Total Project Planning – Case Study 1: PCI Building

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Presentation Outline

- Overview of Projects
- Research Conceptual Phase
- Proposal Planning Phase
- Project Pre-Test Phase
- Project Testing Phase
- Project Post-Test Phase

Overview of Projects

➢ Project 1: Development of a Seismic Design Methodology for Precast Concrete Diaphragms (DSDM)

- **Pre-NEES/GOALI**
  - 2005-2009
- **$1.5M Funds**
  - $467K GOALI
  - $101K NEES
  - $415K CPF
  - $365K PCI
  - $168K Industry
- **$1.1M Other**
  - $335K NEES O&M
  - $583K In-Kind
  - $190K University

Overview of Projects

➢Project 2: NEESR-Inertial Force-Limiting Floor Anchorage Systems for Seismic Resistant Building Structures (IFAS)

- **NEESR**
  - 2011-2015
  - $1.2M NEESR Grant
- **$790K Other**
  - $312K NEES O&M
  - $ 50K NEES Supp.
  - $ 50K PCI/PCI West
  - $ 58K Industry
  - $320k Univ./Ext. Student Support

Objective and Deliverables

➢Project 1: DSDM (GOALI/Pre-NEES)

- **Deliverable**: A new seismic design methodology for precast concrete diaphragms.
- **Research**: Evaluate existing designs for typical construction.
- **Outcome**: New design provisions approved for inclusion in ASCE 7-16 and Part 3 of the 2015 NEHRP Provisions.

➢Project 2: IFAS (NEESR)

- **Deliverable**: Demonstrate an innovative system to reduce inertial forces in building structures during earthquakes.
- **Research**: Develop a new seismic-resistant system.
- **Outcome**: Successful demonstration of a system prototype.

Phase 1:

Research Conceptual Phase

➢ Role of the Shake Table Testing:

- What key scientific role in the overall project does the shake table test serve?
  - Sketch out the project w/out the shake table test, or with a smaller shake table test to justify the need for the test.

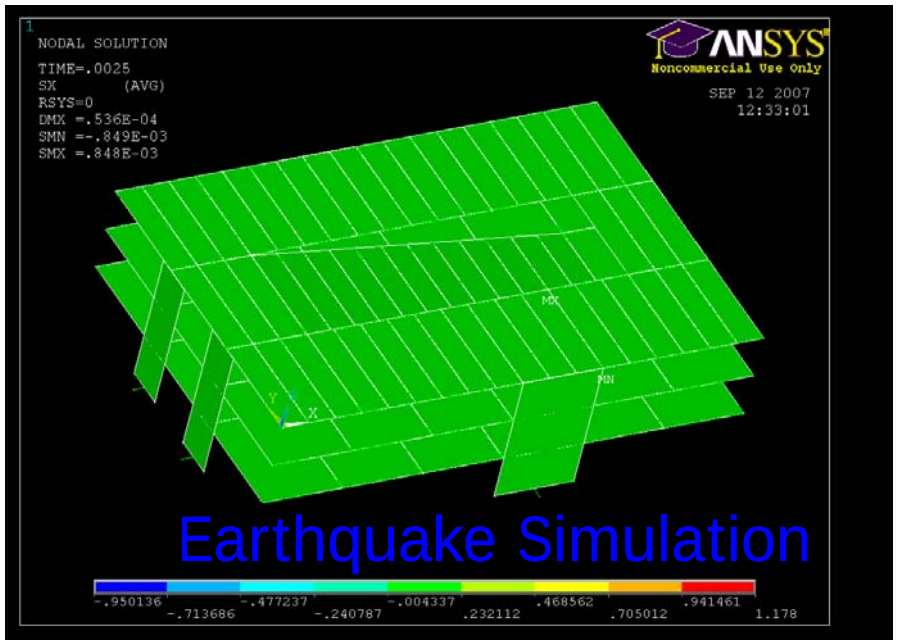
- What is the objective of the shake table testing?
  - Name the specific data products the testing will produce, and how this will be used in the project and/or future research.

Role of Shake Table Testing

Conceptual Phase

➢Project 1: DSDM (GOALI/Pre-NEES)

- **Rationale for shake testing**:
- Boundary Conditions of a distributed system such as a diaphragm do not lend themselves to concentrated actions (e.g. from actuators)
- Finite Element Analysis can produce realistic boundary conditions, but *calibrated* models are required for code change.



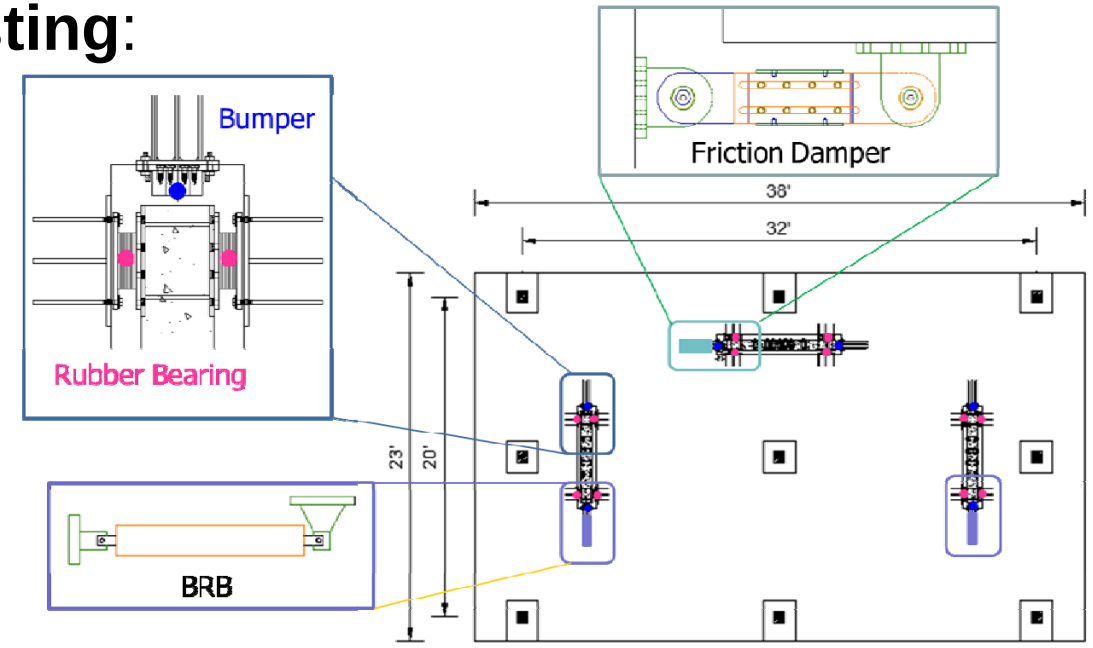
- **Rationale for NEES@UCSD Shake Table**:
  - Scaling of precast elements, reinforcement and connectors has lower limit of 1/3rd to ½ scale before testing details become “toys”
  - Observed diaphragm failures in precast diaphragms have historically occurred in longer span floor decks

Role of Shake Table Testing

Conceptual Phase

➢Project 2: IFAS (NEESR)

- **Rationale for shake testing**:
  - A new concept is fine in abstract but construction industry is conservative and requires physical demonstration for proof of concept.
  - A key aspect of proof of concept for the prototype system is its ability to handle articulation of the three dimensional structure.

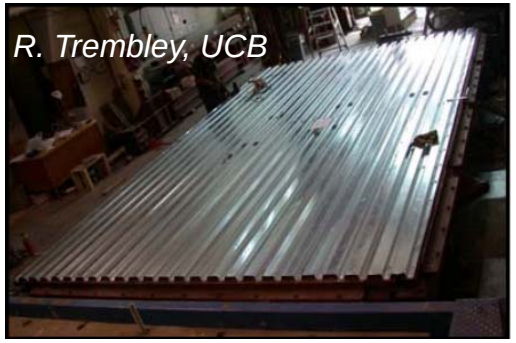


- **Rationale for NEES@UCSD Shake Table**:
  - The inertial force tributary to an isolated lateral force resisting system (LFRS) element (as well as the P-Δ effect) is based on a significant floor area
  - A key aspect of the system is the participation of the gravity columns as the floor system becomes partially decoupled from the primary LFRS elements.

Role of Shake Table Testing

Conceptual Phase

- What is the appropriate testing scheme for the project?
  - Laboratory-type (isolated portion, slice or component)
  - Structural System



Phase 2:

Proposal Planning

- **After drawing up your conceptual research plan, contact UCSD:**
  - Is the planned test realistic?
  - Is the draft budget appropriate?
  - Is the required shared use available?
  - Is the needed instrumentation available?

- **Both projects presented here involved a UCSD co-PI**

Research Team Composition

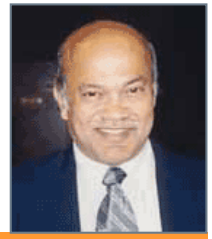
Proposal Planning

DSDM

University of Arizona
Robert Fleischman
Consortium Leader

University of California
San Diego
Jose' Restrepo, PI

Lehigh University
Clay Naito, PI
Richard Sause, Co-PI



Industry Liaison
S. K. Ghosh, Co-PI
DSDM Task Group

Producer Members

Producer Members

Industry Advisory Panel

Dichuan Zhang and Ge Wan, University of Arizona
Liling Cao, Rui Ren, Wesley Peter, Lehigh Univ.
Matt Schoettler, Carlos Blandon, Andrea Belleri, UCSD
Mario Rodriguez, Humberto Cabrera Roa, UNAM

Research Team Composition

Proposal Planning

IFAS

Academic collaborators

The University of Arizona

Dr. Robert Fleischman, PI
Zhi Zhang, Ph.D. student
Ulina Shakya, Ph.D. student
Anshul Agarwal
Austin Houk, REU
Scott Kuhlman, REU
Mackenzie Lostra, REU
Daniel Lizarraga, REU
Fernando Gastelum, REU
Patrick Hughes, REU
Ziyi Li, REU

University of California, San Diego

Dr. Jose Restrepo, Co-PI
Arpit Nema, Ph.D. student
Gabriele Guerrini
David Duck
Nelson Angel
Armita Pebdani
Steve Mintz, Ph.D. student

Lehigh University

Dr. Richard Sause, Co-PI
Georgios Tsampras, Ph.D. student
Alronil Pacheco, REU (San Jose State University)

Nazarbayev University

Dr. Dichuan Zhang

University of Rome

Dr. Giorgio Monti
Dr. Alessandro Scodeggio

Technical University of Bari

Dr. Beppe Marano
Dr. Giuseppe Quaranta

Seismic Design Consultants

Tipping Mar

David Mar

Rutherford + Chekene

Joseph Maffei
Saeed Fathali

Joe Maffei Association

Joseph Maffei

K12 partner

Utterback Middle School

Gricelda Meraz

Proposal Planning

➢ Practical Considerations:

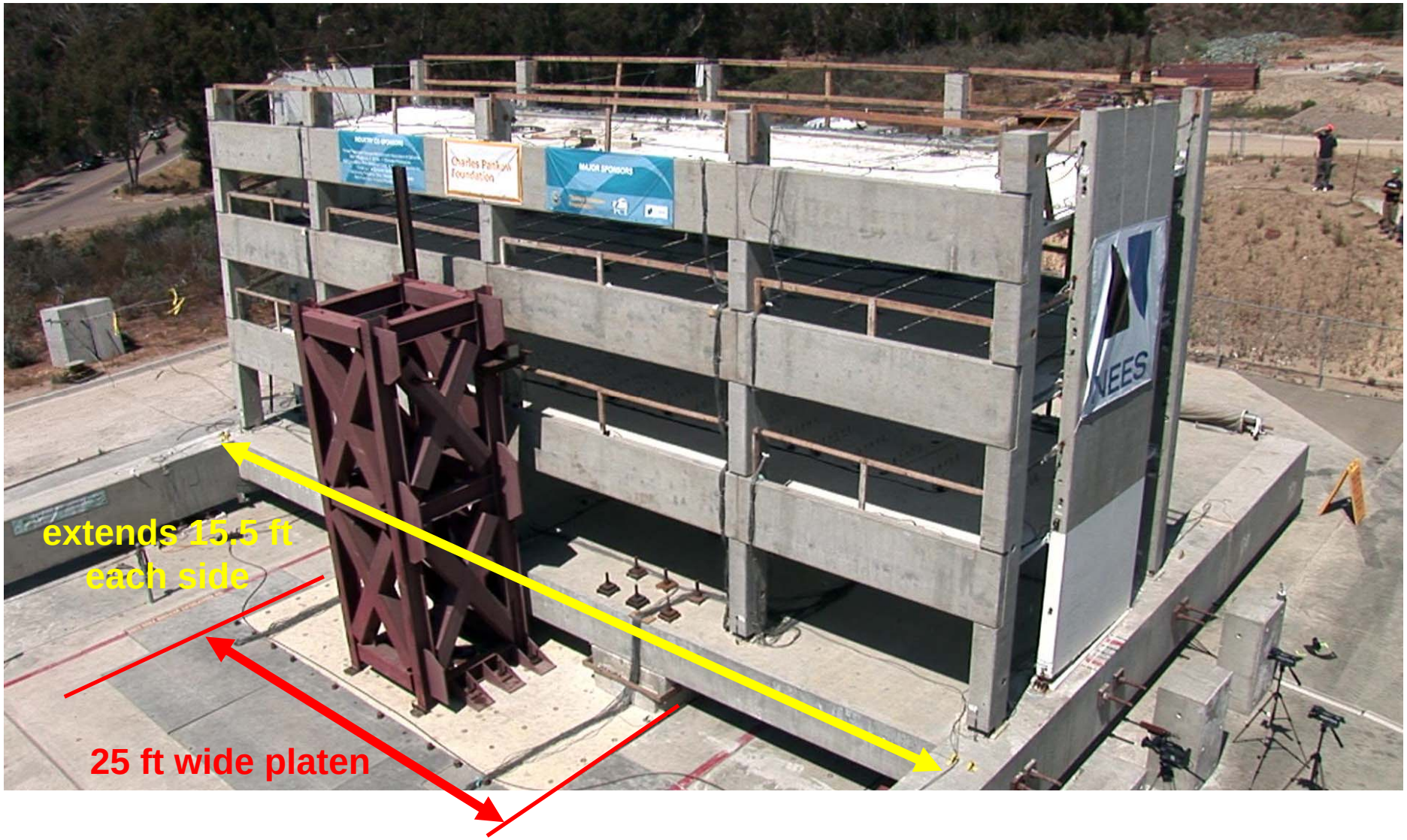
- What is the needed extent of the specimen (structural system, building slice, component, etc.) to obtain the behavior desired for study?

