11 WCEE

Copyright © 1996 Elsevier Science Ltd
Paper No. 1873. (quote when citing this article)
Eleventh World Conference on Earthquake Engineering
ISBN: 0 08 042822 3

SENSITIVITY ANALYSIS IN THE PROBABILISTIC SEISMIC HAZARD ANALYSIS

J. K. KIM[1], C.H. YUN,[2] & C.B. IM[2]

[1]Dept of Mineral & Energy Resources Eng., Semyung University, Jecheon, Choongbuk 390-230, Korea

[2]Dept of Structural Systems & Site Evaluations, KINS, Daejeon, Yusunggu, P.O.Box 114, 305-338, Korea

ABSTRACT

The uncertainties in the analysis of probabilistic seismic hazard have been issued when applying to seismic design of nuclear power plants and related nuclear facilities. In evaluating the probabilistic seismic hazard, the characteristics of uncertainties and function shape of probabilities of exceedence per year for the interested ranges of seismic hazard levels are analyzed by considering focal depth additionally among several seismic input parameters proposed by two groups of panelists (seismicity and strong ground motion attenuation). The seismic input data set including seismicity and strong ground motion attenuation, etc., are suggested principally by the experts of corresponding group. The computer code published by USGS and related codes are applied for evaluating the probabilistic seismic hazard and the characteristics of uncertainty. The results of this study suggest that, even for the same input data set including the seismicity and strong ground motion attenuation, etc., which are proposed by corresponding panelists, to consider focal depth for each seismotectonic province additionally makes significant changes the absolute values and the shape of the resultant probability density functions of annual exceedence.

KEYWORDS

Probabilistic Seismic Hazard Analysis (PSHA), Cumulative Probability Density Function, Uncertainty, Skewness, Core Damage Frequency (CDF), g (Accerlation), Individual Plant Examination of External Event (IPEEE)

INTRODUCTION

Lessons (KEPCO, 1993) learned from the Individual Plant Examination of External Event of Yonggwang Nuclear Power Plant, Unit 3 & 4 in Korea have shown that the high degree of dependence on the experts' opinions is supposed to be generic cause of uncertainty of annual exceedence probability in the probabilistic seismic hazard analysis. The report (KEPCO, 1993) 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 interested ranges of seismic hazards propagate finally into those in estimating core damage frequencies of nuclear power plant, it is necessary to reduce uncertainty at the primary stage of probabilistic seismic hazard analysis.

This study investigated the sensitivity of seismicity parameters, especially focal depth, which is one of the most uncertain seismicity parameters of the seismological phenomena in the Korean Peninsula. The results from this study could be used for steering the future direction of geological and seismological researches in Korea, and, finally, in core damage frequencies of nuclear power plants.

METHODOLOGY AND RESULTS FROM PROBABILISTIC SEISMIC HAZARD ANALYSIS

For the analysis of the characteristics of probabilistic seismic hazard, the influence on the uncertainties and shape of annual probability density function of exceedence for the whole ranges of seismic hazard levels from 0.1g to 0.99g was investigated. This study applied input data set such as seismicity, focal depth, and attenuation function, etc., which were proposed by two groups of experts including seismicity and strong ground motion attenuation model. The computer code in USGS open file (McGuire, R.K., 1976) was mainly used for evaluating probabilistic seismic hazard values and characteristics of uncertainties of annual exceedence probabilities for the interested ranges of seismic hazard levels.

At first, the cumulative probability density functions, which are resultant from considering corresponding weights for all the combinations of seismic zonation, seismicity, attenuation model for all the 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 more effectively, the whole set of probabilistic seismic hazards from numbers of all the possible combinations of seismic zonation, seismicity, attenuation model for all the experts were used instead of applying any linear fitting technique, which the other studies applied.

