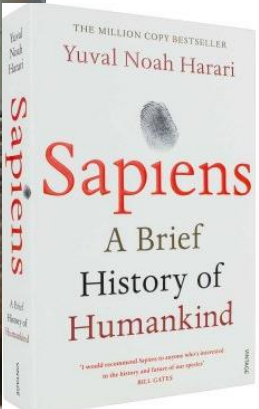




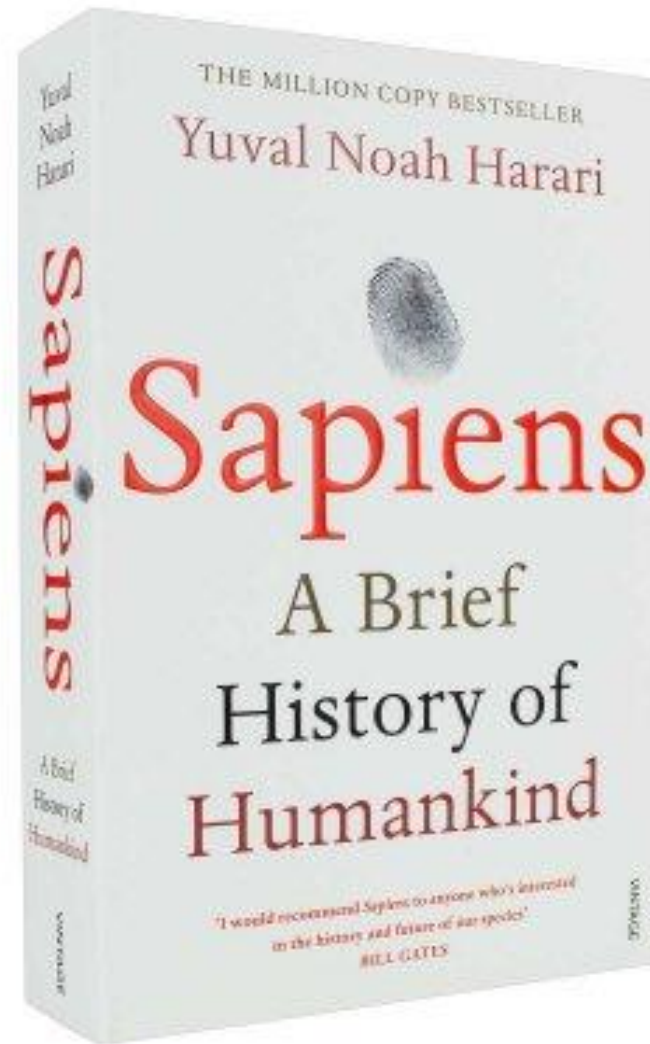
It depends:
The best answer for most causal
questions in earthquake engineering

