

Global fragility assessments considering uncertainties in response threshold



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ABSTRACT

A multi-dimensional definition of fragility is developed considering multiple variables such as floor acceleration and interstory drifts. The limit states which have uncertainties are defined as random variables in the calculation of fragility. A random description of the limit state has been adopted to calculate fragility.

A generalized formula for multidimensional threshold of limit states has been proposed and different cases have been considered as particular cases of the main general case. The procedure of evaluation fragility was programmed and implemented in a pre and post processor for IDARC2D, an inelastic analysis program. The MCEER west coast Demonstration Hospital located in the San Fernando Valley in Southern California has been considered to show the applicability of this technique. The development of fragility for different cases show how important a correct evaluation of the limit state is for comparison of different techniques. The MCEER series and SAC series are used as input ground motion and compared in term of response.

The study investigates how conservative or unconservative the fragility curves are when uncertainties in limit states are considered. Different parameters that influence fragility damping have a considerable effect in reducing displacements. Influence of other parameters like stiffness and acceleration threshold and uncertainties due to the structural model and input ground motion are also investigated.

BACKGROUND

Multidimensional fragility represents the probability that the response expressed in term of acceleration or interstory drift exceeds the respective limit-state conditional on earthquake intensity I on a specific structure (or family of structures) in a given period of time. In mathematical form it is written as:

