



PEER GSM Program: Results and Findings

Presented by:

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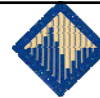
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A Product of the PEER Ground Motion Selection and Modification (GMSM) Program

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Overview

- ⇒ Results by Method Class:
 - ⇒ Building code methods (reiterate)
 - ⇒ $S_a(T_1)$ scaling methods
 - ⇒ CMS matching methods
 - ⇒ Proxy methods
 - ⇒ Inelastic methods
- ⇒ Results for individual methods
- ⇒ Summary and conclusions

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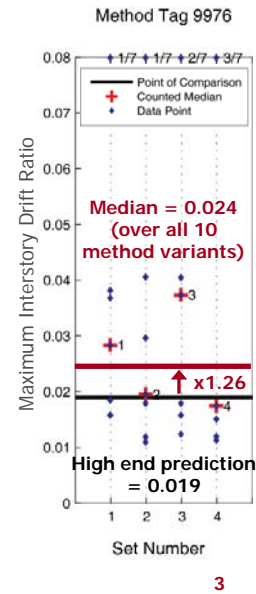
Method Class: Building Code Methods

⇒ For all four buildings (for M7 and M7.5):

Method Class	Building A, M7	Building B, M7	Building C, M7	Building D, M7	Building C, M7.5	Median
UHS	1.40	1.33	1.26	1.09	1.08	1.26

⇒ Current building code practice:

- ⇒ Median over-prediction of 1.26x.
- ⇒ Range from 1.08x to 1.40x for the five cases.
- ⇒ For each individual set of seven records, the range is 0.8x to 2.1x.



Method Class: Sa(T₁) Scaling

⇒ Method Class: Sa(T₁) Scaling [2 methods]

- ⇒ These methods select a bin of ground motions and then scale a randomly-selected set to the target Sa(T₁).

⇒ This has been a commonly used method in structural research.

⇒ Results for all four buildings (for M7 and M7.5):

Method Class	Building A, M7	Building B, M7	Building C, M7	Building D, M7	Building C, M7.5	Median
Sa(T ₁)	1.48	1.55	1.36	1.29	1.22	1.36

Method Classes: Building Code and $Sa(T_1)$

- ⇒ Summary of commonly used methods:
 - ⇒ Building code (common for engineering practice): Median over-prediction of 1.26x.
 - ⇒ $Sa(T_1)$ scaling (common for research): Median over-prediction of 1.36x.
- ⇒ We desire better methods that do not have this bias and conservatism in structural response prediction.

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Method Class: CMS Matching

- ⇒ Method Class: Matching to the Conditional Mean Spectrum (CMS) [4 methods]
- ⇒ Explanation of a Conditional Mean Spectrum (CMS):

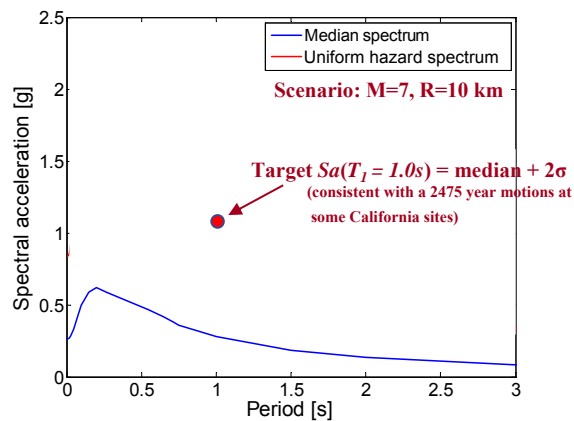


Figure reference: J.W. Baker – 2006 COSMOS

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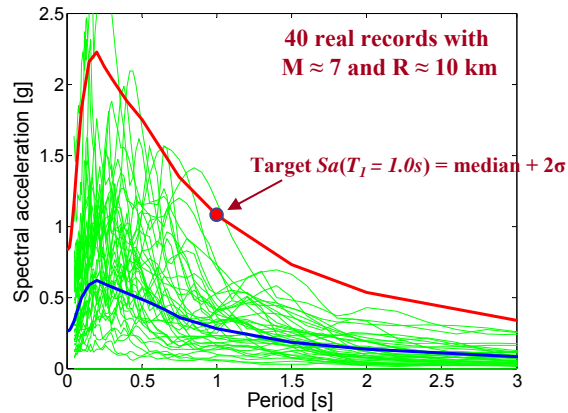


