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SPECIAL MOBILITY STRAND

SEISMIC PERFORMANCE OF MASONRY INFILLED FRAMES WITH OPEN FIRST STOREY

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Novi Sad, 2020

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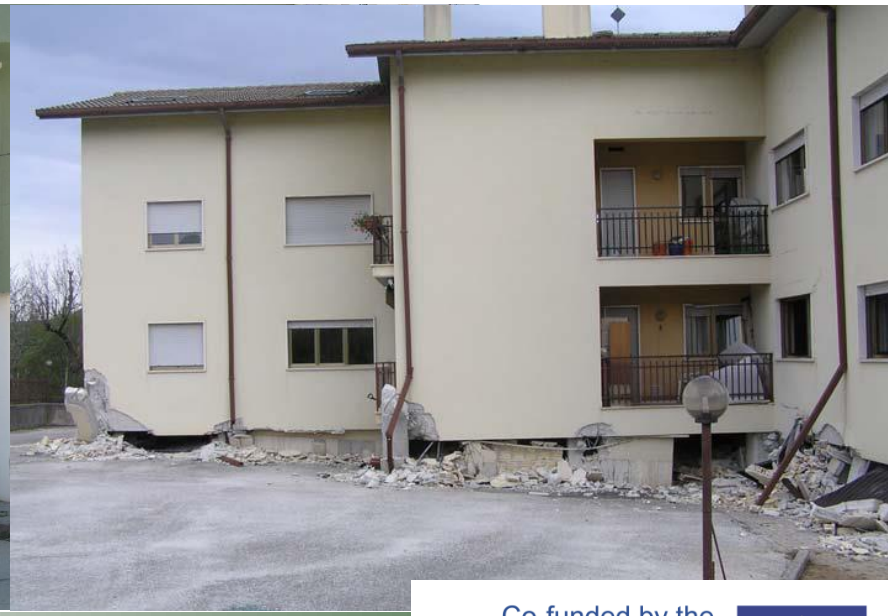
Why masonry infilled frames?

- **Positive effects:**
  - increase the structural stiffness, strength and damping,
  - act as a first line of defense in seismic activity reducing the ductility demand and consequent damage of structural elements.
- **Negative effects:**
  - torsion,
  - dangerous collapse mechanisms,
  - soft or weak storey,
  - variations in the vibration period, etc.





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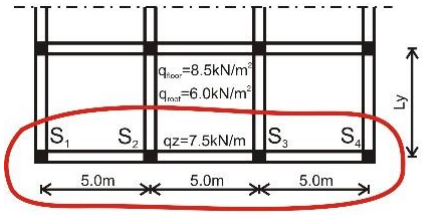
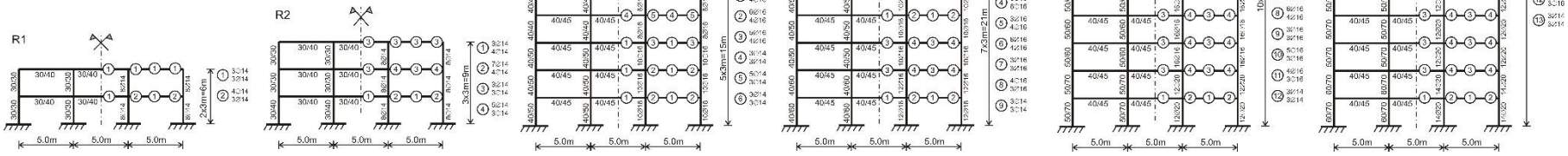
Numerical evaluation – design parameters

- Six frames with different number of storey





- Three types of frames
  - Bare frames (BF)
  - Infilled frames with open first storey
    - weak infill (WI), fm=0.8MPa, thickness 15 cm
    - strong infill (SI), fm=1.2MPa, thickness 25 cm
- Three groups of earthquakes
  - Seven records per group
  - 10 level of PGA per record

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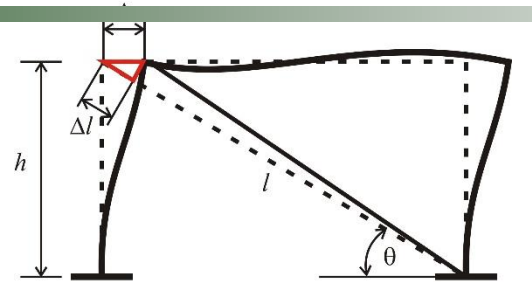
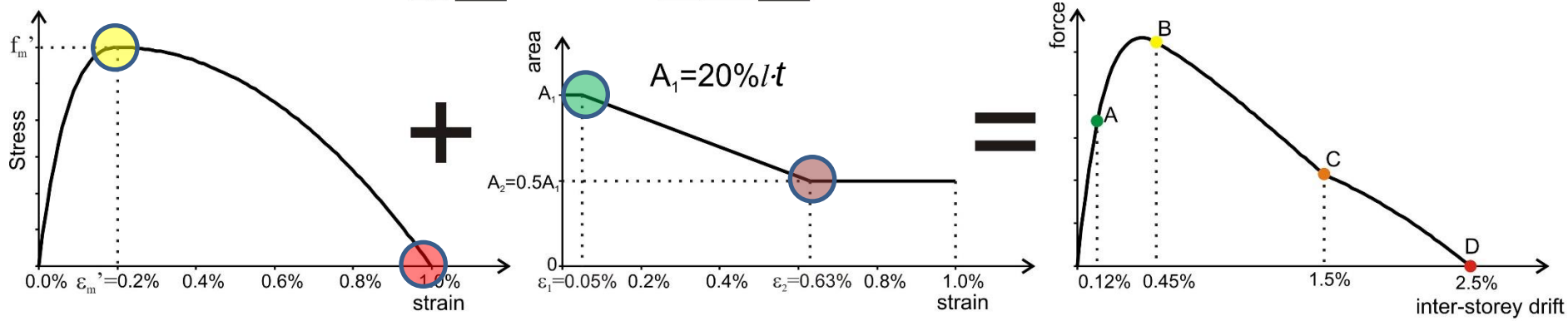
Damage measure of masonary infill – discrete levels of SP



$$\varepsilon = \frac{\delta}{2}\sin 2\theta$$



Performance level	Range	Boundary values of strain	Adopted strain limit	Boundary values of interstorey drifts	Adopted values of interstorey drifts
Operational	0-A	ε_A 0.02-0.07%	0.05%	δ_A 0.05-0.15%	0.12%
Immediate occupancy	A-B	ε_B 0.1-0.3%	0.2%	δ_B 0.25-0.7%	0.45%
Life safety	B-C	ε_C 0.4-0.85%	0.63%	δ_C 1-2%	1.5%
Collapse prevention	C-D	ε_C 0.75-1.25%	1%	δ_D 2-3%	2.5%

