# TÉRBELI TARTÓKERETEK HATÉKONY SZÁMÍTÁSI MODELLEZÉSE
# DIFFERENT FAILURE MODES OF A LARGE PRECAST PANEL STRUCTURE
# DIVERSE MODURI DE CEDARE A UNEI STRUCTURI DIN PANOURI MARI PREFABRICATE

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# 1. INTRODUCTION

- The purpose of this paper is to to show the failure modes of a large precast panel structure obtained by seismic loads.
- For the simulation of the earthquake, Vrancea 1977 accelerogram was used and it was scaled with several factors equal to 5,10 and 20 [1].
- After scaling the accelerogram with a scale factor of 5, only a few plastic zones appear in the structure at a few coupling beams but the safety of the structure is not in danger.
- When a factor of 10 is used besides the coupling beams the joints seemed to form plastic zones but again we have an overall good behaviour of the structure because the base wall doesn’t forms plastic zones.
- The scale factor of 20 was the most satisfying for observing the gradual forming of plastic zones which lead to the collapse of the structure.

# 2. MODELING OF THE STRUCTURE.MATERIALS.ANALYSIS RESULTS

For this analysis a typical precast large panel building with horizontal and vertical joints was used. The reinforcement grid is made of steel rebars with 6 mm diameter for the precast panels and 12 and 14 mm diameter for the vertical and horizontal joints.

A tangential and normal behavior was assigned for the contact of the precast panels units with the monolith parts using a friction coefficient equal to 0.9 [2] . Reinforcement was embedded in the concrete elements considering a perfect bond between the two materials.

Solid elements were used for modeling the precast and monolith concrete and beam elements for the steel parts [3]. The dynamic analysis was conducted using an explicit step with the earthquake accelerogram as seen in figure 1 given as a displacement boundary conditions in the base of the structure.

