

ABSTRACT

This study presents an analytical study on the computation of seismic fragilities of structural and non-structural components contained in acute care facilities. The WC70 MCEER Demonstration Hospital is selected as a prototype building. An ensemble of the MCEER strong ground motions representative of hypothetical hospital sites on the west-coast of the US, with different hazard levels, are utilized. Fragility curves of both the structure and the non-structural components contained in the building are presented.

OBJECTIVES

This task aims to perform numerical studies on the WC70 MCEER Demonstration Hospital as a support for the experiments on the seismic fragility evaluation of non-structural components in hospital. The obtained floor motions will be used for the shake table tests of a centrifuge water chiller unit as a part of MCEER Thrust Area 2.

METHODS

Modeling of Building Structure

The WC70 Hospital is a 4-storey steel frame, symmetrical and rectangular in plan. Figure 1 shows the plan view of the building. Because of the symmetry, the building is modeled as a 2-dimensional structure. P-Δ effect from those non-seismic frames are accounted for by including the gravity column into the model. Figure 2 presents the building model.

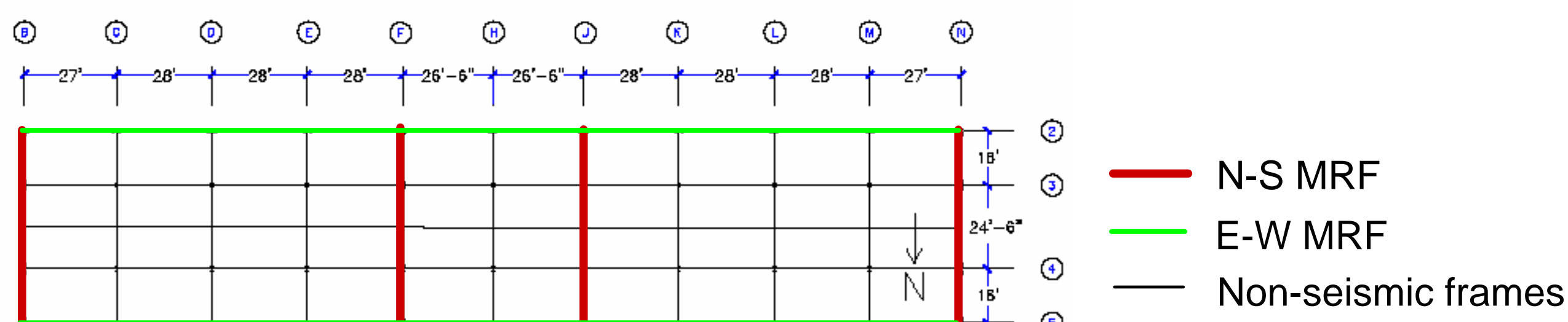


Figure 1 Plan view of the WC70 Hospital

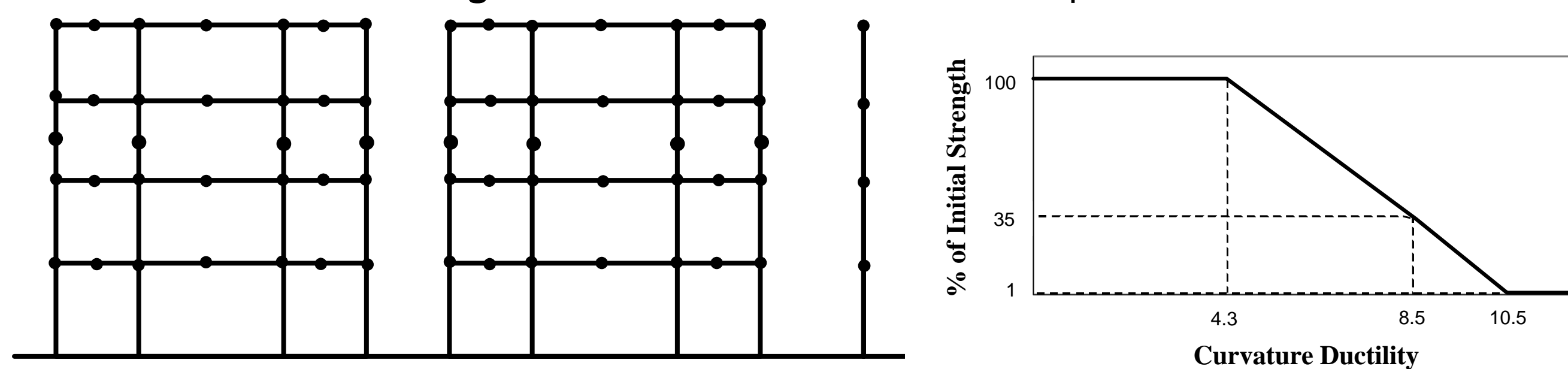


Figure 2 Structural model (N-S direction)

A bi-linear moment-curvature hysteresis with 2% curvature hardening ratio is assigned to all frame elements. The flexural strength degradation model [1] shown in Figure 3 is included to account for the brittle behaviour of the welded beam-column connection.

Modeling of Nonstructural Components