For the analysis of cumulative probability density function, annual exceedence probabilities corresponding to 10%, 50%, and 90% were compared to mean value at each seismic hazard level. The resultant values of annual exceedence probabilities in Fig 1, which consider focal depth, corresponding to 10 seismic hazard levels, are much less than those in Fig. 2, without considering focal depths. The decrease in the values of annual exceedence probabilities is up to $1/10^{5}$, especially at the high seismic hazard levels.

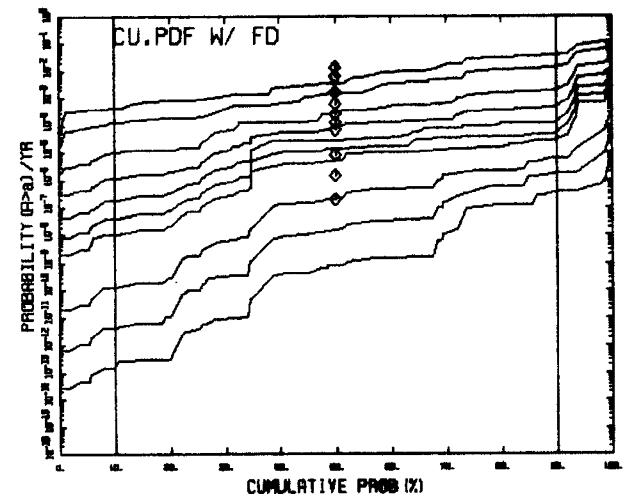

Fig. 1. Cumulative Probability Distribution Functions of Annual Exceedence with mean value caused by all the uncertainties for 10 seismic hazard levels, which are resultant from considering focal depth parameters.

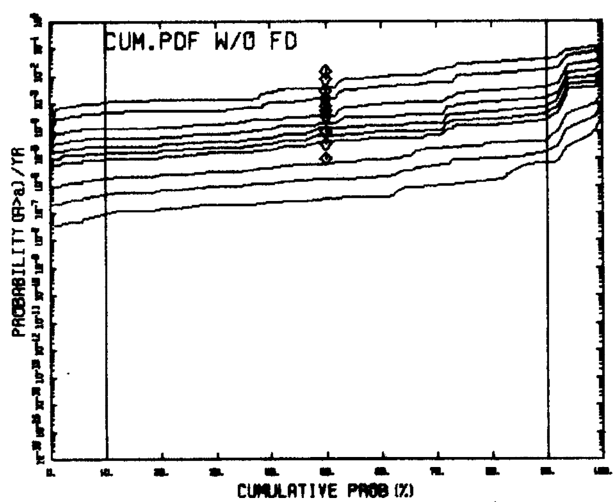

Fig. 2. Cumulative Probability Distribution Functions of Annual Exceedence with mean value caused by all the uncertainties for 10 seismic hazard levels, which are resultant from not considering focal depth parameters.

Secondly, a single weighted probability density function, which is resultant from aggregation of all the combinations of the whole experts' opinions with corresponding weights, were investigated. The results in Fig. 3, which considered the focal depth parameter, showed that the absolute values of annual exceedence probabilities were reduced by order of 2 or 3 compared to those in Fig. 4 without considering focal depth parameter. The results in Fig. 3 and 4 show that the absolute values of annual exceedence probabilities were reduced much more at high seismic hazard levels than at low levels. The shape characteristics of the probability density function in Fig. 3, which considered the focal depth parameter, was much more symmetrical and similar to normal distribution function, compared to those in Fig. 4, without considering focal depth parameter.

