PACIFIC EARTHQUAKE ENGINEERING RESEARCH CENTER

Report of the Eighth Planning Meeting of NEES/E-Defense Collaborative Research on Earthquake Engineering

Held in Miki, Hyogo, Japan
September 17–18, 2010

Convened by
Hyogo Earthquake Engineering Research Center (NIED)
NEES Operation Center (NEEScomm)

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Report of the Eighth Planning Meeting of NEES/E-Defense Collaborative Research on Earthquake Engineering

held at

Hyogo Earthquake Engineering Research Center of the
National Research Institute for Earth Science and Disaster Prevention
and
Hyogo Prefectural Emergency Management and Training Center
in Miki, Hyogo, Japan

during

September 17 and 18, 2010

convened by

Hyogo Earthquake Engineering Research Center, NIED
and
NEES Operation Center, NEEScomm

September 2010

Preface

Following an agreement between the Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the U.S. National Science Foundation (NSF), the First Planning Meeting for NEES/E-Defense Collaboration on Earthquake Engineering Research was held in 2004. This meeting laid the groundwork for a joint research program related to improving understanding of seismic effects and thereby reducing the seismic vulnerability of buildings and civil infrastructural systems. The emphasis of the program is to conduct experimental research using the George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) equipment sites and the three-dimensional full-scale earthquake testing facility (E-Defense) of the National Research Institute for Earth Science and Disaster Prevention (NIED). To formalize the collaboration, two Memorandums of Understanding (MOU) were executed, one between NSF and MEXT in September 2005 and one between the NEES Consortium Inc. (NEES Inc.) and NIED in July 2005. In order to continue the collaboration to the "second phase" that began in 2010, the latter MOU was updated in May 2010 by the NEES Operation Center (NEEScomm) and NIED.

Before updating the MOU between NEEScomm and NIED, two meetings were held to prepare for the second-phase collaboration. The First Planning Meeting for the Second Phase of the NEES/E-Defense was held in January 2009 to discuss the need for and benefits of continued NEES/E-Defense collaboration. This meeting identified a number of important topics of mutual interest to the U.S. and Japan that would benefit from continued research collaboration and sharing of NEES and E-Defense resources. In addition, a follow-up meeting to discuss details of the next phase of collaboration was recommended. In response, the Seventh Planning Meeting of NEES/E-Defense Collaborative Research on Earthquake Engineering was convened in September 2009 to review the efforts and accomplishments of the past four and one half years and to discuss specific opportunities for continued and hopefully stronger collaboration for the coming years.

Following these two meetings, the Eighth Planning Meeting of NEES/E-Defense Collaborative Research on Earthquake Engineering was convened during September 17 and 18, 2010. The meeting was attended by leading researchers from both countries as well as representatives from NSF, MEXT and other government agencies. In the plenary and breakout sessions of the meeting, thirty-two participants from the U.S. and forty participants from Japan discussed NEES/E-Defense collaboration in the second phase that started in 2010.

This report contains a summary of the Eighth Planning Meeting along with the recommendations and resolutions reached by the participants. The appendices contain the list of participants, the meeting agenda and schedule, the materials presented during the plenary sessions, and summaries of the recommendations developed by individual breakout sessions where participants discussed in detail various scientific and engineering challenges that should be addressed during the second phase of the NEES/E-Defense collaboration.

Acknowledgements

The Joint Technical Coordinating Committee for the NEES/E-Defense Collaborative Research Program in Earthquake Engineering would like to thank the meeting participants for making the meeting a success by generously sharing their time, experience and ideas. The participants agree that the cordial and harmonious atmosphere at the meeting, and the candid and thoroughgoing discussions signal an outstanding future for NEES/E-Defense Collaboration.

The meeting was held at the Hyogo Earthquake Engineering Research Center, NIED, and at the Hyogo Prefectural Emergency Management and Training Center in Miki, Hyogo, Japan. The participants would like to express their gratitude to NIED and Hyogo Prefecture for opening their facilities for the meeting.

The Hyogo Earthquake Engineering Research Center hosted the meeting, including making local arrangements. The support of the center's staff contributed greatly to the success of the meeting.

Many participants from the U.S. and Japan attended the meeting using their own travel funds. Travel support for a significant number of the U.S. participants was made possible by the U.S. National Science Foundation though Award No. CMMI-0958774 (Coordinating Workshops for the NEES/E-Defense Collaborative Research Program in Earthquake Engineering (Phase 2). This support is greatly appreciated.

The findings, recommendations and conclusions contained in this report are the consensus views of the meeting participants, and do not necessarily reflect opinions of any one individual or the policy or views of the National Science Foundation, the National Earthquake Hazards Reduction Program, the NEES Operation Center or other organization in the U.S., nor of the Ministry of Education, Culture, Sports, Science and Technology, National Research Institute for Earth Science and Disaster Prevention or the Hyogo Earthquake Engineering Research Center in Japan.

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Summary and Resolutions

Background

The U.S.-Japan Joint High Level Committee (JHLC) on Science and Technology emphasized, in the Joint Communiqué of the Ninth Meeting, which the two countries should cooperate on multiple aspects of earthquake-related research. During the first Japan-U.S. Workshop on Science and Technology for a Secure and Safe Society held in February 2004, the Japan Ministry of Education, Culture, Sports, Science and Technology (MEXT) and the U.S. National Science Foundation (NSF) agreed to discuss opportunities for cooperative activities related to earthquake research, citing NEES/E-Defense collaboration as a specific example of such cooperation.

To realize the cooperation, the First Planning Meeting for NEES/E-Defense Collaboration was held in 2004, and the basic scheme for a five-year joint research was established. Two thrust areas, i.e., steel buildings and bridges, were given highest priority for the joint research. To formalize the collaboration, two Memorandums of Understanding (MOU) were executed, one between NSF and MEXT in September 2005 and one between NEES Consortium Inc. (NEES Inc.) and the National Research Institute for Earth Science and Disaster Prevention (NIED) in July 2005.

In order to examine the need and benefits of continuing NEES/E-Defense collaboration into a "second phase," the First Planning Meeting for the Second Phase of the NEES/E-Defense was held in January 2009 at NSF in Arlington, Virginia, U.S.A. The participants unanimously recommended the second-phase collaboration be carried out, and recommended a number of high priority research needs to be discussed in future planning meetings. In response, the Seventh NEES/E-Defense Planning Meeting of NEES/E-Defense Collaborative Research on Earthquake Engineering was held in September 2009, reviewing the efforts and accomplishments made during the past four years and discussing possibility of collaboration beyond March 2010 in which the first-phase NEES/E-Defense collaborative research expired. To secure the implementation of the "second-phase" collaboration, NEES Operation Center (NEEScomm) and NIED updated their MOU in 2010.

Issues discussed

This Eighth Planning Meeting was organized to discuss in detail continuing collaboration in the second phase beyond March 2010. The following six topics were chosen as the targets of collaboration based on the discussions during the First Planning Meeting for the Second Phase (January 2009) and the Seventh Planning Meeting (September 2009).

(a) High performance R/C structures,
(b) Base-isolation and vibration control,
(c) Geotechnical engineering,
(d) Energy facilities,
(e) Numerical simulation, and
(f) Monitoring.

In this two-day meeting, progress on both the Japanese and U.S. sides related to the above topics since the last meeting were reported, and six breakout sessions related to these topics were organized to facilitate in-depth discussion on the type and organization of collaboration between the U.S. and Japan. The agenda of the meeting and the list of participants are shown in Appendices I and II. The materials presented during the two plenary sessions are presented in Appendices III and IV, while the detailed breakout session discussions are summarized in Appendix V.

Resolutions and Recommendations

Based on the presentations, discussions and deliberations, the participants of the Eighth Planning Meeting of the NEES/E-Defense Collaborative Research on Earthquake Engineering formulated and unanimously adopted the following specific resolutions and recommendations:

(1) Collaborative research should proceed without delay. The participants reaffirmed that the six topics chosen for NEES/E-Defense collaboration are very timely, and that collaboration will accelerate scientific and engineering advances of great importance to the U.S. and Japan. The proposed collaborative research on these topics leverages important intellectual, laboratory, computational and other resources available in each country.

(2) Task Groups working on each topic should meet/communicate frequently. Annual planning meetings to review overall progress and to refine overall strategic goals are essential. However, the success of research programs on the topics selected depends on extensive discussion and detailed planning. To achieve the desired benefit of collaboration, and maximize the outcomes from the research, frequent meetings (2-4 times a year) are required for planning and preparation of test programs and for interpreting and analyzing results. To facilitate planning, funding is needed to allow Task Group members to carry out necessary exploratory design studies and analyses. Adequate resources are needed to enable a broad range of participants to participate in these activities.

(3) Payload opportunities should be sought more comprehensively to maximize the benefit of large-scale tests. The large-scale tests utilizing E-Defense or NEES facilities provide a useful test bed for others to explore their own research objectives or to contribute to the specific goals of the NEES/E-Defense tests. Payload projects might range from the addition of sensors for health monitoring and nonstructural elements and contents to assess their seismic performance, to the addition of extra test days to study modified structures. Such payload projects need to be sought out and incorporated early in the test planning process.

(4) Exchange of human resources, particularly young researchers and graduate students, should be promoted to strengthen the conditions needed for a vigorous continuing program of US-Japan collaboration.

(5) Funding agencies are encouraged to provide needed resources.

Closure

The participants believe that the Eighth Planning Meeting of the NEES/E-Defense Collaborative Research Program on Earthquake Engineering was highly successful, and that NSF and MEXT should be congratulated for providing the earthquake engineering community with cutting-edge tools that will substantially accelerate progress towards the important goals of earthquake loss reduction. The attendees agree that the cordial and harmonious atmosphere at the meeting and the candid and thoroughgoing discussions signal an outstanding future for NEES/E-Defense Collaboration.

The participants also appreciate and heartily thank the Hyogo Earthquake Engineering Research Center for its efforts in hosting this successful meeting.

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Appendix I: List of Participants

First Name	Last Name	Affiliation	Title
United States of America			
Tracy	Becker	University of California, Berkeley	PhD Student
JoAnn	Browning	University of Kansas	Professor
Ian	Buckle	University of Nevada, Reno	Professor
Shin-Ho	Chao	University of Texas at Arlington	Assistant Professor
Nhan	Dao	University of Nevada, Reno	PhD Student
Shideh	Dashti	University of Colorado at Boulder	Assistant Professor
Gregory	Deierlein	Stanford University	Professor
Shirley	Dyke	Purdue University	Professor
Catherine	French	University of Minnesota	Professor
Wassim	Ghannoum	University of Texas at Austin	Assistant Professor
John	Hayes	National Institute of Standards and Technology	Director, National Earthquake Hazard Reduction Program
Peter	Lee	Skidmore Owens Merrill LLP	Associate Director
Anne	Lemnitzer	California State University, Fullerton	Assistant Professor
Stephen	Mahin	University of California, Berkeley	Director, Pacific Earthquake Engineering Research Center and Professor
Manos	Maragakis	University of Nevada, Reno	Professor and Dean of Engineering
Troy	Morgan	Tokyo Institute of Technology	Assistant Professor
Khalid	Mosalam	University of California, Berkeley	Professor and Vice Chair

LIST OF PARTICIPANTS (CONTINUED)

First Name	Last Name	Affiliation	Title
United States of America			
Gilberto	Mosqueda	University at Buffalo	Associate Professor
Farzad	Naeim	John A. Martin & Associates, Inc.	Vice President and General Counsel
Narutoshi	Nakata	Johns Hopkins University	Assistant Professor
Gustavo	Parra-Montesinos	University of Michigan	Associate Professor
Joy	Pauschke	National Science Foundation	NEES Program Director
Julio	Ramirez	Purdue University	Professor and NEEScomm Center Director
Keri	Ryan	University of Nevada, Reno	Assistant Professor
Nick	Sitar	University of California, Berkeley	Professor
Sri	Sritharan	Iowa State University	Professor
Zeynep	Tuna	University of California at Los Angeles	PhD Student
John	Wallace	University of California at Los Angeles	Professor
Gordon	Warn	Pennsylvania State University	Assistant Professor

First Name	Last Name	Affiliation	Title
Canada			
Tony	Yang	University of British Columbia	Assistant Professor

LIST OF PARTICIPANTS (CONTINUED)

First Name	Last Name	Affiliation	Title
Japan			
Kenichi	Abe	NIED	Acting Director
Satoshi	Fujita	Tokyo Denki University	Professor
Hideo	Fujitani	Kobe University	Professor
Muneo	Hori	ERI, The University of Tokyo	Professor
Tatsuhiko	Ine	NIED	Invited Research Fellow
Takahito	Inoue	NIED	Chief of Planning Section
Tomohiro	Ito	Osaka Prefecture University	Professor
Toshimi	Kabeyasawa	ERI, The University of Tokyo	Professor
Yoshiro	Kai	NIED	Facilities Administration Section Chief
Kouichi	Kajiwara	NIED	Deputy Director, Project Director
Rebun	Kariyasono	MEXT	Researcher
Kazuhiko	Kasai	Tokyo Institute of Technology	Professor
Yohsuke	Kawamata	NIED	Research Fellow
Kazuhiko	Kawashima	Tokyo Institute of Technology	Professor
Susumu	Kono	Kyoto University	Associate Professor
Taizo	Matsumori	NIED	Senior Researcher
Keisuke	Minagawa	Tokyo Denki University	Assistant Professor

LIST OF PARTICIPANTS (CONTINUED)

First Name	Last Name	Affiliation	Title
Japan			
Takuya	Nagae	NIED	Senior Researcher
Izumi	Nakamura	NIED	Senior Researcher
Masayoshi	Nakashima	NIED	Director
Manabu	Nakayama	NIED	Invited Research Fellow
Hidekazu	Nishimura	Keio University	Professor
Akira	Nishitani	Waseda University	Vice President and Professor
Minehiro	Nishiyama	Kyoto University	Professor
Isao	Nishiyama	NILIM	Director of Building Department
Yoshihiro	Nitta	Ashikaga Institute of Technology	Associate Professor
Rai	Okabe	MEXT	Senior Specialist for Earthquake Research
Yoshimitsu	Okada	NIED	President
Taichiro	Okazaki	NIED	Research Fellow
Hisanobu	Sakai	NIED	Research Fellow
Eiji	Sato	NIED	Senior Researcher
Hitoshi	Shiohara	The University of Tokyo	Associate Professor
Yoshinori	Suzuki	MEXT	Director, Earthquake and Disaster-Reduction Research Division
Kentaro	Tabata	NIED	Senior Researcher

LIST OF PARTICIPANTS (CONTINUED)

First Name	Last Name	Affiliation	Title
Japan			
Kenichi	Tahara	NIED	Research Fellow
Keiichi	Tamura	PWRI	Research Coordinator for Earthquake Engineering
Kohji	Tokimatsu	Tokyo Institute of Technology	Professor
Ikuo	Towhata	The University of Tokyo	Professor
Takuzo	Yamashita	NIED	Research Fellow
Susumu	Yasuda	Tokyo Denki University	Professor

Appendix II: Agenda of Program

Friday, September 17, 2010

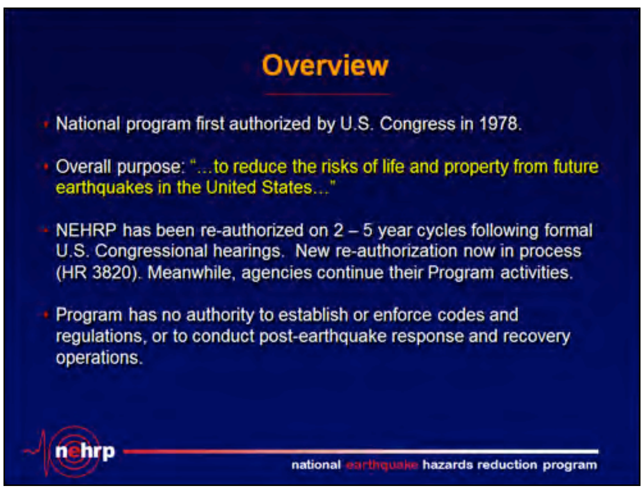
Time	Event	Location
10:00	*Gather at Crowne Plaza Hotel Lobby and Ride on Limousine*	Crowne Plaza Hotel
10:45	*Arrive at Hyogo Prefectural Training Center* Registration	Hyogo Prefectural Training Center
11:00-11:20	Opening Session Chair: Stephen Mahin (UC Berkeley) & Masayoshi Nakashima (NIED) Welcoming Remarks Yoshinori Suzuki (MEXT) Joy Pauschke (NSF) Jack Hayes (NIST) Yoshimitsu Okada (NIED) Julio Ramirez (Purdue University)	Auditorium
11:20-12:15	Plenary Session 1 Chair: Farzad Naeim (JAMA) & Kazuhiko Kawashima (Tokyo Tech)	Auditorium
(11:20-12:15)	NEHRP Research Goals (15 minutes) Jack Hayes (NIST) Overview of NEES Research Program (15 minutes) Joy Pauschke (NSF) Introduction to NEEScomm (15 minutes) Julio Ramirez (Purdue University) Summary of 7th NEES/E-Defense Planning Meeting (10 minutes) Masayoshi Nakashima (NIED) Stephen Mahin (University of California, Berkeley)	
(12:15-13:00)	Outline of NIED Research Projects (10 minutes) Taizo Matsumori (NIED) High Performance R/C Structures (25 minutes) Takuya Nagae (NIED) Base-Isolation & Vibration Control (10 minutes) Eiji Sato (NIED), Taichiro Okazaki (NIED)	
13:00-13:50	Lunch	Cafeteria
13:50-14:55	Plenary Session 2 Chair: Ian Buckle (Univ. of Nevada, Reno) & Kohji Tokimatsu (Tokyo Tech) Geotechnical Engineering (20 minutes) Kentaro Tabata (NIED) Energy Facilities (10 minutes) Izumi Nakamura (NIED) Numerical Simulation (30 minutes) Takuzo Yamashita (NIED) Monitoring & Data Archival System (5 minutes) Kentaro Tabata (NIED), Hisanobu Sakai (NIED)	Auditorium
14:55-15:00	*Move to Breakout Session Rooms*	
15:00-16:20	Breakout Sessions #1 (a) Numerical simulation Moderator: Gregory Deierlein (Stanford University) Muneo Hori (ERI, University of Tokyo) (b) Monitoring Moderator: Shirley Dyke (Purdue University) Akira Nishitani (Waseda University) (c) JTCC Meeting Moderator: Stephen Mahin (University of California, Berkeley) Masayoshi Nakashima (NIED)	(a) Auditorium (b) Lecture room 1 (c) Director room of E-Defense
16:20	*Leave Hyogo Prefectural Training Center for E-Defense by Limousine*	

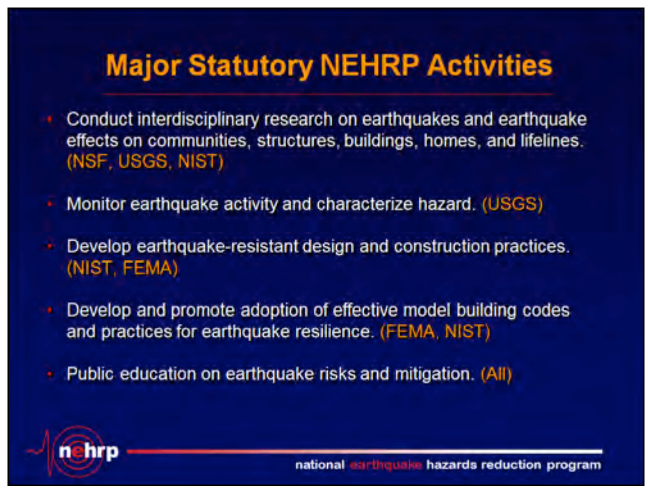
16:25	*Arrive at E-Defense*	E-Defense
16:30-16:50	Introduction of Test on Isolated R/C Hospital Building (20minites) Eiji Sato (NIED), Takahito Inoue (NIED)	Entrance lobby
17:00	Test Observation	Experiment building
17:30	*Leave E-Defense for Crowne Plaza Hotel by Limousine*	
18:10	*Arrive at Crowne Plaza Hotel*	Crown Plaza Hotel
19:00-21:00	Banquet	Crown Plaza Hotel

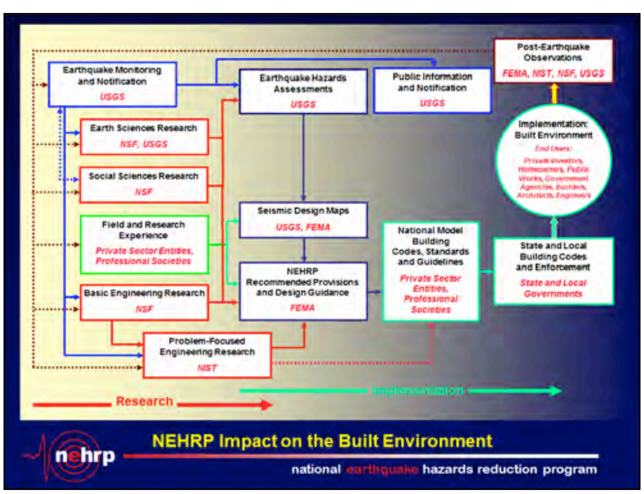
Saturday, September 18, 2010

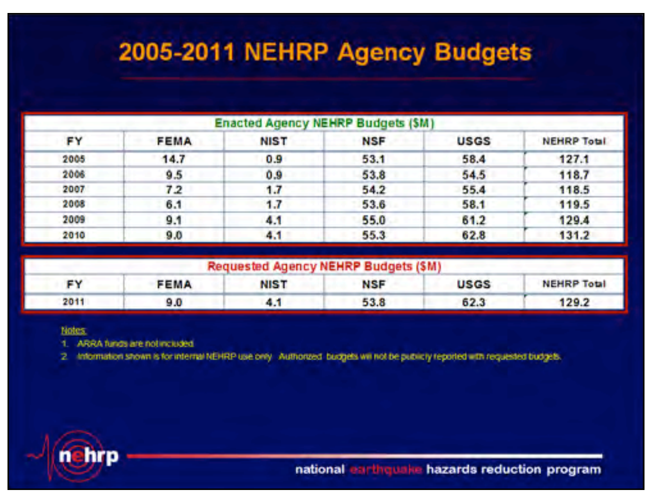
Time	Event	Location
9:00	*Gather at Crowne Plaza Hotel Lobby and Ride on Limousine*	Crowne Plaza Hotel
9:45	*Arrive at E-Defense*	E-Defense
9:50-15:00	Breakout Sessions #2 (a) High performance R/C structures Moderator: John Wallace (University of California, Los Angeles) Hitoshi Shiohara (University of Tokyo) (b) Base isolation & vibration control, Moderator: Keri Ryan (University of Nevada, Reno) Kouichi Kajiwara (NIED) (c) Geotechnical engineering Moderator: Nick Sitar (University of California, Berkeley) Ikuo Towhata (University of Tokyo) (d) Energy facilities Moderator: Khalid Mosalam (University of California, Berkeley) Tomohiro Ito (Osaka Prefecture University)	(a) Meeting room 3 (b) Meeting room 2 (c) Meeting room 1 (d) Reception room
(12:15-13:00)	Lunch	
(14:00-14:45)	Summarize breakout sessions	
14:45-15:00	Afternoon Break	
15:00-16:00	Closing Session Chair: Julio Ramirez (Purdue University) & Masayoshi Nakashima (NIED)	Meeting room 3&2
16:00	*Leave E-Defense by Limousine*	
16:40	*Arrive at Shin-Kobe Station*	Shin-Kobe Station
16:45	*Arrive at Crowne Plaza Hotel*	Crowne Plaza Hotel

Appendix III: Plenary Session - Introduction





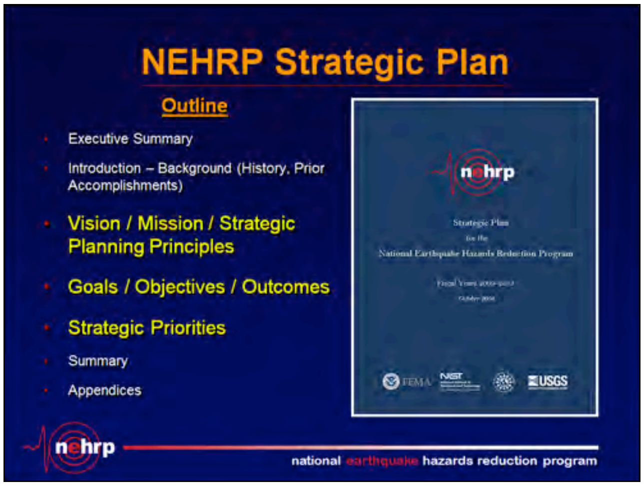




Enacted Agency NEHRP Budgets ($M)					
FY	FEMA	NIST	NSF	USGS	NEHRP Total
2005	14.7	0.9	53.1	58.4	127.1
2006	9.5	0.9	53.8	54.5	118.7
2007	7.2	1.7	54.2	55.4	118.5
2008	6.1	1.7	53.6	58.1	119.5
2009	9.1	4.1	55.0	61.2	129.4
2010	9.0	4.1	55.3	62.8	131.2

Requested Agency NEHRP Budgets ($M)					
FY	FEMA	NIST	NSF	USGS	NEHRP Total
2011	9.0	4.1	53.8	62.3	129.2

Notes:
1. ARRA funds are not included.
2. Information shown is for internal NEHRP use only. Authorized budgets will not be publicly reported with requested budgets.

