PROBABILISTIC DEMAND ASSESSMENT OF SEISMIC BASE-ISOLATED STRUCTURES IN IMMEDIATE OCCUPANCY PERFORMANCE LEVEL

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Keywords: Seismic Isolation, Performance-Based Design, Fragility Curves, Incremental Dynamic Analysis, Immediate Occupancy Performance Level

Seismic isolation would mitigate damages caused by earthquake. These systems are feasible mostly in highly seismic zones and in structures with important occupancies and therefore should remain non-stop. Thus in this study immediate occupancy (IO) performance state is going to be studied. Performance evaluation has been done based on framework introduced by PEER using Incremental Dynamic Analysis (IDA) of 2-D frames (Vamvatsikos & Cornel, 2002). Various sources of uncertainties have been considered too (FEMA P-695, 2009). Three samples of 4, 6 and 8-story steel structures with office occupancy which possess special ductility property, located in San Diego, California, USA is selected and modelled in OpenSees Platform. The superstructures are designed according to AISC 360-10 and AISC 341-10 in a 3-D mode. Earthquake loads and other criteria that must be observed were based on ASCE 7-2010 standard (ASCE 7, 2010). Yield Stress of Lead, Shear Modulus of Lead and Shear Modulus of Rubber, are considered to be 7967, 583 and 385 (KN/m2), respectively. In this study perimeter and interior frames are considered to be moment and gravitational respectively. Two types of Lead Rubber Bearing (LRB) isolations have been equipped based on their general concept behavior (Naem & Kelly, 1999). Type 1 and 2 are modelled below the interior and perimeter columns, respectively. Table 1 presents their related properties.

Table 1. Manufacturer's specifications of LRB Isolations

No.	Number of Stories	Area of Rubber (m^2) Type1	Area of Rubber (m^2) Type 2	Total Thickness of Rubber (m) Type1	Total Thickness of Rubber (m) Type2	Area of Lead Plug (m^2) Type1	Area of Lead Plug (m^2) Type2
1	4	0.220618344	0.166190251	0.24	0.24	0.006503882	0.004778362
2	6	0.196349541	0.14522012	0.256	0.248	0.005674502	0.004071504
3	8	0.138544236	0.090792028	0.252	0.248	0.003739281	0.002642079

Contrary to most previous elements developed, this element is able to include hardening effects at high strains and interaction of isolator's axial force on shearing capacity. Other structural properties are listed in Table 2.

Table 2. Developed Archetype Properties

No.	Number of Stories	Transformed Period at MCE Earthquake (sec)	Transformed Period at DBE Earthquake (sec)	$R_{Isolated}$
1	4	3.34182	3.09163	1.0
2	6	3.235163	2.996135	1.0
3	8	3.1926951	2.9476315	1.0

In this study a comprehensive nonlinear modeling in geometry and material using Lumped plasticity is implemented. The response was extracted based on engineering demand Parameters (EDP) for different Intensity Measures (IM) at each stage. Figure 1 shows a sample of these responses. Morgan and Mahin (2011) has introduced maximum interstory's drift and story's maximum acceleration limit states for IO. Table 3 indicates the quantity value of these parameters.

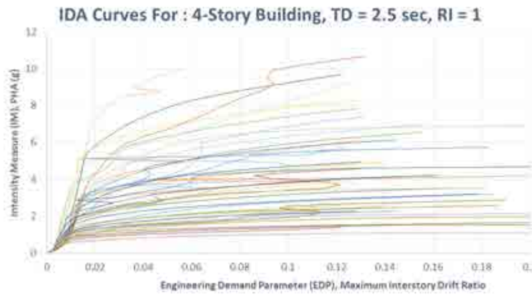

Figure 1. EDP vs. IM Curve of 4-story Building with DBE transformed Period 2.5 second

Table 3. IO Performance Limit State (Morgan & Mahin, 2011)

Performance Index	Performance limit state
Maximum Interstory Drift Ratio	0.8%
Maximum Story Acceleration	0.5g

Next, by calculating conditional failure possibility, fragility curves were plotted in Figure 2. The curves confirm that Seismic Isolation in decreasing possible damage corresponding to IO level much more than Fixed-Base structures and this is the goal which has been pursued by means of isolation technology. Therefore current modern standards are able to meet prerequisites for preparation of IO level. It also shows that IO is more efficient in 6- and 8-Story models. Majority failures of 4-story model are because of their exceedance in acceleration limit state. Results show that whatever the structure height becomes more, Interstory drift will have more share in reaching limit state criteria.

Figure 2. Immediate Occupancy Fragility Curve

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