

“MATCH”

Title: MATCH – Material Choice for seismic resistant structures

Funding: Research Fund for Coal and Steel (RFSR-CT-2013-00024)

Participants: National Technical University of Athens (NTUA), Aachen University (RWTH), University of Thessaly (UTH), University of Pisa (UNIPI), SSAB Europe Oy, ILVA S.p.A.

Scientific coordinator in NTUA: Prof. I. Vayas

Research group: S. Avgerinou, X. Lignos, S. Katsatsidis

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Total budget: 1.394.599€

Summary

In the framework of this research project, three types of seismic structures were investigated through tests and numerical simulations. These types were: Moment Resisting Frames (MRF), Eccentrically Braced Frames (EBF) and innovative FUSEIS systems. In all cases, high strength steel was applied for the dissipative elements (S355, S500, S700). In the Institute of Steel Structures of NTUA, eleven full scale cyclic tests were performed on MRF and FUSEIS systems. Those tests were later simulated and calibrated using finite elements software.

The FUSEIS tested were composed by two strong columns rigidly connected to each other via five horizontal links (either beams or pins) thus forming a vertical Vierendeel system. These easily replaceable links were designed with energy dissipation zones thus enabling the rest of the system to remain elastic throughout the cycles of horizontal loading. The behavior of FUSEIS systems had also been investigated in the framework of the previous research project called “FUSEIS”.

Regarding the tested MRFs, they were two-storey with either one or two bays and had welded beam-to-column connections and pinned supports. The frames were designed with strong column and weak beams, with reinforced connection areas and reduced beam flanges at selected locations in order to shift plastic hinge formation away from the welds and the heat affected zones.

Apart from the experimental investigations, for each structural type a set of multi-storey case studies was designed following current Eurocode rules. Those case studies were subjected to non-linear static and dynamic analyses (pushover and IDA respectively) in order to assess their ductility and q factors and produce a set of representative deformation time-histories for the critical dissipative elements that could be used for further parametric investigation.

The overall objective of the “MATCH-project” was the development of a toughness based damage criterion for the choice of steel material for cyclic (seismic) loading conditions.

Publications

Conferences:

1. Avgerinou S., Vayas I., “BEHAVIOR OF HIGH STRENGTH STEEL FUSEIS SEISMIC RESISTANT SYSTEMS” , COMPDYN 2015, 25–27 May 2015, Crete island, Greece
2. Avgerinou S., Lignos X., Thanopoulos P., Vayas I., “Full scale tests on moment-resistant-frames under cyclic loading”, EUROSTEEL 2017, September 13–15, 2017, Copenhagen, Denmark
3. Avgerinou S., Lignos X., Spiliopoulos A., Thanopoulos P., Vayas I., “Full scale tests on moment-resistant-frames under cyclic loading”, 9th Hellenic National Conference of Steel Structures, 5-7 October, 2017, Larisa, Greece

