DESIGN OF SEISMICALLY ISOLATED STRUCTURE FOR TARGET RELIABILITY

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Motivation and Objective

❖ Target safety reliability for seismic design (ASCE 7)

Risk Category	Conditional Probability of Failure Caused by the MCER shaking hazard (%)
I&II	10
III	5
IV	2.5

❖ Safety of seismically isolated structure

(Photo courtesy of : USGS)

Safety of Supported Structure

(Photo courtesy of : Alireza Sarebanha)

Safety of Isolators

❖ Current design regulation

- Displacement capacity based on average demand under MCER
- No displacement restraint is required
- Isolator capacity is the same for different risk categories

Following minimum code requirement

Risk Category	Calculated probability of failure of upper structure (%)	Calculated probability of failure of Isolator (%)	Combined probability of failure (%)	Target probability of failure (%)
I&II	<0.1	43	43	10
III	<0.1	43	43	5
IV	<0.1	43	43	2.5

Resulted Prob. of failure >> Target Prob. of failure

❖Objective

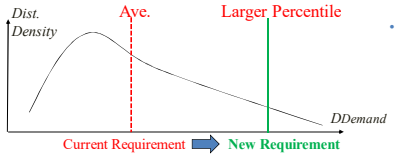
Seek efficient solution to design seismically isolated structure to meet target safety reliability

Methodology

❖ Possible solutions investigated

Meet target safety reliability → Provide **enough capacity** for isolation system beyond average MCER demand

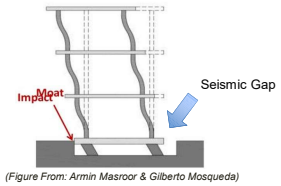
Method I: Large enough isolator without displacement restraint



- Method I
  - Force Demand on upper structure
  - Isolator Deformation

Deformation demand is mostly taken by isolator

Method II: Physical stopping mechanism (Moat Wall)

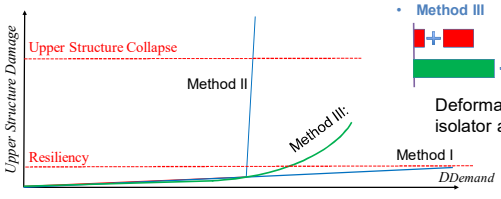


(Figure From: Armin Masroor & Gilberto Mosqueda)

- Method II
  - Force Demand on upper structure
  - Isolator Deformation

Deformation demand is mostly taken by upper structure

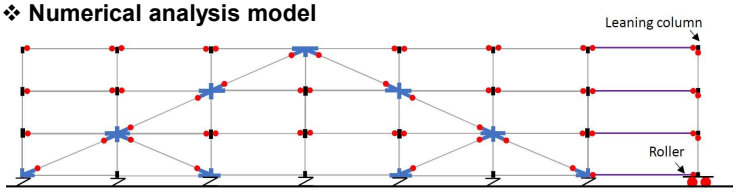
Method III: Isolator with internal soft stopping mechanism (Stiffening)



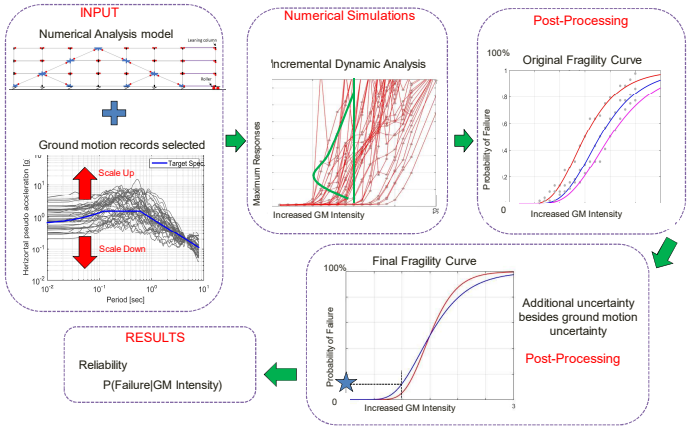
- Method III
  - Force Demand on upperstructure
  - Isolator Deformation

Deformation demand is shared by isolator and upper structure

❖ Numerical analysis model

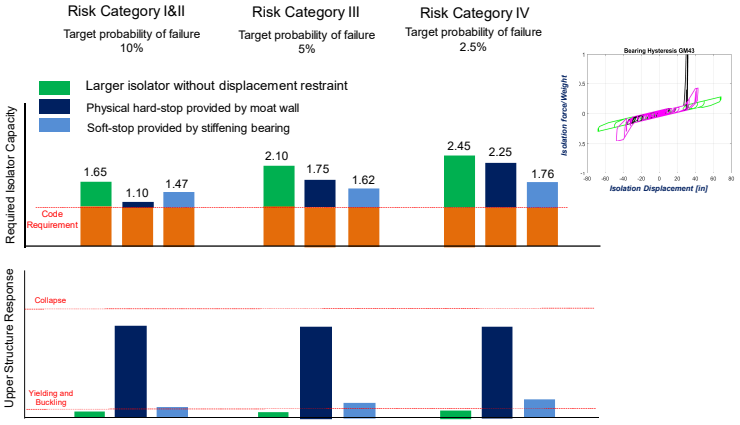


❖ Probabilistic framework (FEMA P695)



Selected Results

❖ Required capacities considering three methods



Using of stiffening isolator is the **an efficient and economical** solution

Main Conclusions

❖ Safety of seismically isolated structure requires safety of both upper-structure and isolator

❖ Design of seismically isolated structure following minimum code requirement does not achieve required safety reliability

❖ Seismic isolation system which can provide capacity beyond code requirement is needed for achieving target safety reliability, using stiffening isolator is an efficient solution

Selected References

[1] F. McKenna, M. Scott and G. Fenves, "Nonlinear finite-element analysis software architecture using object composition," *J. Comput. Civ. Eng.* , Vols. 10.1061/(ASCE)CP.1943-5487-0000002, pp. 96-107, 2010.
[2] P. Uriz and S. Mahin, "Toward earthquake-resistant design of concentrically braced steel-frame structures," Berkeley, CA, 2008.
[3] Zayas, V., Low, S., and Mahin, S., 1990. A Simple Pendulum Technique for Achieving Seismic Isolation, Earthquake Spectra 6, 317–333.
[4] Masroor, A., and Mosqueda, G., 2015. Assessing the Collapse Probability of Base-Isolated Buildings Considering Pounding to Moat Walls Using the FEMA P695 Methodology, Earthquake Spectra 31, 2069-2086.