INVESTIGATION OF THE INELASTIC RESPONSE OF STRUCTURAL SYSTEMS VIA INCREMENTAL DYNAMIC ANALYSIS TO INFORM PRACTICAL ASEISMIC STRUCTURAL DESIGN SCENARIOS

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December 2014
PhD SCOPE

ASSESSMENT OF FIXED BASED OFFSHORE STRUCTURES

INCREMENTAL DYNAMIC ANALYSIS

INFLUENCE OF POUNDING ON ADJACENT RC STRUCTURES

The Four Stages of the PBEE Framework

1. Seismic Hazard Analysis
   - Annual Probabilities of Exceedance of Various Levels of Seismic Intensity $\lambda(\text{IM})$.
   - Identify ground motions of interest.

2. Response Analysis
   - Perform response history analyses for the pre-identified ground motions.
   - Obtain response curves as a function of the IM and an EDP.

3. Damage Analysis
   - Identify ground motions of interest.
   - Obtain EDP: engineering demand parameter $G(\text{dm}|\text{edp})$.

4. Loss Analysis
   - Perform response history analyses for the pre-identified ground motions.
   - Obtain return period $\lambda(\text{im})$.

Analytical Expression of the PBEE Framework

$$
\lambda(\text{dv}<\text{DV}) = \int \int \int \mathcal{G}(\text{dv}|\text{dm}) |d\mathcal{G}(\text{dm}|\text{edp})| d\mathcal{G}(\text{edp}|\text{im}) |d\lambda(\text{im})|
$$

Damage Analysis

Limit state values that correlate well with various damage states are identified on the IM-EDP response curve.

Loss Analysis

The obtained damage values are translated into loss quantities of interest.
INCREMENTAL DYNAMIC ANALYSIS (IDA) FOR PROBABILISTIC SEISMIC DEMAND ANALYSIS

IMPACT OF THE POUNDING MODELING PARAMETERS ON THE SEISMIC PERFORMANCE OF ADJACENT RC FRAMES WITH EQUAL STOREY HEIGHTS
**Finite Element Models**

**Modelling Assumptions**
- 2D Distributed plasticity RC Frames & P-Delta phenomena
- Columns share the same section
- Beams share the same section
- 5% Structural Damping
- Fixed Boundary conditions

\[ F = \begin{cases} 
  Kx + C\dot{x}, & \delta > 0 \\
  0, & \text{otherwise} 
\end{cases} \]

Where: \( \delta = u_1 - u_2 - \text{gap} \)

**Contact model**

**Floor Heights: 3.00 m - Bay Widths: 5.00 m**

**T=0.64 sec**

**T=0.84 sec**
METHODOLOGY

IDA BASED SENSITIVITY ANALYSIS (Vamvatsikos and Fragiadakis, 2009)

1. Incremental Dynamic Analysis (Vamvatsikos and Cornell, 2002)

ENSEMBLE OF 30 GROUND MOTIONS

IDA CURVES

METHODOLOGY

IDA BASED SENSITIVITY ANALYSIS (Vamvatsikos and Fragiadakis, 2009)

2. Efficient IM for Structural Pounding/Interaction Studies (vs. PGA)

“Linear” Geometric Mean

$$\sqrt{Spa_{A,T_1} \times Spa_{B,T_1}}$$

$K$ number of interacting structures

$$\sqrt{Spa_{1,T_1} \times Spa_{2,T_1} \times \cdots \times Spa_{K,T_1}}$$
3. Statistical Analysis of IDA Curves

IDA BASED SENSITIVITY ANALYSIS (Vamvatsikos and Fragiadakis, 2009)

METHODOLOGY

- IDA Curves
- Summarized IDA Curves
- Fractile IDA Curves
5. Fragility Functions

Lognormal Distribution

Limit State: Immediate Occupancy

\[
\ln \hat{\theta} = \frac{1}{N} \sum_{i=1}^{k} \ln(IM_i)
\]

Limit State: Global Instability

\[
\hat{\beta} = \sqrt{\frac{1}{N-1} \sum_{i=1}^{k} (\ln(IM_i / \theta))^2}
\]

5. Fragility Functions

IDA BASED SENSITIVITY ANALYSIS (Vamvatsikos and Fragiadakis, 2009)

Base Model

Gap
- Min: 0.00 m
- Max: 0.04 m

Damping Coef.
- Min: 0.5

Spring Stiff.
- Min: $10^9$ N/m
- Max: $10^{21}$ N/m

Max: 0.5
COMPARISON BETWEEN THE MEAN SHEAR FORCES FOR THE COUPLED AND UNCOUPLED STRUCTURES

\[
\frac{\text{Mean Shear Forces}_{\text{Coupled}} - \text{Mean Shear Forces}_{\text{Uncoupled}}}{\text{Mean Shear Forces}_{\text{Coupled}}} \times 100
\]

FRAME A

Columns

Beams

FRAME B

Columns

Beams
CONCLUDING REMARKS

Conclusions

Low Seismic Intensity
- The coupled structural system is marginally sensitive to the separation distance
- The coupled structural system is insensitive to the spring stiffness and damping coefficient

High Seismic Intensity
- The coupled structural system is sensitive to all three modelling parameters

We need Shear Sensitive Damage Indices
**ASSESSMENT OF FIXED BASED OF OFFSHORE STRUCTURES**

**SOME MORE RESULTS-1**

**FAR-FIELD GROUND MOTION EXCITATION**

**NEAR-FIELD GROUND MOTION EXCITATION**

THANK YOU