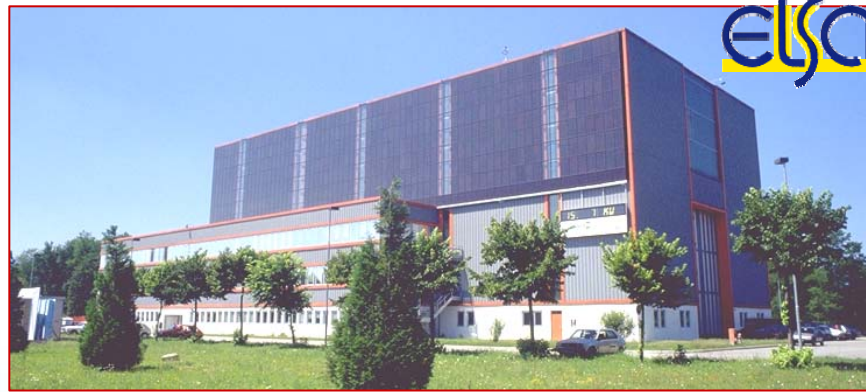




Pre-normative research in support of Eurocode 8: The JRC contribution

Artur Pinto, Paolo Negro, Fabio Taucer

(Credits: European Partners involved in joint projects with JRC; ELSA Laboratory staff)



Construction & Earthquake Engineering

European Laboratory for Structural Assessment (ELSA)

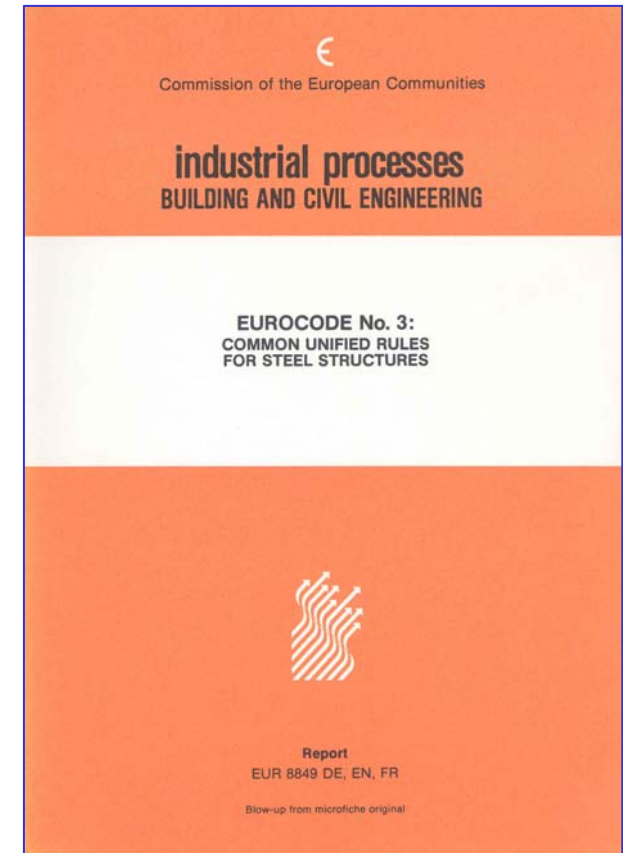
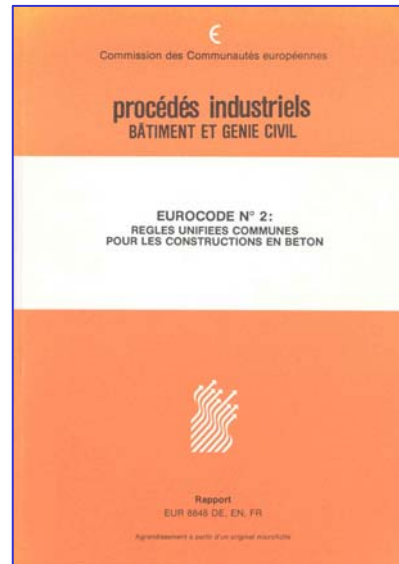
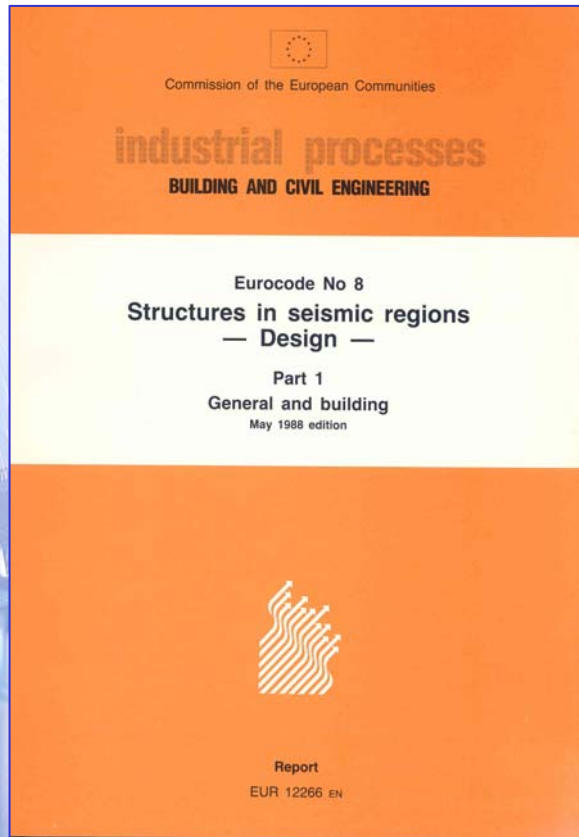
Institute for the Protection and Security of the Citizen (IPSC)



