

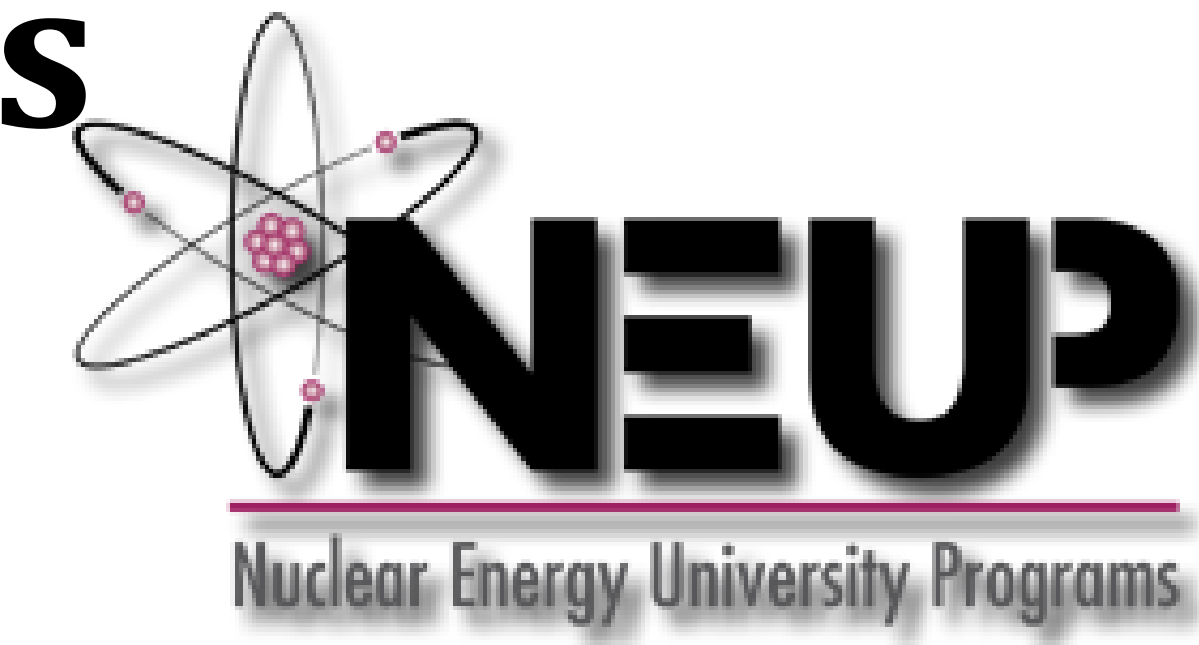


University of Nevada, Reno



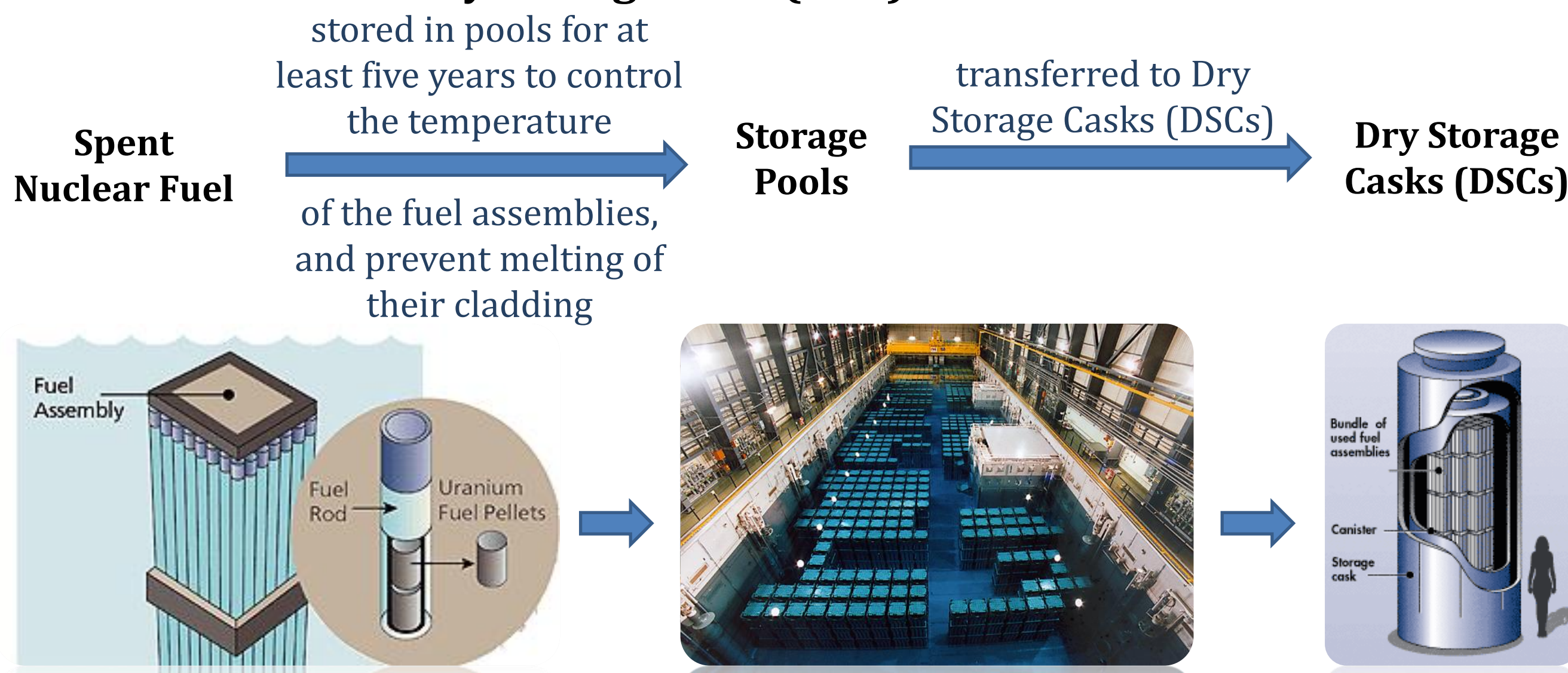
Dry Storage Cask Shake Table Experiments

