*46*
% reduction in acceleration	*77.80*	*79.67*	*76.25*	*75.73*	*74.11*	*69.77*
% reduction in base shear	*57.39*	*60.46*	*63.27*	*63.16*	*67.27*	*66.03*
% increase in time period	*54.63*	*51.96*	*54.74*	*52.87*	*58.59*	*53.61*

IV. CONCLUSIONS

From the above work following conclusions can draw out.

1) Non isolated building shows more displacement than isolated buildings both in symmetric and asymmetric case. Asymmetric buildings have slightly higher displacement than symmetric building.
2) In the case of both symmetric and asymmetric building with base isolator acceleration and base shear decreases; whereas time period increases in comparison with fixed base one.
3) Base shear of symmetric building is higher than asymmetric one but less in the case of time period.

Finally it is concluded that friction pendulum system is very significant in order to reduce the seismic response of both symmetric and asymmetric buildings compared to fixed base buildings and control the damages in the building during seismic loading.

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