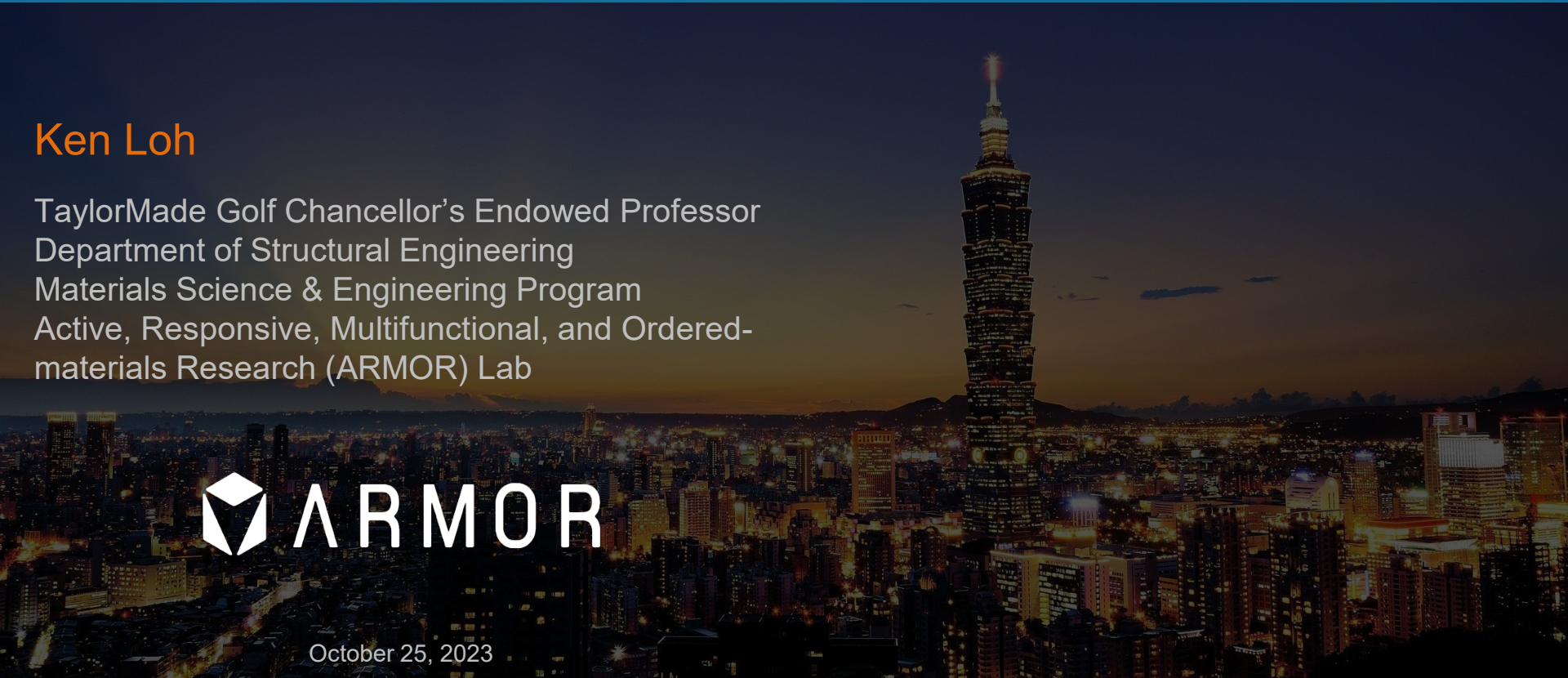
# 2024 Global Seminar in Taiwan:
# How Shaky Structures Become the Safest in Taiwan

*SE 164 Sensors & Data Acquisition* and *SE 167 Signal Processing*

UNIVERSITY OF CALIFORNIA SAN DIEGO




Ken Loh

TaylorMade Golf Chancellor's Endowed Professor
Department of Structural Engineering
Materials Science & Engineering Program
Active, Responsive, Multifunctional, and Ordered-materials Research (ARMOR) Lab


