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Dynamic Performance Characteristic Tests of Real Scale Lead Rubber Bearing for the Evaluation of Performance Criteria

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1. Introduction

Dynamic characteristic tests of full scale lead rubber bearing were performed for the evaluation of performance criteria of isolation system for nuclear power plants. For the dynamic test for a full scale rubber bearing, two 1500mm diameter lead rubber bearings were manufactured.

The viewpoints of this dynamic test are determination of an ultimate shear strain level of lead rubber bearing, behavior of rubber bearing according to static and dynamic input motion, sinusoidal and random (earthquake) motion, and 1-dimentional and 2-dimensional input motion.

2. Overview of Test

For the evaluation of a dynamic characteristic test, two full scale isolation devices were manufactured. The diameter, total rubber thickness diameter of lead core are 1500mm, 224mm, 320mm, respectively. The drawing and figure of lead rubber bearing is shown in figure 1.

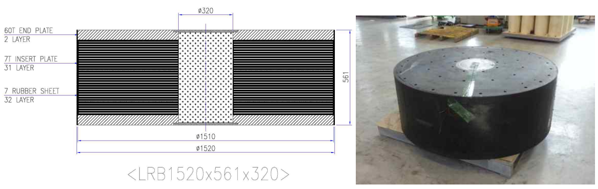


Figure 1. Drawing and LRB for Mechanical property test

For the considering two dimensional input motion, a dynamic input motions were generated. In the case of generating input motion, a capacity of test machine should be considered. For the 100% and 200% shear strain level test, seismic input motions were considered but over 300% shear test, only elliptical motions were considered because of the limit displacement of test machine in UCSD. Especially, in the case of 500% shear test, special input motion was considered. For the evaluation of differences between 1-dimensional and 2-dimensinal input motion, only one dimensional test was performed for specimen 1 and two dimensional test for specimen 2. The seismic input motion, 300% and 400% shear strain level test motion and 500% shear strain level test motion are shown in figure 2,3 and 4, respectively.

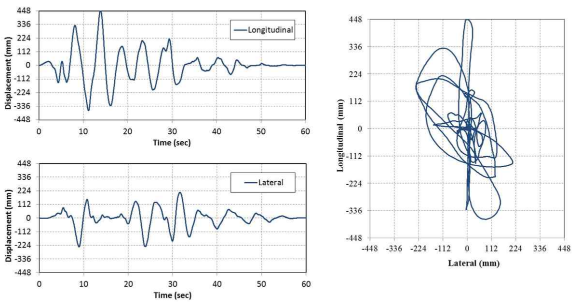


Figure 2. Seismic input motion for 100% and 200% shear test

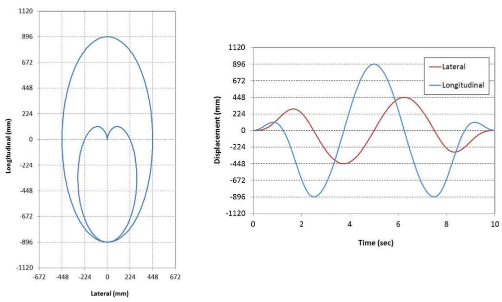


Figure 3. 300%, 400% Elliptical Trace Sinusoidal Motion

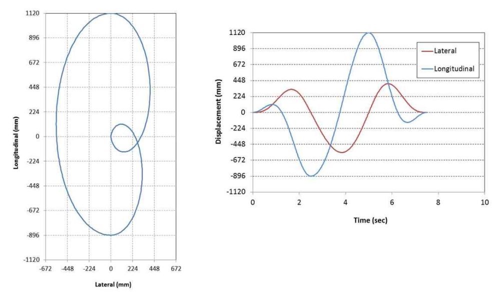


Figure 4. 500% Elliptical Trace Sinusoidal Motion

A test protocol was decided for considering a dimension of test and shear strain level of test. All the test protocols are summarized in table 1.

