A REPORT ON VISIT TO JAPAN ON RESEARCH WORK

Date: 05-12-2023.

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One month research work at National Research Institute for Earth Science and Disaster Resilience (NIED) as a foreign specialist from 1 to 30 November, 2023. The research project entitled "Detailed FE Simulation of RC Buildings for Seismic Damage Prediction Using a Non-Local Plasticity Based Damage Models for Concrete" adopted by the JSPS bilateral program, to collaborate in the development of numerical simulation techniques. It is a DST approved project under INDO-JAPAN collaboration. Invitation letter also attached.

First week of visit: Introduction to NIED, Discussion on work to be done and E-defence Visit near Kobe.

Second week of visit: Introduction to E-simulator coding using C^{++}, practicing on E-simulator.

Third week of visit: Algorithm and applying Damage plasticity coding in E-simulator.

Fourth week of Visit: Working on E-simulator coding by applying Damage plasticity of Concrete.

OVERVIEW OF E-DEFENCE JAPAN

"E-defence" generally refers to the E-Defense (Full-Scale Earthquake Testing Facility) in Japan. The E-Defense facility is a large-scale earthquake testing facility located in Miki City, Hyogo Prefecture, Japan. It is operated by the National Research Institute for Earth Science and Disaster Resilience (NIED). The E-Defense (Full-Scale Earthquake Testing Facility) in Japan was officially opened and began operations in 2005.

Purpose: E-Defense is designed to conduct full-scale, realistic earthquake simulations to test the structural integrity and safety of buildings and infrastructure. The facility aims to contribute to the development of earthquake-resistant technology and improve the resilience of structures in the face of seismic events.

Testing Capabilities: E-Defense has a massive shaking table that can replicate the motion of various earthquake scenarios. The facility is equipped to test large-scale structures, including full-sized buildings, bridges, and other infrastructure elements. Researchers use the facility to assess how well different structures can withstand the forces generated by earthquakes.

Shaking Table: The heart of E-Defense is its gigantic shaking table, one of the largest in the world. This table can simulate a wide range of ground motions, replicating the complex and destructive nature of earthquakes. The ability to reproduce realistic seismic conditions is crucial for accurately evaluating the seismic performance of structures.

Size and Capacity: The shake table at E-Defense is exceptionally large and has a high load-carrying capacity, enabling it to test full-scale structures, including buildings and bridges. The size of shake table is : 20 x 15 m, maximum loading capacity: 12,000kN. This facility has already implemented over 80 full-scale or large-scale experiments since its operation commenced in 2005.

Three-Dimensional Motion: One of the unique features of the shake table is its ability to simulate three-dimensional earthquake motions. This means that the table can move not only horizontally but also vertically and in the lateral direction. This capability is crucial for replicating the complex and multidirectional forces experienced during actual earthquakes.

Realistic Ground Motion Reproduction: The shake table is designed to reproduce realistic ground motions recorded during past earthquakes. Researchers input data from actual seismic events to simulate the specific characteristics of ground shaking, providing a more accurate representation of the challenges structures face during earthquakes.

Hydraulic Actuators: The E-Defense (Full-Scale Earthquake Testing Facility) in Japan features a shake table with a total of 24 hydraulic actuators. These actuators are responsible for generating the dynamic forces needed to simulate realistic earthquake motions during experiments. The shake table is driven by powerful hydraulic actuators that generate the required forces to simulate earthquake motions. These actuators are capable of precise control, allowing researchers to replicate a wide range of seismic scenarios with varying intensities and frequencies.

Research and Development: The facility is used for research and development in earthquake engineering. Researchers and engineers from around the world use E-Defense to test and improve seismic design and construction methods. The data collected from these tests contribute to the development of better earthquake-resistant building codes and standards.

Shake Table at E-Defence

Hydraulic liquid pipes for Actuators

With Chief Scientist at E-defence, Kobe

WORK LOCATION IN JAPAN:

National Research Institute for Earth Science and Disaster Resilience (NIED): NIED is an independent administrative institution in Japan that conducts research in various fields related to earth science and disaster resilience. It plays a significant role in studying earthquakes, tsunamis, volcanic activities, and other natural disasters to enhance understanding, monitoring, and preparedness.

Location in Tsukuba: Tsukuba is a city located in Ibaraki Prefecture, Japan. It is known for being a major centre for academic and scientific research. NIED has a facility in Tsukuba where it conducts research and operates various projects related to its mission.

Earthquake and Tsunami Research: NIED is particularly active in earthquake and tsunami research. It operates seismic and geodetic networks, conducts studies on seismic hazards, and develops technologies for earthquake early warning systems. The institute plays a crucial role in advancing the understanding of earthquake processes and improving methods for disaster mitigation.

National Research Institute for Earth Science & Disaster Resilience (NIED), Tsukuba, Japan

RESEARCH TOPIC WORKED:

Damage Plasticity Modelling:

Concept: Damage plasticity is a modelling approach used in structural engineering to simulate the response of materials, such as concrete, under cyclic loading or other forms of stress. It combines aspects of plasticity theory (deformation beyond the elastic limit) with damage mechanics (accounting for material degradation).

Purpose: This type of modelling is particularly useful for simulating the behaviour of structures subjected to repeated loading, such as those experienced during earthquakes. This modelling technique combines principles of plasticity theory, which deals with permanent deformation beyond the elastic limit, with concepts from damage mechanics, which account for material degradation under stress.

Plasticity Theory:

Plasticity in materials refers to the ability to undergo permanent deformation, particularly after surpassing the elastic limit. In the context of concrete, this often occurs under high-stress conditions, such as those experienced during seismic events.

Damage Mechanics:

Damage mechanics involves the study of material deterioration as a result of applied loads. In concrete, damage can occur due to factors like micro-cracking, which can accumulate over time and affect the material's overall integrity.

Coupling Plasticity with Damage:

Damage plasticity modelling integrates plasticity and damage mechanics to better capture the behaviour of concrete under both reversible (elastic) and irreversible (plastic and damaged) deformations.

Yielding and Plastic Flow: The model accounts for the yielding of concrete under stress and subsequent plastic flow. This is crucial for understanding how concrete deforms beyond its elastic range.

Damage Evolution: The model considers how damage evolves over time as the material undergoes repeated loading cycles. This includes the initiation and propagation of micro-cracks within the concrete matrix.

Stiffness Reduction: As damage accumulates, the stiffness of the material decreases. This reduction in stiffness reflects the deteriorating mechanical properties of the damaged concrete.

Strength Reduction: Damage plasticity models also incorporate the reduction in strength that occurs as the material undergoes damage. This is crucial for predicting the load-carrying capacity of structures.