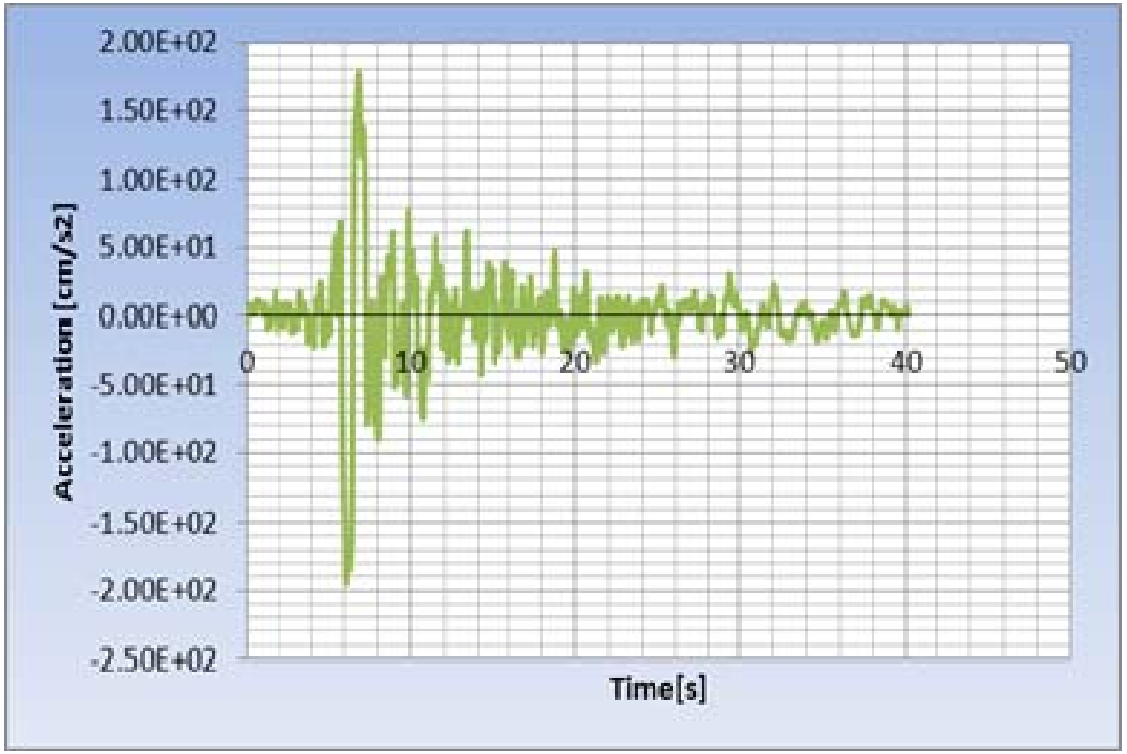


***Fig. 1.*** *Vrancea 1977 N-S earthquake accelerogram*

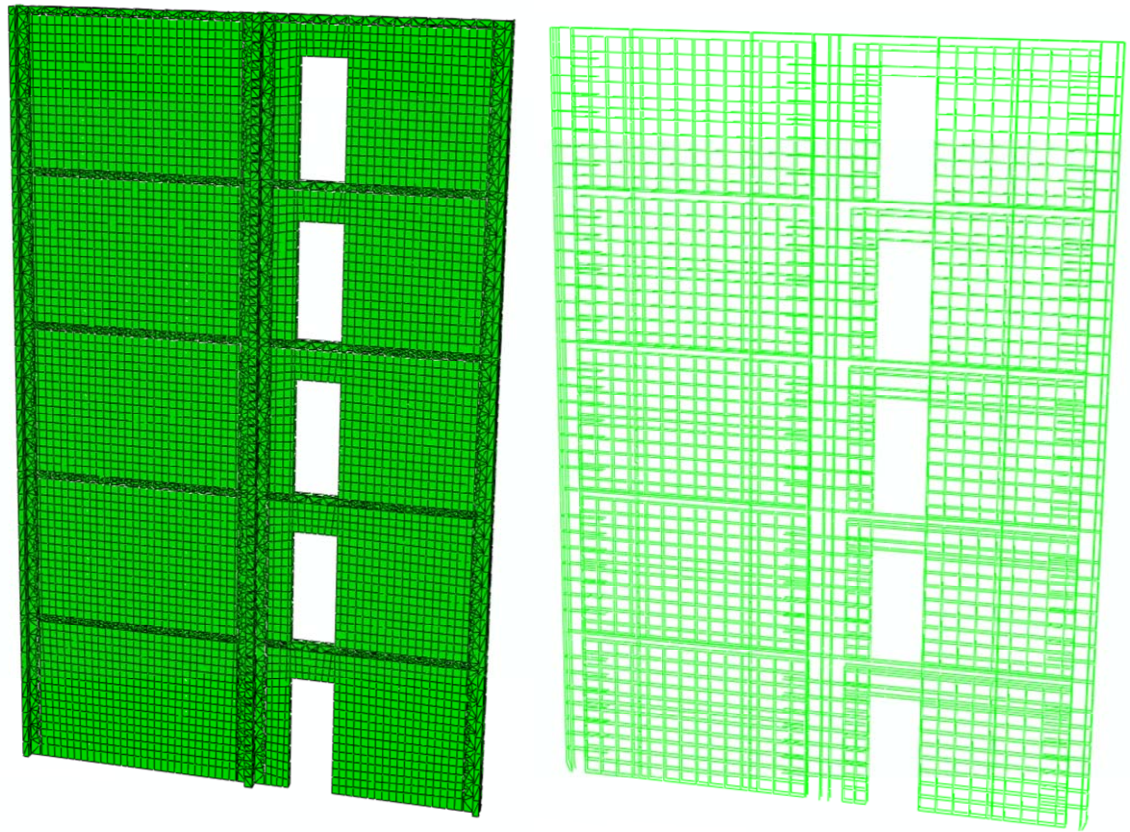

Fig. 2. Assembly of the wall and reinforcement

- # 2.2. Materials

The concrete damaged plasticity[4] is based on a scalar coefficient „d'' in both compression and tension, that affects the stiffness as in formula (1).

(1) $$\sigma = (1 - d)D_0^{el} : (\varepsilon - \varepsilon^{pl}) = D^{el} : (\varepsilon - \varepsilon^{pl})$$

$D_0^{el}$ – initial stiffness;
$D^{el}$ – damaged stiffness;
d - scalar damage coefficient;

