EFFECT OF VERTICAL MOTION OF NEAR-FAULT EVENTS ON SDOF SYSTEMS EQUIPPED BY SLIDING BEARINGS

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Seismic isolation of structures is considered vulnerable to near-fault excitations. Nevertheless, the system is sometimes applied in the sites close to active faults (Liauw et al., 2009). Considerable amplitude of vertical motion in such events was taken as a threatening factor to the friction isolation systems. To investigate the effects of the long-period pulse and strong vertical components of the ground motion on the performance of the sliding isolator systems, two seismic isolation systems including sliding bearings and Friction Pendulum isolators are modelled and analysed when subjected to near fault ground motions.

The purpose of the study is to investigate the effects of vertical motions in near-fault sites to performance of such system, including displacement and acceleration. Figures 1 and 2 show schematically the isolation systems and their logical models.

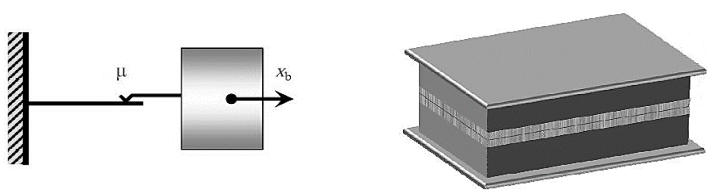


Figure 1. Sliding Bearing

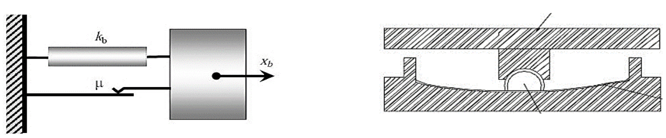


Figure 2. Friction Pendulum System

Nonlinear behaviour of the SDOF systems equipped by simple sliding and FPS isolators as show in equations 1 and 2, respectively, were modelled in MATLAB® Software [MATLAB]. The results were then verified according to the initial assumptions and output of the calculations.

$$m\ddot{x}_{b(i)} + [\mu \times m \times (g + \ddot{x}_{g(i)})] \times sign(\dot{x}_{b(i)}) = -m \times (g + \ddot{x}_{g(i)}) \quad (1)$$

$$m\ddot{x}_{b(i)} + [\mu \times m \times (g + \ddot{x}_{g(i)})] \times sign(\dot{x}_{b(i)}) + k_b \times x_b = -m \times (g + \ddot{x}_{g(i)}) \quad (2)$$

Coefficient of friction is taken as 0.1. The radius of the FPS system is chosen such that natural period of the system is 2.0 sec.

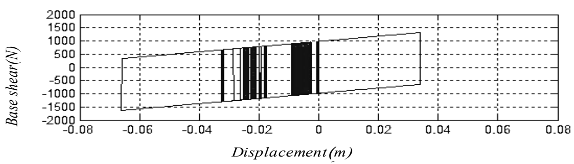
A nonlinear time history analysis was performed and force-displacement curves were calculated for the systems (Figure 3) when being excited by three ground motions (Table 1).

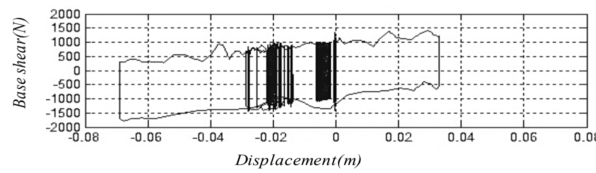
As presented in Table 2, including vertical ground motion in analysis results in larger force and displacement response of sliding isolation system indicating that neglecting the vertical motion of near-fault events may lead to underestimation of the response.

Table 1. Ground motions applied in the study

Earthquake	**Station**	Distance (km)	PGA		**Duration(sec)**	$\frac{\mathbf{PGA-V}}{\mathbf{PGA-H}}$
			Horizontal	Vertical		
Tabas	9101 Tabas	3	0.836	0.688	32.8	0.823
Lomaperia	Capitola	14.5	0.529	0.541	39.94	1.022
Northridge	Arleta - Nordhoff Fire	9.2	0.344	0.552	39.96	1.605

Figure 3 demonstrates the hysteresis curves of the FPS system when excited by a) horizontal and vertical and b) horizontal ground motion.





a) Horizontal Ground Motion Effects b) Horizontal and Vertical Ground MotionEffects

Figure 3. Effects of vertical ground motion on the force-displacement curves of friction pendulum system

Table 2. Analysis results for sliding and FPS systems excited by three ground motions

	Simple sliding bearing				FPS			
	without vertical motion		With vertical motion		Without vertical motion		With vertical motion	
	D*	V**	D	V	D	V	D	V
Tabas	0.025	981	0.027	1263.50	0.0195	1173.6	0.0194	1340.7
Lomaperia	0.031	981	0.037	1332.50	0.0192	1171	0.0224	1486.6
Northridge	0.073	981	0.075	1417.8	0.0660	1632.5	0.0691	1799

D: Max. Displacement (m)
V: Max. Base Shear (N)

The restoring force developed by the curvature in the FPS isolators has limited the displacement in comparison with sliding bearings. It is shown that the maximum displacement and absolute acceleration or base shear of the system increase when the intensity of the vertical motion increases.

REFERENCES

Liauw TC, Tian QL and Cheung YK (2009) Structure on sliding base subject to horizontal and vertical motion, *ASCE*, 2119-2129