論 文

Simplified Fragility Evaluation Method for RC Piers

RC 橋脚の損傷度簡易評価方法

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研究の目的

For seismic safety analysis of the typical RC structures, fragility analysis could help quantify the probabilistic seismic risk. Monte Carlo Simulations (MCS) are typically being applied but are expensive in terms of computational time. A new Fragility Analysis Method is proposed for evaluation of the effect of uncertainty of structural materials and of foundation soil. Simplified Fragility Analysis Method is being proposed for determining characteristic fragility curve, while achieving faster computational speed than an equivalent Monte Carlo Simulation (MCS). The computational flow and its implementation are being presented. The method applicability for typical RC structures is being presented.

研究の概要

The seismic fragility analysis computational method is being developed and is being applied for structural safety evaluation. MCS based methods are expensive in terms of the number of computation cases; therefore a new and faster Simplified Fragility Evaluation Method is proposed and implemented.

Simplified Fragility Evaluation Method requires that only one complete set of simulations modeling parameter variability to be computed at one given peak acceleration loading level, corresponding to the point where the characteristic load-response curve is crossing the threshold level. The behavior of the RC pier load-response is nonlinear and is assumed to be represented by the response computed using the mean value as the characteristic value of parameters. The method uses the characteristic reference load-response curve to determine extra points on each analysis set load-response curve by extrapolation. Fragility analysis of a typical RC pier structure with a spread foundation is being conducted for evaluation of seismic risk and its variability associated with the uncertainty of the structural materials and foundation soil. A parameter variability analysis is conducted for the relevant parameters.

The computational advantages of the Simplified Fragility Evaluation Method are being evaluated by comparison to classic MCS fragility simulation.

結　論

Simplified Fragility Evaluation Method was proposed as a speedy fragility analysis method for highway and viaduct RC piers. For RC pier elements the variability of structural materials and soil parameters is significant and could potentially increase the earthquake effects. Both MCS Method and Simplified Fragility Evaluation Method have been evaluated for fragility analysis of a typical RC pier structure.

Proposed Simplified Fragility Evaluation Method could provide a faster way to determine the earthquake level where response exceeds a certain safety threshold, reducing significantly the number of FEM cases required for the mean fragility curve evaluation and therefore the overall computational time. The detailed analysis flow is being presented and a programmatic analysis procedure is implemented.

Estimation of the effect of variability of structural materials and soil characteristics is being performed by Monte Carlo multi-parametric simulation and dynamic nonlinear time-history FEM analysis.

The fragility analysis of the bridge pier with a spread foundation and ground springs was performed, with focus on the modeling of structural materials and soil parameters variability. The variability of each parameter was evaluated independently, and then the analysis was performed for the most significant parameters combination which includes foundation soil and concrete material variability. Modeling of the foundation soil flexibility and soil parameters variability is significant for more accurate modeling of structural response but is increasing modeling complexity and computational cost.

The proposed Simplified Fragility Evaluation Method has been evaluated in comparison with the classic MCS in identical conditions, on the analysis of the same RC structure. Proposed method had reduced the overall computational time proportional to the achieved reduction in the number of analysis cases.

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