Table 1. Test protocol for dynamic characteristic test of lead rubber bearing

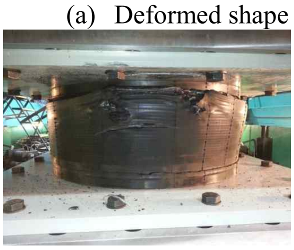
	Run #	Test Name	Strain (%)	Disp (mm)	Max vel. (mm/sec)	Vert Load (kN)	Freq (Hz)	Load shape	Cycles	Direction
specimen 1	1	S1-Vert	vert	0		22000	0.01	triangle	3	z
	2	S1-1D-100L-SIN	100%	224	14.1	22000	0.01	sine	10	x
	3	S1-1D-100-SIN	100%	224	281.5	22000	0.2	sine	10	x
	4	S1-1D-100H-SIN	100%	224	703.7	22000	0.5	sine	5 and 5	x
	5	S1-1D-100-EQ	100%	224		22000		EQ 1D		x
	6	S1-2D-100-EQ	100%	224		22000		EQ 2D		xy
	7	S1-1D-200-SIN	200%	448	563.0	22000	0.2	sine	5	x
	8	S1-1D-200-EQ	200%	448		22000		EQ 1D		x
	9	S1-2D-200-EQ	200%	448		22000		EQ 2D		xy
	10	S1-1D-100-A200	100%	224	281.5	22000	0.2	sine	3	x
	11	S1-1D-300-ETS	300%	672	844.5	22000	0.2	1D sinusoidal		xy
	12	S1-1D-100-A300	100%	224	281.5	22000	0.2	sine	3	x
	13	S1-1D-400-ETS	400%	896	1125.9	22000	0.2	1D sinusoidal		xy
	14	S1-1D-100-A400	100%	224	281.5	22000	0.2	sine	3	x
	15	S1-1D-500-ETS	500%	1120		22000	0.2	1D sinusoidal		xy
	16	S1-1D-500-ETS	500%	1120		22000	<0.01	1D monotonic		xy
specimen 2	1	S1-Vert	vert	0		22000	0.01	triangle	3	z
	2	S1-1D-100L-SIN	100%	224	14.1	22000	0.01	sine	10	x
	3	S1-1D-100-SIN	100%	224	281.5	22000	0.2	sine	10	x
	4	S1-1D-100H-SIN	100%	224	703.7	22000	0.5	sine	5 and 5	x
	5	S1-1D-100-EQ	100%	224		22000		EQ 1D		x
	6	S1-2D-100-EQ	100%	224		22000		EQ 2D		xy
	7	S1-1D-200-SIN	200%	448	563.0	22000	0.2	sine	5	x
	8	S1-1D-200-EQ	200%	448		22000		EQ 1D		x
	9-1	S1-2D-200-EQ	200%	448		22000		EQ 2D		xy
	9-2	S1-2D-200-EQ	200%	448		22000		EQ 2D		xy
	10	S1-1D-100-A200	100%	224	281.5	22000	0.2	sine	3	x
	11	S1-2D-300-ETS	300%	672	844.5	22000	0.2	2D sinusoidal		x
	12	S1-1D-100-A300	100%	224	281.5	22000	0.2	sine	3	x
	13	S1-2D-400-ETS	400%	896	1125.9	22000	0.2	2D sinusoidal		x
	14	S1-1D-100-A400	100%	224	281.5	22000	0.2	sine	3	x
	15	S1-2D-500-ETS	500%	1120		22000	0.2	2D sinusoidal		x

3. Test Results

The brief test results are summarized in table 2. As shown in table 2, and deformed and failure shape of LRB after dynamic tests are shown in figure 5.

Strain	1D	2D
100%	Not many differences	
200%		
300%	No damage	Deformed shape
400%	No damage	Severely deformed shape
500%	Slightly damage No failure Failure occurred in 516% shear strain	Failure occurred during 2D dynamic test

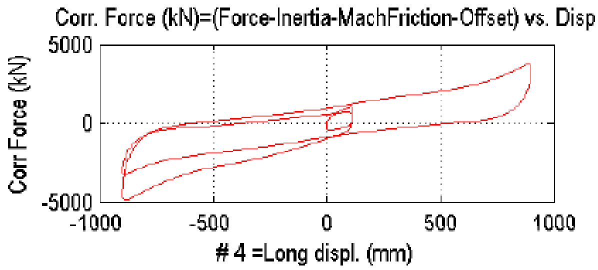
(a) Deformed shape after 2 dimensional test



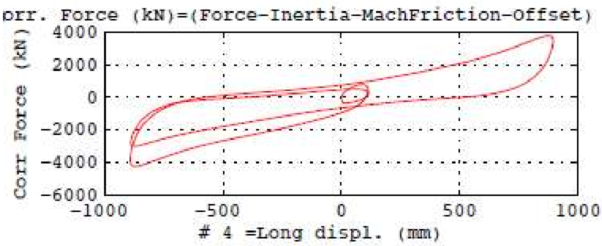
(b) failure after 2-D test (c) failure after 1-D test

Figure 5. Deformed and failure shape of after 1-D, 2-D test

The load-displacement relations according to 1 and 2 dimensional dynamic test are shown in figure 6. As shown in figure 6, even though a failure behavior was different but the dynamic characteristics are not many changed according to the dynamic input motion.



(a) load-displacement relation for 1 dimensional 400% shear strain level test



(b) load-displacement relation for 1 dimensional 400% shear strain level test

Figure 6. Test results for LRB

4. Conclusions

In this study, seismic isolation device tests were performed for the evaluation of performance criteria of isolation system. Through this test, it can be recognized that in the case of considering a mechanical property test, dynamic and multi degree of loading conditions should be determined. But these differences should be examined how much affect to the global structural behavior.

ACKNOWLEDGEMENT

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