RESPONSE OF EQUIPMENT IN NUCLEAR POWER PLANTS TO AIRPLANE CRASH

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SUMMARY

Nuclear power plants in Germany are to be designed against airplane crash. Two problems arise: First, the local problem of penetration as well as local destruction of the building. Second the airplane induced vibrations of the whole building, which cause loadings for secondary systems (equipment). This paper especially deals with the second problem. The main question is, whether—respectively in which cases—airplane crash may become the dominant design load case for equipment, i.e. whether it may exceed earthquake loading.

Floor response spectra due to airplane crash will be presented for three different power plant buildings. Especially attention is drawn to the influence of (a) time history of impact, (b) soil-building interaction, (c) flexibility of the building itself besides flexibility of soil, (d) rotatory vibrations due to eccentricity of impact.

The known time histories of impact, developed for analysing the local problem of penetration and local destruction cover the crashes of many different airplanes, because the local reactions do not depend so much on the exact time history. Floor responses spectra however are strongly affected by exact time history of impact. They too prove to be sensitive to the mathematical model of the building as well as of the soil. Suggestions are made for developing suitable floor design spectra considering the uncertainty in the knowledge of time history of impact as well as material characteristics and taking into account sensitivity of response to the mathematical model.

In addition the investigations show the great influence of eccentricity of impact: eccentric response due to eccentric impact may considerably exceed centric response.

Floor response spectra are a very good help for estimating the importance as well as the characteristics of a special load case. For calculating the response of multi-degree-of-freedom secondary systems there are still four methods as known from seismic analysis. The response spectrum methods—calculating the whole system by response spectra as well as separating the secondary systems by starting from floor response spectra—require a special method of mode superposition. The root mean square—well approved for earthquake excitation—seems not to be sufficient for the analysis of excitation by airplane crash. Further work will have to be done on this subject. There is also need for developing simplified methods of calculation. The authors are working on these problems, starting from suitable floor design spectra.

A comparison between floor response spectra, respectively floor design spectra, due to airplane crash and the corresponding spectra due to earthquake leads to the result, that airplane crash must be expected to be the governing load case for equipment if (a) the mass of the building is small, (b) there is only a small intensity of earthquake, (c) there is the possibility of great eccentricity of impact, (d) there are special modes (e.g. antisymmetric modes) contributing to the response, which are excited by airplane crash but not by earthquake.