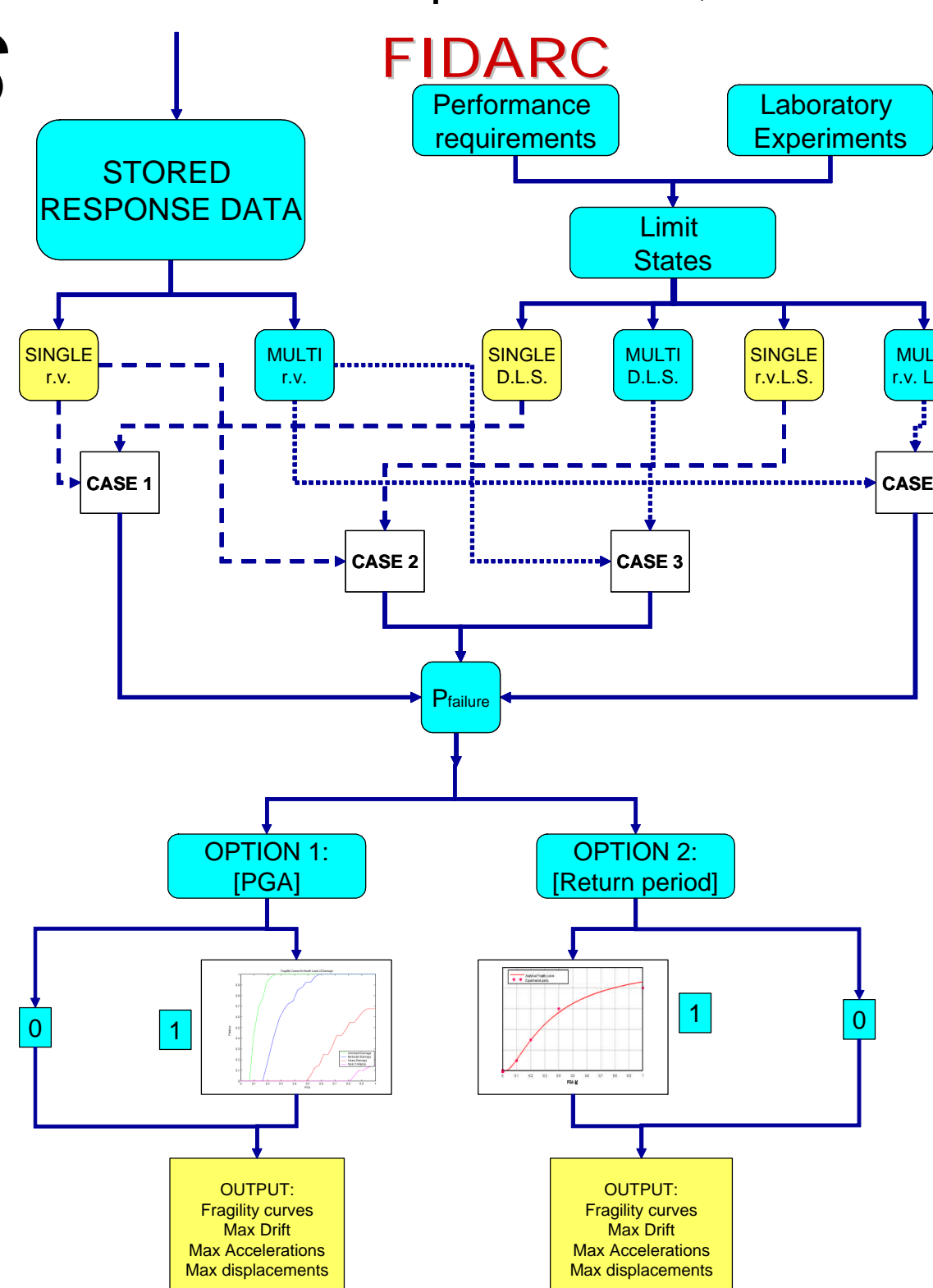
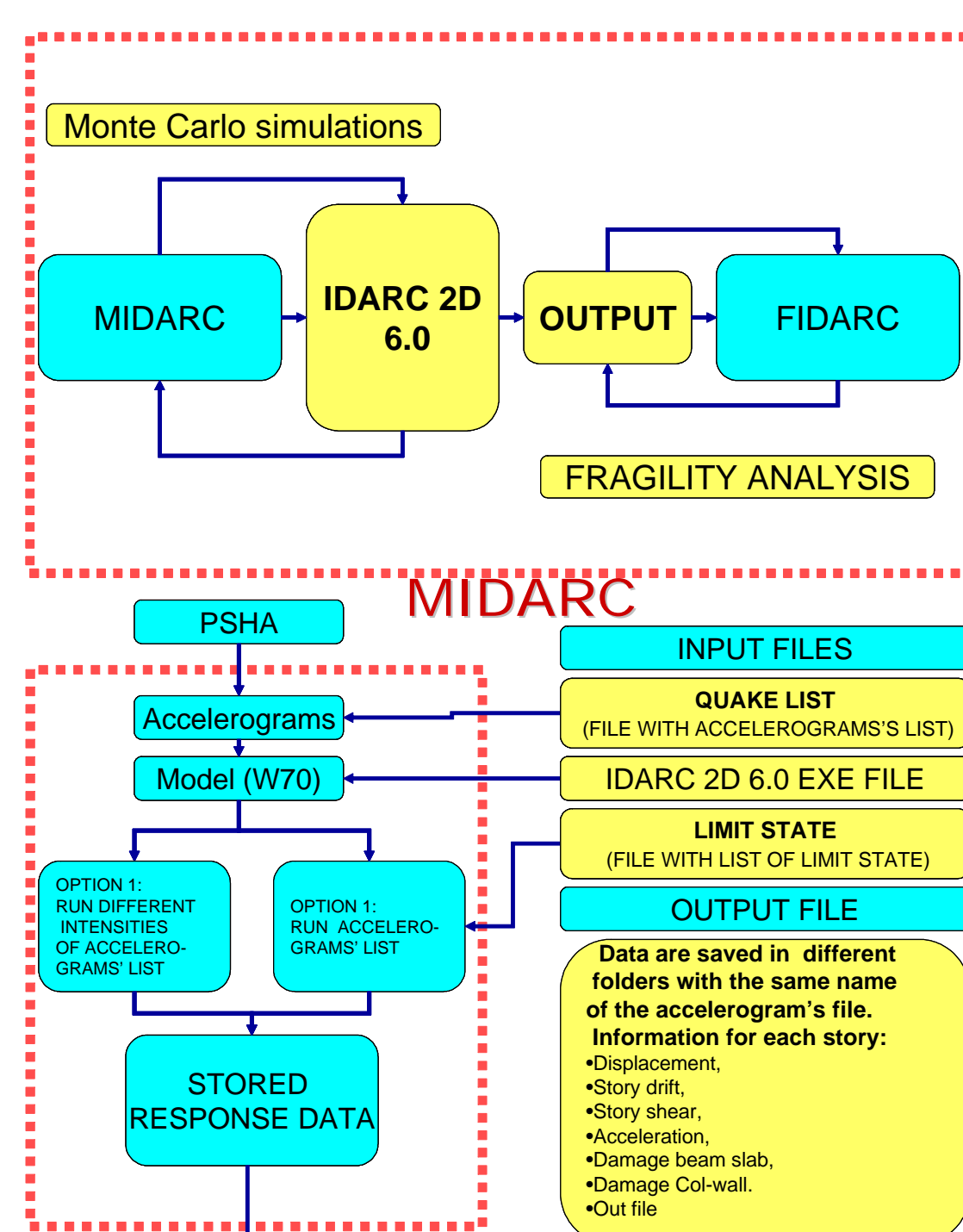
$$Fragility = P\{\Delta \geq D_{lim} \cup Z \geq A_{lim} / I\}$$