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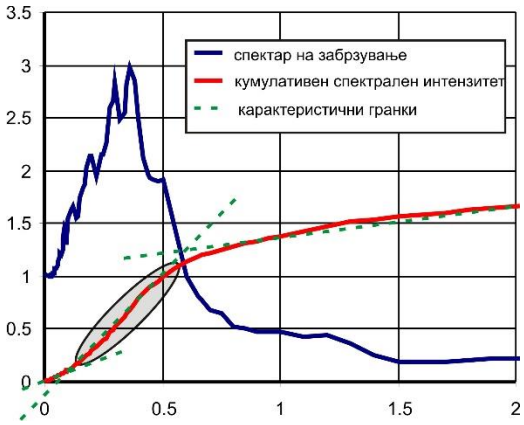
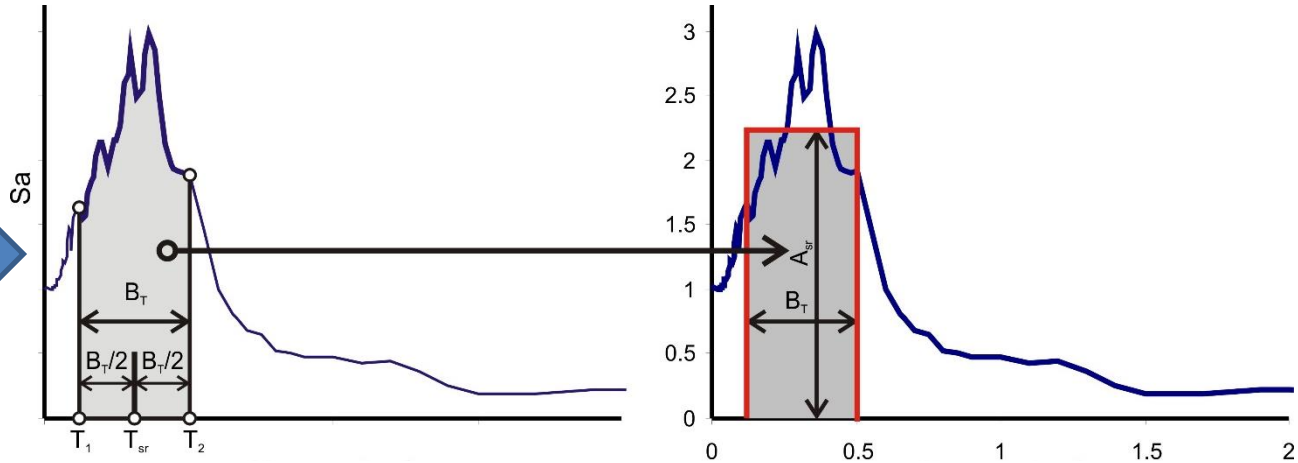
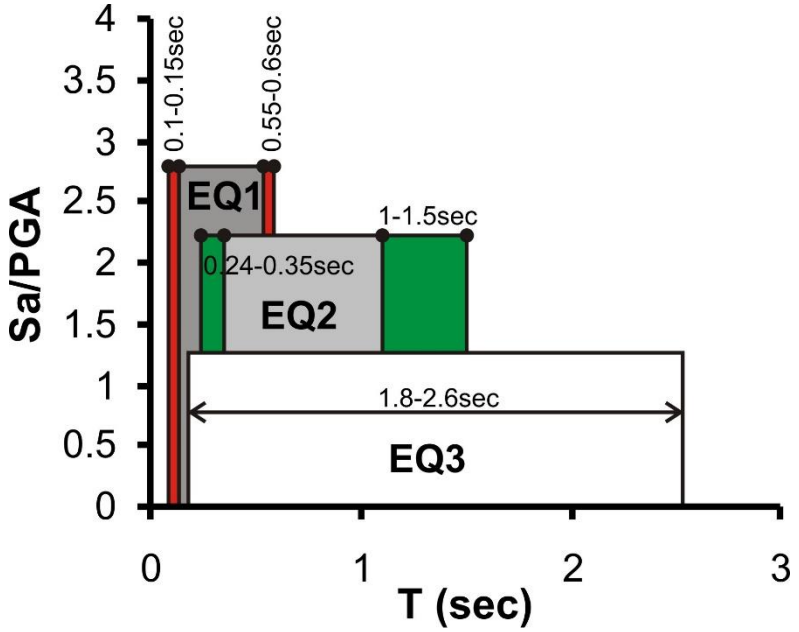
Selection of earthquake ground motions





- Criteria for selection
- Three groups of earthquakes
  - EQ1: low periods

    (0.1<T1<0.15 sec.) (0.55<T2<0.6 sec.)
    (0.4<BT<0.5 sec.) (0.325<Tsr<0.375 sec.)
  - EQ2: middle and high periods
    (0.24<T1<0.35 sec.) (1.1<T2<1.5 sec.)
    (0.75<BT<1.26 sec.) (0.725<Tsr<0.91 sec.)
  - EQ3: wide frequency range (1.8<BT<2.6 sec.)



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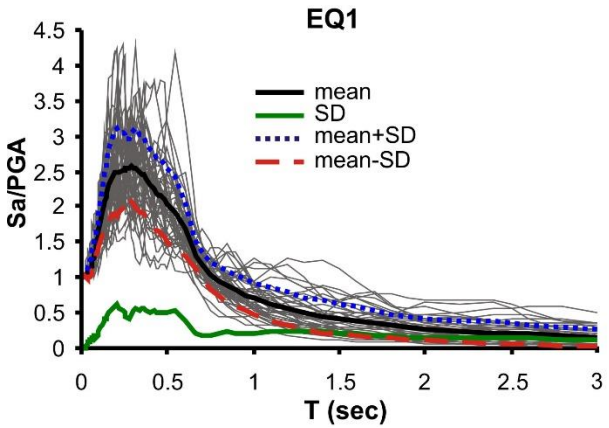
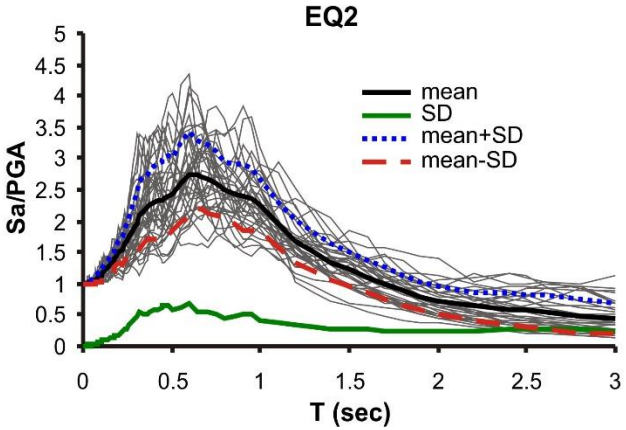
Selection of earthquake ground motions

