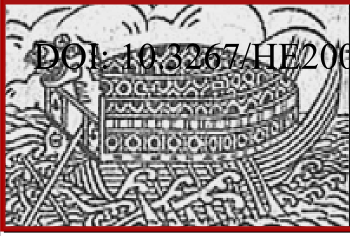

DOI: 10.3267/HE2008

"BENCHMARKING/BETATESTING DI CODICI DI CALCOLO UTILIZZABILI PER L'ANALISI STRUTTURALE IN CASO DI INCENDIO"

"BENCHMARKING/BETATESTING OF NUMERICAL CODES USED TO ANALYZE STRUCTURES SUBJECTED TO FIRE"

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Department of Structural and Geotechnical Engineering

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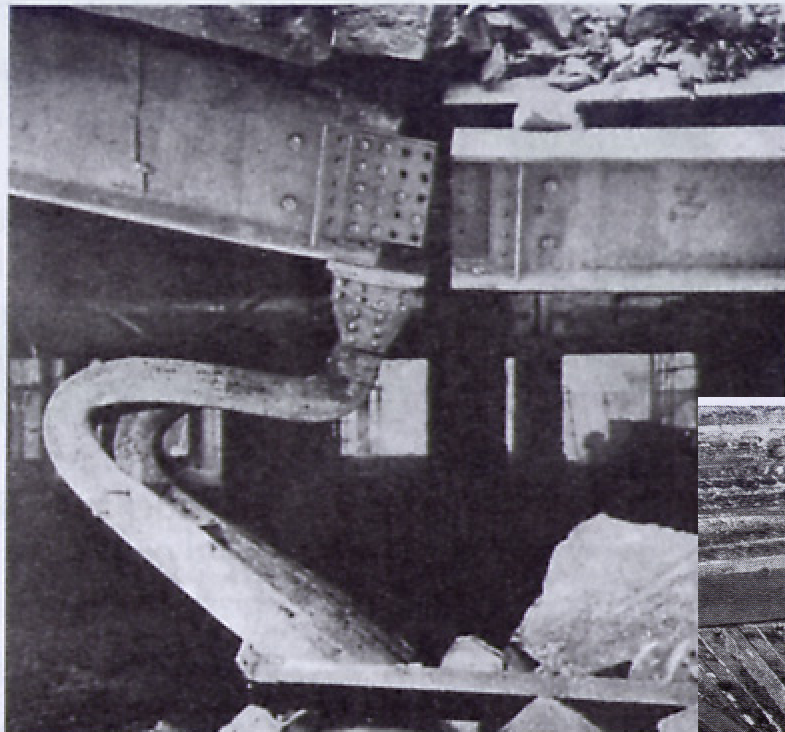
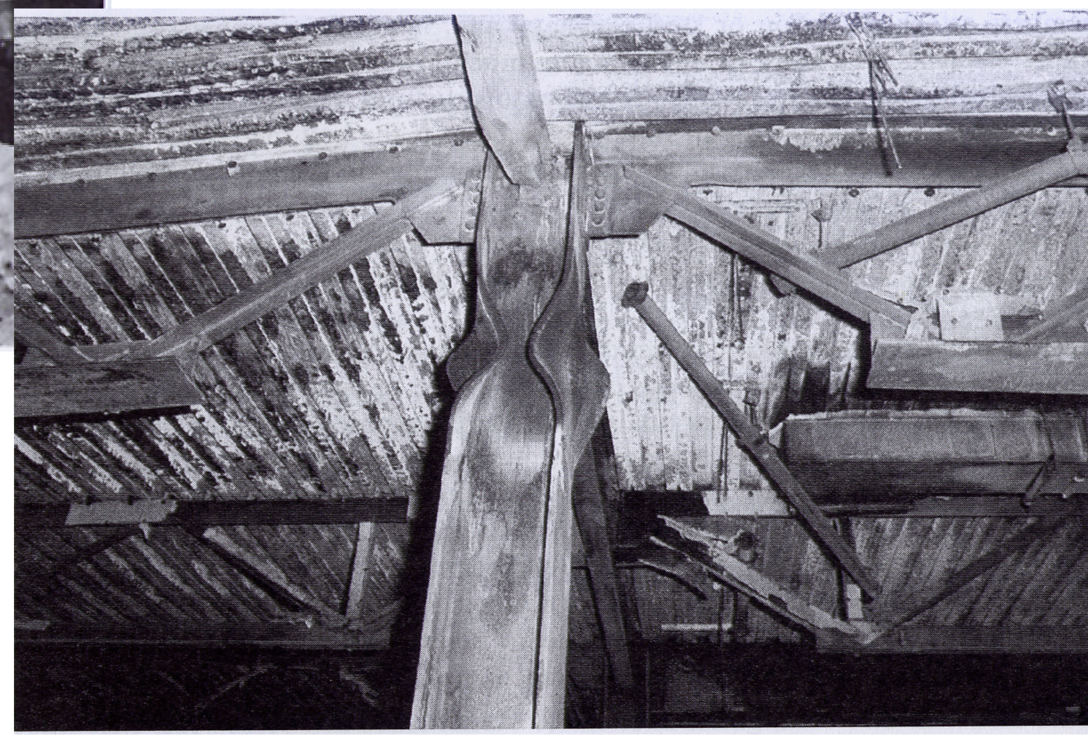
AIM OF WORK



The aim of this work is to **test** commercial finite able to modeling the **real behavior** of steel elements subject to fire in order to assess its capacity to point out some **basic mechanism**.



The study of what happens in **isolated elements** in steel when subjected to high temperature is useful to understand **complex structures**.

Andrew H.Buchanan (2000), *Structural Design for Fire Safety*

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PRESENTATION STRUCTURE

Introduction

General model to analyze elements subject to fire action

Part I

Numerical application on isolated steel elements

Not restrained axial expansion

Restrained axial expansion

Part II

Numerical application on steel park cars

Conclusions

Conclusive evaluations

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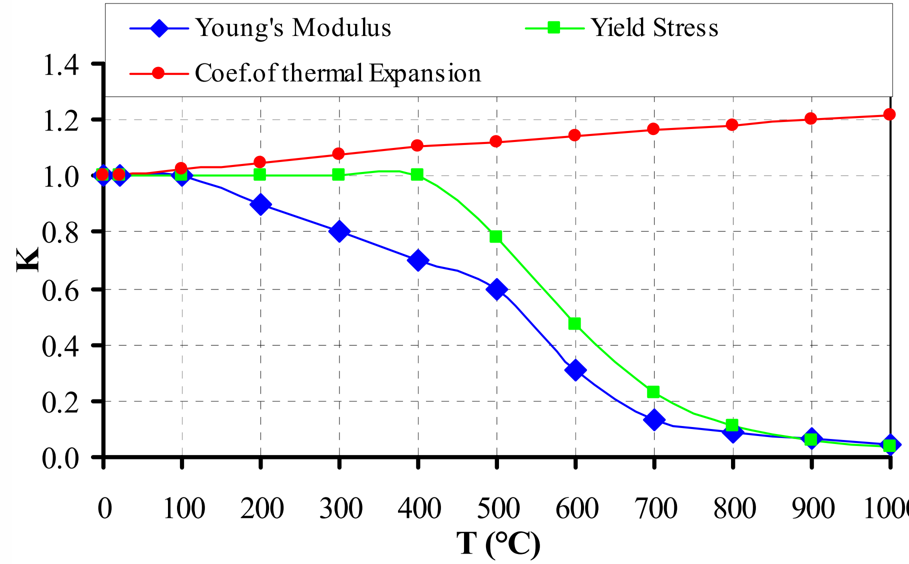
General model to analyze elements under fire

✓ ***Material Properties of Steel***: prEN 1993-1-2 **Thermo-Plastic material**

Steel Temperature θ_a	Reduction factors at temperature θ_a relative to the value of f_y or E_a at 20°C		
	Reduction factor (relative to f_y) for effective yield strength $k_{y,\theta} = f_{y,\theta}/f_y$	Reduction factor (relative to f_y) for proportional limit $k_{p,\theta} = f_{p,\theta}/f_y$	Reduction factor (relative to E_a) for the slope of the linear elastic range $k_{E,\theta} = E_{a,\theta}/E_a$
20°C	1,000	1,000	1,000
100°C	1,000	1,000	1,000
200°C	1,000	0,807	0,900
300°C	1,000	0,613	0,800
400°C	1,000	0,420	0,700
500°C	0,780	0,360	0,600
600°C	0,470	0,180	0,310
700°C	0,230	0,075	0,130
800°C	0,110	0,050	0,090
900°C	0,060	0,0375	0,0675
1000°C	0,040	0,0250	0,0450
1100°C	0,020	0,0125	0,0225
1200°C	0,000	0,0000	0,0000

NOTE: For intermediate values of the steel temperature, linear interpolation may be used.



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General model to analyze elements under fire

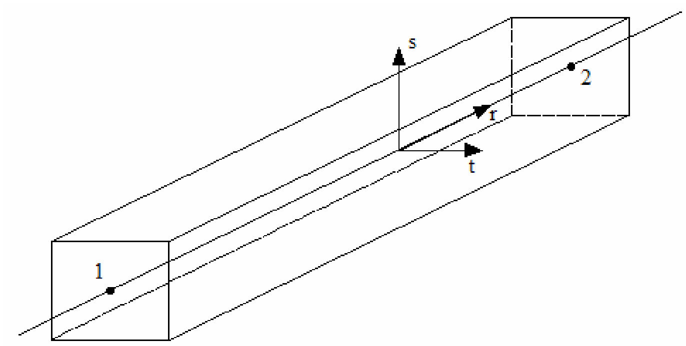
✓ ***Material Properties of Steel***: prEN 1993-1-2

Thermo-Plastic material

Finite Elemest Codes used:

ADINA

- ***Finite Element Used:*** Isoparametric

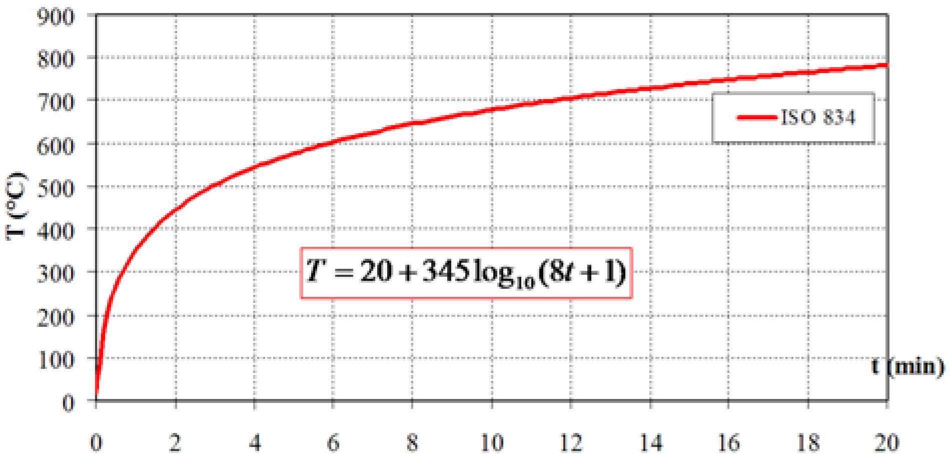


Non Linear Isobeam elements

- 2 node isobeam;
- General 3D beam with six degrees of freedom per node;
- Elements have constant rectangular cross-section;

Straus7

- ***Finite Element Used:*** Beam



✓ ***Modelling of Fire:*** Nominal Curve

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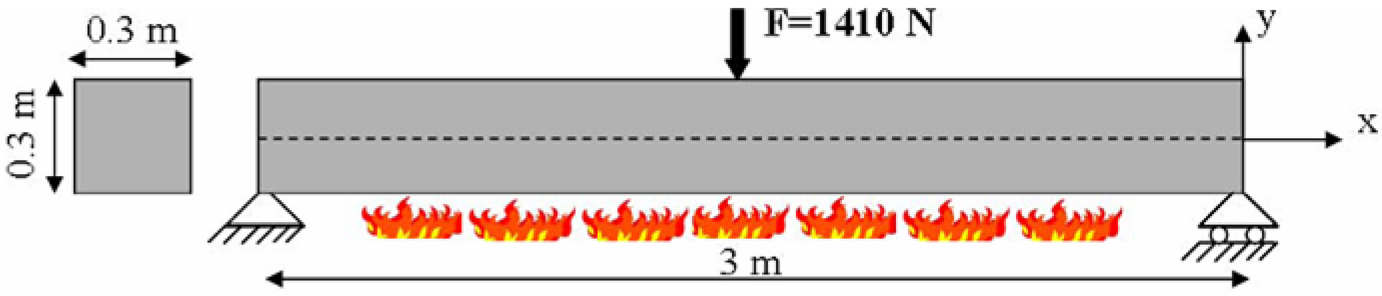
Numerical application on isolated elements

Not restrained axial expansion



Sezione: 0.3x0.3 m

Materiale: S235

ISO834

Material and geometrical non linear analyses

Benchmark of results obtained by two Finite Element Codes:

