Focal Depth Factors in the PSH Analysis

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ABSTRACT

IThe results from the Individual Plant Examination of External Event of Yonggwyang nuclear power plants, unit 3 & 4, in Korea have shown that the high degree of diversities of the experts' opinions on seismicity and attenuation models is supposed to be generic cause of uncertainty of APEs(annual exceedance probability) in the PSHA(probabilistic seismic hazard analysis). This study investigated the sensitivity of the focal depth, which is one of the most uncertain seismicity parameters in Korea. Significant differences in resultant values of annual exceedance probabilities and much more symmetrical shape of the resultant PDFs(probability density functions), in case of consideration of focal depth, are found. These two results suggest that, even for the same seismic input data set including the seismicity models and ground motion attenuation models, to consider focal depth additionally for probabilistic seismic hazard analysis evaluation makes significant influence on the distributions of uncertainties and probabilities of exceedance per year for the whole ranges of seismic hazard levels. These facts suggest that it is necessary to derive focal depth parameter more effectively from the historical and instrumental documents on earthquake phenomena in Korean Peninsula for the future study of PSHA.

Key words *: PSHA, APE, PDF, CPDF, SSE*

1. Introduction

Lessons learned from the analysis of Individual Plant Examination of External Event of nuclear power plants in Korea have shown that the high degree of dependence on the experts' opinions is supposed to be generic cause of uncertainty of annual exceedance probability in the probabilistic seismic hazard analysis. The report has also suggested that the large difference in input data of seismicity and ground motion attenuation model among the corresponding experts is one of the principal causes of uncertainty. Since the large uncertainties for the ranges of seismic hazard levels propagates finally into those in estimating core damage frequency of nuclear power plants, it is necessary to reduce uncertainty at the primary stage of seismic hazard analysis. This study investigated the sensitivity of seismicity parameters, including focal depth, which is one of the most uncertain seismicity parameters in Korea. The results from this study could be used for steering the future direction of geological and seismological research in Korea, which may reduce the uncertainty in seismic hazard analysis and, finally, in core damage frequency nuclear power plants .

2. Analysis of propabilistic seismic hazards

In the analysis of the probabilistic seismic hazard, the influence on the uncertainties of probabilities of exceedance per year for the whole ranges of seismic hazard levels from 0.1g to 0.99g was investigated for several seismic input parameters. In this study, those parameters such as seismicity, focal depth,

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and attenuation function, etc., which were proposed by two groups of experts including seismicity and strong ground motion attenuation model, were considered. The computer code in USGS open file was mainly used for evaluating probabilistic seismic hazard and resultant uncertainties of annual exceedance probabilities for the interested ranges of seismic hazard levels.

2.1 Analysis of CPDF(cumulative probability density functions)

At first, the cumulative probability density functions, which consider corresponding weights for all the combinations of seismic zonation, seismicity, attenuation model, and experts were investigated. For 10 seismic hazard levels from 0.1g to 0.99g, each cumulative probability density function was calculated by adding probability density from the smallest value up to the largest one, number by number, in order of magnitude. To find cumulative probability density function, the whole set of numbers of possible combinations of seismic zonation, seismicity, attenuation model, and experts were used instead of applying any linear fitting technique, which the other studies applied. Using cumulative probability density function, annual exceedance probabilities corresponding to 10%, 50%, and 90% were compared to mean value at each seismic hazard level. As shown in Fig. 1 and 2, the resultant values of annual exceedance probabilities, which are resultant from considering focal depth, corresponding to 10 seismic hazard levels are much less than those without considering focal depth. The decrease in the values of annual exceedance probabilities is up to 1/105.

