Willkommen zu meinem Vortrag!

Bauhaus-Universität Weimar

Ich bin

Anastasia ATHANASIOU, PhD

Assistant Professor in Natural Hazards and Structural Resilience

Faculty of Civil and Environmental Engineering

Position funded by Carl Zeiss Stiftung

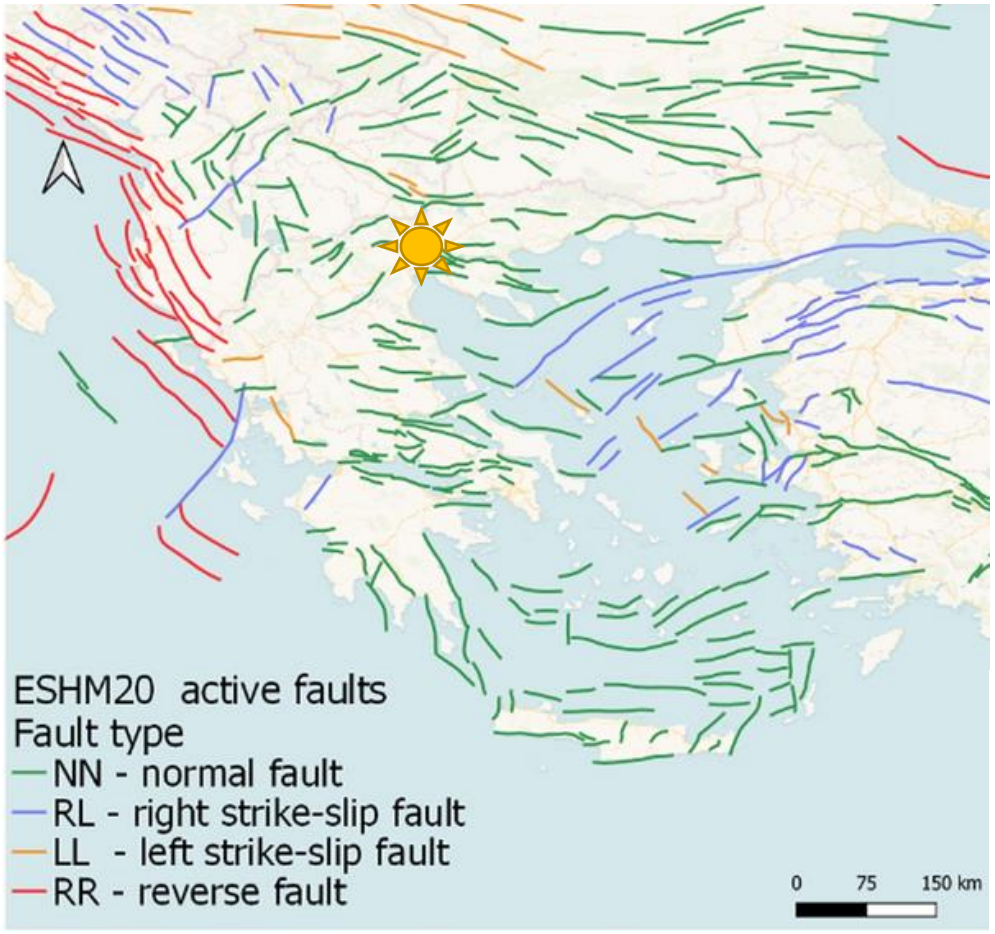
I am an earthquake engineering of course I was in Japan when..

2011 Tōhoku earthquake and tsunami

https://www.britannica.com/event/Japan-earthquake-and-tsunami-of-2011

BEng and integrated MEng in Structural Engineering (2002-08)

MEng in Earthquake Design of Structures (2008-09)



ARISTOTLE UNIVERSITY OF THESSALONIKI

Erasmus+
Enriching lives, opening minds.

https://doi.org/10.1007/s10518-024-01919-8

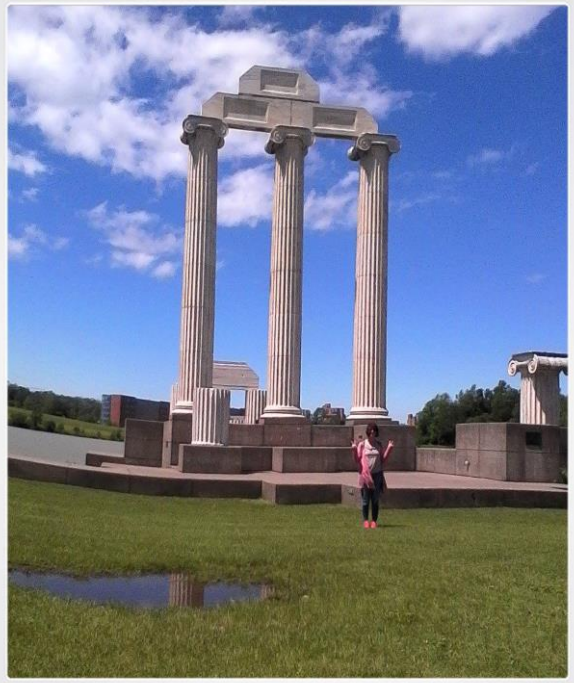
Res.assistant, PhD, Postdoc at University of Catania (2009-18)

UNIVERSITÀ degli STUDI di CATANIA

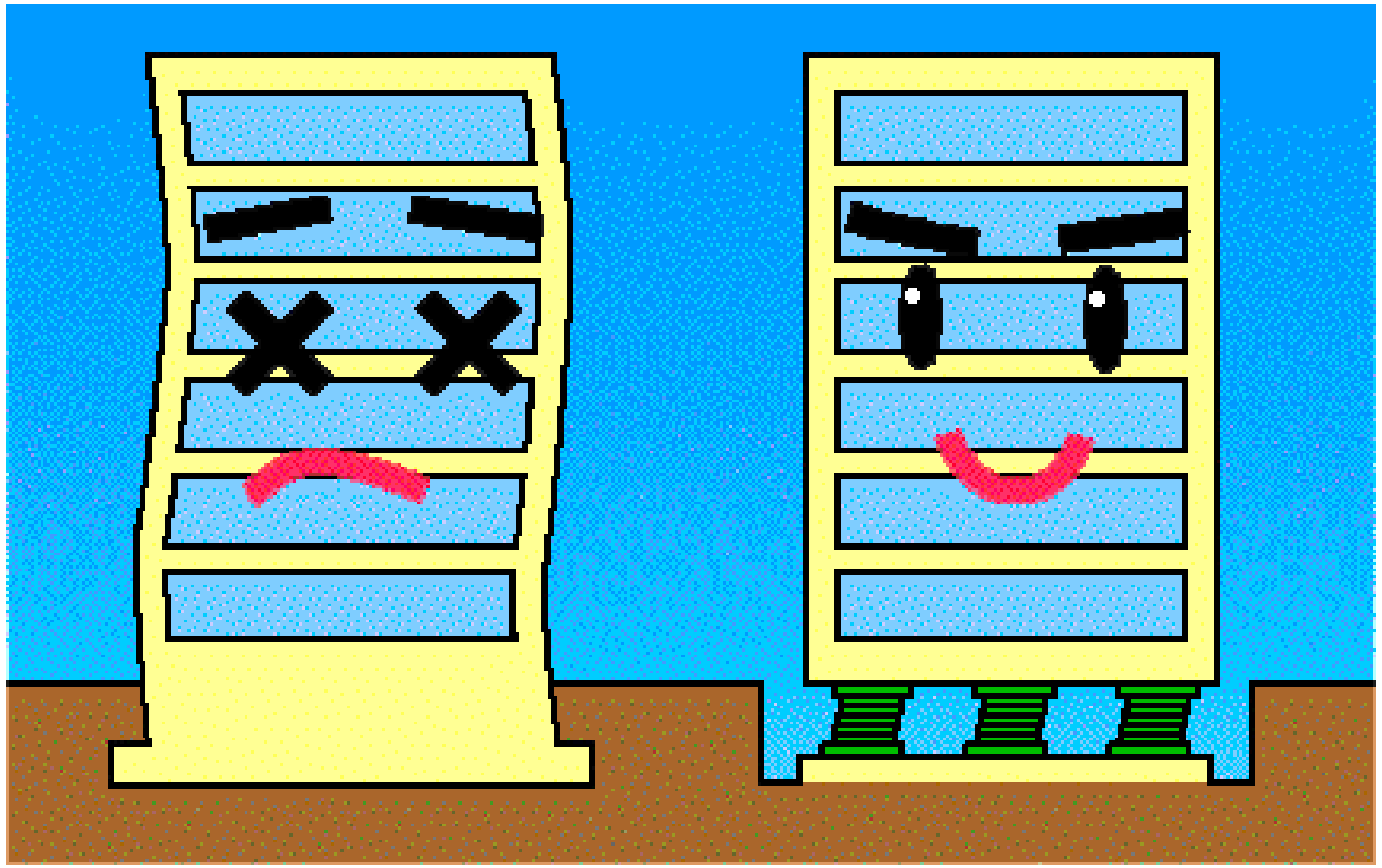
Visiting scholar at University at Buffalo (Jan-June 2015)

UNIVERSITÀ degli STUDI di CATANIA

University at Buffalo
The State University of New York

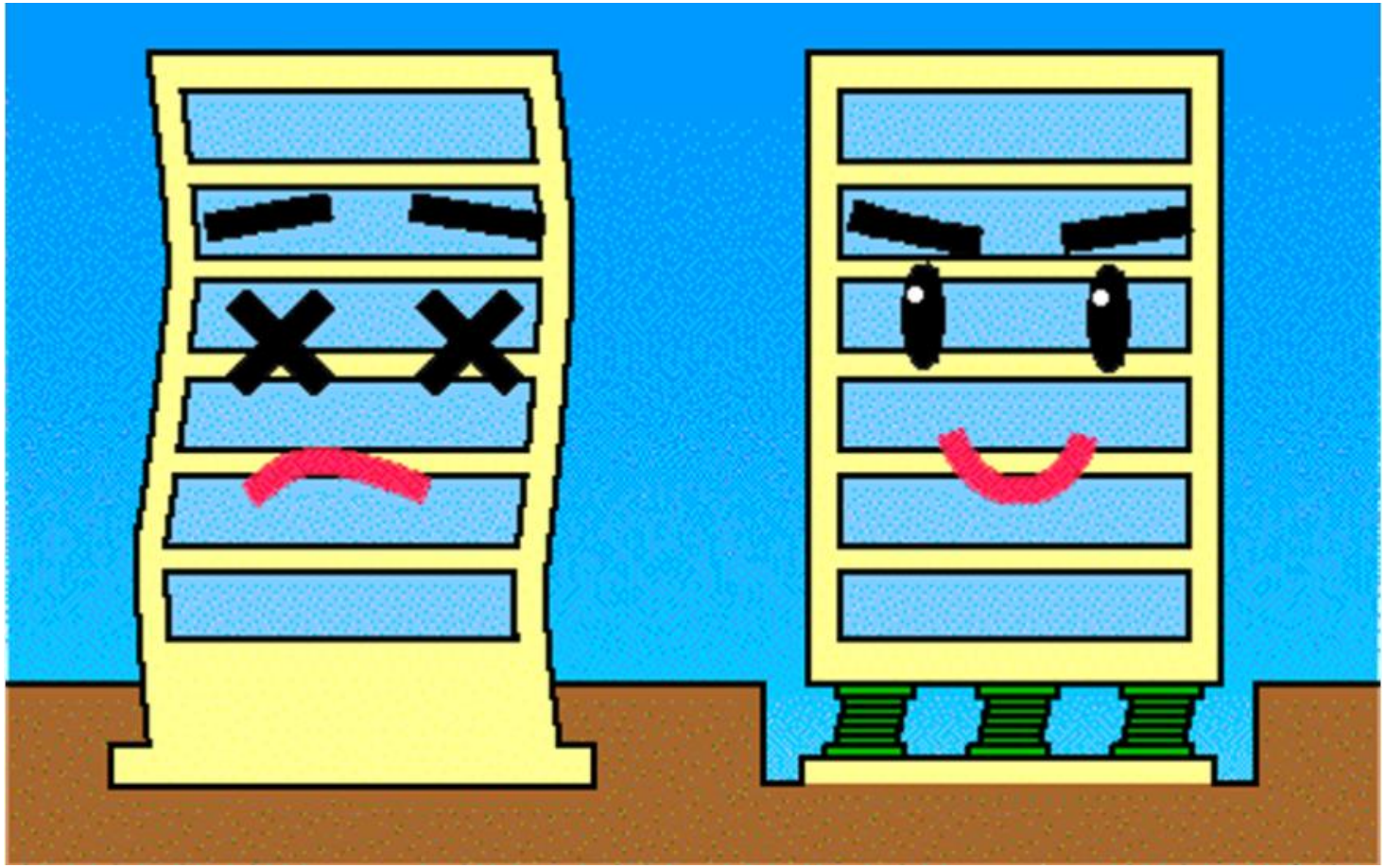


Base isolation mitigates seismic damage



From https://en.jssi.or.jp/en/whats-si_vc/#1

Base isolation mitigates seismic damage



From https://en.jssi.or.jp/en/whats-si_vc/#1

Earthquake simulator,

18WCEE, July 2024, Milano

Dynamic identification of the Augusta hybrid base isolated building using data from full scale push and sudden release tests

by Anastasia Athanasiou

Advisor: Professor Giuseppe Oliveto

Dottorato in Ingegneria Strutturale e Geotecnica, Ciclo XXVIII

Università di Catania

Committee

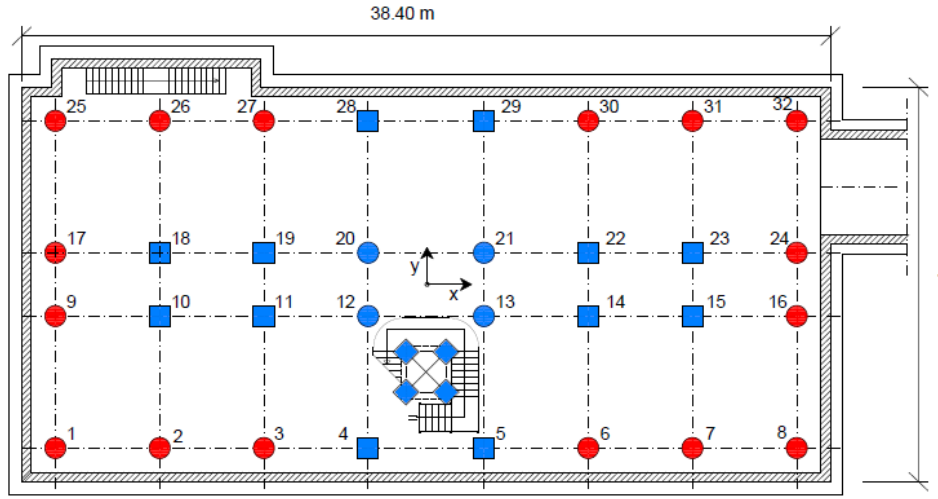
Prof. Akira Wada (Tokyo Institute of Technology)

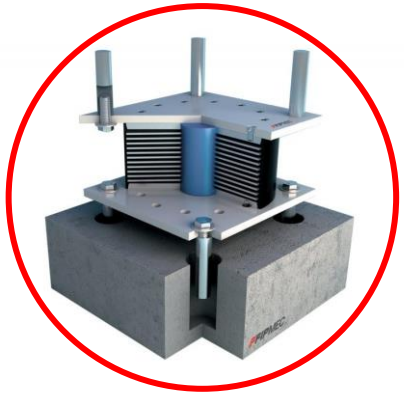
Prof. Michael Constantinou (University in Buffalo, NY)