A single-degree-of-freedom spring-dashpot system is employed for modeling of the nonstructural elements. Three types of nonstructural components are considered: "resonant", "isolated", and "sliding". The resonant type has a fundamental period equal to the resonant period of the building (0.76 sec). For the "isolated" type, the element is selected to have a fundamental period of 2 sec. A stiff spring with very low yield strength is used for the "sliding" type of nonstructural component. The resonant and isolated components are assigned a damping ratio of 1% of critical. Note that there is no dashpot for the "sliding" nonstructural component, i.e. no damping. These single-degree-of-freedom systems are incorporated on roof and base floors of the building model.

Earthquake Ground Motions

An ensemble of the MCEER simulated strong ground motions [2] representative of hypothetical hospital sites on the west-coast of the US, with four different hazard levels: 2%, 5%, 10%, and 20% probabilities of exceedance in 50 years (25 earthquakes in each hazard level), are used in this study. Figure 4 illustrates the mean spectra with 5% damping. The uniform hazard spectra obtained from USGS (2002 version) are included for comparison purposes.

References: 1. Filiatrault, A., Tremblay, R., and Wanitkorkul, A. (2001) "Performance evaluation of passive damping systems for the seismic retrofit of steel moment resisting frames subjected to near field ground motions," *Earthquake Spectra* 17(3), 427-456.

2. Wanitkorkul, A. and Filiatrault, A. "Simulation of strong ground motions for seismic fragility evaluation of nonstructural components in hospitals," *MCEER Technical report (under review)*.

