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Effect on the Floor Response Spectra by the Initial Stiffness of Seismic Isolators

Hyung-Kui Park [a*], Jung Han Kim [a], Min Kyu Kim [a], In-Kil Choi [a]
[a]*Integrated Safety Assessment Division, Korea Atomic Energy Research Institute, 989-111 Deadeok-daero, Deajeon,305-353, Republic of Korea*
[*]*Corresponding author: hyungkui@kaeri.re.kr*

1. Introduction

The floor response spectra (FRS) of the structure should be sought for evaluating of the integrity of the internal equipment. The floor response spectrum depends on 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, damping ratio. An evaluation of the structural integrity using the equivalent stiffness of the seismic base isolation system was satisfactory. However, the influence of a nonlinear of the isolated system is expected to have a huge difference in case of the floor response spectra, and research on this area is necessary.

Therefore, in this study, the effect of the non-linearity of isolated system in the floor response spectrum of the structure is analyzed. If the initial stiffness of the seismic isolators changes, it can influence the floor response spectrum. In this study, the analysis of an initial stiffness effect on the floor response spectrum 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.

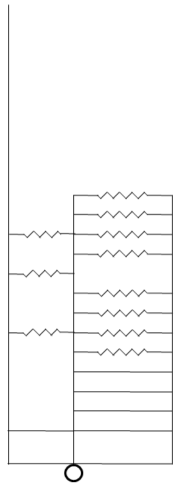


Fig. 1. The seismic isolation system

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

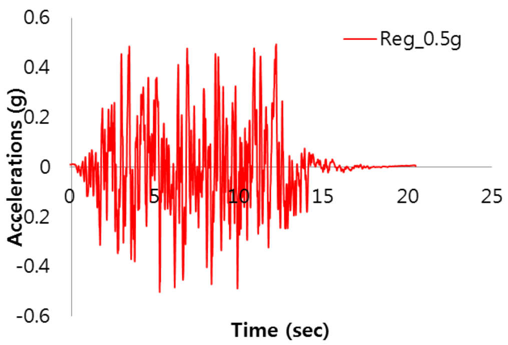
Table I: The major specifications total of the rubber bearing isolator (Unit: N/mm)

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

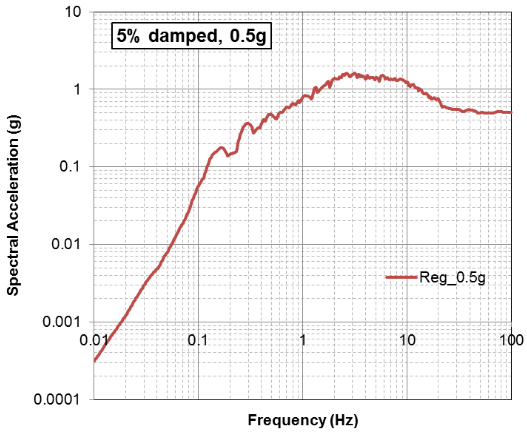
Commercial software SAP2000 was used for an analysis of the floor response spectra. A nonlinear response history analysis performed considering the non-linearity of the LRB. A bi-linear model based on rate-independent plasticity theory can be used to characterize the bi-directional behavior of LRB.

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



(a) Input ground acceleration



(b) Spectral acceleration
Fig. 2. Input ground motion

3. The response comparison with seismic base isolation system considering initial stiffness of seismic isolators.

The results of the shear force of the seismic base isolation system from the analysis were compared as shown in Fig. 3.

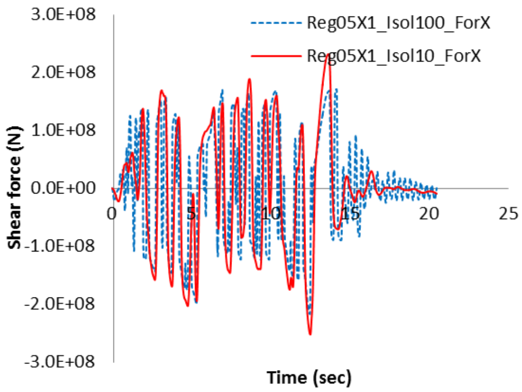


Fig. 3. The results of the shear force of the seismic base isolation system

The maximum shear force of the seismic base isolation system was similar at about 2.2E+8N. However, it was observed that when an initial stiffness ratio (10) is applied, the overall shear force is more reduced than when initial stiffness ratio (100) is applied.

The results of the displacement-shear force for a seismic base isolation system from the analysis were compared and are shown in Fig. 4.

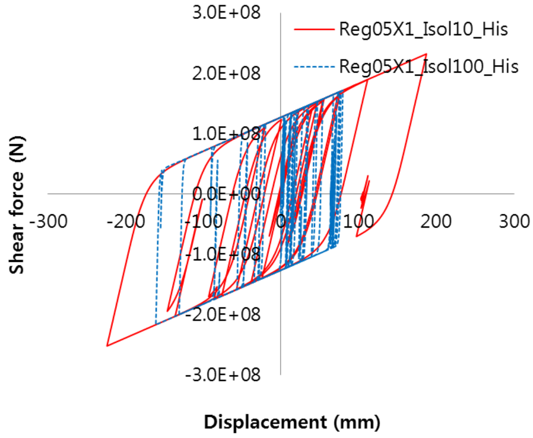


Fig. 4. The results of the displacement-shear force of the seismic base isolation system

As described above, the maximum shear force of the isolator was almost the same. However, it was observed that when initial stiffness ratio (100) is applied, the cumulated energy dissipated area is more reduced than when initial stiffness ratio (10) is applied. This can be determined as a result of the initial stiffness effects of the seismic isolation system. The results of the floor response spectrum of the seismic base isolation system from the analysis were compared and are shown in Fig. 5.

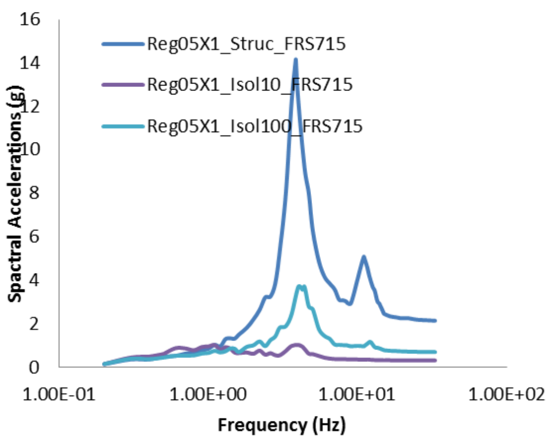


Fig. 5. The results of the floor response spectrum of the seismic base isolation system

Owing to the decreased shear force, the floor response spectrum is more reduced in a 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.

4. Conclusions

In this study, the response of the seismic base isolation system based on the initial stiffness ratio effects was analyzed. By analyzing the time history result, while there is no alteration in the maximum shear force of seismic base isolation system, it is confirmed that the shear force is generally more decreased in a low initial stiffness ratio that most parts. Due to the overall decreased shear force, the floor response spectrum is more reduced in a low initial stiffness ratio than in a high initial stiffness ratio. The FRS of the high initial stiffness ratio is able to confirm an increase of 26.5% at the nature frequency of superstructure. It appears to be a result of a initial stiffness effect of the seismic base isolatior. Therefore, the initial stiffness effect of the seismic base isolator is required to draw the conclusion of the floor response spectrum.

Acknowledgement

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