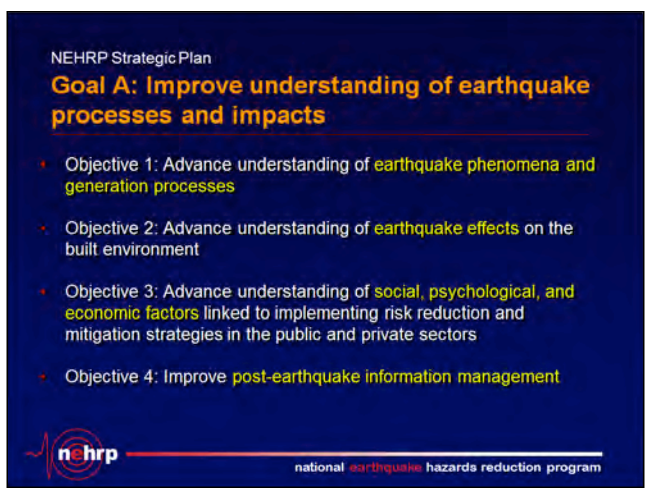

NEHRP Strategic Plan
Outline
Executive Summary
Introduction – Background (History, Prior Accomplishments)
Vision / Mission / Strategic Planning Principles
Goals / Objectives / Outcomes
Strategic Priorities
Summary
Appendices
nehrp
Strategic Plan for the National Earthquake Hazards Reduction Program
USGS
nehrp
national earthquake hazards reduction program


NEHRP Strategic Plan
National Vision Statement
… a national vision for the future:
A nation that is earthquake-resilient in public safety, economic strength, and national security.
This vision gives rise to the NEHRP Mission Statement (see next slide).
nehrp
national earthquake hazards reduction program

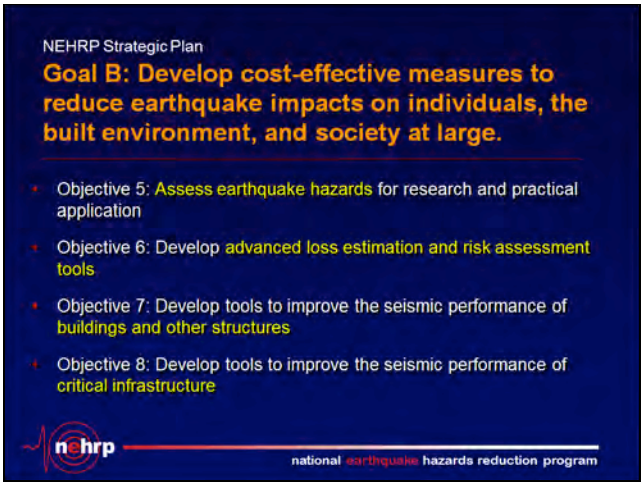

NEHRP Strategic Plan
NEHRP Mission Statement
To develop, disseminate, and promote knowledge, tools, and practices for earthquake risk reduction – through coordinated, multi-disciplinary partnerships among the NEHRP agencies and their stakeholders – that improve the nation's earthquake resilience in public safety, economic strength and national security.
nehrp
national earthquake hazards reduction program

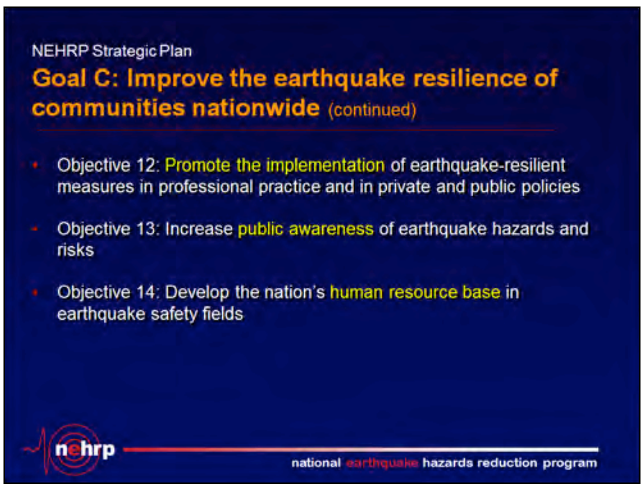

NEHRP Strategic Plan
Strategic Planning Principles
… including …
Program impact through effective development and transfer of knowledge, tools, and practices
Program revision – not reinvention
Interagency coordination / cooperation / synergy
Includes coordinated budget development
Emphasizes that progress towards all Plan goals and objectives presented in this Plan will be made, but not all of the outcomes will be fully realized during the Plan period of 2008 – 2012
Adoption of nine Strategic Priorities that support Program goals and objectives
nehrp
national earthquake hazards reduction program


NEHRP Strategic Plan
Strategic Planning Principles (cont'd)
Close partnerships with stakeholder communities
Exploitation of ANSS, GSN, IRIS, NEES
Includes emphasis on instrumentation and facility utilization by program
Includes recurring support for operating key research and data collection facilities (e.g. ANSS, NEES), providing the necessary foundation for achieving Plan goals and objectives
Multi-disciplinary approach
Multi-hazard leveraging awareness
Linkages with broader federal policies, plans, and priorities (e.g. SDR Grand Challenges for Disaster Reduction)
Increased international cooperation
nehrp
national earthquake hazards reduction program

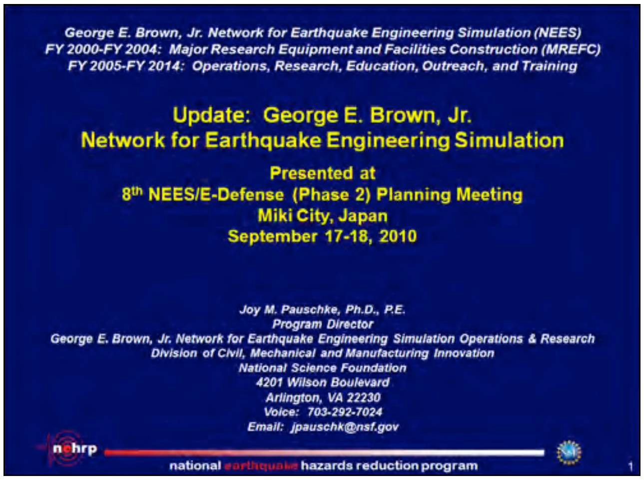

NEHRP Strategic Plan
Goal A: Improve understanding of earthquake processes and impacts
Objective 1: Advance understanding of earthquake phenomena and generation processes
Objective 2: Advance understanding of earthquake effects on the built environment
Objective 3: Advance understanding of social, psychological, and economic factors linked to implementing risk reduction and mitigation strategies in the public and private sectors
Objective 4: Improve post-earthquake information management
nehrp
national earthquake hazards reduction program

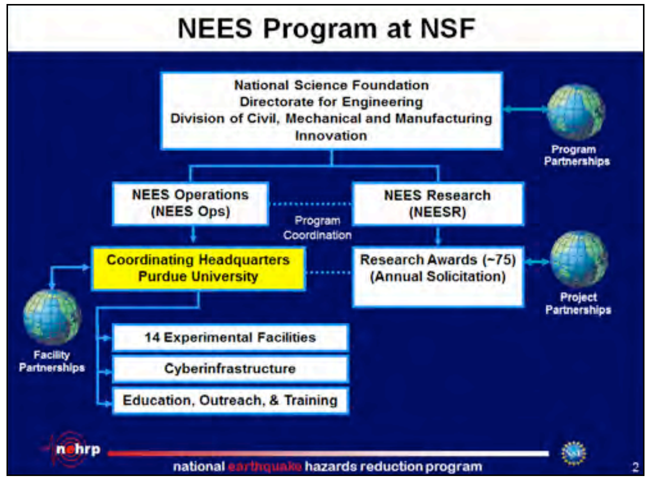
NEHRP Research Goals: Jack Hayes

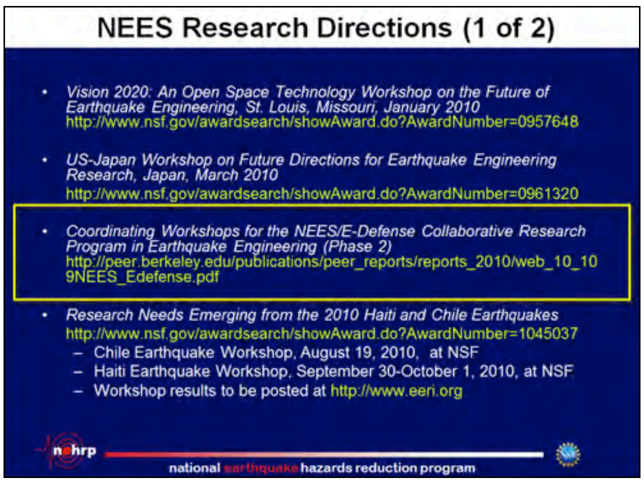


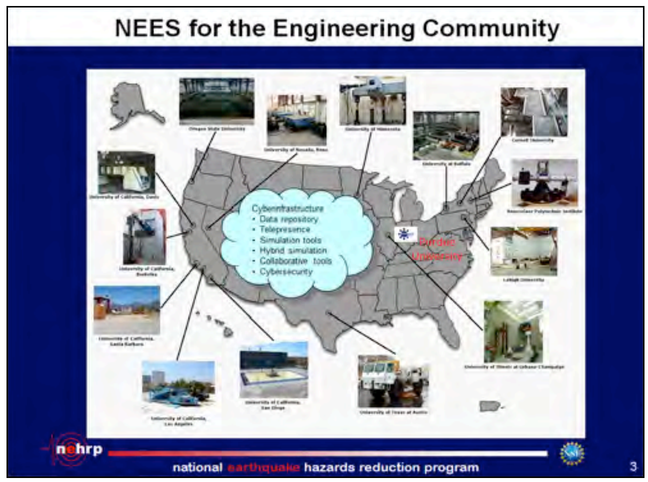


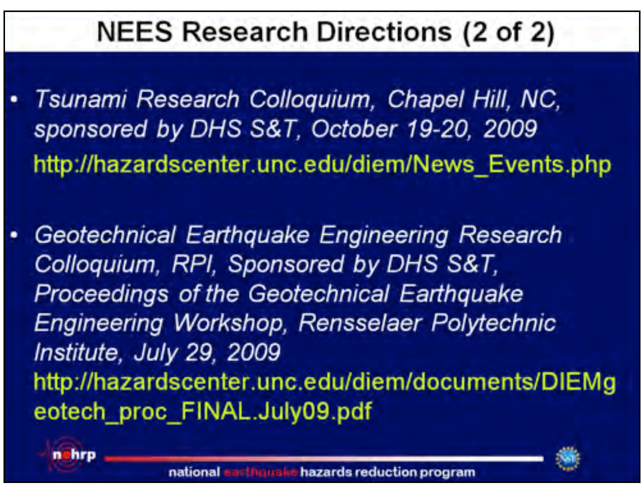
Overview of NEES Research Program: Joy Pauschke

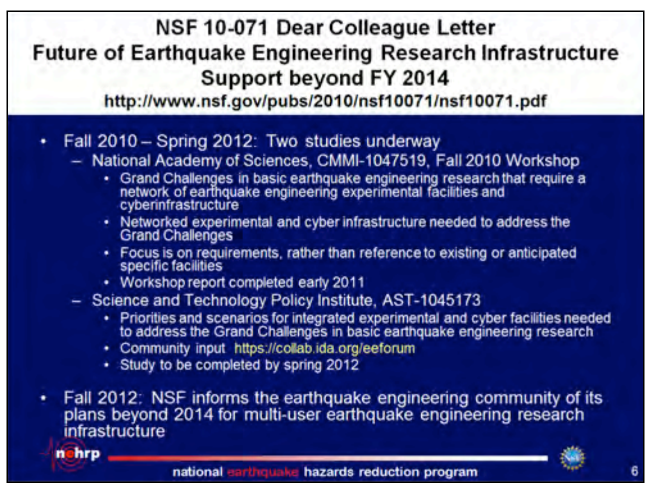




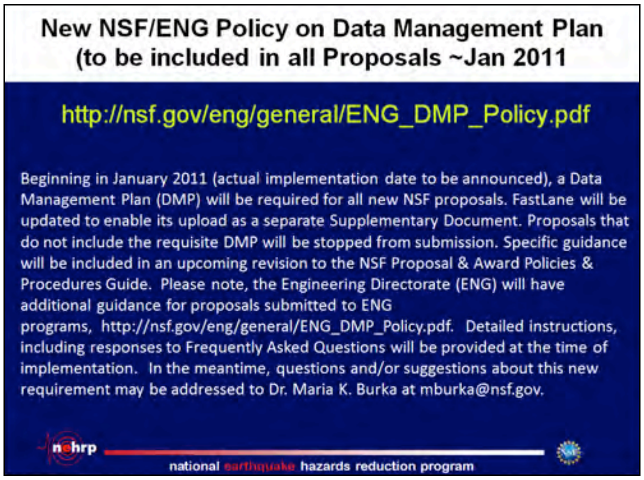




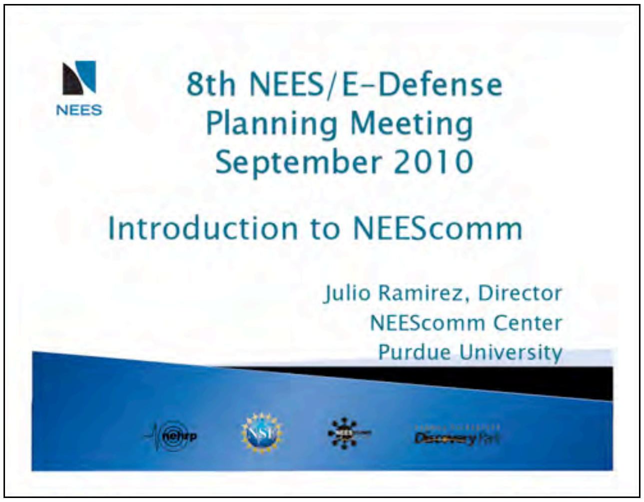


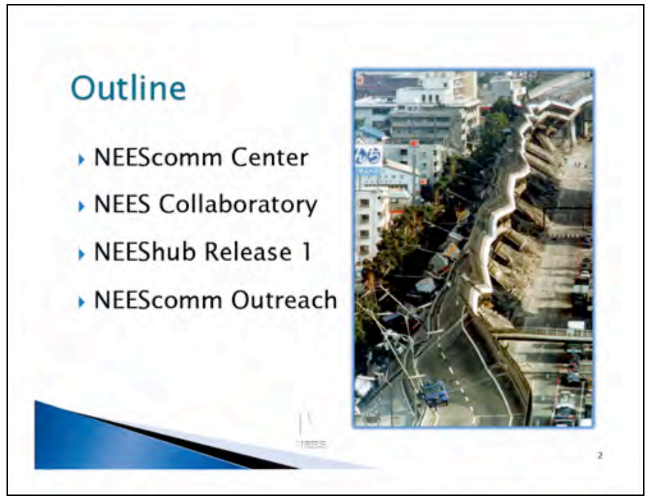


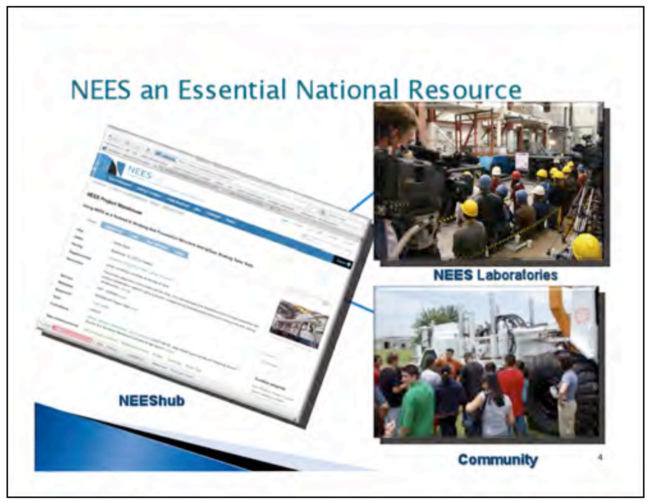
Overview of NEES Research Program: Joy Pauschke

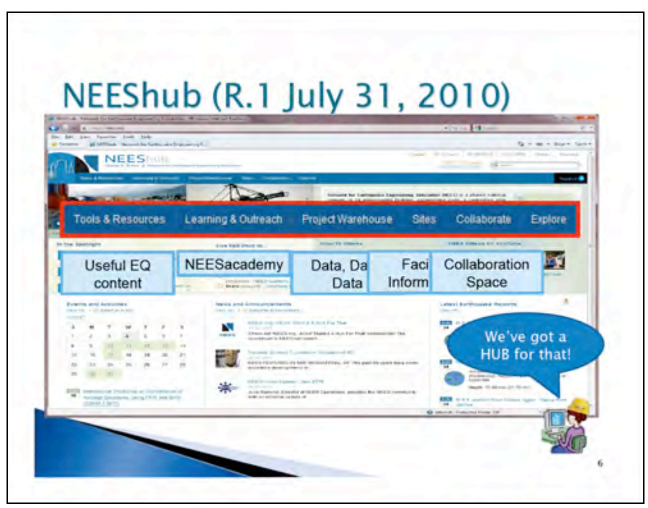


Introduction to NEEScomm: Julio Ramirez

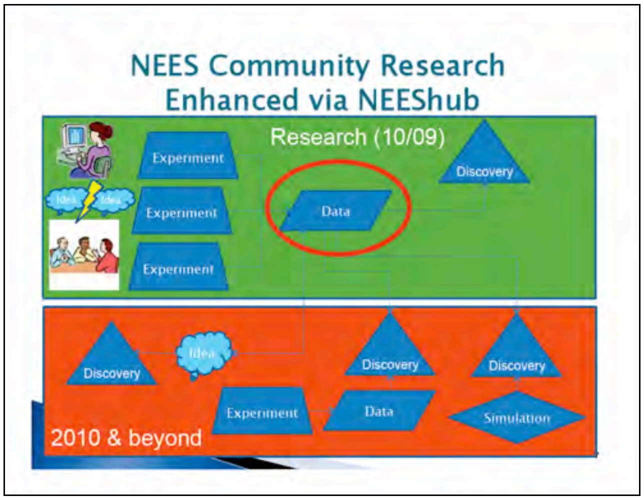


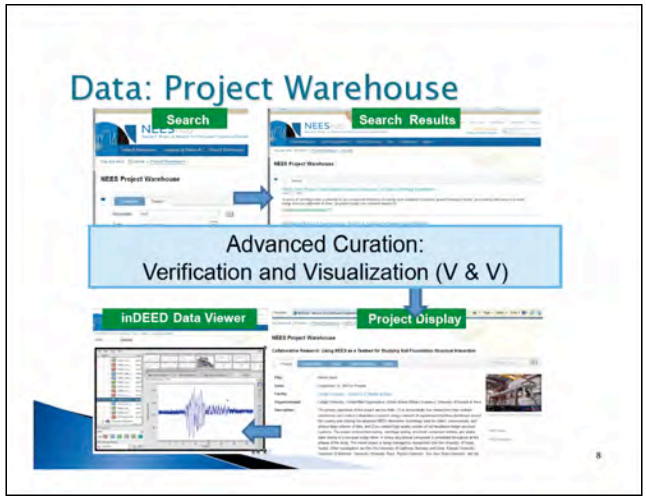


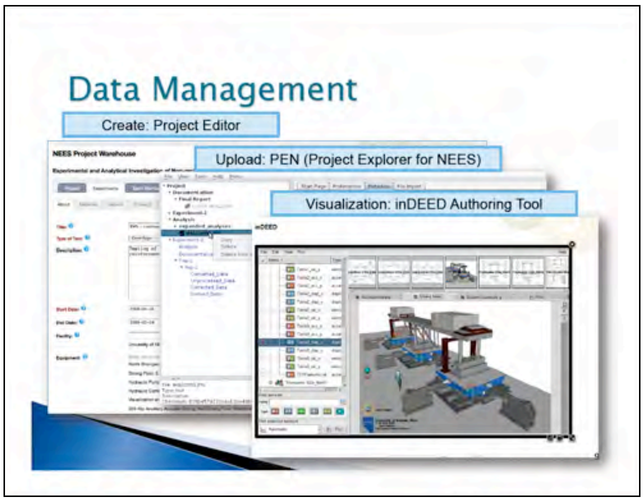


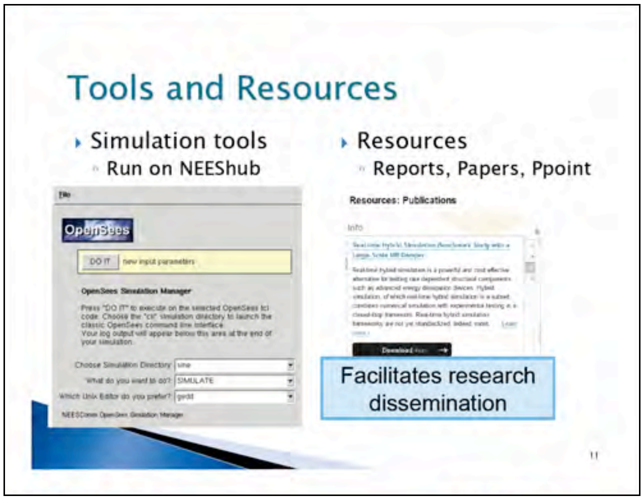


Introduction to NEEScomm: Julio Ramirez








Tools and Resources
Simulation tools
Run on NEEShub
OpenSees
DO IT
OpenSees Simulation Manager
Resources
Reports, Papers, Ppoint
Resources: Publications
Facilitates research dissemination
11


Engaging Researchers and Practitioners
Communications
NEEScomm monthly update
NEES/PEER Annual Meeting
QUAKE SUMMIT 2010
Sessions dedicated to NEEScomm activities
NEEScomm committee meetings
Partnerships
Research: International MoUs (NIED & PARI in Japan)
Practitioner: EERI collaborative agreement
http://nees.org/
12

Summary

Second Planning Meeting
Phase 2 NEES/E-Defense Collaborative
Earthquake Engineering Research Program

Held at E-Defense, September 18-19, 2009

neehrp NSF NEES E-Defense NIED

Third Planning Meeting, E-Defense, Miki & Kobe, Japan September 17-18, 2010

First Planning Meeting*

- ✓ Discuss desirability of a second five-year phase of NEES/E-Defense Collaborative Research Program on Earthquake Engineering
- ✓ Identify high priority research topics of mutual interest to the US and Japan that:
  - → Utilize the unique capabilities of the E-Defense and NEES facilities
  - → Lead to major new discoveries, solve important scientific challenges and result in innovative and transformational approaches to earthquake loss reduction.
  - → Provide opportunities for solid collaboration and synergy

* For Phase 2

Observations from First Planning Meeting

Contemporary urban society in US and Japan:

- → Are recognized to be more vulnerable to earthquakes due to complex interaction and interdependency of engineered structures and systems
- → Have higher expectations for safety and continuity of normal social, cultural and business operations

- US & Japanese research communities each working to address these issues
- NEES and E-Defense provide uniquely complementary tools to address engineering and science challenges.
- Second Phase of NEES/E-Defense Collaboration on Earthquake Engineering best means to accelerate resolution of problems of mutual interest.