ARMOR

October 25, 2023

# Who Are We?

## Ken Loh, Ph.D.

- TaylorMade Golf Chancellor's Endowed Professor, Structural Engineering
- M.S. and Ph.D. in Structural Engineering, University of Michigan (2005, 2008)
- B.S. in Civil Engineering, Johns Hopkins University
- Director, ARMOR Lab
- Instructor, *SE 164 – Sensors and Data Acquisition*
- Interesting facts:
  - Went to GK-12 (Taipei American School) in Taipei, Taiwan
  - Engineering Duty Officer, U.S. Navy Reserve
  - Co-founder of JAK Labs

## Chin-Hsiung (CH) Loh, Ph.D.

- Adjunct Professor, Structural Engineering
- Distinguished Professor Emeritus, Civil Engineering, National Taiwan University
- B.S., M.S., and Ph.D. in Civil Engineering, National Taiwan University (!@#$)
- Former Director, National Center for Research on Earthquake Engineering
- Instructor, *SE 167 – Signal Processing & Spectral Analysis*
- Interesting facts:
  - Born and raised in Taipei, Taiwan
  - Three amazing grand children (Jacob 10, Peter 9, Olive 7)
  - Father of Prof. Ken Loh


# Taiwan?

**Just the basics…**

# Why Teach in Taiwan?

**Its history…and our history…is perfect for this two-course sequence**

# Multi-hazard Vulnerability in the U.S.

2004 Indian Ocean Tsunami

2011 Tohoku Tsunami

2014 & 2015 Polar vortex winters

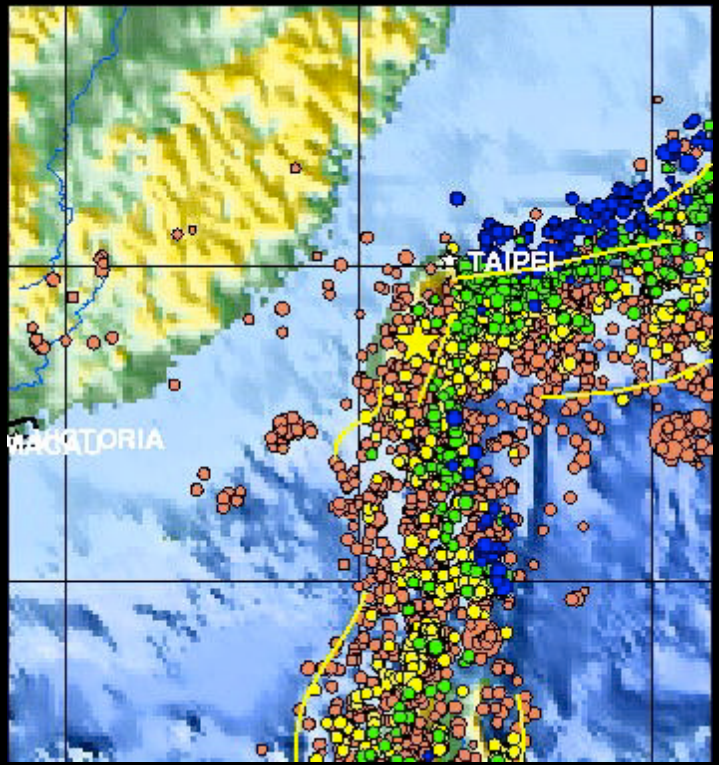
- Infrastructure and property damage
- Jeopardize public safety
- Loss of lives
- Socioeconomic losses

