Studies on the Needs of Seismic Base Isolation Concept and its Standardization

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1. Introduction

Unlike Japan and the U.S., where there are frequent earthquakes, Korea has not experienced earthquakes; naturally, seismic design hasn't been one of the primary architectural concerns in the past. Even when the concept was introduced in Korea, it was not taken seriously during the design process because it raises design and construction costs in general. Furthermore, economic forces and technological developments were not in place to support its development in Korea. In the late 1970s, seismic resistance design was introduced as a new design concept through the construction of nuclear power plants. Before this, lateral forces other than wind loads, such as seismic forces, were not taken into consideration in the structural design process. However, in response to the building of increasingly large and heavy structures such as nuclear power plants, a consensus began to form in society regarding the importance of seismic resistance design to avoid a large-scale calamity. Since then, Korea has reinforced the relevant regulations, and there has been some progress. At the same time, the seismic base isolation concept was introduced to encourage active research activities related to building safety issues. It has lately been applied for the purpose of reducing construction costs.

Table 1: Present Condition for the Seismic Resistance and Seismic Base Isolation Concepts in Korea

1970	1986	1988	1992
Seismic resistance design concept was first introduced and used for constructing a nuclear power plant (Gori-1 Plant)	'Building Act' stipulated and enforced that buildings should have safe structures concerning the seismic	"Regulations on structure standards of buildings" legislates systematic 'seismic resistance design standard for buildings' for the first time.	'Standard specification for highway bridges' adopts the seismic resistance design concept for bridges.
1990s - Early 2000s		2000 - Present	
Seismic resistance regulations were increasingly enforced, introducing simultaneously the seismic base isolation concepts from advanced countries.		Technological developments have settled seismic resistance design concepts, and tried introducing and introduced a seismic base isolation concept for the purpose of construction cost reduction.	

In 1980s, seismic base isolation design was applied for 'Cruas' plant in France and 'Koeberg' plant in South Africa. Those two are the few cases in which the seismic base isolation design was applied; for the rest, seismic resistance design was applied in most nuclear power plants that are in operation and in construction in the world. Rather than welcoming innovative technology on a trial basis, nuclear power plant design makes use only of proven technologies, which explains the application of seismic resistance design. As seismic base isolation design has become more accepted for use in the building of domestic general bridges, which has, thereby, confirmed its safety, it has been accepted for nuclear power plant design and has even been actively applied.

2. Seismic Base Isolation Design

2.1 Definitions of Seismic Design: Seismic Resistance, Vibration Control, Seismic Base Isolation

Seismic resistance design means a structural design that reduces the input load effects on the structure during earthquakes by increasing the structure's rigidity. The design principle is applied to most domestic structures, and there is a wide range of design and construction knowledge accumulated on this. However, the system requires an increase in sectional areas and additional reinforcing as a way to stiffen a structure itself, which leads to construction cost increases and makes the process financially not plausible.

Vibration control design means a structural design that reverses the seismic force resisting system by installing an additional active mass driver to the structure or that absorbs the seismic energy by concentrating the external forces to the driver. There are active and passive control methods depending on whether external electric power is used or not. For active control, structures can be considered as individual mechanical elements.

Seismic base isolation design means a structural design in which a collection of structural elements decouples a superstructure from its substructure resting on shaking ground thus protecting a structure's integrity. Seismic base isolation does not simply separate the superstructure from its substructure but rather decreases the seismic energy by using the relative displacement or friction created within the devices.

2.2 Seismic Base Isolation Concepts Needed

Structural seismic base isolation is currently regarded as a satisfactory design technology both financially and in terms of safety. Table 2 shows the design's application needs that are being discussed in Korea and overseas.

Table 2: Seismic base isolation Concept Needed

Division	Domestic	Overseas
General Structure	• Export possibilities to high seismic zones overseas • Construction cost reduction • Alternatives for gradually increasing seismic resistance design load	•Construction cost reduction • Alternatives for gradually increasing seismic resistance design load
Nuclear Structure	• Margin of safety secured for safety-related seismic resistance • Alternative for exporting nuclear plants overseas	• Effective for nuclear plant construction in high seismic zones. • Effective alternative for nuclear plant sites in high frequency zone • Increasing pressure to use the design for new nuclear plants

2.3 Current Status of Seismic Base Isolation Standardization

Considering the current conditions of domestic construction industries, we need to explore various ways to export domestic construction industries. For this purpose, we need to first establish the related industry standards. Table 3 describes a standardization procedure of domestic technology by KEPIC(Korea Electric Power Industry Code).