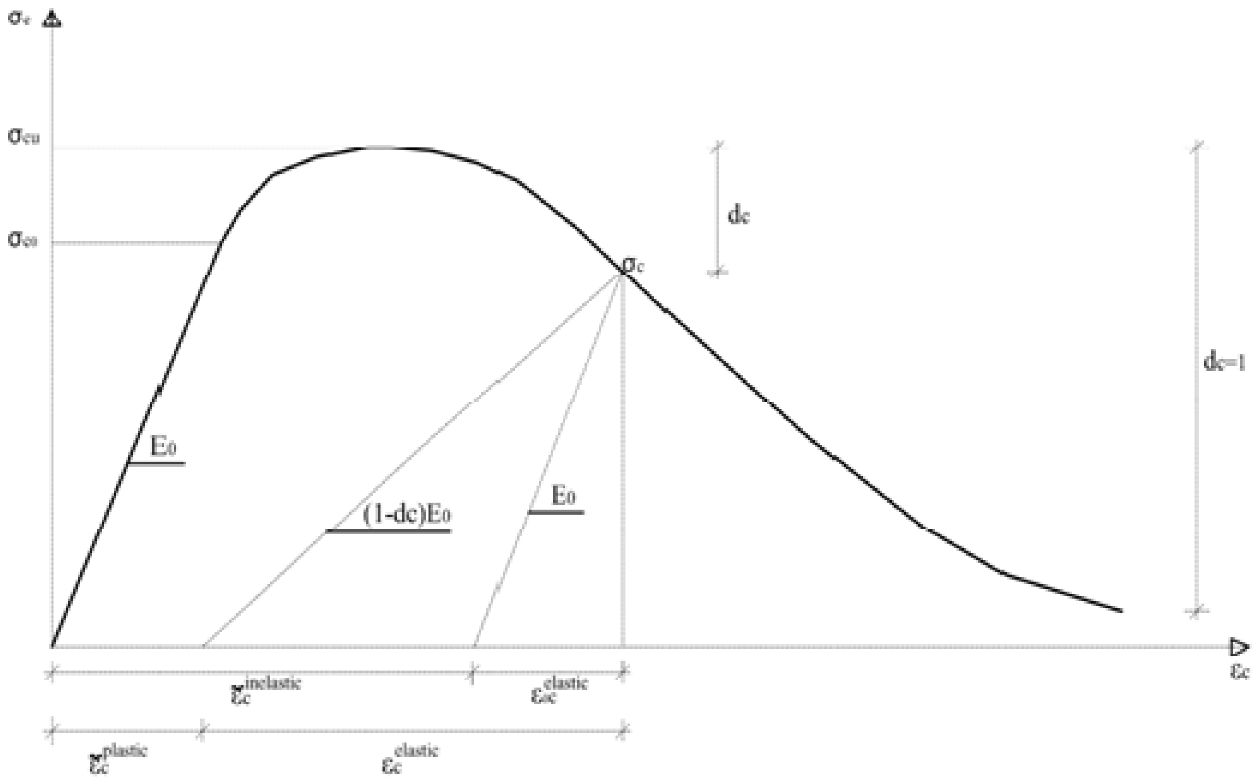


Fig. 3. Compression-strain for concrete

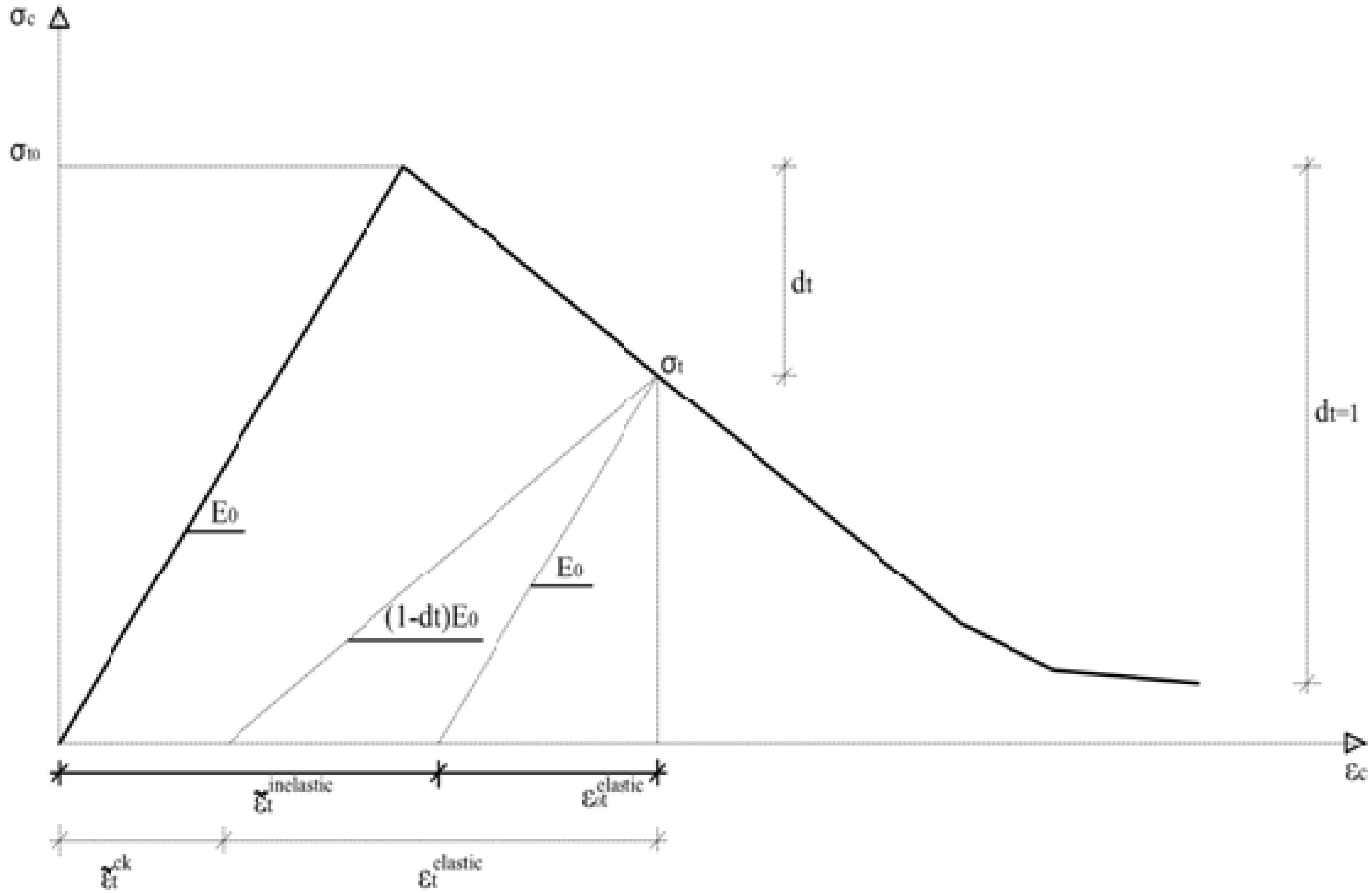


Fig. 4. Tension-strain for concrete

Concrete damaged plasticity:
E=3E07 kN/m$^2$; Poisson coefficient $\upsilon$=0.2;

| $\psi$ | $m$ | $\gamma$ | $\rho$ | $\eta$ |
|---|---|---|---|---|
| 32 | 0.5 | 1.17 | 0.7 | 0.01 |

***Table 1.*** *CDM parameters*

| Yield stress [Kn/cm2] | Inelastic strain |
|---|---|
| 2.254 | 0 |
| 2.692021 | 0.000626 |
| 2.8 | 0.00107 |
| 2.648767 | 0.00192 |
| 2.386753 | 0.0027 |

***Table 2.*** *Compressive behaviour*

| Yield stress [kN/cm2] | Cracking strain |
|---|---|
| 0.318 | 0 |
| 0.217 | 0.000412 |
| 0.000115 | 0.00115 |

***Table 3.*** *Tensile behaviour*

Steel :
E=2.1E08 kN/m$^2$;Poisson coefficient $\upsilon$=0.3;

| Yield stress [kN/cm2 | Plastic strain |
|---|---|
| 34.738 | 0 |
| 34.738 | 0.01334581 |
| 42.9028 | 0.16795701 |
| 0.549 | 0.190373857 |