Nikolaos Karaferis, Gerontati Angeliki, Dimitrios Vamvatsikos

This is all Terje's fault.....back in 2016



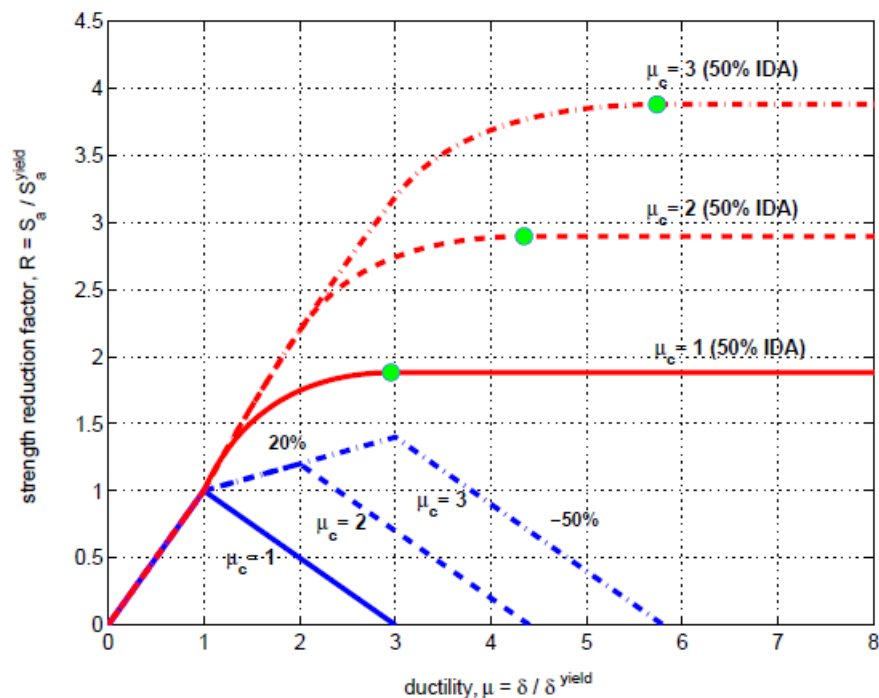
Let us zoom in a bit



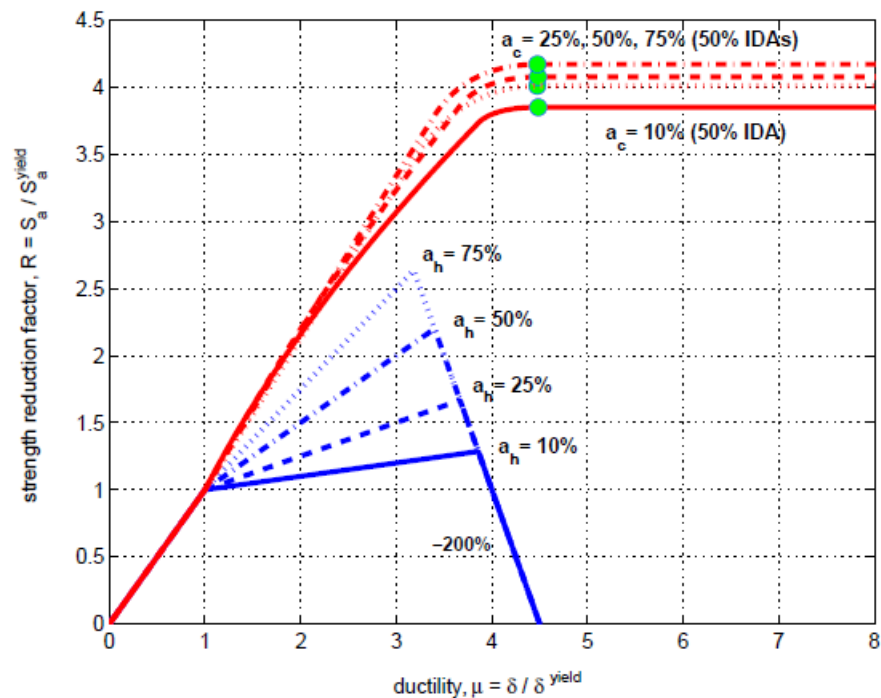
What is wrong with Sapiens?

- Author offers very convincing answers to **important milestones** in human societal evolution
- Reaching each milestone is explained by a **single concept** and attributed to a **single cause**
- Very convincing if you are **not** an earthquake engineer
- Non-engineers like **simple explanations** that make the matter go away with minimal hassle
- Earthquake engineers **thrive in mayhem**

Does the backbone shape matter?



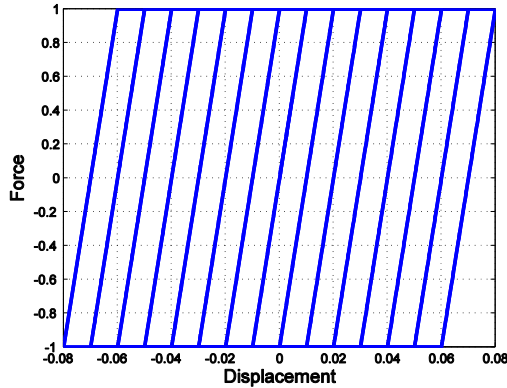
- Increasing μ_c helps performance.



