BUDAPEST UNIVERSITY OF TECHNOLOGY AND ECONOMICS
DEPARTMENT OF STRUCTURAL ENGINEERING

SEISMIC PERFORMANCE EVALUATION OF BUCKLING RESTRAINED BRACES AND FRAME STRUCTURES

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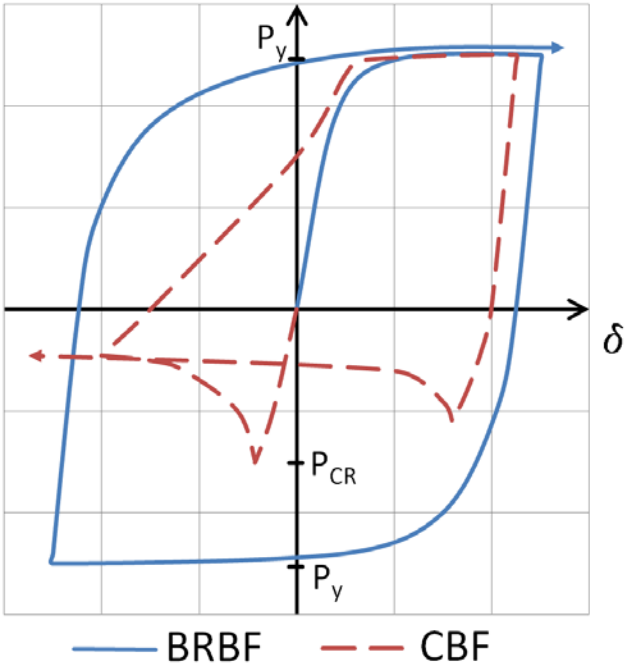
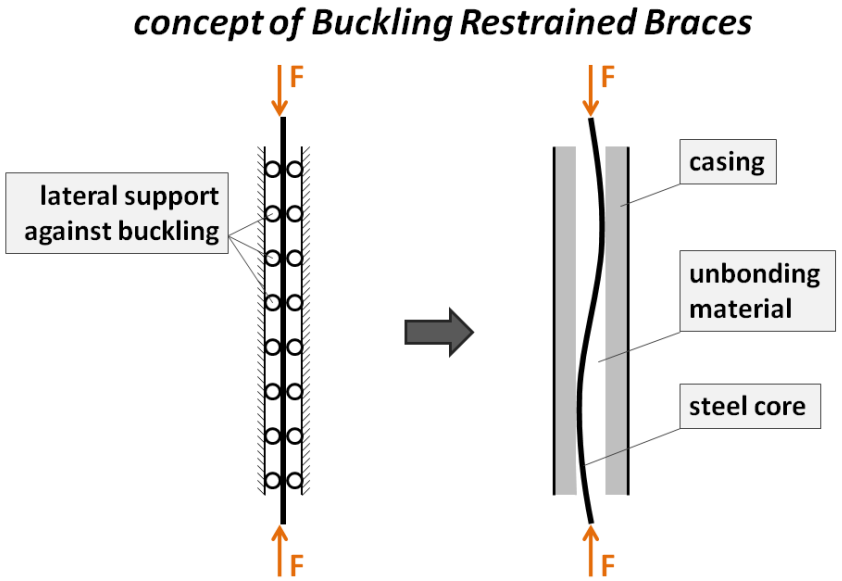
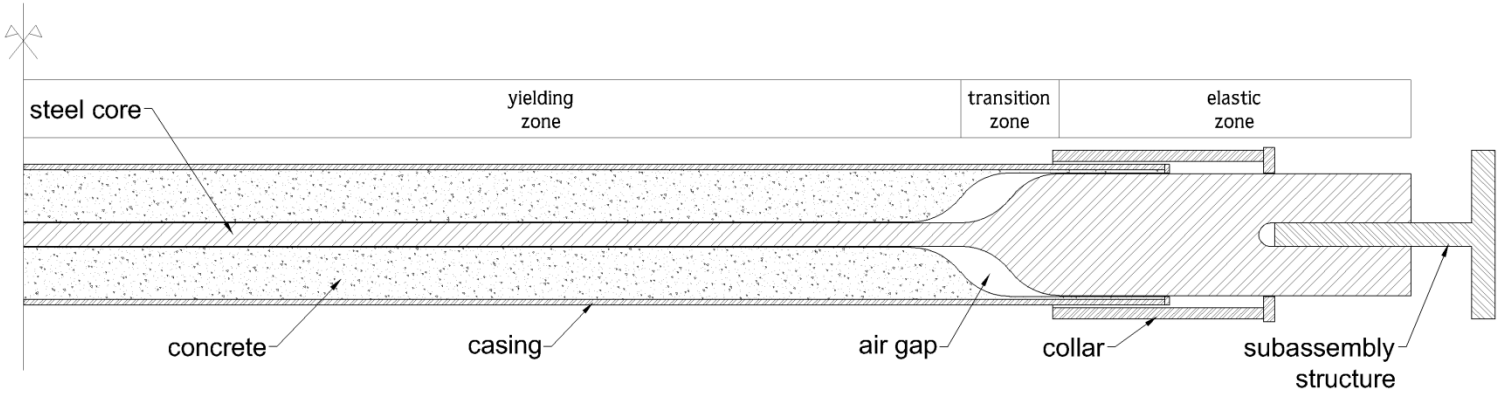
supervisor
László Gergely VIGH PhD
associate professor