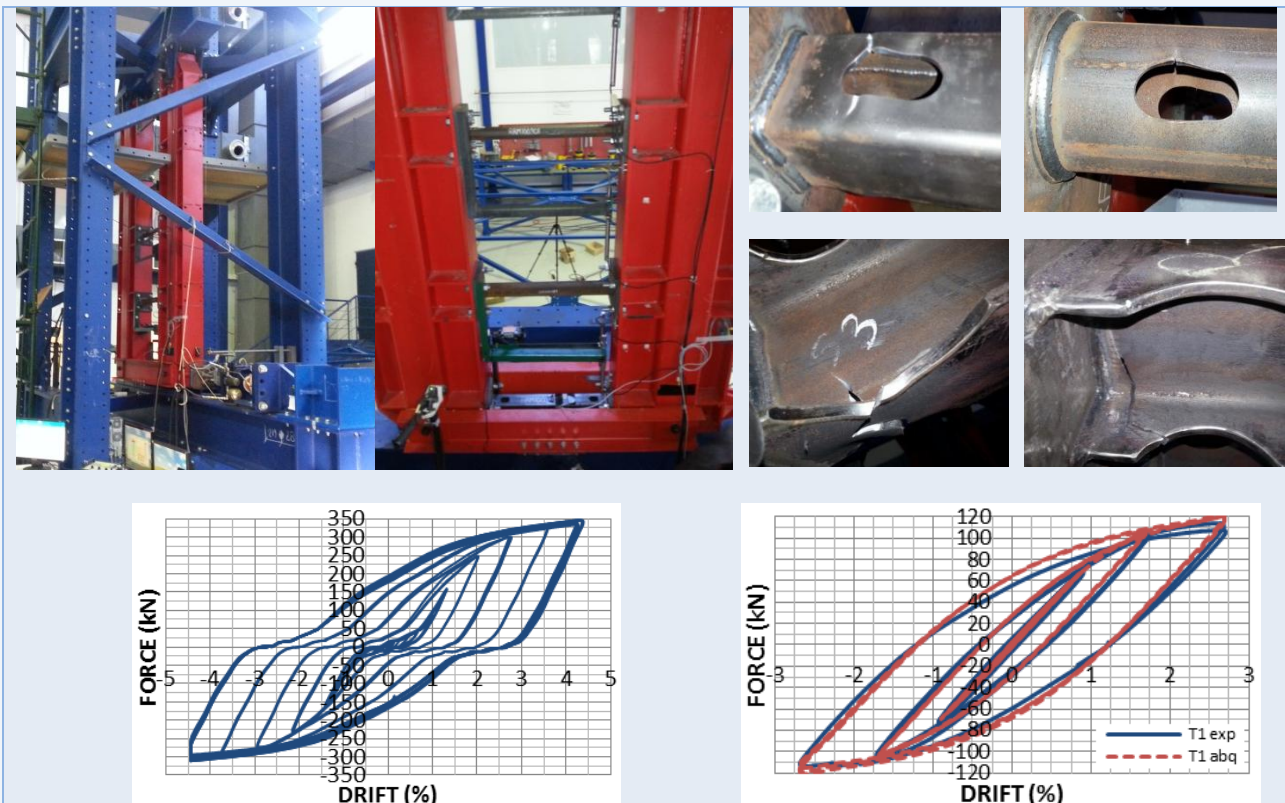
Test matrix and instrumentation

| Test | Specimens | Steel | Load Protocol |
|------|--------------------------|-------|---------------------------------|
| T1 | FUSEIS with Hollow beams | S700 | ECCS up to 4.5% |
| T2 | | | Constant amplitude, $\pm 2.8\%$ |
| T3 | FUSEIS with HEA beams | S355 | ECCS up to 4.5% |
| T4 | | | Constant amplitude, $\pm 2.8\%$ |
| T5 | | | Constant amplitude, $\pm 3.8\%$ |
| T6 | | | Monotonic up to 7.6% |
| T7 | FUSEIS with Rods | S500 | ECCS up to 4.7% |
| T8 | | | Constant amplitude, $\pm 1.6\%$ |
| T9 | FRAME 1 (2bay) | S355 | ECCS up to 4.8% |
| T10 | FRAME 2 (2bay) | S355 | ECCS up to 4.8% |
| T11 | FRAME 3 (1bay) | S355 | ECCS up to 4.8% |