JRC research in support of Eurocode 8 (1992-2006)

- Inauguration of ELSA (1992), First demonstration tests, Development of testing techniques, equipment and tools
- Networking with EU research institutions (Universities, Laboratories, Industry)
- A series of reference full/large-scale earthquake tests in support of Eurocode 8 as part of European joint projects financed by the Commission (e.g. PREC8, ICONS, ECOEST)

RESEARCH (PRE-NORMATIVE) IN SUPPORT OF THE EUROCODES





1992-1998 – Reference tests with impact on the ENVs conversion

A few examples →



Eurocode 8 – Part 1- RC buildings (1994)

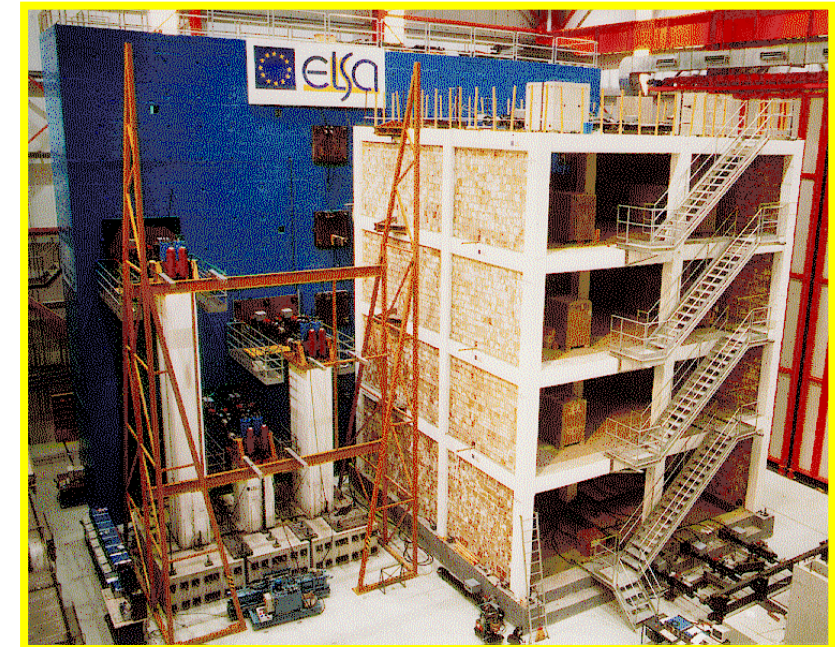
□ Concrete buildings designed to EC2 and EC8

- The first building designed to EC2/EC8
- Use of Tempcore Steel Reinforcement
- Check performance for Serviceability, Damage Limit and Ultimate Limit States
- Effects of infill panels

➤ Consequences:

Tempcore steel allowed for seismic design

From 3 to 2 ductility classes in EC8





Eurocode 8 – “Part 2” (EN1998-2)-Bridges

□ Concrete Bridges designed to EC2 and EC8

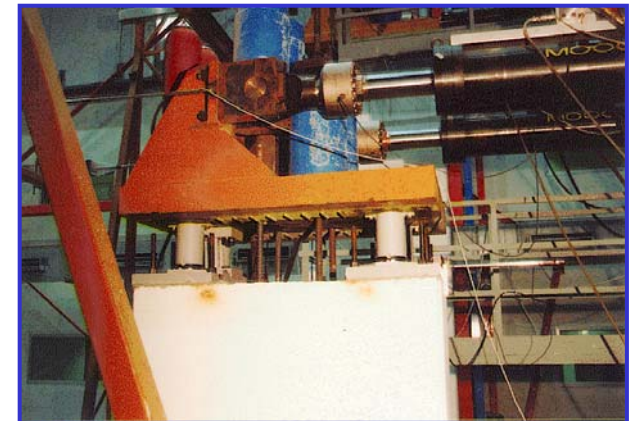
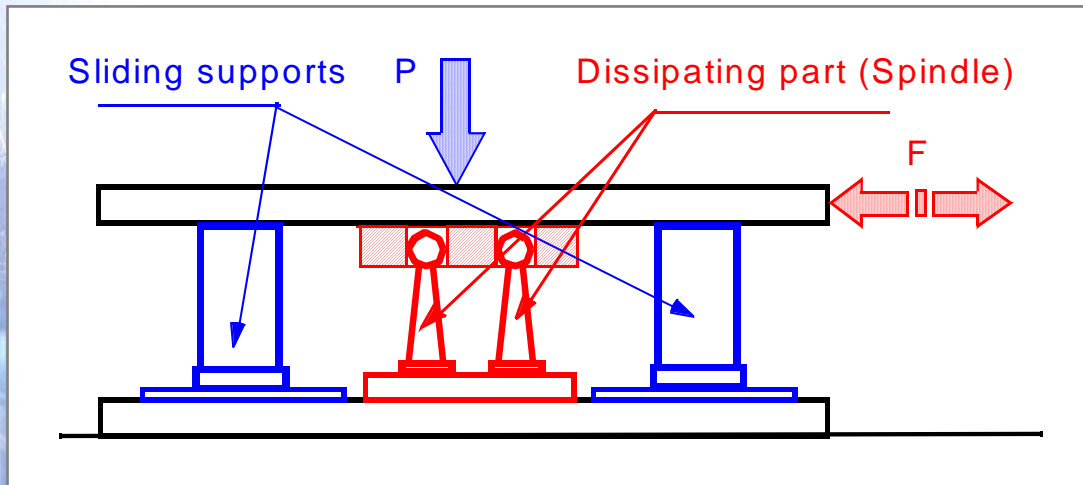
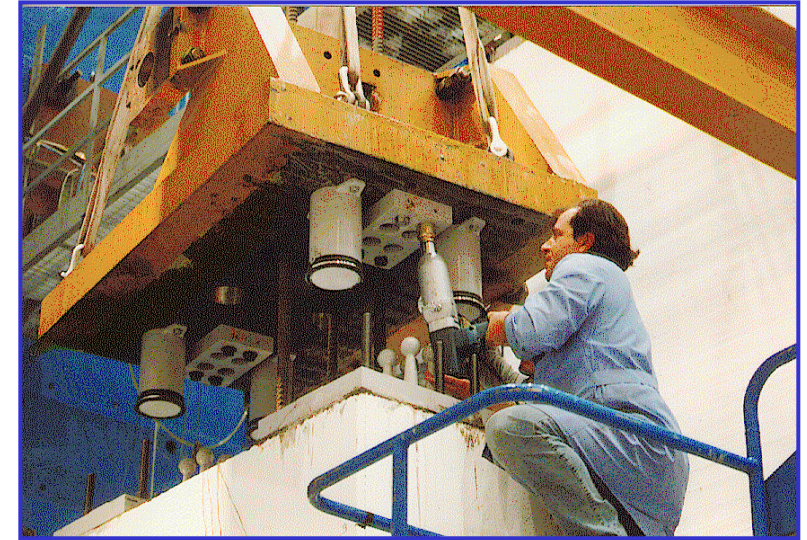
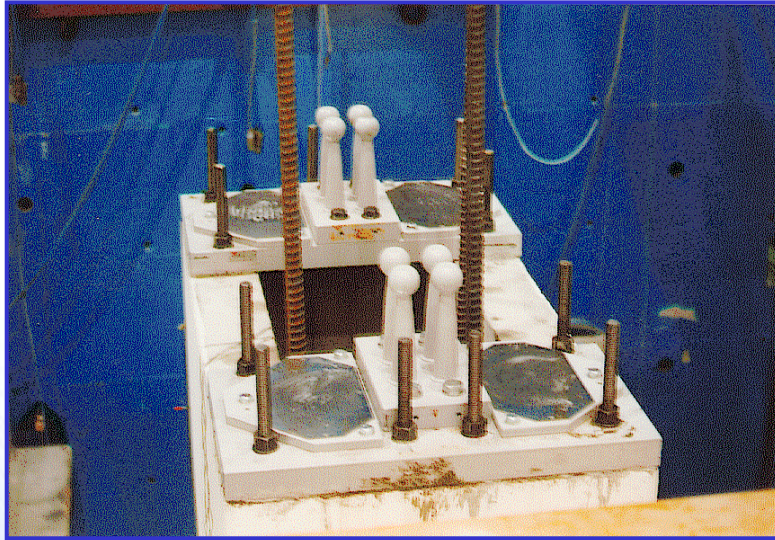
- The first bridges designed to EC8 part 2
- Rectangular Hollow cross-section (most common in Europe)
- Ductile capacity of bridge Piers
- Irregularity in bridges, Alternative design methods
- Non-synchronous earthquake motions
- Seismic Isolation

