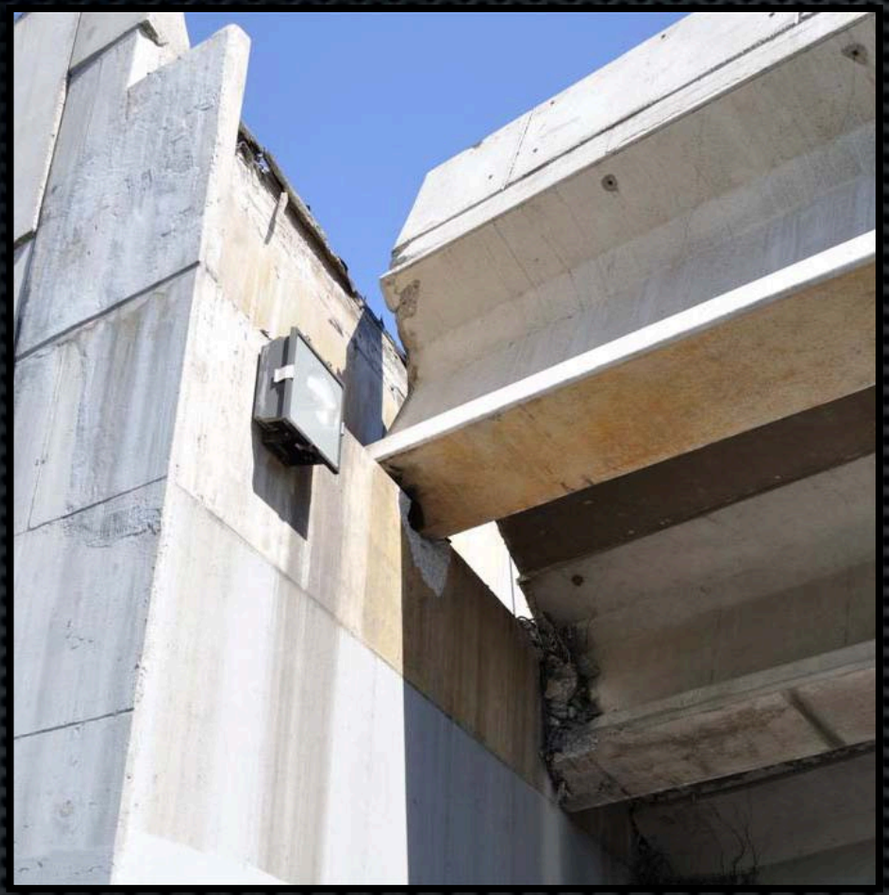
Performance-Based Seismic Assessment of Skewed Bridges



by
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PEER Transportation Systems Research Program

Pacific Earthquake Engineering Research Center
2011 PEER ANNUAL MEETING
September 30 - October 1, 2011
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PEER

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Goals

Modeling skew abutment response

Developing *NLTH* simulation models for skew bridges

Exploring and quantifying skew-bridge response

$$\lambda(DV) = \int\int\int G(DV \mid DM) \cdot dG(DM \mid EDP) \cdot dG(EDP \mid IM) \cdot d\lambda(IM)$$

Previous Studies

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Straight Abutment:

Aviram, Mackie, and Stojadinovic 2008

Johnson et al. (2009), Kotsoglou and Pantazopoulou (2010), Mackie and Stojadinovic (2007), Paraskeva et al. (2006)

Skewed Abutment:

Abdel-Mohti and Pekcan (2008)

Meng and Lui (2000), Maragakis (1984), Wakefield et al. (1991), Ghobarah and Tso (1974)

Outcome Summary

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1. New Skewed Bridge Modeling Technique
2. Efficient Ground Motion Intensity Measure (*IM*)
3. Trend Observations of Skewed Bridge Response
4. Multi-phase Probabilistic Assessment of Structural Response to Seismic Excitations (M-PARS) Method

Anatomy of Bridge Model

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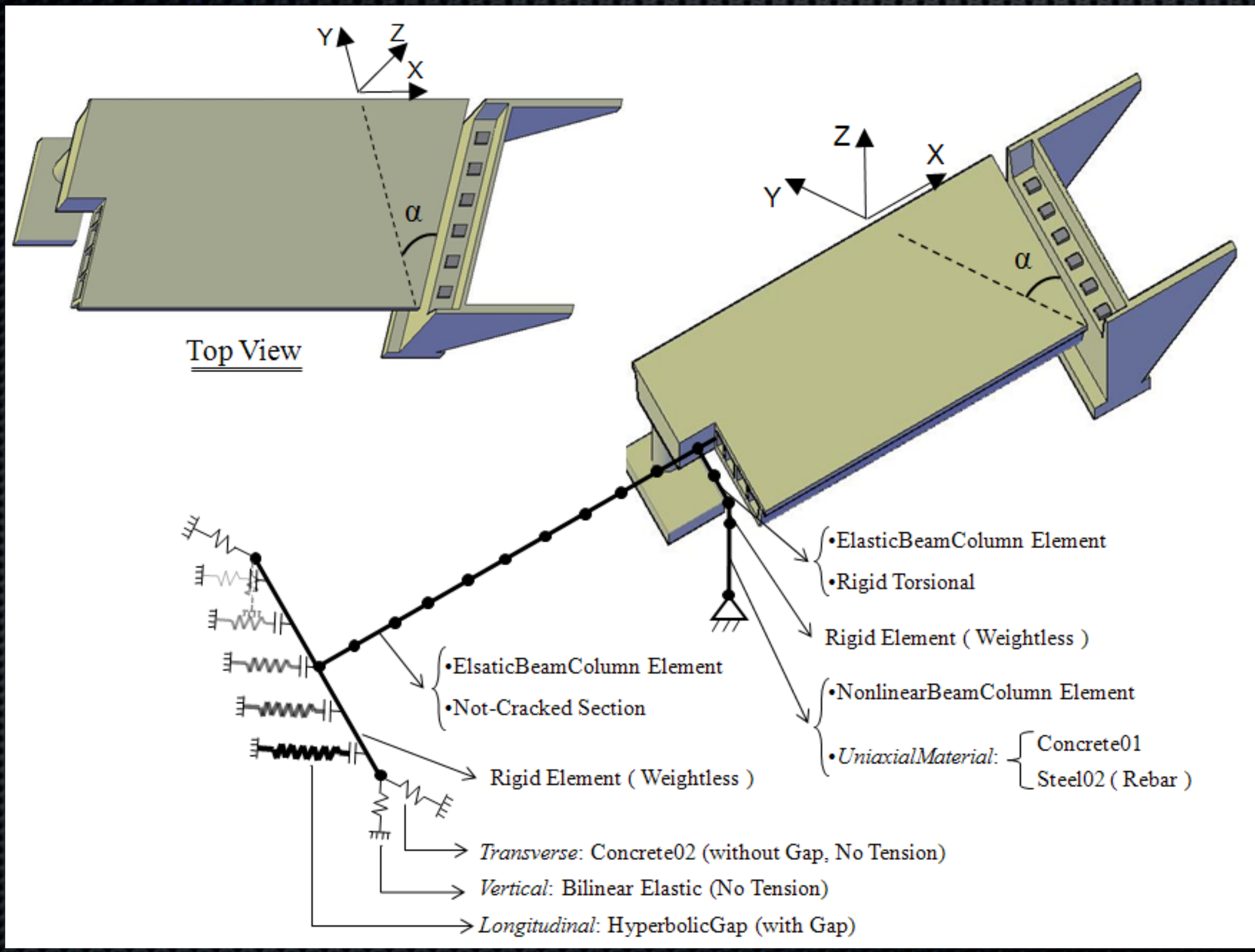