INTRODUCTION







no standardized design procedure in Europe at the moment

RESEARCH OVERVIEW

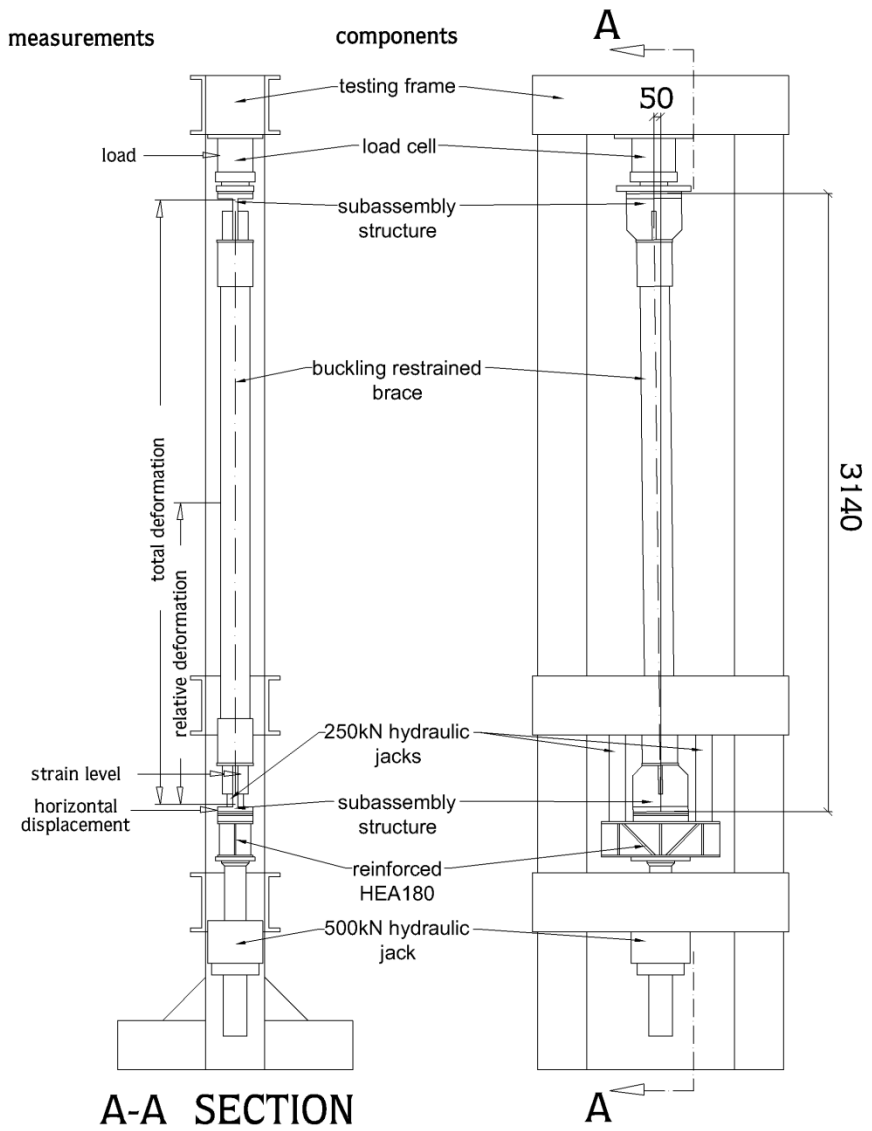
laboratory tests

numerical BRB model

global analysis framework

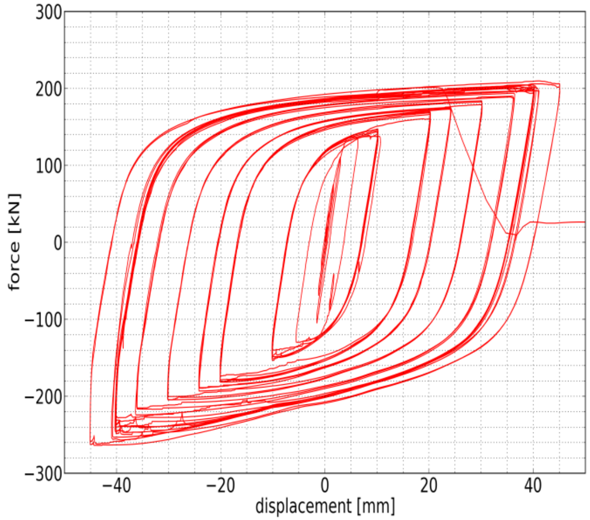
design procedure development

TEST SETUP


measurements
components
A
testing frame
50
load
load cell
subassembly structure
buckling restrained brace
total deformation
relative deformation
3140
strain level
horizontal displacement
250kN hydraulic jacks
subassembly structure
reinforced HEA180
500kN hydraulic jack
A-A SECTION
A


Full scale testing of
Buckling Restrained Braces
in accordance with
EN 15129
STAR SEISMIC
Europe
www.starseismic.eu