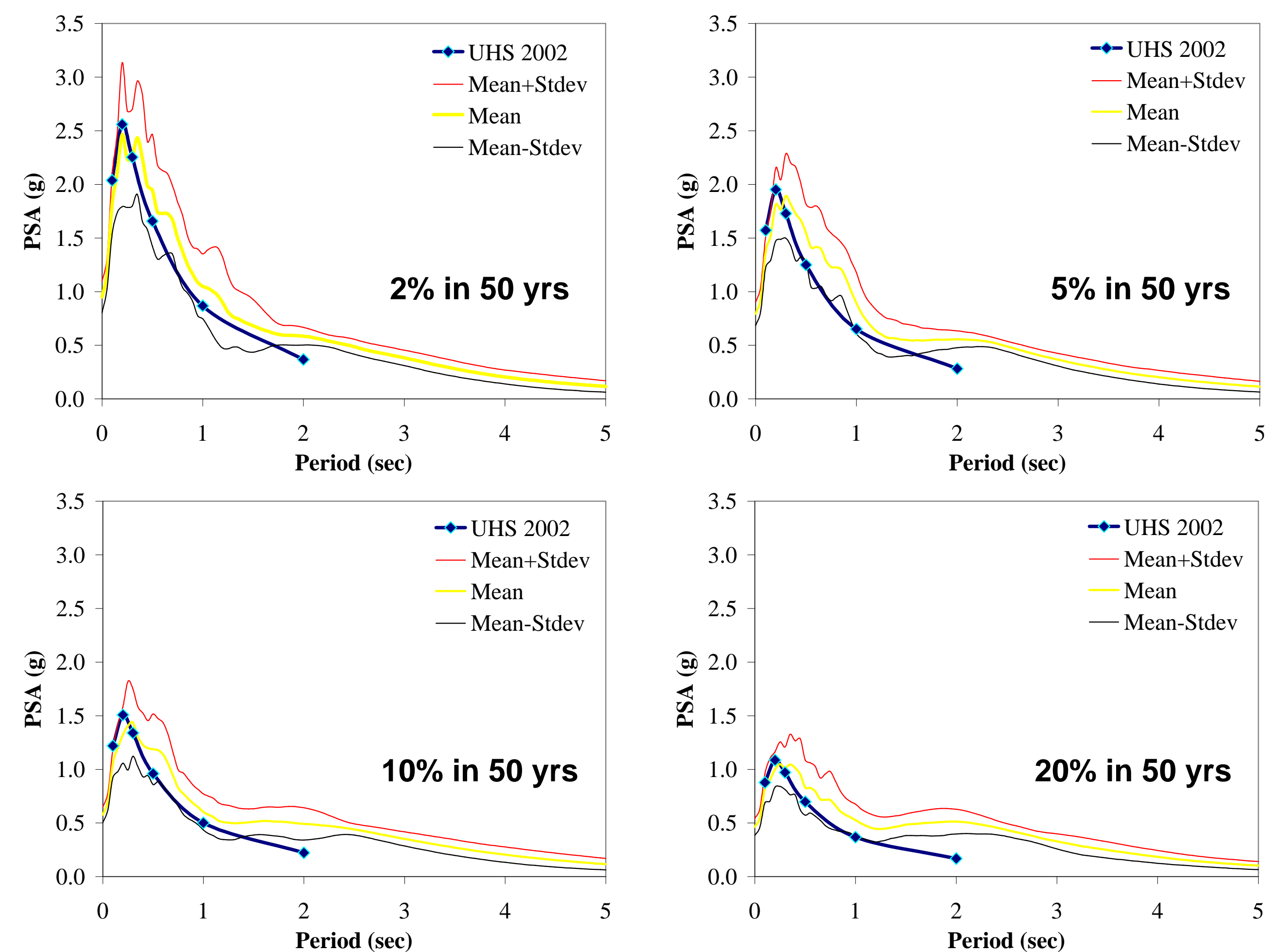


Figure 4 Pseudo-acceleration response spectra with 5% damping:

RESULTS

For structural fragilities, an inter-storey drift is chosen as the performance index. The criteria based on the NEHRP recommended provisions are selected as the inter-storey drift limit, i.e. immediate occupancy (0.7%), life safety (2.5%), and collapse prevention (5.0%). Figure 5 shows the structural fragilities. The building responses exceeds the immediate occupancy limit for all cases; however, no collapse occur. Retrofit would be needed for this structure.



Figure 5 Structural fragilities

For this building, the effect of weld fracture on the seismic fragilities is not significant. Hence, the weld fracture is neglected for the cases of nonstructural fragilities.