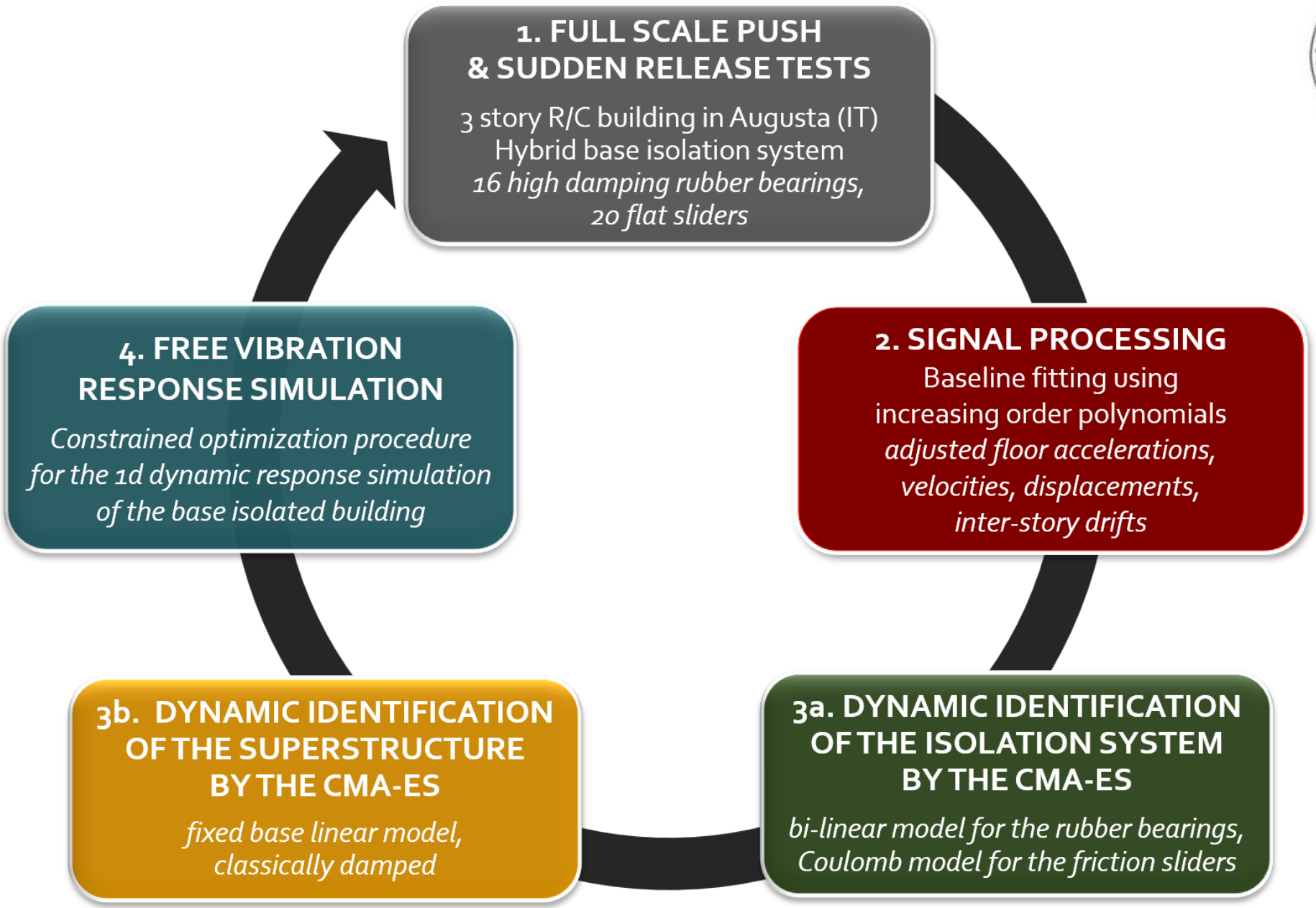
Prof. Felice Ponzo (University of Basilicata)

Prof. Elena Mele (University of Naples Federico II)

Prof. Ernesto Cascone (University of Messina)







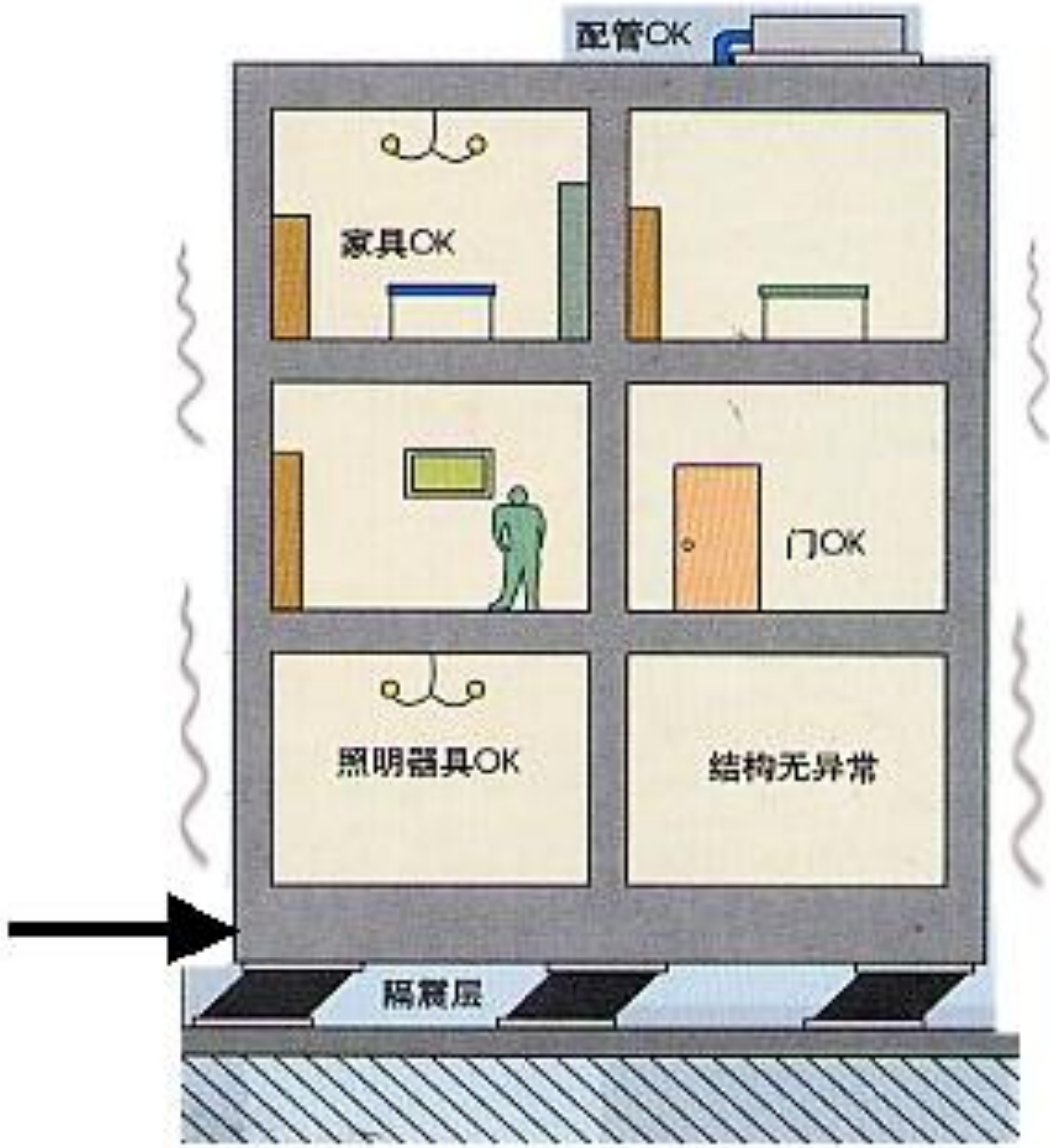
UNIVERSITÀ degli STUDI di CATANIA

Università degli Studi della Basilicata

S.A.P. Studio Engineering S.R.L.

1. FULL SCALE PUSH & SUDDEN RELEASE TESTS

3 story R/C building in Augusta (IT)
Hybrid base isolation system
16 high damping rubber bearings,
20 flat sliders



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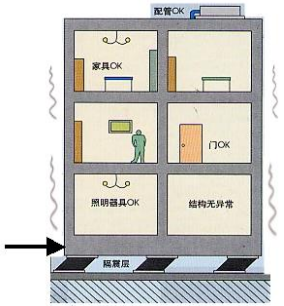

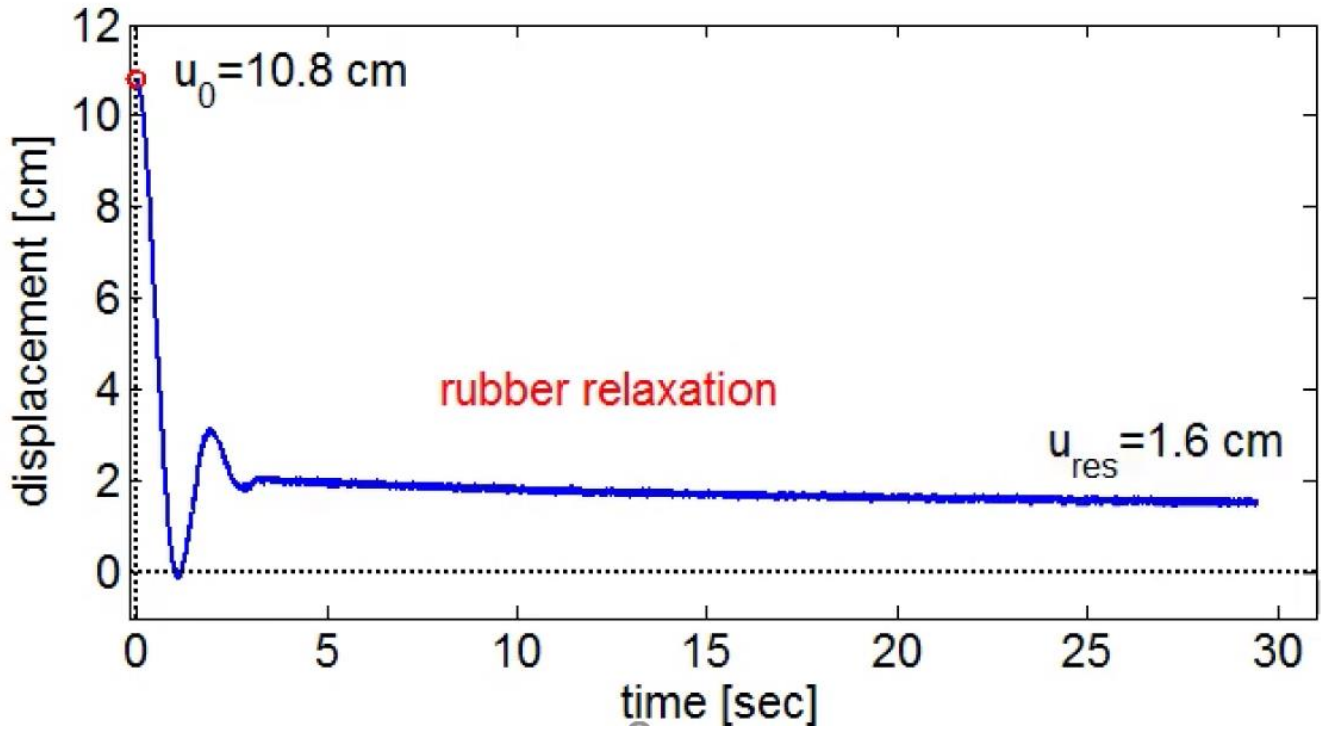

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2. SIGNAL PROCESSING

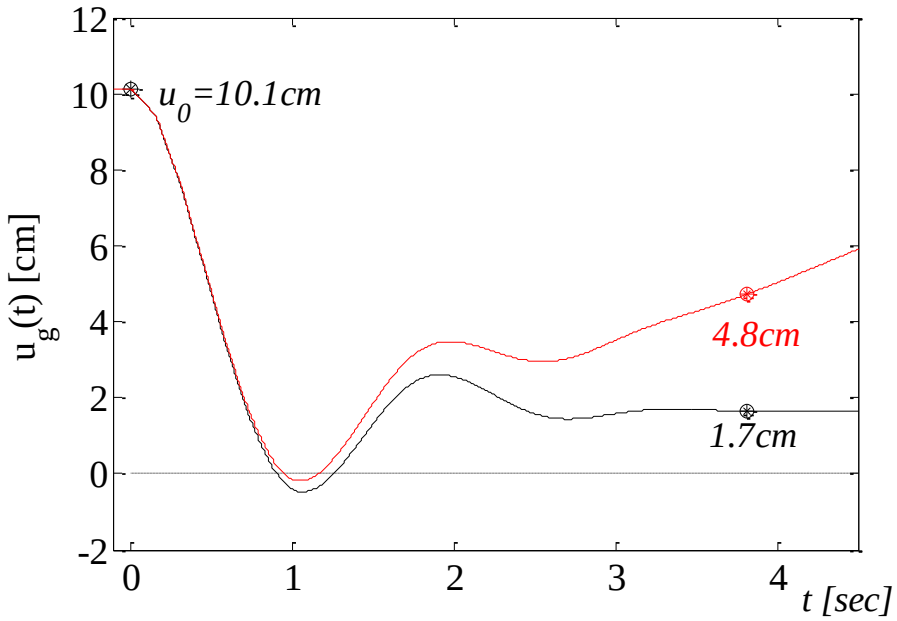
Baseline fitting using increasing order polynomials
adjusted floor accelerations, velocities, displacements, inter-story drifts

$$\ddot{u}(t) = \ddot{u}_{raw}(t) + 2p_2 + 6p_3 t + 4p_4 t^2 + 20p_5 t^3$$

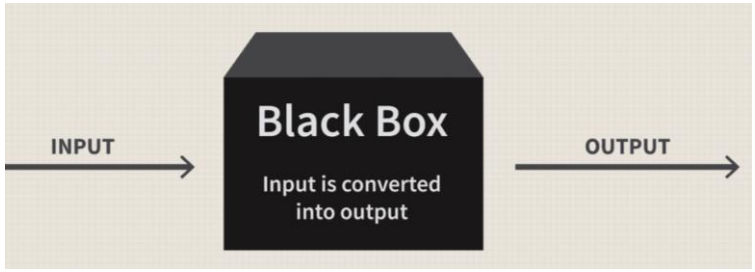
$$\dot{u}(t) = \int_0^t \ddot{u}_{raw}(\tau)d\tau + p_1 + 2p_2 t + 3p_3 t^2 + 4p_4 t^3 + 5p_5 t^4$$

$$u(t) = \int_0^t \int_0^{\tilde{\tau}} \ddot{u}_{raw}(\tau)d\tau d\tilde{\tau} + p_0 + p_1 t + p_2 t^2 + p_3 t^3 + p_4 t^4 + p_5 t^5$$

