COSMOS CP-2009/01

COSMOS Summary Annual Meetings/Technical Sessions

2004-2008

COSMOS
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Consortium of Organizations for
Strong-Motion
Observation Systems

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Summary

Annual Meeting/Technical Sessions

2004-2008

J. Watson-Lamprey

COSMOS
PUBLICATION
NO. CP-2009/01

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Editor

C. M. Johnson

Acknowledgments

These Technical Sessions would not be possible without the financial support of the California Geological Survey and the U.S. Geological Survey. Their involvement in the COSMOS organization has been critical to its continuing success, and their support of these Technical Sessions is just one example. We thank them and look forward to continued collaboration with the shared goal of the acquisition, processing, and dissemination, and application of earthquake strong-motion data in the interest of public safety. We would also like to thank Bob Bachman and Norm Abrahamson for their time and support. This project and its relevance to the seimological and engineering community is largely the result of their efforts. We would also like to thank the Pacific Earthquake Engineering Research Center for co-sponsoring these sessions. We appreciate their support. Finally, we would like to thank the presenters for the time and effort they have made on behalf of this organization: N. Abrahamson, Adda Athanasopoulos-Zekkos, B. Bachman, C. Allin Cornell, J. Baker, Y. Bozorgnia, C. B. Crouse, C. Goulet, R. Hamburger, C. Haselton, J. Howard, C. Kircher, P. Lam, N. Luco, M. Power, M. Sinclair, W. U. Savage, A. Shakal, P. Somerville, J. I. Sun, T. Travasarou, A. Whittaker, R. Youngs, and F. Zareian.

Contents

Introduction

The site-specific elastic response spectrum and associated suite of time series developed by engineering seismologists and geotechnical engineers for the design analysis or evaluation of structures to earthquakes represent the transfer of knowledge from seismologists to structural engineers. The complex models of the seismic characterization of the site are simplified by engineering seismologists and geotechnical engineers to provide structural engineers with estimates of structural forces and dynamic inputs that they can understand and incorporate into their complex structural models.

The method of selecting representative time series employed is an important one. There is no suite of time series existent that can represent the entire seismic hazard at a site, nor would most structural engineers want the thousands of time series that would be in such a suite. A small set of time series must be selected that represents the desired level of hazard to permit practical designs and evaluations. In most cases, structural engineers use these time series to perform nonlinear dynamic analysis of the structures they are evaluating. The results of nonlinear dynamic structural analyses are sensitive to the selection of the initial time series and the method of time series modification, thus the selection and modification method used significantly impact the seismic evaluation of a project. An appropriate selection and modification method must be selected so that the suite passed off to the structural engineer achieves the desired goal of the nonlinear dynamic analysis with a reasonably small number of records.

In order for the hand off between the engineering seismologist or geotechnical engineer and structural engineer to work, the suite of time series has to be selected appropriately and the structural engineer has to apply the suite to the nonlinear dynamic analysis consistently. Currently, there is no consensus on the best approach for selection of appropriate suites of acceleration time series by the engineering seismologist or geotechnical engineer for use in nonlinear dynamic analyses. As the number of time series available has increased, the selection of an appropriate suite has become more complex and subjective. Years ago, when there were few recordings available, most structural analyses used the 1940 El Centro record, so there was consistent selection of time series. Now, selecting an appropriate method requires communication between the engineering seismologist and the structural engineer as to the aspects of ground motion that are important to the structure and as to the goal of the analysis and this has not always taken place. Just knowing the desired goal of the nonlinear dynamic analysis is not enough to determine if the time series selection method is working appropriately.

One of the goals of COSMOS is to advance the use of strong-motion data for the design of new facilities and evaluation of existing facilities. The COSMOS Annual Meeting/Technical session achieves this goal by raising the level of discussion of time series selection methods and providing engineers with a basis of comparison to determine which method is most appropriate for their application. The Annual Meetings

convened from 2004 through 2008 addressed the issues of ground motion selection and modification for nonlinear dynamic analysis mentioned previously. Here, the major findings of these annual meetings are presented.

Year 2004: Scaling of Ground Motions for Engineering Applications

It was agreed upon by the attendees at the 2004 Technical Session that there is large variability of nonlinear structural response from time series with similar M, R, and ground motion level. When using a small number of time series, such as 3 – 7, the average results are sensitive to the selection of the input time series. Currently, there is no well-founded, objective criterion for selecting time series as inputs. The selection is left to judgment, and the problem of how to select is getting worse as the number of potential time series continues to grow.

Nico Luco and Jennie Watson-Lamprey demonstrated the problems inherent with using time series selected based only on seismological properties such as magnitude and distance. These suites of time series can lead to large variability in results, and scaling these records using large factors can lead to biased results. Nico Luco showed that using records from a similar magnitude and distance bin scaled by a factor of two can lead to a 30% overestimation of response as seen in Figure 1. Even when the scale factor was close to one,

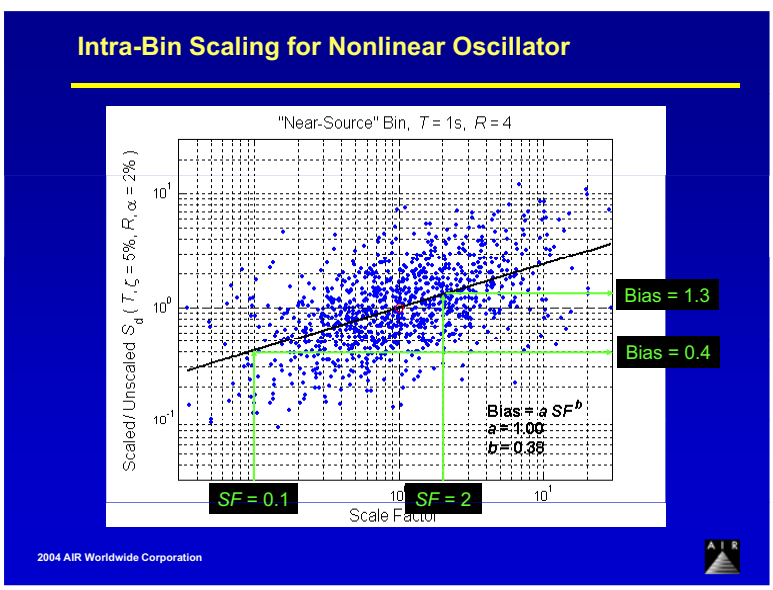

Figure 1. Example of bias found in structural response due to scale factor and variability of results [Luco, 2004].

