Transactions of the Korean Nuclear Society Autumn Meeting
Gyeongju, Korea, October 24-25, 2013

Assessment of EQS Seismic Isolation Device for Nuclear Power Plant

Hong-Pyo Lee [a*], Myung-Sug Cho [a]
[a]*KHNP-CRI,1312-70 Yuseong-Daero, Yuseong-Gu, Daejeon, korea, 305-343*
[*]*Corresponding author: hplee@khnp.co.kr*

1. Introduction

This study describes research on a performance test of an EQS seismic protection isolator for application to structures in nuclear power plants (NPP) as part of the R&D project, "Development for the localization of seismic protection isolator for the structures in NPP". The Eradi Quake System (EQS) is a seismic protection isolator which has been applied up to now for seismic protection isolation in bridge structures both locally and overseas, but higher performance is required for application to the structures in NPP. To reflect this need, a continual R&D study has been performed through this project in order that improved performance can be achieved with the EQS seismic protection isolator. Performance test results with regard to the EQS isolator are shown in this paper.

2. Performance Test of EQS Seismic Isolator

To ascertain the performance of the EQS seismic protection isolator, a pilot scale isolator was designed and manufactured and the performance test was conducted. This paper includes a description of the various types of test and methods, and the test results.

2.1 Introduction to the Test

The tests on the EQS seismic protection isolator were broadly divided into three types as shown in Table 1. The seismic pressure dependency test was performed as the vertical loads applied to the isolator were applied variably in the range 465~1,163 ton, and the displacement dependency test was performed as the dimensions of the historical displacement were varied in the range 20~100mm. Lastly, the velocity dependency test was performed as the horizontal loads were changed with changing loading velocity in the range 1~100mm/sec. The configuration of the isolator used in the test is shown in Fig. 2; it broadly comprises an MER-Spring, PTFE, Disk, Bearing Block and Upper/Lower Plate.

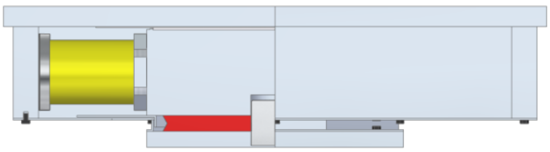

Fig. 1 EQS Test Specimen

Table 1 EQS Test Type

Type	Test Method
Seismic pressure dependency test	10~25MPa
Displacement dependency test	20~100mm
Velocity dependency test	1~100mm/sec

2.2 EQS Performance Test

The real view of the EQS seismic protection isolator used in the test is shown in Fig. 2. The dimensions of the test specimen are: length, 1700mm, width, 1700mm (same as length) and height, 420mm. It was designed in consideration of the vertical load, 1000 tons and the horizontal displacement, 100mm. The design EDC value of the isolator is 200,000kN.mm and the Keff value is 10.050kN/mm.

Fig. 2 View of the test specimen

This test was performed in the test center of SGS, which is the officially approved test authority, and for the test, equipment was adopted to which the required loads (vertical capacity, 30,000kN and horizontal capacity, 2,000kN) could be applied (Fig. 2).
The test procedure was as follows. First, the vertical load was loaded to the EQS seismic protection isolator, and then the horizontal direction behavior tests were conducted according to the test conditions. History curves were obtained from the horizontal displacements and loads of the isolator obtained from the test results. The three test types described above were applied, and for each type, tests on four parameters were performed.

2.3 Test Result

The performance test results by seismic pressure, displacement and velocity in EQS seismic isolator are shown below in Tables 2~4 and Figs. 3~5. The EDC values and effective stiffness of the isolator are verified through load-displacement history curves in each test and the characteristics are presented. Through the characteristics of the isolator, effects which may be produced when an earthquake occurs are briefly analyzed.

Table 2 Seismic pressure dependency test result

Type	**Test condition**	**EDC (kN.mm)**	**Keff (kN/mm)**
Seismic pressure dependency test	10MPa	156,681	7.836
	15MPa	190,425	8.542
	20MPa	215,893	9.174
	25MPa	246,186	9.995

From the test results according to seismic pressure shown in Table 2, it can be verified that EDC value and effective stiffness increase as the seismic pressure increases. But Fig. 3 shows that the yield strength is not increased along with an increase in vertical load. Also, it can be verified that the coefficient of friction decreases as seismic pressure increases.