- What are the lower bound limitations on scaling of elements to still produce the desired behavior?

- How do the answers to the above two questions square with the geometry and the capacity of the UCSD NHERI Shake Table?

Practical Considerations

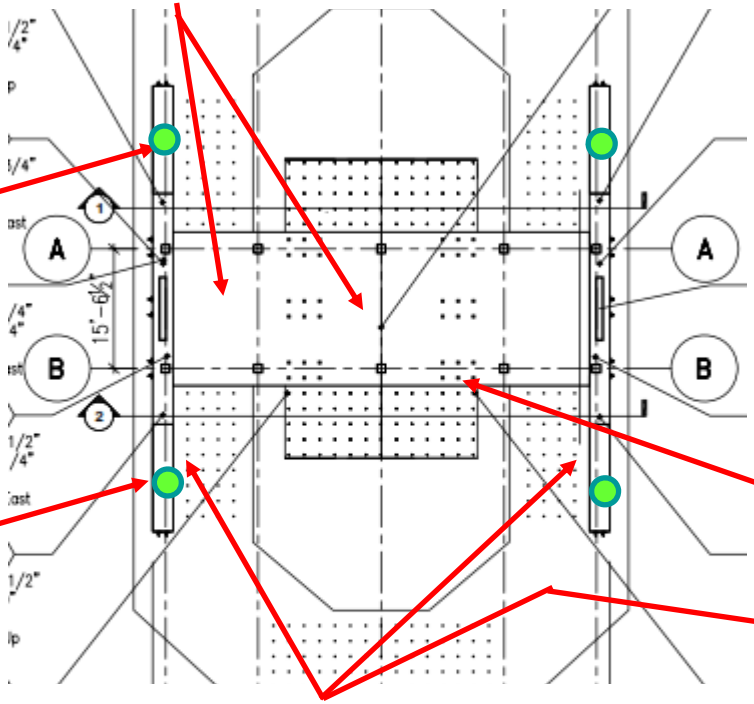
Proposal Planning



Practical Considerations

Proposal Planning

7” thick, in situ concrete topping
for stiff and strong diaphragm



outriggers to provide counterbalance
weight to resist overturning… sliding on

pre-compressed hydrostatic slider bearings
on mirrored-finish stainless-steel plates

Proposal Planning

- **Budget Considerations:**
  - What is the target budget range of the overall proposal?
  - What portion of the overall can be $ number can be realistically apportioned to the shake table test?
  - What industry partners, champions or other funding sources can be identified to rely on for contributions, in-kind engineering, materials, components, erection, construction, etc.?

Industry Partnerships

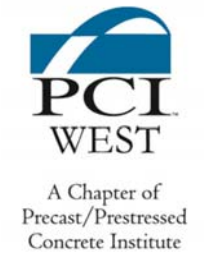
Proposal Planning

DSDM

- $415K CPF
- $365K PCI
- $168K Industry
- $583K In-kind

Industry Partners: NEESR Shake Table Test

$160K



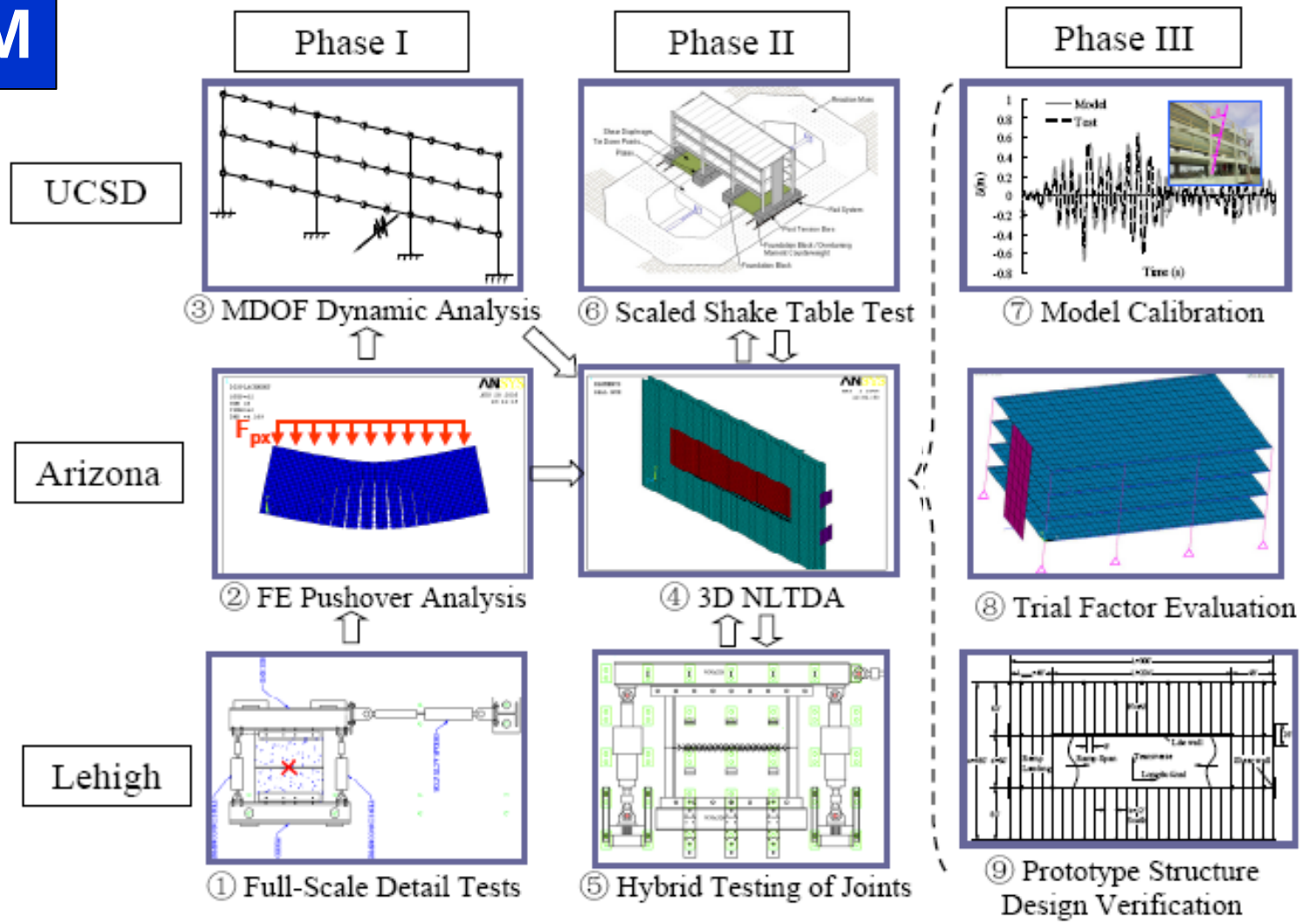
Proposal Planning

- **Scheduling shake test within project duration**
  - Early (Year 1)– Pros and Cons
    - **Pro**: get to use shake table test data for most of the project
    - **Con**: not much planning, not much knowledge gained prior
  - Late (Year 3) –
    - **Pro**: a lot of planning time, a lot of knowledge gained prior
    - **Con**: not much use of data during project
  - Middle (Year 2)
    - Often the best compromise – able to do gain sufficient knowledge yet have time to utilize findings
  - 3 year + 1 cost NCE – helps for these projects

Shake Table Test Scheduling

Proposal Planning

DSDM



Phase 3:

Project Pre-Test Phase

- **Your research team must multi-task 1st Year:**
  - Obtain research findings needed to inform the shake table testing, including any component tests
  - Preliminary design shake table specimen
  - Perform analytical predictions to maximize odds shake table testing will produce desired results
  - Design and detail specimen; create drawings
  - Source materials including donations
  - Schedule specimen fabrication, erection, demolition
  - Create instrumentation plan

Project Pre-Test Phase

➢ Logistics

- Trades - What tasks can be handled by the UCSD NHERI staff and what requires local contractors (riggers, demolition, special fabrication, etc.)?
- Manpower – REUs, budget or locate university or external funds for graduate students to spend extended time at site
- Communication - In the lead-up year to testing, establish regular web-conferences for shake table test planning (weekly for internal group, as needed with UCSD staff)

Logistics: Planning Meetings

Pre-Test Phase

DSDM Task Group Final Pre-Test Meeting, La Jolla CA

Logistics: Planning Meetings

Pre-Test Phase

NEESR IFAS Research Meeting #3 at R&C Offices

Payload Projects

Pre-Test Phase

System Identification: Belleri, Restrepo, Conte

Equipment Isolation Systems
Henri Gavin, Duke

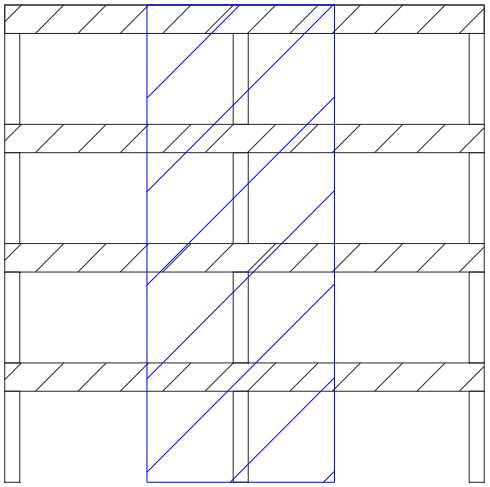
GPS Building Monitoring
Yehuda Bock, Scripps

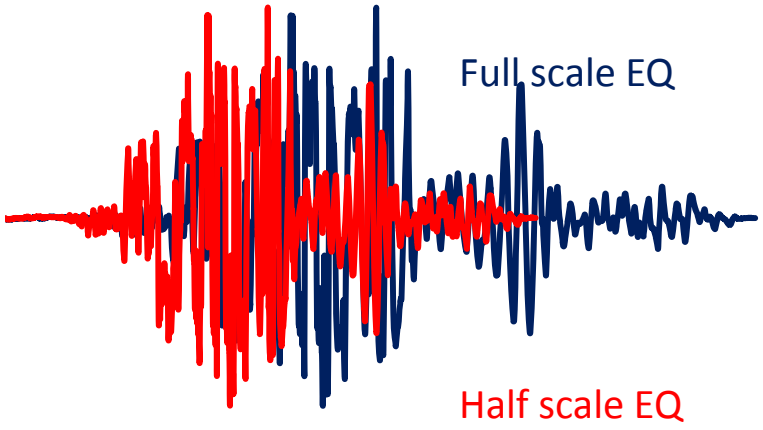
Specimen Design

Pre-Test Phase

➢ IFAS Half-Scale Specimen

- Involves design of system under study & structure
- Faithful similitude from evaluation structure was maintained on all parameters except two:
  1. Slab thickness was not scaled
  2. Floor-to-floor height was “under-scaled”

