"FUSEIS"

Title: **FUSEIS – Dissipative Devices for Seismic Resistant Steel Frames**
Fund: Research Fund for Coal and Steel (RFSR-CT-2008-00032)
Partners: National Technical University of Athens (NTUA), Aachen University (RWTH), Politecnico di Milano (PMIL), Technical University of Lisbon (IST), SIDENOR S.A.
Coordinator: Professor I. Vayas (NTUA Athens)
Research group: D. Dimakogianni, G. Dougka, X. Lignos, S. Katsatsidis, Ph. Karydakis
Duration: 01/07/08 - 30/06/11
Budget: 741.350,97 €

Summary

Two innovative types of seismic resistant steel frames with dissipative fuses were developed, FUSEIS1 and FUSEIS2. Experimental and theoretical investigations were carried out at the Steel Structures Laboratory of NTUA to study the response of FUSEIS1. The system provides stiffness, strength, ductility and architectural transparency. In case of strong earthquakes damage is concentrated only in the fuses, while the rest of the structure remains elastic and undamaged. Repair work, if needed, is limited only in replacing the fuses. The system exhibits a self-centering behavior with minimal residual drifts.

Publications

Journals:

1. Vayas I., Karydakis Ph., Dimakogianni D., Dougka G., Castiglioni C. A., Kanyilmaz A. et al.: Dissipative devices for seismic resistant steel frames - The FUSEIS Project, Design Guide, Research Fund for Coal and Steel, 2012. http://fuseis.ntua.gr/Documents/FUSEIS_design%20guide.pdf
2. Dimakogianni D., Dougka G., Vayas I.: Innovative seismic-resistant steel frames (FUSEIS 1-2) experimental analysis, Steel Construction Design and Research, Volume 5, Issue 4, 2012, pp. 212-221. DOI: 10.1002/stco.201210026
3. Vayas I., Karydakis Ph., Dimakogianni D., Dougka G., Castiglioni C. A., Kanyilmaz A. et al.: Dissipative devices for seismic-resistant steel frames (FUSEIS), Research Fund for Coal and Steel, European Commission EU 25901 EN 2013. DOI: 10.2777/88177
4. Dougka G., Dimakogianni D., Vayas I.: Innovative energy dissipation systems (FUSEIS 1-1) - Experimental analysis, Journal of Constructional Steel Research, Volume 96, Issue 5, 2014, pp. 69-80. DOI: 10.1016/j.jcsr.2014.01.003
5. Dougka G., Dimakogianni D., Vayas I.: Seismic behavior of frames with innovative energy dissipation systems (FUSEIS 1-1), Earthquakes and Structures, Volume 6, Number 5, 2014, pp 561-580. DOI: 10.12989/eas.2014.6.5.561

Conferences:

1. Dougka G., Dimakogianni D., Karydakis Ph., Vayas I.: Energy dissipation systems (FUSEIS1) to seismic loading. Eurosteel 2011, August 31- September 2, 2011, Budapest, Hungary.
2. Dougka G., Dimakogianni D., Karydakis Ph., Vayas I.: Innovative energy dissipation systems (FUSEIS1): Experimental investigations. 7th National Conference on Steel Structures, 29-30 September and 1 October, 2011, Volos, Greece.
3. Dimakogianni D., Dougka G., Karydakis Ph., Vayas I.: Innovative energy dissipation systems (FUSEIS1): Analytical investigations. 7th National Conference on Steel Structures, 29-30 September and 1 October, 2011, Volos, Greece.
4. Dimakogianni D., Dougka G., Karydakis Ph., Vayas I., Calado L.& Castiglioni C.A.: Innovative energy dissipation systems (FUSEIS 1). Stessa 2012, January 9-11, 2012, Santiago, Chile. http://www.crcnetbase.com/doi/abs/10.1201/b11396-116