➤ Consequences:

- ✓ EC8 design accepted for regular bridges
- ✓ Deformability in detriment of strength for irregular bridges (isolation – a suitable and economical solution)



Hysteretic Isolation-Dissipation (I/D) Devices for Bridges





Steel-concrete composite buildings

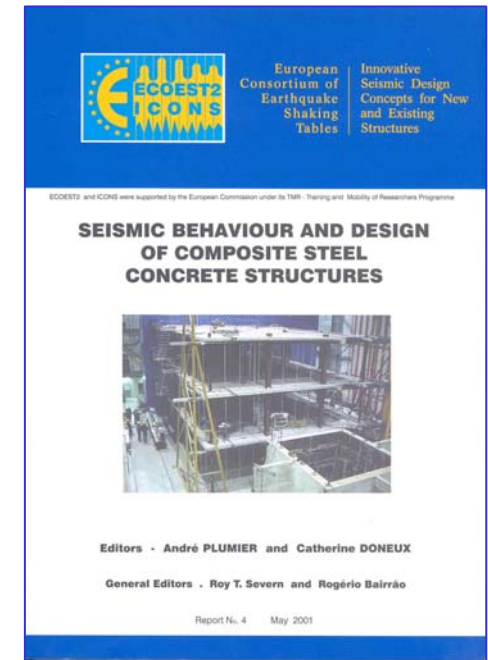
□ Composite (Steel-Concrete) buildings

– Informative Annex in EC8 because of insufficient evidence on:

- Ductility of partially-encased composite sections
- Beam/slab assemblage – slab participation – influence in the plastic hinge zones
- Capacity design issues
- Semi-rigid connections

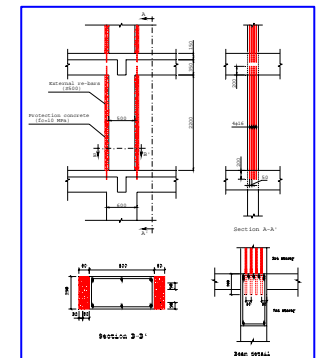
➤ Consequences:

- ✓ Composite buildings back to the normative part (EN1998-1, Section 7)
- ✓ PT1 basis proposal on the experimental work at ELSA



Assessment and retrofitting of existing buildings (EC8 'Part 1.4' - EN1998-3)

- ❑ Existing Vulnerable Buildings (60~70's) – A major source of risk
 - Assessment, Retrofit
 - Re-design methods
 - Effects of infill walls
 - Cost/benefit analysis for different techniques/solutions including demolition
 - EC8 – part 1.4
- Consequences:
 - ✓ Input to PT4 technical work
 - Different Traditions/Common Practice – other techniques aspects for further research



Dual (Frame-Wall) Structures and Innovative Design Methods

- ❑ Innovative 'against' Eurocode 8 Design
 - Deformation based design – the fashion – more rational
 - Compare Eurocode 8 design with newly proposed design methods
- **Consequences:**
 - ✓ **Better performance for the EC8 design - ! ?**
 - ✓ **Innovative methods – 'Not yet enough mature for codification'**
 - ✓ **Further research is needed**