OBJECTIVES

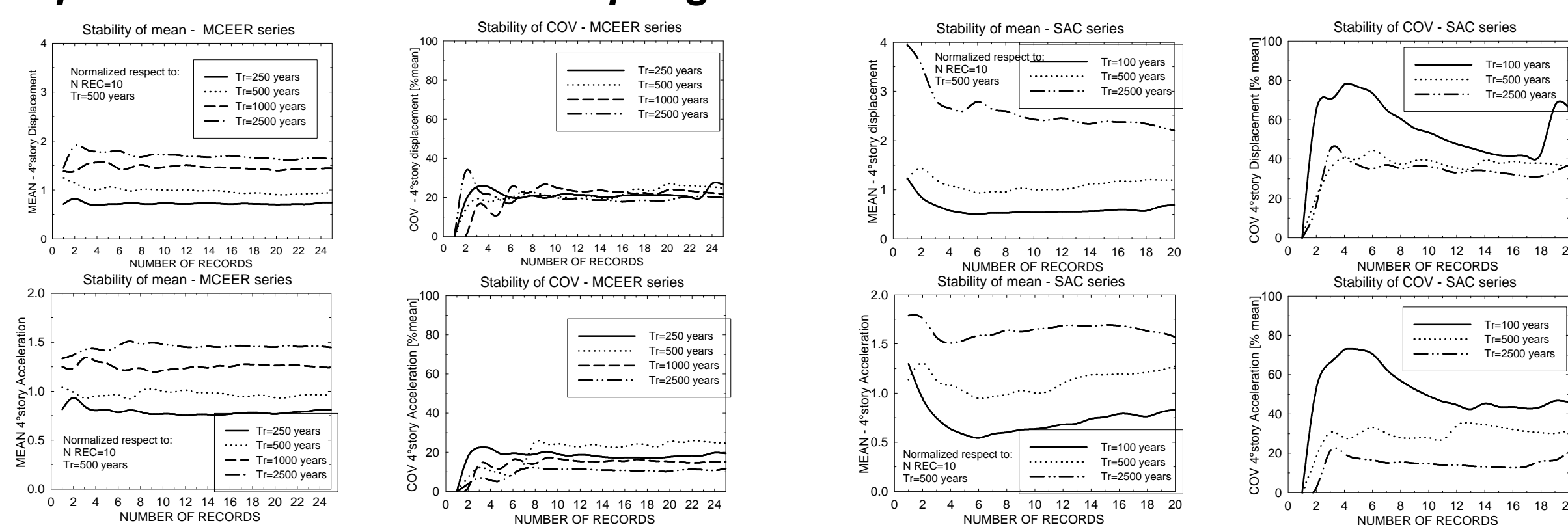
The objectives of this research are:

- Evaluate the probability of exceed a given performance limit threshold in the spectral space of acceleration and interstory-drift;
- Describe the limit threshold using random variables;
- Describe the multidimensional limit threshold using a generalized formula that includes both accelerations and displacement threshold;
- Develop a pre-processor in IDARC2D that allows multiple running and stores the data;
- Develop a post-processor in IDARC2D that allows the evaluation of fragility considering different option;
- Parametric analysis that shows the sensitivity of curves to different parameters;