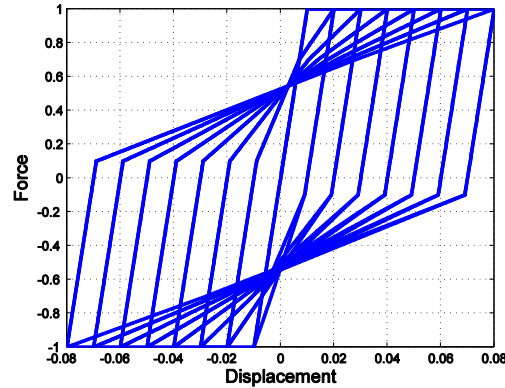
- Increasing a_h has negligible effects if same μ_{eq} .

Are full loops better than skinny ones?

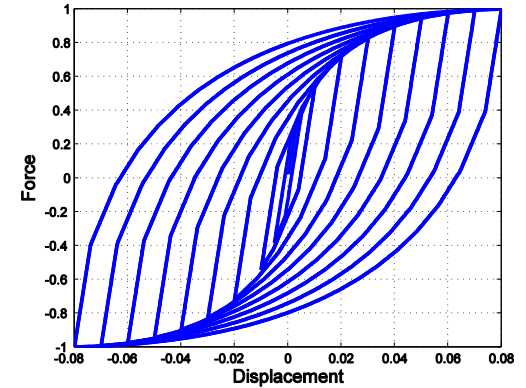
FULL DISSIPATION



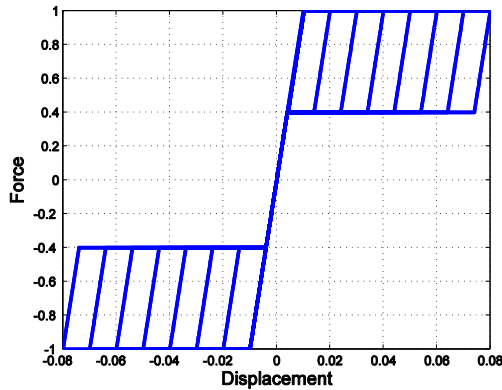
Kinematic hardening



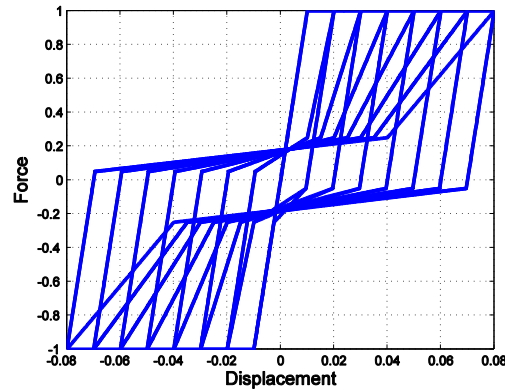
Peak-oriented



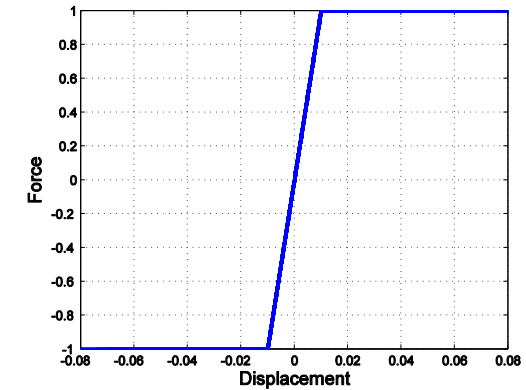
Curved kinematic hardening



Flag-shaped



Pinching



Nonlinear elastic



ZERO DISSIPATION

Is Soil-Structure-Interaction detrimental?

Journal of Earthquake Engineering, Vol. 4, No. 3 (2000) 277–301
© Imperial College Press

SEISMIC SOIL-STRUCTURE INTERACTION: BENEFICIAL OR DETRIMENTAL?

