



# NCREE South Laboratory

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## ➤ NCREE South Laboratory

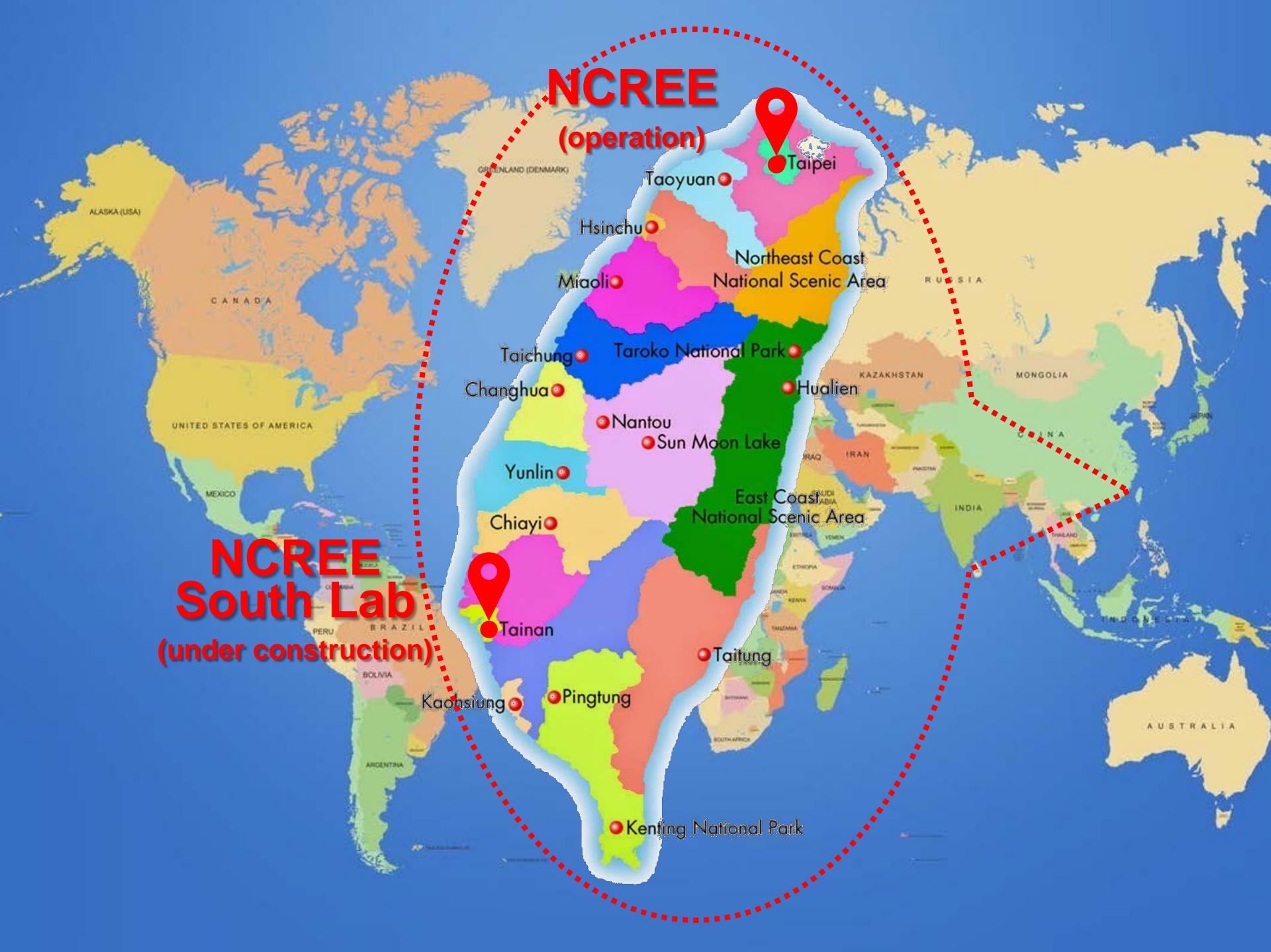
- ✓ Geographic location
- ✓ Facility layout

## ➤ Experimental Facilities

- ✓ Hydraulic power
- ✓ High-performance shaking table
- ✓ Biaxial dynamic testing system (BATS)

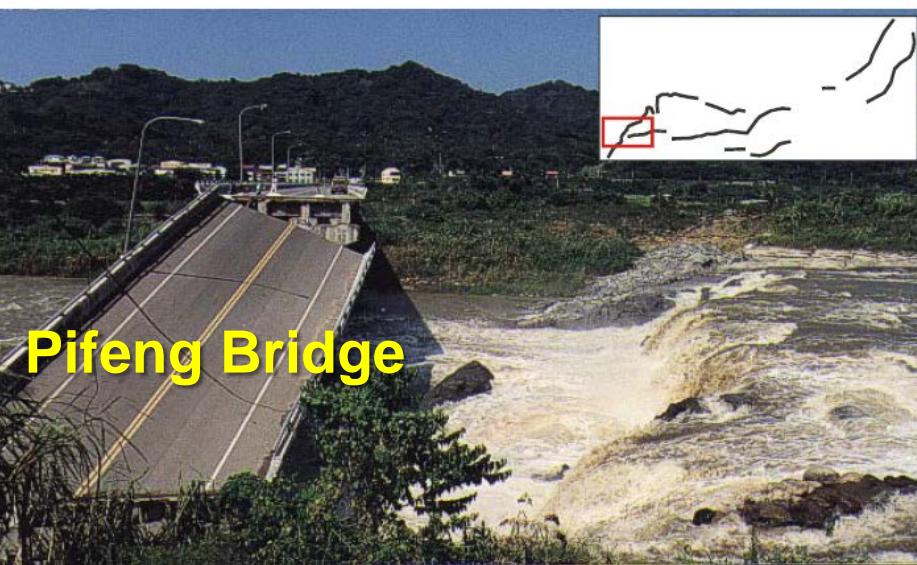
**NCREE  
South Lab**  
**(under construction)**