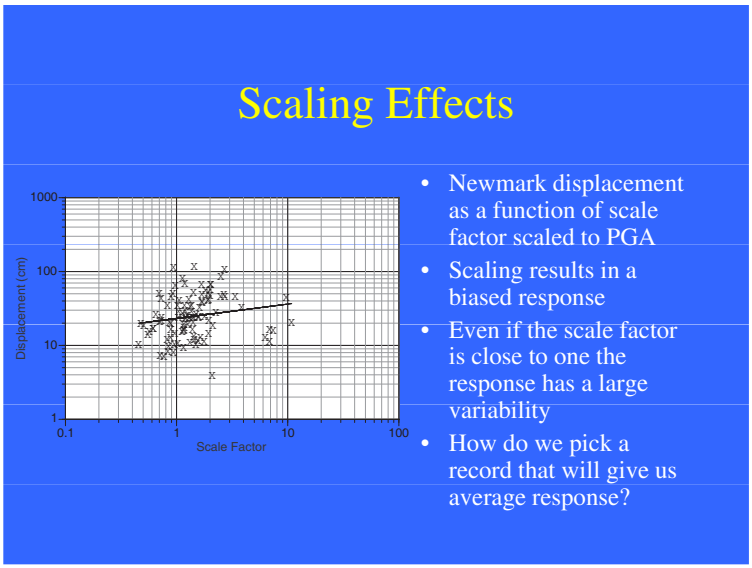

Figure 2. Example of bias found in slope displacement due to scale factor and variability of results [Watson-Lamprey, 2004].

there was a difference in a factor of nearly 100 in the results. Some records with large scale factors are unbiased indicating that scale factor by itself is not a reliable indication of a "good" record. Jennie Watson-Lamprey demonstrated that a similar bias exists for slope stability problems, as seen in Figure 2, and that there is a difference of a factor of thirty in the results even when scale factors close to one are used.

Due to this bias in scale factor and the large variability in response even when small scale factors are used, objective criteria that lead to more accurate estimates of median response are desirable. Before such an objective selection criteria can be developed, it is necessary to determine the intended use of the time series and the goal of the nonlinear dynamic analysis. For a specific project, the engineer must decide if the purpose of performing the nonlinear dynamic analysis is to develop estimates of average response values or estimates of the distribution of response values. Most attendees at the meeting agreed that, for most projects, they are trying to estimate average response of their system given the design spectrum, not the variability. The reason given by the attendees was that the design spectrum already has a return period associated with it, and the attendees were not trying to estimate response beyond that return period. There was also strong disagreement with this by some participants who felt that the variability was a key factor. This disagreement highlighted the difficulty of identifying the best approach to select and modify time series, because the best approach will depend on the objective.

Criteria that were under development that performed better for selecting records to estimate average response than random selection from a magnitude and distance bin were presented. This included a selection method presented by Jennie Watson-Lamprey that identified properties important to nonlinear earth dam response and selects based on those properties. For the case of earth dam response, the important properties identified were root-mean-square of acceleration and yield-acceleration duration. By using these additional

time series properties as additional targets, the bias in large scale factors is removed and the nonlinear response is more accurately estimated. The method presented requires greater interaction between ground motion analysts and engineers who perform the dynamic analyses to be successfully applied. Nico Luco suggested that record properties such as spectral shape or epsilon could help the selection and reduce bias.

Year 2005: Recommendations for the Selection and Scaling of Ground Motion Time Histories for Building Code Applications

The agenda for the 2005 COSMOS Annual Meeting/Technical Session was prompted by the previous year's discussion. In the words of Bob Bachman: "There was a request by the structural engineering community to address the issues of concern in building code and seismic evaluation standard regarding the use of time histories." The 2005 session began with a presentation by Charlie Kircher on the history of the building code and current requirements (Figure 3).

Next, a number of examples in which both scaled and spectrum compatible ground motions used in

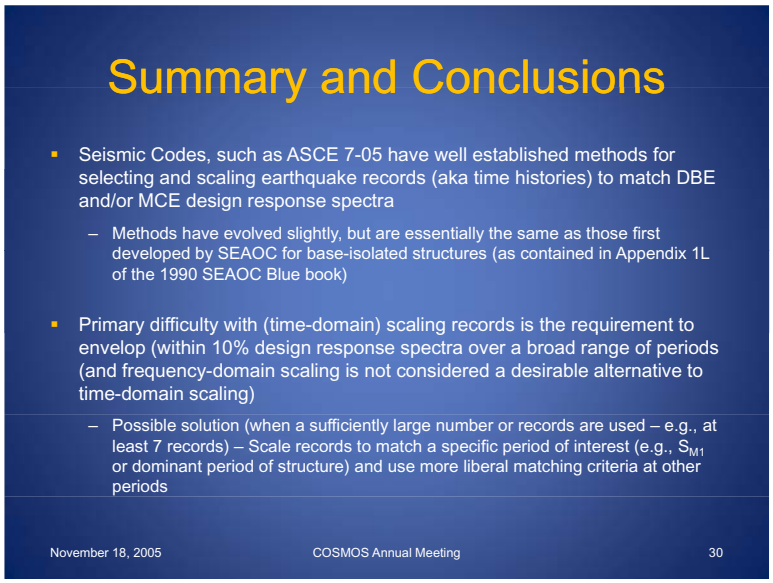

Figure 3. Summary of building code methods for selection and scaling ground motions [Kircher, 2005].

nonlinear structural analyses were presented. These examples included scaled records selected for a base-isolated structure in Los Angeles presented by C. B. Crouse. "Good" records were defined as those with a spectral shape that was close to the target spectrum. These records were selected to closely match the design spectrum, as seen in Figure 4. A second example project used spectrum compatible records for a seismically isolated hospital to be located in downtown San Francisco, presented by Mark Sinclair. Spectral matching

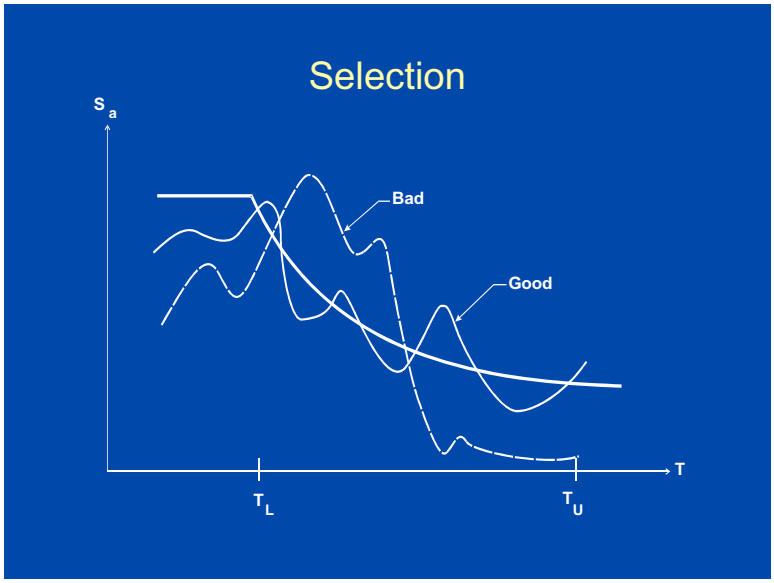

Figure 4. Example of selection of time series to closely match a target spectrum [Crouse, 2005].

