“Seisracks 2”

Title: **Seisracks 2– Seismic behavior of steel storage pallet racking systems**
Fund: Research Fund for Coal and Steel (RFSR-CT-2011-00031)
Partners: National Technical University of Athens (NTUA), Politecnico di Milano (POLIMI), Aachen University (RWTH), University of Liege (ULGG), CCS S.A., SCL Ingeneria, Modulblok, Nedcon, SSI-Schaeffer, Stow
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Budget: 1.442.116,00 €

Summary

Different configurations of steel storage pallet racks were examined under experimental and numerical analyses in order to clarify the seismic response of these structures and to propose a safer and a more sufficient design for racks especially in seismic areas. The steel structures laboratory of the NTUA was responsible for the numerical analyses of the project and the compiling of a Designer’s manual which includes further development of the existing norm of racking systems under seismic actions.

Publications

Journals:

1. Adamakos K., Vayas I., Tragverhalten von Palettenregalsystemen unter Erdbebenbeanspruchung, Stahlbau, DOI:10.1002/stab.201490001, Ernst & Sohn Verlag für Architektur und technische Wissenschaften GmbH & Co. KG, Berlin, vol. 1, p.35-46, 2014

Conferences:

1. Adamakos K., Vayas I.: Static and Seismic behavior of steel storage pallet racks. 8th National Conference on Steel Structures, 2-4 October 2014, Tripoli, Greece.
2. Adamakos K., Vayas I., “Seismic Performance of steel storage pallet racks”, European Conference on Steel and Composite Structures, Setember 2014, Naples, Italy.
3. Adamakos K., Avgerinou S., Vayas I., “Estimation of the behavior factor of steel storage pallet racks”, COMPDYN 2013 Conference, June 2013, Kos Island, Greece.

Description of Steel storage pallet racks

The steel storage pallet racks are composed of thin walled sections which present limited ductility. These structures are designed to work perfectly under vertical loads; however the semi-rigid connections, between beam-columns and beam-base floor, and some types of bracing systems make these structures to present a sufficient response under horizontal seismic forces as well.

Fig.1 Typical unbraced racking system in full scale test

Numerical investigations

- Calibration of the numerical models using experimental results
- Incremental dynamic analyses
- Nonlinear static analyses
- Linear and nonlinear Response spectrum analyses
- FEM analyses of the detailing of the structures
- Detailed analyses for the interaction between structure and merchandize