RESULTS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force [kN]
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20
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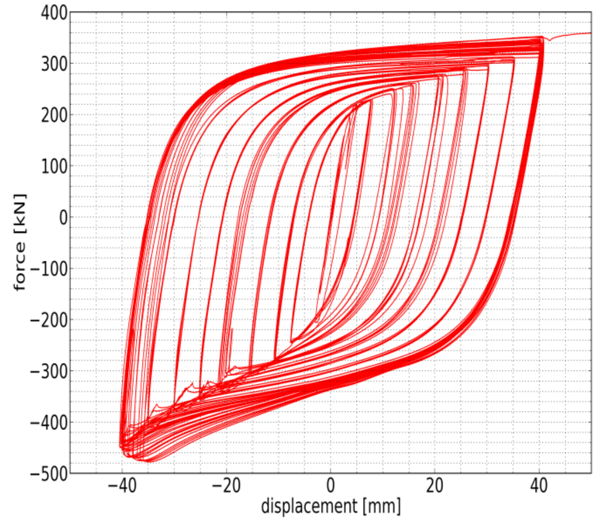
displacement [mm]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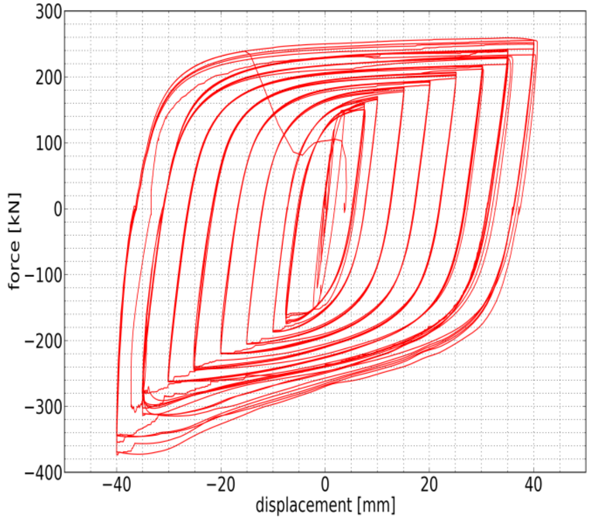
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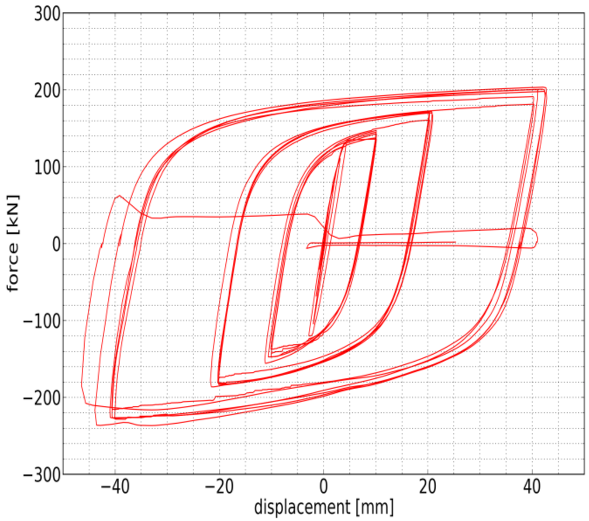
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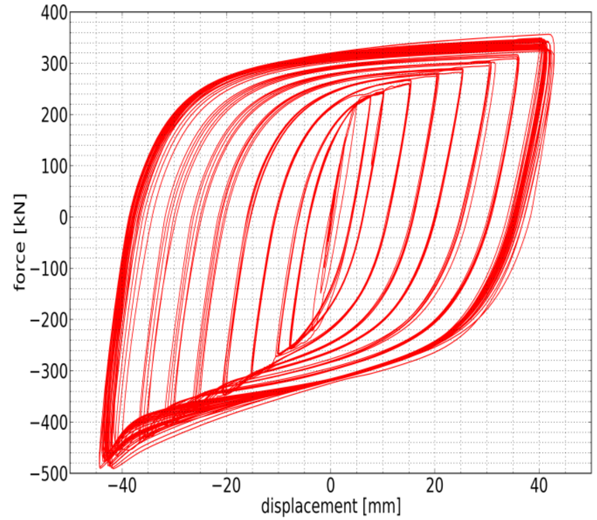
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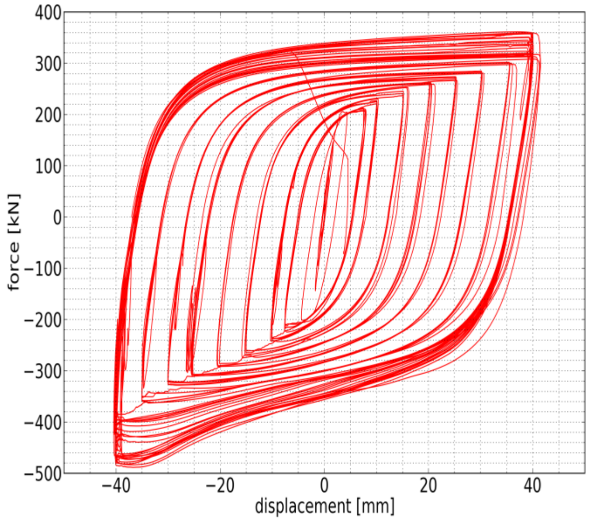
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RESEARCH OVERVIEW