Student Investigators: Ahmed Maree and Taylor Nielsen, University of Nevada, Reno
Principal Investigator: Professor David Sanders, University of Nevada, Reno
Project Principal Investigator: Luis Ibarra, University of Utah



Introduction

What is a nuclear dry storage cask (DSC)?



The regulations for these storage systems (10 CFR 72) are designed to ensure

- Adequate passive heat removal.
- Radiation shielding during normal operations.
- Radiation shielding during off-normal events and accident scenarios.

Problem Statement

Recent seismic events have underlined the risks DSCs are exposed.

- Dominion Virginia Power's North Anna during Virginia 5.8 earthquake, August 2011:
 - 25 of 27 DSCs moved on their concrete pad.
 - DSCs shifted from 1.0 to 4½ inches.
 - Metal components were not damaged.
 - No radiation was released.



Dominion Virginia Power's North Anna

DSCs have been considered as a temporary storage solution. Licensed for 20 years.

Although they can be relicensed for operating periods of up to 60 years.

Reevaluation of DSCs as a potential solution, in which the operating period may be extended for up to 300 years.

Project Objectives

The main goals of this study is to evaluate the long-term seismic performance of DSCs using experimental tests.

Through use of Scaled DSC Specimens on the UNR six Degree-of-Freedom (DOF) Shaking Table.

Scaled model specimen shall satisfy the following:

- Model aspect ratio shall cover the range in the available commercial DSCs.
- Scaled 1/2.5 specimens shall be representative for the actual prototype (specially under vertical excitation).
- Designed specimen shall sustain handling, sliding and impact during testing.