Abutment Modeling

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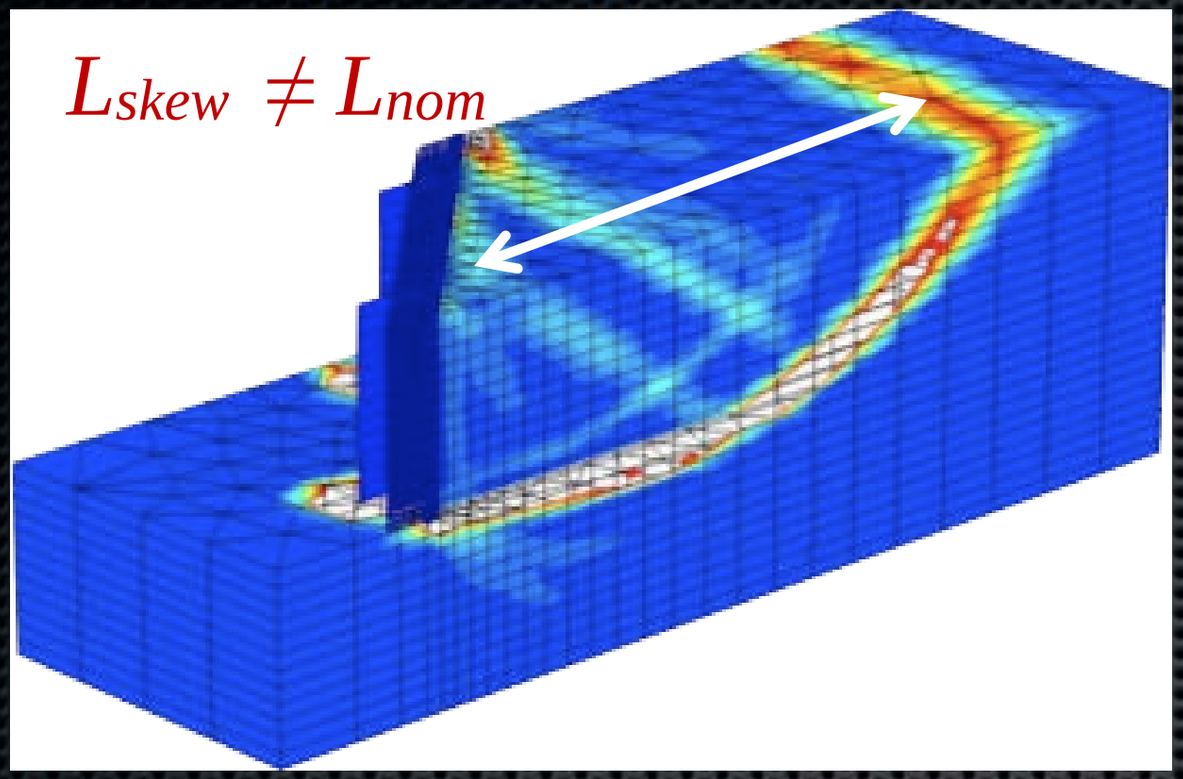