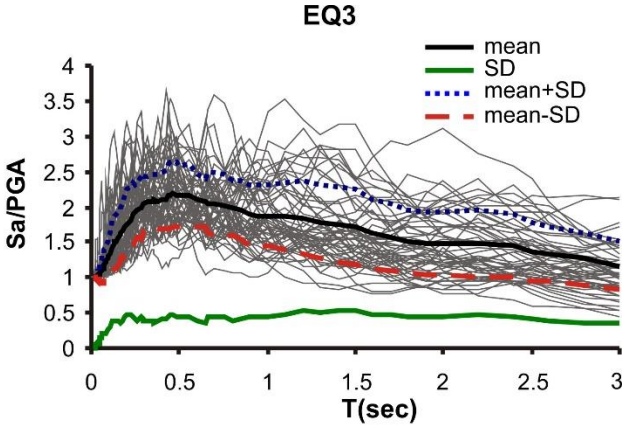
45 records



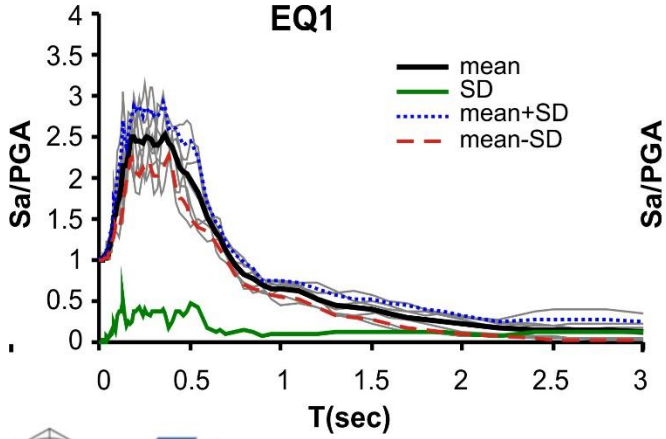
34 records

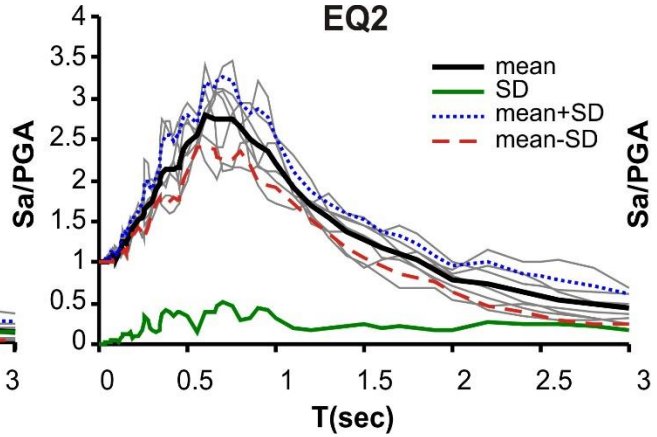


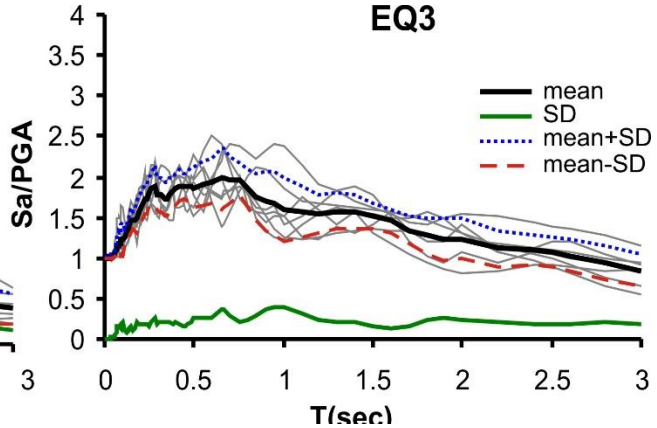
55 records



$$C\Delta S_a = \sum_{i=1}^{n} \sqrt{\left(S_a(i) - meanS_a\right)^2}$$







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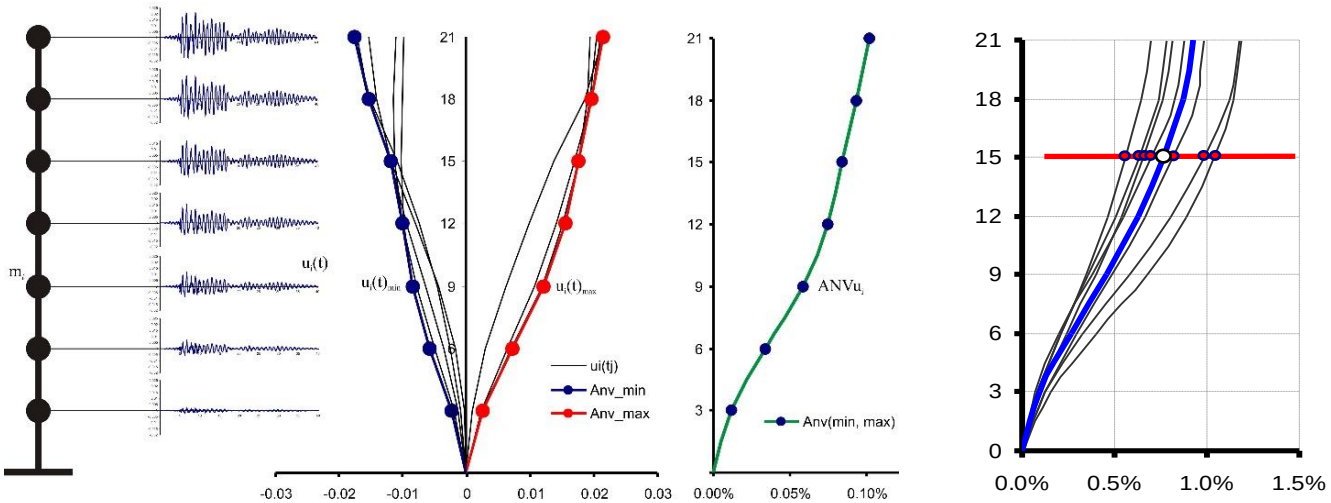
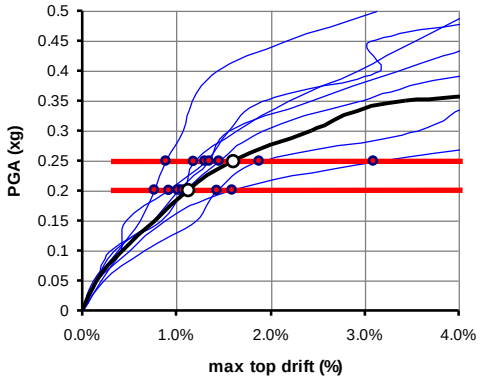
Numerical evaluation – processing the results

3780RHA

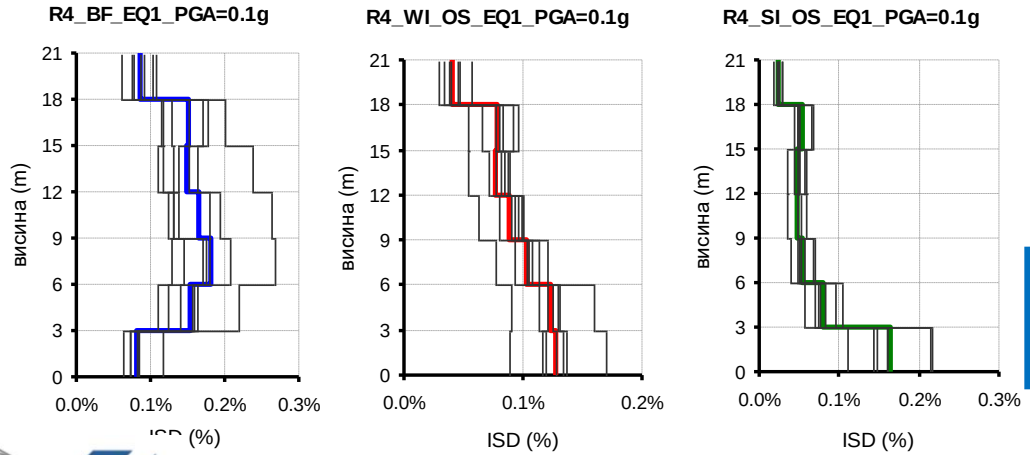
Envelope curves from individual records

$$ANVu_i = \frac{\max\left(u_i(t)_{\max}; \left|u_i(t)_{\min}\right|\right)}{H_{tot}}$$