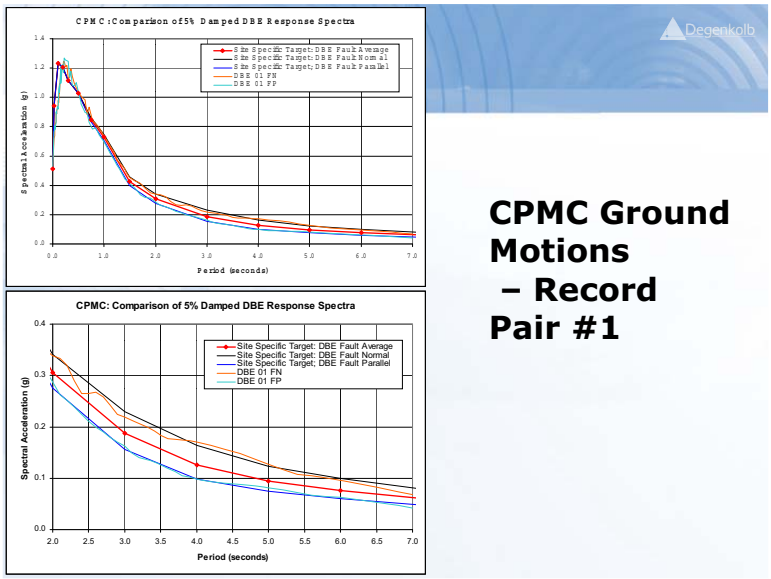

Figure 5. Example of ground motions made spectrum compatible to a target spectrum [Sinclair, 2005].

extends the concept of "good" records used by C. B. Crouse to modifying the records so that they more closely match the target spectrum. The example is shown in Figure 5.

At issue for the attendees was whether records should be selected to capture variability or suppress variability. The two examples shown above both suppress variability by using scaled or modified time series that closely match the design spectrum. This is considered appropriate if the analysis is meant to estimate average response parameters. If the analysis is instead aimed at estimating the distribution of a response parameter, then the reduced variability seen in the examples would lead to reduced variability of the response parameter and, thus, are not appropriate to use.

One attendee told the participants that he wanted to know if there was a time history out there that could fail his structure. Given the large variability in nonlinear structural response, there is a very good chance that such a time history exists. Once the structural engineer is able to accept that his structure could fail, the question becomes what to do about the case in which one recording leads to unacceptable response of the structure.

For example, if one such recording causes collapse, should it be addressed, replaced with a "better" recording, or ignored? Again, at issue is the purpose of the analysis. If the goal of the analysis is to estimate the median response parameters, then the outlying response parameter can be ignored as above average and not of interest. If the analysis is aimed at the distribution of response, and the entire distribution is meant to pass certain requirements, then the outlier cannot be ignored. If we require a structure to pass for all time series, then we are effectively increasing the return period of the design ground motion.

In practice, the engineering seismologist is often asked to replace the "bad" time series if there is an unusually large response. When the times series are selected based on seismological principals, there is little reason to prefer one time series over another, thus the "bad" time series can be replaced with an alternative. If we take this to the extreme, we could keep discarding the time series with the highest response and force our median response lower and lower. This is obviously unacceptable behavior on the part of the structural engineer making the request and the engineering seismologist for acquiescing. There needs to be an objective method of time series selection that leads to more accurate results so that this abuse of selection can not occur.

Nico Luco followed up on his presentation from 2004 and presented an alternative selection method that employs the epsilon value of the design spectrum as an additional selection criterion. By using epsilon as an additional target, the bias in large scale factors is removed and the nonlinear response is more accurately estimated, as seen in Figure 6. This is attributed to the importance of spectral shape in nonlinear structural response. Epsilon values are correlated with spectral shape: thus by selecting based on epsilon values, the spectral shape of the ground motions is controlled.

It was difficult to draw conclusions about the alternative methods presented in 2005 because there was no common basis for comparison: the intended use of the ground motions was not agreed upon; the scenario earthquakes were different in magnitude, distance, and ground motion level; and the structures analyzed were different. The examples demonstrated the need to apply multiple methods to the same structure so that direct conclusions could be drawn.

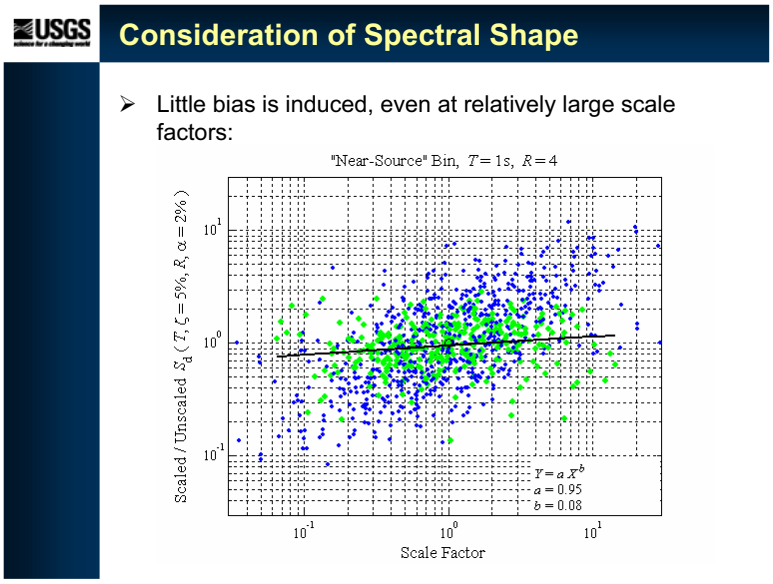

Figure 6. Removal of bias due to scale factor by selecting based on epsilon [Luco, 2005].

Year 2006: Evaluation of Methods for the Selection and Modification of Ground Motion Time Histories for Building Code and PBEE Applications

The 2006 Annual Meeting/Technical Session program built upon the need for a common basis of comparison in order to evaluate the selection procedures. The Technical Session focused on various building code procedures and the most current Performance-Based Earthquake Engineering (PBEE) procedures considering the performance they are trying to achieve.