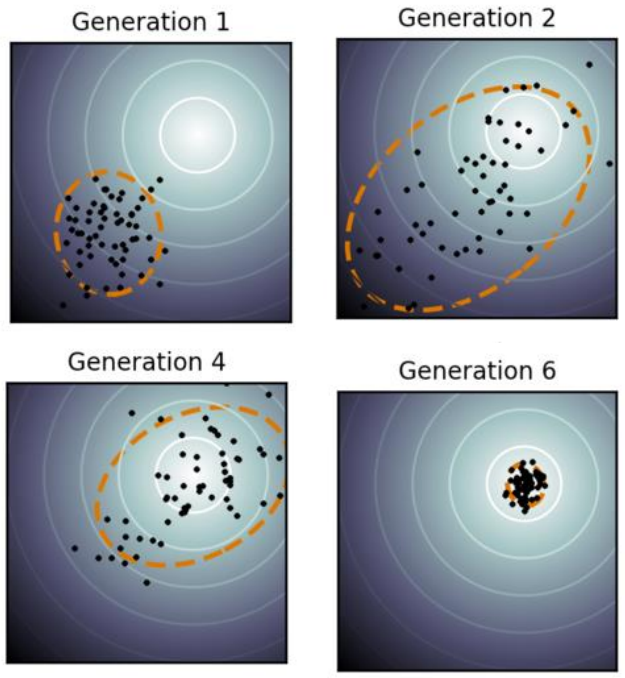
$$\ddot{u}(0) = \ddot{u}(t_d) = 0, \quad \dot{u}(0) = \dot{u}(t_d) = 0, \quad u(0) = u_0, \quad u(t_d) = u_{res}$$

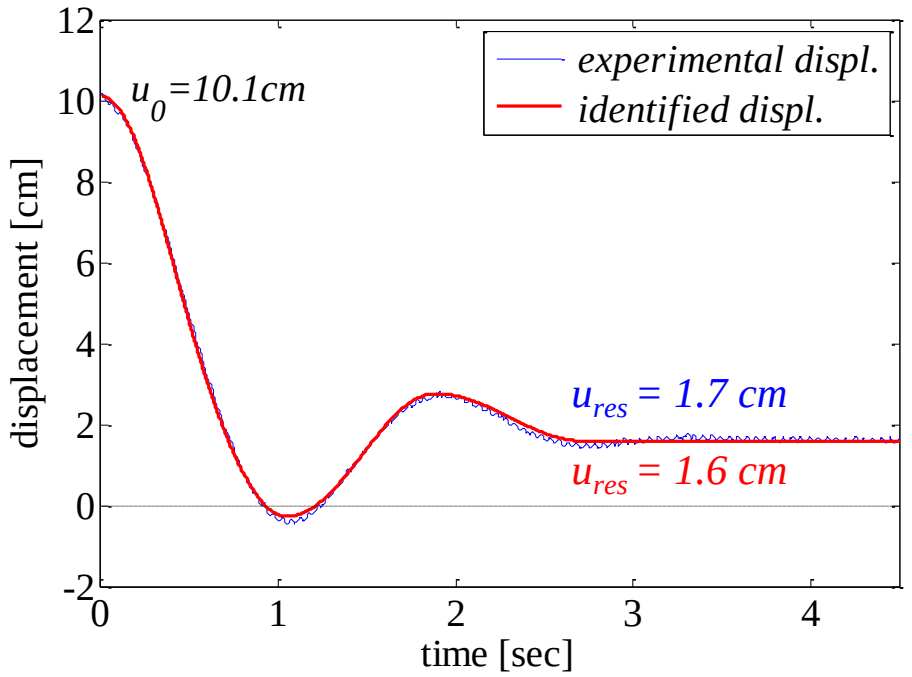


Athanasiou A, Oliveto G, Ponzo F (2018). Baseline correction of digital accelerograms from field testing of a seismically isolated building. Earthquake Spectra, 34 (2), p. 915-939, https://doi.org/10.1193/022817EQS040M



$$minimize \quad f = \frac{\sum_{i=1}^{3}\int [\dot{u}^i_{exp}(t) - \dot{u}^i(t)]^2\, dt}{\sum_{i=1}^{3}\int \dot{u}^i_{exp}(t)^2\, dt} + \frac{\sum_{i=1}^{3}\int [\ddot{u}^i_{exp}(t) - \ddot{u}^i(t)]^2\, dt}{\sum_{i=1}^{3}\int \ddot{u}^i_{exp}(t)^2\, dt}$$





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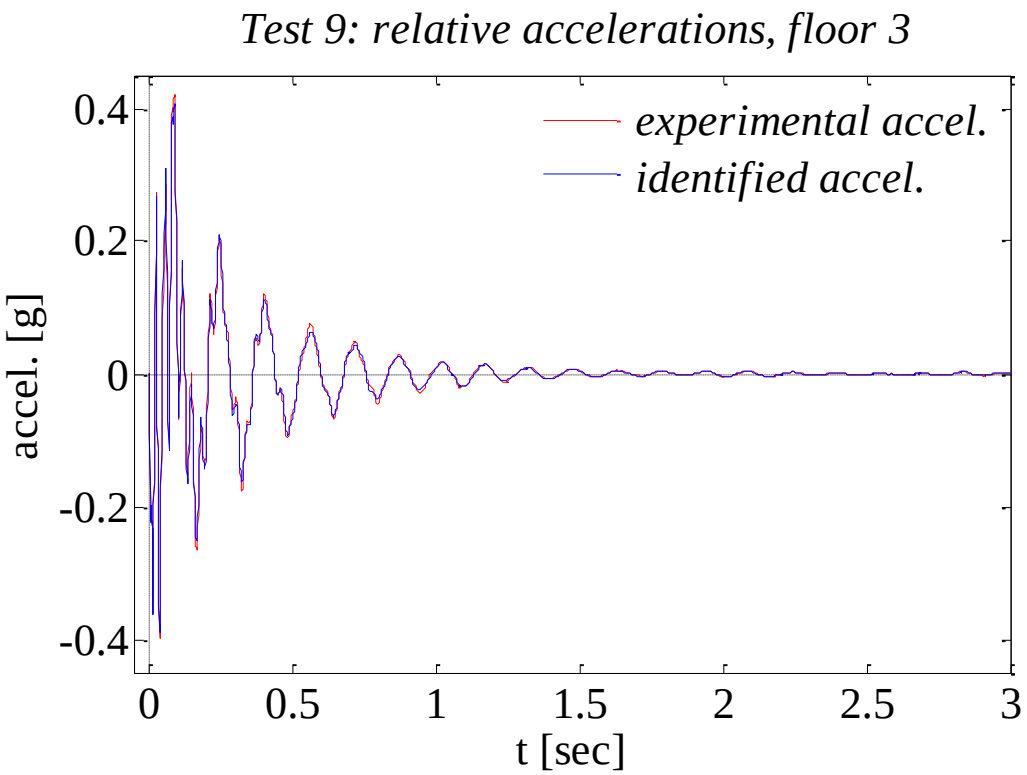
3a. DYNAMIC IDENTIFICATION OF THE ISOLATION SYSTEM BY THE CMA-ES

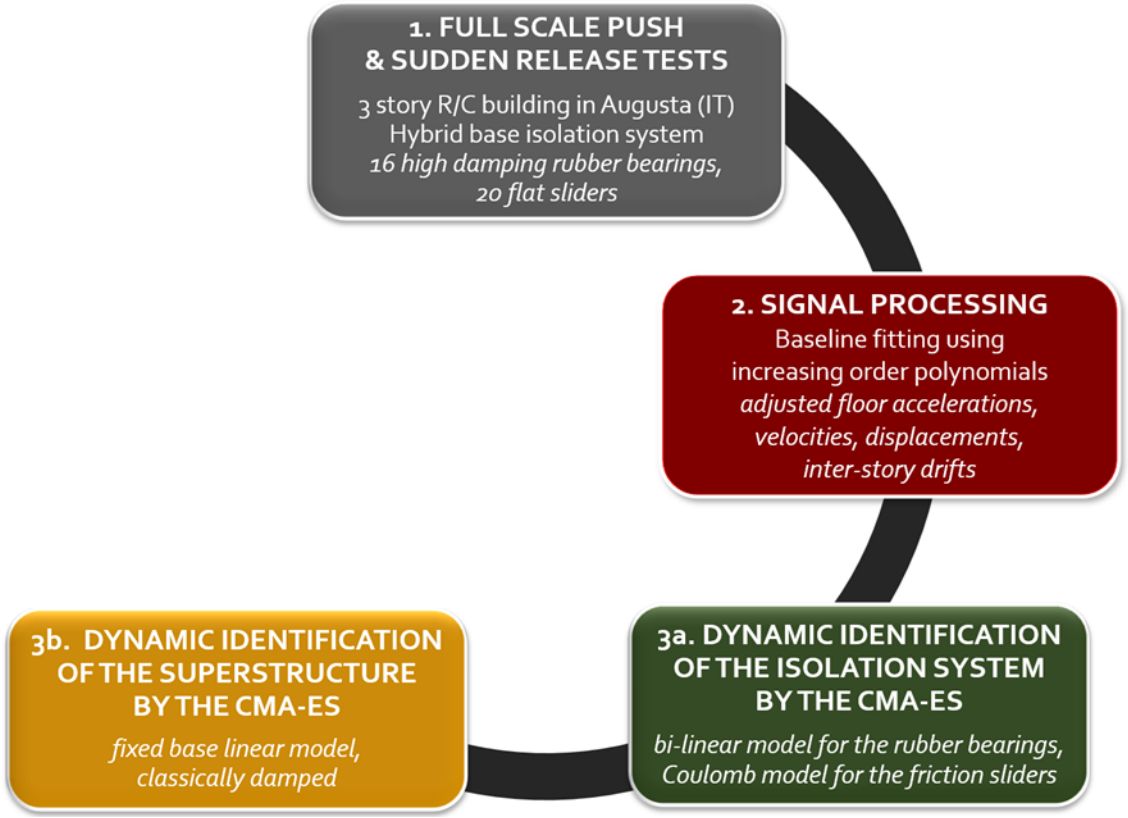
bi-linear model for the rubber bearings, Coulomb model for the friction sliders

Hansen N. The CMA Evolution Strategy. http://www.cmap.polytechnique.fr/~nikolaus.hansen/cmaesintro.html

Hansen N and Ostermeier A. Adapting arbitrary normal mutation distributions in evolution strategies: The covariance matrix adaptation. In: Proceedings of the 1996 IEEE International Conference on Evolutionary Computation. 1996, pp. 312317.

Athanasiou A, De Felice M, Oliveto G, Oliveto P S (2013) Dynamical modeling and parameter identification of seismic isolation systems by Evolution Strategies. In: Madani K, Dourado A, Rosa A, Filipe J (eds) Computational Intelligence. Studies in Computational Intelligence, vol 465. Springer, Berlin, Heidelberg.





Athanasiou A, Oliveto N D, Ponzo F. (2020) Identification of first and second order models for the superstructure of a base-isolated building using free vibration tests. Soil Dynamics and Earthquake Engineering, 135, https://doi.org/10.1016/j.soildyn.2020.106178

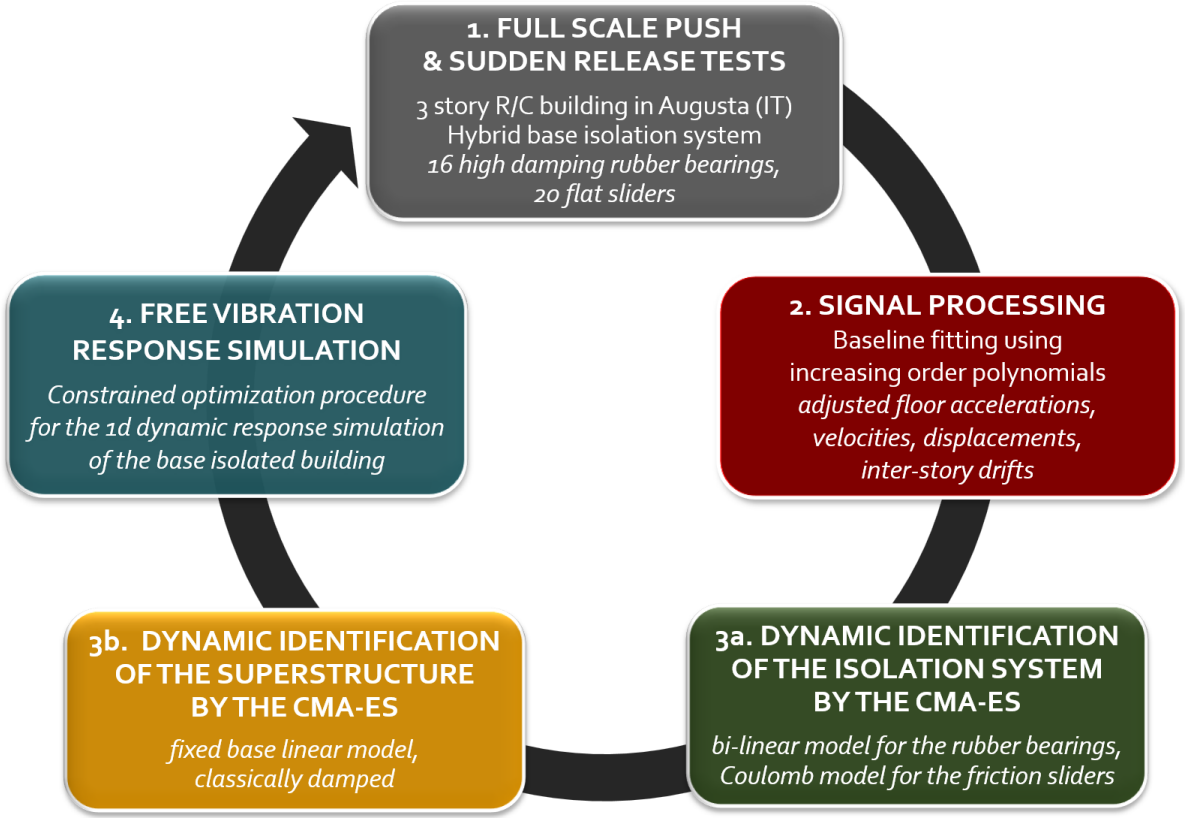
$$\boldsymbol{M}\,\ddot{\boldsymbol{u}} + \boldsymbol{C}\,\dot{\boldsymbol{u}} + \boldsymbol{K}\,\boldsymbol{u} + \boldsymbol{B}\,\dot{\boldsymbol{J}} - \boldsymbol{P} = \boldsymbol{0}$$

$$\boldsymbol{A}\,\ddot{\boldsymbol{J}} + \frac{\partial \varphi}{\partial \dot{\boldsymbol{J}}} - \boldsymbol{B}^T\,\dot{\boldsymbol{u}} = \boldsymbol{0}$$

$$\hat{\boldsymbol{\nu}}^{i+1} = \tilde{\boldsymbol{\nu}}^{i} - \boldsymbol{D}\,\hat{\boldsymbol{F}}^{i+1}$$

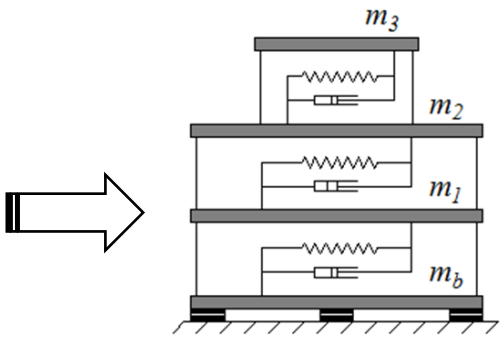
$$\textit{Minimize}\ \Psi(\hat{\boldsymbol{\nu}}^{i+1}) = \tfrac{1}{2}(\hat{\boldsymbol{\nu}}^{i+1} - \tilde{\boldsymbol{\nu}}^{i})^T \boldsymbol{D}^{-1}(\hat{\boldsymbol{\nu}}^{i+1} - \tilde{\boldsymbol{\nu}}^{i}) - (\hat{\boldsymbol{\nu}}^{i+1} - \tilde{\boldsymbol{\nu}}^{i})^T \boldsymbol{D}^{-1}\tilde{\boldsymbol{\nu}}^{i}$$

$$\textit{subject to the non linear constraints}\ |\boldsymbol{F}| - \boldsymbol{U} \leq 0$$