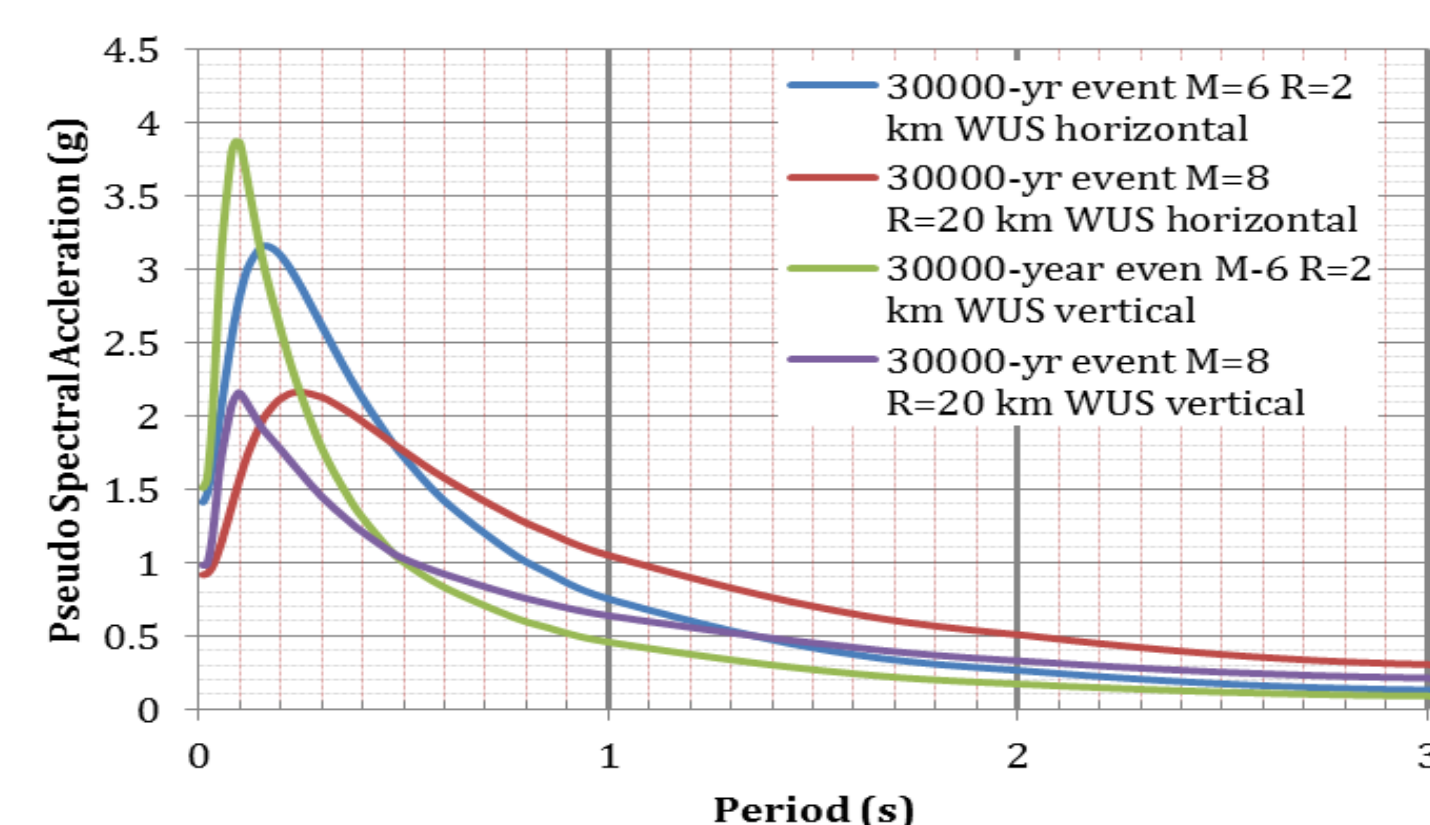
Selected Ground Motions

Selected evaluation basis earthquakes:

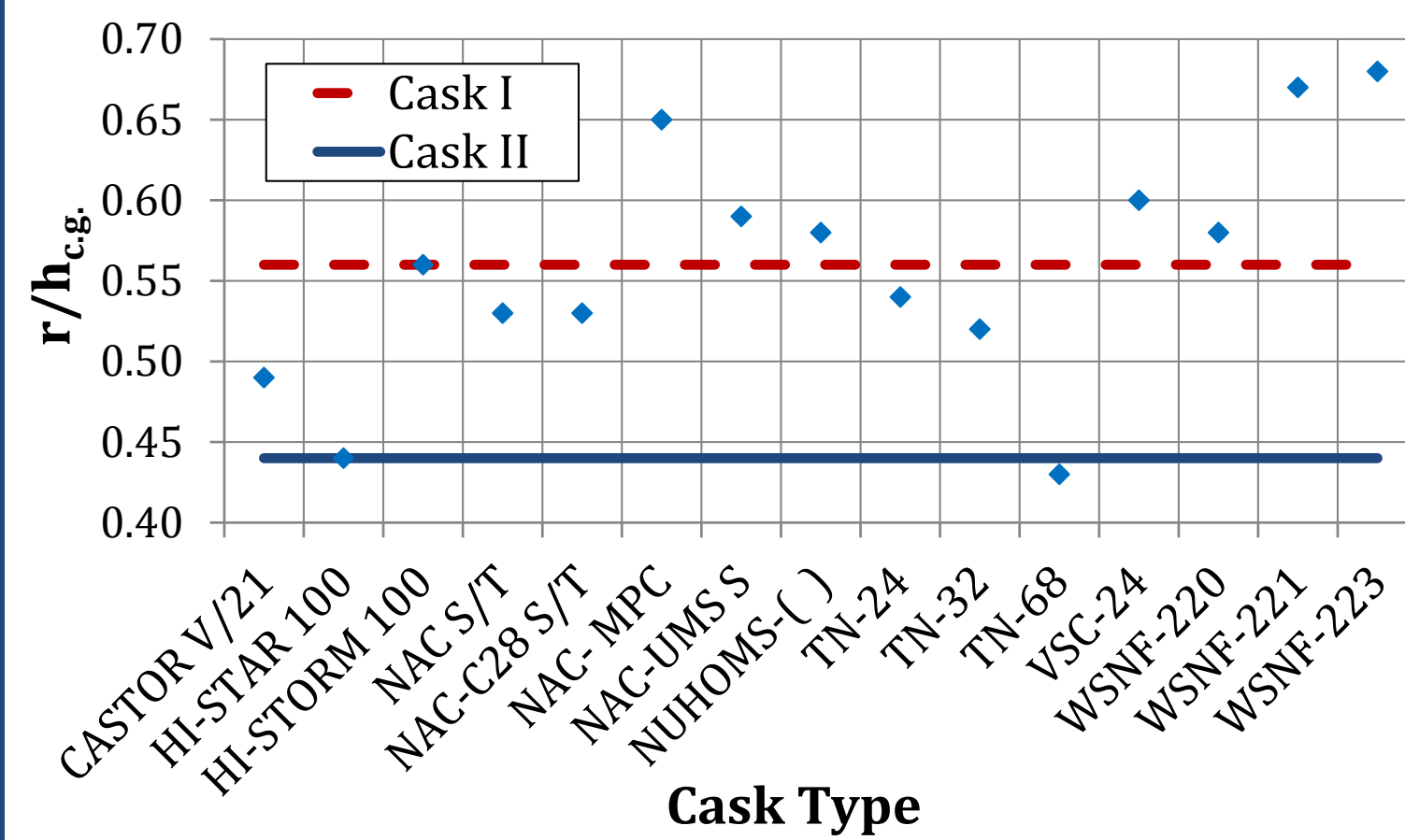
- Near Field Earthquake (M6.0 at 2 km)
- Far Field Earthquake (M8.0 at 20 km)