Two PBEE ATC projects demonstrated the selection procedures they developed for their specific purposes. The ATC-63 project looked at "collapse probability considering response and capacity variability"

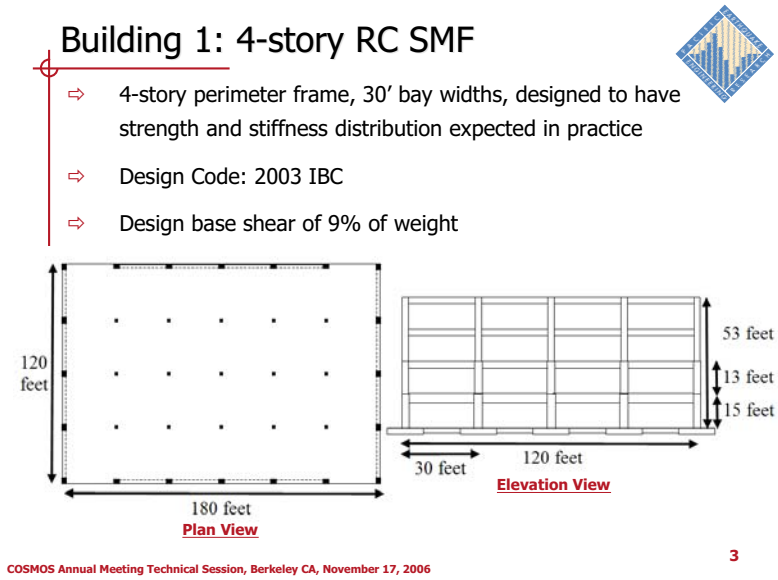

Figure 7. Structural model used in preliminary results from PEER GMSM [Haselton, 2006].

GMSM Methods Currently being Compared

ID	Method	Contributor(s)	Affiliation(s)	Objectives			
				#1	#2	#3	#4
?	Bin Selection, No Scaling	Jennie Watson-Lamprey	U.C. Berkeley	A	(√)		
?	$S_a(T_1)$ Scaling	Nilesh Shome	EQECAT (ABS)	D	A	C	(√)
?	$S_d(T_1, d_y)$ Scaling	Polsak Tothong Allin Cornell	AIR Worlwide Corp. Stanford Univ.		A		B
?	$S_d(T_1, d_y)$ Selection	Jennie Watson-Lamprey	U.C. Berkeley		B		B
?	ATC-63 Selection & Scaling	Curt Haselton Charlie Kircher	Stanford Univ. Kircher & Associates		A?		
?	Median Spectral Shape Selection with Scaling (DGML)	Bob Youngs	Geomatrix Consultants	C	B	C	A
?	Conditional Mean Spectrum Selection with Scaling	Jack Baker	Stanford Univ.		B		B
?	Inelastic Response Surface Scaling	Tom Shantz	Caltrans		B		B?
?	Conditional Mean Spectrum Matching with RASCAL	Paolo Bazzurro	AIR Worldwide Corp.		C		C
?	Conditional Mean Spectrum Matching with RSPMATCH	Jennie Watson-Lamprey	U.C. Berkeley		C		C
?	Genetic Algorithm Selection	Farzad Naiem Arzhang Alimoradi	John A. Martin & Associates	C?	B	C?	B
?	Selection with Amplitude Scaling	Ellen Rathje	U.T. Austin	C	(√)	C	(√)
?	Building Code	Jennie Watson-Lamprey	U.C. Berkeley				B

Notes: A, B, C = Class of GMSM Method for given Objective.
#ID = Adjust resulting variability of EDP for effects of scaling.
(√) = Median for Objective #2 or 4 obtained via CDF from Objective #1 or 3, respectively.

USGS e Visit

PEER

Figure 8. Time series selection and modification methods used in preliminary results of PEER GMSM [Luco, 2006].

[Kircher, 2006], using a large number of ground motions (44), while the ATC-58 project looked at three different predictions: median response given a response spectrum, the full distribution of response given a scenario earthquake, and fragility curves to be combined with a probabilistic seismic hazard analysis to develop an estimate of risk [Huang, 2006]. These two projects tried to estimate specific response values, which made it possible to discuss whether a selection and modification procedure provides accurate estimates.

Next, the PEER Ground Motion Selection and Modification (GMSM) Working Group made a presentation. The stated goal of the working group was "to determine a basis for evaluation of ground motion selection and modification methods which will depend on the intended use of the time series" [Watson-Lamprey, 2006]. These presentations provided initial results from a comparison of selection and modification procedures with a common basis. A single structure was used (see Figure 7), a large number of selection procedures were compared (see Figure 8), and the intended purpose of the analysis was agreed upon prior to the selection.

One promising selection and modification method was presented by Jack Baker. At the heart of this method was the concept of the conditional mean spectrum, shown in Figure 9. The conditional mean spectrum assumes that a single period is dominant and constructs the rest of the elastic response spectrum based on the spectral acceleration of that single period. The resulting spectral shape is more consistent with the spectral shapes of rare ground motions that produce the above average spectral values that earthquake engineers are concerned with. Jack Baker posited that using a uniform hazard spectrum or 84th percentile scenario spectrum is more conservative than might be assumed, and that by using conditional mean spectra instead this conservatism can be reduced. This concept is consistent with the previous presentations of Nico Luco, who showed that spectral shape is an important predictor of nonlinear response, and that above and below average ground motions have different spectral shapes.

The conditional mean spectrum

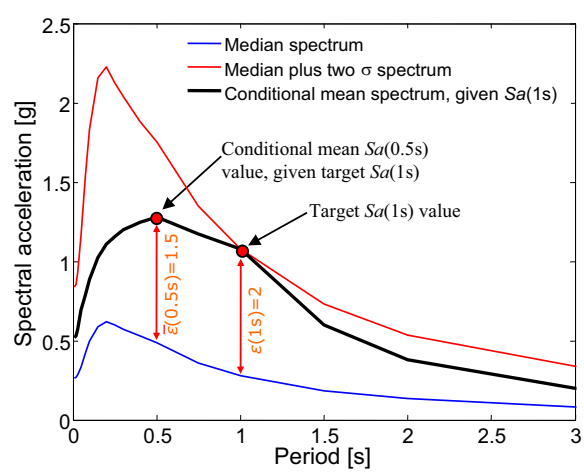

Figure 9. The conditional mean spectrum [Baker, 2006].

The results showed a range of a factor of three in estimates of structural response, as seen in Figure 10, even when the same parameter was estimated for the same structure using the same elastic response spectrum as a target. The selection and modification methods that provided the most accurate estimates of the median response all used record properties that influence nonlinear response to select and modify potential ground motions. These methods had smaller variability between estimates, and the more record properties they used,

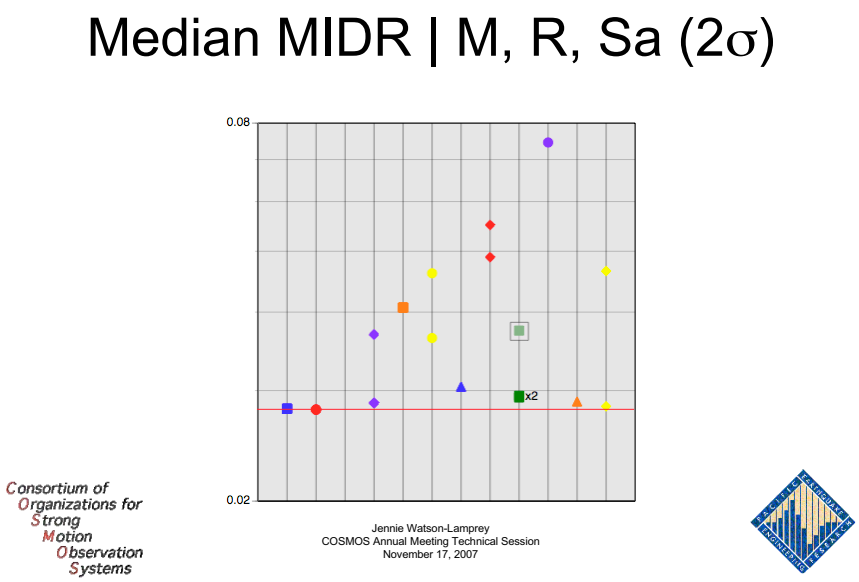

Figure 10. Preliminary results of comparison performed by PEER GMSM [Watson-Lamprey, 2006].