2012 Hurricane Sandy

1989 Loma Prieta Earthquake

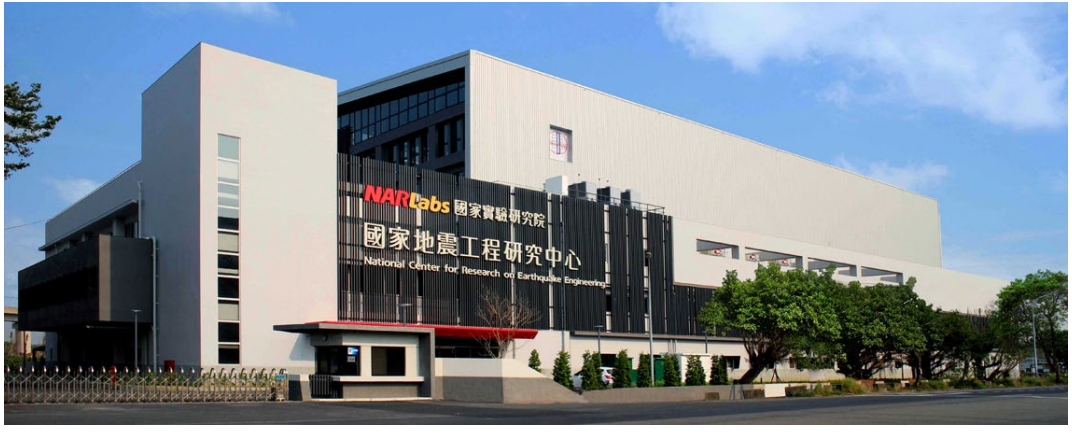
1994 Northridge Earthquake

2005 Hurricane Katrina

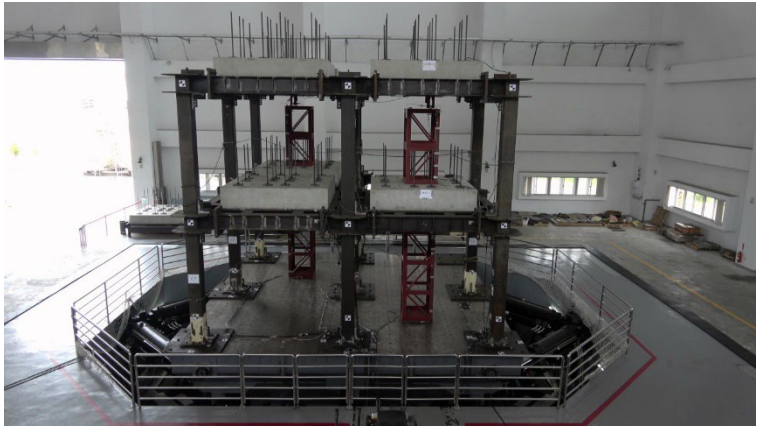

TAIPEI

# They Learned – And Advanced

- National Center for Research on Earthquake Engineering (NCREE) in Taiwan
  - Most advanced testing facilities and engineering capabilities, capable of full-scale testing