**NCREE  
(operation)**

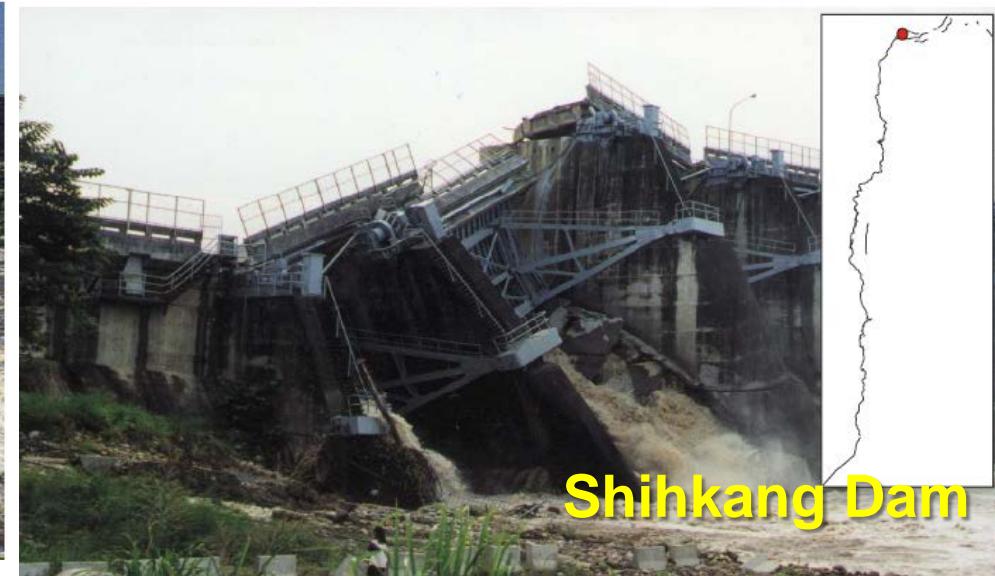


# Near-fault Effect on Building and Infrastructure

**NARLabs**



Pifeng Bridge



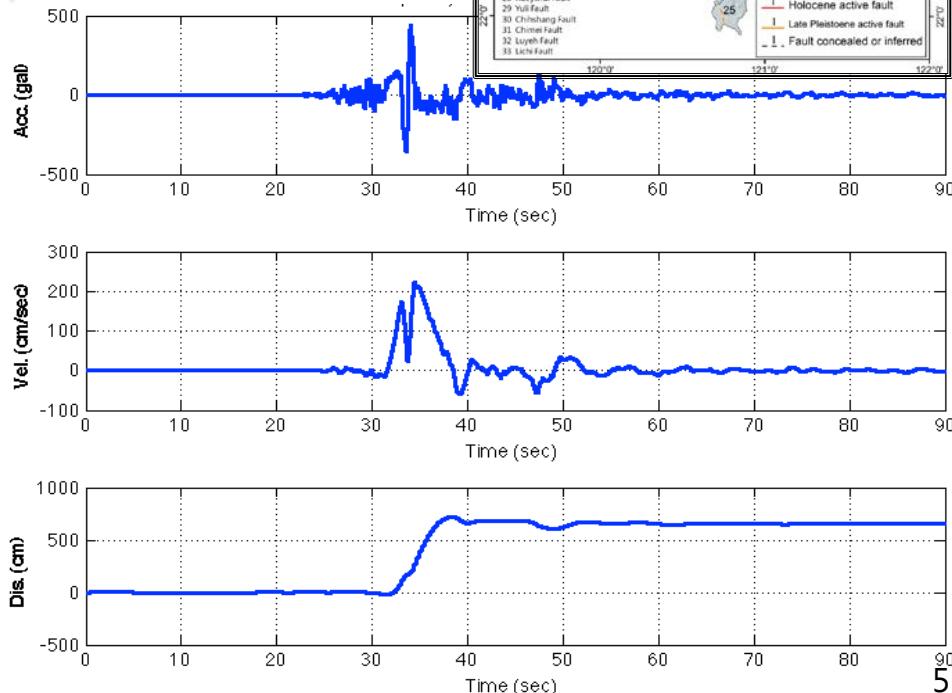
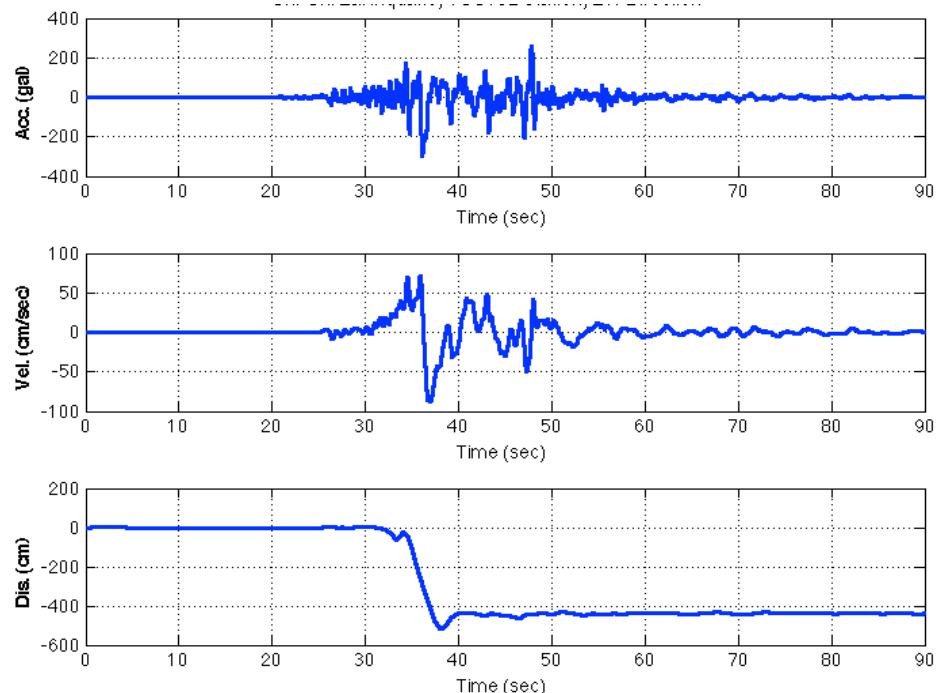
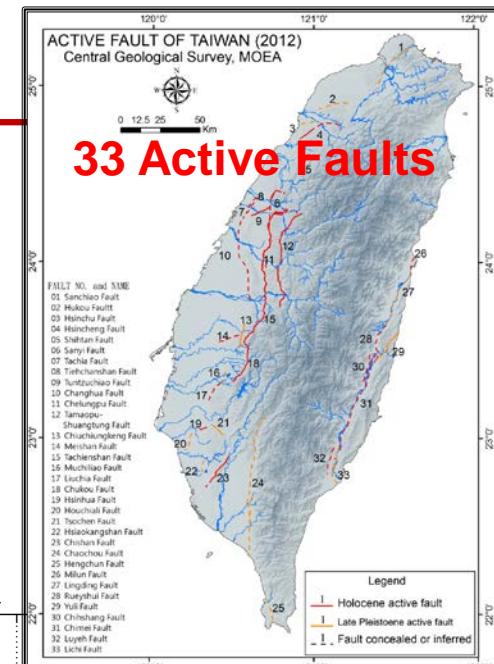
Shihkang Dam



# Characterizing Near-Fault Ground Motions

NARLabs

- Strong coherent dynamic long period pulse
- Permanent ground displacement



# NCREE South Laboratory

- MOU between NARL and NCKU signed in 2013
- Started building in 2014
- Complete in December, 2016
- Start operation in January, 2017



