## LECTURE PLAN

**Course title:** Vibration Control and Monitoring for Buildings – Theory and Application –
**Class style:** A 16-hour face-to-face lecture (Eight 2-hour sessions, Equivalent to 2 ECTS)
**Date:** Thursday, 10 – Monday, 21 September 2026
**Language:** English
**Lectures 1 and 2:** Two 2-hour lectures with a short break, **10 September** (9-11 am; 12am-2pm)
**Lectures 3 and 4:** Two 2-hour lectures with a short break, **11 September** (9-11 am; 12am-2pm).
**Lecture 5:** One 2-hour lecture, **15-September** (10-12 am).
**Lectures 6 and 7:** Two 2-hour lectures with a short break on **16-September** (9-11 am; 12am-2pm).
**Lecture 8:** One 2-hour lecture (Comprehension test and review) on **21 September** (10-12 am).

### Course summary (272 words)

This course provides an overview of vibration control and monitoring in architectural buildings with an introduction to the practical applications in Japan. It emphasizes how research and development are translated into real-world structures, highlighting the underlying theories and design philosophies.

Structural control sessions introduce fundamental strategies such as active and passive mass dampers, hysteresis dampers (displacement-dependent), viscous dampers (velocity-dependent), seismic base isolation, and joint dampers for adjacent buildings. Fixed-point theories provide the basic design principles for tuned mass dampers, interstory dampers, and joint dampers. The Maxwell model is employed to evaluate realistic control effectiveness. Pole allocation reveals a unified equation governing passively controlled buildings. This unified equation plays a significant role in preliminary design, as it constrains parameter variations, clarifies the physical meaning of control effects, and improves the trial-and-error design process. Integrating pole allocation with fixed-point theory further links structural damping effects with damper capacities.

Structural monitoring sessions introduce several modal identification methods that can be applied to real buildings with a limited number of sensors. Among these, the ARX model is particularly useful when both inputs and outputs are measured under seismic excitation. In contrast, singular value decomposition of the output power spectral density provides a simple and effective tool when only output data is available. The ARX model is closely associated with online, offline, and total least squares methods. Identified ARX models reveal the nonlinear behavior of earthquake-resistant buildings and confirm the effectiveness of structural control as well as seismic base-isolation. Output-only identification methods are highly applicable for investigating modal properties under microtremors. Accelerograms recorded in actual buildings are distributed to experience the integration of structural control and monitoring.

## 1. Introduction to Structural Monitoring – Least Squares Method and practical applications –

The online Least Squares Method (LSM) is derived from the offline LSM. The Total LSM becomes a valuable tool when vibration measurements are noisy. These LSMs are closely related to modal identification using the ARX model. The online LSM with the ARX model serves as an effective identification technique for understanding the nonlinear dynamic behavior of buildings through equivalent linearization. Practical applications demonstrate control effectiveness of both active and passive structural control as well as seismic base isolation.

## 2. Modal Identification Methods Based on ARX model and Power Spectral Density

The modal identification using the ARX model is explained in detail. This approach is applied when both inputs and outputs are measured. When only the outputs are measured, the ARX model is simplified to the AR model. The AR model is closely associated with the Random Decrement technique. In the frequency domain, the Singular Value Decomposition of the outputs' power spectral density becomes an easy and useful method for determining natural frequencies and mode shapes of a structure. In practice, the decomposition technique extracts dynamic behavior of large-scale buildings with irregular geometries and atriums.

## 3. Introduction to Structural Control (1) – Mass damper, hysteresis damper, viscous damper, joint damper and seismic base isolation –

Many types of control strategies have already been implemented in actual buildings in Japan. The typical strategies – together with their underlying theories, design philosophies, and practical applications– include tuned mass damper (TMD), active mass damper, hysteresis damper (displacement-dependent), viscous damper (velocity-dependent), seismic base-isolation, and joint damper for two adjacent buildings.

## 4. Introduction to Structural Control (2) – Fixed-point theories and practical application tendency in Japan –

Fixed-point theories are a key to understand dynamic fundamental behaviors of passive viscous dampers: TMD, interstory damper, and joint damper. The Maxwell model is another key to evaluate realistic control effectiveness. The practical application tendency in Japan is presented for considering research directions.

## 5. Unified Description/Constraint Equation for Passive Control

Pole allocation reveals a unified equation governing passively controlled buildings. This unified equation plays a significant role in preliminary design, as it constrains parameter variations, clarifies the physical meaning of control effects, and improves the trial-and-error design process. Integrating pole allocation with fixed-point theory further links structural damping effects with damper capacities.

**6. Modal Identification Working Using Actual Measurements (1)**

**7. Modal Identification Working Using Actual Measurements (2)**

In these two lectures, students will apply the system identification techniques introduced in Lectures 1 and 2 to accelerograms recorded from actual buildings. The recorded accelerograms, executable programs for system identification, and sample analysis data will be provided. Students must bring their own personal computers to participate in the exercises. Lectures 1–3 serve as the foundational knowledge for the applications.

**8. Comprehension Test**

The final lecture evaluates students' understanding of fundamental structural control technologies. The first half of the session will be an examination, followed by a review and explanation of the answers in the second half. Taking this examination is required to receive course credit for the lecture series.