Phase 2 Recommendations

By concentrating on different aspects of a common meta-theme, rapid progress possible

Enabling the Earthquake Resilient City

- → Provides a strong framework for addressing all of the high priority topics identified
- → Provides life safety, while minimizing damage and speeding recovery
- → Many new and exciting engineering and scientific challenges addressed

Need research on:

- Building systems utilizing high performance and sustainable materials
- New protective systems and advanced technologies
- Lifelines
- Underground structures

Includes:

- Numerical and experimental simulation
- Health monitoring and prognosis
- Protecting contents and nonstructural components

Resolutions

Strong collaboration is desired among projects and disciplines to achieve overall goal of meta-theme

Recommended that:

- → "Theme Structures" be devised to focus efforts by different groups
- → Joint Japan-US "capstone" experiments be considered

Implementation actions

- Joint Technical Coordinating Committee
  - Steve Mahin, Berkeley
  - Farzad Naeim, JAMA
  - Masayoshi Nakashima, E-Defense
  - Yoshimitsu Okada, NIED
  - Julio Ramirez, Purdue
  - Yoshinori Suzuki, MExT
- Technical Subcommittees on each major theme area
- Planning meetings needed to define needs and scope of work

Proceedings

Contains:

- White papers
- Plenary papers on past and possible future research
- Breakout session reports
- Workshop resolutions
- Participant list
- Agenda

Mechanism established for coordinating US side of program

NSF has funded four-year coordination effort

- Publicizing opportunities, activities and outcomes in conjunction with NEEScomm and NSF
- Encouraging broad participation by various means, including:
  - Funding travel to meetings by investigators having a diversity of interests, gender, ethnicity and age, engineering practitioners, specialized experts, and students.
- Annual NEES/E-Defense planning and coordination meetings in Japan
- Periodic Technical Subcommittee Meetings in the US
- Technical support for managing theme structures
- Facilitate communications

PI: Stephen Mahin

Opportunities

Maintaining communications

- Develop effective overall research and work plan for capstone tests being conducted on E-Defense
- Future planning meetings
- NEESR solicitation
  - Full projects collaborating with Japanese counterparts on one of the four thrust areas
  - Payload projects!
    - Sensors, monitoring and health assessment
    - Nonstructural issues
- Computational Simulation

A Summary of Seventh NEES/E-Defense Planning Meeting

by
Masayoshi Nakashima
E-Defense
National Research Center for Earth Science and Disaster Prevention (NIED)

NEES/E-Defense Collaboration Memorandum of Understanding (MOU)

MEXT & NSF (National Science Foundation) :
Research Collaboration on Disaster Mitigation
NIED & NEES (J. Brown Jr. Network for Earthquake Engineering Simulation) :
Collaboration on Joint Research Using NEES/E-Defense

NIED-NEES, August 3, 2005

MEXT-NSF, Sept 13, 2005

A History of Planning and JTCC Meeting

Planning Meetings

First	April, 6 to 8, 2004 at Kobe
Second	July 12 to 13, 2004 at Washington DC
Third	January 17, 2005 at E-Defense
Fourth	August 2 to 3, 2005 at E-Defense
Fifth	September 27 to 29, 2006 at E-Defense
Sixth	September 28 to 30, 2007 at E-Defense
(First for Second Phase of NEES/E-Defense	
	January 12 to 13, 2009 at Washington DC
Seventh	September 18 to 19, 2009 at E-Defense

JTCC Meetings

First	August 8, 2005 at E-Defense
Second	April 17, 2006 at San Francisco
Third	June 24, 2009 at Honolulu

Resolutions Adopted in First Joint Planning Meeting for Second Phase of NEES/E-Defense Collaborative Research Washington DC, USA January 11 to 12, 2009

Resilient City as a Common Meta-Theme

The three meta-themes discussed in the meeting, i.e., "**Disaster Resilient Communities**", "**Preparing for the Big One**", and "**Low-Probability, High-Consequence Events**" are linked in many ways. The fundamentals of the first meta-theme are the damage reduction and quick recovery. These require developments of new materials and technologies that would enhance the performance of various components that form the urban area. Methods to detect the damage quickly and systems that can be repaired (or re-built) with minimal interruption of life and business are also the important topics to consider. In the second meta-theme, developments of new materials and technologies are the key to the prevention of a downward spiral of deterioration. The third meta-theme has much in common with the preceding two in light of the specific scientific challenges to be pursued. Thus, it was agreed that the 'Resilient City' provided a mutually important goal upon which members of the US and Japanese earthquake engineering communities could work and that US-Japan collaboration would accelerate realization of this goal and leverage the resources available in both countries.

Seventh NEES/E-Defense Planning Meeting

Agenda

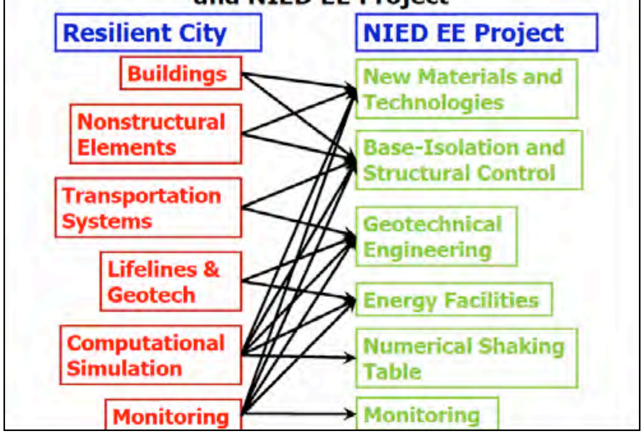
September 17
Overview, NEEScomm, Japanese Proposals, Test Observations,

September 18
Six Breakout Sessions, Plenary, Closure

Japanese Proposals for Phase II

Project (a) New Materials and Technologies
Project (b) Base-Isolation and Structural Control
Project (c) Lifelines and Geotech
Project (d) Energy Facilities
Project (e) Monitoring
Project (f) Numerical Shaking Table
(Data Repository)

Interaction Between "Resilient City" Approach and NIED EE Project



Resolutions

Pages 6 – 8 of Report of the Seventh Joint Planning Meeting of NEES/E-Defense Collaborative Research on Earthquake Engineering

- NEES/E-Defense Collaboration should continue without interruption into Phase.
- Projects (a) to (f) are suitable for NEES/E-Defense Collaboration.
- Theme structure concept is most preferable.
- Respective task teams should be established as soon as possible.
- Funding agencies are encouraged to provided needed resources

Appendix IV: Plenary Session - Japanese Proposals

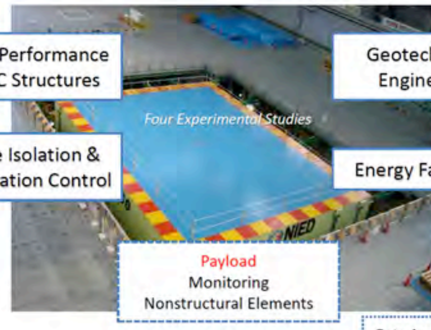
Outline of NIED Research Projects: Taizo Matsumori

Outline of NIED Research Projects

Taizo Matsumori
National Research Institute for Earth Science and Disaster Prevention

1

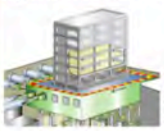
Introduction of NIED Earthquake Engineering Project



2

Four Experimental Studies

High Performance R/C Structures — Takuya Nagae, Kenichi Tahara



- ✓ High-strength concrete and steel
- ✓ High-performance walls
- ✓ Self-centering systems

➢ Verify seismic performance of reinforced concrete building structures in which new materials, new elements, and new systems are incorporated.

Geotechnical Engineering — Kentaro Tabata, Yousuke Kawamata

shear soil container

Targets = transportation systems in an urban area (subways, railroads, expressways...)

➢ Investigate behavior of underground structures such as shielded/cut-and-cover tunnels, curves, complicated sections, traversing heterogeneous layers.

Base Isolation & Vibration Control — Eiji Sato, Taichiro Okazaki

- ✓ Hybrid seismic isolation with TMD or AMD
- ✓ Active or Semi-Active seismic isolation
- ✓ 3D seismic isolation

➢ Develop next generation seismic isolation and vibration control systems that mitigates both long period and short period earthquake motions.

Energy Facilities — Izumi Nakamura, Manabu Nakayama

- Electric generating facilities
- High-pressure gas facilities, ...

- ✓ Piping systems
- ✓ Supports
- ✓ Containers
- ✓ Tanks, ...

➢ Clarify the seismic safety margins and structural integrity of energy facilities and their components under large seismic motions exceeding the design level.

Timetable of E-Defense Large-Scale Shaking Table Tests

Plan as of September 2009

Fiscal year	2010	2011	2012	2013	2014	2015
High performance R/C structures	O		O			
Base isolation & vibration control		O		O		
Geotechnical engineering		O		O		
Energy facilities	O		O			

Plan as of September 2010

Japanese fiscal year begins on April 1

Fiscal year	2010	2011	2012	2013	2014	2015
High performance R/C structures	O			O		
Base isolation & vibration control		NEES	O			O
Geotechnical engineering		O			O	
Energy facilities		O			O	
Equipments, Nonstructural elements	o		o	o		o

Pending budget approval

4

E-Defense Executive Committee

High Performance R/C Structures

- ➢ Hitoshi Shiohara (chair)
- ➢ Toshimi Kabeyasawa
- ➢ Susumu Kono
- ➢ Isao Nishiyama
- ➢ Minehiro Nishiyama

Geotechnical Engineering

- ➢ Ikuo Towhata (chair)
- ➢ Koichi Maekawa
- ➢ Susumu Yasuda

Numerical Simulation

- ➢ Muneo Hori (chair)
- ➢ Tsuyoshi Ichimura
- ➢ Daigoro Isobe
- ➢ Mika Kaneko
- ➢ Kazuo Kashiyama
- ➢ Masayuki Kohiyama
- ➢ Mitsutoshi Kuroda
- ➢ Takeshi Maki
- ➢ Tomoshi Miyamura
- ➢ Taro Mizutani
- ➢ Akitsugu Muramatsu
- ➢ Naohiro Nakamura
- ➢ Kenji Oguni
- ➢ Makoto Ohsaki
- ➢ Shigenobu Okazawa
- ➢ Yoshikazu Takahashi
- ➢ Masashi Yamamoto
- ➢ Shinobu Yoshimura

Base Isolation & Vibration Control

- ➢ Satoshi Fujita (chair)
- ➢ Hideo Fujitani
- ➢ Nagahide Kani
- ➢ Hidekazu Nishimura
- ➢ Mineo Takayama

Energy Facilities

(currently assembling)

- ➢ Tomohiro Ito (chair)
- ➢ Keisuke Minagawa

:

Each research committee will provide guidance and advice regarding

- ➢ Research plans and research progress status;
- ➢ How to develop output and outcomes;
- ➢ How to promote NEES/E-Defense collaborative research.

5

Discussions in Breakout Sessions

Summarize discussions within two pages

Breakout Sessions from 3:00 PM until 4:20 PM on Friday, September 17

(a) Numerical Simulation (at Auditorium)
Modaretor : Gregory Deierlein, Muneo Hori

(b) Monitoring (at Lecture room No.1)
Moderator : Shirley Dyke, Akira Nishitani

Suggested issues to discuss:
1) How to best utilize the test data obtained at E-Defense and NEES. (both)
2) How to use the tests as an opportunity for payload tests to install instruments and health monitoring systems. (monitoring)

Breakout Sessions from 9:40 AM until 2:45 PM on Saturday, September 18

(a) High Performance R/C Structures
Moderator : John Wallace, Hitoshi Shiohara

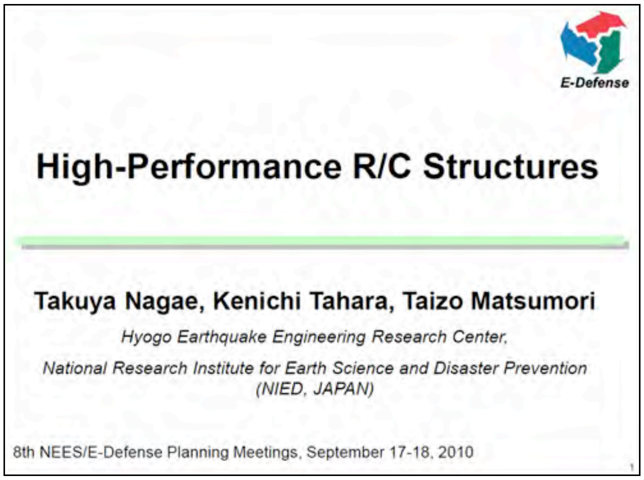
(b) Base Isolation & Vibration Control
Moderator : Keri Ryan, Kouichi Kajiwara

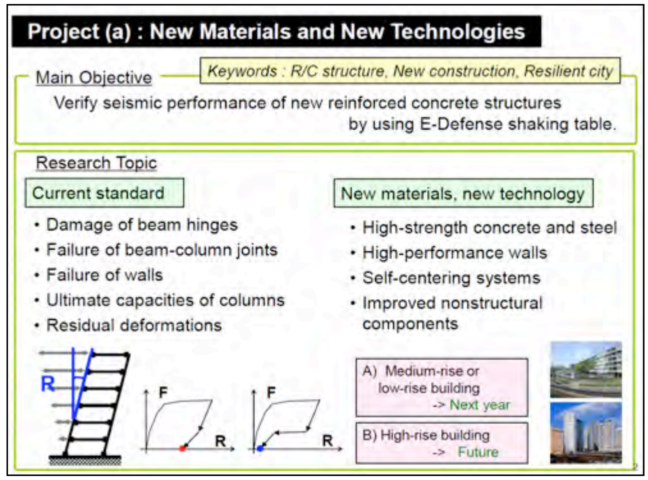
(c) Geotechnical Engineering
Moderator : Nick Sitar, Ikuo Towhata

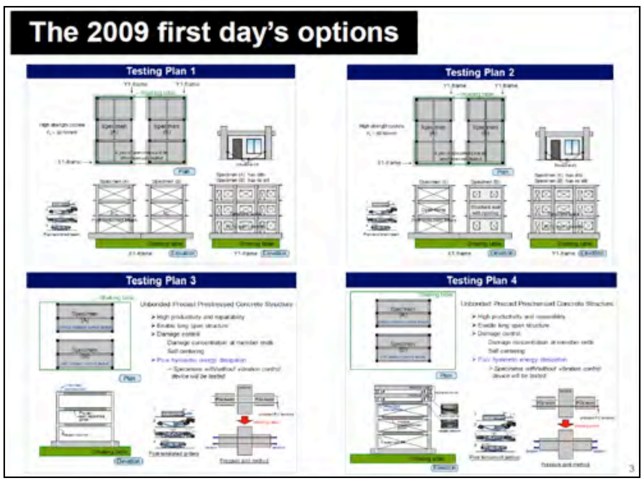
(d) Energy Facilities
Moderator : Khalid Mosalam, Tomohiro Ito

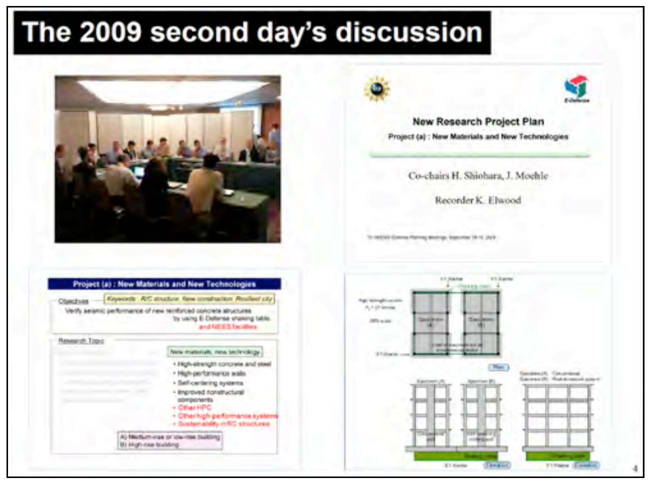
Suggested issues to discuss:
1) Comments and suggestions to Japanese projects from the US
2) Research plans in the US and comments from Japan
3) Possible issues for collaboration
4) Complementary research strategies

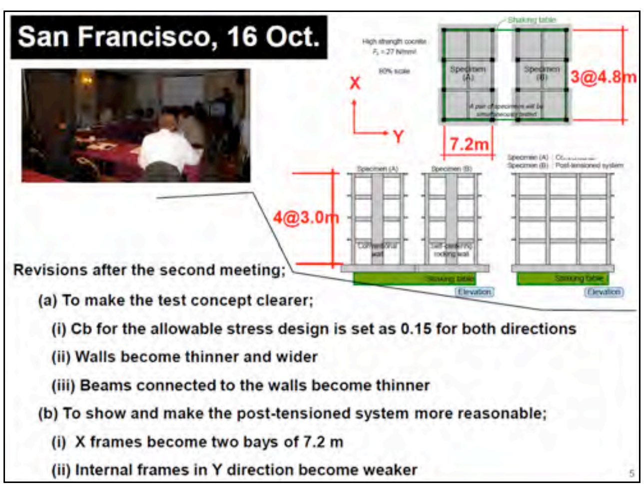
6

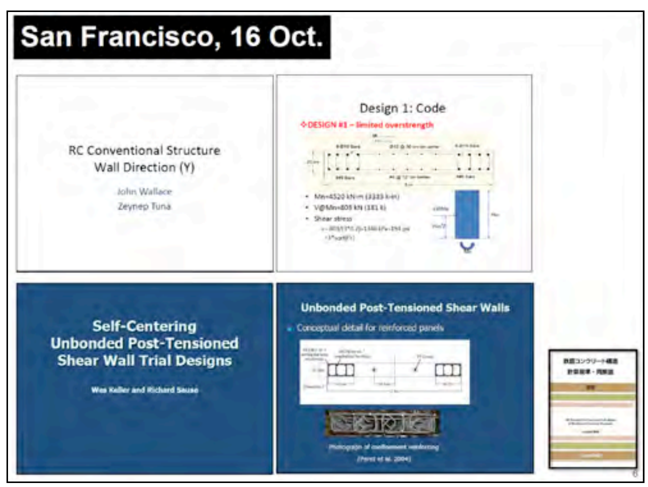

E-Defense
High-Performance R/C Structures
Takuya Nagae, Kenichi Tahara, Taizo Matsumori
Hyogo Earthquake Engineering Research Center,
National Research Institute for Earth Science and Disaster Prevention (NIED, JAPAN)
8th NEES/E-Defense Planning Meetings, September 17-18, 2010
1

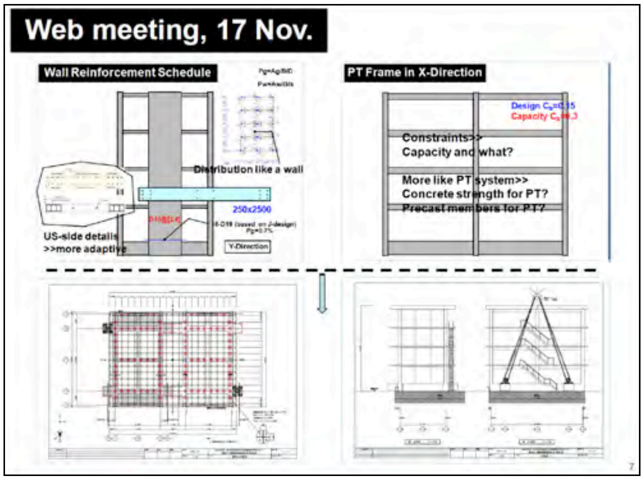

Project (a) : New Materials and New Technologies
Main Objective
Keywords : R/C structure, New construction, Resilient city
Verify seismic performance of new reinforced concrete structures by using E-Defense shaking table.
Research Topic
Current standard
• Damage of beam hinges
• Failure of beam-column joints
• Failure of walls
• Ultimate capacities of columns
• Residual deformations
New materials, new technology
• High-strength concrete and steel
• High-performance walls
• Self-centering systems
• Improved nonstructural components
R
F
R
F
R
A) Medium-rise or low-rise building -> Next year
B) High-rise building -> Future
2

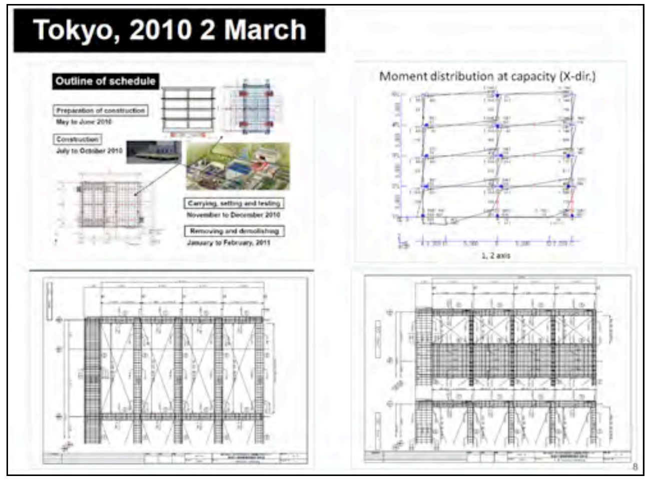

The 2009 first day's options
Testing Plan 1
Testing Plan 2
Testing Plan 3
Testing Plan 4
3