# Multi-hazard Research Park



Wind Tunnel & Mock-up  
Testing Laboratory, ABRI



Fire Experiment  
Center, ABRI



**NCREE  
South Lab**



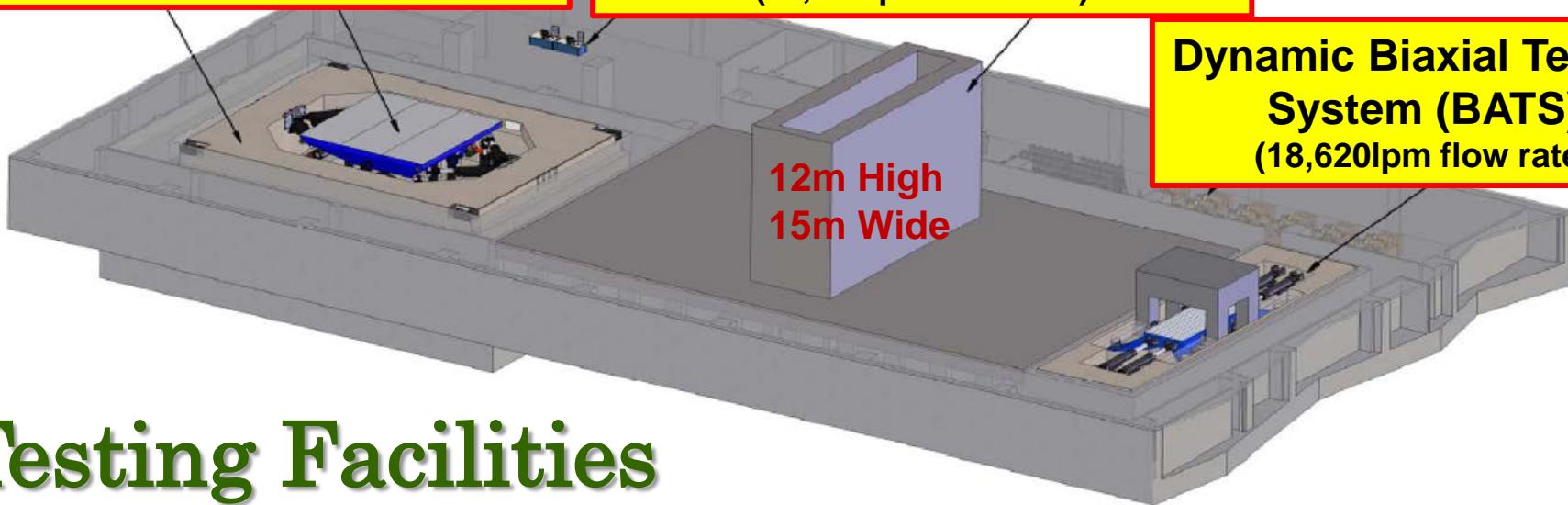
Fire Protection Laboratory, NCKU

中正南路  
二段

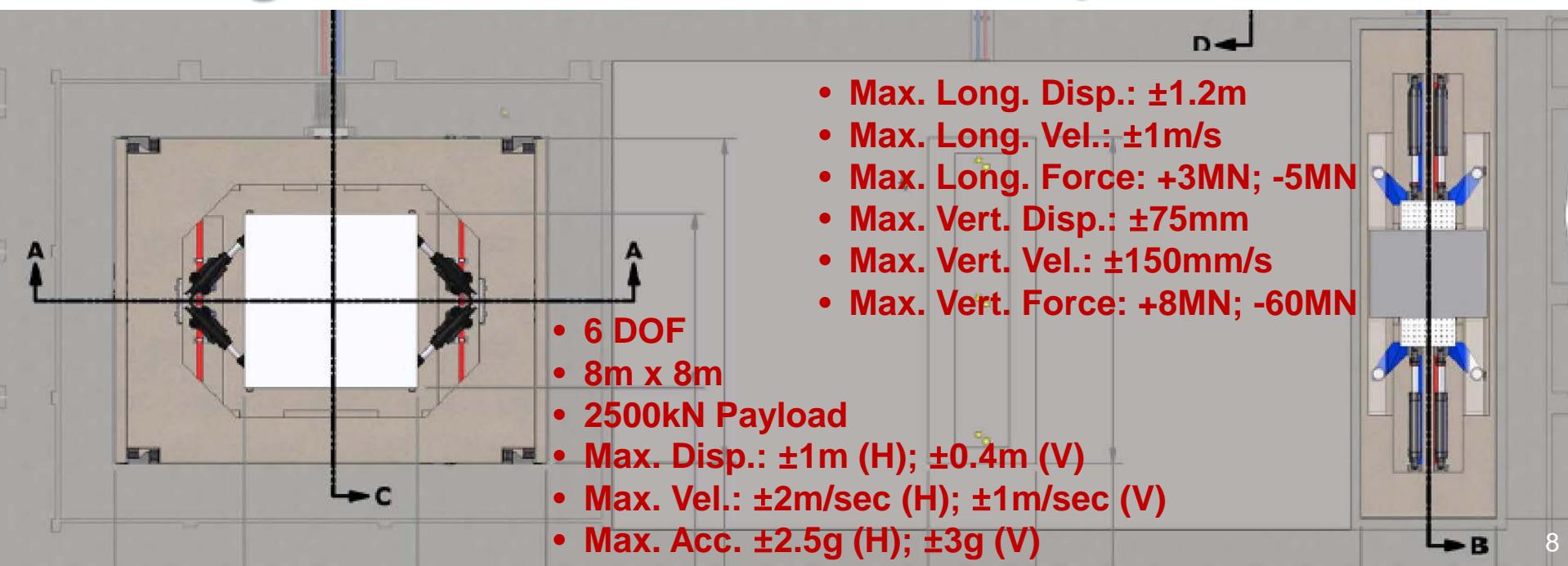
**Long-stroke High-velocity  
Shaking Table**  
(26,000lpm flow rate)

**Reaction Wall & Strong Floor**  
(11,000lpm flow rate)

**Dynamic Biaxial Testing  
System (BATS)**  
(18,620lpm flow rate)



## Testing Facilities



# Experimental Facilities



Commitment • Passion • Innovation

# Experimental Facilities

**NARLabs**

| Description     | Seismic System | Structural Actuators | BATS   |
|-----------------|----------------|----------------------|--------|
| Peak Flow (lpm) | 26,000         | 11,000               | 18,620 |



## » 8m X 8m Table

- Horizontal actuators (qty-4)
- Vertical actuators (qty-4)
- Static support actuators (qty-4)

## » BATS System

- 30MN vertical static actuator (qty-1)
- 5MN vertical dynamic actuator (qty-6)
- 4MN Hold-down actuators (qty-2)
- Longitudinal actuators (qty-4)

## » Hydraulic Power System

- Utilizes 5.5 Hydraulic Power Units (3500 lpm main flow)
- 6 banks of 12 x 160 liters of accumulation (11,520 liters)