Adina, Strand

To point out the some general aspects of the behavior

of steel elements under fire action

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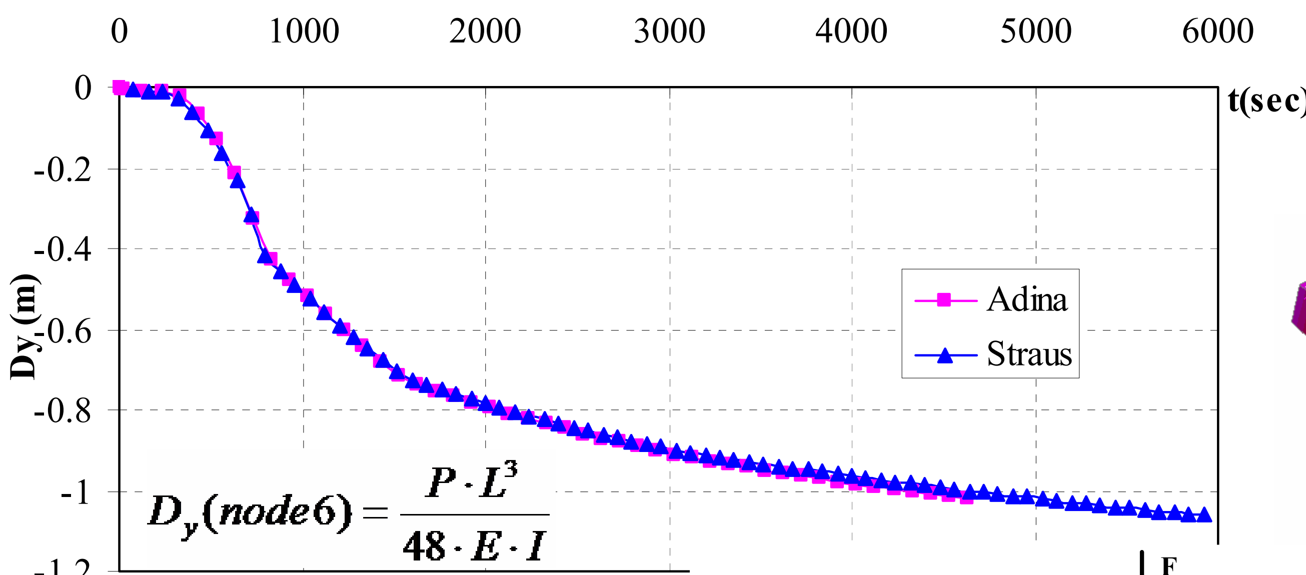
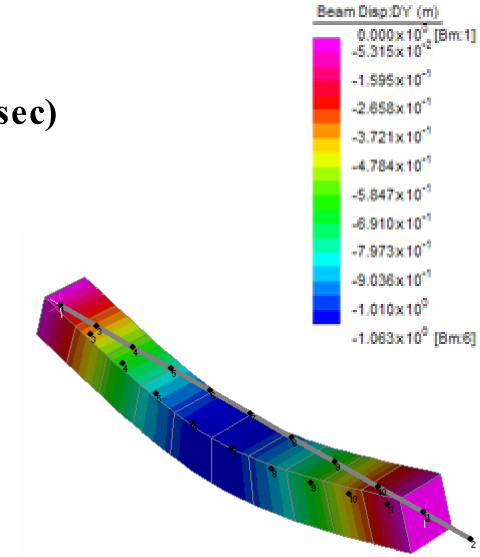
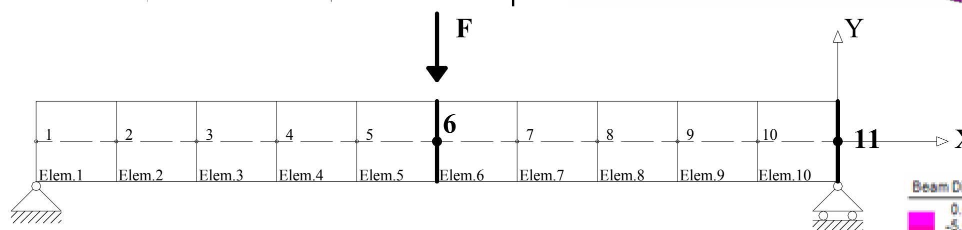
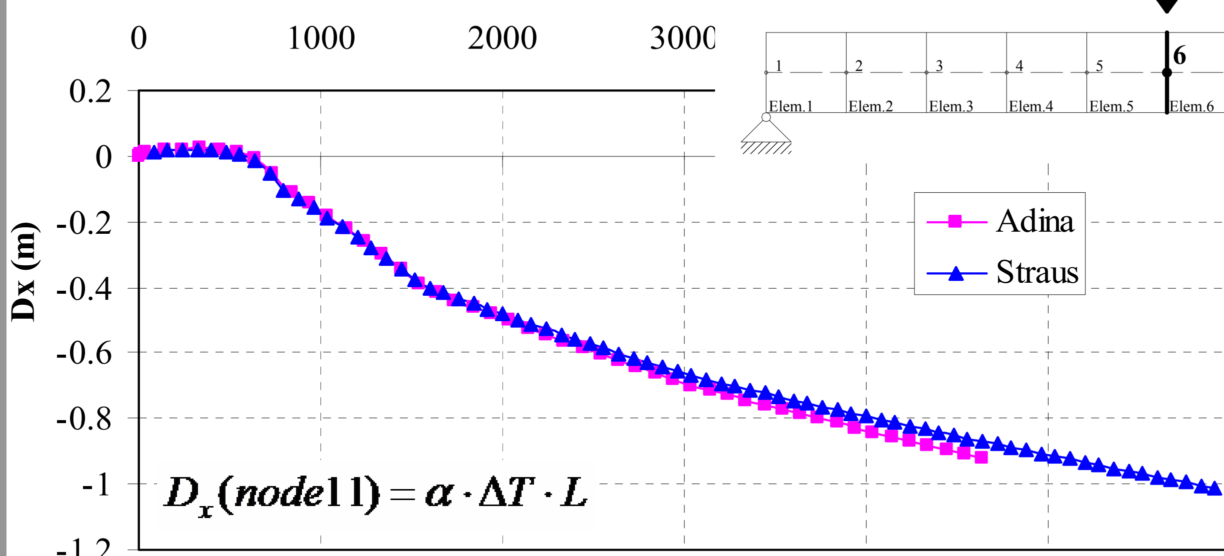
Numerical application on isolated elements



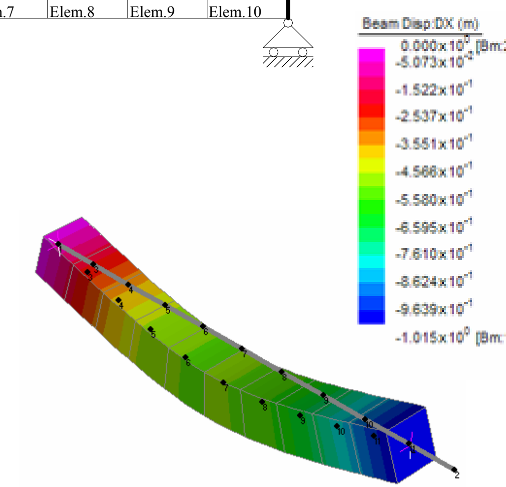
$$D_y(node6) = \frac{P \cdot L^3}{48 \cdot E \cdot I}$$







$$D_x(node11) = \alpha \cdot \Delta T \cdot L$$



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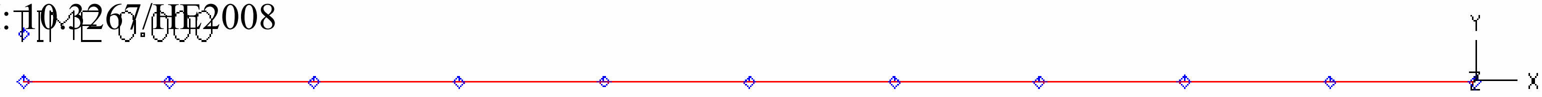

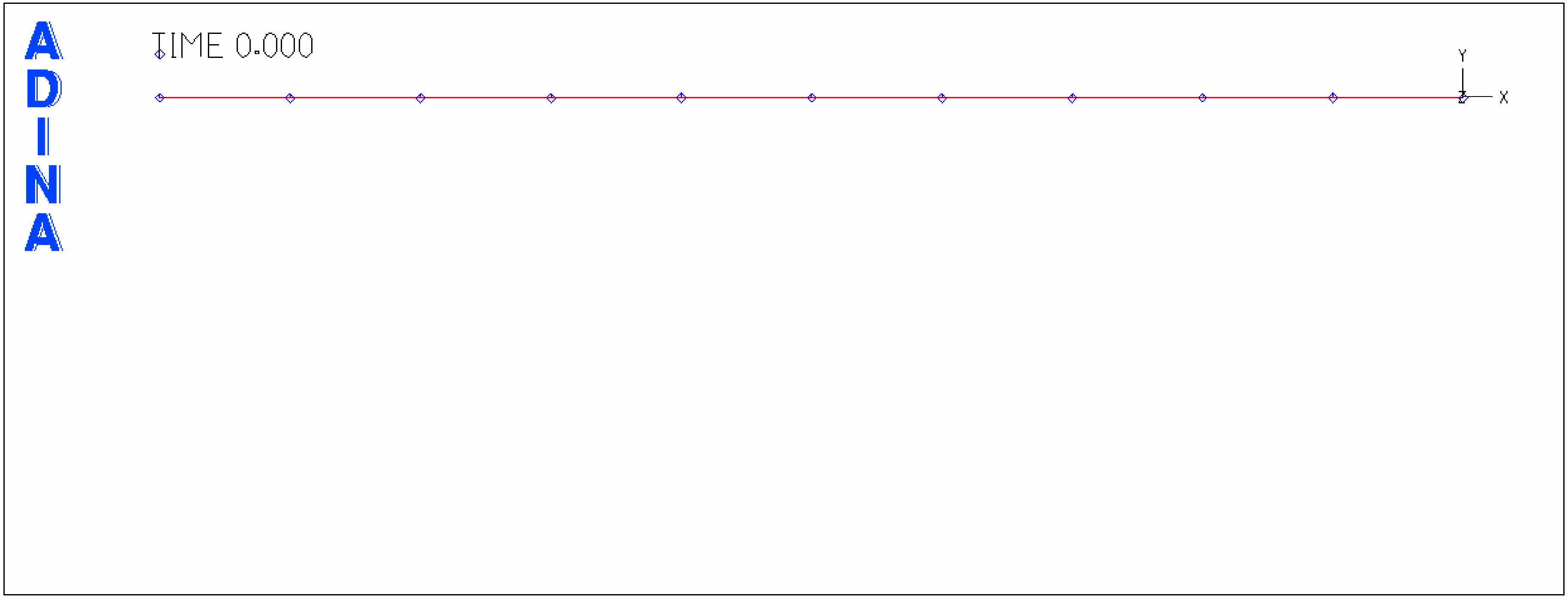

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Numerical application on isolated elements

