PHILOSOPHY AND PRACTICE OF THE ASEISMIC DESIGN OF NUCLEAR POWER PLANTS : SUMMARY OF THE GUIDELINES IN JAPAN

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This report is summarizing guidelines for aseismic design of nuclear power plants. The guide-line was prepared by the Japan Electric Association in April, 1970, after laborious three year's works.

In *chapter 1*, philosophy and criteria are described. All components in plant should be classified into three classes in accordance with their contributions to reactor safeties. Design to earthquake loadings should be based on "Design Basis Earthquake" which is decided in consideration of local seismisity.

In *chapter 2*, site selection and review for ground are described in sense of seismic aspect.

In *chapter 3*, it is discussed how to decide on the earthquake motion for design. In Japan, semi-statistical approaches are used in usual practice.

In *chapter 4*, design philosophy and practice of building structures and containment vessels are described. They are designed under statical seismic forces, and the design of the class "A" structures should be checked by dynamic response technique.

In *chapter 5*, design philosophy and practice of piping, vessels and equipment are described. Those which belong to class "A" items should be designed in dynamic sense. Several programs for dynamic analyses of these items are prepared. Allowable stress under earthquake conditions is discussed in relation to other codes, for example, ASME Section III.

The most part of the philosophy and design criteria have been adopted to all nuclear power plants which were built and being built in Japan.

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DISCUSSION

Q H. BARNERT, Germany

Is there any activity in the field of forecast of earthquakes in Japan ? Work on these questions might be important if design criteria turn out to be too hard, for example for the shutdown system.

A K. OMATSUZAWA, Japan

Yes. An organisation has been established to study how to forecast the earthquake. The activity of this organisation is as follows:

1. Accurate measurement of level of ground surface in a shorter period.
2. Measurement of micro-earthquake near the area where large earthquake is expected in comparatively near future.
3. Accurate measurement of horizontal movement of the ground by laser beam.

At present, however, it is not practical to forecast the large earthquake before a few minutes or seconds for shutting down the reactor, although under consideration in other field of engineering seismology.

Q H. WÖLFEL, Germany

When performing a time history analysis,which time duration of the earthquake and which time histories do you use ?

A K. OMATSUZAWA, Japan

Time duration of input earthquake wave for dynamic analysis depends on the selected waves. At the very beginning of analysis of a certain structure, we use full record of earthquake waves, and then we will find the time when the maximum response will occur. After that we use the waves a little longer than the time of maximum response.

Q H. WÖLFEL, Germany

For determining the stresses of the building do you take the acceleration multiplied with the mass distribution as dynamic loading or do you take the forces of your mechanical model ?

A K. OMATSUZAWA, Japan

For determining the stress for member design, we use the force, such as shear force and bending moment, derived from the time history analysis. Acceleration of the building is only used for determining the seismic loading of equipment and piping installed at each point of reactor building.

Q L. ESTEVA, Mexico

You mentioned some numbers by which you multiply the lateral force coefficients of ordinary structures in order to obtain the lateral force coefficients applicable to the various types of structural elements of nuclear reactors. On the other hand, you also showed charts of ground velocities and accelerations for given return periods. Have those coefficients been derived from the mentioned chart ? If so, in what manner ? What is the quantitative justification of those numbers ?

A K. OMATSUZAWA, Japan

In the design of "A" class items, lateral forces are determined by both static and dynamic analysis. And the members of structures are also determined by the larger forces. Static seismic coefficient is based on the building standard law of Japan, and the dynamic analysis is more scientifically determined by the local seismicity.
So, the earthquake forces in a low seismicity area, being determined by the static seismic coefficient (factor of 3), are controlling the design, and on the contrary, in a high seismicity area by the dynamic response analysis.

Q N. N. KULKARNI, India

In some reactor buildings very heavy equipment like pressure vessel and steam raising units are directly supported on foundations or floors which are rigid.
But there are reactor buildings like CANDU reactors in which the equipment is suspended in the form of a pendulum type support.
How do these systems compare from earthquake response point of view ? What will be your recommendation to support and locate such load ?

A K. OMATSUZAWA, Japan

The way to minimize the response of acceleration, or of force, for the equipment in a reactor building during an earthquake is as follows:

1. to lower the input acceleration,
2. to prevent the resonant phenomenon,
3. to increase damping.

To support the equipment at a higher level as you asked is not good for item 1. In this case, however, if the frequency is much lower than the supporting structure because of its pendulum system, then the responsive acceleration or force of such items will become low, while the relative displacement will increase.

Q D. LUTOSCH, Germany

You mentioned the importance of damping. What are the damping factors you are considering in Japan in your nuclear power plants ?

A

K. OMATSUZAWA, Japan

The damping factors used for our design purposes of reactor facilities are as follows:

	%
Reinforced concrete	5
Welded steel structure	1
Riveted or bolted steel structure	2
Vital piping system	0.5
Control rod drive mechanism	3.5
Fuel assemblies in water	7.0