## » Hydraulic Distribution System

- » Power Requirements (~2000 KVA)
  - HPU's: 1972 KVA
  - Controller: 5 KVA

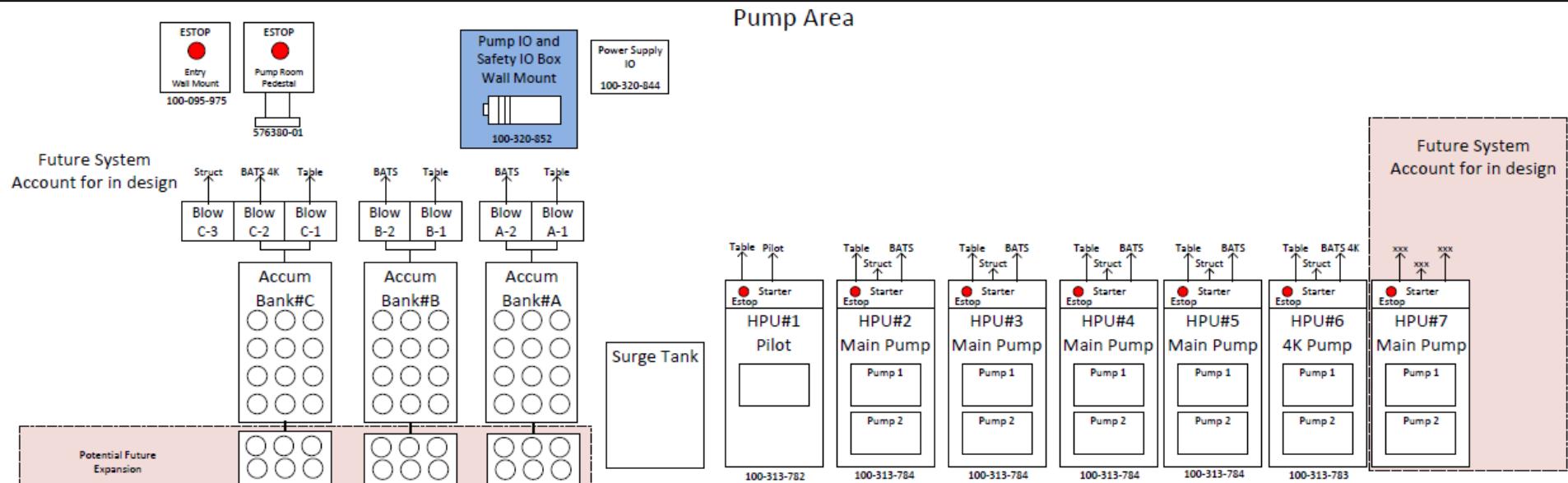
# Hydraulic Power



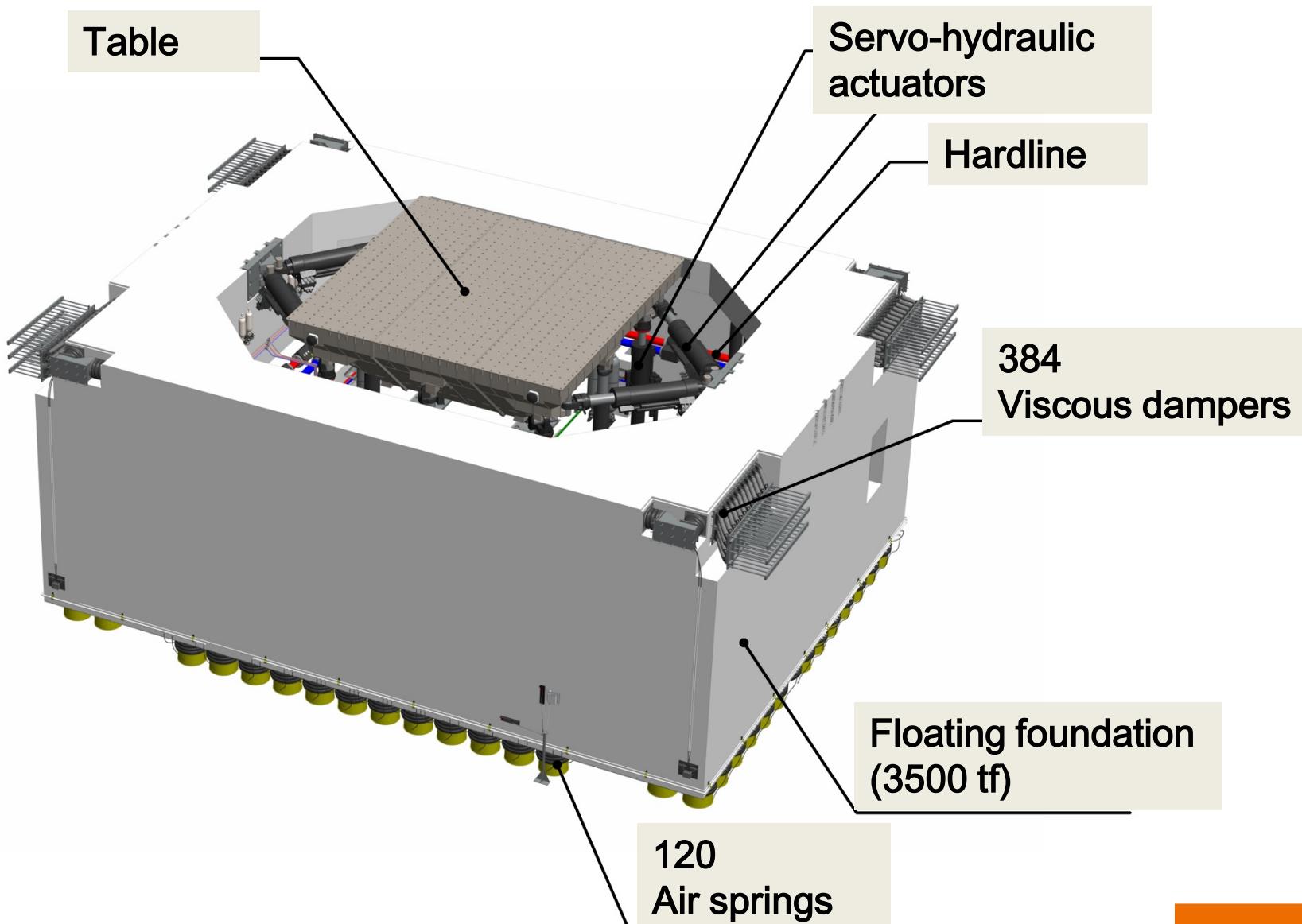
**MTS 507.200**  
**Hydraulic Power Unit**

# Accumulator Banks

# Layout



# Shaking Table



# Shaking Table

## Quantity 1 – 6 DOF 8m x 8m Seismic Table

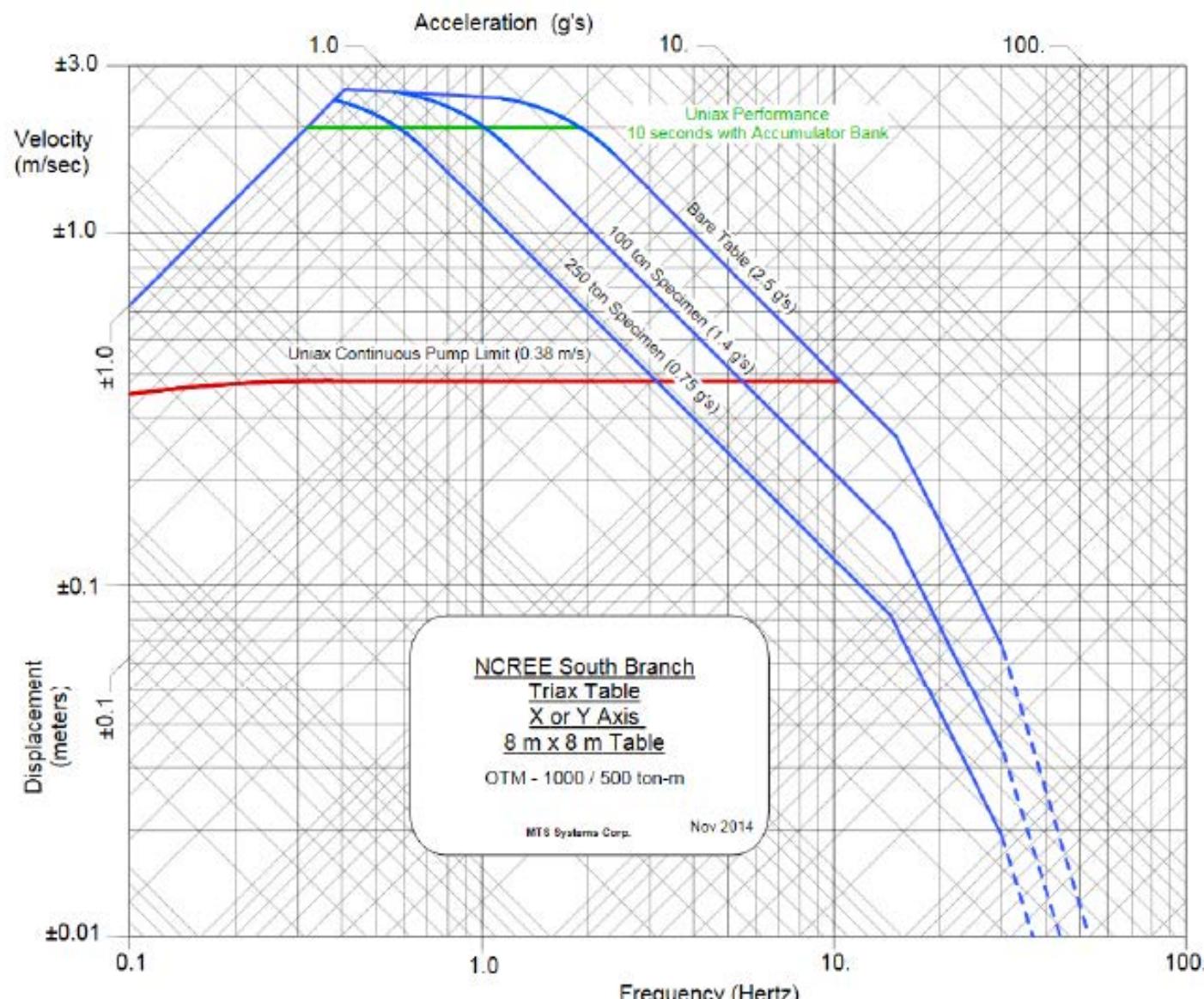
250 ton specimen mass at maximum acceleration