ADINA

Time
0.00

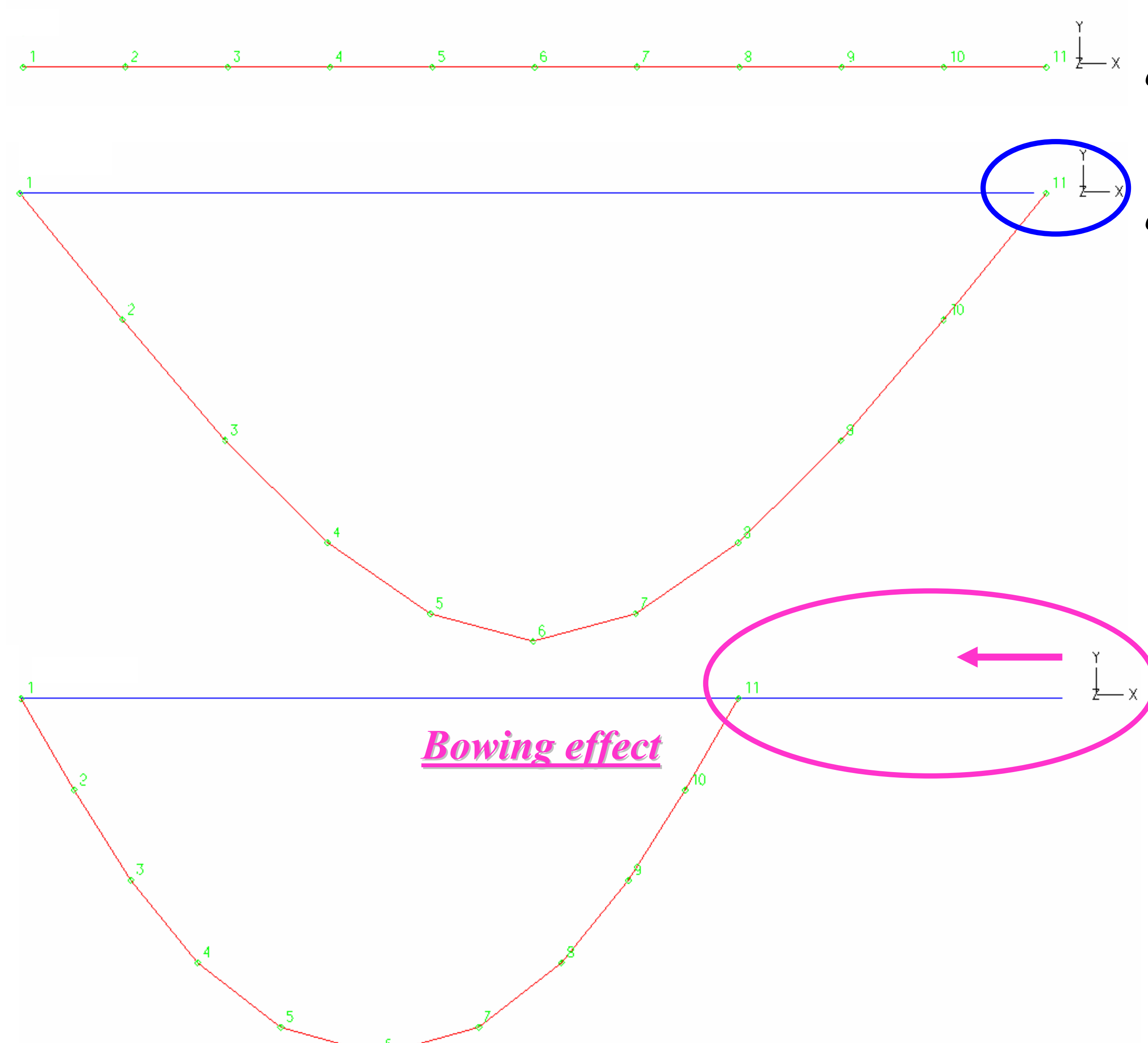
Initial configuration

Time
2600.00

NLM configuration

Time
4730.00

NLM +NLG configuration



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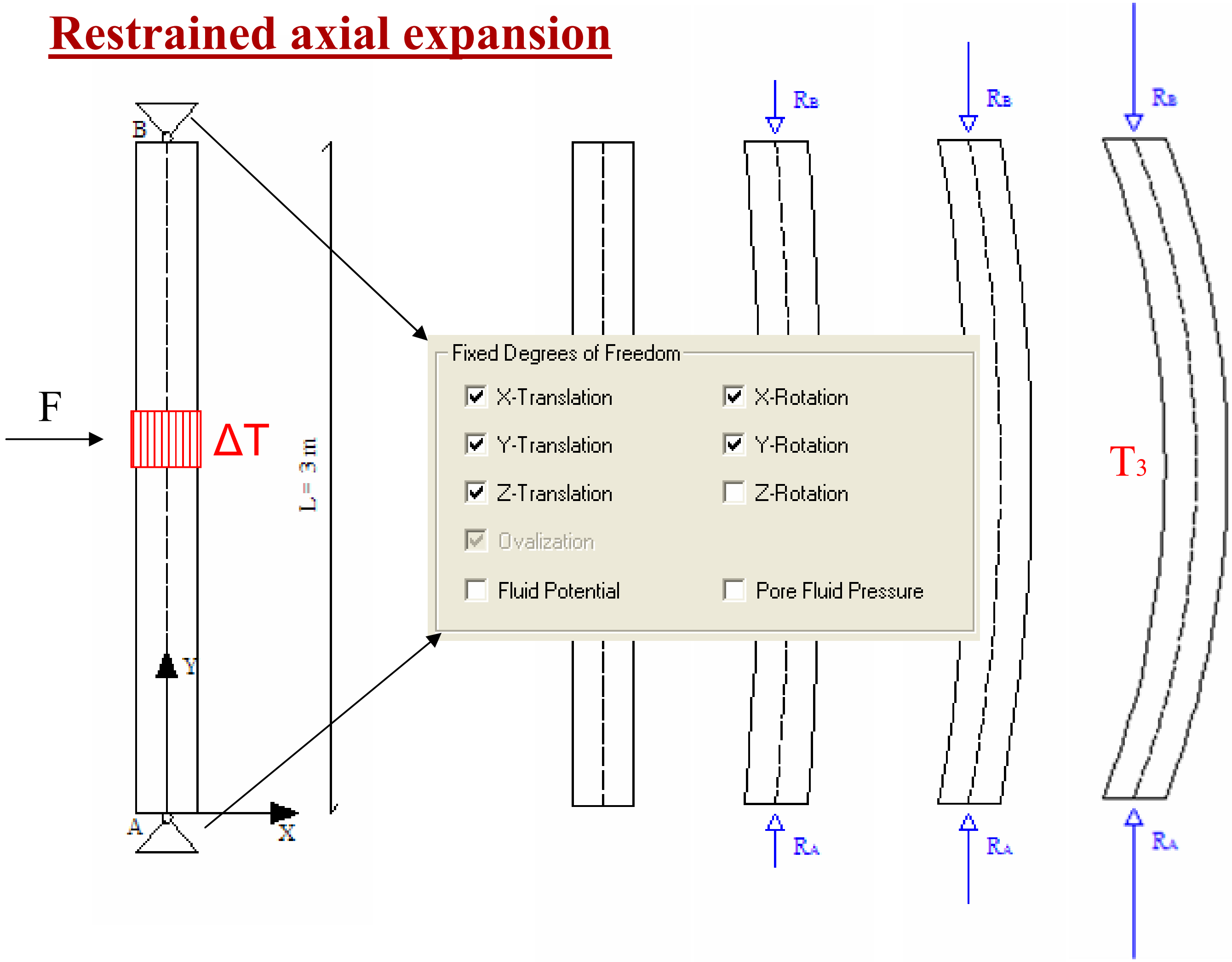
Numerical application on isolated elements

Restrained axial expansion



Analyses with non linearity of Geometry and of Material

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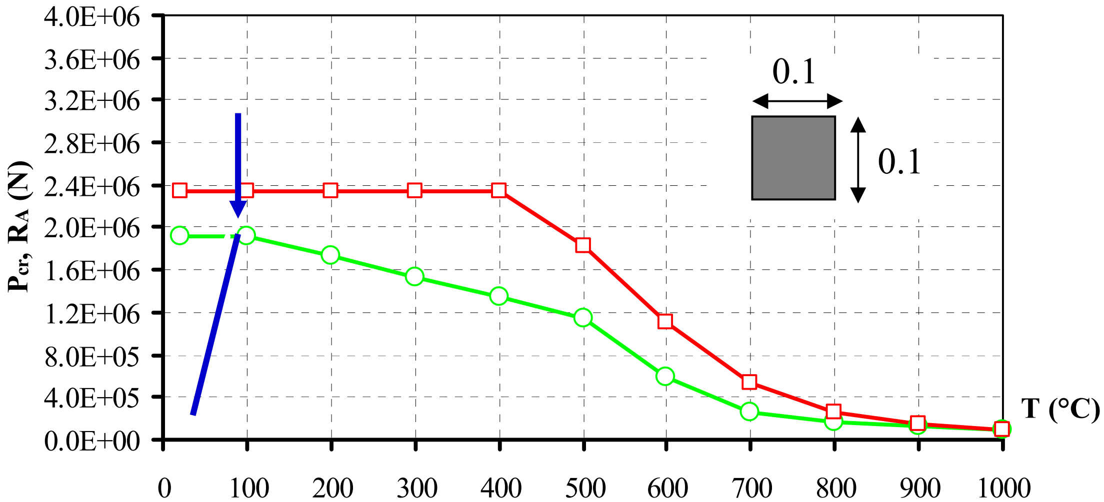
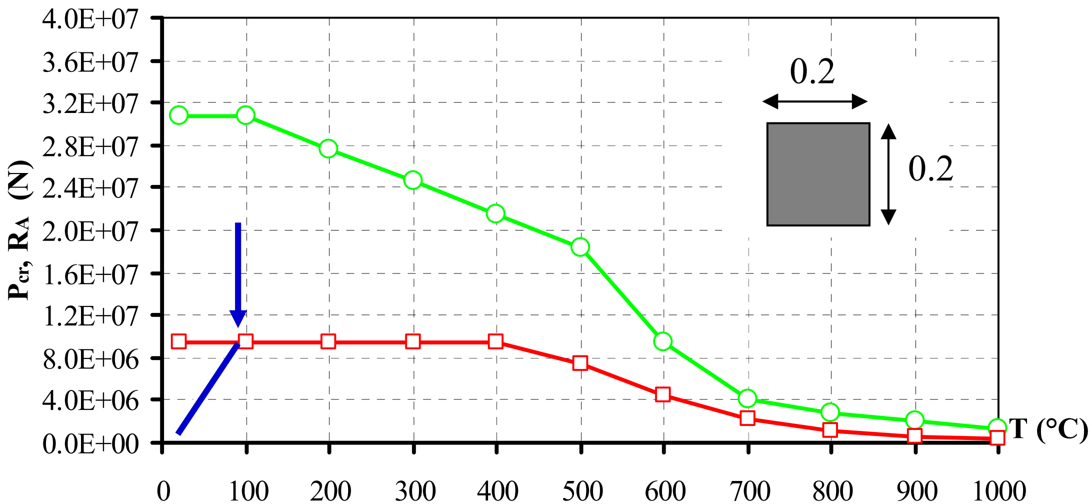
Numerical application on isolated elements

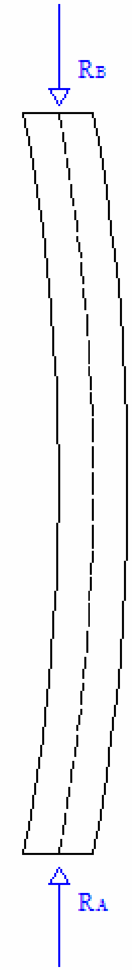




$P_y = \sigma_y(T) * A$

$P_E = \dfrac{\pi^2 E(T) I}{L^2}$

R_A



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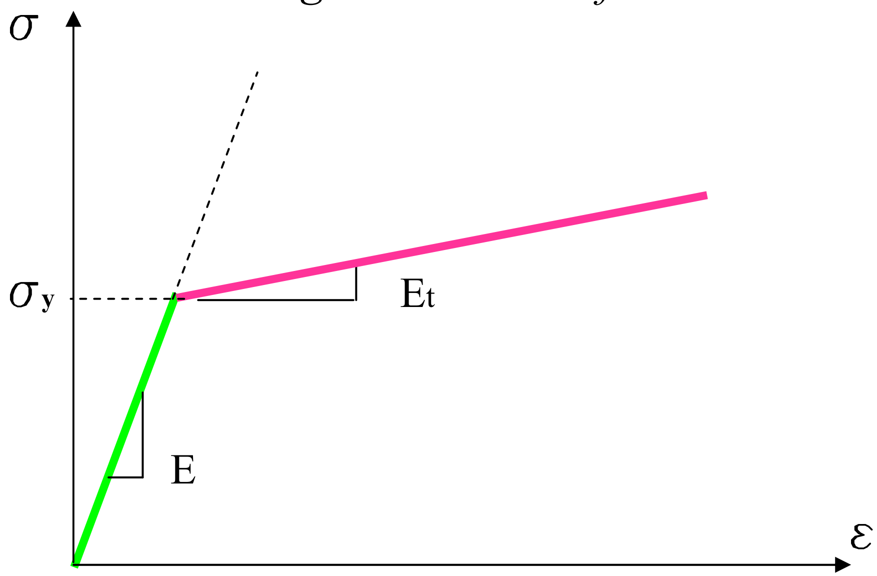
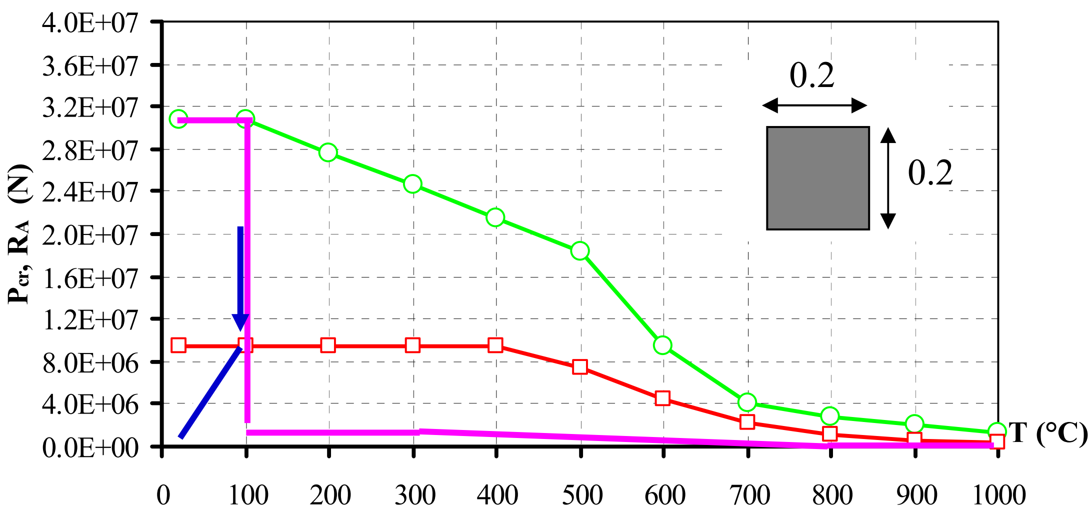
Numerical application on isolated elements