Individual and mean response – absolute displacement –



Individual and mean response – interstorey drifts –

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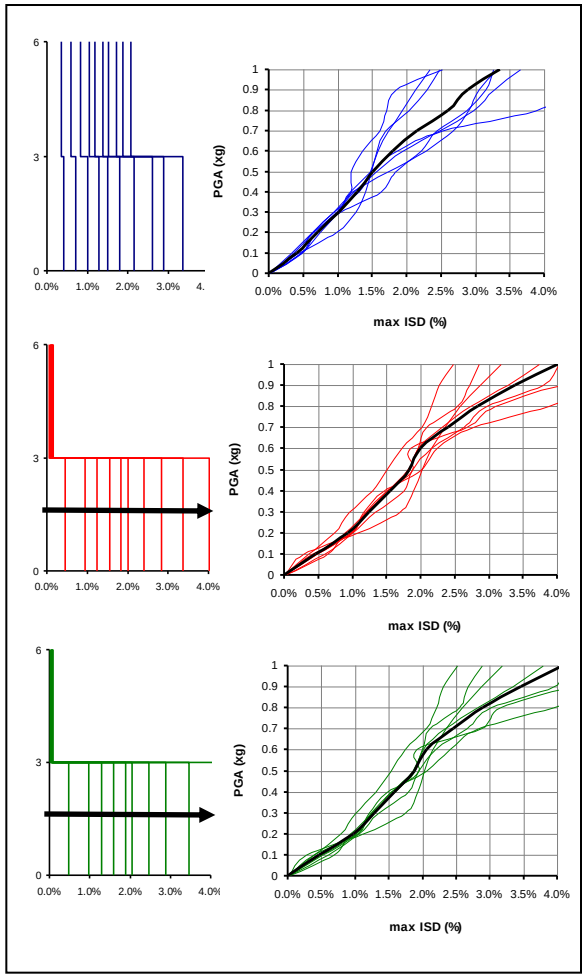
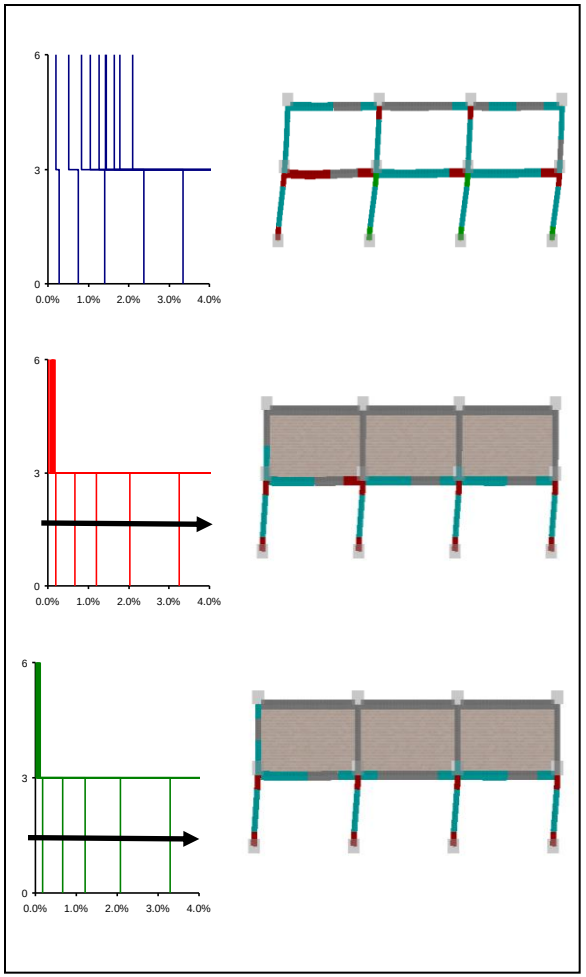
Numerical evaluation – Incremental curves – interstorey drifts, frame R1 – 2 storey

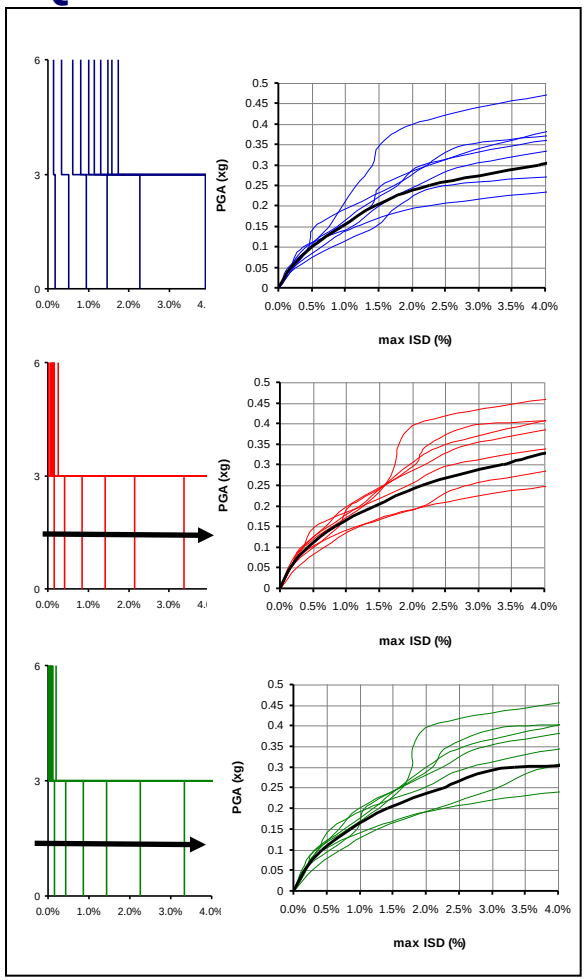
EQ1



EQ2



EQ3



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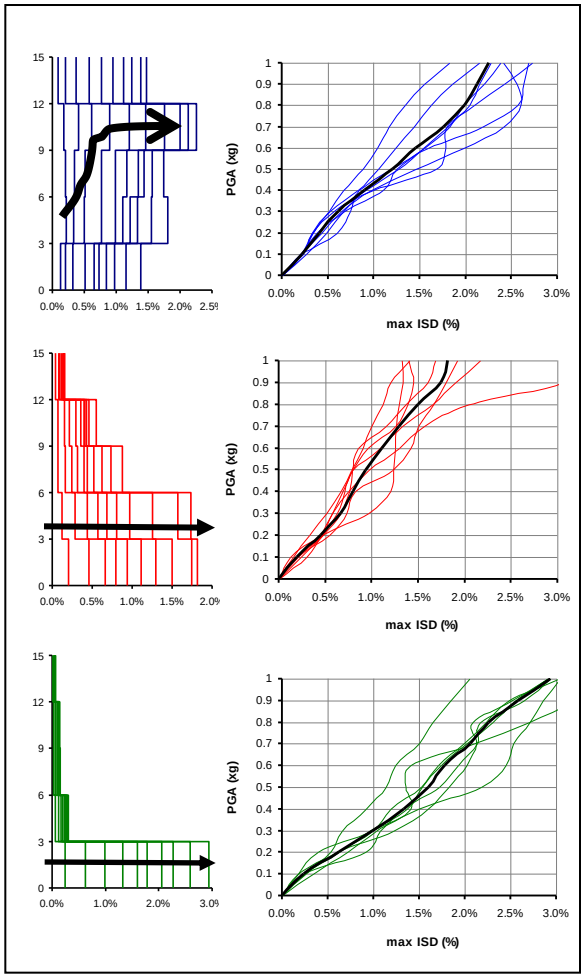
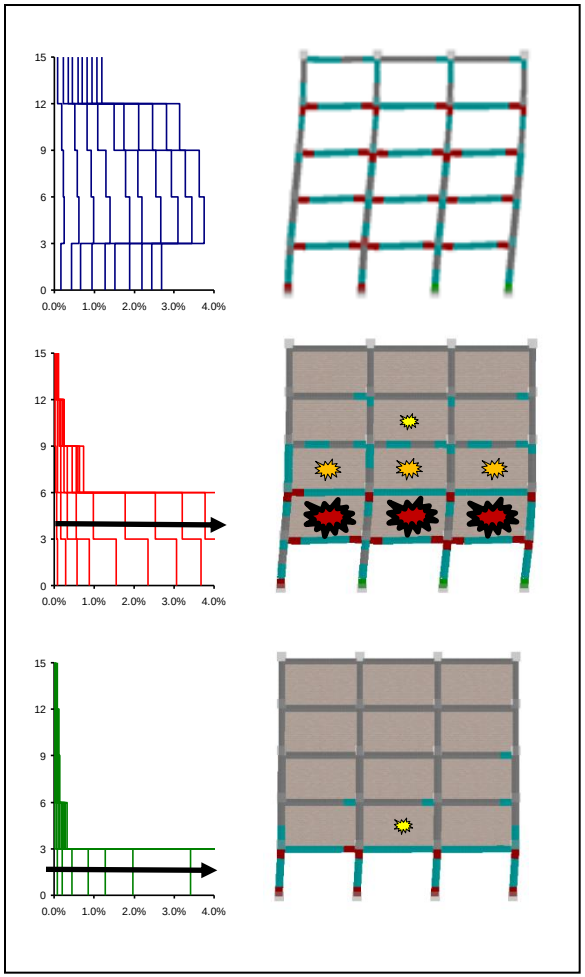
Numerical evaluation – Incremental curves – interstorey drifts, frame R3 – 5 storey