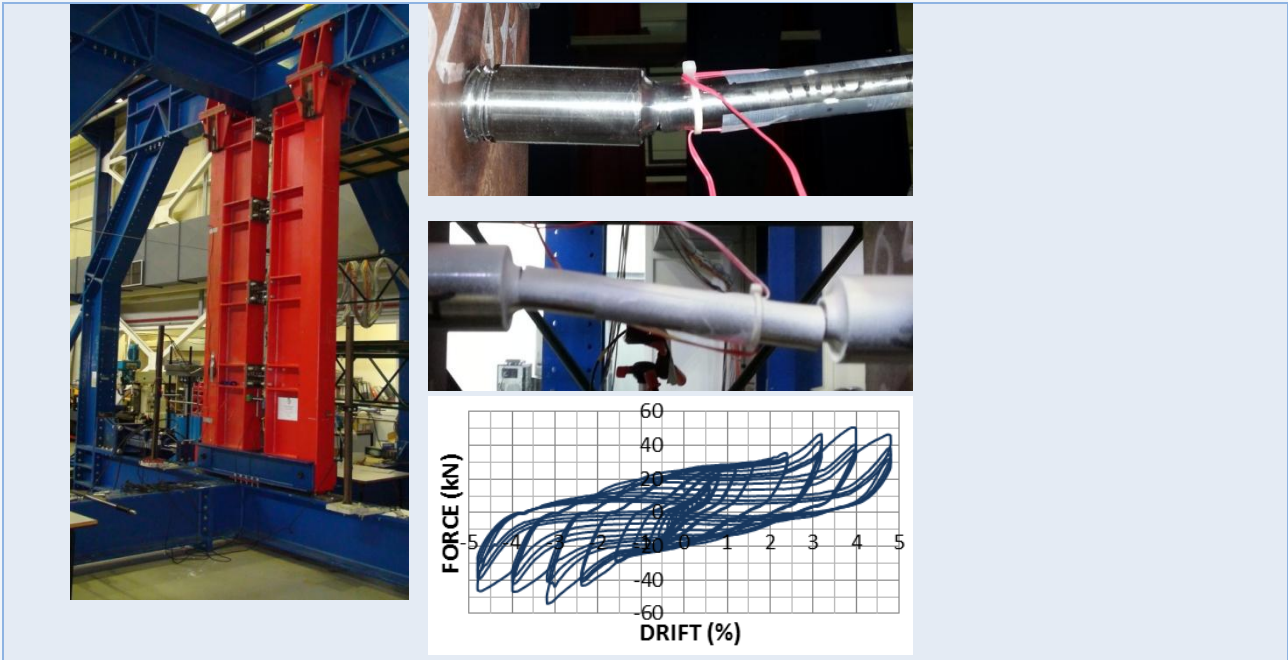
Instrumentation for data acquisition:

- Computers
- LVDTs
- Inclinometers
- Stain gauges
- Camera/ Video-camera / Thermal-camera

