

Assessment of seismic design methodologies for steel moment frames

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Earthquakes and Steel Structures

- Earthquakes can induce significant levels of **damage** in steel structures, eventually leading to local/global **collapse**.

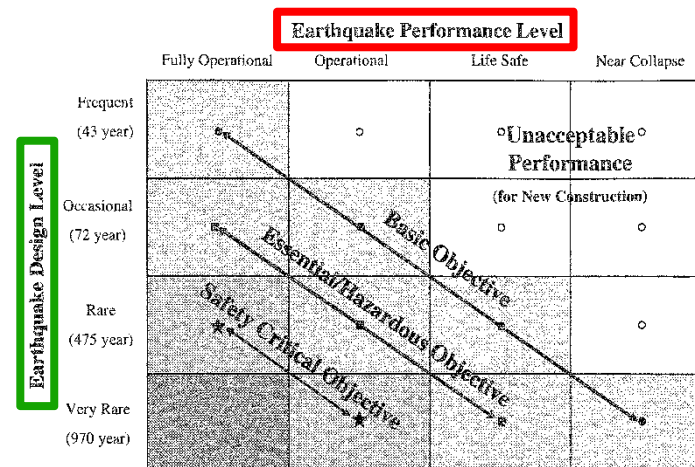


- Damage should not be a concern on itself! It is actually implicit in seismic design when one adopts a behaviour factor (q).
- Critical is to control the level of damage for a pre-defined seismic intensity level (e.g., return period).



Performance-Based EQ Engineering

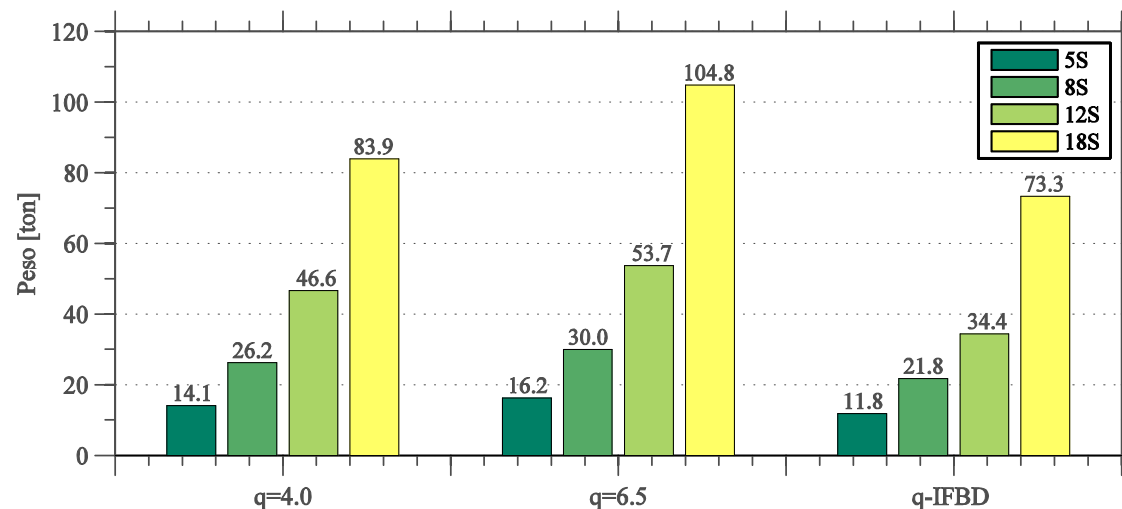
- This concept was introduced during the 1990s after the occurrence of the 1994 Northridge and 1995 Kobe earthquakes.
- Main idea is to define performance objectives which basically consist of specifying performance level for a given level of seismic hazard.