5. Dougka G., Dimakogianni D., Vayas I., Karydakis Ph.: Seismic behaviour of innovative energy dissipation systems FUSEIS 1-1, Proc. COMPDYN 2013 Conference C 1076, 2013, Kos, Greece. http://www.eccomasproceedings.org/cs2013/pdf/1076.pdf
6. Dimakogianni D., Dougka G., Vayas I., Karydakis Ph.: Seismic behaviour of innovative energy dissipation systems FUSEIS 1-2, Proc. COMPDYN 2013 Conference C 1075, 2013, Kos, Greece. http://www.eccomasproceedings.org/cs2013/pdf/1075.pdf

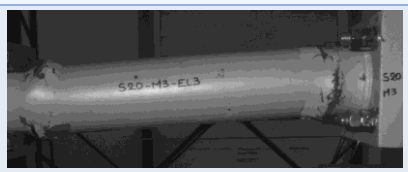
Description of FUSEIS1

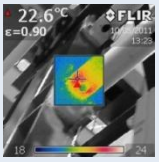
The system consists of two closely spaced strong columns, rigidly connected to multiple beams. The beams run from column to column, FUSEIS1-1, or alternatively are interrupted and connected by short pins, FUSEIS1-2.

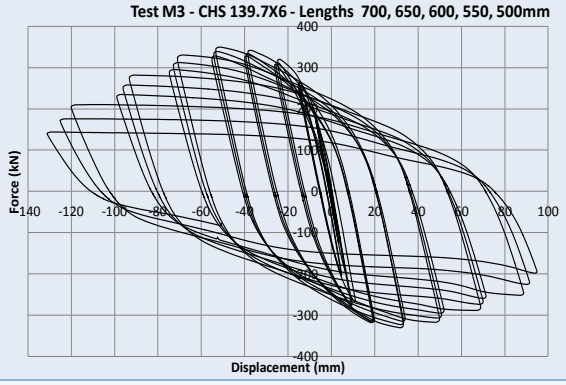
Experimental investigations

- 2 test rigs
- 6 full scale tests on overall frames with FUSEIS1-1
- 2 full scale tests on overall frames with FUSEIS1-2
- Cyclic loading procedure according to ECCS
- Duration 4 months

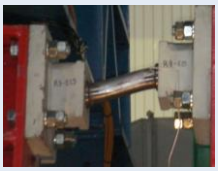
FUSEIS1-1: Test configuration with beam fuses IPE, SHS, CHS

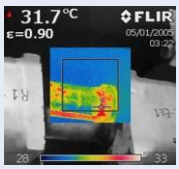


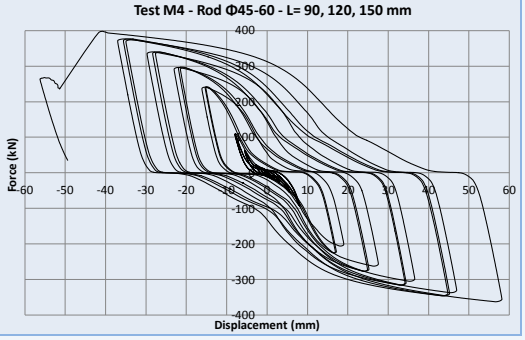




FUSEIS1-2: Test configuration with circular pin fuses

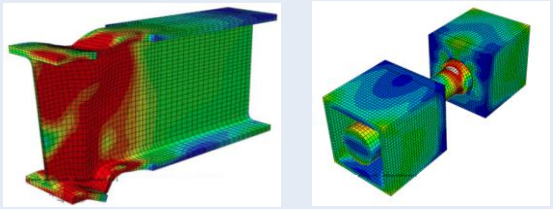






Analytical investigations

- Development and calibration of FEA models based on the experimental results (Fig. 1).
- Linear analyses on several building frames with FUSEIS1 and design according to European (EC3, 4, 8) and International practice.
- Non-linear static pushover analysis (SPO) to verify the collapse mechanism and evaluate the behavior factors (Fig. 2,3).
- Development of a Design Guide that includes the necessary information for conceptual design, analysis and design of buildings with FUSEIS1. The relevant clauses of EC8 were rearranged to cover the use of the devices by the normal Code provisions.
- Non-linear dynamic time history analysis along with Incremental Dynamic Analysis (IDA) to assess whether the elastic design meets the seismic performance objectives, examine the self-centering behavior of the system (Fig. 4), generate the IDA curves and verify the definition of limit states (IO, LS, CP) (Fig. 5) and conclude with the development of the collapse fragility curves (Fig. 6).