laboratory tests

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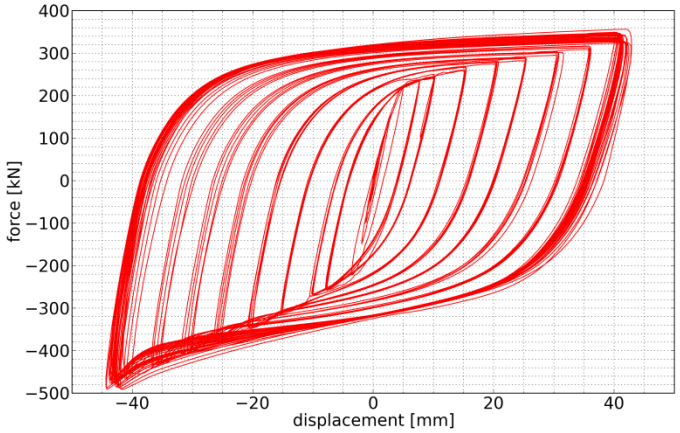
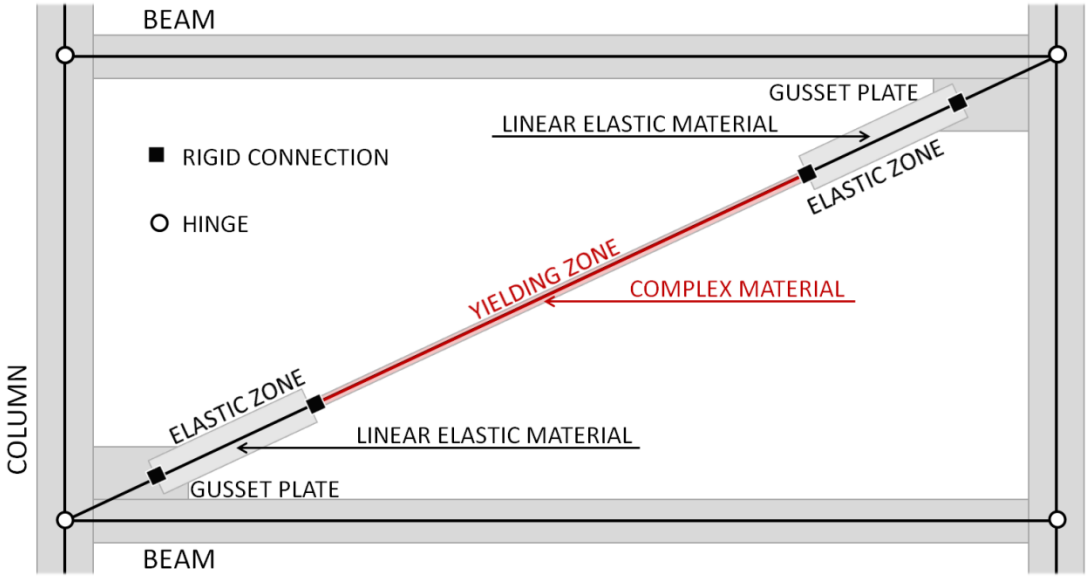
design procedure development

CONFIGURATION



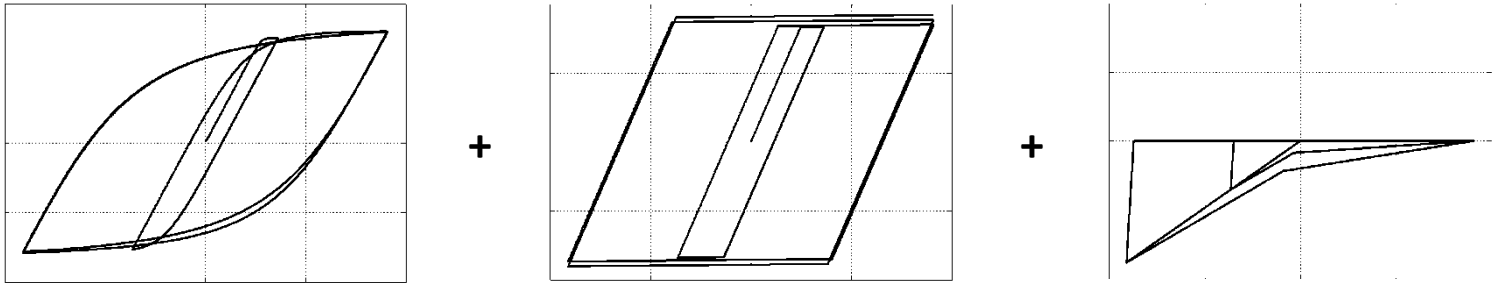
important characteristics:

- Bauschinger effect
- plastic strain hardening
- cyclic hardening
- asymmetric hardening
- monotonic loading curve