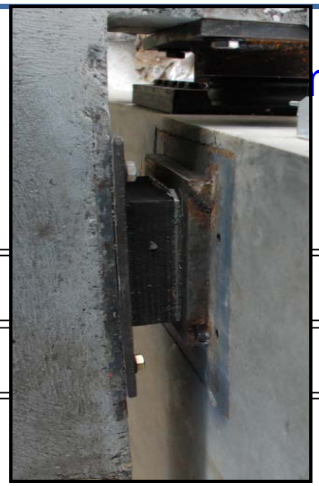




Specimen Design

Pre-Test Phase

IFAS Structure



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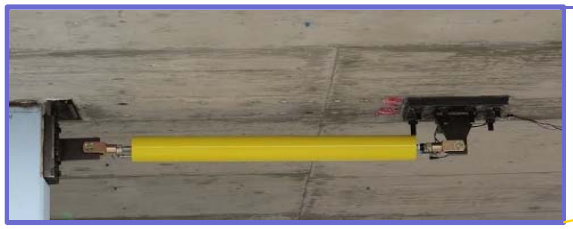
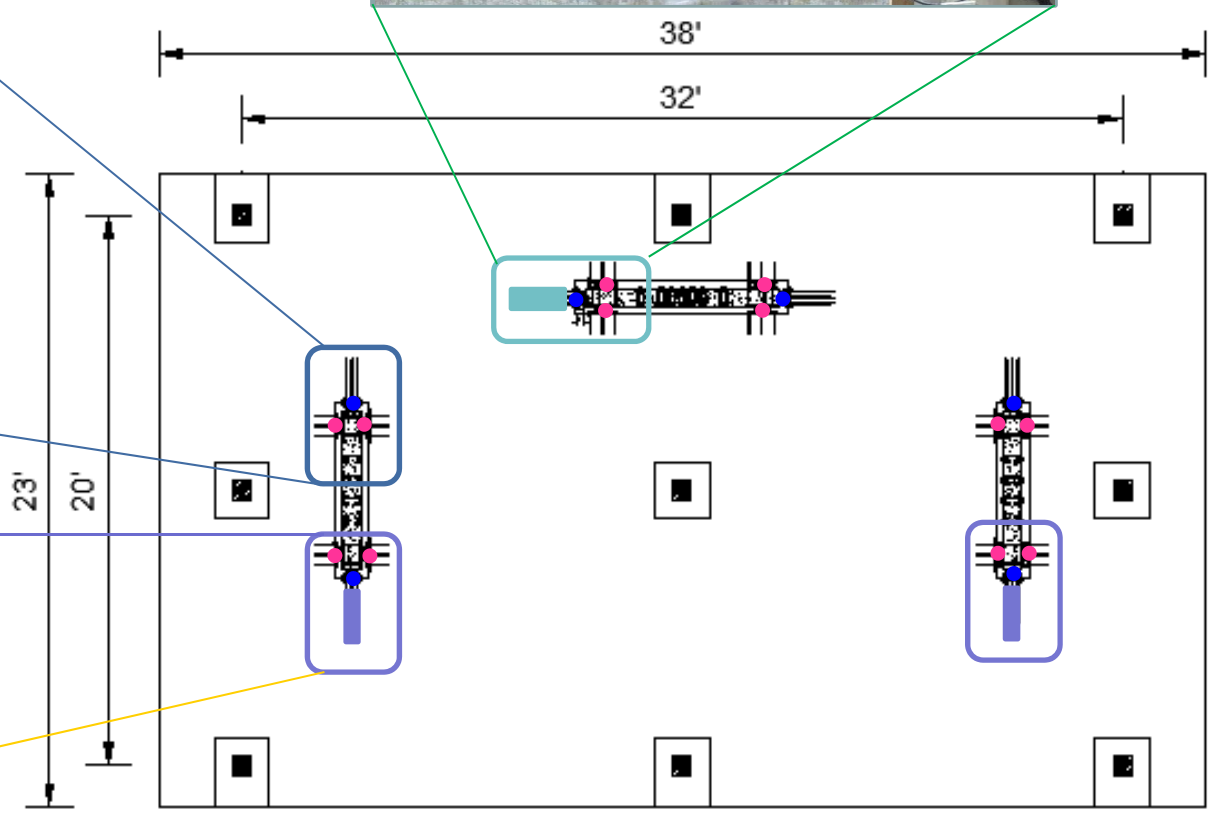
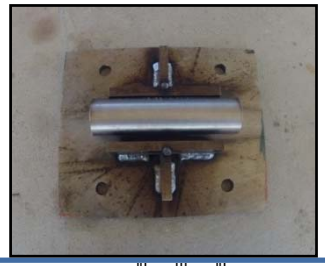
Rubber Bearing

