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ANOVA of Seismic Responses for Isolated Structures

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A seismic response of isolated structures varies with mechanical properties of a base isolation system. In this study, a sensitivity study is carried out to investigate the effect of maximum seismic response changes due to the mechanical properties changes of a base isolation system. For investigation, the 30 sets of earthquakes pairs are selected form PEER (Pacific Earthquake Engineering Research Center) database. Selected earthquakes are modified to match with design response spectrum which is represented in Reg. Guide 1.60.

The isolated structure model is consisted with one mass and four isolators as shown in figure 1. A kinematic hardening of isolation system is idealized by bi-linear model. Five parameters are selected which is affecting the seismic response of an isolated structure, which are T_d, Q_p, α, e_r, and R_p. T_d is period calculated by second stiffness (K_d), Q_p is ratio between characteristic strength (Q_d) and weight (W) of isolated structure, α is ratio between K_u and K_d. R_p is ratio between radius of gyration (R_m) and radius of disposition (R_k). e_r is ratio between eccentricity (e) of center of mass and center of rigidity and radius of gyration (R_m). And various models of isolated structure are generated with variation of five parameters.

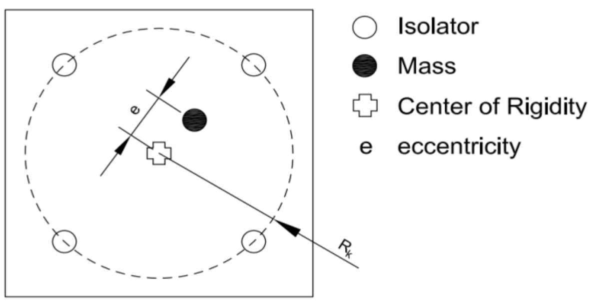

Figure 1. Isolated structure model

Non-linear dynamic analyses are performed with selected earthquakes and generated isolated structure models. And two seismic intensities (i.e., PGA level 0.5g and 1.0g) are considered for seismic response analyses. The ANOVA is performed by gathering maximum seismic responses from seismic response analyses of isolated structure models. ANOVA tables are represented in table 1 and table 2.

Table 1. ANOVA table of maximum translational displacement at 0.5g

Source	Sum Square	DOF	Mean Square	F-statistic	p-value
T_d	41.8092	2	20.9046	2647.6931	0.0000
α	0.6736	2	0.3368	42.6595	0.0000
Q_p	110.0905	2	55.0453	6971.8062	0.0000
R_p	0.0001	2	0.0001	0.0093	0.9908
e_r	0.0013	2	0.0006	0.0821	0.9212
Error	57.4707	7279	0.0079		
Total	210.0455	7289			

Table 2. ANOVA table of maximum translational displacement at 1.0g

Source	Sum Square	DOF	Mean Square	F-statistic	p-value
T_d	534.8690	2	267.4345	5738.6462	0.0000
α	0.1637	2	0.0819	1.7564	0.1727
Q_p	457.9748	2	228.9874	4913.6435	0.0000
R_p	0.0149	2	0.0075	0.1600	0.8521
e_r	0.0718	2	0.0359	0.7708	0.4627
Error	339.2186	7279	0.0466		
Total	1332.3129	7289			

It is found that a large variation in the maximum translational displacement is due to the T_d, α, and Q_p with 0.5g seismic intensity. Its sensitivity is found to be large in the order of $Q_p > T_d > \alpha$. In seismic intensity 1.0g, the sensitivity of the maximum translational displacement is found to be larger in T_d than Q_p.

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