8th International Conference on Seismology & Earthquake Engineering
11-13 Nov. 2019, Tehran, Iran

SEISMIC RESPONSE OF BEARING WITH YIELDING SHEAR PLATE INSTALLED ON THE STEEL MOMENT FRAME

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Keywords: Rubber bearing, Perforated yielding shear plates, Base shear, Relative displacement

Seismic-base-isolation of buildings and bridges is one of the most commonly adopted methods in controlling structures against severe earthquakes. Base isolation is usually divided into two groups of rubber bearing and friction pendulum bearing. The record of seismic-base-isolation is provided by (Warn and Ryan, 2012). Rubber bearing consists of: natural rubber bearings (NRBs) (Iizuka, 2000; Sanchez et al., 2012) lead rubber bearing (LRB) (Ghobarah and Ali, 1990; Ryan et al., 2005) and high-damping rubber [HDR] bearing (Bhuiyan et al., 2009). A method considered in seismic-base-isolation design is the transition of fundamental natural period of a structure into a greater period. In this method, the behavior of the superstructure is mostly of linear nature. The base isolation, in addition to having the ability to move, must be equipped by the means of an energy dissipation device to prevent large displacements. The lead core of LRB is an energy dissipater which generates the necessary damping. HDRB consists of additional materials to enhance the necessary damping. After a destructive earthquake, the reshaped lead of LRB will be subjected to a drop in yield stress and its effective stiffness and dissipated energy capacity decreases, and in this situation, it is reasonable to replace the entire isolator. Many studies have been conducted on the selection of new damper instead of the lead core in rubber bearing. A study has recently been carried out on a rubber bearing with perforated yielding shear device (PYSD-NRB) (Saadatnia et al., 2018). This study assessed the seismic behavior of steel moment frame with PYSD-NRB. Frames of 3, 8 and 12 story have been studied. ASCE7 and the AISC360 codes are used to design the frames. The structure is located in a high seismicity region. Sap2000 software is used for analysis and design of the frames. PYSD -NRB is designed based on the height of LRB, after removing its lead core. These frames are designed for four different cases: fixed-base, isolated with two different types of LRB (LRB-1, LRB-2) and PYSD-NRB. Fundamental period of LRB-1 is longer than that of LRB-2. In the following, the shear base and the relative displacement of different frames has been compared. Dynamic time history analyses were performed to compare the performance among fixed-base and three mentioned cases of isolated structures. Seven earthquake records scaled to the response spectrum code were used. Table 1 shows the maximum displacement of three isolators used on an 8-story frame for seven records. As it can be observed, the demand displacement of isolator increases by increasing the flexibility of the isolator. The average displacement of the PYSD isolator is 32 mm which is less that 50 mm. The base shears of the fixed-base frame and three cases of isolated frames are shown in Table 2. Among the three isolators, the base shear reduction of LRB-2 is higher than others. The base shear reduction of the PYSD isolator and LRB-1 is approximately the same as compared to that of fixed-base structure. It can be concluded that for PYSD isolator with a lower capacity in displacement, a more proper performance can be achieved compared to LRB isolator with larger displacement capacity. Similar results can be achieved for the other two frames. The relative displacement of the 3-story frame is acceptable according to the permissible cod, but it has been slightly exceeded for 8 and 12-story frames.

REFERENCES

Bhuiyan, A., Okui, Y., Mitamura, H., and Imai, T. (2009). A rheology model of high damping rubber bearings for seismic analysis: Identification of nonlinear viscosity. *International Journal of Solids and Structures*, *46*, 1778-1792.

Ghobarah, A. and Ali, H. (1990). Seismic design of base-isolated highway bridges utilizing lead–rubber bearings. *Canadian Journal of Civil Engineering*, *17*, 413-422.

Iizuka, M. (2000). A macroscopic model for predicting large-deformation behaviors of laminated rubber bearings. *Engineering Structures*, *22*, 323-334.

Ryan, K.L., Kelly, J.M. and Chopra, A.K. (2005). Nonlinear model for lead–rubber bearings including axial-load effects. *Journal of Engineering Mechanics*, *131*: 1270-1278.

Saadatnia, M., Riahi, H.T. and Izadinia, M. (2018). Hysteretic Behavior of Rubber Bearing with Yielding Shear Devices. *International Journal of Steel Structures*, 1-13.

Sanchez, J., Masroor, A., Mosqueda, G., and Ryan, K. (2012). Static and dynamic stability of elastomeric bearings for seismic protection of structures. *Journal of Structural Engineering*, *139*, 1149-1159.

Warn, G.P. and Ryan, K.L. (2012). A review of seismic isolation for buildings: historical development and research needs. *Buildings*, *2*, 300-325.

Table 1. Displacement of three isolators for the 8-story frame under the seven record.

Earthquake	**PYSD-NRB**	**LRB-2**	**LRB-1**
	$d_{\max}(mm)$	$d_{\max}(mm)$	$d_{\max}(mm)$
Northridge	44	158	212
Duzce	24	126	348
Loma Prieta	38	97	122
Erzincan	73	267	668
Imperial Valley	23	93.5	219
Mendocino	21	96.5	147
Tabas	67	239	873
Average	41	153	369

Table 2. Base shear of the 8-story frame for non-isolated, PYSD-NRB, LRB-1 and LRB-2.

Earthquake	**Non-isolated structure**	**PYSD1-NRB**		**LRB-1**		**LRB-2**	
	$F_{\max}$ **(kN)**	$F_{\max}$ **(kN)**	Δ^*	$F_{\max}$ **(kN)**	Δ^*	$F_{\max}$ **(kN)**	Δ^*
Northridge	2856	1687	41%	740	74%	1931	32%
Duzce	2269	1558	31%	1039	54%	1638	28%
Loma Prieta	2760	1669	40%	542	80%	1378	50%
Erzincan	3053	1975	35%	1743	43%	2936	4%
Imperial Valley	2341	1551	34%	755	67%	1348	42%
Mendocino	2519	1542	39%	598	76%	1374	45%
Tabas	3166	1901	40%	2193	30%	2673	15%
Average	2709	1698	37%	1087	61%	1897	31%