Abstract

The thesis starts with a presentation of reliability theory. The background of the semiprobabilistic safety concept is explained using a simple example. Based in this, transition takes places to more and more general and complicated systems, whereas the resulting limitations are elaborated. This leads to Monte-Carlo simulation (MCS), which is the most universal method of reliability calculation.

The topic of the subsequent chapter is the estimation of small failure probabilities. In that case, conventional MCS may become unaffordable since the high number of necessary simulation runs increases the computational effort substantially. The problem may be addressed by the asymptotic sampling technique. Thereby, first, the reliability problem, i.e. the multivariate probability distribution and the limit state condition, is transformed to standard normal space. Then, some MCS estimates are performed for the failure probabilities of some artificially stretched (scaled) systems. The computational effort is thereby much smaller because the failure probabilities are higher. The failure probability of the original system is obtained by extrapolation of the results of the stretched systems. This can be accomplished by exploiting some asymptotic properties in standard normal space, which are explained in detail in this work. Strategies to optimize the asymptotic sampling technique are presented. By means of several examples, the advantages of the methods developed or refined are shown.

In the next chapter, the seismic safety of an arch dam is analysed. The associated challenges arise not only from the extension to the complicated earthquake load case, but also from the fact that a finite element model of a realistic structure is analysed. Four damage mechanisms as well as failure of the dam are analysed. Since failure occurs as a consequence of progressive concrete deterioration, the implementation of a special material model for concrete is necessary.

At the centre of the analyses of damage and failure is the development of fragility curves, which indicate the occurrence probabilities as functions of the seismic intensity. Since this is accomplished by means of MCSs (involving, furthermore, a complex nonlinear finite element model), one is particularly interested in a reduction of the computational effort. In this regard, two approaches are successfully tested and refined, which are based on the assumption of a lognormal distribution of the fragility curves.

Finally, the fragility curves are combined with the seismic risk of three selected locations. As a result of that it can be shown that an additional investigation of smaller earthquakes in greater detail is expendable, and that MCS for a single intensity level is inappropriate for seismic safety analysis.