

PEER Ground Motion Selection and Modification Program

Christine Goulet, PhD
Assistant Researcher, UCLA

*For the
PEER Ground Motion Selection & Modification (GMSM) Program*

Slides preparation in collaboration with Curt Haselton, Jennie Watson-Lamprey, Nico Luco and Jack Baker



Menu du jour : GMSM

- ▶ Introduction and overview *Christine Goulet*
- ▶ GMSM methods *Jennie Watson-Lamprey*
- ▶ Structural models *Curt Haselton*
- ▶ Results: building code study *Jack Baker*
- ▶ Results: median prediction by groups of methods *Curt Haselton*
- ▶ Conclusion and future work *Nico Luco*



Motivation

- ▶ The results of nonlinear response history analyses are very sensitive to the suite of input ground motions.
- ▶ There is currently no consensus as to the best method, thus the choice is largely subjective.
- ▶ Selection based on seismological principles only leads to large variability of results.
- ▶ There are two solutions to this problem:
 - ▶ Perform a high end analysis that uses more records
 - ▶ Be smarter about picking records

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Focus of the last 2 years

- ▶ Hybrid approach – use the high-end approach to test the “smart-selection” methods.
- ▶ Compare structural response predictions from various “smart-selection” methods.
- ▶ This involves a continued collaboration with many method contributors.
- ▶ Purpose:
 - ▶ Work toward consensus in the ground motion community.
 - ▶ Use results to develop guidance for the engineering community.

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GMSM Mission



To provide guidance to the engineering community on appropriate GMSM methods for nonlinear response history analyses.

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What constitutes a GMSM method



- ▶ Given a scenario, the ground motion record *selection* can be based on
 - ▶ Magnitude and distance (M,r) bins only
 - ▶ M,r plus spectral acceleration or spectral displacement, etc.
- ▶ The *modification* can consist in
 - ▶ Different scaling schemes : at a single spectral period or over a period range
 - ▶ Spectral matching

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GMSM Approach

- ▶ Identify applications for which ground motions will be used.
- ▶ Identify the goal of the application.
- ▶ Identify candidate GMSM methods.
- ▶ Develop an evaluation procedure (includes conducting simulations).
- ▶ Compare the results of the analyses using the evaluation procedure.
- ▶ Hybrid approach – use the high-end approach to test the smart-selection methods

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2006 Research – developing the procedure

- ▶ Used a well-understood structure to develop the procedure.
 - ▶ “Benchmark Structure” used in the past by participants as part of PEER multi-institution project.
 - ▶ Typical California 4-story office-type structure

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- structi

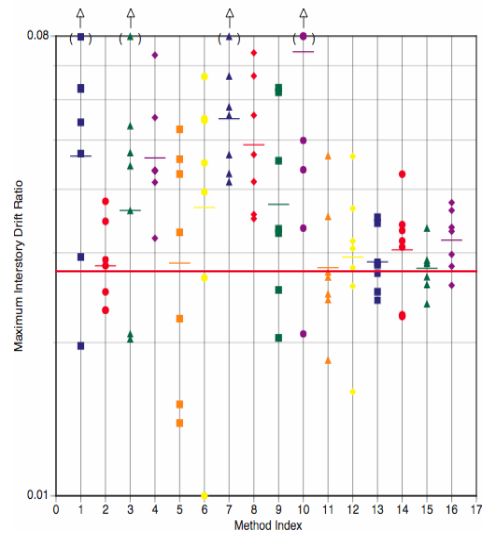


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2006 Results

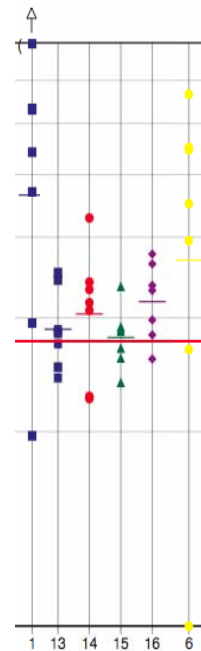


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2006 Results

- ▶ Large variability in median predictions
- ▶ Overestimation of median on average
- ▶ Improved predictions for methods that consider the nonlinear response in some way
- ▶ Variability of structural response was not accurately predicted



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2007 Research

- ▶ Focus on median predictions
- ▶ Addition of structural models
- ▶ Addition of a deterministic event
- ▶ Continued collaboration with method developers
- ▶ Sample results shown today

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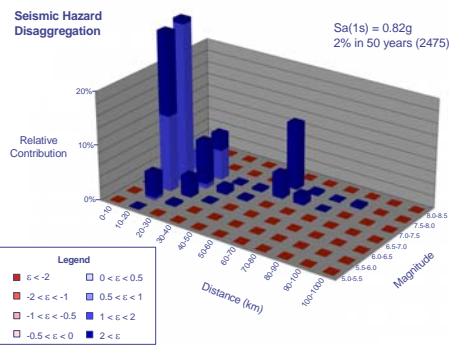


Methodology

- ▶ Select earthquake scenarios
 - ▶ $M=7, r=10 \text{ km}, \mu+2\sigma = +2\epsilon$
 - ▶ $M=7.5, r=10 \text{ km}, \mu+1\sigma = +1\epsilon$
- ▶ Why $+2\epsilon$?
 - ▶ To push the structures well in the NL range
 - ▶ It is not unreasonable