Frequency of operation: 0.1~30 Hz Uniaxial Sinusoidal waveforms

|                                | <u>X axis</u>                          | <u>Y axis</u>            | <u>Z axis</u>            |
|--------------------------------|--|--------------------------|--------------------------|
| Stroke:                        | ±1.0 m                                 | ±1.0 m                   | ±0.4 m                   |
| Velocity:                      | ±2.0 m/sec<br>(for 10 sec)             | ±2.0 m/s<br>(for 10 sec) | ±1.0 m/s<br>(for 20 sec) |
| Acceleration:<br>250t specimen | ±0.75 g                                | ±0.75 g                  | ±0.5 g                   |
| 100t specimen                  | ±1.4 g                                 | ±1.4 g                   | ±0.8 g                   |
| Bare Table                     | ±2.5 g                                 | ±2.5 g                   | ±3.0 g                   |
| <b>Overshooting Moment</b>     | 500 ton-m (biax)<br>1000 ton-m (uniax) |                          |                          |

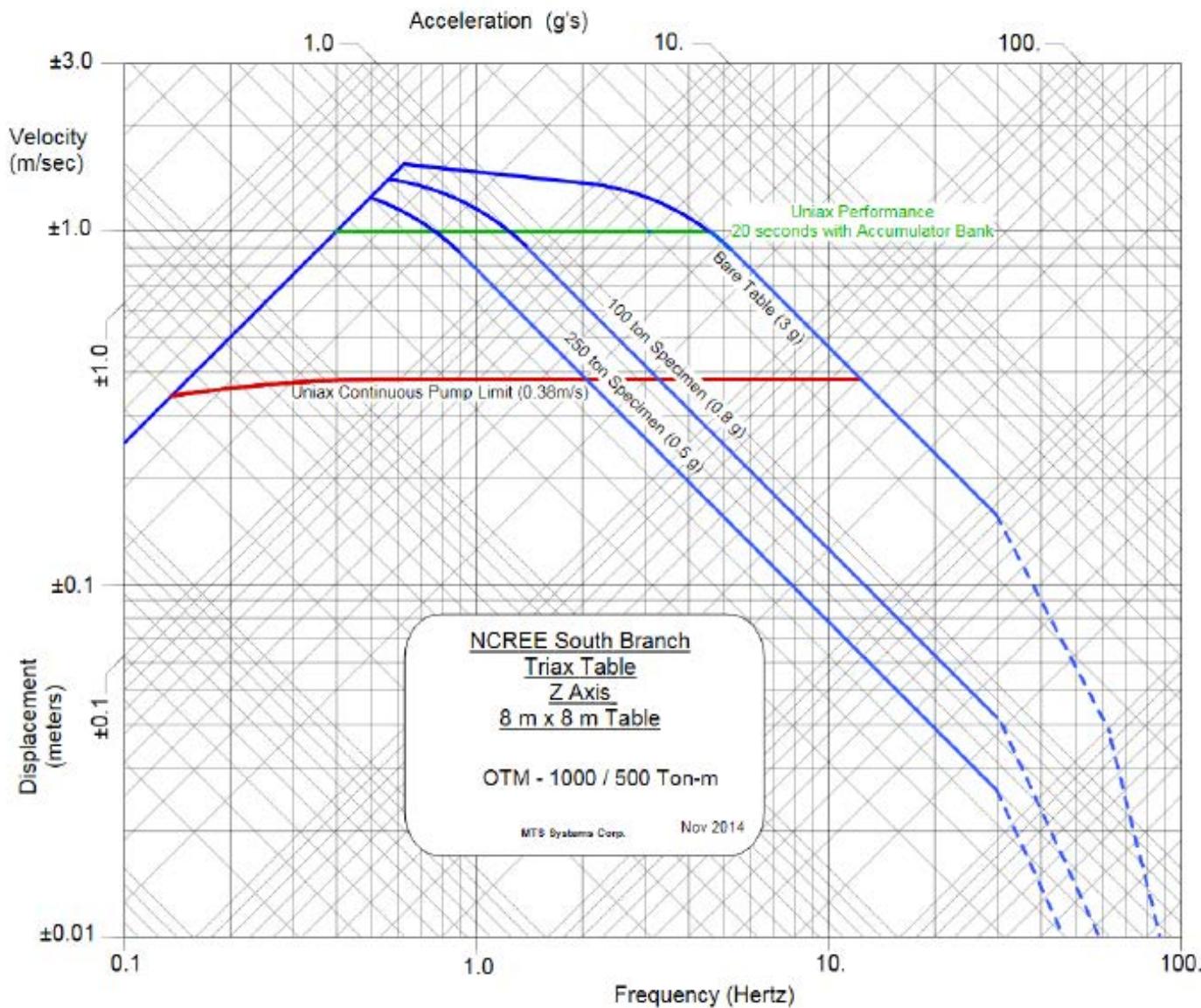
# Performance Curve (X&Y)