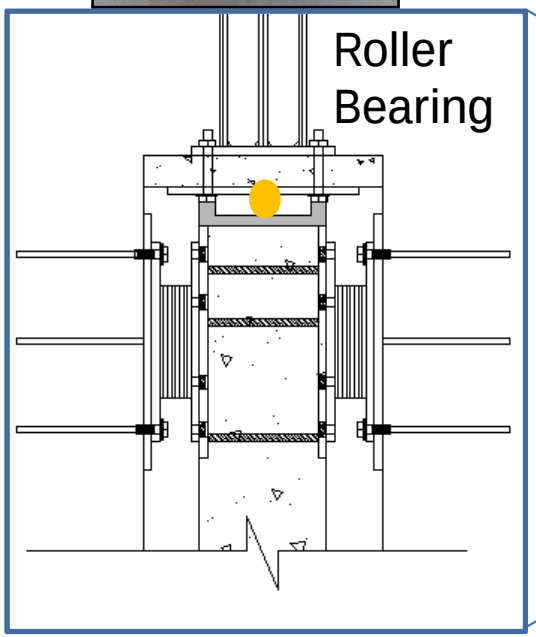


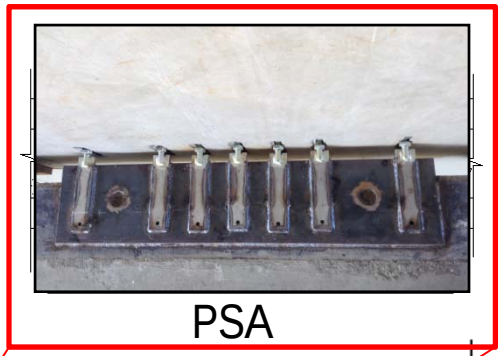


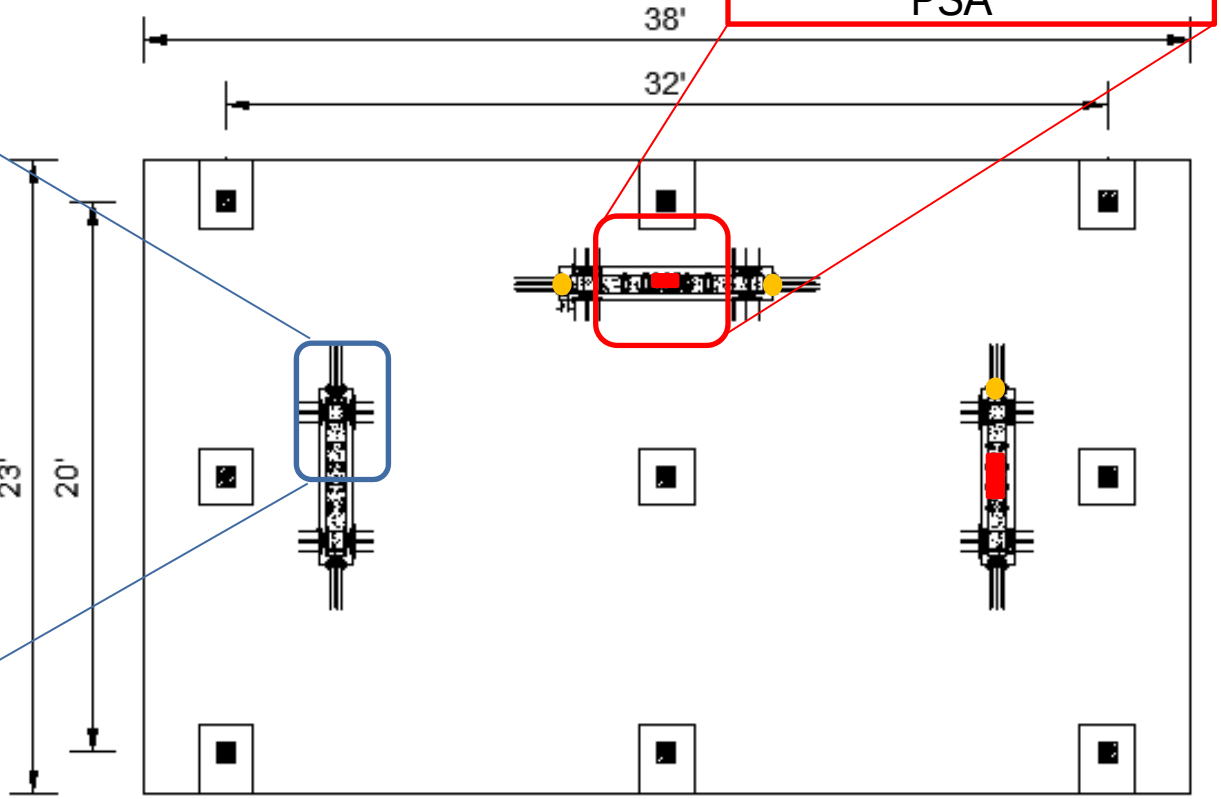
Specimen Design

TRAD Structure



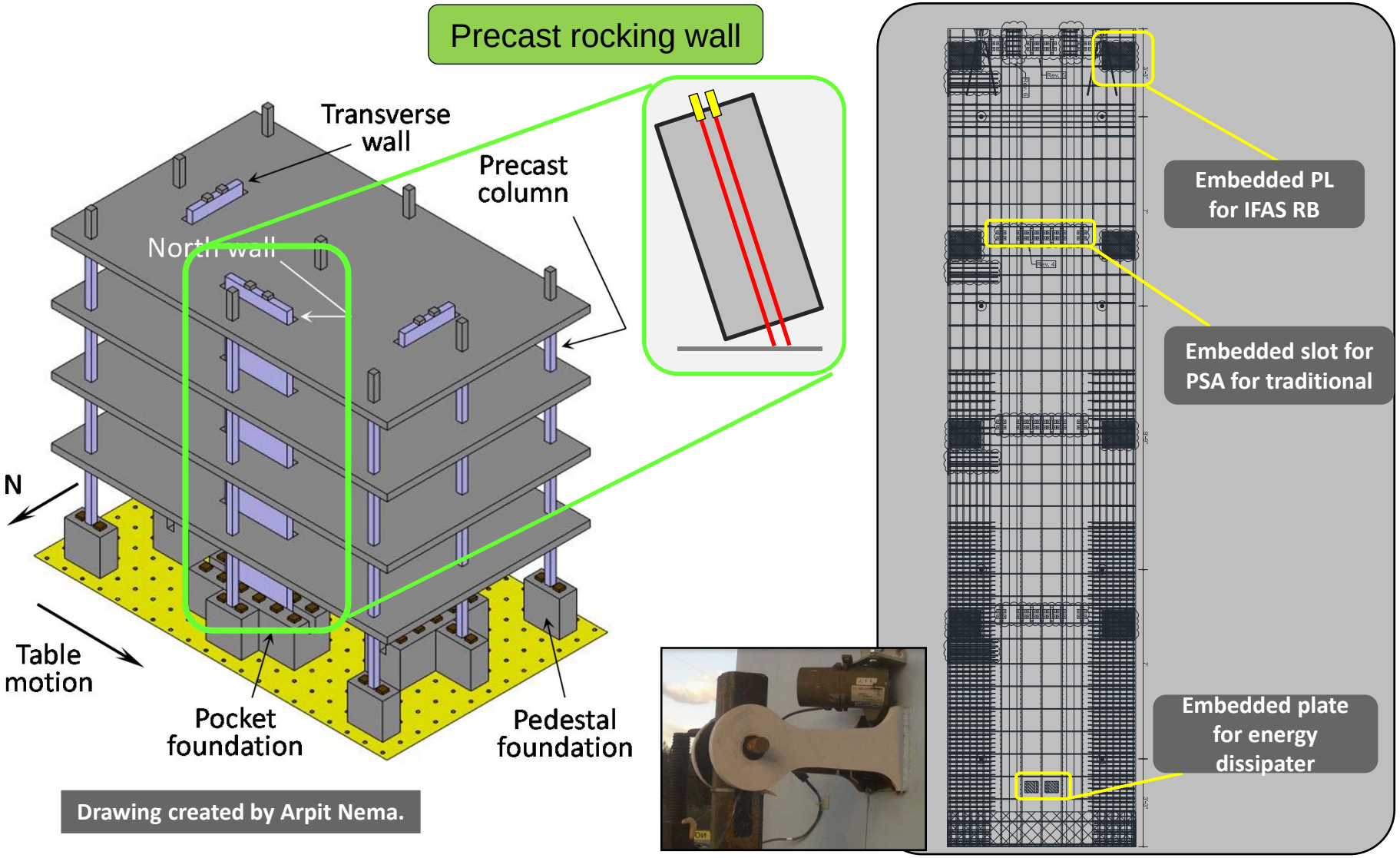






Test Repeatability

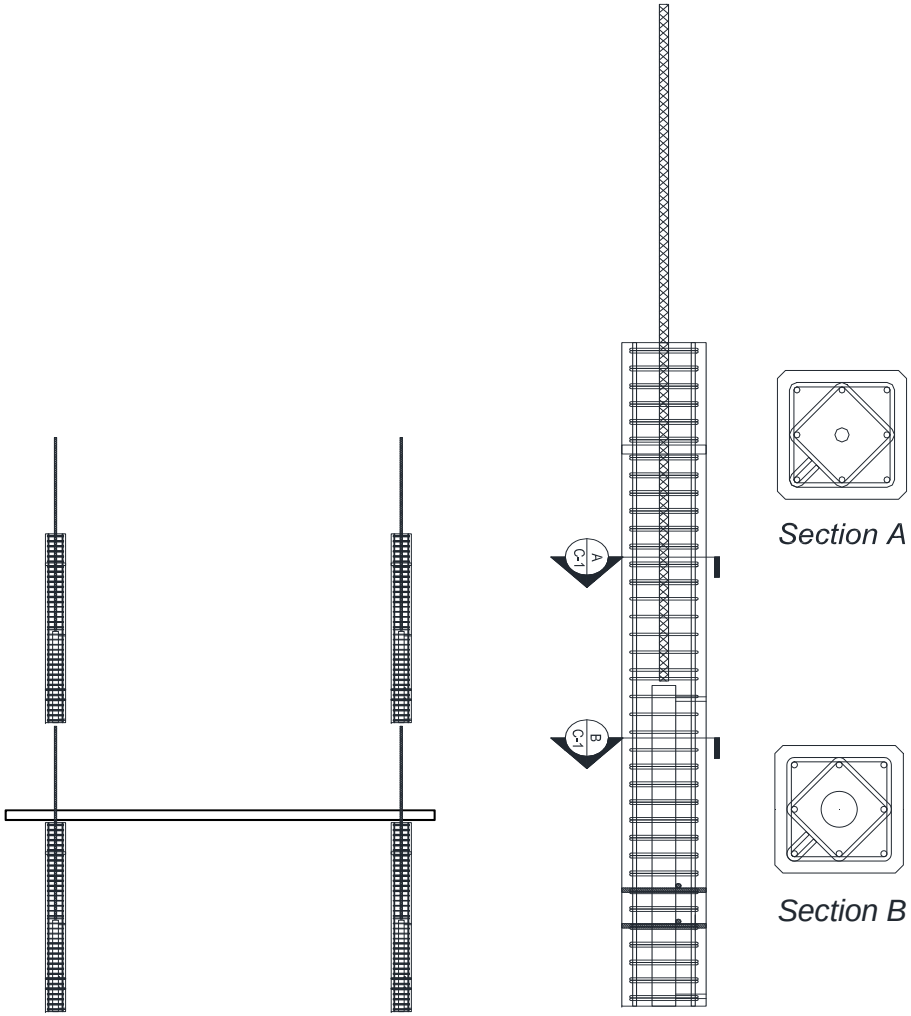
Pre-Test Phase



Specimen Design

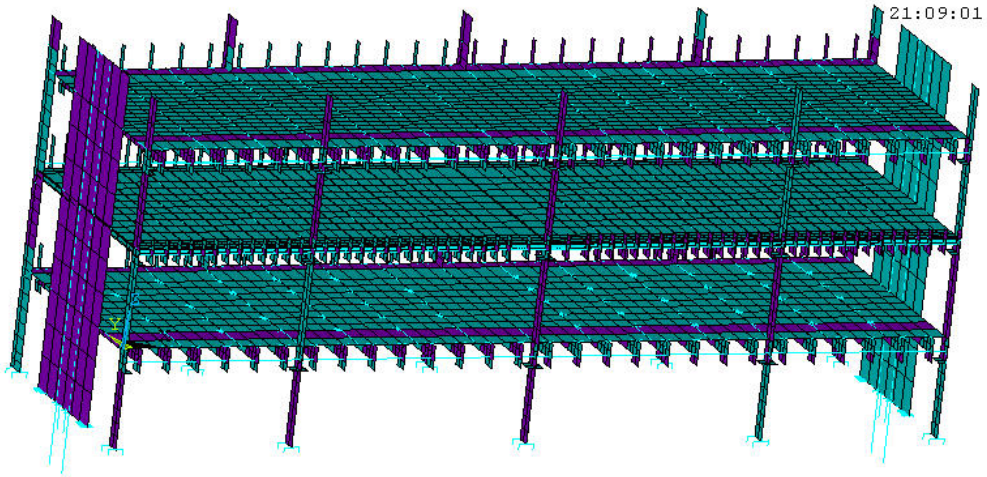
Pre-Test Phase

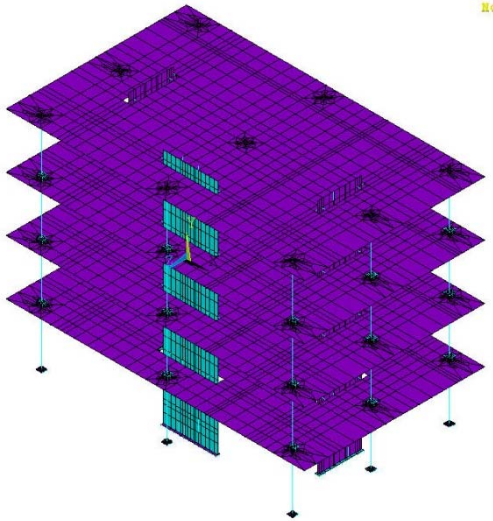
Precast columns



Analytical Simulation

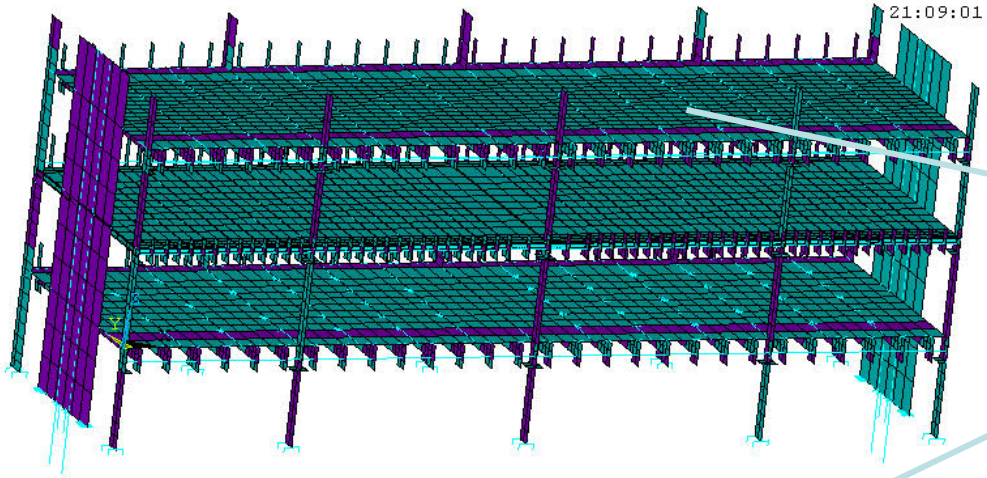
Project Pre-Test Phase

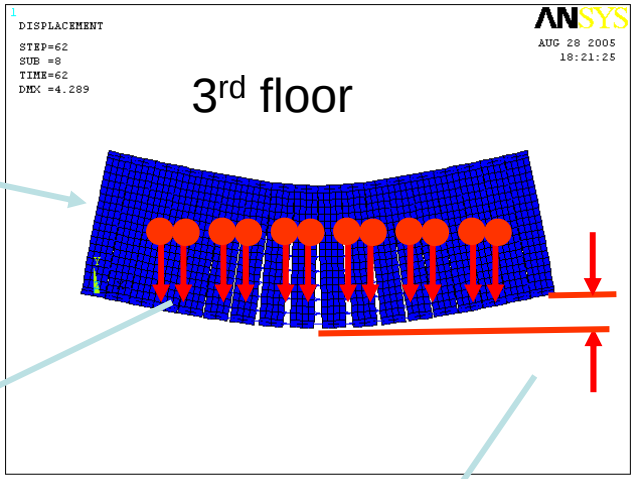


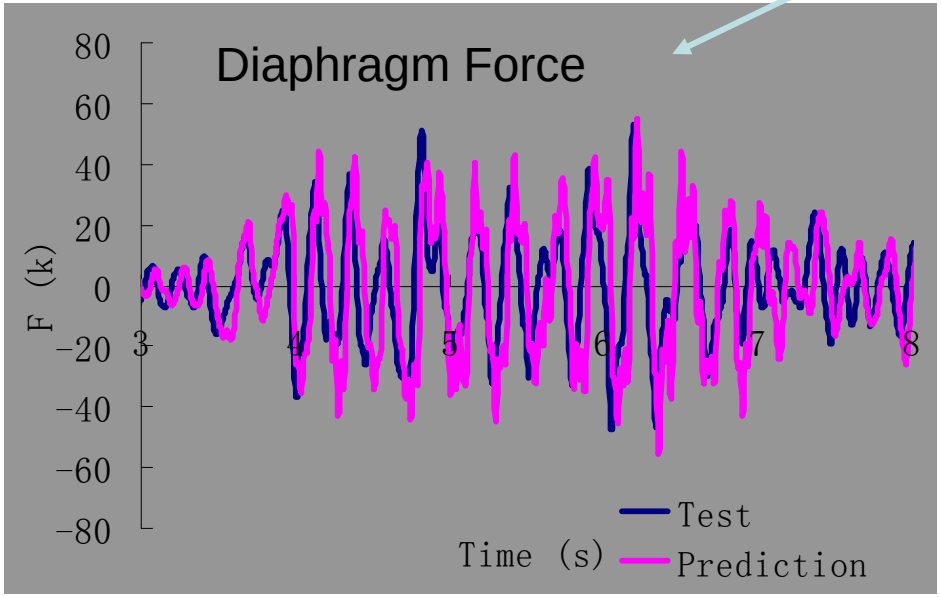


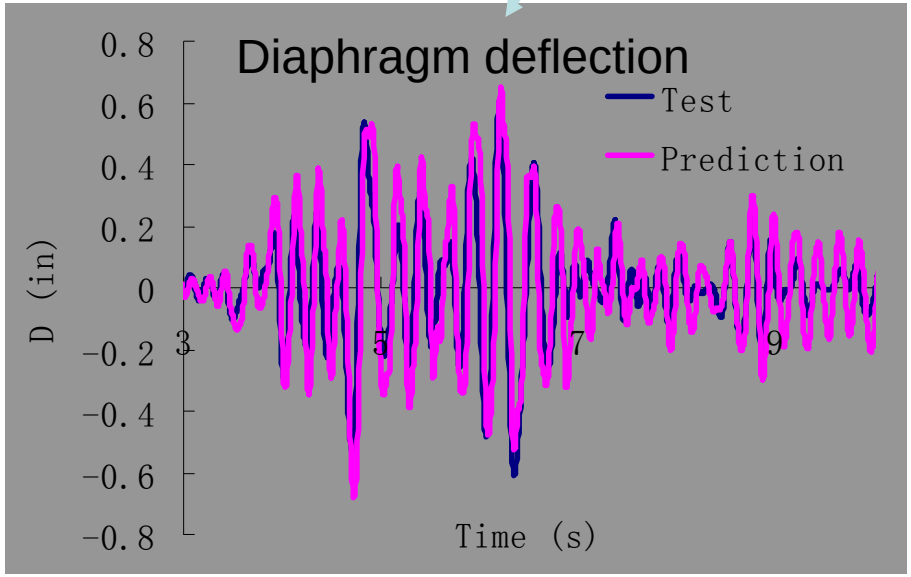
Analytical Simulation

Project Pre-Test Phase



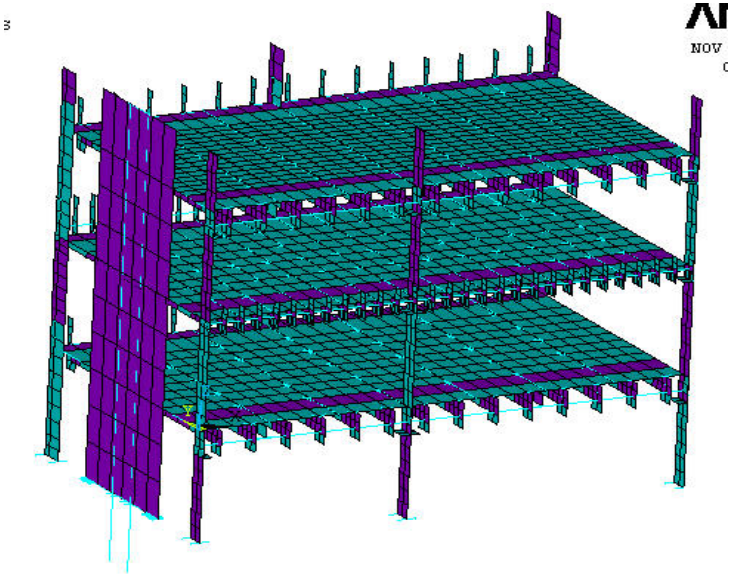


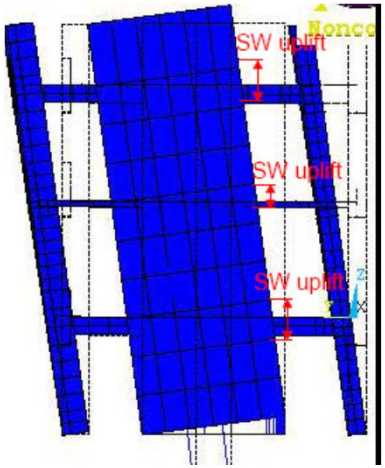


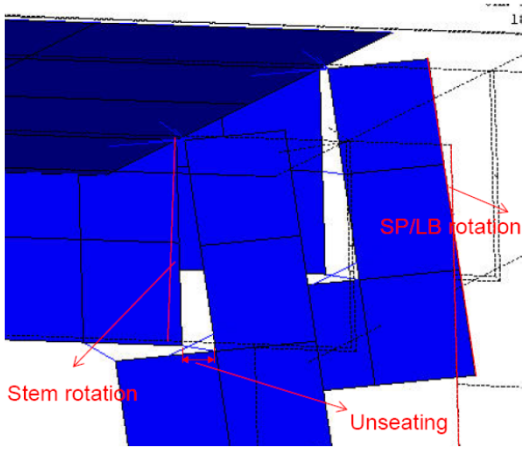


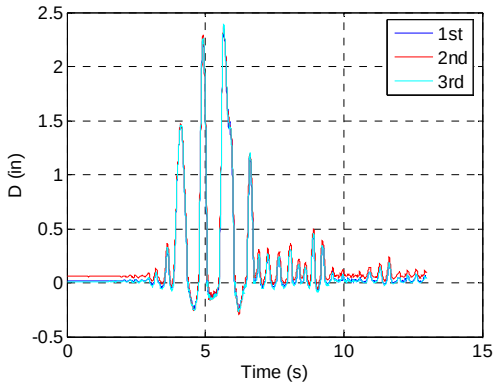
Analytical Simulation

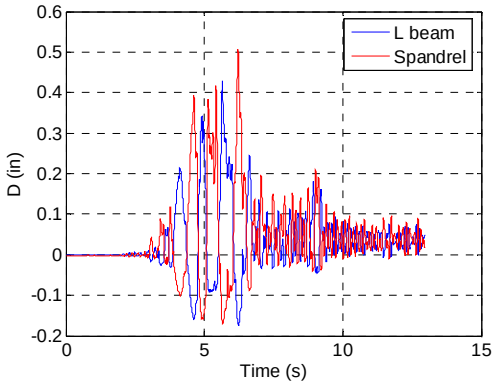
Project Pre-Test Phase







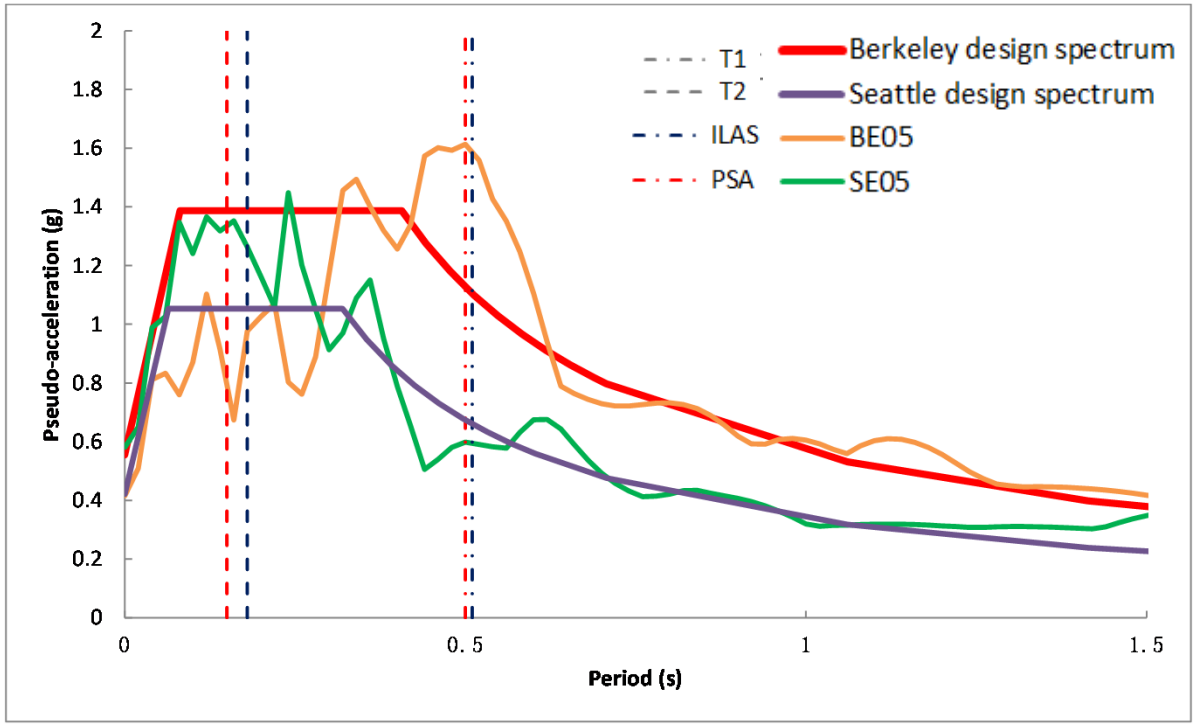




Ground Motion Selection

Project Pre-Test Phase

EQ Name	DT (s)	PGA [g]	Earthquake	Date	Station	Component	Magnitude	Distance [km]
SE05	0.005	0.59	Imperial Valley	1979/10/15	El Centro Array #5	140	6.5	1.0
BE05	0.005	0.41	Loma Prieta	1989/10/17	Los Gatos Presentation Center	000	7.0	3.5



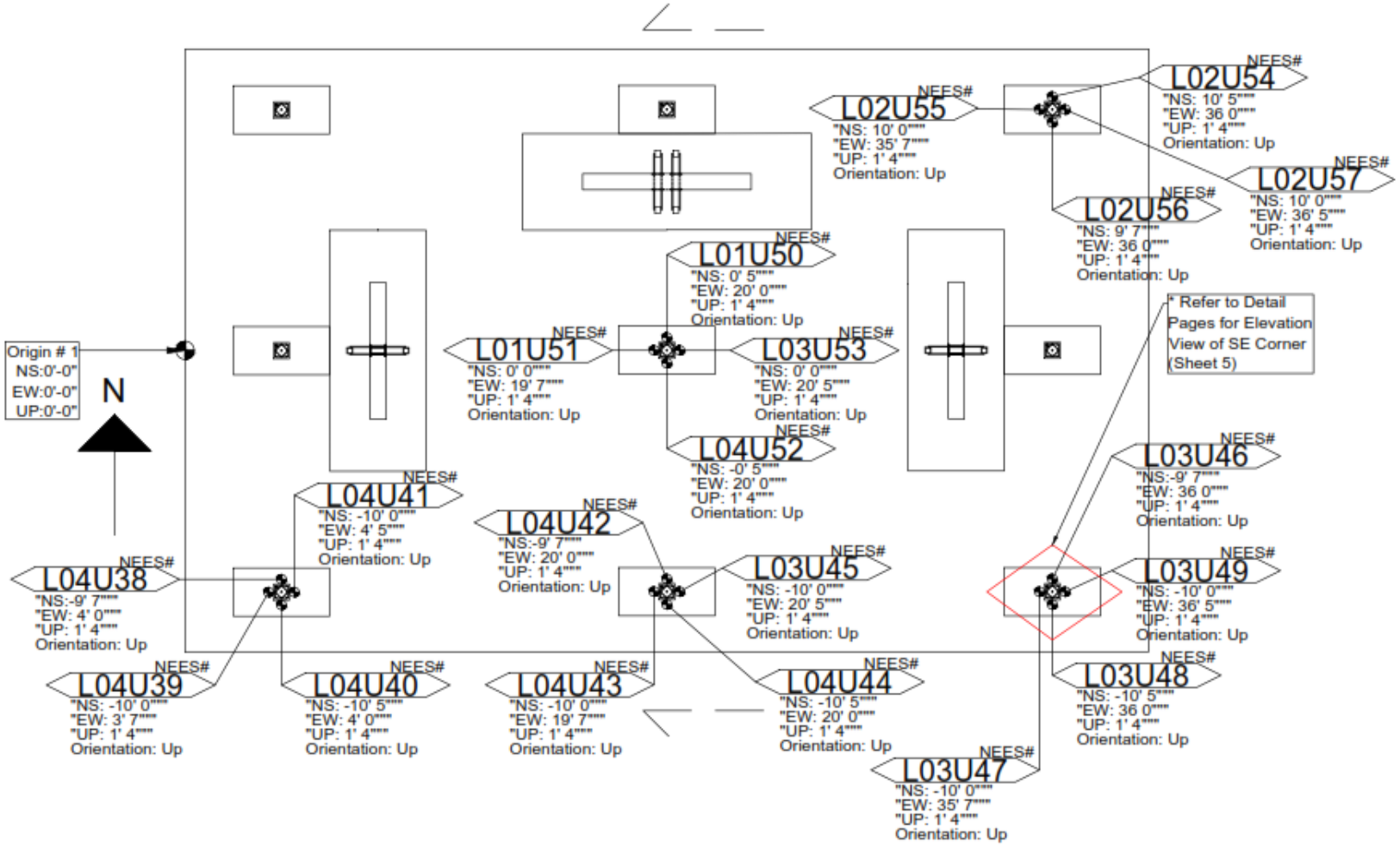
Testing Program

➢ Test Program

	TEST #	Ground Motion	Level	Wall PT Ratio (EW/NS)	α		TEST #	Ground Motion	Level	Wall PT Ratio (EW/NS)	α
Phase I	1-W1	White Noise	3%-WN	0.62/0.60	0.24		1-W10	White Noise	3%-WN	0.60/0.66	0.43
	Test-1	Berkeley	BE-Svc	0.62/0.60	0.24		Test-13	Berkeley	DBE	0.60/0.66	0.43
	1-W2	White Noise	3%-WN	0.61/0.42	0.44		Test-14	Berkeley	MCE	0.60/0.66	0.43
	Test-2	Berkeley	BE-Svc	0.61/0.42	0.44		1-W11	White Noise	3%-WN	0.60/0.66	0.43
