International Technical Meeting
on
''Seismic Safety of NPPs''
Tivoli (Roma) - March 25-26, 2010

ITER - IAEA Cooperation on seismic safety issue of NPP

Giampiero Orsini

ITER-Consult

- ITER-Consult is an independent "expert organization" created in 2003 with the main Objectives:
  - provide independent evaluation and review in the field of nuclear and radiation safety for siting, design, construction, commissioning, operation and decommissioning of nuclear facilities.
  - make available a resource already existing in other EU Countries, as independent "expert organization".
  - contribute in maintaining knowledge and strengthening the nuclear safety culture in Italy
  - establish international cooperation and networking

INTERNATIONAL COOPERATION

- International cooperation and networking is a fundamental way to maintain competence, capability and knowledge.
- ITER-Consult has established relations and cooperation with EU international organizations (Regulators and TSOs).
- Special attention has been given to IAEA as leading organization for promoting international cooperation.

Cooperation with IAEA

- ITER has established relations for cooperation with IAEA since 2003
- In April 2009 joined the IAEA EBP on the "Seismic Safety of Existing NPP"
- After preparatory activities, in August 2009 ITER started its activity as member of the international team involved in the KARISMA BENCHMARK

The EBP – KARISMA Benchmark

- The earthquake of 16 July 2007 in Japan, affected the TEPCO Kashiwazaki-Kariwa Nuclear Power Station (NPS) with a magnitude of 6.6;
- The large amount of observations and data collected on site (soil and structures both inputs and outputs), raised the idea of organizing a benchmark.
- A Benchmark on the seismic behavior of NPP has been organized by IAEA, in the framework of the Working Area 2 (WA2) of the IAEA – EBP on Seismic Safety of Existing Nuclear Power Plants.

KARISMA Benchmark OBJECTIVES

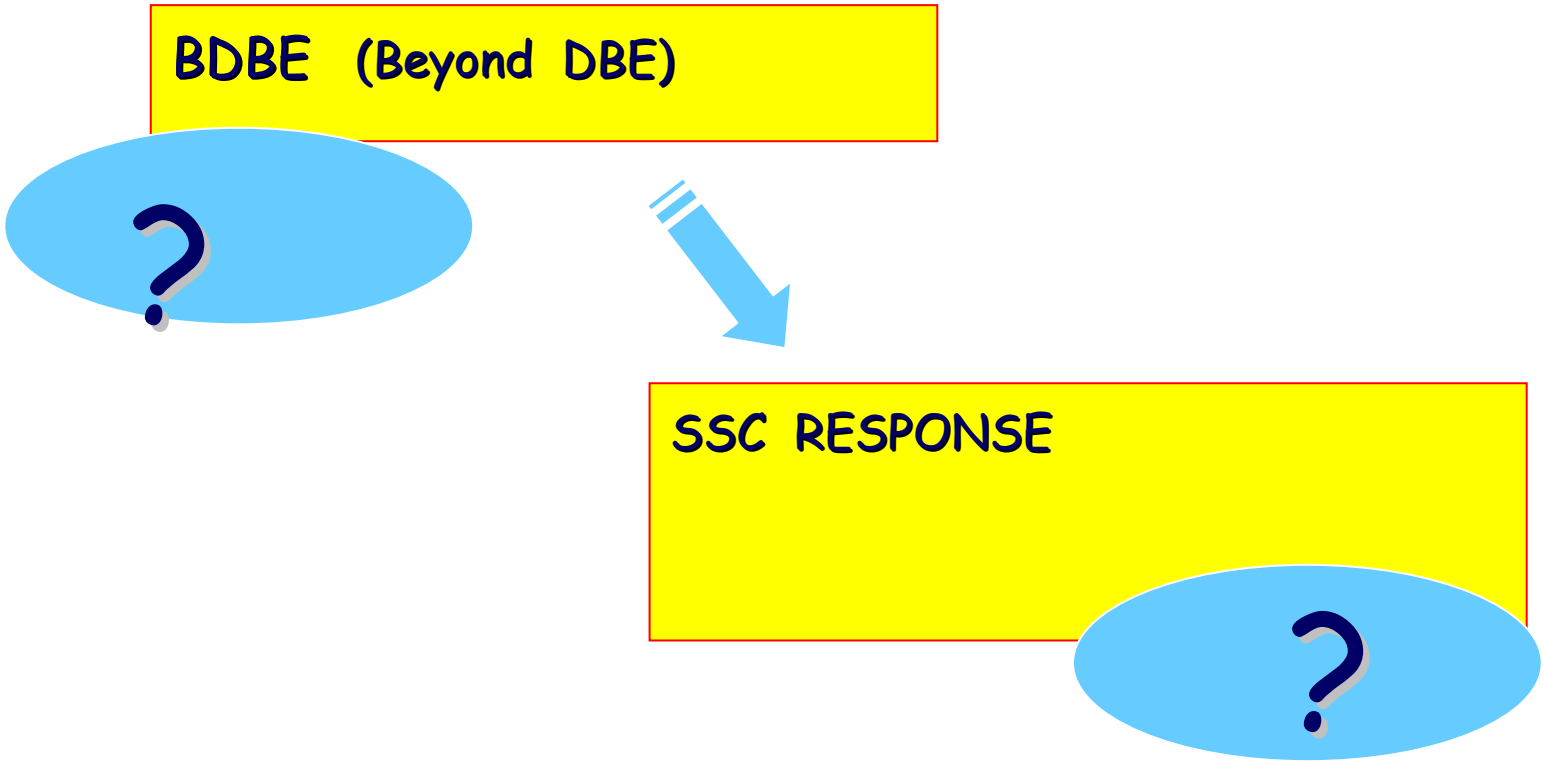
- Understanding what happened to the soil and structures during the July 2007 earthquake;
- Understanding of margins: quantifying what will happen both in soil and in structure, when the input is increased;
- Calibration of different simulation methodologies;
- Identification of main parameters influencing the response, by collecting and analysing the results from different teams.
- Understanding of equipment behaviour;
- Consideration of the effect of differential movements beneath buildings .

Understanding of margins:
a key issue

- Design process of structures and components is based on the assumption of safety factors, to take into account epistemic and random uncertainties.

- This assumption implies that the actual response of a structure and components is expected to be higher than the one (seismic load) assumed in the design.

