

## Final Project Summary — PEER Lifelines Program

|                                                             |                                                                        |                                   |                     |
|-------------------------------------------------------------|------------------------------------------------------------------------|-----------------------------------|---------------------|
| <b>Project Title—ID Number</b>                              | <i>Test Applications of Advanced Seismic Assessment Guidelines—508</i> |                                   |                     |
| <b>Start/End Dates</b>                                      | 7/1/02 – 6/30/04                                                       | <b>Budget/<br/>Funding Source</b> | \$79,138 / PG&E/CEC |
| <b>Project Leader (boldface) and<br/>Other Team Members</b> | <b>Maffei (Rutherford &amp; Chekene)</b>                               |                                   |                     |

### 1. Project goals and objectives

Advanced seismic assessment guidelines were developed by Stanford University (C. Allin Cornell, Paolo Bazzurro, Charles Menun, Maziar Motahari) as part of the PEER Lifelines Program, Building Vulnerability Studies (Project Task Number 507). Predicting the post-earthquake functionality of utility structures is a crucial step in evaluating the likelihood of the electric distribution network being able to provide gas and electricity to its customers. The final product of the guidelines is a set of fragility curves for structural limit states directly related to post-earthquake building occupancy status, namely green, yellow, or red tagging.

This project is for a practicing Structural Engineer to apply these guidelines to utility type buildings.

The objectives are to:

1. Identify potential difficulties that Structural Engineers would encounter in using the procedure described in the advanced seismic assessment guidelines.
2. Recommend possible revisions to the procedure to address any identified difficulties.
3. Identify and make recommendations on other issues related to assessing the seismic reliability of utility structures and systems.

### 2. Benefits of the results of this project to develop technologies and protocols to mitigate the vulnerability of electric systems and other lifelines to damage directly and indirectly caused by earthquakes. Also, benefits to develop assessment techniques to evaluate damage to electric systems caused by earthquakes and to assess fiscal impacts due to the loss of electric service to the community.

The project is a key step in investigating the practical application and potential of performance based seismic assessment methods. As such, the project can lead to the wider application of seismic and structural engineering procedures that use state of the art techniques.

In the application to fragility curves for buildings of utility systems, the project can lead to a better understanding of the seismic vulnerability of lifeline systems, and a better understanding of the most effective ways to reduce seismic vulnerability.

### 3. Brief description of the accomplishments of the project

Detailed assessment and understanding of two example buildings, leading to

- Better knowledge of characteristics of steel moment frame behavior.
- Improved understanding of reliability based structural engineering and effects of vulnerability and uncertainty.
- Better knowledge of mill building concrete wall behavior
- Understanding of the effects of various modeling assumptions for concrete and steel buildings, including pushover load pattern, foundation flexibility, inclusion of gravity frames, assumed concrete stiffness and strength properties.

### 4. Describe any instances where you are aware that your results have been used in industry

Recommendations used by PG&E, with Rutherford & Chekene and Simpson Gumpertz and Heger on the evaluation of an 8-story building.

### 5. Methodology employed

Structural analyses using Nonlinear Static Procedures and Incremental Dynamic Analyses. Evaluation of damaged structures, proposal of tagging criteria, and creation of fragility curves.

### 6. Other related work conducted within and/or outside PEER

Being integrally related to task 507 project, this project takes advantage of developments in two other projects being carried out by professor C. Allin Cornell. The first is investigating Incremental Dynamic Analysis, global ductility, and approximate techniques for NL dynamic analysis. The second is focused on intensity measures and near source motions. The project has made use of the PEER project on nonstructural damage to gypsum wall board partitions being carried out under Professor Restrepo at UCSD. The project has been coordinated with the Task 509 project.

**7. Recommendations for the future work: what do you think should be done next?**

1. Evaluation of modeling methods for steel and concrete buildings.
2. Applicability of analysis techniques for high-rise buildings.
3. Possible techniques for deriving fragility curves using less detailed analysis.
4. Building-specific tagging criteria.

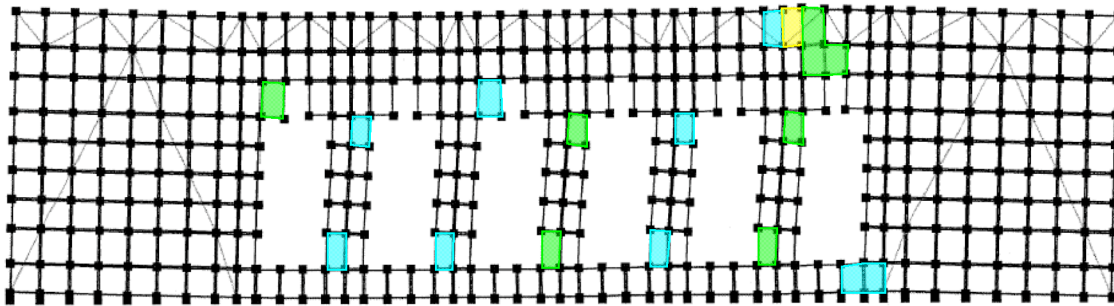
**8. Author(s), Title, and Date for the final report for this project**

Maffei, Nakayama, Mohr, Holmes

*Test Applications of Advanced Seismic Assessment Procedures*

Expected completion in August 2004





### DEFLECTED SHAPE SHOWING USAGE RATIOS

Reference Drift = 0.004958

Limit state group = all deformation states

Minimum usage ratio for each color :

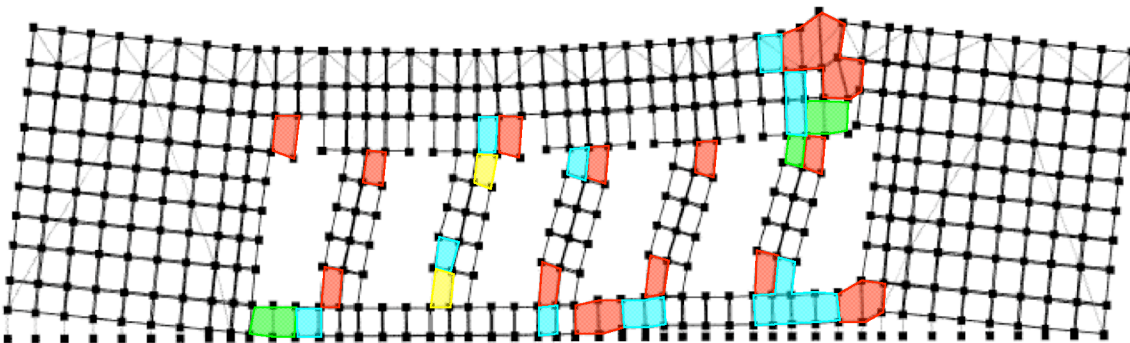
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### DEFLECTED SHAPE SHOWING USAGE RATIOS

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