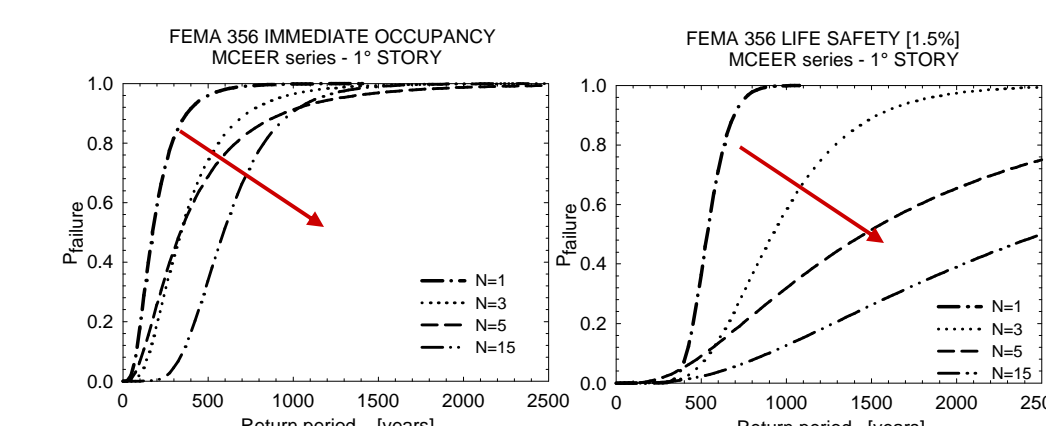
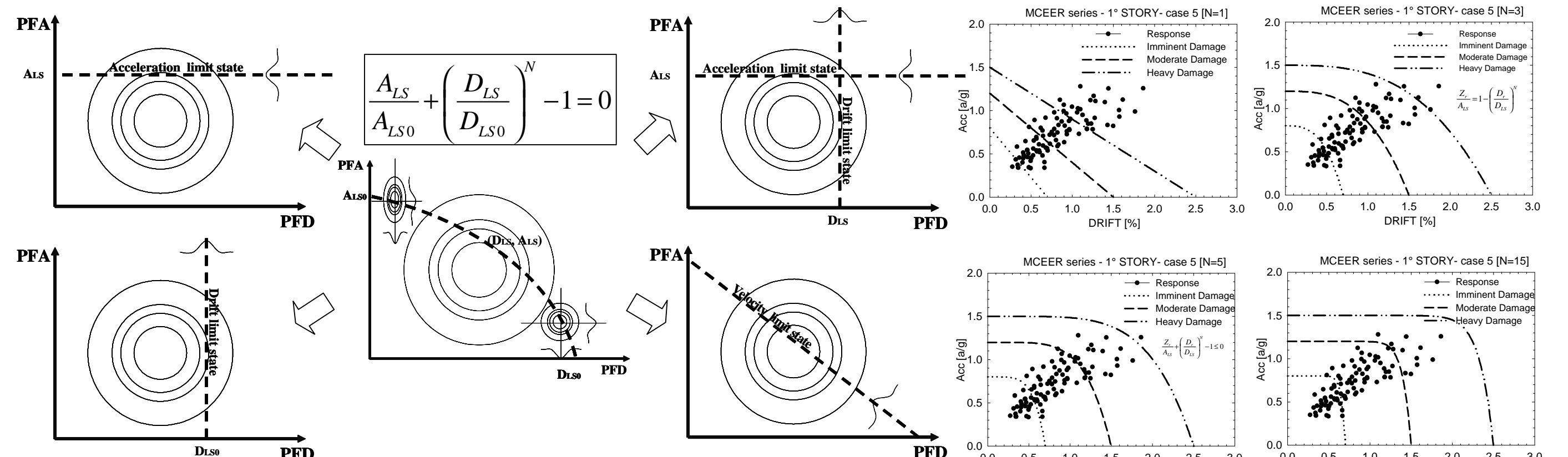
METHODS & RESULTS