	Test-3	Seattle	DBE	0.61/0.42	0.44	Phase II	2-W12	White Noise	3%-WN	0.60/0.70	PSA+damper
	Test-4	Berkeley	DBE	0.61/0.42	0.44		Test-15	Seattle	DBE	0.60/0.70	
	1-W3	White Noise	3%-WN	0.61/0.42	0.44		Test-16	Berkeley	BE-Svc	0.60/0.70	
	1-W4	White Noise	3%-WN	0.49/0.41	0.60		Test-17	Berkeley	DBE	0.60/0.70	
	Test-5	Berkeley	BE-Svc	0.49/0.41	0.60		2-W13	White Noise	3%-WN	0.60/0.70	
	Test-6	Seattle	DBE	0.49/0.41	0.60		2-W14	White Noise	3%-WN	0.64/0.64	PSA+roller bearing
	Test-7	Berkeley	DBE	0.49/0.41	0.60		Test-18	Berkeley	DBE	0.64/0.64	
	1-W5	White Noise	3%-WN	0.49/0.41	0.60		2-W15	White Noise	3%-WN	0.64/0.64	
	1-W6	White Noise	3%-WN	0.50/0.42	0.41		Test-19	Berkeley	MCE	0.64/0.64	
	Test-8	Berkeley	DBE	0.50/0.42	0.41		2-W16	White Noise	3%-WN	0.64/0.64	
	Test-9	Seattle	MCE	0.50/0.42	0.41	Phase III	3-W17	White Noise	3%-WN	0.63/0.64	High-strength RC wall
	Test-10	Berkeley	MCE	0.50/0.42	0.41		Test-20	Berkeley	DBE	0.46/0.43	
	1-W7	White Noise	3%-WN	0.50/0.42	0.41		3-W18	White Noise	3%-WN	0.46/0.43	
	1-W8	White Noise	3%-WN	0.60/0.62	0.55		Test-21	Berkeley	MCE	0.46/0.43	
	Test-11	Berkeley	DBE	0.60/0.62	0.55		Test-22	Berkeley	MCE	0.46/0.43	
	Test-12	Berkeley	MCE	0.60/0.62	0.55		3-W19	White Noise	3%-WN	0.46/0.43	
	1-W9	White Noise	3%-WN	0.60/0.62	0.55						

Instrumentation Plan

Project Pre-Test Phase



Zero Floor Plan View: 1st Floor Columns Linear Pots	IFLFAS Shake Table Test Instrumentation Layout	Drawn By: Scott Kuhlman Graduate Student Researcher University of Arizona	Sheet 6 of

Phase 4:

Project Testing Phase

- **Four main stages of Testing Phase:**
  - Specimen Construction Stage
  - Specimen Instrumentation Stage
  - Shake Table Testing Stage
  - Specimen Demolition Stage

Ironically Testing is typically only a small portion of the Testing Phase!