Assessment of seismic design methodologies

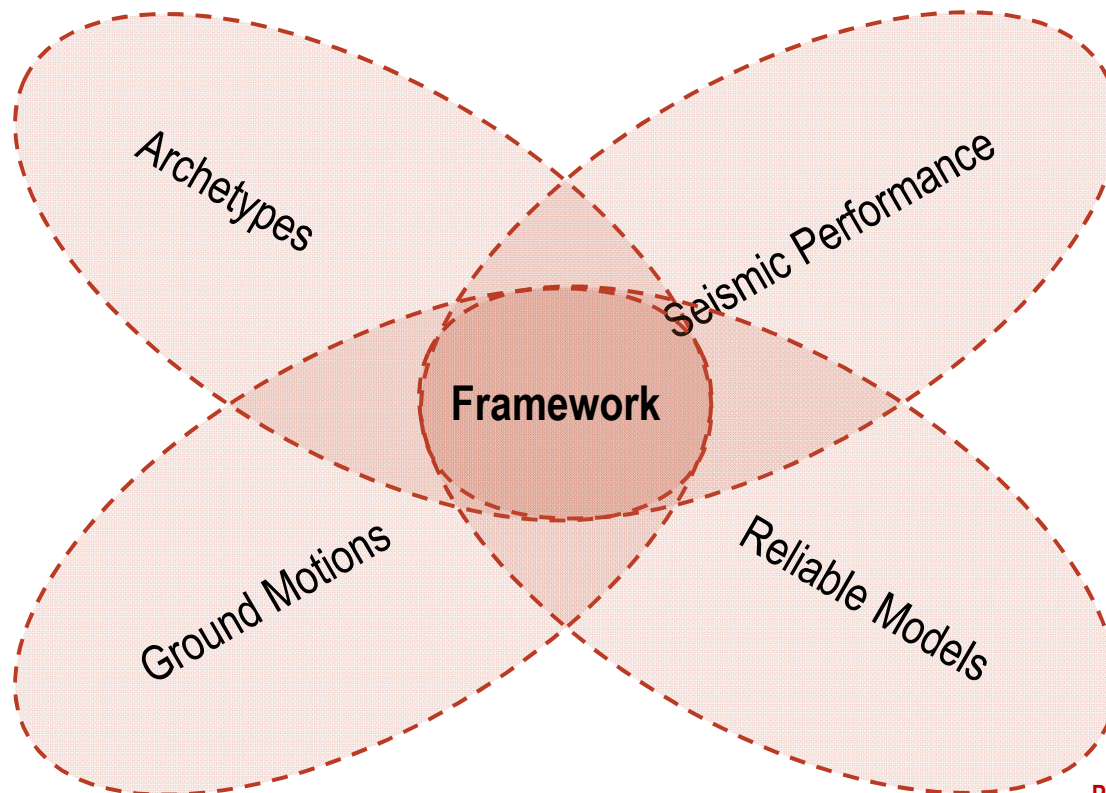
- Eurocode 8
 - Performance requirements (No-collapse & Damage Limitation)
 - Compliance criteria (ULS & SLS)
- However some problems have been identified:
 - Same structure in different seismic zones (eg. Porto and Lagos)
 - Contrary to expected, higher behaviour factor results in heavier structures





Assessment of seismic design methodologies

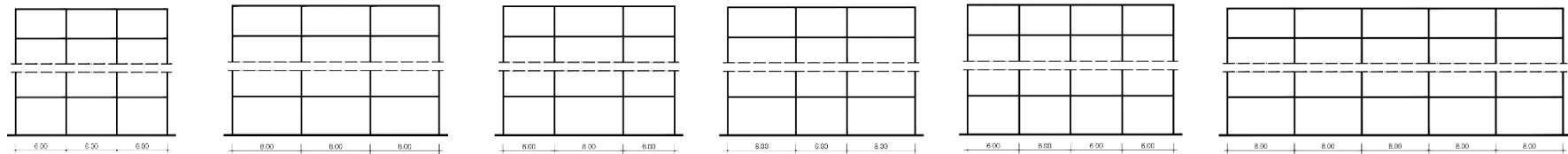
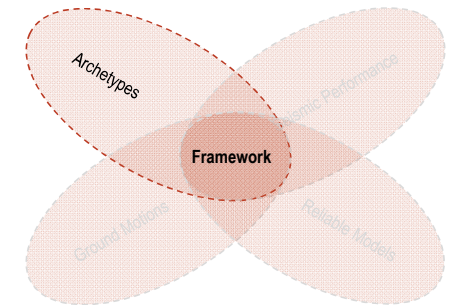
- Available assessment methodologies
 - **FEMA P695** – Quantification of building seismic performance factors
 - **FEMA P58** – Loss assessment methodology
- Key Elements





Archetypes

- Six different layouts (2, 3, 4, 5 and 8 storeys)



