Karisma benchmark

Preliminary results of the phase III

Vittorio Lucarelli, Giampiero Orsini, Roberto W. Romeo

Margin assessment

The outcome of the Subtask 1.3 is to assess seismic margins.

This general objective, as referred to the RB seismic response, can be seen from two perspectives:

A.Assess margin with respect to limit states of RB structure. That is the increase in the seismic demand causing a limit state of the RB structure, either collapse or extensive cracking with loss of containment. This perspective is strictly structural.

B.Assess margin with respect to the loss of the ''NPP capacity to bring and maintain the NPP (reactor core and spent fuel) in a safe status". This loss is logically linked with the systems and equipment needed to ensure the three main safety functions, caused by interaction of the RB structure with systems and equipment. In fact even if the structural limit state of the RB is not attained, the displacements and/or accelerations can cause the loss of capacity of systems and components needed to ''bring and maintain the NPP in safe status''. This second perspective is linked with activity of Task 2 of the Benchmark.

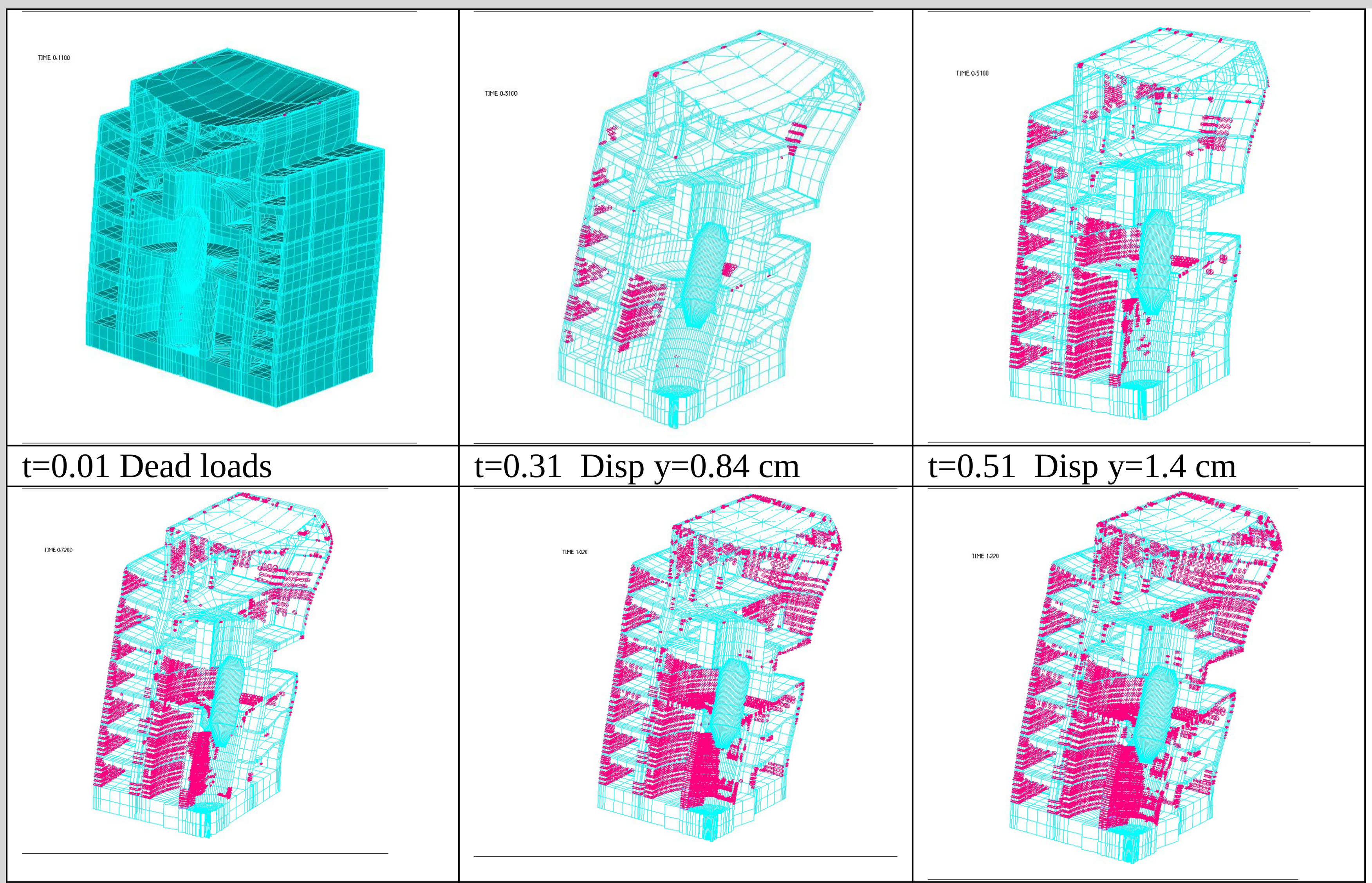
ITER experts opinion is that margings have to be evaluated according the approach B.