The level of spectral acceleration using NUREG 6728 seismic hazard curves. Developed for the following return periods:

- 1,000-year return period
- 30,000-year return period



Choice of DSC Specimens



Specifications of Chosen Scaled Specimens of DSCs

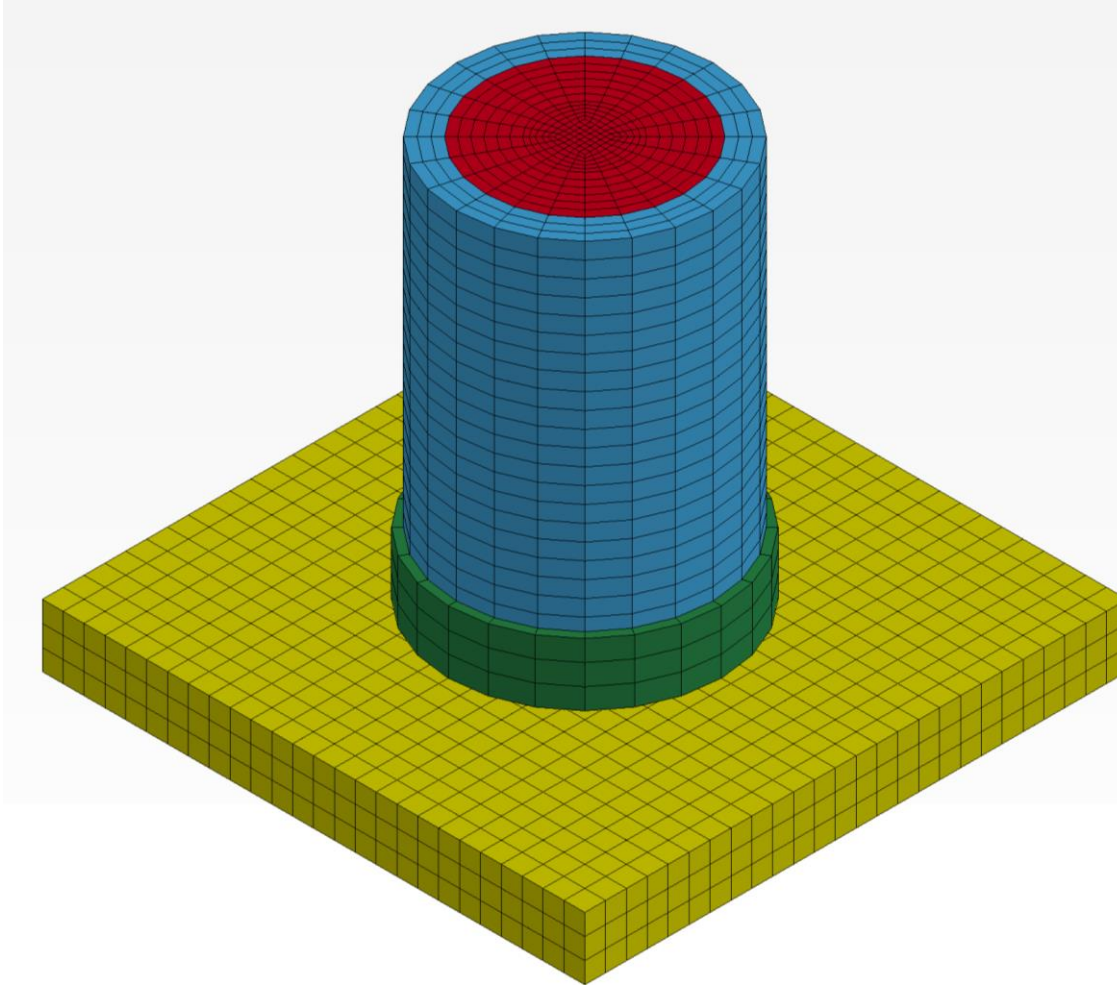
Cask Type	r/h_{cg} *	Weight (ton)	Diameter (mm)	Height (mm)
Cask (I)	0.566	16.56	1156	2134
Cask (II)	0.437	14.61	1054	2388