Calibration of numerical models

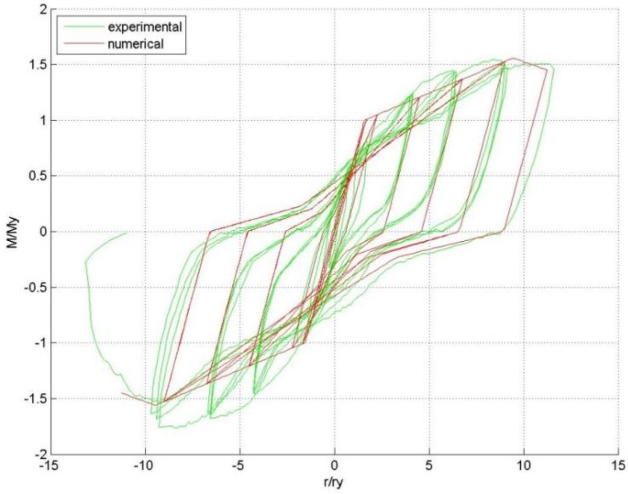

Fig.2 Calibration of the beam-end-connector’s cyclic behavior

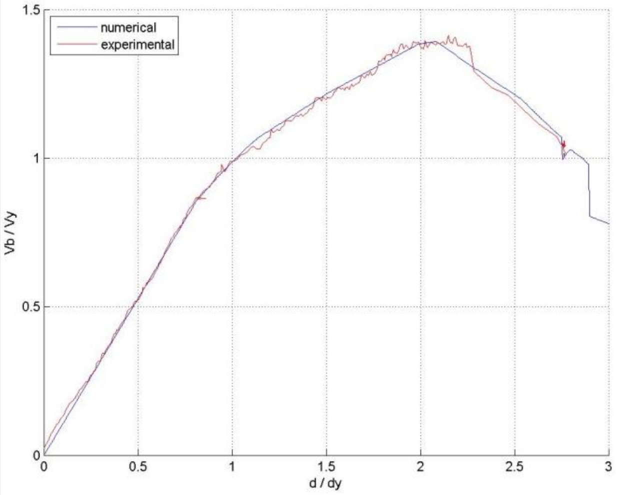

Fig.3 Calibration of the full scale test of an upright frame

Static and dynamic analyses

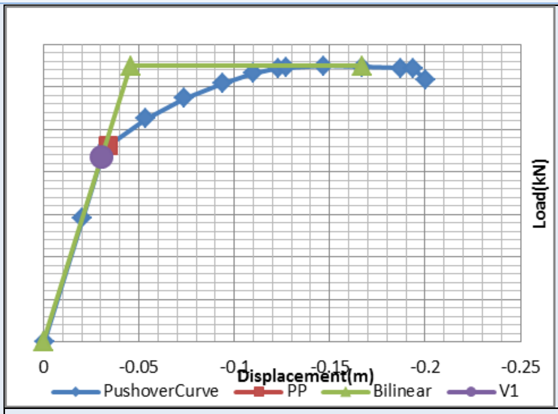

Fig.4 Pushover curve of an unbraced racking system

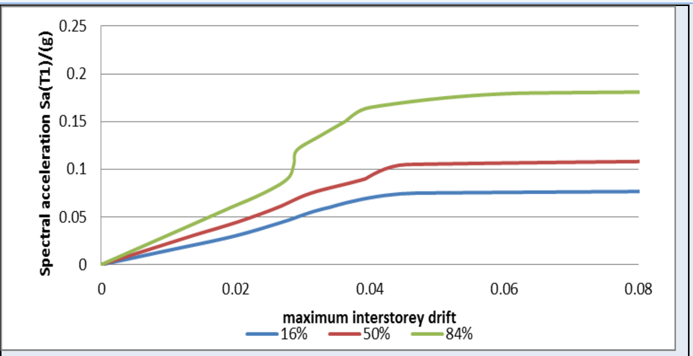

Fig.5 Fractile curve derived from an incremental dynamic analysis for an unbraced racking system

