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A Study on the Development of Prototype Seismic Isolation Device for NPP

Hong-Pyo Lee [a*], Myung-Sug Cho [a], Sunyong Kim[a], Yong-Hee Lee[a], Kyung-Hun Kang[a]
[a]*KHNP-CRI, 1312-70 yuseong-Daero, Yuseong-Gu, Daejeon, Korea 305-343*
[*]*Corresponding author: hplee@khnp.co.kr*

1. Introduction

Seismic isolation technology will reduce the seismic force on the facilities by creation separation from the ground with the special devices such as LRB(Lead Rubber Bearing) and EQS(Eradi-Quake System). Basically, Korean nuclear power plants have been and still are based on seismic resistance design including all of the natural disasters. However, in regions of high seismic hazard, seismic isolation technology is needed to guarantee the seismic safety on nuclear power plants. To achieve this purpose, the research and development of seismic isolation system for the construction in high seismicity area is on-going in Korea. In this study, prototype seismic isolation devices as mentioned above are developed and tested to identify the basic shear and compressive characteristics of them.

2. Design of Seismic Isolation Devices

LRB and EQS seismic isolation devices are widely applied to bridge as well as general buildings in Korea. They are also evaluated the most appropriate system for the nuclear power plant through the experts.

2.1 Design of LRB

The design characteristics of LRB seismic isolation device are followings.

- Target period: 2 sec
- Design displacement: 152 mm
- Weight of the super-structure: about 450,000 ton
- Diameter of LRB: Φ 1,500 mm

Table 1: Design Factor of prototype LRB

Item	Design Factor
Design pressure	13.0 MPa
Shear modulus	0.392 MPa
Total rubber thickness	152.0 mm
First shape factor	46.9
Second shape factor	9.9

The design of LRB based on ASCE 7-10 is employed using the design characteristics. Table 1 and Fig. 1 show the design factor and force-displacement curve, respectively. Herein, the number of devices of LRB is 630 in the seismic isolation area for nuclear power plant.

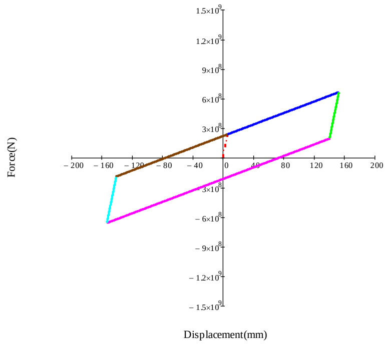


Fig. 1. Force-displacement of LRB seismic isolation device regarding the design

2.2 Design of EQS

The design characteristics of EQS seismic isolation device are followings.

- Target period: 2 sec
- Design displacement: 100 mm
- Weight of the super-structure: about 450,000 ton
- Size of EQS: 1,700 mm x 1,700 mm x 424 mm

Table 2 shows the design factor of EQS seismic isolation device with respect to design characteristics.

Table 2: Design Factor of prototype EQS

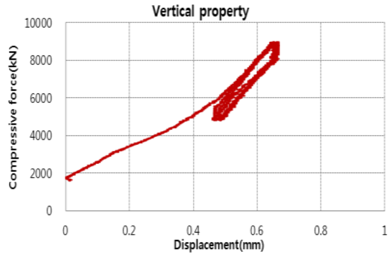
Item	Design Factor
Design Load	10,000 kN
Characteristic strength	500 kN
Post-yield stiffness	5.05 kN/mm
Effective stiffness	10.05 kN/mm

3. Experimental Test and Result

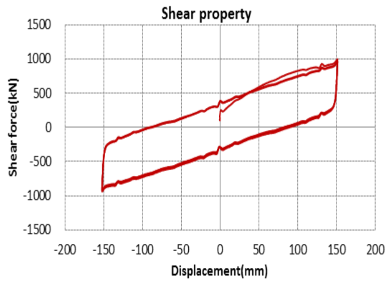
3.1 Basic Characteristics Test and Result of LRB

The compression and shear characteristics test of the prototype LRB was performed according to ISO 22762-1 to find out the performance newly manufactured prototype LRB production and measurements were taken within the variation of ±30% of vertical loads of design pressure. Fig. 2 shows the compressive and shear property test result. As a result of experiment, based on design compressive stress of 13MPa, compressive stiffness, shear stiffness, equivalent damping ratio and characteristic strength were calculated to show results in Table 3. From the test result, compressive stiffness and effective stiffness changed +15.7% and -1.20%

compared with design value, respectively. Therefore, considering the margin of error of compressive (±30%) and shear (±10%) characteristic, the result is well matched between design and experiment.



(a) Compressive force-displacement relationship



(b) Shear force-displacement relationship

Fig. 2. Compressive and shear curves of prototype LRB

Table 3: Test results of prototype LRB

Item	Design(A)	Test(B)	Error ratio (A/B)
Compressive stiffness (kN/mm)	16,702	19,332	+15.7%
Second stiffness (kN/mm)	3.920	3.929	+0.23%
Effective stiffness (kN/mm)	6.079	6.006	-1.20%
Equivalent damping ratio (%)	21.6	22.1	+2.26%
Characteristic strength (kN)	328.3	315.6	-3.86%

3.2 Basic Characteristics Test and Result of EQS

According to Guide Specifications for Seismic Isolation Design, basic characteristics test of prototype EQS were employed. As a result of comparing calculation results based on the standard and the hysteresis graph obtained from an experiment as seen Fig. 3, it was found that the overall behavior showed similar results.

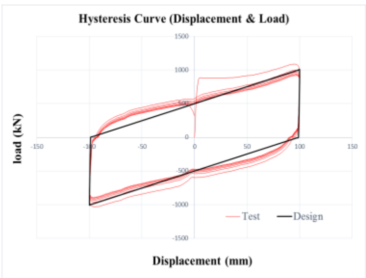


Fig. 3. Hysteresis curve of prototype EQS

From the test result as seen Table 3, effective stiffness changed -7.0% compared with design value. Therefore, considering the margin of error of shear characteristic (±10%), the result is well matched between design and experiment.

Table 3: Test results of prototype EQS

Item	Design(A)	Test(B)	Error ratio (A/B)
Peak load (kN)	1,005	998	-1%
Second stiffness (kN/mm)	5.05	4.55	-10%
Effective stiffness (kN/mm)	10.05	9.37	-7%
Equivalent damping ratio (%)	0.32	0.35	12%
EDC (kN-mm)	200,000	208,864	4%

4. Conclusions

In this study, assessment performance of basic characteristics on the prototype LRB and EQS seismic isolation for nuclear power plant structures is employed to compare with design values. Based on the test results of compression and shear characteristics, it is judged that they meet the measuring efficiency range conditions which are presented in ISO 22762 and AASHOT guide specification. Therefore, prototype seismic isolation devices like LRB and EQS developed in this study can be expected to be used as reference data when designing a seismic isolation system for nuclear power plant structures in the future.

ACKNOWLEDGMENT

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