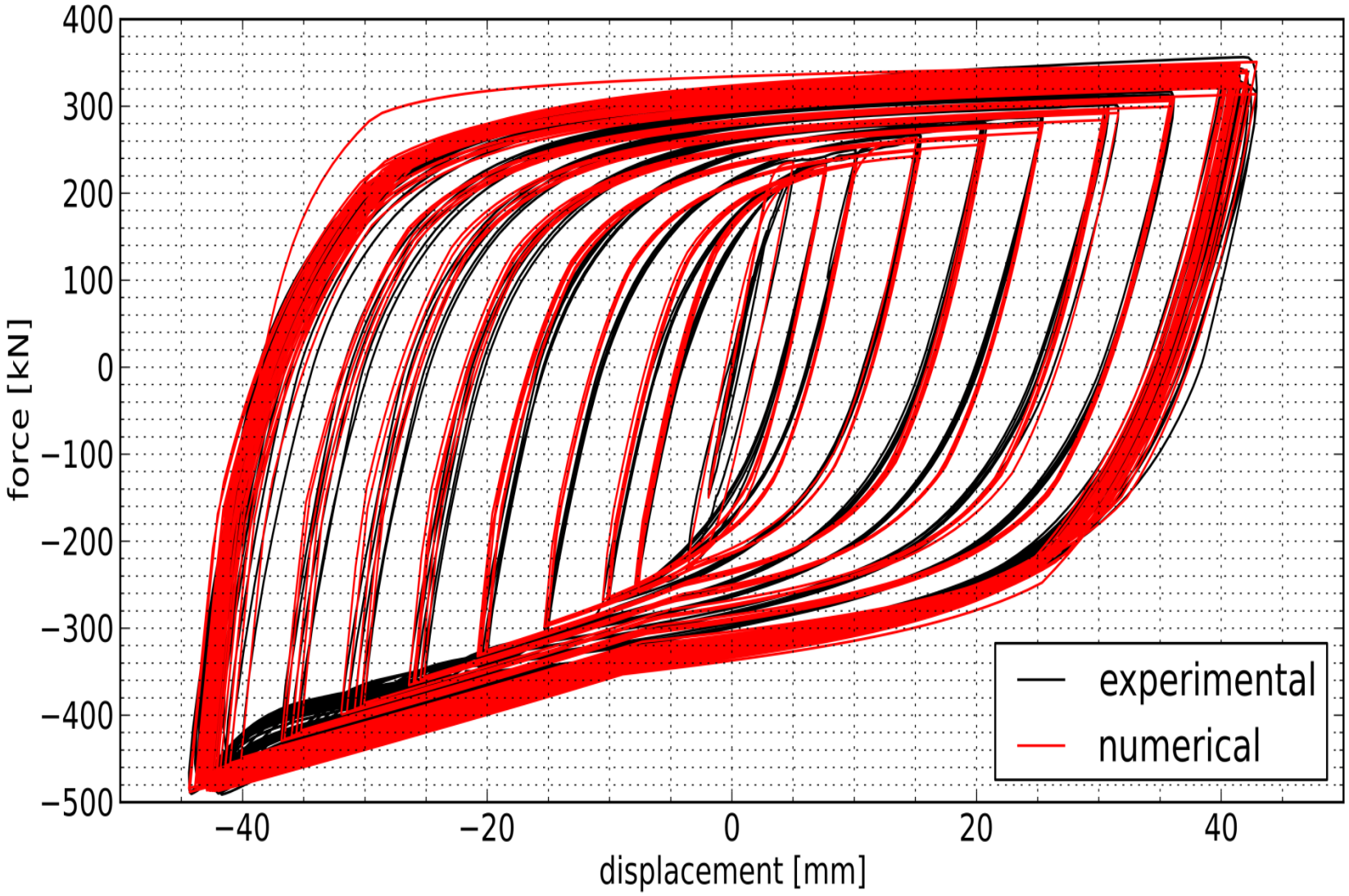


Parallel materials in a single element using OpenSEES:

STEEL 02 + **HARDENING** + **PINCHING 4**



VERIFICATION



RESEARCH OVERVIEW

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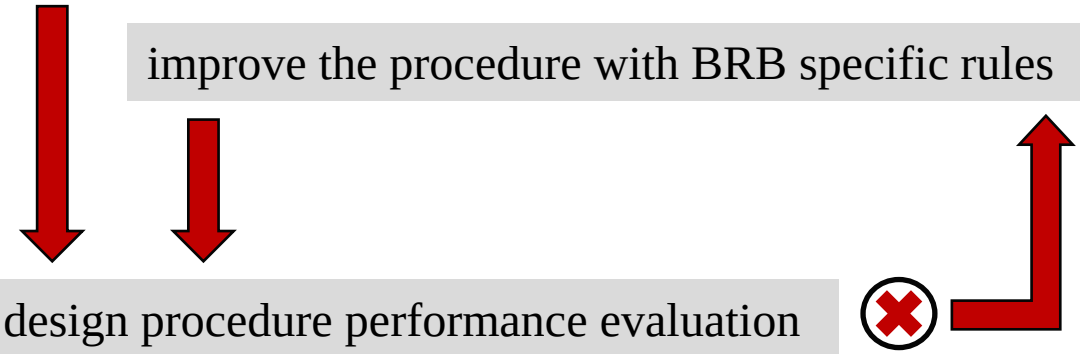
CONCEPT

based on FEMA P695 recommendation

start: design procedure for DCH concentric steel braced frames from Eurocode 8:



improve the procedure with BRB specific rules

design procedure performance evaluation

linear elastic analysis
capacity design
global mechanism
structural overstrength
displacement limits

objective: **develop a standardized BRBF design procedure**

PERFORMANCE EVALUATION

based on FEMA P695 recommendation

design procedure performance evaluation

structural archetypes

ARCHETYPE PARAMETER SPACE

parameter	description	range / options
number of stories	the range of common building heights in Europe.	1-20
bay configuration	a set of frequently used combinations are selected from the height and width ranges	height: 3-5 m width: 4-8 m
gravity loading	provides different mass possibilities for buildings with the same height while influencing non-BRBF column sections	dead load: 3.5 – 12.0 kN/m^2 live load: 2.0 – 4.0 kN/m^2
braced area	size of floor area that is supported by a single braced frame makes the actual building layout irrelevant as long as it is regular both in plan and in elevation	150-650 m^2
seismic intensity	the peak ground acceleration corresponds to 475 year return period according to European design practice the type of spectra separates near-field and far-field records common soil classes are B, C and D with D corresponding to the least favourable acceleration response	a_{gr}=1.0-4.0 m/s^2 type I or type II spectrum soil class B, C or D
non-structural elements	influences the interstorey drift limitation the values after the element types are the limits under 475 year return period seismic excitation	brittle – 0.01h ductile – 0.015h independent – 0.02h