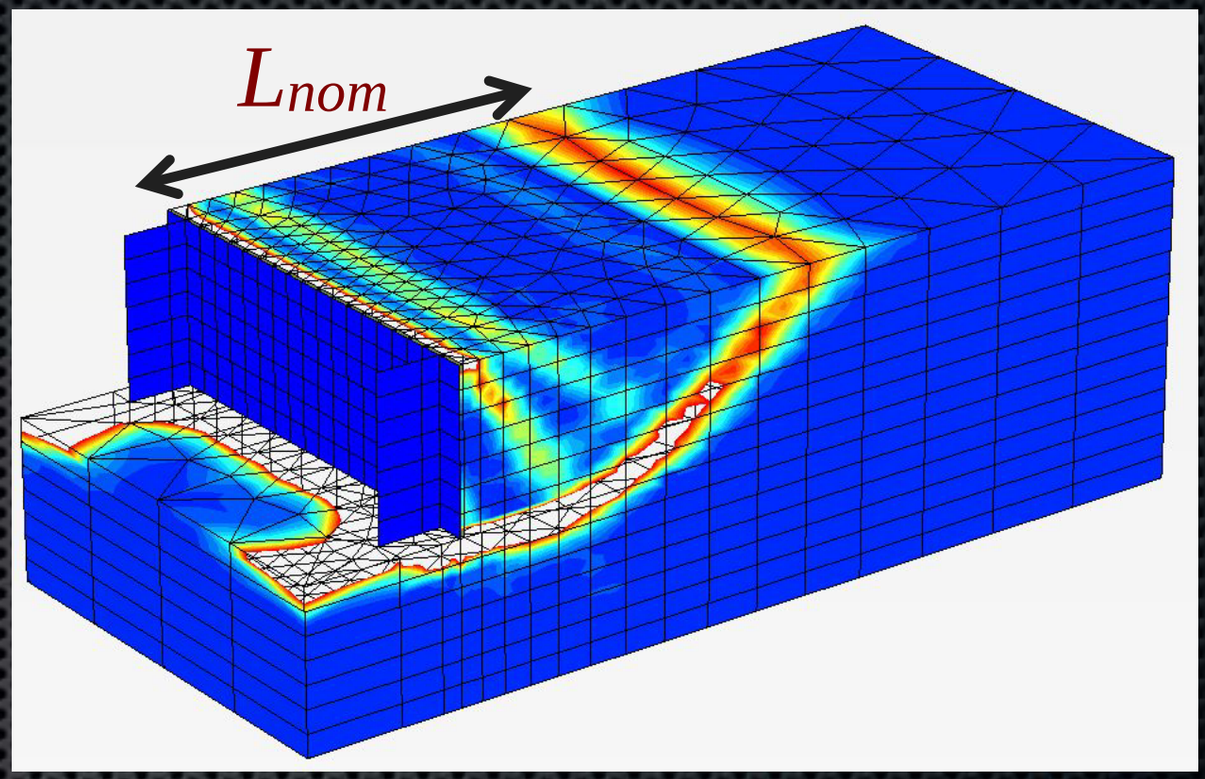

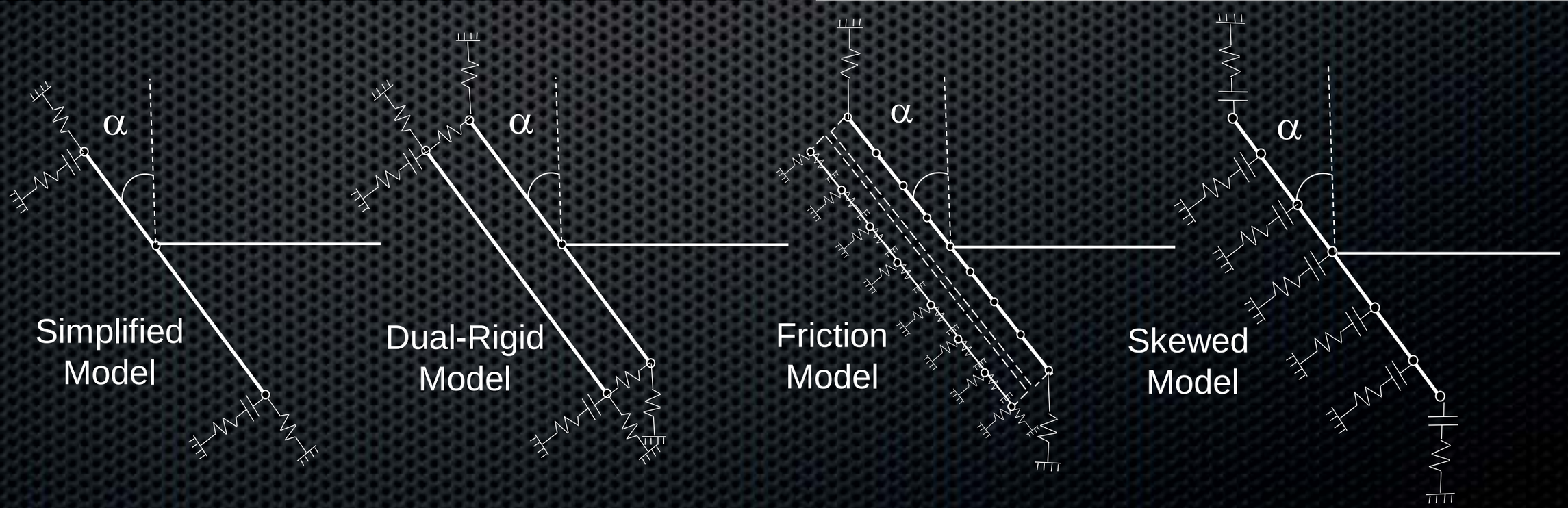

Shear Key Modeling

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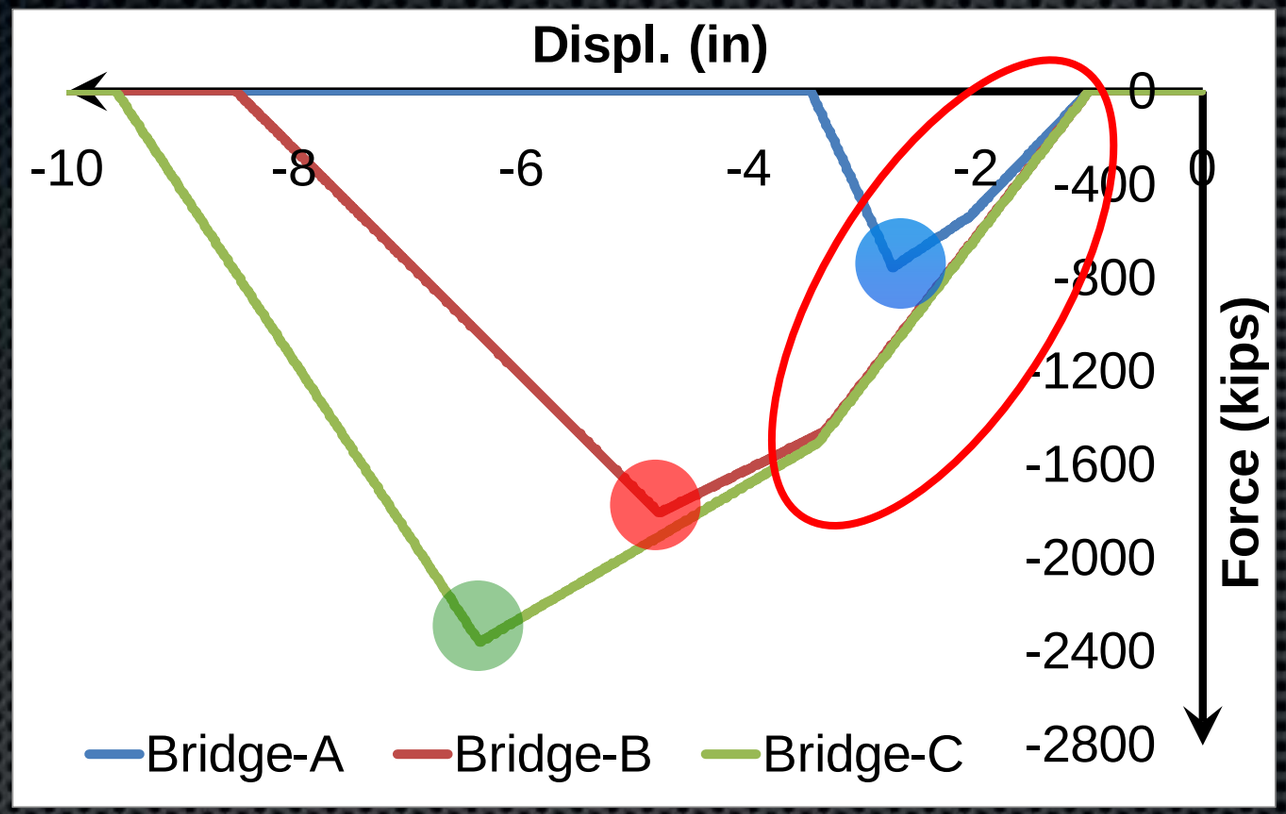