Beyond DBE response:



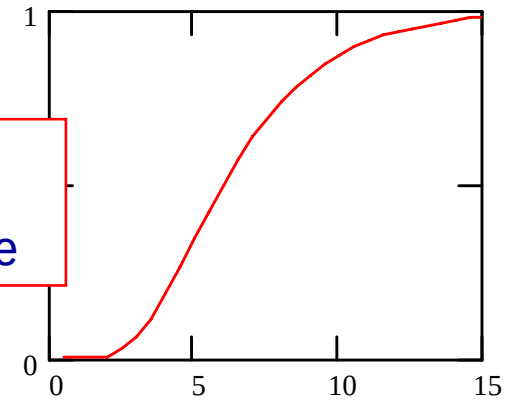
Understanding of margins

Response to DBE

LIMIT STATE

Prob. of

Damage state



Horiz. Acceleration

Margins

(as result of many factors)

Response to BDBE

still acceptable ?

KARISMA Benchmark STRUCTURE

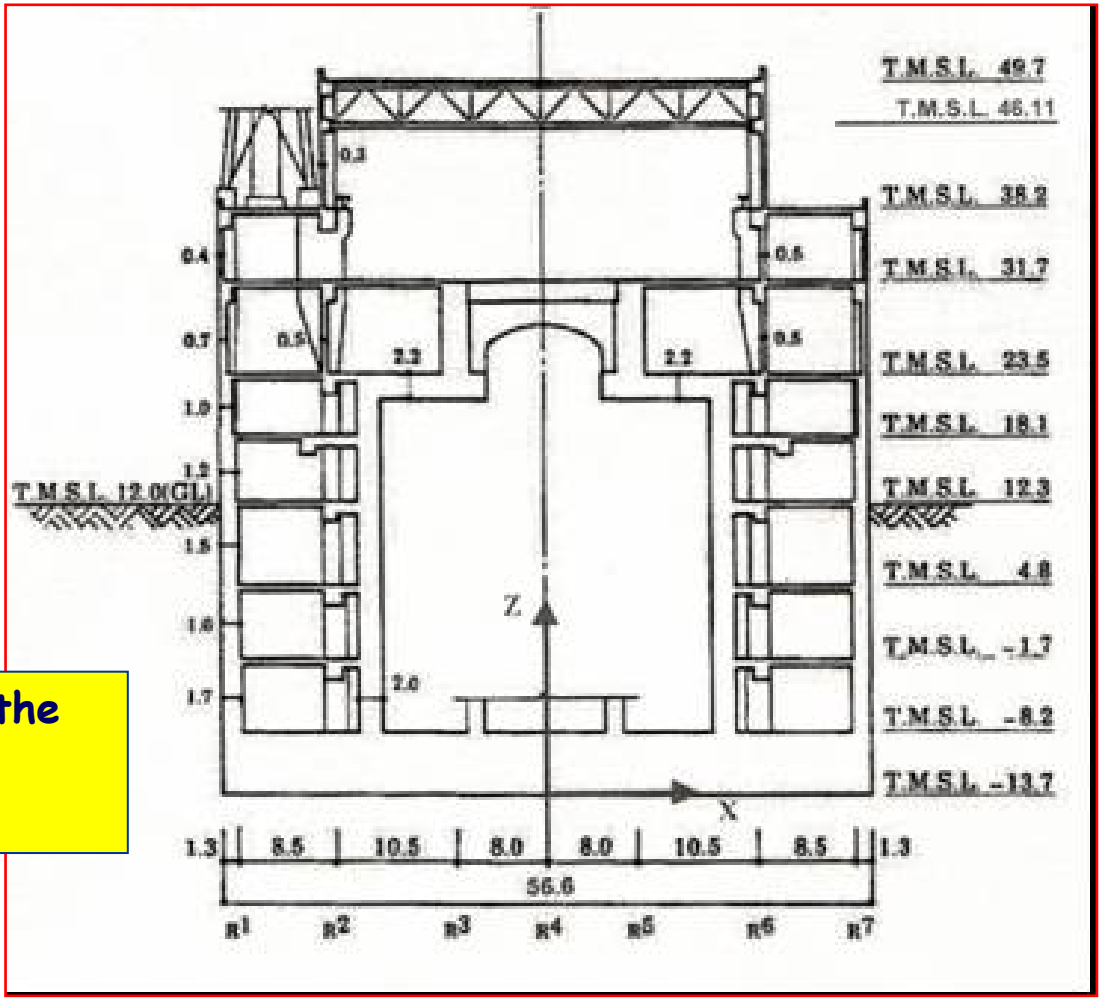
- TASK 1: Structural BenchmarkSUBTASKSUB-SUBTAKS
- Task 1.1 Construction and validation of the soil and structures models
  - 1.1.1 Static and modal analysis of the fixed base model under vertical and horizontal forces
  - 1.1.2 Soil Column analyses
  - 1.1.3 Analysis of the complete model
- Task 1.2 Main shock response
  - 1.2.1 Transfer of spectra analysis, Conventional basic design study ,Best estimate study
  - 1.2.2 Analysis of the main shock
  - Task 1.3 Margins assessment
- TASK 2: Equipment Benchmark
- Task 2.1 Piping System
- Task 2.2 Sloshing of the fuel pool
- Task 2.3 Atmospheric tanks buckling

EBP – KARISMA Benchmark

In the first phase of the benchmark, a prediction of the structural behavior of the Reactor Building of the Unit 7, has been performed for the following aspects:

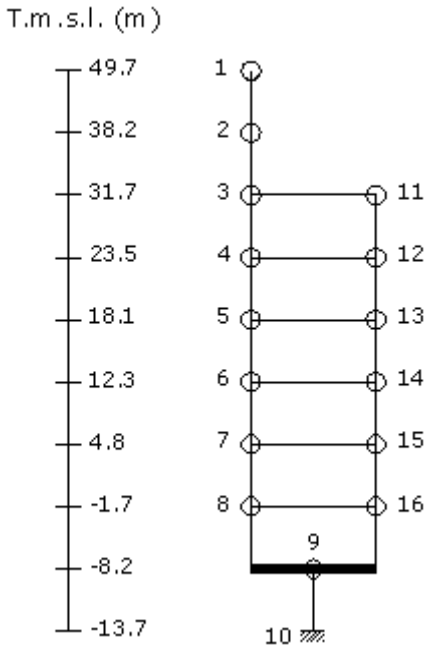
- response under static loads;
- modal analysis;
- soil column analyses;
- modal analyses of soil-structure model