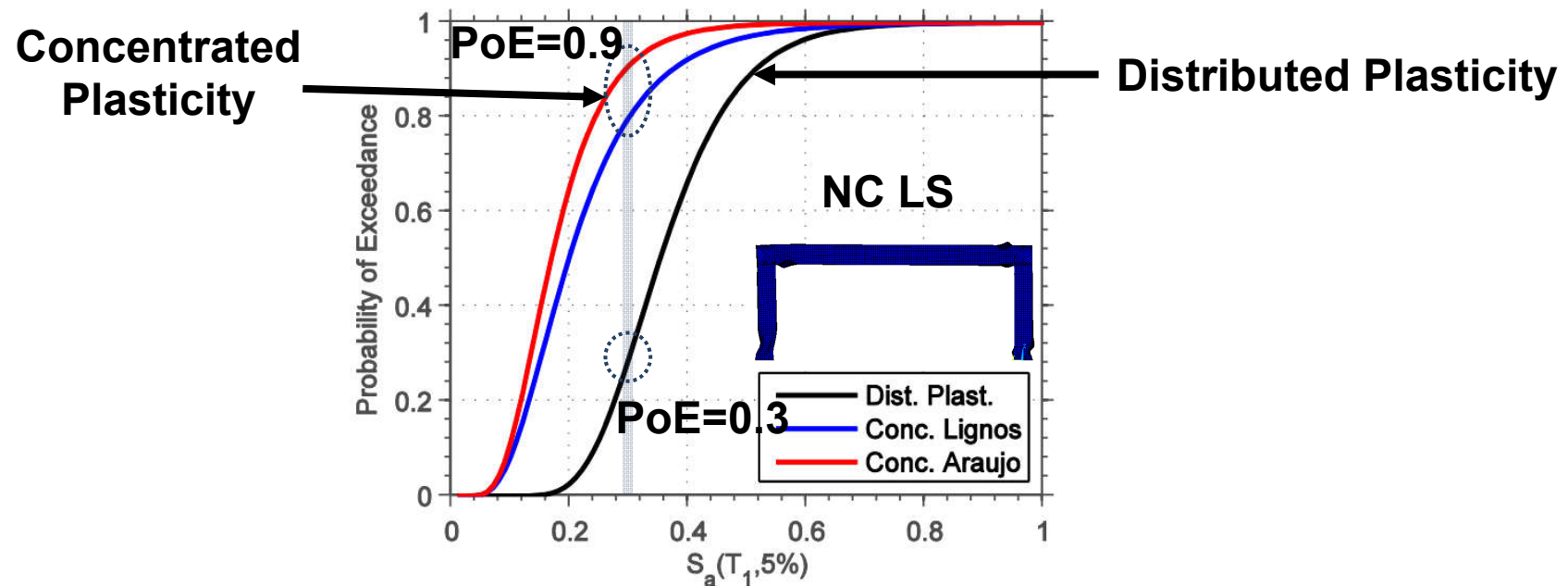
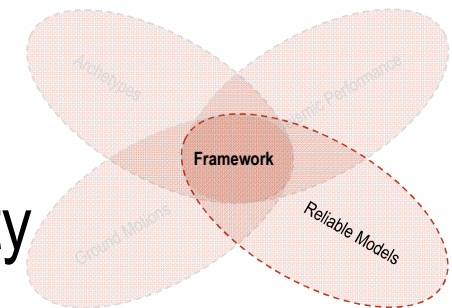
- Three different locations: Porto, Lisbon and Lagos
- Designed according to EC8 using three different behaviour factors: 4, 6.5 and IFBD