Construction Phase

Project Testing Phase

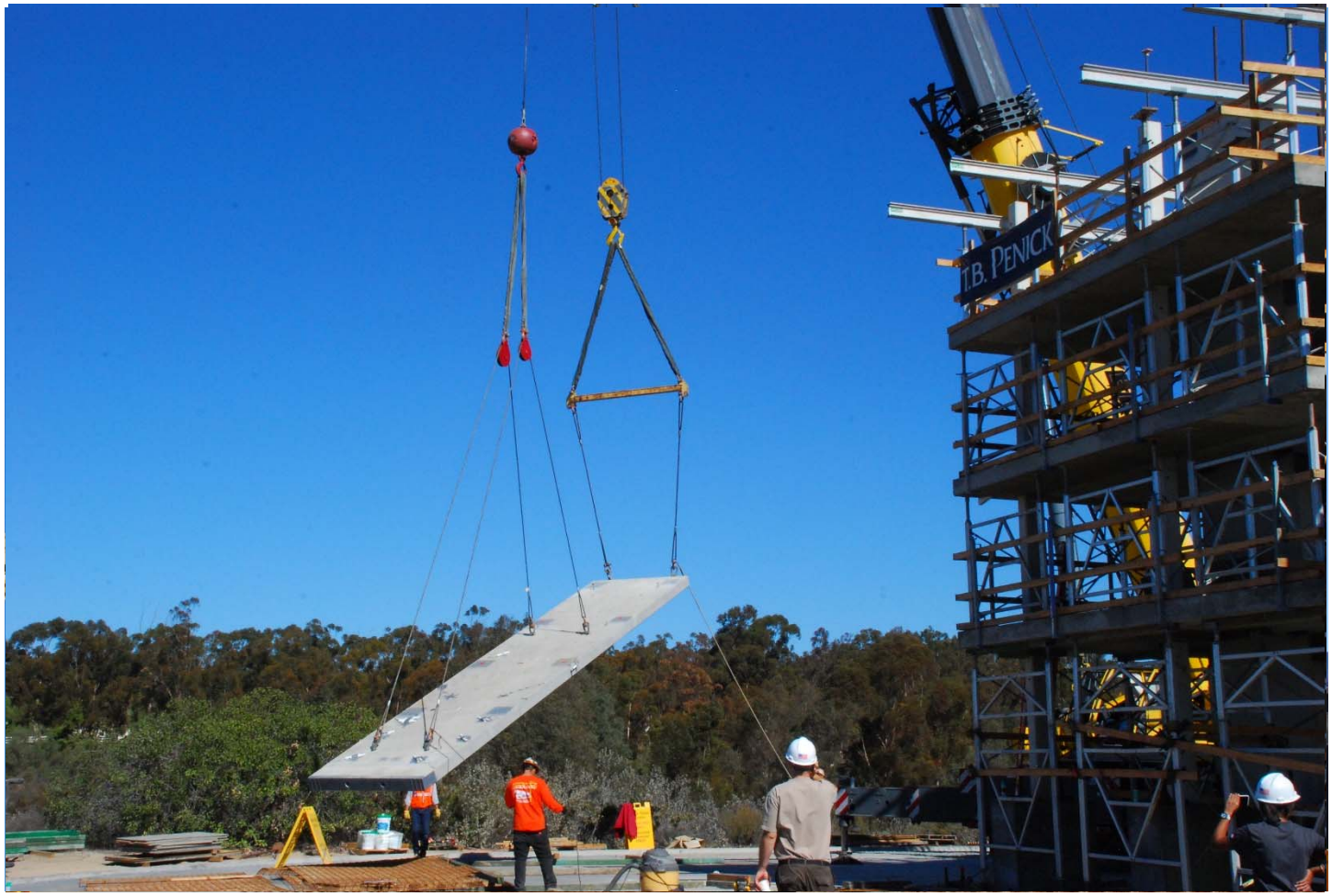
Slab cast in place

Construction Phase

- **Table time saving via use of elements created off-site**

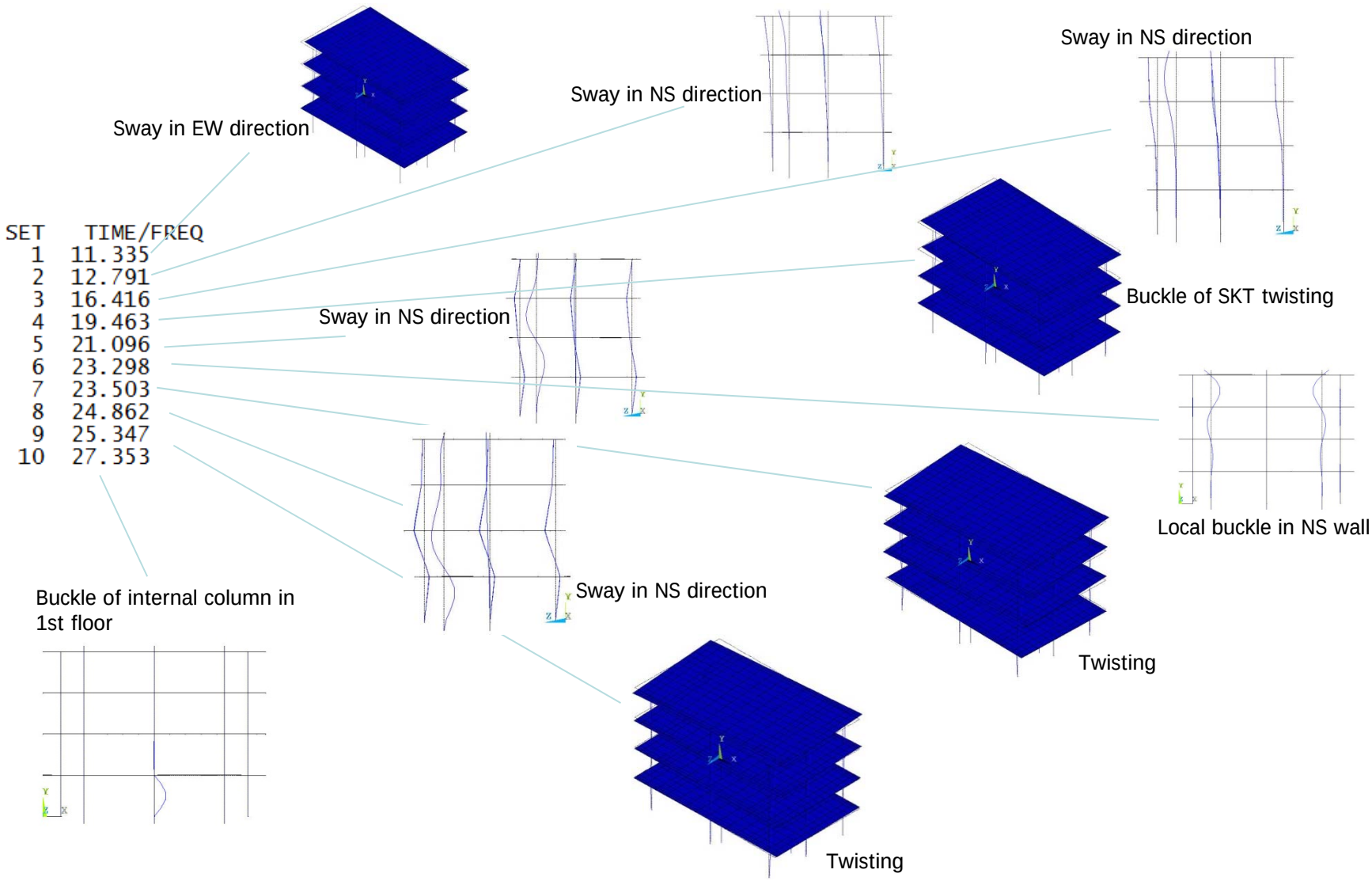
Construction Phase

Project Testing Phase



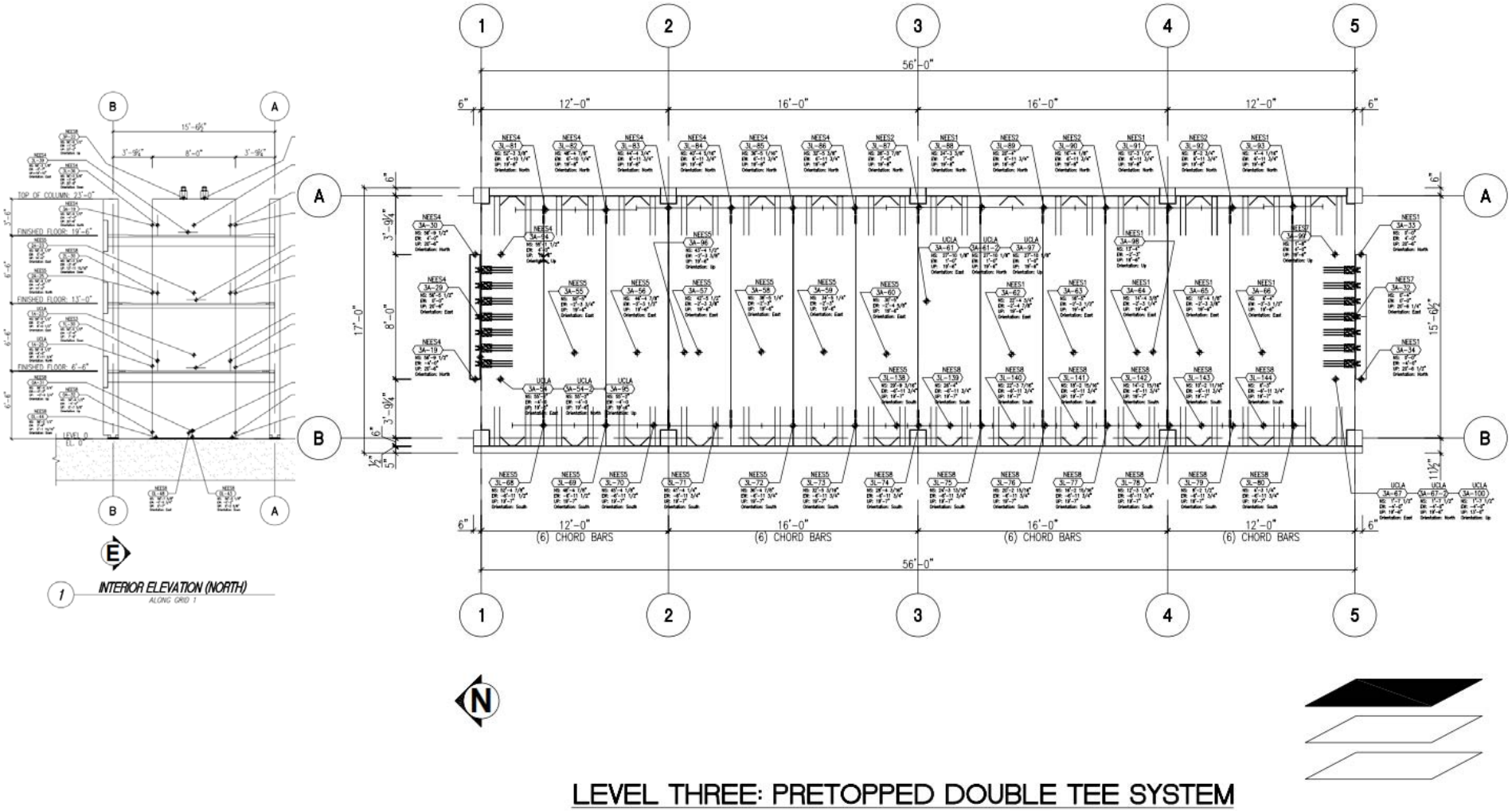
Stability during Construction Phase

Construction Phase



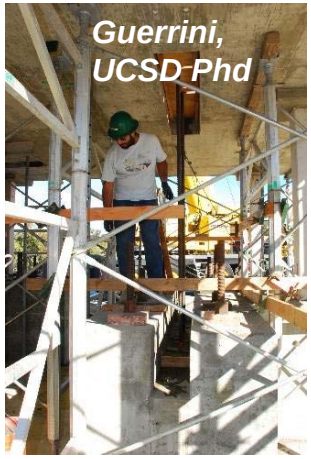
Specimen Instrumentation Phase

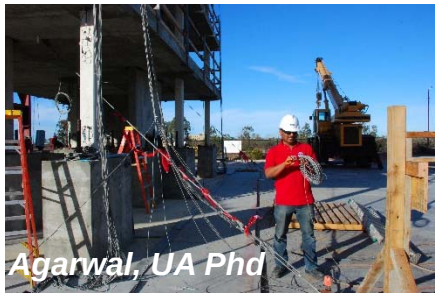
Project Testing Phase

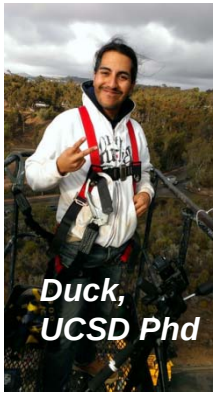


Student Participation

Specimen Construction/ Instrumentation







Student Participation

Specimen Construction/ Instrumentation

Preparing Rubber Bearing Assemblies

Shake Table Testing Phase

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UC San Diego

Berkeley BE05 MCE
Traditional system vs IFAS

PLAN VIEW COMPARISON

Shake Table Testing Phase