# What are we teaching?

## Background and Course Information

# Structures

Civil

Geotechnical


Automotive

## Structure:

Materials + Geometry + Function

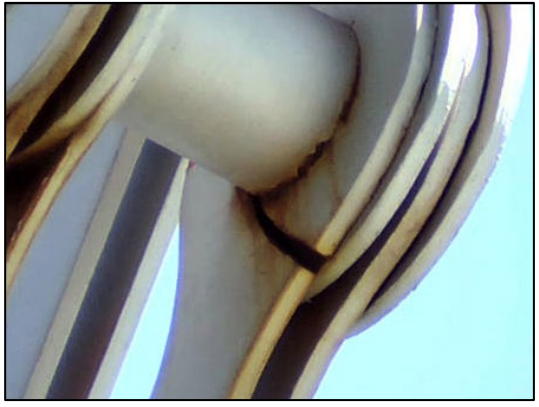
Aerospace

Marine

Biological

# Damage and Degradation

Environment



Repeated loading

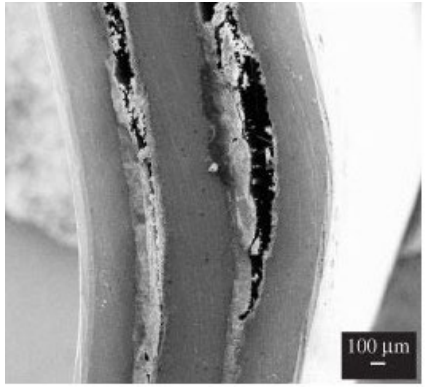
Impulse-type events

Natural disasters

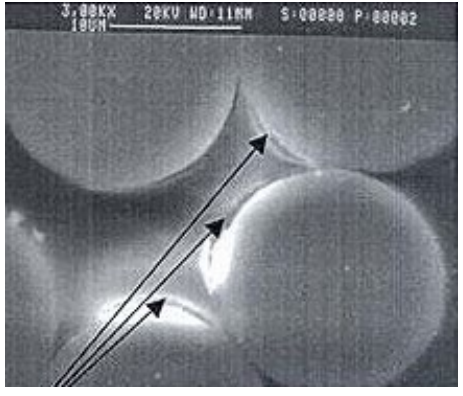
Extreme events

Manmade

# Need




Delamination



Fiber-matrix cracking

**Undetected damage**

**Propagation**


Composite rudder failure in-flight

***Structural Damage***

***Structural Failure***

**Timely Intervention**

# Grand Challenge

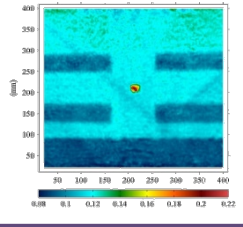
- How can we generate, in a **scalable** manner, **appropriate data streams** that contain rich information about **spatially distributed structural properties** and **damage characteristics** suitable for **structural health diagnostics** and **decision-making**?

## 1. SENSING

F. Lanza di Scalea & K. Loh

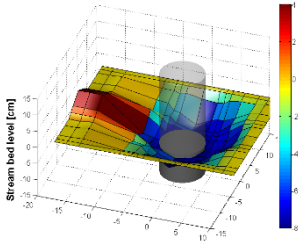
## 2. DETECTION

C. Farrar, F. Lanza di Scalea, C-H. Loh, K. Loh & M. Todd



## 3. DIAGNOSIS

C. Farrar, C-H. Loh & M. Todd



# SE 164 – Sensors and Data Acquisition

ARMOR

- What are current and emerging sensors that we can use to understand how our built environment is interacting with the natural environment?
- Topics:
  - Sensor classification and characteristics
  - Fundamentals of electric circuits
  - Resistive, capacitive, and inductive sensing mechanisms
  - Piezoelectricity and thermoelectricity
  - Analog sensor interfaces
  - Analog-to-digital converters (ADC), aliasing, and signal conditioning
  - Data transmission and wireless sensor networks
  - Radio frequency identification (RFID) and emerging technologies

# SE 167 – Signal Processing and Spectral Analysis

ARMOR

- How do we use real-world data, process them to reveal relevant features, and extract knowledge about our structures and potential damage?
- Topics:
  - Random data and Fourier Transforms
  - Signal convolution and correlation, and sampling theorem
  - Discrete-, Fast-, and Short-Time Fourier Transforms
  - Power spectral density and input-output relationships in the frequency domain
  - Low-pass filter and time-domain analysis
  - Time-domain signal decomposition
  - Hilbert Transform
  - Time-frequency analysis
  - Digital filters
  - Online structural system identification