A TOTAL OF 270 STRUCTURES



Modelling Strategies

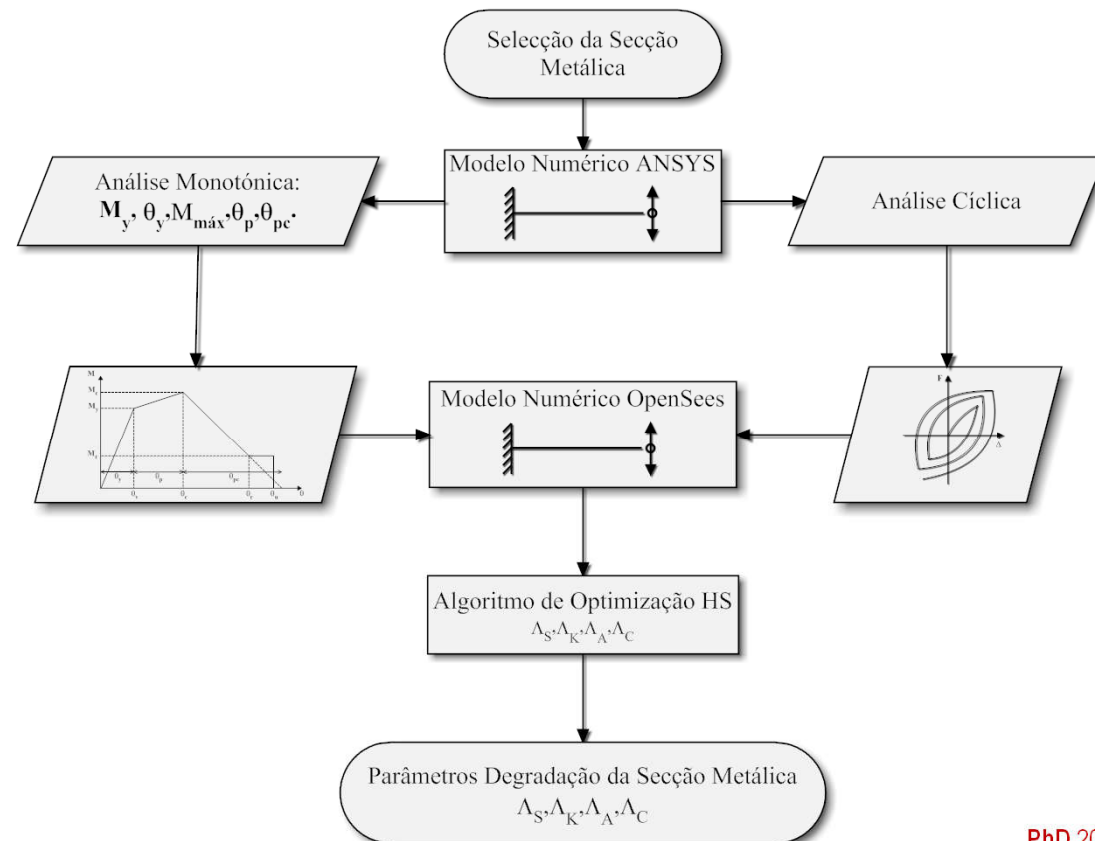
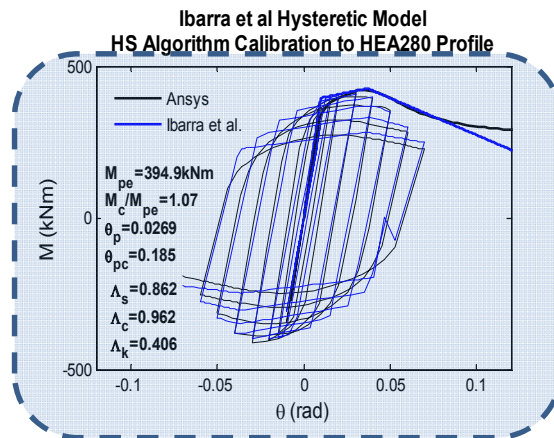
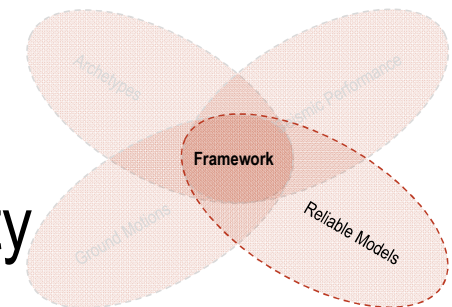
- Distributed Plasticity vs Concentrated Plasticity