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Received 12 November 1999

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Accepted 3 March 2000

The role of soil-structure interaction (SSI) in the seismic response of structures is reexplored using recorded motions and theoretical considerations. *Firstly*, the way current seismic provisions treat SSI effects is briefly discussed. The idealised design spectra of the codes along with the increased fundamental period and effective damping due to SSI lead invariably to reduced forces in the structure. Reality, however, often differs from this view. It is shown that, in certain seismic and soil environments, an increase in the fundamental natural period of a moderately flexible structure due to SSI may have a detrimental effect on the imposed seismic demand. *Secondly*, a widely used structural model for assessing SSI effects on inelastic bridge piers is examined. Using theoretical arguments and rigorous numerical analyses it is shown that indiscriminate use of ductility concepts and geometric relations may lead to erroneous conclusions in the assessment of seismic performance. Numerical examples are presented which highlight critical issues of the problem.

Keywords: Soil-structure interaction, earthquake, ductility, inelastic response, seismic regulations, bridge.

**I think I can let someone
else take this one**

Does duration matter?

EARTHQUAKE ENGINEERING AND STRUCTURAL DYNAMICS

Earthquake Engng Struct. Dyn. 2006; **35**:21–38

Published online 19 September 2005 in Wiley InterScience (www.interscience.wiley.com). DOI: 10.1002/eqe.529

Ground motion duration effects on nonlinear seismic response

Iunio Iervolino, Gaetano Manfredi*[†] and Edoardo Cosenza

*Department of Structural Analysis and Design, University of Naples Federico II,
Via Claudio 21, 80125, Naples, Italy*

This one too

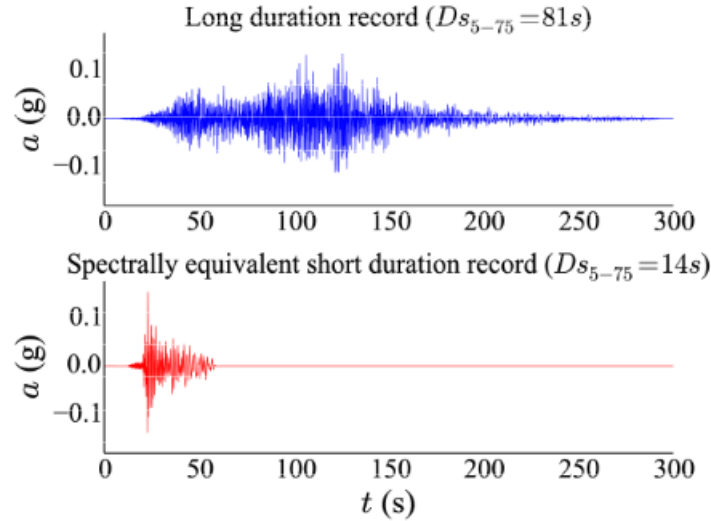
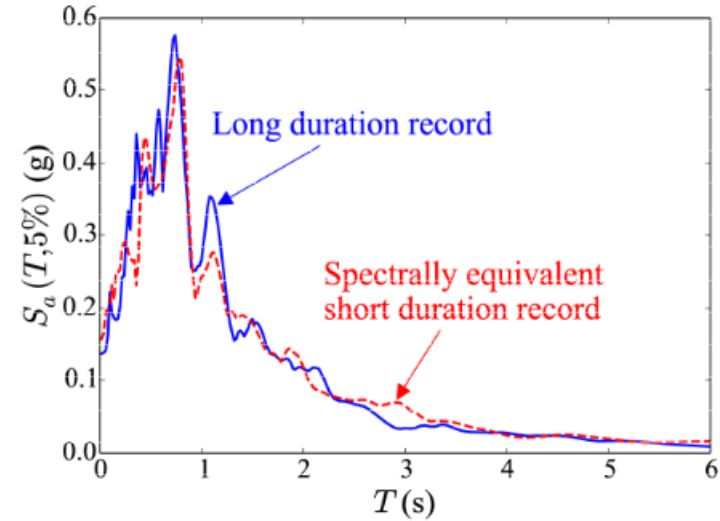
SUMMARY

The study presented in this paper addresses the question of which nonlinear demand measures are sensitive to ground motion duration by statistical analyses of several case studies. A number of single degree of freedom (SDOF) structures were selected considering: (1) four oscillation periods; (2) three evolutionary and non-evolutionary hysteretic behaviours; (3) two target ductility levels.

