Considerations for the evaluation of floor response spectra of a seismically isolated structure

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1. Introduction

The floor response spectra (FRS) of the structure should be considered for evaluating of the integrity of the internal equipment. Generally the floor response spectra are increases according to the height of the floor of the structure. Also FRS depends on the characteristics of the seismic base isolation system such as the natural frequency and damping ratio. An evaluation of the seismic isolated structural integrity, using the equivalent stiffness of the seismic base isolation system was satisfied. However, a FRS of seismic isolated structure is greatly changed because of the nonlinear behavior of seismic isolation system.

Therefor the generating of FRS for seismic isolated structure, more researches are needed about nonlinear behavior of seismic isolation system.

In this study, the analysis of the effects on the floor response spectra by the nonlinear behavior of a seismic base isolation system was performed.

2. Analysis Model

2.1 Analysis Model

The seismic isolation system was represented as the beam-stick model in which the superstructure is rigid body and isolator is spring element. Example the seismic isolation system was assumed as shown in Fig. 1. The total mass of superstructure is 118,000 tonf, and has a natural period of 2 sec.

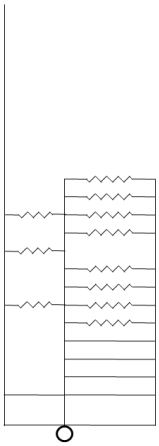


Fig. 1. The seismic isolation system

A lead-rubber bearing (LRB) isolator was used for this study. The modeling parameters total of the LRB are listed in Table1.

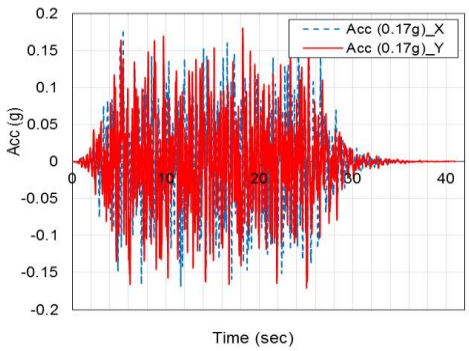
Table I: The major specifications total of the rubber bearing isolator (Unit: N/mm)

K1/K2	10	100
1st Stiffness (Ku)	1333	13300
2nd Stiffness (Kd)	133	133
Load of cross-axis (Qd)	4490N	4082N
Equivalent stiffness (Keq)	201	201

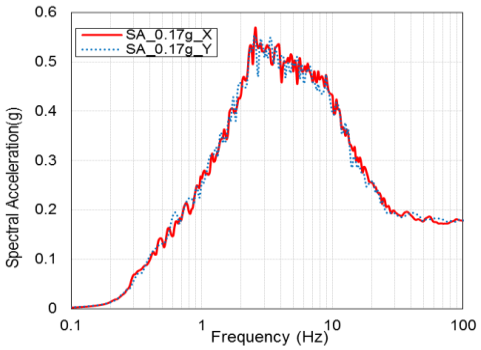
Commercial software SAP2000 was used for an analysis of the floor response spectra. A nonlinear response history analysis performed considering the non-linearity of the LRB. A bi-linear model based on rate-independent plasticity theory can be used to characterize the bi-directional behavior of LRB.

2.2 input ground acceleration

The ground acceleration was generated on the basis of the RG 1.60. Input ground acceleration was adjusted to fit the design displacement of the LRB. The ground acceleration was used for an analysis of the FRS. The generated ground motion is as shown in Fig. 2. To analyze the bi-directional effect, two situations will be compared, one where ground acceleration is applied in a one-direction and the other case where ground acceleration is applied in a two-direction manner.



(a) Input ground acceleration



(b) Spectral acceleration

Fig. 2. Input ground motion

3. Compare to the response about the seismic base isolation system

3.1 linear/non-linearity of the seismic base isolation system

The floor response spectrum of the structure result from the analysis in consideration of the linear/non-linearity of isolated structure was compared and shown in Fig 3.