Modelling Strategies

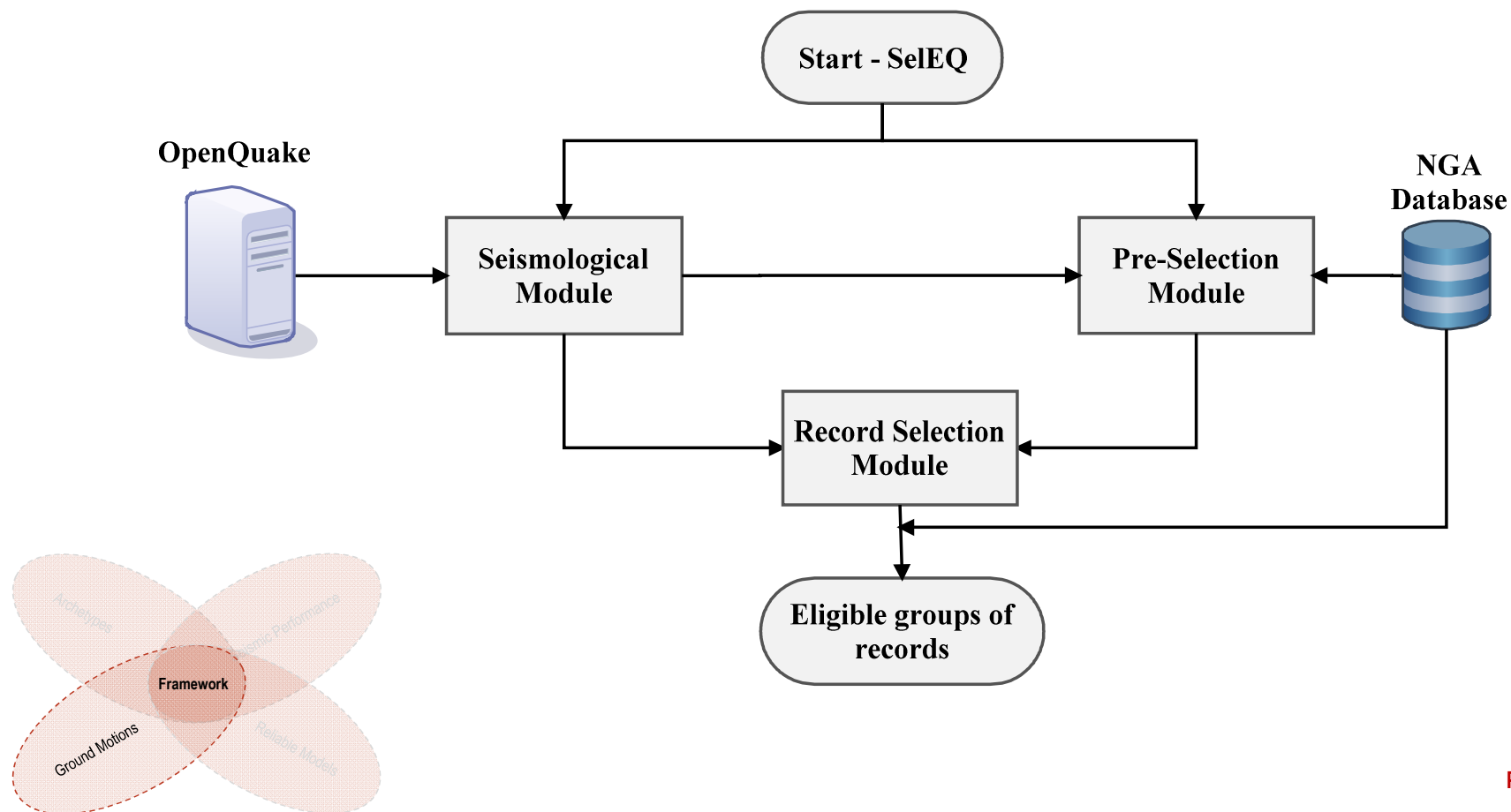
- Distributed Plasticity vs Concentrated Plasticity
- Calibration procedure for european shape profiles





Ground Motion Selection

- SelEQ: An advanced ground motion selection and scaling tool





Ground Motion Selection

- Seismological Module (Conditional Spectrum generation)

Pre-Selection Module

Re **CS -Based**

Seismological **Preliminary Selection** **Record Selection**

Input

Latitude:
Longitude:
Soil V_{530} :
 T_1 [sec]:
Occurrence Probability:

Analysis Options

☐ Hazard Curve
☒ Disaggregation
☐ Uniform Hazard Spectra
☐ Conditional Spectrum

Preliminary Selection

☒ Magnitude
Min: 5.5

☒ Epicentral Distance
Min: 10

☐ V_{s30} [m/s]
Min:

☒ PGA [g]
Min: 0.1

☐ PGV [m/s]
Min:

☐ LUF [Hz]
Min:

Record Selection

Code-Based Record Selection

Design Code: EC8 - Part 1: Buildings (EN1998-1: 2004)
Spectrum Type: I Site Class: B
Importance Class: II a_{gr} [g]: 0.30
Viscous Damping [%]: 5 T_1 [sec]: 1.25
 T_B [sec]: 0.15 T_C [sec]: 0.50 T_D [sec]: 2.00

Group Options

T_{min} [sec]: 0.2 T_{max} [sec]: 2.0
Lower Limit [%]: 90 Upper Limit [%]: 110
Individual Limit [%]: 50
 SF_{min} : 0.25 SF_{max} : 4

CMS-Based Record Selection

T_1 [sec]: SF_{min} : SF_{max} :

Number of Records: 20 **Run Selection**

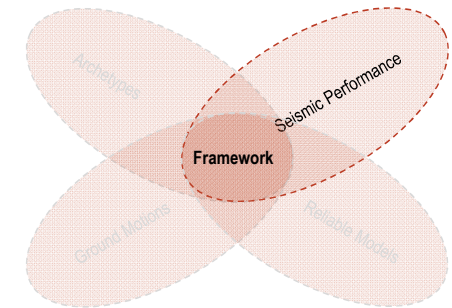
Figure: A line graph showing the conditional spectrum S_a (g) versus Period [sec]. The y-axis ranges from 0.0 to 1.4, and the x-axis ranges from 0.0 to 4.0. Multiple colored lines represent different ground motion records, showing a peak around 0.5 seconds and then decaying. A dashed black line represents the target spectrum.

Diagram: A Venn diagram with four overlapping circles labeled "Archetypes", "Ground Motions", "Framework", and "Reliable Models". The "Framework" circle is the central intersection of all four.

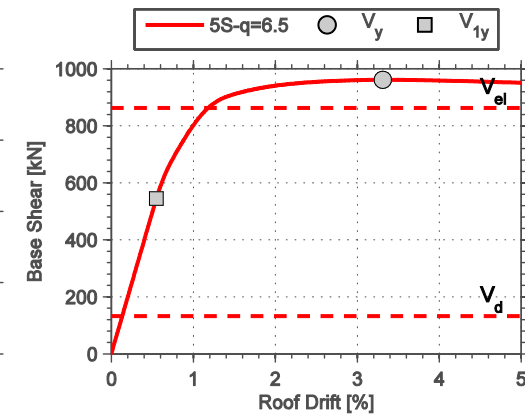
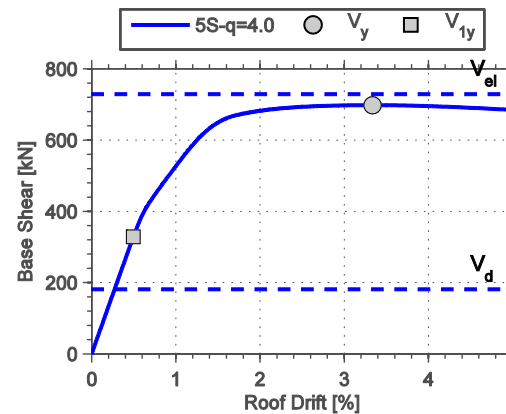
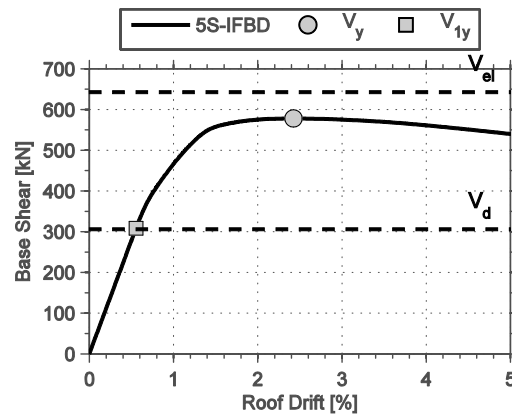