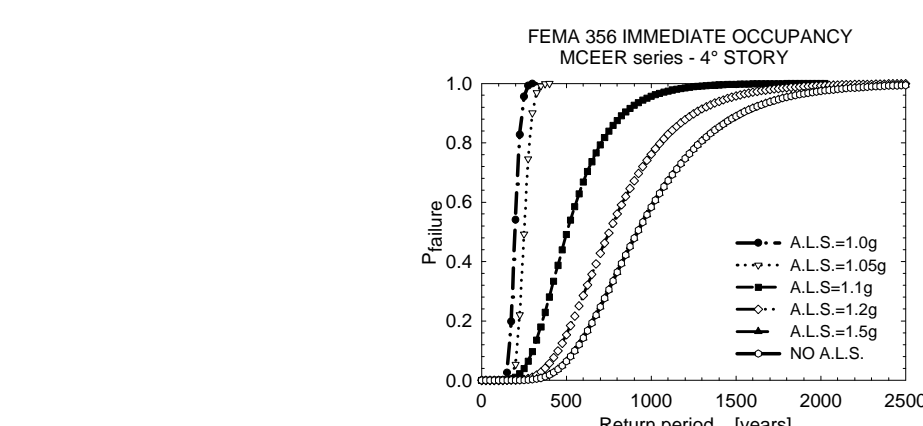
Response characterization of input ground motion