NARLabs

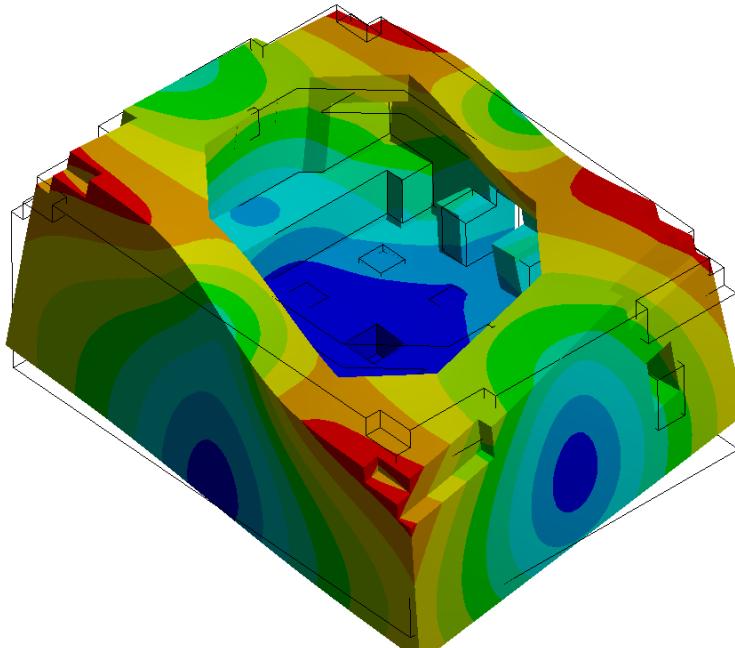


# Performance Curve (Z)

NARLabs

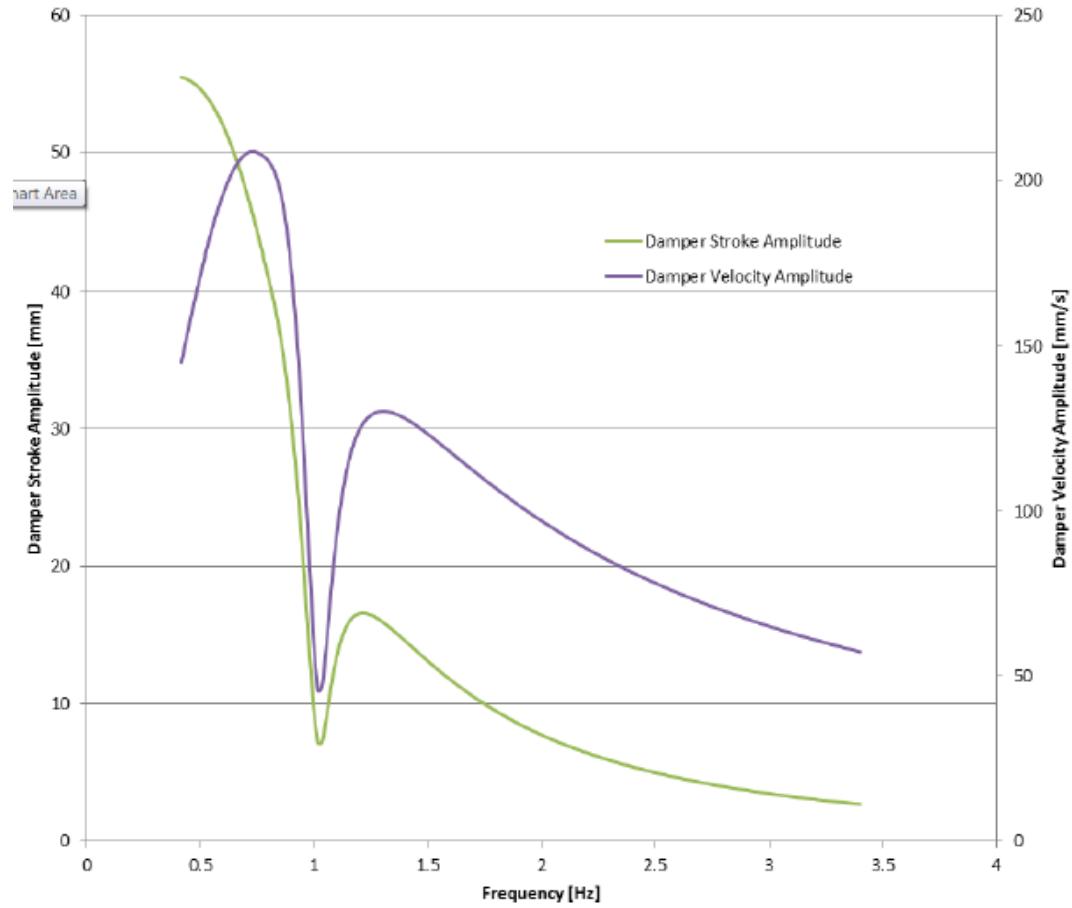


# Finite Element Analysis



Floating Foundation Modal Analyses

| Mode | Frequency (Hz) |
|------|----------------|
| 1    | 19             |
| 2    | 31             |
| 3    | 45             |



Harmony Motion Analyses

# Finite Element Analysis

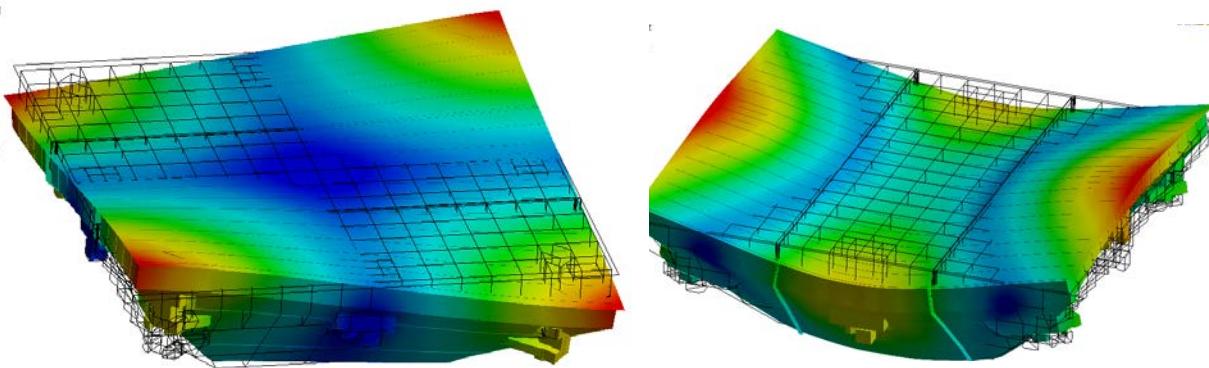
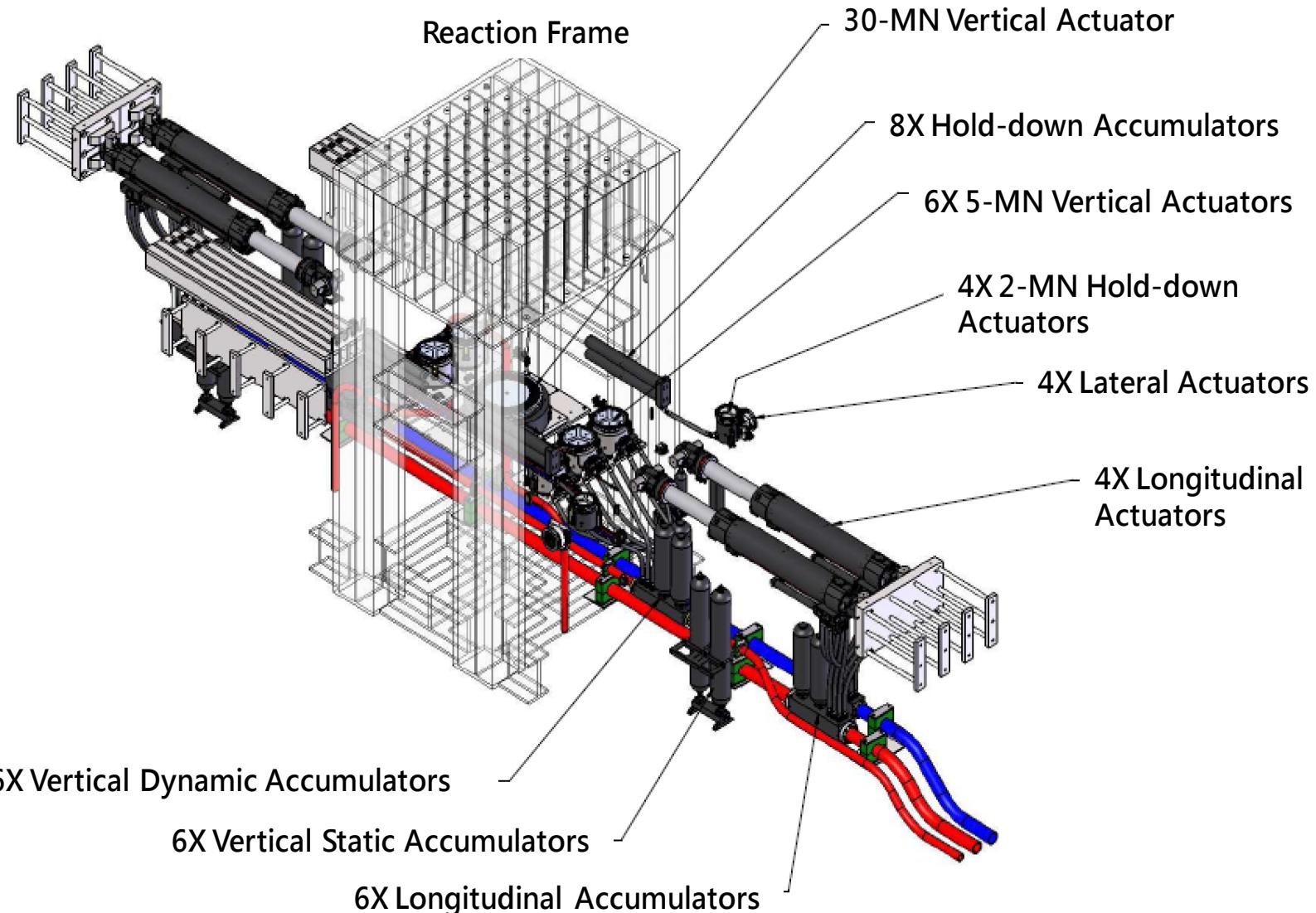