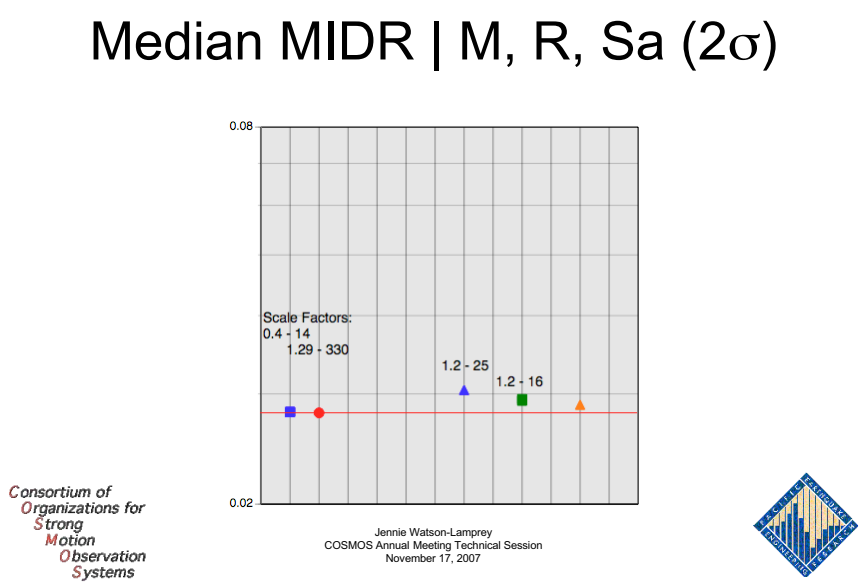

Figure 11. Predictions from most accurate selection methods and their scaled factors from preliminary results of PEER GMSM [Watson-Lamprey, 2006].

the smaller the variability became. An additional benefit of these methods was that large-scale factors (over 10) could be used without introducing bias as shown in Figure 11 [Watson-Lamprey, 2006]. While the use of time series requiring large-scale factors remains controversial, these results indicate that the restrictions on scale factors could be eased for cases in which the record properties that affect nonlinear response are known.

The results were preliminary, but the development of an objective procedure was an important step in solving the problem of time series selection and modification.

Year 2007: Evaluations and Recommendations for the Selection and Scaling of Ground Motions for Building Code and PBEE Applications

From 2004 through 2006 it was demonstrated numerous times that selection processes using traditional approaches leads to large variability in results. In 2007 two solutions that are available to the engineer to solve this problem were presented. The first solution is to perform a high-end analysis using a large number of ground motions. This approach was used in the ATC-63 project presented by Charlie Kircher (see Figure 12) to create a methodology for determining seismic performance factors. This approach was also used in an example provided by Jennie Watson-Lamprey (Figure 13) to create the point of comparison by which to

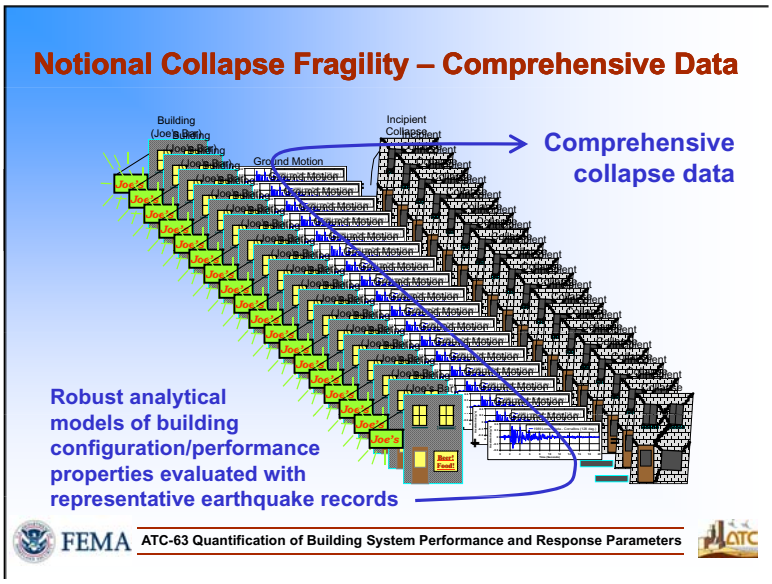

Figure 12. Method for creating robust analytical models of building performace in ATC-63 project [Kircher, 2007].

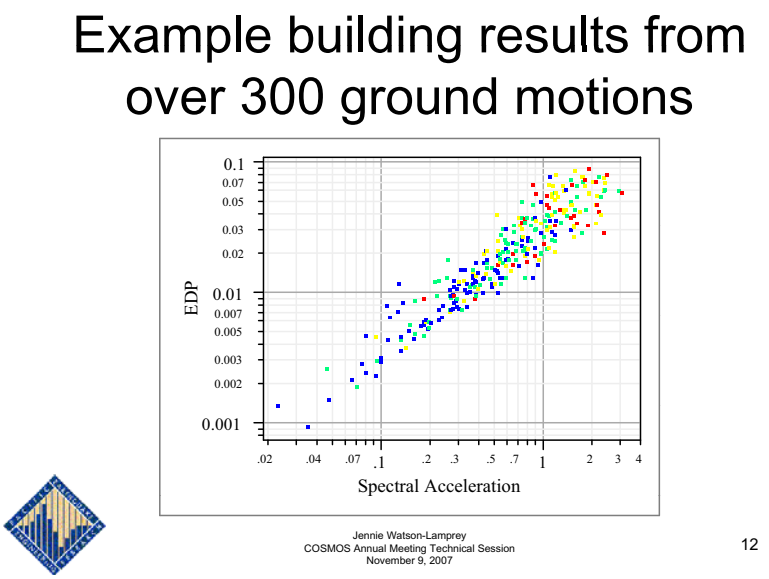

Figure 13. Example results from large number of time series used to created point of comparison for PEER GMSM results [Watson-Lamprey, 2007].