***Table 4.*** *Steel plasticity*

• 2.3. Analysis results.Dynamic nonlinear analysis

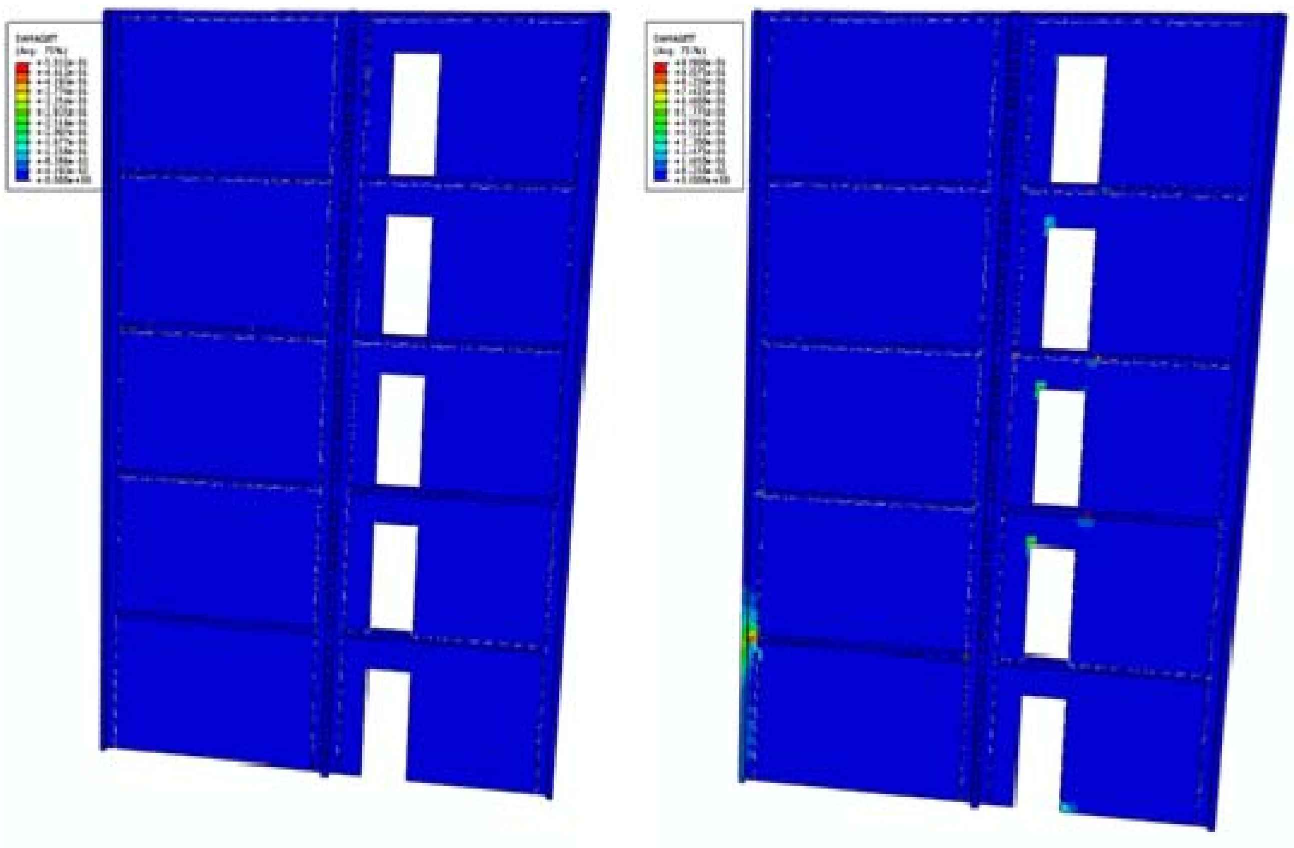

Fig. 5. Damage of the structure at time interval T=5.441s and T=5.991s

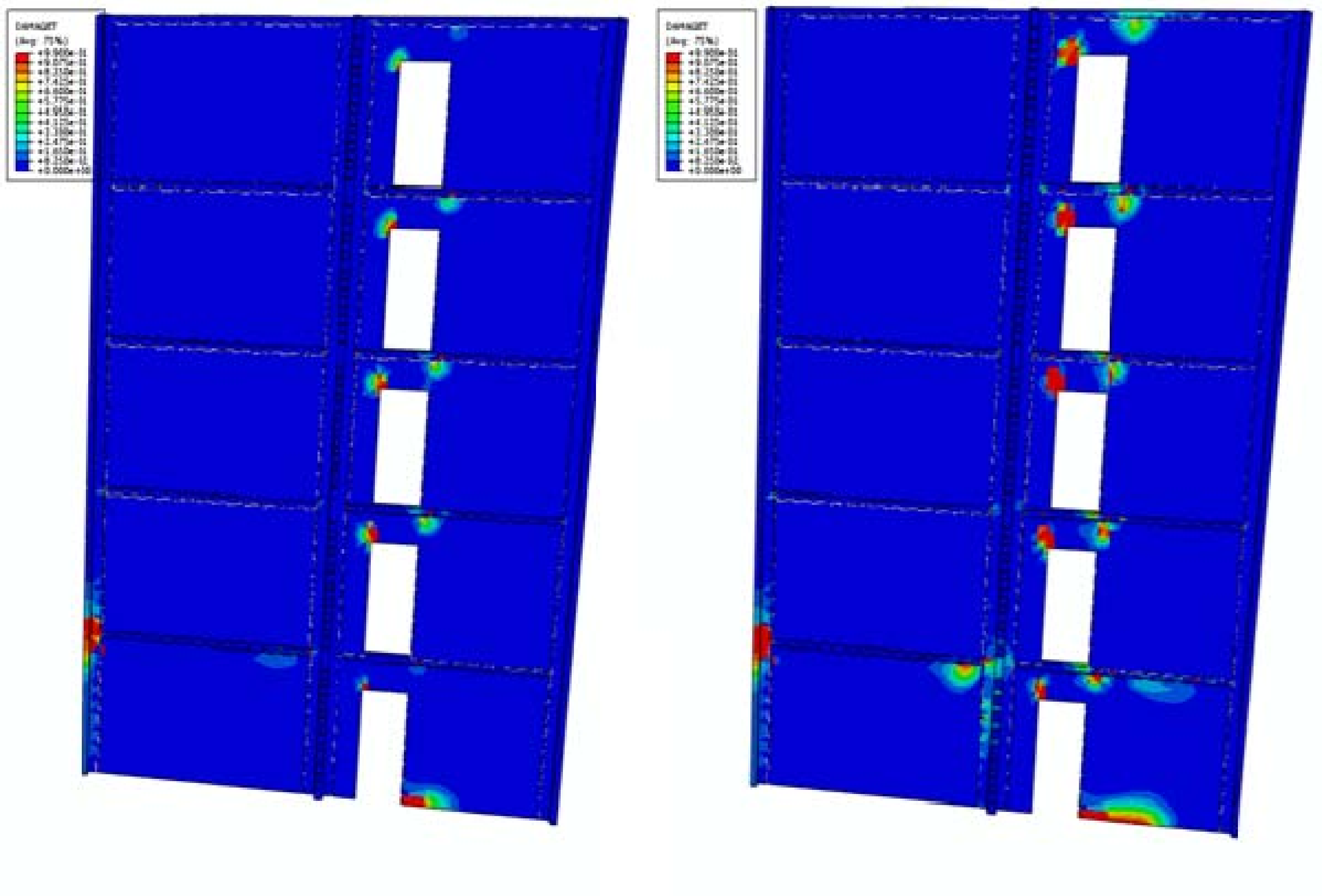

Fig. 6. Damage of the structure at time interval T=6.067 s and T=6.117s

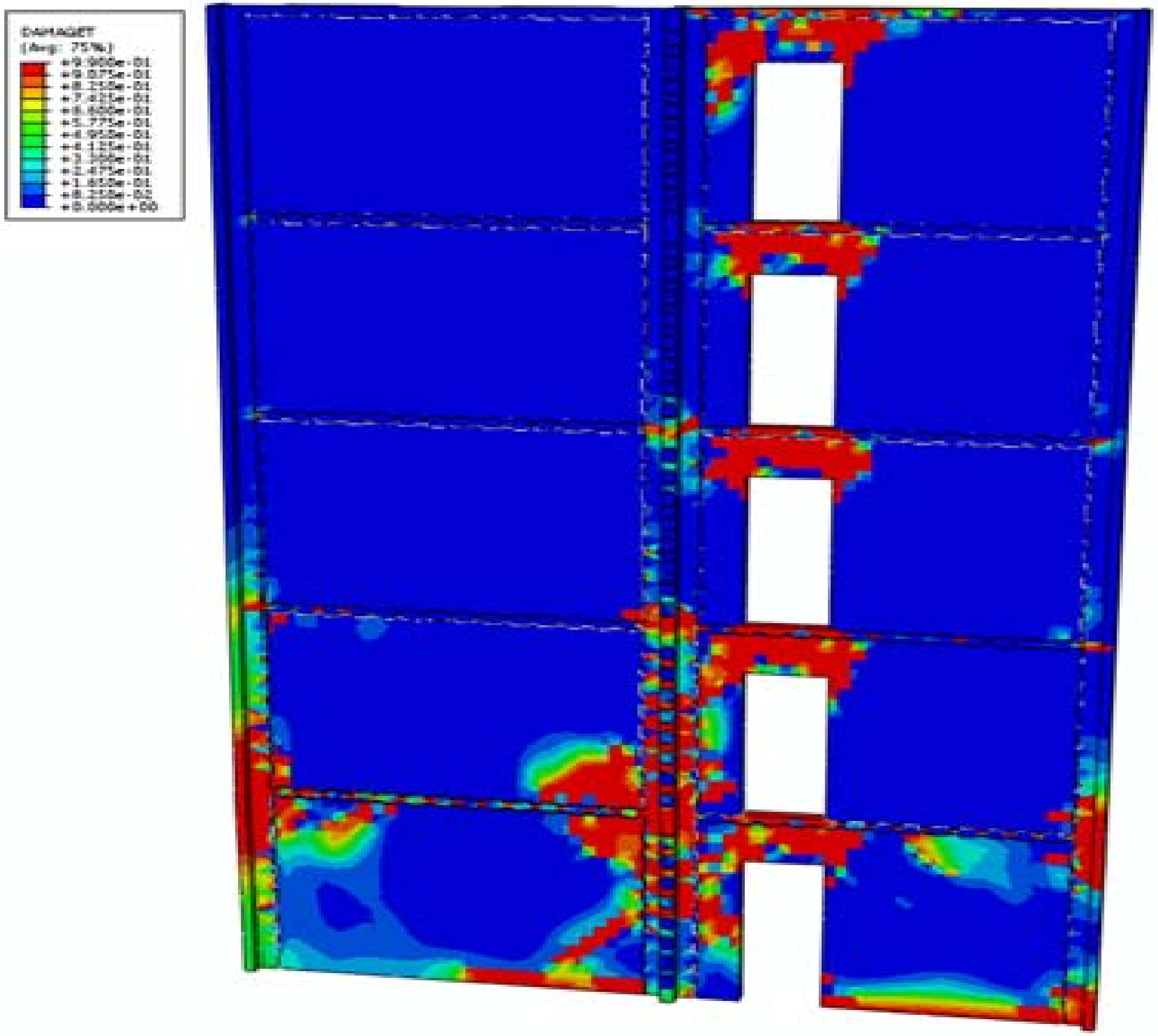