Table Modal Analyses

| Mode | Frequency (Hz) |
|------|----------------|
| 1    | 85             |
| 2    | 123            |
| 3    | 143            |

# BATS

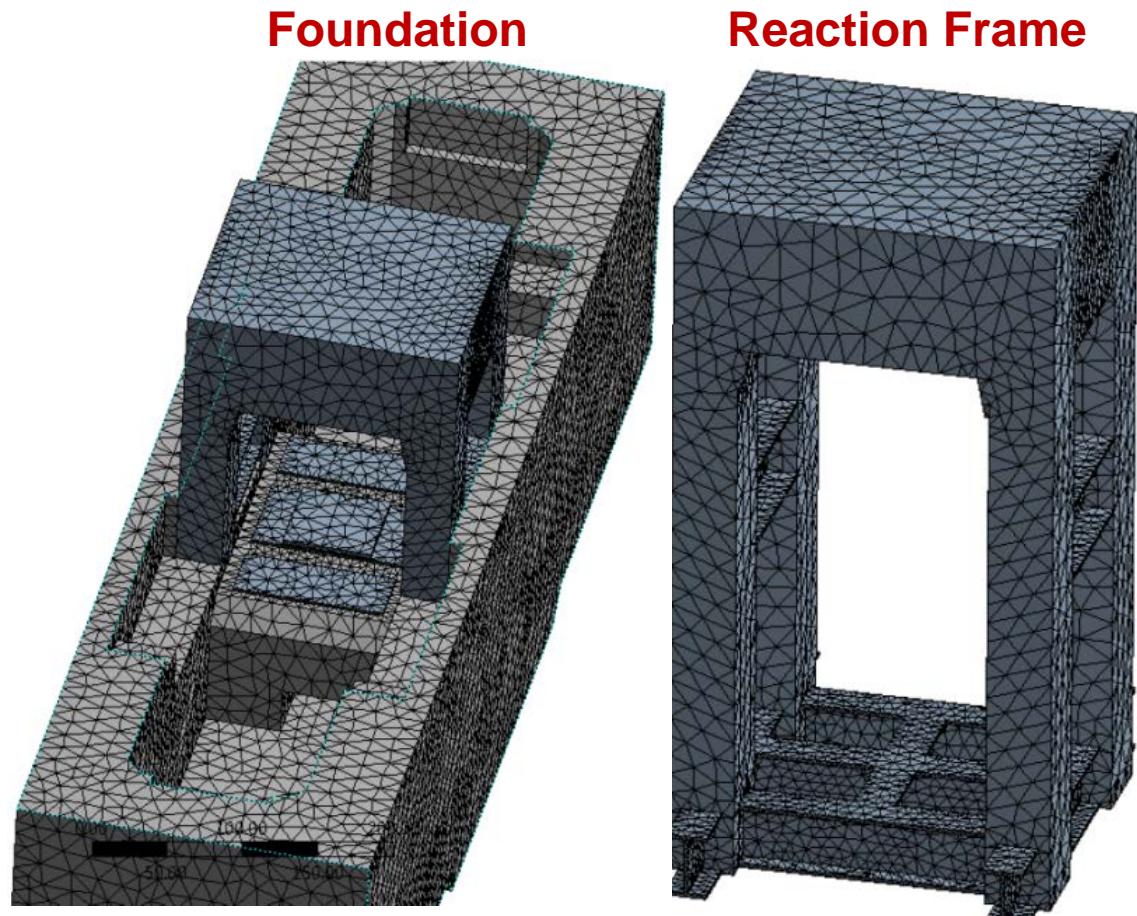


# BATS Capacity

| Description                      | MATS  | BATS  |
|----------------------------------|-------|-------|
| Main Pump flow lpm               | 3800  | 3500  |
| Accumulation Volume liters       | 3200  | 11520 |
| Peak flow rate lpm               | 8000? | 18620 |
| Constant Pressure Supply         | Yes   | Yes   |
|                                  |       |       |
| Vertical Force (static) +MN      | 30    | 30    |
| Vertical Force (dynamic) +MN     | 30    | 30    |
| Vertical Force (Total) +MN       | 60    | 60    |
| Vertical Tension Force -MN       | 4     | 8     |
| Vertical velocity +/- m/s        | 0.033 | 0.15  |
| Vertical displacement +/- mm     | 75    | 75    |
|                                  |       |       |
| Longitudinal Force +/- MN        | 3.9   | 3.9   |
| Longitudinal velocity +/- m/s    | 0.25  | 1     |
| Longitudinal displacement +/- mm | 1200  | 1200  |
|                                  |       |       |
| Lateral Force +/- MN             | 3.9   | -     |
| Lateral velocity +/- m/s         | 0.025 | -     |
| Lateral displacement +/- mm      | 100   | -     |
| Maximum Specimen height m        | 4+    | 4+    |

# Finite Element Analysis

- To ensure BATS's dynamic performance
- Two static loading cases:
  - (1) 60 MN vertical compressive force
  - (2) 55 MN vertical compressive force and 3900 kN longitudinal force
- Maximum principle stress at interface between foundation and reaction frame < 30 MPa
- Maximum principle stresses of cross beam are 246 MPa for case 1 and 226 MPa for case 2



| Material | Young's Modulus (GPa) | Poisson's Ratio | Density (kg/m <sup>3</sup> ) |
|----------|-----------------------|-----------------|------------------------------|
| Steel    | 200                   | 0.3             | 7850                         |
| Concrete | 30                    | 0.18            | 2300                         |