1999-2006 – Reference tests with implications on the EN conversion

A few examples →



Cyclic and PSD testing of a high ductility moment resisting composite structure

- ❑ Composite sway frames designed according to EC3, EC4 and EC8
 - Provide background information on the behaviour of composite frames under monotonic and cyclic loads
 - Study the second order effects on sway frames and current limitations and restriction of current standards (EC3, EC4, EC8)
- **Consequences:**
 - ✓ EC3 criterion to distinguish between sway and rigid frames is appropriate
 - Improved solutions proposed to satisfy the serviceability limit-state of EC8
 - ✓ Proposal of more accurate q values



Seismic behaviour of RC industrial buildings

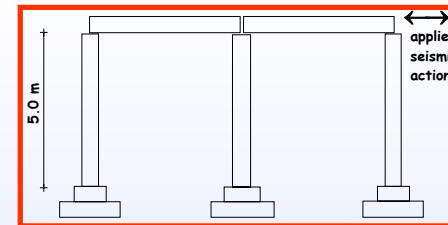
❑ Precast structures penalized as for force reduction factor?

- q factor much smaller than in current national codes
- Possible penalization of precast industry with respect to cast in situ technologies
- Need for a rational definition of q factor

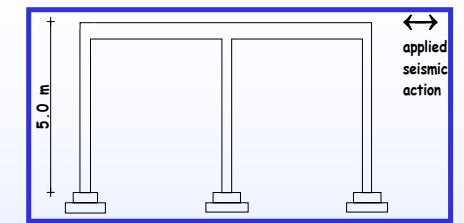
➤ Consequences:

- ✓ Proposal for a new value of the q factor for precast structures
- ✓ Light thrown onto the deformation limits
- ✓ Importance of the connections.

Pre-cast



Cast in-situ



Seismic Behaviour & Assessment of RC flat-slab structures

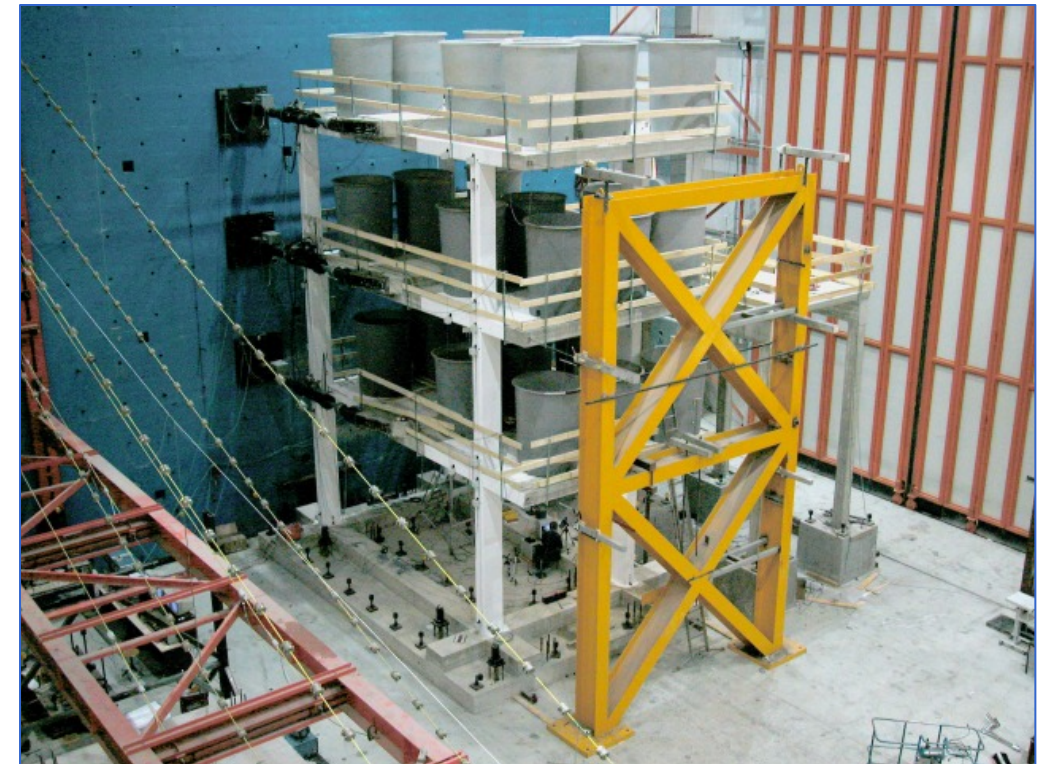
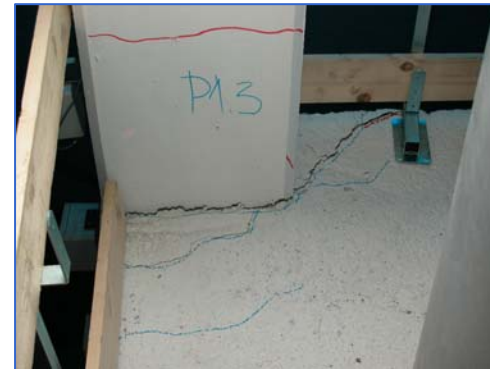
□ Flat-slab structures