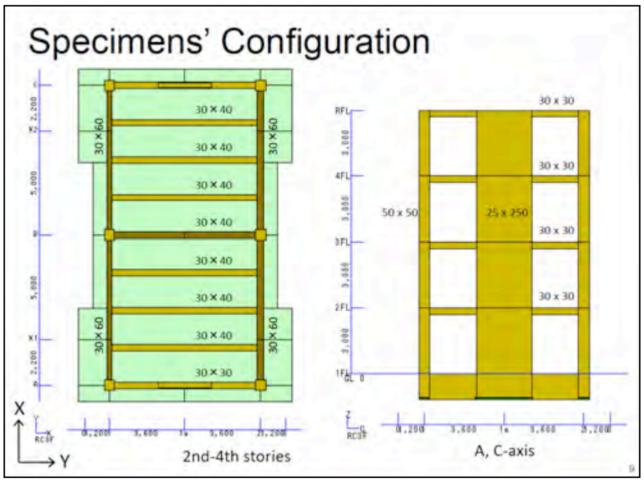

The 2009 second day's discussion
New Research Project Plan
Project (a) : New Materials and New Technologies
Co-chairs H. Shiohara, J. Moehle
Recorder K. Elwood
Project (a) : New Materials and New Technologies
4

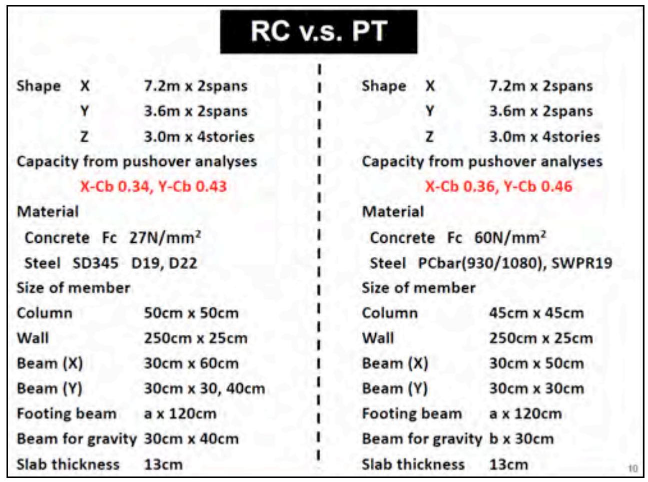

San Francisco, 16 Oct.
X
Y
3@4.8m
7.2m
4@3.0m
Revisions after the second meeting;
(a) To make the test concept clearer;
(i) Cb for the allowable stress design is set as 0.15 for both directions
(ii) Walls become thinner and wider
(iii) Beams connected to the walls become thinner
(b) To show and make the post-tensioned system more reasonable;
(i) X frames become two bays of 7.2 m
(ii) Internal frames in Y direction become weaker
5

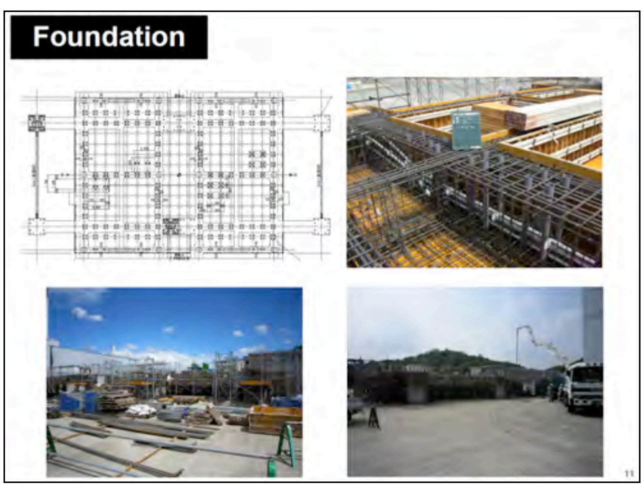

San Francisco, 16 Oct.
RC Conventional Structure
Wall Direction (Y)
John Wallace
Zeynep Tuna
Design 1: Code
Self-Centering
Unbonded Post-Tensioned
Shear Wall Trial Designs
Unbonded Post-Tensioned Shear Walls
6

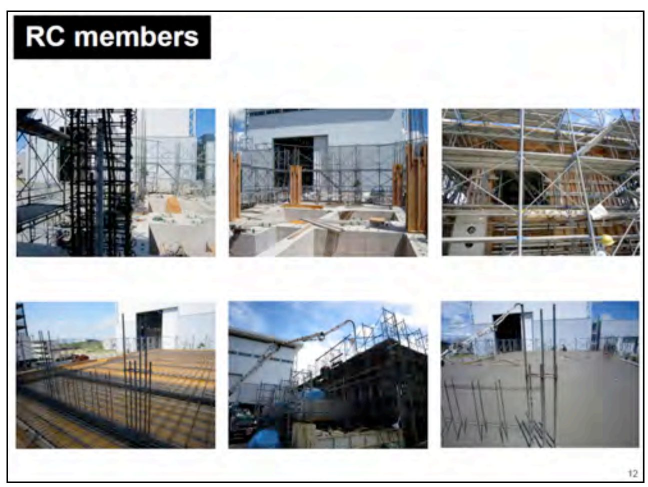

Web meeting, 17 Nov.
Wall Reinforcement Schedule
PT Frame in X-Direction
Distribution like a wall
250x2500
US-side details
>>more adaptive
Y-Direction
Constraints>>
Capacity and what?
More like PT system>>
Concrete strength for PT?
Precast members for PT?
7

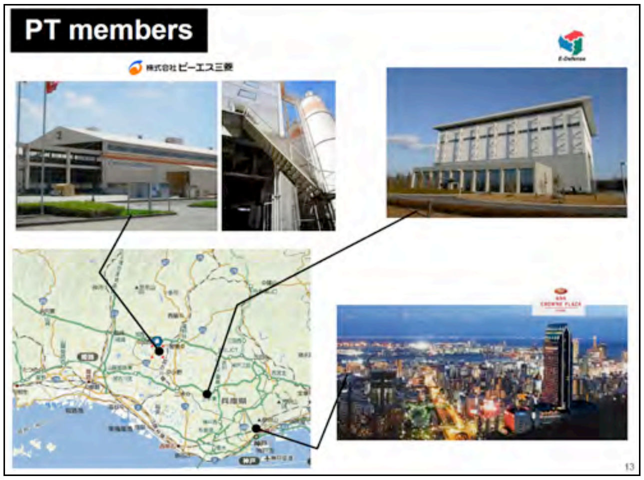

Tokyo, 2010 2 March
Outline of schedule
Moment distribution at capacity (X-dir.)
8

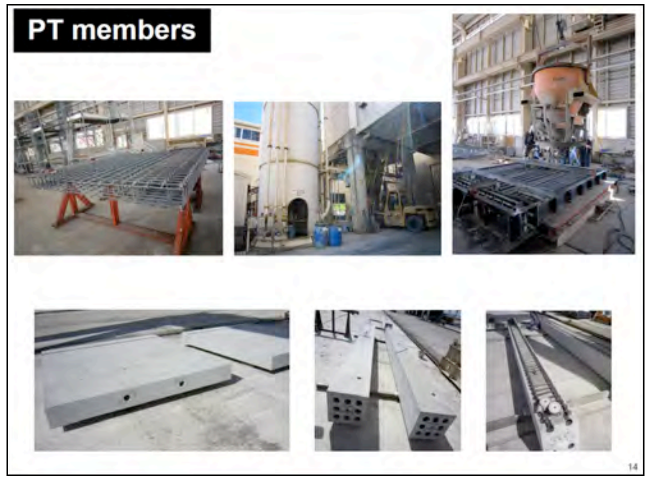

Specimens' Configuration
30 x 40
30 x 30
30 x 60
30 x 30
50 x 50
25 x 250
RFL
4FL
3FL
2FL
1FL
X
Y
2nd-4th stories
A, C-axis
9


RC v.s. PT
Shape X 7.2m x 2spans
Y 3.6m x 2spans
Z 3.0m x 4stories
Capacity from pushover analyses
X-Cb 0.34, Y-Cb 0.43
Material
Concrete Fc 27N/mm2
Steel SD345 D19, D22
Size of member
Column 50cm x 50cm
Wall 250cm x 25cm
Beam (X) 30cm x 60cm
Beam (Y) 30cm x 30, 40cm
Footing beam a x 120cm
Beam for gravity 30cm x 40cm
Slab thickness 13cm
Shape X 7.2m x 2spans
Y 3.6m x 2spans
Z 3.0m x 4stories
Capacity from pushover analyses
X-Cb 0.36, Y-Cb 0.46
Material
Concrete Fc 60N/mm2
Steel PCbar(930/1080), SWPR19
Size of member
Column 45cm x 45cm
Wall 250cm x 25cm
Beam (X) 30cm x 50cm
Beam (Y) 30cm x 30cm
Footing beam a x 120cm
Beam for gravity b x 30cm
Slab thickness 13cm
10


Foundation
11


RC members
12





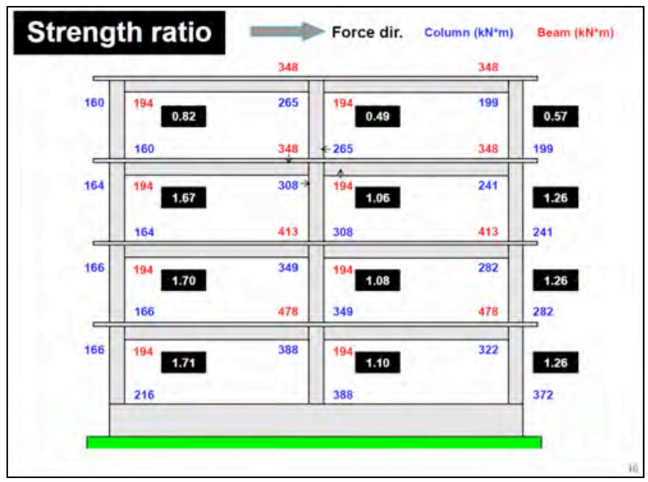
RC Design

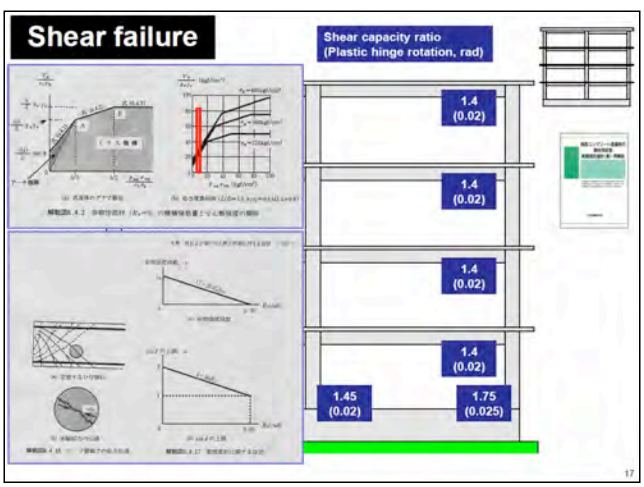
Capacity criteria in J-Design's law requirement

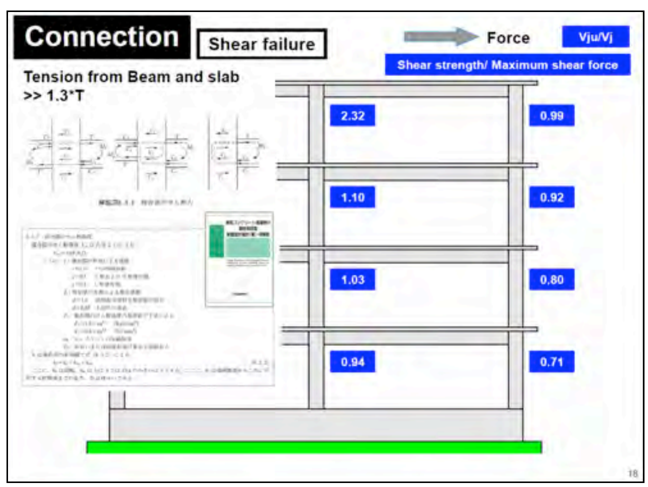
	Story	Fes	Ds	1g Demand Qd(kN)	Design Demand Qun(kN)	Capacity Qu(kN)	Qu/Qun	Check	Qu/Qd
Y	4	1.0	0.35	1,390	487	579	1.19	OK	0.42
	3	1.0	0.40	2,298	919	956	1.04	OK	0.42
	2	1.0	0.40	3,048	1,219	1,268	1.04	OK	0.42
	1	1.0	0.35	3,629	1,270	1,510	1.19	OK	0.42
X	4	1.0	0.30	1,390	417	490	1.18	OK	0.35
	3	1.0	0.30	2,298	689	810	1.18	OK	0.35
	2	1.0	0.30	3,048	914	1,075	1.18	OK	0.35
	1	1.0	0.30	3,629	1,089	1,279	1.18	OK	0.35

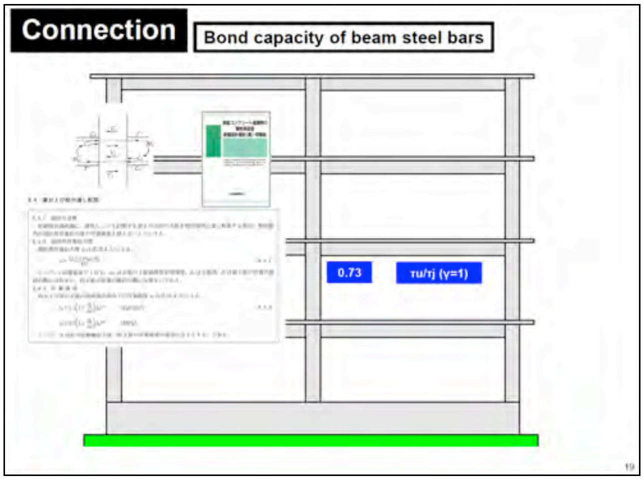
Capacity of 1% drift angle

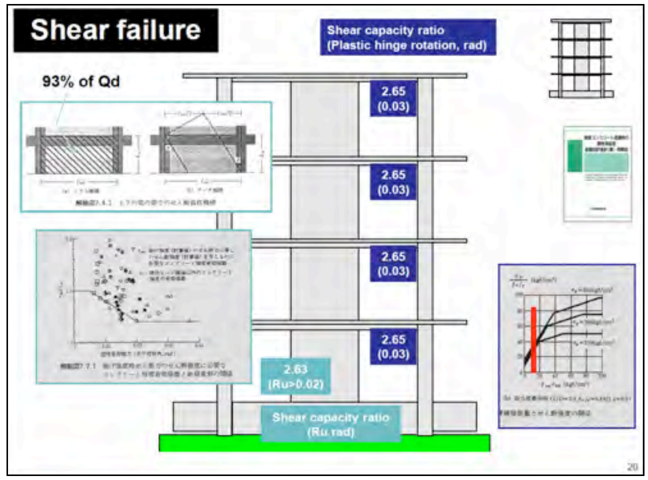
15

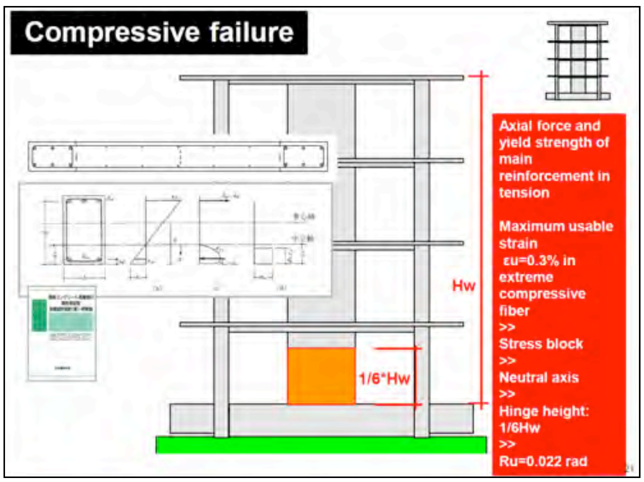


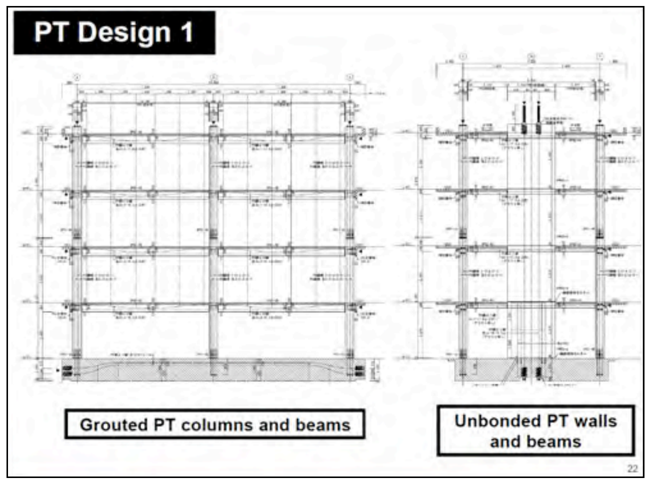


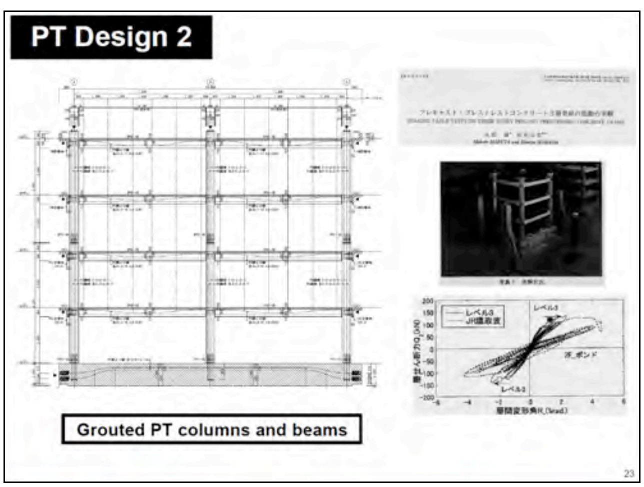


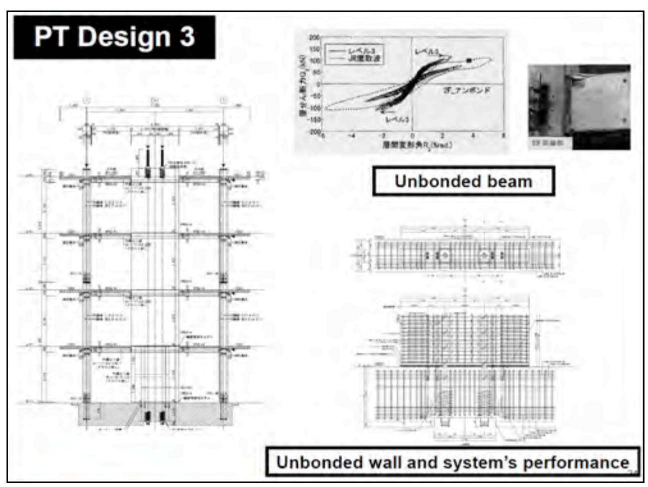

Connection
Bond capacity of beam steel bars
0.73
τu/τj (γ=1)
19

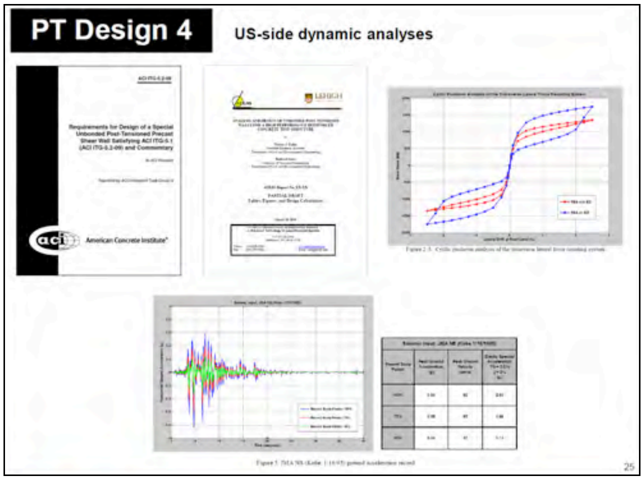

Shear failure
Shear capacity ratio
(Plastic hinge rotation, rad)
93% of Qd
2.65
(0.03)
2.65
(0.03)
2.65
(0.03)
2.65
(0.03)
2.63
(Ru>0.02)
Shear capacity ratio
(Ru,rad)
20

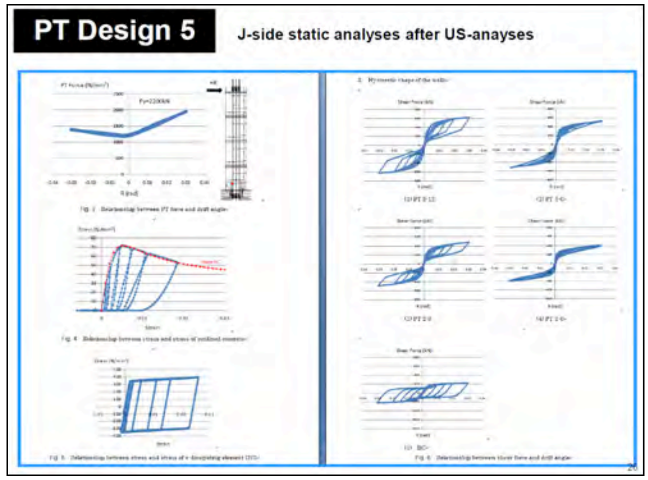

Compressive failure
Axial force and yield strength of main reinforcement in tension
Maximum usable strain
εu=0.3% in extreme compressive fiber
>>
Stress block
>>
Neutral axis
>>
Hinge height: 1/6Hw
>>
Ru=0.022 rad
Hw
1/6*Hw
21


PT Design 1
Grouted PT columns and beams
Unbonded PT walls and beams
22


PT Design 2
Grouted PT columns and beams
23


PT Design 3
Unbonded beam
Unbonded wall and system's performance


PT Design 4
US-side dynamic analyses
American Concrete Institute
25


PT Design 5
J-side static analyses after US-anayses
26

Base-Isolation & Vibration Control

Taichiro Okazaki
National Research Institute for Earth Science and Disaster Prevention

1

Background and Motivation

- Increasing popularity of isolation systems following 1995 Kobe Earthquake
  - 2000 condominium, office, and hospital buildings, 3000 residential buildings constructed to date
- Characteristic frequency is 2 sec for earlier systems, 3 to 5 seconds for later systems. Considers horizontal motion only.
- Partial isolation (isolated floors, equipment isolation) is used frequently .
- Need to address vertical motions
  - Vertical motion exceeding 1G recorded from 2004 Chuetsu EQ
  - 3D isolation is becoming reality (planned for at least one project), but verification has not been performed.
  - Little verification data available for partial isolation.
- Concern for long-period ground motions
  - Limited verification
  - Elongating the characteristic period is not the solution for long-period ground motions → What is needed is absolute isolation