# SHM & NDE Specialization

ARMOR

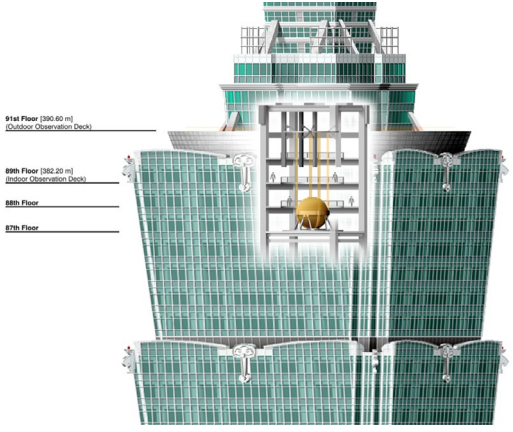
- Specialization in SHM/NDE equips you with interdisciplinary knowledge in sensing technologies, data interrogation, and modeling and analysis
  - Encompasses structural, civil, mechanical, aerospace, and marine engineering
  - Supports “design-to-retirement” life cycle management of systems
- One-year M.S. program (36 units):

| Requirement | Thesis option | Comprehensive option |
|---|---|---|
| **Core courses:** | SE 263 – NDE (4)<br>SE 265 – SHM Principles (4) | SE 263 – NDE (4)<br>SE 265 – SHM Principles (4) |
| **Capstone experience:** | No requirement | SE 296 – Independent Study (4) |
| **Thesis research:** | SE 299 – Graduate Research (8) | No requirement |
| **Sensing Technology focus area** | One course (4) | One course (4) |
| **Data Interrogation focus area** | Two courses (8) | Two courses (8) |
| **Modeling & Analysis focus area** | Two courses (8) | Two courses (8) |
| **Technical elective:** | No requirement | One course (4) |
| **Total Units:** | **36** | **36** |
| **Graduate seminar:** | Three quarters of SE 290 (3) | Three quarters of SE 290 (3) |

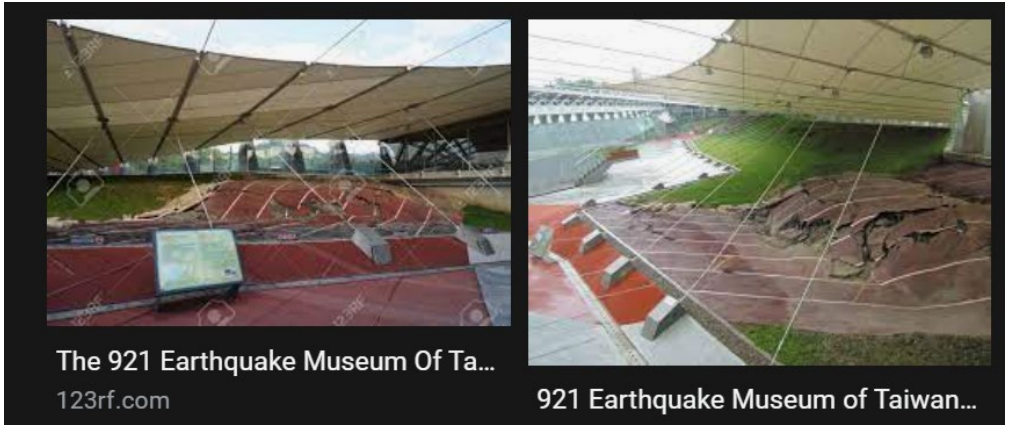
# Complementing Classroom Education

- Technical tours and museums

NTU Civil Engineering building adjacent to NCREE




Taipei 101 and tuned mass damper




921 Chi-Chi Earthquake Museum


Taiwan Semiconductor Manufacturing Company (tsmc)

ARMOR

# Beyond Studying

**Living, experiencing, socializing, eating, and having fun**

# Interested?

ARMOR

- Application details:
  - Application Period: Opens on **November 1, 2023**
  - Application Deadline: Closes on **March 1, 2024 or until full**
  - Space is limited – program is capped at 28 students

- Financial aid and scholarships:
  - Funding options: https://studyabroad.ucsd.edu/students/programs/global-seminars/funding.html

# Questions?

UNIVERSITY OF CALIFORNIA SAN DIEGO