Effects of duration are investigated, by nonlinear dynamic analysis, with respect to six different demand indices ranging from displacement ductility ratio to equivalent number of cycles. Input is made of six real accelerogram sets representing three specific duration scenarios (small, moderate and large duration). For all considered demand quantities time-history results are formally compared by statistical hypothesis test to assess the difference, if any, in the demand concerning different scenarios. Incremental dynamic analysis curves are used to evaluate duration effect as function of ground motion intensity (e.g. spectral acceleration corresponding to the SDOF's oscillation period). Duration impact on structural failure probability is evaluated by fragility curves.

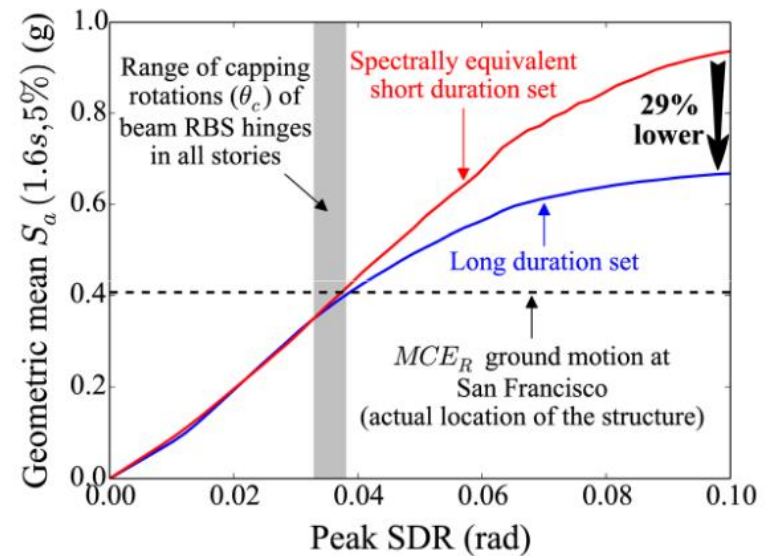
The results lead to the conclusion that duration content of ground motion is statistically insignificant to displacement ductility and cyclic ductility demand. The conclusions hold regardless of SDOF's period and hysteretic relationship investigated. Copyright © 2005 John Wiley & Sons, Ltd.

But does it matter?