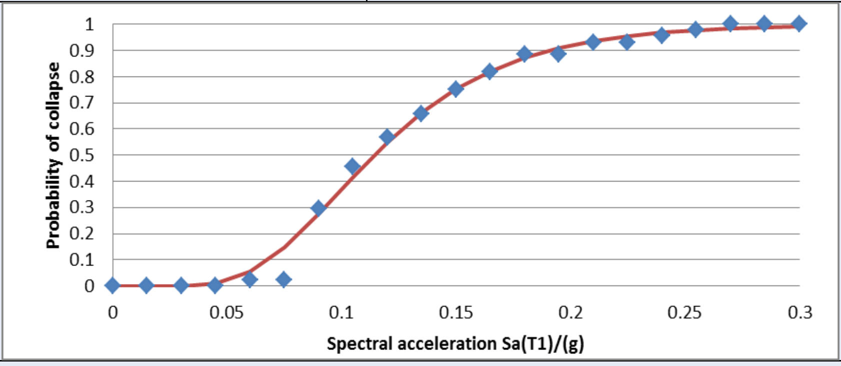

Fig.6 Fragile curve of an unbraced racking system

Detailed analyses

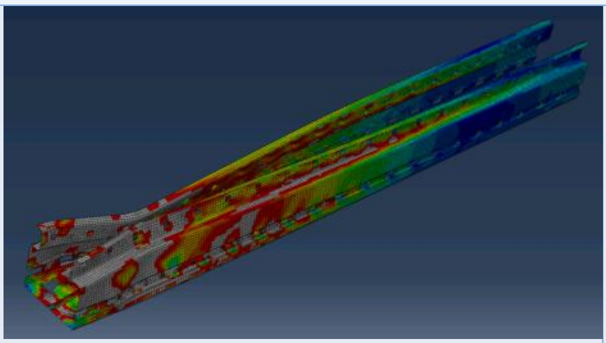

Fig.7 Analysis of a single upright member under monotonic loading

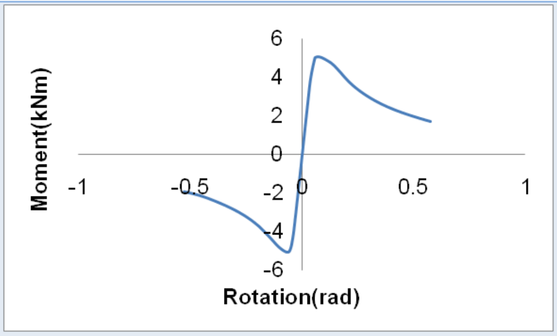

Fig.8 Moment-rotation curve of the examined upright section

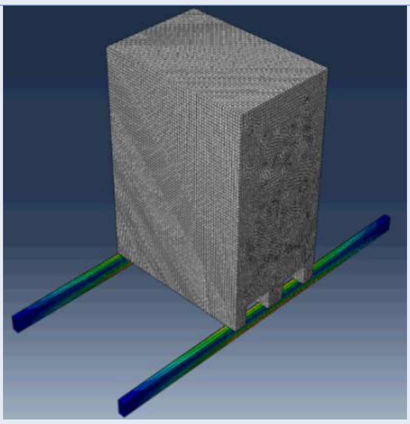

Fig.9 Examination of the pallet-beam’s buckling length with the existance of pallets on the pallet-beams (friction elements)

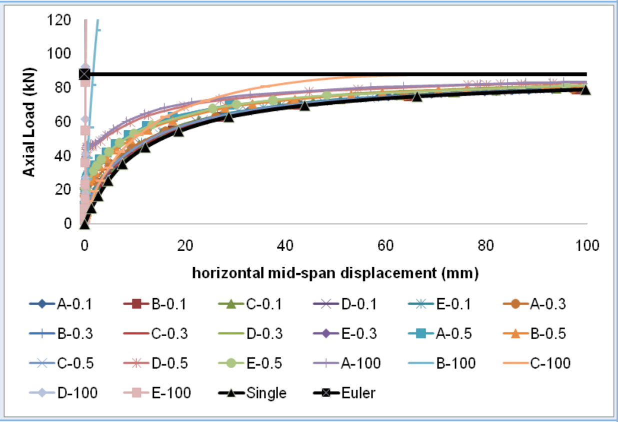

Fig.10 Load-displacement curves for different positions of the pallets and different friction coefficient values between pallet and beam

Analytical investigations

Development of a simple equation for the estimation of the maximum value of the sliding force which is developed on a beam under horizontal-eccentric seismic forces

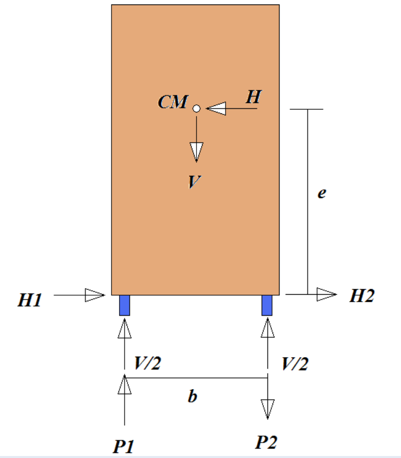

Fig.11 Theoretical model

$$H_2 = \frac{Vb\mu}{2(b+2e\mu)} \qquad H_1 = \frac{Vb\mu}{4(b-e\mu)}\frac{2b+5e\mu}{(b+2e\mu)}$$

Fig.12 The maximum forces developed on two supporting beams during the sliding of a pallet

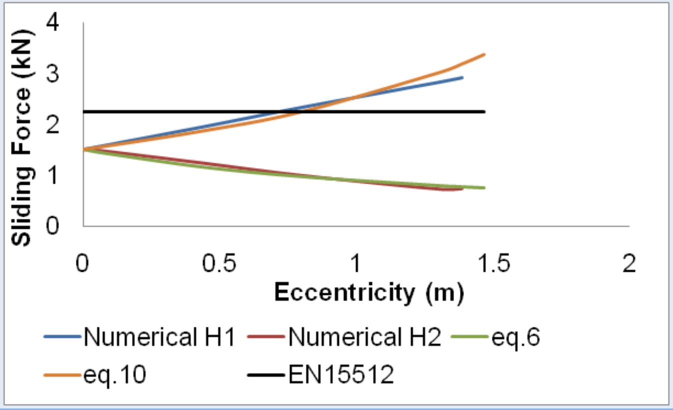

Fig.13 Numerical evaluation of the theoretical results