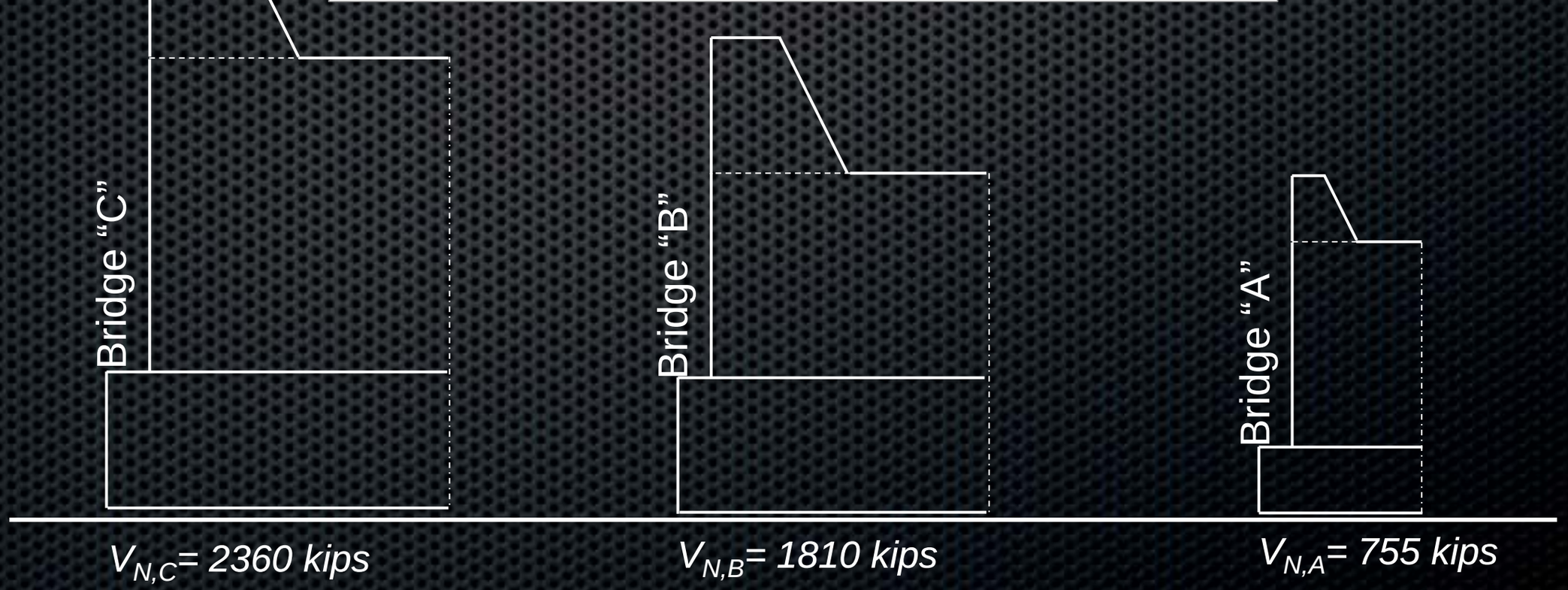

Bridge Matrix

The Jack Tone Road On-Ramp Overcrossing

The La Veta Avenue Overcrossing

The Jack Tone Road Overhead

Bridge Matrix

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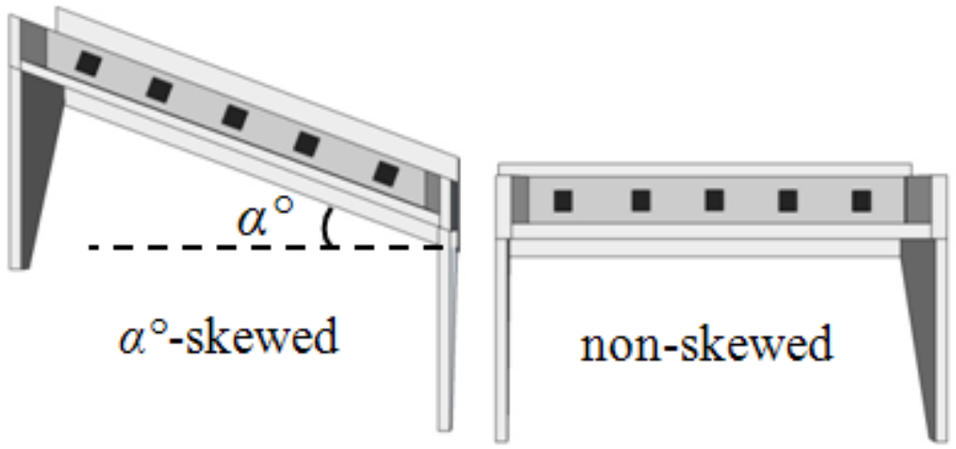
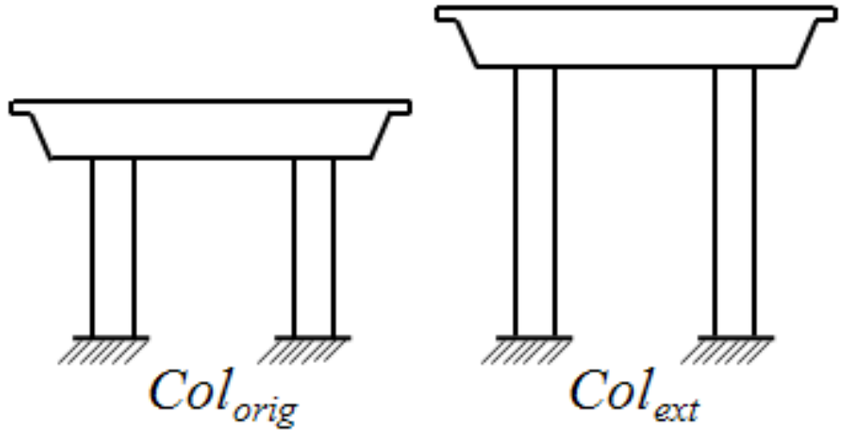
Abutment skew angle
- 0°
- 15°
- 30°
- 45°
- 60°



Column-bent height
- ➢Original height (Col_{orig})
- ➢Extended height ($Col_{ext} = 1.5 \times Col_{orig}$)



Span arrangement
- ➢Symmetric
- ➢Asymmetric

Bridges	Symmetric	Asymmetric
"Bridge A"	L_A L_A	$1.2L_A/1.1$ $L_A/1.1$
"Bridge B"	L_B L_B	$1.2L_B/1.1$ $L_B/1.1$
"Bridge C"	$1.1L_C$ L_C $1.1L_C$	$1.2L_C$ L_C L_C

Bridge Matrix

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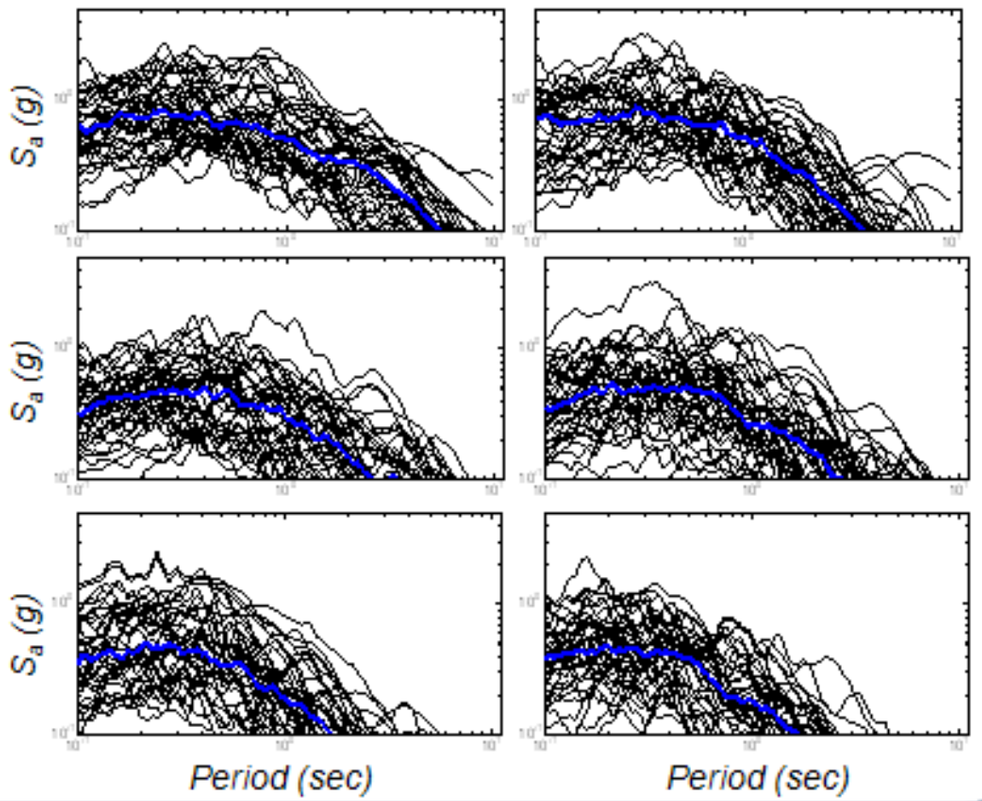
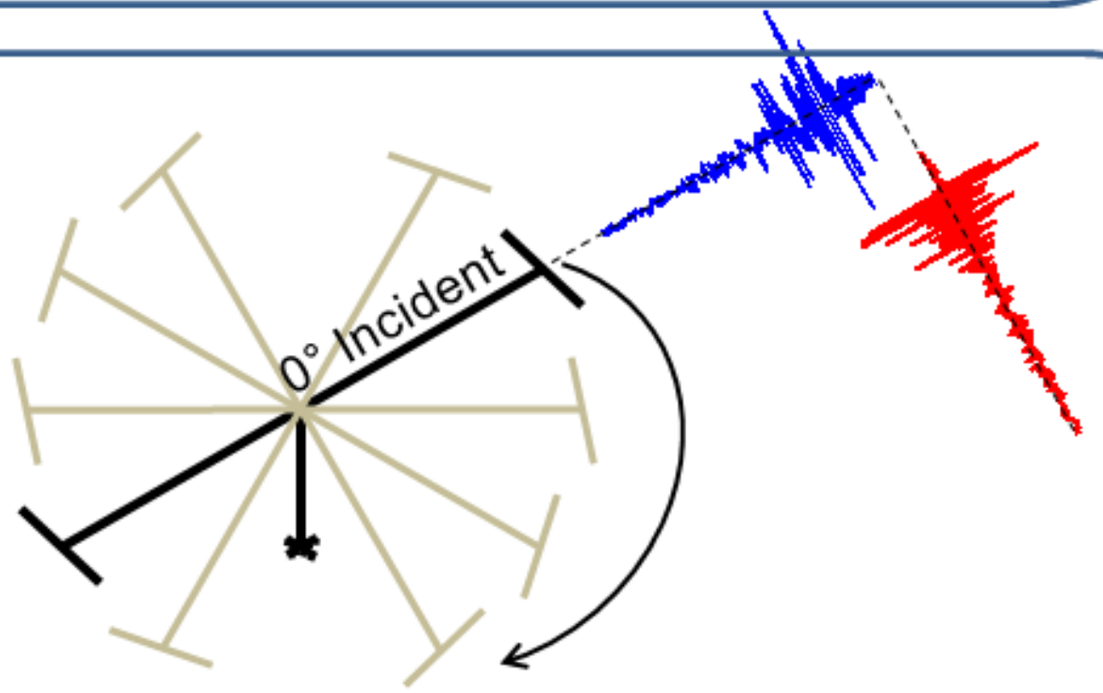
Ground Motion Type