PERFORMANCE EVALUATION

based on FEMA P695 recommendation

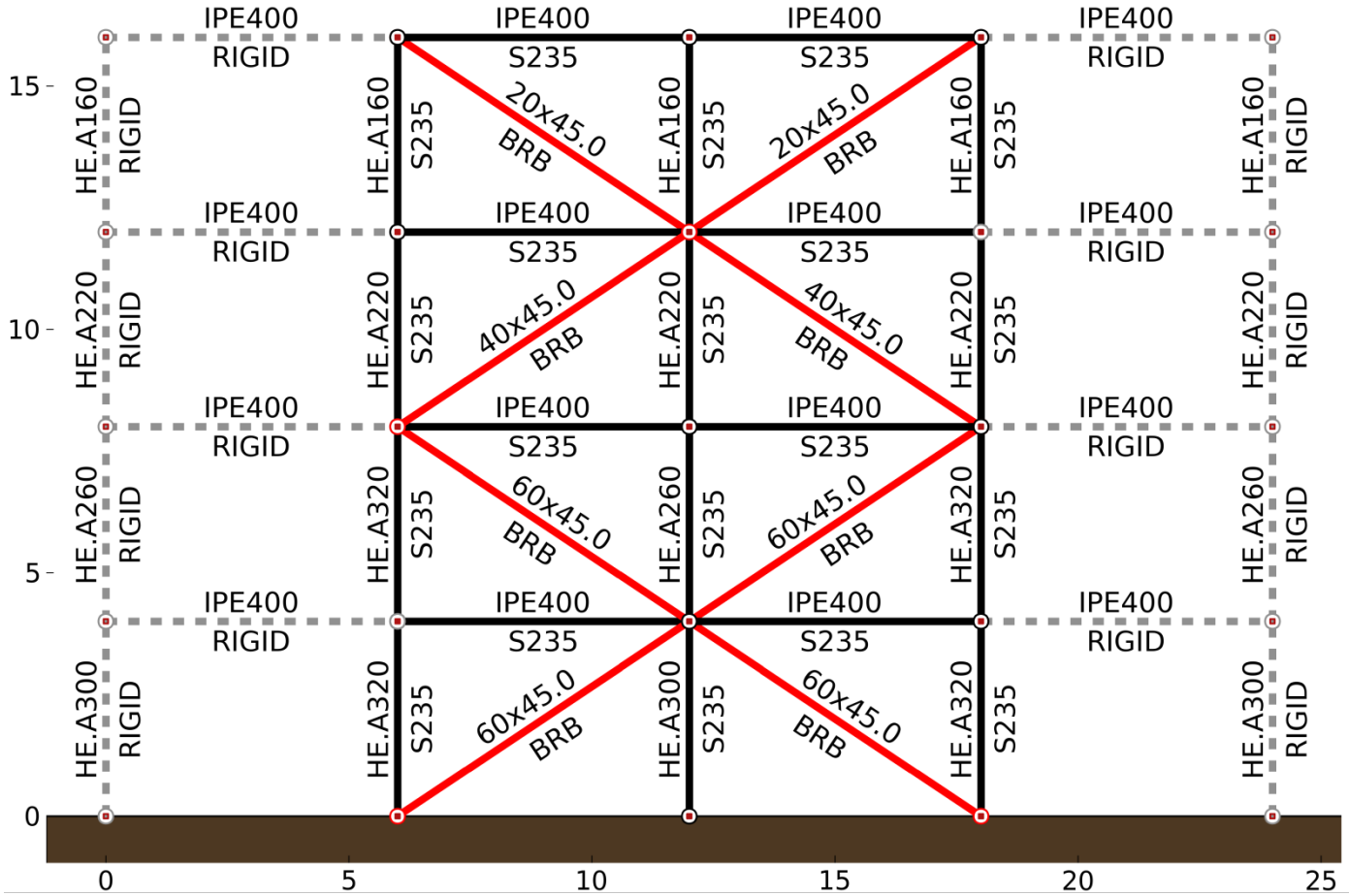
design procedure performance evaluation

for each archetype:

- **design using linear static analysis**

structural archetypes

ARCHETYPE DESIGN



PARAMETERS	
stories	*4*
bay config width height	 *6 m* *4 m*
gravity loads dead live	 *5 kN/m²* *3 kN/m²*
braced area	*250 m²*
seismicity PGA spectrum soil class	 *4.0 m/s²* *type I.* *D*
non-struct. elements	*independent*