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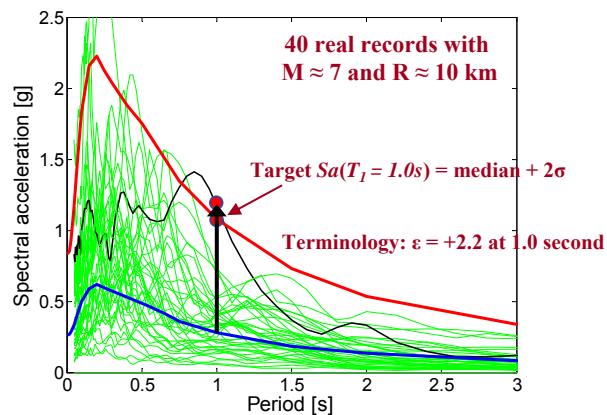
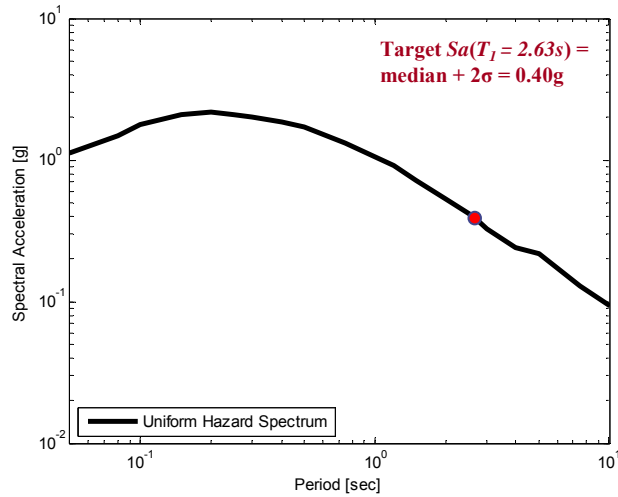


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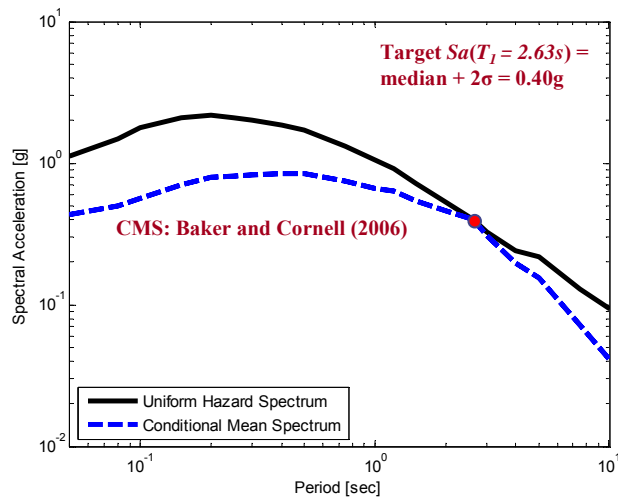
⇒ Illustration of using a Conditional Mean Spectrum (CMS) for Building C (20-story RC frame with $T_1 = 2.63s$):



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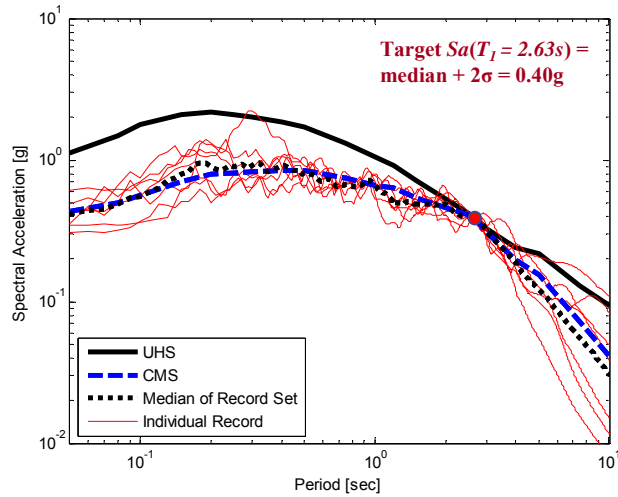
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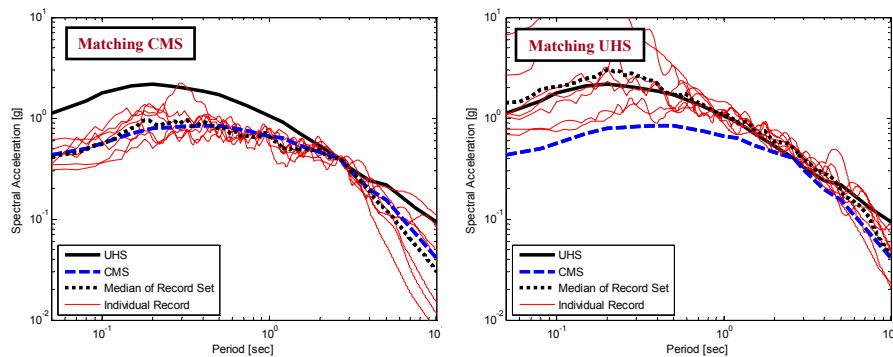
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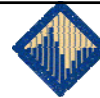


⇒ Results for all four buildings (for M7 and M7.5):

Method Class	Building A, M7	Building B, M7	Building C, M7	Building D, M7	Building C, M7.5	Median
CMS	1.02	1.01	1.01	0.95	0.93	1.01

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Method Class: Proxy for CMS



⇒ Method Class: CMS Proxy [3 methods]

⇒ These methods do not directly match the CMS.
Instead they chose records by some *indicator* of spectral shape (e.g. ε , or ratio of $Sa(T_1)/Sa(2T_1)$, etc.).