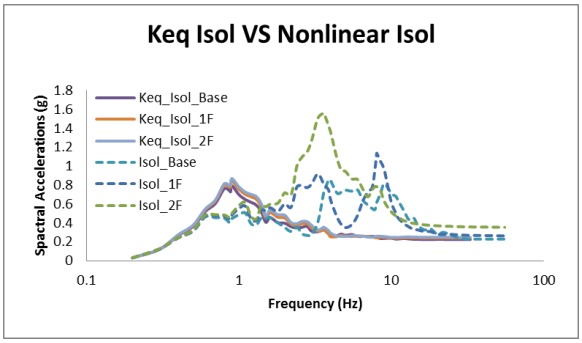


Fig. 3. The floor response spectrum of the structure in consideration of linear/non-linearity of structure

The similar results were observed in a previous about 0.6Hz, but shows different of results on remaining region. The influence of the nonlinear isolation system was increased in the hi-frequency domain. In addition, in the case of considering the nonlinearity of the isolation system, the values of floor response spectra appeared to have a different of responses in each floor. The non-linearity of the isolated structure was considered, because of a more reliable floor response spectrum of a seismic base isolation system.

3.2 The ratio of stiffness of the seismic isolator

If the initial stiffness of the seismic isolators changes, it can influence the floor response spectrum.

The results of the floor response spectrum of the seismic base isolation system from the analysis were compared and are shown in Fig. 4.

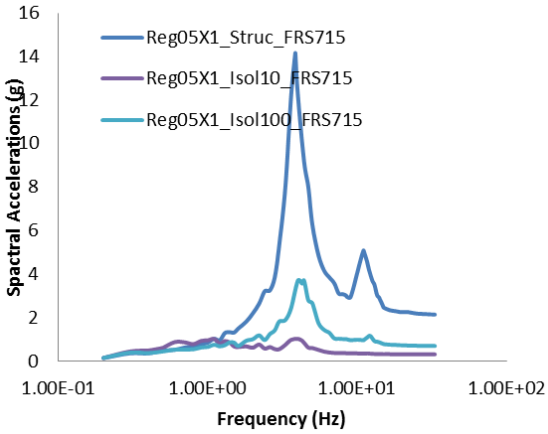


Fig. 4. The results of the floor response spectrum of the seismic base isolation system

Owing to the decreased shear force, the floor response spectrum is more reduced in a low initial stiffness ratio than high initial stiffness. On the other hand, the result of the high initial stiffness is able to confirm an increase of 26.5% at the nature frequency of superstructure.

3.3 The Bi-directional effects of the seismic isolator

The results of the floor response spectrum of the seismic base isolation system from the analysis were compared and are shown in Fig. 5.

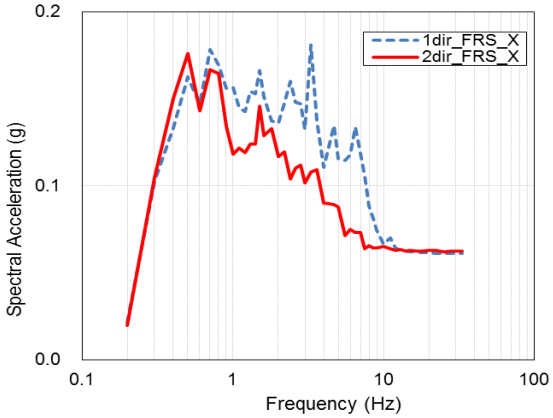


Fig. 5. The results of the floor response spectrum of the seismic base isolation system

Owing to the decreased shear force, the floor response spectrum is more reduced in a two-directional than in one-directional. On the other hand, the result of the two-directional is able to confirm an increase of 11.3% in the low frequency region.

4. Conclusions

In this study, the analysis of the effects on the floor response spectra by the nonlinear behavior of a seismic base isolation system was performed.

The nonlinear behavior was defined as the ratio of stiffness and the effect of bi-direction. As a result, the FRS was increased in hi-frequency domain because the influence by the nonlinear behavior of isolation system. In addition, each floor exhibited a more different of responses compared with the equivalent linear model of the seismic isolated structure. The nonlinear behavior of the seismic isolation system was considered, because of a more reliable assessment of integrity about equipment at each floor of seismic isolated structure.

Acknowledgement

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