Oliveto ND, Oliveto G, Athanasiou A. Mixed Lagrangian Formulation for Dynamic and Earthquake Response of 2D Hybrid Base Isolation Systems, In: 9th International Conference on Urban Earthquake Engineering/ 4th Asia Conference on Earthquake Engineering. Center for Urban Earthquake Engineering, Tokyo Institute of Technology. Mar. 2012, pp. 1373-1382

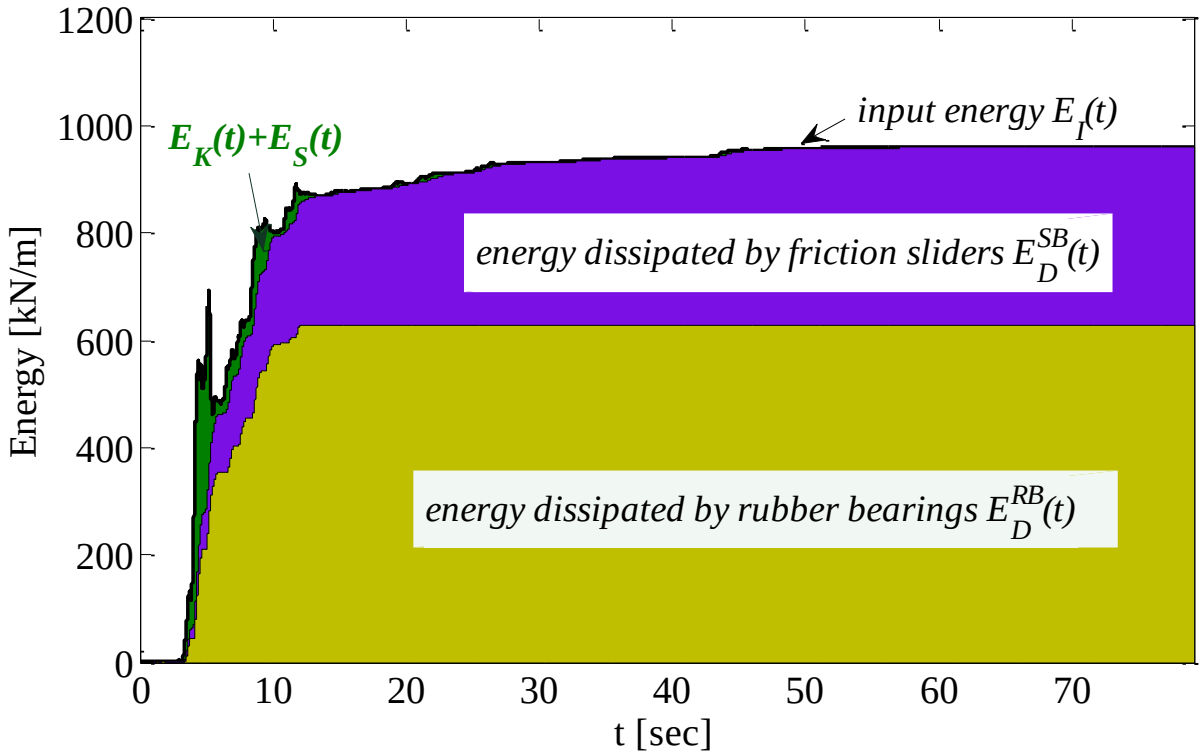
Oliveto G, Oliveto N D, and Athanasiou A. Constrained optimization for 1-D dynamic and earthquake response analysis of hybrid base-isolation systems. Soil Dyn and Earthquake Eng 67 (2014), pp. 44-53.



$$\boldsymbol{M}\,\ddot{\boldsymbol{u}} + \boldsymbol{C}\,\dot{\boldsymbol{u}} + \boldsymbol{K}\,\boldsymbol{u} + \boldsymbol{B}\,\dot{\boldsymbol{J}} - \boldsymbol{P} = \boldsymbol{0}$$

$$\boldsymbol{A}\,\ddot{\boldsymbol{J}} + \frac{\partial \varphi}{\partial \dot{\boldsymbol{J}}} - \boldsymbol{B}^{T}\,\dot{\boldsymbol{u}} = \boldsymbol{0}$$

How does the building respond to a design level earthquake (1-in-475yrs) ?



Postdoc in multi-hazard design of steel structures

[Building Aerodynamics / Wind Tunnel Lab](#) (2018-2023)

Trends in Engineering

Why Is Everyone Talking About Performance-Based Multi-Hazard Design?

By Anastasia Athanasiou, Ph.D.

TSEC 65: Performance-Based Multi-Hazard Design of Buildings

November 25, 2021 By EMI

00:00 00:00

Podcast: Play in new window | Download | Embed

https://engineeringmanagementinstitute.org/tsec-65-performance-based-multi-hazard-design-of-buildings/

Define hazards

Are hazards independent?

Account for all hazards and their correlations

Apply hazards separately

Select model, numerical method

Simulate response

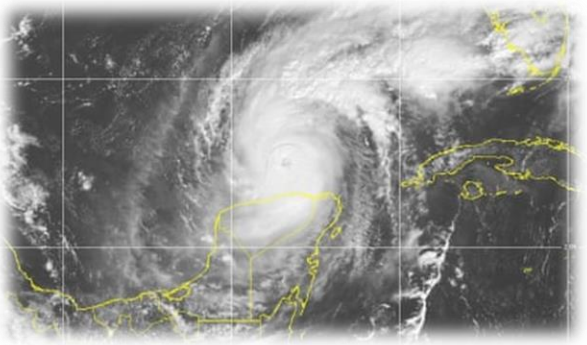
Set performance objectives (PO)

Design / retrofit

are PO met?

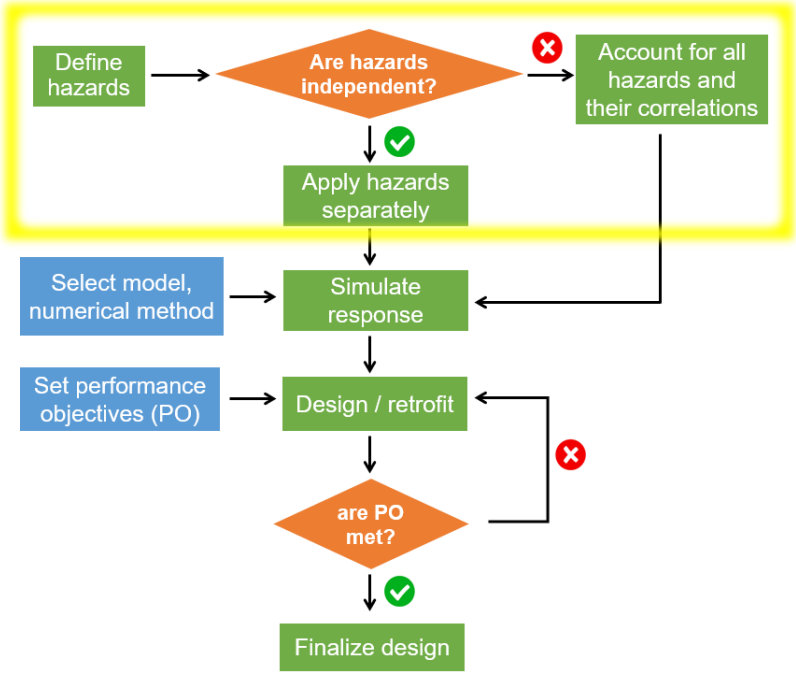
Finalize design

https://iugs-geoheritage.org/geoheritage_sites/nojima-fault/



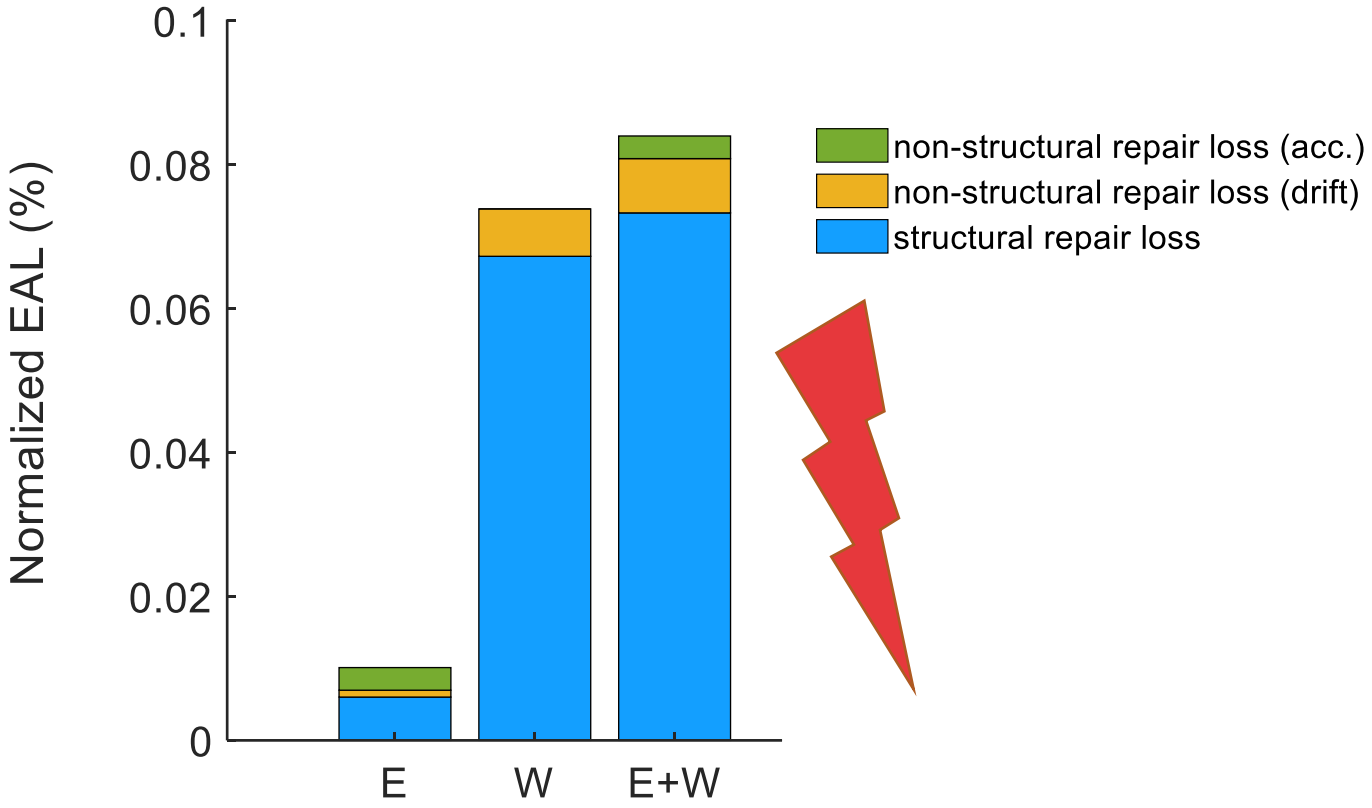
https://www.theguardian.com/us-news/2024/oct/10/hurricane-milton-maps-charts-graphics-damage

Original aspect #1 : multi-hazard excitation



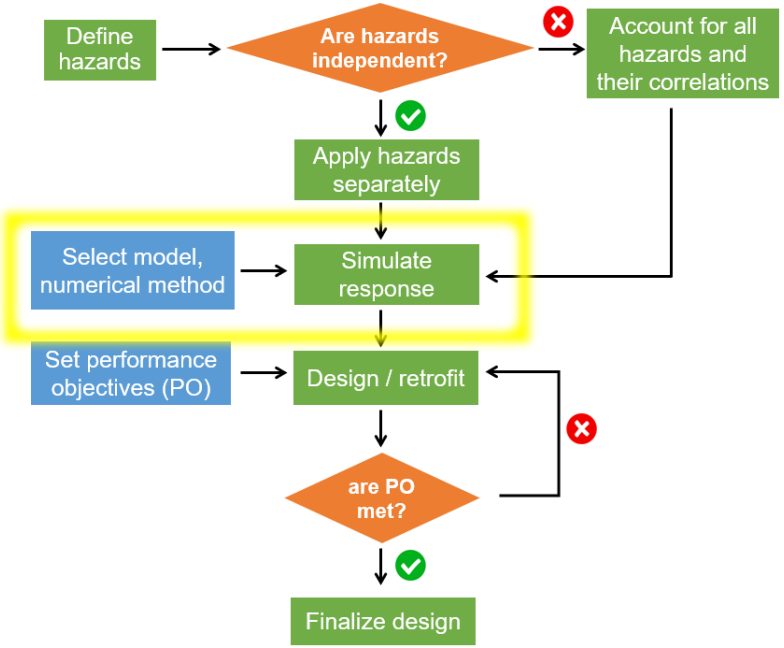
- **Building codes account for the single hazard.**
- Seismic design is performance-based and accounts for overstrength and ductility.
- Traditional wind design is linear prescriptive.

Case study: 16-story LD-CBF office building, Montreal



Athanasiou A, Dakour M, Pejmanfar S, Tirca L, Stathopoulos T (2022) Multihazard performance-based assessment framework for multi-story steel buildings. ASCE Journal of Structural Engineering, 148(6): 04022054, https://ascelibrary.org/doi/full/10.1061/%28ASCE%29ST.1943-541X.0003331

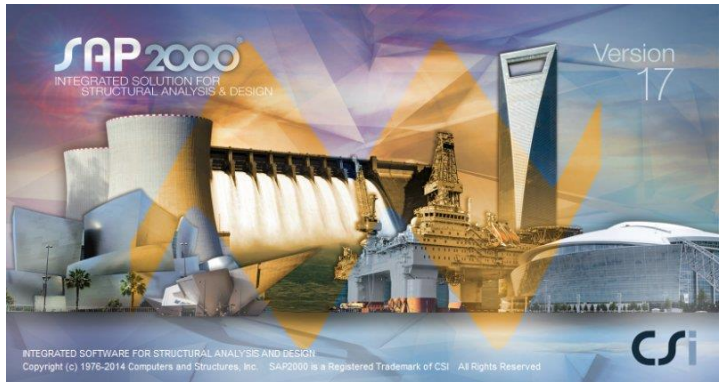
Original aspect #2 : nonlinear dynamic wind simulations



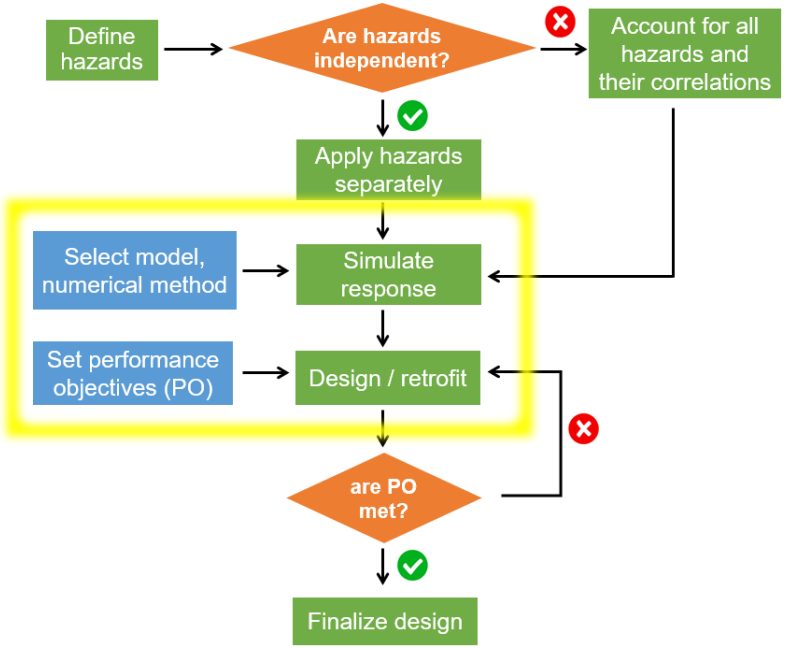
Performance-based methods require reasonable estimates of inelastic deformation, i.e., damage.