a) FUSEIS1- -1 b) FUSEIS1-2

Fig. 1: FEA models of FUSEIS1 devices

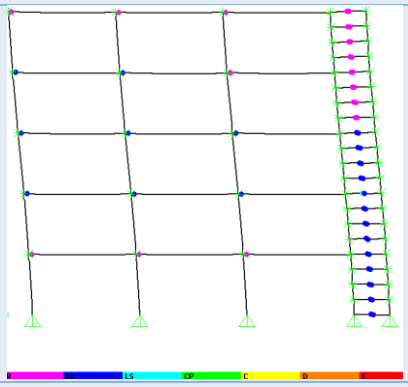


Fig. 2: Deformed frame with FUSEIS1-2, SPO

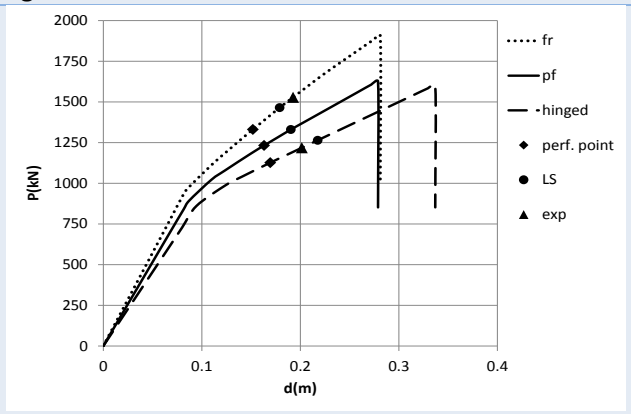


Fig. 3: Capacity curves of frames with FUSEIS1 for various types of floor beam to column connections.

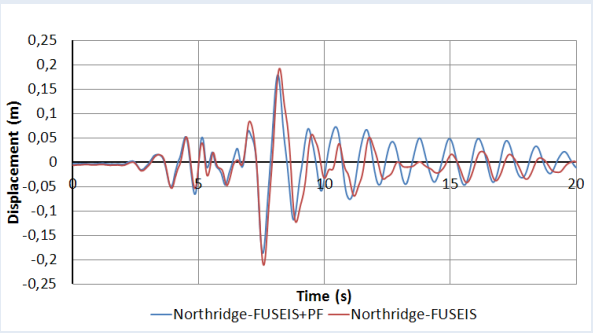


Fig. 4: Self-centering behavior; minimal residual roof displacements

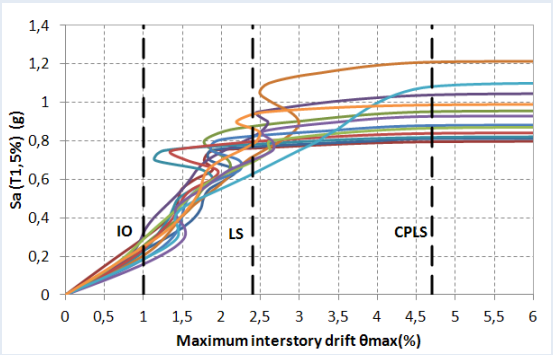


Fig. 5: IDA curves and limit-state capacities

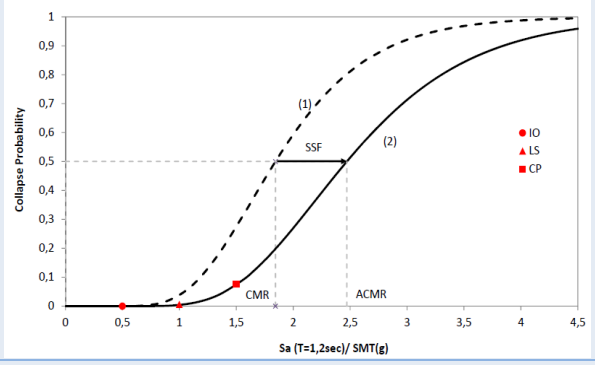


Fig. 6: Collapse fragility curve