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UC San Diego

Shake Table test

Rocking of Main(North) wall

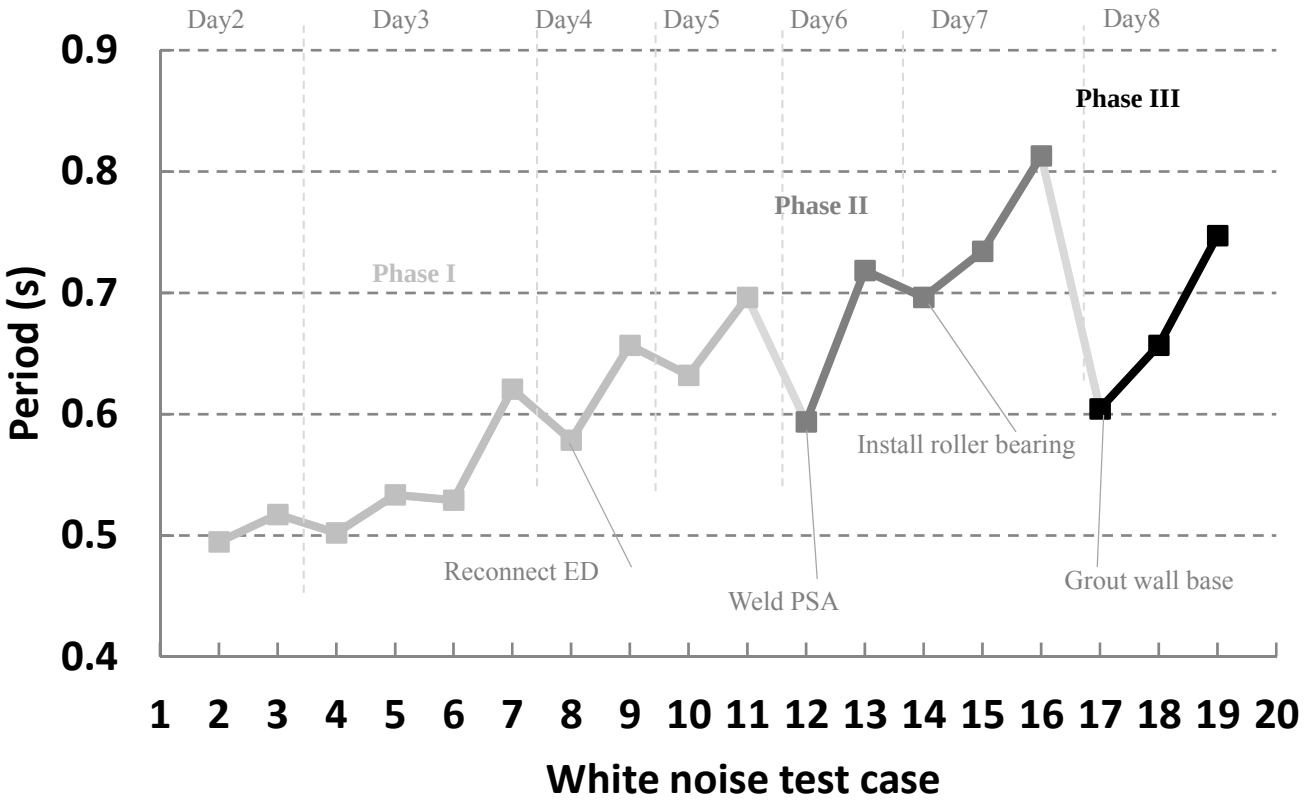
PHASE I VS PHASE II

Shake Table Testing Phase

Project Testing Phase

➢ Destructive Testing

IFAS

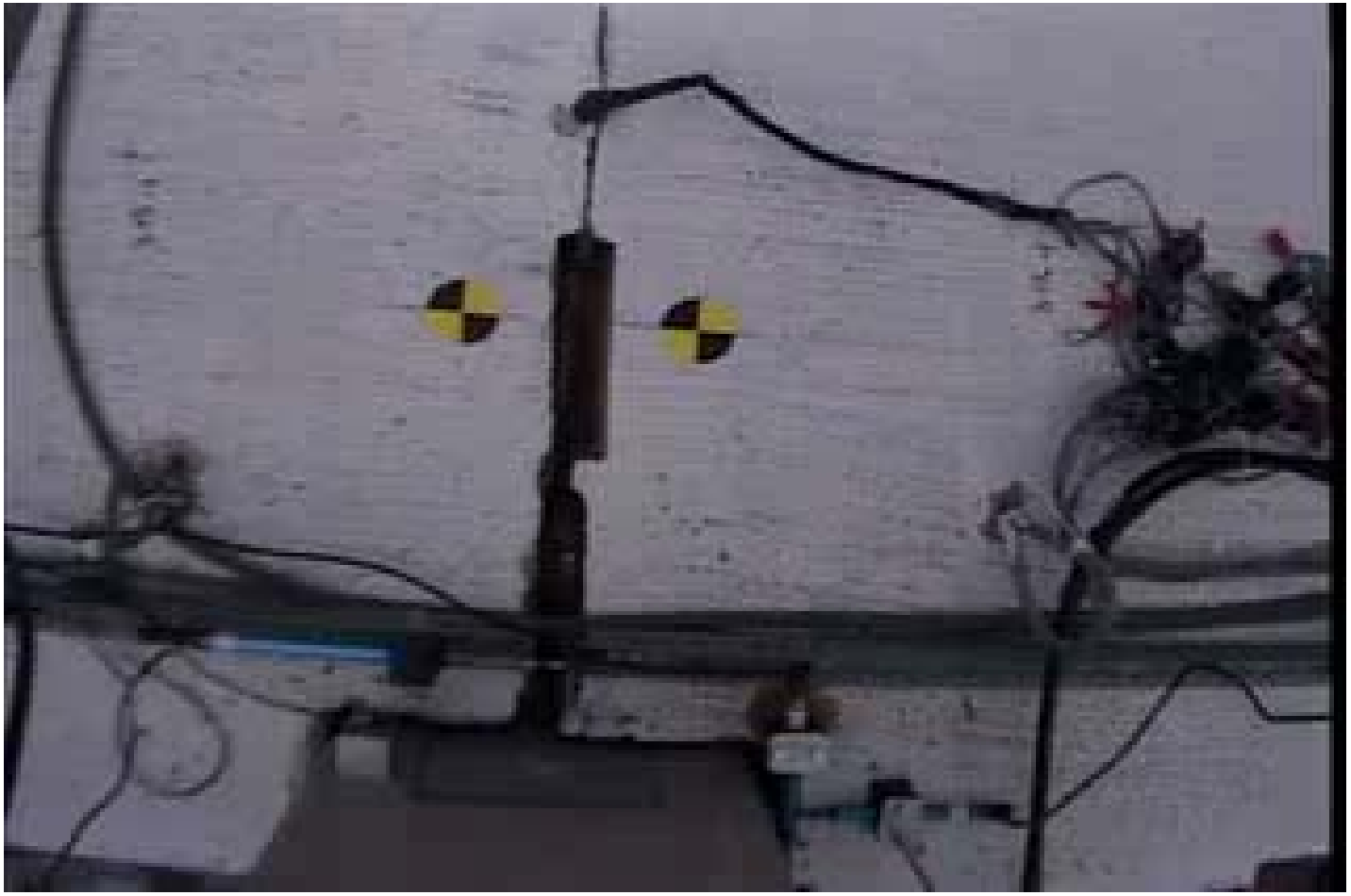


Test Inspection

Shake Table Testing Phase

Unexpected Events

Shake Table Testing Phase



Project Testing Phase

- **Public Relations and Marketing**

Project Testing Phase

- **Professional Interest and Collegiality**

Specimen Demolition Phase

Project Testing Phase

NEES @ UC San Diego

r Seismic

NEESR: Inertial Force-Limiting Floor Anchorage Systems for Seismic Resistant Building Structures

Site Cameras

Southwest

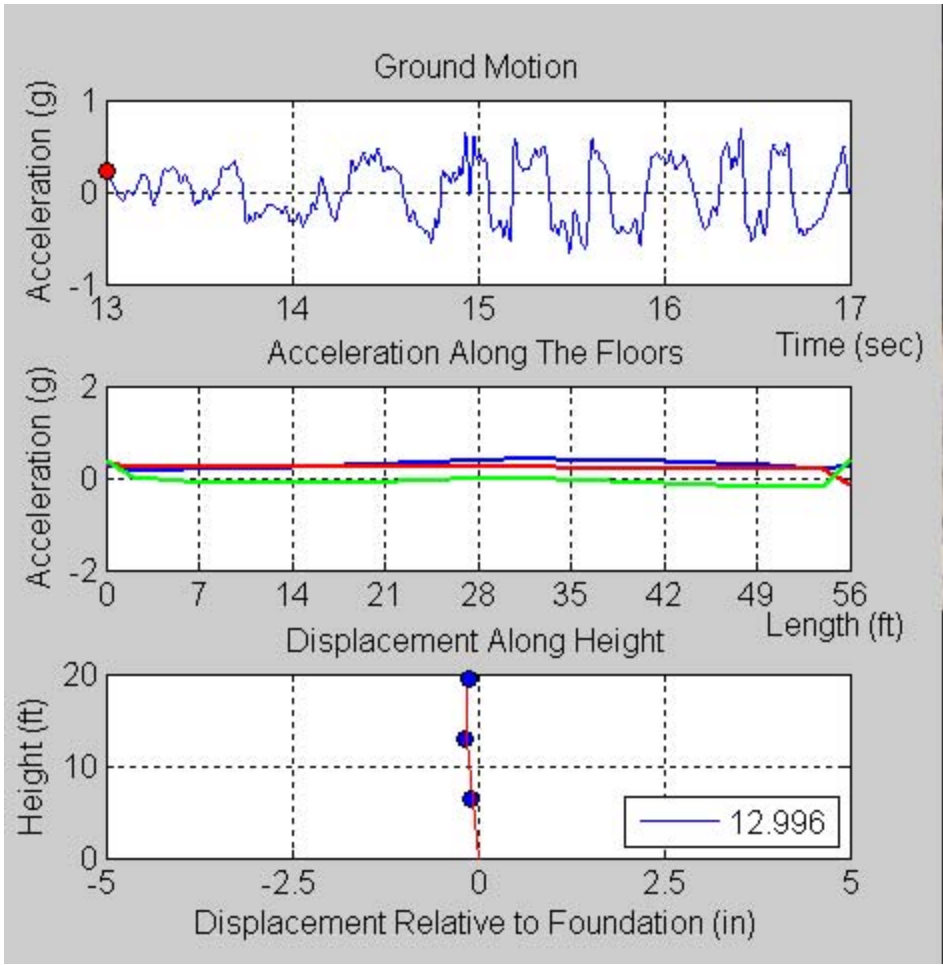
Northwest

Project Post-Test Phase

- Data Management
- Data Visualization / Manipulation
- Data Interpretation
- Data Archiving
- Model Calibration
- Findings and Conclusions
- Dissemination & Reporting