Generalized formula for multidimensional threshold

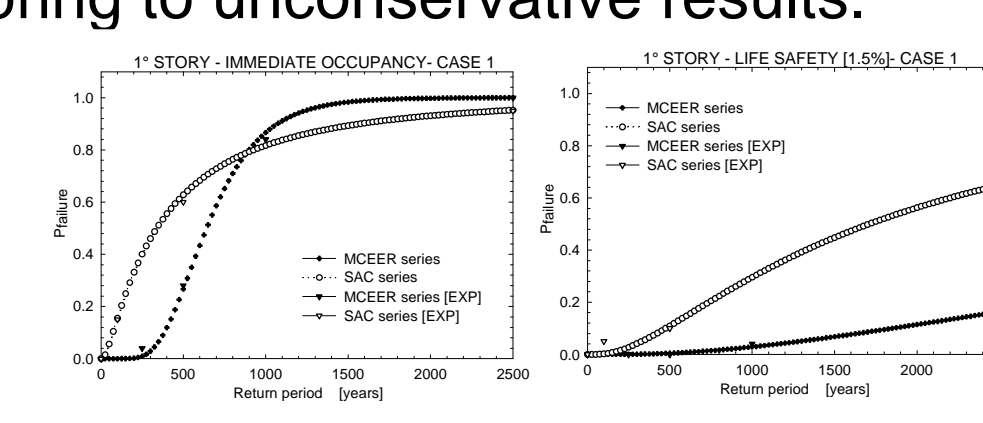


Sensitivity of parameter N on fragility curves

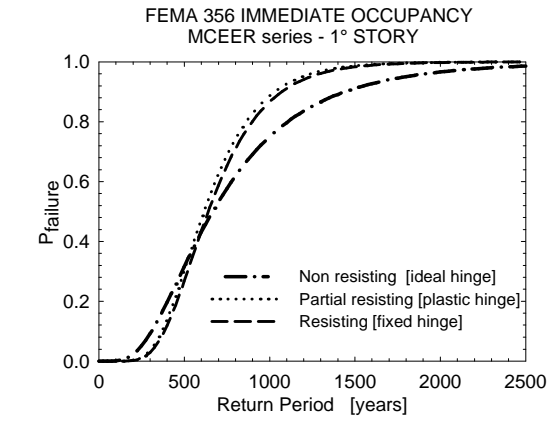


Sensitivity of acceleration threshold on fragility curves

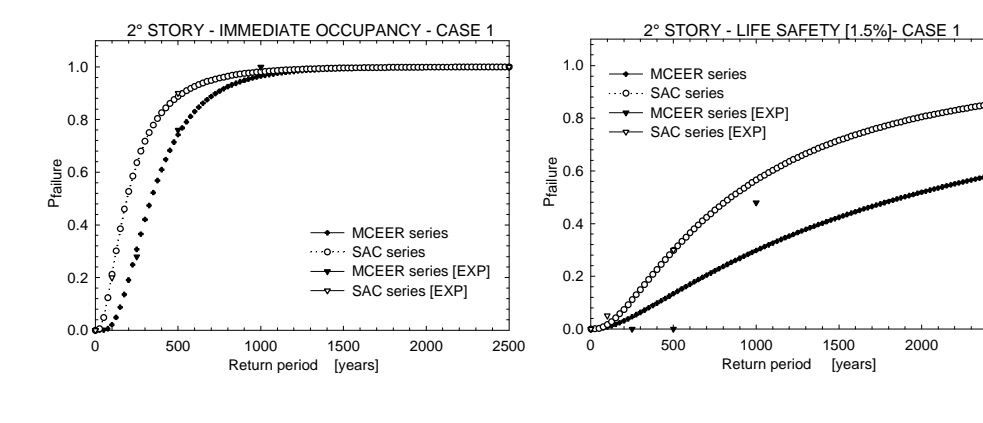
Fragility curves are very sensitive to acceleration threshold as it is shown in Figure where are plotted the fragility curves related to the fourth story level of the hospital, for a fixed value of interstory drift limit state corresponding to the immediate occupancy of FEMA 356 and different values of acceleration thresholds. Do not consider the acceleration threshold can bring to unconservative results.



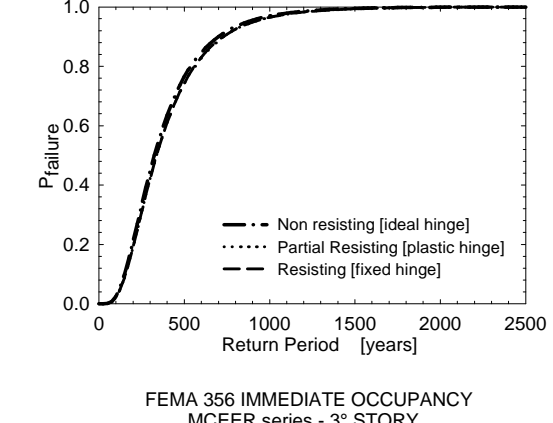
Comparison between SAC and MCEER series at 1°-2°-3°-4° story level.



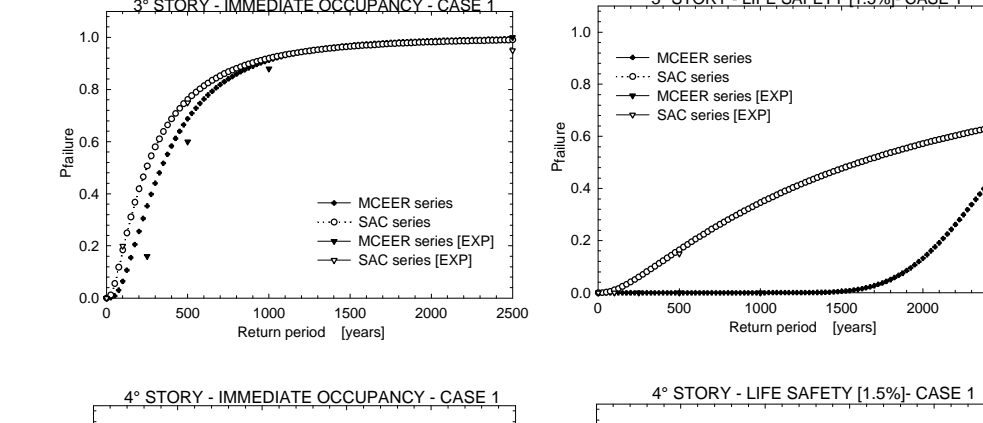
Comparison among different structural models at the 1°-2°-3°-4° story level



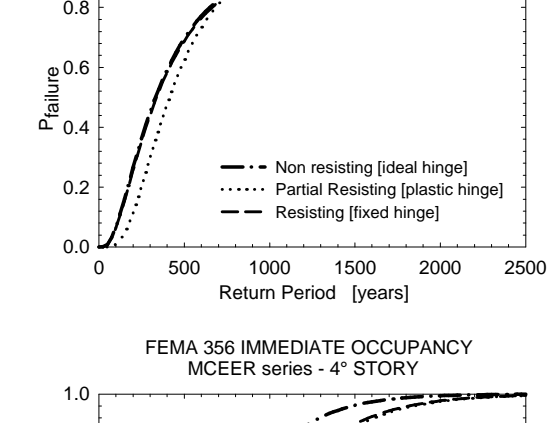
Comparison between SAC and MCEER series at 1°-2°-3°-4° story level.