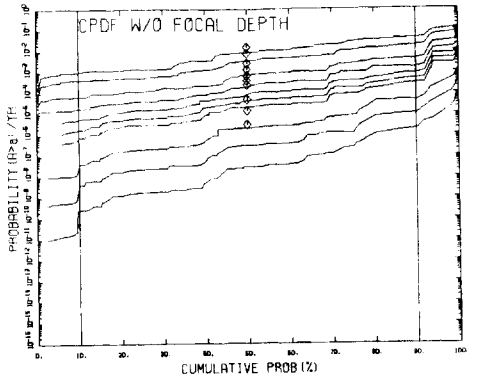

Fig. 1 Cumulative probability density functions (CPDF) without considering focal depth

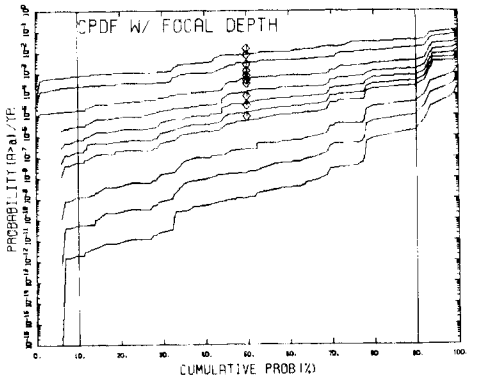

Fig. 2 Cumulative probability density functions (CPDF) with considering focal depth

2.2 Analysis of a single best-estimated PDF(probability density function)

Secondly, both a single best-estimated probability density function, which is resultant from aggregation of all the combinations of experts opinions, and 5 different probability density functions, which are respectively resultant from aggregation of the combinations for 5 different experts, were investigated. Fig. 3 and 4 show that the results, which considered

the focal depth parameter, showed that the absolute values of annual exceedance probabilities were reduced by order of 2 or 3 compared to those without considering focal depth parameter. Moreover, the absolute values of annual exceedance probabilities were reduced much more at the high seismic hazard levels than at low levels.

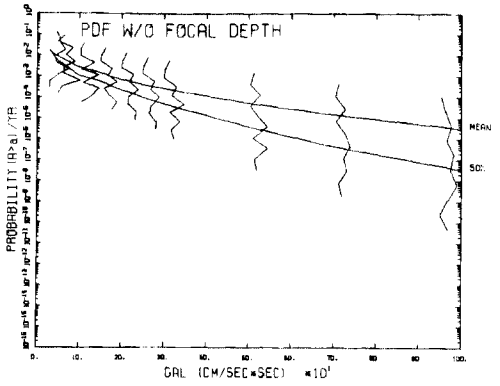

Fig. 3 Probability density functions(PDF) without considering focal depth

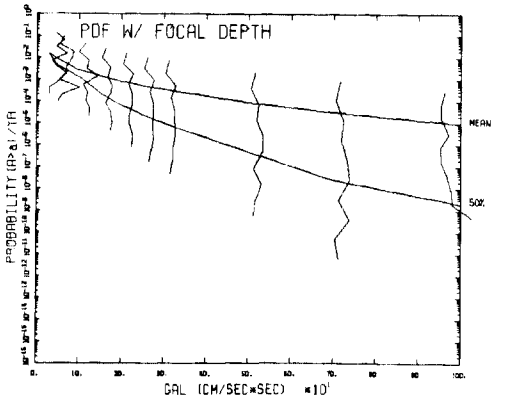

Fig. 4 Probability density functions(PDF) with considering focal depth

For 5 different probability density functions, which aggregate the combinations for 5 different experts individually, the shapes of the probability density function, which considered the focal depth parameter, were much more symmetrical compared to those without considering focal depth parameter. The shapes of the probability density functions of 5 experts for each seismic input group may be good measure to investigate degree of consistency of each expert.

3. Conclusions

This study suggest that, even for the same seismic input data set including the seismicity and ground motion attenuation model, to consider focal depth additionally for probabilistic seismic hazard analysis (PSHA) makes significant influence on the uncertainties and probabilities of exceedance per year for the whole ranges of seismic hazard levels. Specifically, at first, significant difference in resultant absolute values of annual exceedance probabilities may suggest that it is necessary to consider other parameters for the probabilistic seismic hazard analysis for estimating SSE (Safe Shutdown Earthquake) more certainly, which is one of the important seismic design parameters of nuclear power plants located in Korean Peninsula. Secondly, much more symmetrical shapes of the resultant probability density functions, which are resultant from considering focal depth factor additionally, suggest significant improvement in uncertainty of the resultant probability density functions. Two suggestions imply that it is necessary to derive focal depth parameter more effectively from the historical and instrumental documents on earthquake phenomena in Korean Peninsula for the future study of PSHA.

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