Fig. 7. Damage of the structure at time interval T=6.912s

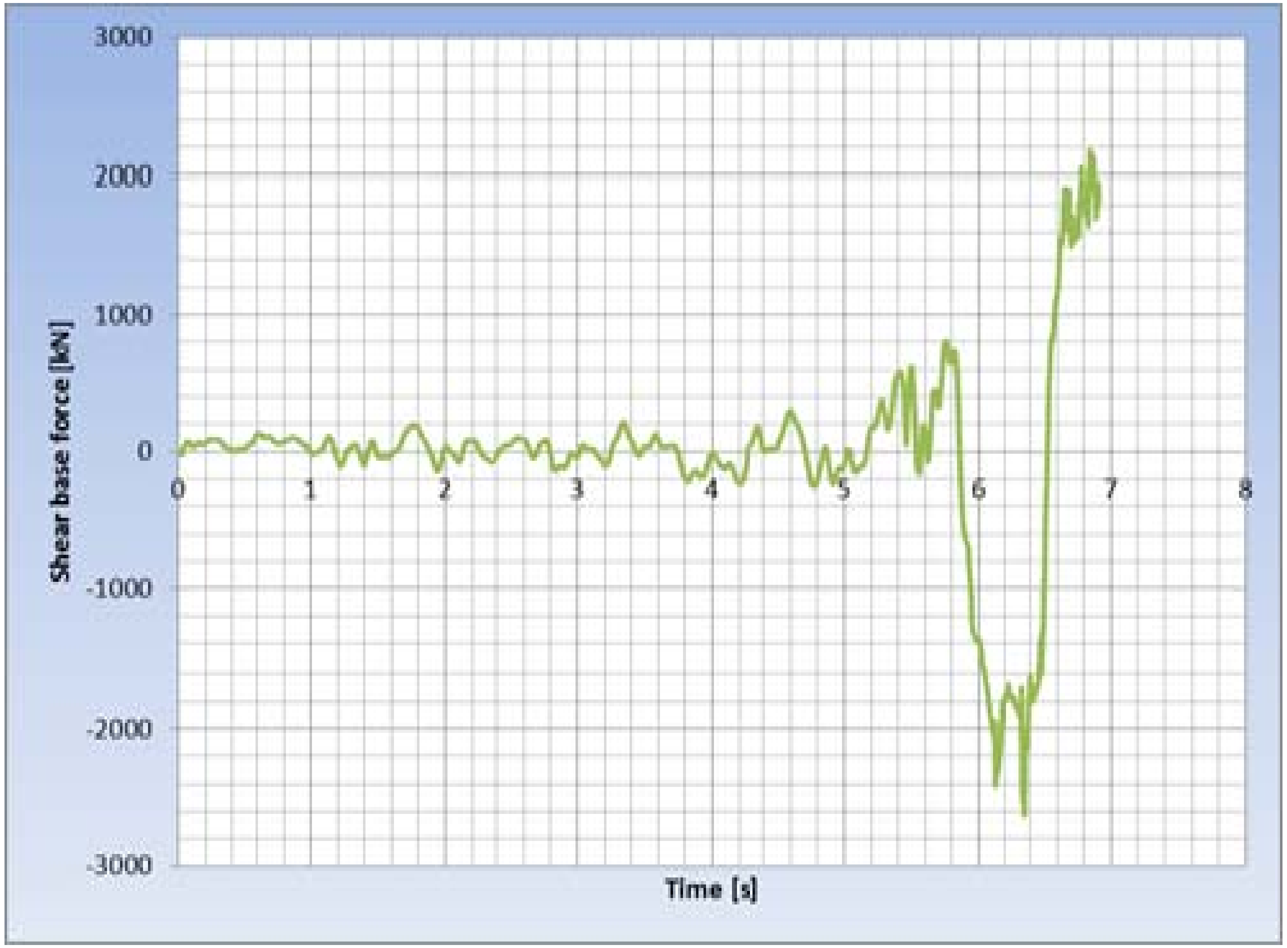


Fig. 8. Shear base force

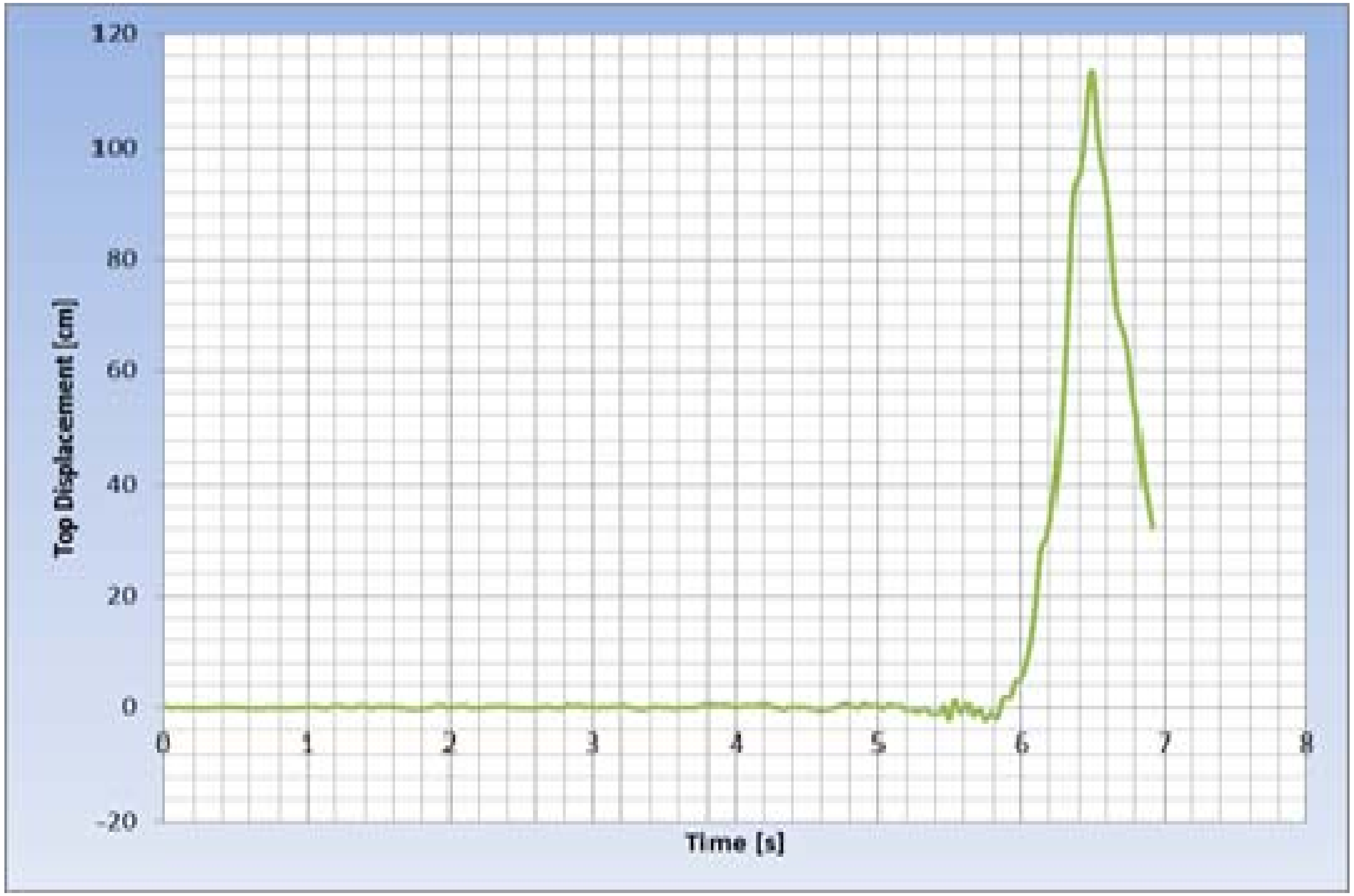


Fig. 9. Top displacement

- 2.3.1. Analysis results.Static Riks analysis


Fig. 10. Shear base force vs. Top displacement

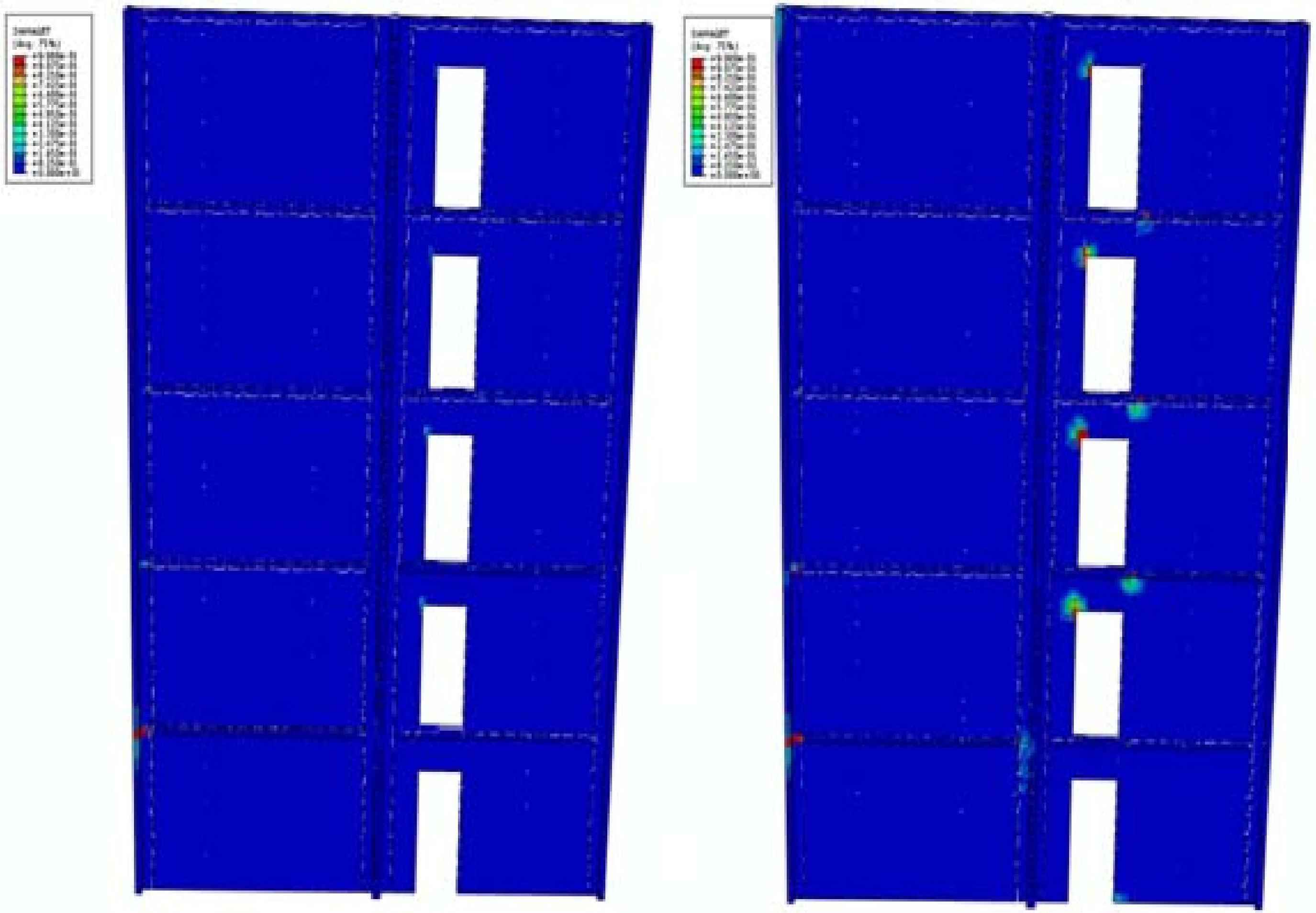

