EVALUATION OF A POLYNOMIAL CHAOS EXPANSION APPROACH FOR STEEL MRFS WITH VISCOUS DAMPERS

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Introduction

• Numerical simulation plays an important role for seismic risk assessment of civil engineering infrastructures under earthquakes, and it can be time-consuming when the model involves significant complexity or requires large amounts of analyses.

• One approach for reducing this burden is the integration of surrogate modeling (i.e., metamodeling) techniques, which offer an approximate functional relationship between the input of the adopted models and the resultant structural response.

• In this study, the polynomial chaos expansion (PCE) is evaluated for response prediction of nonlinear building structures under earthquakes.

Assume that the system output is described by a numerical model $y(x)$, and the PCE representation of the model $y(x)$ can be written as below:

$$ y(x) \approx y^{pc}(x) = \sum_{a \in A} c_a \psi_a(x) $$
A five-story three-bay steel MRF with viscous dampers is selected in this study.

- The seismic mass: 100% of 100 ksf dead load and 25% of 80 ksf live load.
- Young’s modulus: 29,000 ksi
- Yield strength: 36 ksi for beams and 50 ksi for columns.
- Inherent Rayleigh damping: 5% based on 1\text{st} and 3\text{rd} elastic mode.
- Viscous dampers: damping coefficient of 82.8 lbf(s/in)^{0.5}, and the velocity exponent of 0.5.
- Fundamental period: 1.54 second.
Meta-modeling using PCE

- The 1994 Northridge earthquake recorded at Beverly Hills-12520 Mulhol station is used in this study.
- Vector $X$ is generated to modify ground motion. $X$ and structure response under modified ground motion will be used to form PCE models.
- Comparison of roof displacements at (a) 4s, (b) 8s between PCE model and OpenSees output.
- The LOO error for 1st and 2nd order PCE meta-model at 4s.
Evaluations of PCE for MRF

PCE models were conducted for every time instants of the selected ground motion. After the PCE meta-models are established, a new set of X is generated for validation.
Summary and Conclusions

- PCE is used to reproduce the time history of a steel moment frame with viscous dampers under earthquake in this study.
- The PCE coefficients, sampling number and PCE order are determined based on the comparison between meta-model outputs and FEM analysis.
- The comparison of structural response with the OpenSees model output over the entire ground motion duration shows that PCE technique could be a potential tool for nonlinear structural response prediction.
- There, however, are limitations to this approach while every time instant requires a PCE model, which may lead to heavy computational burden when the prediction duration is long.
Thank you!

Today Poster Session:

- **Time**: 5:15 – 7:00 pm
- **Poster location**: 138