OpenSees

MATLAB®



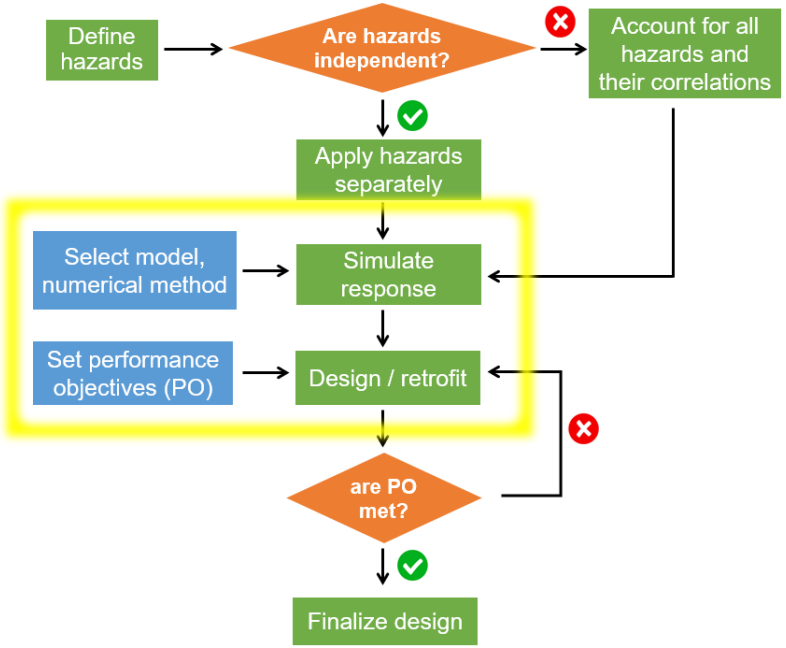
Original aspect #3 : transfer of PBEE know-how



Wind Hazard	Mean Return Interval (MRI)	Occupant comfort	Operational	Continuous occupancy	Collapse prevention
		No yielding Accel. thresholds a per ISO	No yiel	Limited yielding	Damage allowed
Frequent	**1 year**				
Occasional	**50 years**				
Rare	**700 years**				
Very rare	**3,000 years**				

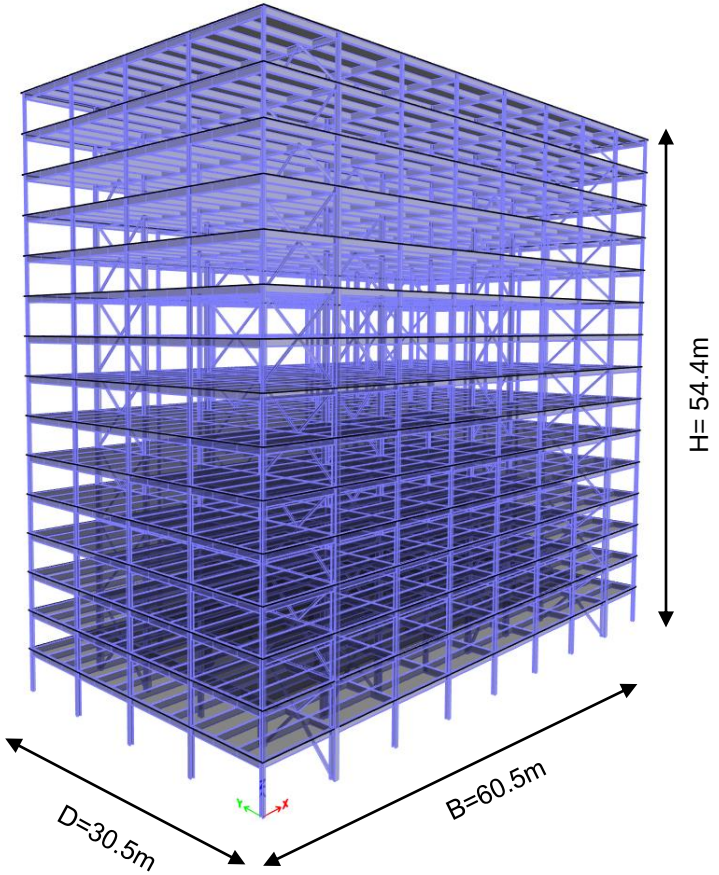
Building codes are life safety-oriented

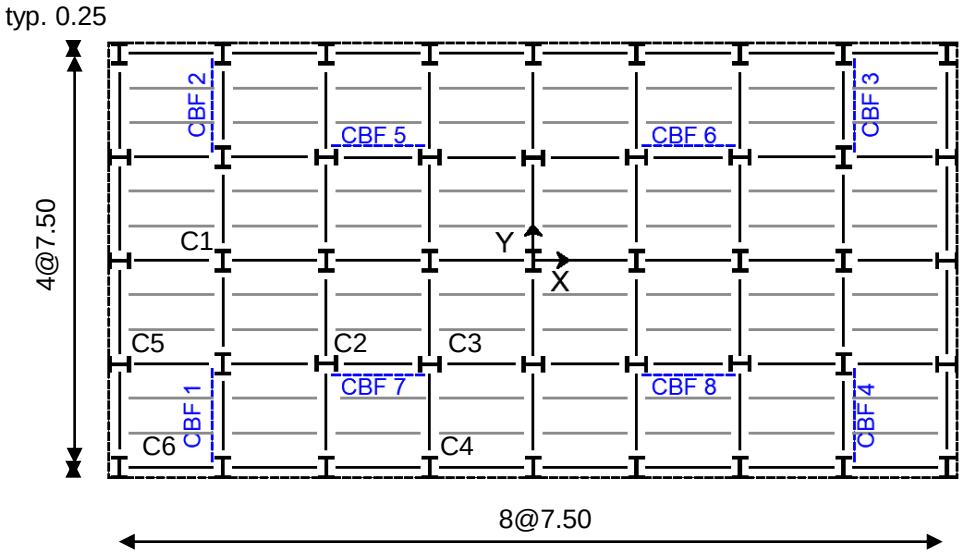
Original aspect #3 : transfer of PBEE know-how

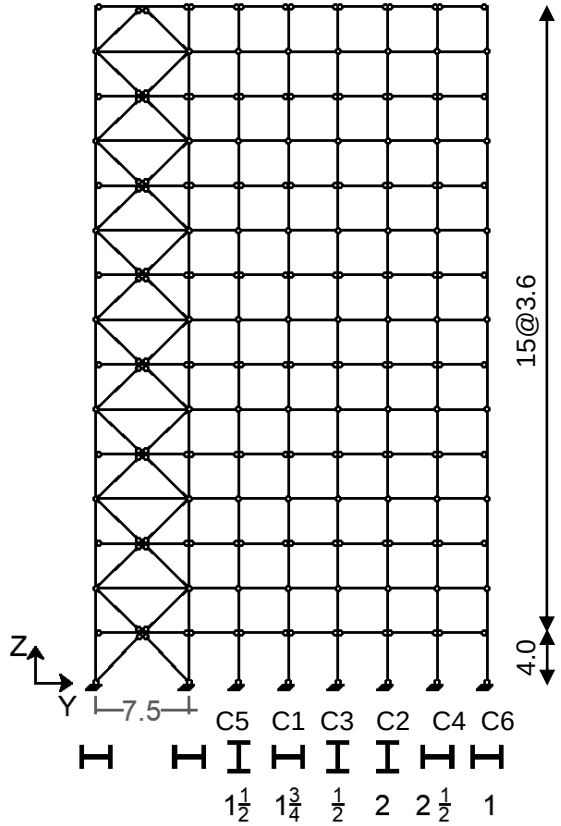


Wind Hazard	Mean Return Interval (MRI)	Occupant comfort	Operational	Continuous occupancy	Collapse prevention
		No yielding Accel. thresholds as per ISO 10137	No yielding Drift < 1/400-1/500 (Accel< 15milli-g)	Limited yielding *Functional recovery<… *Probable loss < …	Damage allowed *No collapse *Functional recovery <…
Frequent	**1 year**				
Occasional	**50 years**				
Rare	**700 years**				
Very rare	**3,000 years**				

Case study: 15-story MD-CBF hospital in Montreal

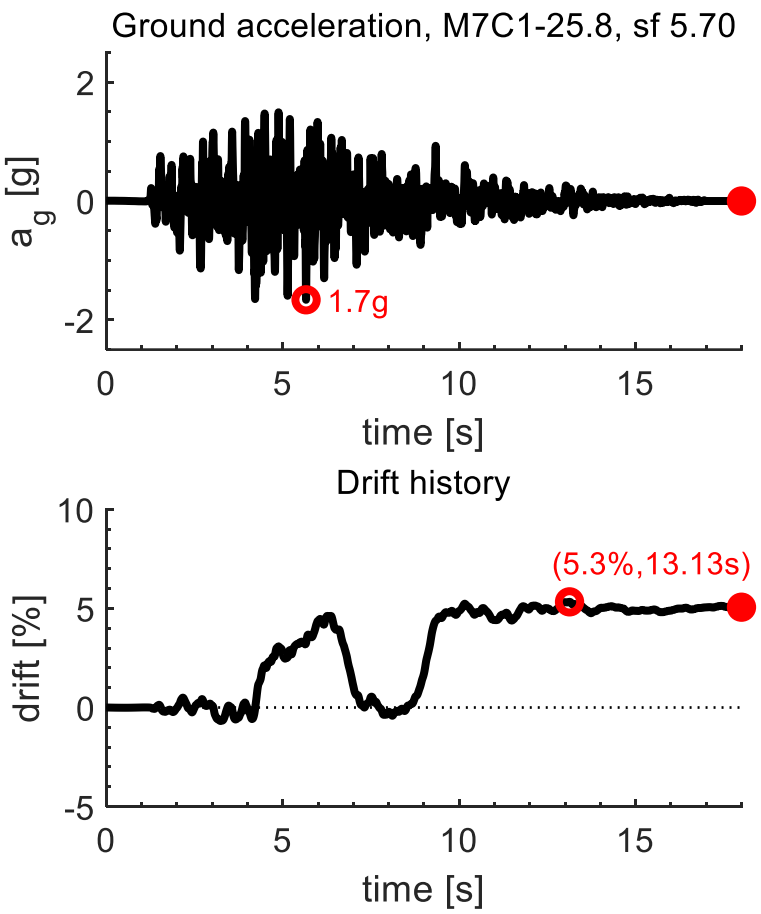


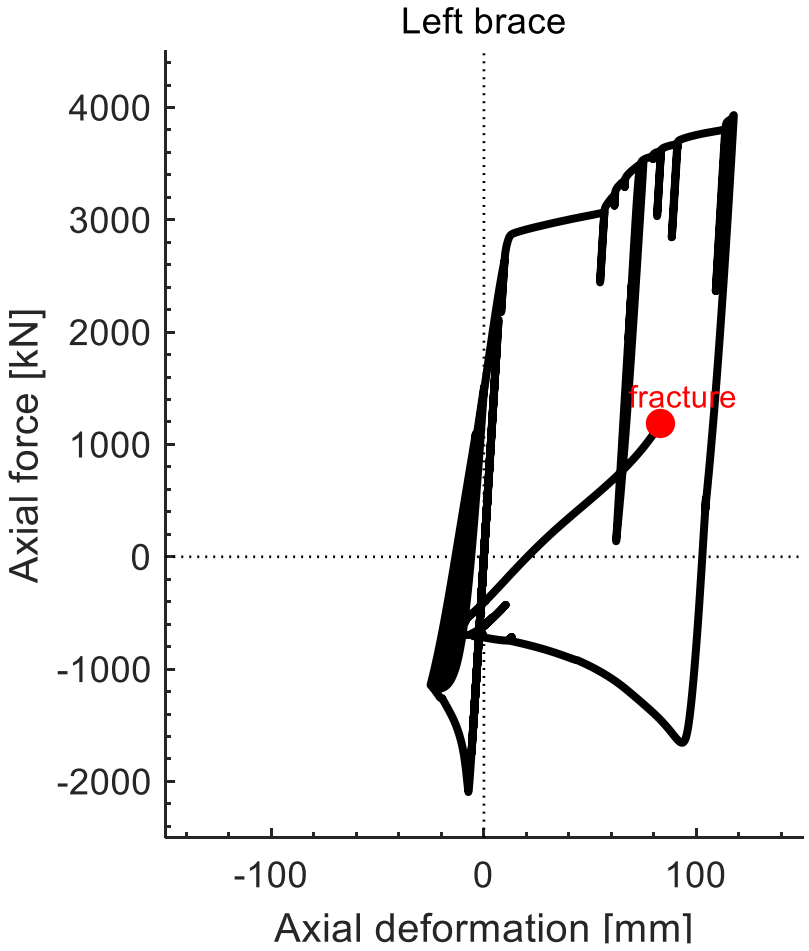


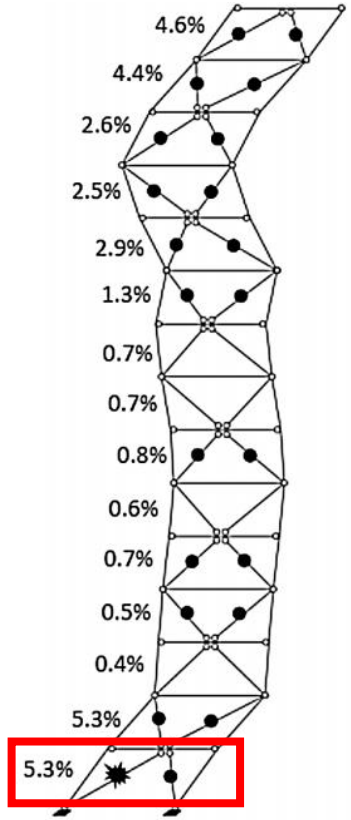


Athanasiou A, Tirca L, Stathopoulos T (2022) Nonlinear wind and earthquake loads on tall steel braced frame buildings. ASCE Journal of Structural Engineering, 148(8): 04022098, https://ascelibrary.org/doi/10.1061/%28ASCE%29ST.1943-541X.0003375