– Deformability/Damage:

- System flexibility
→ second-order effects
- Torsion of transversal
beams → Severe local
damages
- Residual deformations

➤ Consequences:

- ✓ Calibration of existing
models.
- ✓ Reduced slab-participation
compared to EC2 (vertical
loading)
- ✓ Primary and Secondary
resisting-systems approach



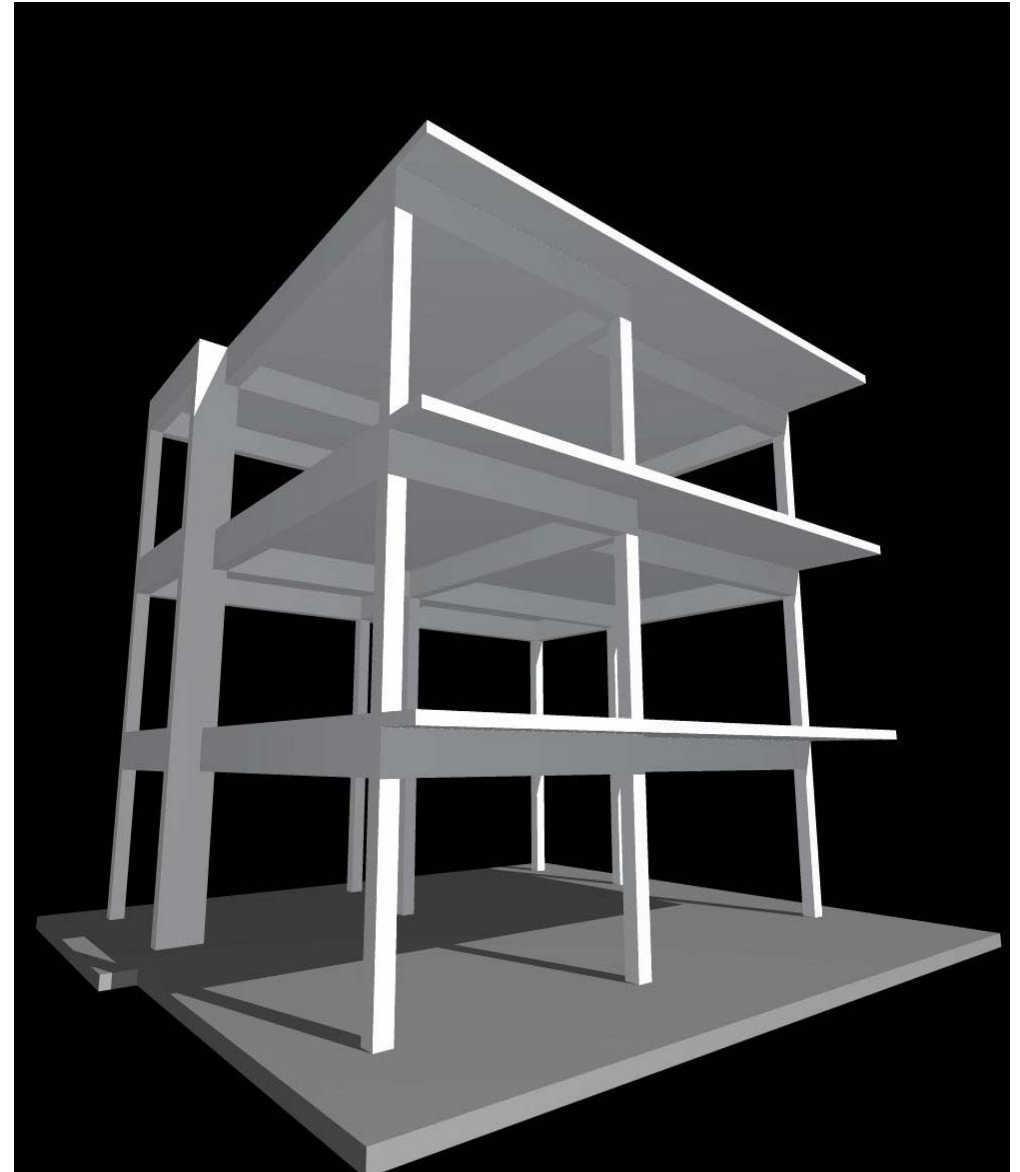
3D - PsD Testing of a Torsionally Unbalanced Structure (Spear project)