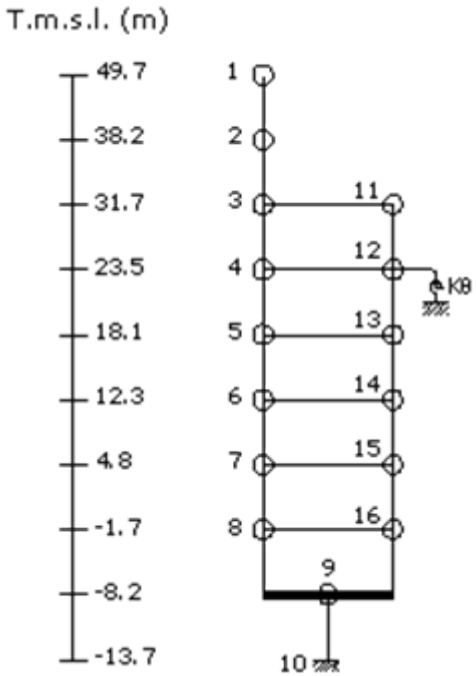
EBP – KARISMA Benchmark



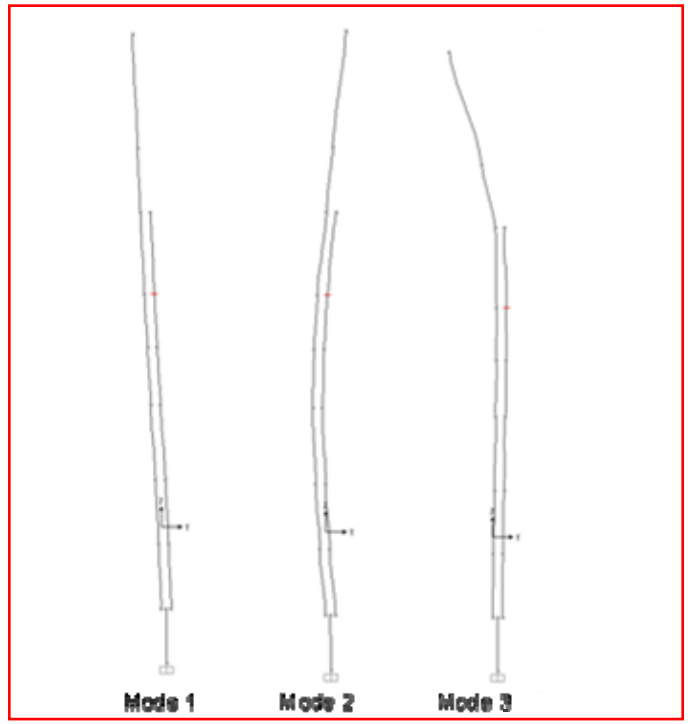
General cross section of the R/B 7

EBP – KARISMA Benchmark

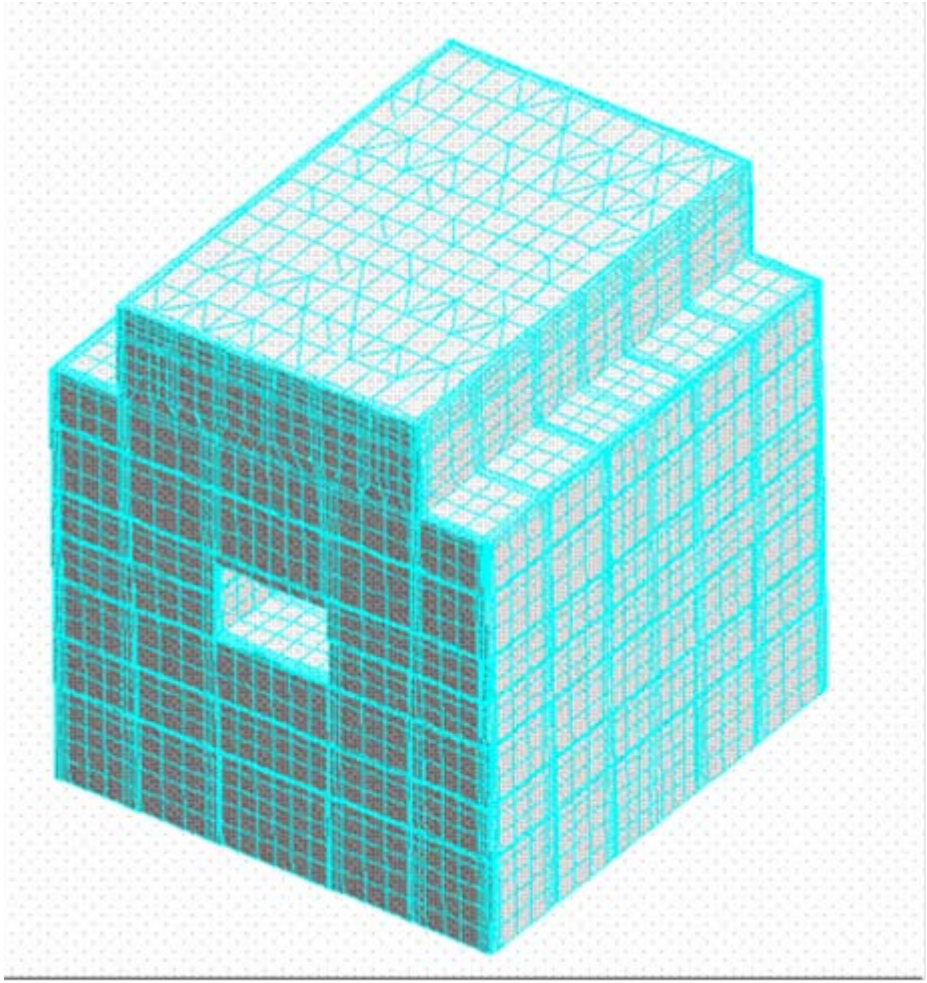




Preliminary analyses:
STICK MODELS