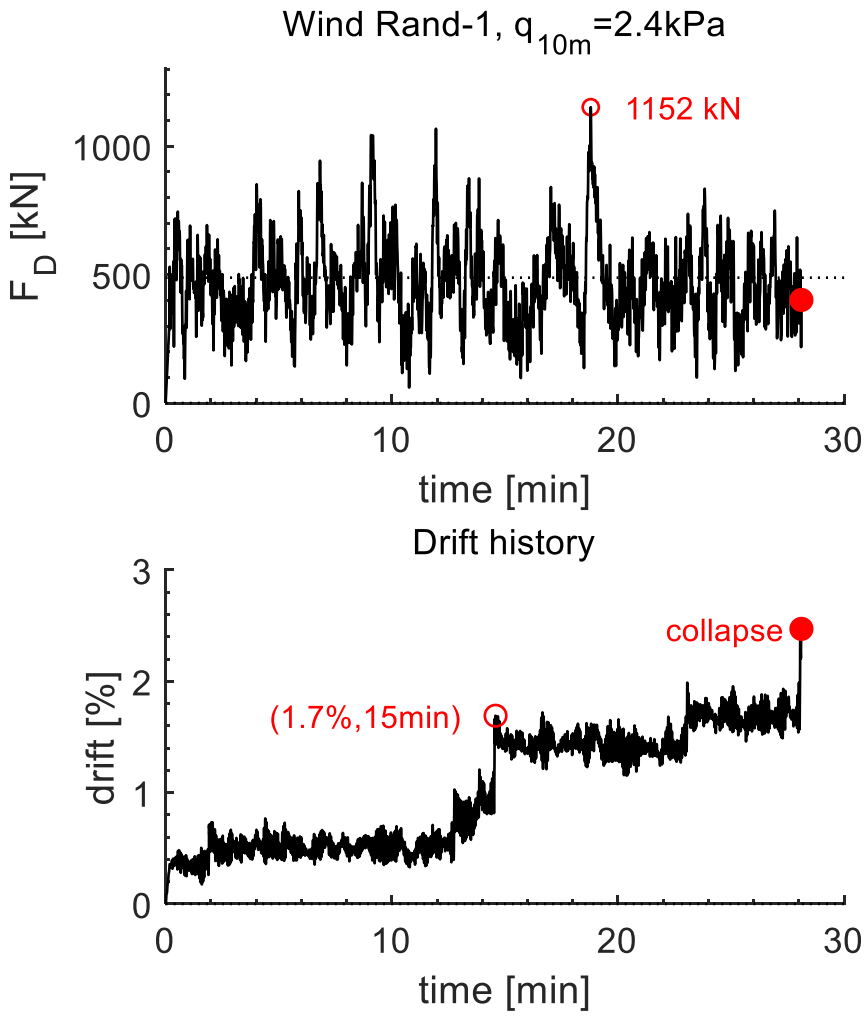
Collapse response simulation under M7 C1-25.8

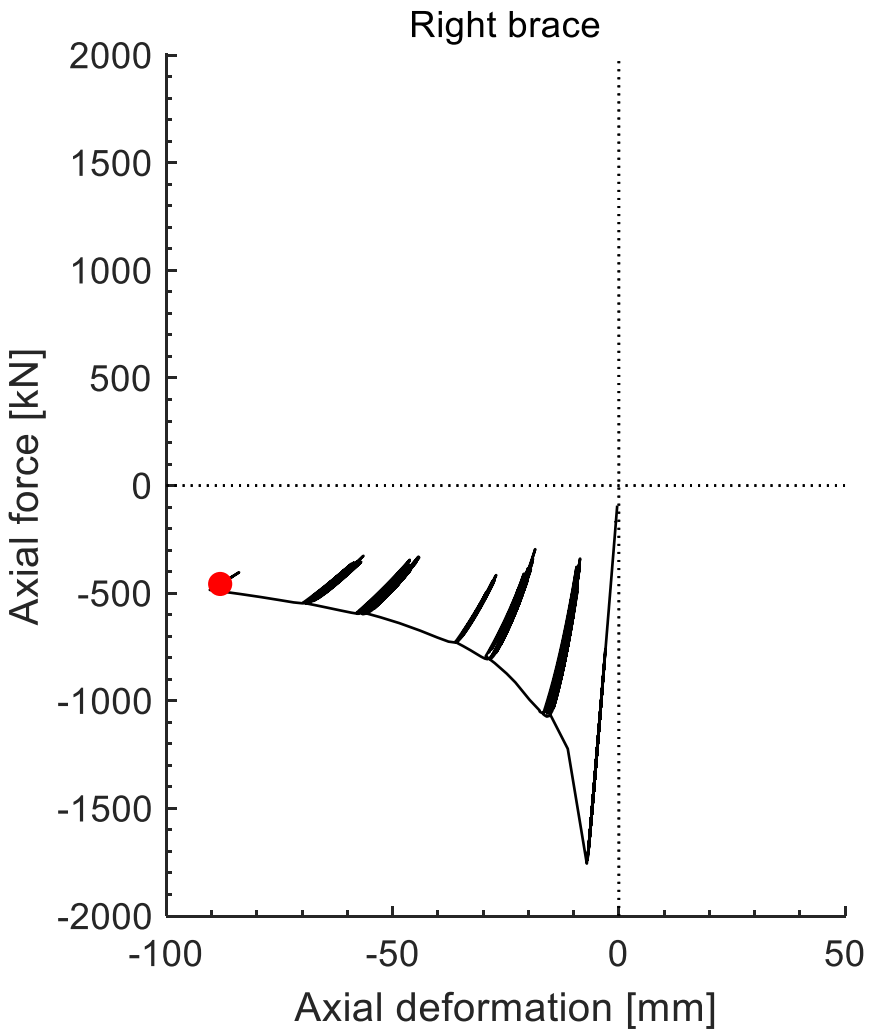


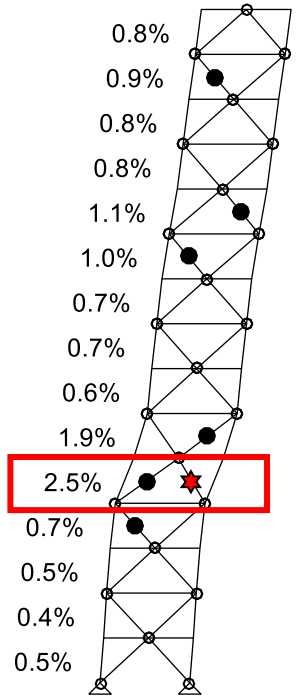




Alongwind collapse simulation under wind Rand#1







Journal of Wind Engineering & Industrial Aerodynamics 240 (2023) 105492

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Performance-based wind and earthquake design framework for tall steel buildings with ductile detailing

Anastasia Athanasiou *, Lucia Tirca, Ted Stathopoulos

Department of Building, Civil and Environmental Engineering, Concordia University, 1455 de Maisonneuve Blvd. West, H3G 1M8, Montreal, Canada

$$F = A_{trib}\, p \qquad p = I_W\, q C_e C_t C_g C_p, \quad q = \frac{1}{2}\rho U^2 \quad (NBCC, 2020)$$

$$C_g = 1 + g_p \frac{\sigma}{\mu}, \quad \frac{\sigma}{\mu} = \sqrt{\frac{K}{C_{eH}}\left(B + \frac{1}{R_w^2}\frac{sF}{\beta}\right)}$$

A wind reduction factor of $1 < R_W = 2 < R_E$ reduces the wind demand by 15% and…

For hospital in Montreal: q= 0.42kPa, T=2.94s, $C_{g,static}$ =2 < $C_{g,Rw=2}$=2.14 < $C_{g,Rw=1}$=2.5

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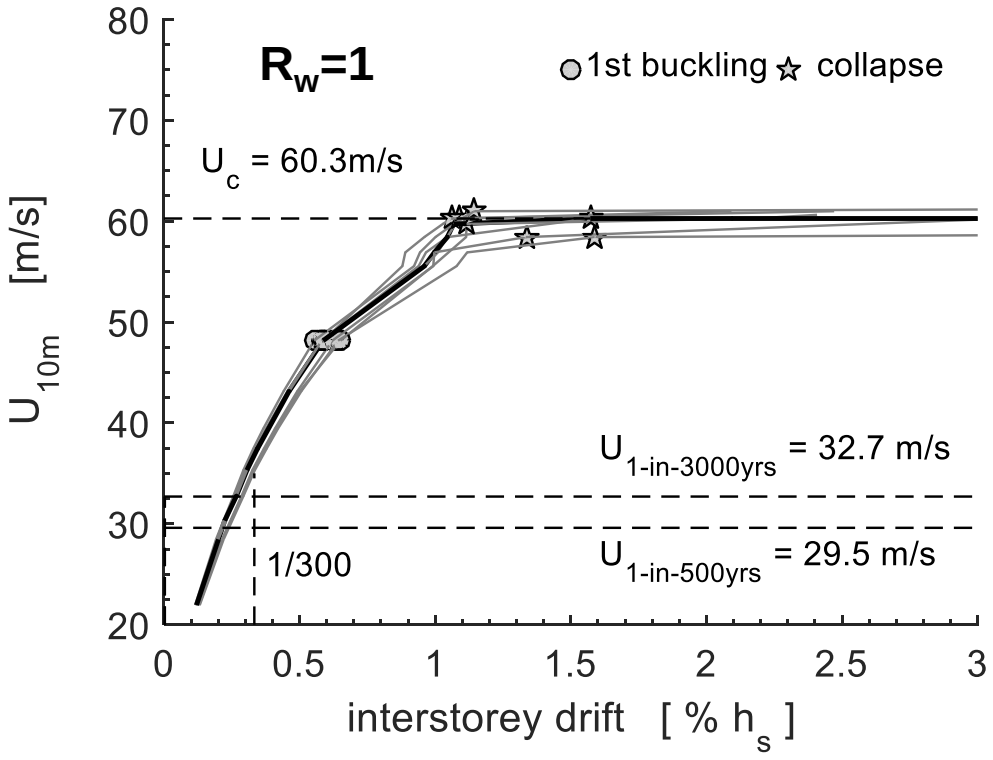
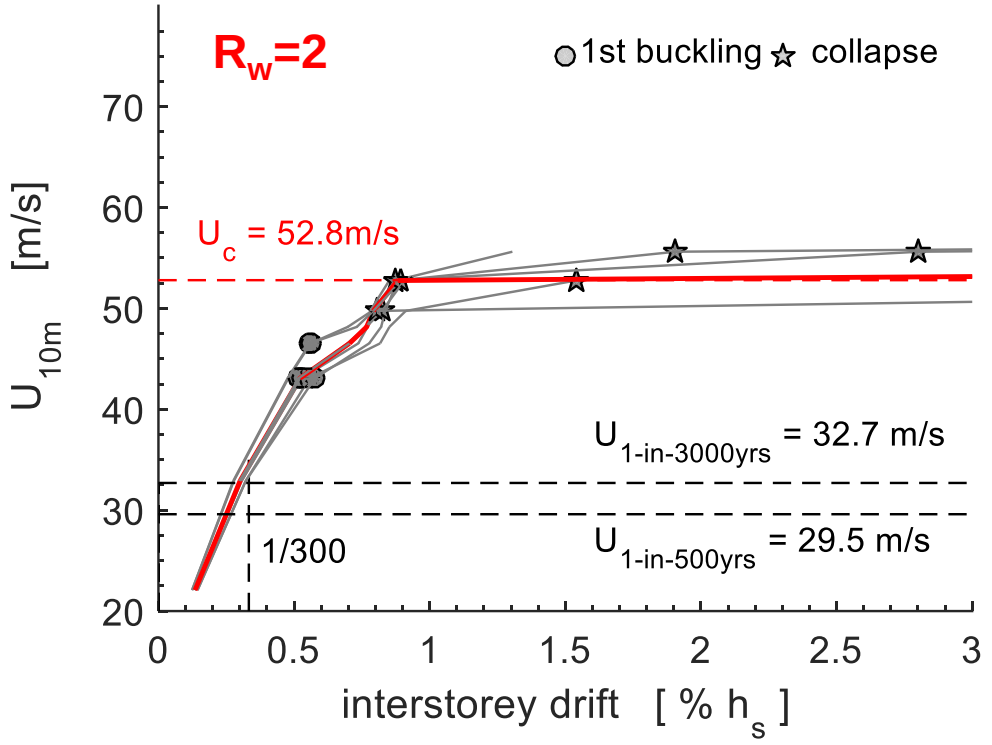
A wind reduction factor of $1 < R_W = 2 < R_E$ reduces the wind demand by 15% and…

accounts for system overstrength and ductility

The introduction of R_w=2 does not change the seismic response

The introduction of R_w=2 enhances structural economy!





**Limited interruption (1-in-3000yrs) : inelasticity allowed in specific members, cladding and nonstructural elements should remain attached*

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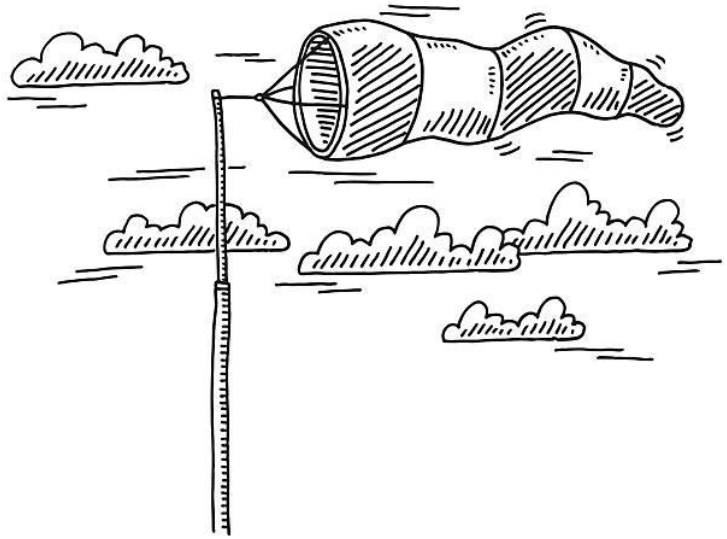
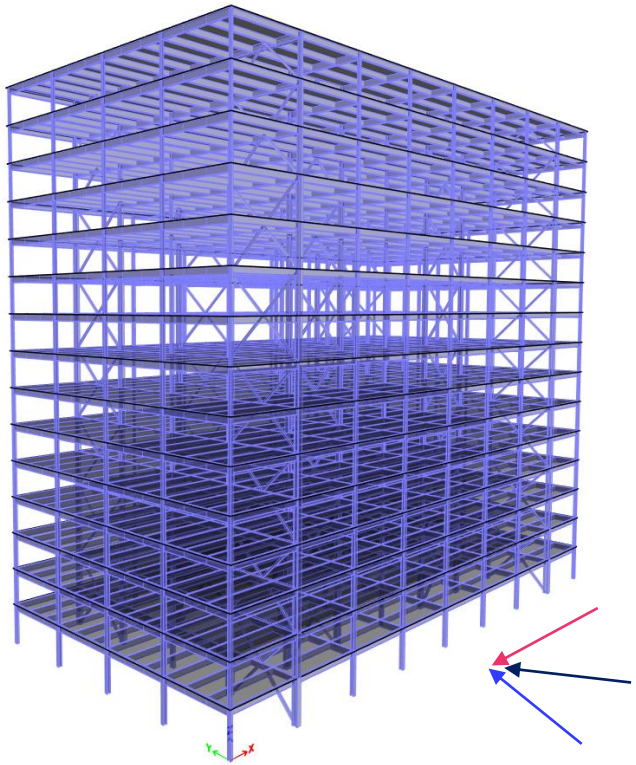
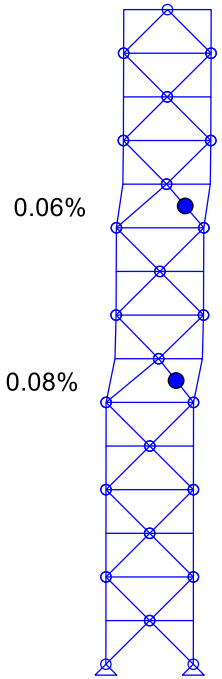


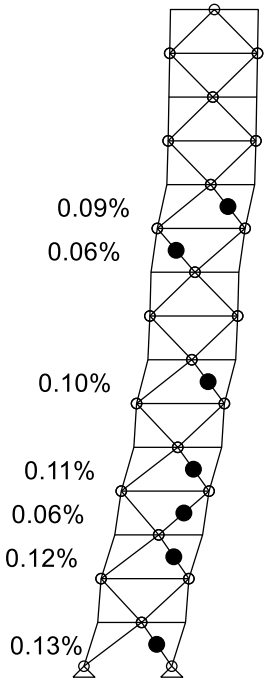
Directional alongwind and crosswind effects on the performance of a 15-storey steel braced frame building in seismic environment

