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SEISMIC PERFORMANCE OF RUBBER BEARING WITH PERFORATED YIELDING SHEAR DEVICES

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Seismic isolator is considered as a structural control system against a destructive earthquake, and the lead rubber bearing is the most commonly used type of seismic isolator. The lead is used as a damper in the rubber bearing.

Rubber bearing with high damping is another variety of dampers. Although rubber properties are vulnerable to cyclic behaviour, high damping rubber results in a waste of energy. The weakness of the LRB is the lack of access to the lead core after losing its mechanical characteristics in distractive earthquake and for this reason, the replaceable damper of rubber bearing is required. Steel cantilever dampers (Cousins et al., 1991), and torsional steel dampers (Skinner et al., 1993) are typical hysteretic dampers that have been implemented into several buildings using laminated rubber bearings. A U-shaped damper in rubber bearings is adopted by Suzuki et al. (2005) to stabilize the hysteretic response. The yielding shear devices (YSD) are another type of dampers that are mostly applied on top of an inverted-V brace (Chan et al., 2009). YSD is located in a hollow section which provides a continuous support to the diaphragm plate and at the same time provides an interface to connect to the main structure. Due to the slenderness of these plates, they tend to buckle out-of-plane and produce pinched hysteresis. High initial stiffness and low yield stress are their two unique properties compared to the flexural and axial yielding of steel components. The stiffness of these plates controls the structure movement.

In this study, shear plates are applied instead of lead core in a rubber bearing. These shear plates are welded on the four sides of the isolator to the top and bottom steel plates of the bearing (Figure 1).

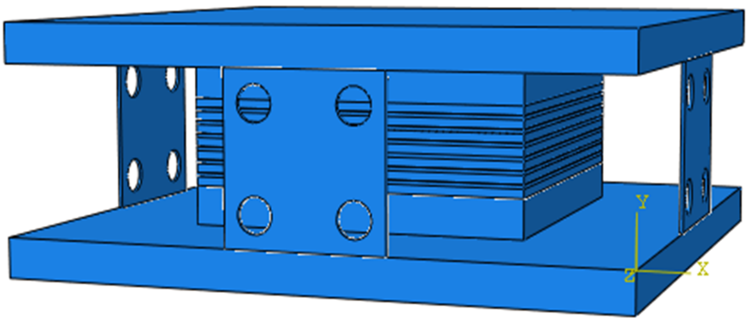

Figure 1. Full view of the bearing with perforated shear plates.

Advantages of PYSD-NRB in comparison with that of the lead rubber bearing are its simplicity in manufacturing process and replacement of its yielding parts. Also, PYSD-NRB has the same ability to dissipate energy with smaller displacement. In order to investigate the precise behavior of the PYSD-NRB, an experimental and numerical study on the shear plates compared to the lead core was performed. For this purpose, three laboratory samples from the isolator have been assessed. The change in the shear plate thickness and also in the shear plate holes have been studied separately. The general and localized buckling of the shear plates have been studied. After comparing the experimental and numerical results, effective stiffness, effective damping, dissipated energy and lateral force of the isolator were calculated. A comparison of this cyclic behavior of the numerical model with the experimental sample of PYSD2-t3-st37 indicated the accuracy of the numerical results, (Figure 2).

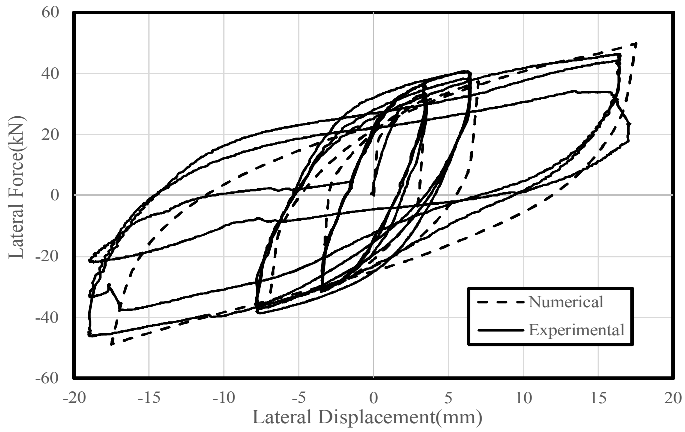

Figure 2. Comparison of the numerical analysis with the experimental results of PYSD2-t3-st37.

By increasing the perforation of the shear plate, the effective stiffness, dissipated energy and lateral force of the isolator decreased, with a slight change in viscous damping. By increasing the thickness of the plate, the effective stiffness, dissipated energy and lateral force of the isolator increased due to the direct correlation between the thickness and yield strength of the plate.

Since the PYSD-NRB dimensions are the same with LRB dimensions (Abe et al., 2004) , two isolators can be compared. For example, in the PYSD2-t3-st37, the energy dissipation at 50% shear strain is approximately equal to that of LRB at 150% shear strain. The amount of lateral force transferred to the superstructure is about 5% higher.

Also due to the limitation of shear strain in this type of isolator, design basics of this type should be defined differently rather than LRB.

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