# Current Status (July 28)

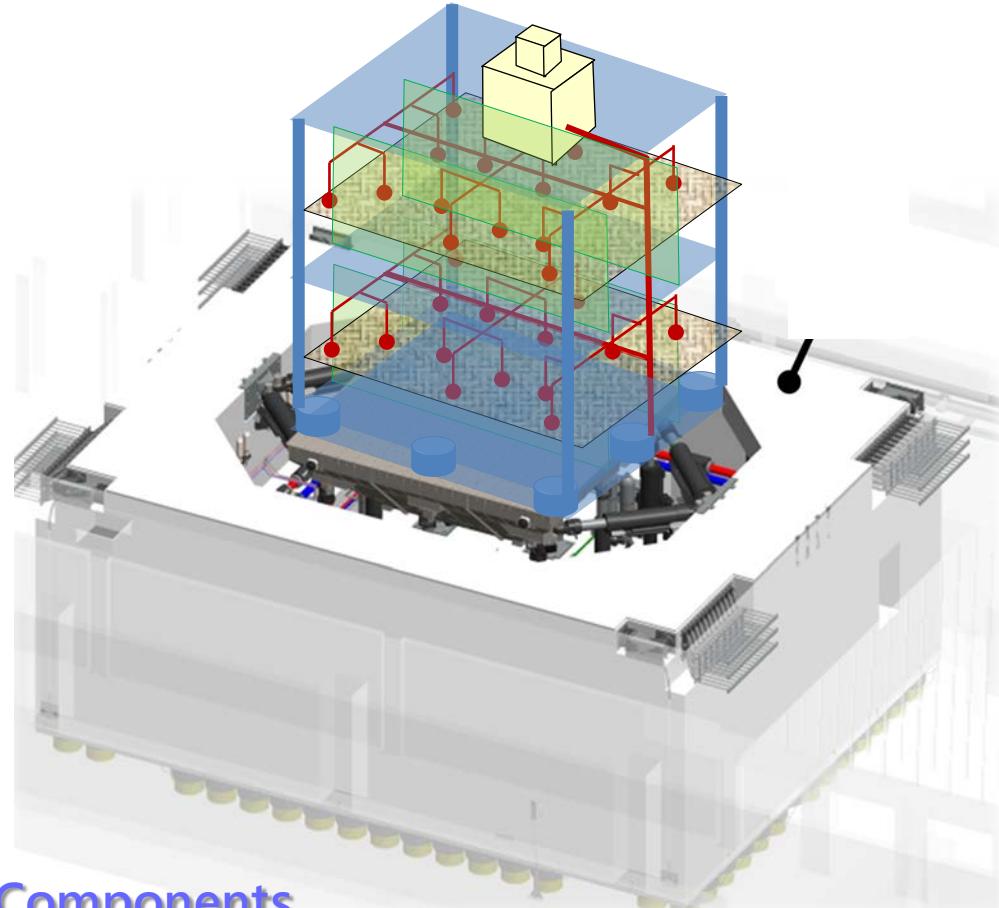
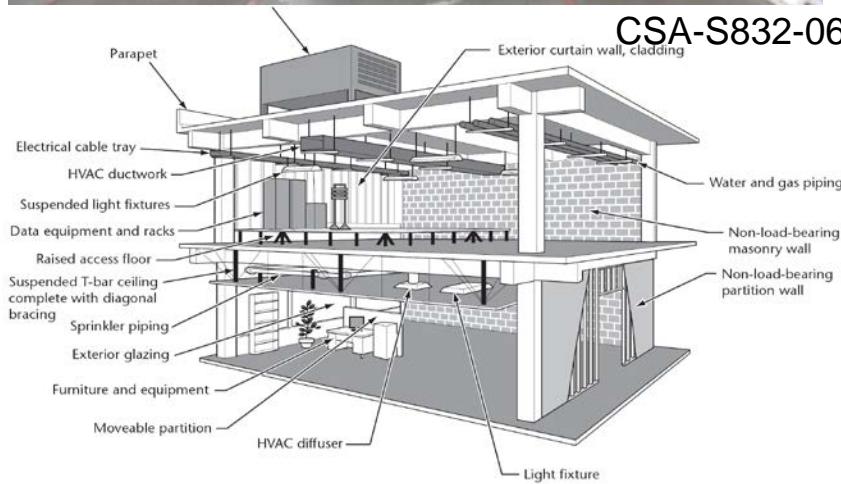


# Potential Applications

## Seismic Testing for Operational and Functional Components Located at High-rise Buildings



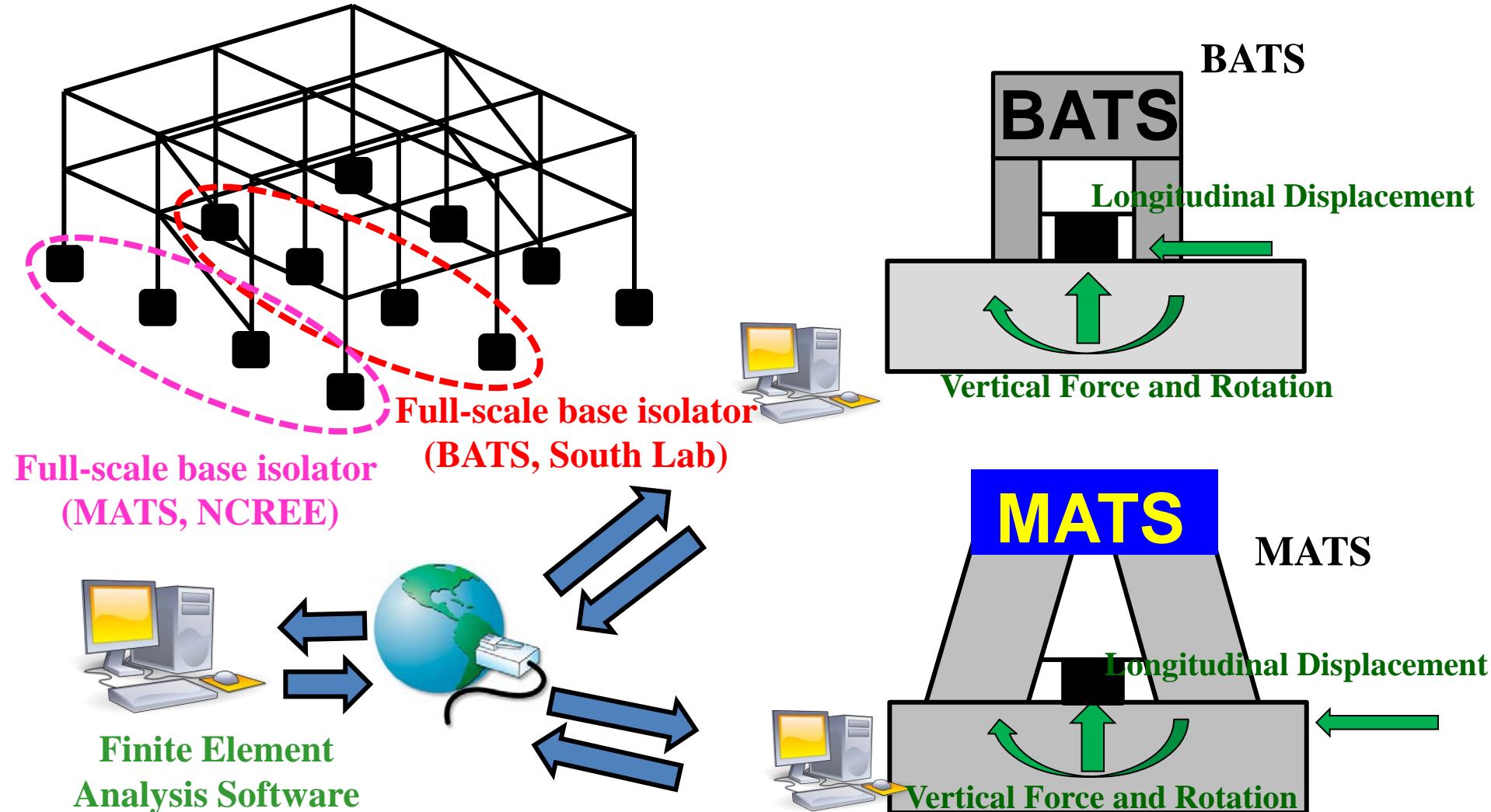
CSA-S832-06



OFCs, Operational and Functional Components

# Potential Applications

## Distributed Hybrid Simulation for Base-isolated Buildings





# Thank You for Your Attention

