ON THE STRUCTURAL RELIABILITY OF REACTOR SAFETY CONTAINMENTS

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SUMMARY

1. *Introduction*

The application of a "factor on safety" for design of complex structures such as nuclear reactors does not lead to a satisfying quantitative measure of structural safety. However, the reliability approach proposed in this paper can furnish this information. The method takes into account the probability of occurrence of loads and load combinations and also the probability of occurrence of different failure modes and mechanisms. The purpose of this paper is to discuss the basis of a structural reliability analysis of secondary reactor safety containments.

2. *Load analysis*

For a safe and economical design of important structures such as reactor safety containments it is necessary to determine the magnitude of loads associated with their probability of occurrence. For example the model time unit could be one year and the probabilities of all possible load types would have to be combined to obtain the probabilities of the most serious condition during the year.

Considering a secondary safety containment the following loads have to be taken into account: (1) Seismic loads, (2) wind loads, (3) snow loads, (4) internal pressure (accident condition).

It is generally accepted that loads are considered to be random variables with respect to their magnitude and time. In other words they can be modeled by stochastic processes.

In order to develop a realistic design prediction model a careful study of the historic records of the climatic and seismic loads for a proposed site of a reactor has to be performed. Several prediction models are described. For example, for California historical seismic records the compound Poisson process has been shown to be the most suitable law to model the occurrences of earthquakes and their Modified Mercalli (MM) intensity. Climatic loads such as severe storms of a certain magnitude can be modeled by periodic Poisson process as shown e.g. for Texas Gulf Coast data. The occurrence of heavy snow load can also be predicted by the same model, however, the cyclicity will be for this case quite different. The probability of occurrence of the accident condition can be obtained from the risk analysis of the particular primary containment.

The design load combinations can now be determined rationally by utilizing such models based on the probabilities of their simultaneous occurrence in time and magnitude. For this purpose statistical independence can be introduced as a reasonable assumption.

3. *Failure mechanisms*

The problem to be investigated now is that of determining the overall probability of failure of the safety containment structure whose failure mechanisms are expressed as a combination of several structural resistances and loadings. The criterion failure considered here is that of collapse determined by plastic hinge formation. A failure mechanism describes a particular regime of plastic hinge formation and can be composed of any one of a number of possible failure modes.

Similarily to the load variable the moment resistance variable can also be described by a statistical distribution function with a certain mean value and standard deviation. Statistical independence between the load and the resistance distributions can be assumed. This description is in contrast with the deterministic analysis where only mean values are considered explicitly and safety factors are used to compensate for undefined standard deviations and distribution functions.

In order to determine the overall structural reliability the individual failure mode probabilities of failure must be combined by considering the correlation between different possible failure modes.