Diagram Stress-Deformation





$$R_x \geq P_y \Rightarrow \sigma \geq \sigma_y(T)$$

The Elastic Buckling Load defined by Euler Formula:

$$P_E = \frac{\pi^2 E(T) I}{L^2}$$

Becomes Elastic-Plastic Buckling Load, defined by Shanley Formula:

$$P_S = \frac{\pi^2 E_t(T) I}{L^2}$$

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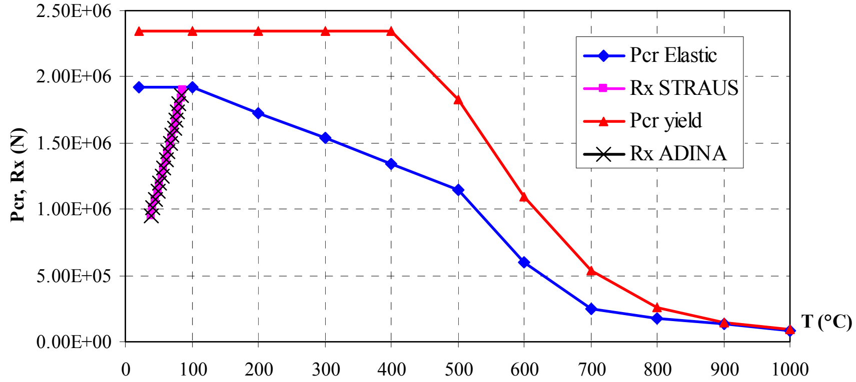
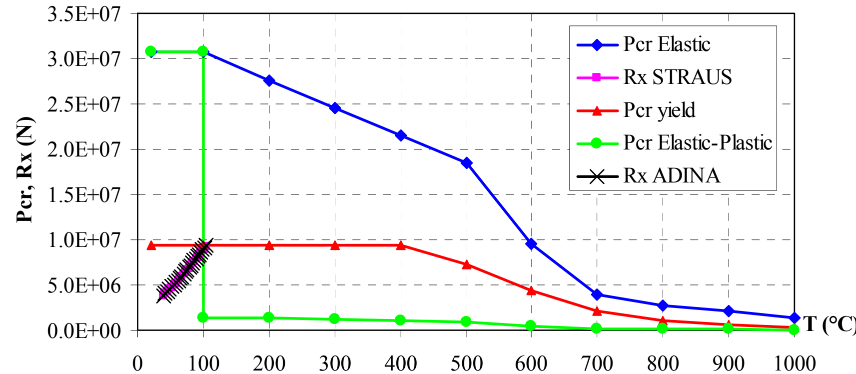
Numerical application on isolated elements

Section 0.1x0.1 m

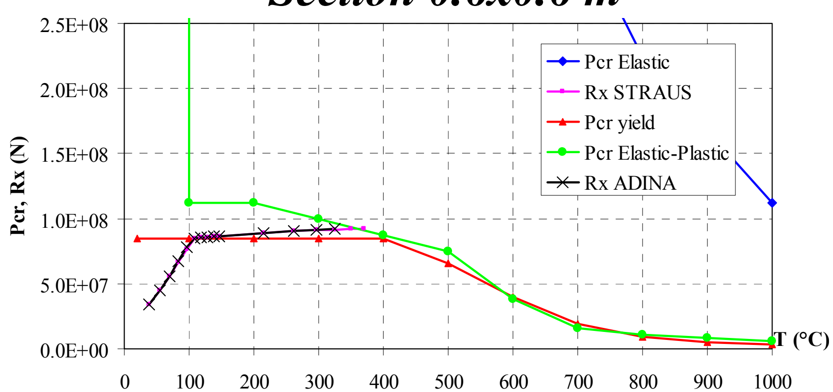


Section 0.2x0.2 m

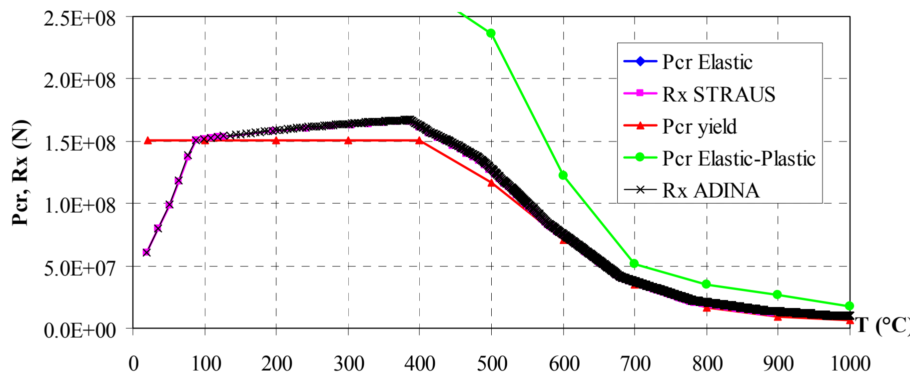


Point	*Section*	*T (°C)*	*Collapse for achievement of*
A	0.1x0.1	77	Elastic Buckling Load (Euler)
B	0.2x0.2	89,5	Elastic-Plastic Buckling Load (Shanley)
C	0.6x0.6	331	Elastic-Plastic Buckling Load (Shanley)
D	0.8x0.8	1000	No collapse

Section 0.6x0.6 m



Section 0.8x0.8 m



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STEEL OPEN CAR PARK

Report of "Commissione per la Sicurezza delle Strutture in Acciaio"

Commissione per la Sicurezza
delle Costruzioni in Acciaio
in caso d'Incendio

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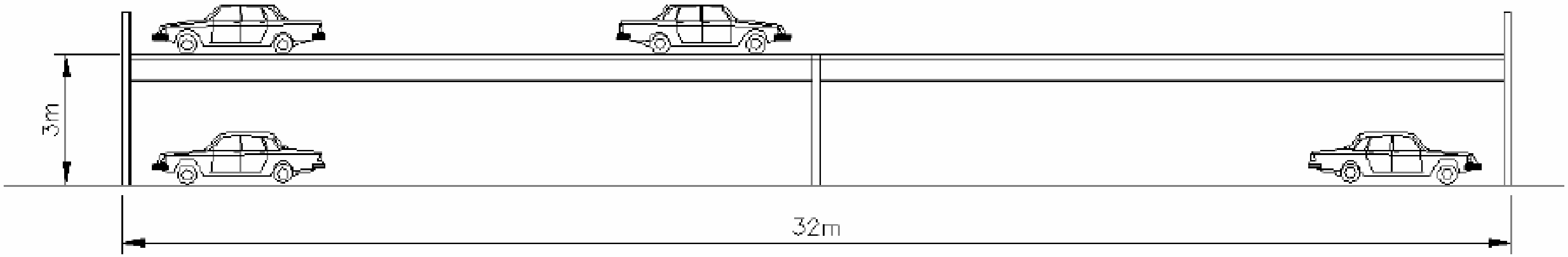
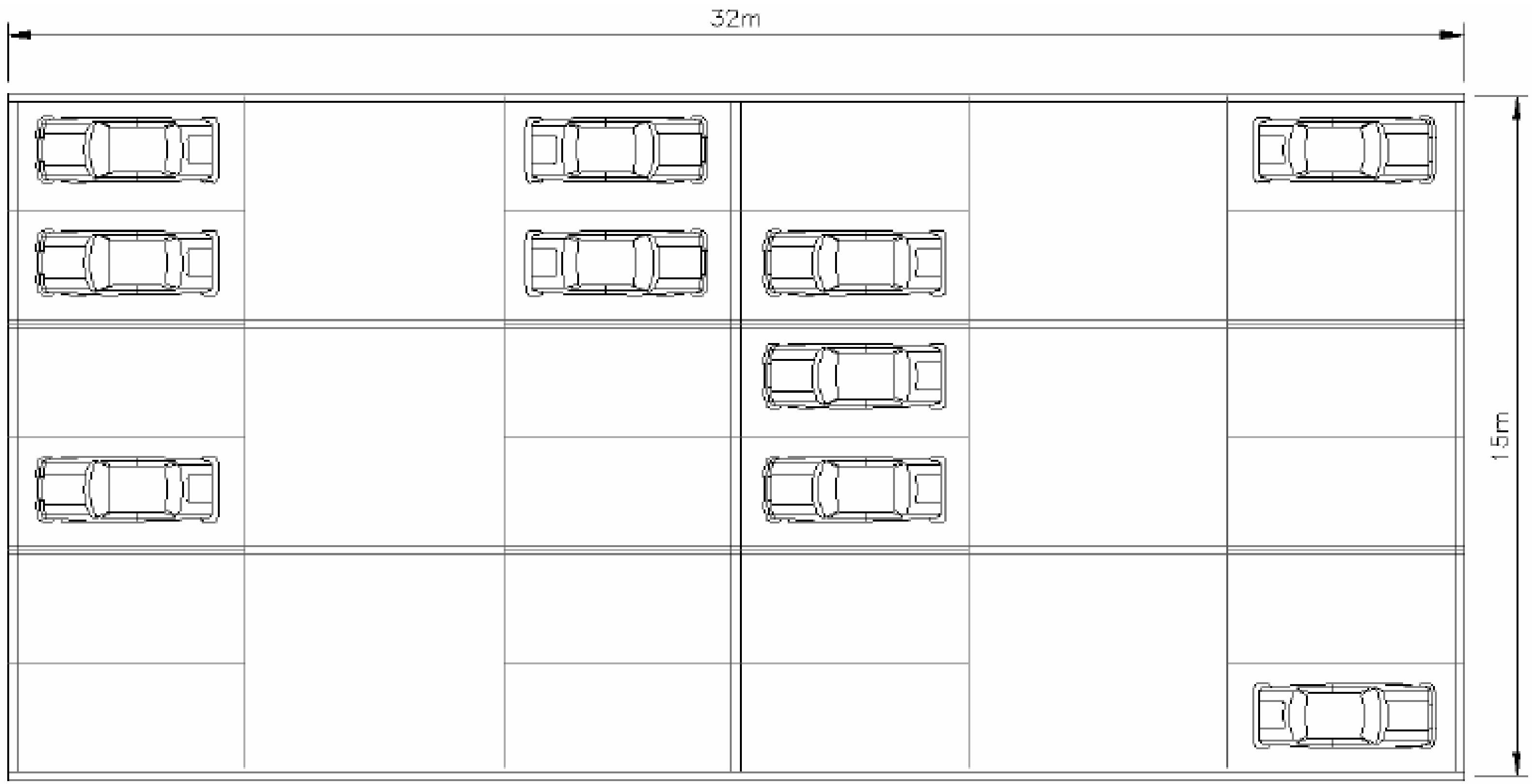
Numerical application on steel open car park