EBP – KARISMA Benchmark



GLOBAL F.E. MODEL

EBP – KARISMA Benchmark

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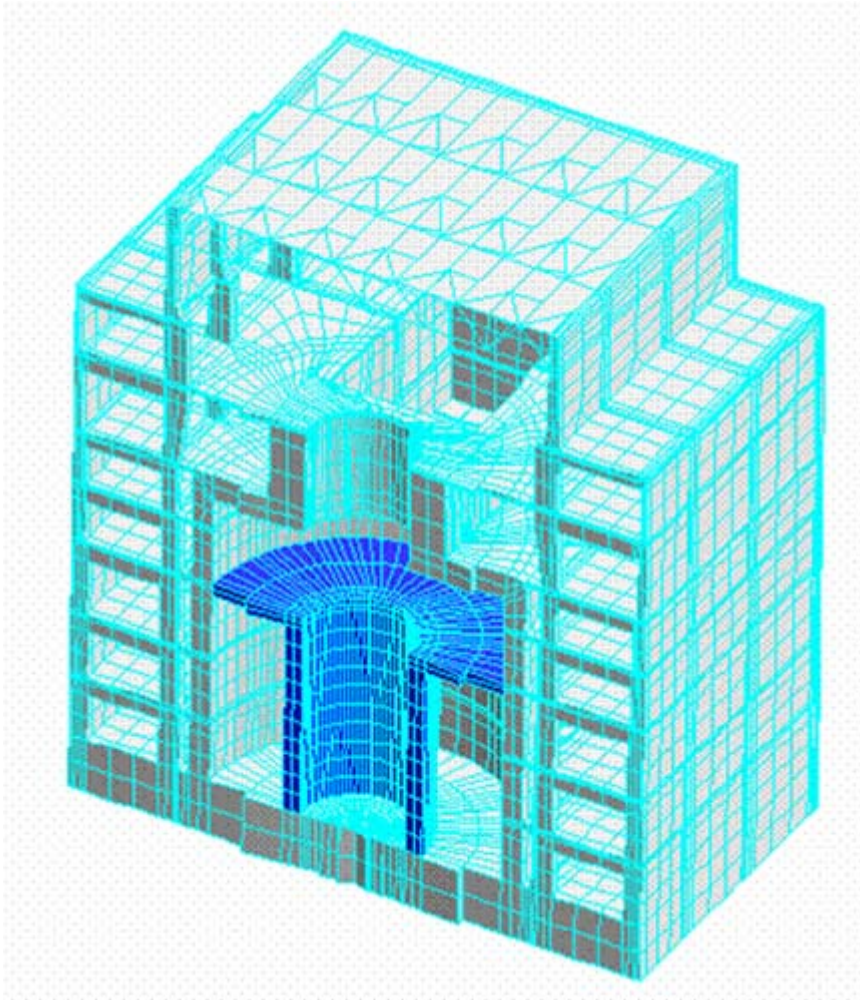
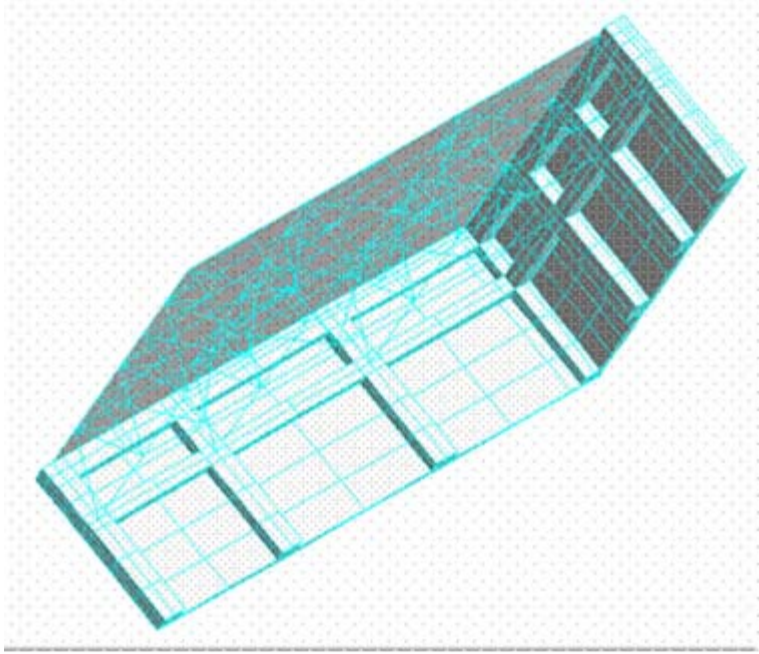
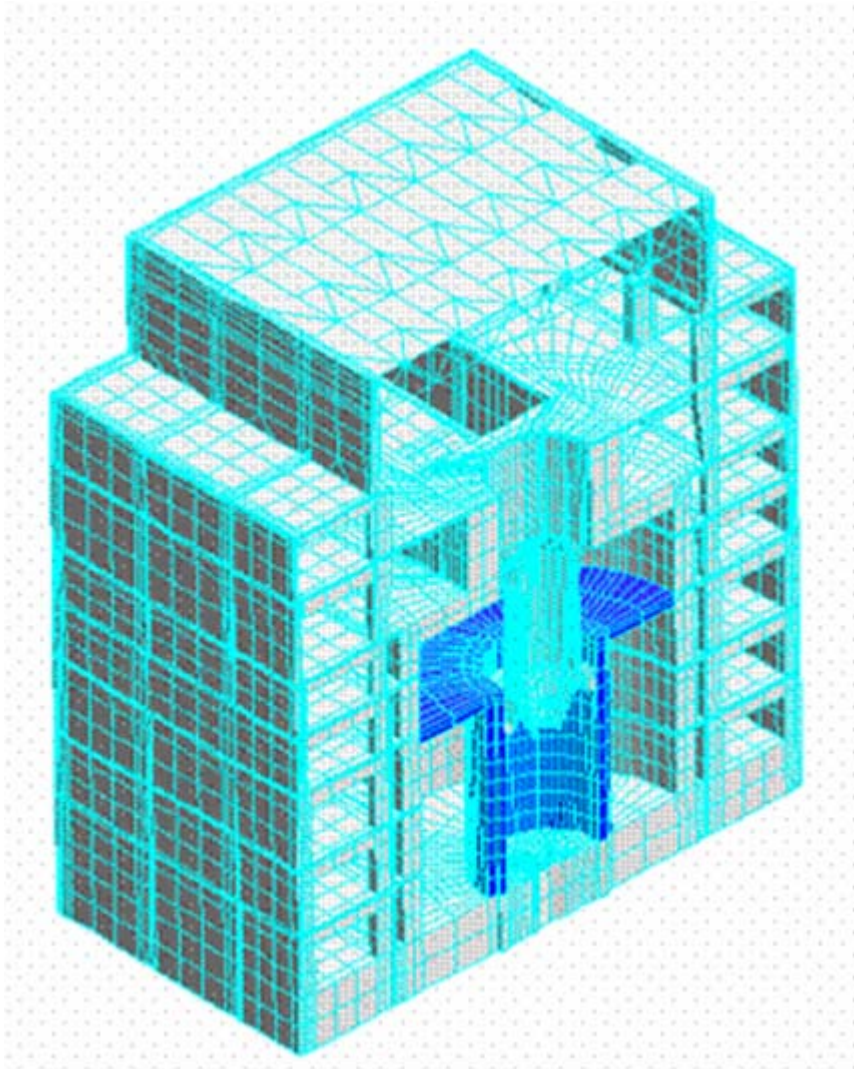