Experimental investigations on FUSEIS systems with beams

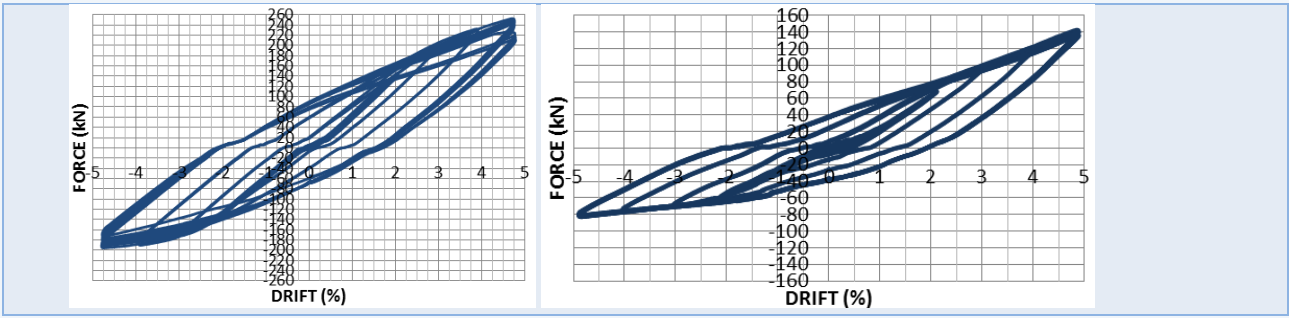


Experimental investigations on FUSEIS systems with pin links

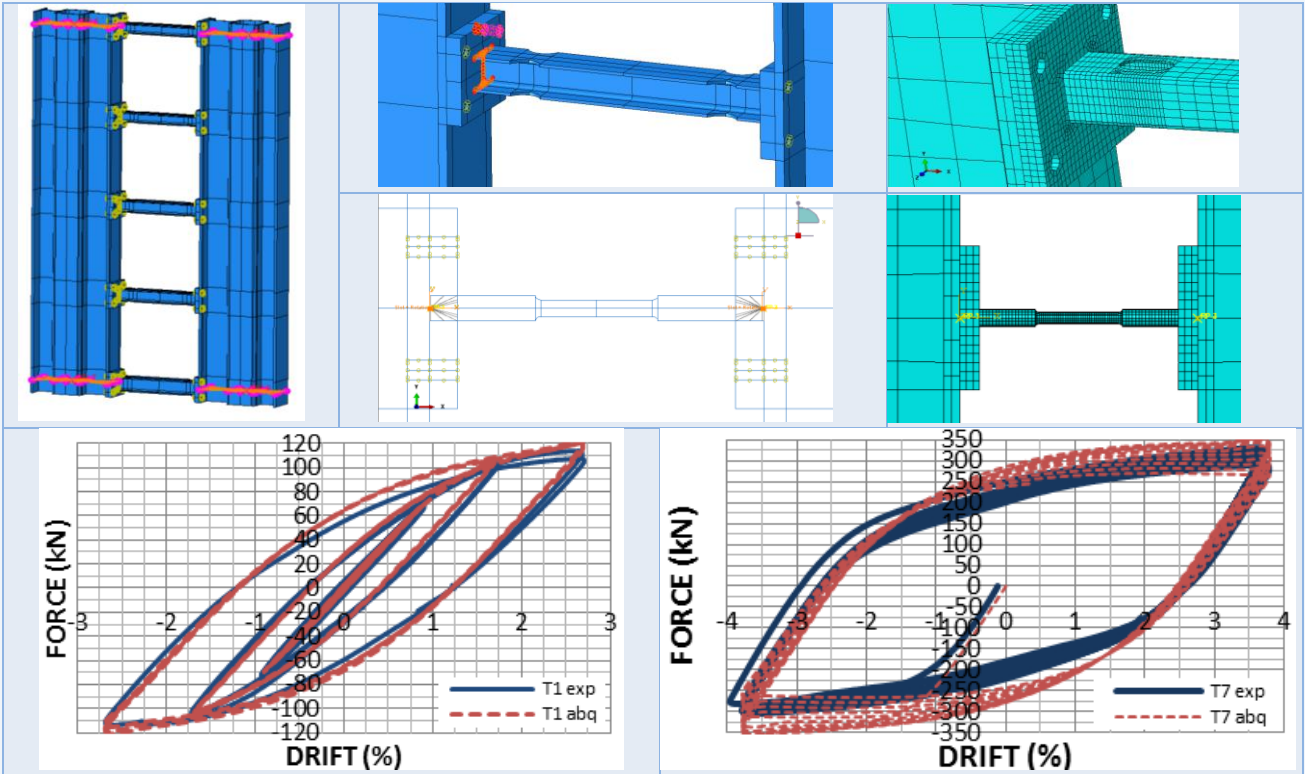


Tests on Moment Resistant Frames (MRF)