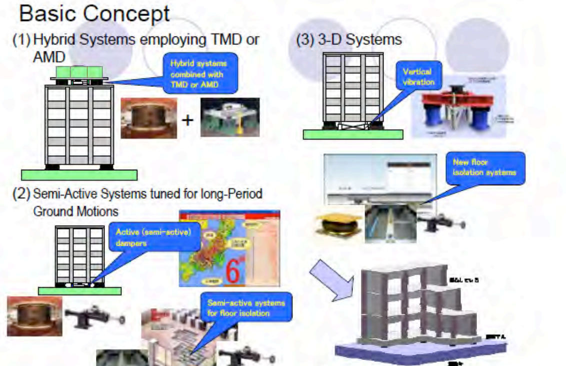
2

Objectives

- Adjust characteristic period and damping to the ground motion → “Active (semi-active) isolation” (1)、(2)
- “Absolute isolation”
  — Elongating the characteristic period is not enough (2)
- Address vertical motions (3)
- Validate cost effective, high-performance solutions (e.g. floor isolation, equipment isolation) (2)、(3)

3

Basic Concept



Non-symmetric building specimen

4

- Expected Outcomes
  - Solutions against long-period motions
  - Isolation systems tuned/adjusted for various ground motions (both long and short-period motions)
  - Solutions for 3D vibration
  - Improvement of floor isolation systems

- Impact on Society
  - Collaboration with industry (Japan Society of Seismic Isolation, construction industry, device manufacturers) to develop guidelines
  - Wider acceptance of isolation technology
  - Active (semi-active) isolation systems for important structures and facilities
  - Establish 3D limit states
  - Benchmark for isolation systems applied to residential buildings

5

The 8th NEES/E-Defense Planning Meeting

E-Defense

E-Defense Geotechnical Test Project

Underground Structures in Urban Areas

Kentaro Tabata

Senior Researcher

Hyogo Earthquake Engineering Research Center

National Research Institute for Earth Science and Disaster Prevention

Reviews of geotechnical projects at E-Defense

- FY2005-06: Dai-Dai-Toku project years
  - Preparation of the containers, sand and sensoring devices


Laminar container


Rigid container


Carrier


3D measurement


Albany silica sand

Reviews of geotechnical projects at E-Defense

- FY2005-06: Dai-Dai-Toku project years
  - Four tests performed = soil-pile-foundation interaction, liquefaction-induced lateral spreading phenomenon

Soil-pile-foundation interaction in level ground 	Liquefaction-induced lateral spreading 
#1: February 14-24, 2006 Non-liquefiable deposits	#2: March 23, 2006 Sheet-pile-type quay wall
#3: August 22-25, 2006 Liquefiable deposits	#4: December 15, 2006 Caisson-type quay wall

E-Defense geotechnical testing

- Through the two-year process, the E-Defense testing capability had been verified:
  - Reproduction of ground motion records on the table
  - Simulation of liquefaction and liquefaction-induced phenomena such as lateral spreading
  - Simulation of failures on structures (e.g. piles and caissons)
  - Preparation and installation of soil, structure models and sensors
- Two unique advantages of the E-Defense testing:
  - Large-scale model
    - > *Observe "more realistic" situations and phenomena*
    - > *Record "more detailed" behavior placing more sensors*
  - Performance to produce earthquake disaster
    - > *Obtain the case histories of an "artificial" disaster*

"Resilient City" as a common meta-theme

- Achieve a disaster resilient city by:
  - Maintaining function of lifelines including supply of water and electricity, and transportation system during and even after a large earthquake
  - Recovering damaged function quickly
- To fulfill the above, define target structures for the E-Defense geotechnical test project
  - Lifeline structures in focus = transportation systems in urban areas
    - > *Tunnels for subways, underground expressways...*
    - > *Underground structures such as subway stations*
    - > *Access structures to subway stations*
    - > *Neighboring underground structures*

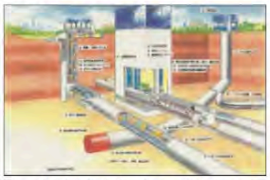
Targets of the geotechnical research

- In urban areas, widespread networks of buried, underground lifelines exist
  - < *Technology innovations, effective usage of land, landscape preservation…*
- Complex structures, complicated distribution of structures, structures placed into heterogeneous soil strata, deeper locations…
  - > *Behavior during earthquake?*
  - > *Interaction between neighboring structures?*
  - > *Evaluation method of their seismic capacity?*

Need to investigate seismic behavior of underground structures mentioned above…

Underground space in mega-cities

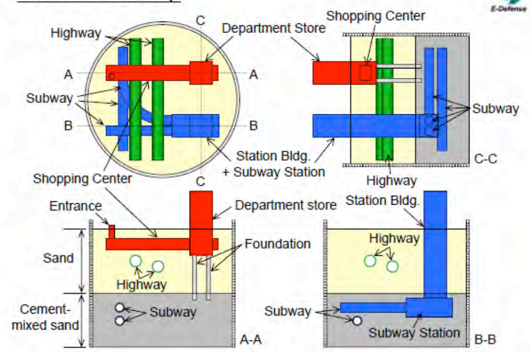
- Exchanging ideas with practitioners, define research targets:
  - Damage development at a joint
  - Effect of neighboring structures on seismic behavior of structure
  - Seismic behavior of vertical underground structures



(Courtesy: MILT, Vision of technology development for usage of deep underground)

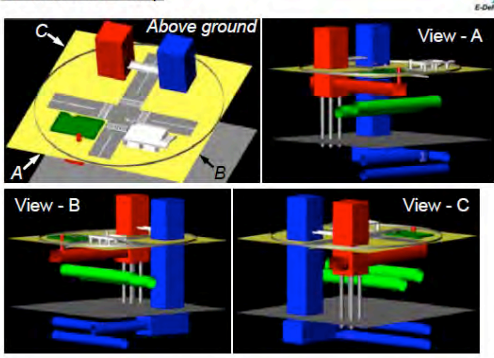
7

Draft of test setup



8

Draft of test setup



9

Testing schedule

- FY 2010: Preliminary studies
  - Perform a series of small-scaled model centrifuge and shaking-table tests, element tests of geo-material and numerical simulations to obtain fundamental data
- FY 2011: Large-scaled model test at E-Defense
- FY 2012: Evaluation of the test results
- FY 2013~2015: Another series of preliminary studies and large-scaled model test
  - Based on the results from the first series of the tests, define target structures for the second series

10

Energy Facilities: Izumi Nakamura

E-Defense

Research project plan
- Energy facilities

Izumi Nakamura
National Research Institute for Earth Science and Disaster Prevention

8th NEES/E-Defense planning meeting, Sept. 17-18, 2010 1

Background

- ✓ Components of energy facilities need to remain in safety at seismic events.
  - ➢Not to cause the leakage of the high-energy content in these components.
  - ➢To keep the function of the facilities.
  - ➢The energy plants are expected to resume operations after the seismic events, provided the safety of the facilities are assured.
- ✓ The safety margin and structural integrity of the components is not clear which are struck by unexpected input motions.
- ✓ The integrity of the components with aging degradation under the seismic events is also an important issue.

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Objective

Objective

To clarify the seismic safety margins and structural integrity of components of energy facilities under large seismic motions, especially over the design level.

Energy facilities
- ✓ Power generation structures
- ✓ Oil and natural gas processing and storage facilities
- ✓ Chemical facilities, …etc.

Components of energy facilities
- ✓ Piping systems and supports
- ✓ Containers
- ✓ Tanks, …etc.

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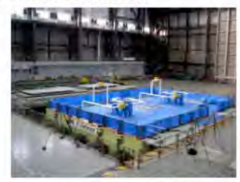
Past studies in NIED

- ✓ Several shake table tests on piping system models with and without aging degradation have been conducted.

One-directional shake table test (1998-2005)



Three-directional shake table test (July 2010)

- ✓ Behavior and failure mode beyond design basis input were obtained for piping system itself (with and without degradation).
- ✓ FEM analysis is well estimated the piping systems' behavior and failure mode.

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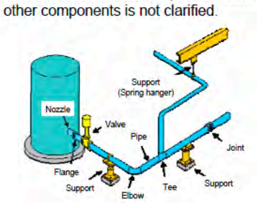
Seismic reliability of steam cycle

- ✓ To clarify the behavior of steam cycle systems with piping and other components, like supports, tanks, pumps, etc.
  - ✓ The past tests are focused on the behavior of the piping system itself, and the test model configuration is relatively simple.
  - ✓ It is known that there is a certain level of the seismic margin of the piping itself until it loses its function, but the seismic margin including other components is not clarified.



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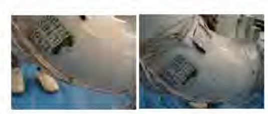
Failure process of piping systems

- ✓ From the several experimental studies, the failure mode of the piping system under high-stress level cyclic load is mainly the fatigue failure.



Initial status → Allowable stress level by the seismic design → Ultimate status (Fatigue failure)

- A part where the high stress is applied comes to the plastic region.
- Little sign of the damage is observed.

- The plastic region is extended.
- Ratchet deformation is occurred.
- Coating paint is damaged → Fatigue failure

- When and how can we detect the damage before failure?
- Are NDI or other inspection method useful to find the damage by seismic events?

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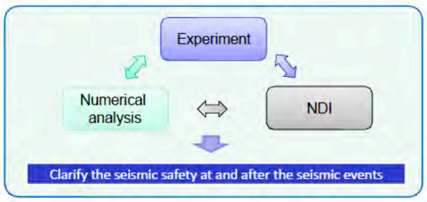
How to approach the tasks

- ✓ Shake table test (E-Defense Shake Table Test)
  - to clarify the seismic response and failure modes of components
- ✓ Non destructive inspection (NDI) during the test
  - to detect the invisible damage before failure
- ✓ Numerical Analysis
  - to establish the numerical model to estimate the elastic-plastic response behavior and failure modes of the components



Test model and contents of the experiment

- ✓ Among the components of energy facilities, a piping system with some supports will be tested at the first year (2011).
  - ✓ Three dimensional shake table test on a piping system model.
  - ✓ Some containers or tanks may be included.
- ✓ Ultimate strength and failure mode will be obtained by increasing the input motion levels and repeated shaking.
  - ✓ At several input level, to detect the damage on the test model before failure,
    - ✓ NDI - such as visual check and ultrasonic test - will be attempted.
    - ✓ The vibration characteristics of the test model will be investigated.

Following topics may be included in 2011 tests
- ✓Seismic behavior of the piping systems under operation
  - ✓ With high-pressure / With flow velocity

Future tasks

The following items are not in scope in 2011 shake table test

- ✓ Aging problem
  - Seismic reliability of the components with degradation by aging
- ✓Interaction with other structures
  - Interaction of the soil foundation, structures which include the energy facilities' components

These research items will be treated in the future shake table test.

Numerical Simulation: Takuzo Yamashita

The 8th NEES/E-Defense Planning Meeting
Numerical Simulation

E-Defense

Large-Scale Numerical Simulation for Seismic Failure of Structures by E-Simulator

Takuzo Yamashita
Research Fellow
Hyogo Earthquake Engineering Research Center
National Institute for Earth Science and Disaster Prevention

What's "*E-Simulator*"?

- Developed at Hyogo Earthquake Engineering Research Center (E-Defense) of NIED
- Virtual shaking table: Large-scale seismic response analysis using mesh with solid elements
- Final form: software environment to simulate global and local seismic responses of buildings and civil structures (and city)
- Platform: *ADVENTURE/ADVENTURECluster* (parallel finite element analysis software for large-scale analyses)
- Developing constitutive equations and method to model fractures of buildings, bridges etc.

NIED

Advantages to Use Solid Elements

- Macro constitutive equations are not necessary.
  → Implementation of constitutive equation for materials is easy.
- Consideration of discontinuity (contact, fracture, rupture etc.) is easy compared with shell elements.
- Both local and global collapse behaviors can be simulated simultaneously.

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Section Meeting of E-Simulator

Chairperson : Prof. Muneo Hori (Univ. of Tokyo)
Vice-Chairperson : Prof. Makoto Ohsaki (Hiroshima Univ.)

Working Group
- Civil Engineering (RC structure)
  → RC Pier
- Building (Steel structure)
  → 4-story steel building
- Computational Engineering
  → fast solver
- Facilities
  → seismic response on facilities in buildings
- Urban Disaster
  → Integrated earthquake simulation
- Geotechnical Engineering (from 2011)
  →Underground Structure

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Topic 1

Failure Analysis of Reinforced Concrete Pier subjected to Seismic Loading

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E-defense Experiment to be Analyzed

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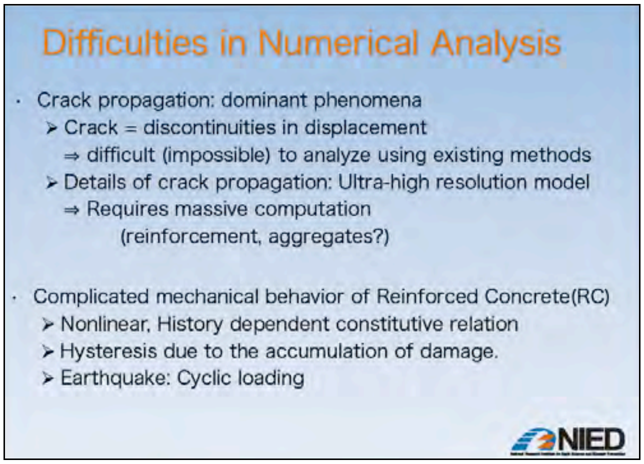
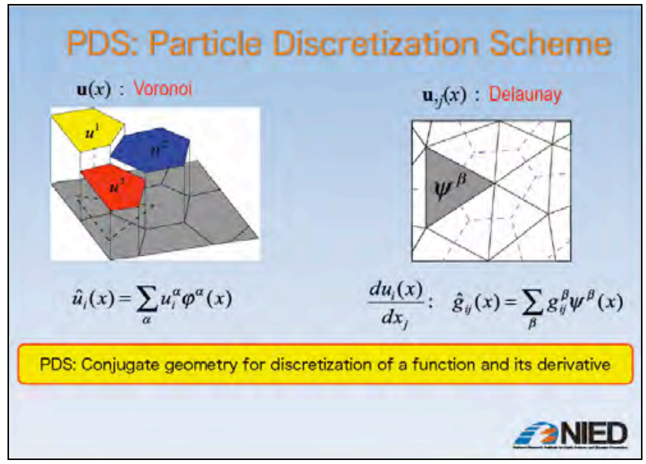
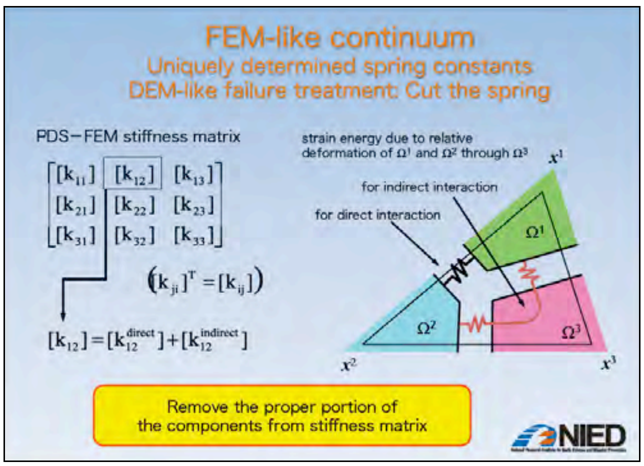
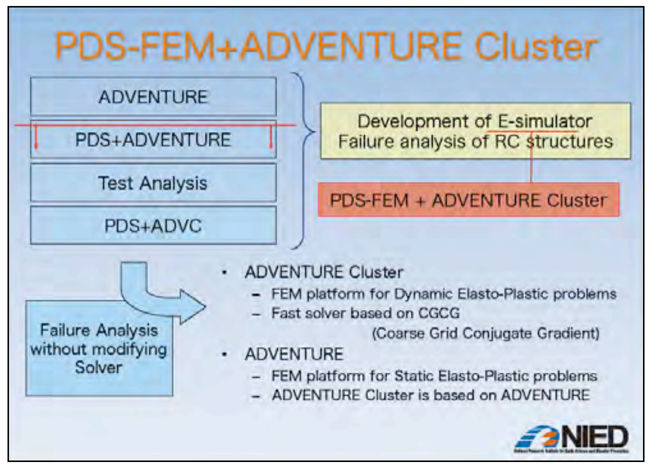
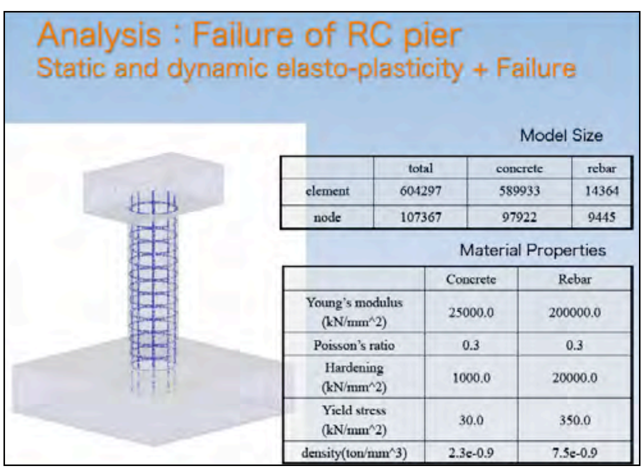
Numerical Simulation: Takuzo Yamashita





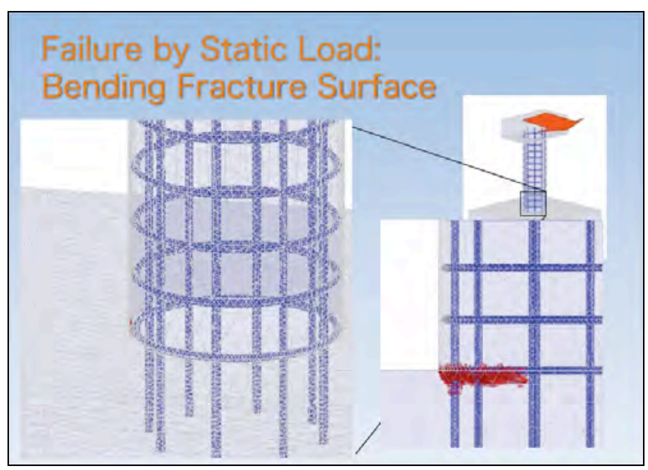


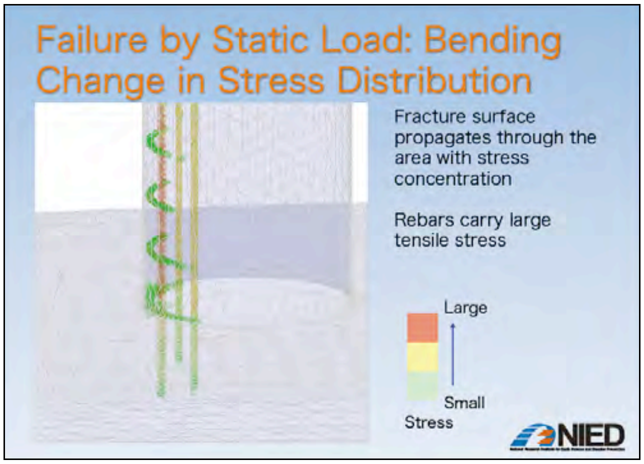


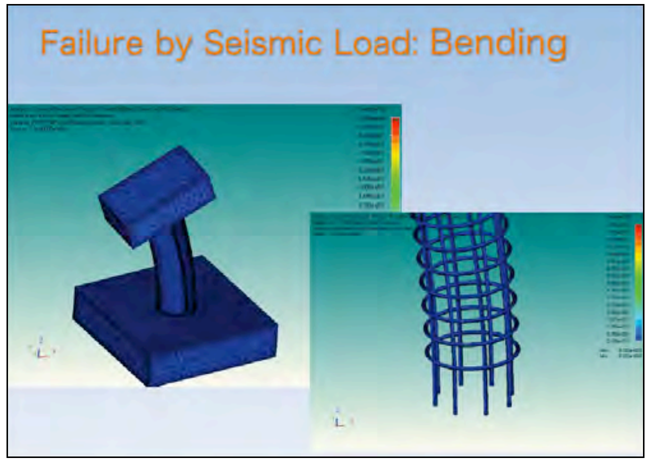


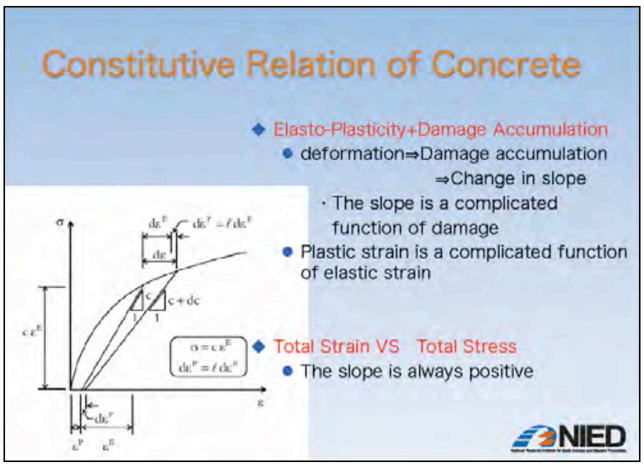
	total	concrete	rebar
element	604297	589933	14364
node	107367	97922	9445

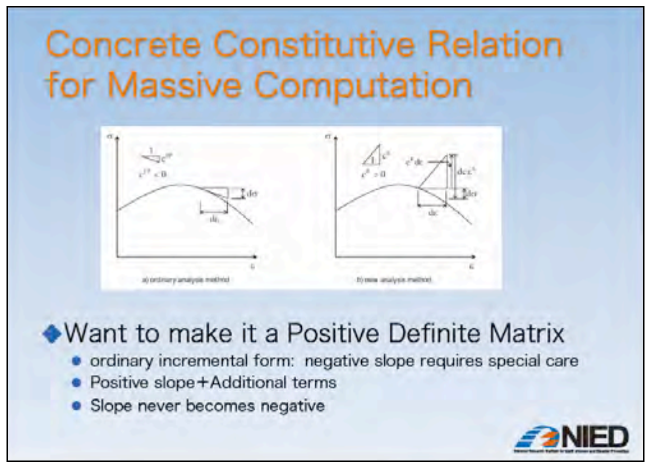
	Concrete	Rebar
Young's modulus (kN/mm^2)	25000.0	200000.0
Poisson's ratio	0.3	0.3
Hardening (kN/mm^2)	1000.0	20000.0
Yield stress (kN/mm^2)	30.0	350.0
density(ton/mm^3)	2.3e-0.9	7.5e-0.9

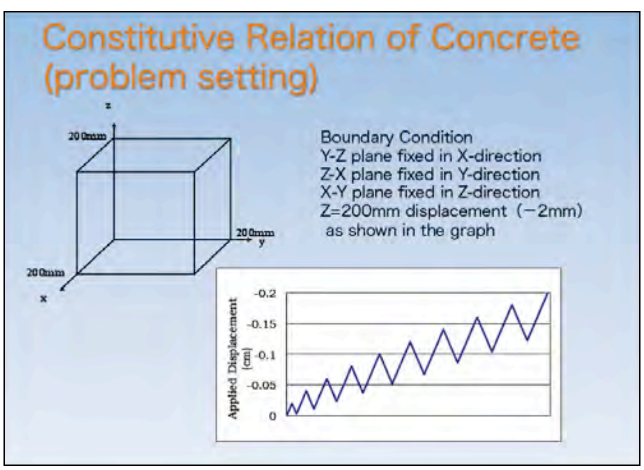


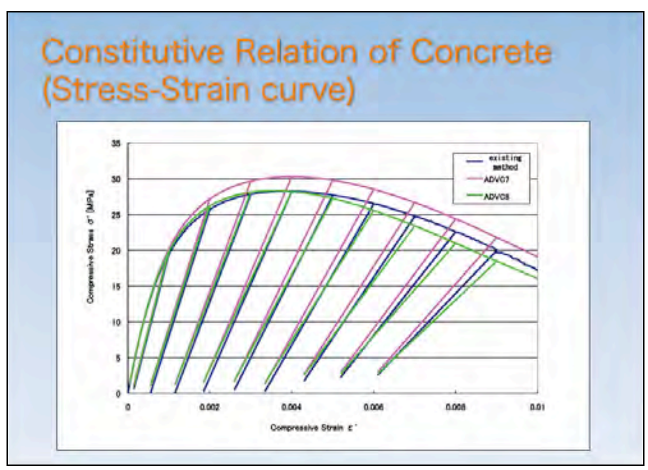

Failure by Static Load: Bending
Change in Stress Distribution
Fracture surface propagates through the area with stress concentration
Rebars carry large tensile stress
Large
Small
Stress
NIED