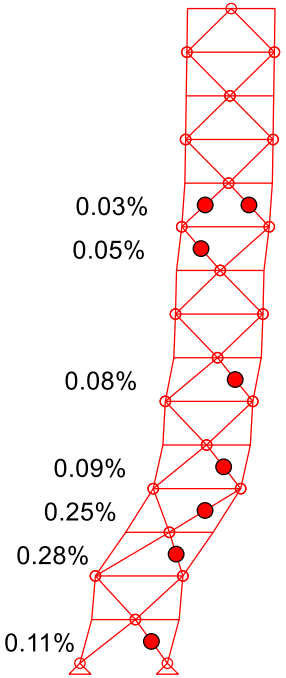
Anastasia Athanasiou [a,*], Lucia Tirca [b], Ted Stathopoulos [b]

[a] Department of Civil and Environmental Engineering, Bauhaus University Weimar, Marienstr. 7A, 99423, Germany
[b] Department of Building, Civil and Environmental Engineering, Concordia University, 1455 de Maisonneuve Blvd. West, H3G 1M8, Montreal, Canada



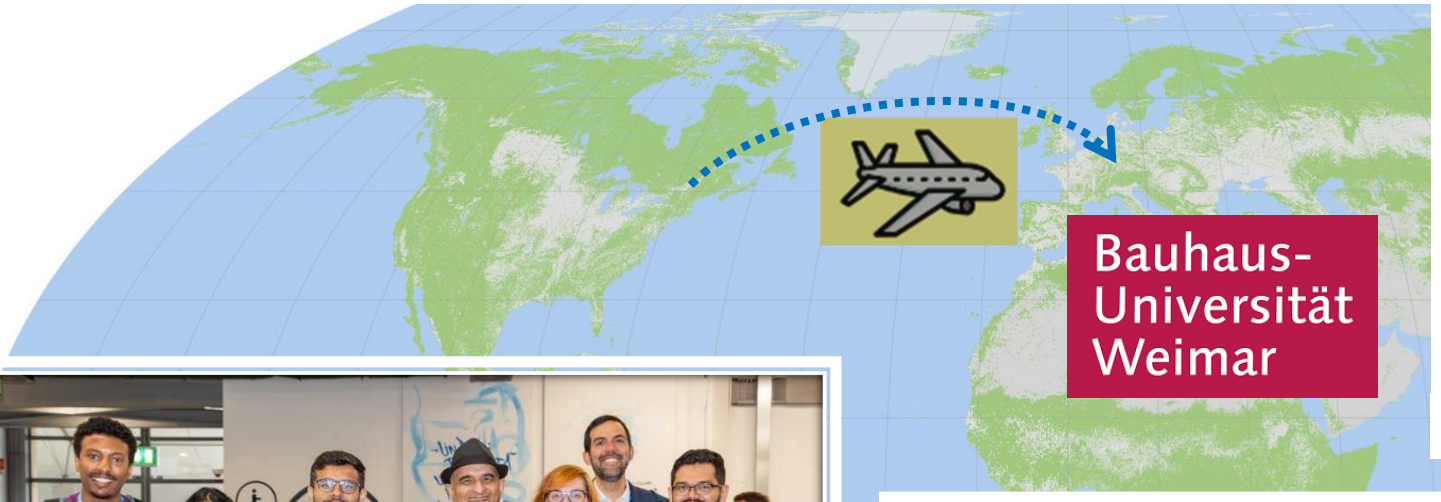






Assistant Professor in Natural Hazards and Structural Resilience

(since July 2023)

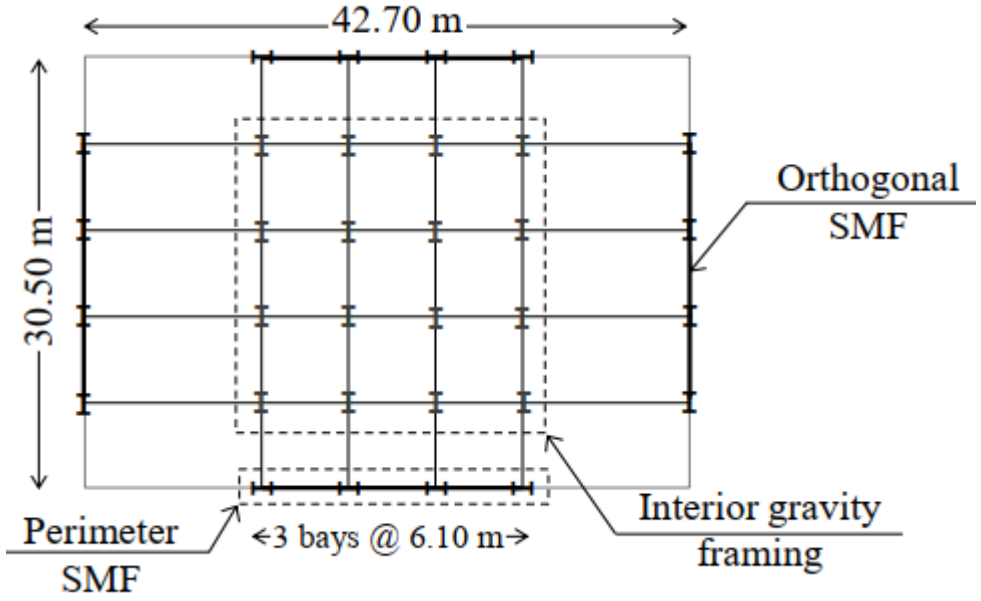


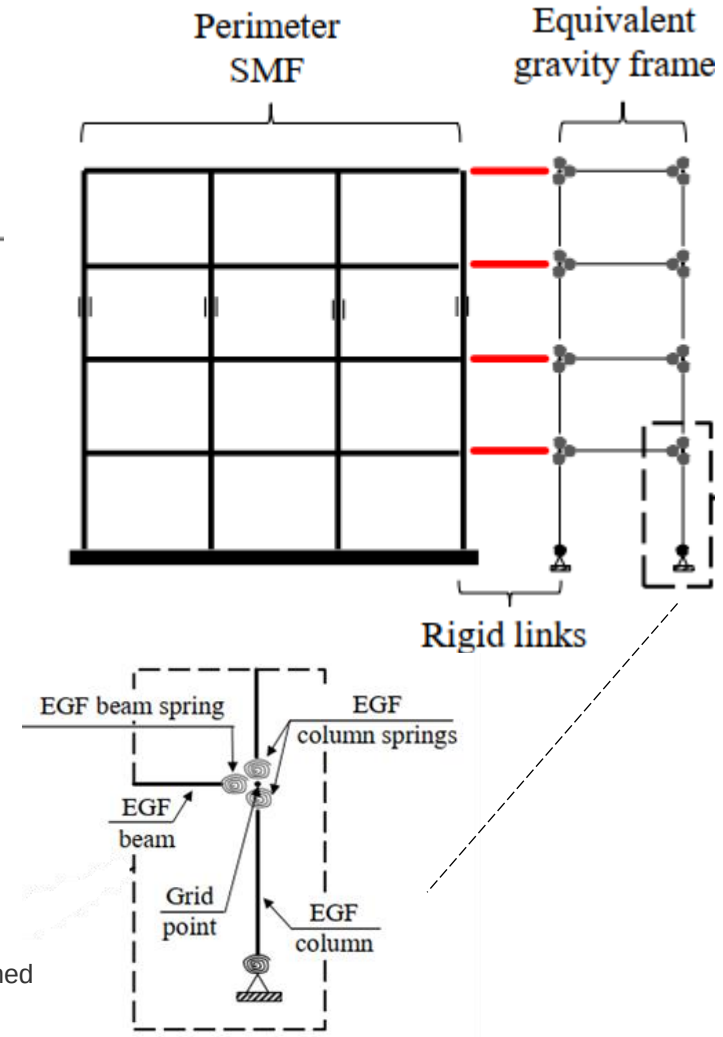
Applied Dynamics, NHRE, WiSe 2023/24

18WCEE, Milano, July 2024

VIV symposium, Bochum, June 2024

Case study: Nonlinear performance of a 20-story steel building under recurring seismic and wind loads





Shairin Islam, NHRE student

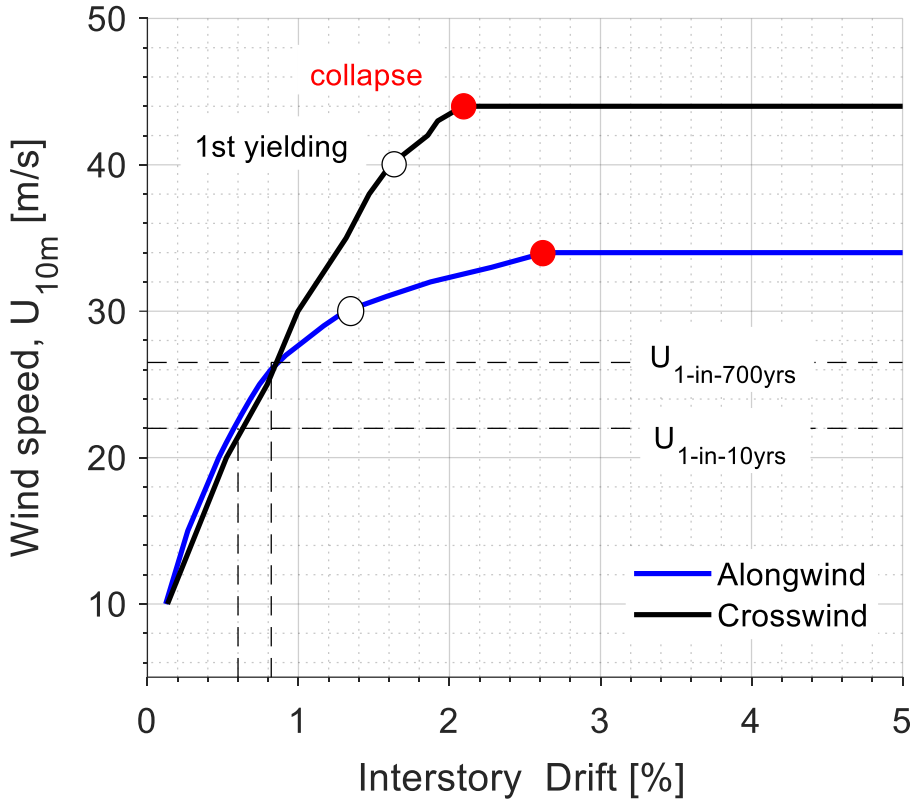
Asad Ullah, NHRE student

Elkady A (2016) Collapse risk assessment of steel moment resisting frames designed with deep wide-flange columns in seismic regions. PhD thesis, McGill University

Case study: Nonlinear performance of a 20-story steel building under recurring seismic and wind loads

Carl Zeiss Stiftung

Bauhaus-Universität Weimar



OpenSees

MATLAB

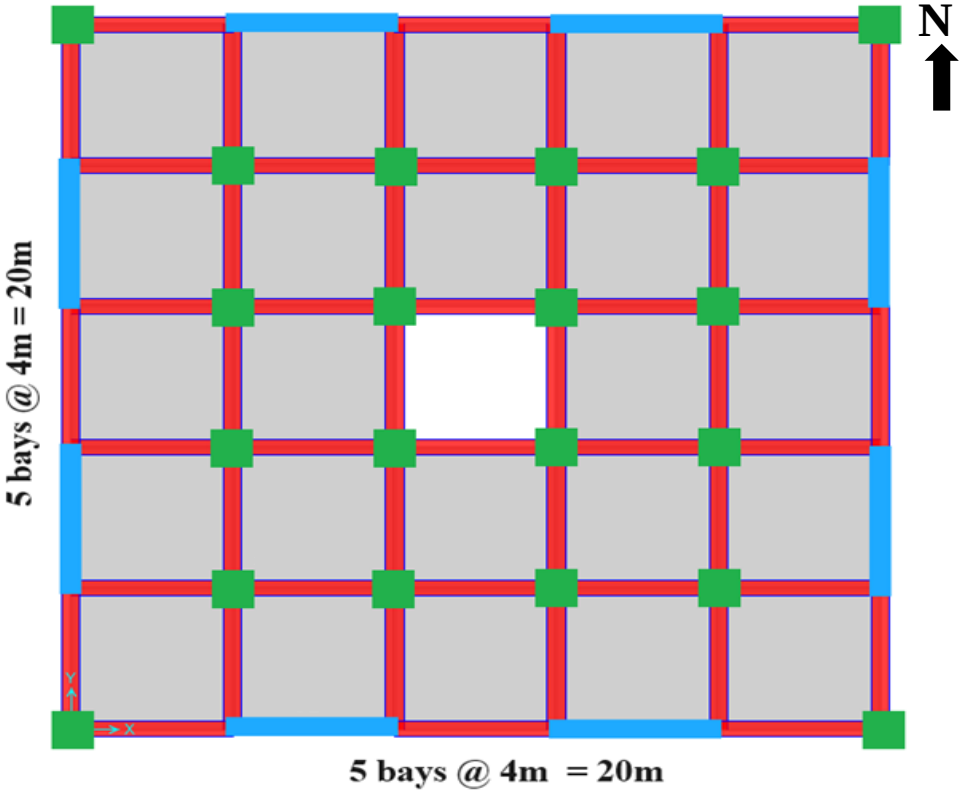
3NCWE Bucharest September 11-13, 2024

What's next

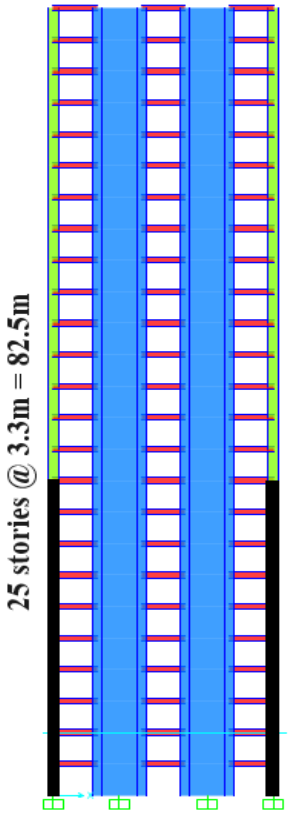
Bauhaus-
Universität
Weimar

?