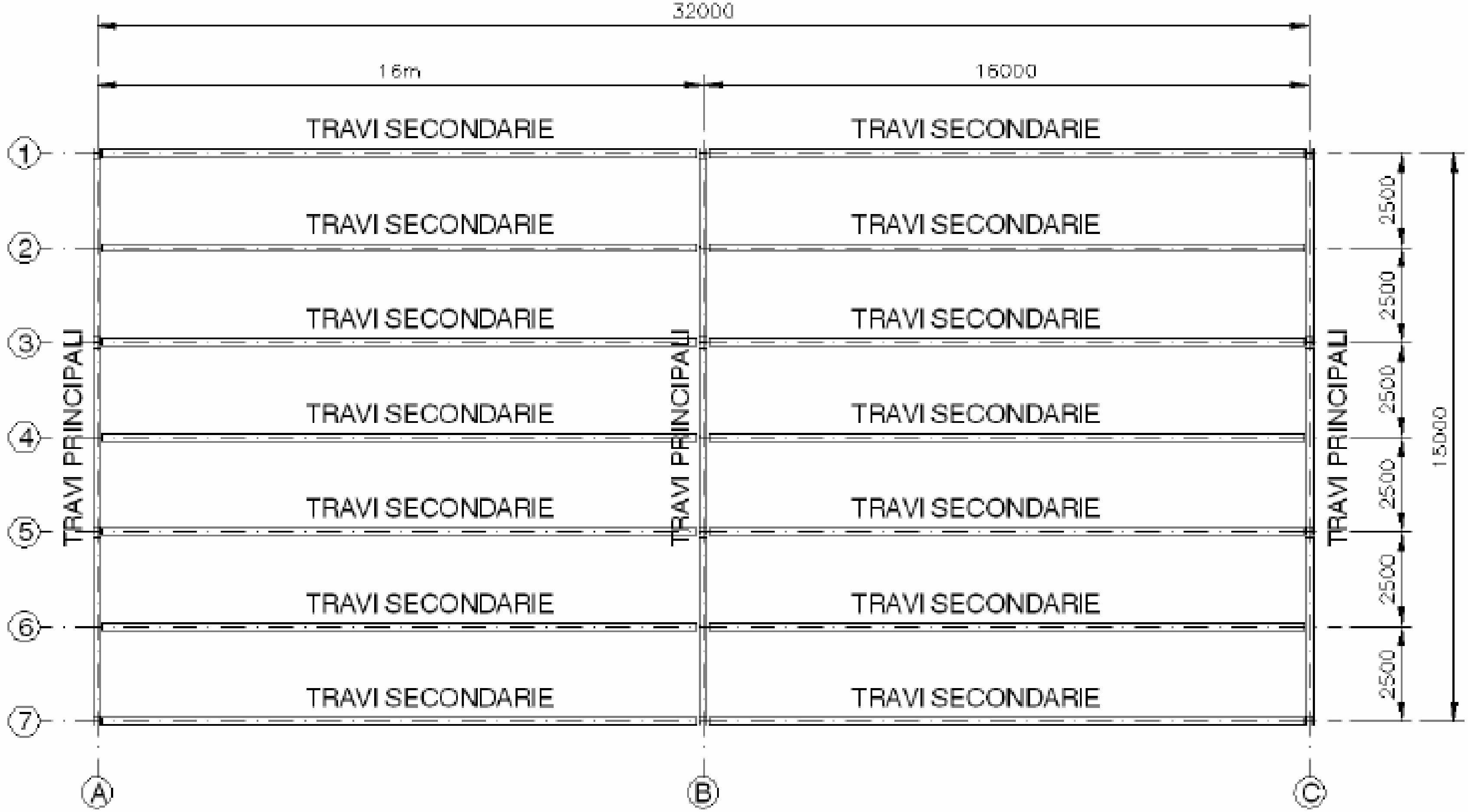




DOI: 10.3267/HE2008

Numerical application on steel open car park

STRUCTURAL GEOMETRY



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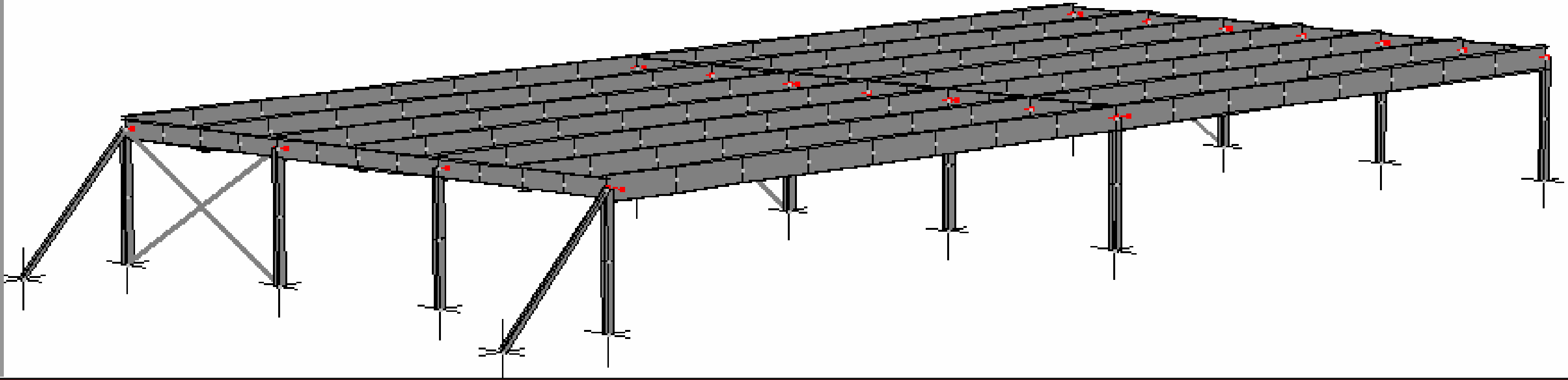
Numerical application on steel open car park

REAL STRUCTURE

STRAND MODEL



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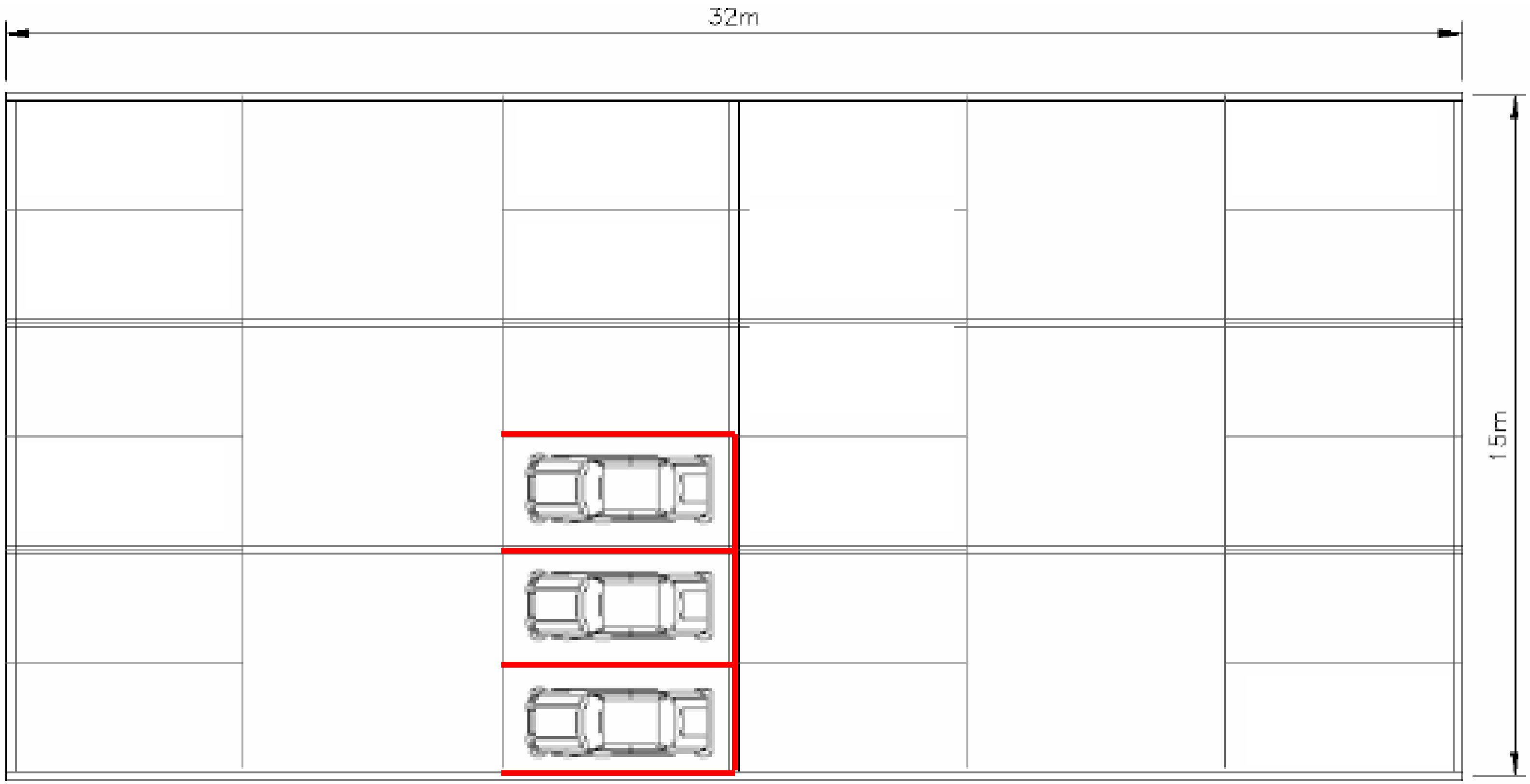
Numerical application on steel open car park