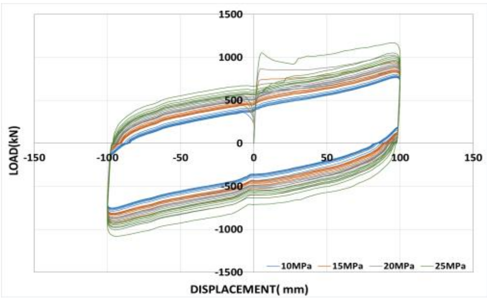

Fig. 3 Seismic pressure dependency test result

Table 3 EQS displacement dependency test result

Type	**Test condition**	**EDC (kN.mm)**	**Keff (kN/mm)**
Displacement dependency test	20mm	41,568	31.953
	40mm	82,316	16.726
	60mm	125,232	11.700
	100mm	216,165	9.040

Table 4 EQS velocity dependency test result

Type	**Test condition**	**EDC (kN.mm)**	**Keff (kN/mm)**
Velocity dependency test	1mm/sec	103,863	6.541
	5mm/sec	144,455	7.202
	20mm/sec	191,801	8.324
	100mm/sec	215,308	9.574

The EDC values and effective stiffness obtained from the test results on the displacement dependency of the EQS seismic isolator are shown in Table 3, while Table 4 shows the result for velocity dependency. From the result on displacement dependency shown in Fig. 3, it can be verified that the coefficient of friction is not nearly changed according to an increase in displacement. This shows that effective stiffness decreases and EDC value increases as the displacement is increased. It can also be verified that the coefficient of friction increases as the velocity is increased, in contrast to the result on seismic pressure.

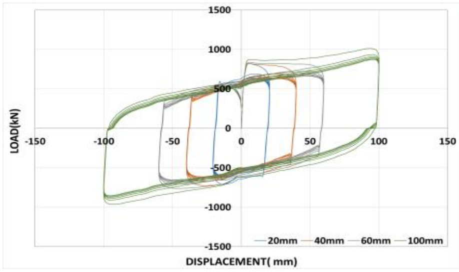

Fig. 4 Displacement dependency test result

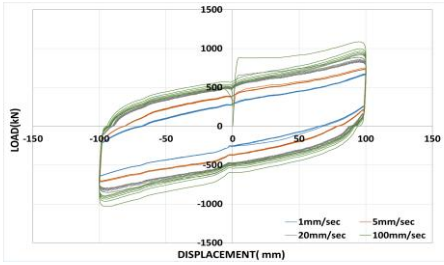

Fig. 5 Velocity dependency test result

It can be verified that the deviations between test result and the design value attain 10% at maximum, showing 8% in EDC area and 10% in effective stiffness.

3. Conclusion

It can be verified from the test results of the EQS seismic protection isolator that there is a dependency in seismic pressure, velocity and displacement. It can be also verified that safety is enhanced because the EQS damping capability is raised in the event of a heavy seismic load, and low resistance capability is possible towards the recovery of the structure following an earthquake.

ACKNOWLEDGMENT

This work was supported by the Energy Efficiency & Resources of the Korea Institute of Energy Technology Evaluation and Planning(KETEP) grant funded by the Korea government Ministry of Knowledge Economy (No. 2011T100200081)

REFERENCES

[1] Park, H.K, Lee Y.I and Chung D.Y (2011), "Test and Analytical Research on Dynamic Behavior of Polyurethane Spring Recovery Type Disk Support", Earthquake Engineering Society of Korea, vol. 15, no.2, pp 61-69

[2] Yoo, S.M, Lee Y.I, Ji Y.S, Choi, D.S and Kim D.K, "A Study on the Application of EQS bearings for the Seismic Isolation of Building Structures by ICT Case study", Earthquake Engineering Society of Korea, vol. 17, no.2, pp 61-70