- ➢Pulse-like
- ➢Soil-site
- ➢Rock-site



Incidence Angle

- 0°
- 30°
- 60°
- 90°
- 120°
- 150°



Efficient GM Intensity Measure

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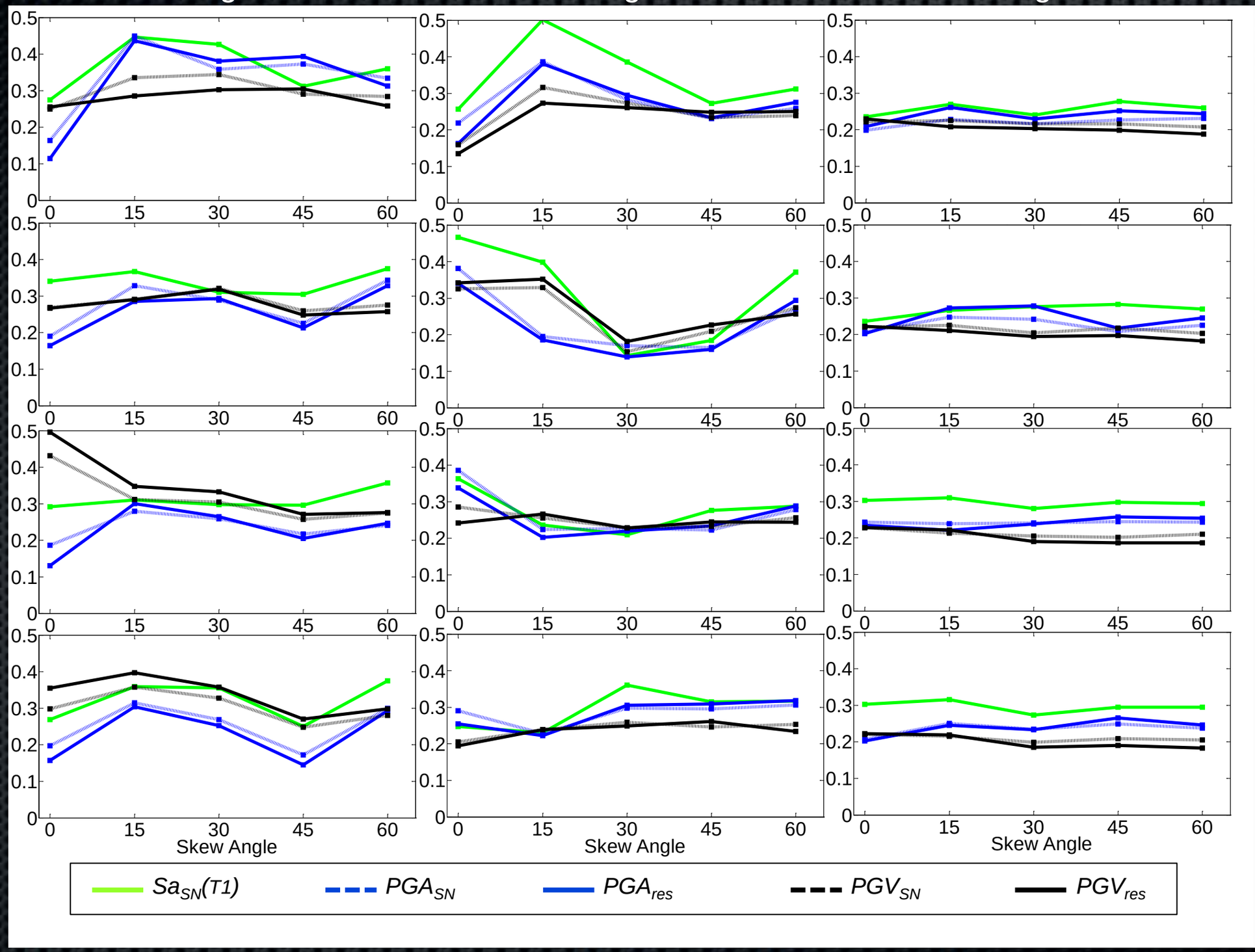
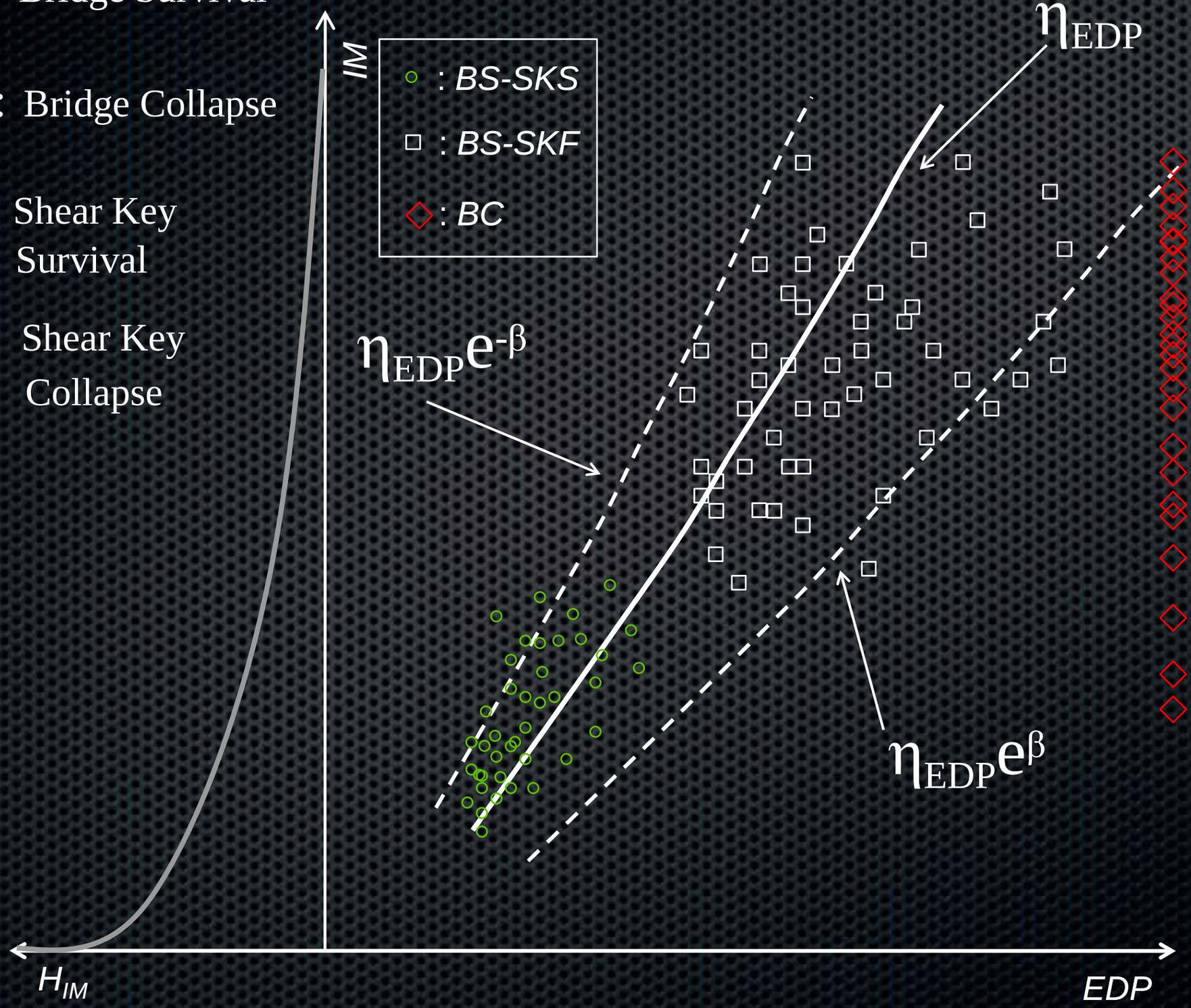