Table 3: KEPIC Standardization Procedure of Domestic Technology.

Technology Development	→	Experts Review	→	Standardization	→	Globalization

Presently, in response to the industries' needs, KEPIC is developing the new standard, KEPIC-STC, for structural seismic base isolation.

STC will be developed based on the characteristics of seismic base isolation devices that are designed specifically for nuclear plants in Korea with domestic technology. The technology will be developed in reference to various major standards available both domestically and overseas: first, seismic base isolation-related contents will be approved for nuclear facility structures and will then be expanded to seismic base isolation design used in general structures such as electric power transmission and distribution.

Table 4 shows the current KEPIC-S composition and operation. In case of STC, it will be the self-development standard based on domestic technology for the second time in KEPIC-S. It is scheduled to be published in 2016.

Table 5 shows the current Seismic base isolation related overseas standards. KEPIC will apply this standard in STC development.

Table 4: Current Status of KEPIC-S Composition and Operation

Field	Sub-Field		Reference Standards
	Designation	Title	Corresponding International Standards
SN	SNA	General Requirements	ASME Sec.ⅢSubsec. NCA
	SNB	Concrete Containments	ASME Sec.Ⅲ Div.2
	SNC	Concrete Structures	ACI 349
	SND	Steel Structures	ANSI/AISC N690
	SNE	Protective Coatings	ASTM D 16 Types, SSPC 8 Types
	SNF	Steel Structures-LRFD	ANSI/AISC N690L
	SNG	Steel-Plate Concrete Structures	Self-Development
SG	SGA	General Requirements	-
	SGB	Concrete Structures	ACI 318
	SGC	Steel Structures-ASD	AISC-ASD
	SGD	Steel Structures-LRFD	AISC-LRFD
	SGE	Steel Structures	ANSI/AISC 360
ST	STA	Minimum Design Loads	ASCE 7, KBC 2009
	STB	Seismic Analysis and Seismic Capacity evaluation	ASCE 4
SW	SWS	Structural Welding-Steel	AWS D1.1/D1.1M
	SWT	Structural Welding-Sheet Steel	AWS D1.3/D1.3M
	SWR	Structural Welding-Reinforcing Steel	AWS D1.4/D1.4M

Note: In categorizing KEPIC-S into 17 Types, 'Technical Regulations' are assigned for the seven types (SNA, SNB, SNC, SND, SNE, STA, STB) according to 'Nuclear Safety and Security Commission'; for the rest of ten Types belong to the 'standards'.

Table 5: Seismic Base Isolation Related Standards, Overseas

Standard	Contents
US NRC	RG/SRP related information is not listed separately; however, presently NUREG Report is scheduled to be published.
ASCE 4-98, Section 3.5.6	The only code listing seismic base isolation-related requirements in the nuclear field. Scheduled to be changed greatly in the next edition.
ASCE 7-02, Section 9.13	Write code of seismic base isolation structures based on NEHRP 2000 document.
FEMA 04, Chapter 13	Provides the latest requirements for seismic base isolation structure design.

3. Conclusions

So far, most structures of nuclear facility have been constructed with seismic resistance design and engineering methods. However, seismic force prediction is not perfect in reality; nor is it financially beneficial to apply the system for gradually increasing seismic resistance design loads. Therefore, it is necessary to apply a seismic base isolation system as a way to help secure the seismic protection of the structures of nuclear facility rather than to solely depend on seismic resistance design alone. This can also bring cost reduction effects both in early construction and in disaster control aftermath. Domestically, various types of devices are used for seismic base isolation systems in bridge projects. The 2005 revised edition of 'the highway bridge design standard' includes seismic base isolation standards under seismic resistance design for the first time in history; however, no efforts have been made to implement this technology in other fields. Therefore, KEPIC is developing seismic base isolation technology standards for the electrical industry. This is not to mention the domestic construction industries, since even the nuclear power plant industry strives to make income through exporting. In these circumstances, the nuclear field especially needs technical regulations or standards that need to be followed based on the design of relevant technologies. Therefore, KEPIC Department of Korea Electric Association is currently on the progress of developing the new standard for seismic base isolation based on domestic technologies.