⇒ Results for all four buildings (for M7 and M7.5):

Method Class	Building A, M7	Building B, M7	Building C, M7	Building D, M7	Building C, M7.5	Median
Proxy (i.e. ε)	1.05	1.12	1.06	1.05	1.01	1.05

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Method Class: Inelastic Methods



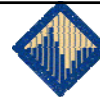
- ⇒ Method Class: Inelastic Response Based Methods [4 methods]
 - ⇒ These methods consider the inelastic response in some way (e.g. inelastic spectral displacement, etc.).
- ⇒ Results for all four buildings (for M7 and M7.5):

Method Class	Building A, M7	Building B, M7	Building C, M7	Building D, M7	Building C, M7.5	Median
Inelastic	1.28	1.39	1.19	1.04	0.91	1.19

- ⇒ Notes about the bias:
 - ⇒ Not observed for all methods.
 - ⇒ It may relate to how the inelastic target is computed.

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Summary of Results by Method Class



- ⇒ Summary of results by method class:

Method Class	Building A, M7	Building B, M7	Building C, M7	Building D, M7	Building C, M7.5	Median
UHS	1.40	1.33	1.26	1.09	1.08	1.26
Sa(T1)	1.48	1.55	1.36	1.29	1.22	1.36
CMS	1.02	1.01	1.01	0.95	0.93	1.01
Proxy (i.e. ϵ)	1.05	1.12	1.06	1.05	1.01	1.05
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Results for Individual Methods

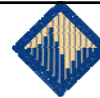


- ⇒ So far we have focused on results by *classes* of methods, and found that CMS and Proxy methods work well on average.
- ⇒ Looking at individual methods shows that some inelastic methods also work well.

Method Information		Median(MIDR/POC) for Combined Record Set					
Method Class	Method Name	Bldg. A, M7	Bldg. B, M7	Bldg. C, M7	Bldg. D, M7	Bldg. C, M7.5	Median
CMS	Design Ground Motion Library (DGML) (Objective 4)	--	1.05	1.00	--	--	1.03
CMS	Semi-Automated Selection & Scaling (to match CMS)	1.06	1.01	1.07	1.01	--	1.04
CMS	Conditional Mean Spectrum Selection with Scaling	--	0.92	0.98	0.95	0.89	0.94
Proxy	ATC-63 Method Applied to MIDR - Near-Field Set	--	1.05	0.96	1.04	1.00	1.02
Inelastic	Inelastic Response Surface Scaling (1st-2nd modes)	--	1.62	1.03	0.78	0.95	0.99
Inelastic	Vector of Record Properties Identified by Proxy	--	0.80	0.96	0.85	0.80	0.83

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Summary, Conclusions, Limitations



- ⇒ We compared the prediction accuracy of 14 GSM methods (25 variants) based on:
 - ⇒ Scenarios:
 - ⇒ $M = 7.0, R = 10\text{km}, Sa(T_i) = \text{median} + 2\sigma$
 - ⇒ $M = 7.5, R = 10\text{km}, Sa(T_i) = \text{median} + 1\sigma$
 - ⇒ Buildings: Four modern RC frame and wall structures
 - ⇒ Response: Median of the max. interstory drift ratio (MIDR) [other responses will likely lead to some different conclusions]
 - ⇒ Motions: Sets of 7 records
- ⇒ Specific Observations from this Study:
 - ⇒ One way to obtain an accurate median prediction is to account for the expected spectral shape (CMS-matching, CMS Proxy methods). This is needed because spectral shape is important to nonlinear response.
 - ⇒ Some inelastic methods still provide an accurate prediction, but do not explicitly consider spectral shape. This is because they consider other factors important to nonlinear response (e.g. inelastic spectral displacement). This is another approach which leads to accurate predictions.

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Closing



- ⇒ We would appreciate your thoughts/feedback/suggestions.
 - ⇒ Please direct comments to myself (chaselton@csuchico.edu).
- ⇒ Additional materials for those interested:
 - ⇒ PEER report (to be published in mid-summer), and two associated journal papers.
 - ⇒ Full data from this study also available electronically:
 - ⇒ Ground motion sets
 - ⇒ Spectra
 - ⇒ Detailed structural response files