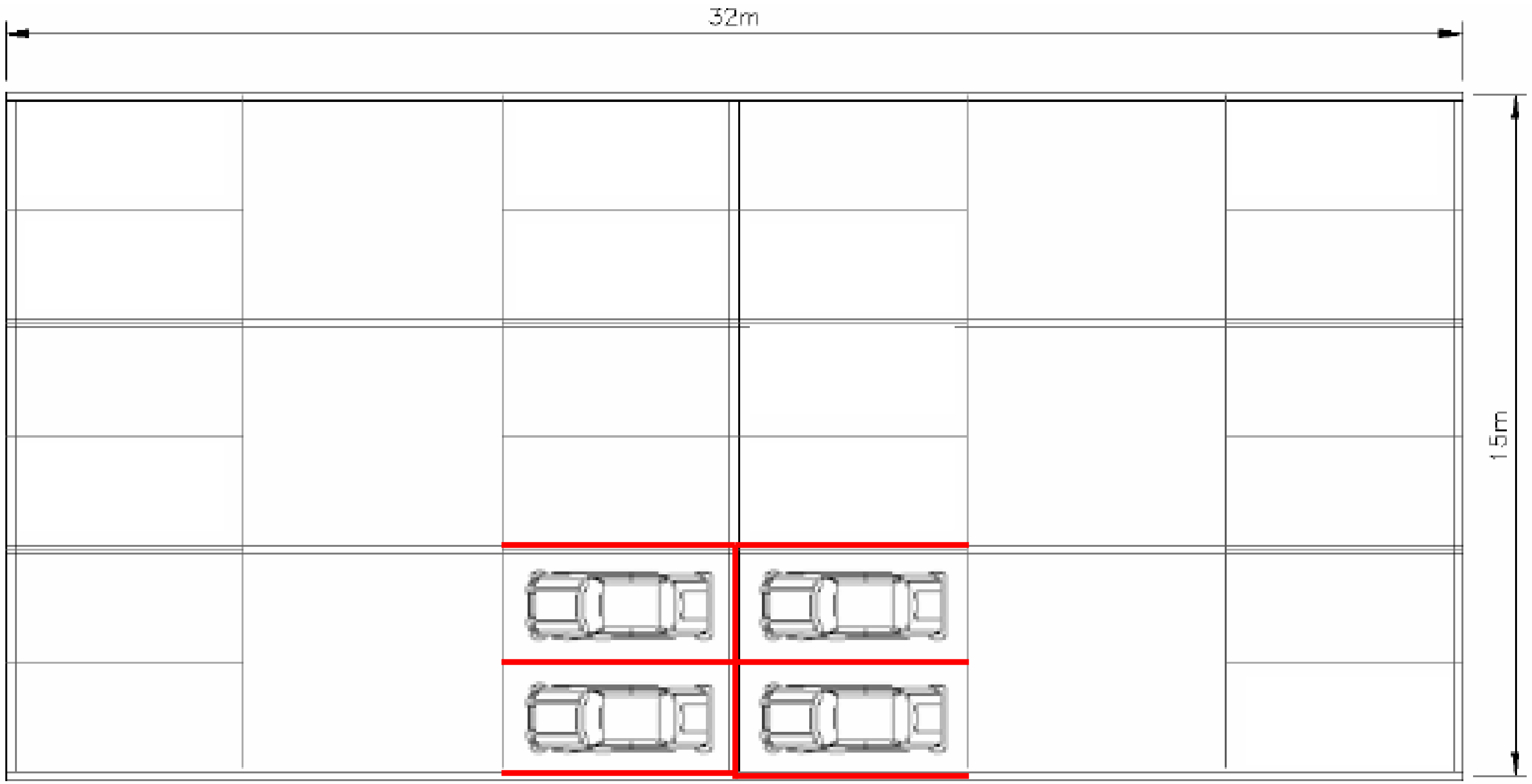
1° SCENARIO



DOI: 10.3267/HE2008

Numerical application on steel open car park

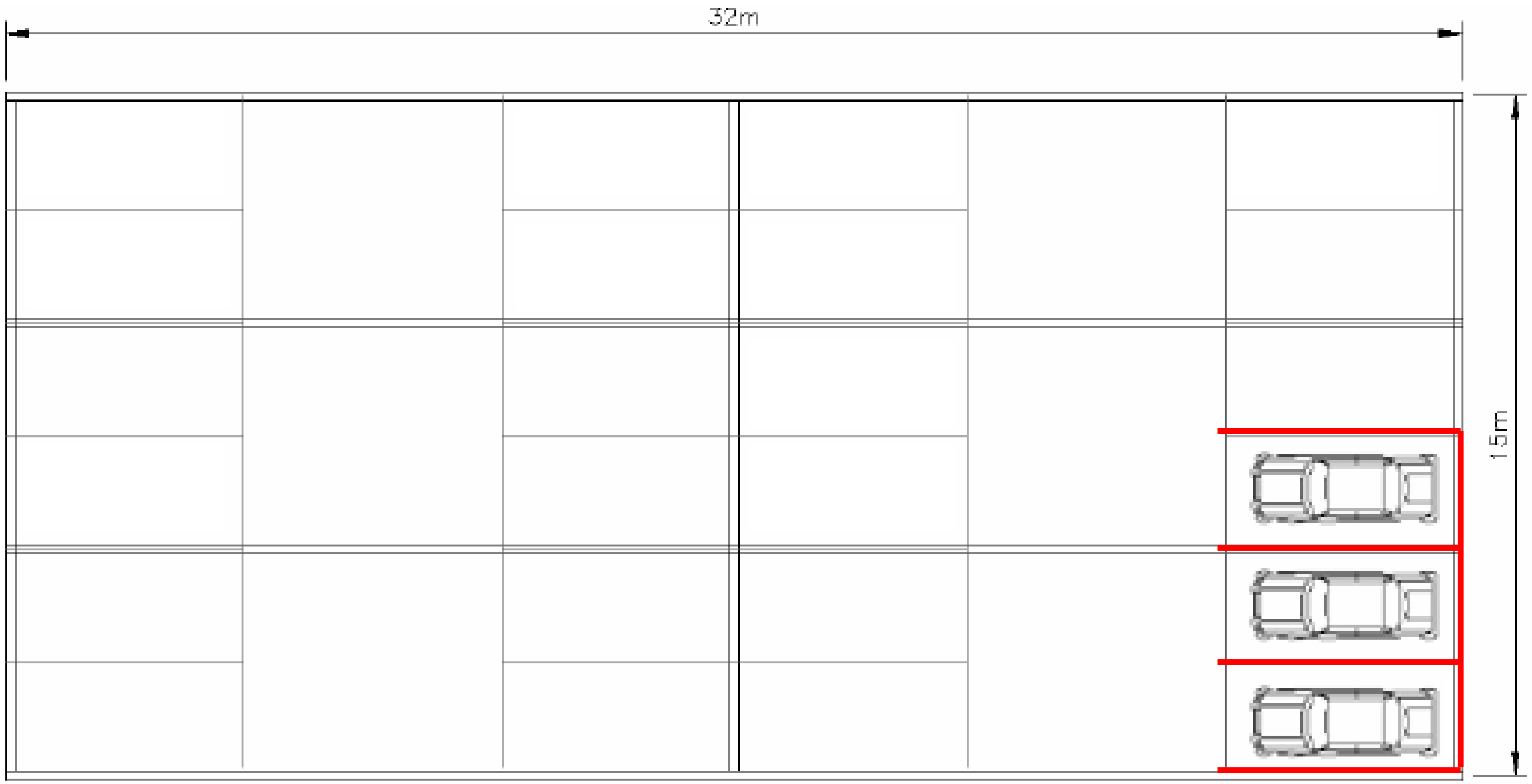
2° SCENARIO



DOI: 10.3267/HE2008

Numerical application on steel open car park

3° SCENARIO



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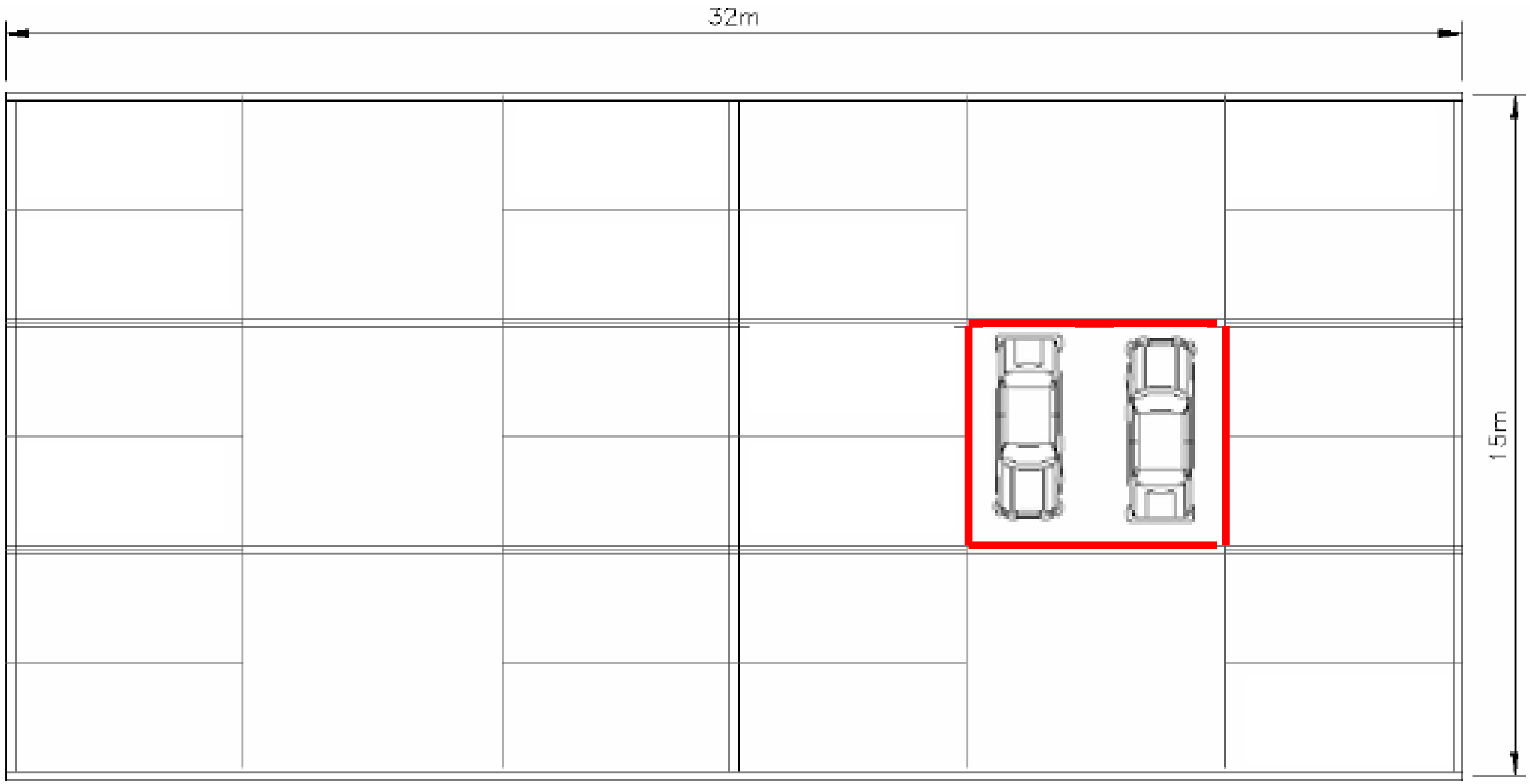
Numerical application on steel open car park

4° SCENARIO



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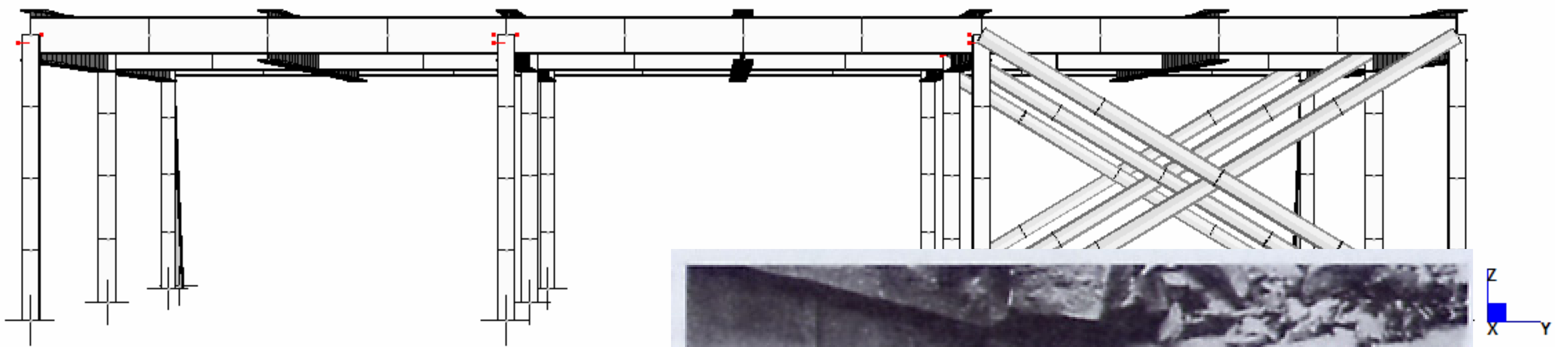
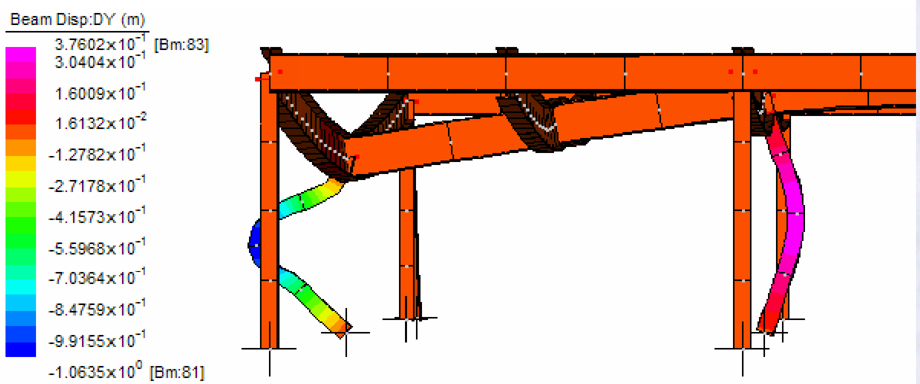
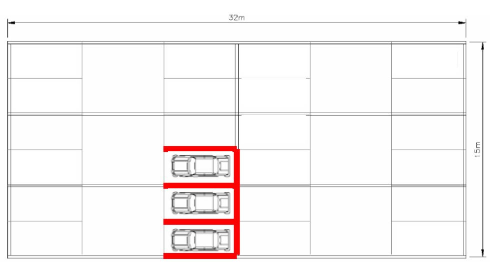
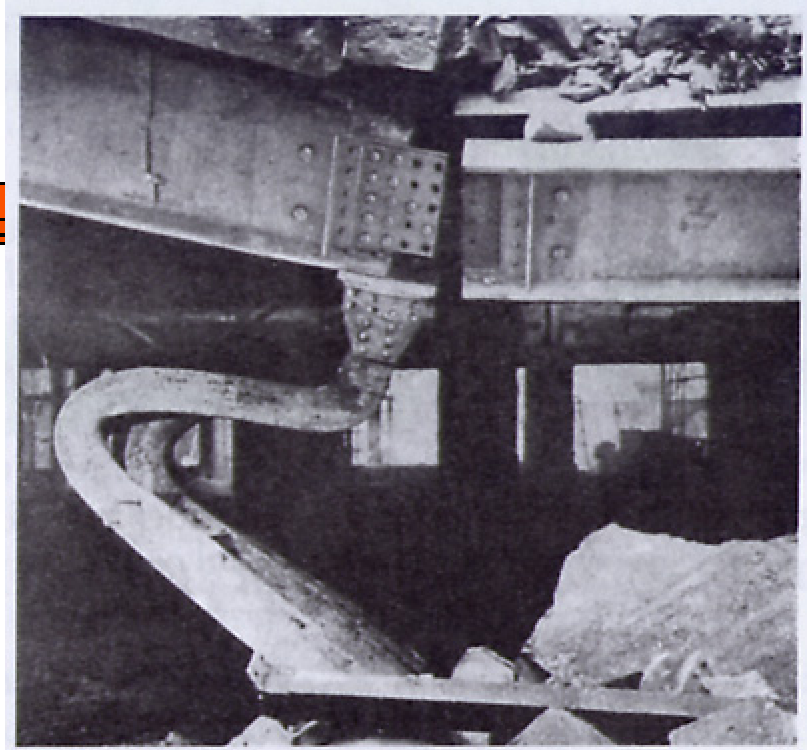
Numerical application on steel open car park

1° SCENARIO









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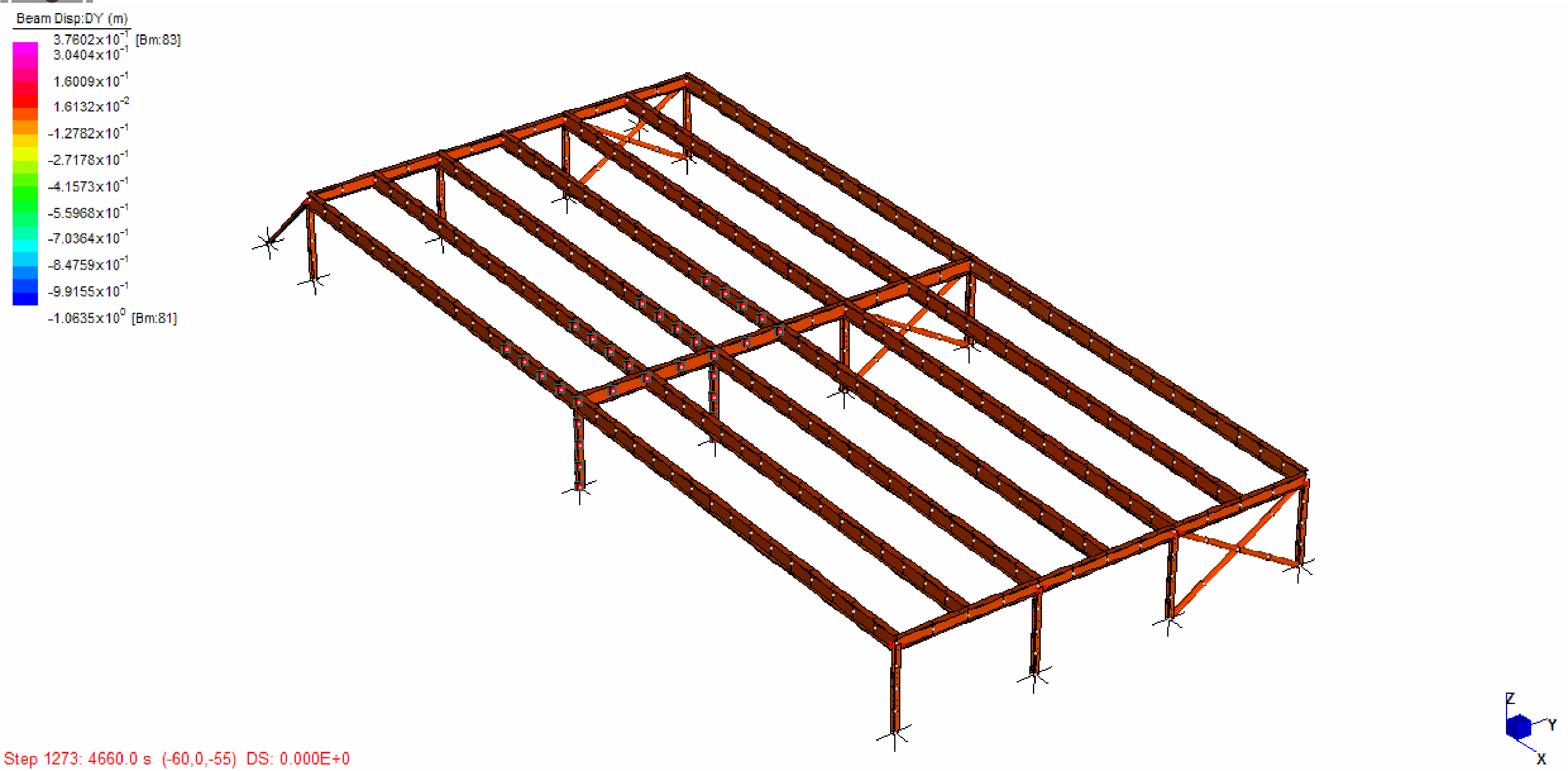
Numerical application on steel open car park