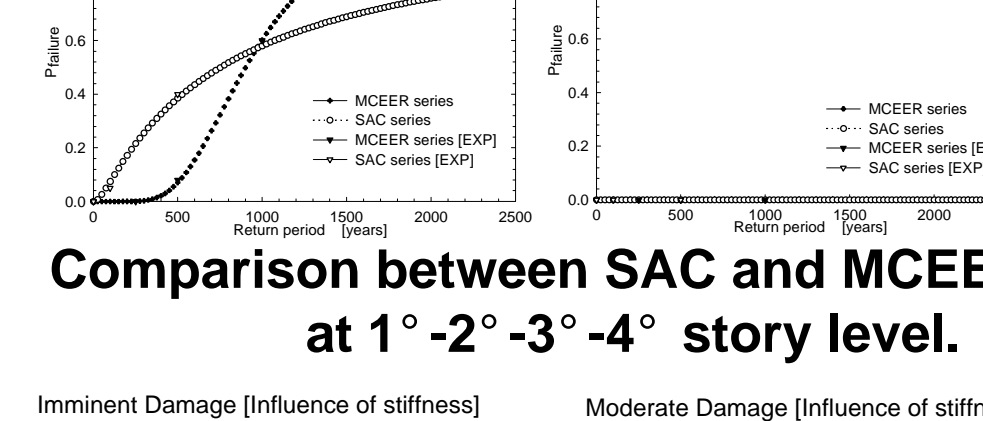
Comparison among different structural models at the 1°-2°-3°-4° story level



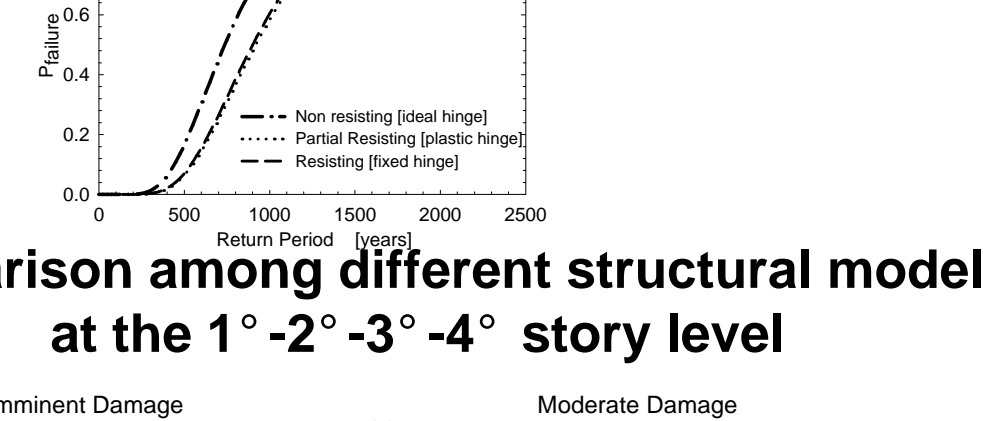
Comparison between SAC and MCEER series at 1°-2°-3°-4° story level.



Comparison among different structural models at the 1°-2°-3°-4° story level



Comparison in term of fragility curves between different values of dispersion of limit state threshold for Moderate and Imminent Damage state.



Comparison in term of fragility curves between different values of dispersion of limit state threshold and different values of damping for Moderate and Imminent Damage state.

CONCLUSIONS

The development of fragility for different cases show how important is a correct evaluation of the limit threshold for example for comparison of different retrofit techniques. Besides if uncertainties of the limit state are not considered unconservative results can be developed. Parametric analysis has been performed to show the sensitivity of different parameters on fragility curves, calculated using the proposed technique.

ACKNOWLEDGEMENTS

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