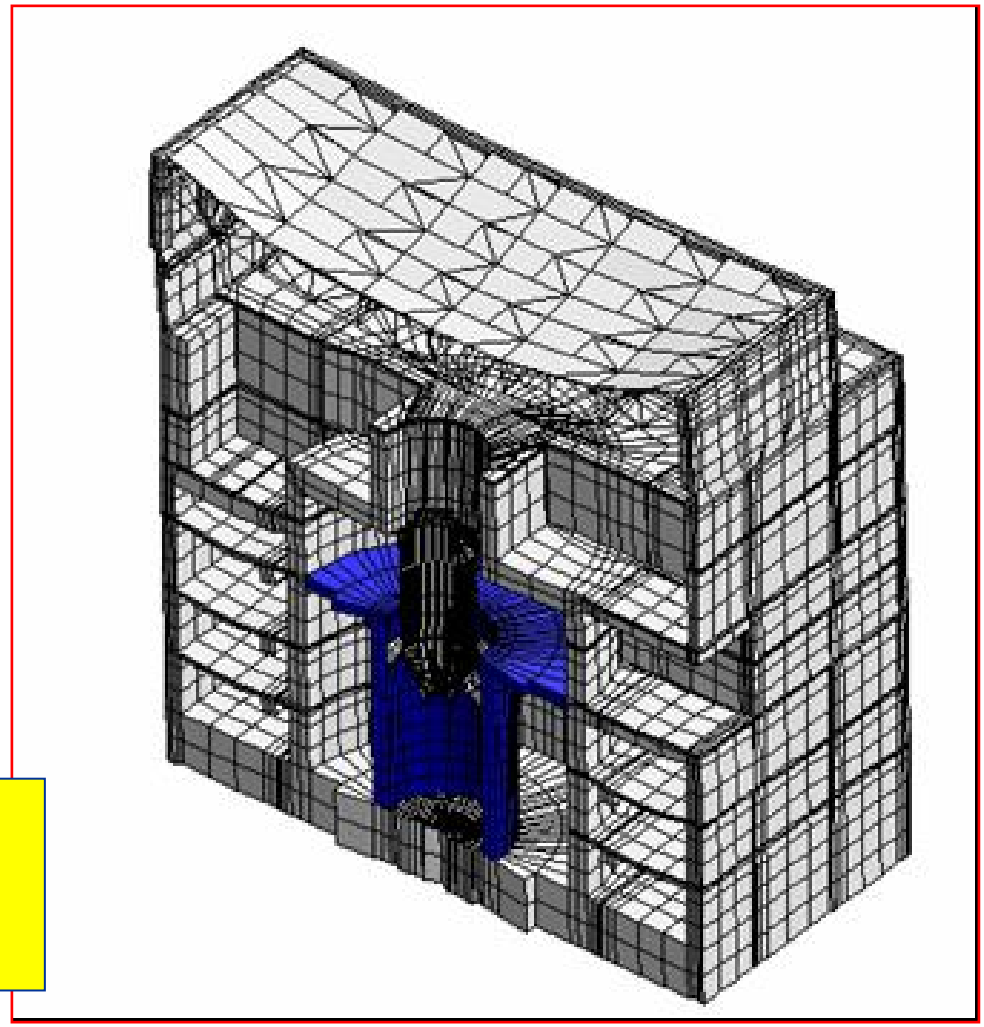
EBP – KARISMA Benchmark





GLOBAL F.E. MODEL:
Vessel modelization
Roof structure

EBP – KARISMA Benchmark



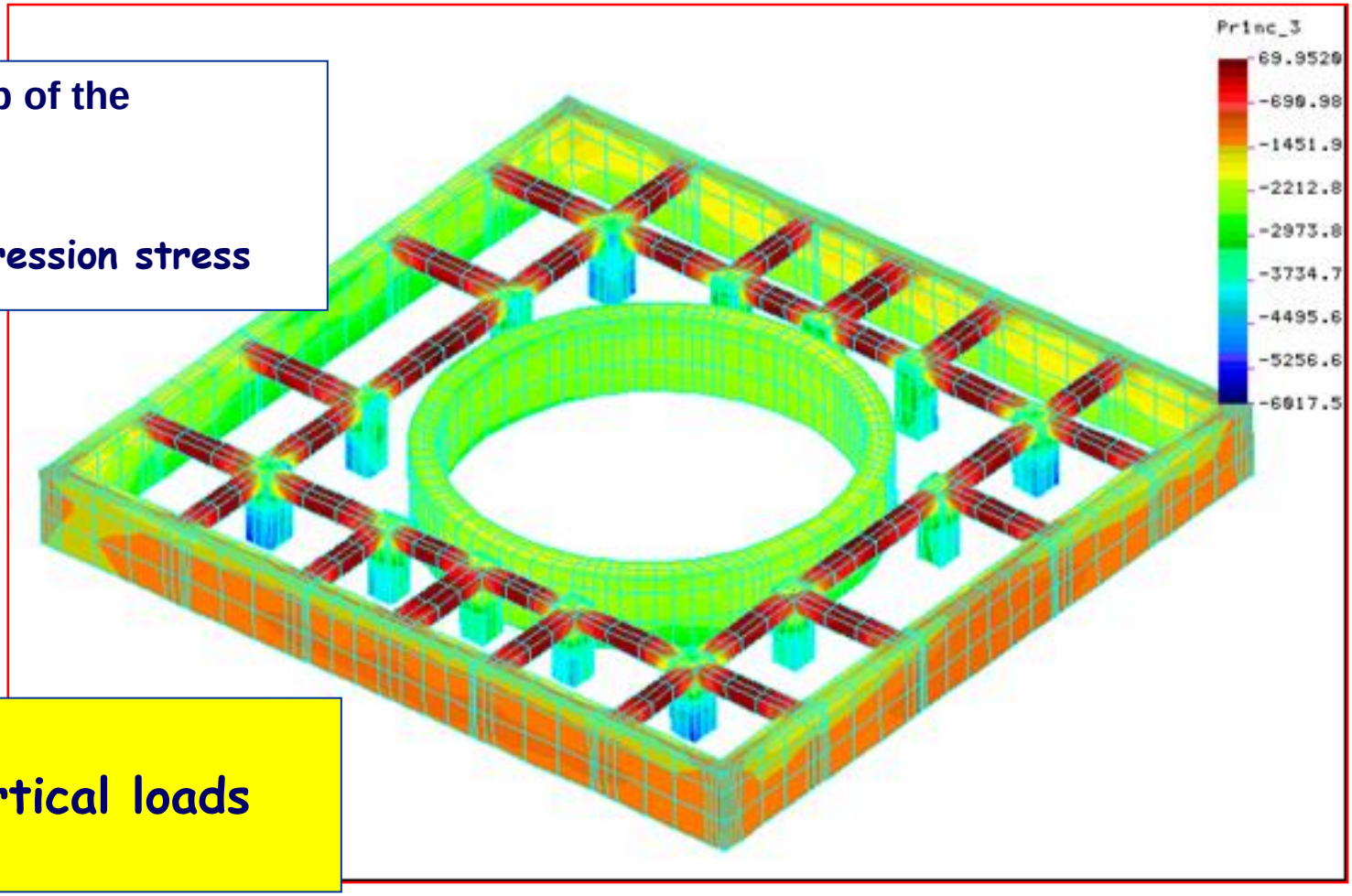
RESULTS:

Vertical loads

EBP – KARISMA Benchmark

Walls at the top of the basemat:

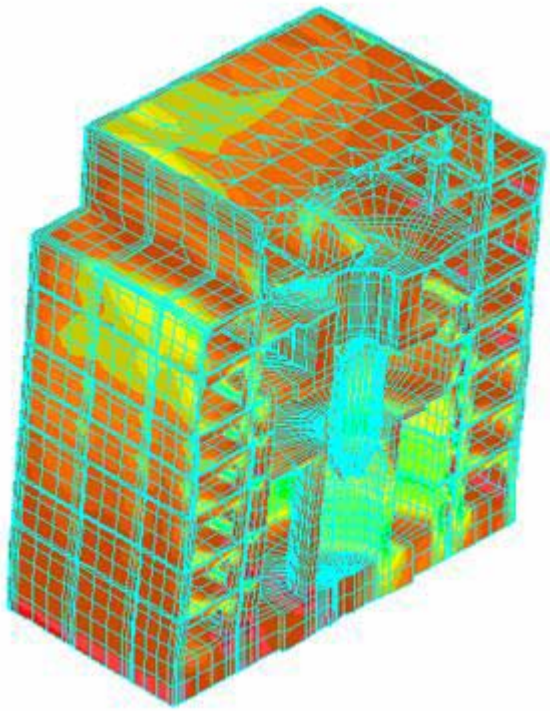
Principal compression stress

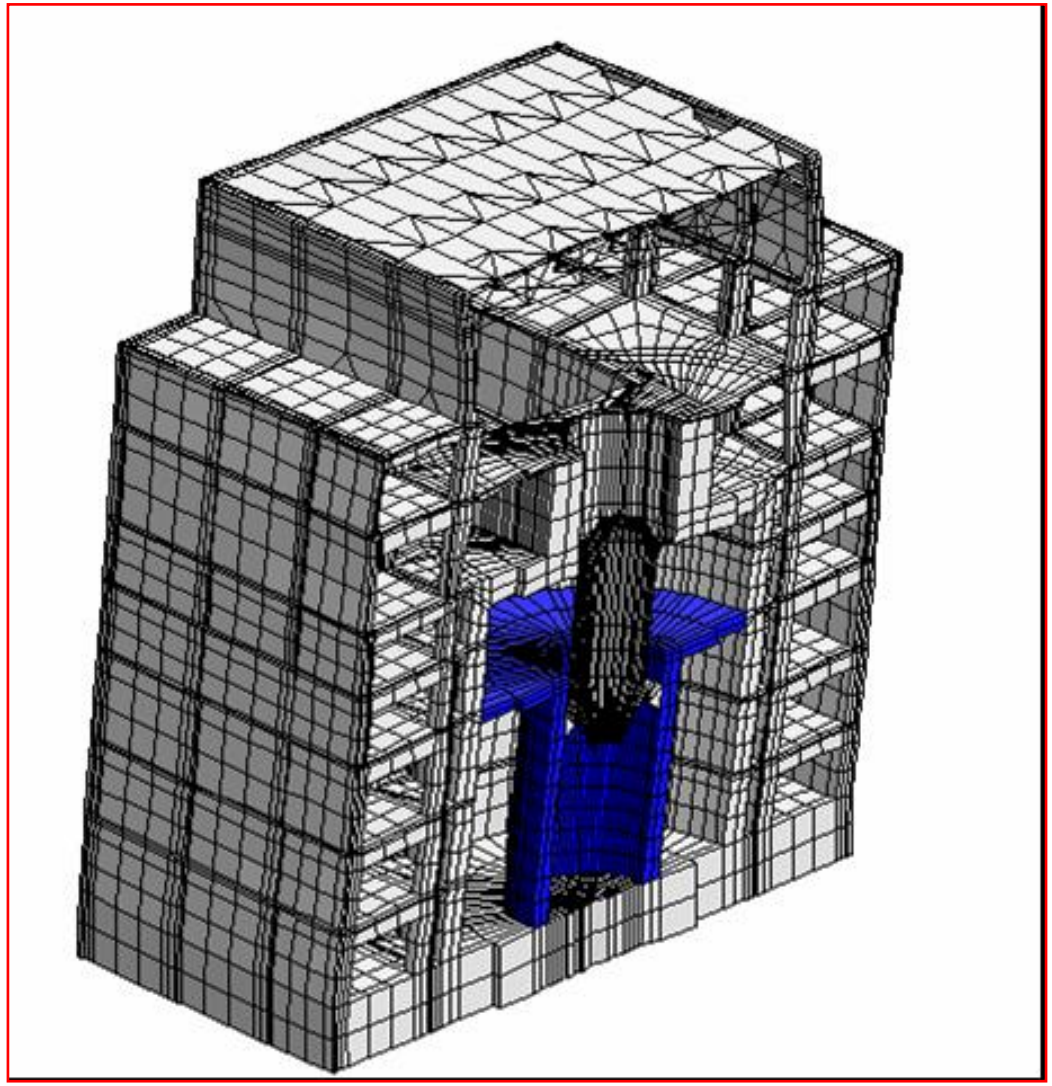


RESULTS:

Vertical loads

EBP – KARISMA Benchmark





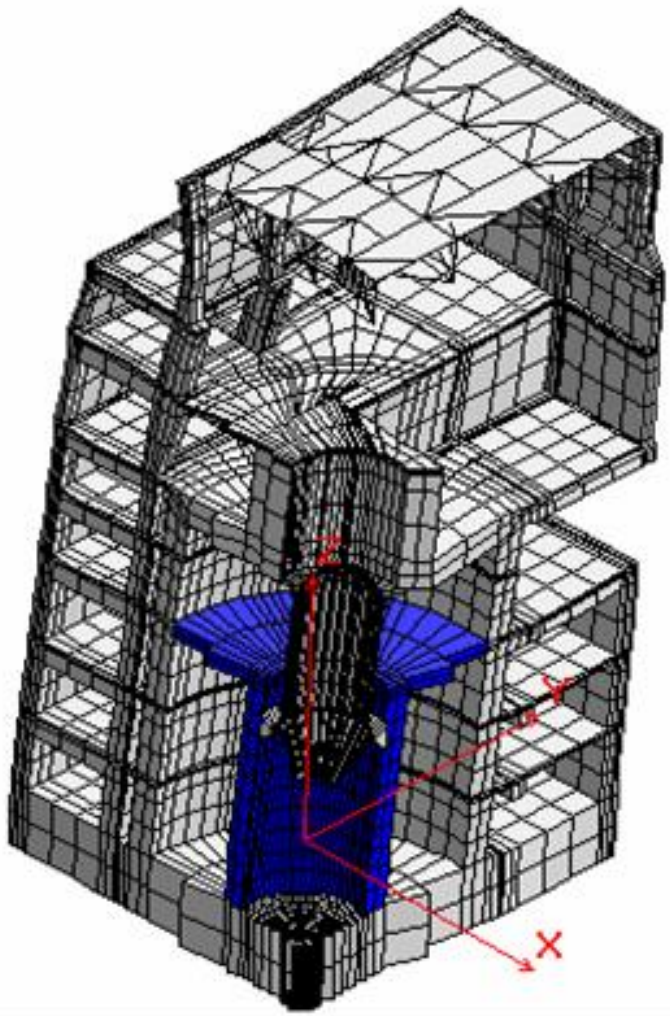
RESULTS:

Horizontal acceleration (uniform horizontal 1.0 g)

EBP – KARISMA Benchmark

Modal analysis- First mode

(4.48 Hz)

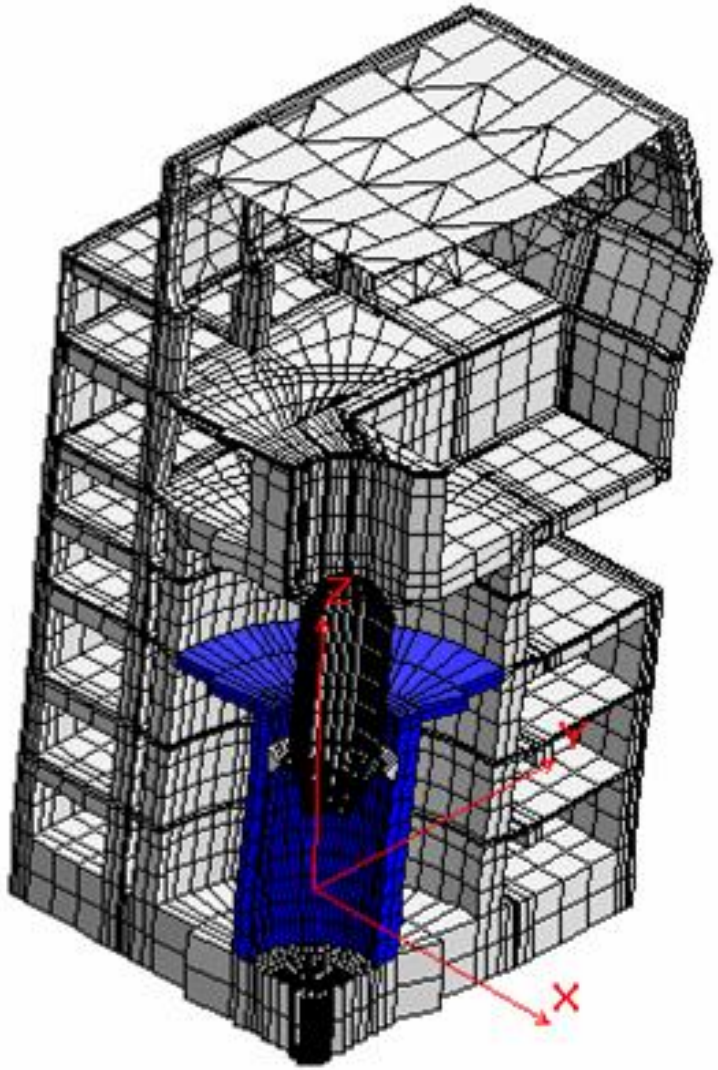


RESULTS:

Modal analysis

EBP – KARISMA Benchmark

Modal analysis- Second mode (4.77 Hz)



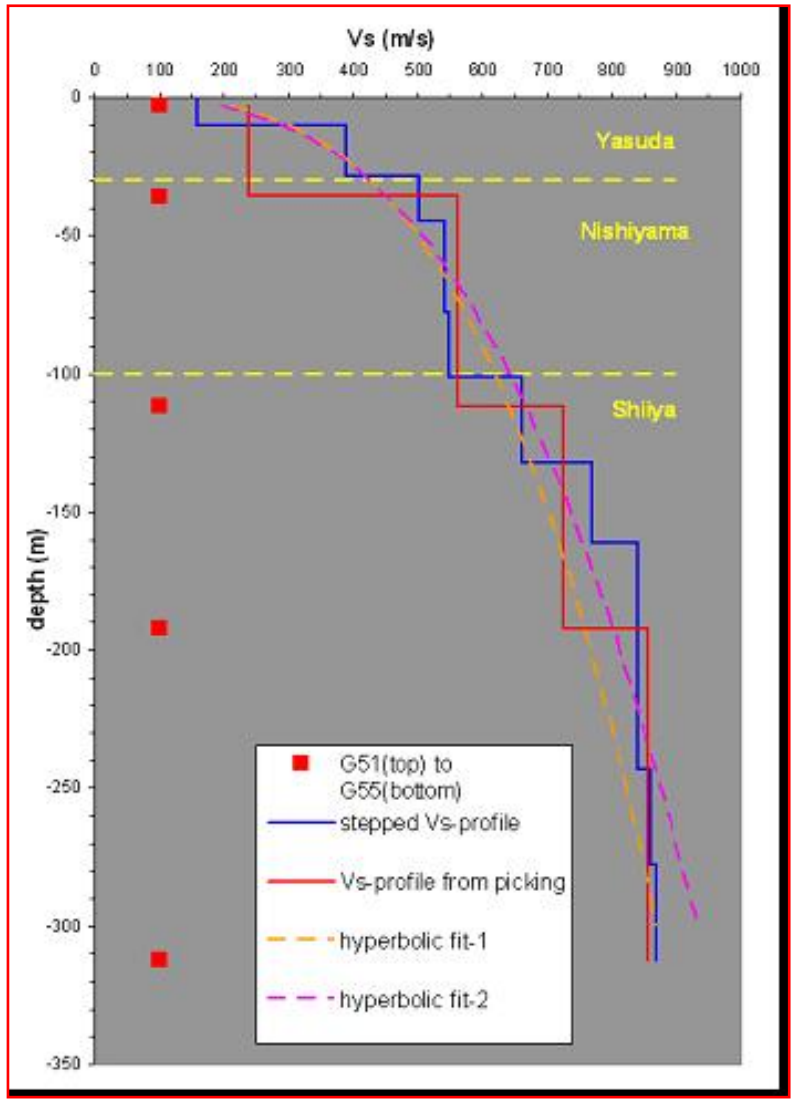
RESULTS:

Modal analysis

EBP – KARISMA Benchmark

Soil column analysis

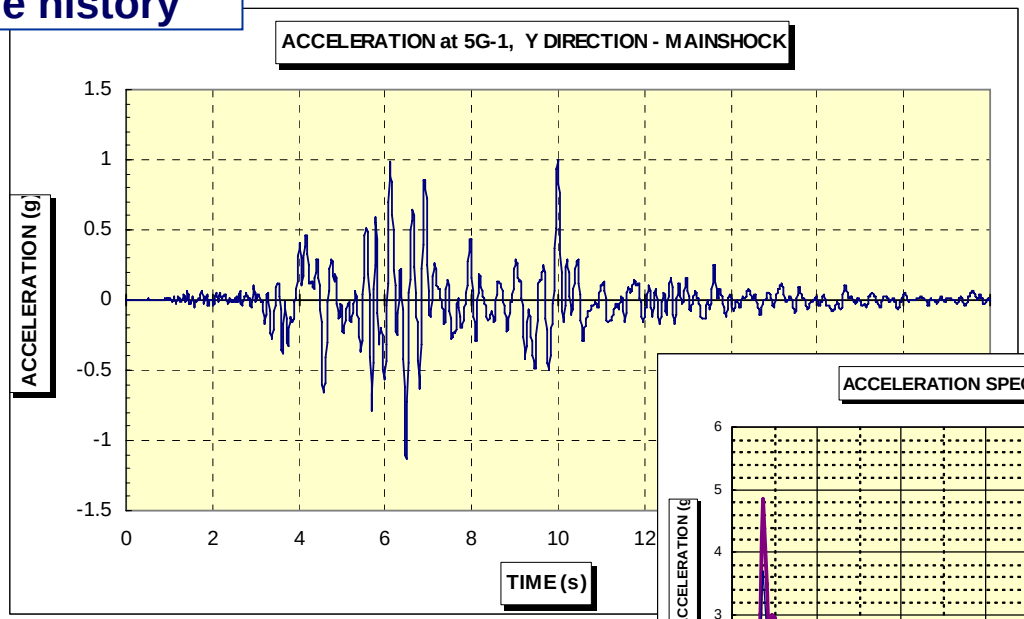
Soil Vs Profile



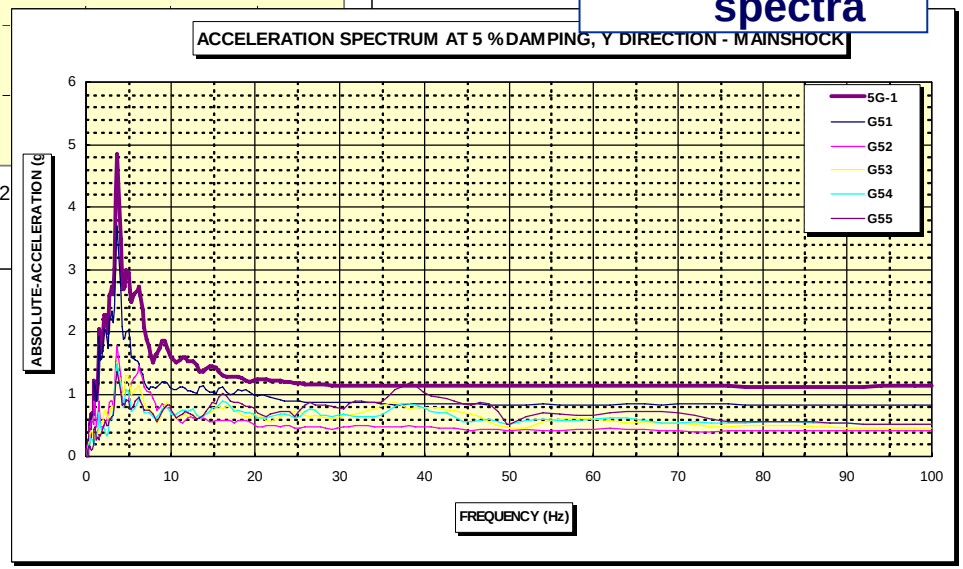
EBP – KARISMA Benchmark

Soil column analysis

Calculated acceleration time history



Calculated response spectra



EBP – KARISMA Benchmark

What in next steps ?

- Evaluation of soil structure interaction.
- Evaluation of non-linear behaviour. Actual limit strength and deformation of material
- Evaluation of structural response under increasing seismic loads higher than design one.
- Evaluation of margins

Final remarks:

Karisma Benchmark will allow us to get an insight into the issue of:

seismic design for DBE and seismic response for BDBE of a NPP

Seismic Design (DBE)	Evaluation of Seismic Response to BDBE

On this issue particular effort will be developed by ITER-Consult in its contribution to the Benchmark

SEISMIC DESIGN PROCESS

- **Definition of DBE**
- **Seismic Categorization** of Structures, Systems and Components (SSC) : definition of seismic classes and associated requirements
- Definition of **Functional and Structural integrity limit states** of **SSC**
- **Design and Verification of the design limits** against defined DBE , generally defined by Codes and Regulations

BDBE Seismic Response

The Karisma Benchmark should provide a better understanding of the seismic response of SSC to BDBE. In particular:

- **improve understanding of non-linear behaviour of SSC**
- **get a quantitative insight into the margin assessment**
- **improve capacity to model failure modes of SSC**
- **promote knowledge sharing among international nuclear community**

THANKS FOR THE ATTENTION