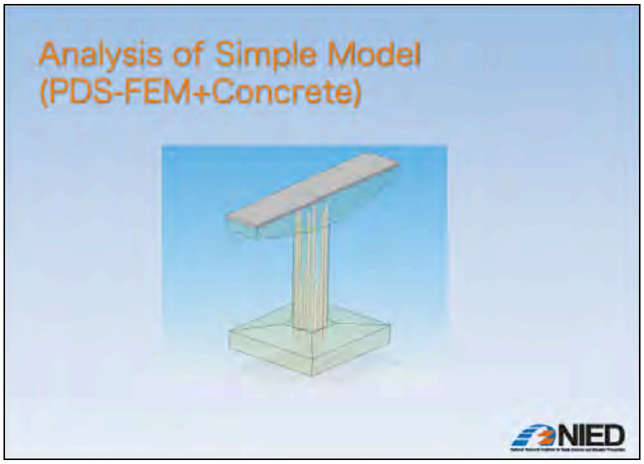

Failure by Seismic Load: Bending


Constitutive Relation of Concrete
Elasto-Plasticity+Damage Accumulation
deformation⇒Damage accumulation
⇒Change in slope
· The slope is a complicated function of damage
Plastic strain is a complicated function of elastic strain
Total Strain VS Total Stress
The slope is always positive
NIED


Concrete Constitutive Relation for Massive Computation
Want to make it a Positive Definite Matrix
ordinary incremental form: negative slope requires special care
Positive slope+Additional terms
Slope never becomes negative
NIED


Constitutive Relation of Concrete (problem setting)
200mm
200mm
200mm
z
y
x
Boundary Condition
Y-Z plane fixed in X-direction
Z-X plane fixed in Y-direction
X-Y plane fixed in Z-direction
Z=200mm displacement (−2mm)
as shown in the graph
Applied Displacement [cm]
-0.2
-0.15
-0.1
-0.05
0


Constitutive Relation of Concrete (Stress-Strain curve)
existing method
ADVC7
ADVC8
Compressive Strain



Conditions for Analysis

- Machine : SGI Altix 4700 Intel Itanium 1.66GHz
- Cores : 256(1node x 256cores)
- Convergence Parameters : cg_nr_tol=1.0e-4
  cg_nr_disp_tol=1.0e-5
  newton_disp_tol=1.0e-4
  newton_tol=5.0e-4
- Computation Time:
  Static Self Weight 4,146 s
  Dynamic (earthquake) 25 s/1step
  # of steps before abortion 21903
- nodes, elements:
  - nodes: 1,298,661 (3,895,983DOF)
  - linear tetrahedron element: 7,647,069

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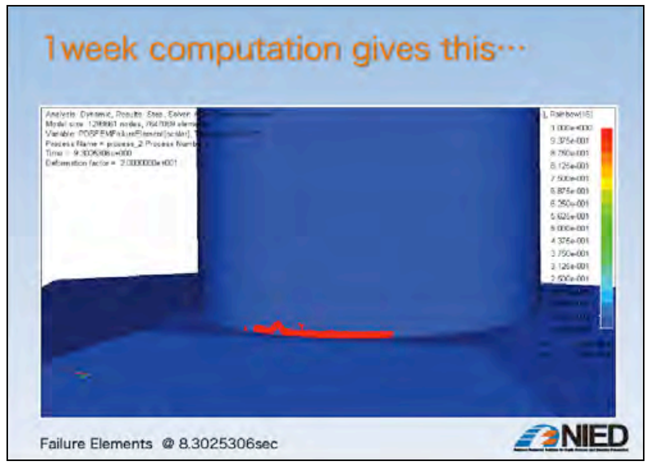
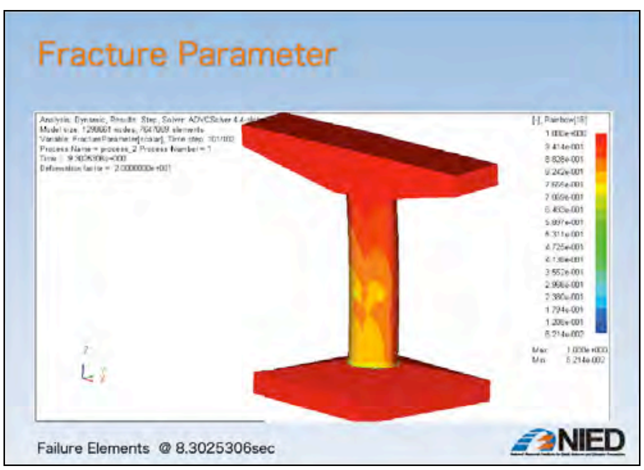
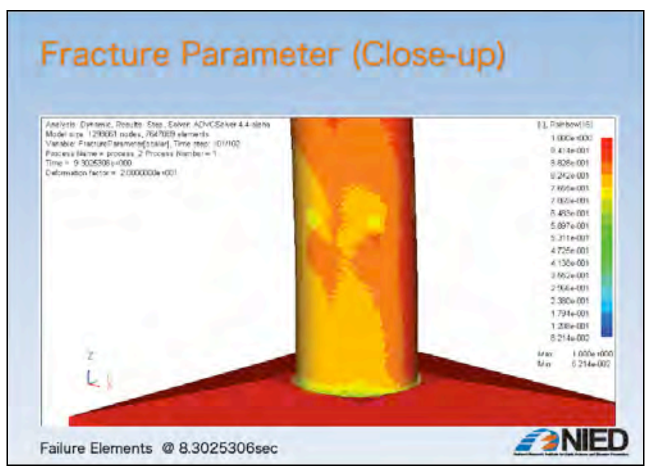
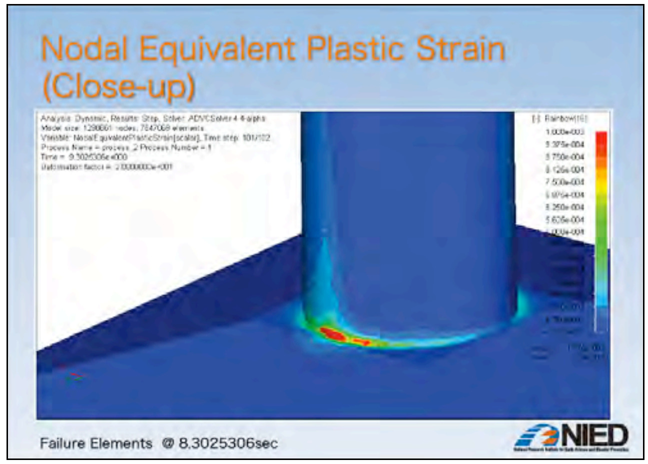
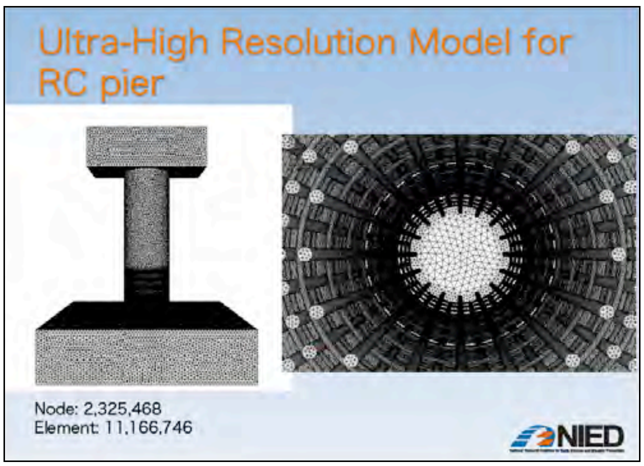


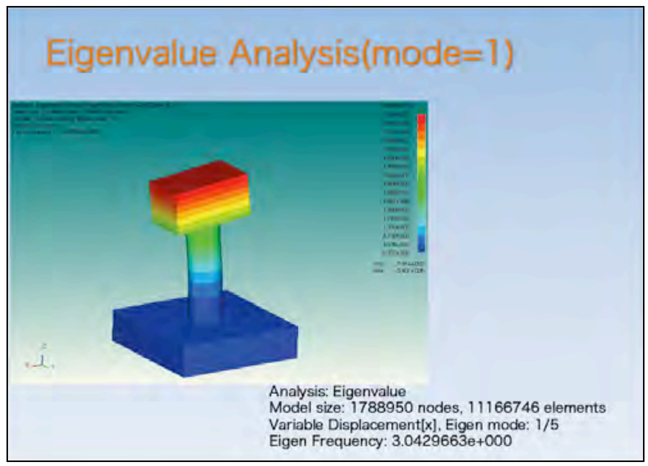


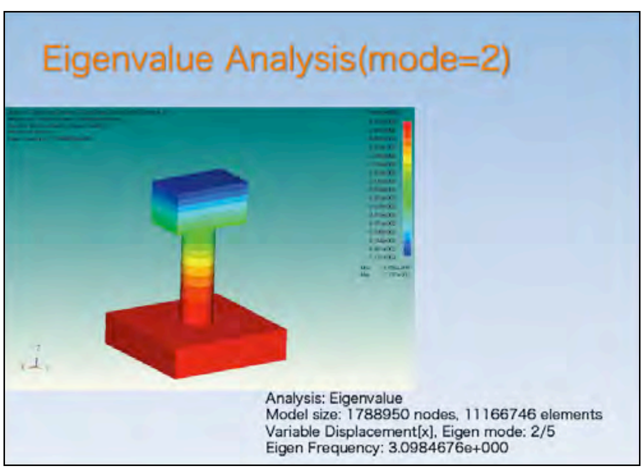


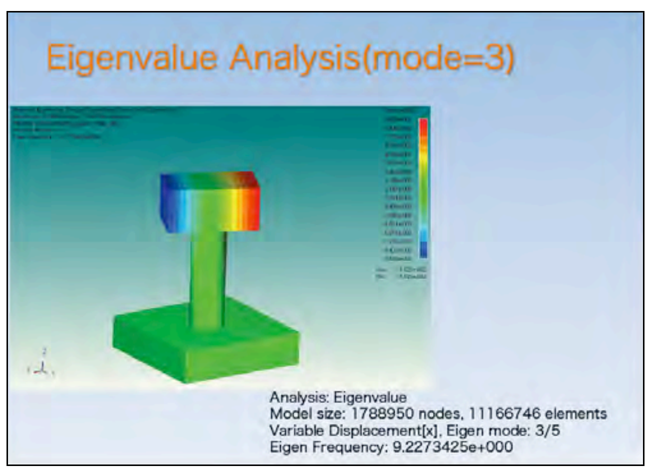
Numerical Simulation: Takuzo Yamashita



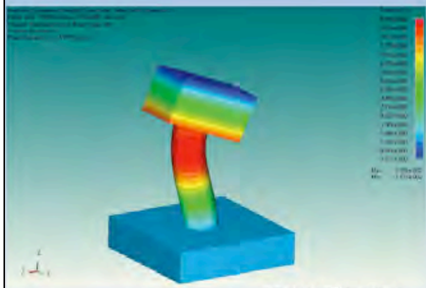








Eigenvalue Analysis(mode=4)



Analysis: Eigenvalue
Model size: 1788950 nodes, 11166746 elements
Variable Displacement[x], Eigen mode: 4/5
Eigen Frequency: 2.5197254e+001

Conclusion of Topic 1

- Implementation to ADVENTURECluster
  - PDS-FEM
    → Crack propagation
  - Constitutive Relation for Concrete
    →Complicated mechanical behavior of RC
- Failure Analysis of simple RC pier model
- Ultra-high resolution model

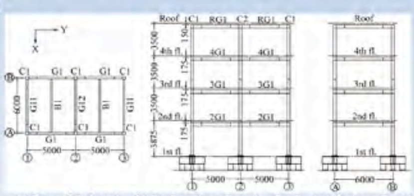
Topic 2

Collapse simulation of full-scale 4-story steel frame

Total-Collapse Shaking-Table Test of 4-Story Steel Frame at E-Defense

Purpose of This Analysis

- Elasto-plastic time-history analysis for the 4-story steel frame using mesh with hexahedral solid elements using the prototype of E-Simulator
- Compare the results with those of shaking table test

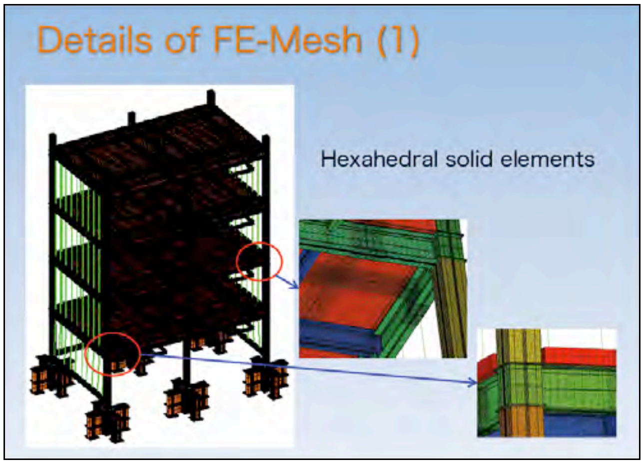


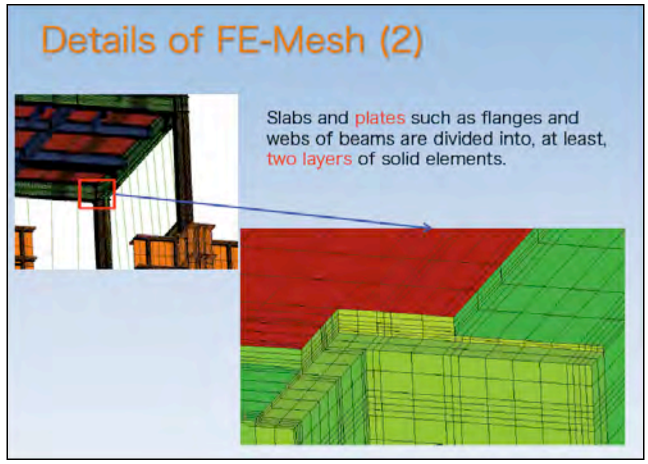
(a) Plan (1st floor) (b) Y-elevation (longitudinal) (c) X-elevation (transverse)

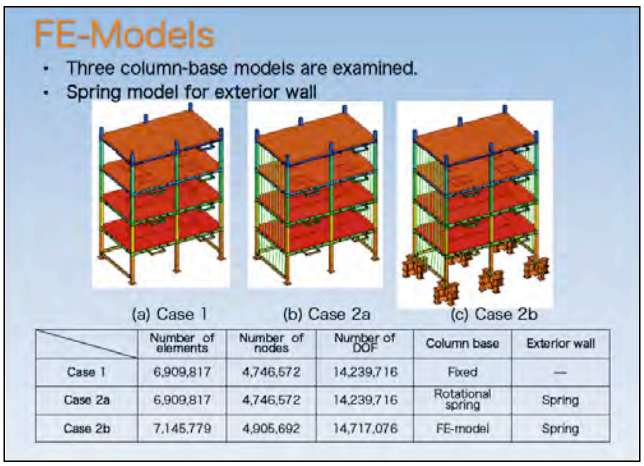
4-Story Steel Frame Model

- **Steel material**
  - Piecewise linear isotropic hardening
  - Parameters identified by uniaxial test results
  - Mass density: 7.86×10^3 kg/m^3
- **Concrete material for slab**
  - Bilinear elastoplastic material
  - Mass density: added equivalent density for nonstructural components and retaining members to the density of concrete, 2.3×10^3 kg/m^3.
- **Damping**
  - Rayleigh damping of 0.02 for 1st and 4th modes (two lowest translational modes in X-direction)

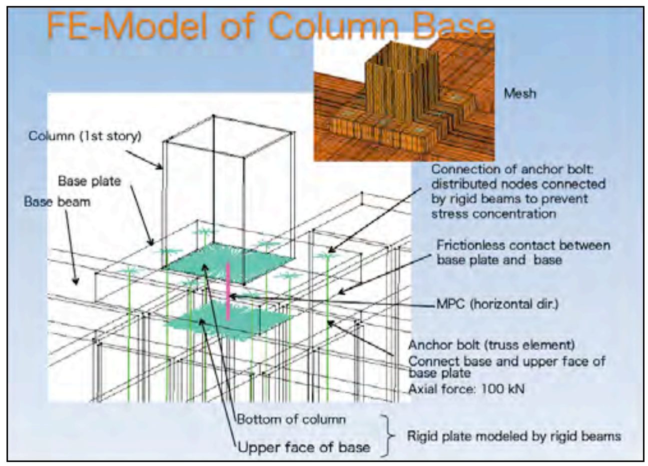
Numerical Simulation: Takuzo Yamashita

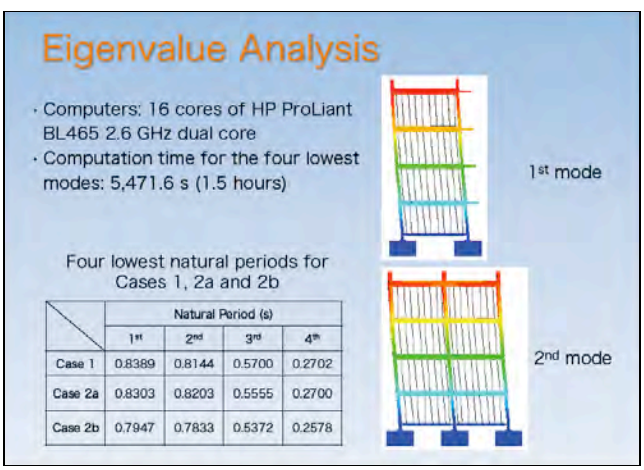




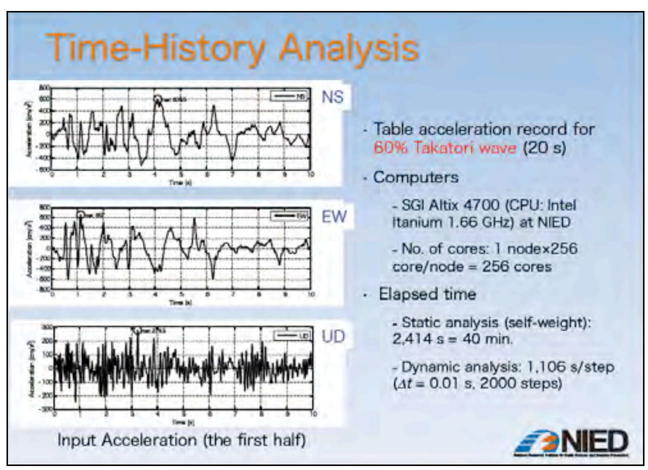


	Number of elements	Number of nodes	Number of DOF	Column base	Exterior wall
Case 1	6,909,817	4,746,572	14,239,716	Fixed	—
Case 2a	6,909,817	4,746,572	14,239,716	Rotational spring	Spring
Case 2b	7,145,779	4,905,692	14,717,076	FE-model	Spring

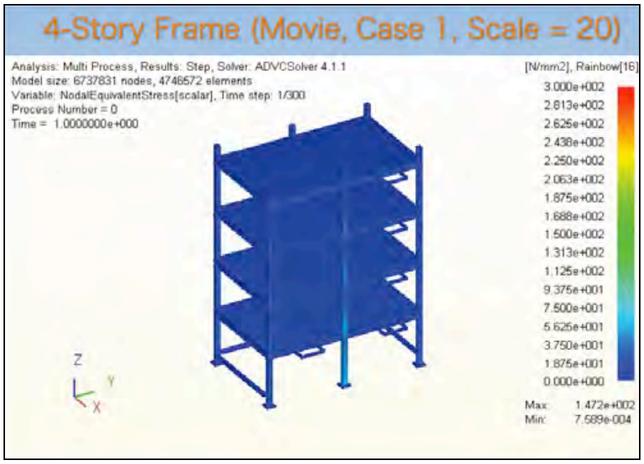


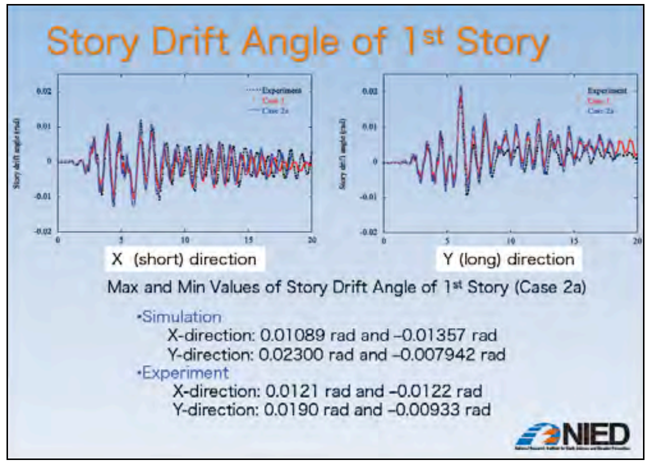


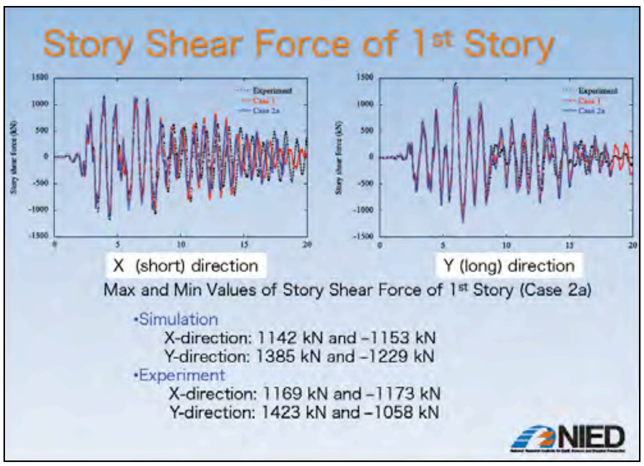
	Natural Period (s)			
	1st	2nd	3rd	4th
Case 1	0.8389	0.8144	0.5700	0.2702
Case 2a	0.8303	0.8203	0.5555	0.2700
Case 2b	0.7947	0.7833	0.5372	0.2578

