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Data-Driven Surrogate Models for Damage Prediction of Steel Liquid Storage Tanks under Seismic Hazard

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Abstract : The damage reported by oil and gas industrial facilities revealed the utmost vulnerability of steel liquid storage tanks to seismic events. The failure of steel storage tanks may yield devastating and long-lasting consequences on built and natural environments, including the release of hazardous substances, uncontrolled fires, and soil contamination with hazardous materials. It is, therefore, fundamental to reliably predict the damage that steel liquid storage tanks will likely experience under future seismic hazard events. The seismic performance of steel liquid storage tanks is usually assessed using vulnerability curves obtained from the numerical simulation of a tank under different hazard scenarios. However, the computational demand of high-fidelity numerical simulation models, such as finite element models, makes the vulnerability assessment of liquid storage tanks time-consuming and often impractical. As a solution, this paper presents a surrogate model-based strategy for predicting seismic-induced damage in steel liquid storage tanks. In the proposed strategy, the surrogate model is leveraged to reduce the computational demand of time-consuming numerical simulations. To create the data set for training the surrogate model, field damage data from past earthquakes reconnaissance surveys and reports are collected. Features representative of steel liquid storage tank characteristics (e.g., diameter, height, liquid level, yielding stress) and seismic excitation parameters (e.g., peak ground acceleration, magnitude) are extracted from the field damage data. The collected data are then utilized to train a surrogate model that maps the relationship between tank characteristics, seismic hazard parameters, and seismic-induced damage via a data-driven surrogate model. Different types of surrogate algorithms, including naïve Bayes, k-nearest neighbors, decision tree, and random forest, are investigated, and results in terms of accuracy are reported. The model that yields the most accurate predictions is employed to predict future damage as a function of tank characteristics and seismic hazard intensity level. Results show that the proposed approach can be used to estimate the extent of damage in steel liquid storage tanks, where the use of data-driven surrogates represents a viable alternative to computationally expensive numerical simulation models.

Keywords : damage prediction , data-driven model, seismic performance, steel liquid storage tanks, surrogate model
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