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Seismic Retrofit due to Dynamic Characteristics of RCS Equipment of NPP in BDBE

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1. Introduction

The seismic capacity of the nuclear power plants has been handled at the plant building level, but recently approaches and measures for the safety-related components or individual equipment have taken increasing concerns as efficient and practical options for seismic enhancement. Those are control cabinets, emergency diesel generator, remote shutdown console, battery pack, spent fuel racks, and so on. has become important in determining the seismic capacity of nuclear power plants. The paper investigates how to enhance seismic performance of the NSSS (Nuclear Steam Supply System) equipment of the NPP (Nuclear Power Plant) in BDBE (Beyond Design Basis Earthquake). As a major system among the NSSS, RCS (Reactor Coolant System) located in containment building is mainly reviewed. The NSSS equipment in a nuclear power plant can be classified into several groups based on their structural and dynamic characteristics by weight and seismic safety within the containment building during a BDBE. In next chapter, it is investigated that optimal technology of enhancing seismic performance suitable to each equipment group

2. Seismic Retrofit Tech. for NSSS Equipment

There are some technologies used to enhance seismic performance of equipment in NPP so far. They are reinforcement or bracing, base isolation, increase of damping, seismic qualification by analysis or test, upgrading supports. 1) Reinforcement or bracing: is the basic option whoever could consider in case of external design load increase. This involves increase of main body stiffness by thickness or material change, and adding additional support structures, such as steel bracing, to the equipment to improve its seismic resistance. This is often used for relatively light weight equipment that is less sensitive to dynamic interaction with building structures, and that is not critical to the safety of the NPP, but still needs to be protected during an earthquake. 2) Base isolation can be the second option which is widely known and applied. This involves installing seismic isolation systems, such as rubber bearings or friction pendulum systems, at the base of the equipment to reduce the seismic response of the equipment during an earthquake. This technique is effective for improving the seismic performance of critical equipment, such as the reactor pressure vessel and steam generators. 3) Damping increase: This involves adding damping systems, such as tuned mass dampers or viscoelastic dampers, to the equipment to reduce its seismic response during an earthquake. This technique is effective for reducing the seismic response of large, heavy components in the NSSS. 4) Seismic qualification by analysis or test: This involves conducting extensive seismic testing and analysis on the equipment to demonstrate its seismic performance during a BDBE and ensure that it meets the required seismic safety standards. 5) Upgrading supports: this involves upgrading the anchoring and restraining systems used to secure the equipment in place during an earthquake. This may involve adding additional anchors or reinforcing existing anchors to improve their seismic resistance

These seismic retrofit technologies can be used individually or in combination to improve the seismic performance of RCS equipment in NPPs. The choice of technology and the extent of retrofit required will depend on the specific design and safety requirements of the NPP, as well as the specific characteristics of the equipment that needs to be retrofitted

3. Classification of Major NSSS Equipment

There are some ways of NSSS equipment categorization by their structural characteristics. For efficient application of seismic retrofit technologies to the equipment groups for BDBE. It can be proposed such as critical components, structurally important components, dynamically important components, and supporting components, and et cetera. First of all, critical component group include the reactor **pressure vessel**, steam generators, and large coolant pipes, which play a critical role in maintaining the structural integrity and function of the NSSS during a BDBE. These components are essential for ensuring the safe shutdown of the reactor and preventing the release of radioactive materials. Secondly, structurally important components include the group of intermediate weight components such as medium-sized coolant **pipings**, pumps, and auxiliary components, which have a significant impact on the structural stability of the RCS within the containment building during an earthquake. Thirdly, dynamically important components mean both heavy and intermediate weight **rigid components**, which have a significant impact on the dynamic response of the RCS within the containment building during a BDBE. This group includes components that are essential for maintaining the stability and performance of the RCS during an earthquake. Fourthly, supporting component group includes lightweight components such as small coolant pipes, support structures, and **control systems**, which have a relatively low weight and smaller impact on the overall dynamic response of the RCS within the containment building during a BDBE. These components play a secondary role in enhancing the safety and performance of the NSSS during an earthquake.

4. Optimal Seismic Approach for RCS Equipment

From the previous review, the NSSS equipment can be recategorized into several groups such as, pressure vessels, pipings, rigid blocks, control cabinets, and others in viewpoint of dynamic characteristics and practical application for enhancement of seismic capacity.

5. Conclusions

It is important to consider both the structural and dynamic characteristics of the NSSS equipment within the containment building in a BDBE scenario, as each component contributes to the overall seismic safety and performance of the system. The classification of components based on their weight and their role in enhancing seismic safety can help to prioritize the design and assessment of the RCS equipment during a BDBE, and ensure that the most critical components are given the highest level of attention.

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