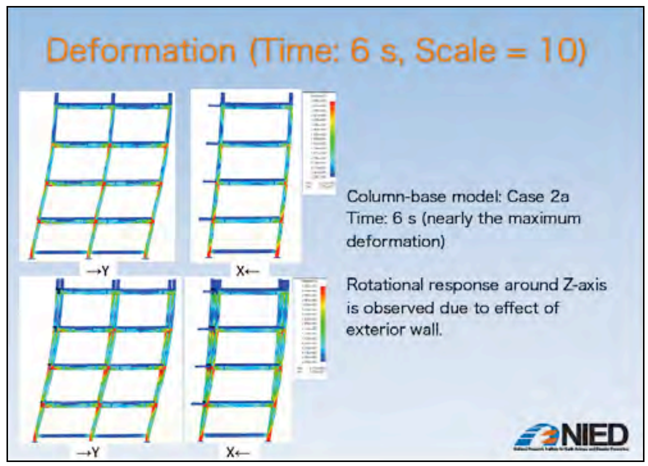


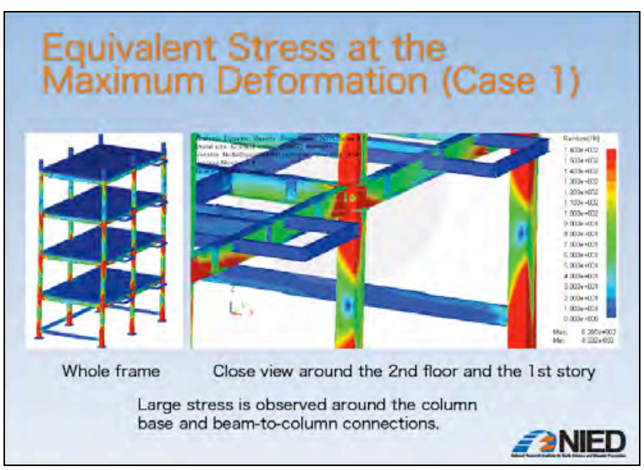
Numerical Simulation: Takuzo Yamashita

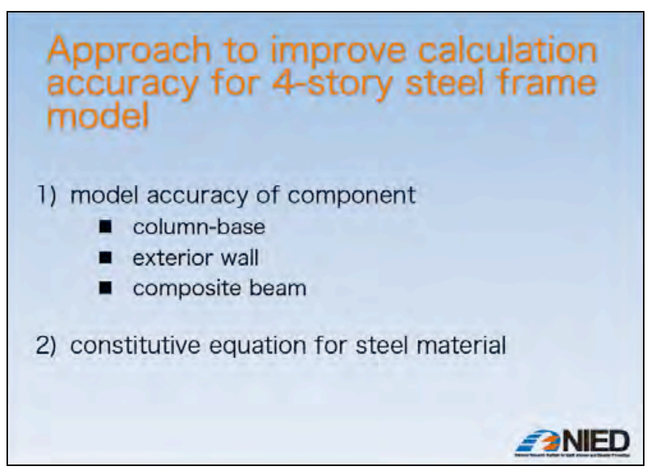




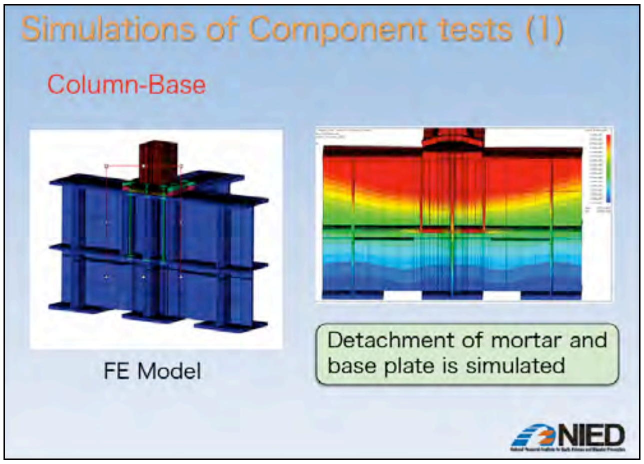


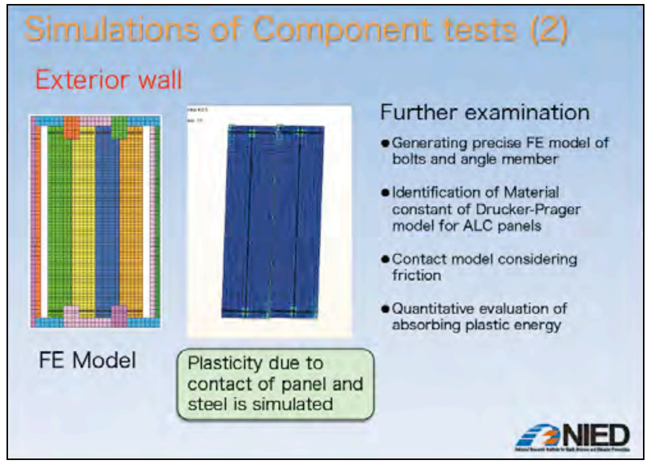


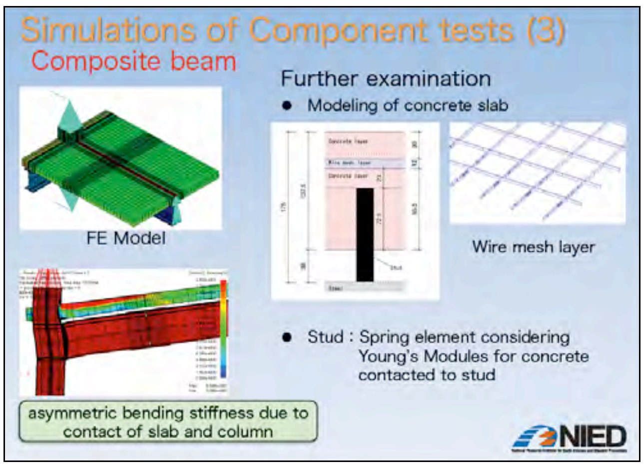


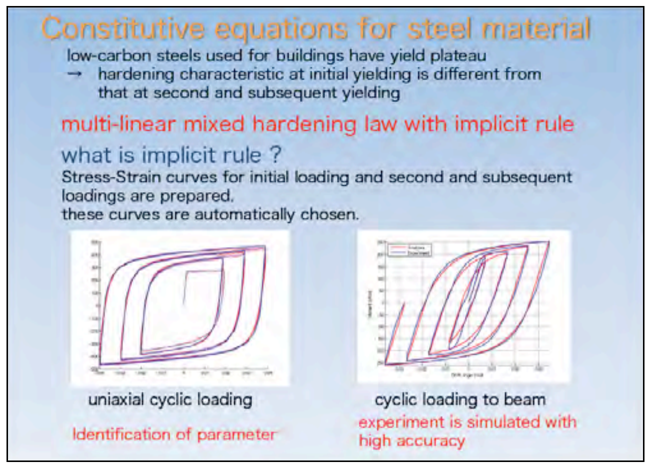


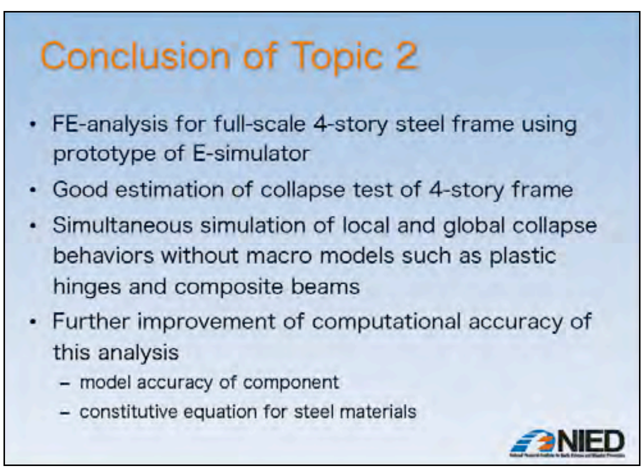
Numerical Simulation: Takuzo Yamashita











The 8th NEES/E-Defense Planning Meeting

E-Defense

Monitoring & Data Archival System

Kentaro Tabata

Senior Researcher

Hyogo Earthquake Engineering Research Center

National Research Institute for Earth Science and Disaster Prevention

Monitoring

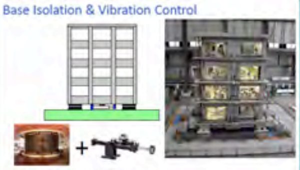
High Performance R/C Structures

- Practical application of structural health monitoring
- Damage identification from video or experimental data
- Ambient vibration-based damage detection
- Development and application of new SI sensors

Geotechnical Engineering

- Measuring distribution of ground deformation
- Visualizing distribution of earth pressure on structure's surface
- Monitoring pore water pressure in slope, embankments, etc.
- Monitoring contamination in liquefiable ground

Base Isolation & Vibration Control



- Feedback to active control
- Record and store damage history of isolated level

Energy Facilities

- Detection of the invisible damage before failure
- Application of the NDI method for damage detection
- Development and validation of the seismic damage indicator

Data Archival System

- Archives of shaking-table experimentation database and information – "ASEBI"
- Web-based system to share and publish data obtained from E-Defense tests
- Archival system built on ZOPE/Plone (contents management system)
  - Reducing development and operation costs
- Open in 2009

Data Archival System

- As of June, 2010:
  - Publishing 9 E-Defense tests through the system
  - 211 users registered
  - Approx. 450 PV/month accesses
- Currently available for users in Japan

Appendix V: Breakout Session Summaries

Session Summary Report

Breakout Session 1(a) Numerical Simulation

Moderators: Muneo Hori (University of Tokyo) and Greg Deierlein (Stanford University)
Recorders: Tony Yang (University of British Columbia)
Members (in alphabetical order of last names)**:** Tracy Becker (University of California, Berkeley), JoAnn Browning (University of Kansas), Nhan Dao (University of Nevada, Reno), Hideo Fujitani (Kobe University), Tatsuhiko Ine (NIED), Manos Maragakis (University of Nevada, Reno), Taizo Matsumori (NIED), Keisuke Minagawa (Tokyo Denki University), Khalid Mosalam (University of California, Berkeley), Minehiro Nishiyama (Kyoto University), Taichiro Okazaki (NIED), Sri Sritharan (Iowa State University), Kentaro Tabata (NIED), Ikuo Towhata (University of Tokyo), Zeynep Tuna (University of California, Los Angeles), Takuzo Yamashita (NIED)

Background:

As described in reports from previous NEES/E-Defense coordination meetings (January 2009 at the U.S. NSF and September 2009 at E-Defense), modern computational tools offer unprecedented capabilities to simulate earthquake and tsunami effects on buildings, bridges, distributed lifelines, and other facilities. However, research in earthquake engineering is generally not making full use of the available computing capabilities of modern multi-processor supercomputers and supporting massive data storage, networking and modern information technologies. Without sufficient research and development on new computational simulation methods that utilize today's state-of-the-art peta-scale computing capabilities, future generations of earthquake engineering researchers and practitioners will be without the necessary technologies to make effective use of advanced computing. Moreover, given the inherent limitations of physical testing, many important earthquake risk assessment and mitigation problems facing society can only be addressed through computational simulations.

Many of the computational methods that have become routine nowadays, such as nonlinear dynamic analyses that utilize interactive graphic pre- and post-processing, trace their development to pioneering research of the 1960's and 1970's, when access to computers were limited to leading research universities and a few major corporations. At the time of their development, many of the computational methods seemed impractical for earthquake engineering practice, owing to the prohibitive cost of computing and lack of data to calibrate and validate the models. But without such visionary research, the computational tools that are used routinely today would not exist. Looking ahead, this begs the question as to whether sufficient attention is being given to develop computational models and technologies that utilize most powerful supercomputing power of today, which will provide the tools for computing that will be routine 10 to 20 years from now.

In Japan, E-Defense is conducting research on advanced computation through the "E-Simulator" initiative that uses the "Kei-Soku-Keisanki" supercomputer (a cluster-type computer with 10 peta-flops performance). The Kei-Soku-Keisanki computer center hosts several major computing initiatives, one of which concerns natural hazards. The computational mechanics research component of the natural hazards initiative is built upon the ADVENTURECluster system, which is a parallel finite element software system for large-scale analyses. The ADVENTURECluster (http://www.alde.co.jp/english/advc/index.html) software is a commercial platform that is based on the ADVENTURE Project at the University of Tokyo (http://adventure.sys.t.u-tokyo.ac.jp). During the NEES/E-Defense meeting, Dr. Yamashita provided an overview of some of the advanced simulation research that is organized into six working groups: civil engineering (RC structures), buildings (steel structures), computational methods, facility condition and operation, urban disasters, and geotechnical engineering (underground structures). Apart from the challenges of creating and analyzing very large models with millions of finite elements and degrees of freedom, a key focus of the research is the development of appropriate constitutive and failure models to simulate local material response. These engineering-focused projects have links to earth science projects dealing with earthquake, tsunami and flood simulations.

In the U.S., a major new peta-scale computing effort is getting underway at the NCSA facility at the University of Illinois, which is constructing the "Blue Waters" computer - an IBM machine that is expected to have a calculation speed of 10 peta-flops. The Southern California Earthquake Center (SCEC) has initiated a project called "preparing for the big one" to conduct coupled seismic-geotechnical-structural simulations on the Blue Waters machine. This project proposes linking codes for earthquake source modeling with ones for site response, soil-structure interaction, and structural modeling. The OpenSees software framework is proposed for the local site, soil-structure interaction and structure modeling. A related peta-scale computing project is one by Bielak, Fenves, and Elgamal, who are performing soil-structure-interaction analyses of a highway interchange that incorporates a site model measuring 0.5 x 1.0 km with a source-to-site transmitting boundary and uses OpenSeesPL (the parallel version of OpenSees). This project embraces the goal described in the summary report of the January 2009 NEES/E-Defense meeting "to develop the capability to simulate the full range of damage mechanisms of *structure-foundation-soil systems* all the way to collapse under a wide range of earthquakes, including the *uncertainties* associated with the design, construction, and health of the structure in addition to the inherent uncertainty of the hazard".

Specific Research Needs:

Many challenges remain for to predict the realistic behavior of structures (including buildings, bridges and distributed infrastructure) under extreme earthquake motions. While progress is being made, such as through the peta-scale computing initiatives mentioned previously and other computational research, significant challenges remain to achieve high-performance models that can simulate accurately the fundamental behavior of structural materials (including soils) over the range of response that may occur in earthquakes. The following specific research and development needs were identified during the breakout meeting discussion:

- Material constitutive models and damage models that capture accurately both the local and global behavior and failure modes in structures: Several examples were cited of situations where localized softening behavior is critical to the overall response, such as the fractures in steel structures in the Northridge and Kobe earthquakes, or concrete spalling and lap splice failures in concrete structures. Thus, research and model development must strive to represent fundamental behavior at scales that appropriately capture significant effects. This will require development and validation of constitutive and damage models to improve simulation under complex stress states and loading conditions.
- Modeling and analysis tools and services to facilitate the creation and processing of detailed models: Owing to the large size of peta-scale problems (e.g., models with millions of elements and degrees of freedom), new technologies are needed to create and manage the models with reasonable levels of effort. The required technologies include user-friendly graphical interfaces, database management and query tools, strategies to facilitate translation between physical and idealized models, automated meshing facilities, parallelized codes for fast computations, and tools for rapid data visualization.

- Advanced computational methods for solving large-scale problems: Improvement of computational solution and numerical integration techniques are needed to simulate large structures more efficiently, and to achieve more robust solutions for highly nonlinear systems exhibiting degrading behavior. In particular, improved algorithms are necessary to capture post-peak response and guarantee uniqueness of solutions for softening structures.
- Model validation through blind predictions and benchmark studies: Compare and validate results predicted by computational models with observed behavior in physical tests, including material, component, sub-assemblage, shaking table and field tests. Carryout challenging testbed applications to evaluate and improve the simulation tools. Candidates for testbeds include: structural systems constructed from reinforced concrete, steel and other materials, soil and soil/structure interaction problems (underground structures), distributed electrical systems, and fluid and fluid/structure interaction problems. Validation case studies should also be conducted, including consideration of the effects of uncertainties. These studies should include experiments conducted on sub-assemblages, shaking tables (NEES and E-Defense) and in the field (NEES facilities at UC Santa Barbara, UCLA, and the University of Texas).
- On-line grid computing technologies: Continue to extend, validate and deploy high performance simulation platforms such as ADVC, OpenSees, and others. NEES has made progress in this area through the OpenSees Lab, whereby OpenSees can be accessed and run using tera-grid resources. In Japan, ADVC is available on the Kei computer. Efforts should be continued to make these tools available to a larger population of researchers.
- Leverage research approaches in hybrid simulation and monitoring/sensing to facilitate digital communication and information management between (a) various analysis software systems or models, (b) analysis platforms and databases of computational and experimental results, and (c) analyses with data from proprietary databases (e.g., simulation tools of distributed networks with proprietary/confidential data on utility networks).
- Multidisciplinary approaches: Further emphasis should be given toward research that embraces the strengths of multi-disciplinary teams, including expertise areas in engineering, earth science and seismology, physics and material science, computational science, and social sciences.
- Multi-scale research that spans length-scales and physics from detailed response of structures, to buildings and infrastructure systems, to earthquake effects on urban regions: The "resilient city" theme introduced in previous meetings requires simulations that can encompass very localized behavior up through large geographically distributed systems. Additionally, to assess system effects, simulation tools should extend beyond modeling of structural behavior (calculation of engineering demand parameters) to simulate other contributors to earthquake losses and disruption (e.g., calculation of monetary losses, facility downtime, injuries and fatalities). Whereas current performance-based tools tend to model losses through empirical relationships, further research is needed to develop fundamental models of these effects (e.g., development of models to simulate egress from a city, disruption to utility or traffic systems, facility repair and recovery operations).

Desired Collaborations and Suggested Initiatives:

The following are proposed as steps to take to increase collaborations between the US and Japan that will contribute to the advancement of high-performance simulations for earthquake engineering:

a. Direct collaboration between NEEScomm (OpenSees, NEEShub, etc.) and E-Defense (KEI computing) groups developing, deploying and maintaining high performance computational simulation capabilities and information exchange and database systems is desirable to leverage resources and knowledge and to promote sharing of critical information and technologies.
b. It is believed that advanced computational simulation should be an integral part of all

NEES/E-Defense projects, and that payload and other efforts to apply specialized computational simulation tools and models to these projects should be encouraged.

c. Beyond the current research activities and collaboration mechanisms, a large concerted initiative is required to provide the critical mass of expertise and effort that is necessary to achieve substantive advancements in peta-scale computing to simulate the realistic response of buildings, bridges and other civil infrastructure.
d. In addition to regular NEES/E-Defense planning meetings, it would be useful to establish a website to facilitate communication and collaboration.
e. It is recommended to explore opportunities for graduate research student exchanges that can nurture US-Japan research collaboration.

Finally, given the anticipated gains to earthquake engineering through high-performance simulation, it is recommended that groups in both countries pursue planning and funding opportunities to support development of advanced peta-scale simulation. In Japan, some funding mechanisms are already in place through the KEI E-Simulation initiative. In the US, some modest support for basic software infrastructure is available through NEES; however, more substantial dedicated funding is required to engage multidisciplinary research from the earthquake engineering, computational mechanics, computer science and other communities. Possible opportunities may exist through the NSF-EFRI (Emerging Frontiers in Research Innovation) program, the NSF-CDI (Cyber-enabled Discovery and Innovation) program, or other programs at the NSF. Other support for fundamental advancements in large-scale simulations may be possible through the U.S. Department of Energy or other government agencies.

Session Summary Report

Breakout Session 1(b) Monitoring

Moderators: Shirley Dyke (Purdue University) and Akira Nishitani (Waseda University)
Recorder: Naru Nakata (Johns Hopkins University)
Members (in alphabetical order of last names)**:** Shin-Ho Chao (University of Texas, Arlington), Shideh Dashti (University of Colorado, Boulder), Catherine French (University of Minnesota), Satoshi Fujita (Tokyo Denki University), Yohsuke Kawamata (NIED), Susumu Kono (Kyoto University), Peter Lee (Skidmore Owens Merrill LLP), Anne Lemnitzer (California State University, Fullerton), Manos Maragakis (University of Nevada, Reno), Khalid Mosalam (University of California, Berkeley), Takuya Nagae (NIED), Izumi Nakamura (NIED), Manabu Nakayama (NIED), Hidekazu Nishimura (Keio University), Isao Nishiyama (NILIM), Yoshihiro Nitta (Ashikaga Institute of Technology), Gustavo Parra-Montesinos (University of Michigan), Zeynep Tuna (University of California, Los Angeles), Gordon Warn (Pennsylvania State University), Susumu Yasuda (Tokyo Denki University)

Background:

The user of monitoring systems may play a key role in bringing the concept of "resiliency" to fruition. There are numerous reasons to monitor a system; for example, for model identification, model updating, characterization of loading, damage detection, etc. To achieve the various goals involved in the monitoring of structural systems, the two of the main questions that need to be answered are: What do we need to measure? And how do we accomplish it?

The E-defense and NEES collaboration offers the opportunity to consider very realistic engineering systems and situations/earthquakes. The experiments performed will provide the community with information and data for research in monitoring. However, the researcher trying to add a payload experiment will typically need to be involved in the planning and execution of the main experiment. It is unlikely that the data acquired for the main experiment will happen to acquire the appropriate data for most monitoring purposes. Thus, it is best for the payload team to establish a good relationship with the main experimental team and get involved during the early planning stages. Mechanisms for such planning are needed.

Discussions:

The discussion revolved around two questions:

- HOW to utilize efficiently a variety of data from the experiments conducted at NEES/E-Defense from the SHM point of view?
- HOW to put WHAT additional sensors WHERE in the structure for the purpose of conducting monitoring, etc.

Use of Data from Experiments

- Issues in Global Sensing / Local Sensing?
- Unprocessed data is necessary for users who are interested in signal processing.
- Need to specify a signal to noise ratio for each sensor to find out reliability of data
- Any standard format of data in NEES/E-Defense for others to use
- How many years until data is released after the experiments?
- Centralized or distributed data collection
- Synchronization of data from different data acquisition systems
- Comparison of data from different tests and sites

Technical Challenges in Monitoring

- Data aggregation / reduction
- Centralized vs. distributed methods
- Global behavior/ local behavior
- Synchronization of data sources
- Number of sensors needed
- Data fusion methods
- Important indicators of damage

Mechanisms for Monitoring Projects

- How to add new sensors in NEES/E-Defense?
- Ask personnel in NEES/E-Defense to add sensors?
- Can we borrow sensors from different sites?
- Users guide of NEES and E-Defense facilities for users in terms of monitoring
- Planning monitoring has to be done prior to the experiment.
- Monitoring teams need to join the main project teams for the testing in the planning stage
- What will be the mechanism to monitor the type of data that the main team is not intended to monitor?

Opportunities and Funds

- Recommendation to NSF to encourage payload projects in monitoring
- Better way to allocate funds for payload in monitoring projects
- 'EAGER' style proposal?
- NIST funds to develop new sensors and instrumentation

Development of New Sensors

- Use NEES/E-Defense experiments to validate new sensors in full/large-scale tests
- Data fusion from different sensor types and sources for validation
- Accuracy of sensors: Do we know sensors are already working fine?
- How is data from new sensors used? Is the date from the new sensors used by the other users?