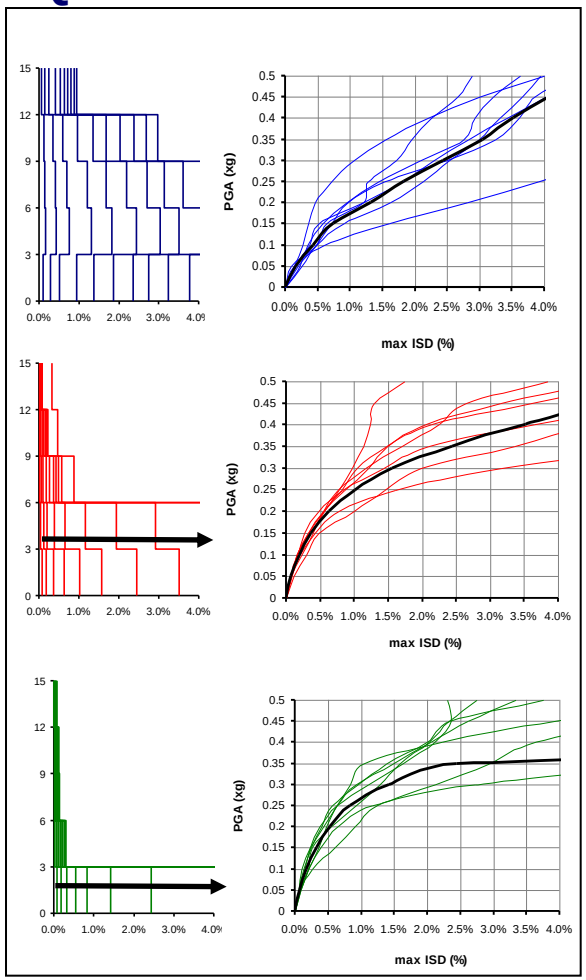
EQ1



EQ2



EQ3



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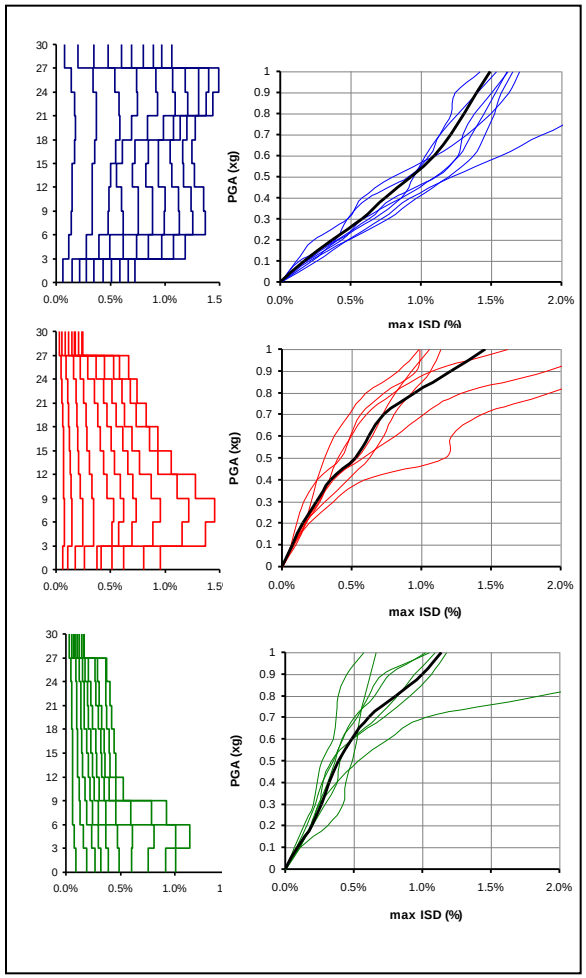
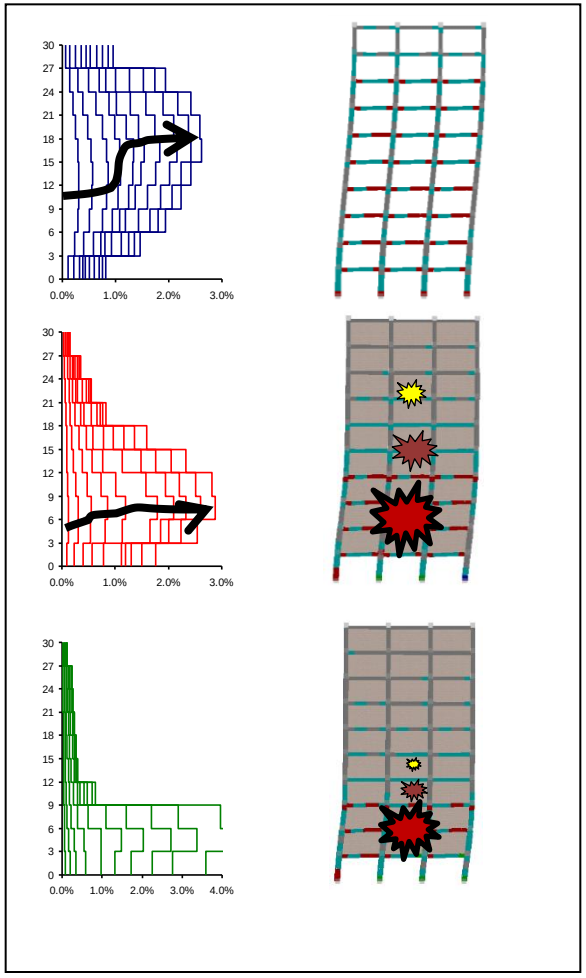
Numerical evaluation – Incremental curves – interstorey drifts, frame R5 – 10 storey