Results: Summary

Median(MIDR/HighEnd)	Building T_1 (sec)	UHS	CMS	Proxy (i.e. ε)	Inelastic	$Sa(T_1)$
Building C (20-story RC frame)	2.63	1.26	1.01	1.15	1.14	1.48
Building A (4-story RC frame)	1.00	--	1.05	1.05	1.17	1.48
Building D (12-story RC wall)	1.20	--	0.94	1.09	1.00	1.17
	Averages:	1.26	1.00	1.10	1.10	1.38
Minimum Prediction from 7 Records		0.91	0.63	0.76	0.72	0.96
Maximum Prediction from 7 Records		2.07	1.53	1.88	1.82	2.74

Figure 14. Structural results from PEER GMSM Analysis [Haselton, 2007].

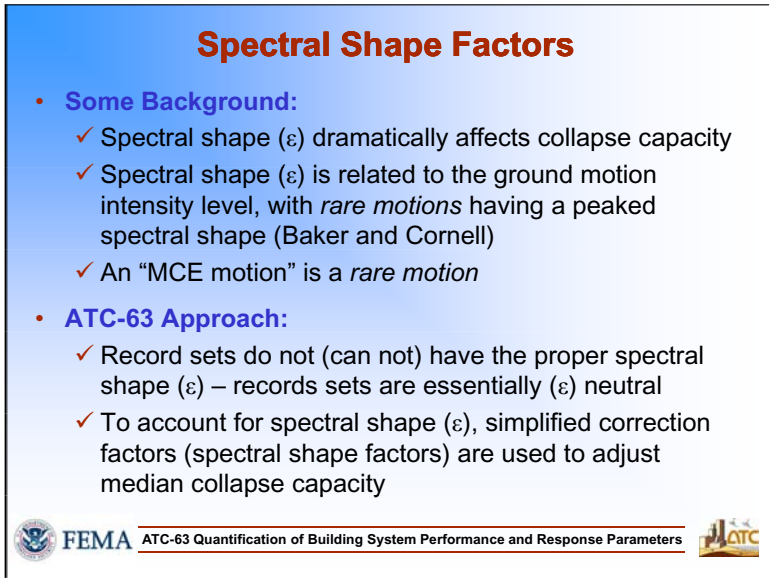

Figure 15. Spectral shape factors used in ATC-63 [Kircher, 2007].

judge other selection procedures. A high-end analysis using a large number of records is not practical for most projects, however.

The second solution is to use a small number of records and be smart about their selection. The goal, as Ron Hamburger described it for the ATC-58 project [Hamburger, 2007], "is to select and scale motions such that the statistics obtained from analyses accurately represent the…response...and we...minimize the number of records required to achieve this." The PEER GMSM Program presented an analysis of current selection and scaling procedures using seven ground motions and found that in order to reduce the variability in prediction, motions need to be selected based on record properties that are important for nonlinear structural response and not just on seismological properties [Haselton, 2007].

For the structures and response parameter analyzed by the PEER GMSM Program, spectral shape was found to be a very important property for nonlinear response. The class of selection procedures that closely matched the conditional mean spectrum most accurately predicted nonlinear response, as shown in Figure 13. Spectral shape was also found to be a record property of importance by the ATC-63 project, which included spectral shape through spectral shape factors, as shown in Figure 15. The ATC-58 project project team noted that they were aware of spectral shape effects and were considering their inclusion where extreme ground motion evaluations are being done.

For the structures and properties analyzed by these groups, a time series property found to be important for nonlinear response was spectral shape. The time series selection and modification methods that used this time series property to aid in selection showed improved accuracy. It was noted that the important time series properties will change depending on the structure and the response parameter, so the engineering seismologist must know something about the structure to be able to select an appropriately small number of representative time series.

Year 2008: Selection and Scaling of Ground Motions for Site Response Analysis and Geotechnical Evaluations

While buildings are a prominent application for the use of time series, there are a number of different nonlinear systems that suffer from sensitivity to the input ground motion selected. The 2008 Annual Meeting/Technical Session chose to focus on geotechnical applications and their use of ground motions. The 2007 Technical Session determined that time series that are selected based on time series properties that are important for nonlinear response give more consistently accurate estimates of nonlinear response. The 2008 Technical Session provided geotechnical examples of nonlinear systems and the time series properties that are important for nonlinear response and thus selection.

In acknowledgement of the limitations of traditional selection and modification criteria, Jeff Howard presented a new approach from the DSOD for evaluating design motions for earth dams to include Arias

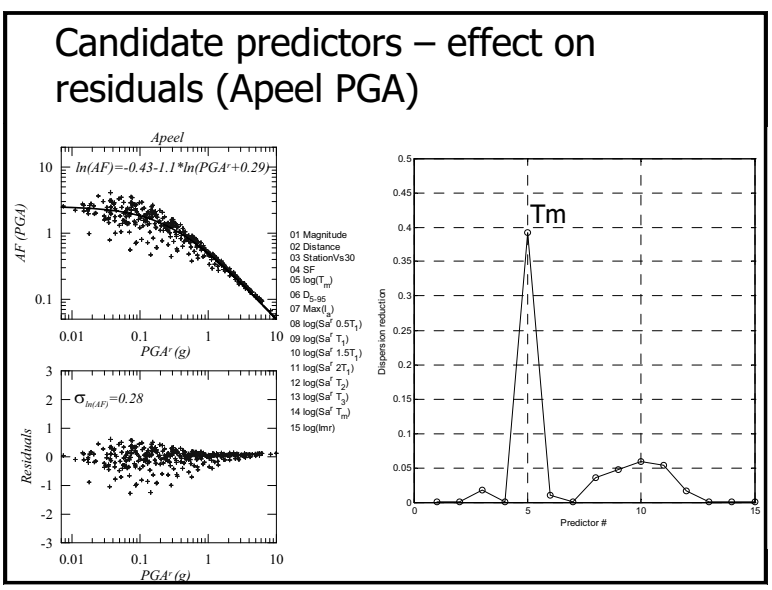

Figure 16. Time series properties important for nonlinear site response [Goulet, 2008].

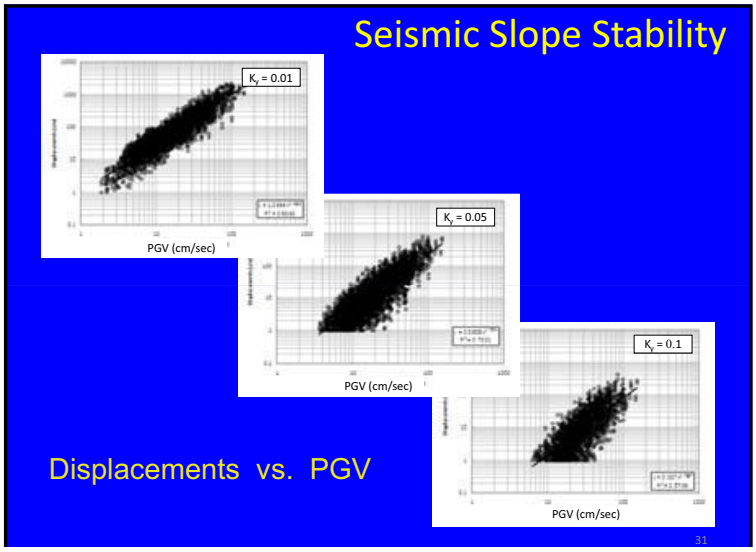

Figure 17. Importance of spectral acceleration at the degraded period of the site for slope stability of earthen levees [(Athanasopoulos-Zekkos, 2008].