Fig. 11. Damage of the structure at shear base force equal to F=334kN and F=528kN

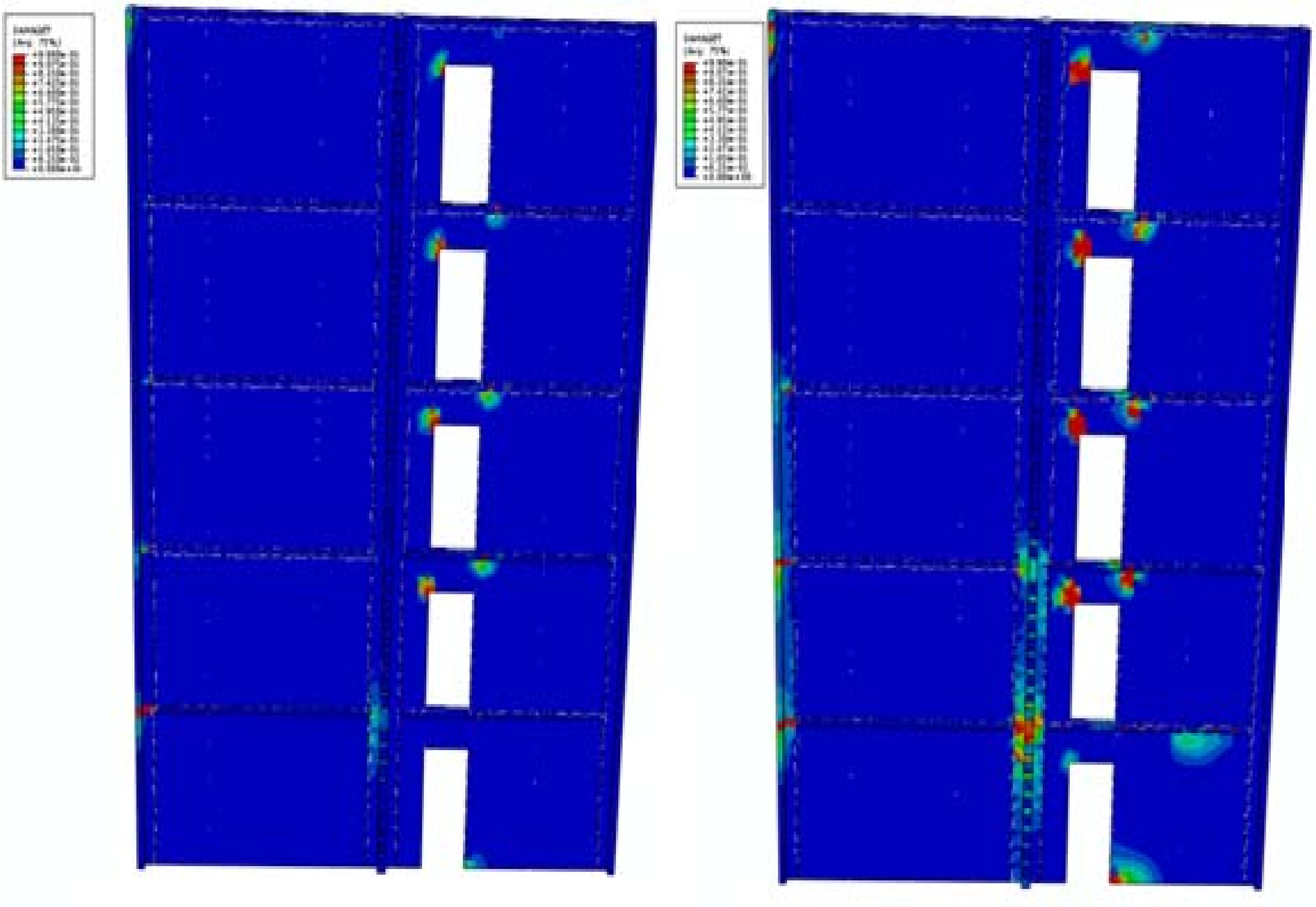

Fig. 12. Damage of the structure at shear base force equal to F=620kN and F=853kN

# 3. CONCLUSIONS

- Although the earthquake was scaled with a factor equal to 20 the structure remains in the elastic zone until second 6 when the maximum acceleration of the accelerogram it is reached and the coupling beams start to form plastic zones.
- As the earthquake developes further plastic zones appear at the horizontal and vertical joints.
- The collapse of the structure was produced by the plastic zones that were formed at the base of the wall as it can be seen in figure 5,6 and 7.
- The Riks analysis behaves similar to the dynamic analysis showing the same evolution of the plastic zones. In figure 10 it is observed the changes of the slope as a result of  more plastic zones appear.
- Both analysis showed a good behavior of the structures both leading to collapse as the base shear wall enters the plastic zone.