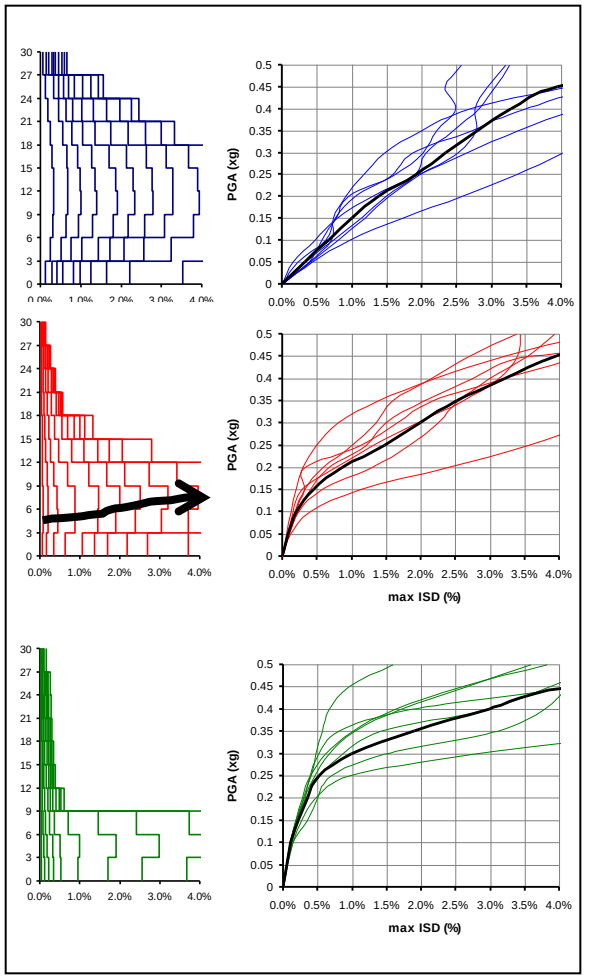
EQ1



EQ2



EQ3



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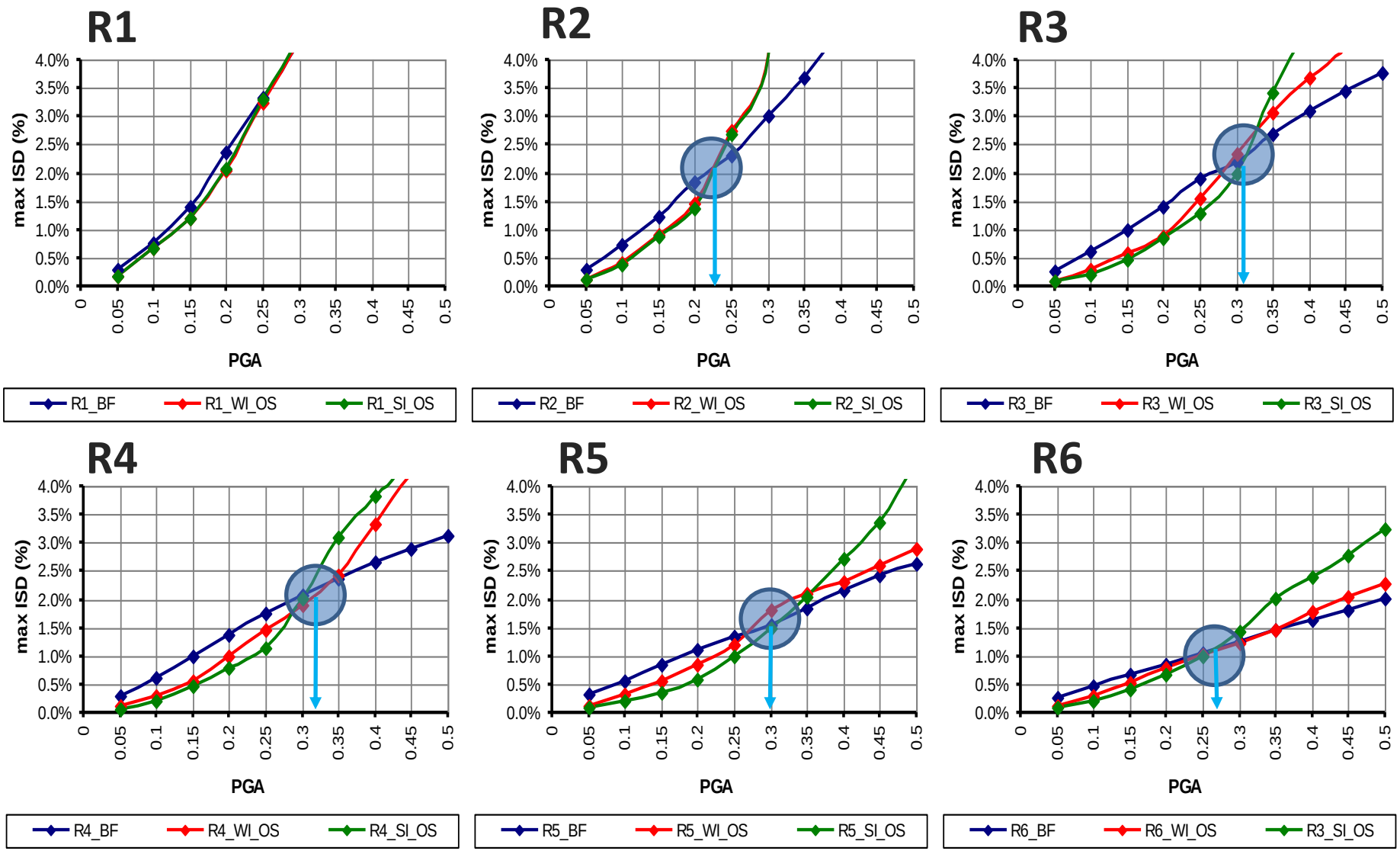
Numerical evaluation – interstorey drifts _ EQ2



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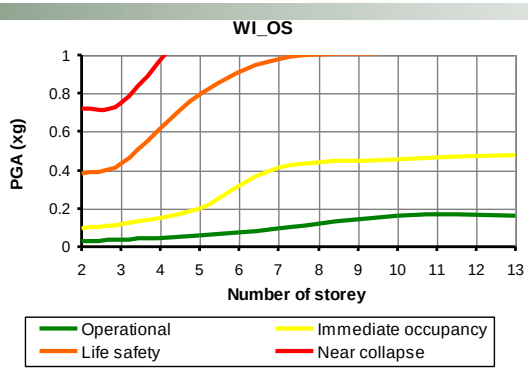
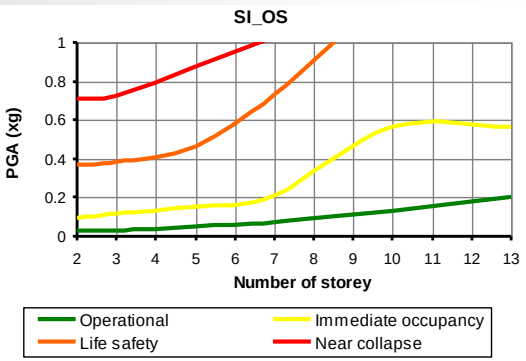
Discrete levels of seismic performance

EQ1

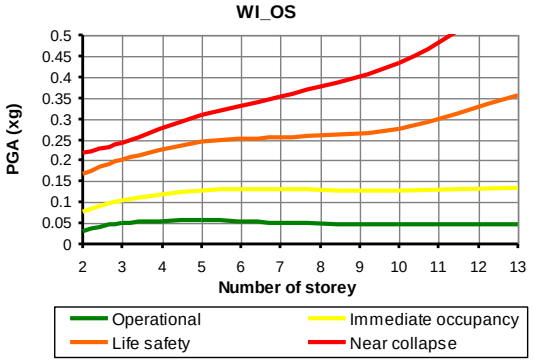
Operational – ISD 0.12%
0.03g – 0.2g
Immediate occupancy – ISD 0.45%
0.1g – 0.45g_WI (0.57g_SI)
Life safety – ISD 1.5%
0.4g
Near collapse – ISD 2.5%
0.7g

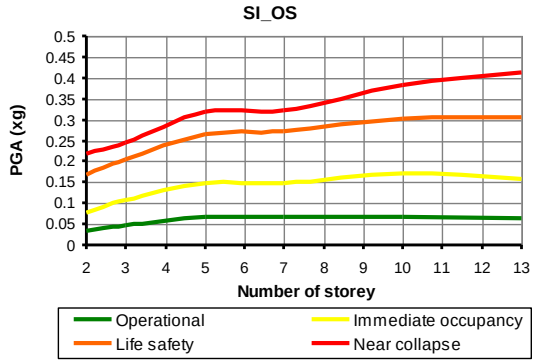


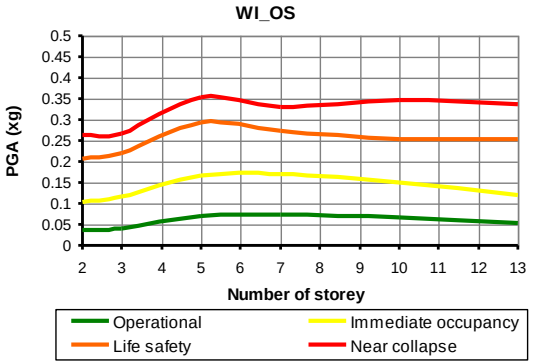


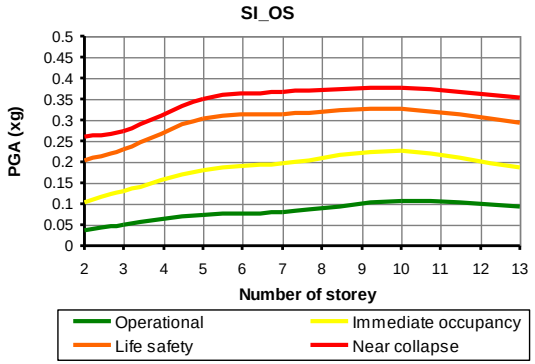
EQ2; EQ3

Operational – ISD 0.12%
0.05g – 0.1g
Immediate occupancy – ISD 0.45%
0.1g – 0.2g
Life safety – ISD 1.5%
0.17g – 0.35g
Near collapse – ISD 2.5%
0.22-0.5g