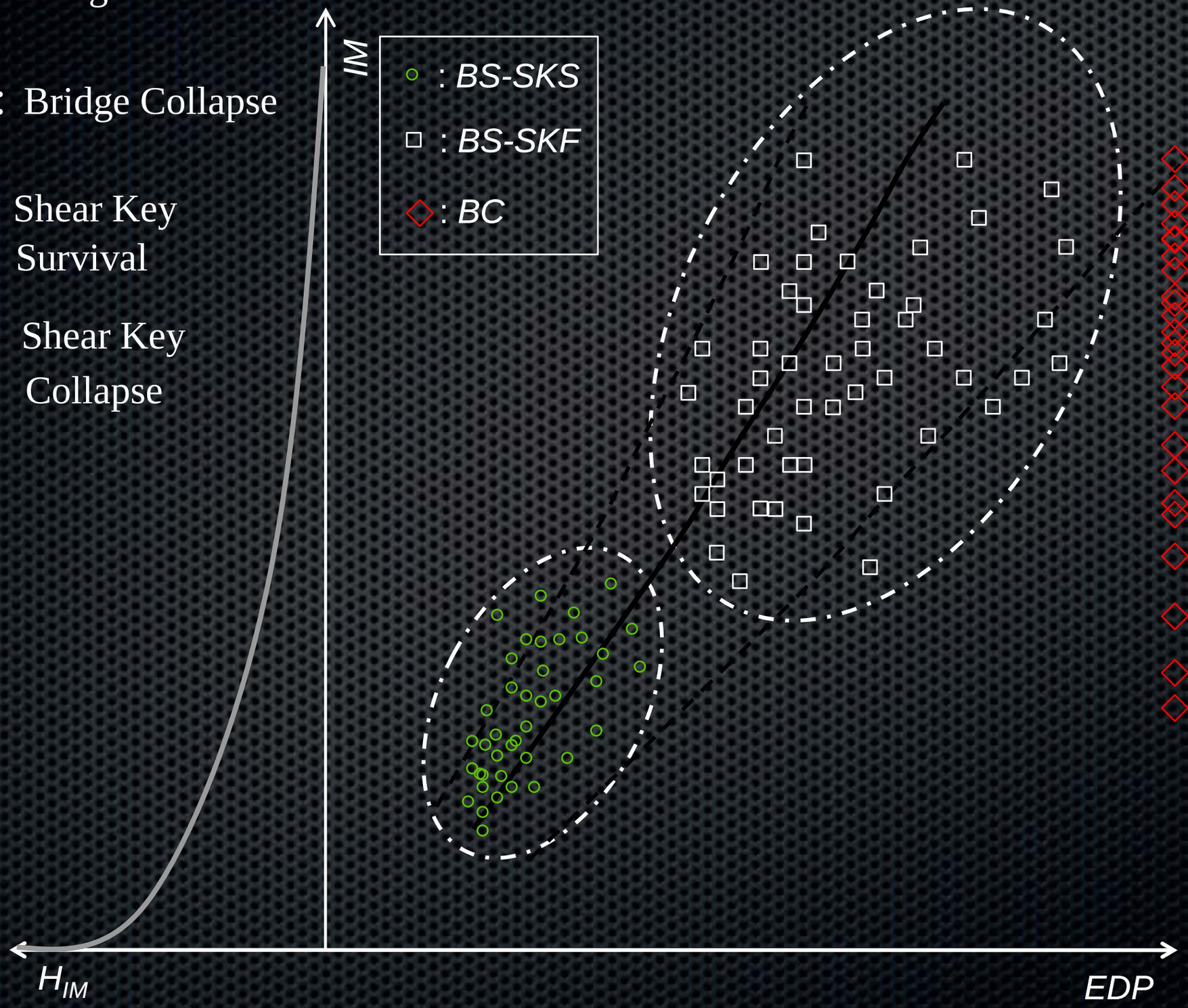
Traditional IM-EDP

- ***BS***: Bridge Survival
- ***BC***: Bridge Collapse
- ***SKS***: Shear Key Survival
- ***SKS***: Shear Key Collapse



Multi-phase IM-EDP

- ***BS***: Bridge Survival
- ***BC***: Bridge Collapse
- ***SKS***: Shear Key Survival
- ***SKS***: Shear Key Collapse