1° SCENARIO



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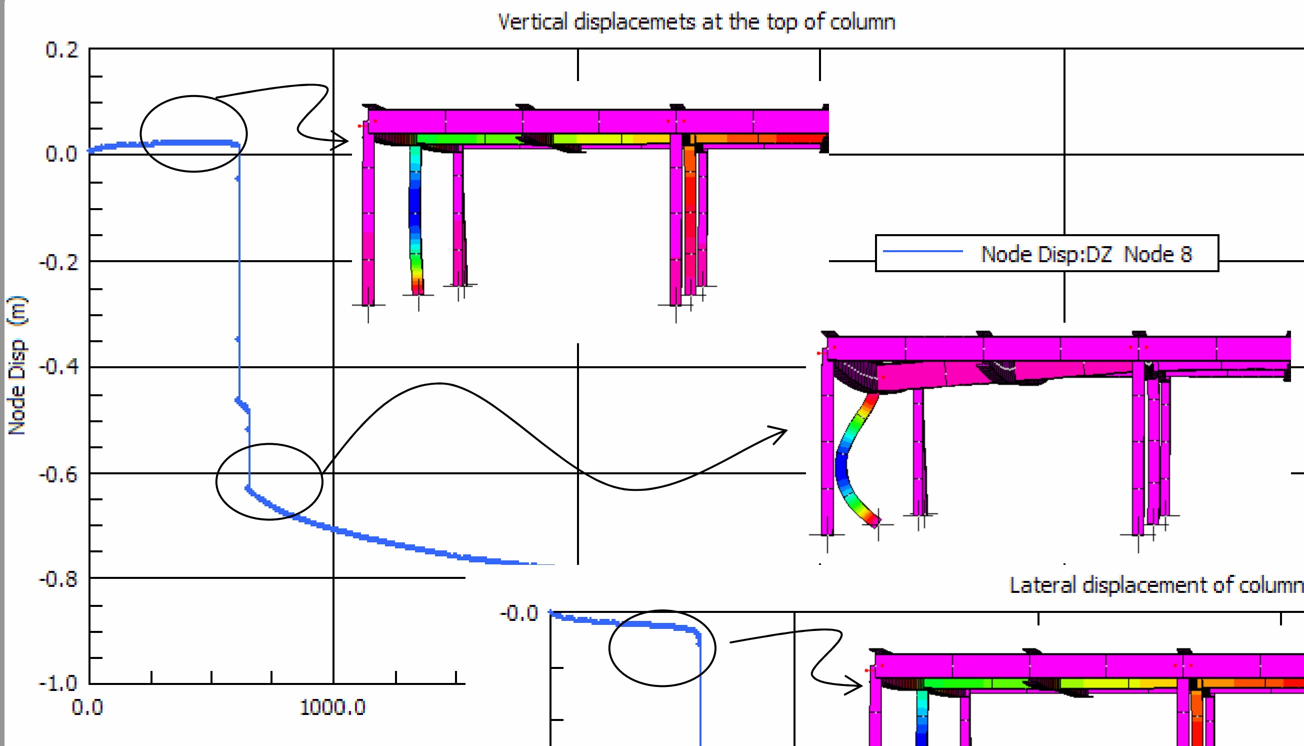
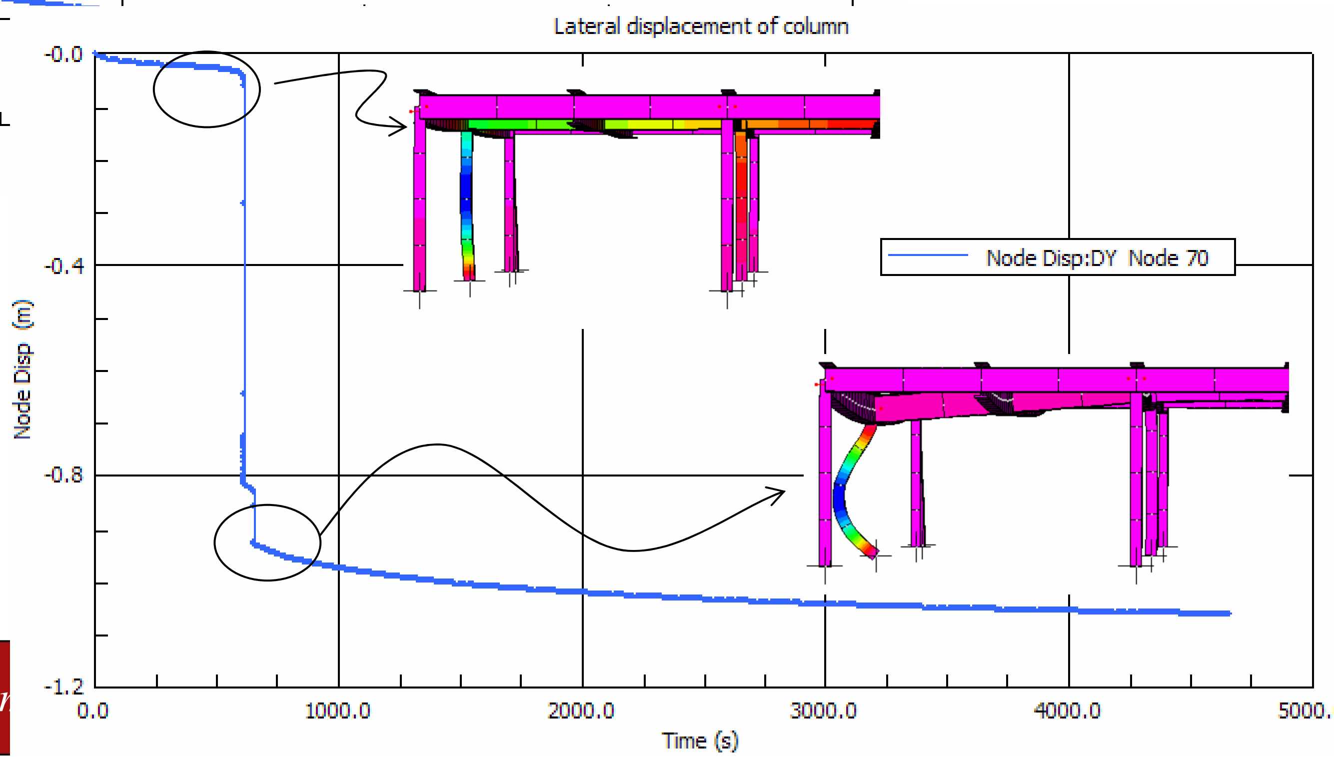
Numerical application on steel open car park





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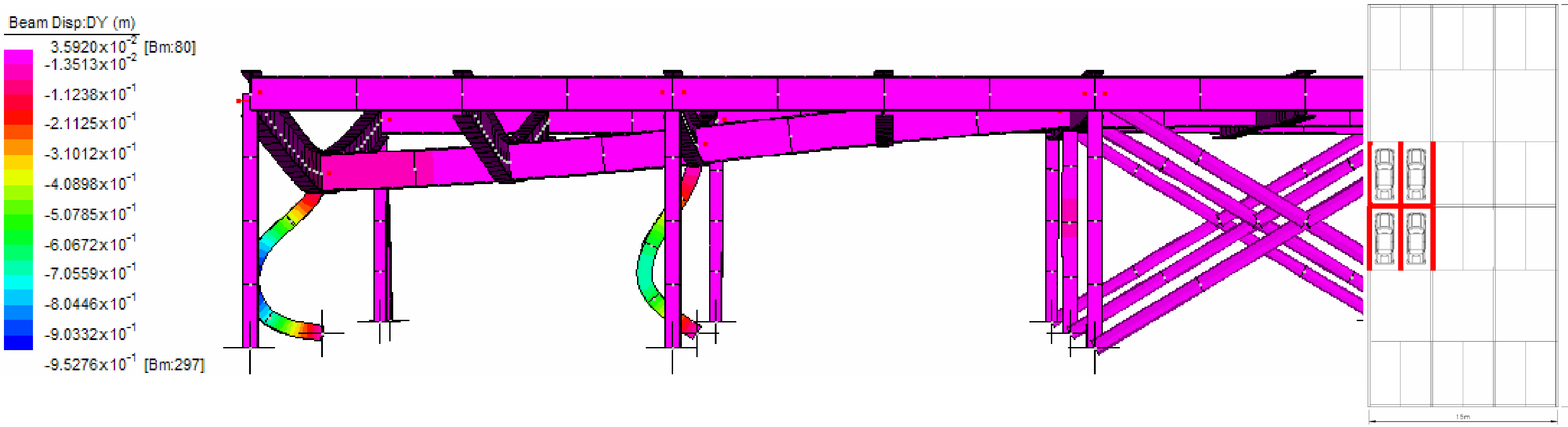
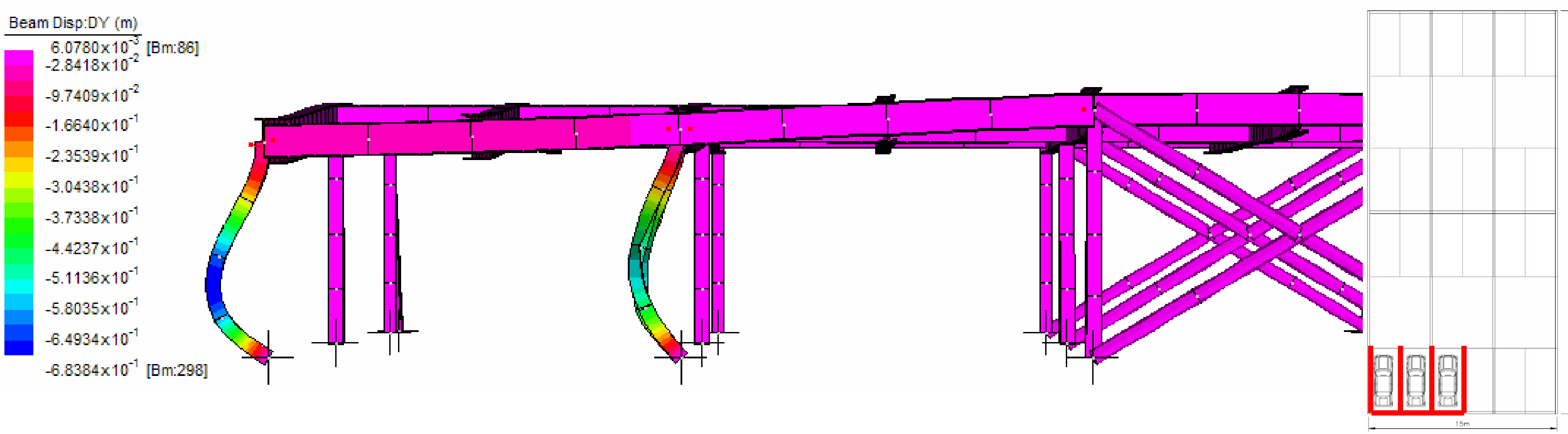
Numerical application on steel open car park