East Bay

- 2% in 50 average: 1.6



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Methodology

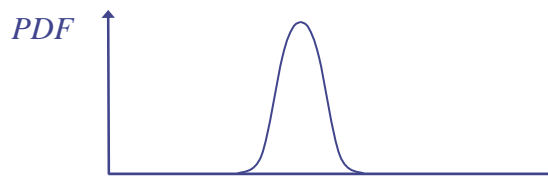
- ▶ Select structural models (4 different building configurations)
- ▶ Define response parameters (EDPs)
 - ▶ Maximum Inter-Story Drift Ratio (MIDR)
 - ▶ Others considered:
 - ▶ Peak Floor Acceleration
 - ▶ Base shear
- ▶ Request ground motion suites for each method of GSM
- ▶ Perform nonlinear response history analyses
- ▶ Compute the distribution for selected EDP response

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Methodology

- ▶ Compute the Point of Comparison (POC) (High end analysis)
 - ▶ Use larger set of records corresponding to the scenario
 - ▶ Perform the nonlinear response history analyses
 - ▶ Compute a regression model that relates the response to the ground motion properties and earthquake metadata
 - ▶ Integrate over the ground motion properties to get a distribution of the selected EDP response



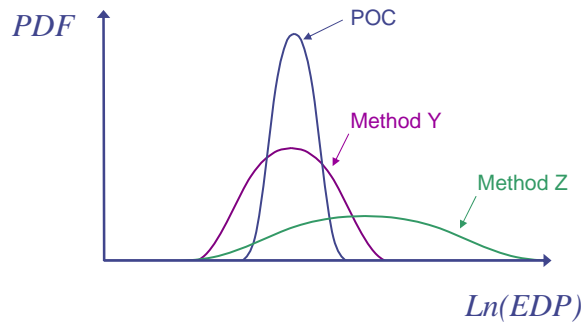
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$\text{Ln}(\text{EDP}=\text{MIDR})$



Methodology

- ▶ Analysis of results, observations and conclusions
 - ▶ Compare results of suites with POC
 - ▶ Draw conclusions and recommendations



- ▶ ... Repeat the whole procedure for other structures and scenarios ...

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Submitted sets

Objective: predict the MIDR for these structures/scenario combinations

- ▶ Building A, C and D scenario M7
 - ▶ Building B, scenario M7 and M7.5
 - ▶ Four sets of 7 records
 - ▶ To match building code requirements (7)
 - ▶ To allow larger suites for statistics and research purposes (28)
- 14 methods
25 variants

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Collaboration Among Many Researchers – Program members

- ▶ Today's presenters +
- ▶ Norm Abrahamson
- ▶ Yousef Bozorgnia
- ▶ Allin Cornell
- ▶ Erol Kalkan
- ▶ Nilesh Shome
- ▶ Polsak Tothong
- ▶ Farzin Zareian

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Collaboration Among Many Researchers - Collaborators

- ▶ Arzhang Alimoradi
- ▶ Paolo Bazzurro
- ▶ Jamshid Ghaboussi
- ▶ Charlie Kircher
- ▶ Frank McKenna
- ▶ Coleen McQuoid
- ▶ Steve Mahin
- ▶ Preveen Malhotra
- ▶ Jack Moehle
- ▶ Farzad Naeim
- ▶ Maury Power
- ▶ Ellen Rathje
- ▶ Brian Skyers
- ▶ Jonathan Stewart
- ▶ Gang Wang
- ▶ Andrew Whittaker
- ▶ Tony Yang
- ▶ Bob Youngs

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2008 and beyond

Mission: To provide guidance to the engineering community on appropriate GSM methods for nonlinear response history analyses.

Vision: To serve as a resource for major research projects to address this key issue.

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General info and contact

<http://peer.berkeley.edu/gsm/>

PEER *GROUND MOTION SELECTION AND MODIFICATION PROGRAM (GSM)*
PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Home Who are we Mission Methodology Documentation Links Contact us

Upcoming Core Group Meetings
TBD: Regular meeting

The GSM Mission Statement
To provide guidance and tools to the engineering community on appropriate GSM methods for nonlinear dynamic analyses.

The GSM Mission
Nonlinear dynamic analysis of structures is becoming increasingly prevalent in engineering practice. Such analyses are often completed to meet building code or other regulatory requirements, but are also being used more frequently as part of performance-based earthquake engineering assessments. A recurring issue for both practicing engineers and the developers of regulatory documents is the selection of modification of input ground motions for these nonlinear dynamic analyses, and there is currently no consensus regarding appropriate methods. The engineering community is faced with numerous existing ground motion selection and modification (GSM) methods, and the method choice can have a large impact on the results of nonlinear dynamic analysis.

Pilot studies have demonstrated that the particulars of a method can affect the predicted structural response by as much as a factor of three (re: COSMOS TS 2006). The chosen method can thereby lead to costly over-design of structures, or worse, dangerous under-design.

To address this issue, the Pacific Earthquake Engineering Research (PEER) Center has established the Ground Motion Selection and Modification (GSM) Program. The mission



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Thank you

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