To do that, it is necessary to develop (and investigate) the needed assessment about the interfaces between structures and systems/equipment to identify the margins with respect to loss of NPP system capacity to '' bring and maintain the NPP in a safe status''.

Criticalities of interfaces between RB structures and NPP systems/components

1) Interface between RB structure response and stability of pressure vessel (potential loss of cooling function);
2) Interface between RB structure response and loss of suppression function of the wet-well (potential loss of containment function);
3) Interface between RB roof structure and stability of the RB crane (possible failure and impact on the floor covering the SF pool);
4) Interface between RB structure response and insertion of shutdown rods (potential loss of reactivity control function);
5) Interface between RB structure response and spent fuel pool (loss of cooling function and sub criticality);
6) Interface between RB structure response and reactor containment internal liner at penetrations points (loss of containment function);
7) Interface between RB structure response and other buildings interconnected through piping (Turbine Building and Auxiliary Building);
8) Interface between RB structure response and anchors/ supports stiffness of piping and mechanical components (loss of safety functions);
9) Interface between RB structure response and anchorages of electrical cabinets, local instrumentation, including sensors and associated electronics (loss of safety functions);

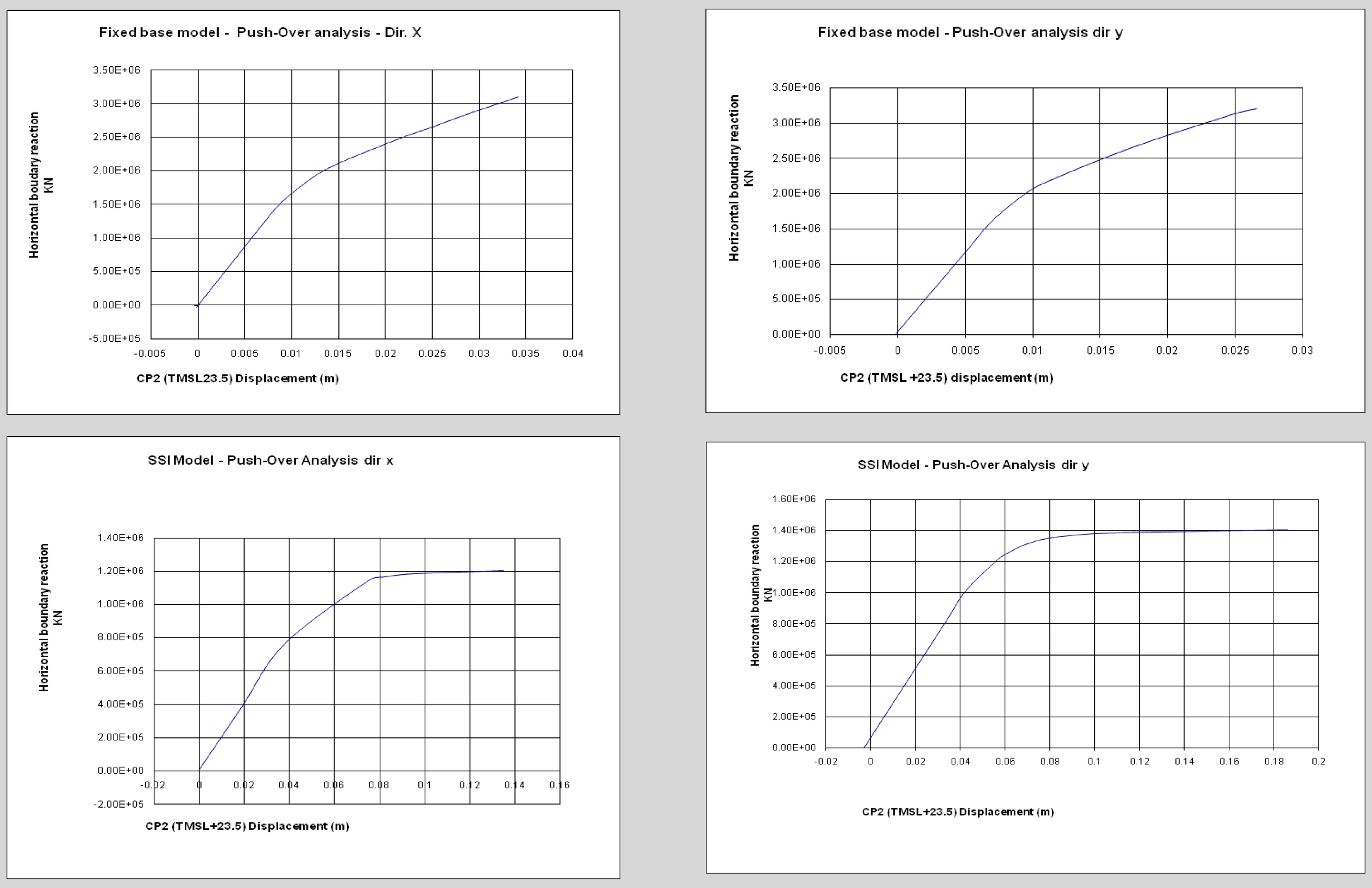
Pushover Analyses



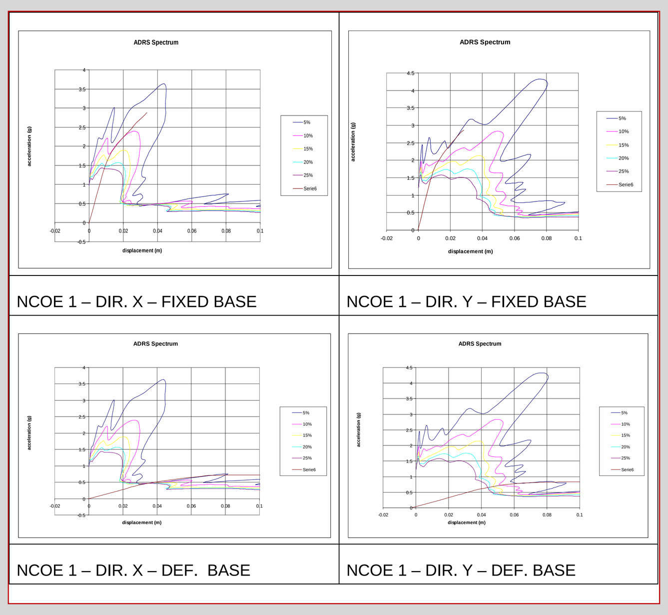
t=0.01 Dead loads | t=0.31 Disp y=0.84 cm | t=0.51 Disp y=1.4 cm

t=0.72 Disp y=2.0 cm | t=1.02 Disp y=2.8 cm | t=1.22 Disp y=3.4 cm

Force displacement relationships

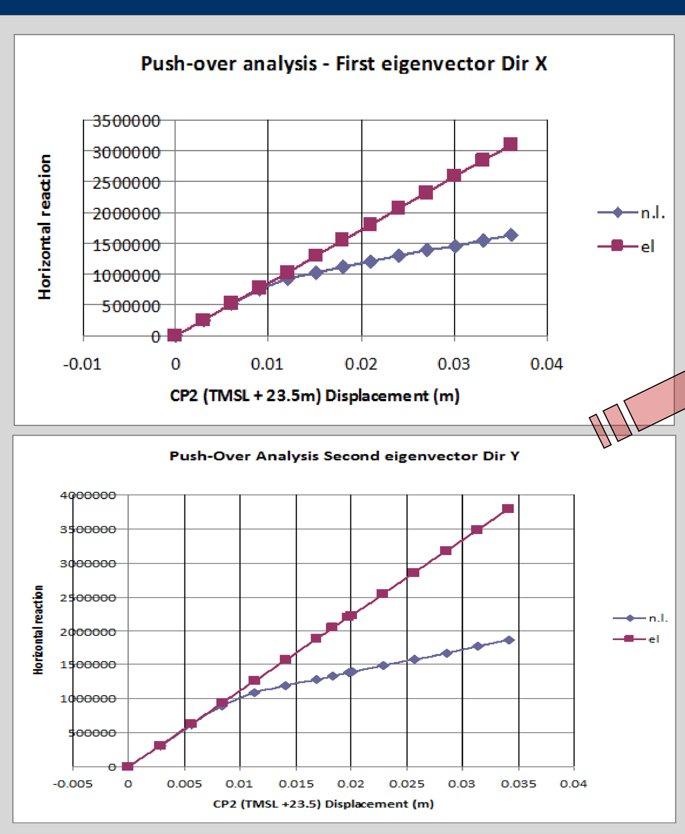


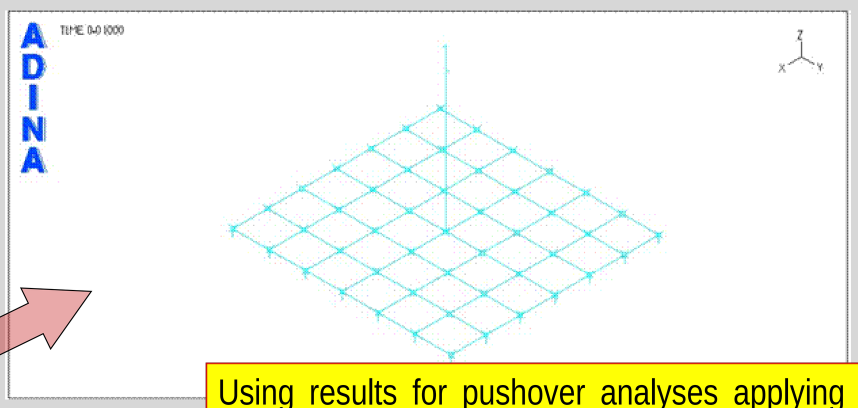
Capacity Vs seismic Demand: first results with ADRS Spectra