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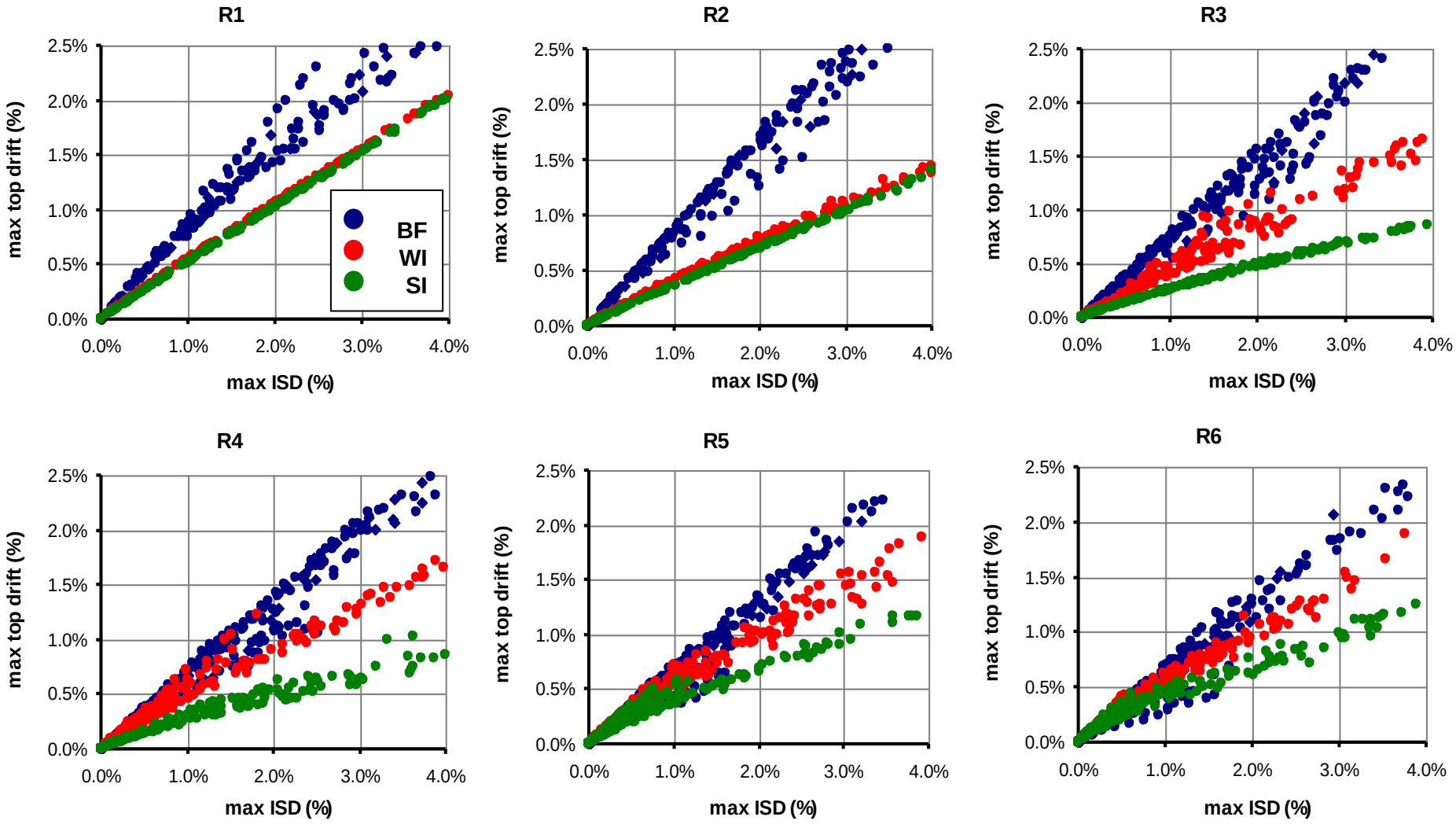
Top drift VS Interstorey drift



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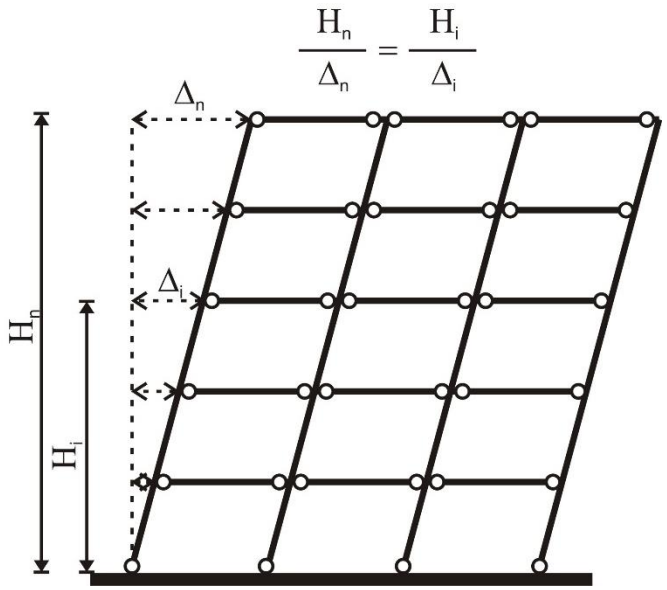
Top drift VS Interstorey drift

- Index for distribution of displacement at height (DDH)

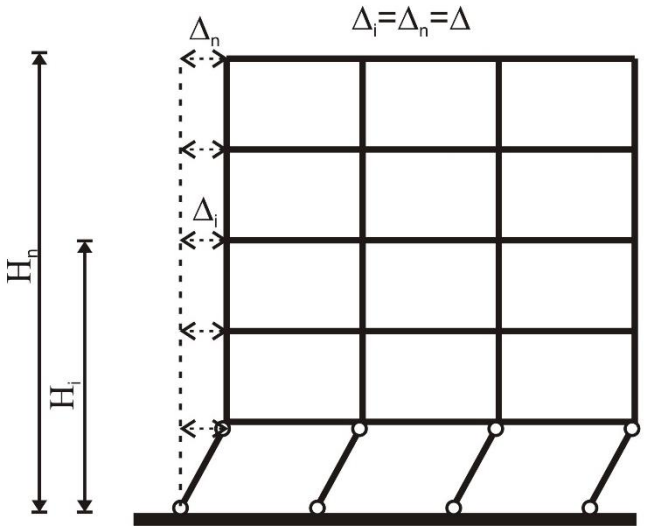
$$DDH = \frac{\frac{\max ISD}{\max TD} - 1}{n - 1}$$