□ Assessment and rehabilitation of existing buildings

- Importance of the torsional response in irregular structures
- Testing of existing analysis and assessment methods
- Need for a conceptual framework in rehabilitation

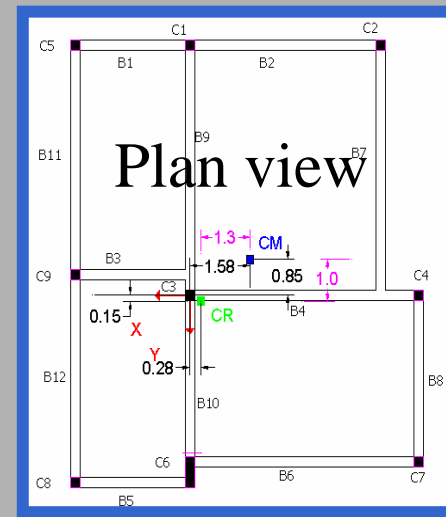
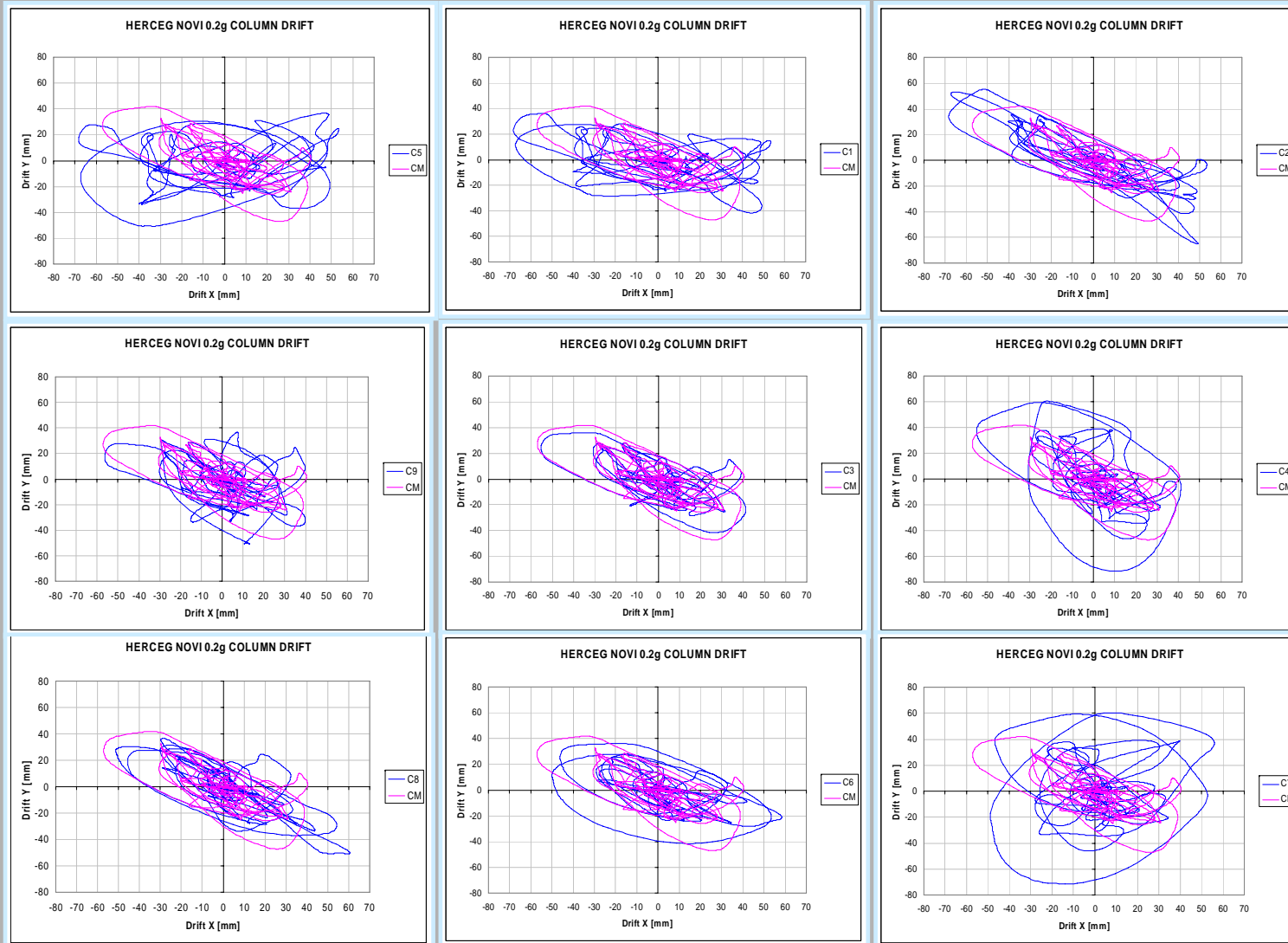
➤ Consequences:

- ✓ Improved knowledge of the effects of torsional response
- ✓ New assessment methods
- ✓ Improved guidelines for the rehabilitation of existing buildings



Original Structure: 0.20g Input

2nd st. column polar diagrams



Columns C5, C1,
C2

Columns C9, C3,
C4

Columns C8, C6,
C7

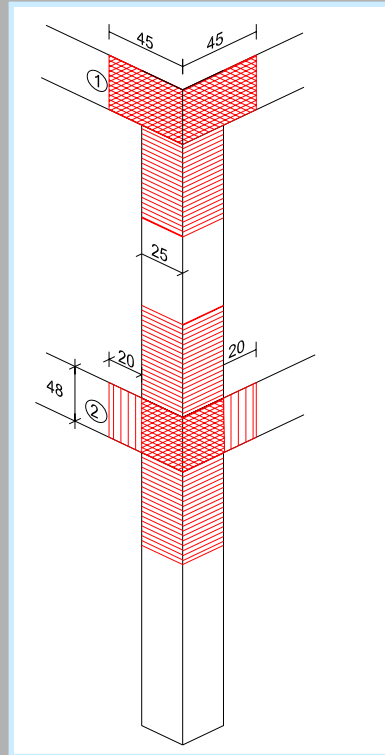
Spear structure

Damage Pattern

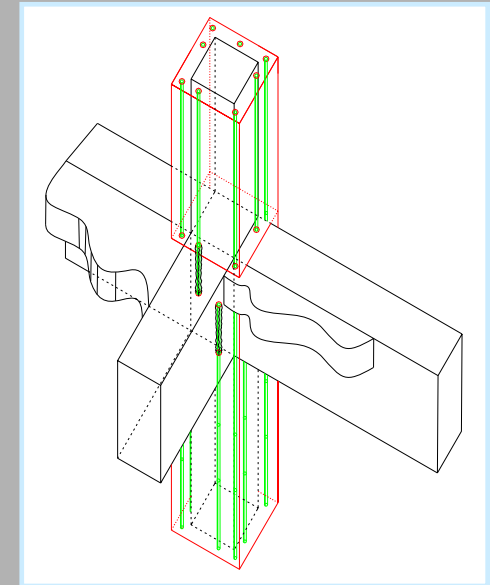


Visible damage after the
0.20g PGA test

FRP Wrapping



RC jackets





Ongoing and Future research in support of Eurocode 8

- Ongoing:
 - Pre-cast structures, Masonry (unreinforced) structures, New Materials (FRP)...
- Research needs for improved seismic protection
 - Harmonized seismic hazard map for Europe; Flat-slab structures; Masonry, Structure-foundation-soil system ...
- Framework Programme 7 (FP7 / 2007-2013)
 - European Technology Platforms (ECTP, ESTEP, ...) Defining research priorities for short, medium and long terms (competitiveness, quality of life, ...)
 - Vision and Research Agenda for Earthquake Engineering (Key issues, Appropriate placement, Effective mitigation, ...)
 - Vision and programme for the European Research Infrastructures - Integration of New European Countries and Internal Collaboration (America, Asia, Others)



Conclusion

- Eurocode 8: a seismic design code backed by experimental verification and complementary numerical calibration:
 - Check of structural performance (deformation capacities and damage states checked experimentally for earthquake motions corresponding to serviceability, damage and collapse limit states).
- Framework Programme 7 (FP7 / 2007-2013)
 - Eurocode 8 (say: The Eurocodes) must take advantage of the opportunities, offered by FP7 (longer duration, innovation, ...), for:
 - their Further Development, and
 - their Further Harmonization (NDPs in need of scientific evidence for Harmonization)



Thank you for your attention

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