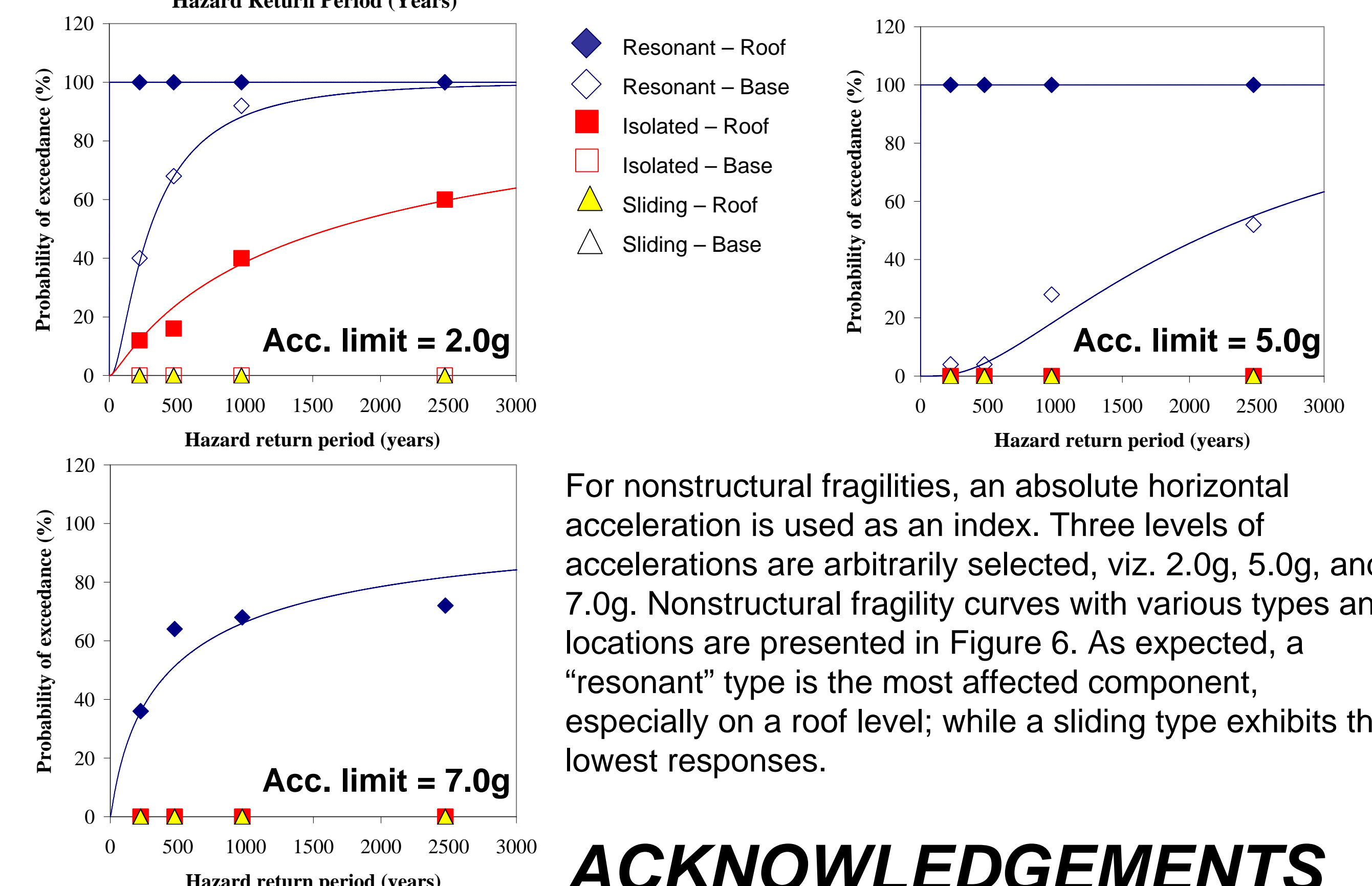


Figure 6 Non-structural fragilities

For nonstructural fragilities, an absolute horizontal acceleration is used as an index. Three levels of accelerations are arbitrarily selected, viz. 2.0g, 5.0g, and 7.0g. Nonstructural fragility curves with various types and locations are presented in Figure 6. As expected, a "resonant" type is the most affected component, especially on a roof level; while a sliding type exhibits the lowest responses.

ACKNOWLEDGEMENTS

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