Monitoring in Geotech Applications

- Monitoring in Geotech systems is different than in structures.
- Geotech monitoring is complicated. Interested in deformation of ground, pressure changes, etc.
- We still do not know how to measure may quantities of interests
- Monitoring in Centrifuge Tests should also be considered

Specific NEES/E-Defense projects discussed include:

- RC structures tested in December, teams may consider the energy dissipation by rocking motion, other aspects
- Three monitoring teams participated in the RC test at E-Defense
- Energy dissipation capabilities in Base Isolation Projects
- Thermo-couple for rubber bearing

Several Key Ideas Resulted from the Discussion:

- Need a discussion forum (perhaps using existing NEEShub functionality) to discuss experiment plan, instrumentation, etc. and facilitate discussion of small steps or sensors to add to the usefulness of the data from the experiments
- Develop blind monitoring competitions / benchmark problems to compare algorithms, validate sensors, etc.

- Standard data formats and need for unprocessed data should be agreed upon
- Shared "monitoring kit" should be developed for research teams to borrow including various sensors & DAQ to supplement laboratory equipment perform monitoring, including accelerometer, displacement, gap, pressure, force, Krypton, etc.

Session Summary Report

Breakout Session 2(a) High Performance R/C Structures

Moderators: John Wallace (University of California, Los Angeles) and Hitoshi Shiohara (University of Tokyo)

Recorder: Wassim Ghannoum (University of Texas at Austin)

Members (in alphabetical order of last names)**:** Shih-ho Chao (University of Texas, Arlington), Greg Deierlein (Stanford University), Cathy French (University of Minnesota), Jack Hayes (National Institute of Standards and Technology), Toshimi Kabeyasawa (University of Tokyo), Yoshiro Kai (NIED), Susumu Kono (Kyoto University), Taizo Matsumori (NIED), Farzad Naeim (John A. Martin & Associates, Inc.), Takuya Nagae (NIED), Isao Nishiyama (NILIM), Minehiro Nishiyama (Kyoto University), Gustavo Para-Montesinos (University of Michigan), Julio Ramirez (Purdue University), Sri Sritharan (Iowa State University), Kenichi Tahara (NIED), Zeynep Tuna (University of California, Los Angeles), Tony Yang (University of British Columbia)

Visit Construction Site:

The group started the meeting by touring the construction site of the two RC structures being prepared for testing in December 2010. The group had the privilege of witnessing the casting of the 2nd floor.

Presentations:

1- Takuya Nagae: Overview of RC structure test specimen being prepared
- Designed to satisfy most requirement for minimum Japanese practice
- No joint requirement in Japanese code
- Rectangular walls not currently allowed in Japanese code – shape was determined with US input

2- Hitoshi Shiohara: Beam/column connections
- Shiohara presented some of his research on RC joints
- Shiohara raised concern of joint performance in RC test structure

3- Wassim Ghannoum: Modeling of RC structure
- A 3D analytical model of the RC structure was presented (developed in OpenSees)
- Results for the Kobe – Takatori motion were presented
- Very large drifts are anticipated for that motion
- Results compare well with Kenichi Tahara model results
- Further development of model is planned

4- Zeynep Tuna: Modeling of RC structure
- Zeynep Tuna and John Wallace from UCLA will work with Wassim Ghannoum on improving 3D model of RC structure

5- Takuya Nagae: Overview of PT structure test specimen being prepared
- PT wall has twice the capacity of the RC wall but significantly less energy dissipation
- Wall post-tensioning is unbonded, while beam and column PT is bonded
- Beam and column details already in use in Japan, whereas the unbonded wall details are new to Japanese practice
- Mild steel is used at wall base for energy dissipation

6- Kenichi Tahara: Response analysis of RC and PT test structures
- 2 ground motions considered: JMA Kobe, Takatori Kobe
- Non-linear rotational spring models for both RC and PT

- Takatori drifts very large → decided to use only JMA Kobe
- Analyze structures with 4 rotation variants for the bi-directional motion: 0, 45, 90, 135 degrees
- Recommend using JMA Kobe, with 0 degrees for wall direction and 90 degrees for frame
- Scale of motions: 10%, 40%, 70%, 100%

7- Susumu Kono: PT structure analysis by Richard Sause
- Brief look at Prof. Sause's analytical work on PT specimen

8- Sri Sritharan: New NEESR project: Rocking walls (collaborating with Japanese)
- Overview of recently awarded NEES project
- NEES team amenable to collaboration with Japanese researchers

9- Shih-ho Chao: New NEESR project: collapse of ductile columns
- Overview of recently awarded NEES project
- NEES team amenable to collaboration with Japanese researchers

10- John Wallace: NEES/E-Defense collaboration efforts (see next section)

Collaborative Effort:

1- Test Schedule (Nagae)
- December 15th +/- 2 days
- JCI-ACI workshop group will join the tests

2- Component Tests
- Shiohara asks if there is budget for component tests on US side
- Only two projects funded that have some relation to Japan tests – projects have limited budget for component testing directly related to Japan tests

3- High-rise RC project for 2013 – Format not known from Japan side
- US side asks if plans can be made earlier so that proposals can be submitted earlier to NEES prior to E-Defense tests
- Need to meet often and early to continue the collaboration
- Good communication is essential
- As early as March 2011 planning and coordination should commence

4- Monitoring of RC and PT specimens
- Discussed potential for US researchers to bring own instrumentation and additional channels to 2010 or 2013 tests. Japan side amenable.

5- Blind Analysis or Prediction Contest (Wallace & Shiohara)
- US side could organize semi-blind contest
- Details to be finalized by US side prior to December tests
- Deadline for submissions about June 2011
- Report results perhaps at NEES/PEER annual meeting
- Need some support for a couple of students to organize the contest
- NEEScomm may be able to fund such effort through high impact EOT

6- Other
- Organizing yearly workshop to present collaboration work is proposed by Wallace and Kabeyasawa.
- Workshop to focus on RC testing related to collaboration effort.
- Possibly can be opened to international collaborators
- Should involve participation from practicing engineers

Resolutions:

1- COLLABORATION MEETINGS

- The group gave top priority for scheduling and conducting future meetings. They should be conducted often (2-4 times a year) and early (prior to Japanese initiatives) to build on the fruitful collaboration. Good communication is essential for this effort. In-person meeting is preferred but WebEx could be used when in-person meeting is not possible or convenient.

2- WITNESSING TESTS (Education)

- US to pursue funding to send as many researchers and students to December 2010 Japan tests
- Longer term: student and researcher exchanges should be encouraged

3- INSTRUMENTATION

- Discussed potential for US researchers to bring own instrumentation and additional channels to 2010 or 2013 tests. Japan side amenable.

4- SIMULATION CHALLENGE

- US will pursue organization and funding of prediction challenge. Japan side agrees to share limited data for competition.
- Time frame: US to finalize details by December, submissions by June, results announced in NEES annual meeting. Continue effort for 2013 tests.
- Consider doing this contest as a multi-site high-impact NEES EOT activity

5- NEW KNOWLEDGE AND TRANSFER

- Group wants to draw knowledge from simulations and chart new research in analytical tools
- Important to share new knowledge at venues with practicing engineers. EERI will present collaboration efforts in newsletter.
- Data sharing with Japan. Standard time lapse is 24 months for Japan data to become public. Similar time frame for data exchange exists in NEES. Need to reduce time delay from both sides.

6- WORKSHOP

- There is interest in starting workshops and perhaps open them to international participation to discuss experimental work
- Workshops should be focused on topics of relevance to RC collaborative tests
- Workshops should bring in practicing engineers

7- POTENTIAL FUNDING FOR 2013 TESTS

- The group think it would be useful to submit for NEESR funding (this March) for preliminary analyses to develop concepts for 2013 tests

Session Summary Report

Breakout Session 2(b) Base isolation & vibration control

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Recorder: Gordon Warn (Pennsylvania State University)
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Specific Research Needs:

The discussions held during the breakout session demonstrated unanimous agreement between the Japanese and US participants that protective systems, including base isolation, are an essential component to achieve the 'Resilient City' meta-theme adopted for the second phase of the NEES/E-Defense collaboration. Key challenges that remain and the research needed to address these challenges were identified and are summarized as follows:

Challenge 1: Vertical earthquake motion
Participants are concerned that "traditional" base isolation hardware might not provide effective protection for nonstructural components and essential equipment housed within an isolated structure from the high frequency, vertical component of excitation that can be significant relative to the horizontal motion. Damage to nonstructural components (e.g., ceiling systems, piping systems, etc.) or essential equipment (e.g., computer servers, medical imaging devices, etc.) during severe earthquake shaking could disrupt, or prevent, post-event operation of critical facilities that contribute to the resiliency of the community and economy.

Specific research needs to address Challenge 1:
1. <u>Full scale testing of isolated structures outfitted with nonstructural components:</u> The E-Defense shake table provides a unique opportunity to test structures and components at full-scale under three components of earthquake ground shaking. Tests conducted on structures isolated with "traditional" hardware would provide new data of the response of nonstructural components housed within isolated structures so that the efficacy of traditional hardware and current design procedures could be evaluated.
2. <u>Three-dimensional (3D) isolation:</u> Both the US and Japanese participants are interested in developing and experimentally validating new and innovative isolation system or combinations of protective systems that effectively provide three-dimensional (3D) isolation. Efforts are underway in Japan to develop such 3D systems and to explore combinations of base isolation and floor isolation to achieve 3D isolation; however, these systems have not been validated experimentally at reduced or full-scale.

Challenge 2: Long period/long duration earthquake ground motion
Long-period, long-duration ground motion produced by earthquakes in subduction zones are considered to be a serious concern for base-isolated buildings. The concern stems from the

predominant frequency content of this type of ground motion that is in the range of the effective period of traditional isolation systems (typically between 3 and 5 seconds). This type of ground motion could lead to a resonant condition with unbounded displacements in the isolation system. This resonance, coupled with the long-duration, could place extreme demands on the bearings; for example, heating in a lead-rubber bearing that would reduce the effectiveness of the lead-core to dissipate energy and therefore control displacements.

Specific research needs to address Challenge 2:

1. Development of new and innovative isolation systems that adjust to the incoming ground excitation: Potential innovative isolation systems include active, semi-active and hybrid systems, that are able to adjust the period of the system and damping properties based on the characteristics of the earthquake ground motion. These innovative systems are needed to address concerns related to the long-period, long-duration motions as well as achieving specific local and global system performance objectives. Participants agree that the availability of a versatile testbed structure that would allow for rapid specimen assembly and reconfiguration, and direct evaluation of one isolation/control strategy against another would accelerate the development of innovative systems and enhance collaboration.
2. Damage detection and health monitoring: There is concern that isolation systems subjected to the extreme demands associated with large amplitude, short-duration as well as long-period, long duration ground motions might sustain damage that is difficult to detect following a major earthquake event. Participants from both sides are interested to pursue the development of damage detection and health monitoring methodologies for these devices to aid in post-event replacement decision-making.

Research need to address Challenges 1 and 2

Absolute/Perfect isolation grand challenge: The US and E-Defense researchers identified the grand challenge of achieving “absolute” or “perfect” isolation using base isolation and seismic protective systems. This research would require the development of innovative hardware and control algorithms so that the structures could remain inert (zero absolute accelerations) under any earthquake ground motion. An “absolute” isolation system would provide maximum protection of the structure and its contents from the damaging effects of earthquake ground shaking, thus contributing to the realization of the “resilient city.”

Desired Collaborations and Benefits of Collaboration:

NEES-TIPS project

The planned NEES-TIPS testing of a base isolated five-story steel structure on the E-Defense shake table provides an opportunity for collaboration in the following areas:

1. Nonstructural component and contents payload
   At present, sufficient funds are available to the NEES TIPS project only to test the bare structural frame. However, given the considerable costs associated with the test program, not adding nonstructural components and contents to the test setup would be a missed opportunity. Testing ceiling systems under 3D excitation is seen to be especially compelling.
2. Damage detection payload
3. Blind prediction contest
   Utilizing the data for the previous blind prediction contest on the same specimen, a parallel contest for the isolated building would test the hypothesis that the design community can collectively predict the demands in an isolated building with greater accuracy and less variance than in a fixed-base building.

Test-bed structure for innovative seismic isolation systems and control strategies

The participants of the breakout session expressed a deep interest and desire for the collaborative development of a test-bed structure that would enable: rapid specimen assembly; accelerated testing and development of innovative systems and control algorithms; full-scale verification; and comparative evaluation of newly developed systems. As envisioned, the test-bed structure should be: modular; reconfigurable steel or concrete segments; capable of three-dimensional loading; and provide ease of hardware replacement. The test-bed structure would also need to be able to accommodate mass dampers, either active or passive, at the isolation level or in the upper levels of the test-bed structure. Two possibilities exist for the test-bed:

1. E-Defense previously constructed eight isolated mass pieces, which, when assembled with linear sliders, function as a gravity load carrying system. Four pieces can be stacked vertically for testing. The linear sliders can be arranged to achieve planar motion (as done in all previous projects) or they can be arranged differently to permit motion in both translational directions. The pieces can be assembled with lateral framing in either direction to act as a complete system. The pieces can also be reconfigured, for instance, with isolation and control systems at different interstory levels. The pieces have been used in the NEES/E-Defense Self Centering Rocking Steel Frame project and two other E-Defense projects. However, currently, E-Defense has no specific plan to utilize the test-bed pieces for Phase 2 research on isolation and control.

2. E-Defense plans to design and build a full scale realistic building specimen to test innovative isolation and control strategies for the Phase 2 research projects. The design concept of the specimen is expected to be complete by about March 2011. US researchers planning collaborative NEESR projects at E-Defense could therefore propose to utilize this specimen. Both US and E-Defense participants are enthusiastic to contribute to the design of this planned full-scale, non-symmetric building specimen, and tentative plans were made to establish a NEEShub group for online communication. The specimen is envisioned to be non-symmetric, perhaps containing both horizontal and vertical irregularities. Collaboration on the design of the non-symmetric building specimen would ensure maximum versatility for future collaborative and independent testing. The key benefits of this collaboration would be a consistent specimen for comparative evaluation of new systems and new design procedures. The collaboratively designed non-symmetric building specimen would also enable further joint investigations of the performance of nonstructural components and essential equipment housed within seismically isolated buildings.

Session Summary Report

Breakout Session 2(c) Geotechnical Engineering

Moderators: Nick Sitar (University of California, Berkeley) and Ikuo Towhata (University of Tokyo)
Recorder: Shideh Dashti (University of Colorado, Boulder)
Members (in alphabetical order of last names)**:** Youssef Hashash (University of Illinois, Urbana-Campaign, in WebEx), Muneo Hori (University of Tokyo), Tatsuhiko Ine (NIED), Takahito Inoue (NIED), Yohsuke Kawamata (NIED), Anne Lemnitzer (California State University, Fullerton), Manabu Nakayama (NIED), Kentaro Tabata (NIED), Keiichi Tamura (PWRI), Takuzo Yamashita (NIED), Susumu Yasuda (Tokyo Denki University)

Background:

As large numbers of people live and work in mega cities, they depend on various lifeline systems, including transportation systems, such as subways, and water and power supply systems. In most mega cities around the world, the availability of land above the ground surface level for lifeline systems is very limited; therefore, these lifeline systems tend to be constructed underground. Accordingly, mega cities often have spatially complicated underground corridors composed of the various lifeline systems and other structures, such as building foundations.

In terms of earthquake engineering, many mega cities exist in seismically active regions in Japan as well as in the U.S. In design practice, seismic performance is generally evaluated on the basis of a single structure. There is no or few assessments of accounting for possible interaction between multiple neighboring structures and soil during strong earthquake motions.

In light of this, a series of large-scale model tests are planned at E-Defense in 2011 and 2014 to obtain better understanding of the seismic behavior of complicated underground systems. Based on ideas exchanged with practitioners and discussions by a technical advisory board, target structures are have been selected to address the following conditions: (1) effect of neighboring structures, (2) seismic behavior of vertical structures and (3) damage development at joints.

Review of the Draft of the Test Plan:

Based on the research background above, the draft of the large-scale model test at E-Defense (Figure 1) was prepared prior to the breakout session of the meeting. In the session, the participants reviewed and discussed the draft. During discussions in the session, a number of areas that need to be clarified before finalizing the test specifications were identified as follows:

1. Scaling issues in terms of similitude between the structure and soil
2. Scaling of the mass of the tunnel structure in order to adequately represent the length of the tunnel structure
3. Properties of model structures (e.g. stiffness)
4. Spacing of the structures showing significant interaction
5. Properties of structural joints between vertical and horizontal components
6. The issue of sand density and settlement
7. Characteristics of input ground motions for the test specimen on the shaking table
8. Instrumentation options, especially for the area of contact pressures (tactile sensors) and deformation measurements (fiber optic)

It is essential that details of the test plan need to be finalized by February 2011.

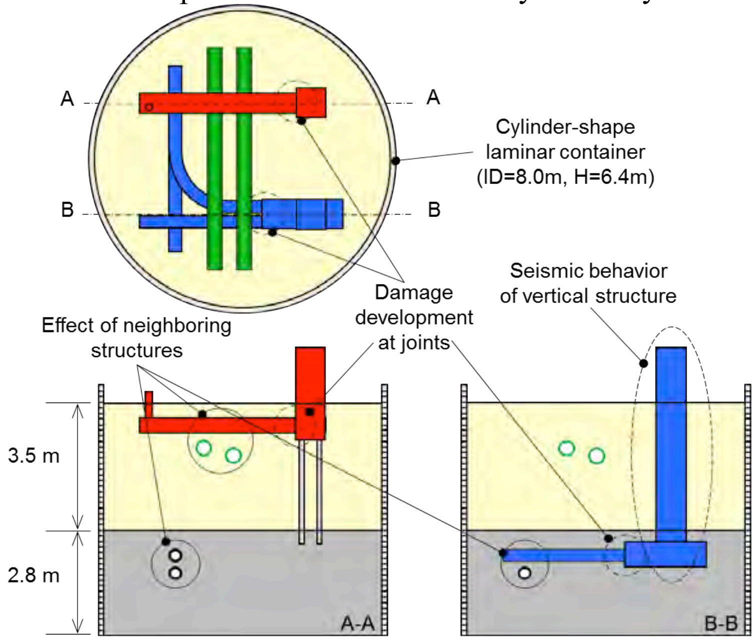

Figure 1 Draft of test setup plan

Possible Collaborations:

The sophisticated nature of this research project presents a number of areas for potential U.S. and Japan research collaboration. Specifically, the following areas have been identified as areas of opportunity for future collaboration:

1. Performance of centrifuge tests for baseline data and to provide independent verification of the consistency of test results
2. Calibration of numerical modeling and parameters, especially for dry sand
3. Comparison of possible instruments to establish the best sensoring plan for the large-scale model test (e.g. tactile sensor, fiber optic sensor)
4. Collaboration with NEES for data simulation and visualization
5. Development of an environment for more frequent exchange of data and opinions

Possibilities of such collaboration work needs to be carefully considered considering policies for NEES/E-Defense research projects.

Specifically, the following steps will be carried in close collaboration in order to help in the development of the detailed test plan:

1. A preliminary elastic analysis will be performed to assess the issues of horizontal spacing of tunnel structures and their interaction with vertical shafts.
2. The proposed centrifuge test and 1-g shaking table test will be used to perform a baseline physical model study.
3. The potential use of tactile and fiber optic sensors will be further explored.
4. Further material characterization will be performed.
5. The current status of the project will be presented to interested potential NEES participants at the Quake Summit in San Francisco at 11 am-12:30 pm, Saturday October 9th.

6. The time of the next planning meeting will be established as soon as possible to assure maximum participation.

Session Summary Report

Breakout Session 2(d) Energy Facilities

Moderators: Khalid Mosalam (University of California, Berkeley) and Tomohiro Ito (Osaka Prefecture University)
Recorder: Khalid Mosalam (University of California, Berkeley)
Members (in alphabetical order of last names)**:** Keisuke Minagawa (Tokyo Denki University), Izumi Nakamura (NIED), Masayoshi Nakashima (NIED)

Background:

Our modern way of life in both Japan and the US depends on an uninterrupted supply of electric energy. Electricity permeates not only industry, transportation and communications, but also conduct of business, education and social functions in our societies. Insuring uninterrupted production and supply of electricity is, therefore, a task of the utmost importance for the structural engineers in Japan and in the US. The NEES/E-Defense meeting focused on the seismic hazard exposure of electricity transmission and production facilities.

The discussion in the meeting was mainly focused on the electric facility, but the energy facility components present a special case of the general class of high-importance infrastructure facilities. These include natural gas energy generation facilities, liquid natural gas storage facilities, petrochemical refineries, storage and transportation facilities, and water purification, transportation and storage facilities.

Discussions:

In the meeting, we were reminded that the prior research activities were limited in this field and the community of researchers was small. The seismic issues for the energy facilities were less understood compared with other structures, though the structures had a high impact on society when they were damaged by earthquakes. Therefore, it was agreed that the Japanese and the US sides should made an effort to gather more participants in the next year meeting with possible representatives from the industry and practitioners to identify key problems related to the seismic performance of energy facilities.

The rough plan of the shake table test on piping system models was proposed by the Japanese side, and we agreed that the test objectives are suitable for the large scale shake table test as the first stage of the experimental study in the field of the energy facilities. This is indeed the case since the piping system is generic and the knowledge from the study would be useful to many plants and facilities. The example of the structural damage in the Kobe earthquake and the outline of the multiple input simulators for the piping system model were also introduced by Professor Ito. Based on the proposed tests and the related discussion, the following effects or problems were agreed as essential ones to consider in conjunction with the planned seismic performance of the piping system.

1. High fidelity simulation
2. Aging
3. Fatigue
4. Effect of high pressure / flow velocity, i.e. involving multi-physics problems
5. Different support conditions
6. Non-destructive inspection and monitoring systems

7. Connecting isolated to non-isolated structures, e.g. nuclear reactor to turbine building
8. Multiple input to the system using the hybrid simulation framework
9. Multi-directional excitation, especially including vertical acceleration (evidence from the Kobe earthquake observations)

From the US side, the shake table test and hybrid simulation on the porcelain insulators were introduced by Professor Mosalam. We agreed to promote the development and validation of hybrid simulation framework for energy facilities, because it is a natural approach, from practicality and accuracy points of view, given by the segmented nature of these facilities.

Desired Collaborations and Benefits of collaboration:

It was concluded that Japan and the US should collaborate in characterizing the general and common features for a large benchmark shake table test for energy facilities. The benchmark test would be an effective vehicle to identify and tackle the unique seismic issue in the energy facilities. Moreover, other researchers can utilize the data to validate and improve analytical structural models for energy facilities. Both sides will greatly benefit from a coordinated research approach in the important area of energy facilities.

The following topics, which were discussed in the 2009 NEES/E-Defense meeting, should also be promoted at every chance for collaboration between the Japanese and the US sides.

1. Integrate equipment qualification test data from tests already conducted in the US and Japan with the newly conducted beyond-design-basis tests planned at E-Defense.
2. Conduct complementary large-scale tests using E-Defense for large and US shaking tables for comparatively smaller equipment. Use US shaking tables to conduct tests under differential support motions.
3. Conduct complementary and cooperative computational simulations to calibrate the numerical models using large-scale test data on the response of components, systems and structures.
4. Integrate response modification devices into the design of electric power facilities.
5. Develop fragility data with the common performance basis.
6. Develop design guidelines, assessment tools and practical recommendations based on the E-Defense and NEES data sets.
7. Enable fast dissemination of results at an international level and promote international collaboration in the field of critical infrastructure.
8. Educate younger generations of structural engineers to specialize in critical infrastructure facilities.

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