Case study: 25-story RC buildings sited in various wind and seismic zones in India



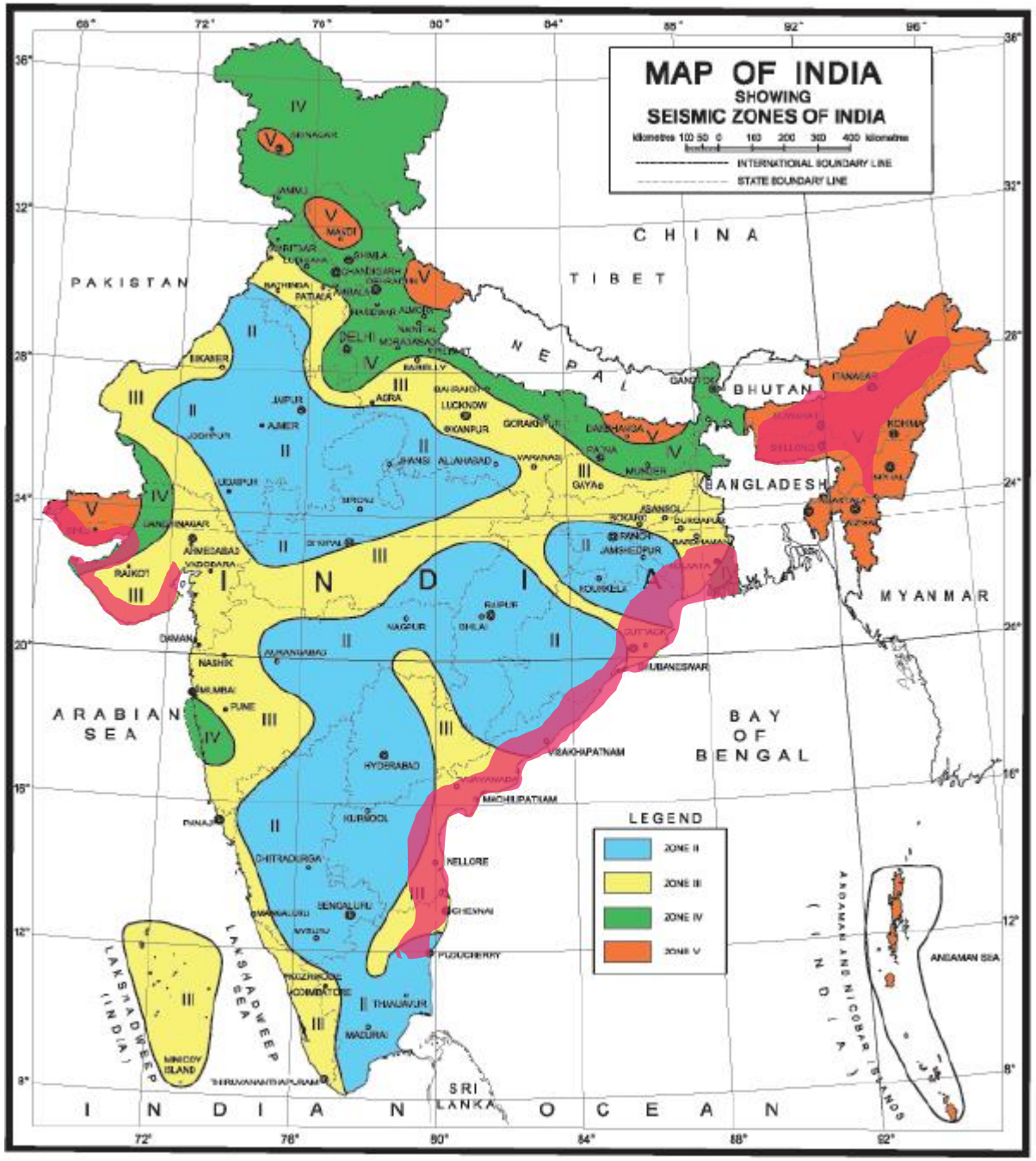
Building Plan

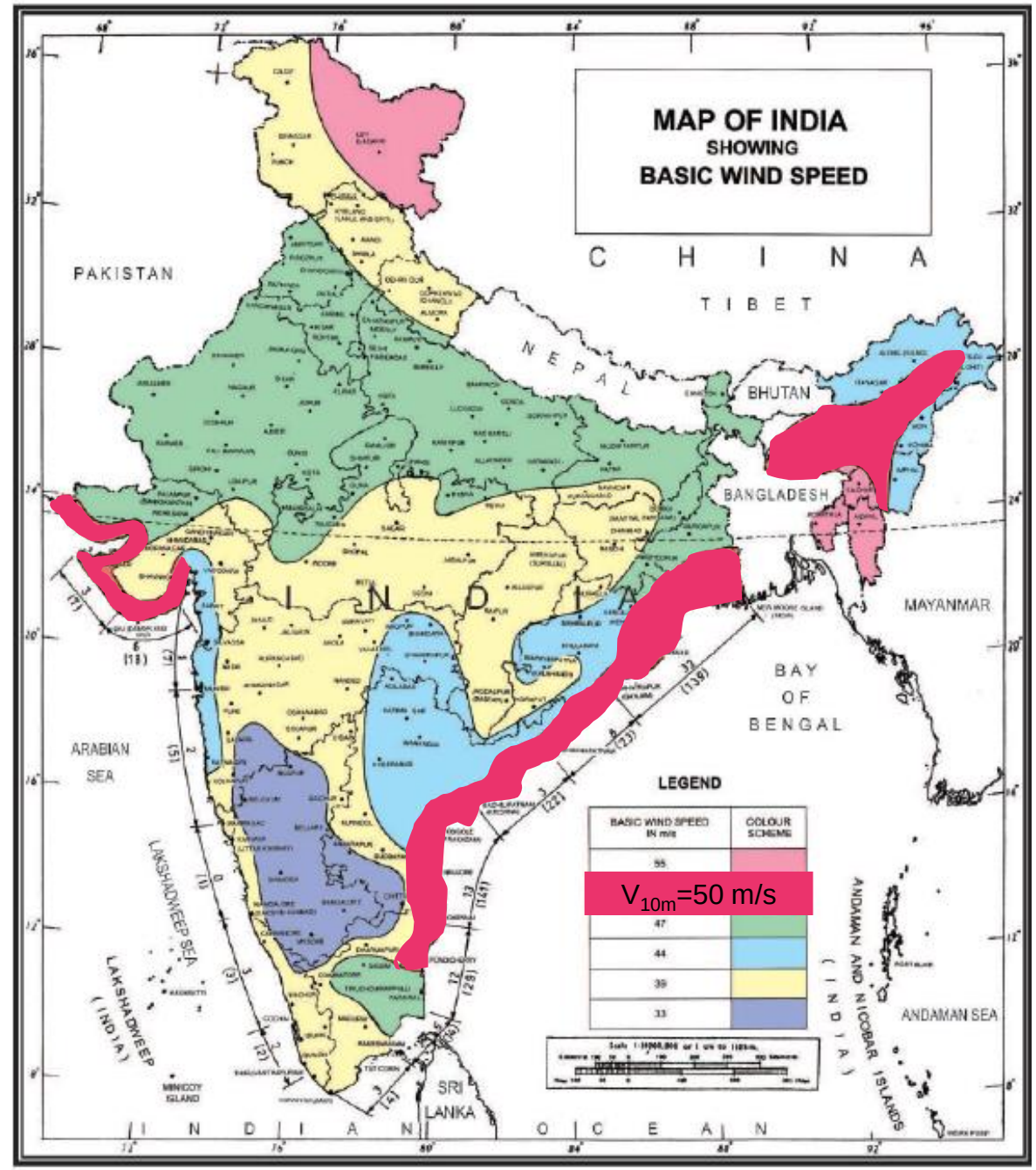


Building Elevation

Aniket Panchal
PhD candidate, IIT Gandhinagar

Morewe Mall
NHRE student





Based upon Survey of India Outline Map printed in 1963.

We shape the future through experimentation

Carl Zeiss Stiftung

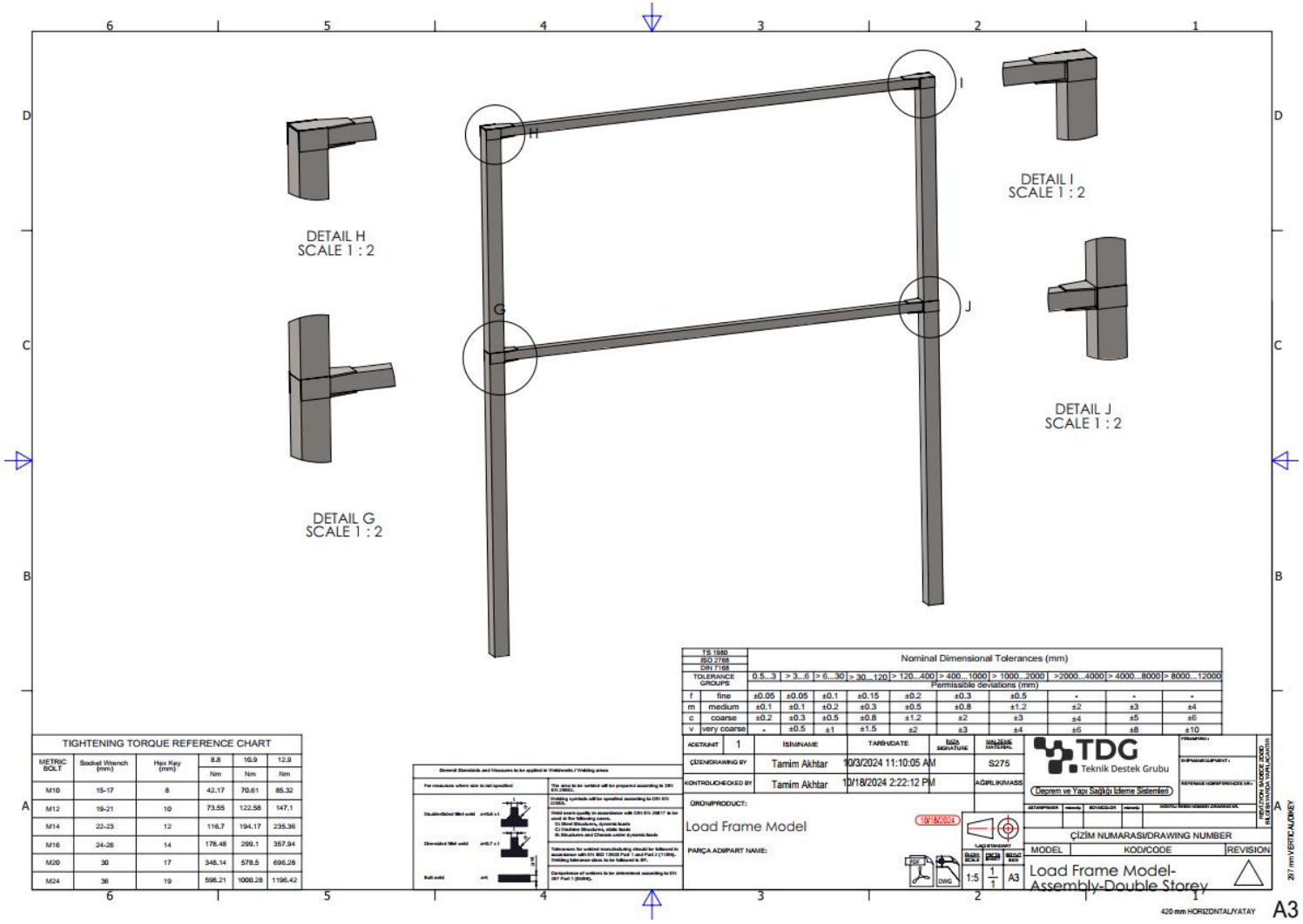
Bauhaus-Universität Weimar

Martha Bimrew Alemu

NHRE / DAAD scholar

Thank you Matthias Krauss, Christopher Taube, Marko Friedel, Christian Köffman and VTE staff !

We shape the future through experimentation

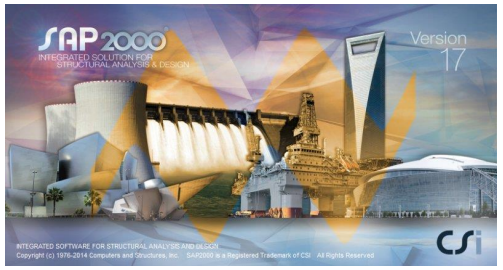


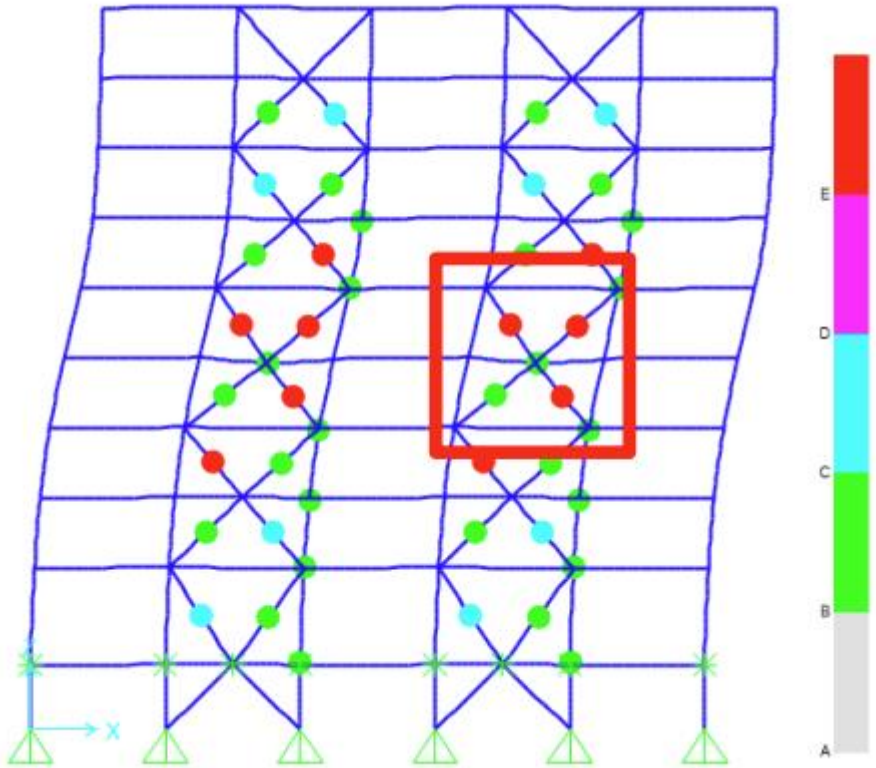
Endegena Ayalew Zelelew

NHRE / DAAD scholar

Thank you Patrick Staubach and Geotechnics Lab!

We envision the future (digital twining)

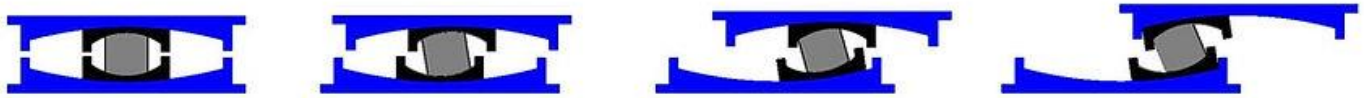




Rodrigo Benjamin Recinos Garcia

NHRE student

We envision the future (base-isolated tall buildings)



https://www.earthquakeprotection.com/hospitals

Elizabeth Alexandra Fuertes Fuentes

NHRE / DAAD scholar

I value

- ⭐ student-oriented teaching
- ⭐ international networking (Poland, China, India, Canada, Greece, Italy)
- ⭐ industrial collaboration (EPS, ARUP N. America, RSB, TDG)
- ⭐ interdisciplinary research (Prof. Ali Asgari, York University)

Η ισχύς εν τη ενώσει (Αίσωπος)

Eastern Canada Delegation (Sept. 2024)

Cuba Delegation (Feb. 2024)

Thank you ☺

Johanna Vanderwalle

Katharina Reinholdt

Christian Kästner

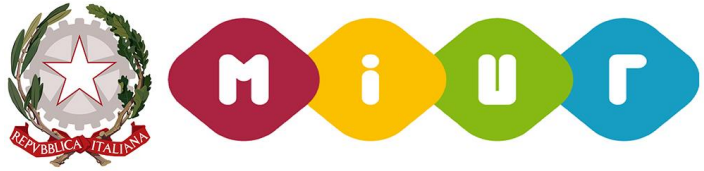
Guido Morghental

Tom Lahmer

Peter Benz

Università degli Studi della Basilicata

Bauhaus-Universität Weimar



MINISTERO DELL' ISTRUZIONE, DELL'UNIVERSITÀ E DELLA RICERCA