Multi-phase IM-EDP

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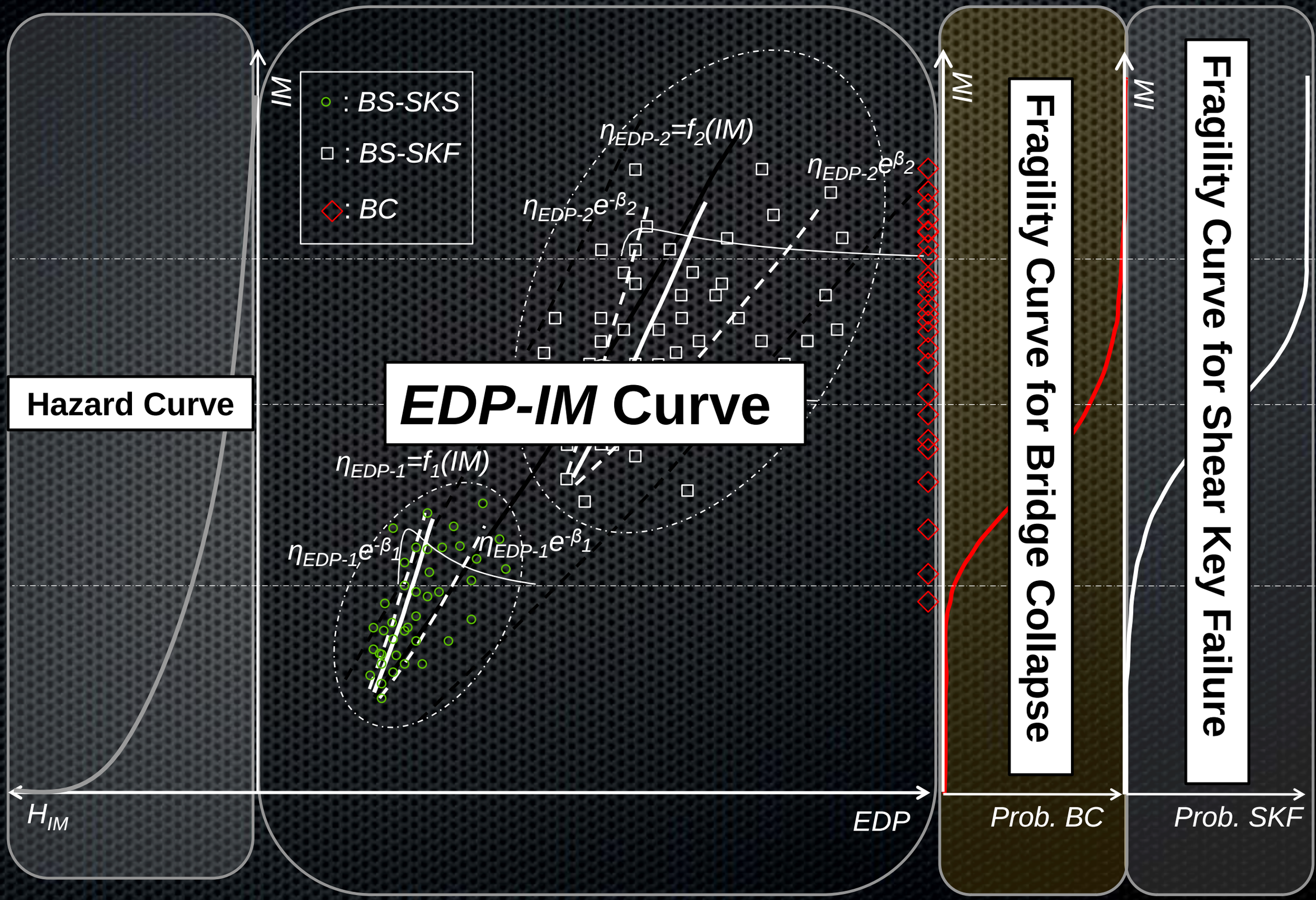

Deck Rotation – Bridge A

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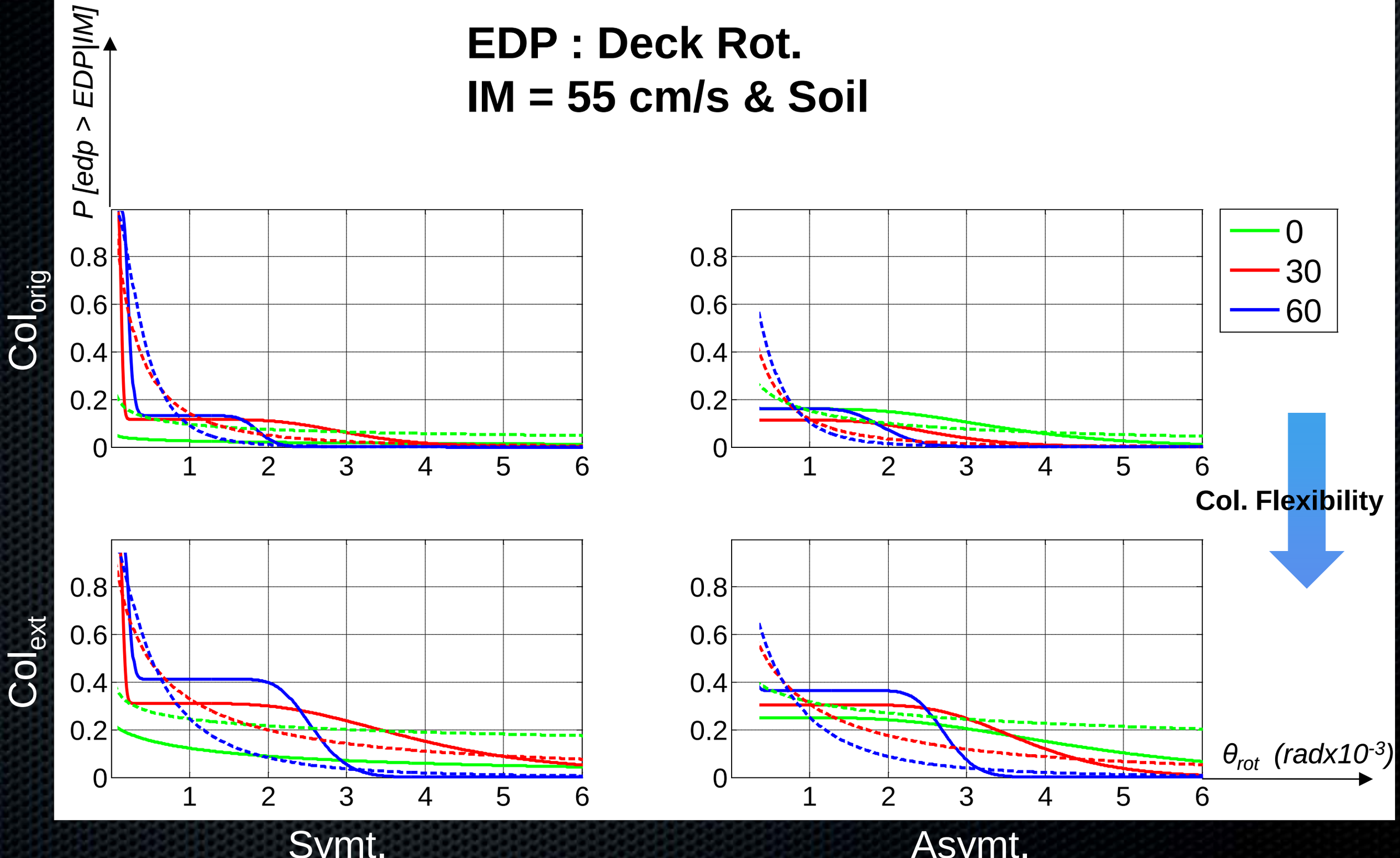
EDP : Deck Rot.
IM = 55 cm/s & Soil