2° SCENARIO



3° SCENARIO



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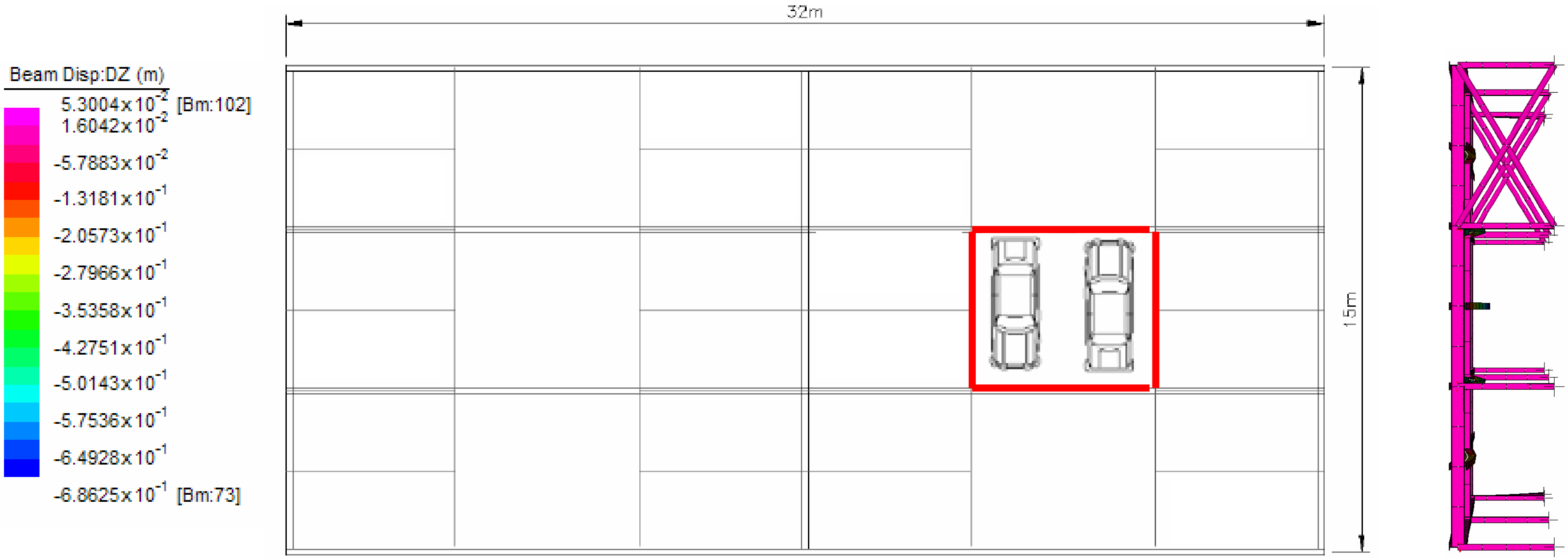
Numerical application on steel open car park

4° SCENARIO



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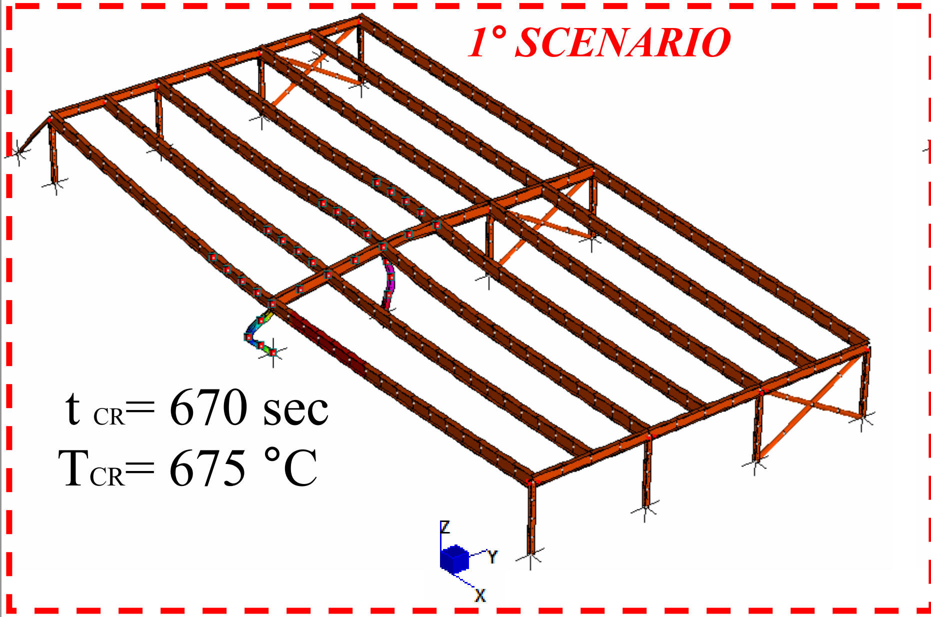
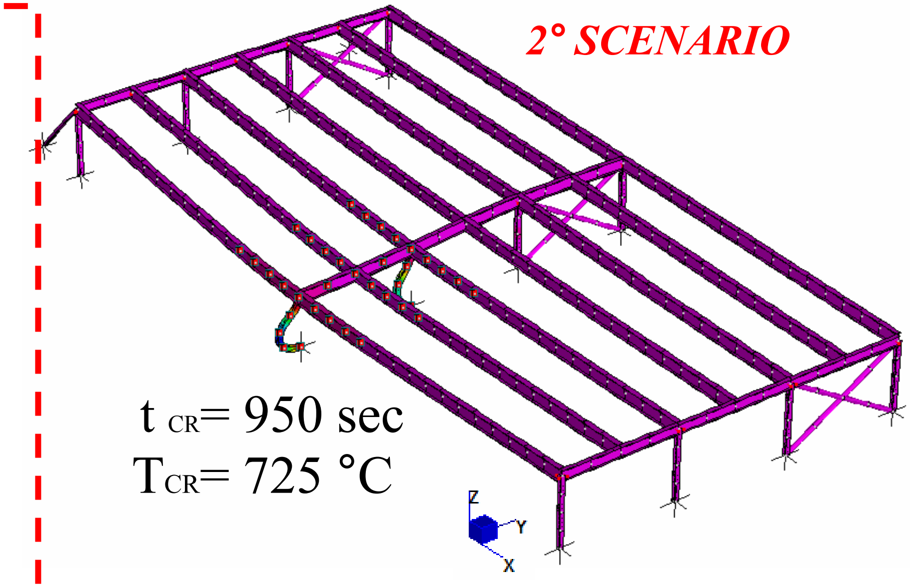
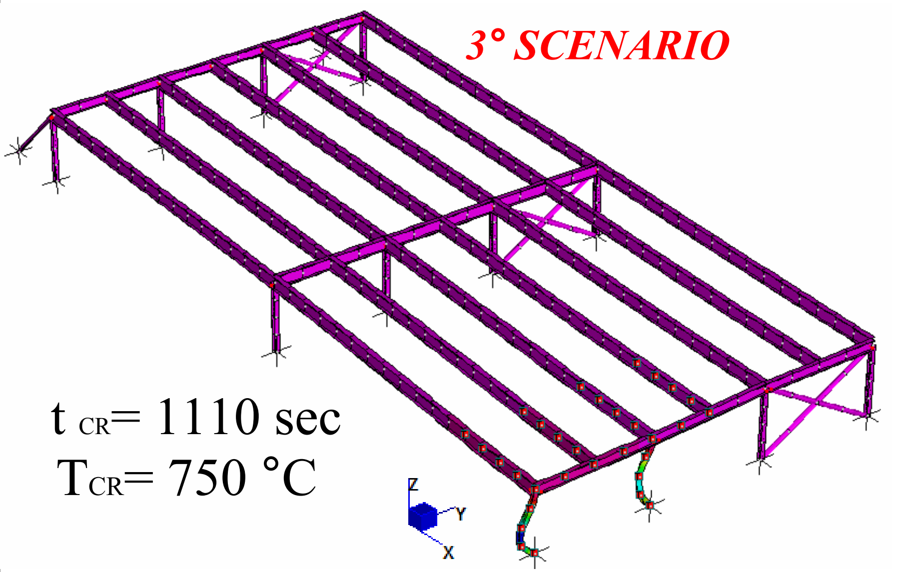
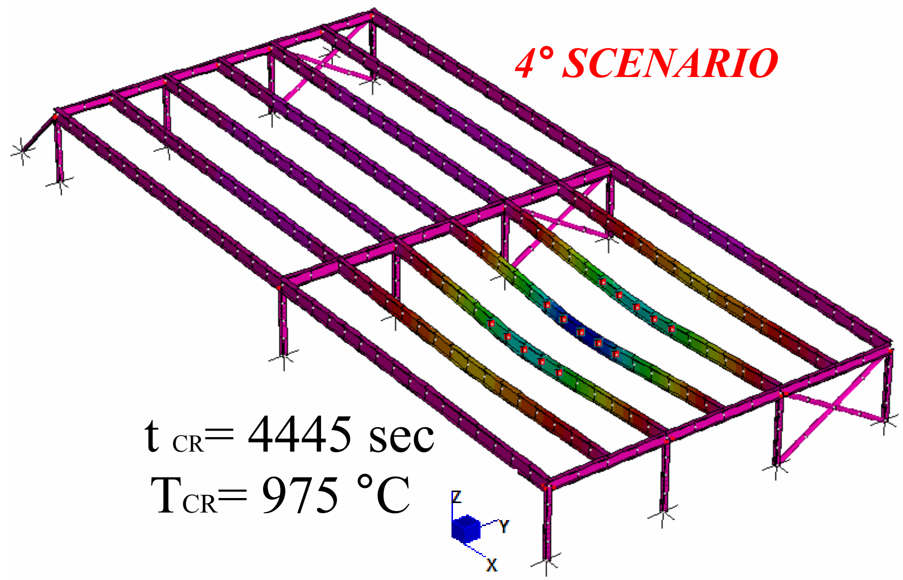
Numerical application on steel open car park









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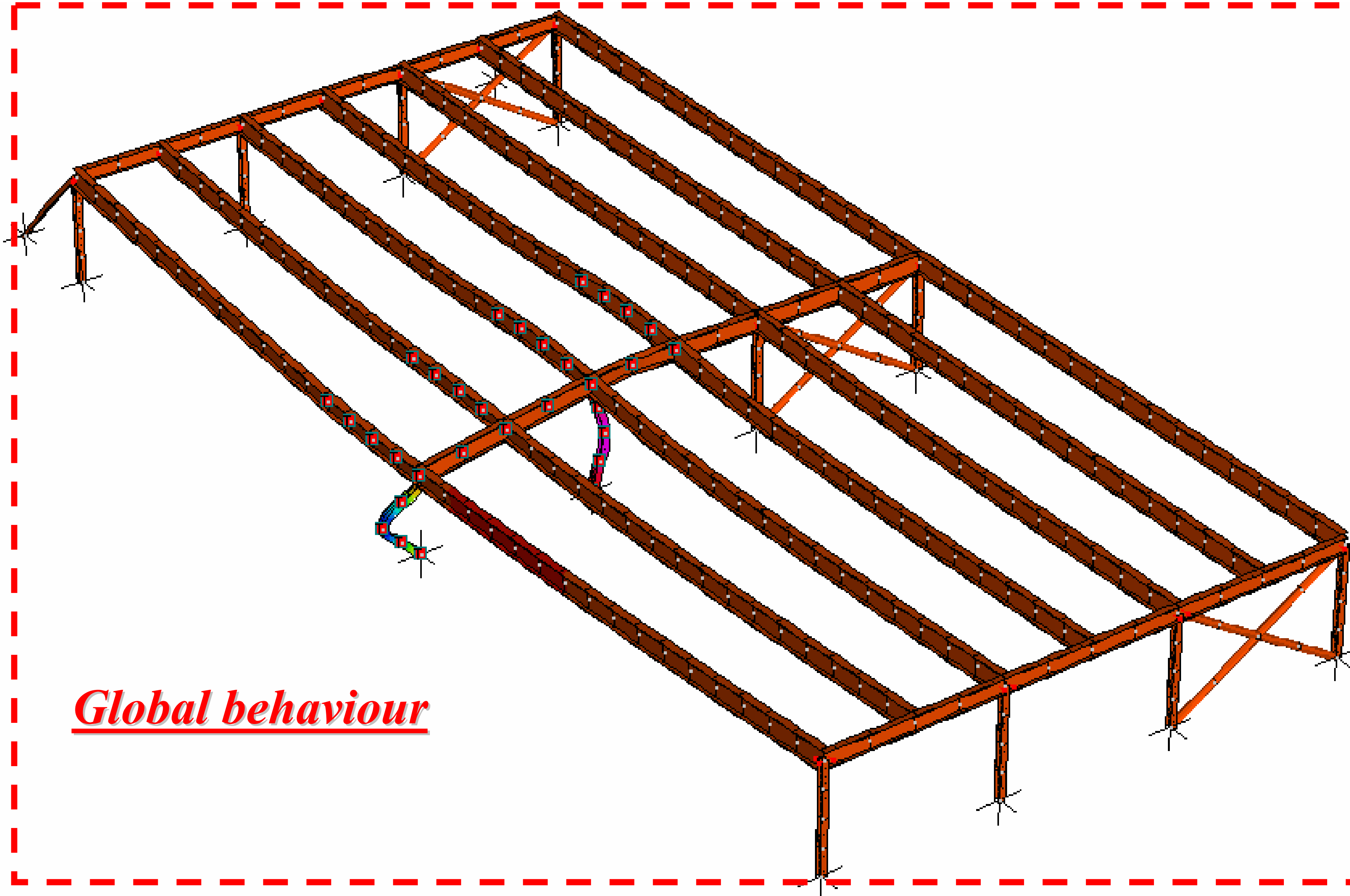
Conclusive evaluations



Global behaviour