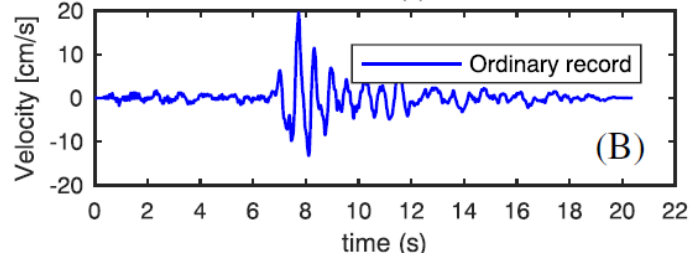
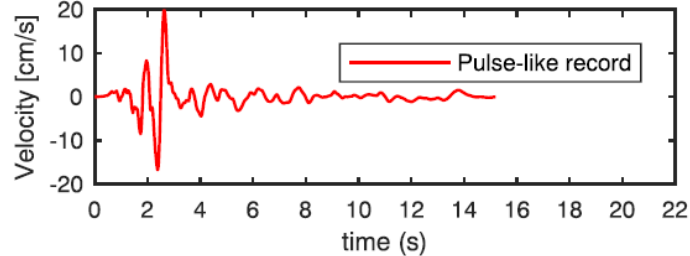
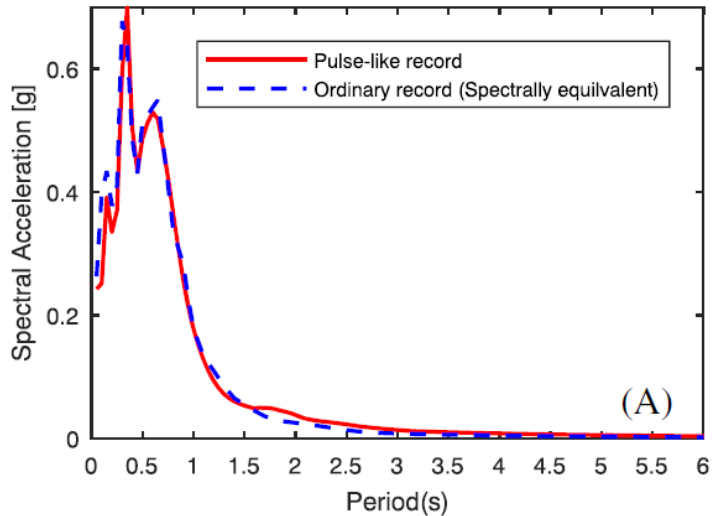


Spectral twins!

Chandramohan, Baker, Deierlein
2015

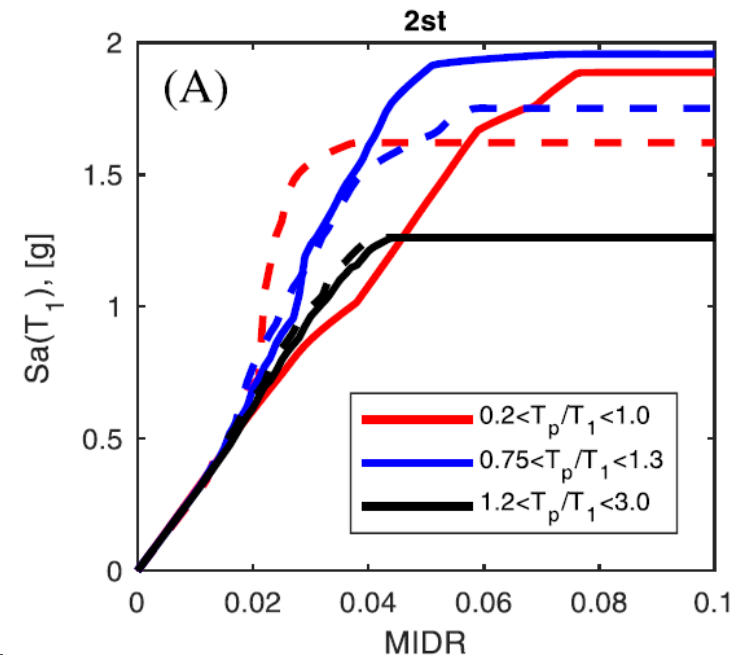


Is a pulse-like motion worse?