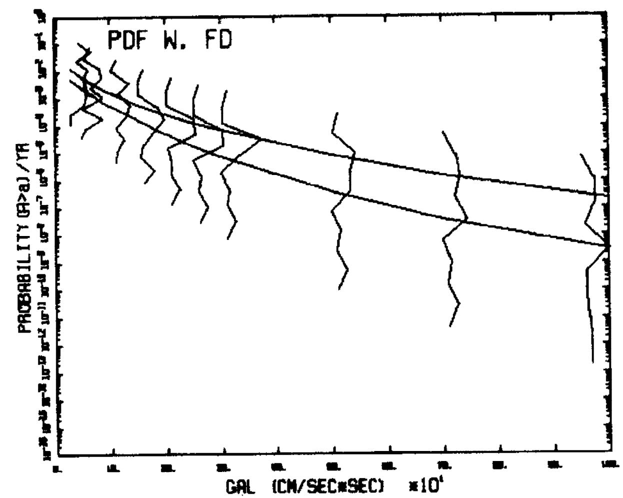

Fig. 3. Mean, 50%, and probability distribution functions of annual exceedence for 10 seismic hazard levels, which considered all the panelists' input parameters with focal depth parameters.

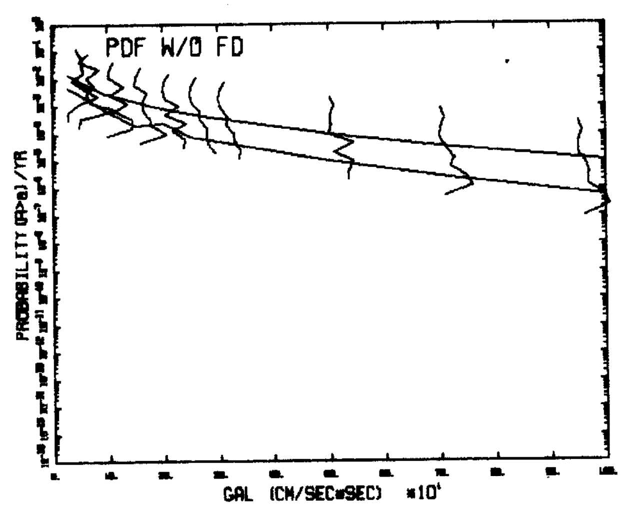

Fig. 4. Mean, 50%, and probability distribution functions of annual exceedence for 10 seismic hazard levels, which considered all the panelists' input parameters without focal depth parameters.

The shapes of the probability density functions of five experts individually may be good measure to investigate degree of consistency of each expert.

CONCLUSION

This study showed 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 makes significant influence on the uncertainties and shape characteristics of probability density function of exceedence per year for the whole ranges of seismic hazard levels.

Specifically, significant changes in characteristics of absolute values of annual exceedence probabilities may suggest that it is necessary to consider the focal depth parameter for 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.

Much more symmetrical shape of the resultant probability density functions, which are resultant from considering focal depth factor additionally, suggests 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.

REFERENCES

Gutenberg B. and C. F. Richter, (1954), Seismicity of the Earth and Associated Phenomena, 2nd ed., Princeton University Press, Princeton, New Jersey.

Gumble E. J., (1958), Statistics of Extremes, Columbia University Press, New York.

McGuire, R.K., (1976), Fortran Computer Program for Seismic Risk Analysis, USGS Open File Report.

Katsumi Ebisawa, (1993), Issue on Seismic Hazard Analysis in Japan and an Approach to Better Estimation, The 2nd Japan-Korea Workshop on Probabilistic Safety Assessment, Tokyo, Japan.

KEPCO, (1993), The Study of Probabilistic Safety Analysis of Yonggwang 3,4 NPP Unit.

KINS, (1993), The Safety Review Report of the Younggwang 3,4 NPPs for the Operation Permit.

Kim, J. K., (1994), Sensitive Parameters in PSHA, Korean Institute of Mineral & Energy Resources Engineering, Vol 31.

Kim, J. K., (1994), Seismicity and Attenuation Model Parameters in PSHA, Proceedings of the Korean Nuclear Society Autumn Meeting, Vol 2.

William, B. Joyner and David M. Boore, (1989), Measurement, Characterization, and Prediction of Strong Ground Motion, Recent Advances in Ground-Motion Evaluation, ASME.