Performance points NCOE 1			
		Displacement m	Force KN
Fixed base	X direction	0.012	1.93e6
Fixed base	Y direction	0.014	2.44e6
Deformed base	X direction	0.038	0.75e6
Deformed base	Y direction	0.056	1.21e6

3D simplified model





Using results for pushover analyses applying the first and second eigenvector a simplified model has been constructed to perform several non linear dynamic analyses to evaluate the SEISMIC DEMAND.

The seismic demand has to compared to the SEISMIC CAPACITY of the structure identified by means of the pushover analyses of the£D Global Model

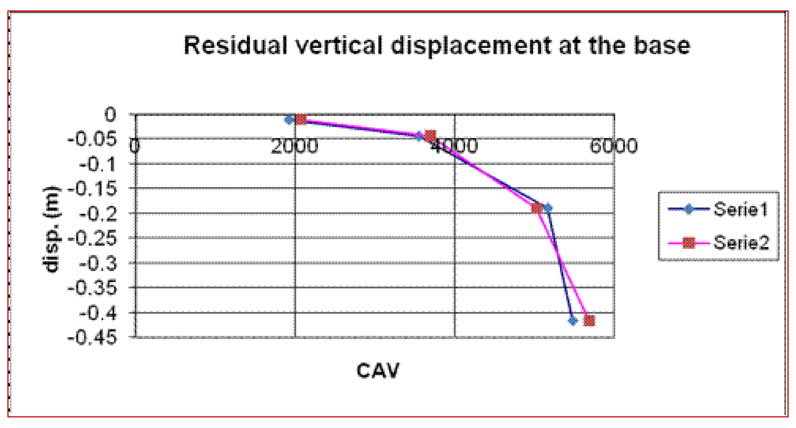
Structural limit states

Looking to the structural behaviour during the four events studied , different structural "limit states" for each considered event can be identified. These limit states are described in the following table, in terms of response parameters or as qualitative performance levels. The analyses of the obtained results do not show a "collapse state" of the structure, even for the NCOE_6 event. In fact no global collapse have been identified. Also local collapses seems to be excluded during the events. The structure response is controlled by the soil structure interface: the superstructure reaches limited deformation values with respect to the rigid mode configuration. Anyway, very high values have been recorded for acceleration peaks and residual vertical displacements, that are probably not compatible with systems and components.
The soil-foundation system behaviour resulted as one of the critical issues to obtain an accurate evaluation of the response. The data about the soil stiffness and strength should be adequately refined.

	NCOE1 CAV≈ 2000 m/s	NCOE2 CAV≈ 3500 m/s	NCOE4 CAV≈ 5000 m/s	NCOE6 CAV≈ 5500 m/s
Global collapse of the structure	to be excluded	to be excluded	to be excluded	to be excluded
Residual vertical displacements at foundation level	≈ 1 cm	≈ 4 cm	≈ 19 cm	≈ 42 cm
Relative max displacement of control point	≈ 0.5 cm	≈ 1. cm	≈ 2.8 cm	≈ 4.5 cm
Peak acceleration at reference floor	≈ 2.2 g	≈ 5.4 g	≈ 6.5 g	≈ 6 g
Cracks distribution				
Localized collapses of internal structures	No evidence. Analysis of detailed situations	No evidence. Analysis of detailed situations	No evidence. Analysis of detailed situations	No evidence. Analysis of detailed situations

Conclusions and developments

Further information can be collected looking to the global behaviour of the structure. As an example, in the following graph the residual vertical displacement of the RB, vs the CAV of the four considered events is reported.
It is evident that from a global point of view, a critical situation seems to appear for values of CAV larger than 5000 cm/sec.
A critical aspect has been highlighted in the soil-foundation nonlinear response, that has a strong influence in the overall behaviour of SSCs, also with regard to the connections with nearby buildings.
An accurate modeling of this response requires a deeper knowledge of soil properties.



Contact information

Independent Technical Evaluation and Review

Piazza S. Pietro, 36
I-00029 Vicovaro (Rome), ITALY

Tel: +39-06-7707 2888
Fax: +39-06-2332 8132
Email: iter@iter-consult.it
URL: www.iter-consult.it