Intensity as a time series parameter the design motions must meet. Arias Intensity is used as an additional parameter because it has been shown to have a strong correlation with Newmark Displacement. He suggested that Arias Intensity would be an improved target for time series, and that Arias Intensity hazard curves could be used in place of peak ground acceleration hazard curves.

Two researchers showed preliminary results from sensitivity analyses using large numbers of time series of time series properties important for the nonlinear response of their system. For site response analysis, Christine Goulet showed results for the effect of ground motion properties on amplification factor as seen in Figure 16. She found that for nonlinear sites, mean period and PGA have a large affect on amplification. For liquefaction and seismic slope stability analyses of earthen levees, Adda Athanasopoulos-Zekkos showed that time series properties important for response are mean period, spectral acceleration at the degraded period (see Figure 17), and PGV. Both researchers recommended that the time series properties they had found to be important for nonlinear response be used when selecting and modifying time series for dynamic analyses.

The findings and recommendations of the geotechnical engineers are consistent with those of the structural response analyses of previous COSMOS Annual Meeting/Technical Sessions. When selecting time series for nonlinear analyses one must determine the time series properties that are important for nonlinear response and select based on those properties. These properties will change depending on the application, but the methodology is always the same.

Titles of Slide Presentations

2004

Bachman, R., "2004 COSMOS Technical Session: Introduction."

Luco, N., and P. Bazzurro, "Effects of Ground Motion Scaling on Nonlinear Structural Response."

Power, M., "Design Ground Motion Library (DGML)."

Watson-Lamprey, J., "Scaling Effects for Newmark Displacements: Selection of Ground Motion Time Series and Limits on Scaling."

2005

Bachman, R., "2005 COSMOS Technical Session: Introduction."

Abrahamson, N., "Additional Remarks and Setting the Stage for the Session."

Kircher, C., "Code Requirements for the Selection and Scaling of Ground Motion Records."

Crouse, C. B., "Time-History Selection and Scaling."

Sinclair, M., "Example of Current Code Procedure Applied to Ground Motion Scaling at a Northern California Site."

Luco, N., "Record Selection Insights from the Study of Epsilon and Inelastic Displacements: Use with Deterministic Code Applications"

Somerville, P., "Guidelines for the Selection, Modification and Scaling of Ground Motion Time Histories."

Youngs, B., "Selection of Ground Motion Time Histories for Code Applications Using the PEER Lifeline Project Procedures."

2006

Bachman, R., "2006 COSMOS Technical Session: Introduction."

Abrahamson, N., "Introductory Comments."

Watson, Lamprey, J., "Example of Wide Dispersion of Results following Code Procedures."

Kircher, C., C. B. Haselton, and G. G. Deierlein, " Overview of Ground Motions: ATC-63 Project "Quantification of Building Systems and Response Parameters."

Huang, Y.-N., A. S. Whittaker, and R. Hamburger, "DHS/FEMA ATC-58 Project Selection and Scaling of Ground Motions."

Baker, J., "Breaking the Uniform Hazard Spectra into Component Scenario Events: the Effect of Epsilon on Structural Response."

Bozorgnia, Y., "PEER Ground Motion Selection & Modification Working Group."

Luco, N., "Categorization of Ground Motion Selection and Modification Methods."

Haselton, C., A. B. Liel, C. Goulet, F. Zarein, E. Kalkan, T. Yang, C. McQuoid, and J. P. Moehle, "Structural Models Used to Evaluate GMSM Methods."

Watson-Lamprey, J., "Evaluation of GMSM Methods Results."

2007

Bachman, R., "2007 COSMOS Technical Session: Introduction."

Hamburger, R., A. S. Whittaker, and Y.-N. Huang, "The ATC-58 Project Development of Next-Generation Performance-Based Seismic Design Criteria for Buildings."

Kircher, C., and C. B. Haselton, "ATC-63 Project: Quantification of Building System Performance and Response Parameters."

Haselton, C. B., "PEER GMSM Program: Findings and Initial Recommendations."

Watson-Lamprey, J., "PEER GMSM Program: Recommendations for Selection and Scaling of Ground Motions and Evaluation of the ATC-58 Procedures."

Zareian, F., "Assessment of Ground Motion Selection and Scaling Methods Presented in ATC-59 35% Draft."

2008

Crouse, C. B., "Site Response Analysis and its Link to Structural Analysis, Design, and Code Requirements."

Lam, P., "Lessons from Recent Projects Involving Time-History Analyses."

Watson-Lamprey, J., "Introduction to Research on Time Series Selection for Geotechnical Projects."

Howard, J., "DSOD Approach to Developing Design Ground Motions for Earth Dams."

Goulet, C., "Ground Motion Parameters that Control Ground Response Analysis Results."

Athanasopoulos-Zekkos, A., "Variability of Levee Response Due to Time History Selection."

Appendix 1: Agenda for Technical Sessions

2004: SCALING OF GROUND MOTIONS FOR ENGINEERING APPLICATION

November 12, 2004
University of California, Richmond Field Station, Richmond, California

11:00 AM	**Introduction** *N. Abrahamson*
11:10 AM	**Design Ground Motion Library (DGML)** *M. Power*
11:30 AM	**Scaling Effects for Newmark Displacements** *J. Watson-Lamprey*
Noon	**Scaling Effects for Nonlinear Oscillators** *N. Abrahamson*
12:30 PM	**Break**
1:30 PM	**Effects of Ground Motion Scaling on Nonlinear Structural Response** *N. Luco and P. Bazzurro*
2:00 PM	**Scaling Effects for Earth Dams** *J. I. Sun*
2:30 PM	**Panel Discussion of Scaling Guidelines (selected speakers)** *Moderator: B. Bachman*
3:30 PM	**Break**
4:00 PM	**Summary** *N. Abrahamson*
4:30 PM	**Technical Topics for Future COSMOS Meetings** *J. Davis*
4:45 PM	**Adjourn**

2005: RECOMMENDATIONS FOR THE SELECTION AND SCALING OF GROUND MOTION TIME HISTORIES FOR BUILDING CODE APPLICATIONS

November 18, 2005
Westin Hotel, Millbrae, California

10:00 AM **Welcoming Remarks and Technical Session Overview**
B. Bachman

10:15 AM **Additional Remarks and Setting the Stage for the Session**
N. Abrahamson