- DDH=0, maxISD = maxTD
- DDH=1, maxISD = maxTD*n

Beam sway mechanism



Soft storey mechanism



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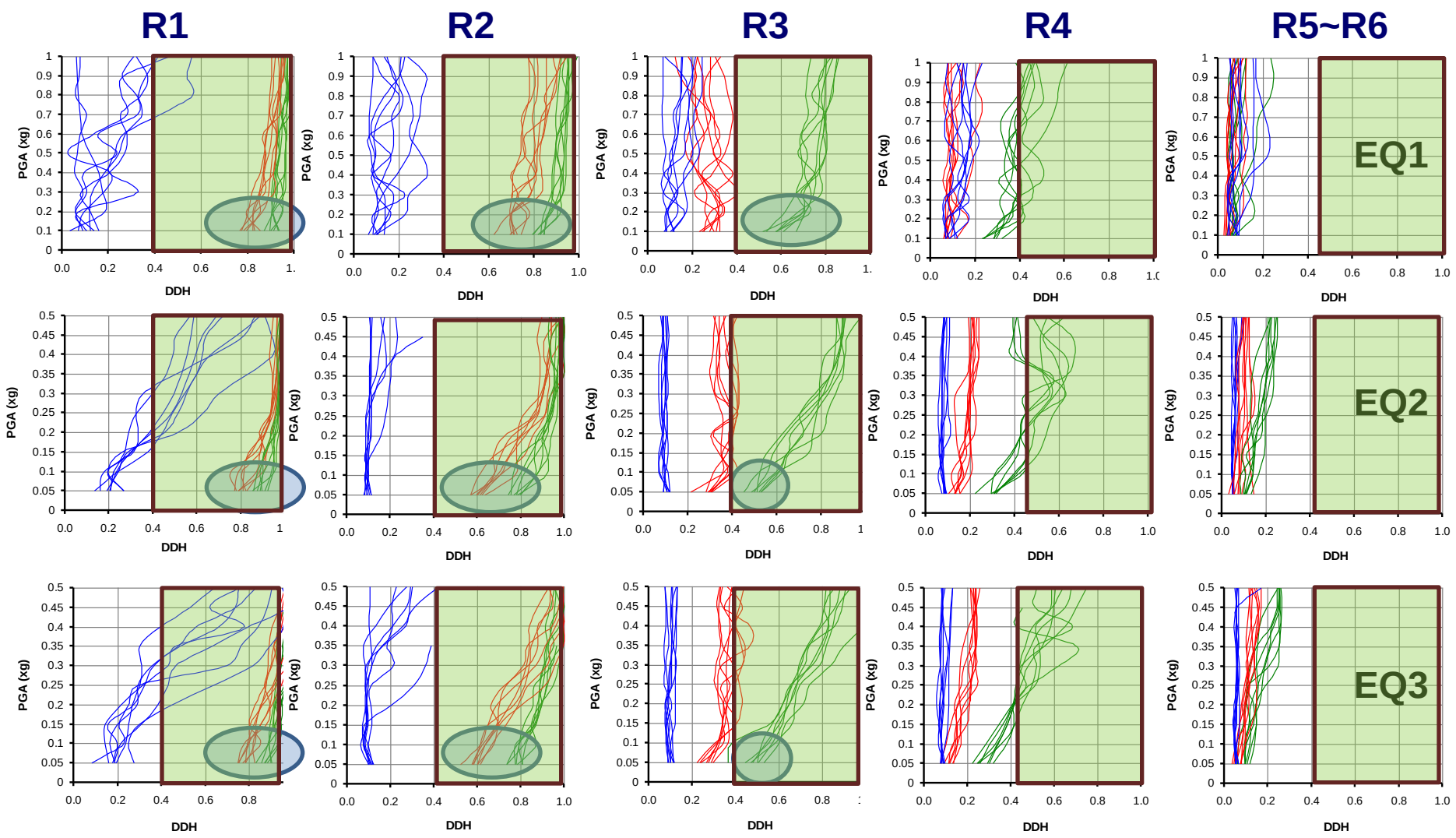
Index for distribution of displacement at height – DDH



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CONCLUSIONS – masonry infill, favourable or not?

- In the cases of low rise buildings (n=2 and 3 storeys), the **quality of infill** doesn't have a remarkable effect to the structural behaviour.
- For this type of structure, the **presence of infill is usually unfavourable** for all levels of PGA, leading to the formation of soft storey mechanism in the first storey.
- In the case of **high rise buildings**, the presence of infill reduces the seismic demand up to the PGA of 0.3g.

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CONCLUSIONS – masonry infill, favourable or not?

- For higher level of PGA, presence of infill increases seismic demands. Usually, strong infill corresponds to small interstorey drift demand, at low level of seismic hazard, compared with the weak infill.
- Defined index of displacement distribution on height (DDH) can be used as a marker – indicator for detection of structure potential to develop an unfavourable mode of failure

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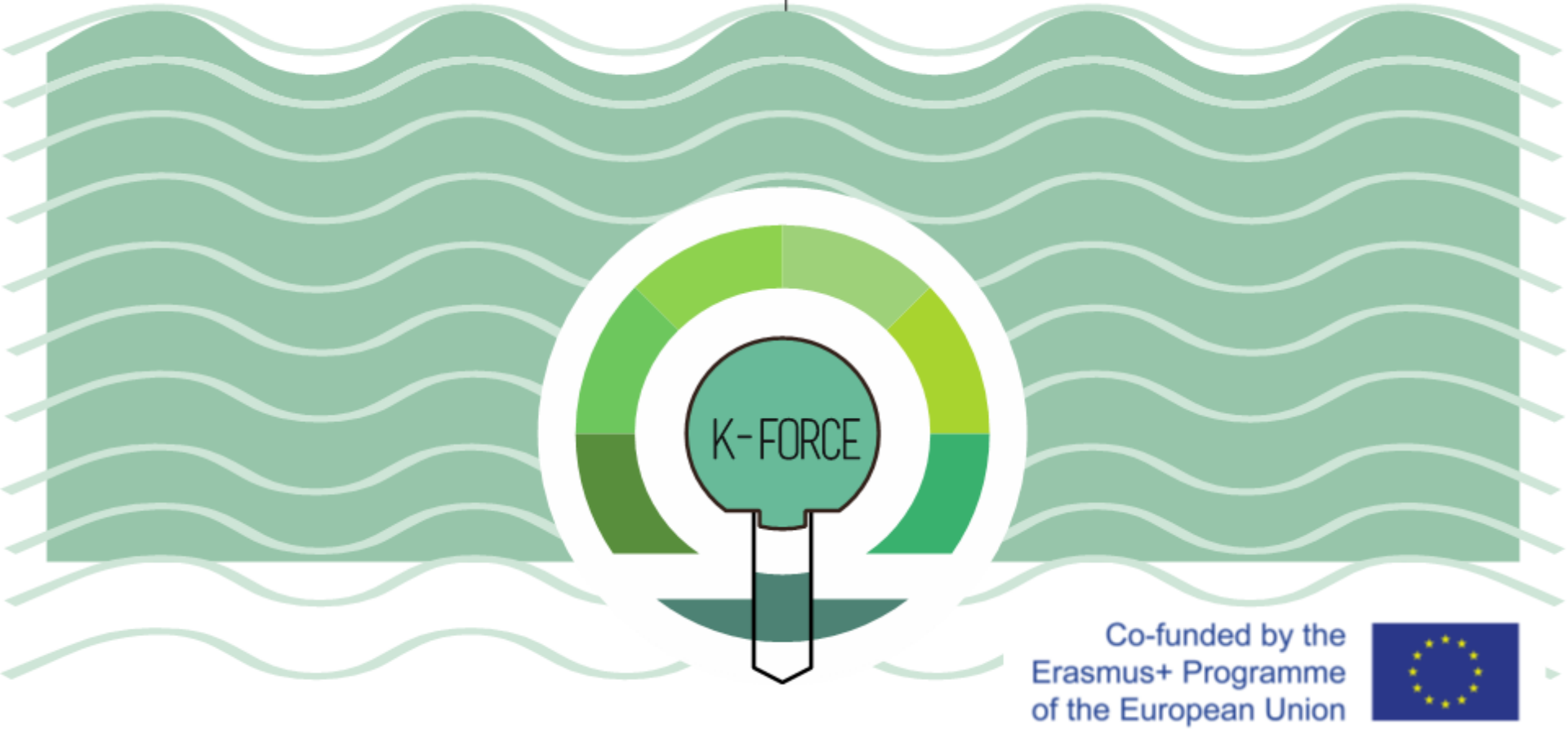

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Knowledge **FO**r **R**esilient so**C**i**E**ty