(* r/h_{cg} is the ratio between the cask radius and the height from the base to its center of gravity)

Finite Element Model Verification



Koji Shirai et al
Experimental Test 2003
X and Z Motions

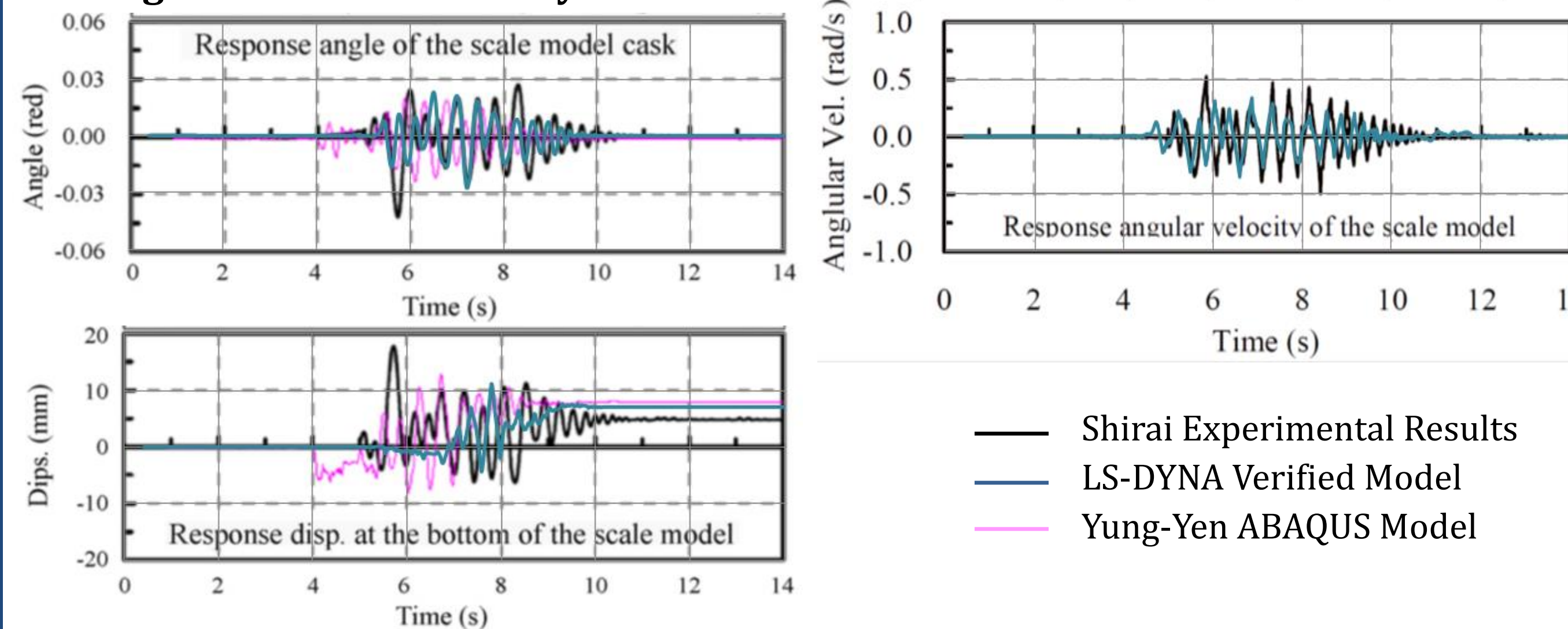


Developed LS-DYNA Model

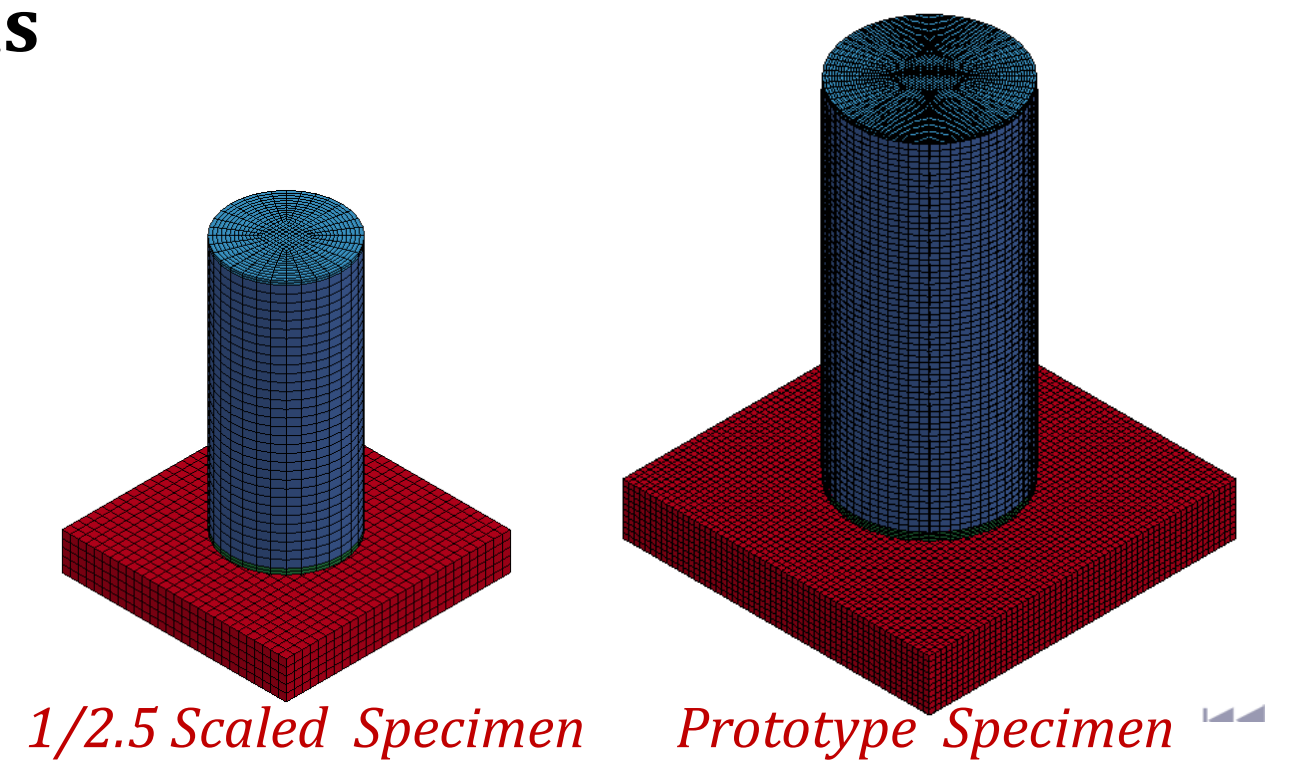
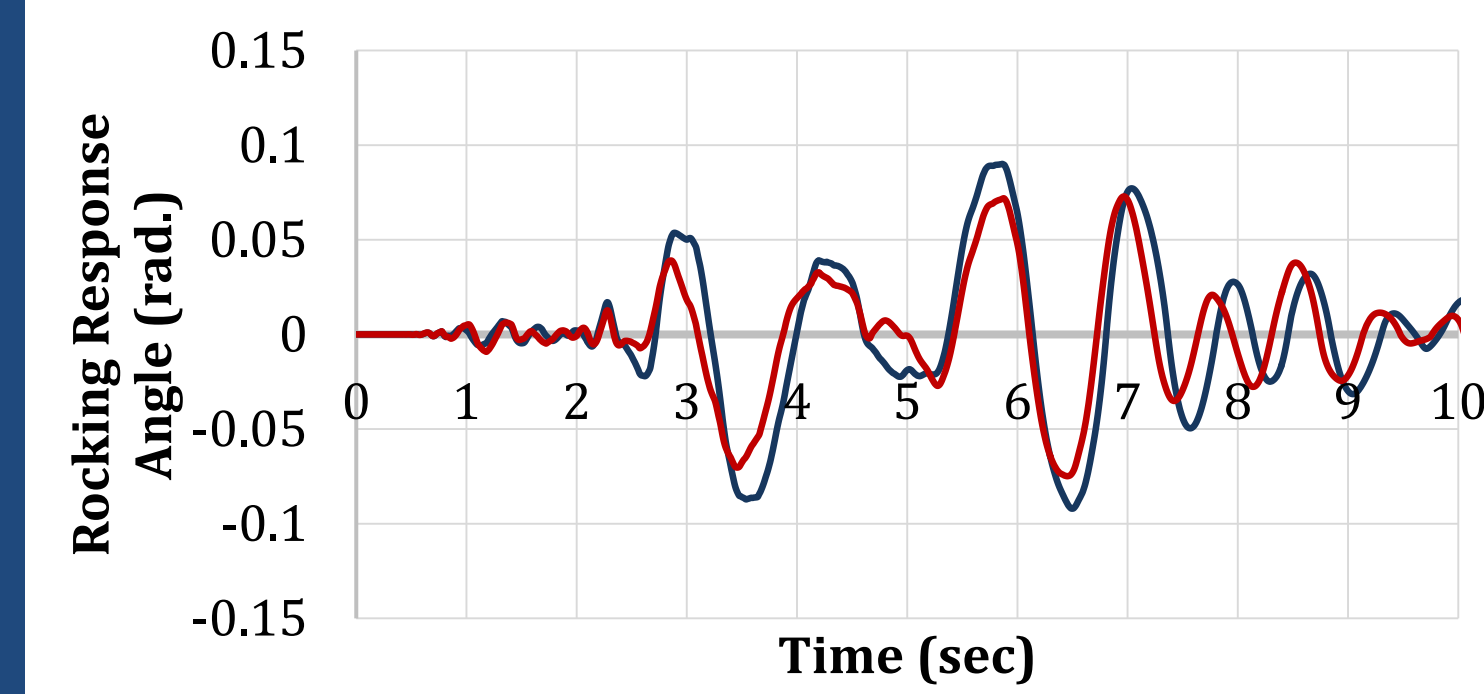