PERFORMANCE EVALUATION

based on FEMA P695 recommendation

design procedure performance evaluation

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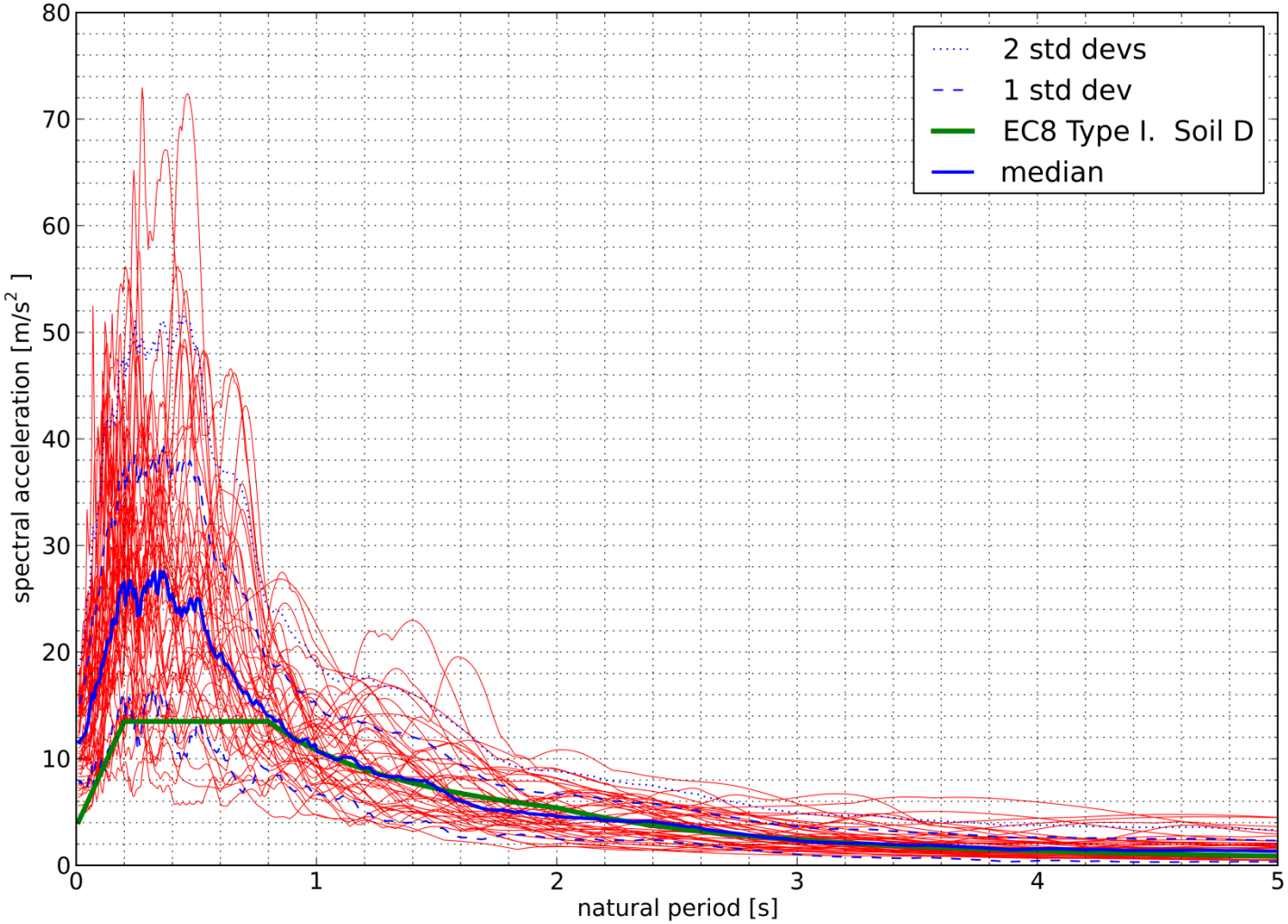
structural archetypes

statistically independent ground motion records

GROUND MOTION RECORD SET

44 records from major earthquakes around the world
adjusted and scaled to European response spectra
at the natural period of each structure



PERFORMANCE EVALUATION

based on FEMA P695 recommendation

design procedure performance evaluation

for each archetype:

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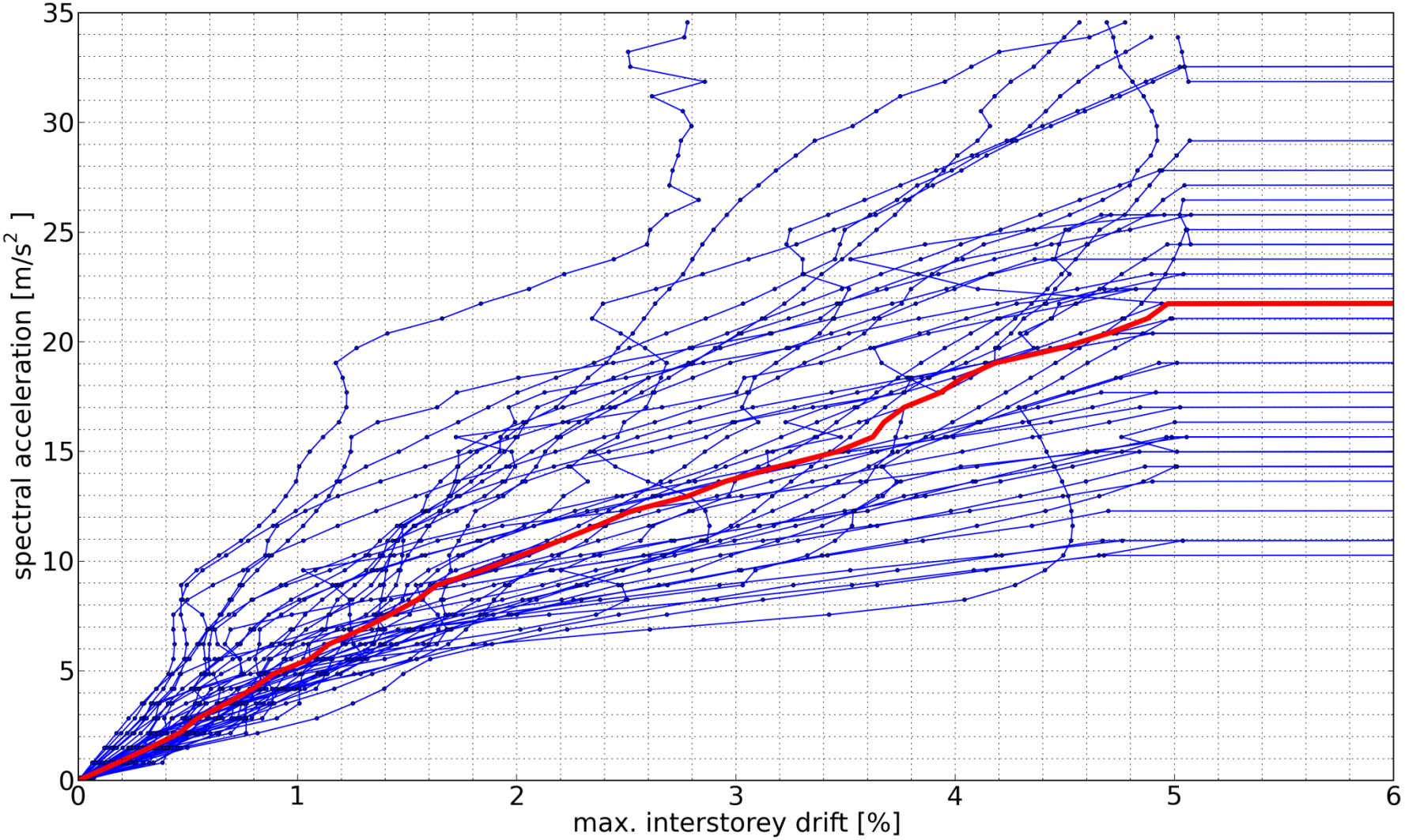
- **check the performance with dynamic analysis**

structural archetypes

statistically independent ground motion records

INCREMENTAL DYNAMIC ANALYSIS



PERFORMANCE EVALUATION

based on FEMA P695 recommendation

design procedure performance evaluation

for each archetype:

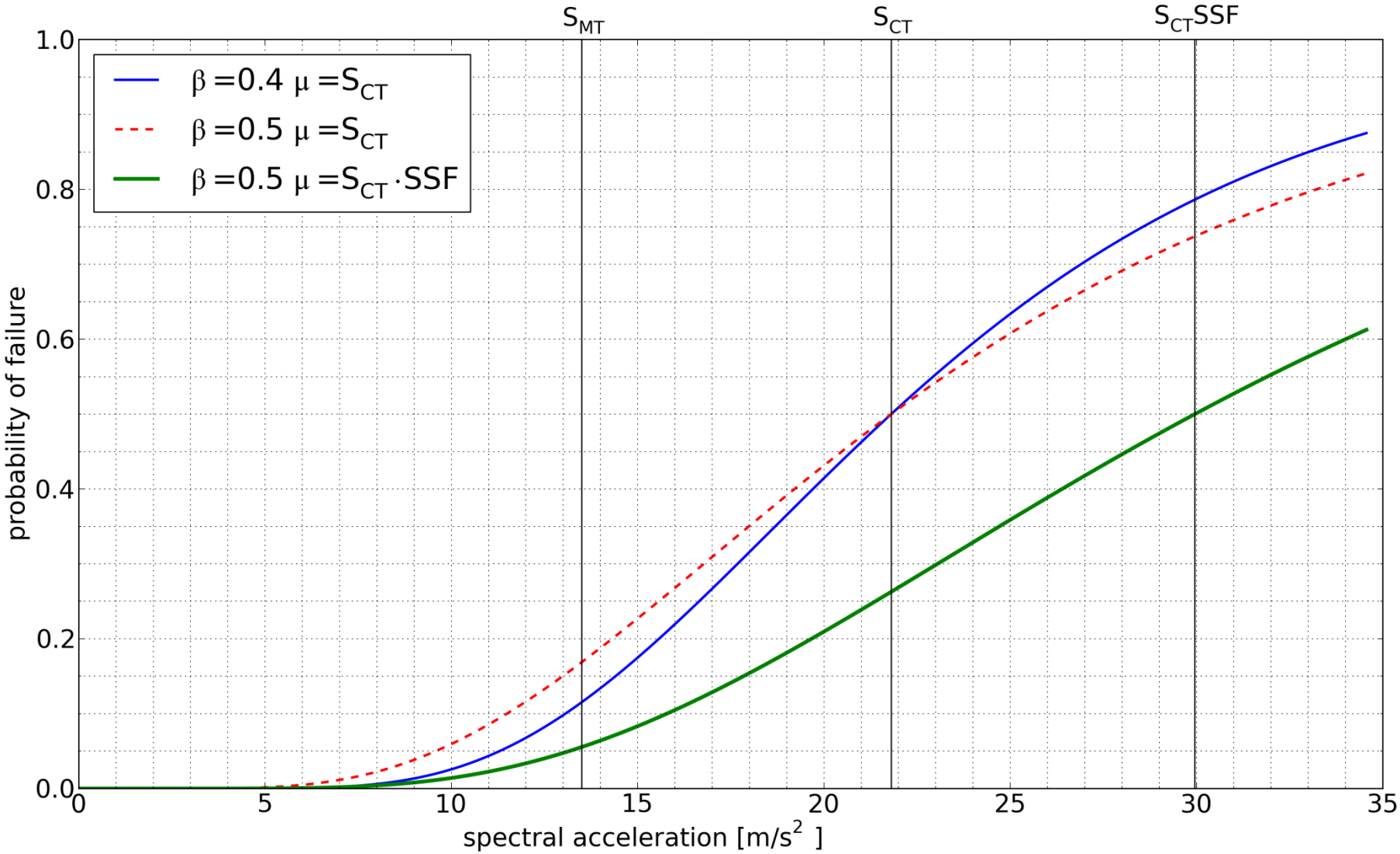
- design using linear static analysis
- check the performance with dynamic analysis
- **evaluate the probability of failure**

structural archetypes

statistically independent ground motion records

FRAGILITY CURVES

uncertainties in ground motions, numerical model, analysis, evaluation are considered



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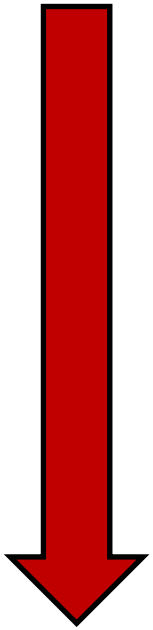

standardized design procedure

Acknowledgements:

Star Seismic Europe Ltd.

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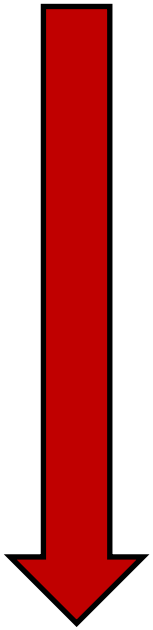

standardized design procedure

thank you for your attention