Deck Rotation – Bridge A

PEER

EDP : Deck Rot.
IM = 55 cm/s & Soil

$P\,[edp > EDP|IM]$

Col_{orig}

Col_{ext}

0
30
60

Asymmetry

θ_{rot} $(radx10^{-3})$

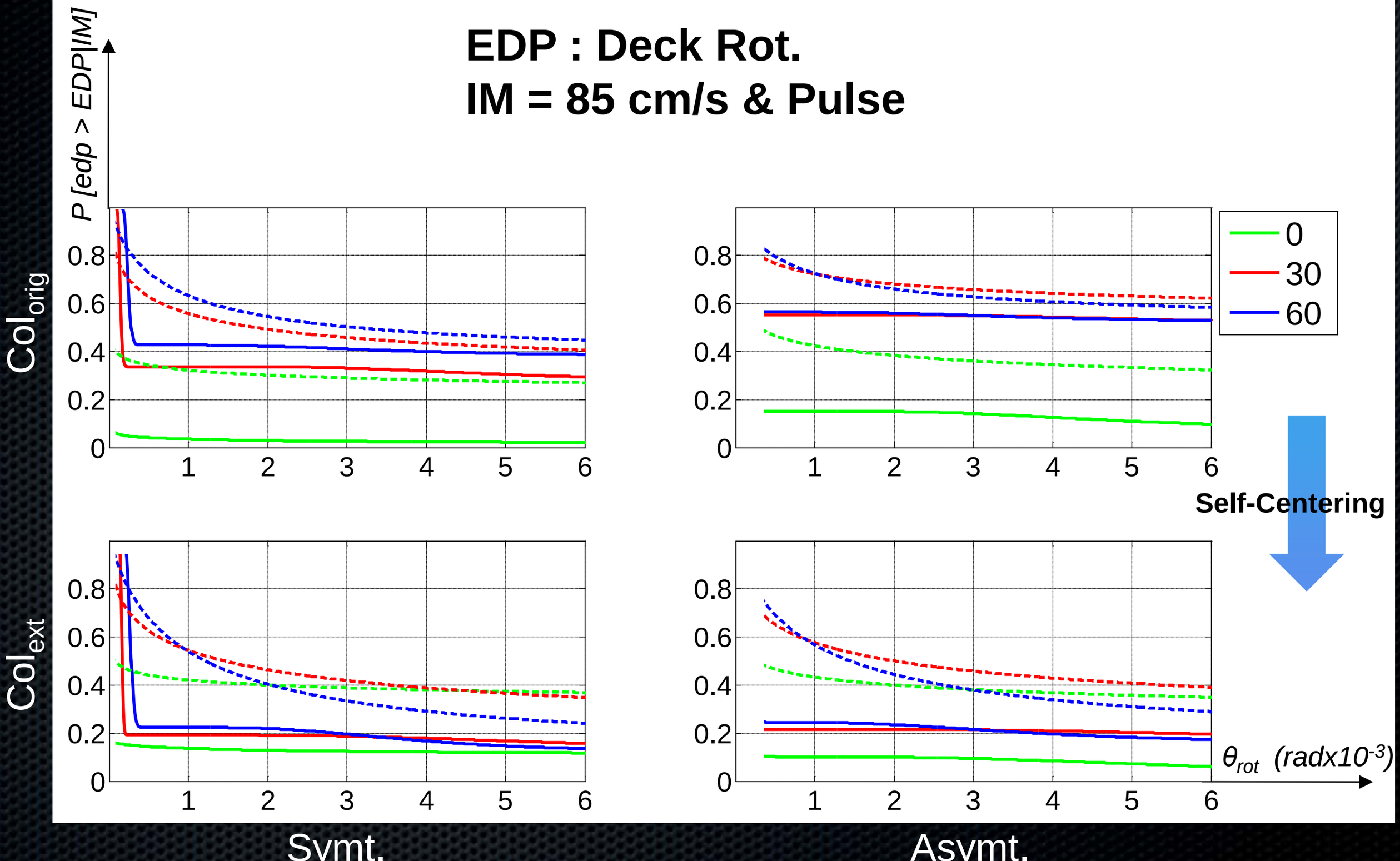
Symt.

Asymt.

Deck Rotation – Bridge A

PEER

EDP : Deck Rot.
IM = 85 cm/s & Pulse



Col. Drift Ratio – Bridge A

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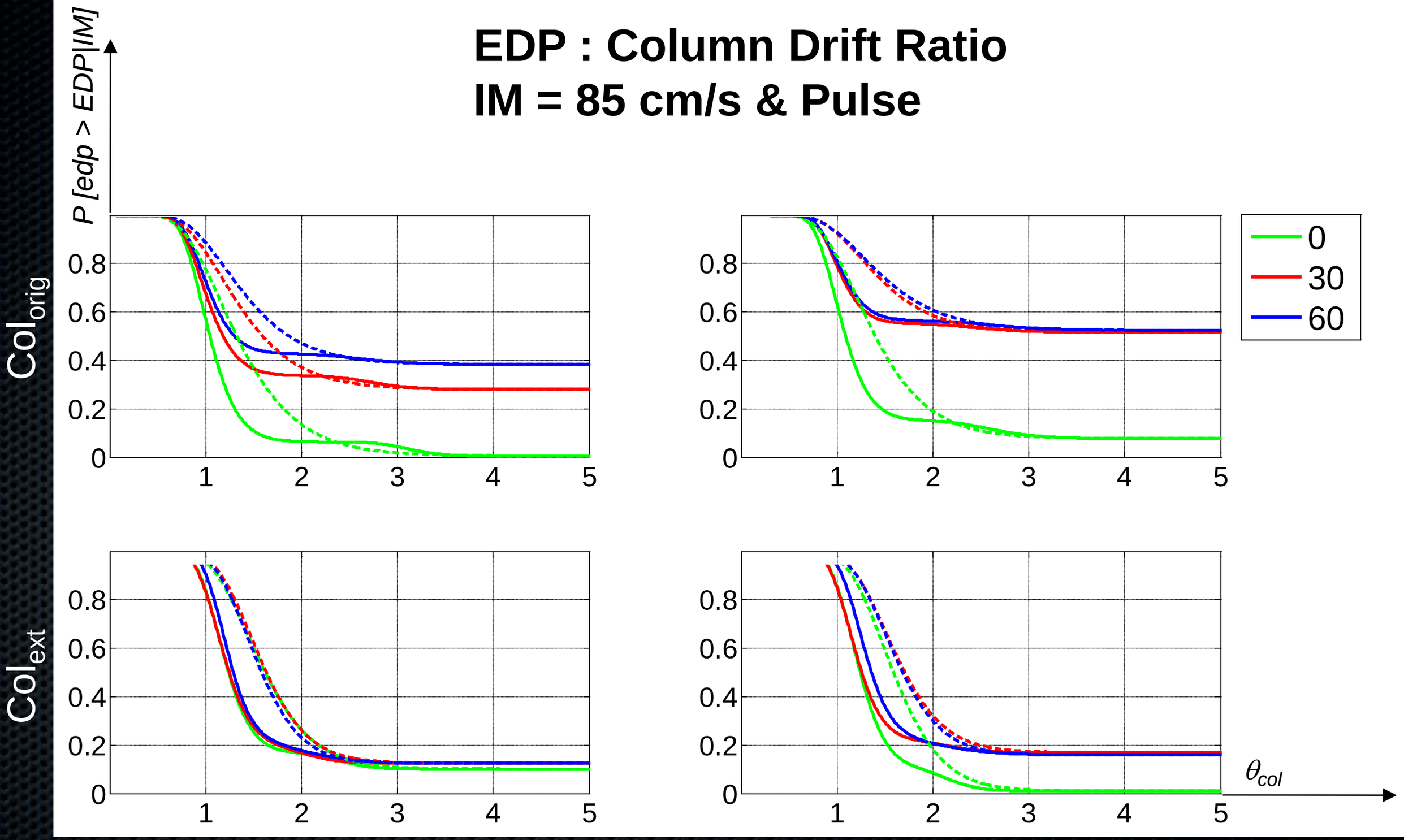
EDP : Column Drift Ratio
IM = 85 cm/s & Pulse



Future Research

1. Extension of the study to other type of bridge configuration:
   - Abutments (e.g., monolithic),
   - Geometry (e.g., curved deck),
   - Deck configuration (e.g., seat-type),
   - New Technologies (e.g., self-centering columns)
2. Define rigorous structural damage measures and collapse indicators.
3. Performance assessment on the network level.
4. Enhancement in component and ground motion modeling