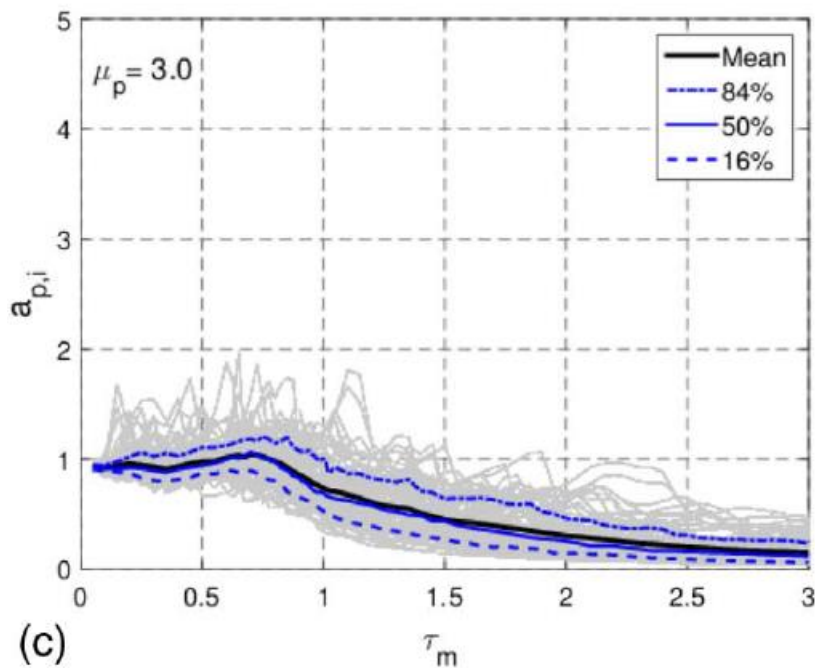
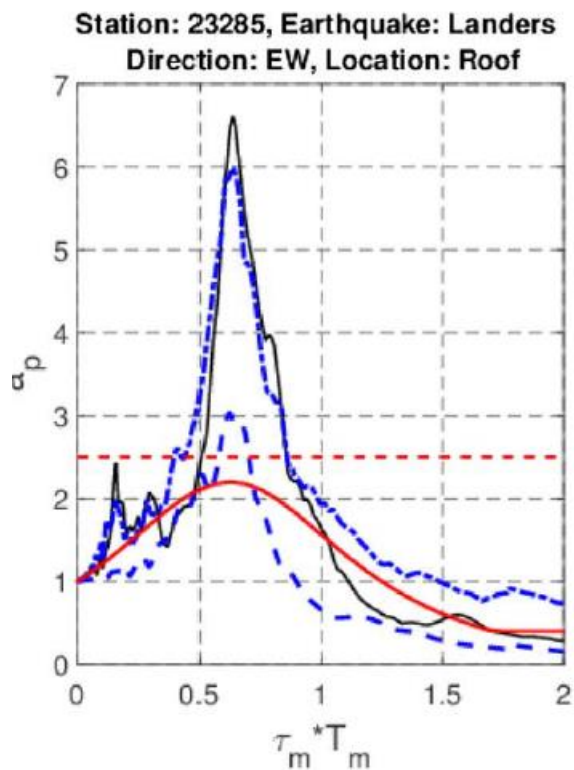


More Spectral Twins!

Kohrangi, Vamvatsikos, Bazzurro
2018



Does NS component resonance matter?



Of course it does if your component is elastic

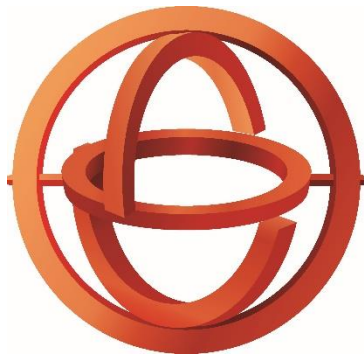
Not if it is inelastic!

Kazantzi, Vamvatsikos, Miranda 2018

Just one thing to remember

- You **knew it already**, but let me say it again
- Beware of monocausal explanations in **EQ engineering**
- Beware of them in **any kind** of engineering
- Actually, beware of them **in any context**
- Feel free to use **probabilistic concepts** to refute them
- After all, this is why we are here

...and now a message from our sponsors



H.F.R.I.
Hellenic Foundation for
Research & Innovation

The research project was supported by the Hellenic Foundation for Research and Innovation (H.F.R.I.) under the “2nd Call for H.F.R.I. Research Projects to support Faculty Members & Researchers” (Project Number: 2515).

Thank you all for coming!

See you in the **51+** Risk, Hazard, and
Uncertainty Workshop!

Could not and would not have done it
without you!

Thank you all for coming!