Koji Shirai Experimental Specimen

Verified Model Rocking Response Angle, Cask Base Displacement and Angular Rotation Velocity Results

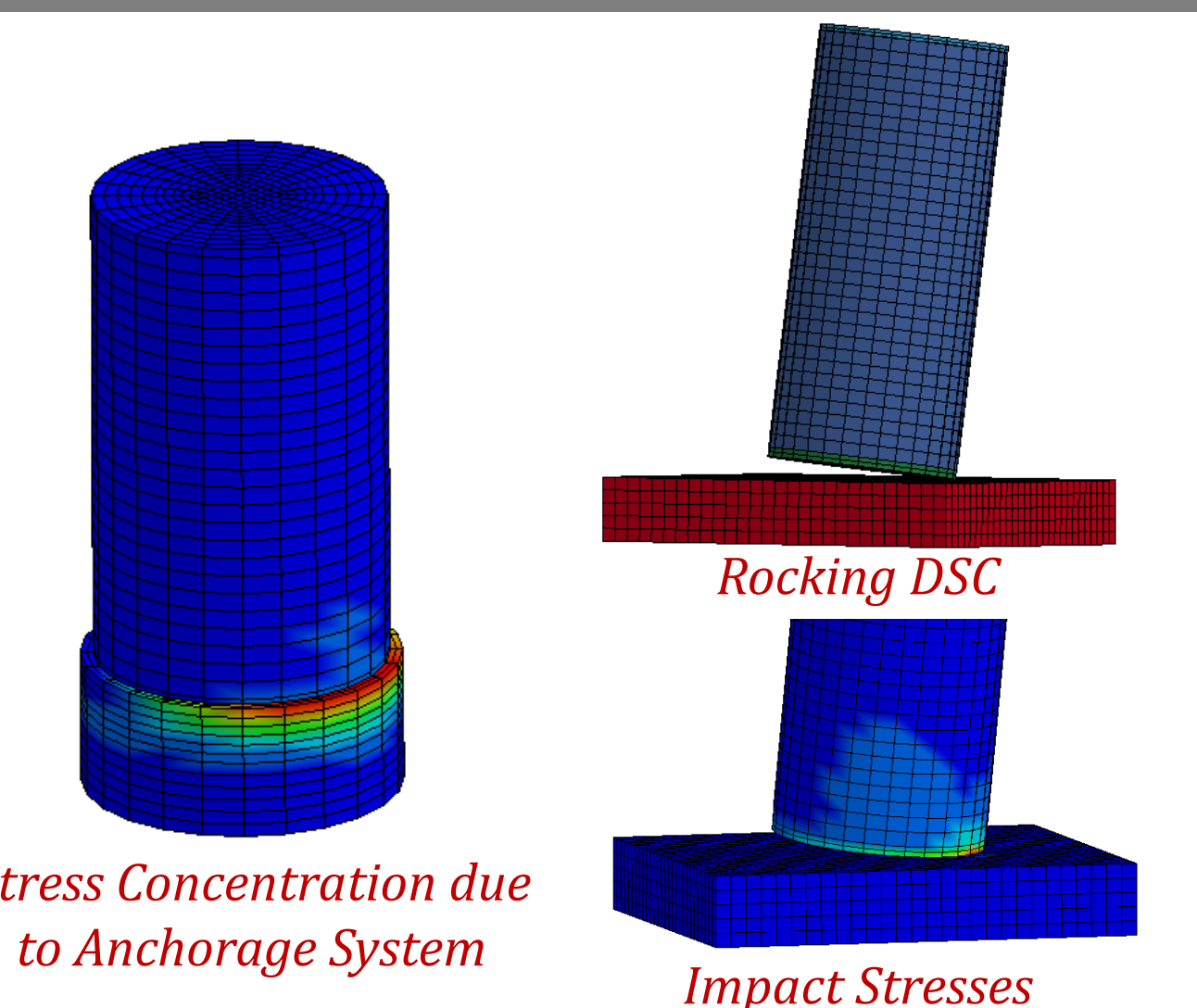


Verify specimens scaling using models



Specimen's Design

- Design handling system for overpack and MPC.
- Check stresses on the outer cylindrical shell of the overpack in case of using anchorage system for the DSCs.
- Check resulted stresses due to impact of the scaled specimen on the supporting concrete pad.
 - Check safety of shell thicknesses.
 - Design of connections between different parts
 - Design of the concrete pads to resist impact during the test.