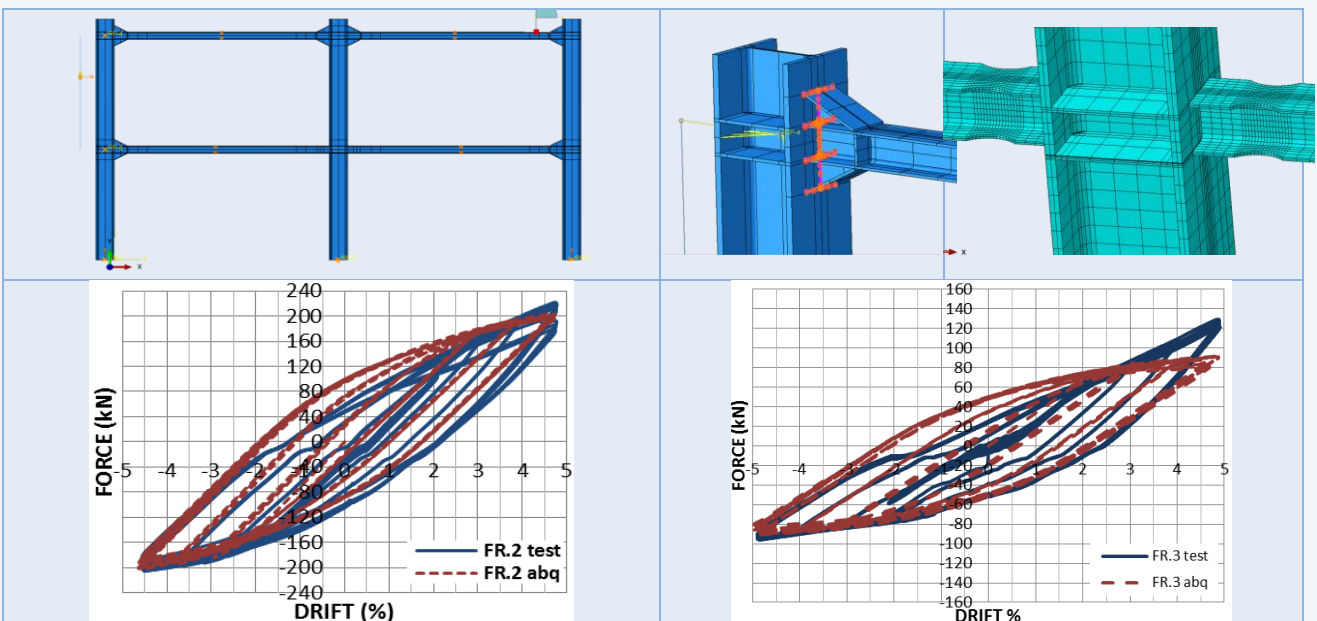




Numerical simulations of tests on FUSEIS



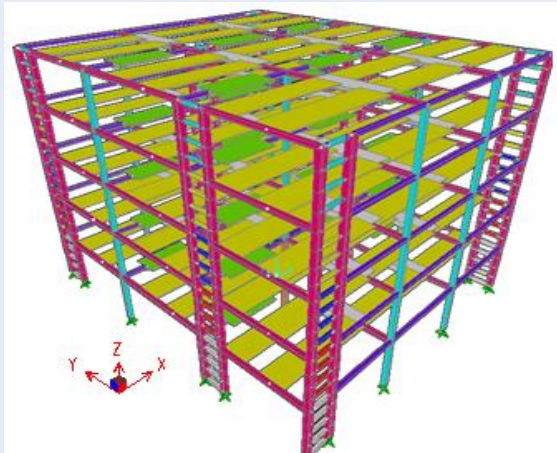
Numerical simulations of tests on MRF



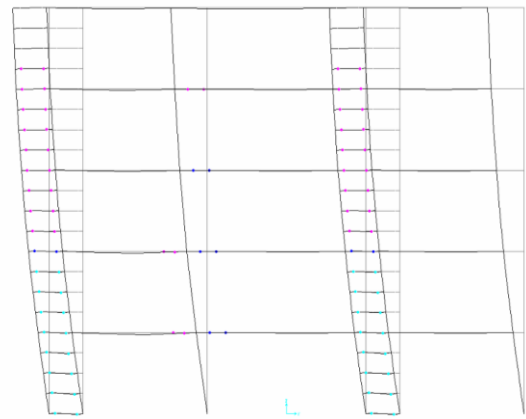
Damage criterion – Crack initiation prediction (red colour)



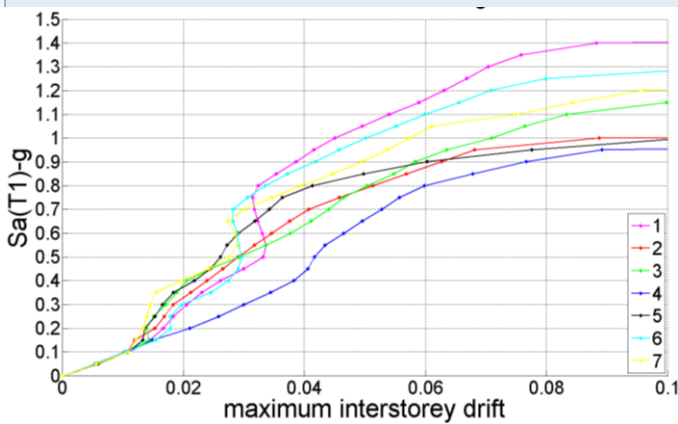
Design and Simulation of case studies and Parametric study of critical dissipative elements



3D model of case study



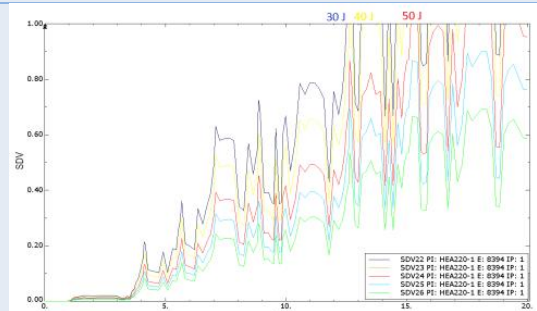
Non-linear static analysis (pushover)



Incremental dynamic analysis (IDA)



Numerical simulation of critical fuse



Parametric study- investigation of damage for different levels of material toughness