Seismic Performance Assessment

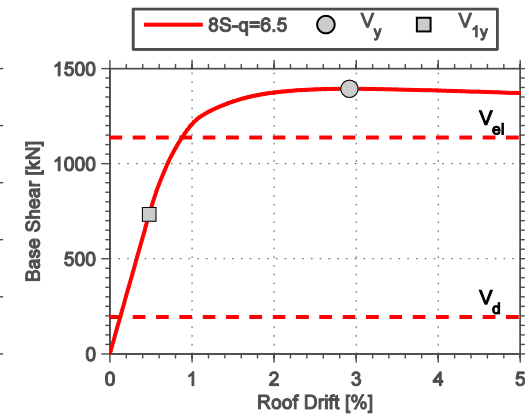
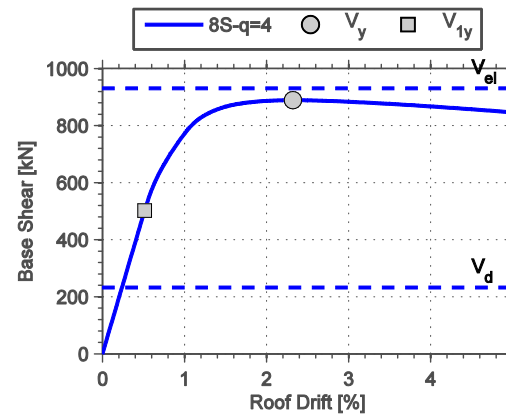
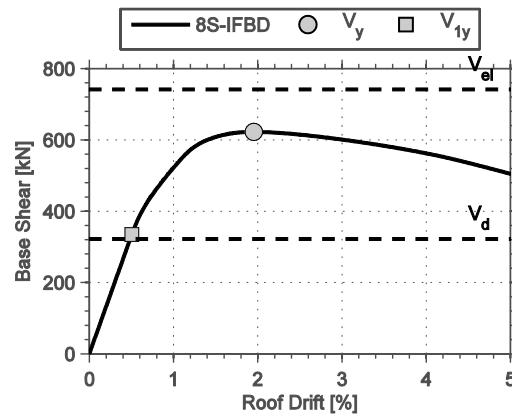
- System overstrength



5 Storeys



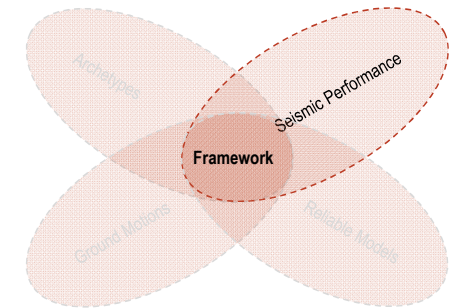
8 Storeys



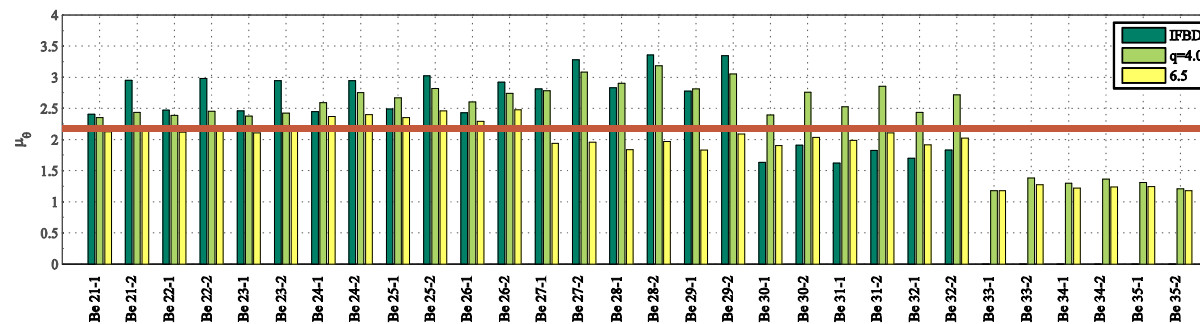


Seismic Performance Assessment

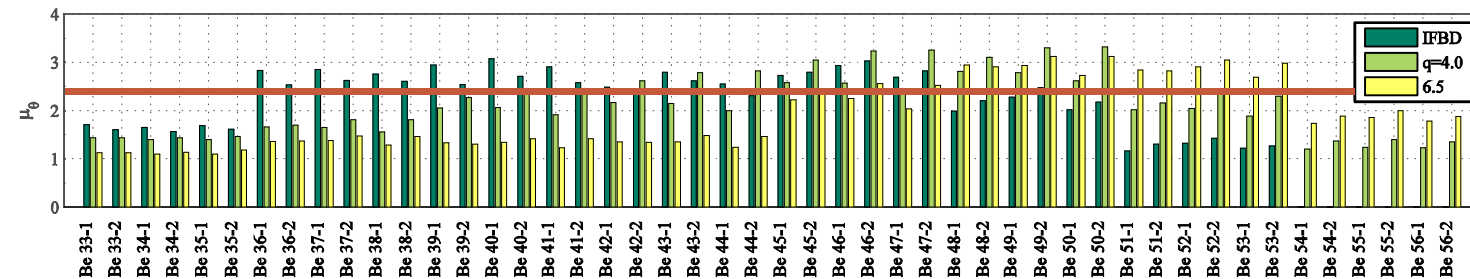
- System overstrength
- Rotation ductility