Data Interpretation

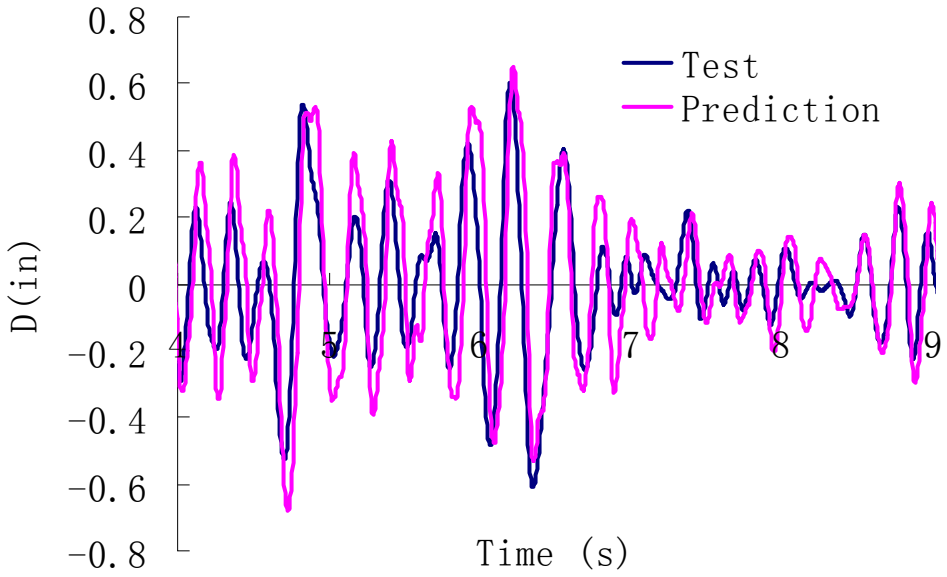
Project Post-Test Phase



Model Calibration

Project Post-Test Phase

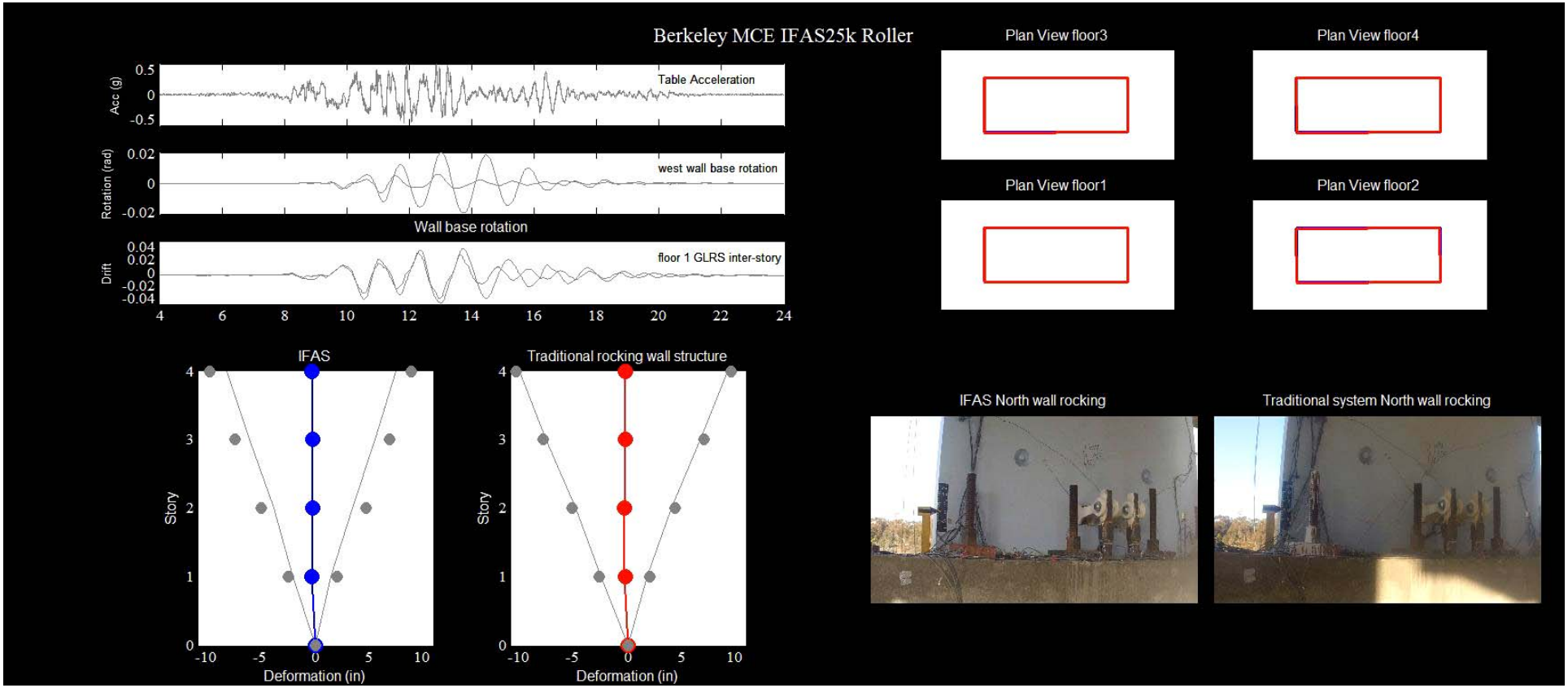
Knoxville DBE



Diaphragm midspan roof drift

Data Interpretation

Project Post-Test Phase



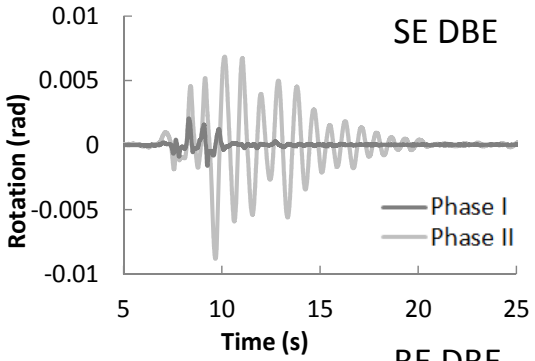
IFAS

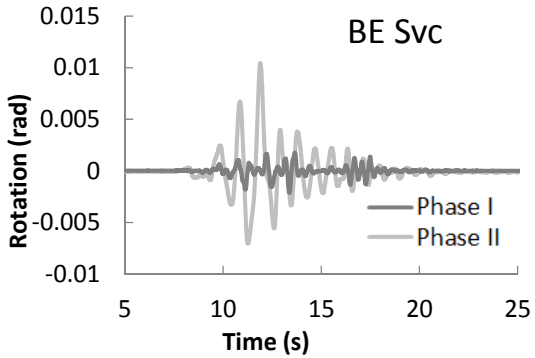
Data Interpretation

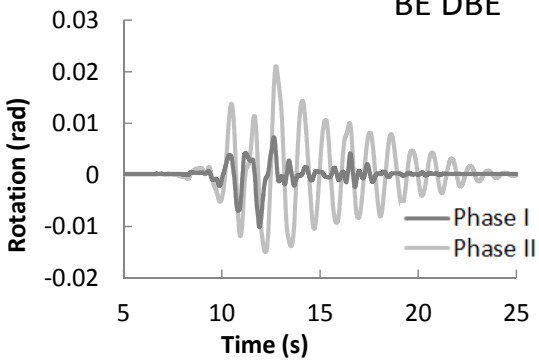
Project Post-Test Phase

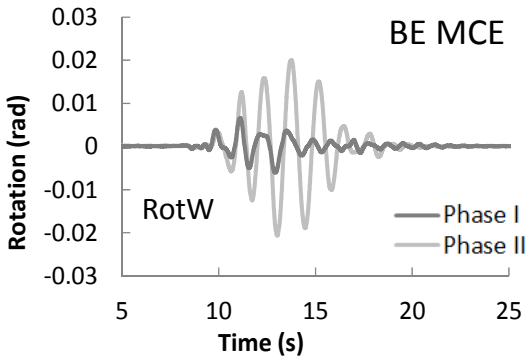
IFAS

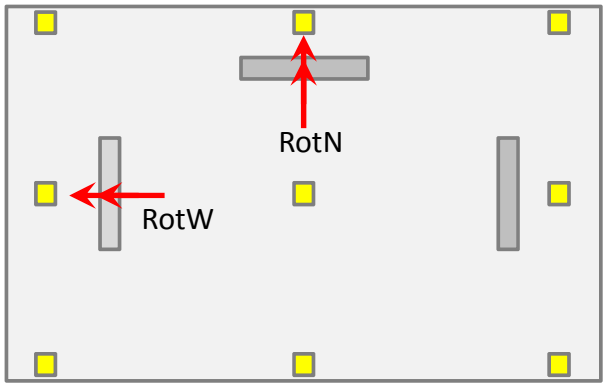
North and West wall base in plane rotation











Data Interpretation

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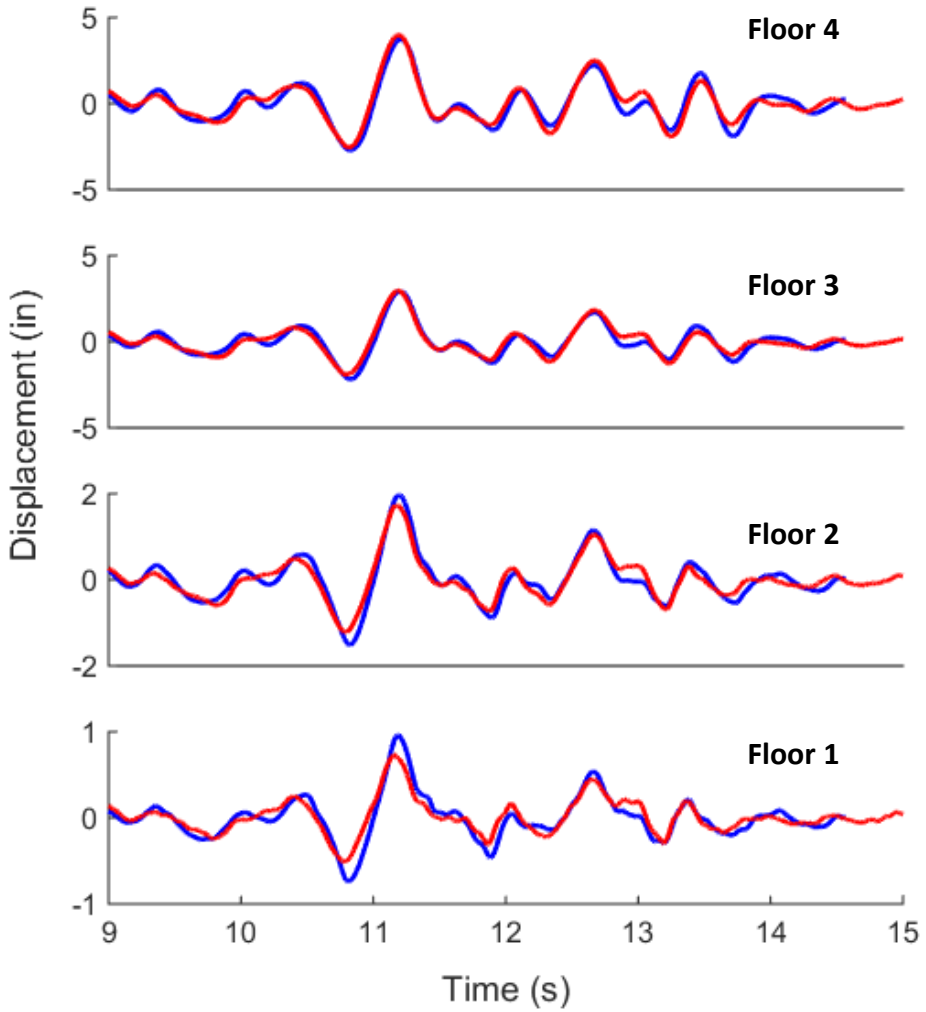
Berkeley BE05 MCE
ANSYS model with real time shake table test

ISOMETRIC VIEW –PHASEI

IFAS

Model Calibration

Project Post-Test Phase



Dissemination

Dave Dieter
Vice-President
MidState Precasters

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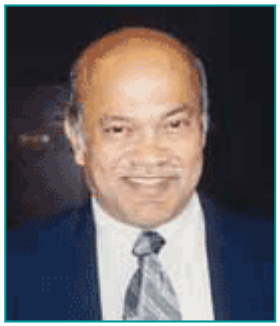
DSDM Task Group Chair
President, S. K. Ghosh Associates



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Tom D'Arcy
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Joe Maffei
Engineering Consultant
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Engineers

Susie Nakaki
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The Nakaki
Bashaw Group, Inc.

Harry Gleich
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Metromont Prestress

Thank You !

Photos and drawings used in this slide show are taken from researchers at UCSD, Lehigh Arizona and Nazarbayev U. The efforts of all the faculty, students, technicians and industry partners involved in these projects and the support of the project funders is acknowledged.