10:30 AM **Code Requirements for the Selection and Scaling of Ground Motion Records**
C. Kircher

11:00 AM **Time-History Selection and Scaling**
C. B. Crouse

11:30 AM **Example of Current Code Procedure Applied to the Selection and Scaling of Ground Motion Time Histories at a Northern California Site**
M. Sinclair

Noon **Break**

12:45 PM **Recommendations for Selection and Scaling of Ground Motion Records to Satisfy Code Requirements including Spectrum Compatible Scaling (Frequency Scaling)**
N. Abrahamson

1:30 PM **Record Selection Insights from the Study of Epsilon and Inelastic Displacement: Use with Deterministic Code Applications**
N. Luco and C. Allin Cornell

2:00 PM **Guidelines for the Selection, Modification and Scaling of Ground Motion Time Histories**
P. Somerville

Continued

2:30 PM **Selection of Ground Motion Time Histories Using the CSMIP-PEER Design Ground Motion Library**
B. Youngs

3:00 PM **Break**

3:15 PM **Panel Discussion: Includes Questions and Opinions from Audience**
Moderator: *B. Bachman*
Panelists: *C. Kircher, C. B. Crouse, N. Abrahamson, M. Sinclair, C. Allin Cornell, P. Somerville, and B. Youngs*

4:45 PM **Summary and Wrap up**
B. Bachman and N. Abrahamson

5:00 PM **Adjourn**

2006: EVALUATION OF METHODS FOR THE SELECTION AND MODIFICATION OF GROUND MOTION TIME HISTORIES FOR BUILDING CODE AND PBEE APPLICATIONS

November 17, 2006
Doubletree Hotel, Berkeley, California

10:00 AM **Welcome and Overview of Session**
B. Bachman

10:10 AM **Introductory Comments**
N. Abrahamson

10:20 AM **Example of Wide Dispersion of Results following Code Procedure**
J. Watson-Lamprey

10:45 AM **Overview of Ground Motions: ATC-63 Project: Quantification of Building Systems and Response Parameters**
C. Kircher, C. B. Haselton, and G. G. Deierlein

11:05 AM **DHS/FEMA ATC-58 Project Selection and Scaling of Ground Motions**
Y.-N. Huang, A. S. Whittaker, and R. Hamburger

11:25 AM **Breaking the Uniform Hazard Spectra into Component Scenario Events: the Effect of Epsilon on Structural Response**
J. Baker

11:45 AM **Break**

12:45 PM **PEER Ground Motion Selection and Scaling Working Group**
* Overview: *Y. Bozorgnia and N. Abrahamson*
* Categorization of Selection and Procedures Based on the Goal of the Analysis Procedures: *N. Luco*
* Structural Models: *C. B. Haselton*
* Results: *J. Watson-Lamprey*

3:00 PM **Break**

Continued

3:15 PM	**Panel Discussion: Observations Regarding Discussion of Evaluation Results, Suggestions for Improvements in Selection and Scaling Procedures** Moderator: *B. Bachman* Panelists: *N. Abrahamson, J. Baker, Y. Bozorgnia, C. Kircher, N. Luco, and A. S. Whittaker*
4:00 PM	**Audience Participation: Q&A for Panelists** Moderator: B. Bachman
4:00 PM	**Wrap-up and Summary** *B. Bachman and N. Abrahamson*
5:00 PM	**Adjourn**
5:00 PM	**No-host Cocktail Hour + Poster Session**

2007: EVALUATIONS AND RECOMMENDATIONS FOR THE SELECTION AND SCALING OF GROUND MOTIONS FOR BUILDING CODE AND PBEE APPLICATIONS

November 9, 2007
Hilton Garden Inn, Emeryville, California

8:30 AM **Welcome and Overview of Session**
B. Bachman

8:45 AM **Consensus on Observations and Selection and Scaling of Ground Motions to Meet Building Code Requirements from Previous Technical Sessions**
N. Abrahamson

9:15 AM **The ATC-58 Project: Development of Next Generation Performance-Based Seismic Design Criteria for Buildings**
R. Hamburger, A. S. Whittaker, and Y.-N. Huang

9:45 AM **Break**

10:00 AM **Selection and Scaling of Ground Motions per the ATC-58 Procedures**
R. Hamburger

10:30 AM **ATC-63 Project: Quantification of Building System Performance and Response Parameters**
C. Kircher and C. B. Haselton

11:00 AM **New National Center for Engineering Strong-Motion Data**
W. U. Savage and A. Shakal

11:30 AM **Break**

Noon **COSMOS Annual Meeting**
J. F. Davis

1:15 PM **PEER GMSM Program: Recommendations for Selection and Scaling of Ground Motions and Evaluation of the ATC-58 Procedures**
J. Watson-Lamprey, C. B. Haselton, F. Zareian, and N. Luco

Continued

3:00 PM	**Break**
3:15 PM	**Panel Discussion** *Moderator: B. Bachman*
4:15 PM	**Technical Session Wrap-up**
5:00 PM	**Adjourn**
5:00 PM	**No-host Cocktail Hour + Poster Session**

2008: SELECTION AND SCALING OF GROUND MOTIONS FOR SITE RESPONSE ANALYSIS AND GEOTECHNICAL EVALUATIONS

November 21, 2008
Hilton Oakland Airport, Oakland, California

8:30 AM	Welcome and Overview of Day *B. Bachman*
8:45 AM	Conclusions from Previous COSMOS Meeting and Importance of Today's Topic *N. Abrahamson*
9:15 AM	Site-Specific Site Response Analysis and Its Link to Structural Analysis, Design, and Code Requirements *C. B. Crouse*
9:45 AM	Lessons from Recent Projects Involving Time History Analyses *P. Lam*
10:15 AM	Break
10:45 AM	Update on New Center for Earthquake Strong-Motion Data *W. U. Savage and A. Shakal*
11:00 AM	Update on COSMOS Initiatives *B. Iwan*
11:30 AM	Break
Noon	COSMOS Annual Meeting *J. F. Davis*
1:00 PM	Introduction to Research on Time Series Selection for Geotechnical Projects *J. Watson-Lamprey*
1:15 PM	BART Tube Project Time Series Selection Concerns and the Final Resolution *T. Travasarou*

Continued

1:45 PM	**DSOD Approach to Developing Design Ground Motions for Earth Dams,** *J. Howard*
2:15 PM	**Ground Motion Parameters that Control Ground Response Analysis Results** *C. Goulet*
2:45 PM	**Variability of Levee Response Due to Time History Selection** *A. Athanasopoulos-Zekkos*
3:15 PM	**Break**
3:45 PM	**Panel Discussion**
5:00 PM	**Adjourn**
5:00 PM	**No-host Cocktail Hour + Poster Session**