5 Storeys



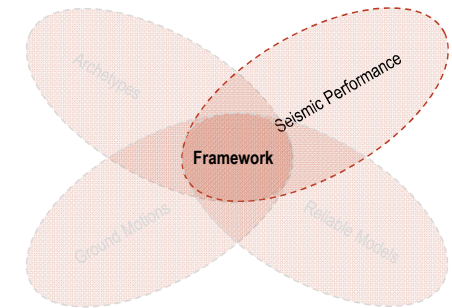
8 Storeys



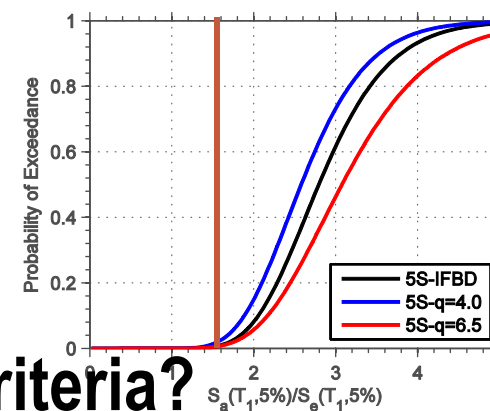
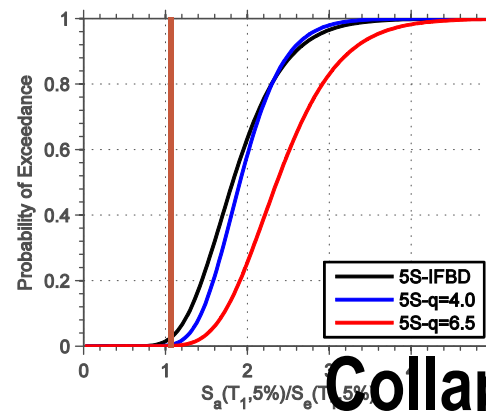


Seismic Performance Assessment

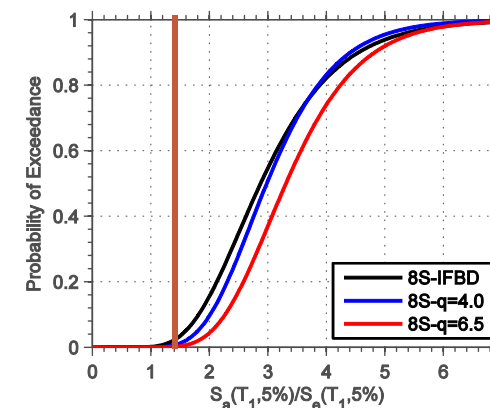
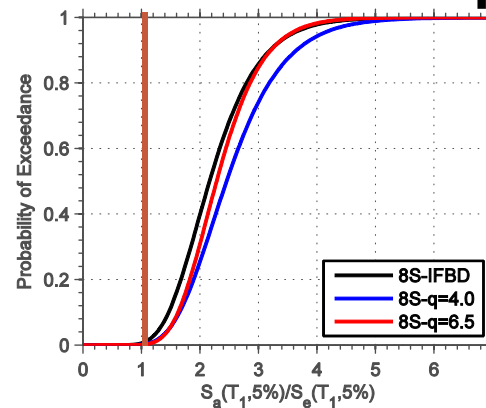
- System overstrength
- Rotation ductility
- Collapse assessment



5 Storeys



8 Storeys



Collapse Criteria?



Conclusions

- New deterioration parameters of steel members with European profiles have been defined.
- An advanced ground motion selection and scaling tool have been developed
- Application of FEMA P695 validates and demonstrates the advantages of using IFBD procedure
- The developments are fully compliant and could be integrated in EC8.