Experimental Work Program



Overpacks of Cask I and Cask II



DSC Anchorage System



Top View of MPC

Test Configuration for Shaking Table Experiments

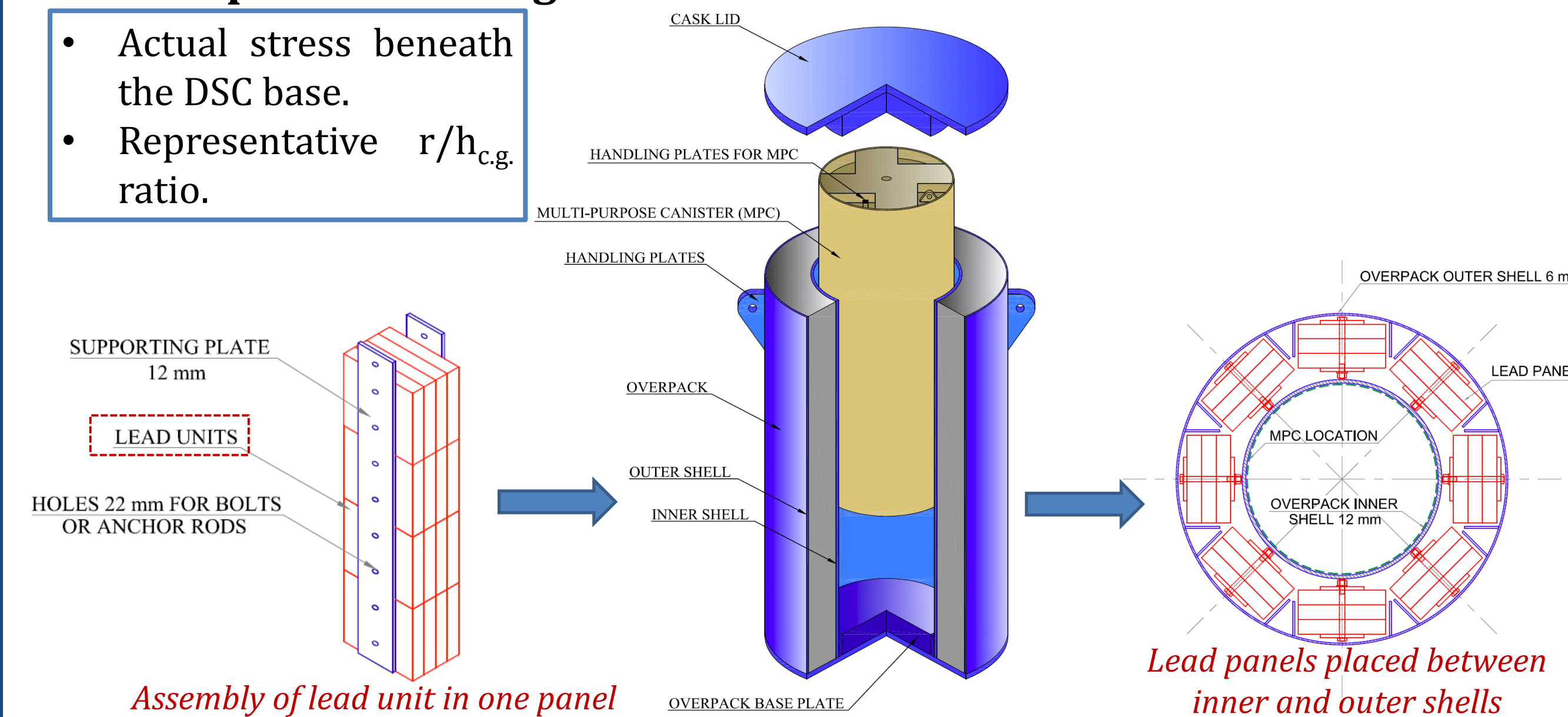
Case	Cask Type	Cask Configuration	Concrete Pad	GM Components *	Expected Behavior
1	Cask I	Freestanding	Smooth	xy and xyz / FF and NFGM	Sliding
2	Cask II			xy and xyz / FF and NFGM	
3	Cask I		Rough	xy and xyz / FF and NFGM	Rocking/Tip over
4	Cask II	xy and xyz / FF and NFGM			
5	Cask II	Conventional Anchors	Standard	xy and xyz / FF and NFGM	
6	Cask II	Stretch Anchors		xy and xyz / FF and NFGM	

(* "xy" represents two horizontal acceleration components. "xyz" represents acceleration in three orthogonal directions.)

Scaling and Similitude

Main aspects of Scaling and Similitude

- Actual stress beneath the DSC base.
- Representative r/h_{cg} ratio.



Assembly of lead unit in one panel

Lead panels placed between inner and outer shells

Future Plans

- Evaluate the long-term seismic performance of the existing dry storage casks in U.S. and develop guidelines for relicensing operating periods of DSCs.
- Provide a performance based design guidelines for DSCs to maintain its safety against earthquakes.