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An Experimental Study on the Effect of γ-Irradiation of Seismic Isolation Device

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1. Introduction

The seismic isolation system is one of the methods of improving seismic safety in the structures. Applying the seismic isolator in nuclear structures requires various performance verifications; in particular, the effects on radiation are not needed in the structures except nuclear field. To install the seismic protection isolator in the structures in nuclear power plants, however, the performance changes vis-a-vis radiation effects should be analyzed. Thus, this paper implements the experiments on the Gamma effects, and the performance changes are evaluated with regard to the seismic isolation device, which is developed to be applied to structures in nuclear power plants.

2. Overview

The seismic isolation used in irradiation were LRB (Lead Rubber Bearing) and EQS (Eradi-Quake System). The radiation used in the experiment was Gamma, and the radiation doses were determined at $7.5x10^3$Gy, $2.0x10^5$Gy, and $1.0x10^6$Gy. According to the tester's characteristics, LBR and EQS were manufactured in the sizes of Φ250mm and 500mm x 500mm x 150mm, respectively. At this time, the irradiation dose refers to that used in the design of the corresponding nuclear power plant. Table 1 shows the irradiation doses used in the experiments and each quantity of the seismic protection isolators.

Table 1: Type and quantity of the specimen

Item	Irradiation Dose (Gy)		
	Case 1 ($7.5x10^3$)	Case 2 ($2.0x10^5$)	Case3 ($1.0x10^6$)
LRB	3	3	3
EQS	3	3	3

3. Results

Basic characteristics evaluation for the LRB and EQS specimen was performed before and after the irradiation test.

3.1 Experiment Result for the LRB Seismic Isolation Device

Fig. 1 shows the view of LRB seismic isolation's basic characteristics test. The test method for the basic characteristics evaluation was performed according to ISO 22762-1, and compression and shear characteristics values were derived.

Fig. 1. View of the LRB seismic isolation device

Table 1 presents the characteristics before and after irradiation as a result of the compression characteristics experiment. Each result shows the ratio vis-a-vis the characteristics before the irradiation. As the irradiation dose increases, compression stiffness increases, but compression strain decreases. Specifically, compression stiffness in the seismic isolation is enhanced because the stiffness of the rubber material increases with increasing exposure to radiation. Fig. 2 shows the compression stiffness variation rate according to the dose exposure.

Table 2: Result of experiment on LRB's compression characteristics

Item		Before(a)	After(b)	Ratio(b/a)
CASE1	Compression Stiffness (kN/mm)	877.248	889.228	1.37%
	Compression Strain (mm)	0.423	0.420	-0.77%
CASE2	Compression Stiffness (kN/mm)	877.567	901.812	2.76%
	Compression Strain (mm)	0.425	0.413	-2.68%
CASE3	Compression Stiffness (kN/mm)	853.805	933.859	9.38%
	Compression Strain (mm)	0.435	0.404	-7.12%

Table 3 lists the result of the experiment on the shear characteristics; the data are normalized as characteristics values before the irradiation. In the case of the shear characteristics, equivalent stiffness and secondary stiffness increase as the irradiation dose is increased, but the equivalent stiffness gradually decreases. This means that the phenomenon of the rubber material hardening as the irradiation dose increases wields effects on the total behavior as mentioned before. In contrast, yield stiffness shows nearly no variations due to the lead's characteristics. In other words, the lead is not affected by the irradiation dose.

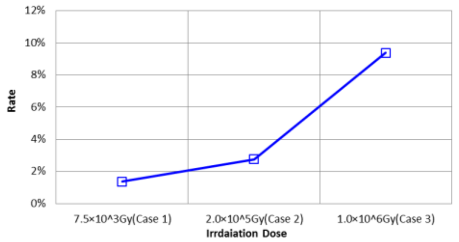

Fig. 2. Compression stiffness variation rate in LRB seismic isolation device according to the irradiation dose

Table 3: Result of the experiment on LRB's shear characteristics

Case	K_h	K_d	Q_d	H_{eq}
Case 1	7.68%	14.35%	0.174%	-0.51%
Case 2	4.56%	16.18%	-4.187%	-8.87%
Case 3	20.12%	41.17%	-2.375%	-14.71%

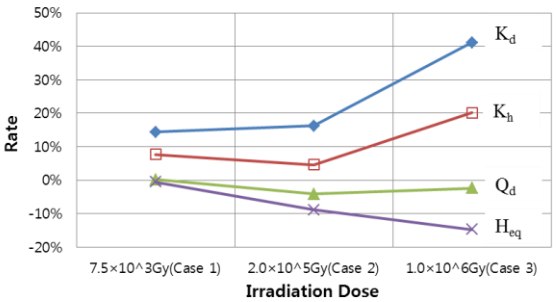

Fig. 3. LRB seismic isolation device's shear characteristics variation rate according to the irradiation dose

3.2 Result of the Experiment on EQS Seismic Protection Isolator

The characteristics experiment was performed on the EQS Seismic Protection Isolator at 40mm design displacement by applying 75-ton compression load after the irradiation. As shown in Figure 4, effective and secondary additivity increased as the irradiation dose increased. The coefficient of friction and EDC value exhibited an increasing trend. Note, however, that the coefficient of friction slightly decreased in case 3, since case 2 is deemed to be the critical point of increase of coefficient of friction.

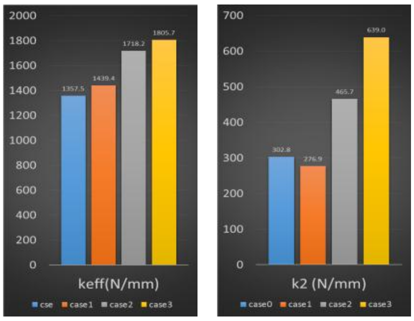

Fig. 4. Stiffness variation rate of EQS

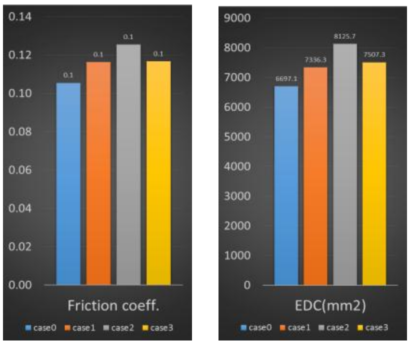

Fig. 5. Coefficient of friction and EDC value variation rate of EQS

4. Conclusion

This paper shows the irradiation experiment on LRB and EQS seismic isolation device, which are being developed as R&D for applying seismic protection isolators to the structures in nuclear power plants, and also describes the results. The experiment results for LRB and EQS seismic isolation all show effects on radiation. In particular, as the irradiation dose increases, stiffness in seismic isolation generally increases. Thus, the materials composing the seismic isolation are hardened by the radiation. The results of this R&D are expected to be utilized as basic data on the radiation effects on seismic isolation device in nuclear power plants in the future.

ACKNOWLEDGMENT

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